Self-Contained
Acoustic Doppler Current Profiler

TECHNICAL MANUAL

RD Instruments

Acoustic Doppler Current Profilers

P/N 67118 (9/92-C2)

RD Instruments

Acoustic Doppler Current Profilers

RD INSTRUMENTS

SELF-CONTAINED ACOUSTIC DOPPLER CURRENT PROFILER (SC-ADCP) TECHNICAL MANUAL

SEPTEMBER 1992
(Incorporates Change 2)

NOTE
This manual assumes you are using firmware version 17.10 (or later).

RD INSTRUMENTS
9855 Businesspark Ave.
San Diego, California 92131
(619) 693-1178
TLX 46-7731
FAX (619) 695-1459

LIST OF EFFECTIVE PAGES

Base document - March 1, 1991
Change 1 - April 1, 1992
Change 2 - September 1, 1992

On a changed page, a vertical bar in the left margin shows the part of text affected by the change. The last line (footer) of each page lists the effective date of the change. The total number of pages in this manual is 328 consisting of the following changes. A change number of zero indicates an original page.

Page	Change
i – xiv	2
1-1 – 1-6	2
2-1 – 2-18	2
3-1 – 3-4	2
4-1 – 4-26	2
5-1 – 5-34	2
6-1 – 6-34	2
A-1 – A-8	2
B-1 – B-7	1
B-8 – B-14	0
C-1 – C-12	2
D-1 – D-32	2
F-1 – F-10	2
S-1 – S-5	0
S-6	2
S-7	0
S-8	2
S-9 – S-10	0
T-1 – T-20	2
V-1 – V-16	0
W-1 – W-4	2
X-1 – X-22	2
Y-1	2
Y-2 – Y-3	0
Y-4 – Y-5	2
Y-6 – Y-9	0
Y-10	2
Y-11 – Y-12	0
Z-1 – Z-18	0
Glossary-1	2
Glossary-2 – 4	0
Index-1 – 10	2

RECORD OF CHANGES

Change	Effective	Description
0	01 MAR 91	Base document; firmware version 17.07; EPROM recorder
1	01 APR 92	New lithium battery pack designations and warnings
2	01 SEP 92	Firmware version 17.10; technical/editorial changes

NOTES

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF TABLES

NOTES

CHAPTER 1
INTRODUCTION

1-1. SCOPE

This document is the technical manual for the RD Instruments (RDI) Self-Contained Acoustic Doppler Current Profiler (SC-ADCP) with EPROM Recorder. It is the primary reference for SC-ADCPs using the firmware version listed on the title page.

This manual has information on ADCP setup, operation, data format, maintenance, and troubleshooting. The appendices have information on interconnection, battery requirements, formulas, direct commands, test procedures, calculating absolute backscatter, switch settings, specifications, dimensions, functional processing, board layouts, and cabling/wiring.

NOTE

THIS MANUAL HAS INFORMATION ON OPERATING THE ADCP WITH A DUMB TERMINAL/EMULATOR PROGRAM USING THE ADCP'S DIRECT COMMAND SET (APPENDIX D). THIS METHOD IS HARD TO USE. WE RECOMMEND YOU USE OUR IBM-COMPATIBLE SOFTWARE PROGRAMS TO SET UP THE ADCP (SC-ADCP DEPLOYMENT PROGRAM - SCADCP.EXE), PROCESS DATA FROM THE ADCP (LOGADCP.EXE, LISTADCP.EXE, PLAYBACK.EXE), AND TEST THE ADCP (SCTEST.EXE). FOR INFORMATION ON THESE PROGRAMS, SEE THEIR INDIVIDUAL MANUALS.

1-2. WHERE DO I BEGIN?

If ADCPs are new to you, you are probably eager to get started. But first, let us offer a few words of guidance. We have tried to make the ADCP and its manuals easy to use. However, the ADCP <u>is</u> a complex instrument. Take time to read the manuals. Use the checklists and work sheets to guide you through the procedures. Appendix F has reproducible copies of the most-used checklists and work sheets.

___ a. Follow the instructions in the READ THIS FIRST packet you received with your system. It may have updated information not in this manual.
___ b. Look through this manual. Become familiar with its contents.
___ c. Verify your system is operating using the following steps.

  ___ (1) Interconnect the ADCP system as described in Appendix A.
  ___ (2) If using a computer (recommended), run RDI's SCTEST program (Appendix ¶T-1). If using a dumb terminal/emulator (very <u>un</u>friendly), do the direct command "Y" tests (Appendix ¶T-2).
  ___ (3) If using a computer, you also might want to run RDI's SC-ADCP Deployment Program as a tutorial. If so, see Chapter 2 of the on-disk SC-ADCP Deployment Program User's Manual.

___ d. After completing the initial checkout of the ADCP, you will want to learn how to prepare the ADCP for a deployment. The easiest way to do this is through a practice deployment. Use Chapter 2 of this manual, or Chapter 3 of the on-disk SC-ADCP Deployment Program User's Manual, to guide you through a practice deployment.

1-3. IF YOU NEED FURTHER HELP OR HAVE SUGGESTIONS

This manual is useful only if it meets YOUR needs. We are always improving the quality of our products, but we need your help. We really WANT to hear your suggestions. If you have questions or suggestions, please contact us at:

RD Instruments	Telephone: (619) 693-1178
9855 Businesspark Ave	Telex : 46-7731
San Diego, CA 92131, USA	FAX : (619) 695-1459

You also can reach us on OMNET, an international network of oceanographers. Our mailbox is *RD.Instruments*. We also have two bulletin boards – *RDI* for general ADCP information, and *RDI.Field.Service* for Field Service and Technical Bulletins. If you want us to prompt you when new messages appear on our bulletin boards, send us a telemail. For OMNET information contact OMNET Inc, 137 Tonawanda Street, Boston MA 02124, (617) 265-9230.

1-4. SYSTEM DESCRIPTION

This section has general information about ADCP abilities, configurations, operator control, and a typical deployment sequence.

1-4.1. OVERVIEW. The ADCP transmits acoustic pulses from a transducer assembly along four beams (Figure 1-1). The transducers receive backscattered sound from plankton and small particles riding the water currents. Using the Doppler effect and some basic trigonometry, the ADCP converts the backscattered sound into components of water-current velocity. The ADCP measures the speed and direction of the current at multiple locations in the water column. The ADCP makes a profile of these measurements for up to 128 locations called depth cells or bins. Depth cells can be from 1 to 32 meters in length. For information on ADCP principles of operation and the Doppler effect, see RDI's *Acoustic Doppler Current Profilers - Principles of Operation: A Practical Primer*. Appendix S has information on system specifications and dimensions. Appendix X has a functional description.

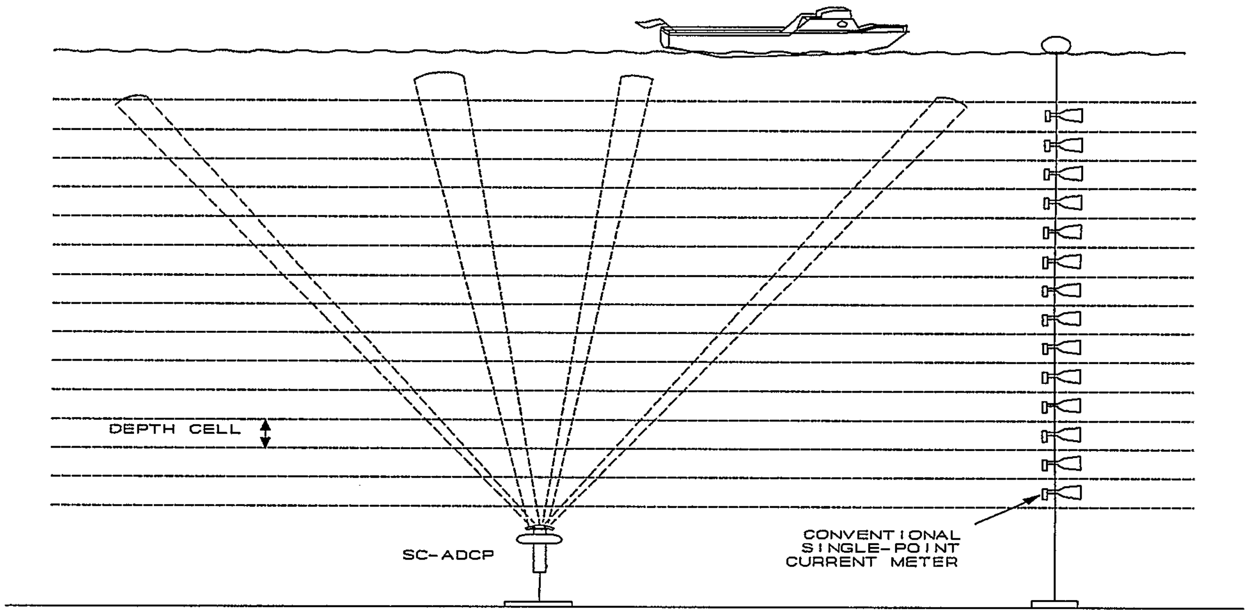


Figure 1-1. SC-ADCP Profiling Technique

1-4.2. SC-ADCP HARDWARE/CONFIGURATIONS/OPTIONS. The SC-ADCP is a modular instrument (Figure 1-2). It consists of a water-tight transducer assembly and pressure case. The case protects the internal low-power electronics, EPROM recorder, battery-pack power supplies, and heading/tilt sensors. The SC-ADCP can operate unattended for deployment periods of a year or more, storing data on its internal EPROM recorder. ADCPs can face up or down on fixed or moving platforms. The ADCP's modular construction lets you use several options to set up for specific applications. These options include:

a. Five interchangeable transducer assemblies operating at acoustic frequencies of 75, 150, 300, 600, and 1200 kHz. This option provides a wide range of operating depth capability vs spatial resolution (see Appendix S for specifications and dimensions).
b. Internal EPROM recorder.
c. Heading and pendulum tilt sensors to correct for ADCP motion.
d. Expanded or external battery packs for extended deployments.
e. Transducer beam angles of 30°(standard) or 20°.
f. A 90° transducer assembly adaptor for mounting the ADCP on its side.
g. Conductivity-Temperature-Depth (CTD) sensors and an interface module to allow single-point readings near the ADCP.
h. Pressure cases rated to operating pressures of 1480 psi (1000 m).
i. External interface junction box (J-Box).
j. Conversion to AC power (¶5-10).
k. Computer software for testing, parameter setting, power usage calculations, data retrieval, and post-deployment processing.

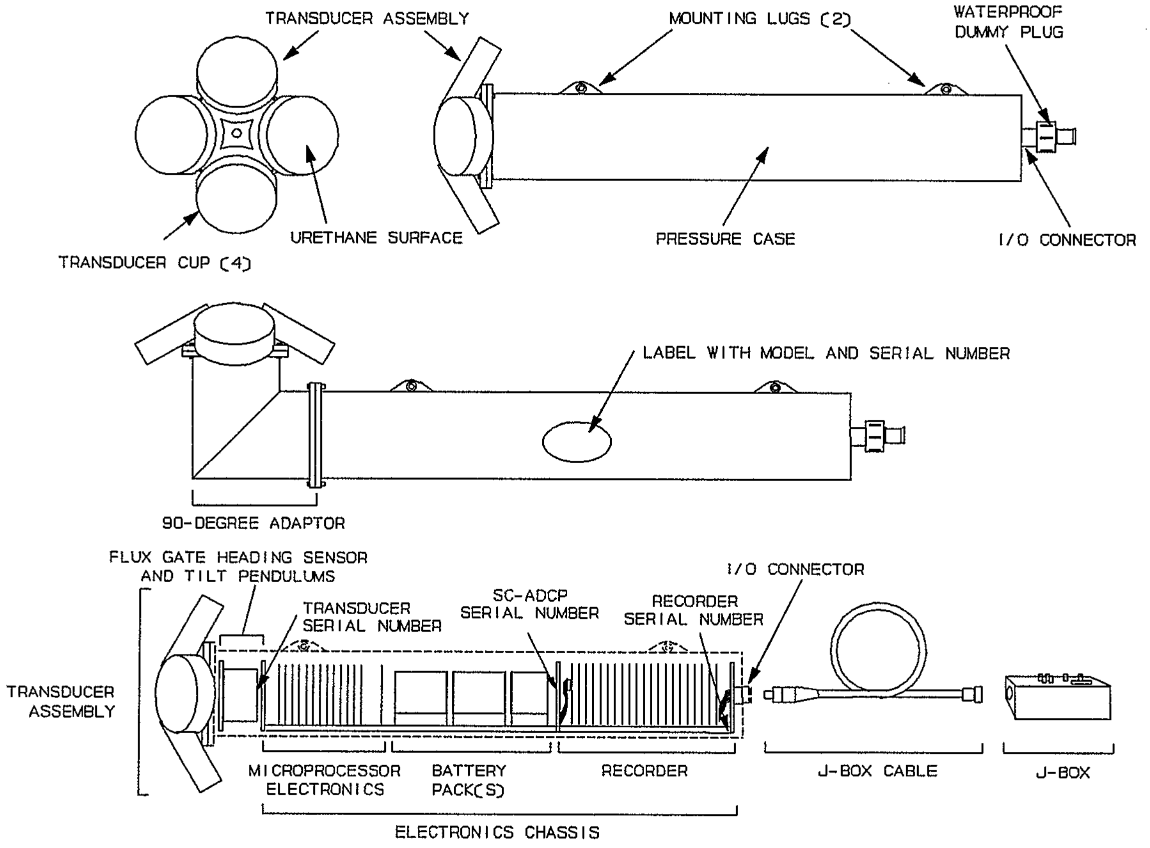


Figure 1-2. SC-ADCP Configurations

1-4.3. OPERATIONAL DESCRIPTION. The microprocessor-based ADCP is programmable through a computer or dumb terminal interface (Figure 1-3). Operator commands set the ADCP profiling parameters for specific applications.

Computer Software Control. You can operate the SC-ADCP most effectively with RDI's Deployment Program. This menu-driven software lets you control ADCP functions and profiling parameters by selecting from options displayed on an IBM PC/XT/AT-compatible personal computer. You can create application configurations, store them on disk, and retrieve them for later use. This keeps to a minimum the steps needed to prepare the ADCP for a variety of data collection and retrieval applications. For information on how to use this program, refer to the on-disk SC-ADCP Deployment Program User's Manual.

Dumb-Terminal Control. A dumb terminal consists of a CRT monitor and keyboard. It does no internal processing. You can control the ADCP with a dumb terminal, but this method is hard to use. You should limit dumb-terminal control to testing and special applications that the Deployment Program cannot handle. Appendix A has information on connecting the ADCP to a dumb terminal. Appendix D lists the direct commands used in the dumb-terminal mode. NOTE: This manual describes the direct commands, but does not treat the use of an ADCP with a dumb terminal as normal operation.

1-4.4. SC-ADCP INPUTS AND OUTPUTS. Figure 1-4 lists all SC-ADCP inputs and outputs. We set many of these inputs to specific values at the factory. Do NOT arbitrarily change these values. You can use all ADCP outputs for data analysis. Appendix D describes the available inputs. Chapter 4 describes the outputs and their data format.

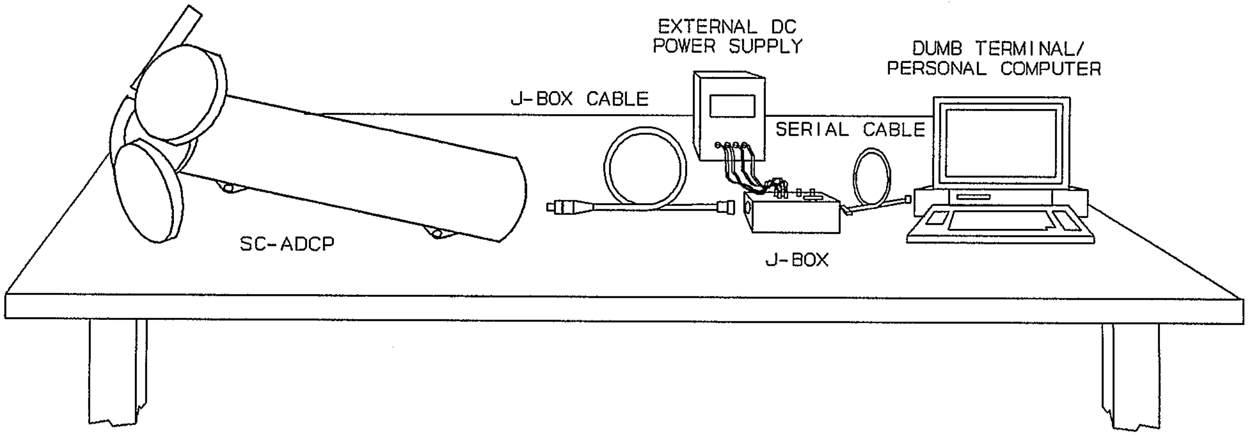


Figure 1-3. SC-ADCP System Interconnection

INPUT COMMANDS

COMMON DEPLOYMENT COMMANDS

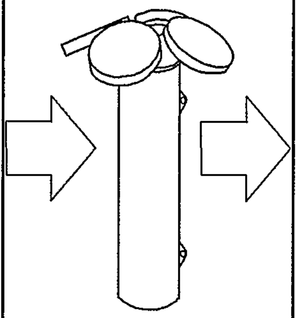
- -NUMBER OF DEPTH CELLS (BINS)
- -DEPTH CELL (BIN) LENGTH
- -NO. OF PINGS PER ENSEMBLE
- -TIME BETWEEN ENSEMBLES
- -OUTPUT DATA TYPES
- -SET REAL-TIME CLOCK
- -TIME OF FIRST PING
- -START DATA COLLECTION

SPECIAL, APPLICATION AND TESTING COMMANDS

- -BIN-TO-BIN ACQUISITION AND FILTER CONTROL
- -BIN-TO-BIN TRACKING FILTER GAIN
- -BLANK AFTER TRANSMIT
- -CLEAR SECONDS FROM REAL-TIME CLOCK
- -CTD MEASUREMENT TIME
- -DELAY AFTER BLANK
- -DELAY BEFORE DATA OUTPUT
- -ENSEMBLE PERCENT-GOOD DATA
- -FISH REJECTION THRESHOLD
- -HEADING OFFSET
- -I/O CONTROL
- -INCREASE BAUD RATE BY FACTOR OF 4
- -FORCE POWER-ON INITIALIZATION
- -INTERRUPT OPERATION
- -PERFORM BIT DIAGNOSTICS
- -PING-TO-PING FIRST BIN TRACKING CONTROL
- -REASONABLENESS VELOCITY THRESHOLD
- -SIGNAL-TO-NOISE THRESHOLD
- -SPECIAL TEST SIG./DATA OUTPUT SEL.
- -TIME BETWEEN PINGS
- -TRANSMIT INTERVAL
- -TRANSMIT LEADER DATA
- -BOTTOM-TRACK (BT) XMIT PULSE LENGTH
- -BT DEPTH CELL LENGTH
- -BT NUMBER OF DEPTH CELLS
- -BT MODE
- -BT TRANSMIT LENGTH CONTROL
- -BT DETECTION THRESHOLD
- -ENSEMBLES BEFORE BT RE-ACQUIRE
- -PROFILING PINGS PER BT PING

RECORDER COMMANDS

- -ADVANCE READ POINTER WITHIN FILE
- -DISPLAY RESULTS OF EPROM ERASURE
- -DUMP SECTORS
- -FIND FILE NUMBER
- -GET DATA TO READ
- -INCREASE READ VOLTAGE
- -LOCATE READ POINTER
- -POSITION DUMP POINTER
- -READ AND TRANSMIT RECORDER DATA
- -SUMMARIZE CONTENTS OF MEMORY
- -TEST RECORDER HARDWARE/CARDS
- -WRITE CONFIG. DATA FOR NEW DEPLOY.



OUTPUT DATA

ENSEMBLE HEADER

- -TOTAL NUMBER OF DATA BYTES
- -NO. OF LEADER DATA BYTES
- -NO. OF VELOCITY DATA BYTES
- -NO. OF SPECTRAL WIDTH DATA BYTES
- -NO. OF ECHO INTENSITY DATA BYTES
- -NO. OF PERCENT-GOOD DATA BYTES
- -NO. OF STATUS DATA BYTES

ENSEMBLE LEADER

- -DAY/TIME OF ENSEMBLE
- -TIME BETWEEN PINGS
- -PINGS PER ENSEMBLE
- -DEPTH CELLS PER PING
- -DEPTH CELL LENGTH
- -TRANSMIT INTERVAL
- -DELAY AFTER TRANSMIT
- -ADCP CONFIGURATION STATUS
- -ENSEMBLE NUMBER
- -BIT STATUS
- -SIGNAL-TO-NOISE THRESHOLD
- -PERCENT-GOOD THRESHOLD
- -PITCH
- -ROLL
- -HEADING
- -STANDARD DEVIATION - PITCH
- -STANDARD DEVIATION - ROLL
- -STANDARD DEVIATION - HEADING
- -TEMPERATURE (SC-ADCP)
- -HIGH VOLTAGE INPUT
- -TRANSMIT CURRENT
- -LOW VOLTAGE INPUT
- -CONDUCTIVITY (CTD)
- -TEMPERATURE (CTD)
- -DEPTH (CTD)
- -CTD MEASUREMENT INTERVAL
- -BT VELOCITY (EACH BEAM)
- -BT RANGE (EACH BEAM)
- -BT PERCENT GOOD (EACH BEAM)

SELECTED DATA (EACH BIN AND BEAM)

- -VELOCITY
- -SPECTRAL WIDTH
- -ECHO INTENSITY
- -PERCENT-GOOD
- -STATUS

CHECKSUM

Figure 1-4. SC-ADCP Inputs and Outputs

1-4.5. TYPICAL DEPLOYMENT AND RECOVERY CYCLE. You can prepare the ADCP for deployment in several ways. A typical deployment and recovery cycle goes through the following phases. We cover these phases in Chapters 2 and 3.

a. *Planning phase* - Gather information about the deployment such as what data to collect, length of deployment, processing range, profiling parameters, accuracy requirements, and environmental conditions.

b. *Evaluation phase* - Determine what tradeoffs you may need to make because of SC-ADCP limitations.

c. *Testing phase* - Check ADCP operation.

d. *Instrument preparation phase* - Do maintenance tasks to prepare the ADCP for deployment.

e. *Programming phase* - Send the profiling parameters to the ADCP.

f. *Deployment phase* - Deploy the ADCP and begin data collection. During a normal data collection cycle, the ADCP

   (1) Measures current velocity (first moment), spectral width (second moment), and echo intensity profiles along the four beams.
   (2) Reads heading and tilt angles.
   (3) Measures conductivity, temperature, and depth (CTD) readings from optional sensors.
   (4) If selected, transforms data from ADCP beam coordinates to earth coordinates.
   (5) Runs an end-to-end self-test.
   (6) Records the resulting ensemble of data (velocity, spectral width, echo intensity, percent good, status, etc) on the internal EPROM recorder.

g. *Retrieval phase* - Recover the ADCP and its recorded data.

CHAPTER 2
SC-ADCP DEPLOYMENT PROCEDURES

2-0. INTRODUCTION

This chapter presents a logical sequence you can follow when preparing the SC-ADCP for deployment. The preferred method of preparing the ADCP for deployment is through RDI's Deployment Program (described in the SC-ADCP Deployment Program User's Manual). This chapter provides a general overview on preparing the ADCP for deployment using a dumb terminal/emulator program and the ADCP direct command set (Appendix D). The disadvantages of using direct commands to set up the ADCP are: more room for operator error and manually calculating many of the ADCP parameters. We strongly suggest you use the Deployment Program to prepare the ADCP for deployment. In either case, we recommend doing practice deployments in the laboratory. This way, you can become familiar with operating the ADCP. Practice deployments also ensure the ADCP is operating properly.

Deploying the ADCP consists of a series of steps. Figure 2-1 shows an overview of these steps in a simplified block diagram. These steps include:

a. Planning the deployment and determining tradeoffs (¶2-1).
b. Testing the ADCP (¶2-2).
c. Preparing the instrument for deployment (¶2-3).
d. Transferring the deployment parameters to the ADCP (¶2-4).

Deployment planning and tradeoff evaluation are application related and do not require an ADCP. Testing the ADCP and preparing it for deployment are hardware related and can be done independently of planning and evaluation. Transferring the deployment parameters to the ADCP can be done for an actual deployment or for a practice deployment in the laboratory.

Table 2-1 provides a checklist for ADCP deployment. USE THIS CHECKLIST AND ITS REFERENCES TO BE SURE YOU COMPLETE ALL DEPLOYMENT PROCEDURES. Appendix F has a reproducible copy of this checklist.

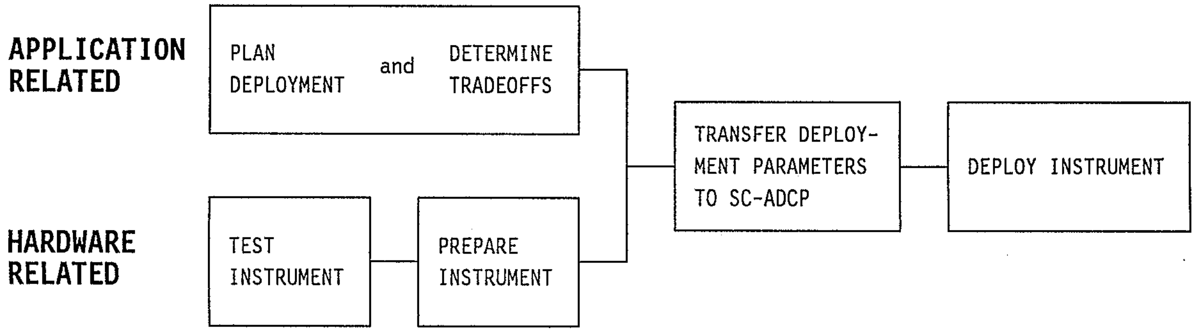


Figure 2-1. Simplified SC-ADCP Deployment Sequence Block Diagram

Table 2-1. SC-ADCP Deployment Checklist

Step	Action	Reference
	NOTE Step 1 is application related and can be done independent of steps 2 and 3, which are instrument related. Steps 1 through 3 should be done before step 4.	
__1	PLAN DEPLOYMENT AND DETERMINE TRADEOFFS – Use the Deployment Information Work Sheet (Table 2-2) to gather the following initial information before the actual deployment date and to determine tradeoff requirements.	¶2-1
	__ ADCP instrument configuration	¶2-1.1
	__ Output data requirements	¶2-1.2
	__ Primary profiling parameters	¶2-1.3
	__ ADCP limitations	¶2-1.4
	__ Deployment logistics and postprocessing requirements	¶2-1.5
__2	PREDEPLOYMENT TESTING – Do predeployment testing with enough lead time to allow for correction of problems.	¶2-2
	__ Modular ADCP tests	2-2.1
	__ Practice deployment	2-2.2
__3	PHYSICAL PREPARATION OF THE ADCP FOR DEPLOYMENT – Perform physical instrument preparation with enough lead time to correct problems.	¶2-3
	__ ADCP switch settings	Appendix W
	__ Compass orientation (up/down)	¶5-9
	__ Battery installation	¶5-13
	__ EPROM recorder preparation	¶5-14
	__ Silica-gel air dryer replacement/restoration	¶5-15
	__ O-ring inspection/replacement	¶5-16
	__ Transducer head inspection	¶5-17
	__ Zinc anode inspection/replacement	¶5-18
	__ Mounting bushing inspection/replacement	¶5-19
	__ Protective coating inspection/repair	¶5-20
	__ Sealing the ADCP for deployment	¶5-21
	__ Prevention of biofouling	¶5-22
__4	TRANSFERRING DEPLOYMENT PARAMETERS TO THE ADCP – Transfer all profiling parameters and commands to the ADCP. This process can be done for a real or practice deployment.	¶2-4
__5	PHYSICALLY DEPLOYING THE ADCP – Read final recommendations on physically deploying the ADCP.	¶2-5

NOTE: APPENDIX F HAS A REPRODUCIBLE COPY OF THIS CHECKLIST.

Table 2-2. SC-ADCP Deployment Information Work Sheet

DEPLOYMENT LOGISTICS AND POSTPROCESSING REQUIREMENTS

Deployment name ____________________ Chief scientist ________________
ADCP serial no. __________ Mounting method (FIXED/MOORED) ________________
Location: Depth (m) ________ Latitude ________ Longitude ________
Time reference {T} (i.e. GMT/LOCAL) ________ ADCP wake-up time {U} ________
Water data: Speed of sound ______ m/s Temperature ______ °C Salinity ______ ppt
Environmental conditions ______________________________________

ADCP INSTRUMENT CONFIGURATION

__________ Frequency (75, 150, 300, 600, OR 1200 kHz)
__________ Beam angles (20° OR 30°; MOST COMMON IS 30°)
__________ Transducer/compass orientation (UP OR DOWN)
__________ Range switch setting (LOW OR HIGH)

OUTPUT DATA REQUIREMENTS

Y N 32 Earth-coordinate velocity 〉 SELECT ONLY ONE COORDINATE VELOCITY SYSTEM
Y N 1 Beam-coordinate velocity
Y N 2 Spectral width (NOT SELECTABLE IF EARTH-COORDINATE VELOCITY SELECTED)
Y N 4 Echo intensity
Y N 8 Percent-good pings
Y N +16 Status
____ = O-COMMAND SETTING; IF BOTTOM-TRACKING, SEE O-COMMAND IN APPENDIX D

PRIMARY PROFILING PARAMETERS — LIST ALL OTHER NONDEFAULT SETTINGS (APPENDIX D) ON SEPARATE SHEET

______________ Expected profiling range in meters {$2^L \times Q$}
______________{L} Depth cell length (2^L FOR 1, 2, 4, 8, 16, OR 32 METERS)
______________{I} Transmit pulse length (1 TO 99 METERS; USUALLY SET TO EQUAL 2^L)
______________{Q} Number of depth cells (8 TO 128)
______________{P} Pings per ensemble (1 TO 65,535 PINGS)
___:___:___.___{R} Ensemble interval (00:00:01.00 TO 23:59:59.99)

ADCP LIMITATIONS

__________ cm/s Desired/calculated velocity data accuracy (STANDARD DEVIATION)
__________ days Deployment duration
__________ A·h Available V1 battery capacity ⎤
__________ A·h Expected V1 power consumption ⎥ — FROM APPENDIX B
__________ A·h Available V2 battery capacity ⎥
__________ A·h Expected V2 power consumption ⎦
__________ MB Available recorder memory (FROM RECORDER TEST; APPENDIX T)
__________ MB Expected recorder storage requirement

NOTES:

NOTE: APPLICABLE DIRECT COMMANDS ARE SHOWN IN BRACES {x}.

NOTE: APPENDIX F HAS A REPRODUCIBLE COPY OF THIS WORK SHEET.

2-1. DEPLOYMENT PLANNING AND TRADEOFF EVALUATION

This section has information and guidance on the planning you must do before deploying the ADCP. Planning consists of gathering information about the deployment and evaluating this information to see if you must make tradeoffs because of ADCP limitations. Consider the following questions.

a. ADCP instrument configuration (¶2-1.1)

  (1) What is the acoustic frequency of the ADCP?
  (2) What is the angle of the transducer beams?
  (3) Will the ADCP face up or down?
  (4) Will the range switch be set to high or low?

b. Output data requirements (¶2-1.2)

  (1) What type of data do you need to collect for analysis?
  (2) Do you want velocity data recorded in earth or beam coordinates?

c. Primary profiling parameters (¶2-1.3)

  (1) What is the approximate range you want to profile?
  (2) What vertical resolution (depth cell length) do you need?
  (3) How many depth cells do you want to profile?
  (4) How many pings do you want to average together?
  (5) Over what interval do you want to average these pings?

d. Limitations (¶2-1.4)

  (1) How accurate (standard deviation) must the velocity data be?
  (2) How long will you deploy the ADCP?
  (3) What is the battery capacity of all battery packs?
  (4) How much recorder memory is available?

e. Deployment logistics and postprocessing (¶2-1.5)

  (1) What record-keeping information do you need (location, people)?
  (2) What time reference will you use to correlate data readings?
  (3) Should the ADCP ping immediately on deployment?
  (4) How will you mount the ADCP (up/down/swaying/fixed in place)?
  (5) What is the expected speed of sound, temperature, and salinity?
  (6) How will the local environment affect the ADCP?

By answering these questions, you can begin to plan and evaluate your deployment requirements. Use the Deployment Information Work Sheet (Table 2-2) as a guide to plan and evaluate your settings (Appendix F has a reproducible copy). You do not need an ADCP to use the work sheet.

There are several ways to fill in the work sheet. The procedures outlined here are in a sequence of "what must I know before I can do the next step." You will use many of the items in the work sheet for calculations you will need to do. You might need to change some of your initial entries because of ADCP limitations. In fact, you might have to revise the work sheet several times before you can determine what commands you will send to the ADCP for your application. Items on the work sheet might not be in the order we discuss them. Much of this is purely aesthetic. For example, though we do not discuss deployment logistics until the end of this section, we list it first on the work sheet. This is because many people like to organize their deployments by name, ADCP serial number, or deployment location.

NOTE

WITHIN TABLE 2-2 AND THROUGHOUT THIS MANUAL, YOU WILL SEE REFERENCES (USUALLY IN BRACES { }) TO THE ADCP DIRECT COMMAND BEING DISCUSSED. FOR MORE INFORMATION ON DIRECT COMMANDS, SEE APPENDIX D.

2-1.1. ADCP INSTRUMENT CONFIGURATION. Some items on the Deployment Information Work Sheet (Table 2-2) concern the ADCP instrument configuration. Some are informational, and some require you to check internal switches and mechanical orientations for your particular application. They include:

a. ADCP frequency
b. ADCP transducer beam angle
c. Transducer/compass/pendulum orientation
d. Range switch setting

ADCP Frequency. Table 2-3 lists the SC-ADCP models, their actual frequencies, and their nominal ranges (Appendix S lists maximum ranges). You will later use the frequency to calculate standard deviation and range limitations.

Table 2-3. SC-ADCP Frequency Vs Range Limitations

Model (kHz)	Actual frequency (Hz)	Nominal range (m)
75	76,800	400
150	153,600	240
300	307,200	120
600	614,400	60
1200	1,228,800	30

ADCP Transducer Beam Angle. The standard SC-ADCP has a transducer beam angle of 30°. Other beam angles are available (15°, 20°) for special applications. You will later use the beam angle to calculate standard deviation.

Transducer/Compass/Pendulum Orientation. If you often use the ADCP for both upward and downward-facing applications, you must be sure to set the pendulums and switches properly. If you do not, the ADCP will not record data correctly. Use ¶5-9 to set up and check transducer/compass/pendulum orientation.

Range Switch Setting. The ADCP has a velocity range switch with two settings, LOW and HIGH (see Appendix W, S2 on Peripherals 2 board). In LOW, the ADCP collects data with twice the resolution, but halves the nominal velocity range (see Table 4-3). In HIGH, you can achieve the maximum velocity range, but there is less resolution. Use the HIGH setting if you expect currents above 4 m/s in the horizontal plane, otherwise set the range switch to LOW. There are two exceptions to this requirement.

a. Always set 75-kHz SC-ADCPs to HIGH.
b. Always set 1200-kHz SC-ADCPs to LOW.

2-1.2. OUTPUT DATA REQUIREMENTS. This section has information to help you determine the output data requirements for your application.

Table 2-4 lists the standard data automatically recorded with every ensemble in the output leader data (see Chapter 4). An ensemble can consist of the header, leader, velocity, echo intensity, spectral width, percent-good, status, and checksum data collected by the ADCP after averaging the ping-to-ping data during the ensemble interval. Table 2-5 lists the optional data you can record using the O-command. This table gives a brief description of the optional data and lists the number of storage bytes needed.

We recommend collecting all possible data. However, you must consider some restrictions. The ADCP has three main limitations that interact with each other and affect data collection – data accuracy (standard deviation), power requirements, and available recorder memory (see ¶2-1.4). More data requires more memory capacity and, as a result, more power. You can reduce memory and power requirements by settling for less-accurate data (i.e., fewer pings to average). You will later calculate your accuracy, power, and memory requirements using several factors.

To begin, determine the data you want to record. Now circle the "Y" for your OUTPUT DATA REQUIREMENTS selections on the Deployment Information Work Sheet (Table 2-2). Add the values listed next to your selected output types. The result is your O-command setting. If you will be using the ADCP to bottom-track, see Appendix D to modify the O-command.

Table 2-4. Data Recorded with Every Ensemble

ADCP SETUP STATUS (velocity range & reference, transducer frequency & orientation)
BLANK AFTER TRANSMIT (DELAY AFTER TRANSMIT)
BOTTOM-TRACK PERCENT-GOOD (each beam)
BOTTOM-TRACK RANGE (each beam)
BOTTOM-TRACK VELOCITY (each beam)
BUILT-IN TEST STATUS
CHECKSUM
CONDUCTIVITY (requires CTD interface option)
CTD MEASUREMENT INTERVAL (requires CTD interface option)
DEPTH (requires CTD interface option)
DEPTH CELL LENGTH
ENSEMBLE NUMBER
HEADER DATA (stores total number of bytes recorded for the ensemble)
HEADING (requires compass option)
HIGH VOLTAGE INPUT VALUE
LOW VOLTAGE INPUT VALUE
NUMBER OF DEPTH CELLS
NUMBER OF PINGS PER ENSEMBLE
PERCENT GOOD THRESHOLD (ENSEMBLE PERCENT GOOD DATA)
SIGNAL-TO-NOISE THRESHOLD
STANDARD DEVIATION OF HEADING (requires compass option)
STANDARD DEVIATION OF PITCH (requires tilt sensor option)
STANDARD DEVIATION OF ROLL (requires tilt sensor option)
TILT 1 (x-axis - pitch; requires tilt sensor option)
TILT 2 (y-axis - roll; requires tilt sensor option)
TIME BETWEEN PINGS (minutes, seconds, hundredths of seconds)
TIME OF ENSEMBLE (month, day of month, hours, minutes, seconds)
TRANSMIT CURRENT VALUE
TRANSMIT INTERVAL (PULSE LENGTH)
WATER TEMPERATURE (ADCP)
WATER TEMPERATURE (CTD - requires CTD interface option)

Table 2-5. Optional Recording Data

VELOCITY (6 BYTES PER DEPTH CELL)

The ADCP determines water-mass velocity by measuring the Doppler frequency shift of the backscattered water-mass echo. Velocity data can be either the four radial beam velocity components or the earth-referenced components. The radial beam velocities correspond to beams one through four. The earth-referenced velocity components represent the east, north, vertical, and error velocities, respectively. When in earth coordinates, the ADCP uses 3-beam solutions if any one beam's data quality falls below a specified limit.

SPECTRAL WIDTH (4 BYTES PER DEPTH CELL)

Spectral width is a measure of the bandwidth of the acoustic echo for each depth cell. This measurement is the expected statistical uncertainty in a single ping of the mean water-mass velocity measurement. The ADCP cannot record spectral width data when recording velocity data in earth coordinates because of internal ADCP memory limitations.

ECHO INTENSITY (4 BYTES PER DEPTH CELL)

Echo intensity is a measure of the intensity (energy) of the backscattered echo for each depth cell. Echo intensity is useful in determining signal strength and the relative volume of scatterers in each depth cell. You also can use echo intensity data to check data quality.

PERCENT GOOD PINGS (4 BYTES PER DEPTH CELL)

This output is a data qualifier representing the percent of pings having good data based on the signal-to-noise threshold. If velocity data are in earth coordinates, the ADCP determines both the percentage of pings that were good using four beams and the percentage-good using three beams.

STATUS (2 BYTES PER DEPTH CELL)

The status output records the reasons the ADCP rejects data. Status data are information in an abbreviated format similar to the information provided in Percent Good. For a detailed explanation of status code interpretation, see Table 4-7.

2-1.3. PRIMARY PROFILING PARAMETERS. The primary function of an ADCP is to measure current profiles by taking measurements in a series of discrete depth cells within the ADCP's profiling range. This section helps you determine the parameters needed to produce a profile for the desired range and accuracy for your application. You might have to trade these parameters against one another to find the best combination that fits within the ADCP's limitations. Remember to record your results in the Deployment Information Work Sheet (Table 2-2). When filling in the work sheet, your initial entries should be estimates. Some of these values might need "fine-tuning" later because of ADCP limitations (¶2-1.4).

When first determining ADCP settings, select the relatively fixed parameters. Fixed parameters are those you consider the most critical parameters for your application. Typically, fixed parameters include:

a. Type of data to record (described in ¶2-1.2).
b. Velocity data accuracy (standard deviation; described in ¶2-1.4).
c. Profiling range {$2^L \times Q$}.
d. Depth cell length {2^L}.
e. Transmit pulse length {I}.
f. Number of depth cells {Q}.
g. Pings per ensemble {P}.
h. Ensemble interval {R}.
i. Deployment duration (described in ¶2-1.4).

For the ADCP parameters not described in this section, the default settings will be adequate for most deployments. We set the defaults to what is considered good practice. However, the ADCP does let you control all parameters independently. Special applications such as bottom-tracking (F-commands), operating in shear conditions (A, B, and E-commands), or using CTD sensors (CA-command) might require modified settings. If you need to set up the ADCP for a special application, see Appendix D.

Profiling Range. After determining the data you want to record (¶2-1.2) and knowing the velocity accuracy you want to achieve (¶2-1.4), you must consider the profiling range of your application. What is the approximate range you intend to profile? Keep in mind the nominal ranges listed in Table 2-3.

The maximum profiling range of the ADCP is a function of the signal strength, or echo intensity, of the returned echo. Several factors determine the echo intensity and, therefore, can limit or increase the profiling range. These factors include:

a. Sound absorption
b. Beam spreading
c. Transmitted power (fixed for the SC-ADCP)
d. Backscatter coefficient
e. Bubbles
f. Surface/bottom return

Depth Cell Length. After determining the profiling range, you must select the depth cell size. Depth cell length {2^L} affects the profile's range resolution. You can compare an ADCP depth cell to a single-point current meter. The ADCP velocity profile is comparable to a string of current meters on a mooring (Figure 2-2). Using this analogy, we can make the following definitions.

Depth cell length = distance between current meters
Number of depth cells = number of current meters

There are two important differences between a string of current meters and an ADCP: (1) Depth cells in an ADCP profile are always uniformly spaced, but current meters can be spaced at irregular intervals; (2) An ADCP measures average velocity over the range of <u>each</u> depth cell, but a current meter measures current flow only at one point in space.

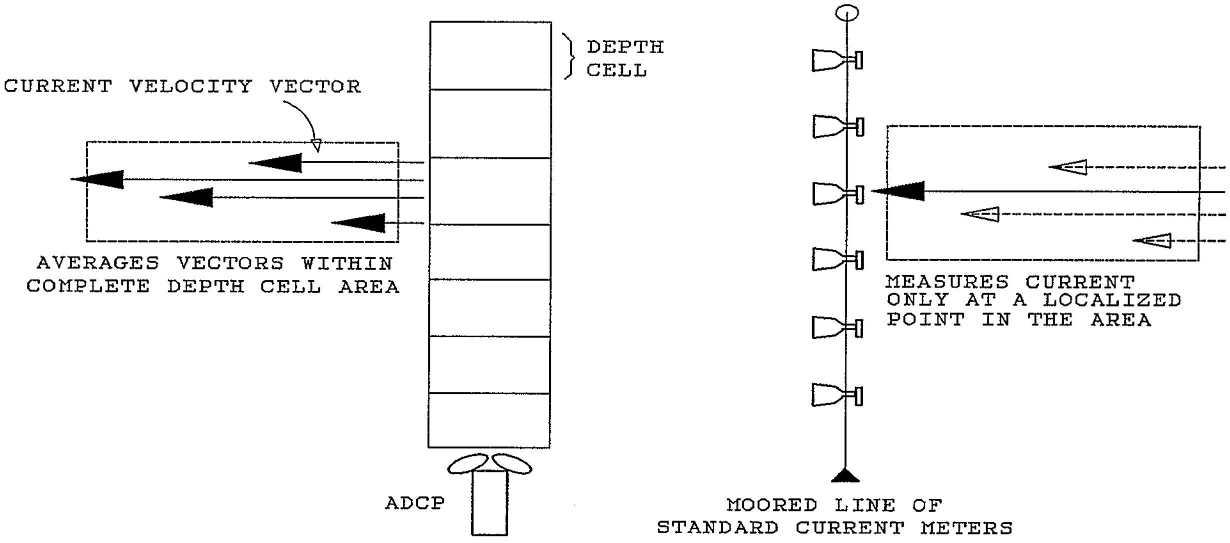


Figure 2-2. Depth Cells Vs Conventional Current Meters

Depth cell lengths range from 1 to 32 meters in power-of-two increments (i.e., 1, 2, 4, 8, 16, 32). Changing the depth cell length affects both range and accuracy (see ¶2-1.4). A small depth cell collects more detailed current profiles but needs more pings to reach a given level of velocity accuracy. Small depth cell lengths also restrict the profiling range. Large depth cell lengths provide a smoother profile (less detail) but usually allow longer profiling ranges. Table 2-6 lists suggested depth cell length settings.

Transmit Pulse Length. The transmit pulse length {I} sets the length of the transmitted sonar pulse. The transmit pulse length is measured in vertical meters even though the ADCP directs the pulse at an angle, usually 30° from vertical. The ADCP converts the pulse length to a transmit interval by multiplying the pulse length by a scaling factor. For most applications, you should set the transmit pulse length {I} equal to the depth cell length {2^L}.

Number of Depth Cells. The product of depth cell length {2^L} and number of depth cells {Q} yields the profiling range. The amount of data collected by the ADCP is roughly proportional to the selected number of depth cells. Doubling the number of depth cells and halving the depth cell length (keeping depth range constant) collects more detailed information. However, this requires a longer sampling interval to reach the same statistical significance. Decreasing the number of depth cells saves data storage space and lets the ADCP average more pings during a given ensemble interval. Table 2-6 lists suggested settings for the number of depth cells.

Pings Per Ensemble. How many pings do you want to average together? The number of pings per ensemble {P} determines how many pings the ADCP collects and averages before sending the data to the recorder. An ensemble can consist of the header, leader, velocity, echo intensity, spectral width, percent-good, status, and checksum data collected by the ADCP after averaging the ping-to-ping data during the ensemble interval {R}. Pings per ensemble can range from 1 to 65,535. More pings per ensemble "smooth" data and decrease the standard deviation (¶2-1.4). Table 2-6 lists suggested pings per ensemble settings.

Ensemble Interval. At what interval would you like to sample the data? This parameter is the interval at which the ADCP repeats a data collection cycle. The ensemble interval {R} can range from 00:00:00.00 to 23:59:59.99. Ensemble intervals from 5 to 15 minutes are typical for 150-kHz systems. Note that shorter intervals consume recorder memory faster than larger intervals, assuming all other parameters remain the same. The ADCP may automatically extend the value for the R-command based on other settings (see Appendix D).

Suggested Profiling Parameter Settings. Table 2-6 lists suggested profiling parameter settings based on ADCP frequency. These settings produce a standard deviation of 1.0 cm/s for systems with a 30° beam angle (see ¶2-1.4). The settings also use the maximum nominal range of the ADCP. The ensemble interval is user-dependent.

Table 2-6. Suggested Profiling Parameter Settings

SC-ADCP Frequency	Xmit pulse length	Number of depth cells	Pings per ensemble	Nominal range	Standard deviation
75 kHz	16 m	25	170	400 m	1.0 cm/s
150 kHz	8 m	30	170	240 m	1.0 cm/s
300 kHz	4 m	30	170	120 m	1.0 cm/s
600 kHz	2 m	30	170	60 m	1.0 cm/s
1200 kHz	1 m	30	170	30 m	1.0 cm/s

2-1.4. ADCP LIMITATIONS. The ADCP has limitations that affect its accuracy, deployment duration, and recording space. Before deploying, make sure the ADCP will meet your accuracy requirements and not exceed your expected battery capacity and recorder memory limitations for the duration of the deployment. Loss of battery power during a deployment will not affect data already recorded to EPROM memory, but you should plan your deployment so there is enough power to collect data for the desired duration. Use the Deployment Information Work Sheet (Table 2-2) to record the following information that you will use to calculate and evaluate the ADCP setup.

a. Velocity data accuracy (standard deviation)
b. Deployment duration
c. Battery capacities
d. Available recorder memory

Desired Velocity Data Accuracy (Standard Deviation). One ADCP limitation is its velocity data inaccuracy caused by internal biasing errors and external random errors. Specifically, the ADCP measures a complete 128-segment profile of water currents in a time duration equal to the two-way propagation time to the maximum range of interest. This "single-ping" time interval is typically only a fraction of a second. Each single-ping depth cell velocity measurement is characterized by a long-term bias error and a short-term random error. Programming the ADCP to average the results of multiple pings can reduce the short-term random error, but because the long-term bias is about 0.5-1.0 cm/s, there is little benefit to reducing standard deviation below 0.5-1.0 cm/s. The magnitude of the random error is a function of acoustic frequency, transmit pulse length {I}, and number of pings per ensemble {P}. The short-term velocity measurement precision for a four-beam ADCP is calculated as follows.

$$\text{Standard Deviation (cm/s)} = \frac{1.6 \times 10^7}{F \times I \times B \times \sqrt{P}}$$

Where:
I = Transmit pulse length in meters
B = Beam angle coefficient (1 for 30°; 0.684 for 20°)
P = Number of pings per ensemble
F = ADCP acoustic frequency in Hz

Model	Actual frequency
75 kHz	76,800 Hz
150 kHz	153,600 Hz
300 kHz	307,200 Hz
600 kHz	614,400 Hz
1200 kHz	1,228,800 Hz

For example: A 150-kHz ADCP (actual acoustic frequency = 153,600 Hz) uses a transmit pulse length of 8 meters and a pings per ensemble value of 170. What is the standard deviation in cm/s?

For a 30° beam angle:

$$\frac{1.6 \times 10^7}{F \times I \times B \times \sqrt{P}} = \frac{16{,}000{,}000}{153{,}600 \times 8 \times 1 \times \sqrt{170}} \approx 1.0 \text{ cm/s}$$

For a 20° beam angle:

$$\frac{1.6 \times 10^7}{F \times I \times B \times \sqrt{P}} = \frac{16{,}000{,}000}{153{,}600 \times 8 \times 0.684 \times \sqrt{170}} \approx 1.46 \text{ cm/s}$$

The easiest way to adjust standard deviation to the desired value is to increase or decrease the pings per ensemble setting {P}. Table 2-6 lists suggested settings for a standard deviation of 1.0 cm/s. (NOTE: RDI's Deployment Program calculates this information for you automatically.)

Deployment Duration. How long will you deploy the ADCP? This is usually planned as a fixed amount of time, but the duration must sometimes be extended because of vessel logistics and weather conditions. You might want to add time to your deployment estimate to account for the additional battery and recorder memory requirements.

Battery Capacity. Before you can determine battery capacity, you must select the size, type, and number of battery packs you are going to use during the deployment. Table B-4 lists the capacities for the different batteries supplied by RDI and the derating factors for different operating temperatures. Select the batteries you will be using. Now find the total ampere·hour (A·h) battery capacities for V1 (ADCP electronics power) and V2 (transmitter and recorder power) using the Battery Capacity Work Sheet (Table B-5). Record the results on the Data Information Work Sheet (Table 2-2). If you are using a CTD interface powered by the V4 supply, see Appendix B to calculate V4 (CTD power). (NOTE: Systems with EPROM recorders do not use the V3 lead-acid battery pack power supply.)

After determining how much battery capacity is available, determine how much power the ADCP will consume during the deployment. Appendix B explains how to determine the power consumption for V1, V2, and V4 using several factors. After determining power consumption, record your results on the Deployment Information Work Sheet and note the following.

a. Compare estimated power consumption with your previously calculated V1 and V2 battery capacities. If the estimated power consumption is too high, you can do the following to lower battery usage.

    (1) Reduce the number of pings per ensemble {P}.
    (2) Increase the ensemble interval {R}.
    (3) Reduce the deployment duration.
    (4) Reduce the number of depth cells {Q}.
    (5) Reduce the total amount or type of data recorded {O}.

b. Sometimes you might have an excess of battery capacity. If you are willing to use partially discharged batteries, keep track of the usage from this deployment so you can subtract it from the next deployment. Be careful though; if the ADCP loses power, data collection stops. However, if the ADCP does lose power, the EPROM recorder still retains the data stored up to that point. If you prefer to use new batteries each time, you can increase the pings per ensemble setting {P}, or some other parameter, to use the extra capacity.

Recorder Limitations. The SC-ADCP stores its measured data on a built-in EPROM recorder. The amount of data the ADCP can store depends on the amount of available recorder memory (at present, maximum is 40 MB).

Recorder Memory. The EPROM recorder lets you store data from as many as 255 different deployments in its memory. At present, the maximum amount of data the recorder can store is 40 megabytes (MB). You can only determine the actual amount of available recorder memory by interconnecting the ADCP system and running the recorder test listed in Appendix T.

Be aware that internal processing requirements reduce the actual capacity of the recorder 1%. Therefore, a 40-MB recorder (40,960,000 bytes actual capacity) is reduced to 40,550,400 bytes of available data-recording memory. You also must consider the life expectancy of an EPROM chip. At present, chip manufacturer's expect about 2% of EPROM memory to fail after 100 write-erase cycles. Because of these losses to memory capacity, allow a safety margin of 3% when determining how much memory is available to you for data recording.

Data Types. The recorder stores data for each ensemble. Each ensemble can provide the following data for recording and uses the listed number of bytes.

a.	Header*	– 14 bytes	
b.	Leader (long)*	– 63 bytes	
c.	Velocity	– 6 bytes per depth cell	Optional, set by O-command
d.	Spectral width	– 4 bytes per depth cell	
e.	Echo intensity	– 4 bytes per depth cell	
f.	Percentage of good pings	– 4 bytes per depth cell	
g.	Status	– 2 bytes per depth cell	
h.	Checksum*	– 2 bytes	

*NOTE: REQUIRED OVERHEAD FOR EACH RECORD = HEADER + LEADER + CHECKSUM = 79 BYTES

Recorder Memory-Use Calculations. By knowing the number of depth cells {Q} and types of data you want to record {O}, you can determine how much recorder memory you will use and how long it will take to fill memory. First, find the length (in bytes) of the ensemble record.

Ensemble record length (bytes) = (No. bytes per cell x No. cells) + Overhead

Second, find the number of ensemble records you can store in memory.

Ensemble records in memory = Available memory / Ensemble record length

For example, if you record 75 depth cells of velocity (6 bytes per cell) and echo intensity (4 bytes per cell) on a 40-MB recorder, then:

Ensemble record length = (10 x 75) + 79 = 829 bytes
Ensembles recorded = 40,550,400 / 829 = 48,914 records.

Third, find how long it will take for the available memory to fill. Assuming unlimited battery capacity in the above example, if the ADCP records ensembles every 30 minutes, recorder memory becomes full after about 1019 days (30 minutes × 48,914 records / 60 minutes / 24 hours).

As an extreme example, if you shortened the ensemble interval to 5 minutes and selected all data for recording for 128 depth cells, then:

Ensemble record length = (20 x 128) + 79 = 2,639 bytes
Ensembles recorded = 40,550,400 / 2,639 = 15,365 records
Memory duration = 53 days.

After determining the available recorder memory and the projected-use requirements for your deployment, record your results on the Deployment Information Work Sheet (Table 2-2) and note the following.

a. Compare your expected use with the actual amount of available memory. If your application produces more data than the recorder can store, you can reduce the amount of recorded data by:

   (1) Eliminating some data (e.g., spectral width, percent-good {O}).
   (2) Reducing the number of depth cells {Q}.
   (3) Increasing the ensemble interval {R}.
   (4) Decreasing the deployment duration.

b. Not all EPROM memory is available to you for data recording because the recorder uses about 1% of the memory for formatting and processing requirements. It is also possible some of the EPROMs might fail (about 2% after 100 write-erase cycles), so we cannot calculate the exact amount of memory available for data collection. We recommend you reduce expected recorder capacity by at least 3%.

c. If you have excess recorder capacity, you can record more ensembles using fewer pings per ensemble. For example, reducing the ensemble interval {R} from 10 minutes to 5 minutes and halving the number of pings per ensemble {P} still lets you rebuild 10-minute averages using two 5-minute ensembles. The rebuilt 10-minute averages have the same accuracy (standard deviation) as the original 10-minute ensembles, but you should weigh the added effort needed to process and store the larger data set against the benefit of increased resolution.

2-1.5. DEPLOYMENT LOGISTICS AND POSTPROCESSING REQUIREMENTS. Several items on the Deployment Information Work Sheet (Table 2-2) concern the logistics of the deployment – some critical, some informational. They include:

a. General deployment information
b. Time reference
c. ADCP wake-up time
d. ADCP mounting method
e. Environmental factors

General Deployment Information. You should make note of record-keeping information that might prove invaluable when trying to analyze data from previous deployments. As a minimum, record the following information on the Deployment Information Work Sheet (Table 2-2).

a. Deployment, expedition, or mooring name
b. Personnel involved – chief scientist, staff members
c. Deployment location – depth, latitude, longitude

Time Reference. During instrument setup, you must set the ADCP's internal clock {T}. This time reference helps you correlate data. Decide now the time reference you will use. Typical time zone references are Greenwich Mean Time (GMT) and local time. When setting the time, remember to account for "offsets" such as "daylight savings time" or "summer time." Record your decision on the Deployment Information Work Sheet (Table 2-2).

ADCP Wake-up Time. The ADCP lets you delay the start of data collection {U}. You can use this delay to deploy the ADCP during calm weather and start recording data after leaving the area (up to one year). Decide whether you will have the ADCP begin pinging immediately or at some specific date and time. Record your decision on the Deployment Information Work Sheet (Table 2-2).

ADCP Mounting Method. You must determine the best method for anchoring the ADCP. Will you fix the instrument rigidly in place or mount it on a swaying mooring line? Will it face up or down? In any case, you must plan how to handle and deploy the ADCP. Consider the following.

a. *Movable mounting* – If you tether the ADCP to a mooring so it is free to change heading/tilt in response to currents, you must convert ADCP velocity readings to earth coordinates (¶2-1.2).

b. *Fixed mounting* – If the ADCP is in a fixed position (e.g., mounted in a frame on the sea bottom), you can have the ADCP convert the data to earth coordinates or use the original raw beam coordinates (¶2-1.2). Earth coordinates simplify data analysis, but beam coordinates let you analyze your data more precisely.

Environmental Factors. You must consider several environmental factors that have an effect on the ADCP or its data. We describe these factors below and summarize them in Table 2-7. Be sure to note on the Deployment Information Work Sheet (Table 2-2) any relevant information.

a. *Speed of Sound* – The speed of sound in water in the deployment area affects the velocity data you are collecting. You can use either a nominal speed of sound, such as 1536 m/s, or you can use different values for each depth cell in the profile. If you want to find the exact speed of sound, you will need to know the water temperature and salinity values in the deployment area (see Appendix C).

b. *Low Temperature* – A low-temperature environment causes battery chemistry to slow down. The battery capacities listed in Table B-4 already reflect a derating to 0°C.

c. *High Humidity* – To help prevent shorts caused by condensation, you must let both the temperature and humidity reach equilibrium. Always use fresh or recharged desiccant to absorb moisture. If available, purge the ADCP pressure case with dry gas before sealing the unit. Chapter 5 explains these procedures.

d. *Pressure* – RDI's standard pressure case can operate at a maximum depth of 1000 meters and withstand pressures to 1480 psi. Our limited experience at 2000 meters with our high-capacity pressure case suggests the pressure does not prevent the ADCP transducers from operating.

NOTE

TRANSDUCERS BUILT BEFORE MID-1987 ARE LESS RELIABLE THAN OUR PRESENT TRANSDUCERS. THESE OLDER TRANSDUCERS HAVE BEEN KNOWN TO DEVELOP CRACKS AT DEPTHS GREATER THAN 500 METERS.

e. *Biofouling* – Objects within about 100 meters (328 feet) of the surface are subject to biofouling. Soft-bodied organisms usually cause no problems, but barnacles can cut through the urethane transducer face causing transducer failure and water leakage into the ADCP. If you are deploying the ADCP in an area subject to biofouling, be sure you take steps to prevent excessive growth of sea life on the transducer faces (see ¶5-21).

Table 2-7. Environmental Problems and Possible Solutions

LOW TEMPERATURE	PROBLEM – HIGHER BATTERY DRAIN, SLOWER BATTERY CHEMISTRY SOLUTION – USE DERATED BATTERY CAPACITY LISTED IN TABLE B-4.
HIGH HUMIDITY	PROBLEM – CONDENSATION, SHORTS SOLUTION – DESICCANT, DRY GAS PURGING, STABILIZE HUMIDITY
PRESSURE	PROBLEM – IMPLOSION OF PRESSURE CASE SOLUTION – USE HIGHER-RATED PRESSURE CASE; RESTRICT DEPTH.
BIOFOULING	PROBLEM – REDUCED PROFILING RANGE, TRANSDUCER DAMAGE, LEAKS SOLUTION – CLEAN FACES PERIODICALLY.

2-2. PREDEPLOYMENT TESTING

This section provides information on testing the ADCP before a deployment. You should test the ADCP with enough lead time to correct discrepancies.

2-2.1. MODULAR ADCP TESTS. Appendix T provides information on testing the ADCP using either the SCTEST program or direct commands. We strongly suggest you thoroughly test the ADCP before your deployment.

2-2.2. USING A PRACTICE DEPLOYMENT FOR TESTING. You should conduct a practice deployment with the ADCP using the actual application parameters. This is especially helpful if you do not have much experience using an ADCP. If the practice deployment is realistic, you can confirm the setup you plan to use can indeed collect the data you expect. A practice deployment also lets you become familiar with the idiosyncrasies of the ADCP.

In a practice deployment, you can place the ADCP on a laboratory bench and use external power supplies to prevent discharging the battery packs. You can then set up the ADCP to collect data for an extended period. You also can read the data from the ADCP and process it as real data. If you want to do a practice deployment, you can skip ¶2-3 and continue with ¶2-4.

2-3. PHYSICAL PREPARATION OF ADCP FOR DEPLOYMENT

This section lists the procedures needed to prepare the ADCP instrument for an actual deployment. If you are conducting a practice deployment, you can omit most of these procedures. Table 2-1 (Deployment Checklist) lists the section that has the detailed instructions for each procedure. Remember to use this checklist to keep track of your progress.

You also must consider the physical condition of the ADCP. Minor dents, corrosion, and missing paint might not seem crucial to the deployment of the ADCP, but they could prove to be damaging. Electrical continuity, the condition of the transducer faces, and water-tight integrity are critical to the proper operation of the ADCP. You must always exercise extreme care during the deployment and handling of the ADCP.

CAUTION

NEVER REST THE TRANSDUCER HEAD ON A ROUGH SURFACE; USE FOAM PADDING TO PROTECT THE TRANSDUCERS.

2-4. TRANSFERRING DEPLOYMENT PARAMETERS TO THE ADCP

This section explains how to send the deployment parameters to the ADCP in preparation for deployment. We assume you are using the Deployment Checklist (Table 2-1), have planned the deployment (¶2-1), tested the ADCP (¶2-2), and physically prepared the instrument (¶2-3). We will now explain how to send your application parameters to the ADCP and tell it how to begin data collection immediately or at a specified time. We will use the ADCP's direct command set (Appendix D) to do this, but using a software program such as RDI's SC-ADCP Deployment Program makes this task much easier.

__ a. Use Appendix A to connect the ADCP system for either a real or practice deployment. Apply power to both the ADCP and your computer/dumb terminal. Wake up the ADCP (establish communications).

__ b. Send the output data command established in ¶2-1.2 using the O-command (e.g., O031).

__ c. Send the primary profiling parameters established in ¶2-1.3 using the L, I, Q, P, and R commands (e.g., L3, I08, Q030, P00170, R00150000).

__ d. Send any additional profiling parameters needed by your application. Some typical applications requiring special parameters include bottom-tracking (F-commands), operating in shear conditions (A, B, and E commands), or using CTD sensors (CA-command). See Appendix D.

__ e. Send any ASCII text to be recorded on the EPROM recorder using the @W command (see Appendix D for specifics).

__ f. Set the ADCP's real-time clock to the desired reference time established in ¶2-1.5 using the T-command (format: T*mmddhhmm*; month, day, hour, and minute; seconds always start at zero).

__ g. Set the ADCP data collection wake-up time. You have two choices here.

(1) BEGIN DATA COLLECTION PROCESS IMMEDIATELY – If you do NOT want to enter a wake-up time, that is, you want the ADCP to begin the data collection process immediately after issuing the START DATA COLLECTION command {S}, do NOT enter a U-command. If you accidentally enter a U-command and want to "erase" it, you must first send the <BREAK> command to the ADCP.

(2) DELAY THE DATA COLLECTION PROCESS – If you want to delay the start of ADCP processing until some future time (up to one year), use the U-command to enter the month, day, hour, minute, and second of the future wake-up time (format: U*mmddhhmmss*).

NOTE

IF POSSIBLE, YOU SHOULD CONSIDER STARTING DATA COLLECTION (PINGING) BEFORE DEPLOYING THE ADCP IN WATER. THIS WAY YOU CAN TAKE STEPS TO ENSURE THE ADCP IS REALLY PINGING. ONE WAY YOU CAN DO THIS IS BY PLACING A RADIO TUNED TO THE TRANSDUCER FREQUENCY (OR A HARMONIC) DIRECTLY NEXT TO THE PRESSURE CASE/TRANSDUCER HEAD MATING FLANGE AND LISTENING FOR THE INTERFERENCE CAUSED BY THE TRANSMIT PULSE FROM THE POWER AMPLIFIER. YOU SHOULD DO THIS IN A LAB ENVIRONMENT, SO YOU KNOW WHAT TO EXPECT AT SEA. THIS METHOD IS NOT ALWAYS CONCLUSIVE, BUT IT SHOULD PROVIDE YOU WITH SOME DEGREE OF CONFIDENCE THAT THE ADCP IS PINGING.

__ h. Start data collection (pinging) by sending an S191 command to the ADCP. You must send this command no matter what your U-command setting was.

__ i. The ADCP is now ready for deployment.

2-5. PHYSICAL INSTRUMENT DEPLOYMENT

The physical deployment of the ADCP can be difficult. You can prepare the ADCP for deployment in the laboratory as described above and delay the data collection process by using the U-command. This places the ADCP in a low-power "sleep" mode, and keeps you from removing the pressure case at sea. This is a sensible approach because environmental conditions at sea are not always ideal. It is also harder to work on instruments aboard a moving vessel.

No matter how you mount the ADCP (fixed in place, on a mooring line, on the bottom), always use caution when deploying and handling the ADCP. Never rest the transducer head on a rough surface. Use foam padding to protect the transducers during handling.

Electrical continuity and isolation are important in helping prevent corrosion to the ADCP (see Chapter 5). If you are mounting the ADCP to a metal structure, be sure you electrically isolate the two units with some type of electrical insulation (e.g., plastic bushings, clamps with plastic liners, etc).

If you plan to communicate to the SC-ADCP while it is in water (e.g., in a DR-ADCP setup with external power), you must take another electrical isolation precaution. The ADCP data communication lines are connected to chassis ground through a 2-μF capacitor. Chassis ground is connected directly to the exterior of the ADCP. At typical baud rates, the 2-μF capacitor appears as a short. This short may result in electrical current being applied to the exterior of the ADCP, which can lead to accelerated corrosion of the pressure case. To avoid this, you must use some type of opto-isolator between the ADCP and your computer/dumb terminal while the ADCP is deployed in water. An opto-isolator/convertor is available through RDI.

The ADCP measures water velocity along four, narrow, vertically-inclined acoustic beams. To ensure accurate current measurement, the water mass in the deployment area must be free of strong acoustic reflectors (e.g., platform members, large cables, surface) within a ±15° conical sector along each beam.

In shallow-water, vertical-profiling applications, acoustic interference from the surface (upward-looking ADCP) or bottom (downward-looking ADCP) limit the vertical current measurement area to a maximum range defined by the following formula. Figure 2-3 shows an example using the standard 30° beam angle.

$$R_{max} = D \cos \phi$$

where: R_{max} = Maximum profiling range
D = Distance to surface/bottom boundary
ϕ = Acoustic beam angle relative to vertical (usually 30°).

See Chapter 3 when you are ready to retrieve the ADCP and its collected data.

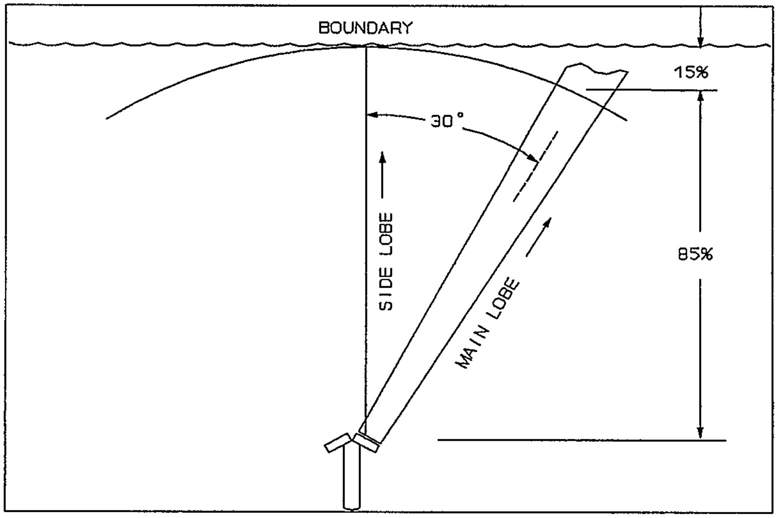


Figure 2-3. Maximum Profiling Range Vs Distance to Boundary

CHAPTER 3
SC-ADCP RETRIEVAL PROCEDURES

3-0. INTRODUCTION

This chapter presents a logical sequence you can follow when retrieving the ADCP and its stored data after a deployment. The preferred method of retrieving data from the ADCP is through RDI's Deployment Program (described in the on-disk SC-ADCP Deployment Program User's Manual). This chapter provides a general overview on retrieving ADCP data using a dumb terminal/emulator program and the ADCP direct command set (Appendix D). The disadvantage of using direct commands to retrieve data is more room for operator error. We strongly suggest you use the Deployment Program to retrieve ADCP data. In either case, we recommend you practice data retrieval in the laboratory on expendable data. This way, you can become familiar with operating the ADCP.

Table 3-1 provides a checklist for ADCP retrieval. USE THIS CHECKLIST AND ITS REFERENCES TO BE SURE YOU COMPLETE ALL RETRIEVAL PROCEDURES. Appendix F has a reproducible copy of this checklist.

3-1. SC-ADCP PHYSICAL RETRIEVAL AND MAINTENANCE

This section has information on the physical recovery of the ADCP and the initial maintenance you must do.

3-1.1. PRELIMINARY RETRIEVAL CHECK (OPTIONAL). After removing the ADCP from the water, you might want to listen for the ADCP's acoustic transmission pulse (ping). This is a rough indicator about whether the ADCP is still operating. One way you can do this is by placing a radio tuned to the transducer frequency (or a harmonic) next to the pressure case/transducer head mating flange and listening for the interference caused by the transmit pulse. The ping occurs at R-command intervals. If you do not detect a ping, the ADCP might have used all its battery power.

Table 3-1. SC-ADCP Recovery Checklist

Step	Action	Reference
__1	<u>SC-ADCP PHYSICAL RETRIEVAL AND MAINTENANCE</u> - Do the following retrieval maintenance.	3-1
	__ Preliminary retrieval check (optional) __ Clean ADCP exterior __ Remove the dummy plug __ Remove the pressure case (optional)	3-1.1 3-1.2 3-1.3 3-1.4
__2	<u>RETRIEVING DATA FROM EPROM MEMORY</u> - This procedure retrieves data from the recorder's EPROM memory using the @S, @F, W, and @R direct commands.	3-2

NOTE: APPENDIX F HAS A REPRODUCIBLE COPY OF THIS CHECKLIST.

3-1.2. CLEANING THE SC-ADCP EXTERIOR. Before proceeding with any other action, rinse the ADCP with fresh, soapy water to remove soft-bodied marine growth. This also helps prevent the formation of salt crystals. Remove foreign material from the transducer faces as soon as possible (¶5-22.1). Be sure to clean such critical places as the pressure case flange, the transducer assembly, and the dummy plug (Figure 5-1). If hard-bodied marine growth exists, you can remove it now or later. See ¶5-22.1 for information on removing biofouling. Dry the ADCP exterior with low-pressure compressed air or soft lint-free towels.

3-1.3. REMOVING THE DUMMY PLUG. Before retrieving data, make sure water has not entered the I/O connector. Unless you take precautions, water can trickle into the connector when you remove the dummy plug. Water within the connector can cause severe corrosion or break down the connector's dielectric.

Before removing the dummy plug, be sure the ADCP exterior is dry. Lay the ADCP on its side on some protective padding. Place the ADCP so the I/O connector end of the ADCP points downward. Remove the dummy plug. Use low-pressure, compressed air or soft, lint-free towels to remove traces of water from the connector and the dummy plug. Do not damage the connector pins.

3-1.4. REMOVING THE PRESSURE CASE. Removing the pressure case is NOT necessary to retrieve data, but you might want to do so. Section 5-1 has pressure case removal instructions.

3-2. RETRIEVING DATA FROM THE RECORDER

The following general procedure extracts data from the recorder's EPROM memory using direct commands (Appendix D). We do not provide information on setting up external equipment such as tape recorders to the ADCP. We present only the method by which data are extracted from the EPROM recorder. We suggest you use RDI's Deployment Program to retrieve data from the recorder. If you are not using the Deployment Program, we must assume you are familiar with our data format (Chapter 4) and the requirements of your data extraction device/ software. If you have special data extraction requirements, Appendix D explains the recorder's direct commands in detail.

NOTE

DATA COLLECTION STOPS WHEN YOU ESTABLISH COMMUNICATIONS WITH THE ADCP.

a. Use Appendix A to connect the ADCP system. We recommend using an external DC power supply to provide the V1 and V2 power requirements. Apply power to both the ADCP and your computer/dumb terminal. Wake up the ADCP (establish communications). If you are NOT using the Deployment Program to retrieve data, continue with the remaining steps; otherwise, follow the Deployment Program procedures in the on-disk SC-ADCP Deployment Program User's Manual.

b. Send the @S command to display a memory map of the recorder's contents (see below). This map shows all the USER and DATA files now stored in memory, the amount of memory used by each file, and the amount of memory still available within the recorder. If you will be sending data to another media (e.g., floppy disk), note the amount of memory used by the selected file so you know how much storage space you will need.

```
@S
USER FILE # 001:   KBYTES: 00008
DATA FILE # 002:   KBYTES: 00020
USER FILE # 003:   KBYTES: 00008
DATA FILE # 004:   KBYTES: 00047
KBYTES LEFT: 19917
```

NOTE

A USER FILE IS AN ASCII TEXT FILE CREATED USING THE @W-COMMAND. A DATA FILE IS A FILE CONTAINING DEPLOYMENT DATA COLLECTED BY THE ADCP AND IS CREATED WHEN DATA COLLECTION BEGINS, USUALLY WITH THE S191 COMMAND.

c. Select the file number you want to retrieve by sending the @Fxxx-command, where *xxx* is the file number displayed by the @S-command. The last file listed will normally be the most recent deployment.

d. If you want to extract the data using the ADCP switch settings as the default condition, you can skip this step. If you want the ADCP to extract the data at a specific baud rate or parity, or select the data for output in ASCII or binary format, you will have to send a W command. For example, to extract data in the binary output mode, send a W064 command. Appendix D has more information on how to use the W-command.

NOTES

1. ALL RDI'S DATA PROCESSING PROGRAMS (e.g., LOGADCP.EXE, LISTADCP.EXE, PLAYBACK.EXE) MUST HAVE DATA IN BINARY FORMAT AS SELECTED BY THE BINARY OUTPUT MODE.
2. IN BINARY OUTPUT MODE, YOUR COMPUTER/DUMB TERMINAL WILL NOT ECHO KEYSTROKES OR ADCP MESSAGES IN ASCII, SO THEY MIGHT APPEAR UNREADABLE.

e. To extract the entire data file you have selected, send one of the following commands.

@R000 – ASCII output mode selected
@R000ΔΔ – Binary output mode selected, where ΔΔ = required spaces

f. When data extraction of the selected file is complete, the ADCP will send an "EOF" character string.

g. If you want to select only certain portions of data files, or if you have more specific data extraction requirements, see Appendix D for details about the recorder's direct commands. Chapter 4 explains how both the ASCII and binary output data formats for the SC-ADCP.

NOTES

CHAPTER 4
OUTPUT DATA FORMATS

4-0. INTRODUCTION

This chapter presents the format of ADCP output data. The output data can be in either an ASCII or binary format. You can select this option with an internal switch (Appendix W) or a direct command (W-command). Appendix D explains all direct commands. We explain the output data formats in enough detail to let you create your own data processing/analysis programs. RDI also has some ready-made data processing programs, which we describe in ¶4-3.

4-1. ASCII OUTPUT DATA FORMAT

Use the ASCII format when you are viewing raw ADCP data on a computer/dumb terminal. The ASCII format uses the ASCII codes for 0 through 9 for decimal data. An exception is the Status byte (Table 4-7). It uses a hexadecimal format. Other standard ASCII characters (text) and control commands (carriage return, line feed, end of file, etc) are interpreted normally.

In ASCII mode, the ADCP sends the data in lines of ASCII characters separated by a carriage return and line feed sequence (CR/LF). The maximum line length is 76 characters (exclusive of CR/LF). Figure 4-1 shows the ASCII data output format and how it looks on a CRT display. The first two lines contain leader data (see Table 4-2 for a description). In the ASCII data output mode, the leader is always the first data item sent. Subsequent lines contain the optional data selected by the O-command (velocity, spectral width, echo intensity, percent-good, status). We define these fields in Tables 4-3 through 4-7. Figure 4-2 shows the format of the ASCII output data.

For the ASCII data output shown in Figures 4-1 and 4-2, we used nine depth cells (bins) and selected all optional data outputs (velocity in beam coordinates, spectral width, echo intensity, percent-good, status) with the O-command. Nine bins of velocity data (all 1's in this example) are displayed after the leader starting on the third line. This is followed by nine bins each of spectral width (all 2's), echo intensity (all 3's), percent-good (all 4's), and status data (all 5's).

NOTE

INTERNALLY, THE ADCP STORES DATA IN BINARY FORMAT. AT DATA TRANSFER, THE ADCP CONVERTS THE DATA TO ASCII WHEN REQUESTED BY THE USER.

4-2. BINARY OUTPUT DATA FORMAT

Use the binary format when recording/processing ADCP data on an external device. This format uses less storage space and has a faster transmission time than the ASCII format. A dumb terminal is of little use in binary format because the terminal interprets some of the data as control characters.

The binary output data buffer contains a header, a leader, optional data selected by the O-command (velocity, spectral width, echo intensity, percent-good, status), and a checksum. All data in the output buffer are collected during an ensemble. Figure 4-3 shows the layout of the binary output buffer format and the sequence in which the ADCP sends it. Figures 4-4 through 4-9 show the layout of the individual items that make up the binary output buffer. Tables 4-1 through 4-8 list the format, bytes, fields, scaling factors, and a detailed description of every item in the binary output buffer.

4-3. RDI DATA PROCESSING PROGRAMS

RDI has a software program called COLLECT that you can use to process or examine ADCP data. This program is available from RDI at no charge. The COLLECT program has two features you may find useful - LOOK and TRANSLATION.

4-3.1. LOOK. The LOOK feature (previously released as LISTADCP) lets you quickly look at data collected in the standard ADCP format (i.e., the binary data output format). LOOK lets you make sure data are reasonable and intact. It also lets you do a variety of conversions, so you can use it to view the details of your data. LOOK processes your data for display ONLY. It NEVER alters your original data files. LOOK lets you:

- Quickly access display screens to view ADCP leader, velocity, spectral width, echo intensity, percent-good, and status data.
- Quickly convert measurement units (e.g., counts, mm/s, cm/s, etc).
- Display data in either earth or beam coordinates.
- Select the velocity data reference (to ADCP, average, bottom, etc).
- Select the depth cell (bin) and ensemble ranges to display.
- Adjust data for effects of roll, pitch, speed of sound, etc.

4-3.2. TRANSLATION. The TRANSLATION feature (previously released as LOGADCP) lets you convert selected binary data from the ADCP into ASCII text. You can then use the newly created ASCII files in other programs that accept and process this format. TRANSLATION never alters your original binary data files. TRANSLATION lets you:

- Select the binary data fields to convert to ASCII.
- Limit the bin range and ensemble range of the data to be converted.
- Monitor and control the progress of the conversion.

```
0101200726000100000100090204010000001000993525643496473300000000000230031830
00000000000000000000000000000000000000055355535553555352926000000000000000
1111111111111111111111111111111111111111111111111111111111111111111111111111
1111111111111111111111111111111111111111111111111111111111111111111111111111
1111111111111111111111111111111111111111
2222222222222222222222222222222222222222222222222222222222222222222222222222
22222222222222222222222222222222222222222222222222222222222222222222
3333333333333333333333333333333333333333333333333333333333333333333333333333
33333333333333333333333333333333333333333333333333333333333333333333
4444444444444444444444444444444444444444444444444444444444444444444444444444
44444444444444444444
555555555555555555555555555555555555555555555555
         NOTE: The values listed here do NOT represent actual data.
```

Figure 4-1. ASCII Output Data Format (CRT Display)

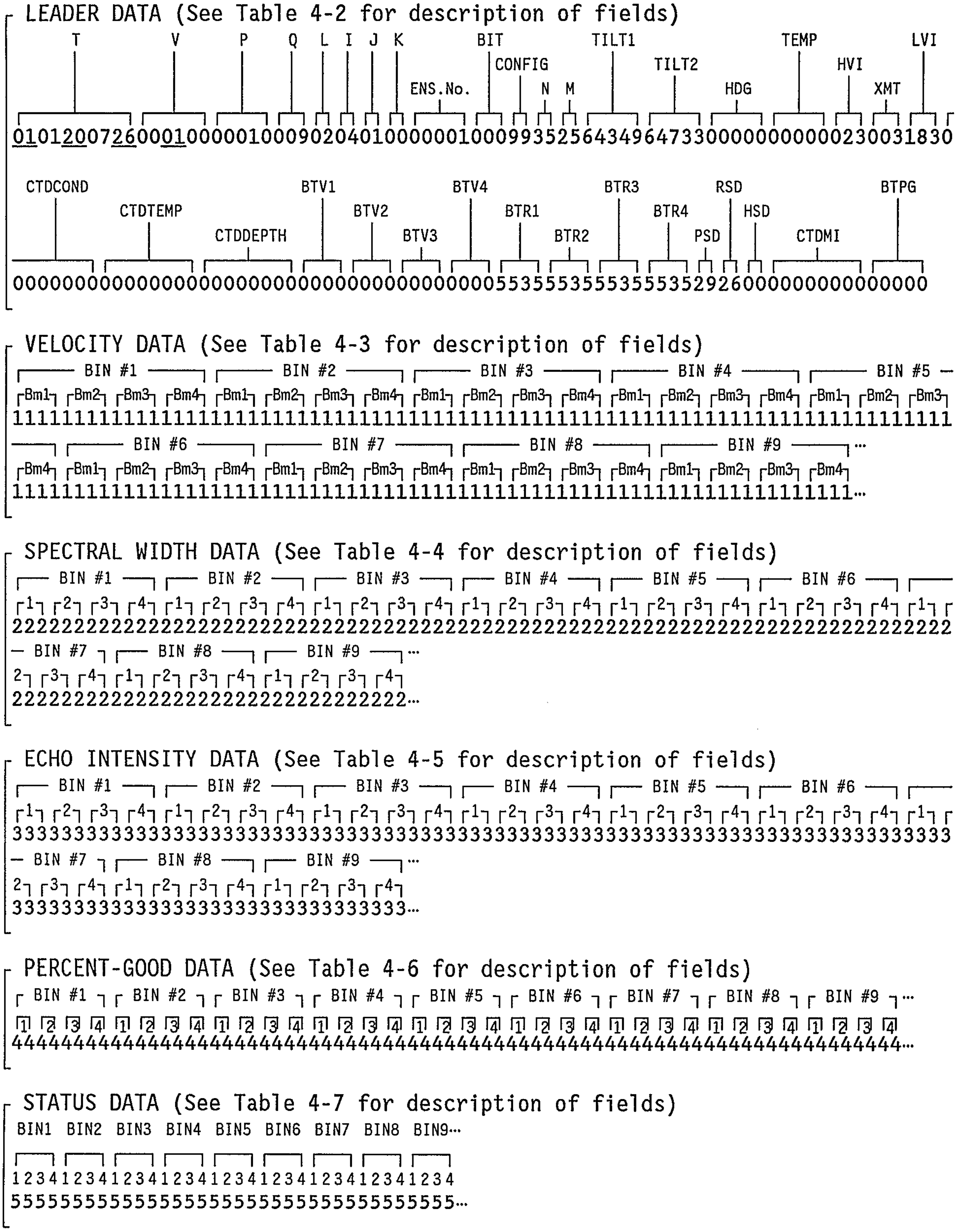
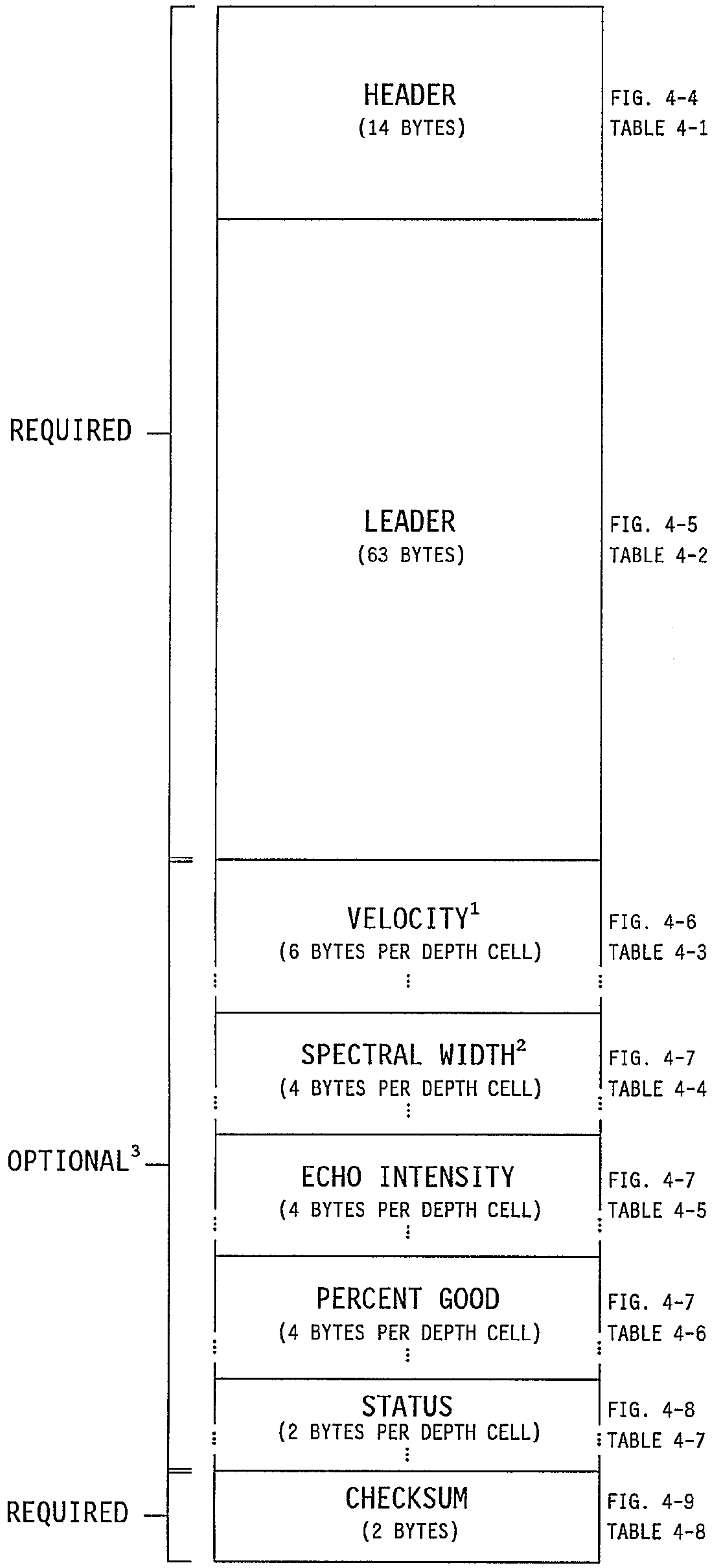


Figure 4-2. ASCII Output Data Format (Layout)



NOTES:

1. VELOCITY DATA CAN BE IN THE EARTH <u>OR</u> BEAM-COORDINATE SYSTEM.
2. SPECTRAL WIDTH DATA NOT SELECTABLE IF VELOCITY DATA ARE IN EARTH COORDINATES.
3. THE OPTIONAL DATA OUTPUTS ARE SELECTED BY THE O-COMMAND. OPTIONAL DATA OUTPUTS ARE IN BYTES PER DEPTH CELL. FOR EXAMPLE, IF THE Q-COMMAND (NO. OF DEPTH CELLS) = 23, AND ALL POSSIBLE DATA ARE SELECTED FOR OUTPUT, THE REQUIRED DATA BUFFER STORAGE SPACE IS 539 BYTES PER ENSEMBLE (SET BY R-COMMAND):

14 BYTES OF HEADER DATA (FIXED)
63 BYTES OF LEADER DATA (FIXED)
138 BYTES OF BEAM-VELOCITY DATA (6×23)
92 BYTES OF SPEC. WIDTH DATA (4×23)
92 BYTES OF ECHO INTENSITY DATA (4×23)
92 BYTES OF PERCENT-GOOD DATA (4×23)
46 BYTES OF STATUS DATA (2×23)
2 BYTES OF CHECKSUM DATA (FIXED)
539 BYTES OF DATA PER ENSEMBLE

Figure 4-3. Binary Output Data Buffer Format

BYTE NUMBER	BIT POSITIONS 7 6 5 4 3 2 1 0	
1	OUTPUT DATA BUFFER SIZE	MSB
2		LSB
3	LEADER DATA BUFFER SIZE	MSB
4		LSB
5	VELOCITY DATA BUFFER SIZE	MSB
6		LSB
7	SPECTRAL WIDTH DATA BUFFER SIZE	MSB
8		LSB
9	ECHO INTENSITY DATA BUFFER SIZE	MSB
10		LSB
11	PERCENT-GOOD DATA BUFFER SIZE	MSB
12		LSB
13	STATUS DATA BUFFER SIZE	MSB
14		LSB

NOTE: SEE TABLE 4-1 FOR DESCRIPTION OF FIELDS

Figure 4-4. Binary Header Data Format

BYTE#	BIT POSITIONS 7 6 5 4 3 2 1 0	
1	RTC MONTH	[T]
2	RTC DAY	
3	RTC HOUR	
4	RTC MINUTE	
5	RTC SECOND	
6	TBP MINUTES	[V]
7	TBP SECONDS	
8	TBP SEC/100	
9	PINGS PER ENSEMBLE	MSB [P]
10		LSB
11	No. OF BINS	[Q]
12	BIN LENGTH	[L]
13	XMT PULSE LNGTH	[I]
14	BLANK AFTER XMT	[J]
15	DLY AFTER BLANK	[K]
16	ENSEMBLE NUMBER	MSB
17		LSB
18	BIT STATUS	
19	ADCP CONFIG	
20	S/N THRESHOLD	[N]
21	%GD THRESHOLD	[M]

BYTE#	BIT POSITIONS 7 6 5 4 3 2 1 0	
22	TILT 1 (PITCH)	MSB
23		LSB
24	TILT 2 (ROLL)	MSB
25		LSB
26	HEADING	MSB
27		LSB
28	ADCP TEMP	MSB
29		LSB
30	HI VOLT IN	
31	XMT CURRENT	
32	LO VOLT IN	
33	CTD CONDUCTIVITY COUNT	MSB
34		
35		LSB
36	CTD TEMPERATURE COUNT	MSB
37		
38		LSB
39	CTD DEPTH COUNT	MSB
40		
41		LSB
42	BTV1-H	

BYTE#	BIT POSITIONS 7 6 5 4 3 2 1 0	
43	BTV1-L LSN BTV2-H MSN	
44	BTV2-L	LSB
45	BTV3-H	MSB
46	BTV3-L LSN BTV4-H MSN	
47	BTV4-L	LSB
48	BT RANGE BEAM #1	MSB
49		LSB
50	BT RANGE BEAM #2	MSB
51		LSB
52	BT RANGE BEAM #3	MSB
53		LSB
54	BT RANGE BEAM #4	MSB
55		LSB
56	PITCH-STD DEV	
57	ROLL-STD DEV	
58	HEADING-STD DEV	
59	CTD MEASUREMENT INTERVAL	MSB
60		
61		LSB
62	BT%GD#1 BT%GD#2	
63	BT%GD#3 BT%GD#4	

NOTE: SEE TABLE 4-2 FOR DESCRIPTION OF FIELDS

Figure 4-5. Binary Leader Data Format

<table>
<tr><th></th><th colspan="8">BIT POSITIONS</th></tr>
<tr><th>BYTE</th><th>7/S</th><th>6</th><th>5</th><th>4</th><th>3/S</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>1</td><td colspan="8">BIN #1, BEAM #1 MSB</td></tr>
<tr><td>2</td><td colspan="4">BIN #1, BEAM #1 LSN</td><td colspan="4">BIN #1, BEAM #2 MSN</td></tr>
<tr><td>3</td><td colspan="8">BIN #1, BEAM #2 LSB</td></tr>
<tr><td>4</td><td colspan="8">BIN #1, BEAM #3 MSB</td></tr>
<tr><td>5</td><td colspan="4">BIN #1, BEAM #3 LSN</td><td colspan="4">BIN #1, BEAM #4 MSN</td></tr>
<tr><td>6</td><td colspan="8">BIN #1, BEAM #4 LSB</td></tr>
<tr><td>7</td><td colspan="8">BIN #2, BEAM #1 MSB</td></tr>
<tr><td>8</td><td colspan="4">BIN #2, BEAM #1 LSN</td><td colspan="4">BIN #2, BEAM #2 MSN</td></tr>
<tr><td>9</td><td colspan="8">BIN #2, BEAM #2 LSB</td></tr>
<tr><td>10</td><td colspan="8">BIN #2, BEAM #3 MSB</td></tr>
<tr><td>11</td><td colspan="4">BIN #2, BEAM #3 LSN</td><td colspan="4">BIN #2, BEAM #4 MSN</td></tr>
<tr><td>12</td><td colspan="8">BIN #2, BEAM #4 LSB</td></tr>
<tr><td>⋮</td><td colspan="8">(This sequence continues for up to 128 bins.)</td></tr>
<tr><td>763</td><td colspan="8">BIN #128, BEAM #1 MSB</td></tr>
<tr><td>764</td><td colspan="4">BIN #128, BEAM #1 LSN</td><td colspan="4">BIN #128, BEAM #2 MSN</td></tr>
<tr><td>765</td><td colspan="8">BIN #128, BEAM #2 LSB</td></tr>
<tr><td>766</td><td colspan="8">BIN #128, BEAM #3 MSB</td></tr>
<tr><td>767</td><td colspan="4">BIN #128, BEAM #3 LSN</td><td colspan="4">BIN #128, BEAM #4 MSN</td></tr>
<tr><td>768</td><td colspan="8">BIN #128, BEAM #4 LSB</td></tr>
</table>

NOTE: SEE TABLE 4-3 FOR DESCRIPTION OF FIELDS

<u>LEGEND</u>:

S = SIGN BIT
MSB = MOST SIGNIFICANT BYTE
LSB = LEAST SIGNIFICANT BYTE
MSN = MOST SIGNIFICANT NIBBLE
LSN = LEAST SIGNIFICANT NIBBLE

Figure 4-6. Binary Velocity Data Format

BYTE	BIT POSITIONS 7/S 6 5 4 3 2 1 0
1	BIN #1, BEAM #1
2	BIN #1, BEAM #2
3	BIN #1, BEAM #3
4	BIN #1, BEAM #4
5	BIN #2, BEAM #1
6	BIN #2, BEAM #2
7	BIN #2, BEAM #3
8	BIN #2, BEAM #4
⋮	(SEQUENCE CONTINUES FOR UP TO 128 BINS.)
509	BIN #128, BEAM #1
510	BIN #128, BEAM #2
511	BIN #128, BEAM #3
512	BIN #128, BEAM #4

NOTE: SEE TABLES 4-4, 4-5, AND 4-6 FOR DESCRIPTION OF FIELDS

Figure 4-7. Binary Spectral Width, Echo Intensity, and Percent-Good Data Format

BYTE	7 6 5 4	3 2 1 0
1	BIN #1, BEAM #1	BIN #1, BEAM #2
2	BIN #1, BEAM #3	BIN #1, BEAM #4
3	BIN #2, BEAM #1	BIN #2, BEAM #2
4	BIN #2, BEAM #3	BIN #2, BEAM #4
⋮	(SEQUENCE CONTINUES	FOR UP TO 128 BINS.)
255	BIN 128, BEAM 1	BIN 128, BEAM 2
256	BIN 128, BEAM 3	BIN 128, BEAM 4

NOTE: SEE TABLE 4-7 FOR DESCRIPTION OF FIELDS

Figure 4-8. Binary Status Data Format

BYTE	7 6 5 4 3 2 1 0	
1	CHECKSUM	MSB
2	DATA	LSB

NOTE: SEE TABLE 4-8 FOR DESCRIPTION OF FIELD

Figure 4-9. Binary Checksum Data Format

Table 4-1. Binary Header Data Format

Byte	Field	Description
		GENERAL — In binary mode, header data is the first item sent by the ADCP to the output buffer. Figure 4-4 shows the format of the header data field. The ADCP does not send header data in ASCII mode.
1,2	Output Data Buffer Size	This field contains the size of the output buffer (in bytes) for one ensemble, excluding the 2-byte checksum (Figure 4-9; Table 4-8). For example, if each ensemble needed 539 bytes of storage space, this field would have a value of 537 (see example in Figure 4-3).
3,4	Leader Data Buffer Size	This field contains the number of bytes stored as leader data (Figure 4-5; Table 4-2) in the output buffer. It is fixed at 63 bytes.
5,6	Velocity Data Buffer Size	This field contains the number of bytes stored contiguously in the output buffer as velocity data (Figure 4-6; Table 4-3). All velocity data fields, whether in earth or beam coordinates, use six bytes of storage per depth cell. For example, if there are 128 depth cells in the profile, and you select velocity data for collection, this field will have a value of 768 (6 x 128). This means the ADCP will store 768 contiguous bytes of velocity data in the output buffer.
7,8	Spectral Width Data Buffer Size	This field contains the number of bytes stored contiguously in the output buffer as spectral width data (Figure 4-7; Table 4-4). All spectral width data fields use four bytes of storage per depth cell. For example, if there are 128 depth cells in the profile, and you select spectral width data for collection, this field will have a value of 512 (4 x 128). This means the ADCP will store 512 contiguous bytes of spectral width data in the output buffer. NOTE: Spectral width is not available for output if you collect velocity data in earth coordinates.
9,10	Echo Intensity Data Buffer Size	This field contains the number of bytes stored contiguously in the output buffer as echo intensity data (Figure 4-7; Table 4-5). All echo intensity data fields use four bytes of storage per depth cell. For example, if there are 128 depth cells in the profile, and you select echo intensity data for collection, this field will have a value of 512 (4 x 128). This means the ADCP will store 512 contiguous bytes of echo intensity data in the output buffer.
11,12	Percent-Good Data Buffer Size	This field contains the number of bytes stored contiguously in the output buffer as percent-good data (Figure 4-7; Table 4-6). All percent-good data fields use four bytes of storage per depth cell. For example, if there are 128 depth cells in the profile, and you select percent-good data for collection, this field will have a value of 512 (4 x 128). This means the ADCP will store 512 contiguous bytes of percent-good data in the output buffer.
13,14	Status Data Buffer Size	This field contains the number of bytes stored contiguously in the output buffer as status data (Figure 4-8; Table 4-7). All status data fields use two bytes of storage per depth cell. For example, if there are 128 depth cells in the profile, and you select status data for collection, this field will have a value of 256 (2 x 128). This means the ADCP will store 256 contiguous bytes of status data in the output buffer.

Table 4-2. Leader Data Format

ASCII Digit	Binary Byte	Field	Description
			GENERAL – ASCII users refer to Figure 4-2. Binary users refer to Figure 4-5.
1,2	1	┌RTC Month	These fields contain the time from the ADCP's real-time clock (RTC) that the current ensemble began. The T-command (Set Real-Time Clock) initially sets the clock. Each ensemble stores the month, day of month, hour, minute, and second. The ADCP does not store the year and assumes February always has 28 days (leap years not accounted for).
3,4	2	│RTC Day	
5,6	3	T┤RTC Hour	
7,8	4	│RTC Minute	
9,10	5	└RTC Second	
			ASCII Scaling: Units of month, day, hour, minute, and second
			Binary Scaling: Bytes 1-5 are in packed binary coded decimal (BCD) format with the upper nibble (bits 7-4) representing the most significant decimal digit (MSD) and the lower nibble (bits 3-0) representing the least significant decimal digit (LSD) for month, day, hour, minute, and second.
11,12	6	┌TBP Minutes	These fields contain the amount of time between each ping in the ensemble. The V-command initially sets the Time Between Pings. The ADCP stores the most recent input value, or the default value after a Z-command (Reset to Factory Defaults).
13,14	7	V┤TBP Seconds	
15,16	8	└TBP Sec/100	
			ASCII Scaling: Units of minutes, seconds, and hundredths of seconds
			Binary Scaling: Bytes 6-8 are in packed BCD format. The upper nibble is the MSD, and the lower nibble represents the LSD for minutes, seconds, and hundredths of seconds.
17-21	9,10	P / Pings Per Ensemble	This field contains the number of pings averaged together during an ensemble. The P-command initially sets the number of Pings Per Ensemble. The ADCP stores the most recent input value, or the default value after a Z-command.
			Scaling: LSD = 1 ping; RANGE = 1 to 65,535 pings
22-24	11	Q / No. of Bins	This field contains the number of bins (depth cells) over which the ADCP collects data. The Q-command initially sets the Number of Depth Cells. The ADCP stores the most recent input value, or the default value after a Z-command.
			Scaling: LSD = 1 bin; RANGE = 1 to 128 bins

Table 4-2. Leader Data Format (Continued)

ASCII Digit	Binary Byte	Field	Description
25,26	12	L / Bin Length	This field contains the length of one bin (depth cell). The L-command initially sets the Depth Cell Length. The value stored is the value entered through the L-command, so $2^{\text{L-COMMAND}}$ yields bin length in meters. The ADCP stores the most recent input value or the default value after a Z-command. *Scaling:* LSD = 2^0meter = 1 meter; RANGE = 0 to 5 units (1, 2, 4, 8, 16, or 32 meters)
27,28	13	I / Xmt Pulse Lngth	This field contains the length of the transmitted sonar pulse. The I-command initially sets the Transmit Pulse Length. The ADCP stores the most recent input value, or the default value after a Z-command. *Scaling:* LSD = 1 meter; RANGE = 1 to 99 meters
29,30	14	J / Blank After Xmt	This field contains the distance blanked out by the ADCP to allow time for the transducers to recover after transmitting the sonar pulse. The J-command initially sets the Blank After Transmit distance. The ADCP stores the most recent input value, or the default value after a Z-command. Though the input value is in meters and tenths, the ADCP truncates the decimal portion in the output. For example, the ADCP would use an input of J999 (99.9 meters) for its calculations but display it in the output buffer as 99 meters. *Scaling:* LSD = 1 meter; RANGE = 0 to 99 meters
31,32	15	K / Dly After Blank	This field contains a delay distance added to the J-command value where echo processing for the first depth cell will begin. *Scaling:* LSD = 1 meter; RANGE = 0 to 99 meters
33-37	16,17	ENS. NO. / Ensemble Number	This field contains the sequential number of the ensemble to which the data in the output buffer apply. *Scaling:* LSD = 1 ensemble; RANGE = Ens. 1 to Ens. 65,535 NOTE: The first ADCP ensemble is 00001. At "rollover," we have the following sequence: 00001 = Ensemble number 1 ⋮ 65535 = Ensemble number 65,535 00000 = Ensemble number 65,536 00001 = Ensemble number 65,537 ⋮

Table 4-2. Leader Data Format (Continued)

<table>
<tr><th>ASCII Digit</th><th>Binary Byte</th><th>Field</th><th>Description</th></tr>
<tr><td>38-40</td><td>18</td><td>BIT /
BIT Status</td><td>This field contains the results of the Built-In Test function. The BIT-1 test checks the transmit, receive, and echo processing functions after the last ping of each data collection cycle (ensemble). If the BIT detects only one fault, the ADCP stores the test result code in the output buffer after the first ping of the *next* ensemble. The output buffer can store only one test result code per ensemble. If more than one fault exists, the ADCP remembers all faults and displays the result codes in successive ensembles. A zero code indicates a successful BIT result. See ¶6-3 for a detailed explanation of the BIT function and all its result codes. Briefly, the following decimal codes indicate the more common problems.
<table>
<tr><th>CODES</th><th>DESCRIPTION</th></tr>
<tr><td>17-31</td><td>BEAM 1 RELATED PROBLEM</td></tr>
<tr><td>33-47</td><td>BEAM 2 RELATED PROBLEM</td></tr>
<tr><td>49-63</td><td>BEAM 3 RELATED PROBLEM</td></tr>
<tr><td>65-79</td><td>BEAM 4 RELATED PROBLEM</td></tr>
<tr><td>81</td><td>VERY LOW TRANSMITTER CURRENT</td></tr>
<tr><td>82</td><td>LOW TRANSMITTER CURRENT (BATTERY ALERT IN SC-ADCPs)</td></tr>
<tr><td>83</td><td>HIGH TRANSMITTER CURRENT</td></tr>
</table></td></tr>
<tr><td>41,42</td><td>19</td><td>CONFIG /
ADCP Config</td><td>This field contains information about the ADCP's configuration. The following information explains how to interpret the bits within the configuration byte (ASCII users must first convert this field to a binary value).
<table>
<tr><th>BIT</th><th>DESCRIPTION</th></tr>
<tr><td>0</td><td>VELOCITY RANGE SWITCH SETTING
0 = LOW RANGE (HIGH RESOLUTION)
1 = HIGH RANGE (LOW RESOLUTION)</td></tr>
<tr><td>1</td><td>VELOCITY REFERENCE (FROM O-COMMAND)
0 = RELATIVE TO ADCP (BEAM-COORDINATE SYSTEM)
1 = RELATIVE TO EARTH (EARTH-COORDINATE SYSTEM)</td></tr>
<tr><td>2</td><td>TRANSDUCER ORIENTATION (FROM SWITCH SETTINGS)
0 = UPWARD-LOOKING
1 = DOWNWARD-LOOKING</td></tr>
<tr><td>3</td><td>TRANSDUCER BEAM PATTERN
0 = CONVEX
1 = CONCAVE</td></tr>
<tr><td>4,5,6</td><td>ADCP ACOUSTIC FREQUENCY
000 = 76.8 kHz (75-kHz MODEL)
001 = 153.6 kHz (150-kHz MODEL)
010 = 307.2 kHz (300-kHz MODEL)
011 = 614.4 kHz (600-kHz MODEL)
100 = 1228.8 kHz (1200-kHz MODEL)
101 = 115.0 kHz (115-kHz MODEL)
111 = NONSTANDARD</td></tr>
<tr><td>7</td><td>BYTE VALIDITY CHECK
0 = THIS BYTE DOES <u>NOT</u> CONTAIN VALID DATA
1 = THIS BYTE <u>DOES</u> CONTAIN VALID DATA</td></tr>
</table></td></tr>
</table>

Table 4-2. Leader Data Format (Continued)

ASCII Digit	Binary Byte	Field	Description
43,44	20	N / S/N Threshold	This field contains the signal-to-noise threshold value used to determine good data. The N-command initially sets the Signal-to-Noise Threshold. The ADCP stores the most recent input value, or the default value after a Z-command. *Scaling:* LSD = 0.1 dB; RANGE = 0 to 9.9 dB
45,46	21	M / %Gd Threshold	This field contains the percent-good threshold value. The M-command initially sets the Percent-Good Threshold. The ADCP stores the most recent input value, or the default value after a Z-command. *Scaling:* LSD = 1 percent; RANGE = 0 to 99 percent
47-51 52-56	22,23 24,25	TILT 1 (Pitch) TILT 2 (Roll)	These fields contain the Tilt-1 and Tilt-2 angles from the internal tilt pendulums or external gyrocompass (if present). Assuming beam 3 is facing north, Tilt-1 angles correspond to PITCH (x-axis) and Tilt-2 angles correspond to ROLL (y-axis). *Scaling:* LSD = 360/65536 degrees; RANGE = See below

ORIEN-TATION	SIGN	VALUES	PHYSICAL	
			TILT-1	TILT-2
DOWN-FACING	+	INCREASING VALUES FROM 0 TO 32766 INDICATE INCREASING POSITIVE VALUES	BEAM 3 HIGHER THAN BEAM 4	BEAM 2 HIGHER THAN BEAM 1
	-	DECREASING VALUES FROM 65535 TO 32767 INDICATE INCREASING NEGATIVE VALUES	BEAM 4 HIGHER THAN BEAM 3	BEAM 1 HIGHER THAN BEAM 2
UP-FACING	+	INCREASING VALUES FROM 0 TO 32766 INDICATE INCREASING POSITIVE VALUES	BEAM 4 HIGHER THAN BEAM 3	BEAM 1 HIGHER THAN BEAM 2
	-	DECREASING VALUES FROM 65535 TO 32767 INDICATE INCREASING NEGATIVE VALUES	BEAM 3 HIGHER THAN BEAM 4	BEAM 2 HIGHER THAN BEAM 1

Table 4-2. Leader Data Format (Continued)

<table>
<thead>
<tr><th>ASCII Digit</th><th>Binary Byte</th><th>Field</th><th>Description</th></tr>
</thead>
<tbody>
<tr><td>57-61</td><td>26,27</td><td>HDG /
Heading</td><td>This field contains the heading angle of the ADCP from the internal flux-gate compass or external gyrocompass. The ADCP assumes that the beam 3-4 axis corresponds to the earth's north-south axis.

Scaling: LSD = 360/65536 degrees; RANGE = 360 degrees</td></tr>
<tr><td>62-66</td><td>28,29</td><td>TEMP /
ADCP Temp</td><td>This field contains the water temperature as measured by the thermistor in the transducer head. The range of the water temperature output is from -5°C to +45°C. A zero in this field corresponds to -5°C. A value of 4096 corresponds to +45°C. To determine water temperature from this field, use the formula: Temperature = 45 - (50 × Value / 4096).

Scaling: LSD = 50/4096°C; RANGE = See above

NOTE: A memory-space problem occurs with the temperature data. If you collect ADCP data with an ADCP recorder and simultaneously send data to the serial port, a comparison of the two temperature values may yield a difference. Both values are correct, but because the internally-stored temperature data are destroyed when saving to a recorder or sending data to the serial port, a new temperature reading will occur during data output to the serial port. If the ADCP is sending data out the serial port only, the temperature value is the average over the ensemble period.</td></tr>
<tr><td>67-69</td><td>30</td><td>HVI /
Hi Volt In</td><td>This field contains the level of the high voltage input to the transducer's power amplifier (V2 battery power for SC-ADCPs).

Scaling: LSD = 0.17 VDC; RANGE = 0 to 43.35 VDC</td></tr>
<tr><td>70-72</td><td>31</td><td>XMT /
Xmt Current</td><td>This field contains the amount of transmitter current being used by the ADCP. Scaling is power-dependent:
<table>
<thead><tr><th>POWER TYPE</th><th>LSD</th><th>RANGE</th></tr></thead>
<tbody>
<tr><td>LOW-POWER</td><td>≈0.01</td><td>0 TO 2.55 A</td></tr>
<tr><td>HIGH-POWER</td><td>≈0.02</td><td>0 TO 5.12 A</td></tr>
</tbody>
</table>
</td></tr>
</tbody>
</table>

Table 4-2. Leader Data Format (Continued)

ASCII Digit	Binary Byte	Field	Description
73-75	32	LVI / Lo Volt In	This field contains the level of the low voltage input to the ADCP's electronics (V1 battery power in SC-ADCPs). *Scaling:* LSD = 0.05 VDC; RANGE = 0 to 12.75 VDC
76-83	33-35	CTDCOND / CTD Conductivity Count	This field contains the conductivity count from the optional conductivity sensor. To convert these counts to their real measurement value, use the manufacturer's calibration sheet, which lists all coefficients and conversion formulas. *ASCII Scaling:* Multiply the five most significant digits by 256 and add the result to the three least significant digits. You can now use the manufacturer's calibration sheet for conversion. *Binary Scaling:* LSD=1 count; RANGE=0 to 16,777,215 counts
84-91	36-38	CTDTEMP / CTD Temperature Count	This field contains the temperature count from the optional temperature sensor. To convert these counts to their real measurement value, use the manufacturer's calibration sheet, which lists all coefficients and conversion formulas. *ASCII Scaling:* Multiply the five most significant digits by 256 and add the result to the three least significant digits. You can now use the manufacturer's calibration sheet for conversion. *Binary Scaling:* LSD=1 count; RANGE=0 to 16,777,215 counts
92-99	39-41	CTDDEPTH / CTD Depth Count	This field contains the depth (pressure) count from the optional depth sensor. To convert these counts to their real measurement value, use the manufacturer's calibration sheet, which lists all coefficients and conversion formulas. *ASCII Scaling:* Multiply the five most significant digits by 256 and add the result to the three least significant digits. You can now use the manufacturer's calibration sheet for conversion. *Binary Scaling:* LSD=1 count; RANGE=0 to 16,777,215 counts
100-103 104-107 108-111 112-115	42-47	BTV1/BTV1-H&L BTV2/BTV2-H&L BTV3/BTV3-H&L BTV4/BTV4-H&L	These fields contain the velocity of the ADCP in relation to the sea-bottom (or surface) as determined by each beam. Bottom-Track Velocities have the same format and scale factor as profiling velocities. Bad bottom-track data are shown the same way as bad profiling velocities. See Table 4-3 for details and scaling factors.

Table 4-2. Leader Data Format (Continued)

ASCII Digit	Binary Byte	Field	Description
116-119 120-123 124-127 128-131	48-55	BTR1┐ BT Range BTR2├ Beam 1 BTR3│ through BTR4┘ Beam 4	These fields contain the range from the ADCP to the sea bottom (or surface) as determined by each beam. The validity of bottom-track range coincides with the validity of bottom-track velocity. *Scaling:* LSD = 1 meter; RANGE = 0 to 9999 meters
132,133	56	PSD / Pitch-Std Dev	This field contains the standard deviation (accuracy) of TILT 1 (pitch; x-axis) from the pendulum/gyrocompass. *Scaling:* LSD = 0.1 degree; RANGE = 0 to 9.9 degrees
134,135	57	RSD / Roll-Std Dev	This field contains the standard deviation (accuracy) of TILT 2 (roll; y-axis) from the pendulum/gyrocompass. *Scaling:* LSD = 0.1 degree; RANGE = 0 to 9.9 degrees
136,137	58	HSD / Heading-StdDev	This field contains the standard deviation (accuracy) of heading from the compass. *Scaling:* LSD = 1.0 degree; RANGE = 0 to 99 degrees
138-145	59-61	CTDMI / CTD Measurement Interval	This field contains the CTD measurement interval used in conversion calculations for external Conductivity, Temperature, and Depth (pressure) sensors. *ASCII Scaling:* Multiply the five most significant digits by 256 and add the result to the three least significant digits. Now multiply the resultant by 0.001 second to yield the measurement interval. *Binary Scaling:* LSD = 0.001 s; RANGE = 0 to 16,777.215 s
146-150	62,63	BT%Gd#1 BT%Gd#2 BT%Gd#3 BT%Gd#4	These fields contain bottom-track percent-good data for each beam. This percentage indicates the reliability of the bottom-track data. It is the percentage of bottom-track pings that have passed the bottom-track detection threshold (FF command) during an ensemble. *ASCII Scaling:* Convert this field to a binary value, and then use the binary scaling description. *Binary Scaling:* The four nibbles that make up these fields represent beams 1, 2, 3, and 4 (Beam 1 is the most significant nibble). Because nibbles (four bit places) are used, the least significant bit in each nibble is equal to 6.67% (100/15).

Table 4-3. Velocity Data Format

ASCII Digit	Binary Byte	Field	Description

GENERAL – The ADCP can reference velocity data to either the four radial beams or the earth as selected by the O-command. The beam velocities correspond to beams one through four. The earth-referenced velocity components correspond to east, north, vertical, and an error velocity, respectively.

The velocity data scale factor depends on the setting of the HIGH/LOW RANGE switch on the Peripherals 2 board (Appendix W) and the transducer frequency. The following table lists the scale factors based on system frequency and the setting of the HIGH/LOW RANGE switch (see note 1). These scale factors assume a water sound velocity of 1536 m/s (see note 2). The table also lists the Doppler frequency shift (in Hz per count) from which the ADCP derives the radial-beam velocity components.

MODEL FREQ. (kHz)	HIGH RANGE[1] / LOW RESOLUTION					LOW RANGE[1] / HIGH RESOLUTION				
	SCALE FACTOR (cm/s PER COUNT)		MAXIMUM VELOCITY[2] (cm/s)		Hz/COUNT	SCALE FACTOR (cm/s PER COUNT)		MAXIMUM VELOCITY[2] (cm/s)		Hz/COUNT
	Beam	Earth	Beam	Earth		Beam	Earth	Beam	Earth	
75	0.25	0.5	512	1024	0.25	0.25	0.5	512	1024	0.25
150	0.25	0.5	512	1024	0.5	0.125	0.25	256	512	0.25
300	0.25	0.5	512	1024	1.0	0.125	0.25	256	512	0.5
600	0.25	0.5	512	1024	2.0	0.125	0.25	256	512	1.0
1200	0.25	0.5	512	1024	4.0	0.125	0.25	256	512	2.0

NOTES:

1. HIGH RESOLUTION DECREASES MAXIMUM VELOCITY RANGE. POLE 7 OF SWITCH 2 ON THE PERIPHERAL 2 BOARD SETS VELOCITY RESOLUTION (OPEN = HIGH RANGE/LOW RESOLUTION, CLOSED = LOW RANGE/HIGH RESOLUTION).
2. THE ASSUMED SPEED OF SOUND IS 1536 m/s. FOR TRUE VELOCITIES, MULTIPLY BY [ACTUAL SPEED OF SOUND / 1536].

The ADCP can flag bad velocity data in two ways:

1. If Status data (Table 4-7) are not selected for output, a velocity value of 2048 (100000000000_2) indicates bad velocity data.
2. If Status data are selected for output, a nonzero Status value indicates bad data (see Table 4-7).

NOTE

YOU MAY NEED TO TAKE PRECAUTIONS WHEN USING STATUS DATA AS AN INDICATOR OF BAD DATA. IN SUCH CASES, A VELOCITY DATA VALUE OF 2048 DOES NOT INDICATE BAD DATA. THEREFORE, IF YOU HAVE DEVELOPED SOFTWARE THAT ONLY CHECKS VELOCITY DATA FOR VALUES OF 2048 AS AN INDICATION OF BAD DATA, YOU MAY BE INCLUDING BAD VALUES IN YOUR DATA. IF STATUS DATA ARE SELECTED FOR OUTPUT, USE IT TO CHECK FOR VELOCITY DATA VALIDITY.

Table 4-3. Velocity Data Format (Continued)

ASCII Digit	Binary Byte	Field	Description
			When Status data are an output, and P=1 (Pings Per Ensemble), a velocity data value of zero indicates bad data. When Status data are an output and P>1, the ADCP provides velocity data independent of the Status indication when any ping within the sampling interval (R-command) passes the signal-to-noise threshold (N-command). When bottom-tracking is ON (FH-command) and the bottom is detected, a DR or VM-ADCP may flag velocity data as bad for depth cells (bins) within 15% of the range to the bottom. However, you may override this automatic data rejection with the O-command. If this override function is ON, the data may or may not be valid. SC-ADCPs do not reject any bottom-track velocity data. **ASCII FORMAT** – With velocity data selected for output, the first digit of velocity data follows the CR/LF sequence after the leader data (see Figures 4-1 and 4-2). ASCII velocity data require four digits per depth cell (bin) per beam. The range of ASCII counts for velocity data is 0-4096. If the count is more than 2048, the Doppler shift is negative. To get the negative count value, subtract 4096 from counts greater than 2048. For example, if the ASCII count is 3010, the actual ASCII count is 3010 - 4096, or -1086 counts. To convert velocity counts to cm/s, use the table in the general description above. We explain the format for only the first 16 digits of the ASCII velocity data format (Bin #1). The same 16-digit sequence continues for up to 128 bins. The number of 16-digit bin groups depends on the number of bins selected for profiling by the Q-command. With all 128 bins selected, the output uses 2048 ASCII digits (16 × 128) for velocity data. **BINARY FORMAT** – With velocity data selected for output, the first byte of binary velocity data follows the last byte of leader data (see Figure 4-3). Binary velocity data use 6 bytes of output buffer space per depth cell (bin). Figure 4-6 shows how each byte "looks." These 6 bytes store data for each of the four beams. Each beam uses 12 bit positions (1 byte + 1 nibble). The output buffer stores velocity data in two's complement, so either Bit 7 (for Most Significant Bytes) or Bit 3 (for Most Significant Nibbles) serves as the Sign Bit. When the sign bit is set, the velocity data for that bin/beam is a negative value. To convert the ADCP velocity counts to cm/s, use the table in the general description above. We explain the format for only the first 6 bytes of the binary velocity data format (Bin #1). The same 6-byte sequence continues for up to 128 bins. The number of 6-byte bin groups depends on the number of bins selected for profiling (Q-command). With all 128 bins selected, the output buffer uses 768 bytes (6 × 128) of storage space for velocity data.

Table 4-3. Velocity Data Format (Continued)

ASCII Digit	Binary Byte	Field	Description
1-4	1,2	Bin 1, Beam 1	This field contains the velocity data for bin #1, beam #1. See the descriptions above for more information.
5-8	2,3	Bin 1, Beam 2	This field contains the velocity data for bin #1, beam #2. See the descriptions above for more information.
9-12	4,5	Bin 1, Beam 3	This field contains the velocity data for bin #1, beam #3. See the descriptions above for more information.
13-16	5,6	Bin 1, Beam 4	This field contains the velocity data for bin #1, beam #4. See the descriptions above for more information.
17-2048	7-768	Bins 2 - 128 (if used)	These fields contain the velocity data for bins 2 through 128 (depending on the setting of the Q-command) for all four beams. These fields follow the same format as listed above for bin 1.

Table 4-4. Spectral Width Data Format

ASCII Digit	Binary Byte	Field	Description
			GENERAL — If you collect velocity data in earth coordinates (set by O-command), the ADCP cannot collect spectral width data. The spectral width scale factor is twice the velocity data scale factor (see Table 4-3). The ADCP can flag bad spectral width data in two ways: 1. If Status data (Table 4-7) are not selected for output, a spectral width value of zero indicates bad spectral width data. 2. If Status data are selected for output, a nonzero Status value indicates bad data (see Table 4-7). **ASCII FORMAT** — When selected for output, the first digit of spectral width data follows the CR/LF sequence after the last data field collected (see Figure 4-2). Spectral width data use 3 digits per bin per beam, so the first 12 digits correspond to Bin #1. This 12-digit sequence continues for up to 128 bins (determined by Q). Selecting all 128 bins uses 1536 digits (12 × 128) for spectral width data. To convert spectral width counts to cm/s, see the discussion in Table 4-3. **BINARY FORMAT** — When selected for output, the first byte of spectral width data follows the last byte of the last data field collected (see Figure 4-3). Spectral width data use 4 bytes of output buffer space per bin, with each byte storing data for one beam (see Figure 4-7). The first 4 bytes of spectral width data correspond to Bin #1. This 4-byte sequence continues for up to 128 bins (determined by Q). Selecting all 128 bins uses 512 bytes (4 × 128) of buffer space for spectral width data. Spectral width is in two's complement, with Bit 7 being the Sign Bit. When the Sign Bit = 1, spectral width data for that bin/beam is negative. To convert spectral width counts to cm/s, see the discussion in Table 4-3.
1-3	1	Bin 1, Beam 1	This field stores spectral width data for bin #1, beam #1. See the descriptions above for more information.
4-6	2	Bin 1, Beam 2	This field stores spectral width data for bin #1, beam #2. See the descriptions above for more information.
7-9	3	Bin 1, Beam 3	This field stores spectral width data for bin #1, beam #3. See the descriptions above for more information.
10-12	4	Bin 1, Beam 4	This field stores spectral width data for bin #1, beam #4. See the descriptions above for more information.
13-1536	5-512	Bins 2 - 128 (if used)	These fields store spectral width data for bins 2 through 128 (depending on the Q-command) for all four beams. These fields follow the same format as listed above for bin 1.

Table 4-5. Echo Intensity Data Format

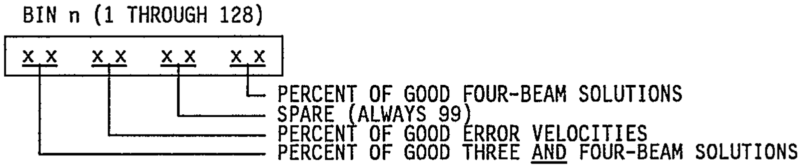
ASCII Digit	Binary Byte	Field	Description
			GENERAL — The echo intensity scale factor is about 0.45 dB per ADCP count. The ADCP does not directly check for the validity of echo intensity data. **ASCII FORMAT** — When selected for output, the first digit of echo intensity data follows the CR/LF sequence after the last data field collected (see Figure 4-2). Echo intensity data use 3 digits per bin per beam, so the first 12 digits correspond to Bin #1. This 12-digit sequence continues for up to 128 bins (determined by Q). Selecting all 128 bins uses 1536 digits (12 × 128) for echo intensity data. To convert echo intensity counts to dB, multiply counts by 0.45 dB. **BINARY FORMAT** — When selected for output, the first byte of echo intensity data follows the last byte of the last data field collected (see Figure 4-3). Echo intensity data use 4 bytes of output buffer space per bin, with each byte storing data for one beam (see Figure 4-7). The first 4 bytes of echo intensity data correspond to Bin #1. This 4-byte sequence continues for up to 128 bins (determined by Q). Selecting all 128 bins uses 512 bytes (4 × 128) of buffer space for echo intensity data. To convert echo intensity counts to dB, multiply counts by 0.45 dB.
1-3	1	Bin 1, Beam 1	This field stores echo intensity data for bin #1, beam #1. See the descriptions above for more information.
4-6	2	Bin 1, Beam 2	This field stores echo intensity data for bin #1, beam #2. See the descriptions above for more information.
7-9	3	Bin 1, Beam 3	This field stores echo intensity data for bin #1, beam #3. See the descriptions above for more information.
10-12	4	Bin 1, Beam 4	This field stores echo intensity data for bin #1, beam #4. See the descriptions above for more information.
13-1536	5-512	Bins 2 - 128 (if used)	These fields store echo intensity data for bins 2 through 128 (depending on the Q-command) for all four beams. These fields follow the same format as listed above for bin 1.

Table 4-6. Percent-Good Data Format

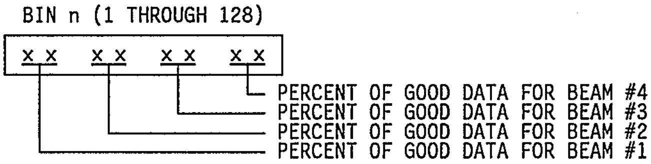
ASCII Digit	Binary Byte	Field	Description

GENERAL – The percent-good data field is a data-quality indicator that reports the percentage (0-99) of GOOD data collected for each depth cell (bin) of the velocity profile. The meaning of the percent-good data depends on whether you collect the velocity data in EARTH or BEAM coordinates (set by O-command).

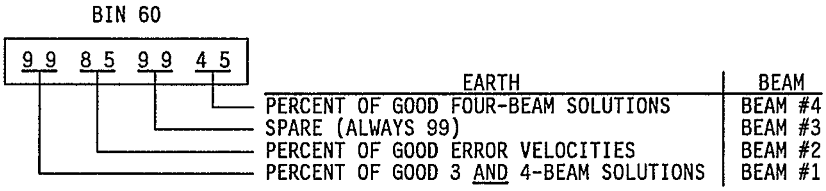
Earth-coordinate velocities – With velocities in EARTH coordinates, decode the percent-good field as follows:



Beam-coordinate velocities – With velocities in BEAM coordinates, decode the percent-good field as follows:



Example – At the start of the velocity profile, the echo intensity is usually high on all four beams. Under this condition the ADCP uses all 4 beams to calculate the orthogonal and error velocities. As the echo returns from far away bins, echo intensity decreases. At some point, the echo will be weak enough on any given beam to cause the ADCP to reject some of its bin data. This causes the ADCP to calculate velocities with 3 beams instead of 4 beams. When the ADCP does 3-beam solutions, it stops calculating the error velocity because it needs 4 beams to do this. At some further bin, the ADCP rejects all bin data because of the weak echo. The following example represents percent-good from a distant bin where some data are being rejected, and the ADCP is doing 3-beam solutions.



With velocities collected in BEAM coordinates, the example values show the percentage of pings having good solutions in bin 60 for each beam based on the Signal-to-Noise Threshold (N-command). Here, beam 1=99%, beam 2=85%, beam 3=99%, beam 4=45%.

Table 4-6. Percent-Good Data Format (Continued)

ASCII Digit	Binary Byte	Field	Description
			On the other hand, with velocities collected in EARTH coordinates, the example values show (from right to left): · Percent of good 4-beam solutions-45% of the velocity data collected during the ensemble for bin 60 was calculated using 4 beams · Spare-Always 99 · Percent of good error velocities-Shows the percent of error velocity (85%) that was less than the CB-command setting. CB has a default of 10000. The ADCP multiplies CB by the velocity scale factor setting to get the error in cm/s. This large CB setting effectively prevents the ADCP from rejecting data based on error velocity. · Percent of good 3 and 4-beam solutions-Shows the TOTAL percentage of successful velocity calculations (99%) using 3 and 4-beam solutions. Subtracting the percentage of 4-beam solutions (45%) from the percentage of 3 and 4-beam solutions (99%), yields the percentage of calculations for bin 60 done using 3-beam solutions (54%). The value in this field decreases to zero at some point where the echo intensity is too weak to measure in any beam. **ASCII FORMAT** – When selected, percent-good data follow the CR/LF after the last data field collected (Figure 4-2). Percent-good data use 2 digits per bin per beam in beam coordinates, or 2 digits per field in earth coordinates. In either case, the first 8 digits correspond to bin 1. This 8-digit sequence continues for up to 128 bins (set by Q). Selecting all 128 bins uses 1024 digits (8 × 128). **BINARY FORMAT** – When selected, percent-good data follow the last byte of the last data field collected (Figure 4-3). Percent-good data use 4 bytes of output buffer space per bin (Figure 4-7). The first 4 bytes correspond to bin 1. This 4-byte sequence continues for up to 128 bins (set by Q). Selecting all 128 bins uses 512 bytes (4 × 128) of buffer space.
1-2	1	Bin 1, Beam 1	This field stores percent-good data for Bin #1: beam #1 (BEAM) or percent of good 3 and 4-beam solutions (EARTH). See above.
3-4	2	Bin 1, Beam 2	This field stores percent-good data for Bin #1: beam #2 (BEAM) or percent of good error velocities (EARTH). See above.
5-6	3	Bin 1, Beam 3	This field stores percent-good data for Bin #1: beam #3 (BEAM) or spare (EARTH). See above.
7-8	4	Bin 1, Beam 4	This field stores percent-good data for Bin #1: beam #4 (BEAM) or percent of good 4-beam solutions (EARTH). See above.
9-1024	5-512	Bins 2 - 128 (if used)	These fields store percent-good data for bins 2 through 128 (depending on Q), following the same format as listed above for bin 1.

Table 4-7. Status Data Format

ASCII Digit	Binary Byte	Field	Description
			GENERAL – These fields contain information about the status and quality of ADCP data. To conserve buffer space, the status data fields are condensed and represent a series of flags (bits) being set or not set. The setting of each bit shows a particular status condition for each beam and the overall depth cell (bin) quality at that depth. When you view the Status data, most times it will show all zeros. This means NO bits are set and data quality is 100%. Toward the end of the ADCP's profiling range as the acoustic signal begins to die out, the echo intensity gets weaker and is approaching levels equal to, and finally less than the thermal noise levels in each receive channel of the ADCP. It is in this area that the ADCP begins reporting varying status conditions about the data it is collecting and rejecting. The following information and example explain how to interpret the bits within the status field (ASCII users must first convert the hexadecimal digits to binary).

BIT	BEAM STATUS DESCRIPTION
0	IF SET, THE PERCENTAGE OF DATA REJECTED DUE TO THE SIGNAL-TO-NOISE CRITERIA SET BY THE M-COMMAND HAS BEEN EXCEEDED. THE M-COMMAND SETS THE MINIMUM PERCENTAGE OF GOOD DATA ALLOWED IN ANY BIN (TYPICALLY 25%). IF THIS BIT IS SET, THE ECHO INTENSITY FOR THIS BEAM WAS TOO WEAK FOR THE ADCP TO PROCESS.
1	ALWAYS 0.
2	BIT 2 WILL BE SET IF BIT 0 IS SET, OR IF THE BOTTOM-TRACK RANGE IS BEYOND THE BOTTOM (OR SURFACE). THIS MEANS IF YOU ARE USING BOTTOM TRACK, AND THE VELOCITY DATA ARE BEYOND THE DETECTED OCEAN BOTTOM, THE ADCP SETS BIT 2.
3	ALWAYS 0 WHEN COLLECTING VELOCITY DATA IN BEAM COORDINATES. WHEN COLLECTING VELOCITY DATA IN EARTH COORDINATES, THE ADCP COMBINES THE BIT-3s FROM EACH BEAM TO CREATE A SEPARATE NIBBLE THAT PROVIDES A BIN STATUS CODE. DECODE THE BITS IN THIS BIN-STATUS NIBBLE AS FOLLOWS:

BIT	BIN STATUS DESCRIPTION
0	IF SET, THE NUMBER OF 4-BEAM SOLUTIONS WAS LESS THAN THE PERCENT-GOOD THRESHOLD SET BY THE M-COMMAND (TYPICALLY 25%). THIS MEANS BIT 0 OF THE BIN STATUS WILL BE SET IF THE ADCP COLLECTED MORE THAN 75% OF THE DATA USING 3-BEAM SOLUTIONS.
1	ALWAYS 0.
2	IF SET, ERROR VELOCITY DOES NOT MEET CRITERIA SET BY THE REASONABLENESS THRESHOLD (CB-COMMAND). CB'S DEFAULT IS 10000 AND IS MULTIPLIED BY THE RANGE SWITCH SCALE FACTOR (0.25 FOR HIGH RANGE AND 0.125 FOR LOW RANGE). THIS DEFAULT VALUE EFFECTIVELY DISABLES THE ABILITY OF THE ADCP TO DISCARD DATA IF ERROR VELOCITY IS LARGE.
3	IF SET, THE NUMBER OF 3 AND 4-BEAM SOLUTIONS WAS LESS THAN THE M-COMMAND THRESHOLD (TYPICALLY 25%).

Example – The following sample data are from an "end-of-range" bin where the echo intensity is approaching the thermal noise floor. The velocity data were collected in earth coordinates. We will use a status value of D058.

Table 4-7. Status Data Format (Continued)

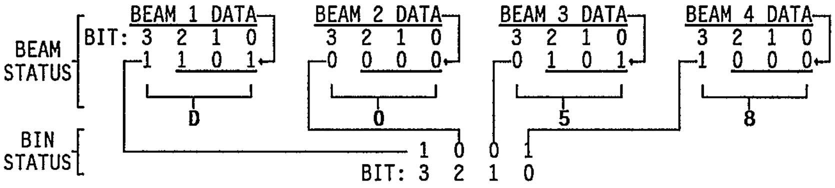
ASCII Digit	Binary Byte	Field	Description
			Decode the status bytes nibble by nibble (4 bits each). The first 3 bits in every nibble represent the status for a particular BEAM. Combine the last bit (the MSB) with the MSBs from the other BEAM status nibbles to create the BIN status nibble.  In this example, beams 1 and 3 rejected data based on M-command criteria (Bit 0 = 1 in BEAM STATUS nibbles). Bit 2 is set for beams 1 and 3 only because their Bit 0's were set. The BIN DATA in this example collected more than M-command percent of the bin data using three beams (Bit 0 = 1 in BIN STATUS nibble). Also, the number of three and four-beam solutions was less than the M-command threshold for this BIN (Bit 3 = 1 in BIN STATUS nibble). **ASCII FORMAT** – When selected for output, the first digit of status data follows the CR/LF sequence after the last data field collected (see Figure 4-2). Status data use 1 hexadecimal digit per bin per beam, so the first 4 hexadecimal digits correspond to Bin #1. This 4-digit sequence continues for up to 128 bins (determined by Q). Selecting all 128 bins uses 512 digits (4 × 128) for status data. **BINARY FORMAT** – When selected for output, the first nibble of status data follows the last byte of the last data field collected (see Figure 4-3). Status data use 2 bytes (4 nibbles) of output buffer space per bin, with each nibble storing data for one beam (see Figure 4-8). The first 2 bytes of status data correspond to Bin #1. This 2-byte sequence continues for up to 128 bins (determined by Q). Selecting all 128 bins uses 256 bytes (2 × 128) of buffer space for status data.
1	1MSN	Bin 1, Beam 1	This field stores status data for bin #1, beam #1. See the descriptions above for more information.
2	1LSN	Bin 1, Beam 2	This field stores status data for bin #1, beam #2. See the descriptions above for more information.
3	2MSN	Bin 1, Beam 3	This field stores status data for bin #1, beam #3. See the descriptions above for more information.
4	2LSN	Bin 1, Beam 4	This field stores status data for bin #1, beam #4. See the descriptions above for more information.
5-512	3-256	Bins 2 - 128 (if used)	These fields store status data for bins 2 through 128 (depending on the Q-command) for all four beams. These fields follow the same format as listed above for bin 1.

Table 4-8. Binary Checksum Data Format

Byte	Field	Description
1,2	Checksum Data	This field contains a modulo 65536 checksum. The ADCP computes the checksum by summing all the bytes in the output buffer excluding the checksum (see Figure 4-3).

CHAPTER 5
INSTRUMENT PREPARATION, MAINTENANCE, AND REPAIR PROCEDURES

5-0. INTRODUCTION

This chapter explains how to prepare the ADCP for deployment, how to do certain maintenance, repair, and equipment modification procedures, and how to prepare the ADCP for storage or shipment. When deploying the ADCP, use Table 2-1 (Deployment Checklist) to keep track of the steps needed for physical preparation of the ADCP before deployment.

Several procedures in this chapter reference the same figures, so all figures are at the end of the chapter. All Printed Circuit Board (PCB) layouts are in Appendix Y. Table 5-1 lists the items in the tools and spare parts kit. Use this kit when doing routine ADCP maintenance.

Briefly, the topics covered in this chapter include:

Section	Description
5-1	Pressure Case Removal
5-2	Transducer Head Removal and Replacement Procedures
5-3	Installing the 90° Transducer Head Adaptor Elbow
5-4	Installing the Remote Transducer Head Adaptor Kit
5-5	Printed Circuit Board Removal and Replacement Procedures
5-6	Gaining Access to the Transducer Assembly Electronics
5-7	Integrated Circuit Removal and Replacement Procedures
5-8	Fuse Removal and Replacement Procedures
5-9	Procedures for Changing the Up/Down Transducer Orientation
5-10	Procedures for Fixing the Tilt/Heading Sensors to Zero Degrees
5-11	Procedures for Converting the SC-ADCP from DC Power to AC Power
5-12	Procedures for Converting the SC-ADCP from AC Power to DC Power
5-13	Battery Installation
5-13.1	V1/V2 Lithium Battery Pack Installation
5-13.2	V4 Battery Pack Installation
5-13.3	Memory Backup Battery Installation
5-13.4	Testing the Batteries after Installation
5-14	EPROM Recorder Preparation
5-14.1	Preparing the Recorder for Deployment - Append Method
5-14.2	Preparing the Recorder for Deployment - Erase Method
5-15	Silica-Gel Air Dryer Replacement and Restoration
5-16	O-ring Inspection and Replacement
5-17	Transducer Head Inspection
5-18	Zinc Anode Inspection and Replacement
5-18.1	Zinc Anode Inspection
5-18.2	Zinc Anode Replacement
5-19	Mounting Bushing Inspection and Replacement
5-20	Protective Coating Inspection and Repair
5-21	Sealing the SC-ADCP for Deployment
5-22	Prevention of Biofouling
5-23	Storage and Shipping Maintenance
5-23.1	Removal of Biofouling
5-23.2	Final Storage or Shipping Preparation

Table 5-1. Tools and Spare Parts Kit

Item	Qty	Part number	Description
1	1	6755A11	Case, plastic, 12-1/8 × 7-1/4 × 4-1/2
2	1	#1PHILLIPS	Screwdriver, Phillips head
3	1	1/2COMBINATION	Wrench, 1/2 inch
4	1	3/8COMBINATION	Wrench, 3/8 inch
5	1	1/4ALLENDRIVER	Ball type allen wrench, 1/4 inch
6	0	-	Deleted
7	1	305D0075	Label, tool kit
8	24	305D0010	Flange bushing, instrument housing
9	2	305D1123	Anode, transducer mounting plate
10	4	305D3206	Mounting lug bushing, instrument housing
11	4	2-017	O-ring, XSL (bore), nitrile, Duro 70, Parker
12	1	2-021	O-ring, BCR (bore), nitrile, Duro 70, Parker
13	1	2-123	O-ring, XSL (face), nitrile, Duro 70, Parker
14	1	2-258	O-ring, XDCR (bore), nitrile, Duro 70, Parker
15	1	2-260	O-ring, XDCR (face), nitrile, Duro 70, Parker
16	4	5-254	O-ring, BCR (face), nitrile, Duro 70, Parker
17	2	AGC1	Fuse, 1 Amp, 250 V, Buss
18	2	AGC1/2	Fuse, 0.5 Amp, 250 V, Buss
19	2	MDA2	Fuse, 2 Amp, 250 V, Buss
20	2	AGC4	Fuse, 4 Amp, 125 V, Buss
21	2	MDA7	Fuse, 7 Amp, 250 V, time delay, Buss
22	1	MF250	Fuse, micro 0.25 Amp, 125 V, Bel
23	1	V-524	Anode, zinc (pressure case), Volvo
24	12	5/16-18X13/4SH	Screw, socket head, stainless steel
25	12	5/16-18X11/2SH	Screw, socket head, stainless steel
26	2	5/16-18X3/4FHS	Screw, flat head, socket, stainless steel
27	4	10-32X3/4SH	Screw, socket head, stainless steel
28	14	4-40X1/4FH	Screw, flat head, stainless steel
29	24	5/16WASHLGOD	Washer, flat, 5/16, 9/16 OD, stainless
30	8	#10WASHLGODB	Washer, #10, 7/16 OD, brass
31	12	5/16WASHSPL	Washer, split lock, stainless steel
32	12	5/16-18NUT	Nut, hex
33	8	99-NM-1032	Locknut, regular, 10-32, brass, Greer
34	1	X-1009	Desiccant, can, Schoofs
35	1	DC-111	Lubricant, silicone, 5.3 oz, Dow-Corning
36	0	-	Deleted
37	1	RTV734	Sealant, silicone, self-leveling, clear
38	1	4408X3/4	Tape, foam, 2 × 1/8 × 3/4, double-sided, 3M
39	1	3/16BLADE	Screwdriver
40	4	305D2106	Clip, mounting, battery pack

5-1. PRESSURE CASE REMOVAL

This section explains how to remove the external pressure case to gain access to the ADCP's internal components. Use Figure 5-1 for parts identification.

__ a. If attached, remove the ADCP external J-Box cable from the pressure case I/O connector and install the dummy plug.

WARNING

A DANGER EXISTS WHEN REMOVING THE PRESSURE CASE FROM THE ADCP IF INTERNAL PRESSURE CAUSED BY THE LITHIUM BATTERIES EXISTS. WHEN LOOSENING THE PRESSURE CASE BOLTS, LOOK FOR EXPANSION BETWEEN THE PRESSURE CASE FLANGE AND THE TRANSDUCER ASSEMBLY FLANGE (OR 90° ADAPTOR FLANGE). IF THE GAP CONTINUALLY WIDENS, INTERNAL PRESSURE MAY EXIST. DO NOT LOOSEN THE BOLTS FURTHER. YOU MAY WANT TO CONTACT LOCAL HAZARDOUS MATERIAL DISPOSAL AUTHORITIES FOR FURTHER INSTRUCTIONS.

__ b. Loosen the four pressure case bolts one turn at a time. Be aware of internal pressure. Remove the bolts.

__ c. Pull the pressure case away from the transducer assembly (or 90° adaptor) to expose the electronics chassis. If the two pieces stick together, separate them using a soft wedge. Do not damage the mating surfaces, paint, or anodize coating. As the two pieces separate, the I/O connector on the end of the case unplugs from the connector and guide-pin receptacles on the electronics chassis.

__ d. When recovering the ADCP from a deployment, remove any water from the transducer assembly O-ring grooves. The water can cause corrosion near the transducer assembly face seal. Clean the O-ring mating surfaces. Inspect the surfaces for damage. Even small pits of corrosion can spread, leading to leakage around the O-ring seal.

__ e. When you are ready to replace the pressure case, see ¶5-21.

5-2. TRANSDUCER HEAD REMOVAL AND REPLACEMENT PROCEDURES

RDI designed the ADCP to let you change the transducer assembly to use different operating frequencies. This improves the ADCP's operating efficiency over a wide variety of ranges and depths. This section explains how to remove and install the transducer assembly and how to set the internal switches to accommodate a new operating frequency (use Figures 5-2 and 5-3).

__ a. Remove the pressure case (¶5-1) and electronics chassis cover. Remove ADCP power by disconnecting the battery pack connectors at the DC Power Supply board.

__ b. Remove the 50-pin ribbon cable from J1 on the electronics chassis.

__ c. Remove the four electronics assembly mounting stud nuts/washers. Gently separate the two assemblies (NOTE: If your system has a 90° adaptor, remove it using the reverse of the procedures listed in ¶5-3). Set the transducer assembly on a piece of soft material with the transducer cups facing down.

__ d. Install the new transducer assembly onto the electronics assembly (or 90° adaptor as per ¶5-3). Replace and tighten the electronics assembly mounting nuts/washers. Reconnect the 50-pin transducer ribbon cable from the transducer assembly to J1 on the chassis.

CAUTION

STATIC ELECTRICITY CAN DAMAGE BOARD COMPONENTS. RDI RECOMMENDS USING AN EARTH-GROUNDED WRIST STRAP TO HELP PREVENT SUCH DAMAGE. YOU MUST HAVE THE WRIST STRAP ON WHENEVER YOU HANDLE A BOARD.

__ e. Attach an earth-grounded wrist strap. Remove the Peripheral 1 board (Figure Y-12) from J9 (¶5-5). Use the following table to set switch S1 on the Peripheral 1 board for the frequency setting of the new transducer assembly. Reinstall the board.

Frequency (kHz)	Per 1 Switch S1 Pole Settings 1	2	3	4	5	6	7	8
1200	C	O	O	O	O	O	O	O
600	O	C	O	O	O	C	C	C
300	O	O	C	O	O	C	C	C
150	O	O	O	C	O	C	C	C
75	O	O	O	O	C	C	C	C

__ f. Remove the <u>old</u> Power Amplifier (Figure Y-7) from J2 (¶5-5). Install the <u>new</u> Power Amplifier for the new transducer assembly.

__ g. If the new transducer assembly has a different compass manufacturer than the old transducer assembly (e.g., KVH or EG&G), you must install a new CPU EPROM that has been coded for the correct compass.

CAUTION

THE NEXT TWO STEPS (5-2h and 5-2i) APPLY ONLY TO SYSTEMS CONVERTING EITHER <u>TO OR FROM</u> AN <u>AC</u>-POWERED 1200-kHz SYSTEM. IN 1200-kHz <u>AC</u>-POWERED SYSTEMS, DO <u>NOT</u> USE EITHER OF THE BLACK-AND-WHITE TWISTED-PAIR WIRES FROM THE I/O CONNECTOR ON THE <u>AC</u> POWER SUPPLY BOARD.

__ h. <u>Users converting TO a 1200-kHz AC-powered system</u>: If the AC Power Supply (Figure Y-18) has a pair of <u>black-and-white</u> wires connected to J2, disconnect them. Transformer T2 has a pair of <u>orange</u> wires. Connect these wires to J2. If you do not have these orange wires, or if you are unsure, contact RDI <u>before</u> applying power to the ADCP. The orange-wire connection provides 40 VDC transmit power to the ADCP. Higher transmit voltages cause "water shock," which leads to bad data readings in 1200-kHz ADCPs.

__ i. <u>Users converting FROM a 1200-kHz AC-powered system</u>: If the AC Power Supply (Figure Y-18) has a pair of <u>orange</u> wires connected to J2, disconnect them. You should have a pair of <u>black-and-white</u> wires coming from the I/O connector. Connect a pair of <u>black-and-white</u> wires from the I/O connector to J2. If you do not have the black-and-white wires, or if you are unsure, contact RDI <u>before</u> applying power to the system.

__ j. Connect the battery packs. Replace the chassis cover and pressure case (¶5-21). Test the system (Appendix T).

5-3. INSTALLING THE 90-DEGREE TRANSDUCER HEAD ADAPTOR ELBOW

This section explains how to install the optional 90° transducer head adaptor elbow. This adaptor lets you moor the ADCP on its side. Use Figure 5-5 for parts identification.

___ a. If necessary, remove the existing transducer head (¶5-2a through ¶5-2c). Save all hardware for re-use.

___ b. Connect the 50-pin ribbon cable extension to J1 on the electronics chassis. Be sure to align pin 1 correctly.

___ c. Place the blue spacer over the four mounting studs extending from the 90° adaptor.

___ d. With the 90° adaptor facing up, slide the four mounting studs through the electronics assembly end plate. The studs are offset to allow mating in only one way. Be sure to route the ribbon cable extension through the 90° adaptor. Center the blue spacer on the end plate and tighten the four nylock nuts on the studs.

___ e. Place the transducer head next to the 90° adaptor. Remove one of the four nuts holding the tilt/heading assembly in place. Connect the ground wire from the 90° adaptor to the appropriate stud. Tighten the nut onto the stud.

___ f. Connect the 50-pin ribbon cable from the transducer head to the extension cable. The connectors are keyed so you can only connect them in one way. Each connector also has a triangle at pin one, be sure you align these marks.

___ g. Install the transducer head onto the 90° adaptor. Be sure to route the ribbon cable and ground wire into the 90° adaptor so they are not pinched. As mate the two pieces, be sure to apply equal pressure to all parts of the O-rings. Make sure the O-rings do not pop out of their retaining groove or become pinched or torn. If this happens, a leakage path into the electronics assembly could exist.

___ h. Examine the nuts, bolts, and washers for corrosion and replace if necessary. Be sure plastic bushings are in each bolt hole on both the 90° adaptor and the transducer head. Insert each socket head bolt through a flat washer. Insert the bolt through the 90° adaptor flange and transducer head. Install a flat washer, lock washer, and hex nut on the transducer side of the assembly. In rotation, tighten the bolts to compress the face seal O-ring evenly. Do not over-tighten the bolts. Do not deform the plastic bushings.

___ i. Connect the battery packs. Replace the chassis cover and pressure case (¶5-21). Test the system (Appendix T).

5-4. INSTALLING THE REMOTE TRANSDUCER HEAD ADAPTOR

This section explains how to install the optional remote transducer head adaptor. This adaptor lets you moor the ADCP transducer head apart from the electronics chassis. Use Figure 5-6 for parts identification.

__ a. If necessary, remove the existing transducer head (¶5-2a through ¶5-2c). Save all hardware for re-use.

__ b. Place the blue spacer over the four mounting studs extending from the remote head adaptor plate. Be sure to route the adaptor plate's 50-pin ribbon cable through the spacer.

__ c. Connect the 50-pin ribbon cable to J1 on the electronics chassis. Be sure to align pin 1 correctly.

__ d. Slide the four adaptor plate mounting studs through the electronics assembly end plate. The studs are offset to allow mating in only one way. Center the blue spacer on the end plate and tighten the four nylock nuts on the studs.

__ e. Connect the 50-pin ribbon cable from the remote-head transducer pressure case to the transducer head's 50-pin ribbon cable. The connectors are keyed so you can only connect them in one way. Each connector also has a triangle at pin one, be sure you align these marks.

__ f. Slide the remote head pressure case over the transducer assembly. If a dry purging gas (e.g., nitrogen) is available, direct the gas into the remote head pressure case through a long flexible tube as you slide the case over the transducer head. Remove the tube when the case gets close to the transducer head.

__ g. As you mate the two pieces, be sure to apply equal pressure to all parts of the O-rings. Make sure the O-rings do not pop out of their retaining groove or become pinched or torn. If this happens, a leakage path into the electronics assembly could exist.

__ h. Examine the nuts, bolts, and washers for corrosion and replace if necessary. Be sure plastic bushings are in each bolt hole on both the remote head pressure case and the transducer head. Insert each socket head bolt through a flat washer. Insert the bolt through the remote head pressure case flange and transducer head. Install a flat washer, lock washer, and hex nut on the transducer side of the assembly. In rotation, tighten the bolts to compress the face seal O-ring evenly. Do not over-tighten the bolts. Do not deform the plastic bushings.

__ i. Connect the 40-pin waterproof cable between the remote head transducer assembly and the remote head end plate on the pressure case.

__ j. Connect the battery packs. Replace the chassis cover and pressure case (¶5-21). Test the system (Appendix T).

5-5. PRINTED CIRCUIT BOARD REMOVAL AND REPLACEMENT PROCEDURES

Use this procedure and Figure 5-2 to remove/replace Printed Circuit Boards (PCBs) inside the electronics chassis. For boards inside the transducer assembly, see ¶5-6.

__ a. Remove the pressure case (¶5-1) and electronics chassis cover. Remove ADCP power by disconnecting the battery pack connectors at the DC Power Supply board.

CAUTION

STATIC ELECTRICITY CAN DAMAGE BOARD COMPONENTS. RDI RECOMMENDS USING AN EARTH-GROUNDED WRIST STRAP TO HELP PREVENT SUCH DAMAGE. YOU MUST HAVE THE WRIST STRAP ON WHENEVER YOU HANDLE A BOARD.

__ b. Attach an earth-grounded wrist strap. Find the board needing removal. Remove it with a gentle rocking and lifting motion. As a precaution against mixing boards, remove and replace only one board at a time, or label the boards as you remove them.

__ c. Before replacing a board, be sure you have the correct one. Align the board's connector edge with the chassis jack. Gently, but firmly, push the board into the jack.

__ d. Connect the battery packs. Replace the chassis cover and pressure case (¶5-21). Test the system (Appendix T).

5-6. GAINING ACCESS TO THE TRANSDUCER ASSEMBLY ELECTRONICS

Use this procedure and Figure 5-3 to gain access to the electronic components inside the transducer assembly. Figure 5-3 shows a generic transducer assembly. All the components shown may not apply to your system, but the layout is about the same.

CAUTION

STATIC ELECTRICITY CAN DAMAGE BOARD COMPONENTS. RDI RECOMMENDS USING AN EARTH-GROUNDED WRIST STRAP TO HELP PREVENT SUCH DAMAGE. YOU MUST HAVE THE WRIST STRAP ON WHENEVER YOU HANDLE A BOARD.

__ a. To gain access to a Preamplifier board (Figure Y-3 or Y-4), use ¶5-2a to access the transducer head's preamplifier assembly. Now remove the screws holding the preamplifier shield. Rest the shield on the transducer cup, but do not damage the ground lead connections. Remove the nylon screw holding the board in place. Remove the board.

__ b. To gain access to the Transducer Compensation board (Figure Y-2) or the Motherboard (Figure Y-1), use ¶5-2a through ¶5-2c to remove the transducer head assembly from the chassis. Now remove the four preamplifier shields (step a, above). Remove the nuts holding the tilt sensor mounting plate/retaining ring and gently lift the plate/ring. Rest the sensor assembly on its side on the transducer cup. Remove the nylon screw holding the Transducer Compensation board in place. Remove the board.

__ c. Reassemble the ADCP. Connect the battery packs. Replace the chassis cover and pressure case (¶5-21). Test the system (Appendix T).

5-7. INTEGRATED CIRCUIT REMOVAL AND REPLACEMENT PROCEDURES

Use this procedure to remove/replace ADCP Integrated Circuits (ICs). Table 5-2 lists the most commonly replaced ICs.

Table 5-2. Most Commonly Replaced Integrated Circuits

Integrated Circuit	Board / Slot	Designator
CPU (Fig. Y-14)	CPU / J12	U10
Transducer Compensation (Fig. Y-2)	Transducer Head	U8
Synchro-to-Digital Convertors	Synchro Interface / J15	U1, U2, U3

__ a. Remove the pressure case (¶5-1) and electronics chassis cover. Remove ADCP power by disconnecting the battery pack connectors at the DC Power Supply board (Figure 5-2). To gain access to an IC inside the transducer head, use ¶5-6 to access transducer assembly electronics.

CAUTION

STATIC ELECTRICITY CAN DAMAGE BOARD COMPONENTS. RDI RECOMMENDS USING AN EARTH-GROUNDED WRIST STRAP TO HELP PREVENT SUCH DAMAGE. YOU MUST HAVE THE WRIST STRAP ON WHENEVER YOU HANDLE A BOARD.

__ b. Attach an earth-grounded wrist strap. Remove the board needing IC removal/replacement (¶5-5).

__ c. Locate the IC on the board. Note the position of the IC in its socket. Use the IC's notch or dot as a reference. Use an IC removal tool to remove the IC from its socket.

__ d. To install the IC, align the IC as noted in step c. Make sure all pins enter the socket properly. Gently, but firmly, push the IC into its socket.

__ e. Reinstall the board. Reassemble the transducer head if necessary. Connect the battery packs. Replace the chassis cover and pressure case (¶5-21). Test the system (Appendix T).

5-8. FUSE REMOVAL AND REPLACEMENT PROCEDURES

Use this procedure and Figure 5-2 to remove/replace ADCP fuses. Table 5-3 lists the fuses used in a DC-powered SC-ADCP.

Table 5-3. SC-ADCP Fuses (DC Power)

Designator	Size/Type	Use
F1	1.0A, 250V, fast blow	V1 power out
F2	2.0A, 250V, slow blow	V2 power out
F3	3.0A, 250V, fast blow	Recorder power
F4	0.5A, 250V, fast blow	CTD power

NOTE

IF THE SC-ADCP IS USING AC POWER, SEE THE DR-ADCP TECHNICAL MANUAL FOR FUSE INFORMATION.

__ a. Remove the pressure case (¶5-1) and electronics chassis cover. Remove ADCP power by disconnecting the battery pack connectors at the DC Power Supply board.

CAUTION

STATIC ELECTRICITY CAN DAMAGE BOARD COMPONENTS. RDI RECOMMENDS USING AN EARTH-GROUNDED WRIST STRAP TO HELP PREVENT SUCH DAMAGE. YOU MUST HAVE THE WRIST STRAP ON WHENEVER YOU HANDLE A BOARD.

__ b. Attach an earth-grounded wrist strap. Remove the DC Power Supply board from J17 (¶5-5).

__ c. Pry the bad fuse from its holder. Install a new one.

__ d. Reinstall the board. Connect the battery packs. Replace the chassis cover and pressure case (¶5-21). Test the system (Appendix T).

5-9. PROCEDURES FOR CHANGING THE UP/DOWN TRANSDUCER ORIENTATION

RDI designed the ADCP to let you easily change the up/down orientation of the transducer assembly. Different orientations let you collect data with the ADCP facing up or down. This procedure explains how to install the pendulums and how to set the internal switches to accommodate a new orientation.

__ a. Use ¶5-2a through ¶5-2c to gain access to the transducer head and electronics assembly. Now refer to Figures 5-3 and 5-4 and continue with the following steps.

NOTE

FIGURE 5-3 SHOWS A GENERIC SC-ADCP TRANSDUCER ASSEMBLY. ALL THE COMPONENTS SHOWN MAY NOT BE APPLICABLE TO YOUR SYSTEM, BUT THE LAYOUT IS ESSENTIALLY THE SAME. IF, HOWEVER, YOU HAVE PENDULUMS SECURED BY STEEL BANDS AND NOT FLAT-HEAD SCREWS, CONTACT RDI FOR INSTRUCTIONS.

__ b. Remove the screws holding the four preamplifier shields to the tilt sensor (pendulum) mounting plate. Rest the shields on the transducer cups, taking care not to damage the ground lead connections.

__ c. Remove the nuts holding the mounting plate. Lift the mounting plate. Rest the tilt sensor assembly on its side on the transducer cup.

__ d. Disconnect the 10-pin ribbon cable (J6) and the 50-pin ribbon cable (J7) from the motherboard. Set the mounting plate on its mounting studs on your work bench.

__ e. Use Figure 5-4 and find the orientation arrow on both pendulums. This arrow must always point towards the ocean surface. Figure 5-4 shows the pendulums set for an upward-facing orientation.

__ f. To change the pendulum orientation, remove the retaining screws from the pendulums. Rotate the pendulums 180°. Reinstall the screws.

__ g. On the Transducer Compensation board, set pole 1 of switch S1 (Figure Y-2) as follows:

- Upward-facing transducer — CLOSED
- Downward-facing transducer — OPEN

__ h. Reinstall the 10-pin (J6) and 50-pin (J7) ribbon cable connectors to the motherboard. Be sure to align the triangular keyways.

__ i. Reassemble the transducer head to the electronics chassis by reversing the disassembly procedures.

CAUTION

STATIC ELECTRICITY CAN DAMAGE BOARD COMPONENTS. RDI RECOMMENDS USING AN EARTH-GROUNDED WRIST STRAP TO HELP PREVENT SUCH DAMAGE. YOU MUST HAVE THE WRIST STRAP ON WHENEVER YOU HANDLE A BOARD.

__ j. Attach an earth-grounded wrist strap. Remove the Peripheral 3 board (Figure Y-15) from J13 (¶5-5). Set pole 1 of switch S1 as follows, and then reinstall the board.

- Upward-facing transducer – OPEN
- Downward-facing transducer – CLOSED

__ k. Connect the battery packs. Replace the chassis cover and pressure case (¶5-21). Test the system (Appendix T).

5-10. PROCEDURES FOR FIXING THE TILT/HEADING SENSORS TO ZERO DEGREES

This procedure explains how to semi-permanently fix the tilt/heading sensors to output a value of zero degrees.

__ a. Disconnecting/removing the tilt/heading sensors: Though not essential to fixing the tilt/heading output values to zero degrees, you may want to electrically disconnect and/or physically remove the tilt/heading sensors from the ADCP to prevent needless cycling. The tilt pendulums have a limited life cycle, so removing them will preserve them for future use. To electrically disconnect and/or remove the tilt/heading sensors, do the following steps. Read all steps before taking action.

__ (1) Use ¶5-2a through ¶5-2c to gain access to the transducer head and electronics assembly.

__ (2) Use ¶5-9b through ¶5-9d and Figures 5-3 and 5-4 to gain access to the tilt/heading sensors.

NOTE

FIGURE 5-3 SHOWS A GENERIC SC-ADCP TRANSDUCER ASSEMBLY. ALL THE COMPONENTS SHOWN MAY NOT BE APPLICABLE TO YOUR SYSTEM, BUT THE LAYOUT IS ESSENTIALLY THE SAME. IF, HOWEVER, YOU HAVE PENDULUMS SECURED BY STEEL BANDS AND NOT FLAT-HEAD SCREWS, CONTACT RDI FOR INSTRUCTIONS.

__ (3) To electrically disconnect the tilt sensors: Use wire cutters to cut the wires going to the pendulums on the tilt sensor mounting plate. Leave a small length of insulated wire on each pendulum connection. This will make reconnecting the pendulums easier. Make sure you insulate any exposed wires.

__ (4) To physically remove the tilt sensors: After electrically disconnecting the tilt sensors as described in step (3), remove the flat-head retaining screws from the pendulums. Remove the sensor. To prevent loss, reinstall the screws into the pendulums.

___ (5) To electrically disconnect the compass: Disconnect the connector going to J1 on the Flux Gate Heading Sensor (Figure Y-6).

___ (6) If both the tilt and heading sensors have been disabled, do NOT reinstall the 10-pin ribbon cable connector (J6) to the motherboard (either tie it down or remove it). If either the tilt or heading sensor is to remain active, reinstall the 10-pin connector (be sure to align the triangular keyway).

___ (7) Reinstall the 50-pin (J7) ribbon cable connector to the motherboard. Be sure to align the triangular keyway.

___ (8) Reassemble the transducer head to the electronics chassis by reversing the disassembly procedures.

___ b. To electrically set the tilt sensors to zero degrees: Remove the Peripheral 2 board (Figure Y-11) from J9 (¶5-5). On the 96-pin edge connector, solder a jumper wire from B8 to C5, and then from C5 to C4 on the back side of the board (see Figure 5-7). Reinstall the board.

___ c. To electrically set the heading sensor to zero degrees: Remove the Peripheral 3 board from J13 (¶5-5). Set pole 2 of switch S1 (Figure Y-15) to the OPEN position.

___ d. Connect the battery packs. Replace the chassis cover and pressure case (¶5-21).

___ e. Test the system (Appendix T). Verify the ADCP has no BIT errors and that the tilt/heading sensor output is zero degrees.

5-11. PROCEDURES FOR CONVERTING THE SC-ADCP FROM DC POWER TO AC POWER

This section explains how to convert an SC-ADCP from DC power to AC power. This lets the SC-ADCP operate as if it were a DR-ADCP, but you can still use the recorder. Use Figure 5-2 throughout this procedure. Besides normal hand tools, you will need:

- AC Power Supply Assembly
- Resistor: 10-ohm, 1/4-Watt, 5-percent tolerance
- Four AC Power Supply hold-down brackets
- Opto-isolator/convertor (RD-RSCONV)

After converting the SC-ADCP for use with AC power, use the DR-ADCP Technical Manual for information on how to operate the ADCP. To convert the ADCP back to DC power, see ¶5-12.

___ a. Remove the pressure case (¶5-1) and electronics chassis cover. Remove ADCP power by disconnecting the battery pack connectors at the DC Power Supply board.

CAUTION

STATIC ELECTRICITY CAN DAMAGE BOARD COMPONENTS. RDI RECOMMENDS USING AN EARTH-GROUNDED WRIST STRAP TO HELP PREVENT SUCH DAMAGE. YOU MUST HAVE THE WRIST STRAP ON WHENEVER YOU HANDLE A BOARD.

__ b. Attach an earth-grounded wrist strap. Remove the DC Power Supply board from J17 (¶5-5).

__ c. Remove all battery packs from the chassis. Slotted rails in the chassis bottom hold the batteries. Four clamps on the bottom of the battery pack hold it in place. To remove the battery packs, loosen the screw on each clamp. After removing the battery packs, reattach the mounting hardware to prevent accidental loss. Wrap the battery pack connector ends with electrician's tape to prevent shorting.

__ d. Remove the black-potted Synchro Slot Jumper Plug from J15. This plug is a connector that has some of its pins jumpered together. An ADCP using DC power will not operate without this plug installed. However, you **MUST** remove the plug to operate an ADCP with AC power. Serious damage to the ADCP will result if you do not remove this plug.

CAUTION

NEVER APPLY AC POWER TO AN ADCP THAT HAS THE SYNCHRO SLOT PLUG INSTALLED OR SERIOUS ADCP DAMAGE WILL OCCUR. MAKE SURE YOU REMOVE THIS PLUG BEFORE APPLYING AC POWER TO THE ADCP.

__ e. If you want to disable commands to the recorder, remove the Peripheral 2 board (Figure Y-11) from J9 (¶5-5). Close pole 7 of S1. Reinstall the board.

__ f. Remove the heat sink hold-down screws on the Power Amplifier board. Remove the board. Replace this board with a spare that has a 10-ohm resistor at R10. If you do not have a spare, unsolder and remove resistor R10 (Figure Y-7) from the board. R10 is usually between 33 and 39 ohms. Keep this resistor (or at least make note of its value: __ ohms) for converting the ADCP back to DC power. Solder a 10-ohm, 1/4-Watt, 5% tolerance resistor as R10. Reinstall the board.

NOTE

PROPER RESISTOR SIZE IS IMPORTANT TO ADCP OPERATION. AN INCORRECT RESISTANCE WILL CAUSE THE ADCP'S BUILT-IN TEST (BIT) TO MISINTERPRET TRANSMITTER CURRENT AS TOO HIGH OR TOO LOW. IN EITHER CASE, THE ADCP WILL NOT OPERATE CORRECTLY AND MAY CAUSE DAMAGE TO ADCP CIRCUITS.

__ g. Make sure the two black-and-white twisted-pair AC power connectors from the I/O connector plug are not tied down inside the chassis so you can reroute them.

__ h. Install the AC Power Supply into J17. The AC Power Supply is a one-piece unit consisting of two circuit boards attached to a frame holding two large capacitors and two large transformers. Route the two AC power connectors from the I/O connector plug under the AC Power Supply and through the notch near the J1 and J2 AC power connector jacks. Secure the AC Power Supply with four hold-down brackets.

__ i. Connect one set of the black-and-white AC power connectors to J1 (electronics power) on the AC Power Supply. Do one of the following steps based on the frequency of the ADCP system.

CAUTION

IN 1200-KHZ SC-ADCP SYSTEMS, DO NOT CONNECT EITHER SET OF THE BLACK-AND-WHITE TWISTED-PAIR WIRES FROM THE I/O CONNECTOR TO THE J2 CONNECTOR ON THE AC POWER SUPPLY BOARD.

__ (1) 1200-kHz systems only - Connect the pair of orange wires from transformer T2 to the J2 connector on the AC Power Supply. This connection provides 40 VDC transmit power to the ADCP. Higher transmit voltages result in "water shock" for this system. Water shock causes bad data readings in the 1200-kHz ADCP.

__ (2) All systems EXCEPT 1200-kHz - Connect the second set of black-and-white twisted-pair wires from the I/O connector to the J2 connector on the AC Power Supply. This connection provides 160 VDC transmit power to the ADCP.

NOTE

YOU CAN LEAVE J2 DISCONNECTED IF YOU ARE NOT GOING TO USE TRANSMIT POWER DURING BENCH TESTING, BUT WRAP THE CONNECTOR WITH ELECTRICIAN'S TAPE. REMEMBER TO CONNECT J2 BEFORE DEPLOYING THE ADCP.

__ j. If the ADCP has a second switch (S2) on the Peripherals 1 board (Figure Y-12), set the following switches to select the communications mode and power supply voltage type.

		Peripherals 1 Board Switch S2				AC Power Supply Board Switch S1	
Communications Mode	Power Supply Type	P1 MODE	P2 GND	P3 -5V	P4 AC/DC	P1 -5V	P2 GND
RS-232	AC	O	O	O	C	C	O
RS-422	AC	C	C	O	O	O	O
RS-423	AC	C	O	O	C	C	O

(O=OPEN, C=CLOSED)

__ k. For all practical purposes, you can operate an AC-powered SC-ADCP as a DR-ADCP. However, be aware of the following.

__ (1) The factory default for most SC-ADCPs is upward-looking. If you plan to operate the ADCP in a downward-looking orientation, make sure you reconfigure the flux gate heading sensor (compass) and pendulums for the new application (¶5-9).

__ (2) Use the DR-ADCP Technical Manual for instructions on system interconnection, operation, AC power requirements, and synchro interface options. You will need to connect an opto-isolator/convertor box between the ADCP data lines and your terminal/computer. If you plan to use the recorder, you will need to refer to the SC-ADCP Technical Manual for recorder instructions.

__ l. Reassemble the ADCP.

__ m. Test the newly converted unit by placing the transducer head in water and running the direct command Y6 test. This test checks transmitter current, ensuring you have installed the correct resistor value. If the transmitter current is too high, the R10 resistor value is too small. If transmitter current is too low, the R10 resistor value is too large. See ¶6-3 for more information on the BIT function and interpretation of test results.

__ n. Save the following items so you can convert the ADCP back to DC power.

  __ (1) R10 resistor (approximately 33-39 ohms)
  __ (2) DC Power Supply board
  __ (3) Synchro Slot Jumper Plug

5-12. PROCEDURES FOR CONVERTING THE SC-ADCP FROM AC POWER TO DC POWER

This section explains how to convert an SC-ADCP from AC power to DC power. We assume the SC-ADCP was originally a DC-powered unit. You must have the DC Power Supply board, Synchro Slot Jumper Plug, and R10 resistor (33-39 Ω, 1/4-watt, 5% tolerance) from the original DC-to-AC conversion (¶5-11). It is important you use the same value for R10 when converting back to DC power. This component is a critical part of the conversion process. Use Figure 5-2 throughout this procedure. Besides normal hand tools, you will need:

- DC Power Supply Board
- Synchro Slot Jumper Plug
- Resistor: 33 to 39 ohm, 1/4-Watt, 5-percent tolerance
- Battery pack power supplies with hold-down brackets

__ a. Turn OFF all external power supplies connected to the ADCP.

__ b. Remove the pressure case (¶5-1) and electronics chassis cover.

__ c. Remove the set of black-and-white AC power connectors from J1 (electronics power) on the AC Power Supply. The AC Power Supply is a one-piece unit with two circuit boards attached to a frame holding two large capacitors and two large transformers. All ADCPs except the 1200-kHz model also have a set of black-and-white twisted-pair wires running from the I/O connector to the J2 connector on the AC Power Supply. Disconnect these wires at the J2 connector. (NOTE: 1200-kHz models do NOT have to remove the orange wires running from the J2 connector to the T2 transformer).

CAUTION

STATIC ELECTRICITY CAN DAMAGE BOARD COMPONENTS. RDI RECOMMENDS USING AN EARTH-GROUNDED WRIST STRAP TO HELP PREVENT SUCH DAMAGE. YOU MUST HAVE THE WRIST STRAP ON WHENEVER YOU HANDLE A BOARD.

__ d. Attach an earth-grounded wrist strap. Remove the four hold-down brackets that secure the AC Power Supply to the chassis. Remove the AC Power Supply from J17 (¶5-5).

__ e. A DC-powered ADCP does not use the two black-and-white twisted-pair AC power connectors from the I/O connector plug, so you can tie down these wires inside the chassis.

__ f. Remove the hold-down screws on the heat sink on the Power Amplifier. Remove the board from J2 (¶5-5). Replace this board with a spare that has an original-value resistor (33-39 Ω) at R10. If you do not have a spare, unsolder R10 (Figure Y-7) from the Power Amplifier. This resistor has a value of 10 ohms. Keep this resistor for converting the ADCP back to AC power. Solder an original-value resistor as R10 (33-39 Ω, 1/4-Watt, 5% tolerance). Reinstall the board.

NOTES

1. IN 1200-KHZ SC-ADCP SYSTEMS, THE ORIGINAL VALUE R10 RESISTOR (33-39 OHMS) CAN BE USED FOR BOTH AC AND DC APPLICATIONS. THEREFORE, CHECK TO SEE IF THE ORIGINAL VALUE R10 RESISTOR IS ALREADY INSTALLED.
2. PROPER R10 RESISTOR SIZE IS IMPORTANT TO ADCP OPERATION. AN INCORRECT RESISTANCE WILL CAUSE THE ADCP'S BUILT-IN TEST (BIT) TO MISINTERPRET TRANSMITTER CURRENT AS TOO HIGH OR TOO LOW. IN EITHER CASE, THE ADCP WILL NOT OPERATE CORRECTLY AND MAY SUSTAIN CIRCUIT DAMAGE.

| __ g. Remove the Peripheral 2 board (Figure Y-11) from J9 (¶5-5). Set pole 7 of switch S1 to the open position. This enables commands to the recorder. If you do not set open this pole, the monitor will display a *STOP - RECORDER NOT FUNCTIONING* error message whenever you issue an S191 direct command. Reinstall the board.

__ h. Install the black-potted Synchro Slot Jumper Plug into J15. This plug is a connector that has some of its pins jumpered together. An SC-ADCP using DC power will not operate without this plug installed.

CAUTION

NEVER APPLY AC POWER TO AN ADCP WITH A SYNCHRO SLOT PLUG INSTALLED. SERIOUS DAMAGE WILL OCCUR TO THE ADCP. BE SURE TO REMOVE THIS PLUG BEFORE APPLYING AC POWER TO THE ADCP.

__ i. Install the DC Power Supply board into J17.

__ j. If the SC-ADCP has a second switch (S2) on the Peripherals 1 board (Figure Y-12), set the following switches to select the communications mode and power supply voltage type.

Communications Mode	Power Supply Type	Peripherals 1 Board Switch S2 P1 MODE	 P2 GND	 P3 -5V	 P4 AC/DC
RS-232	DC	O	O	C	O
RS-422	DC	C	C	O	O
RS-423	DC	C	O	C	O

(O=OPEN, C=CLOSED)

__ k. The factory default for most SC-ADCPs is upward-looking. If you plan to operate the ADCP in a downward-looking orientation, make sure you reconfigure the flux gate heading sensor (compass) and pendulums for the new application (¶5-9).

| __ l. Install the battery pack power supplies (¶5-13). Reassemble the ADCP.

__ m. Test the newly-converted unit by placing the transducer head in water and running the direct command Y6 test. This test checks transmitter current, ensuring you have installed the correct R10 resistor value. If the transmitter current is too high, R10 is too small. If transmitter current is too low, R10 is too large. See ¶6-3 for more information on the BIT function and interpretation of test results.

__ n. Save the following items so you can reconvert the ADCP to AC power.

- __ (1) R10 resistor (10 ohms)
- __ (2) AC Power Supply Assembly

5-13. BATTERY INSTALLATION

This section explains how to install the battery pack power supplies (see Table B-4). Battery packs can be lithium, alkaline, or lead-acid. For these procedures, we assume you are using lithium battery packs. Read Appendix B for special lithium battery warnings before handling the lithium battery packs. Use Figure 5-2 for parts identification. NOTE: V3 is not used.

5-13.1. V1/V2 BATTERY PACK INSTALLATION. V1/V2 battery packs provide primary SC-ADCP power. V1 supplies ADCP electronics power (≈7.2 VDC); V2 supplies transmitter and recorder power (≈36 VDC). Table B-4 lists the capacities and part numbers of our standard battery packs. Use the following procedure and Figure 5-2 to install or replace the V1/V2 battery packs.

__ a. Remove the pressure case (¶5-1) and electronics chassis cover.

__ b. Slotted rails in the chassis bottom hold the battery packs. Four clamps on the bottom of the battery pack hold the packs in place. To remove the battery packs, loosen the hex head screw on each clamp.

__ c. When installing battery packs, set them in the desired location on the rails. The mounting clamps have a lip that must rest in the horizontal groove on the chassis rail. The clamp screw hole must align with the threaded hole in the mounting bracket. Insert the hex head screw and tighten it slightly. Attach the remaining three clamps (per pack). If you did not tighten the clamps too much, you can slip the battery pack into its final position. Tighten the screws.

__ d. Besides the Appendix B warnings, observe the following precautions BEFORE plugging lithium batteries into the DC Power Supply board.

  __ (1) The DC Power Supply jacks and the battery connectors are keyed. The DC Power Supply connectors should have pins 5 and 6 removed from connectors J1 and J2. The battery connectors for LBP5-A and LBP3-A should have pin positions 5 and 6 plugged. However, it is still possible to force the battery connector into the wrong position. Do NOT offset, rotate, or misalign the battery connector when plugging it into the DC Power Supply jack.

  __ (2) You can plug the LBP5-A (V1/V2 power) and LBP3-A (V1 power only) lithium batteries into either J1 or J2 on the DC Power Supply board. Typically, LBP5-A is connected to J1, and either LBP3-A or another LBP5-A is connected to J2.

  __ (3) You must use LBP5-A to power the ADCP. This battery pack provides V1 power to the ADCP electronics and V2 power to the transmitter and recorder. If you need more V1 power, connect either LBP3-A or another LBP5-A in parallel with the first LBP5-A by plugging into the unused J1 or J2 jack on the DC Power Supply. If you want use more than two battery packs for V1 or V2, you must use a special harness (305A2445) to interconnect the packs.

__ e. Connect the V1/V2 lithium battery pack (LBP5-A) to J1 on the DC Power Supply. If using an additional V1 lithium battery pack (LBP3-A or another LBP5-A), connect it to J2 on the DC Power Supply.

___ f. Use the following installation procedures to install the V4 and backup memory battery power supplies if necessary. After installing all power supplies, test the battery voltages as described in ¶5-13.4.

5-13.2. V4 BATTERY PACK INSTALLATION. The V4 power supply provides power to the optional CTD interface. This battery pack can be either lithium (LBP4-A; ≈15 VDC) or alkaline (ABP3-A; ≈18 VDC). Table B-4 lists the RDI part number and the capacities of our standard batteries. Use the following procedure and Figure 5-2 to install or replace the V4 battery pack.

___ a. Remove the pressure case (¶5-1) and electronics chassis cover.

___ b. Slotted rails in the chassis bottom hold the battery packs. Four clamps on the bottom of the battery pack hold the packs in place. To remove the battery packs, loosen the hex head screw on each clamp.

___ c. When installing battery packs, set them in the desired location on the rails. The mounting clamps have a lip that must rest in the horizontal groove on the chassis rail. The clamp screw hole must align with the threaded hole in the mounting bracket. Insert the hex head screw and tighten it slightly. Attach the remaining three clamps (per pack). If you did not tighten the clamps too much, you can slip the battery pack into its final position. Tighten the screws.

| ___ d. Besides the Appendix B warnings, observe the following precaution BEFORE plugging lithium batteries into the DC Power Supply board.

- The DC Power Supply jacks and the battery connectors are keyed. The DC Power Supply connectors should have pins 1 and 2 removed from connector J3. The CTD battery cable harness connector for V4 should have pin positions 1 and 2 plugged. However, it is still possible to force the connectors into the wrong position. Do NOT offset, rotate, or misalign the battery connector when plugging it into the DC Power Supply jack. Never plug the CTD battery harness into J1 or J2 of the DC Power Supply.

___ e. Connect the LBP4-A (V4 power) lithium battery pack into connector P1 or P2 of the battery cable harness supplied as part of the CTD option. Connect P3 of the CTD battery cable harness to J3 on the DC Power Supply board.

___ f. Use the following procedure to install the backup memory battery. After installing all power supplies, test the battery voltages as described in ¶5-13.4.

5-13.3. MEMORY BACKUP BATTERY INSTALLATION. A lithium coin cell on the DC Power Supply provides backup power to the real-time clock and non-volatile memory. This battery is a type BR2330 with a nominal voltage of 3 VDC and a capacity of 250 mA·h. Replace the backup battery every six months using the following procedure and Figure 5-2.

___ a. Remove the pressure case (¶5-1) and electronics chassis cover.

CAUTION

REMOVE ALL POWER TO THE ADCP BEFORE REMOVING CIRCUIT BOARDS OR DAMAGE MAY OCCUR.

___ b. Secure all power to the ADCP. Remove the DC Power Supply board with a gentle rocking and lifting motion.

___ c. Using a non-metallic tool, lift the coin cell retaining clip and slide the battery out of its holder. If necessary, re-tension the clip. Insert the new lithium coin cell into the holder.

___ d. Install the DC Power Supply board.

NOTE

REMOVAL OF THE BACKUP BATTERY WITHOUT V1 AND V2 POWER CAUSES THE CLOCK AND NON-VOLATILE MEMORY TO LOSE STORED DATA. THEREFORE, THE NEXT TIME YOU OPERATE ADCP, THE CLOCK AND ALL OPERATING PARAMETERS RESET TO THEIR DEFAULT VALUES. THIS MEANS YOU MUST RE-ENTER ANY NEW VALUES. BATTERY REPLACEMENT CAN BE DONE WITH V1 AND V2 POWER ON. THIS PRESERVES THE REAL-TIME CLOCK AND THE STORED OPERATING PARAMETERS. THIS PROCEDURE SHOULD ONLY BE DONE BY AN EXPERIENCED TECHNICIAN.

5-13.4. TESTING THE BATTERIES AFTER INSTALLATION. With the batteries installed, you can check the connections and voltages using a DC voltmeter. Measure the battery voltages with the ADCP in both standby and operating modes. If any voltage is less than those listed in Table 5-4, replace the battery. If any voltage is 0V, a fuse on the DC Power Supply or the internal battery pack fuse may be open. All batteries need time to recover their cell voltages after a heavy current drain. If you depassivate the batteries just before taking the readings, you could measure lower than expected voltages. Allow several hours for battery recovery after depassivation before measuring the voltages. Use this procedure and Figure 5-2 to test the battery voltages.

___ a. Use Appendix A to interconnect the SC-ADCP system. Be sure to set the ADCP/RECORDER switch on the RDI J-Box to ADCP.

___ b. If you are concerned only with the operating voltages for V1 and V2, run the SCTEST program's Transmit Test option. The results of this test display the V1 and V2 operating voltages while under load. See Appendix T for more information on the SCTEST program.

___ c. If you wish to use a dumb terminal (or a dumb terminal emulator program such as RDI's DUMBTERM.EXE) to check all battery voltages in both the operating and standby modes, do the remaining steps.

___ d. Enter the following ADCP commands.

___ (1) <BREAK> (wake-up message displayed)
___ (2) Z (initialize)
___ (3) Tmmddhhmm (mmddhhmm = present month, day, hour, minute)
___ (4) Ummddhhmmss (mmddhhmmss = present month, day, hour, minute, seconds plus 15 minutes)

For example, if T = 07310910, set U to 0731092500.

NOTE

YOU MAY USE A LONGER OR SHORTER DELAY (U-COMMAND). THE DELAY DEPENDS ON HOW LONG IT TAKES TO COMPLETE THE STANDBY VOLTAGE MEASUREMENTS.

___ e. Sending the next command places the ADCP and recorder in standby mode. You can then measure and record the standby battery voltages. Figure 5-2 shows all test points. Table 5-4 lists the test points and voltages. Take the standby readings before the U-command delay expires.

  ___ (1) S236 (operate continuously after wakeup)
  ___ (2) Measure and record the standby voltages.

___ f. When the delay expires, the ADCP wakes up and starts pinging. While the ADCP is operating, measure and record the operating mode voltages.

Table 5-4. Battery Test Points and Standby/Operating Voltages

Power supply	Test points	Standby voltage	Operating voltage
V1	TP1 to TP0	6.8	6.1
V2	TP2 to TP0	36.4	33.3
V4	TP4 to TP0	14.2	12.9
Memory	TP6 to TP0	2.75	n/a

NOTE: MEASURE VOLTAGES WITH THE NEGATIVE (-) METER LEAD CONNECTED TO TP0 AND THE POSITIVE (+) METER LEAD CONNECTED TO TEST POINT. ALL MEASUREMENTS ARE IN DC VOLTS AND ARE THE MINIMUM VALUES.

5-14. EPROM RECORDER PREPARATION

This section explains how to prepare the EPROM recorder for deployment. The recorder can store data for up to 255 deployments as long as you do not exceed the recorder's maximum memory capacity. With all 20 memory cards installed, the maximum capacity is 40 megabytes (MB). Be aware that as much as 3% of memory may be unavailable for data recording. This is because the recorder uses 1% of memory for processing requirements and that after 100 write-erase cycles as much as 2% of the EPROMs may fail. This prevents you from calculating the exact amount of memory available for data collection, so you should not plan to use every possible byte of memory because data processed toward the end of a deployment may not be recorded due to lack of memory.

You can add data from a new deployment into memory without erasing the EPROMs if you are sure enough memory is available to meet your expected data collection needs. Chapter 2 explains how to determine data collection requirements. Do the steps from one of the following procedures to prepare the EPROM recorder for deployment.

5-14.1. PREPARING THE RECORDER FOR DEPLOYMENT - APPEND METHOD. This method prepares the recorder for deployment without erasing memory and retains previously recorded data. The disadvantage is that you may not have enough memory available for your data collection requirements.

___ a. Be sure to run the Recorder Test (see ¶T-1.10 if using SCTEST; ¶T-2.7 if using direct commands) to verify proper operation of the recorder.

___ b. Check the existing contents of the recorder by sending the @S command. (NOTE: Deployment Program users can run the RECORDER CHECK option.) This command summarizes (maps) the contents of recorder memory by showing the number and size (in kilobytes) of files already recorded. The @S command also shows the amount space remaining in the recorder. For example:

```
@S
USER FILE # 001:   KBYTES: 00008
DATA FILE # 002:   KBYTES: 00020
KBYTES LEFT: 19945
```

NOTE

A USER FILE STORES TEXT INFORMATION ENTERED BY THE USER THROUGH THE @W COMMAND. A DATA FILE STORES DATA COLLECTED BY THE ADCP.

___ c. If the recorder test (step a) passes, and the recorder check (step b) shows enough free memory for your data collection requirements, you are done preparing the recorder for deployment.

5-14.2. PREPARING THE RECORDER FOR DEPLOYMENT - ERASE METHOD. This method prepares the recorder for deployment by erasing all recorded data from memory. The disadvantage is that you will lose all previously recorded data, but you should have transferred the data from memory to computer disk (Chapter 3).

___ a. Run the Recorder Test (see ¶T-1.10 if using SCTEST; ¶T-2.7 if using direct commands) to verify proper operation of the recorder before erasing the EPROM memory cards.

CAUTION

STATIC ELECTRICITY CAN DAMAGE BOARD COMPONENTS. RDI RECOMMENDS USING AN EARTH-GROUNDED WRIST STRAP TO HELP PREVENT SUCH DAMAGE. YOU MUST HAVE THE WRIST STRAP ON WHENEVER YOU HANDLE A BOARD.

___ b. Remove the pressure case (¶5-1) and recorder chassis cover (Figure 5-2). Remove ADCP power by disconnecting the battery pack connectors at the DC Power Supply board. Attach an earth-grounded wrist strap. Remove the EPROM Recorder Memory cards you want to erase (¶5-5).

___ c. EPROMs typically have a 2% failure rate after 100 write-erase cycles, so you should log the write-erase history for each card. Use a copy of the EPROM Recorder Memory Card write-erase record in Appendix F for each memory card.

___ d. When recording, the recorder starts writing data on the cards in the lower-numbered slots and progresses up through the higher-numbered slots. If you do not always use the full capacity of the recorder, you may want to rotate the cards from the higher-numbered slots into the lower-numbered slots.

___ e. Place the memory cards inside an EPROM eraser (we recommend using the eraser provided). Follow the instructions for using the eraser. We recommend an erase time of about 30 minutes for the eraser provided. Be sure the EPROM windows are uncovered and clean. Also be sure the eraser's light pattern covers all the EPROMs. Erasers built for RDI have their foam pads cut out to indicate proper card alignment.

NOTE

WE CANNOT STRESS ENOUGH THE IMPORTANCE OF ENSURING THE EPROM CARDS ARE PROPERLY ERASED. IT IS BETTER TO TAKE A FEW EXTRA HOURS TO ENSURE PROPER EPROM ERASURE THEN TO RUIN AN ENTIRE DEPLOYMENT BECAUSE OF UNERASED EPROMS. INTERNAL EPROM CHARGE LEAKAGE CAN CAUSE THE FIRMWARE TO READ AN IMPROPERLY ERASED EPROM AS ERASED. LATER, AFTER BYPASSING ITS ZERO-STATE THRESHOLD, THE EPROM WILL INDICATE IT IS NOT ERASED. TO PREVENT THIS PROBLEM, USE LONGER ERASE TIMES. MOST EPROM ERASERS COMPLETELY ERASE A PROPERLY POSITIONED EPROM IN 15-20 MINUTES. IF YOU HAVE DOUBTS ABOUT THE QUALITY OF THE ERASER, MEASURE THE AMOUNT OF TIME NEEDED FOR AN ENTIRE EPROM MEMORY CARD TO "READ" AS ERASED AND THEN DOUBLE THE ERASE TIME.

__ f. Reinstall the memory cards after erasure. You can place the cards in any order. You do not have to fill the slots sequentially, but we recommend you do not skip slots unless you know the slot is bad.

__ g. Run the Recorder Test (¶T-1.10 if using SCTEST; ¶T-2.7 if using direct commands) to reverify proper operation of the recorder.

__ h. Check the existing contents of the recorder by sending the @S command. (NOTE: Deployment Program users can run the RECORDER CHECK option.) This command summarizes (maps) the contents of recorder memory by showing the number and size (in kilobytes) of files already recorded. If you erased the cards properly, no files should be displayed. The @S command also shows the amount of space remaining in the recorder.

__ i. Send the @B command to run an extended memory card check. (NOTE: Deployment Program users can run the extended RECORDER CHECK option.) This check verifies the erasure of all memory chips and cards and shows the maximum capacity of the recorder. You MUST run this check after erasing a memory card. This test can take up to 30 minutes to run. Shown below is information similar to what you will see. Cards with all chips erased have a *GOOD: 08* message. Cards with unerased/used chips have a U next to the affected chip. Missing chips have an M next to the chip's location. Bad chips have a * next to the bad chip's location. Slots without a card have a *NOT PRESENT* message.

```
@B
Card 01: 00  01  02  03  04  05  06  07  : GOOD: 8
Card 02: 00  01  02U 03  04  05* 06  07  : GOOD: 6
Card 03: NOT PRESENT
    :            :           :           :
Card 20: 00  01  02  03  04  05M 06  07  : GOOD: 7
CAPACITY: 40960      [in kilobytes]
```

__ j. If a card is not completely erased, remove the card and repeat the erase process for that card. NOTE: Remember to remove ADCP power before plugging/unplugging the EPROM cards.

__ k. If a card fails to erase after two tries, it is possible some of the chips, or the card, are bad. Remove this card and replace it with a known good card.

5-15. SILICA-GEL AIR DRYER REPLACEMENT AND RESTORATION

Use this procedure to restore and replace the silica-gel air dryer used to dehumidify the pressure case interior. Inspect the silica-gel air dryer (Table 5-1, #34) whenever you remove or replace the pressure case.

__ a. Remove the pressure case (¶5-1). The air dryer canister is attached to the electronics chassis frame with double-sided foam tape (Table 5-1, #38) or hook-and-loop (Velcro) material. Remove the canister.

CAUTION

DO NOT OPEN THE AIR DRYER CANISTER. DO NOT BREATH SILICA-GEL DUST. PROLONGED CONTACT WITH SILICA-GEL CAUSES IRRITATION TO THE NOSE, THROAT, AND SKIN.

__ b. Inspect the silica-gel granulate inside the canister. As the granulate absorbs moisture, it slowly changes color from dark blue to pink. Restore or replace the air dryer before each deployment or whenever the silica-gel begins to turn pink.

__ c. You can restore the silica-gel by heating it in an oven set to 175°C (350°F). The granulate turns dark blue when restored.

NOTE

KEEP UNUSED SILICA-GEL IN AN AIR-TIGHT CONTAINER UNTIL READY TO DEPLOY THE ADCP. THIS ENSURES MAXIMUM EFFECTIVENESS OF THE AIR DRYER.

__ d. Reinstall the silica-gel canister just before sealing the ADCP.

5-16. O-RING INSPECTION AND REPLACEMENT

This section explains how to inspect/replace the ADCP O-rings. A successful deployment may depend on the condition of four O-rings and their retaining grooves. See Figure 5-1 for the locations of the following O-rings.

- Transducer assembly, bore (Table 5-1, #14)
- Transducer assembly, face (Table 5-1, #15)
- BCR-20 I/O connector, face (Table 5-1, #16)
- XSL-20 water-tight dummy plug, bore (Table 5-1, #11).

We strongly recommend replacing these O-rings whenever you deploy the ADCP, regardless of deployment length. Inspecting and replacing the O-rings should be the last maintenance task done before installing the pressure case.

__ a. Inspect the O-rings. When viewed with an unaided eye, the O-rings must be free of cuts, indentations, abrasions, foreign matter, and flow marks. The O-ring must be smooth and uniform in appearance. Defects must be less then 0.1 mm (0.004 in.).

__ b. Clean and inspect the O-ring grooves. Be sure the grooves are free of foreign matter, scratches, indentations, corrosion, and pitting. Run your fingernail across damaged areas. If you cannot feel the defect, the damage may be minor; otherwise, the damage may need repair. Check the anodizing inside the groove. Damaged anodizing can lead to corrosion and, eventually, ADCP leakage.

__ c. Lubricate the O-ring with a thin coat of lubricant (Table 5-1, #35). Apply the lubricant using latex gloves. Do not let loose fibers or lint stick to the O-ring. Fibers can provide a leakage path.

NOTE

DURING INSTALLATION, DO NOT CUT OR TWIST THE O-RING. NEVER FORCE O-RINGS OVER SHARP CORNERS, SCREW THREADS, KEYWAYS, SLOTS, OR OTHER SHARP EDGES.

__ d. You can install both transducer assembly O-rings (bore and face) using a ring-like installation tool made from metal or plastic. The tool should have a smooth, outside diameter of about 16.5 cm (6.5 in.). Lubricate the tool and the O-ring. Stretch the O-ring over the tool. Set the tool over the electronics chassis until the end of the tool is even with the O-ring groove. Slide the O-ring off the tool into the groove. Do not twist the O-ring within the groove.

__ e. Use tweezers to install the BCR-20 I/O connector face O-ring into the connector. Do NOT lubricate this O-ring or bend the connector pins.

__ f. Install the XSL-20 water-tight dummy plug bore O-ring by first lubricating the O-ring. Roll the O-ring over the end of the plug into the O-ring groove. Do not let lubricant enter the pin holes.

5-17. TRANSDUCER HEAD INSPECTION

The urethane coating on the transducer faces is important to ADCP water-tight integrity. Mishandling, chemicals, abrasive cleaners, and excessive depth pressures can damage the transducer ceramics or urethane coating. Inspect the transducer faces for dents, chipping, peeling, urethane shrinkage, hairline cracks, and damage that may affect water-tight integrity or transducer operation. Repair of the transducer faces should only be done by RDI.

CAUTION

NEVER SET THE TRANSDUCER ON A ROUGH SURFACE; ALWAYS USE FOAM PADDING TO PROTECT THE TRANSDUCERS.

5-18. ZINC ANODE INSPECTION AND REPLACEMENT

Most SC-ADCPs have three sacrificial zinc anodes (Figure 5-1). The ADCP has a circular anode on the end of the pressure case and two smaller anodes on the transducer assembly. If the case does not have exposed bare metal, properly installed anodes help protect the ADCP from corrosion while deployed.

5-18.1. ZINC ANODE INSPECTION. The life of a zinc anode is not predictable. An anode may last as long as one year, but dynamic sea conditions may reduce its life. Use a six-month period as a guide. If the total deployment time for the anodes has been six months or more, replace the anodes. If you expect the next deployment to last six months or more, replace the anodes. Inspect the anodes as follows.

__ a. Inspect each anode (Figure 5-1) for corrosion and pitting. If most of the anode still exists, you may not want to replace it.

__ b. Inspect the RTV-covered screws that fasten each anode. If the RTV (Table 5-1, #37) has decayed enough to let water enter between the screws and the anode, replace the RTV (see ¶5-18.2 for procedure).

___ c. Check electrical continuity using a digital multimeter (DMM).

___ (1) For units with the pressure case on, and for units with anodes on the transducer assembly: Measure the resistance between the anode on the pressure case and each anode on the transducer assembly. The resistance must be less than one ohm. If not, reinstall the affected anode (¶5-18.2).

___ (2) For units with the pressure case off, and for units without anodes on the transducer assembly: Measure the resistance between the pressure case anode and the guide pins inside the case. The pins are hard to reach, so fastening a DMM probe to an extension pole may help. If the resistance is more than one ohm, reinstall the affected anode (¶5-18.2).

With the pressure case off, measure resistance between the guide-pin receptacles, the electronics chassis, and the transducer assembly anodes (if present). Refer to Figure 5-2. Connect a DMM lead to one of the banana-clip plugs inside the guide-pin receptacle at the end of the electronics chassis. Connect the other lead to each transducer assembly anode. If the transducer assembly does not have anodes, measure resistance between the plug and one of the eight standoffs or standoff screws located under the preamplifier connectors. To reach the standoffs, remove the preamplifier shields. When removing the shields, do not break the ground lead connecting the shield to the motherboard. You can also measure resistance using one of the four pendulum mounting plate studs or retaining nuts. In either case, you must measure less than one ohm of resistance.

___ d. If you have doubts about the condition of the anodes or the electrical continuity, remove and replace the anode (¶5-18.2).

5-18.2. ZINC ANODE REPLACEMENT. The following steps explain how to remove and replace the zinc anode(s).

___ a. Remove the RTV from the anode screw heads. Remove the screws.

___ b. The anode may stick to the ADCP because of the RTV used during assembly. To break this bond, first place a block of wood on the edge of the anode to protect the pressure case anodizing and paint. Carefully strike the block to loosen the anode.

___ c. Clean the bonding area under the anode. Remove all foreign matter and corrosion. Apply a continuous 1-2 mm bead (0.04-0.08 in.) of RTV (Table 5-1, #37) around each screw hole.

___ d. Set a new anode in place and fasten with new screws. Use item #23, Table 5-1 for the pressure case anode. Use item #9, Table 5-1 for the transducer assembly anodes.

___ e. Fill the counter bore above each screw head with self-leveling RTV. The RTV protects the screw heads from water and prevents breaking the electrical continuity between the anode, screw, and pressure case.

__ f. Check electrical continuity (see ¶5-18.1). If any measurement is greater than one ohm, reinstall the affected anode.

CAUTIONS

1. DO <u>NOT</u> USE ZINC ANODES WITH AN IRON CONTENT OF MORE THAN 0.0015%. THE MAJOR FACTOR CONTROLLING THE ELECTRICAL CURRENT OUTPUT CHARACTERISTICS OF ZINC IN SEA WATER IS THE CORROSION FILM THAT FORMS ON THE SURFACE OF THE ZINC. CORROSION PRODUCT FILMS CONTAINING IRON HAVE A HIGH ELECTRICAL RESISTANCE. AS LITTLE AS 0.002% IRON IN ZINC ANODES DEGRADES THE PERFORMANCE OF THE ANODE.
2. DO <u>NOT</u> USE MAGNESIUM ANODES. MAGNESIUM RAPIDLY CORRODES THE ALUMINUM PRESSURE CASE.
3. DO <u>NOT</u> CONNECT OTHER METAL TO THE ADCP. OTHER METALS MAY CAUSE CORROSION DAMAGE. USE ISOLATING BUSHINGS WHEN MOUNTING THE ADCP TO A METAL STRUCTURE.

5-19. MOUNTING BUSHING INSPECTION AND REPLACEMENT

The two mounting lugs (Figure 5-1) have plastic bushings (Table 5-1, #10) installed on each side. The bushings electrically isolate the ADCP from its mounting. You MUST isolate the ADCP from all metal structures. If using other mounting devices such as clamps, isolate the clamps from the ADCP (e.g., with silicone rubber liners). The following steps explain how to inspect and replace the mounting bushings.

__ a. Inspect the mounting lugs. Look for damaged anodizing inside the mounting lugs. See ¶5-20 for repair instructions.

__ b. To remove a bushing, use pliers to grab the bushing on its shoulder. Pull and twist the bushing to remove it.

__ c. Use a small vice with protective jaws to install new bushings. Press-fit the bushings into the mounting holes. Be sure the bushings are in place, not chipped, and not cracked.

5-20. PROTECTIVE COATING INSPECTION AND REPAIR

RDI uses international orange paint on the pressure case for identification and corrosion protection. For more protection, the case and the transducer assembly are first anodized. Do not damage the surface coatings when handling the ADCP. Inspect and repair the protective coating as follows.

__ a. Inspect the pressure case and transducer assembly for scratches, cracks, abrasions, paint blisters, exposed metal (silver-colored aluminum), exposed anodize (black or dark green), and exposed primer (yellow). Be critical in your judgment; the useful life of the ADCP depends on it. If there is damage to the anodizing, repair it first.

WARNING

THE CHEMICALS USED IN THE FOLLOWING STEPS CAN BE HAZARDOUS TO YOUR HEALTH. READ ALL MATERIAL SAFETY DATA SHEETS AND MANUFACTURER'S INSTRUCTIONS BEFORE HANDLING THESE CHEMICALS.

__ b. If you are familiar with the repair of anodized coatings, proceed as follows; otherwise, send the ADCP to RDI for repair.

  __ (1) Clean and prepare the damaged area using a fine-grade abrasive cloth or a fine-grade abrasive silicon carbide wheel. Remove all corrosion from the bare aluminum.

  __ (2) Clean the area with trichlorethane or alcohol. Do not touch the area after cleaning.

__ (3) Anodize per MIL-A-8625, Type 3, Class 1.

__ (4) Seal with sodium dichromate only.

__ (5) Paint repaired area as described in step c below.

__ c. Proceed as follows to repair or touch up the protective paint.

__ (1) Remove all loose paint without damaging the anodizing. Clean and prepare the damaged area using a fine-grade abrasive cloth. Feather the edges of the paint near the damaged area. Try to have a smooth transition between the paint and the damaged area. Do not sand the anodized area. If you damage the anodizing, see step b above for repair.

__ (2) Clean the area with trichlorethane or alcohol. Do not touch the area after cleaning.

__ (3) Paint with one coat of epoxy primer (manufacturer's part number 4018; see note below).

__ (4) Paint with one coat of orange or black paint (manufacturer's part number 4512-B (orange), 4511-B (black); see note below).

NOTE

RDI USES A TWO-PART EPOXY TYPE PAINT. THIS PAINT IS MANUFACTURED BY PRO-LINE PAINT MANUFACTURING COMPANY, 2426 MAIN ST, SAN DIEGO, CA, 92113; TELEPHONE: (619) 231-2313 OR 1168 HARBOR, LONG BEACH, CA, 98813; TELEPHONE: (213) 432-7961. MANUFACTURER'S PART NUMBERS:

4500-A, PRO-THANE PAINT, CATALYST, PART A
4511-B, PRO-THANE PAINT, BLACK, PART B
4512-B, PRO-THANE PAINT, ORANGE, PART B

5-21. SEALING THE SC-ADCP FOR DEPLOYMENT

Use Figure 5-1 and the following steps to seal the ADCP for a deployment.

__ a. Be sure you have done all appropriate maintenance items (see previous sections). If necessary, replace the desiccant (¶5-15).

__ b. Slide the pressure case over the electronics chassis. If a dry purging gas (e.g., nitrogen) is available, direct the gas into the pressure case through a long flexible tube as you slide the case over the electronics chassis. Remove the tube when the case gets close to the transducer head. Rotate the pressure case until the guide pins on the case align with the receptacles on the electronics chassis.

__ c. When installing the pressure case, apply equal pressure to all parts of the O-rings. This is best done by standing the ADCP on its transducer end on a protective pad and lowering the pressure case onto the transducer/electronics assembly. Watch closely as the pressure case passes over the bore O-ring. Make sure the bore O-ring does not pop out of its retaining groove or become pinched or torn. If this happens, a leakage path into the electronics assembly could exist. Also make sure you properly align the face O-ring in its retaining groove.

__ d. Examine the nuts, bolts, and washers for corrosion; replace if necessary. Be sure plastic bushings (Table 5-1, #8) are in each bolt hole on both the pressure case and the transducer assembly. Insert each socket head bolt through a flat washer. Insert the bolt through the pressure case flange and transducer assembly. Install a flat washer, lock washer, and hex nut on the transducer side of the assembly. In rotation, tighten the bolts to compress the face seal O-ring evenly. Do not over-tighten the bolts. Do not deform the plastic bushings.

___ e. Use Appendix A to connect the SC-ADCP system. Use Chapter 2 for instructions on how to program the ADCP for deployment.

___ f. After programming the ADCP, remove the I/O cable and install the water-tight dummy plug. To help prevent corrosion, you can apply a thin coat (≈0.1 mm; ≈0.004 in.) of lubricant to all water-exposed surfaces except the transducer faces. The ADCP is now ready for deployment unless you want to take steps to prevent biofouling (¶5-22).

5-22. PREVENTION OF BIOFOULING

This section explains how to prevent the buildup of organic sea life (biofouling) on the transducer faces. Objects deployed within about 100 meters (≈328 feet) of the surface are subject to biofouling, especially in warm water. This means shallow-water deployments are subject to biofouling. Biofouling is not usually a problem in deep water. Soft-bodied organisms usually cause no problems, but barnacles can cut through the urethane transducer face causing failure to the transducer and leakage into the ADCP. Therefore, you should take steps to prevent biofouling during shallow water deployments.

Some organizations may decide to use an antifouling grease. However, most antifouling greases are toxic and may cause problems. Recent tests suggest antifouling grease may cause the urethane on the transducer faces to develop cracks. Warmer temperatures accelerate this effect. You should not need to apply antifouling grease if deploying the ADCP in deep water (more than 100 meters). However, in shallow, warm water, barnacles are a threat. In shallow-water applications, the use of antifouling grease may be appropriate if you cannot clean the transducer faces often (weekly), and if the antifouling grease meets all your local safety and environmental laws (see the following cautions). The only other known way to control biofouling is to inspect and clean the transducer faces frequently while deployed.

If using antifouling grease, remove the grease immediately after recovering the ADCP from its deployment (¶5-23.1). Remove the grease with soapy water because cleaning solvents may also cause the urethane to crack. Be sure to wear protective gloves and a face shield.

CAUTIONS

1. DO NOT ARBITRARILY USE ANTIFOULING GREASE FOR DEEP-WATER APPLICATIONS. FOR SHALLOW-WATER APPLICATIONS, BARNACLES ARE A THREAT TO THE TRANSDUCER FACES; USING ANTIFOULING GREASE MAY BE APPROPRIATE IF YOU CANNOT CLEAN THE ADCP REGULARLY (WEEKLY). IF USING ANTIFOULING GREASE, REMOVE IT IMMEDIATELY AFTER RECOVERING THE ADCP.
2. ANTIFOULING GREASE IS TOXIC. READ THE PRODUCT SAFETY DATA SHEET BEFORE USING THE GREASE. WEAR GLOVES AND A FACE SHIELD WHEN APPLYING THE GREASE. IF THE SKIN COMES IN CONTACT WITH THE GREASE, IMMEDIATELY WASH THE AFFECTED AREA WITH WARM, SOAPY WATER.
3. DO NOT COAT THE TRANSDUCER FACES WITH CUPROUS OXIDE OR RELATED PAINTS SUCH AS COPPER, CHROME, OR ARSENIC. THESE PAINTS ADVANCE THE CORROSION OF THE ALUMINUM CASE AND TRANSDUCER ASSEMBLY.
4. ALL U.S. COASTAL STATES PROHIBIT THE USE OF TRIBUTYL-TINS ON BOAT HULLS. THE EUROPEAN ECONOMIC COMMISSION HAS RELEASED A DRAFT DIRECTIVE THAT WOULD PROHIBIT THE USE OF MANY ORGANO-TINS AFTER JULY 1989. WE STRONGLY RECOMMEND YOU OBEY YOUR LOCAL LAWS.

5-23. STORAGE AND SHIPPING MAINTENANCE

This section lists the maintenance items to do before storing the ADCP. These maintenance items include

__ a. Cleaning the ADCP with fresh, soapy water.
__ b. Removing biofouling (¶5-23.1).
__ c. Inspecting the transducer head (¶5-17).
__ d. Inspecting/replacing the zinc anodes (¶5-18).
__ e. Inspecting/replacing mounting bushings (¶5-19).
__ f. Inspecting/repairing the protective coating (¶5-20).
__ g. Inspecting/replacing the O-rings (¶5-16).
__ h. Replacing the silica-gel air dryer (¶5-15).
__ i. Preparing the ADCP for final storage or shipping (¶5-23.2).

5-23.1. REMOVAL OF BIOFOULING. Before storing or shipping the ADCP, remove all foreign matter and biofouling. Remove soft-bodied marine growth or foreign matter with soapy water. Waterless hand cleaners remove most petroleum-based fouling. Rinse with fresh water to remove soap residue. Dry the transducer faces with low-pressure compressed air or soft lint-free towels.

CAUTION

THE SOFT, THIN URETHANE COATING ON THE TRANSDUCER FACES IS EASILY DAMAGED. DO NOT USE POWER SCRUBBERS, ABRASIVE CLEANSERS, SCOURING PADS, HIGH-PRESSURE MARINE CLEANING SYSTEMS, OR BRUSHES STIFFER THAN HAND CLEANING BRUSHES ON THE TRANSDUCER FACES.

If there is heavy fouling or marine growth, the transducer faces may need a thorough cleaning to restore acoustic performance. Barnacles do not usually affect ADCP operation. We do, however, recommend removal of the barnacles to prevent water leakage through the transducer face. Lime dissolving liquids such as Lime-Away break down the shell-like parts. Scrubbing with a medium stiffness brush usually removes the soft-bodied parts. Do NOT use a brush stiffer than a hand cleaning brush. Scrubbing, alternated with soaking in Lime-Away, effectively removes large barnacles. After using Lime-Away, rinse the ADCP with fresh water to remove all residue. If barnacles have entered more than 1.0-1.5 mm (0.04-0.06 in.) into the transducer face urethane, you should send the ADCP to us for repair. If you do not think you can remove barnacles without damaging the transducer faces, contact RDI.

5-23.2. FINAL STORAGE OR SHIPPING PREPARATION. This section explains how to store or ship the ADCP.

We recommend removing all battery packs before storing or shipping the ADCP. Proceed as follows to remove the battery packs.

__ a. Disconnect all battery connectors from the DC Power Supply board (Figure 5-2). Use insulating tape to cover the exposed terminals of the battery connectors to prevent an accidental short.

__ b. Remove batteries from the chassis. Slotted rails in the chassis hold the battery packs. Four clamps on the bottom of the battery pack hold the packs in place. To remove the battery packs, loosen the hex head screw on each clamp. After removing the batteries, reattach the mounting hardware to prevent accidental loss.

WARNING

NEVER SHIP AN ADCP WITH LITHIUM BATTERY PACKS INSTALLED. IN MOST CASES, WE DO NOT NEED NOR WANT YOUR LITHIUM BATTERY PACKS. HOWEVER, IF YOU HAVE ARRANGED TO RETURN YOUR LITHIUM BATTERY PACKS TO US, YOU MUST SEND THEM SEPARATELY. MANY RESTRICTIONS APPLY TO LITHIUM BATTERY PACKS, SO CHECK WITH YOUR SHIPPING SERVICE FIRST. DO NOT SHIP USED BATTERIES TO RDI.

___ c. If you plan to use the battery pack again, estimate the amount of battery capacity used. Record this estimate on the battery pack or in a log book. Store the batteries in a cool and dry location.

NOTE

YOU DO NOT HAVE TO REMOVE THE MEMORY BACKUP BATTERY FROM THE DC POWER SUPPLY BOARD (FIG. 5-2). IF YOU REMOVE THE BATTERY, LOSS OF THE INTERNAL REAL-TIME CLOCK AND NON-VOLATILE MEMORY WILL OCCUR. REPLACE THE MEMORY BACKUP BATTERY EVERY SIX MONTHS (¶5-13.3).

After removing the batteries, slide the pressure case over the chassis. To prevent losing hardware during storage, use all four bolts to seal the ADCP.

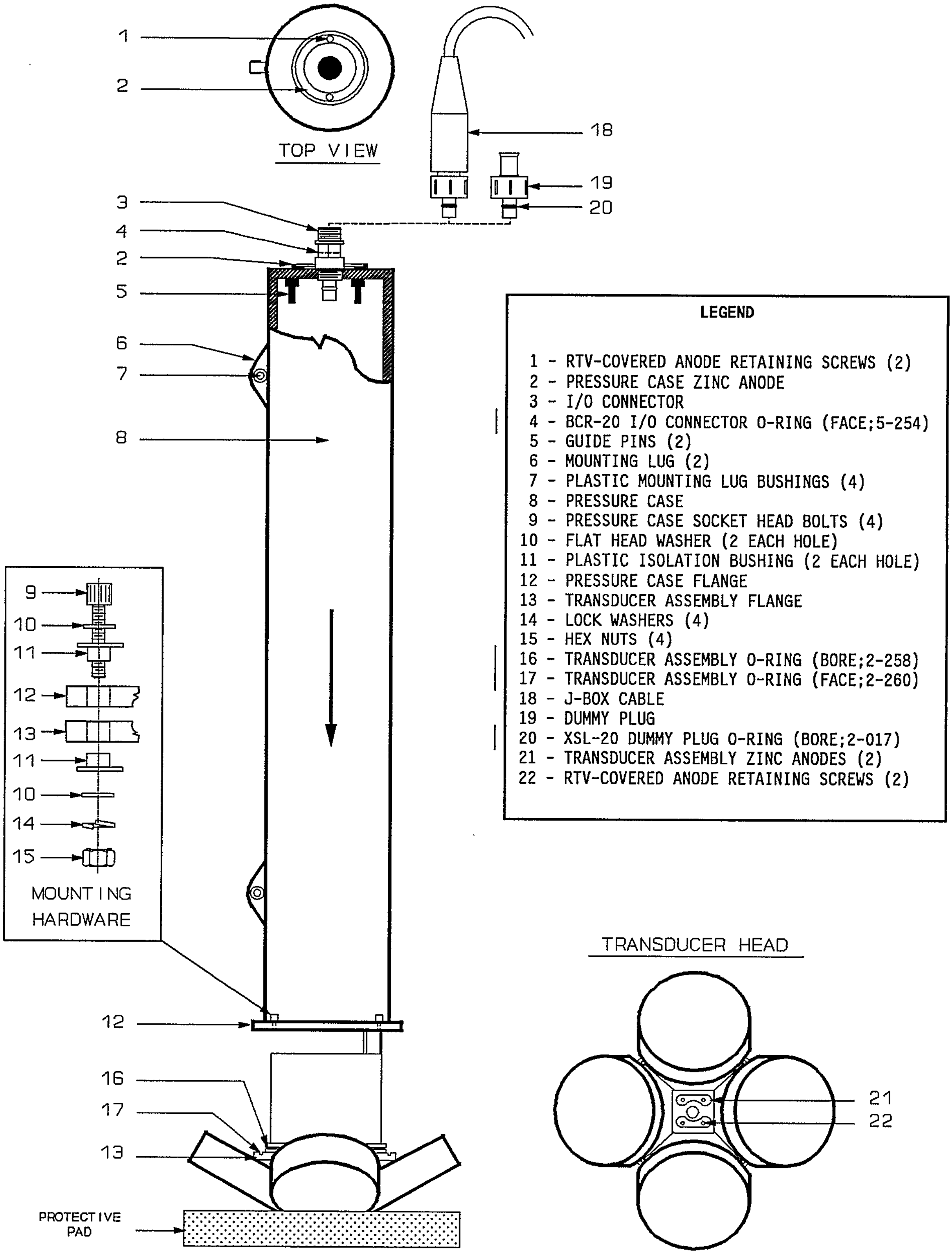
Clean and inspect the I/O connector and dummy plug for water or salt residue (Figure 5-1). Clean the O-rings (bore and face). Install the dummy plug to protect the XSL-20 BCR I/O connector from damage and dust.

Before storing the ADCP, you may want to cover the body of the ADCP with a light coat of a high-viscosity silicone oil or grease to help prevent corrosion. Do NOT apply grease or oil to the urethane transducer faces.

WARNING

IF YOU ARE SHIPPING AN ADCP TO RDI FOR REPAIR OR UPGRADE, REMOVE ALL CUSTOMER-APPLIED COATINGS OR PROVIDE CERTIFICATION THAT THE COATING IS NONTOXIC. THIS CERTIFICATION MUST INCLUDE THE NAME OF A CONTACT PERSON WHO IS KNOWLEDGEABLE ABOUT THE COATING, THE NAME AND MANUFACTURER OF THE COATING, AND THE APPROPRIATE TELEPHONE NUMBERS. IF YOU RETURN THE EQUIPMENT WITHOUT MEETING THESE CONDITIONS, WE HAVE INSTRUCTED OUR EMPLOYEES NOT TO HANDLE THE EQUIPMENT AND TO LEAVE IT IN THE ORIGINAL SHIPPING CONTAINER PENDING CERTIFICATION. IF YOU CANNOT PROVIDE CERTIFICATION, WE WILL RETURN THE EQUIPMENT TO YOU OR TO A CUSTOMER-SPECIFIED CLEANING FACILITY. ALL COSTS ASSOCIATED WITH CUSTOMER-APPLIED COATINGS WILL BE AT THE CUSTOMER'S EXPENSE.

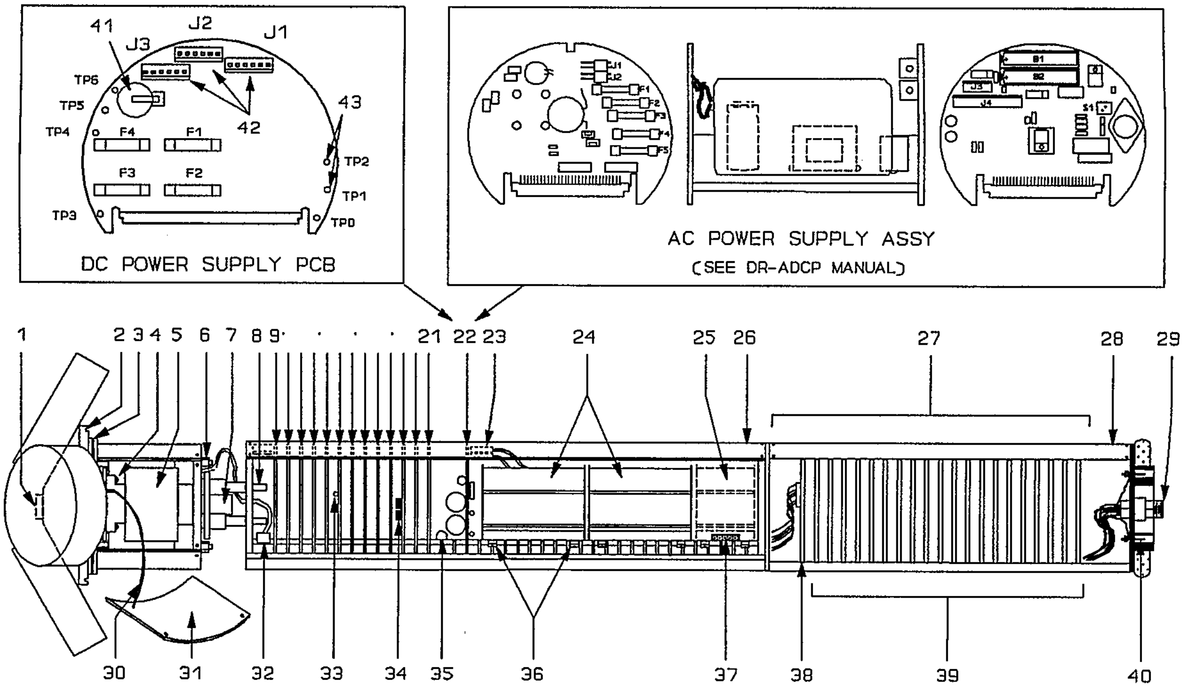
When shipping the ADCP through a Customs facility, be sure to place the unit(s) so identifying labels are not covered and can be seen easily by the Customs Inspector. Failure to do so could delay transit time.



LEGEND

1 - RTV-COVERED ANODE RETAINING SCREWS (2)
2 - PRESSURE CASE ZINC ANODE
3 - I/O CONNECTOR
4 - BCR-20 I/O CONNECTOR O-RING (FACE;5-254)
5 - GUIDE PINS (2)
6 - MOUNTING LUG (2)
7 - PLASTIC MOUNTING LUG BUSHINGS (4)
8 - PRESSURE CASE
9 - PRESSURE CASE SOCKET HEAD BOLTS (4)
10 - FLAT HEAD WASHER (2 EACH HOLE)
11 - PLASTIC ISOLATION BUSHING (2 EACH HOLE)
12 - PRESSURE CASE FLANGE
13 - TRANSDUCER ASSEMBLY FLANGE
14 - LOCK WASHERS (4)
15 - HEX NUTS (4)
16 - TRANSDUCER ASSEMBLY O-RING (BORE;2-258)
17 - TRANSDUCER ASSEMBLY O-RING (FACE;2-260)
18 - J-BOX CABLE
19 - DUMMY PLUG
20 - XSL-20 DUMMY PLUG O-RING (BORE;2-017)
21 - TRANSDUCER ASSEMBLY ZINC ANODES (2)
22 - RTV-COVERED ANODE RETAINING SCREWS (2)

Figure 5-1. SC-ADCP Pressure Case Parts Identification



LEGEND

1 - TRANSDUCER ASSEMBLY ZINC ANODES (2)
2 - TRANSDUCER ASSEMBLY O-RING (FACE;2-260)
3 - TRANSDUCER ASSEMBLY O-RING (BORE;2-258)
4 - PREAMPLIFIER STANDOFF SCREWS (8)
5 - PREAMPLIFIER BOARDS (4)
6 - PENDULUM MOUNTING PLATE STUDS (4)
7 - FLUX GATE HEADING SENSOR (COMPASS)
8 - ELECTRONICS ASSEMBLY MOUNTING STUDS (4)
9 - POWER AMPLIFIER (CHASSIS J2)
10 - RECEIVER 1 (CHASSIS J3)
11 - RECEIVER 2 (CHASSIS J4)
12 - RECEIVER 3 (CHASSIS J5)
13 - RECEIVER 4 (CHASSIS J6)
14 - POWER REGULATOR (CHASSIS J7)
15 - BUTTERFLY (CHASSIS J8)
16 - PERIPHERAL 2 (CHASSIS J9)
17 - PERIPHERAL 1 (CHASSIS J10)
18 - RAM/MULTIPLIER (CHASSIS J11)
19 - CPU (CHASSIS J12)
20 - PERIPHERAL 3 (CHASSIS J13)
21 - CTD INTERFACE (CHASSIS J14)
22 - DC POWER SUPPLY (CHASSIS J17)
[OR AC POWER SUPPLY IF CONVERTED]

23 - BATTERY PACK CONNECTORS (PLUG)
24 - V1/V2 DC BATTERY PACK(S)
25 - V4 CTD BATTERY PACK (OPTIONAL)
26 - ELECTRONICS CHASSIS COVER
27 - SOLID-STATE EPROM RECORDER
28 - EPROM RECORDER COVER
29 - ELEC. CHASSIS I/O CONNECTOR
30 - GROUND LEAD
31 - PREAMPLIFIER SHIELD
32 - 50-PIN RIBBON CABLE (CHASSIS J1)
33 - LED LIGHT SENSOR
34 - TROUBLESHOOTING LEDs ON CPU
35*- SYNCHRO SLOT JUMPER PLUG (CHASSIS J15)
36 - HOLD-DOWN CLAMP (4 EACH PACK)
37 - DESICCANT (VARIABLE LOCATION)
38 - EPROM CONTROLLER BOARD
39 - EPROM MEMORY BOARDS (20 MAX.)
40 - CHASSIS GUIDE PIN RECEPTACLES
AND BANANA-CLIP PLUGS (2)
41 - MEMORY BACKUP BATTERY
42 - BATTERY PACK CONNECTORS (JACK)
43 - BATTERY VOLTAGE TEST POINTS

*NOTE
THE SYNCHRO SLOT JUMPER PLUG MUST BE IN PLACE FOR DC POWER SUPPLIES AND MUST BE REMOVED FOR AC POWER SUPPLIES.

Figure 5-2. SC-ADCP Electronics Chassis Parts Identification

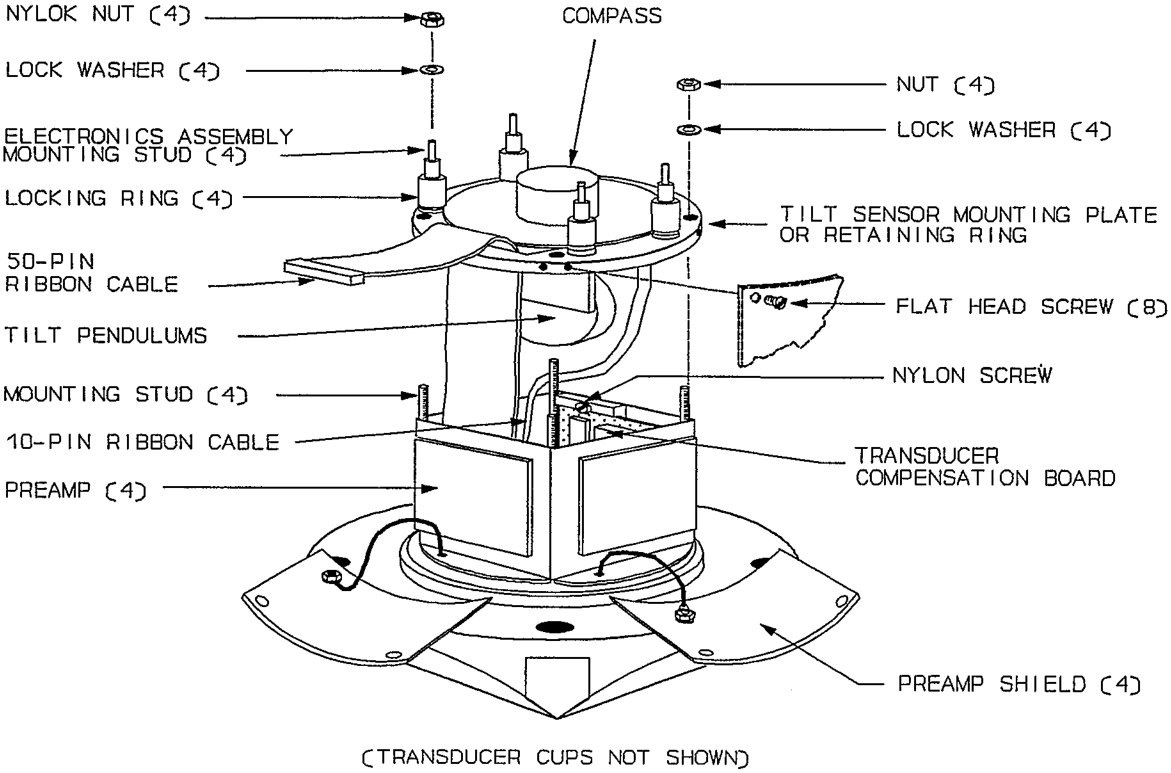


Figure 5-3. SC-ADCP Transducer Assembly Parts Identification

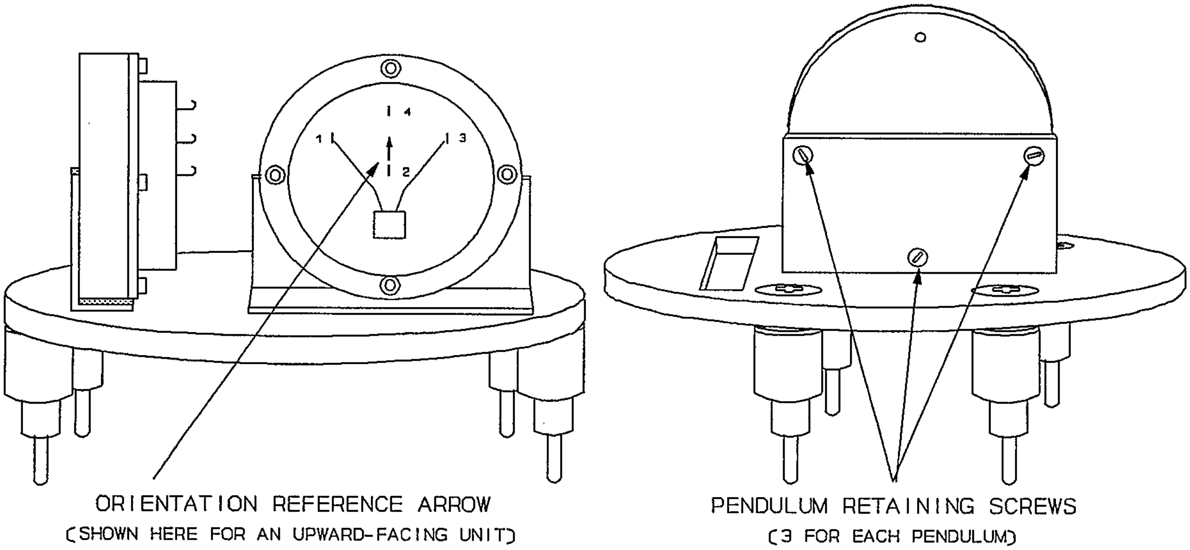


Figure 5-4. Pendulum Assembly Parts Identification

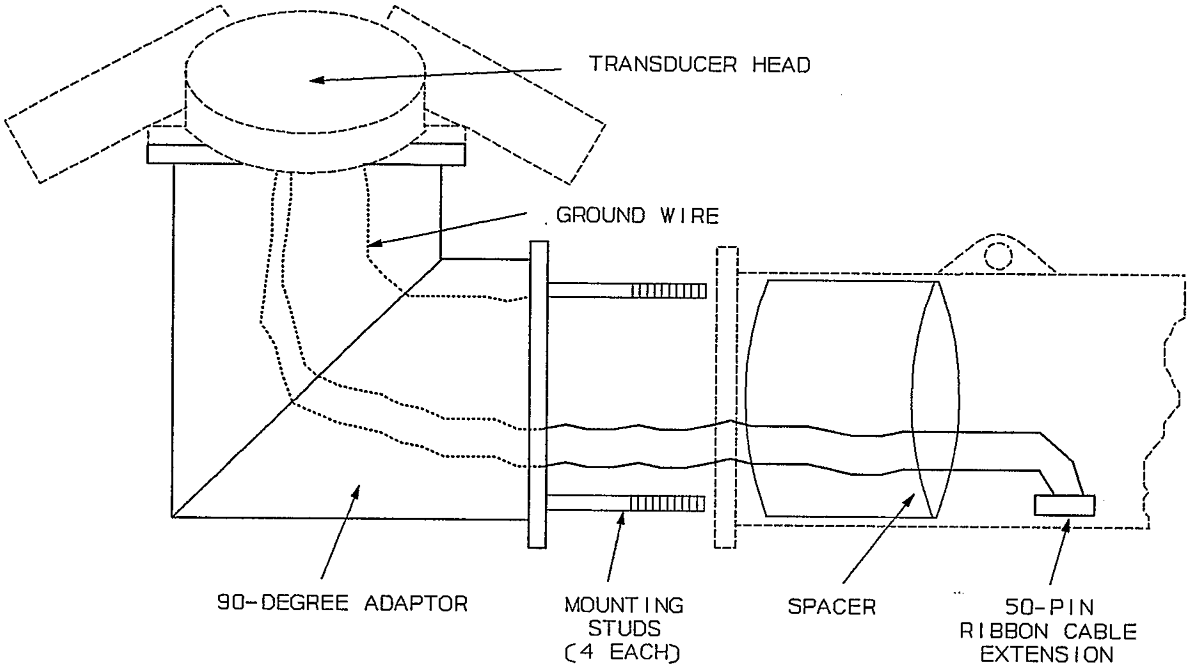


Figure 5-5. 90-Degree Adaptor — Parts Location

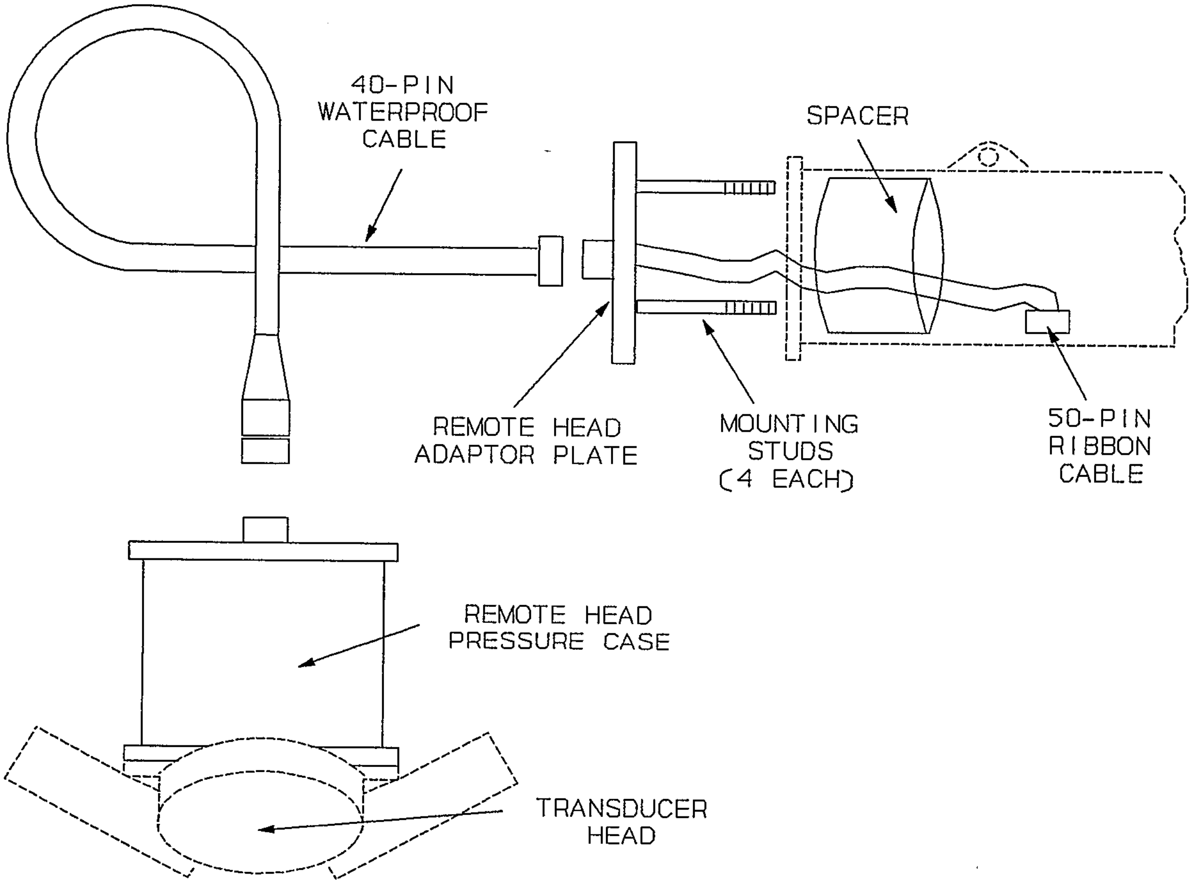


Figure 5-6. Remote Head Adaptor — Parts Location

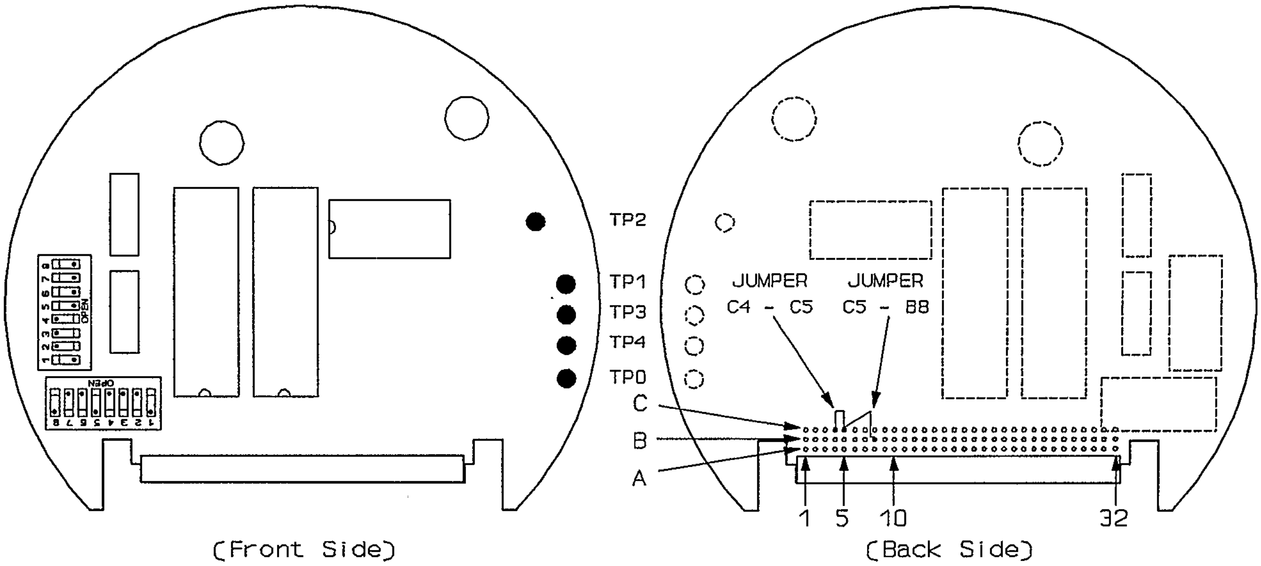


Figure 5-7. Modification of Peripherals 2 Board for Zero-Degree Tilts

CHAPTER 6
TROUBLESHOOTING

6-0. INTRODUCTION

This chapter explains how to troubleshoot and fault isolate problems that may occur with the SC-ADCP. We use several Troubleshooting Flow Charts to help isolate these problems. These charts assume you are using our SCTEST program. Using SCTEST and the charts will lead you to the replacement of a circuit board or a recommendation to call us. This chapter also explains how to isolate problems using the Built-In Test (BIT) function. Use this method only if you are not using SCTEST.

Before troubleshooting, review the procedures, examples, figures, and tables in this chapter. Figure 6-1 shows the standard flowchart symbols. Table 6-1 lists terms and abbreviations. Appendix W has switch settings. Appendix X has circuit board block diagrams, system block diagrams, and a functional description of ADCP processing. Appendix Y has circuit board layouts. Appendix Z has pin-outs and wiring lists.

6-1. USING THE TROUBLESHOOTING FLOW CHARTS WITH SCTEST

This section explains how to use the Troubleshooting Flow Charts with SCTEST. Observe the following points before troubleshooting.

a. The flow charts may give supplemental information in comment boxes. These comment boxes contain information specific to the troubleshooting step being done. Read them <u>before</u> completing the step.

b. The Troubleshooting Flow Charts primarily use SCTEST for fault isolation. At times, you may have to exit SCTEST and use a dumb terminal emulator program (e.g., DUMBTERM.EXE) for further isolation. Failure to set up a test properly could result in troubleshooting a nonexistent problem. You must follow the setup procedures as explained in the flow charts, the SCTEST manual, and the DUMBTERM manual. Table 6-5 lists a quick-start setup procedure for DUMBTERM. Appendix D explains ADCP direct commands in detail.

c. We assume you have troubleshooting experience and are familiar with electrical safety. During fault isolation, you may have to remove/replace the pressure case, transducer head, circuit boards, or other ADCP components. The flow charts may not say: "Turn off power" or "Attach an earth-grounded wrist strap" because we assume you know incorrect removal/replacement of electrical parts can cause personal injury or component damage. If in doubt, see Chapter 5 for information on how to gain access to components for removal, replacement, and test measurements. You may have to step through the test again to return to the failure area.

d. During fault isolation, you may have to measure various types of signals. We assume you know how to use standard test equipment such as multimeters and oscilloscopes. In the charts, we identify signals by top level assembly (circuit board name or other specific assembly), test point, and the expected measurement value. For example, "PWR REG-TP3 = 5.02VDC +/- 0.1" indicates the top level assembly is the POWER REGULATOR circuit board, the local measurement is TEST POINT 3, and the expected measurement value is 5.02 VOLTS DC plus (+) or minus (-) 0.1 volt.

NOTES

1. TPO IS THE GROUND (GND) TEST POINT ON EACH CIRCUIT BOARD.
2. SIGNAL AMPLITUDES WILL TYPICALLY BE LEVELS OF 0 TO ±5 VDC UNLESS OTHERWISE SPECIFIED.

If you must take high-voltage measurements, read the flow chart and note the measurement points. Remove power. Connect the test probes. Apply power and read the voltage measurement.

e. You may reach a point when a part needs replacing. The charts point to the most likely suspect first, and then to secondary choices. There are also situations when the first choice may not help, so the procedure continues to gather information for additional choices. For example, the chart may say:

(1) CHECK CHASSIS TO XDCR CABLE
(2) REPL PWR AMP

Here, you would make sure the cable was securely fastened. If it was, you would replace the Power Amplifier board.

Another case may be:

BOX 1 – SET J-BOX DTE/DCE SWITCH TO PROPER POSITION
BOX 2 – CHECK COMPUTER TO ADCP CABLE CONNECTIONS
BOX 3 – CHECK COMPUTER'S SERIAL CARD

In this example, you would stop troubleshooting at Box 1 if changing the DTE/DCE switch fixed the problem; otherwise, you would try the next suggestion.

f. The charts try reasonable possibilities when looking for a fault. If you come to the end of a flow sequence, and there are no final recommendations, this means all logical fault isolation steps have been exhausted. For example, if you are troubleshooting a problem, and you come to the last box in the flow chart that says *VERIFY PER1-S2 IS SET FOR YOUR CONFIGURATION*, you would check the PER1 switch S2 setting, and then try the test again. If you continued to have problems, you would have to call RDI.

g. If you swap a Preamplifier to help in fault isolation, make sure you return all functioning Preamplifiers to their original slots after completing the test.

6-2. TROUBLESHOOTING EXAMPLES

This section has two examples of fault isolation using the Troubleshooting Flow Charts. The first is an ESTABLISH COMMUNICATIONS failure. The second is a RECEIVE CONTINUITY failure. These examples show how to use the troubleshooting flow charts, system block diagrams (Appendix X), and cable/wire lists (Appendix Z) to troubleshoot the ADCP if there is a failure during SCTEST.

6-2.1. EXAMPLE 1 – ESTABLISH COMMUNICATIONS FAILURE. Failure description – During ADCP operation or testing you lose communications. SCTEST tries to set up communications on both communication ports but eventually displays the message "ADCP not responding to Wake Up" followed by some items to check to verify proper setup. You try the suggestions, but still fail to establish communications with the ADCP. Proceed as follows.

a. Refer to the SCTEST Failure Troubleshooting Flow Chart (Figure 6-2). Find the ESTABLISH COMMUNICATIONS FAILURE decision box.
b. The failure of this test points to an off-page connector containing the figure number of the corresponding flow chart. In this example, Figure 6-3 is the flow chart needed to isolate the problem.
c. Start with Box 1 at the top of Figure 6-3 and do the indicated steps.

BOX 1 – SET J-BOX DTE/DCE SWITCH TO PROPER POSITION

The DTE/DCE switch (Data Terminal Emulator / Data Communications Emulator) compensates for different serial port pin configurations. Some computer equipment uses pin 2 for DATA OUT and pin 3 for DATA IN, while others use pin 2 for DATA IN and pin 3 for DATA OUT. The DTE/DCE switch swaps lines 2 and 3 to be compatible with both. If this switch is in the wrong position for your configuration, you cannot establish communications properly.

BOX 2 – CHECK COMPUTER TO ADCP CABLE CONNECTIONS

First, make sure the communications cable is intact. Often times cables get tugged by the cord resulting in broken or frayed wires inside the connectors. A quick check for good connections can be done by making a resistance measurement of the cable. See Appendix Z for cable pin-outs. Second, make sure the cable connecting the ADCP to the J-Box is seated properly. You may want to remove the cable from the ADCP and inspect the pressure case connector for bent pins. If you want to check both cables at once, remove the serial cable from the computer, remove the J-Box cable from the ADCP pressure case, and measure between the serial cable connector and the ADCP J-Box cable connector P1. For example, you want to measure resistance between DATA OUT A on the serial cable to DATA OUT A on the ADCP J-Box cable connector P1. See Appendix Z for the J-Box cable pin-out description.

BOX 3 – CHECK COMPUTER'S SERIAL CARD

If there are still problems establishing communications, you are getting close to having to remove the ADCP pressure case for further troubleshooting. Pressure case removal is not a quick and easy task, so you want to make sure the problem is not a faulty serial board in the computer. This can be done in one three of ways:

(1) Disconnect the serial line from the ADCP J-Box and connect it to another piece of equipment that uses serial communications. This could be a computer in dumb-terminal mode, a dumb terminal, or another ADCP.

(2) Change communications ports. If COM2 is available, switch the serial cable to COM2 and run ESTABLISH COMMUNICATIONS again.

(3) Do an end-around test. This simply means connect the data-out lines to the data-in lines on the serial board. Table 6-6 has an end-around test procedure. After you connect the jumpers, run the DUMBTERM program and type some characters on the keyboard. If the serial board is working, the terminal screen will display the characters typed on the keyboard. Make sure you set DUMBTERM for the correct port.

BOX 4 - EXIT SCTEST PROGRAM; LOAD DUMBTERM

You must now try to talk to the ADCP directly. Exit SCTEST and load DUMBTERM (SCTEST v1.9 and later can load DUMBTERM by pressing <F3>). Make sure the DUMBTERM communications setup matches the ADCP setup (Table 6-5).

BOX 5 - SEND <BREAK> TO ADCP

Send a BREAK to the ADCP (<End> in DUMBTERM). This sends a WAKE-UP pulse to the ADCP placing it in a READY or AWAKE state and preparing it for command input.

BOX 6 - WAKE-UP MSG ON CRT?

When the ADCP sees a BREAK, it sends WAKE-UP message (RDI copyright notice) out the serial communications line via the Peripherals 1 (PER1) board as DATA OUT. DATA OUT is connected to the computer through the ADCP J-Box cable, J-Box, and serial cable. When in the dumb-terminal mode, the computer shows the WAKE-UP message every time a BREAK is sent. The message should be similar to the following.

```
ACOUSTIC DOPPLER CURRENT PROFILER
COPYRIGHT (c) RD INSTRUMENTS COPYRIGHT 1983-1992
```

There may be other comments preceding the first line such as "EPROM RECORDER" if an EPROM recorder is installed and enabled, or "*+" (asterisk-plus) if a Tape Recorder is installed and enabled.

For our example, no WAKE-UP message is displayed when BREAK is sent (NO).

BOX 7 - PRESS <BREAK> ON J-BOX

The BREAK button simulates a BREAK signal normally sent by the computer. This BREAK signal initiates a power-up or WAKEUP of the ADCP. The BREAK button will only work if V1 voltage is applied. V1 is one of the primary voltages (normally the batteries) that powers the ADCP when it is deployed. The BREAK button uses V1 when pressed. We tell you this because under test conditions you can run the ADCP from system voltage V2 only.

BOX 8 – WAKE-UP MSG ON CRT?

If a WAKE-UP message is displayed, that would be an indication the BREAK signal was not getting sent from the computer. You have proved this by sending the BREAK at the J-Box. For our example, there is no WAKEUP (NO).

BOX 9 – CHECK COMMUNICATION SWITCHES ON PER1 AND PER2

By now you should realize there are no problems with external ADCP connections. Remove the pressure case (¶5-1). Now connect the J-Box cable to the chassis I/O connector. This connector is the same as the one on the pressure case. Make sure the switches on the PER1 (RS-232/422/423) and PER2 (baud rate, parity, etc.) boards are set correctly (see Appendix W).

BOX 10 – DC PWR TP1 = 5.5-12 VDC?

Take a measurement at TP1 on the DC Power Supply board. If it did not measure 5.5-12 volts DC, you would continue troubleshooting at "A" on sheet 2 of figure 6-3, but for our example, the measurement is good (YES).

BOX 11 – DC PWR TP7 = 18 VDC +/- 1.0?

The voltage measured at TP7 on the DC Power Supply should be 18 volts DC plus (+) or minus (-) one volt. Our example measurement is good (YES).

BOX 12 – PWR REG TP3 = 5.02 VDC +/- 0.1?

TP3 on the Power Regulator board should be 5.02 volts DC plus or minus 0.1 volt. For our example, the measurement is good (YES).

BOX 13 – SEND <BREAK> TO ADCP

Same as Box 5. Send a BREAK to attempt a WAKEUP. This step helps to set up conditions for the next voltage measurement.

BOX 14 – PWR REG TP1 = 5.02 VDC +/- 0.1?

When a BREAK is sent to the ADCP, the PER1 board sends a WAKE-UP signal to the PWR REG board. It is inverted from the BREAK signal (active low) and initiates power-up of the VCC1 regulated system voltage (see the PER1 and PWR REG circuit board block diagrams in Appendix X).

The voltages previously measured on the DC Power Supply and Power Regulator should be present whenever power is applied. If you look at DC Power Distribution (Figure X-3), you can see which voltages are in use at each stage of system operation. The voltages present before BREAK are listed as ASLEEP or STANDBY voltages. When BREAK is sent, the ADCP is put in the AWAKE or PROCESS mode. Finally, when the ADCP is collecting data, the DATA COLLECT or RECEIVE voltages are enabled. During actual data collection, the last two sets of voltages are turned on and off as needed.

To find the actual wiring distribution for these voltages (and any other signals listed in the block diagrams), you can look up the signal names in the wiring list (Appendix Z) and find all the connection points.

For our example, we measure 0 volts at TP1 on the Power Regulator (NO). This does NOT meet the specification and provides us with the first indication of failure. Go to "C" on sheet 3 of Figure 6-3.

BOX 15 - CONTINUALLY SEND <BREAK> AND MONITOR FOLLOWING TEST POINTS

As stated before, WAKEUP initially happens when BREAK is sent. In the next step, you are going to look at the BREAK signal with an oscilloscope to see if BREAK is coming in to the PER1 board. To make the signal easier to see, you must send a BREAK repeatedly.

BOX 16 - PER1-TP2 = SEE NOTE 1?

This is the BREAK signal from the computer. The voltage levels and pulse duration measured here depend on the communications standard in use and the BREAK length set by the communications software or dumb terminal. The ADCP accepts RS-232, RS-422, and RS-423 inputs (selectable on the PER1 board). DUMBTERM uses a 400 ms BREAK length. See the specifications on the flow chart for details. In our example, this signal is present (YES).

BOX 17 - PWR REG-TP11 = SEE NOTE 2?

This is the inverted WAKE-UP signal explained in Box 14. It is a negative-going TTL level signal. If you look at the Power Regulator block diagram (Appendix X), you will see the low-going WAKE-UP signal initiates VCC1 ON through wake-up circuit U6. See the specifications on the flow chart for details. For our example, this signal is NOT present. This indication directs us to the replacement of a circuit board.

BOX 18 - REPLACE PER1

The PER1 board is chosen for replacement because the WAKE-UP signal was not present at TP11 on the Power Regulator board. As you recall, the BREAK signal was present at the input to the PER1 board on TP2 (see PER1 block diagram). At this point, BREAK simply gets normalized, inverted, and turned into WAKEUP. WAKEUP then goes straight to the Power Regulator board via diode CR3 on PER1 and a wire wrap. In our example, diode CR3 may have cracked, or a wire wrap may have broken between the PER1 and PWR REG boards. If you feel adventurous, you could look up the WAKE-UP signal in the wire list (Appendix Z) and signal trace it with the oscilloscope or look at the pin numbers listed on the block diagrams.

6-2.2. EXAMPLE 2 – RECEIVE CONTINUITY FAILURE. Failure description – During the Receive Continuity test, rubbing transducer beam #3 did not give an indication of BEAM 3 CONNECTED. Proceed as follows.

a. Refer to the SCTEST Failure Flow Chart (Figure 6-2). Find the RECEIVE CONTINUITY TEST FAILURE decision box.
b. The failure of this test points to an off-page connector containing the figure number of the corresponding chart. In this example, Figure 6-7 is the flow chart needed to isolate the problem.
c. Start with Box 1 at the top of Figure 6-7. Do the indicated steps.

BOX 1 - TURN OFF ALL EQUIPMENT NOT ESSENTIAL TO ADCP OPERATION

If any equipment in the room generates frequencies the ADCP can detect, the Automatic Gain Control (AGC) circuits may act on them. These frequencies could be within a few kilohertz of the system frequency or harmonics that fall into the frequency ranges of the internal system clocks and are picked up by the chassis wiring. SCTEST looks for small amplitude variations in the AGC just above the thermal noise floor while you rub the transducer face. If the ADCP detects any signals, regardless of origin, and the AGC circuitry acts on them as it would with real signals, interference becomes the dominant signal source, and the rubbing action will have no effect.

BOX 2 - RESTART TEST THEN TURN OFF COMPUTER CRT

Computer screens can generate signals that the ADCP can detect, especially in 150-kHz systems. SCTEST provides an audible beep when it detects connection to a beam, so the computer screen does not have to be on to run the test. Start the test, and then turn off the CRT until done.

BOX 3 - TEST FAIL?

If the test does not fail, you are done. If the test fails, move on to the next box. For our example, the test fails (YES).

BOX 4 - VERIFY CHASSIS TO XDCR RIBBON CABLE IS IN PLACE

Remove the pressure case (¶5-1). Connect the J-Box cable to the chassis I/O connector.

The SC-ADCP has three main sections — electronics chassis, transducer, recorder. The electronics chassis is bolted to the transducer. The two sections connect electrically through a ribbon cable that runs from J1 on the chassis to J7 in the transducer. Retaining clips on each connector hold the ribbon cable in place. If the cable is not secure, one or more receiver connections may fail. In our example, the cable is OK.

BOX 5 - CONNECT DVM TO TP1 & GND OF RCVR BOARD ASSOCIATED WITH BAD BEAM

Each transducer beam has an independent receive path, so each beam has one preamplifier and one receiver (see Figure X-1). In our example, Beam 3 failed so we will connect the multimeter to the Beam 3 receiver. Find the Beam 3 Receiver board (Figure 5-2). Connect the positive (+) lead to Test Point 1 (TP1) and the negative (GND) lead to Test Point 0 (TP0) of RCVR 3.

BOX 6 - EXIT SCTEST; LOAD DUMBTERM; SEND <BREAK> TO ADCP

Exit SCTEST and load DUMBTERM (SCTEST v1.9 and later can load DUMBTERM by pressing <F3>). Make sure the DUMBTERM communications setup matches the ADCP setup (Table 6-5).

Send a BREAK to the ADCP (<End> in DUMBTERM). This will send a WAKE-UP pulse to the ADCP placing it in a READY or AWAKE state and preparing it for command input. When the ADCP sees a BREAK, it sends a WAKE-UP message

(RDI copyright notice) out the serial communications line via the PER1 board as DATA OUT. DATA OUT is connected to the computer through the J-Box cable, J-Box, and serial cable. When in the dumb terminal mode, the computer screen displays the WAKE-UP message every time a BREAK is sent. The message is similar to the following.

```
ACOUSTIC DOPPLER CURRENT PROFILER
COPYRIGHT (c) RD INSTRUMENTS COPYRIGHT 1983-1992
```

There may be other comments preceding the first line such as "EPROM RECORDER" if an EPROM recorder is installed and enabled, or "*+" (asterisk-plus) if a Tape Recorder is installed and enabled. If you get a WARNING message, you have additional problems. However, the BIT test should have caught this error. For example, when a BREAK is sent, the ADCP reads the system frequency from an EPROM installed on the Transducer Compensation board and compares it to the system frequency switches on the Power Amplifier board. If the two do not match, the ADCP sends a warning message. Several things can happen to get a warning message:

(1) The transducer ribbon cable has come loose causing the ADCP to see a transducer frequency of zero.
(2) The Power Amplifier switches are not set correctly.
(3) The Power Amplifier is not the same frequency as the transducer.
(4) Communications between the Transducer Compensation and PER2 boards has failed for one of several reasons (bad XDCR COMP, PER2, power fault).

For our example, the WAKE-UP message was displayed when a BREAK was sent.

BOX 7 – WAKE-UP MSG ON CRT?

If the WAKE-UP message does not appear as described in Box 6, there is most likely a problem between the DUMBTERM communications setup and the ADCP setup. You already know you can talk to the ADCP because the ESTABLISH COMMUNICATIONS test passed. Review the DUMBTERM setup by pressing the <F5> function key and make sure the communication port and other parameters are correct. For our example, the WAKE-UP message is OK (YES).

BOX 8 – SEND TO ADCP: <Z>, <DA08>, <S236>

Sending a <Z> causes a firmware reset. This clears out previously-entered commands and returns the ADCP to a factory-default command set. <Z> also produces a WAKE-UP message identical to BREAK.

<DA08> is a test mode command that prepares the ADCP to turn on all the internal regulated power supplies and put the instrument in a constant receive mode after an S-command is sent.

<S236> tells the ADCP to execute the command set last entered (in this case, DA08). Appendix D describes all the direct commands.

BOX 9 – RUB FAULTY BEAM AND OBSERVE 100 mVDC MIN. VARIATIONS ON DVM

First read the average voltage level (noise) without rubbing the transducer face. The level measured without a signal present is the thermal noise of the ADCP receive circuits. The noise level will typically be 200-400 mVDC. Noise level depends on system frequency and the temperature of the ADCP. A voltage higher than this could mean you have an external interference problem (see Box 1). Very low voltage (0 volts) may indicate a bad preamplifier or transducer ribbon cable. However, serious problems with the noise levels would have caused the PREAMP/RECEIVE test to fail.

Next, briskly rub the faulty transducer face (Beam 3). You should see variations of at least 100 mVDC in the DC voltage level on TP1 of Receiver 3. If other beams have passed the test (Beam 1/2/4), you can connect to TP1 of those receivers and note their voltages as you rub the transducer face to get an idea of how it looks. If reading the voltage with a meter is unclear, connect an oscilloscope to TP1 and repeat the test. Use a slow time-base setting (10.0 ms period).

BOX 10 – VOLTAGE CHANGES?

If the voltage changes, run SCTEST again. If the RECEIVE CONTINUITY TEST still does not pass after seeing voltage variations on TP1, call RDI. For our example, the voltage does NOT change (NO).

BOX 11 – SWAP RCVR BOARD WITH KNOWN GOOD BOARD IN CHASSIS

Borrow a Receiver board from a beam that has passed the test. In our example, Beam 3 was bad, but Beam 1 passed. Remove the Beam 3 receiver and set it aside. Remove the Beam 1 Receiver and install it in the Beam 3 slot (¶5-5 has removal instructions).

BOX 12 – REPEAT <BREAK>, <Z>, <DA08>, <S236> TEST

Repeat the steps done in Boxes 6 through 10.

BOX 13 – VOLTAGE CHANGES?

If there are voltage variations when you rub the transducer face, run the RECEIVE CONTINUITY TEST again on Beam 3. If the test passes, the original Beam 3 Receiver is faulty and must be replaced. For our example, the voltage still does NOT change (NO).

BOX 14 – RETURN RCVR BOARDS TO THEIR ORIGINAL LOCATION

In our example, swapping Receiver boards did not help, so return the Receiver boards to their original location.

BOX 15 – SWAP PREAMP BOARD WITH KNOWN GOOD BOARD IN XDCR HEAD

This is similar to the swapping of receiver boards in Box 11. Remove the Preamplifier associated with Beam 3. Replace it with the Beam 1 Preamplifier. The Beam 3 Preamplifier is installed in Transducer Motherboard connector J3 (Beam 1 = J1, Beam 2 = J2, etc).

BOX 16 – REPEAT <BREAK>, <Z>, <DA08>, <S236> TEST

Repeat the steps done in Boxes 6 through 10.

BOX 17 – VOLTAGE CHANGES?

If the voltage changes (YES), the original Beam 3 Preamplifier is faulty and must be replaced. Chapter 5 has replacement procedures. Remember to replace the Beam 1 Preamplifier into its original slot.

If the voltage still does not vary (NO), there is a chance the transducer tuning board or ceramic is faulty. Either way, call RDI.

For our example, the voltage changes (YES), so the Beam 3 Preamplifier is faulty. Return the good Preamplifier to its original location and get a replacement for Preamplifier #3 (Box 18).

6-3. USING THE BUILT-IN TEST FUNCTIONS FOR TROUBLESHOOTING

This section explains how to fault isolate problems with the SC-ADCP using the results of the Built-In Test (BIT) function. The preferred method of using BIT results is through SCTEST (¶6-3.1), but you also can use the dumb-terminal method (¶6-3.2). This section explains both methods.

The BIT feature has two functions – performance verification and system diagnostics. Performance verification indicates a GO/NO GO status in each data collection cycle and provides a time reference if a fault occurs. While the performance verification tests can provide some diagnostic information, a NO GO indication is your prompt to begin system diagnostics tests. System diagnostics tests isolate faults causing the NO GO indication.

The BIT function helps isolate faults to a plug-in module. If multiple faults exist, the BIT function can help localize the fault to a group of plug-in modules. In sequence, you can substitute modules in the localized fault group to isolate the fault to one module. If replacing modules does not correct the problem, transducer or wiring problems may exist.

The BIT function has three distinct tests. The BIT test results are shown in hexadecimal code on the CPU board's LED display and in decimal code with the ASCII output data.

a. BIT 1 – This end-to-end self-test checks the transmitter, receiver, and echo processing operations. It begins immediately after the last ping of each data collection cycle (or after each ping, in single-ping data collection cycles). If only one fault is detected, the test result code is displayed after the first ping of the next data collection cycle. The ADCP can display only one test result code per data collection cycle. If more than one fault exists, the ADCP will remember all the faults and display the result codes, one at a time, in each successive data collection cycle. Specifically, the BIT 1 test:

   (1) Monitors the transmitter current output during acoustic pulse transmission to verify proper acoustic transmission.

   (2) Injects a simulated acoustic echo of known intensity and Doppler frequency-shift into the receivers.

(3) Processes the simulated echo by computing mean Doppler frequency, spectral width, and echo intensity in the same way received echoes are processed.

(4) Compares the measured transmitter current, simulated Doppler frequency, spectral width, and echo intensity test results to internally-stored BIT acceptance test limits to determine BIT GO/NO GO status.

(5) Displays the BIT test result code on the CPU board LED display.

(6) Sends the BIT test result code through the data interface for display in the output data leader (see Chapter 4).

b. BIT 2 – This test includes the BIT 1 test, verifies clock and system frequencies, verifies A/D and D/A conversion accuracy, and checks math result validity. You manually start the BIT 2 test with the Y-command (Appendix D). Y2 runs this test once. Y6 runs this test continually. BIT 2 takes about one second to run. Test result codes appear in the output data leader (Chapter 4). BIT failure is indicated by code FF on the internal LED. Specifically, BIT 2:

(1) Makes time-gated measurements to check the frequencies of the CPU clock, baud rate, real-time clock, and local oscillator LO1 (used to generate receiver IF).

(2) Converts a known analog test signal to a digital signal, converts the digital signal back to analog, and compares the result to verify proper analog-to-digital and digital-to-analog conversion.

(3) Multiplies and divides known values and compares the results to stored test acceptance values to check math results.

c. BIT 3 – This test includes the BIT 1 and BIT 2 tests, reads and writes to all RAM memory addresses, and calculates the ROM checksum to detect memory faults. You manually start the BIT 3 test with the Y-command (Appendix D). Y1 runs this test once. Y5 runs this test continually. BIT 3 takes about ten seconds to run. Test result codes appear in the output data leader (Chapter 4). BIT failure is indicated by code FF on the CPU LED.

6-3.1. USING THE SCTEST BIT RESULTS. If the SCTEST program fails the BIT test, use the following procedure to replace faulty modules.

___ a. Note the BIT result codes(s) in the TESTFORM.xxx file.
___ b. Using the BIT results, do the first recommended corrective action listed in Table 6-2 based on the BIT result code. Chapter 5 has board removal/replacement procedures.
___ c. After doing the corrective action, repeat the BIT test.
___ d. If the BIT test still fails, do the next corrective action listed in Table 6-2 based on the appropriate BIT result.
___ e. If necessary, repeat steps c and d until a BIT GO is indicated. If these steps do not correct the problem, call RDI Customer Service.

6-3.2. USING THE Y-COMMAND BIT RESULTS. You can use the Y-command from the ADCP's direct command set (Appendix D) to help locate faulty modules. Use the following procedure.

__ a. Connect the SC-ADCP system for testing as described in Appendix A using Figure A-2 as a guide. You can use either batteries or external DC power supplies to power the ADCP for testing (see Appendix A).

__ b. Apply power to the system. NOTE: If you suspect interconnection problems during program execution, see Appendix A.

__ c. Immerse the transducer head in water. Use liquid soap and the palm of your hand to remove air bubbles from the transducer faces.

__ d. On the RDI J-Box, set the ADCP/RECORDER switch to ADCP. Set the DTE/DCE switch to the position determined in the Communications Test.

__ e. Enter the following commands.

    __ (1) <BREAK> (wake-up message displayed)
    __ (2) Z (wake-up message displayed)
    __ (3) Y5 (start BIT processing)

__ f. After about ten seconds, the terminal shows a BIT results message or code. Tables 6-2 and 6-3 define all BIT error codes. The following message appears if no BIT errors exist.

```
NO SELFTEST FAILURES mmddhhmmss     (month, day, hour, minute, second)
```

If the transducer is not in water, or if air bubbles exist, the terminal may display: 081 mmddhhmmss. NOTE: The terminal may display 082 or 083. All three values indicate problems with the transmit current.

__ g. The BIT test result message repeats every ten seconds. Check the message at least four times. Send a <BREAK> to end the test.

__ h. Using the BIT results, do the first recommended corrective action listed in Table 6-2 based on the BIT result code. Chapter 5 has board removal/replacement procedures.

__ i. After completing the corrective action, repeat the BIT test.

__ j. If the BIT test still fails, do the next corrective action listed in Table 6-2 based on the BIT result code.

__ k. If necessary, repeat steps i and j until a BIT GO is indicated. If these steps do not correct the problem, call RDI Customer Service.

Table 6-1. Flow Chart Abbreviations

AC PWR : AC Power Supply
ADJ : Adjust
APX : Appendix
BATT : Battery
BIT : Built-In Test
BTRFLY : Butterfly
C : Conductivity (CTD)
CAL : Calibration
CHAS. : Chassis
CHK : Check
COMM : Communications
COND : Conductivity
CONN : Connection
CPU : Central Processing Unit
CRT : Cathode Ray Tube (monitor)
CTD : Conductivity-Temperature-Depth
CTRLR : Controller
D : Depth (CTD)
DVM : Digital Volt Meter
EQPT : Equipment
EXT : External
F : Fuse
FIG. : Figure
FREQ : Frequency
GND : Ground
I/O : Input/Output
J : Jack
kHz : Kilohertz
MEAS. : Measure
ms : Milliseconds
MSG : Message
OSCOPE : Oscilloscope
P : Plug
P.S. : Power Supply
PER1 : Peripherals 1
PER2 : Peripherals 2
PER3 : Peripherals 3
PREAMP : Preamplifier (1 through 4)
PRT : Pulse Repetition Time
PWR AMP : Power Amplifier
PWR REG : Power Regulator
R : Resistor
RAM : RAM/Multiplier
RCVR : Receiver 1 through 4
REPL : Replace
S, s : Switch, seconds
SH. : Sheet
SYNC. : Synchro
T : Temperature (CTD)
TEMP : Temperature
TP : Test Point
V1,V2 : Primary system voltages
V4 : Primary CTD power
XDCR : Transducer
XDCR COMP : Transducer Compensation
XMIT : Transmit

Table 6-2. BIT Result Codes and Corrective Actions

Dec.	Hex	BIT Result	Corrective Action Sequence
000	00	NONE (BIT GO)	Not required
001	01	LO1 FREQUENCY ERROR	Replace Peripherals 1
002	02	CPU CLOCK FREQUENCY ERROR	Replace CPU board
003	03	BAUD RATE FREQUENCY ERROR	Replace Peripherals 2
004	04	MM 810-2 ONE-SHOT ERROR	Replace Peripherals 2
005	05	REAL TIME CLOCK FREQ	Replace Peripherals 2
006	06	D/A - A/D CONVERSION	Replace Peripherals 2
007	07	MULTIPLIER RESULTS	Replace RAM/Multiplier
008	08	DIVIDER RESULTS	Replace Peripherals 1
009	09	ROM CHECKSUM ERROR	Replace CPU board
010	0A	RAM READ/WRITE ERROR	Replace RAM/Multiplier
011	0B	RAM ADDRESSING ERROR	Replace RAM/Multiplier
012	0C	FLUX GATE TIMEOUT	Replace Peripherals 3
013	0D	BAD TRANSDUCER PROM	1) Check for loose transducer cable 2) Replace Transducer Comp
*	*	BEAM *n* FREQUENCY ERROR For any combination of BEAM *n* errors (where *n* = 1, 2, 3, or 4), replace boards in sequence until a BIT GO is indicated. For errors on all beams, do step 2 first.	1) Replace Receiver *n* 2) Replace Butterfly 3) Replace Peripherals 2 4) Replace Peripherals 1 5) Replace RAM/Multiplier 6) Replace CPU
081	51	VERY LOW TRANSMITTER CURRENT	1) Check fuses on Power Supply 2) Replace Power Amplifier 3) Replace Power Supply board
082	52	LOW TRANSMITTER CURRENT (Battery alert for SC-ADCPs)	1) Check batteries (SC-ADCPs) 2) Replace Power Amplifier 3) Replace Power Supply board
083	53	HIGH TRANSMITTER CURRENT	1) Check transducer and cables 2) Replace Power Amplifier

*NOTE: See Table 6-3 for a breakdown of these beam-related codes.

Table 6-3. Breakdown of Beam-Related BIT Result Codes

Beam 1 Code Dec	Beam 1 Code Hex	Beam 2 Code Dec	Beam 2 Code Hex	Beam 3 Code Dec	Beam 3 Code Hex	Beam 4 Code Dec	Beam 4 Code Hex	AGC Level Error	Signal Level Error	Spect Width Error	Dopp. Freq. Error
017	11	033	21	049	31	065	41				X
018	12	034	22	050	32	066	42			X	
019	13	035	23	051	33	067	43			X	X
020	14	036	24	052	34	068	44		X		
021	15	037	25	053	35	069	45		X		X
022	16	038	26	054	36	070	46		X	X	
023	17	039	27	055	37	071	47		X	X	X
024	18	040	28	056	38	072	48	X			
025	19	041	29	057	39	073	49	X			X
026	1A	042	2A	058	3A	074	4A	X		X	
027	1B	043	2B	059	3B	075	4B	X		X	X
028	1C	044	2C	060	3C	076	4C	X	X		
029	1D	045	2D	061	3D	077	4D	X	X		X
030	1E	046	2E	062	3E	078	4E	X	X	X	
031	1F	047	2F	063	3F	079	4F	X	X	X	X

Table 6-4. EPROM Recorder Error Codes

The format of the error codes for EPROM recorder TEST 1 and TEST 2 is:

*ERROR *eee CCC ccc sssss bbb*

where:

eee = Decimal error code / recorder status byte (0-255). Convert this value to binary, and then decode as follows:

Bit	Flag
0	EPRDRS power failure
1	EPRDRS busy failure
2	EPRDRS write failure
3	Byte already written
4	Card is present
5	Chip is present
6	EPRDRS is full
7	EPRDRS failure

CCC = Memory card selected when error occurred (1-20) *[NOTE: If chips 000 and 001 are bad, CCC = 021]*

ccc = Memory chip selected when error occurred (0-7)

sssss = Chip sector selected when error occurred (0-511)

bbb = Byte address selected when error occurred (0-255)

The format of the error codes for recorder TEST 3 is:

```
Card 01: 00  01  02  03  04  05  06  07  : GOOD: 8
Card 02: 00  01  02  03  04  05* 06  07  : GOOD: 7
Card 03: 00  01  02U 03  04U 05  06  07  : GOOD: 6
Card 04: NOT PRESENT
   :             :           :           :
Card 19: 00  01  02  03  04  05M 06  07  : GOOD: 7
Card 20: 00  01  02  03  04  05  06  07  : GOOD: 8
CAPACITY: 40960
```

where:

* = bad EPROM chip

U = used (unerased) EPROM chip

M = missing EPROM chip

NOT PRESENT = missing card

Table 6-5. Quick-Start Setup Procedure for DUMBTERM.EXE

Here is a brief description of how to set up the DUMBTERM.EXE program. Detailed information is on the DUMBTERM distribution disk.

1. Load DUMBTERM program.
2. Go to setup menu <F5>.
3. Use UP/DN arrow keys to select item to be changed.
4. Use <Enter> key to change selected item.
5. Exit setup menu <Esc>.
6. Save setup <F6>.
7. Press <End> key to send BREAK signal to the ADCP.

SC-ADCP Defaults	DR-ADCP Defaults	VM-ADCP Defaults
Baud rate: 9600	Baud rate: 19200	Baud rate: N/A
Parity : None	Parity : Odd	Parity : N/A
Stop bits: 1	Stop bits: 1	Stop bits: N/A
Data bits: 8	Data bits: 8	Data bits: N/A
Interface: Serial	Interface: Serial	Interface: GPIB

Table 6-6. End-Around Test Procedure

The purpose of an end-around test is to help determine if the serial board installed in your computer is working. The idea is to connect the output lines of your serial board to the input lines. You then load DUMBTERM.EXE, or some other dumb terminal emulator, and type on the keyboard. The characters typed on the keyboard should echo on the computer screen. Proceed as follows:

1. Locate your computer's serial port.
2. Jumper the output line to the input line (typically pins 2 and 3 for RS-232). Refer to the manufacturer pin descriptions for your serial board. Leave GROUND unattached.
3. Load DUMBTERM, set the serial communications parameters, and define the correct serial port number (e.g., COM1, COM2).
4. Exit the setup menu and type some characters. If the serial port is working, you should see your keystrokes appear on the computer screen exactly as you typed them.

You also can check the output of the RS-422 converter box in this manner. Failure of this test may indicate a faulty serial board.

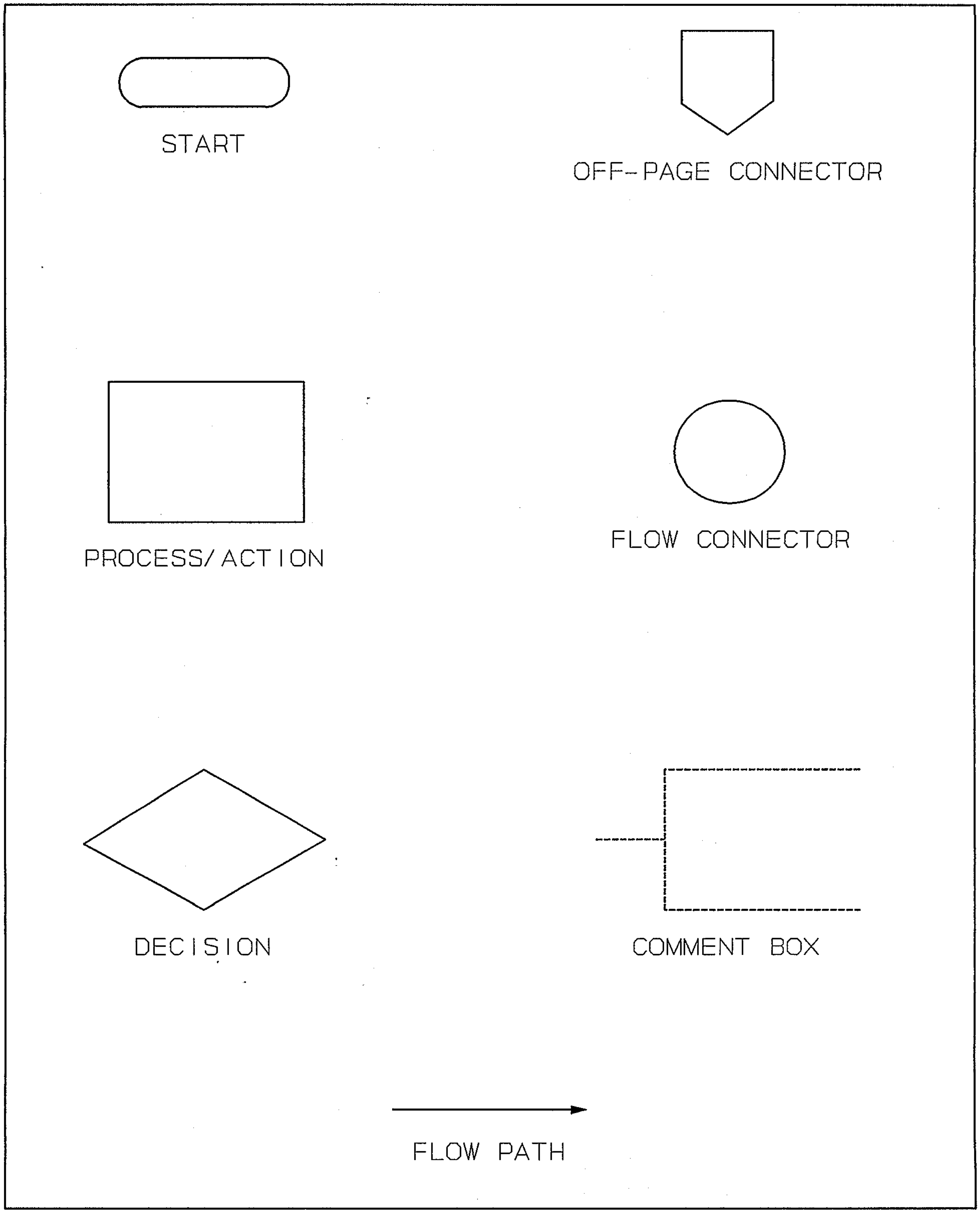


Figure 6-1. Troubleshooting Flow Chart Symbols

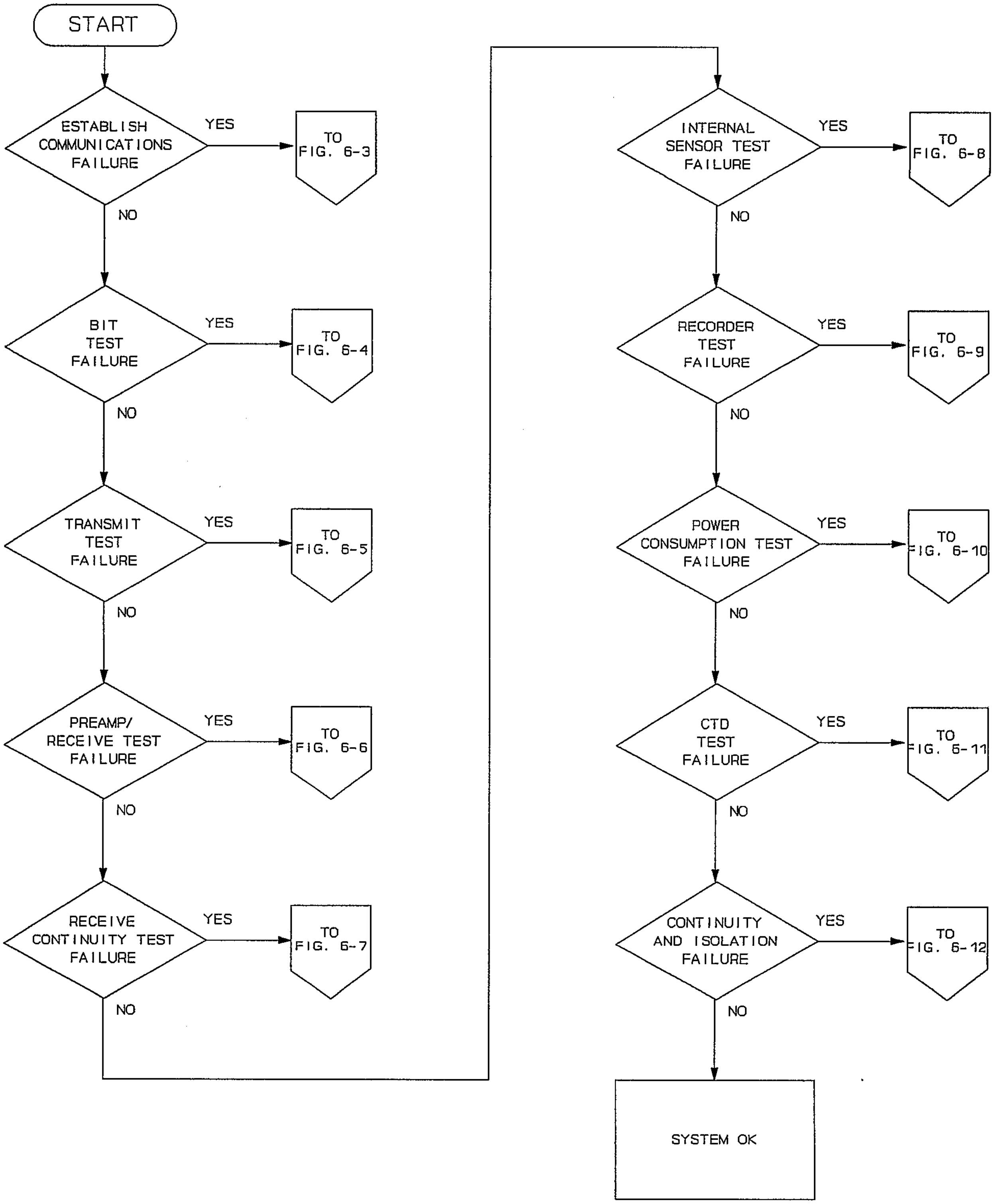


Figure 6-2. SCTEST Failure Troubleshooting Flow Chart

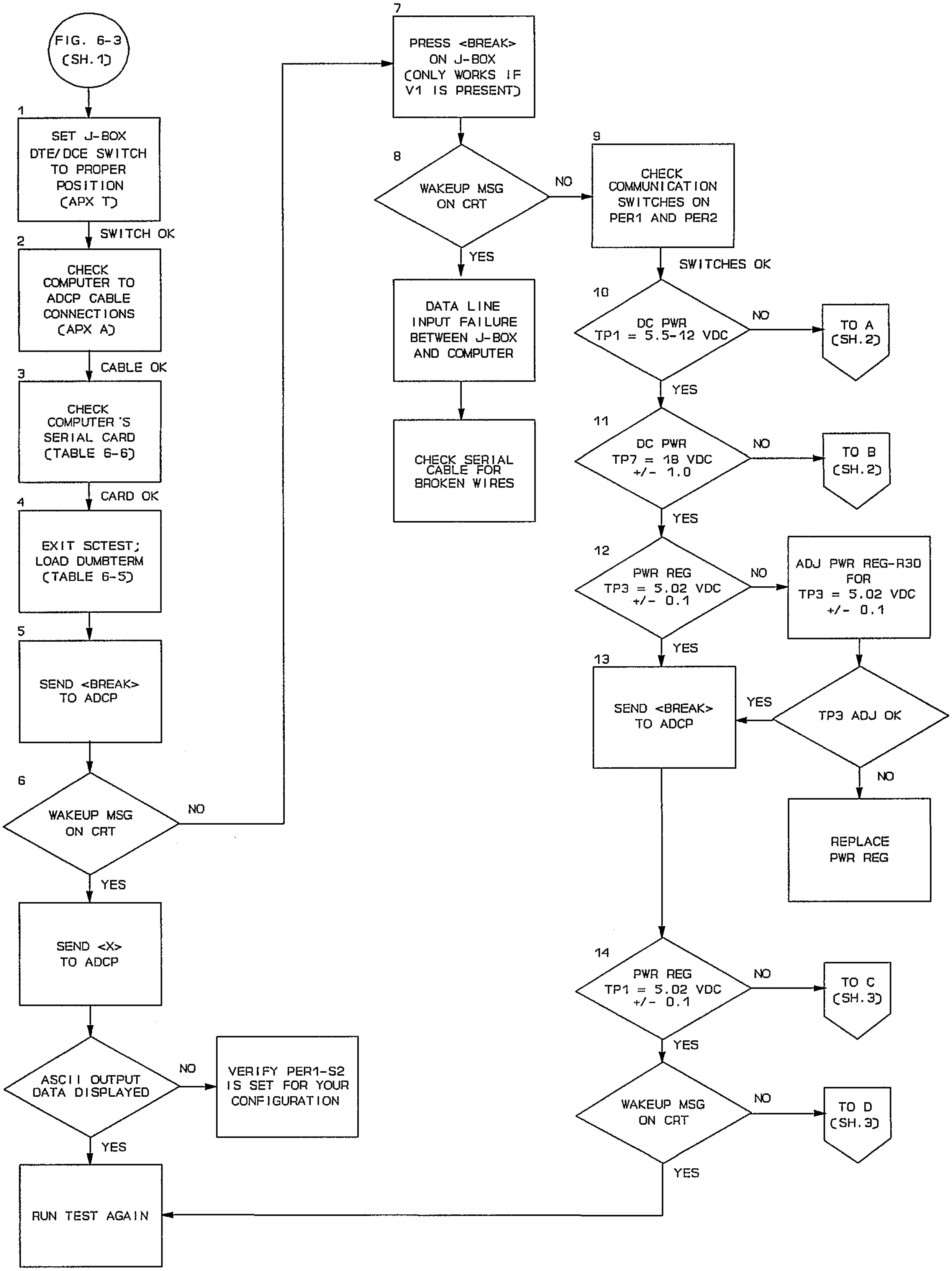


Figure 6-3. Establish Communications Failure Flow Chart (Sheet 1 of 3)

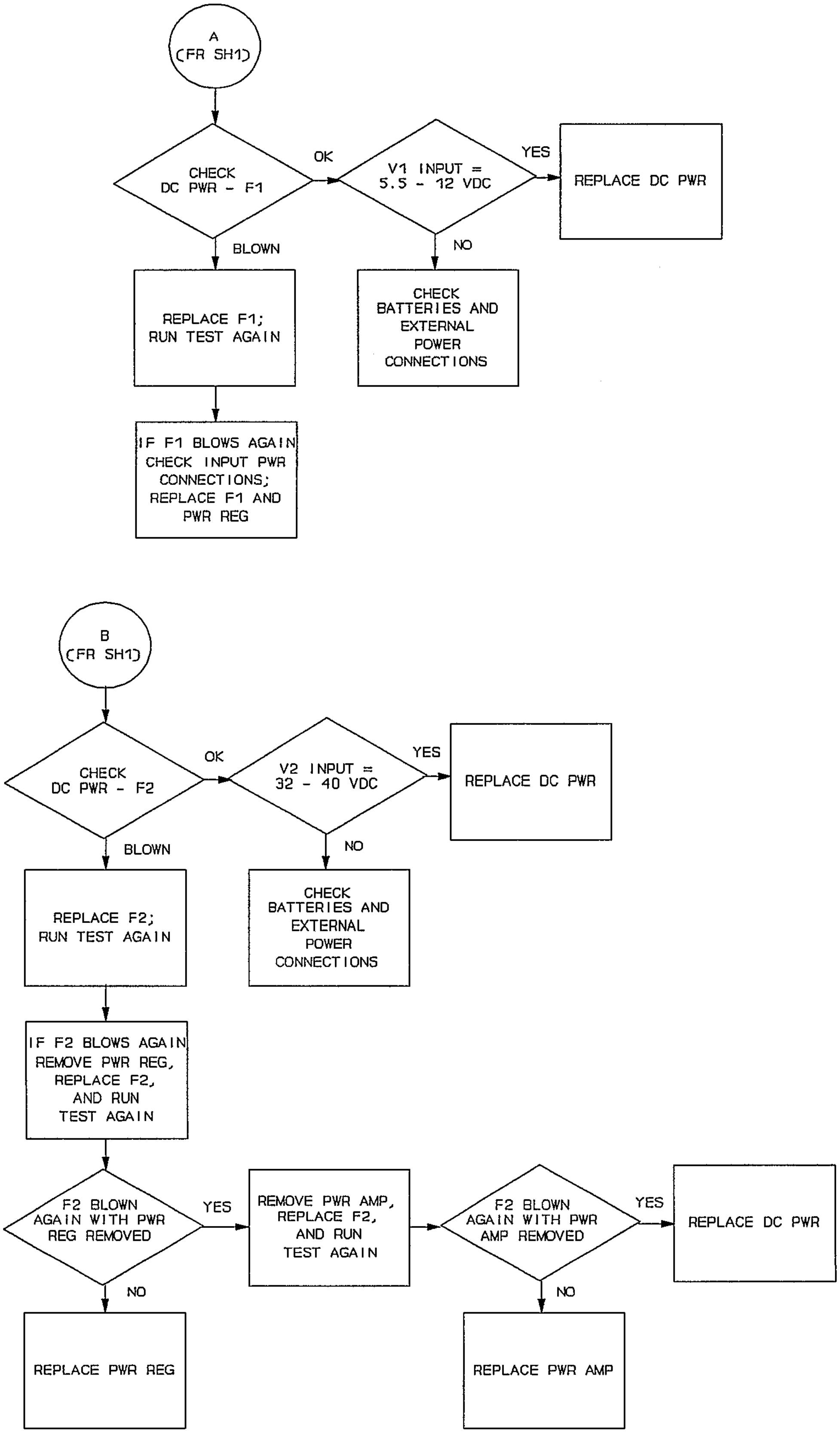
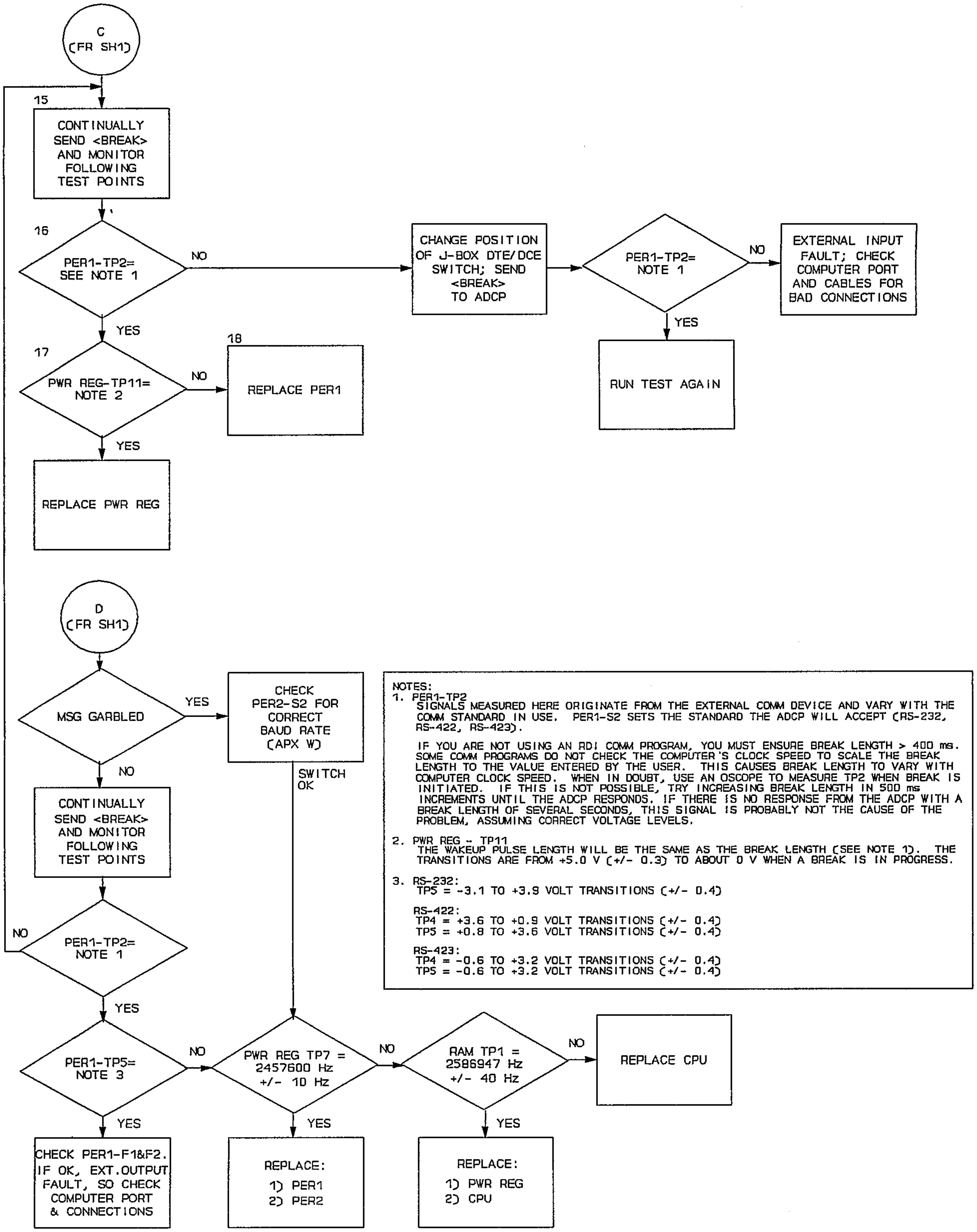


Figure 6-3. Establish Communications Failure Flow Chart (Sheet 2 of 3)



NOTES:

1. PER1-TP2
   SIGNALS MEASURED HERE ORIGINATE FROM THE EXTERNAL COMM DEVICE AND VARY WITH THE COMM STANDARD IN USE. PER1-S2 SETS THE STANDARD THE ADCP WILL ACCEPT (RS-232, RS-422, RS-423).

   IF YOU ARE NOT USING AN RDI COMM PROGRAM, YOU MUST ENSURE BREAK LENGTH > 400 ms. SOME COMM PROGRAMS DO NOT CHECK THE COMPUTER'S CLOCK SPEED TO SCALE THE BREAK LENGTH TO THE VALUE ENTERED BY THE USER. THIS CAUSES BREAK LENGTH TO VARY WITH COMPUTER CLOCK SPEED. WHEN IN DOUBT, USE AN OSCOPE TO MEASURE TP2 WHEN BREAK IS INITIATED. IF THIS IS NOT POSSIBLE, TRY INCREASING BREAK LENGTH IN 500 ms INCREMENTS UNTIL THE ADCP RESPONDS. IF THERE IS NO RESPONSE FROM THE ADCP WITH A BREAK LENGTH OF SEVERAL SECONDS, THIS SIGNAL IS PROBABLY NOT THE CAUSE OF THE PROBLEM, ASSUMING CORRECT VOLTAGE LEVELS.

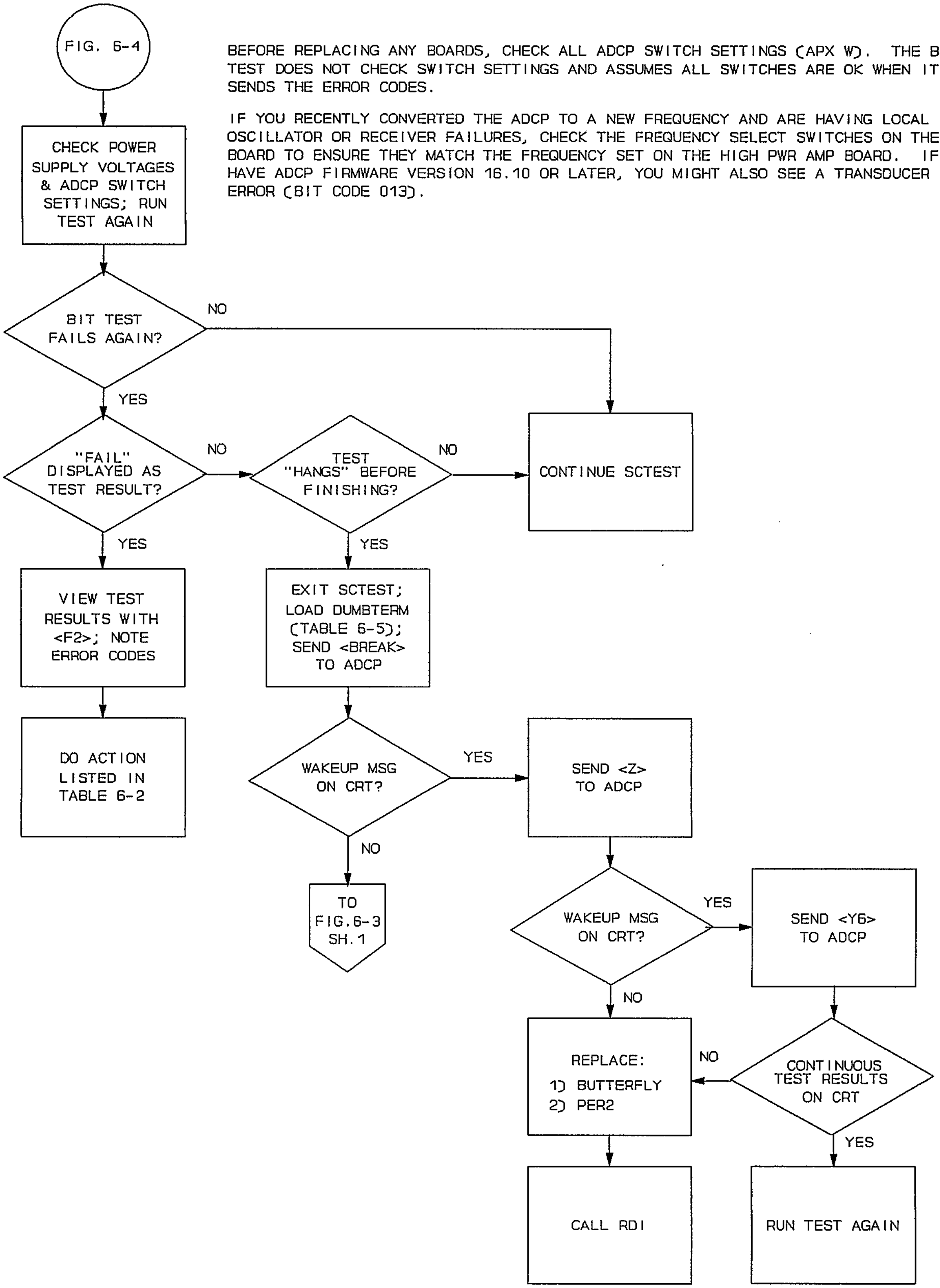
2. PWR REG - TP11
   THE WAKEUP PULSE LENGTH WILL BE THE SAME AS THE BREAK LENGTH (SEE NOTE 1). THE TRANSITIONS ARE FROM +5.0 V (+/- 0.3) TO ABOUT 0 V WHEN A BREAK IS IN PROGRESS.

3. RS-232:
   TP5 = -3.1 TO +3.9 VOLT TRANSITIONS (+/- 0.4)

   RS-422:
   TP4 = +3.6 TO +0.9 VOLT TRANSITIONS (+/- 0.4)
   TP5 = +0.8 TO +3.6 VOLT TRANSITIONS (+/- 0.4)

   RS-423:
   TP4 = -0.6 TO +3.2 VOLT TRANSITIONS (+/- 0.4)
   TP5 = -0.6 TO +3.2 VOLT TRANSITIONS (+/- 0.4)

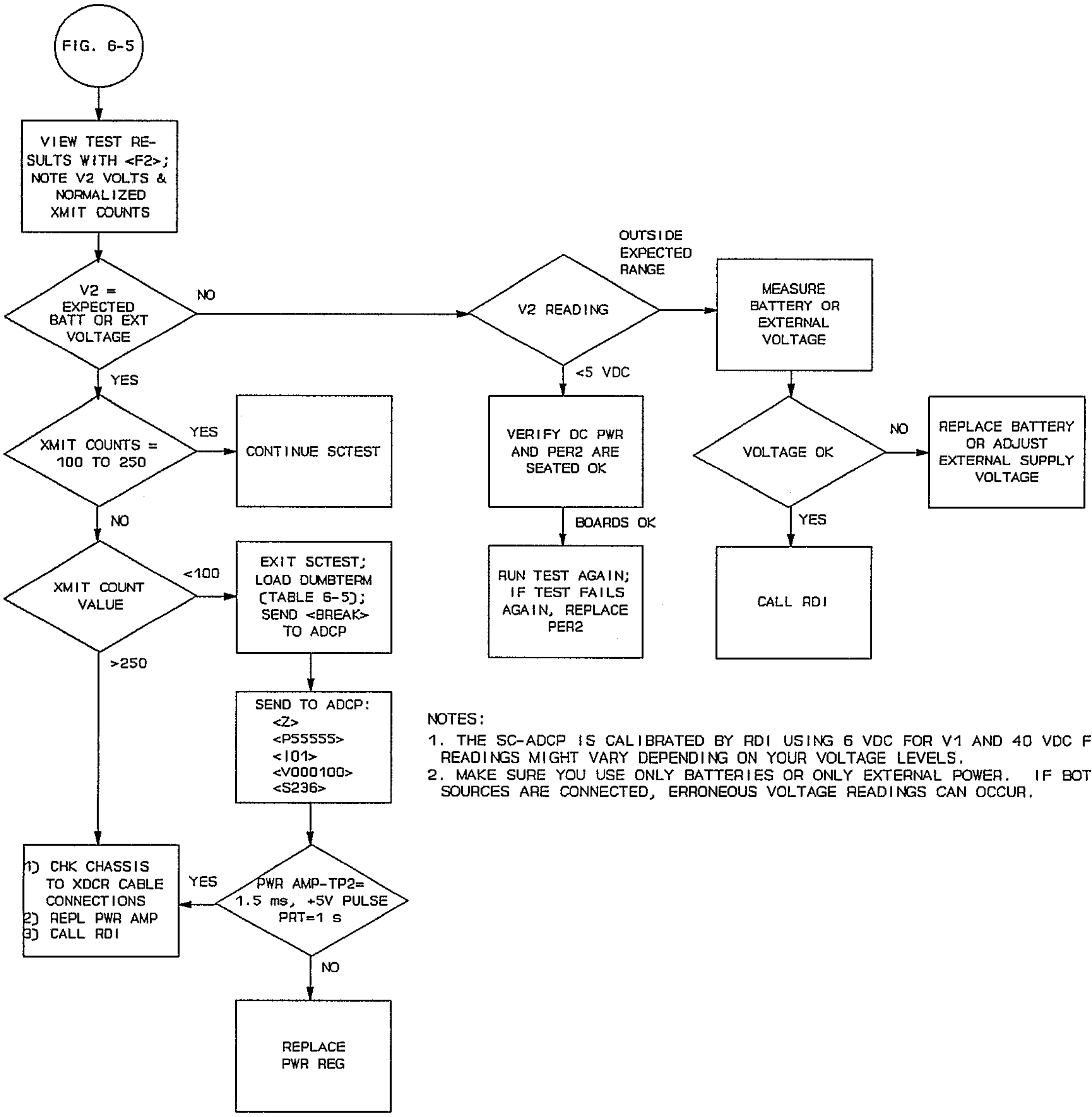
Figure 6-3. Establish Communications Failure Flow Chart (Sheet 3 of 3)



BEFORE REPLACING ANY BOARDS, CHECK ALL ADCP SWITCH SETTINGS (APX W). THE BIT TEST DOES NOT CHECK SWITCH SETTINGS AND ASSUMES ALL SWITCHES ARE OK WHEN IT SENDS THE ERROR CODES.

IF YOU RECENTLY CONVERTED THE ADCP TO A NEW FREQUENCY AND ARE HAVING LOCAL OSCILLATOR OR RECEIVER FAILURES, CHECK THE FREQUENCY SELECT SWITCHES ON THE PER1 BOARD TO ENSURE THEY MATCH THE FREQUENCY SET ON THE HIGH PWR AMP BOARD. IF YOU HAVE ADCP FIRMWARE VERSION 16.10 OR LATER, YOU MIGHT ALSO SEE A TRANSDUCER PROM ERROR (BIT CODE 013).

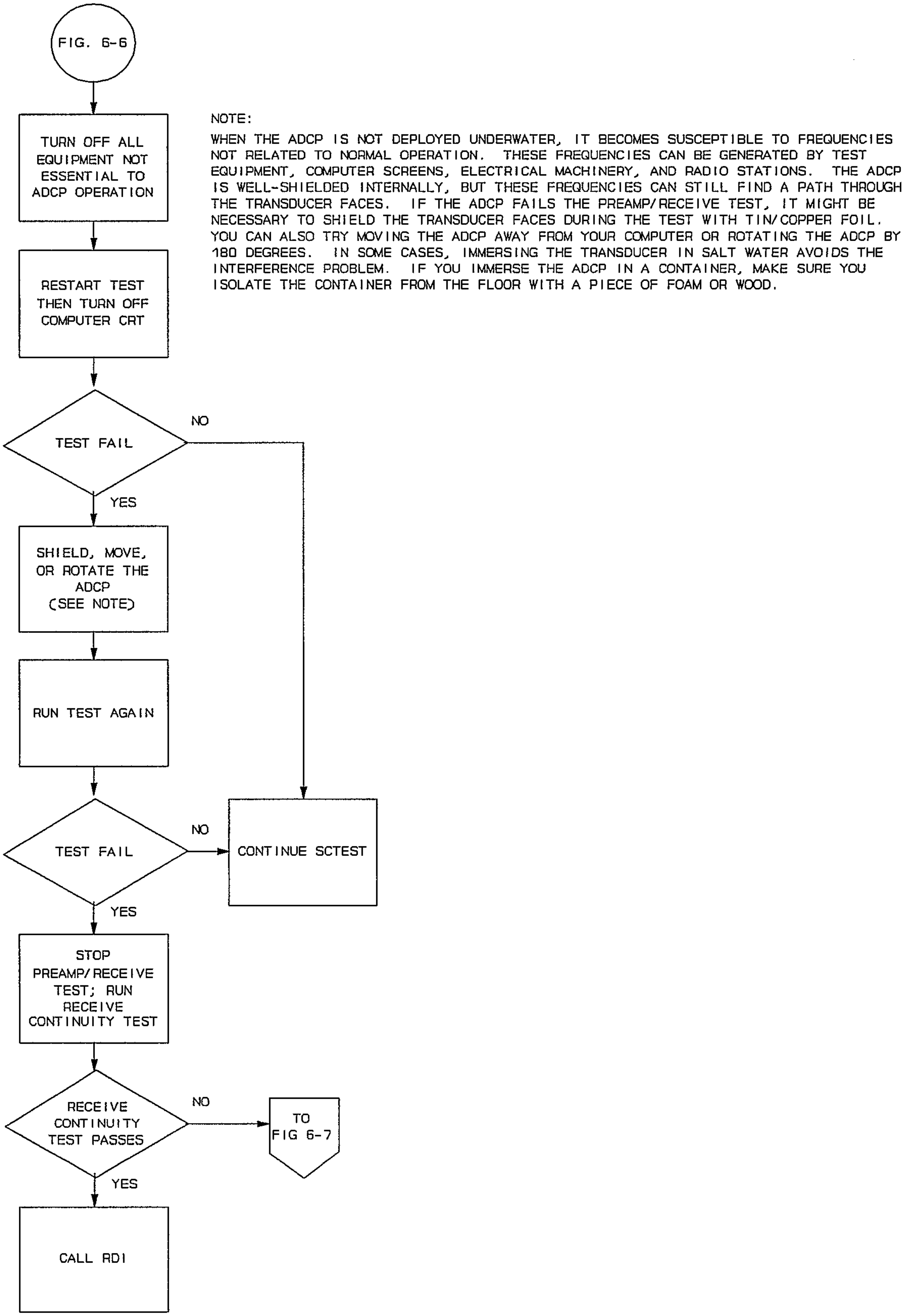
Figure 6-4. BIT Test Failure Flow Chart



NOTES:

1. THE SC-ADCP IS CALIBRATED BY RDI USING 6 VDC FOR V1 AND 40 VDC FOR V2. YOUR READINGS MIGHT VARY DEPENDING ON YOUR VOLTAGE LEVELS.
2. MAKE SURE YOU USE ONLY BATTERIES OR ONLY EXTERNAL POWER. IF BOTH POWER SOURCES ARE CONNECTED, ERRONEOUS VOLTAGE READINGS CAN OCCUR.

Figure 6-5. Transmit Test Failure Flow Chart



NOTE:

WHEN THE ADCP IS NOT DEPLOYED UNDERWATER, IT BECOMES SUSCEPTIBLE TO FREQUENCIES NOT RELATED TO NORMAL OPERATION. THESE FREQUENCIES CAN BE GENERATED BY TEST EQUIPMENT, COMPUTER SCREENS, ELECTRICAL MACHINERY, AND RADIO STATIONS. THE ADCP IS WELL-SHIELDED INTERNALLY, BUT THESE FREQUENCIES CAN STILL FIND A PATH THROUGH THE TRANSDUCER FACES. IF THE ADCP FAILS THE PREAMP/RECEIVE TEST, IT MIGHT BE NECESSARY TO SHIELD THE TRANSDUCER FACES DURING THE TEST WITH TIN/COPPER FOIL. YOU CAN ALSO TRY MOVING THE ADCP AWAY FROM YOUR COMPUTER OR ROTATING THE ADCP BY 180 DEGREES. IN SOME CASES, IMMERSING THE TRANSDUCER IN SALT WATER AVOIDS THE INTERFERENCE PROBLEM. IF YOU IMMERSE THE ADCP IN A CONTAINER, MAKE SURE YOU ISOLATE THE CONTAINER FROM THE FLOOR WITH A PIECE OF FOAM OR WOOD.

Figure 6-6. Preamp/Receive Test Failure Flow Chart

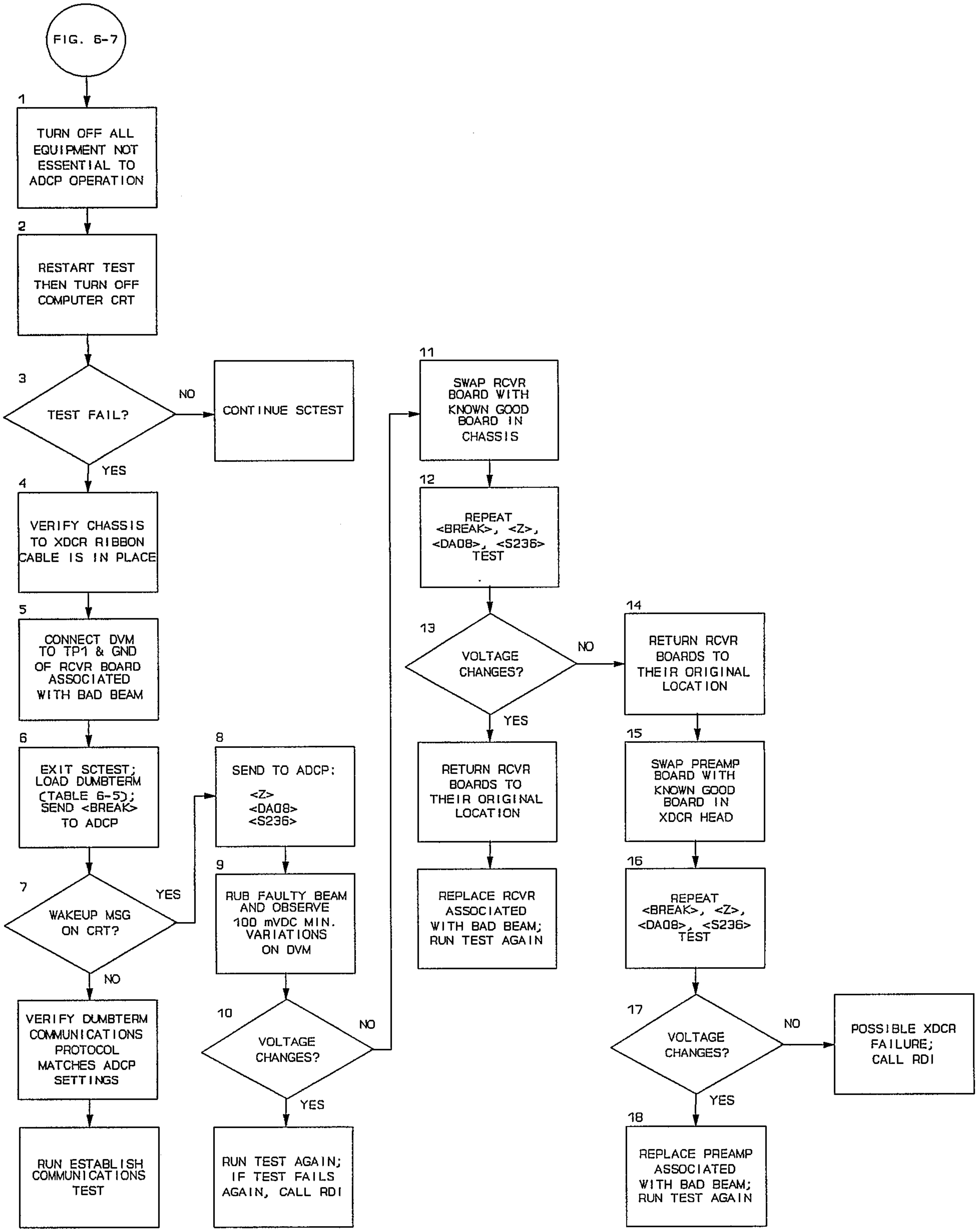


Figure 6-7. Receive Continuity Test Failure Flow Chart

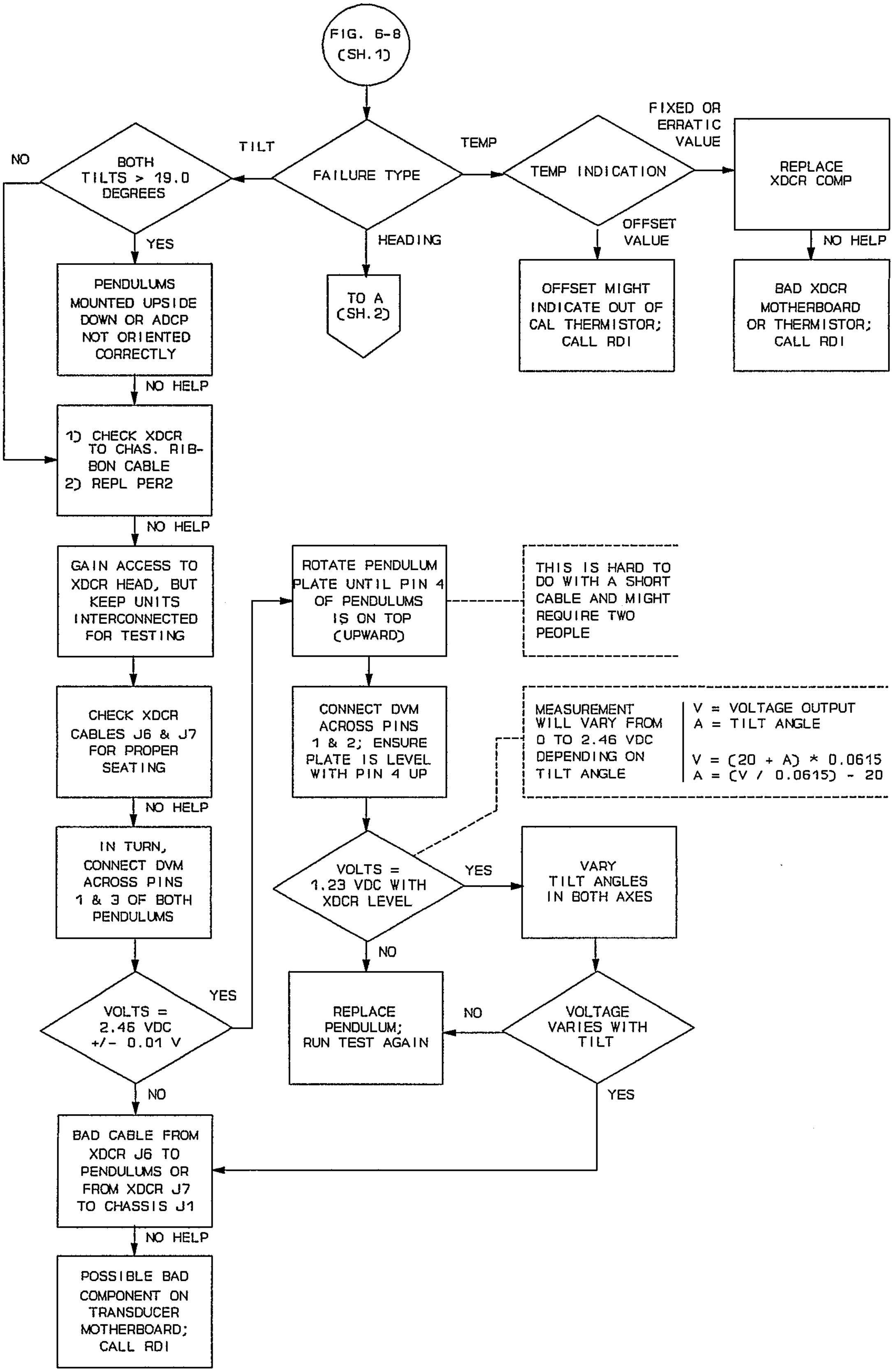
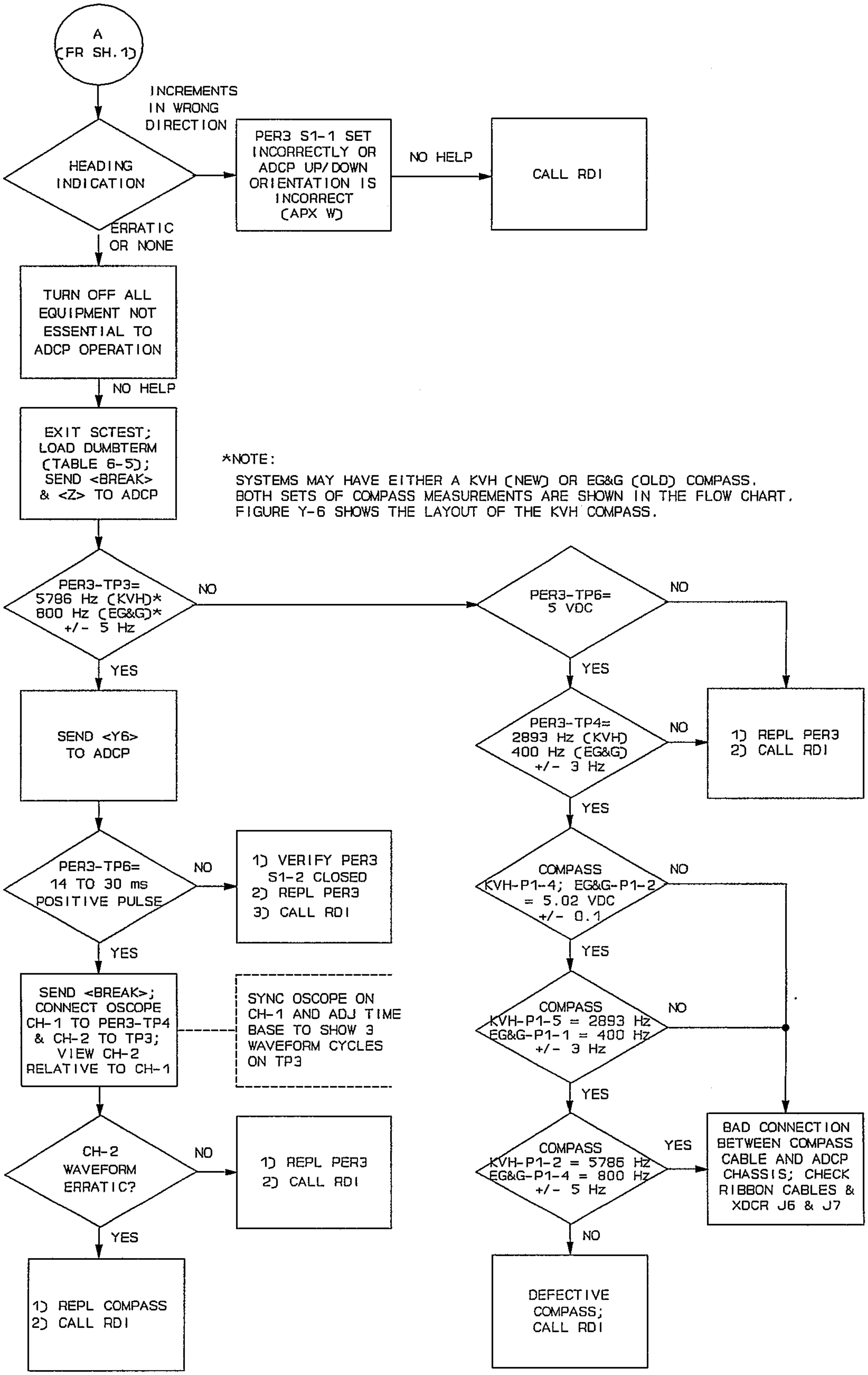


Figure 6-8. Internal Sensors Test Failure Flow Chart (Sheet 1 of 2)



*NOTE:

SYSTEMS MAY HAVE EITHER A KVH (NEW) OR EG&G (OLD) COMPASS. BOTH SETS OF COMPASS MEASUREMENTS ARE SHOWN IN THE FLOW CHART. FIGURE Y-6 SHOWS THE LAYOUT OF THE KVH COMPASS.

Figure 6-8. Internal Sensors Test Failure Flow Chart (Sheet 2 of 2)

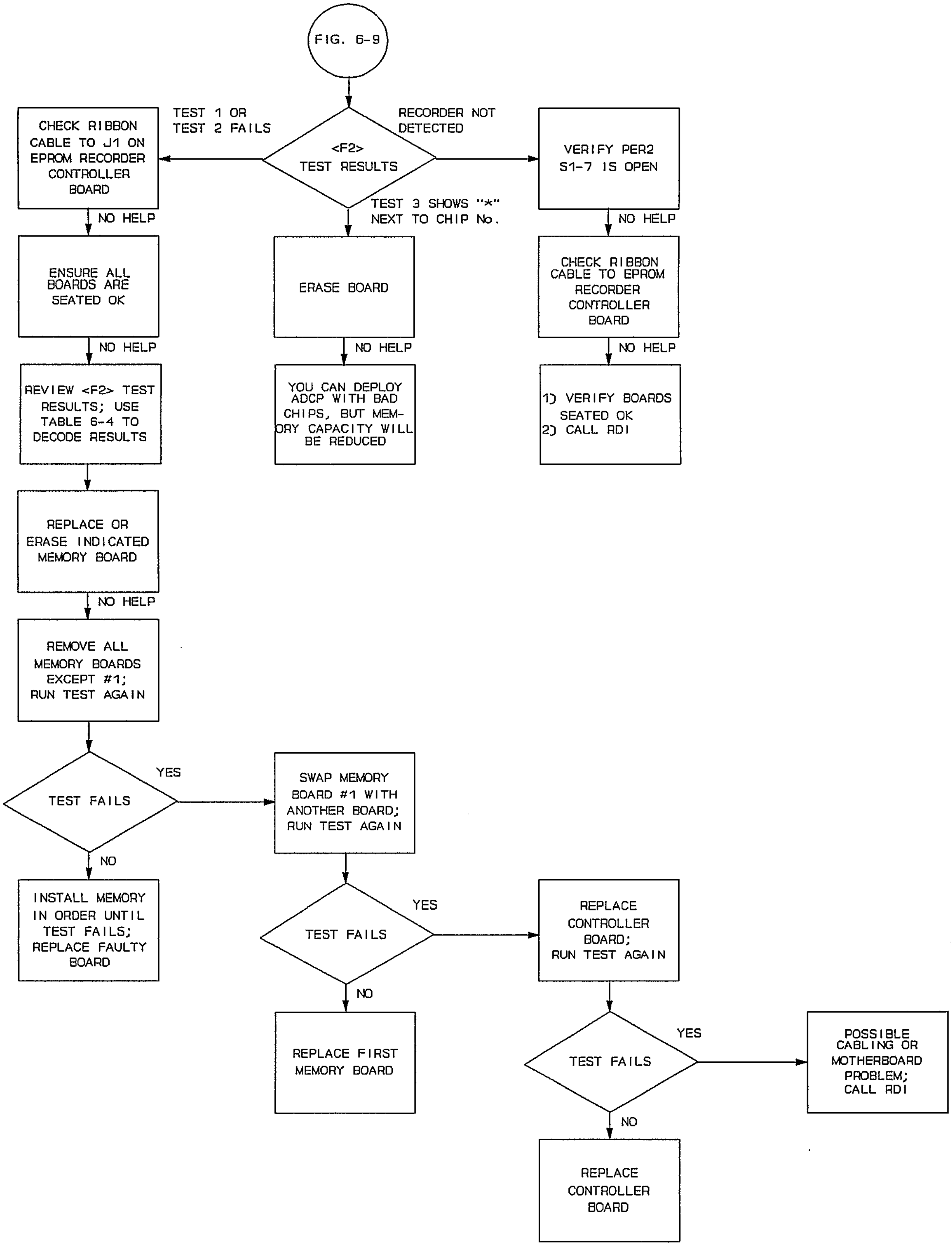


Figure 6-9. Recorder Test Failure Flow Chart

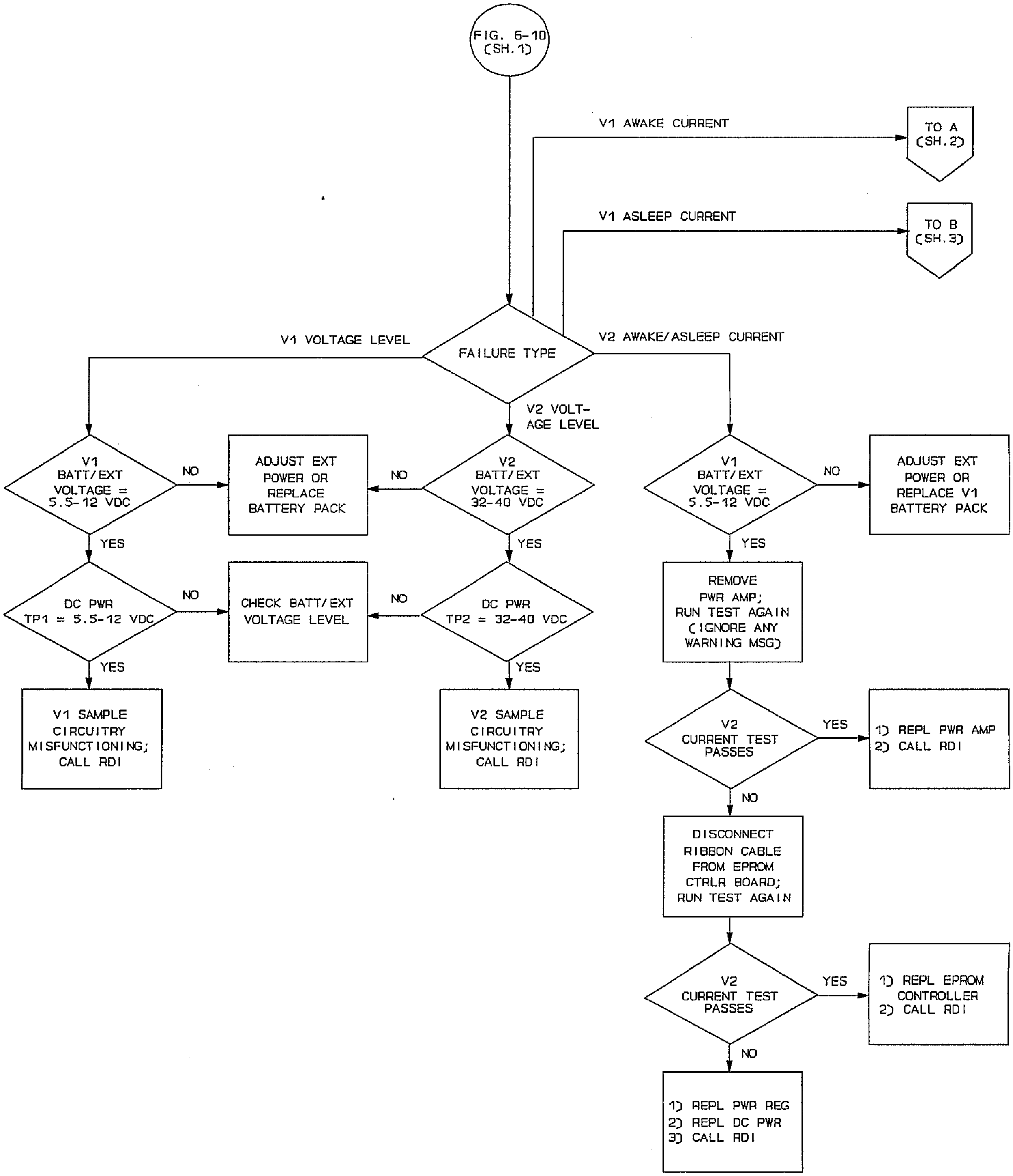


Figure 6-10. Power Consumption Test Failure Flow Chart (Sheet 1 of 3)

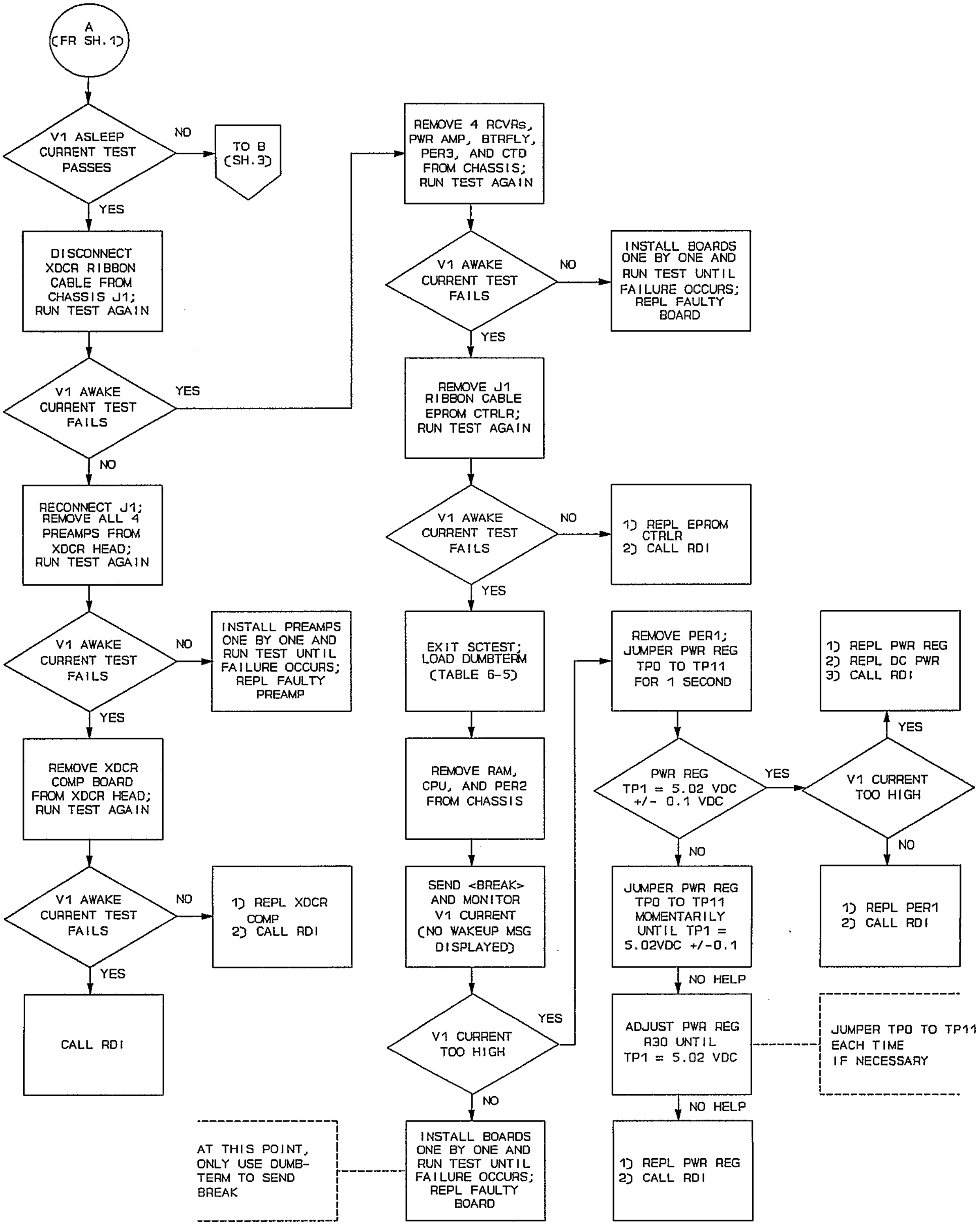


Figure 6-10. Power Consumption Test Failure Flow Chart (Sheet 2 of 3)

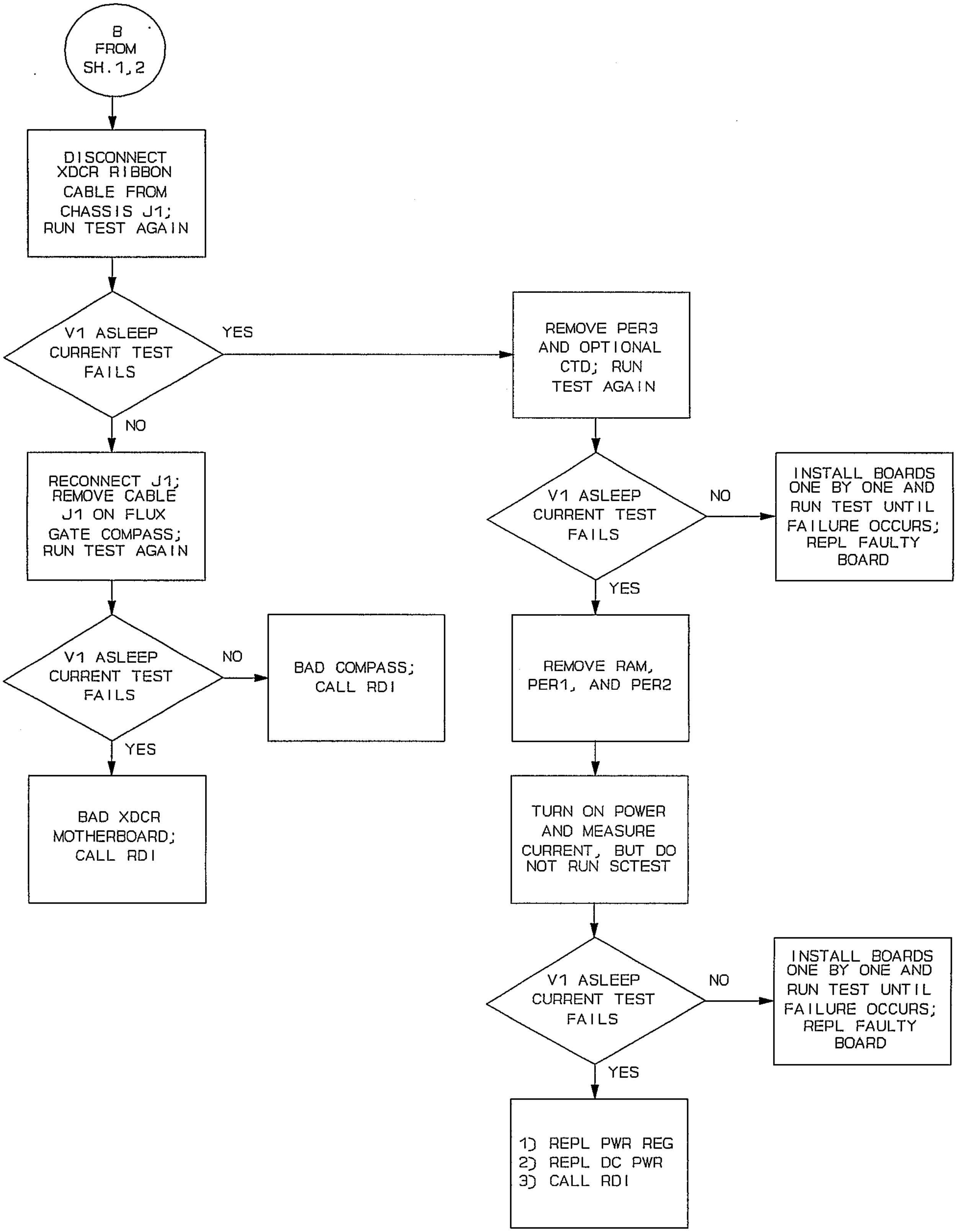


Figure 6-10. Power Consumption Test Failure Flow Chart (Sheet 3 of 3)

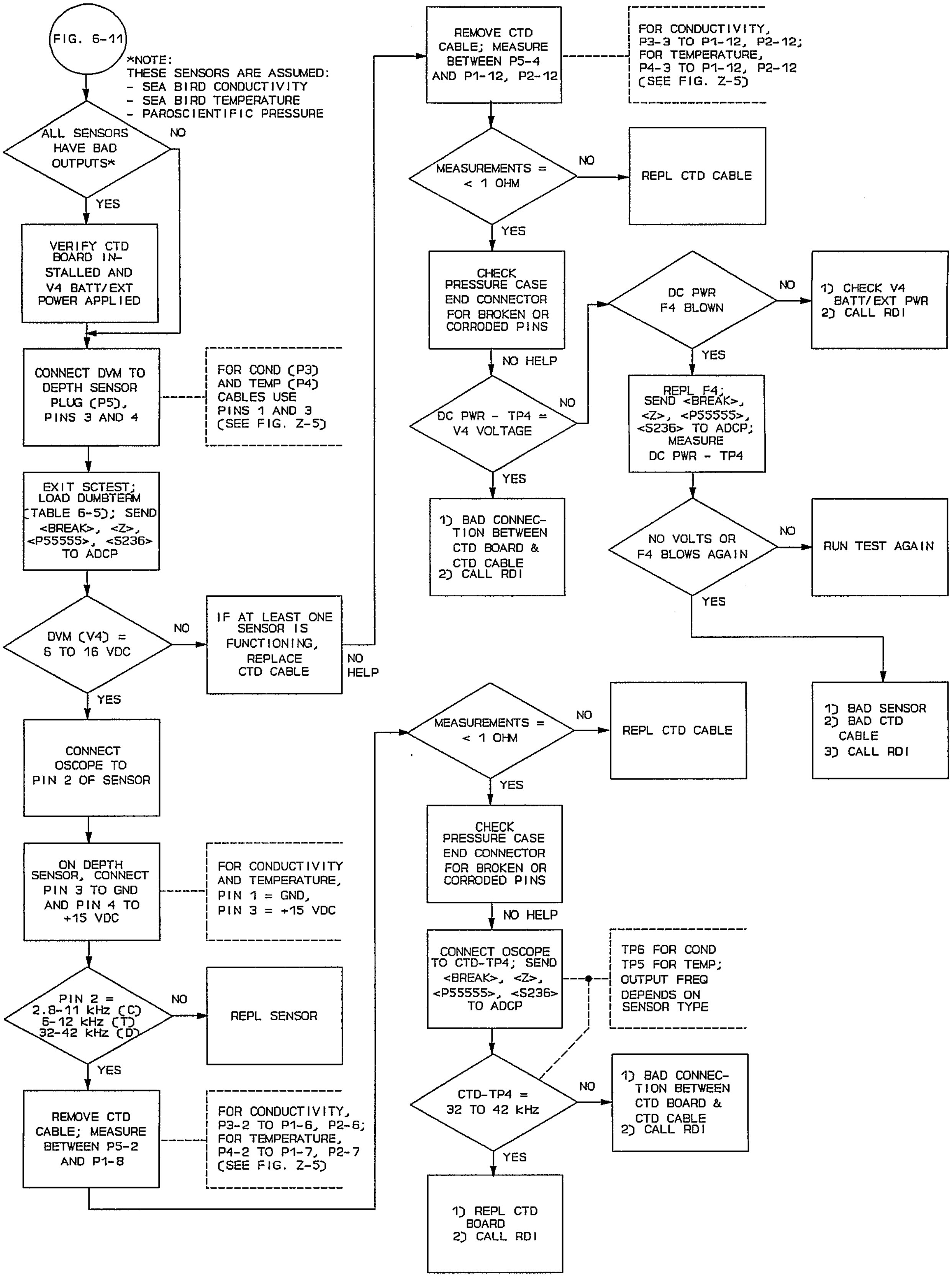


Figure 6-11. External CTD Sensors Test Failure Flow Chart

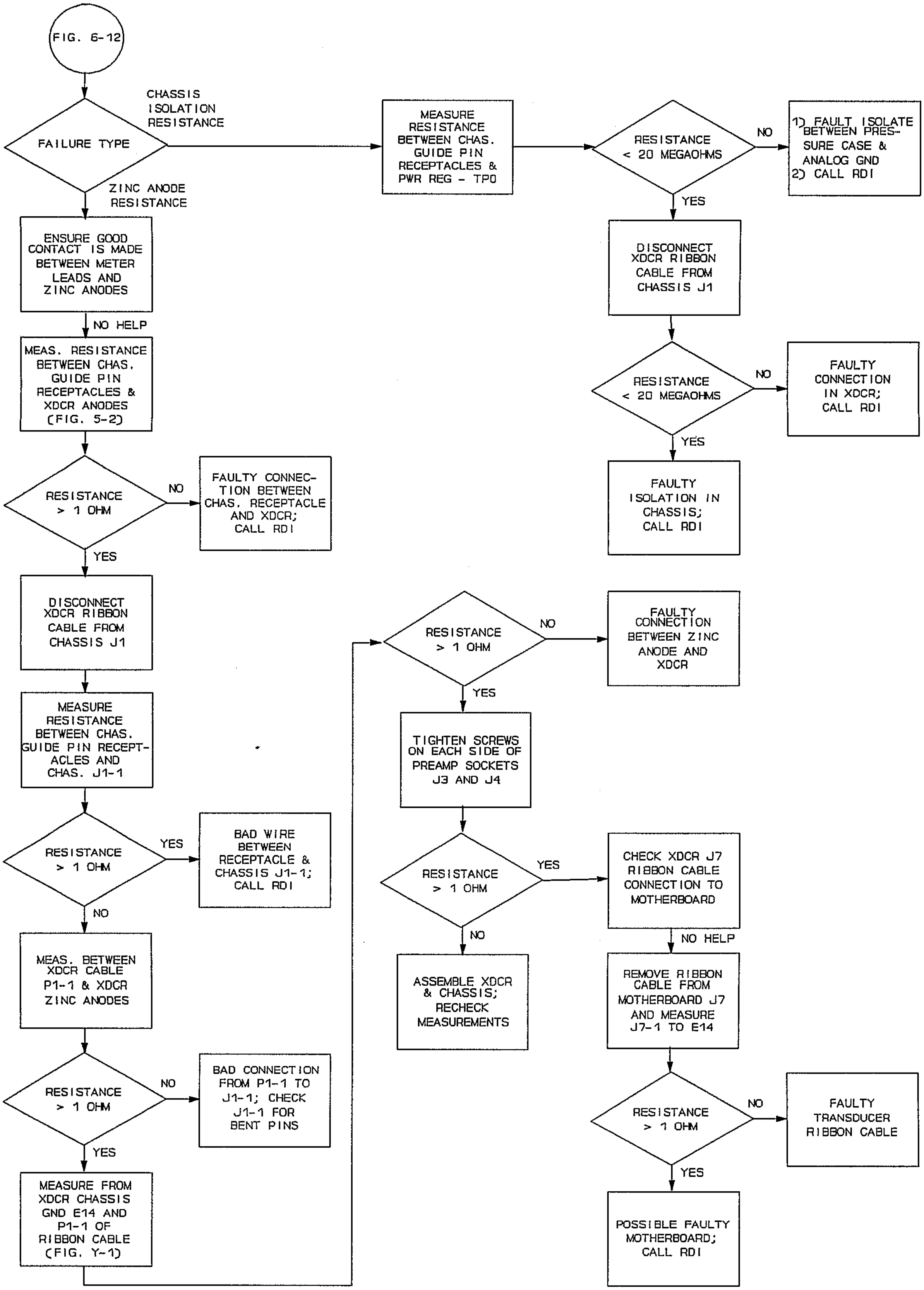


Figure 6-12. Continuity and Isolation Test Failure Flow Chart

APPENDIX A
SYSTEM INTERCONNECTION AND SETUP

A-0. INTRODUCTION

This appendix explains how to:

a. Connect the ADCP system for deployment, data retrieval, and testing.
b. Set up communication with the ADCP.
c. Check for the most common types of communication problems.

A-1. EQUIPMENT REQUIREMENTS

You need the following equipment to set up the ADCP system (Fig. A-1 and A-2).

a. SC-ADCP
b. RDI J-Box (Figure A-3)
c. Serial lab cable from SC-ADCP to J-Box
d. Serial cable from J-Box to computer/terminal (Table A-2)
e. CTD sensor(s) and harness, if you are using this option
f. Power supplies, either battery packs or external DC supplies (¶A-2)
g. One of the following:
    (1) An IBM PC/XT/AT-compatible computer running software developed to operate or test the ADCP. Examples of these programs include our SC-ADCP Deployment Program (SCADCP.EXE) and our SC-ADCP test program (SCTEST.EXE). Table A-1 lists the recommended minimum requirements for the computer.
    (2) A dumb terminal you can set to the following communications protocol: 9600 baud, no parity, 8 data bits, 1 stop bit, and a BREAK length of from 100 to 400 milliseconds.
    (3) A computer running a dumb terminal emulator program such as RDI's *DUMBTERM* or Microstuf's *Crosstalk*.

NOTE

YOU CAN SET UP/TEST THE ADCP USING ANY OF THESE METHODS, BUT METHOD (1) IS THE MOST EFFECTIVE WAY TO COMMUNICATE WITH AND CONTROL THE ADCP.

Table A-1. Minimum Recommended Computer Hardware Requirements

IBM PC/XT/AT-compatible computer with 80286 (or later) microprocessor
640 KB of memory
DOS 2.0 (or later)
Enhanced Graphics Adapter (EGA) with EGA monitor
One floppy disk drive
30-MB (or larger) hard disk drive
One serial port (COM1 or COM2)
Internal real-time clock with battery backup

A-2. POWER REQUIREMENTS

You can power the ADCP system in two ways – internal battery packs or external DC power supplies. If this is a real deployment, you MUST use battery packs (see Appendix B). If this is a practice deployment or maintenance test, you can use either batteries or external DC power supplies. We recommend using external DC power supplies for practice/testing to avoid draining the battery packs. You can connect the external DC power supplies in parallel with lithium battery packs because internal diodes protect the batteries. Alkaline battery packs do not have a protective diode. If using alkaline batteries with an external DC power supply, you MUST disconnect the alkaline battery packs. Table A-3 lists the recommended external DC power supply requirements. The table also lists the external DC power supply setting requirements with and without internal battery packs installed. These values make sure the ADCP uses the external DC power supply voltages, thereby preserving the batteries.

A-3. SYSTEM INTERCONNECTION

Use Figure A-1 and the following steps to interconnect the SC-ADCP system.

__ a. If using external DC power supplies, set them to the values listed in Table A-3 before connecting them to the ADCP, and then turn the power supplies OFF. Connect the V1, V2, and V4 (if using CTD sensors) external power supply output leads to the assigned jacks on the J-Box.

CAUTIONS

1. DAMAGE CAN RESULT IF THE MAXIMUM VOLTAGE SETTINGS ARE EXCEEDED.
2. LITHIUM BATTERY PACKS CAN BE CONNECTED IN PARALLEL WITH AN EXTERNAL DC POWER SUPPLY. ALKALINE BATTERY PACKS CANNOT BE CONNECTED IN PARALLEL WITH AN EXTERNAL DC POWER SUPPLY. IF USING ALKALINE BATTERY PACKS AND AN EXTERNAL DC POWER SUPPLY, DISCONNECT THE ALKALINE BATTERY PACKS BEFORE APPLYING EXTERNAL POWER TO THE ADCP.

__ b. If you are using battery packs and have not yet installed them, see Appendix B for installation instructions. If you are using batteries only, and you do not have the pressure case installed, cover the light sensor on the Power Regulator board. This prevents the LED display on the CPU board from illuminating. The LED uses about as much power as the entire ADCP.

__ c. You must have certain ADCP switches set correctly for serial communications (see Appendix W). RDI sets these switches at the factory, but check them if you have communication problems. Set switch S2 on the Peripherals 1 board for the mode (RS-232, RS-422, RS-423) and power (DC) types. Set switch S2 on the Peripherals 2 board for baud rate (9600), parity (none), output data format (ASCII), velocity scale factor (frequency dependent), and number of data bits (8).

__ d. On the J-Box (Figure A-3), set the DTE/DCE switch to DTE and the ADCP/RECORDER switch to ADCP. If you cannot establish communications after applying power to the system, setting the DTE/DCE switch to DCE may correct the problem.

__ e. Connect the J-Box serial lab cable between the ADCP and J-Box. NOTE: If you are using any CTD sensors, connect the CTD harness cable (RD-CTDHARN) between the ADCP and the J-Box.

__ f. Connect the serial cable between the J-Box and the computer/terminal. See Table A-2 for the proper wiring connections. Two types of serial connectors are commonly found on computers, RS-232 25-pin and 9-pin. The 25-pin connector is usually found on PC/XT models. The 9-pin connector is usually found on AT models and portable computers. RS-422 is less common on IBM-type computers, but expansion slot cards are available. If you use one, choose one that has opto-isolation.

NOTE

RS-232 CABLE TRANSMISSIONS ARE GOOD TO A DISTANCE OF ABOUT 30 METERS (100 FEET). RS-422 CABLE TRANSMISSIONS ARE GOOD TO A DISTANCE OF ABOUT 2000 METERS (6560 FEET).

__ g. If you are using external DC power supplies, turn them ON.

__ h. You must now set up the communications protocol. If you are using a dumb terminal, refer to its manual for protocol setting procedures. If you are using a computer with a terminal emulator program, you must set the protocol through the controlling software. In either case, use the following protocol.

(1) Baud rate - 9600
(2) Parity - None
(3) Data bits - 8
(4) Stop bits - 1
(5) BREAK length - 100 to 400 milliseconds

__ i. Apply power to the computer/terminal. You are now ready to talk to the ADCP.

__ j. If using the Deployment Program, refer to one of the following for additional procedures.

(1) SC-ADCP test procedures (Appendix T-1, this manual)
(2) Tutorial (Chapter 3, SC-ADCP Deployment Program User's Manual)
(3) Deployment procedures (Chapter 4, SC-ADCP Deployment Program User's Manual)
(4) Retrieval procedures (Chapter 5, SC-ADCP Deployment Program User's Manual)

__ k. If you are using a dumb terminal/emulator program (i.e., you are NOT using the Deployment Program), refer to one of the following.

(1) Wake-up procedures (¶A-4)
(2) SC-ADCP test procedures (Appendix T-2)
(3) SC-ADCP deployment procedures (Chapter 2)
(4) SC-ADCP retrieval procedures (Chapter 3)
(5) Explanation of direct commands (Appendix D)

NOTE

IF YOU CANNOT ESTABLISH COMMUNICATION WITH THE SC-ADCP, SEE ¶A-5.

A-4. WAKE-UP PROCEDURES FOR DUMB TERMINALS/EMULATORS

This section describes the wake-up procedures for systems using a dumb terminal or terminal emulator program. Wakeup is the process by which the ADCP sets up communication with a terminal.

Wakeup begins when the ADCP receives a BREAK signal. A BREAK is not a character but a "high" state on the serial IN line. The ADCP recognizes a BREAK that lasts 100 ms or longer. Terminals usually send breaks in the 100 to 400-ms range. To set up ADCP communications, proceed as follows.

__ a. Before trying to wake the ADCP, make sure you connect all components as described previously.

__ b. On the J-Box, set the ADCP/RECORDER switch to ADCP. Send a BREAK to the ADCP by pressing the BREAK pushbutton on the J-Box or the terminal. The green DATA OUT light should flash, and the terminal should display the following wake-up message.

```
ACOUSTIC DOPPLER CURRENT PROFILER
COPYRIGHT (c) RD INSTRUMENTS 1983 - 1992 ALL RIGHTS RESERVED
```

NOTE

MOST TERMINALS HAVE A BREAK KEY, SIMPLY PRESS THAT KEY. ON COMPUTERS USED AS TERMINAL EMULATORS THERE MAY NOT BE A KEY LABELED BREAK. IF THERE IS, THE KEY DOES NOT USUALLY SEND THE CORRECT SIGNAL. IN THESE CASES, A SOFTWARE COMMUNICATIONS PROGRAM DEFINES THE KEY OR KEY SEQUENCE THAT EXECUTES THE BREAK (SEE YOUR MANUAL). IF YOU ARE USING RDI'S DUMBTERM, PRESSING <END> SENDS THE BREAK SIGNAL. FOR EACH BREAK SENT, THE ADCP SHOULD RESPOND WITH THE WAKE-UP MESSAGE.

__ c. If the terminal displays the wake-up message, you have established communication with the ADCP. You can now do maintenance testing (Appendix T-2) or prepare the ADCP for deployment/retrieval using direct commands (Chapters 2 and 3, Appendix D).

__ d. If the wake-up message does not appear, send additional BREAK signals to the ADCP. If wakeup still does not occur, troubleshoot ADCP serial communications as described in ¶A-5.

A-5. SC-ADCP COMMUNICATION PROBLEMS

If you cannot establish communication with the SC-ADCP, proceed as follows.

__ a. Check the interconnection of the ADCP, lab cable, J-Box, serial cable, computer/terminal, and power supplies (¶A-3e, ¶A-3f).
__ b. Check the serial communication switch settings (¶A-3c).
__ c. Check RDI J-Box switch settings (¶A-3d).
__ d. Check communication protocol settings (terminals/emulators only; ¶A-3h).
__ e. Check serial cable wiring (¶A-3f).
__ f. Make sure the W3 jumper is in place on the Peripheral 1 board.
__ g. If using RS-422, check your interface card for proper configuration and wiring (if applicable).
__ h. If communication is still unsuccessful, see the detailed troubleshooting procedures in Chapter 6.

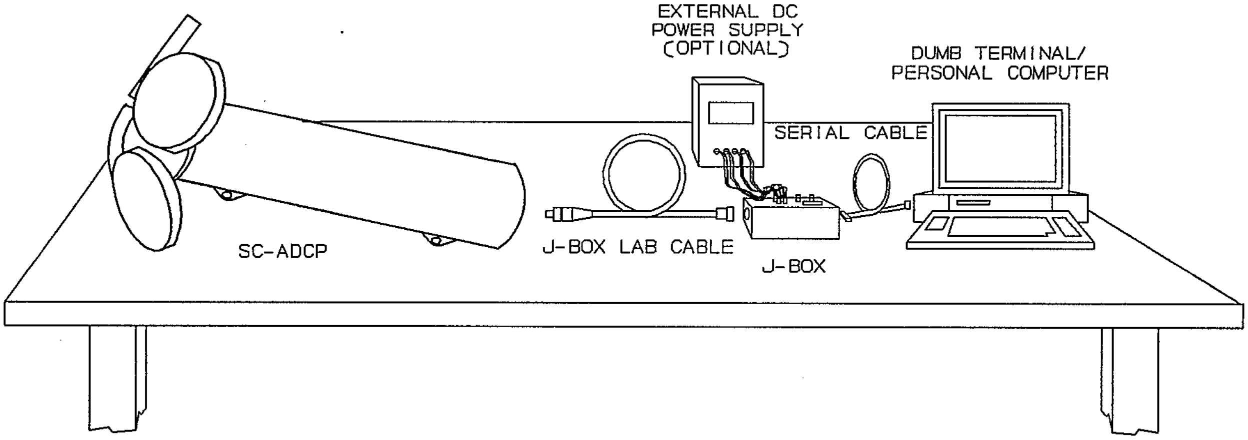
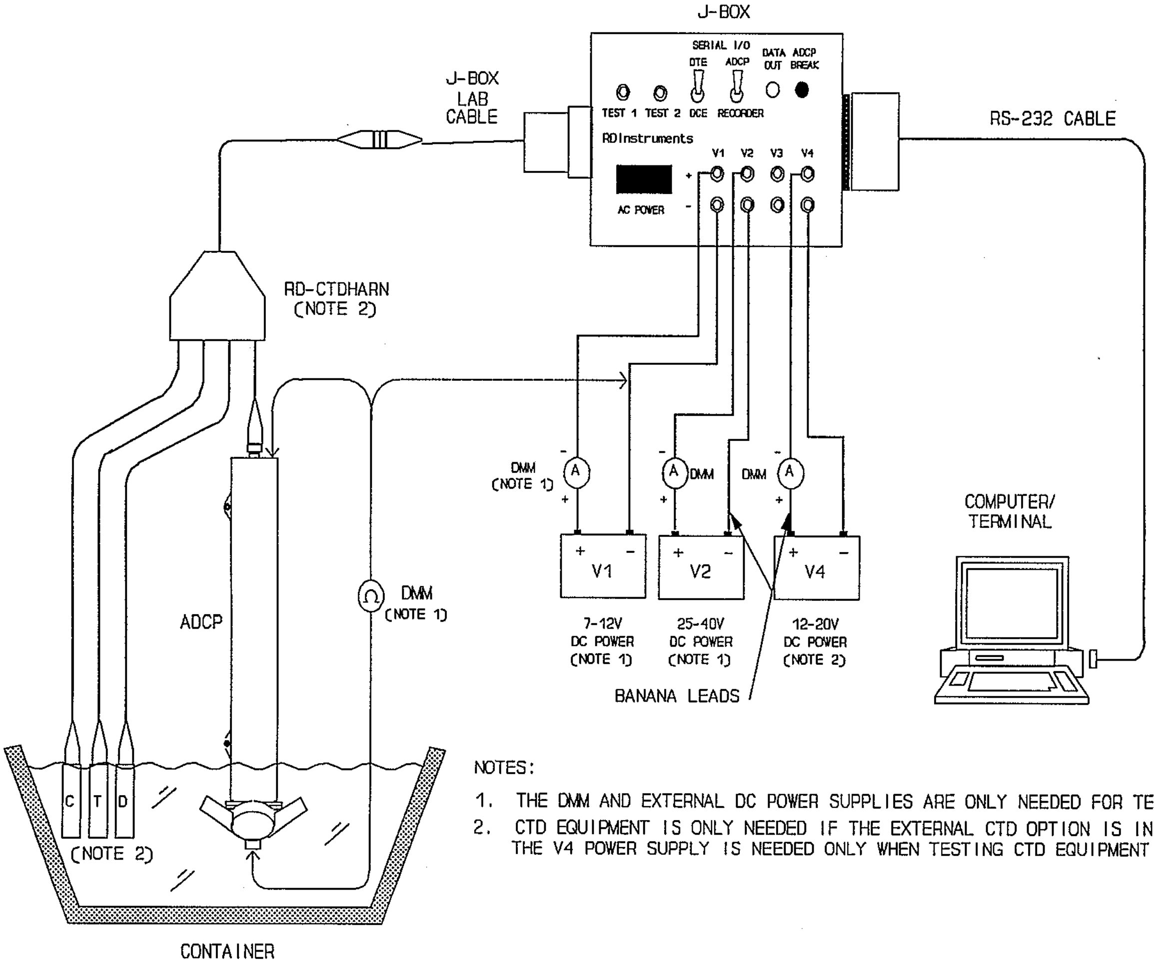


Figure A-1. SC-ADCP System Interconnection



NOTES:

1. THE DMM AND EXTERNAL DC POWER SUPPLIES ARE ONLY NEEDED FOR TESTING.
2. CTD EQUIPMENT IS ONLY NEEDED IF THE EXTERNAL CTD OPTION IS INSTALLED. THE V4 POWER SUPPLY IS NEEDED ONLY WHEN TESTING CTD EQUIPMENT.

Figure A-2. Test Equipment Interconnection

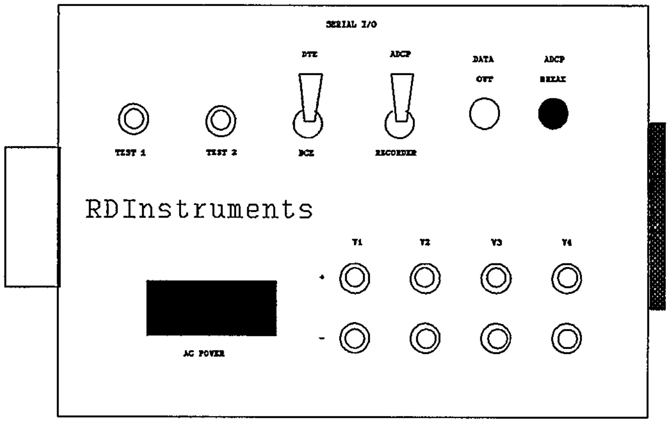


Figure A-3. SC-ADCP J-Box

Table A-2. Serial I/O Interface Cable Connections

SC-ADCP signal	J-Box	Computer	Computer signal
RS-232 (25-pin; usually PCs):			
DATA IN	2	2	DATA OUT
DATA OUT	3	3	DATA IN
GND	7	7	GND
RS-232 (9-pin; usually ATs):			
DATA IN	2	3	DATA OUT
DATA OUT	3	2	DATA IN
GND	7	5	GND
RS-422 (9-pin; computer pins differ):			
DATA IN B	2	-	DATA OUT (-)
DATA OUT B	3	-	DATA IN (-)
COMMON	7	-	COMMON
DATA OUT A	15	-	DATA IN (+)
DATA IN A	16	-	DATA OUT (+)

Table A-3. External DC Power Supply Requirements

Power supply	External voltage WITHOUT batteries connected (lithium or alkaline)		External voltage WITH batteries connected[1,2] (lithium only)		Amperage
	Minimum	Maximum	Minimum	Maximum	
V1	7 VDC	12 VDC	10 VDC	14 VDC	2.0 A
V2 (EPROM)	25 VDC	40 VDC[3]	39 VDC	40 VDC[3]	1.0 A
V4	12 VDC	20 VDC	16 VDC	20 VDC	0.1 A

NOTE:
1. WITH LITHIUM BATTERIES CONNECTED, THE EXTERNAL POWER SUPPLY IS IN PARALLEL WITH THE BATTERIES. THEREFORE, THE EXTERNAL VOLTAGE MUST BE MORE THAN THE INTERNAL BATTERY VOLTAGE.
2. CAUTION! DO NOT CONNECT ALKALINE BATTERY PACKS IN PARALLEL WITH AN EXTERNAL POWER SUPPLY.
3. CAUTION! GOING ABOVE 40 VDC MAY DAMAGE THE POWER AMPLIFIER BOARD.

NOTES

APPENDIX B
BATTERIES

B-0. INTRODUCTION

Batteries are used to power the SC-ADCP. You can use either lithium or alkaline battery packs. Because lithium batteries are the most used and have the highest capacity, we will focus on them. This appendix points out the special characteristics and precautions associated with lithium batteries, and explains how to determine battery capacity and power consumption. Section 5-12 explains how to install and test the batteries.

B-1. LITHIUM BATTERIES

Lithium batteries, or cells, exhibit four to five times the energy density of alkaline batteries. The small size, light weight, and ability to operate over wide temperature ranges make the lithium cell the preferred power source for the SC-ADCP. Lithium cells, however, differ from other types of primary cells. Lithium cells are also more dangerous. The following paragraphs describe lithium cells in more detail as they apply to the SC-ADCP. The paragraphs include the following information.

a. Warnings, cautions, and notes for lithium cell use
b. Discharge characteristics of lithium cells
c. Passivation of lithium cells
d. Depassivation of lithium cells
e. Determining when to replace lithium cells

NOTE

RDI RECOMMENDS USING TYPE CSC93 LITHIUM CELLS MANUFACTURED BY ELECTROCHEM INDUSTRIES, 10000 WEHRLE DRIVE, NEW YORK 14031. THE INFORMATION IN THIS APPENDIX APPLIES TO THIS TYPE OF CELL.

B-1.1. WARNINGS, CAUTIONS, AND NOTES FOR LITHIUM CELL USE. Included with each lithium battery pack shipment is a Product Data Safety Sheet. Please read the safety sheet and the following information BEFORE handling the lithium battery packs. If the two sources of information disagree, follow the information in the Product Data Safety Sheet. Excerpts of these warnings are taken from a U.S. Navy document (NAVSEAINST 9310.1A, March 1982).

WARNINGS

1. USAGE: LITHIUM BATTERIES ARE ALWAYS HAZARDOUS, ESPECIALLY UNDER CONDITIONS OF ABUSE, MISUSE, DEPLETION, OR PARTIAL DISCHARGE. THERE ARE DOCUMENTED INCIDENTS INVOLVING THE VENTING OF TOXIC GASES, FIRES, AND EXPLOSIONS. FIRE, EXPLOSION, BATTERY LEAKAGE, AND SEVERE BURN HAZARDS EXIST WITH LITHIUM CELLS! DO NOT SHORT THE TERMINALS, RECHARGE THE CELL, OR DEEP DISCHARGE THE CELL. DO NOT DISASSEMBLE, CANNIBALIZE, CRUSH, PUNCTURE, BURN, OR HEAT THE CELL ABOVE 93°C (200°F).

2. CHARGING: THE LITHIUM CELLS ARE PRIMARY CELLS. DO NOT RECHARGE THESE CELLS. CHARGING CAN CAUSE THE CELL TO LEAK OR EXPLODE.

3. SHORT CIRCUIT: THE CELLS HAVE AN INTERNAL FUSE THAT PROTECTS AGAINST OVERLOAD. SHORTING THE CELL WILL RUIN IT. DO NOT REPLACE OR BYPASS THE INTERNAL FUSE. IF YOU FIND A CELL WITH AN OPEN FUSE, RETURN THE CELL TO THE FACTORY FOR REPAIR.

4. ASSEMBLY: WE STRONGLY RECOMMEND THAT ALL ASSEMBLY OF LITHIUM BATTERIES BE DONE ONLY BY QUALIFIED BATTERY SPECIALISTS. THESE SPECIALISTS MUST BE AWARE OF ALL SAFETY PRECAUTIONS AND OF THE HAZARDS THAT LITHIUM BATTERIES PRESENT. IN ADDITION, THESE SPECIALISTS SHOULD NEVER SOLDER OR WELD TO THE CASE OF A CELL. THIS CAN RESULT IN LOSS OF CELL CAPACITY, LEAKAGE, OR EXPLOSION. DO NOT MIX USED CELLS IN SERIES WITH FRESH CELLS. NEVER COMBINE CELLS FROM DIFFERENT MANUFACTURERS. WEAKER CELLS CAN DEEP DISCHARGE UNDER LOAD, CREATING HAZARDOUS CONDITIONS.

5. STORAGE: STORE LITHIUM CELLS IN THEIR ORIGINAL SHIPPING CONTAINERS IN A COOL, CONDENSATION-FREE, FIREPROOF CONTAINER THAT HAS ADEQUATE VENTILATION AND SPRINKLER PROTECTION. ISOLATE THE STORAGE AREA FROM OTHER HAZARDOUS AND COMBUSTIBLE MATERIALS, AND USE IT ONLY FOR THE STORAGE OF UNUSED LITHIUM BATTERIES. THE EFFECTS OF MASS STORAGE ARE UNKNOWN, SO KEEP THE NUMBER OF BATTERIES STORED IN ONE LOCATION TO A REASONABLE MINIMUM. AVOID STORAGE TEMPERATURES ABOVE 54°C (130°F). HIGH TEMPERATURES ALSO REDUCE CELL LIFE AND ACCELERATE THE PASSIVATION PROCESS.

   TREAT USED LITHIUM BATTERIES WITH AS MUCH CARE AS NEW BATTERIES. LITHIUM BATTERIES ARE HAZARDOUS EVEN WHEN PARTIALLY OR COMPLETELY DEPLETED. YOU SHOULD DISPOSE OF USED LITHIUM BATTERIES PROMPTLY (WITHIN 30 DAYS). DO NOT LET USED BATTERIES ACCUMULATE (ESPECIALLY MORE THAN 30 POUNDS). DO NOT DISPOSE OF OR TRANSPORT LITHIUM BATTERIES WITH NORMAL REFUSE.

6. TRANSPORTATION: THE U.S. DEPARTMENT OF TRANSPORTATION REGULATES DOMESTIC SHIPMENT OF LITHIUM CELLS THROUGH DOT-E-7052. THIS DIRECTIVE SPECIFIES THE PROPER WARNINGS, PACKAGING, AND TRANSPORTATION METHODS. LITHIUM CELLS USUALLY CONTAIN MORE THAN 0.5g OF LITHIUM. THIS PREVENTS TRANSPORTATION BY PASSENGER AIRCRAFT. INTERNATIONALLY, THE INTERNATIONAL AIR TRANSPORT ASSOCIATION (IATA) AND THE INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO) REGULATE AIR TRANSPORTATION IN A SIMILAR MANNER.

7. DISPOSAL: THE LITHIUM CELLS CONTAIN NO TOXIC HEAVY METALS SUCH AS LEAD OR CADMIUM. THE LITHIUM CHLORIDE (LiCl) DISCHARGED DURING USE IS HARMLESS. HOWEVER, U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA) REGULATIONS REQUIRE THE DISPOSAL OF LITHIUM CELLS IN SECURE LANDFILLS. FOR MORE INFORMATION CONTACT THE REGIONAL OFFICE OF THE EPA. INTERNATIONALLY, CONTACT LOCAL ENVIRONMENTAL OR HAZARDOUS MATERIAL OFFICES FOR THE PROPER DISPOSAL METHOD.

B-1.2. DISCHARGE CHARACTERISTICS OF LITHIUM CELLS. Compared with other primary cells, the voltage discharge characteristics of lithium cells are flat during the useful life of the cell. For fresh cells at 25°C (77°F), the open circuit voltage is 3.90 V per cell (±0.05 V). For a 1-ampere load current at 25°C, the cell voltage is rated at 3.4 VDC. Table B-1 lists the depassivated lithium battery pack voltage measurements using a 1-ampere load at 25°C. The values in the table allow for the voltage drop across the battery pack's internal charge protection diode. Stored or partially discharged cells might have load voltages that differ from those listed in the table. Voltages might increase slightly when the cell is under load for some period.

Table B-1. Depassivated Voltage Readings

Power supply	Voltage
V1	6.1 V
V2	33.3 V
V4	12.9 V

B-1.3. PASSIVATION OF LITHIUM CELLS. Chemical reactions within lithium cells form an internal resistive film on the anode. This process, known as passivation, is both good and bad. For cells in storage, passivation helps prevent self-discharging. However, passivation causes problems in equipment that require a high discharge rate. At the low discharge rates used by V1, V2, and V4, lithium ions on the anode can migrate through the passivation layer without disturbing its ion lattice. This provides V1, V2, and V4 power requirements almost immediately. Because of the low discharge rates of V1, V2, and V4, passivation does not normally cause problems in the SC-ADCP.

B-1.4. DEPASSIVATION OF LITHIUM CELLS. Before using lithium cells that have been stored for an extended period, check them for passivation. Do this just before deployment. This is a precautionary measure to assure a successful deployment. Passivation is not normally a cause for concern because V1, V2, and V4 have moderate current requirements.

To test for passivation, connect a load resistor across the battery pack so there is about a 1-A current drain for each cell. The voltage should not drop below 3.4 VDC for a fresh cell at 25°C (77°F). If the voltage drops below 3.4 VDC, keep the load resistor connected. The voltage might drop as low as one-half the nominal voltage and may take about 30 minutes to reach 70-80% of its nominal voltage. Table B-2 lists the recommended loads for the three power supplies. When the voltage rises no faster than 0.1 V per cell (connected in series) every 5 minutes, and the voltage is at least 85% of its nominal value, depassivation is complete. After disconnecting the load, the voltage should increase to the nominal open circuit voltage listed in Table B-1.

WARNING

LOAD RESISTORS CAN BECOME HOT. THE DANGER OF FIRE AND PERSONAL INJURY EXISTS. USE A LOAD RESISTOR WITH THE SUGGESTED OR HIGHER RATING. NEVER LEAVE A LOAD ON THE LITHIUM BATTERY FOR A PERIOD THAT WOULD CAUSE THE BATTERY TO BECOME DEEP DISCHARGED. DEEP-DISCHARGING A BATTERY CREATES A HAZARDOUS CONDITION.

Table B-2. Depassivation Loads and Voltages

Power supply	Load resistor^1	Minimum power^2	Minimum voltage^3	Maximum rate of change^4
V1	5.6 Ω	7 W	5.2 V	0.2 V / 5 min
V2	33 Ω	35 W	28.3 V	1.0 V / 5 min
V4	12 Ω	15 W	11.0 V	0.4 V / 5 min

NOTES: 1. THESE ARE SUGGESTED LOADS. VOLTAGES CAN VARY DEPENDING ON THE LOAD RESISTANCE. YOU CAN USE ONE LOAD RESISTOR OR A COMBINATION OF RESISTORS EQUALING THE LOAD SIZE AND MINIMUM POWER REQUIREMENT.
2. MINIMUM POWER RATING FOR THE LOAD RESISTOR IN AIR.
3. VOLTAGE THE BATTERY PACK MUST EXHIBIT AT THE SPECIFIED LOAD AND AT THE MAXIMUM RATE OF CHANGE FOR A DEPASSIVATED BATTERY. DO NOT CONFUSE THIS VOLTAGE WITH THE MINIMUM LOAD VOLTAGE OF THE BATTERY PACK OR WITH THE MINIMUM OPERATING VOLTAGE OF THE SC-ADCP. THIS VOLTAGE IS MERELY A GUIDELINE BASED ON THE ASSUMPTION THAT THE BATTERY VOLTAGE RECOVERS AFTER FURTHER USE.
4. THIS IS THE MAXIMUM RATE OF CHANGE OF THE BATTERY PACK VOLTAGE FOR A DEPASSIVATED BATTERY.

B-1.5. WHEN TO REPLACE THE LITHIUM BATTERY PACK. Lithium cell discharge characteristics make it hard to determine the remaining capacity of a partially discharged cell. The best way to find the remaining capacity is to calculate the expected power consumption before each deployment. Record the results in a log book or on the battery pack itself.

Table B-3 lists the load voltages at which you should replace a battery pack. You also should replace the battery pack when its calculated capacity is less than that needed for the next deployment. Use ¶B-2 to determine battery capacity and power consumption. Use the following guidelines to decide if you need to replace a battery pack to have a successful deployment.

___ a. Calculate the remaining battery capacity (C_r) of the battery pack.
___ b. Calculate the battery capacity needed for the next deployment (C_d).
___ c. Calculate the capacity for a new battery pack (C_n).
___ d. If $(C_r - C_d) < (C_n / 10)$, replace the battery pack.

Table B-3. Recommended Lithium Battery Pack Replacement Voltages

Power supply	Voltage
V1	5.3 V
V2	29.3 V
V4	11.3 V

NOTE: DEPASSIVATED READINGS WITH A 1A LOAD AT 25°C.

B-2. BATTERY PACK CONFIGURATIONS AND CAPACITIES

RDI offers a variety of battery packs to power the SC-ADCP (Table B-4). The cells come in two sizes, single-D (D) and double-D (DD). The battery packs are usually mounted inside the SC-ADCP, but you can add external battery packs using our optional battery case (RD-BATCASE). Figure B-1 shows a battery pack assembly drawing, lithium battery pack schematics, and lithium battery pack pin connections. Section B-2.1 has information on determining the capacity of your battery packs. Section B-2.2 has information on determining the power that your deployment setup will consume. You also can determine battery capacity and power consumption in the opposite order. That is, find how much power the deployment will use, and then find the battery capacity required.

B-2.1. DETERMINING BATTERY CAPACITY. Before you can determine battery capacity, you must select the size, type, and number of battery packs you are going to use during the deployment. Table B-4 lists the capacities for the different batteries supplied by RDI and temperature derating factors. Select which batteries you will be using. You can then use Table B-5 (Battery Capacity Work Sheet) to determine the total ampere·hour (A·h) battery capacities for V1 (ADCP electronics power) and V2 (transmitter and recorder power). After determining the battery capacity, use ¶B-2.2 to determine whether you will have enough battery capacity to power the ADCP for your deployment.

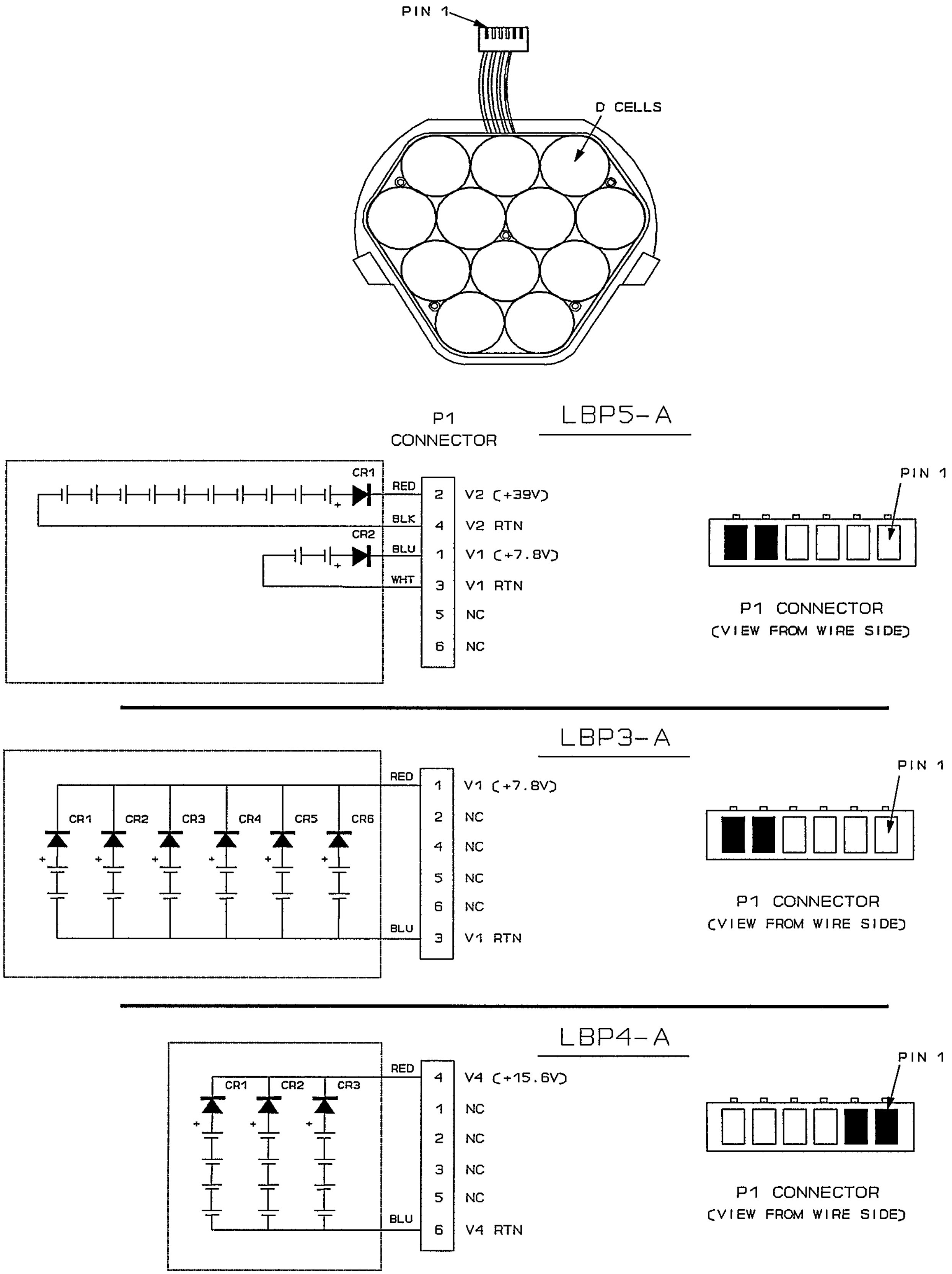


Figure B-1. Lithium Battery Pack Assembly Drawing and Schematics

Table B-4. Capacities of RDI's Standard Batteries

RDI Part No.[1]	Engineer. Part No.	Type (2-3)	Size	V1		V2		V4	
				VDC	A·h	VDC	A·h	VDC	A·h
RD-LBP1-A[4]	305A2431-2	Lith	DD	7.8	22	39	22	-	-
RD-LBP1-B[4]	305A2420-1	Lith	DD	7.8	22	39	22	-	-
RD-LBP2-A[4]	305A2431-4	Lith	DD	7.8	135	-	-	-	-
RD-LBP2-B[4]	305A2420-2	Lith	DD	7.8	135	-	-	-	-
RD-LBP3-A	305A2432-03	Lith	D	7.8	54	-	-	-	-
RD-LBP3-B	305A2420-3	Lith	D	7.8	54	-	-	-	-
RD-LBP4-A	305A2431-7	Lith	D	-	-	-	-	15.6	27
RD-LBP4-B	305A2420-4	Lith	D	-	-	-	-	15.6	27
RD-LBP5-A[5]	305A2432-01	Lith	D	7.8	8.8	39	8.8	-	-
RD-LBP5-B	305A2420-5	Lith	D	7.8	8.8	39	8.8	-	-
RD-ABP1-A	305A2426-1	Alka	D	9.4	12	-	-	-	-
RD-ABP1-B	305A2422-1	Alka	D	9.4	12	-	-	-	-
RD-ABP2-A	305A2426-5	Alka	D+D	-	-	37.6	6	-	-
RD-ABP2-B	305A2423	Alka	D+D	-	-	37.6	6	-	-
RD-ABP3-A	305A2426-4	Alka	D	-	-	-	-	18.8	6
RD-ABP3-B	305A2422-2	Alka	D	-	-	-	-	18.8	6
RD-ABP4-B	305A2422-2	Alka	D+D	9.4	24	-	-	-	-

1. THE "-A" IN THE RDI PART NUMBER SHOWS BATTERIES USED INSIDE THE ADCP. "-B" SHOWS BATTERIES USED INSIDE RDI'S EXTERNAL BATTERY CASE. PLEASE SPECIFY "-A" OR "-B" WHEN ORDERING.
2. LITHIUM - VOLTAGES ARE NOMINAL OPEN-CIRCUIT VOLTAGES AT 25°C. CAPACITIES ARE NOMINAL RATINGS AT 0°C BASED ON RDI TESTS UNDER TYPICAL LOAD CONDITIONS AND ARE LOWER THAN MANUFACTURER SPECIFICATIONS. THIS TABLE DERATES THE MANUFACTURER-SPECIFIED CAPACITIES AT 25°C TO 0°C USING A FACTOR OF 0.73.
3. ALKALINE - VOLTAGES ARE NOMINAL OPEN-CIRCUIT VOLTAGES AT 25°C. CAPACITIES ARE ESTIMATED RATINGS AT 0°C UNDER TYPICAL SC-ADCP LOAD CONDITIONS AND ARE LOWER THAN MANUFACTURER SPECIFICATIONS. THESE ESTIMATES ARE VALID ONLY IF THE ADCP IS POWERED USING AN EXTERNAL BATTERY CASE AND INTERNAL ALKALINE BATTERIES. THIS TABLE DERATES THE MANUFACTURER-SPECIFIED CAPACITIES AT 25°C TO 0°C USING A FACTOR OF 0.43.
4. RDI HAS STOPPED USING THE RD-LBP1 AND RD-LBP2 LITHIUM BATTERY PACKS. WE LIST THE CAPACITIES HERE FOR CUSTOMERS WHO MAY STILL BE USING THESE BATTERY PACKS.
5. EACH RD-LBP5 LITHIUM BATTERY PACK HAS TWO SUB-BATTERIES TO SUPPLY VOLTAGE V1 AND VOLTAGE V2. THE INITIAL PURCHASE OF AN SC-ADCP INCLUDES TWO RD-LBP5-A BATTERY PACKS.

Table B-5. Battery Capacity Work Sheet

Use this work sheet to determine the battery capacity for the battery packs supplying V1 and V2 power. If you are using the CTD interface option, you can compute V4 in the same way.

1. What combination of battery packs will you use? The following is the maximum number of batteries you can place inside an SC-ADCP.

   a. Four D packs
   b. Two D packs and one D+D pack
   c. Two D+D packs

2. Enter V1 and V2 nominal battery capacities (in A·h), temperature derating factor (if necessary), and an estimate of any previous usage for each battery pack you plan to use. See Table B-4 for nominal capacities and derating factors for RDI's standard battery packs. Calculate the total battery capacity for V1 and V2 using the listed formulas.

V1 Computations:	(Nominal Capacity	×	Derating Factor)	-	Previous Use	=	Battery Capacity
Battery pack 1	________		________		________		________
Battery pack 2 (IF USED)	________		________		________		________
Battery pack 3 (IF USED)	________		________		________		________
Battery pack 4 (IF USED)	________		________		________	+	________
	Total expected battery capacity for V1					=	________

V2 Computations:	(Nominal Capacity	×	Derating Factor)	-	Previous Use	=	Battery Capacity
Battery pack 1	________		________		________		________
Battery pack 2 (IF USED)	________		________		________		________
Battery pack 3 (IF USED)	________		________		________		________
Battery pack 4 (IF USED)	________		________		________	+	________
	Total expected battery capacity for V2					=	________

NOTE: APPENDIX F HAS A REPRODUCIBLE COPY OF THIS WORK SHEET.

B-2.2. DETERMINING POWER CONSUMPTION. After determining the battery capacity you will have available during your deployment (¶B-2.1), check to see that your deployment setup will not exceed this battery capacity. If you have an IBM-compatible computer, you can use the SC-ADCP Deployment Program to estimate power consumption for V1 and V2 (see ¶4-2.3 of the SC-ADCP Deployment Program User's Manual). If you do not have this program, you can estimate the expected power consumption for your deployment for V1 (electronics), V2 (recorder/transmitter), and V4 (CTD) using the formulas in the following paragraphs. We also present a sample problem.

V1 Battery Capacity Requirements. You can use the following formula to estimate V1 battery capacity requirements. Table B-6 provides a description of the formula variables. Table B-7 provides a simple BASIC program that uses this equation.

$$C_{V1} = 278\times10^{-9}\times N_M\times I_{A1}\times\left[P\times\left[t_{OH}+[1.6\times\{I_m+J_m+(L_{DC}\times K\times Q)\}]\right]+(t_R\times N_{BE})\right]+(I_{S1}\times t_D)+C_D$$

V2 Battery Capacity Requirements. You can use the following formula to estimate V2 battery capacity requirements. Table B-6 provides a description of the formula variables. Table B-7 provides a simple BASIC program that uses this equation.

$$C_{V2} = 278\times10^{-9}\times N_M\times P\times\left[(1.6\times I_m\times I_x)+\left[I_{A2}\times\left[t_{OH}+[1.6\times\{I_m+J_m+(L_{DC}\times K\times Q)\}]\right]\right]\right]+(I_{S2}\times t_D)+C_R$$

V4 Battery Capacity Requirements. You can use the following formula to estimate V4 battery capacity requirements. Table B-6 provides a description of the formula variables. Table B-7 provides a simple BASIC program that uses this equation.

$$C_{V4} = N_M \times t_{CA} \times (I_C + I_D + I_T)$$

Table B-6. Variable Definitions

<table>
<tr><th>Variable</th><th>Description</th></tr>
<tr><td>C_D</td><td>CTD capacity requirement when depth sensor is installed and V1 is supplying power instead of V4. $C_D = N_M \times I_D \times t_{CA}$</td></tr>
<tr><td>C_R</td><td>Capacity requirements for data recording in ampere·hours:
$C_R = N_M \times ((t_R \times N_{BE}) / 3600) \times I_{R2}$</td></tr>
<tr><td>C_{V1}</td><td>Estimate of V1 battery capacity requirements in ampere·hours</td></tr>
<tr><td>C_{V2}</td><td>Estimate of V2 battery capacity requirements in ampere·hours</td></tr>
<tr><td>C_{V4}</td><td>Estimate of V4 battery capacity requirements in ampere·hours</td></tr>
<tr><td>I_{A1}</td><td>Operating current of V1 (0.235 A)</td></tr>
<tr><td>I_{A2}</td><td>Operating current of V2 (0.001 A)</td></tr>
<tr><td>I_C</td><td>Conductivity sensor operating current (0.011 A)</td></tr>
<tr><td>I_D</td><td>Depth sensor operating current (0.002 A)</td></tr>
<tr><td>I_T</td><td>Temperature sensor operating current (0.011 A)</td></tr>
<tr><td>I_m</td><td>Transmit pulse length in meters (usually equals depth cell length)</td></tr>
<tr><td>I_{R2}</td><td>V2 current requirements for EPROM recorder (0.100 A)</td></tr>
<tr><td>I_{S1}</td><td>Standby current for V1 (280 μA without CTD, 680 μA with CTD)</td></tr>
<tr><td>I_{S2}</td><td>Standby current for V2 (150 μA)</td></tr>
<tr><td>I_x</td><td>Transmit current (2 A)</td></tr>
<tr><td>J_m</td><td>Blank beyond transmit range in meters</td></tr>
<tr><td>K</td><td>Depth cell processing time constant based on depth cell length and coordinate velocity (1 is most typical case):
<table>
<tr><th>Depth cell length (L_{DC})</th><th>K when vel= Earth Coord.</th><th>K when vel= Beam Coord.</th></tr>
<tr><td>1</td><td>3</td><td>2</td></tr>
<tr><td>2</td><td>3</td><td>1</td></tr>
<tr><td>4</td><td>1</td><td>1</td></tr>
<tr><td>8</td><td>1</td><td>1</td></tr>
<tr><td>16</td><td>1</td><td>1</td></tr>
<tr><td>32</td><td>1</td><td>1</td></tr>
</table>
</td></tr>
<tr><td>L_{DC}</td><td>Depth Cell Length in meters (1, 2, 4, 8, 16, or 32)</td></tr>
</table>

Table B-6. Variable Definitions (Continued)

<table>
<tr><th>Variable</th><th>Description</th></tr>
<tr><td>N_{BE}</td><td>Total number of output data bytes per ensemble. $N_{BE} = (N_{DB} \times Q) + 79$</td></tr>
<tr><td>N_{DB}</td><td>Total number of recorded data bytes per depth cell:
Velocity = 6
Spectral width = 4 (Only available when BEAM coordinates used)
Echo intensity = 4
Percent good = 4
Status = 2
For example, if you record velocity in earth coordinates, echo intensity, and percent good, then $N_{DB} = 6 + 4 + 4 = 14$.</td></tr>
<tr><td>N_M</td><td>Total number of profile measurements during the deployment:
$N_M = (60 / t_{EI}) \times t_D$</td></tr>
<tr><td>N_{RB}</td><td>Total number of data bytes to be recorded:
$N_{RB} = N_M \times N_{BE}$</td></tr>
<tr><td>P</td><td>Pings Per Ensemble</td></tr>
<tr><td>Q</td><td>Number of Depth Cells (minimum = 8, maximum = 128)</td></tr>
<tr><td>t_{CA}</td><td>CTD measurement time per ensemble in hours</td></tr>
<tr><td>t_D</td><td>Deployment duration in hours</td></tr>
<tr><td>t_{EI}</td><td>Ensemble interval in minutes</td></tr>
<tr><td>t_{OH}</td><td>Nominal overhead time for ping processing based on compass type and coordinate velocity (46 ms is most typical and safest to use):
<table>
<tr><th>Compass type</th><th>t_{OH} when vel= Earth coord.</th><th>t_{OH} when vel= Beam coord.</th><th></th></tr>
<tr><td>EG&G</td><td>32</td><td>26</td><td></td></tr>
<tr><td>KVH</td><td>46</td><td>40</td><td></td></tr>
<tr><td>None</td><td>32</td><td>26</td><td>(@10 MHz CPU clock)</td></tr>
</table>
</td></tr>
<tr><td>t_R</td><td>Time to record a byte to EPROM recorder (0.003 s)</td></tr>
</table>

B-2.3. SAMPLE PROBLEM FOR ESTIMATING POWER CONSUMPTION. The following example shows how to use the previous formulas to estimate power consumption. Table B-7 lists a simple BASIC program you can use to estimate power consumption. The BASIC program uses the information from the following example.

a. A 300-kHz SC-ADCP will be used to measure data for 60 depth cells ($Q = 60$).
b. The length of each depth cell is four meters ($L_{DC} = 4$).
c. The transmit pulse length is set equal to the depth cell length ($I_m = 4$).
d. A blank beyond transmit range of two meters will be used ($J_m = 2$).
e. The deployment is expected to last six months ($t_D = 4320$ hours).
f. Each ensemble will consist of an average of 100 pings ($P = 100$).
g. The ensemble interval will be one hour ($t_{EI} = 60$ minutes).
h. The total number of measurements during the deployment will be:

$N_M = (60 / t_{EI}) \times t_D = (60 / 60) \times 4320 = 4320.$

i. All three CTD sensors are attached to the SC-ADCP. The sensors will use V4 (not V1) to supply their power. The CTD sensors will measure data over an interval of 1/4 hour for every ensemble. Therefore,

$C_D = 0$ (because power is not being supplied by V1)
$I_C = 0.011$ A
$I_D = 0.002$ A
$I_T = 0.011$ A
$t_{CA} = 0.25$ hour

j. Velocity will be measured in earth coordinates. All available data (velocity, echo intensity, percent good, status) will be recorded to the solid-state EPROM recorder. Therefore,

$N_{DB} = 6 + 4 + 4 + 2 = 16$ bytes
$N_{BE} = (N_{DB} \times Q) + 79 = (16 \times 60) + 79 = 1039$ bytes
$N_{RB} = N_M \times N_{BE} = 4320 \times 1039 = 4,488,480$ bytes
$C_R = N_M \times ((t_R \times N_{BE}) / 3600) \times I_{R2}$
$= 4320 \times ((0.003 \times 1089) / 3600) \times 0.1 = 0.374$ A·h

k. The depth cell processing time constant will be equal to one because $L_{DC} = 4$ meters and velocity is in earth coordinates ($K = 1$).
l. A KVH type compass is in use and velocity is in earth coordinates, so $t_{OH} = 46$.
m. Maximum expected values will be used for:

$I_{A1} = 0.235$ A
$I_{A2} = 0.001$ A
$I_{S1} = 0.00068$ A (CTD in use)
$I_{S2} = 0.00015$ A
$I_x = 2$ A

n. The estimated V1 battery capacity requirement is:

$$C_{V1} = 278\times10^{-9}\times N_M\times I_{A1}\times\left[P\times\left[t_{OH}+[1.6\times\{I_m+J_m+(L_{DC}\times K\times Q)\}]\right]+(t_R\times N_{BE})\right]+(I_{S1}\times t_D)+C_D$$

$$= 0.0002822 \times \left[100 \times \left[46 + [1.6 \times \{4+2+240\}]\right] + 3.117\right]+2.9376+0$$

$$= 0.0002822 \times \left[100 \times \left[46 + [1.6 \times 246]\right] + 3.117\right] + 2.9376$$

$$= 0.0002822 \times \left[100 \times [46 + 393.6] + 3.117\right] + 2.9376$$

$$\begin{aligned}
&= 0.0002822 \times [(100 \times 439.6) + 3.117] + 2.9376 \\
&= 0.0002822 \times (43960 + 3.117) + 2.9376 \\
&= (0.0002822 \times 43963.117) + 2.9376 \\
&= 12.4064 + 2.9376 \\
&= 15.34 \text{ ampere·hours}
\end{aligned}$$

o. The estimated V2 battery capacity requirement is:

$$C_{V2} = 278\times10^{-9}\times N_M\times P\times\left[(1.6\times I_m\times I_x)+\left[I_{A2}\times\left[t_{OH}+[1.6\times\{I_m+J_m+(L_{DC}\times K\times Q)\}]\right]\right]\right]+(I_{S2}\times t_D)+C_R$$

$$= 0.120096 \times \left[12.8+\left[0.001\times\left[46+[1.6\times\{4+2+240\}]\right]\right]\right] + 0.648 + 0.374$$

$$= 0.120096 \times \left[12.8 + \left[0.001 \times \left[46 + [1.6 \times 246]\right]\right]\right] + 1.02$$

$$= 0.120096 \times \left[12.8 + \left[0.001 \times [46 + 393.6]\right]\right] + 1.02$$

$$
\begin{aligned}
&= 0.120096 \times \left[12.8 + [0.001 \times 439.6]\right] + 1.02 \\
&= 0.120096 \times [12.8 + 0.4396] + 1.02 \\
&= (0.120096 \times 13.2396) + 1.02 \\
&= 1.59 + 1.02 \\
&= 2.61 \text{ ampere}\cdot\text{hours}
\end{aligned}
$$

p. The estimated V4 battery capacity requirement is:

$$
\begin{aligned}
C_{V4} &= N_M \times t_{CA} \times (I_C + I_T + I_D) \\
&= 4320 \times 0.25 \times (0.011 + 0.011 + 0.002) \\
&= 4320 \times 0.25 \times 0.024 \\
&= 25.92 \text{ ampere}\cdot\text{hours}
\end{aligned}
$$

Table B-7. Simple BASIC Program to Estimate Power Consumption

```
'     NOTE:  See page B-12 for the sample data used with this program.
010 Q=60                 :'Number of Depth Cells (minimum=8, maximum=128)
020 LDC=4                :'Depth Cell Length (1, 2, 4, 8, 16, or 32 meters)
030 IM=4                 :'Transmit pulse length, meters (usually=LDC)
040 JM=2                 :'Blank beyond transmit range in meters
050 TD=4320              :'Deployment duration in hours
060 P=100                :'Pings Per Ensemble
070 TEI=60               :'Ensemble Interval in minutes
080 NM=(60/TEI)*TD       :'Total no. of profile measurements during deployment
090 IC=.011:ID=.002:IT=.011 :'CTD operating currents in amperes
100 TCA=.25              :'CTD measurement time per ensemble in hours
110 CD=0                 :'V1 CTD capacity rqmt when V4 powers depth sensor
120 REM CD=NM*ID*TCA     :'V1 CTD capacity rqmt when V1 powers depth sensor
130 NDB=6+4+4+2          :'Number of recorded data bytes per cell (see Table B-6)
140 NBE=(NDB*Q)+79       :'Number of bytes in data output per ensemble
150 IR2=.1               :'V2 current requirements for EPROM recorder in amperes
160 TR=.003              :'Time to record a byte to EPROM recorder in seconds
170 CR=NM*((TR*NBE)/3600)*IR2 :'Capacity rqmt for data recording
180 K=1                  :'Depth cell processing time constant (see Table B-6)
190 TOH=46               :'Nominal overhead time (see Table B-6)
200 IA1=.235:IA2=.001    :'Operating currents for V1 and V2 in amperes
210 IS1=.00068           :'V1 standby current (.00028A W/O CTD; .00068A W/ CTD)
220 IS2=.00015           :'V2 standby current in amperes
230 IX=2                 :'Transmit current in amperes
240 'CV1 computation:
250 CV1=2.78E-07*NM*IA1*(P*(TOH+(1.6*(IM+JM+LDC*K*Q)))+(TR*NBE))+(IS1*TD)+CD
260 'CV2 computation:
270 CV2=2.78E-07*NM*P*((1.6*IM*IX)+(IA2*(TOH+(1.6*(IM+JM+LDC*K*Q)))))+(IS2*TD)
    +CR
280 'CV4 computation:
290 CV4=NM*TCA*(IC+IT+ID)
300 NRB=NM*NBE           :'Total number of data bytes to record
310 PRINT:PRINT "CV1 =";CV1:PRINT "CV2 =";CV2:PRINT "CV4 =";CV4:PRINT "NRB =";
    NRB:PRINT
```

NOTES

APPENDIX C
CALCULATIONS AND FORMULAS

C-0. INTRODUCTION

This appendix defines various calculations and formulas used by the ADCP. The ADCP measures range-segmented, horizontal profiles of water-mass velocity, spectral width, and echo intensity. This appendix describes measurement and data processing considerations for these parameters. For more information on ADCP calculations, see RDI's *Principles of Operation: A Practical Primer*.

C-1. WATER-MASS VELOCITY – RADIAL VELOCITY DEFINITION

The ADCP determines water-mass velocity by measuring the Doppler frequency shift (first moment) of the backscattered water-mass echo. When you select beam-coordinate output velocities (O-command), the ADCP supplies the measured Doppler frequency shift as output for each depth cell (bin) and each beam. We can compute the component of relative flow velocity (V, in cm/s) in the direction of each acoustic beam from this measured Doppler frequency shift (F_D) for each depth cell using the equation:

$$V = F_D \frac{C}{2\ F_S}$$

where: F_S = Transmitted acoustic frequency (76.8, 153.6, 307.2, 614.4, or 1228.8 kHz, dependent on ADCP model 75, 150, 300, 600, or 1200 kHz respectively).

C = Velocity of sound in water at the transducer face (in cm/s) calculated from the expression:

$$C = 1449.2 + 4.6T - 0.055T^2 + 0.00029T^3 + (1.34 - 0.01T)(S - 35) + 0.016D$$

where: D = Depth, in meters
S = Salinity, in parts per thousand
T = Temperature, in °C

NOTE: The ADCP measures water temperature at its transducer face. You can calculate C from this measured water temperature using nominal values for depth and salinity. Table C-1 lists several values for C (in cm/s) for various temperature and salinity readings at shallow depths.

Table C-1. Speed of Sound versus Temperature and Salinity

	Speed of Sound (cm/s)					
	Salinity (ppt)					
Temp. (°C)	0	20	25	30	35	40
0	140230	142910	143580	144250	144920	145590
1	140720	143380	144045	144710	145375	146040
2	141198	143838	144498	145158	145818	146478
3	141666	144286	144941	145596	146251	146906
4	142124	144724	145374	146024	146674	147324
5	142571	145151	145796	146441	147086	147731
6	143008	145568	146208	146848	147488	148128
7	143435	145975	146610	147245	147880	148515
8	143853	146373	147003	147633	148263	148893
9	144261	146761	147386	148011	148636	149261
10	144659	147139	147759	148379	148999	149619
11	145048	147508	148123	148738	149353	149968
12	145428	147868	148478	149088	149698	150308
13	145799	148219	148824	149429	150034	150639
14	146162	148562	149162	149762	150362	150962
15	146515	148895	149490	150085	150680	151275
16	146861	149221	149811	150401	150991	151581
17	147198	149538	150123	150708	151293	151878
18	147527	149847	150427	151007	151587	152167
19	147848	150148	150723	151298	151873	152448
20	148162	150442	151012	151582	152152	152722
21	148468	150728	151293	151858	152423	152988
22	148767	151007	151567	152127	152687	153247
23	149058	151278	151833	152388	152943	153498
24	149343	151543	152093	152643	153193	153743
25	149621	151801	152346	152891	153436	153981
26	149892	152052	152592	153132	153672	154212
27	150156	152296	152831	153366	153901	154436
28	150415	152535	153065	153595	154125	154655
29	150667	152767	153292	153817	154342	154867
30	150913	152993	153513	154033	154553	155073
31	151153	153213	153728	154243	154758	155273
32	151388	153428	153938	154448	154958	155468
33	151618	153638	154143	154648	155153	155658
34	151842	153842	154342	154842	155342	155842
35	152061	154041	154536	155031	155526	156021
36	152275	154235	154725	155215	155705	156195
37	152484	154424	154909	155394	155879	156364
38	152689	154609	155089	155569	156049	156529
39	152890	154790	155265	155740	156215	156690
40	153086	154966	155436	155906	156376	156846
41	153278	155138	155603	156068	156533	156998
42	153467	155307	155767	156227	156687	157147
43	153651	155471	155926	156381	156836	157291
44	153832	155632	156082	156532	156982	157432
45	154010	155790	156235	156680	157125	157570

C-2. STANDARD DEVIATION FORMULA

This section presents the formula used to estimate the standard deviation (accuracy) of ADCP velocity calculations.

The ADCP measures a complete 128-segment profile of water currents in a time duration equal to the two-way propagation time to the maximum range of interest. This "single-ping" interval is typically only a fraction of a second. Each single-ping, depth cell velocity measurement has a long-term bias error and a short-term random error. You can reduce the short-term random error by programming the ADCP to average the results of multiple pings. The size of this random error is related to acoustic frequency, transmit pulse length, and number of pings per ensemble. We calculate the short-term velocity measurement precision for a four-beam ADCP as follows.

$$\text{Standard Deviation (cm/s)} = \frac{1.6 \times 10^7}{F \times I \times B \times \sqrt{P}}$$

Where:
F = ADCP acoustic frequency in Hz
I = Transmit pulse length in meters
B = Beam angle coefficient (1 for 30°; 0.684 for 20°)
P = Number of pings per ensemble

For example:

A 150-kHz ADCP (actual acoustic frequency = 153,600 Hz) is used with a transmit pulse length of 8 meters and a pings per ensemble value of 170. What is the standard deviation in cm/s?

For a 30° beam angle (most common):

$$\frac{1.6 \times 10^7}{F \times I \times B \times \sqrt{P}} = \frac{16{,}000{,}000}{153{,}600 \times 8 \times 1 \times \sqrt{170}} \approx 1.0 \text{ cm/s}$$

For a 20° beam angle:

$$\frac{1.6 \times 10^7}{F \times I \times B \times \sqrt{P}} = \frac{16{,}000{,}000}{153{,}600 \times 8 \times 0.684 \times \sqrt{170}} \approx 1.46 \text{ cm/s}$$

C-3. VELOCITY DATA PROCESSING

This section defines the ADCP coordinate systems, presents the velocity processing algorithm, and outlines the algorithm's derivation. When the ADCP is in the radial beam-coordinate velocity output mode (set by O-command), the raw ADCP velocity data is a measurement of the four-beam, radial velocity components. To convert this Doppler frequency data from the ADCP's transducer-coordinate system to earth-referenced east, north, and vertical velocity profiles, we must:

a. Compensate for ADCP pitch and roll to map the tilted, slant-beam Doppler frequency data into cells at the same depth.
b. Compensate for speed of sound variations.
c. Calculate the three orthogonal velocity components for each depth cell in the ADCP coordinates.
d. Check the reasonableness of depth cell velocity components for each depth cell in the ADCP coordinates.
e. Resolve the ADCP velocity components for each depth cell into east, north, and vertical components.

C-3.1. COORDINATE SYSTEMS. We define three coordinate systems for the ADCP – earth, horizontal, and instrument.

Earth-coordinate System. This system has its +X*E* axis pointing east, +Y*E* axis pointing north, and +Z*E* axis pointing up. The *E* indicates an earth-coordinate system component. This is a right-handed coordinate system. The ADCP collects data in the instrument-coordinate system, but can convert the collected data to earth coordinates. This is explained below in the description of the instrument-coordinate system.

Horizontal-coordinate System. This system differs from the earth-coordinate system by a rotation of HH (heading) degrees about the ZE-axis. This system has the components XH, YH, and ZH.

Instrument-coordinate System. We define the instrument-coordinate system such that without any roll, pitch, or heading change, the instrument's X, Y, and Z components are the same as XE, YE, and ZE in the earth-coordinate system. See Figure C-1. The ADCP's X and Y planes pass through the centers of the four transducers. The X-axis runs through transducer beams 1 and 2; the Y-axis runs through beams 3 and 4. When you look at the faces of the transducer head, the transducers are clockwise in the order 3-1-4-2. This means that for upward-facing ADCPs beam 1 is in the +X direction, and beam 3 is in the +Y direction. For downward-facing ADCPs, beam 2 is in the +X direction, and beam 3 remains in the +Y direction. The directions fore, aft, port, and starboard refer to the instrument-coordinate system and are in the +Y, -Y, -X, and +X directions, respectively.

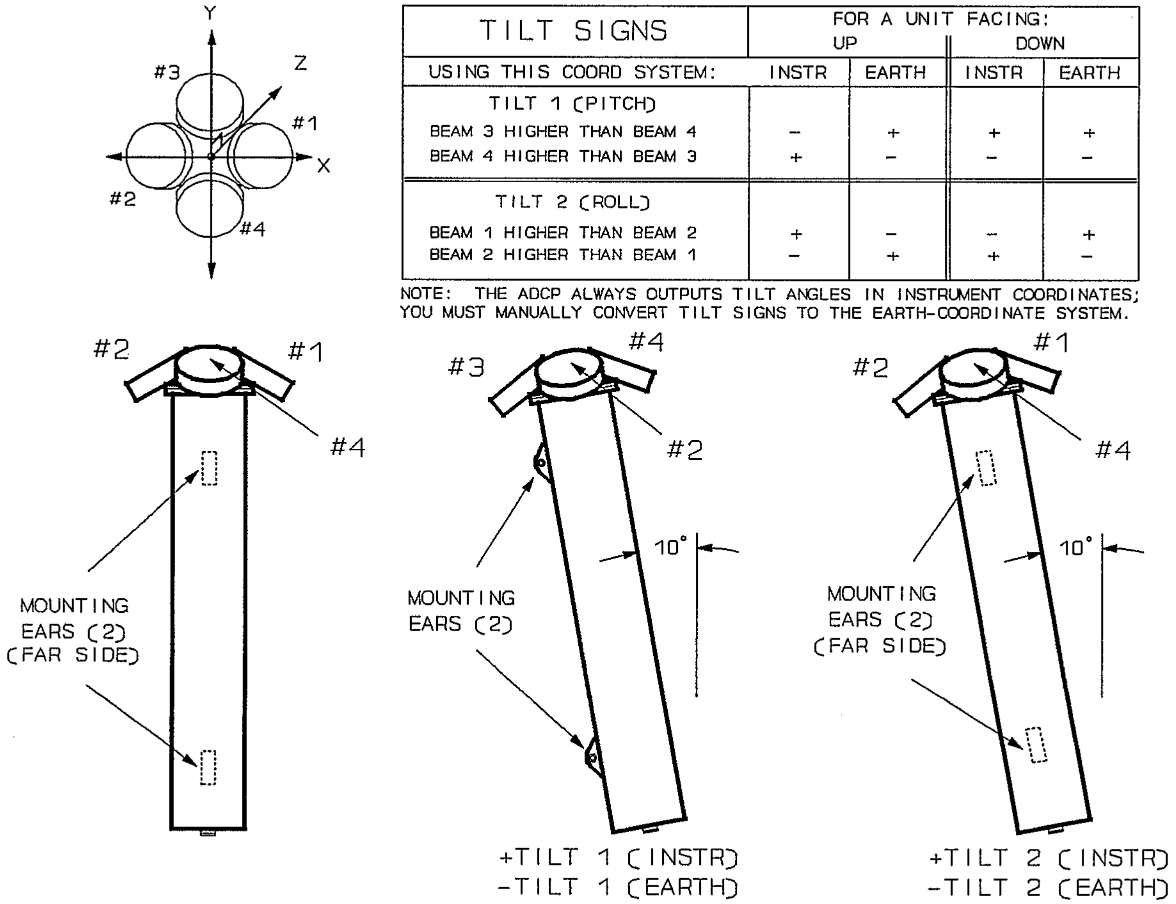
The ADCP collects data in the instrument-coordinate system, but can convert the data to earth coordinates. In Direct-Reading and Vessel-Mounted models, this conversion is usually done by an external software program (e.g., DAS). We can use the tilt sensors and compass readings to define a conversion routine to express any instrument-coordinate vector in earth coordinates. The conversion depends on how the tilt sensors are fixed to the ADCP. The general procedure is to first convert the vectors to a horizontal plane using a combination of rotations about the roll and pitch axes. Heading is then corrected with a rotation about the Z-axis. In general, the actual magnitude of the rotation angles will not be those recorded by the sensors.

If we assume the ADCP platform is nonaccelerating and the tilt sensor pivots are frictionless, we can use the sensor readings to measure roll and pitch. We define the roll, pitch, and heading measures as follows.

Pitch – Pitch angles rotate about the ADCP's X-axis. For upward-facing units, the ADCP outputs a positive pitch value in instrument coordinates when beam 4 is higher than beam 3. For downward-facing ADCPs, a positive pitch occurs when beam 3 is higher than beam 4. See Figure C-1 for information on how to convert pitch data to the earth-coordinate system.

Roll – Roll angles rotate about the ADCP's Y-axis. For upward-facing units, the ADCP outputs a positive roll value in instrument coordinates when beam 1 is higher than beam 2. For downward-facing ADCPs, a positive roll occurs when beam 2 is higher than beam 1. See Figure C-1 for information on how to convert roll data to the earth-coordinate system.

Heading – Heading angles rotate about the ADCP's Z-axis. The compass reading is in degrees with the +YE direction equal to 000° and the +XE direction equal to +090°.



TILT SIGNS	FOR A UNIT FACING:			
	UP		DOWN	
USING THIS COORD SYSTEM:	INSTR	EARTH	INSTR	EARTH
TILT 1 (PITCH)				
BEAM 3 HIGHER THAN BEAM 4	−	+	+	+
BEAM 4 HIGHER THAN BEAM 3	+	−	−	−
TILT 2 (ROLL)				
BEAM 1 HIGHER THAN BEAM 2	+	−	−	+
BEAM 2 HIGHER THAN BEAM 1	−	+	+	−

NOTE: THE ADCP ALWAYS OUTPUTS TILT ANGLES IN INSTRUMENT COORDINATES; YOU MUST MANUALLY CONVERT TILT SIGNS TO THE EARTH-COORDINATE SYSTEM.

Figure C-1. Transducer Beam Axes and Tilt Signs

C-3.2. VELOCITY PROCESSING ALGORITHM. The following algorithm calculates the east (X), north (Y), vertical (Z), and error (E) velocity components from the raw ADCP Doppler frequency data. We describe the algorithm using FORTRAN-like variables and arithmetic.

The algorithm input has NBINS of range-gated Doppler frequency in four arrays (D1, D2, D3, D4) containing frequency estimates from the four transducer beams. Heading is from the flux-gate compass. Pitch and roll data are from the tilt sensors mounted inside the transducer head. The algorithm produces three, resolved-velocity arrays each with NBINS of velocity data at depths corresponding to those measured with zero pitch and roll.

In this algorithm, steps 1 and 2 are done once for each ping. Step 3 begins a loop that ends in step 6. The loop executes NBINS times for each ping.

Step 1 – Determine Rotation Angles from Sensor Readings. For each new set of pitch, roll, heading, and Doppler frequency data, find the rotation angles for the conversion matrix RR, PP, and HH. There are three cases that vary depending on how the tilt sensors are fixed to the ADCP.

Case 1 - Pitch and Roll Axes Fixed to ADCP. The sensor axes are fixed to the ADCP axes and rotate with the ADCP. Use this set of equations with pendulum attitude sensors. The rotation angles are:

RR = ROLL
PP = ARCSIN(SIN(PITCH) * COS(ROLL) / KA)
HH = HEADING

where KA = SQRT(1 - $(\text{SIN(PITCH)} * \text{SIN(ROLL)})^2$)

Case 2 - Roll Axis Fixed to ADCP. The roll axis is fixed to the ADCP, and the pitch axis in gimballed inside the roll axis.

PP = PITCH
RR = ROLL
HH = HEADING

Case 3 - Pitch Axis Fixed to System. The pitch axis is fixed to the ADCP, and the roll axis is gimballed inside the pitch axis.

PP = PITCH
RR = ROLL
HH = HEADING + DD

where DD = ARCSIN(SIN(PITCH) * SIN(ROLL) / KB)
KB = SQRT(COS(PITCH)^2 + $(\text{SIN(PITCH)} * \text{SIN(ROLL)})^2$)

Notice in case 1, an adjusted reading of the pitch sensor was used for the pitch rotation angle, while case 3 requires an adjustment to heading.

Step 2 – Calculate Trigonometric Functions and Scaling Factors. Find the Z component of the conversion matrix M(I,J) that expresses in earth coordinates a vector initially acquired in instrument coordinates. For the three different cases, the components are:

CP = cos(PP)   CR = cos(RR)   CH = cos(HH)   C30 = cos(30)
SP = sin(PP)   SR = sin(RR)   SH = sin(HH)   S30 = sin(30)

Case 1 - Tilt Sensors Fixed to ADCP.

M(3,1) = -SR*CP
M(3,2) = SP
M(3,3) = CP*CR

Case 2 - Roll Axis Fixed, Pitch Axis Gimballed Inside Roll.

M(3,1) = -SR*CP
M(3,2) = SP
M(3,3) = CP*CR

Case 3 - Pitch Axis Fixed, Roll Axis Gimballed Inside Pitch.

M(3,1) = -SR
M(3,2) = CR*SP
M(3,3) = CP*CR

Form the scale factors for the depth index:

SC(1) = C30 / (M(3,3)*C30 + ZSG(1)*M(3,1)*S30)
SC(2) = C30 / (M(3,3)*C30 + ZSG(2)*M(3,1)*S30)
SC(3) = C30 / (M(3,3)*C30 + ZSG(3)*M(3,2)*S30)
SC(4) = C30 / (M(3,3)*C30 + ZSG(4)*M(3,2)*S30)

where ZSG is a sign that varies depending on the orientation and beam pattern of the transducers. The transducers can face up or down and have concave or convex beam patterns. ZSG is given in the following table.

	Up Convex	Up Concave	Down Convex	Down Concave
ZSG(1)	+	-	+	-
ZSG(2)	-	+	-	+
ZSG(3)	+	-	-	+
ZSG(4)	-	+	+	-

Form the transducer to instrument-coordinate system scaling constants and the error velocity constant:

VXS = C / (F_t * 4 * sin(30))
VYS = C / (F_t * 4 * sin(30))
VZS = C / (F_t * 8 * cos(30))
VES = C / (F_t * 8)

where C = speed of sound in the profiled water (in cm/s); see ¶C-1
F_t= is the transmitted sonar frequency (Hz).

Step 3 – Depth Cell Correction for Pitch and Roll. The pitch and roll information maps the tilted, range-gated, Doppler frequency estimates into depth cells (bins) at the same depth. The following loop executes from 1 to the number of bins (NBINS).

```
REPEAT  for IB = 1 to NBINS
    J1 = IB*SC(1) + 0.5
    J2 = IB*SC(2) + 0.5
    J3 = IB*SC(3) + 0.5
    J4 = IB*SC(4) + 0.5
```

where J1, J2, J3, and J4 are integers of the constant depth indices for Doppler frequency data in the IBth bin of the input arrays D1, D2, D3, D4.

Now check that all indices are >0 and ≤NBINS, and that the data in D1(J1), D2(J2), D3(J3), and D4(J4) are valid. The latter test normally uses the STATUS nibble from the ADCP with the Doppler frequency data. If any of the four estimates are bad, skip to the end of the loop.

Step 4 – ADCP Coordinate Velocity Components. Find the VX, VY, VZ, and VE instrument-coordinate velocities for the IBth bin. This conversion depends on transducer orientation (up/down) and beam pattern (concave/convex). The four cases are (Note: D1-D4 are in Hz; Table 4-3 shows scaling factors):

```
UPWARD CONVEX
    VX = VXS * (-D1(J1) + D2(J2))
    VY = VYS * (-D3(J3) + D4(J4))
    VZ = VZS * (-D1(J1) - D2(J2) - D3(J3) - D4(J4))
    VE = VES * (+D1(J1) + D2(J2) - D3(J3) - D4(J4))

DOWNWARD CONVEX
    VX = VXS * (+D1(J1) - D2(J2))
    VY = VYS * (-D3(J3) + D4(J4))
    VZ = VZS * (+D1(J1) + D2(J2) + D3(J3) + D4(J4))
    VE = VES * (+D1(J1) + D2(J2) - D3(J3) - D4(J4))

UPWARD CONCAVE
    VX = VXS * (+D1(J1) - D2(J2))
    VY = VYS * (+D3(J3) - D4(J4))
    VZ = VZS * (-D1(J1) - D2(J2) - D3(J3) - D4(J4))
    VE = VES * (+D1(J1) + D2(J2) - D3(J3) - D4(J4))

DOWNWARD CONCAVE
    VX = VXS * (-D1(J1) + D2(J2))
    VY = VYS * (+D3(J3) - D4(J4))
    VZ = VZS * (+D1(J1) + D2(J2) + D3(J3) + D4(J4))
    VE = VES * (+D1(J1) + D2(J2) - D3(J3) - D4(J4))
```

Check whether the absolute value of VE (error velocity) exceeds a preselected value (e.g., three times the expected velocity standard deviation). VE checks the validity of the calculation of the three orthogonal velocity components VX, VY, and VZ. This is possible because the ADCP needs only three beams to calculate the three velocity components. The fourth beam provides redundant data and allows computation of a "data reasonableness" velocity component.

Step 5 – Convert to Earth Coordinates. The conversion to earth coordinates (shown by the letter E added to the variable name) is done by multiplying the velocity vector by the conversion matrix. For the three cases described above, the results are:

Case 1 - Tilt Sensors Fixed to ADCP.

```
VXE =  VX * (CH*CR + SH*SR*SP) + VY*SH*CP + VZ * (CH*SR - SH*CR*SP)
VYE = -VX * (SH*CR - CH*SR*SP) + VY*CH*CP - VZ * (SH*SR + CH*SP*CR)
VZE = -VX*SR*CP                + VY*SP    + VZ*CP*CR
```

Case 2 - Roll Axis Fixed, Pitch Axis Gimballed Inside Roll. Same as the case 1 transformation.

Case 3 - Pitch Axis Fixed, Roll Axis Gimballed Inside Pitch.

```
VXE =  VX*CH*CR + VY*(CH*SR*SP + SH*CP) + VZ*(CH*SR*CP - SH*SP)
VYE = -VX*SH*CR - VY*(SH*SR*SP - CH*CP) - VZ*(SH*SR*CP + CH*SP)
VZE = -VX*SR    + VY*CR*SP              + VZ*CP*CR
```

Step 6 – Place Results in Output Array. The output arrays U, V, and W are indexed by the bin index IB. U is the east(+)/west(-) component, V is the north(+)/south(-) component, and W is the down(-)/up(+) component. From the directions of the earth-coordinate axes it can be seen that

```
U(IB) = VXE
V(IB) = VYE
W(IB) = VZE
```

This completes the processing for the IBth bin. From here, loop back to process the remaining bins. When all the bins are processed, the velocity processing algorithm is complete.

C-4. ECHO SPECTRAL WIDTH

The ADCP determines the echo spectral width by measuring the second moment of the backscattered water-mass echo for each depth cell (bin). It is a measurement of the expected statistical uncertainty in a single-ping, mean water-mass velocity measurement. See RDI's *Principles of Operation: A Practical Primer* for information on calculating spectral width.

C-5. ECHO INTENSITY

The ADCP echo-intensity data are a measurement of the intensity of the backscattered echo for each depth cell. See RDI's *Principles of Operation: A Practical Primer* for information on calculating echo intensity.

C-6. FISH REJECTION ALGORITHM

This section explains how the CF-command reduces the effects of fish swimming within the ADCP transducer beams.

C-6.1. HISTORY BEHIND THE CF-COMMAND. ADCPs typically have four beams mounted to one transducer head in a JANUS configuration. The beams are mounted at 30° (sometimes 20°) to the horizontal. Because of this configuration, it is possible that an ADCP will "see" fish within one or more beams when profiling.

All four ADCP beams have side lobes. Each side lobe is shaped like a cone (see Figure C-2). Part of this cone looks down a neighboring beam's main lobe. Therefore, when acoustic energy is propagating back to the ADCP along a beam's main lobe, part of this energy is seen by the other beams' side lobes. The amount of energy seen depends on the relative amplitude of the side lobe and the echo intensity of the surrounding water.

When only one beam sees a fish, we can expect to see a larger error velocity in the affected bin. This is true as long as the echo intensity of the fish is not much greater than that of the surrounding water. When the fish echo is much greater than the surrounding water, the strong echo from the "fishy" beam is heard by the two neighboring beams as well as the opposite beam. This causes the ADCP to measure about the SAME velocity in all four beams, which gives a low error velocity.

For buoy-mounted ADCPs, fish tend to "school" at some depth below the ADCP. In this situation, the fish seem to remain "still" relative to the ADCP. If an actual water current is present near the fish, the fish velocity (in this case, a near-zero velocity) will dominate the doppler measurement. Another situation occurs when the fish are not in all four beams. This is a nonhomogeneous situation that can cause a measurement error.

On vessel-mounted ADCPs, a forward-facing beam hears the doppler of the vessel to which it is attached. A strong echo from a fish causes the other three beams to hear the same doppler, and the ADCP outputs an apparent vertical velocity. If a side-facing (port/starboard) beam hears a strong fish echo, the ADCP outputs a low velocity measurement (no apparent vertical or error velocity).

C-6.2. ONE METHOD TO REDUCE FISH EFFECTS. The echo intensity (AGC) measurement from each beam is a good indicator of the relative strength of the returning acoustic energy. If we knew what the normal echo strength was for a given bin, we could detect fish in the profile data. For a large set of single-ping profile data, we could observe these typical AGC values, and then go back through the profile data to remove the "fishy-looking" bins.

ADCPs typically sum together many pings of data before storing or transmitting the average. To screen-out fish from the data before accumulation, the ADCP could compare the echo data from all four beams. If the four echo intensities do not match on a given bin, the ADCP could reject the data. Of course, an exact match will never occur, so we must allow some acceptable difference.

Each beam has a quiescent value that is an offset relative to zero. This value is typically 30-40 counts (one count is about 0.5 dB). The largest side lobe is down 35 dB (70 counts) or more from the beam's main lobe. For each bin of data, we can define an algorithm to remove "fishy" data by repeating the following cycle for each bin of data. Lets assume we start with bin *x* = 1 and CF=25 (50 counts). NOTE: We could probably use a count value of 40 and still not throw out too much "good" data.

Algorithm 1

a. Compare bin x from each beam to find the highest and the lowest bin *x* echo levels.
b. If the difference between the highest and lowest bin *x* value is more than 50 counts, mark the velocities in bin *x* of all four beams as bad.
c. If step b was true (fish detected), also mark bin *x+1* velocities as bad. This is because the ADCP samples AGC near the end of the bin.
d. Increment x and repeat for the next bin until all bins have been tested for the current ping.

This algorithm does not account for the failure of one beam. (Remember, the ADCP needs only three beams to compute velocity in three planes. The ADCP uses the fourth beam as a data-quality check.) If the ADCP is deployed for an extended time, there is a chance a beam could fail. If this happens, Algorithm 1 may flag all the data as "fishy," causing all velocity data from the deployment to be lost. To avoid this situation, we modified Algorithm 1 with Algorithm 2. The CF-command uses Algorithm 2 and repeats the following cycle for each bin of data.

Algorithm 2

a. Compare bin x from each beam to find the highest and the two lowest bin *x* echo levels.
b. If the difference between the highest and the lowest bin *x* value is more than 50 counts, mark the velocity in the beam with the lowest bin *x* value as bad. In effect, we are now using a 3-beam solution for the bin x layer.
c. If the difference between the highest and second lowest bin *x* value is also more than 50 counts, mark the velocities in bin *x* of all four beams as bad (i.e., beam OK, just bins affected).
d. If step c was true (a fish detected), also mark bin *x+1* velocities as bad. This is because the ADCP samples AGC near the end of the bin.
e. Increment *x* and repeat for the next bin until all bins have been tested for the current ping.

As an example, use Algorithm 2 and Figure C-2 to determine the outcome of Case 1 and Case 2 for bin 13 when CF=25 (50 counts).

Using Algorithm 2 and the data supplied for Bin 13 in Figure C-2 we have:

STEP	CASE 1	CASE 2
A	Highest = Beam 4 (81) 2^{ND} Low = Beam 2 (39) Lowest = Beam 1 (30)	Highest = Beam 4 (81) 2^{ND} Low = Beam 2 (29) Lowest = Beam 1 (30)
B	Is 81 (Bm 4) - 30 (Bm 1) > 50? Yes (51), so Beam 1 is bad at this point.	Is 81 (Bm 4) - 29 (Bm 2) > 50? Yes (52), so Beam 2 is bad at this point.
C	Is 81 (Bm 4) - 39 (Bm 2) > 50? No (42), so Step B applies. That is, the ADCP marks all Beam 1 velocities as bad and uses a 3-beam solution for Bin 13.	Is 81 (Bm 4) - 30 (Bm 1) > 50? Yes (51), so Step B no longer applies. The ADCP marks the velocities in Bin 13 of all four beams as bad.
D	Since Step C was false, this step is not applicable.	Since Step C was true, the ADCP also marks the velocities in Bin 14 of all four beams as bad.

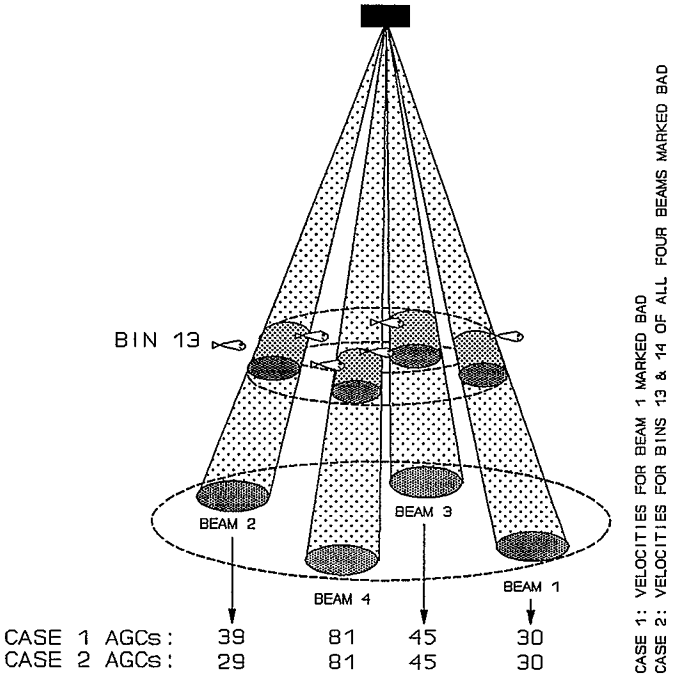


Figure C-2. Example of Fish Rejection Algorithm

APPENDIX D
DIRECT COMMANDS

D-0. INTRODUCTION

This appendix defines each direct command used by the ADCP (Table D-1) and EPROM recorder (Table D-2; usually for SC-ADCPs only). Direct commands let you set up and control the ADCP without the use of external software programs (e.g., RDI's SC-ADCP Deployment Program, DR/VM-ADCP Data Acquisition Software program or TRANSECT program). However, we STRONGLY recommend you use a software program because using direct commands is user-unfriendly and cumbersome. Additionally, many of the settings used by the ADCP are preset to optimum values (Table D-3). If you carelessly change these values, you could ruin your deployment. BE SURE YOU KNOW WHAT EFFECT EACH COMMAND HAS BEFORE USING IT.

Before you can enter direct commands, you must interconnect the ADCP as described in Appendix A. To enter direct commands, you can use either a dumb terminal or an IBM-compatible computer running a dumb terminal emulator program such as RDI's DUMBTERM.EXE. The ADCP accepts direct commands in UPPER CASE only. Appendix T-2 explains how to test the ADCP using direct commands.

D-1. ADCP DATA COMMUNICATIONS USING DIRECT COMMANDS

Input commands are in an ASCII format. Output data can be in either a 7 or 8-bit ASCII format or a binary format as set by the W-command. We will refer to these formats as the ASCII mode and the binary mode. The ASCII mode is useful when a terminal communicates with the ADCP. The binary mode is useful when high-speed communication or densely-packed data are desired.

Input commands alter ADCP operating parameters, start data collection, initiate built-in tests (BIT), and request output data. When a data collection cycle begins, the ADCP uses the parameters last entered or the factory-default parameters. ADCP parameters can only be altered after the ADCP sends its output data set at the end of the data collection cycle. Generally, only DR (direct-reading) and VM (vessel-mounted) ADCPs alter their commands between data collection cycles; SC (self-contained) systems use the same input parameters for the entire deployment.

Immediately after you apply power to the ADCP, it enters the STANDBY mode. Sending a BREAK from the terminal keyboard activates the ADCP. The ADCP then responds with a wake-up message that includes a carriage return/line feed sequence (CR/LF) and an RDI copyright notice similar to the following:

```
ACOUSTIC DOPPLER CURRENT PROFILER COPYRIGHT (c) RD INSTRUMENTS 1983-1992
ALL RIGHTS RESERVED
```

The ADCP then sends another CR/LF. If in the binary mode, the ADCP sends an ACK (hexadecimal code 06H). The ADCP then enters the DATA I/O mode and waits for an operating command.

Input commands are ASCII strings. In the ASCII mode, the input characters are echoed on the terminal; when the ADCP accepts a command, it responds with a CR/LF. In the binary mode, the input data are not echoed, and the ADCP sends a modulo 65536 checksum after the command with the most significant byte first. The checksum is computed on the binary representation of each command character, exclusive of the checksum bytes.

The first, or first and second, alpha character of each input command selects the parameter to be changed. The trailing decimal numbers define the new value of the parameter. Tables D-1 and D-2 give a summary of the ADCP input commands, their format (leading zeros must be included), and a brief description of the parameters they control. Refer to the listed page number for more information about a command.

For a multi-digit entry, the most significant value is sent first using ASCII digits 0 through 9. In the <u>ASCII mode</u>, after the parameter is entered correctly, the ADCP sends a CR/LF sequence. In the <u>binary mode</u>, after the input data are entered correctly, the ADCP sends an ACK. All input commands are stored in battery-backed RAM. After the input commands are entered, the system will continue to be configured from the RAM unless it receives a Z-command or the RAM looses its backup power. In either of these cases, the system will be configured per default values stored in PROM and set by internal switches. Table D-3 lists the standard factory default settings by model frequency.

D-2. COMMUNICATION ERRORS

In the <u>ASCII mode</u>, if there is an input data entry error such as parity, framing, or overrun, the ADCP sends the following.

```
ERR BUS<carriage return><line feed>
```

In the <u>ASCII mode</u>, if the input data fails to conform to the data format, the ADCP sends the following.

```
ERR FORMAT<carriage return><line feed>
```

In the <u>binary mode</u>, if an error occurs, the ADCP sends a NAK (15H) and an error code that describes the type of communication error. Error code length is eight bits. A set bit indicates an error. The error codes are:

BIT	ERROR
0 (LSB)	Overrun
1	Parity
2	Framing
3	Format
4	Time out
5	S-command only
6	Checksum error

Table D-1. ADCP Input Command Summary

Command	Description	Page
A*nn*	Bin-to-bin tracking filter gain (40-60; 40 disables)	D-5
B*aabbcc*	Bin-to-bin acquisition and filter control	D-7
CA*pp*	Percent of ensemble pings in CTD measurement time (0-99)	D-7
CB*nnnnn*	Error velocity threshold (0-65536)	D-9
CF*nn*	Fish rejection threshold (10-99)	D-9
CH*nnnnn*	Heading offset (0-65536 BAMS; 65536 = 360 degrees)	D-9
DA*nn*	Test modes	D-9
E*aabbccddee*	Ping-to-ping first bin tracking control	D-10
FA*nnnnn*	Bottom-track transmit pulse length (3-127 meters)	D-13
FB*nnnnn*	Bottom-track depth cell length (0-3; 2^{FB} meters)	D-14
FC*nnnnn*	Bottom-track number of depth cells (16-128)	D-14
FD*nnnnn*	Bottom-track mode (00000 = automatic; 00255 = manual)	D-15
FE*nnnnn*	Bottom-track transmit length control (10-30%)	D-15
FF*nnnnn*	Bottom-track detection threshold (0-255 AGC counts)	D-15
FG*nnnnn*	Ensembles before bottom-track re-acquire (0-255)	D-16
FH*nnnnn*	Profiling pings per BT ping (1-255; 255=Bottom-track OFF)	D-16
G	Clear seconds from real-time clock	D-16
H*nnn*	Delay before data output (0-255; LSD = 0.1 second)	D-16
I*nn*	Transmit pulse length (1-99 meters)	D-17
J*nnn*	Blank after transmit (0-999; LSD = 0.1 meter)	D-17
K*nn*	Delay after blank (0-99 meters)	D-17
L*n*	Depth cell length (0-5; 2^{L} meters)	D-18
M*pp*	Percent-good threshold (0-99%)	D-18
N*nn*	Signal-to-noise threshold (0-99; LSD = 0.1 dB)	D-18
O*nnn*	Output data select (binary switches)	D-19
P*nnnnn*	Pings per ensemble (1-65535)	D-19
Q*nnn*	Number of depth cells (1-128)	D-19
R*hhmmssff*	Time between ensembles (hr, min, sec, hundredths)	D-20
S*nnn*	Start data collection (binary switches)	D-20
T*mmddhhmm*	Set real-time clock (month, day, hr, min) [sec=0]	D-21
U*mmddhhmmss*	Time of first ping (month, day, hr, min, sec)	D-22
V*mmssff*	Time between pings (min, sec, hundredths)	D-22
W*nnn*	Input/Output control (binary switches)	D-24
X	Transmit system data	D-25
Y*n*	Perform BIT diagnostics	D-26
Z	Reset to factory defaults	D-26
@1	Set normal serial baud rate (reset @4)	D-26
@4	Set serial baud rate × 4	D-26
? and /	Displays input command help menu ("/" shows second page)	D-26
F?	Displays bottom-track input command help menu	D-27
BREAK	Interrupt operation without forcing defaults	D-28

NOTE: THIS TABLE APPLIES TO THE FIRMWARE VERSION LISTED ON THE TITLE PAGE.

Table D-2. Recorder Command Summary (Usually SC-ADCPs Only)

Command	Description	Page
@A*sss*	Advances read pointer *sss* sectors in current deployment	D-29
@B	Verifies memory cards are blank (erased)	D-29
@D*sss*	Dumps *sss* sectors starting at location of @P	D-30
@F*nnn*	Finds deployment file number *nnn*	D-30
@G*sss*	Get data to read without advancing pointer	D-30
@L	Locate and display current read pointer position	D-30
@P*CCccsssss*	Moves dump pointer to selected card, chip, and sector	D-31
@R*sss*	Reads and transmits *sss* sectors from recorder memory	D-31
@S	Summarizes (maps) the contents of recorder memory	D-31
@T	Tests recorder hardware and installation	D-31
@W	Writes configuration data (block 1) for a new deployment	D-32

Table D-3. Input Command Default Settings by Model Frequency

Command	75 kHz	150 kHz	300 kHz	600 kHz	1200 kHz
A*nn*	46	47	48	48	49
B*aabbcc*	009901	009901	009901	009901	009901
CA*pp*	50	50	50	50	50
CB*nnnnn*	10000	10000	10000	10000	10000
CF*nn*	25	25	25	25	25
CH*nnnnn*	00000	00000	00000	00000	00000
DA*nn*	00	00	00	00	00
E*aabbccddee*	0004030199	0004030199	0004030199	0004030199	0004030199
FA*nnnnn*	00003	00003	00003	00003	00003
FB*nnnnn*	00000	00000	00000	00000	00000
FC*nnnnn*	00128	00128	00128	00128	00128
FD*nnnnn*	00000	00000	00000	00000	00000
FE*nnnnn*	00013	00013	00013	00013	00013
FF*nnnnn*	00040	00040	00040	00040	00040
FG*nnnnn*	00000	00000	00000	00000	00000
FH*nnnnn*	00255	00255	00255	00255	00255
H*nnn*	000	000	000	000	000
I*nn*	08	08	04	02	01
J*nnn*	040	040	020	010	005
K*nn*	00	00	00	00	00
L*n*	3	3	2	1	0
M*pp*	25	25	25	25	25
N*nn*	60	60	60	60	40
O*nnn*	005	005	005	005	005
P*nnnnn*	00100	00100	00100	00100	00100
Q*nnn*	060	060	060	060	030
R*hhmmssff*	00000000	00000000	00000000	00000000	00000000
S*nnn*	000	000	000	000	000
V*mmssff*	000100	000100	000100	000100	000050
W*nnn*	000	000	000	000	000
Y*n*	0	0	0	0	0

NOTE: THESE TABLES APPLY TO THE FIRMWARE VERSION LISTED ON THE TITLE PAGE.

D-3. DIRECT COMMAND DESCRIPTIONS

The following paragraphs list all the direct commands. Each listing includes the direct command's purpose, format, range, and description. Many of the listings also include amplifying notes and examples.

A – BIN-TO-BIN TRACKING FILTER GAIN

Purpose : Sets the gain of the bin-to-bin tracking loop
Format : A*nn*
Range : *nn* = 40 to 60
Description: The A-command controls the ADCP's ability to follow changes in water velocity vs depth (shear). Excessive shear values can result in bias errors throughout the shear region. These errors are the largest when the shear is present at the end-of-profile where backscattered signal levels become small.

The ADCP positions a narrow band processing filter around the Doppler signal frequency. The ADCP positions this filter for depth cell 1 as described in the E-command. The ADCP uses the bin-to-bin tracking function to position this filter for all other depth cells. At the end of each depth cell, the ADCP combines that depth cell's velocity data with previous depth cell data. The ADCP uses this information to position the processing filter for the next depth cell. The response of this filter positioning to a step change in velocity is exponential. The A-command controls the time constant of this process.

The default values result in good performance in shear. Table D-4 lists the ADCP shear capabilities as a function of system frequency, depth cell length, and transmit pulse widths. Performance in higher shear environments can be attained by increasing the A-command value. Each increment of one doubles the ability of the ADCP to follow shear. There are limitations, however. Table D-5 lists these limitations.

Notes :
1. A*40* disables the bin-to-bin tracking loop.
2. ADCP firmware before v16.07 had this function disabled at some point in each profile (see note 4). This has been modified in v16.07 and later. If you have firmware earlier than v16.07, do NOT use A-command values above 20.
3. ADCP firmware v16.07-16.26 use a default value of 46 for all systems. If you have v16.07-16.26, manually enter the v16.27 (or later) default values for shear conditions.
4. For more information on the effects of this command, refer to The Journal of Atmospheric and Oceanic Technology – *On identifying and screening filter skew and noise bias in acoustic Doppler current profiler measurements* (Chereskin, Firing, and Gast (1989)).

Table D-4. Approximate ADCP Shear Capabilities

System (kHz)	Default value	Depth cell length (m)	Transmit pulse length (m)	Shear capability (cm/s/m)
75	46	32 {L5}	32 {I32}	0.5
75		16 {L4}	16 {I16}	1.0
75		8 {L3}	8 {I8}	1.0
75		8 {L3}	16 {I16}	2.0
150	47	16 {L4}	16 {I16}	1.0
150		8 {L3}	8 {I8}	1.5
150		8 {L3}	16 {I16}	2.0
150		4 {L2}	4 {I4}	1.0
150		4 {L2}	8 {I8}	2.0
300	48	8 {L3}	8 {I8}	2.0
300		4 {L2}	4 {I4}	3.0
300		4 {L2}	8 {I8}	4.0
300		2 {L1}	2 {I2}	2.0
300		2 {L1}	4 {I4}	4.0
600	48	4 {L2}	4 {I4}	2.5
600		2 {L1}	2 {I2}	3.0
600		2 {L1}	4 {I4}	5.0
1200	49	2 {L1}	2 {I2}	4.0
1200		1 {L0}	1 {I1}	4.0
1200		1 {L0}	2 {I2}	8.0

NOTE: THESE VALUES DEPEND ON MANY FACTORS AND ARE APPROXIMATE. THE CAPABILITIES ARE FOR THE DEFAULT A-COMMAND VALUES. THE CAPABILITIES DOUBLE FOR EACH INCREASE OF ONE. DO NOT EXCEED THE VALUES LISTED IN TABLE D-5.

Table D-5. Maximum Settings for the A-Command

System (kHz)	Depth cell length (meters)					
	1	2	4	8	16	32
75	--	--	47	46	46	46
150	--	48	47	47	47	46
300	49	48	48	48	47	46
600	49	49	48	47	47	46
1200	49	49	48	48	47	46

B – BIN-TO-BIN ACQUISITION AND FILTER CONTROL

Purpose : Sets point where the ADCP narrows the processing filter bandwidth

Format : B*aabbcc*

Range : *aa* = 00, *bb* = 00 to 99, *cc* = 00 to 99

Description: The B-command is an RDI design parameter; do NOT change it carelessly. The *aa* digits MUST always be 00. The *bb* digits control a switch point where the ADCP narrows the Doppler signal processing bandwidth by a factor of two. The switch occurs when the beam with the lowest AGC count goes below *bb*. For example, B009001 tells the ADCP to switch the bandwidth when the beam with the lowest AGC value passes through 90 counts. B000001 locks the ADCP in broadband mode. The *bb* default of 99 (in firmware v16.11 and later) locks the ADCP in the narrow band mode. This improves long-term precision and reduces variance. Occasionally, the ADCP has trouble acquiring the Doppler signal in the upper depth cells (E-command). This could occur on vessel-mounted ADCPs where the roll/pitch rate causes the Doppler frequency of each beam to change significantly from ping to ping. This is indicated by a lower percent-good output in the upper depth cells (2 through 10). The wider bandwidth in the upper part of the profile will help in this situation. The *cc* digits (usually 01) set the width (in bins) of a proofing filter (where 00=1 bin, 01=2 bins, etc). *cc* is the number of consecutive "bad" depth cells to wait before initiating acquisition.

Notes :

1. In firmware before v16.11, do NOT change the default value of B009000. In v16.11-16.34, the default is B009900, but you can use a value of B009901 to improve performance. If using v16.37 or later on a vessel with high flow noise, use a setting of B00*bb*99 (*bb* is usually 99).
2. Recommended settings (v17.07 and later):
   a. General purpose (default) – B009901
   b. Dynamic sea states – B009001
3. For more information, see The Journal of Atmospheric and Oceanic Technology – *On identifying and screening filter skew and noise bias in acoustic Doppler current profiler measurements* (Chereskin, Firing, and Gast (1989)).

CA – PERCENT OF ENSEMBLE PINGS IN CTD MEASUREMENT TIME

Purpose : Sets the percent of profile ensemble pings used in the CTD measurement. Helps conserve V4 battery life in SC-ADCPs by powering the CTD only during the selected percent of pings.

Format : CA*pp*

Range : *pp* = 00 to 99 percent

Description: In systems with a CTD option, the ADCP counts the pulses sent by the CTD sensors. The approximate time used by the ADCP to count pulses is determined by CA for multiple-ping ensembles or by the time between ensembles (R-command) in single-ping mode. CA is the percent of profiling pings used for the CTD measurement interval. Bottom-track pings are not counted. CA has no effect in single-ping mode.

The combined effects of several parameters determine the actual CTD measurement time. Leader data (Table 4-2) shows the actual amount of time the ADCP counts CTD pulses during each ensemble and the CTD pulse count. Dividing CTD counts by CTD time yields the CTD pulse rate. There are three CTD measurement modes.

1. Single-ping mode – The CTD measurement interval is the time between the start of one ping (ensemble) and the start of the next ping. This time can be determined by the R-command value when the ADCP is set to cycle automatically or by the time between S-commands when the ADCP is set to cycle manually.
2. Multiple-ping ensemble WITHOUT bottom-track mode – CTD measurement interval = ((CA × P [rounded UP])-1) × V.
3. Multiple-ping ensemble WITH bottom-track mode – CTD measurement interval is same as mode 2, PLUS the duration of bottom-track pings occurring during the CTD measurement interval.

Example : These examples show how to approximate the CTD measurement interval (CA = % of profiling pings used for CTD interval, P = number of profiling pings per ADCP ensemble, V = time between profiling pings, FH = ratio of profiling pings to bottom-track pings).

1. Single-Ping Mode – The CTD measurement interval equals the time between ensembles (R-command) when the S-command tells the ADCP to cycle automatically, OR the CTD measurement interval equals the time between S-commands when the S-command tells the ADCP to cycle manually (see S-command).
2. Multiple-Ping Mode (bottom-track OFF) – If CA=50, P=17, V=1, and FH=255, CTD measurement interval = ((0.50 × 17)-1) × 1 = (9 [rounded UP] - 1) × 1 = 8 × 1 = 8 seconds.
3. Multiple-Ping Mode (bottom-track ON) – Using example 2 values with FH=1, CTD measurement interval = 8 s PLUS the duration of the bottom-track pings that occur between each profiling ping. With FH=1, the CTD measurement interval is not approximated easily when bottom-track is used because every other ping is a bottom-track ping of undefined duration (because they are not counted). A rough estimate would include the 8 s (from example 2) plus the total duration of the bottom-track pings calculated by (Table Value × ((CA × P [rounded UP]) - 1)) / FH, where Table Value equals:

System Frequency (kHz)	75	150	300	600	1200
5-MHz CPU Clock (s)	1.6	1.1	1.1	1.1	0.3
10-MHz CPU Clock (s)	1.6	1.0	0.6	0.6	0.14

For a 150-kHz ADCP with a 5-MHz clock:
(1.1 × ((0.50 × 17)-1)) / 1 = (1.1 × (9 [rounded UP]-1)) / 1 = (1.1 × 8) / 1 = 8.8 / 1 = 8.8 s. CTD measurement interval = 8 + 8.8 = 16.8 s.

An easier way to determine the CTD measurement interval when using bottom-tracking is to experiment with different CA values, and then look in the leader data (Table 4-2) for the actual CTD measurement interval in milliseconds.

CB – ERROR VELOCITY THRESHOLD

Purpose : Sets the error velocity threshold
Format : CB*nnnnn*
Range : *nnnnn* = 00000 to 65536
Description: This is the magnitude of the error velocity (Ve) above which the coordinate-transformed (Vx, Vy, Vz) velocity calculations are invalid (see Appendix C). The scale factor is 0.125 cm/s (for 150 to 1200-kHz systems) and 0.25 cm/s (for 75-kHz systems) as determined by internal switch S2 (see Table 4-3).
Example : If CB=40 and the scale factor is 0.25 cm/s, the error velocity threshold will be 10 cm/s.

CF – FISH REJECTION THRESHOLD

Purpose : Sets a data rejection threshold to screen data for fish
Format : CF*nn*
Range : *nn* = 10-99, where value entered is AGC/2 (see example)
Description: CF sets an AGC threshold level that, if exceeded, rejects velocity data on a bin-by-bin basis for either the affected beam (fish detected in only one beam) or for the affected bin in all 4 beams (fish detected in more than one beam). This usually occurs when a fish passes through a beam. Appendix C explains algorithm used.
Example : Convert a desired AGC fish rejection threshold of 50 counts to the value used by the CF-command: CF = (50 / 2) = 25.
Notes : 1. A CF value of more than 63 turns off this feature.
2. Press </> to see the CF-command help screen.

CH – HEADING OFFSET

Purpose : Sets a heading offset to correct for the earth's magnetic variations, or to zero the ADCP to another sensor or reference line.
Format : CH*nnnnn*
Range : *nnnnn* = 00000-65536 BAMs
Description: CH allows entry of a heading offset to be used as a new zero reference for the heading output and for transformation to earth coordinates. To determine CH, multiply the desired offset in degrees by a scale factor of 65536/360.
Example : Convert an offset of 34 degrees to the value for the CH-command.

$$CH = 34 \times (65536/360) = 6189.51 = 06190 \text{ (rounded)}$$

DA – TEST MODES

Purpose : Factory use
Format : DA*nn*
Range : See description.
Description: DA (as defined below) selects TEST MODE A test multiplexer signal outputs for monitoring or selects special test and trigger modes.

DA*nn*	Test Output 1	Test Output 2
00	Bottom-track transmit	Water-track transmit
01-04	Log AGC 1/2/3/4	Sine of Doppler signal 1/2/3/4
05-07	Spare	Spare

08 Special test (halts normal operation for testing)

09-23 Special factory output data modes (not supported)

24 External bottom-track trigger signal – Sending DA24 to the ADCP before the S-command sets the DA24 flag. If the bottom-track mode is active (FH < 255), then before each bottom-track ping, the ADCP checks the DA24 flag. If set, the ADCP waits for the READY signal (pin C6 on the Per 3 board) to transition from a low (≈ 0 VDC) to a high (≈ +5 VDC) before pinging. The ADCP responds to the READY signal in less than 1 ms, transmits the bottom-track ping, transmits the appropriate number of water-track pings (as determined by the FH and P-commands), and then again waits for the READY signal to transition before sending the next bottom-track ping in the ensemble. Examples (B = bottom-track ping, W = water-track ping):

FH	P	Sequence for one ensemble
0	4	*wait* B *wait* B *wait* B *wait* B
1	4	*wait* B W *wait* B W *wait* B W *wait* B W
2	4	*wait* B W W *wait* B W W
3	4	*wait* B W W W *wait* B W

To clear the DA24 flag, send a <BREAK> (Note - Sending a BREAK does not clear the DA*nn* help display, but it does clear the DA24 flag).

E – PING-TO-PING FIRST BIN TRACKING CONTROL

Purpose : Controls positioning of first bin (ping-to-ping tracking)

Format : E*aabbccddee*

Range : See description

Description: The ADCP positions a narrow-band processing filter around the Doppler signal. The ADCP must position this filter properly at the beginning of each ping. The E-command controls two modes.

Acquisition mode – During turn-on the ADCP assumes the Doppler frequency shift is at zero (no velocity) and positions the filter at zero. If no signal is present in the filter, the ADCP enters the acquisition mode. In subsequent pings, the ADCP moves the filter toward the signal until the filter detects the signal. This process usually takes fewer than ten pings. *ee* controls the size of the step taken with each ping (step size = *ee* × 150 Hz). The *ee* default of 99 automatically calculates the step size. These calculations consider other parameters such as I, L, and system frequency. We recommend you ALWAYS use 99 for *ee*.

Tracking mode – After the filter detects the signal, the ADCP enters a ping-to-ping tracking mode. The tracking mode uses prior-ping history (controlled by *aa*, *bb*, *cc*, and *dd*) of selected depth cells and prior-ping weighting to position the processing filter for the FIRST depth cell. Subsequent depth cells use the bin-to-bin tracking function (see A-command). The information used is selected as follows.

aa sets PERCENT of total depth cells to use.
bb sets NUMBER of total depth cells to use.
cc sets STARTING depth cell to use.
dd sets WEIGHTING of previous pings to use.

Either *aa* or *bb* MUST be 00. Both CANNOT contain instructions; you must select either percent or number. Each *dd* weighting factor increment halves the weight of the last ping:

00 – weight the last ping 100%
01 – weight the last ping 50%, and weight all previous pings in the ensemble the other 50%
02 – weight the last ping 25%, and weight all previous pings in the ensemble the other 75%

Examples : *E3000020199* – Use 30% of the total depth cells (*aa*), starting at depth cell 2 (*cc*). Weighting is strong toward the preceding ping. Acquisition step size is automatic.

E0004030199 – Use 4 depth cells (*bb*) starting at depth cell 3 (*cc*). The last ping is weighted 50% and all previous pings in the ensemble are weighted the other 50% (*dd*). Acquisition step size (ee) is automatic. In this example, the ADCP looks at the last ping, retrieves the velocities from depth cells 3 through 6 (4 depth cells), averages them, and positions the tracking filter at this average for depth cell 1 of the current ping.

Notes :
1. In firmware before v16.07 the default value for *ee* is 04. Do NOT change this value to 99; it will not work.
2. Recommended settings:
   a. General purpose – E0004030199 (This is the default for v17.07 and later; v16.23-17.06 users should manually set this value.)
   b. High shear conditions near ADCP – E0004020199 uses depth cells 2 through 5 only.
   c. Obstruction near ADCP – E0004040199 uses depth cells 4 through 7 only.
3. Suggestions:
   a. We recommend you do not use information from depth cell 1 for ping-to-ping tracking. It is often contaminated by ship motion or insufficient blanking (J-command).
   b. We recommend you use at least 4 depth cells in the average to reduce the velocity noise. The filter position is influenced by this noise.
   c. Use a minimum number of depth cells in situations where shear is present near the ADCP. The filter is positioned at the average of the depth cells selected. This may be substantially in error in large shear situations.
4. For more information, see The Journal of Atmospheric and Oceanic Technology – *On identifying and screening filter skew and noise bias in acoustic Doppler current profiler measurements* (Chereskin, Firing, and Gast (1989)).
5. An ADCP firmware bug in versions before 16.99 can cause a slight data interpretation problem. The problem is that:

a. For *aa*, the firmware adds one bin to the final calculation of the number of bins to use. For example, if E=3000040199 and the total number of bins = 128 (as set by the Q-command), the ADCP should use 30% of the total number of bins (38 bins). However, the bug adds one to this value, so the ADCP uses 39 bins.

b. For *bb*, the firmware adds one bin to the input value. For example, if E=0038040199 the ADCP interprets the number of total bins as 39 instead of 38.

c. For *cc*, the firmware adds one bin to the input value. For example, if E=3000040199 the ADCP interprets the starting bin number as 5 instead of 4.

Until you can get an updated version of firmware, you can use adjusted values of *bb* and *cc* to counteract the problem. For our example in 5a, you would enter E0037030199 instead of E3000040199. This uses a total of 38 bins (37+1) starting at bin #4 (3+1).

BOTTOM-TRACK COMMANDS

The following eight commands (FA through FH) are special commands used for bottom-tracking applications. The default state of bottom-tracking is off (FH00255). Sending any other FH-command starts bottom-tracking in its AUTOMATIC mode (FD00000). To select the MANUAL bottom-tracking mode, you must also send an FD00255 command to the ADCP.

Briefly, here is how the bottom-track mode processes data. After you turn on the bottom-track mode (FH), you can set the bottom-track parameters either automatically or manually (FD). If you use the AUTOMATIC bottom-track mode, the ADCP automatically sets many of the bottom-track commands. This eliminates guess-work on your part. In bottom-track mode, the ADCP emits a special bottom-track ping (as opposed to a water-track ping) after every FH water-track ping(s). The FA-command (with FE's help in automatic mode) determines the pulse length of this bottom-track ping. The length (FB) and number (FC) of bottom-track depth cells help to determine the bottom depth accurately. After receiving the bottom-track ping's echo, the ADCP collects velocity and echo intensity information for each depth cell of all four beams. After collecting this information, the ADCP checks the echo against a water-noise threshold level (FF) that establishes bottom-depth validity. This process continues with every bottom-track ping unless the bottom is "lost." If this happens, bottom re-acquisition goes through the following process.

a. ADCP makes four attempts to re-acquire the bottom near the last detected depth. NOTE: The four re-acquisition attempts are done at the rate of one bottom-track ping for every FH water-track ping(s).

b. If the ADCP does not detect the bottom after four tries near the last valid depth, the ADCP makes 16 attempts to acquire the bottom at varying depths. NOTE: The 16 acquisition attempts are done at the rate of one bottom-track ping for every FH water-track ping(s).

c. If the ADCP still does not detect the bottom after 16 tries at varying depths, the ADCP will wait a specified number of ensembles (FG) before making another attempt to acquire the bottom. If FG=0 (the default), the ADCP will continually try to acquire the bottom using one bottom-track search ping for every FH water-track ping(s).

d. After FG water-track ensembles, the ADCP will again try 16 acquisition attempts. The cycle of search, wait, search continues until the ADCP detects the bottom.

To begin using the bottom-track mode, you will need to do the following.

a. Enter an FH-command of 00001 to turn on the AUTOMATIC bottom-track mode (you can use other values, but this is the most common). You do not need to enter any other commands to take advantage of the AUTOMATIC bottom-track mode. Most users will find the AUTOMATIC bottom-track mode suitable for their needs because the ADCP continually optimizes the FA, FB, and FC commands to the changing environment.

b. If you are profiling in an area where the bottom is usually beyond the range of the ADCP, you can set FG to a higher value so less time is spent looking for an out-of-range bottom. FG tells the ADCP how many ensembles to wait after *losing* the bottom before trying to re-acquire it. The default of FG=0 always tries to re-acquire the bottom.

c. We are confident the AUTOMATIC bottom-track mode will meet the needs of most applications, so we do not explain the MANUAL bottom-track mode in detail. To enter the MANUAL bottom-track mode, you must still enter the FH00001 command to turn on bottom-tracking. You will also have to enter a command of FD00255 to select the MANUAL bottom-track mode. Finally, you will have to enter values for the FA, FB, FC, FF, and FG commands (NOTE: FE is not used in MANUAL). When adjusting FA, FB, and FC, we recommend you set these values using the algorithms shown in the reference list. If you have an uncommon requirement such as using an SC-ADCP to track an ice floe, contact RDI so we can help you determine any special settings.

FA – BOTTOM-TRACK TRANSMIT PULSE LENGTH

Purpose : Sets the length of the bottom-track transmit pulse
Format : FAnnnnn
Range : nnnnn = 00003 to 00127 meters; initializes at 3 meters
Description: In automatic bottom-track mode, FA is determined by the equation:

$$FA = \frac{FE \times \text{Bottom Depth}}{100} + k$$

where k = 2 for 600 and 1200-kHz systems or
3 for 75, 150, and 300-kHz systems

and Bottom Depth is the range (in meters) to the reflecting boundary during the previous bottom-track ping. This is usually the sea-bottom when the ADCP points down, or the sea-surface when the ADCP points up. Table D-6 lists the minimum bottom-depth detection ranges.

In manual bottom-track mode, you must set this value. For example, FA00010 tells the ADCP to send out a 10-meter long bottom-track transmit pulse.

Notes : The ADCP hardware limits FA to 40 meters for 300, 600, and 1200-kHz systems, and to 120 meters for 75 and 150-kHz systems. If the ADCP receives a Z-command, FA resets to its default.

FB – BOTTOM-TRACK DEPTH CELL LENGTH

Purpose : Sets bottom-track depth cell length
Format : FBnnnnn
Range : nnnnn = 00000 to 00003 (see Description); initializes at zero
Description: In automatic bottom-track mode, FB is determined by the equation:

$$FB = \begin{cases} 0 \text{ (1 m) when Bottom Depth} < 64 \text{ m,} \\ 1 \text{ (2 m) when Bottom Depth} \geq 64 \text{ m and} < 128 \text{ m,} \\ 2 \text{ (4 m) when Bottom Depth} \geq 128 \text{ m and} < 256 \text{ m,} \\ 3 \text{ (8 m) when Bottom Depth} \geq 256 \text{ m} \end{cases}$$

where Bottom Depth is the range (in meters) to the reflecting boundary during the previous bottom-track ping. This is usually the sea-bottom when the ADCP points down, or the sea-surface when the ADCP points up. Table D-6 lists the minimum bottom-depth detection ranges.

Table D-6. Minimum Bottom-Depth Detection Ranges

75 kHz	150 kHz	300 kHz	600 kHz	1200 kHz
7 m	7 m	5 m	4 m	4 m

In manual bottom-track mode, you must set FB = 2^{nnnnn} meters. That is,

nnnnn	Depth cell length
00000	1 m
00001	2 m
00002	4 m
00003	8 m

Notes : If the ADCP receives a Z-command, FB resets to its default.

FC – BOTTOM-TRACK NUMBER OF DEPTH CELLS

Purpose : Sets the number of bottom-track depth cells
Format : FCnnnnn
Range : nnnnn = 00016 to 00128 depth cells; initializes with 128 cells
Description: In automatic bottom-track mode, FC is determined by the equation:

$$FC = \frac{2 \times \text{Bottom Depth}}{\text{FB (in meters)}}$$

where Bottom Depth is the range (in meters) to the reflecting boundary during the previous bottom-track ping. This is usually the sea-bottom when the ADCP points down, or the sea-surface when the ADCP points up. Table D-6 lists the minimum bottom-depth detection ranges.

In manual bottom-track mode, you must set this value. For example, FC00128 selects 128 depth cells of the length used in FB.

Notes : The maximum bottom-track range is the number of bottom-track depth cells (FC) times bottom-track depth cell length (FB). In manual mode, set this value to about two times the actual depth to allow for such environmental factors as pitch, roll, and slanted bottoms. These factors increase the range. If the ADCP receives a Z-command, FC resets to its default.

FD – BOTTOM-TRACK MODE

Purpose : Selects automatic or manual bottom-track mode
Format : FDnnnnn
Range : nnnnn = 00000 or 00255; default = 00000 (automatic mode)
Description: In automatic mode (FD00000), the ADCP optimizes FA, FB, and FC to changing environments. In manual bottom-track mode (FD00255), the ADCP uses the fixed values you select for FA, FB, and FC.

FE – BOTTOM-TRACK TRANSMIT LENGTH CONTROL

Purpose : In automatic bottom-track mode, FE aids in the selection FA.
Format : FEnnnnn
Range : nnnnn = 00010 to 00030 percent; default = 00013
Description: In automatic mode, FE sets the width of the bottom-track transmit pulse (FA) depending on the range to the bottom. For example, if FE=00010 and the range to the bottom is 150 m, the next bottom-track transmit pulse (FA) will be 15 m plus a small constant (see FA command). The manual mode does not use FE.

FF – BOTTOM-TRACK DETECTION THRESHOLD

Purpose : Sets the bottom detection threshold
Format : FFnnnnn
Range : nnnnn = 00000 to 00255 AGC counts; default = 00040
Description: The FF command lets you change the bottom-track detection threshold. We recommend you use the default of 40 AGC counts (about 18 dB), but if you are profiling in an area where the ADCP is detecting a false bottom, you can increase this value. For example, if FF=00050, the bottom-echo's intensity must be 50 AGC counts above the surrounding water noise level before a valid bottom detection can take place.
Notes : Binary bytes 62 and 63 (ASCII digits 146-150) of the ADCP's long-leader display Bottom-Track Percent Good. This is the percentage of bottom-track pings that passed the FF threshold value during an ensemble (see Table 4-2). The four nibbles that make up binary bytes 62 and 63 represent the four ADCP beams. The least significant bit is equal to 6.67% (100/15).

FG — ENSEMBLES BEFORE BOTTOM-TRACK RE-ACQUIRE

Purpose : Allows a higher water-ping rate when the bottom is not in range
Format : FGnnnnn
Range : nnnnn = 00000 to 00255 ensembles; default = 00000
Description: FG sets the number of ADCP ensembles to wait after losing the bottom before trying to re-acquire it. For example, if FG=00020, the ADCP will wait 20 ADCP ensembles after loss of bottom before sending another bottom-track ping. If FG=00000 (the default), the ADCP continually tries to acquire the bottom.

FH — PROFILING PINGS PER BOTTOM-TRACK PING

Purpose : Sets the number of water-track pings between bottom-track pings
Format : FHnnnnn
Range : nnnnn = 00001 to 00255 pings; 00255 turns bottom-track OFF
Description: The default of FH00255 turns off bottom-track mode. A setting of FH00001 turns on bottom-track mode and results in one water-track ping for every bottom-track ping. You can use other values of FH, but we recommend using FH00001 when bottom-tracking. FH00000 results in bottom-track ensembles only (i.e., no water-track pings). When selected, only ADCP leader data are sent. Other settings such as P, V, and R will still be in effect. Use the O-command if you want coordinate transformation done.

G — CLEAR SECONDS FROM REAL-TIME CLOCK

Purpose : Synchronizes ADCP clock
Format : G
Description: The G-command sets the ADCP clock's seconds clock to zero. If ADCP seconds are greater than 40, the ADCP will also increment the minute. First use the T-command to set the ADCP clock to the nearest reference-time minute. When reference-time seconds reach zero, enter the G-command. This synchronizes (to the nearest second) the ADCP clock with the external reference clock.
Examples : The T-command reference time is 10:24:00 and the ADCP time is 10:24:21 when you enter the G-command. This sets the ADCP clock to 10:24:00. If the ADCP time was 10:24:55, the ADCP clock would have been set to 10:25:00 instead.
Notes : The T-command sets ADCP time; the X-command reads ADCP time.

H — DELAY BEFORE DATA OUTPUT

Purpose : Sets minimum amount of delay before ADCP transmits output data
Format : H*nnn*
Range : *nnn* = 000 to 255 tenths of seconds (e.g., 255 = 25.5 seconds)
Description: The H-command sets the minimum time the ADCP waits before sending its output data. The ADCP sends an ASCII "NULL" character (00h) before the delay. When the ADCP is ready to send its data, serial output line "B" goes low. With RS-422, serial output line "A" will also go high. For most applications, you should use the default value of 000.

I – TRANSMIT PULSE LENGTH

Purpose : Sets the length of the sonar's transmit pulse
Format : I*nn*
Range : *nn* = 01 to 99 meters
Description: The I-command sets the length of the transmitted sonar pulse. The units are vertical meters even though the pulse is at an angle, usually 30° from vertical. The ADCP converts the pulse length to a transmit interval by multiplying the pulse length by a scaling factor of about 1.47 ms/m. Actual transmit time has a small dependence on the number of depth cells. ADCP hardware limits the transmit time to about 68 ms, so I-commands larger than 46 (68 ms / 1.47 ms/m) do not increase the actual length of the sonar pulse in the water. An exception is the 75-kHz system, which allows pulses up to 70 meters. If you enter an I-command that represents a duty cycle greater than 5%, the ADCP firmware automatically reduces the length of the transmit pulse. Too large a duty cycle can cause damage to the system.
Examples : I*08* represents a transmit interval of 8×1.47=11.8 ms. For a 30° beam angle, distance to 8 vertical meters along a 30° slant angle is 8/cos(30)=9.24 m. Round trip is twice this or 18.5 m. The 8-meter pulse assumes a speed of sound of 18.5/11.8=1.57 m/ms.

I*99* is entered with a V-command already set to 1 ping per second. A 5% duty cycle would be 50 ms = 50/1.47 m = 34 meters. To be safe, the firmware reduces the actual I-command value to 32.

Notes : The I-command is usually set to equal depth cell length.

J – BLANK AFTER TRANSMIT (DELAY AFTER TRANSMIT)

Purpose : Normally set to give the transducer time to recover after transmit; can extend range beyond 128 depth cell limit by moving out the start of receive; can be used when a depth window is desired to minimize unneeded data in the ensemble.
Format : J*nnn*
Range : *nnn* = 000-999 meters and tenths (e.g., 999 = 99.9 meters)
Description: The J-command value inhibits the receivers and echo processing after the transmit interval. LSD = 0.1 m. Note that the Leader output (Table 4-2) rounds this value to the nearest whole meter (e.g., J106 = 10.6 m, but displayed as 11 in the leader).
Note : See also K – DELAY AFTER BLANK

K – DELAY AFTER BLANK

Purpose : Can extend range beyond 128 depth cell limit by moving out the start of receive; can be used when a depth window is desired to minimize unneeded data in the ensemble.
Format : K*nn*, where *nn* = 00 to 99 meters
Description: K delays the start of first depth cell echo processing after the distance defined by the J-command (blank beyond transmit).

L – DEPTH CELL LENGTH

Purpose : Selects the volume of water for one measurement cell

Format : L*n*, where *n* = 0 to 5 units

Description: The ADCP collects data over a variable number of depth cells (bins). The L-command sets the size of each depth cell. The size of the depth cell in meters is 2 to the power of L.

Example : L*2* selects 4-meter depth cells ($2^L = 2^2 = 4$)

Notes : See the Q-command to set the number of depth cells. The I-command is usually set to match the size of the depth cell. For example, use I*04* with L*2*.

M – PERCENT-GOOD THRESHOLD

Purpose : Rejects data from those depth cells that are averages of only a few good pings.

Format : M*pp*, where *pp* = 00 to 99 percent

Description: Ensemble velocity output is the average of many pings, all of which may not produce valid data. If too few pings contribute to the average in a given depth cell, you can have those depth cells rejected. The M-command represents a minimum percentage of good pings that you require before the ADCP flags data as good.

Example : If M=25, 25% of the data in a depth cell must pass the signal-to-noise (S/N) criterion. If only 2 of 10 pings (20%) were valid as determined by the S/N criterion, the ADCP flags the data as bad. In this example, at least 3 of 10 pings (33%) must pass the S/N criterion before the ADCP flags data as good.

Notes : If M=00, the ADCP flags data as good if at least one good ping is in the ensemble. A velocity value of 2048 counts or a nonzero Status value means bad data. See the O-command.

N – SIGNAL-TO-NOISE THRESHOLD

Purpose : Sets the signal-to-noise (S/N) threshold for good data

Format : N*nn*

Range : *nn* = 00 to 99

Description: This command sets the S/N threshold for good data. The value of this threshold in dB is simply N/10. You should NOT change the N-command from its default value without consulting RDI. In general, each beam will indicate about 50% data-good when the S/N ratio reaches the N value. The S/N ratio strongly influences ADCP accuracy, so we recommend settings no lower than 60. When necessary as a function of depth cell length, the ADCP may automatically reduce the N value. This is common for most 1200-kHz settings. You can view the value used by using the ?-command.

Examples : N*60* sets the data-good threshold at 6 dB (S/N).
N*90* sets the data-good threshold at 9 dB (S/N).

0 – OUTPUT DATA SELECT

Purpose : Selects the data the ADCP will transmit.
Format : O*nnn*
Range : *nnn* = 000 to 127
Description: This command selects the ADCP output data. You can select earth or beam-referenced velocity, echo intensity, spectral width, percent-good, and status. When bottom-tracking, the ADCP normally flags data near the bottom as bad, but the O-command can override this. To determine what O-command value to use, start with zero and then add the values according to the following table.

BIT	TO SELECT	ADD	
0	VELOCITY	1	(BIT 5 SELECTS EARTH OR BEAM REFERENCE)
1	SPECTRAL WIDTH	2	(NOT SELECTABLE W/ EARTH-REFERENCED VELOCITY)
2	ECHO INTENSITY	4	
3	PERCENT-GOOD	8	
4	STATUS	16	
5	COORD. TRANSFORM	32	(FOR EARTH-REFERENCED VELOCITIES)
6	OUTPUT NEAR BOTTOM	64	(DEFEATS BOTTOM-TRACK BAD DATA FLAG)

By default, the ADCP collects data near and beyond the bottom (or surface). If you tell the ADCP to collect spectral width data and to coordinate-transform the velocities, coordinate transformation takes precedence. The ADCP cannot collect spectral width data when coordinate transformations are done.

Examples :

1. To select earth-referenced velocities and echo intensity, use an O-command of 0037 (1+4+32). The value displayed by the ?-command is 0037 before pinging, but 0101 (37+64) after pinging because output near the bottom is enabled in ADCPs.
2. You enter 0063 (all data: 1+2+4+8+16+32). The ?-command displays 0061 (63-2) before pinging because the ADCP cannot collect spectral width when doing coordinate transformation. After pinging, the ?-command shows 0125 (61+64), meaning the ADCP will collect data near and beyond the detected bottom.

Note : Do not enter an O-command greater than 127.

P – PINGS PER ENSEMBLE

Purpose : Selects number of pings to be averaged in each ADCP ensemble.
Format : P*nnnnn*
Range : *nnnnn* = 00001 to 65535 pings

Q – NUMBER OF DEPTH CELLS

Purpose : Sets the number of depth cells over which data are collected.
Format : Q*nnn*
Range : *nnn* = 001 to 128 depth cells
Description: The range of the ADCP is set by the number of depth cells times the size of each depth cell. The Q-command sets the number of depth cells.
Notes : Range from the transducer to the center of depth cell N is: Blank + (depth cell length - pulse length)/2 + N × (depth cell length)

R – TIME BETWEEN ENSEMBLES

Purpose	: Sets the minimum time between ensembles. Start of ensemble averaging begins at precise intervals.
Format	: R*hhmmssff*
Range	: *hh* = 00 to 23 hours *mm* = 00 to 59 minutes *ss* = 00 to 59 seconds *ff* = 00 to 99 hundredths of seconds
Note	: The ADCP may automatically increase the R-command. See Table D-7.

S – START DATA COLLECTION

Purpose	: Selects output modes and starts data collection
Format	: S*nnn*
Range	: *nnn* = 000 to 255
Description:	This command starts the ADCP data collection cycle and initiates one or more of the following actions after the collection cycle.

MANUAL OUTPUT – Enters STANDBY (sleep) mode at the completion of the ensemble interval and waits for receipt of any character to send data.

AUTOMATIC OUTPUT – ADCP automatically sends data after it completes data collection and averaging. The ADCP then goes to sleep until the beginning of the next ensemble interval if the R-command has been set.

MANUAL CYCLE – The ADCP enters NORMAL mode after sending/recording the data ensemble and waits for the next input command.

AUTOMATIC CYCLE – Automatically begins next data collection cycle after sending data. The R-command governs the timing of the first ping of the next ensemble interval. The ADCP enters STANDBY mode until then. Only the BREAK command can interrupt this cycle. This is the normal mode for ADCP data collection.

RECORD OFF – Inhibits internal recording of the data ensemble if a recorder is installed and its memory is not full.

RECORD ON – Enables the internal recording of the data ensemble.

SERIAL I/O OFF – Inhibits serial I/O data ensemble output (not serial communication). Usually OFF when using the recorder.

SERIAL I/O ON – Enables serial I/O data ensemble output (not serial communication).

DEFAULT ACTIONS – Takes specific action defined by internal default selection switch. See the description of PER2-S1 in Appendix W for a description of setting the default actions.

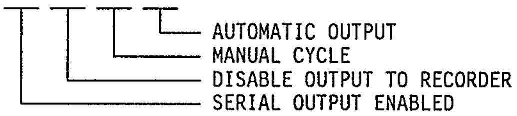
The three-digit command value following S is the decimal equivalent of the binary sum represented in the following matrix. The value controls ADCP actions after the ensemble is complete. Bit 0 is the least significant. X can be either 0 or 1.

BIT 7 6 5 4 3 2 1 0	DESCRIPTION	
- - - - - - 0 X	OUTPUT AUTO/MANUAL PER DEFAULT SWITCH	
- - - - - - 1 0	OUTPUT MANUAL	
- - - - - - 1 1	OUTPUT AUTOMATIC	
- - - - 0 X - -	CYCLE AUTO/MANUAL PER DEFAULT SWITCH	
- - - - 1 0 - -	CYCLE MANUAL	
- - - - 1 1 - -	CYCLE AUTOMATIC	
- - 0 X - - - -	RECORD ON/OFF PER DEFAULT SWITCH	USUALLY SC-ADCPs ONLY
- - 1 0 - - - -	RECORD OFF	
- - 1 1 - - - -	RECORD ON	
0 X - - - - - -	SERIAL I/O ON/OFF PER DEFAULT SWITCH	
1 0 - - - - - -	SERIAL I/O OFF	
1 1 - - - - - -	SERIAL I/O ON	

(BIT VALUES: 7=128, 6=64, 5=32, 4=16, 3=8, 2=4, 1=2, 0=1)

Examples : 1. S235 is sent. Decoding this command:

1 1 1 0 1 0 1 1 = 128 + 64 + 32 + 8 + 2 + 1 = 235



In this example, S235 (normally used during testing) tells the ADCP to send data at the end of the ensemble interval and wait for the next input command. The recorder is off, and the ADCP sends data through the serial I/O. To begin another data collection cycle, you must send another S-command.

2. S191 (128+32+16+8+4+2+1) = 10111111_2; this is the normal command given to start data collection with an SC-ADCP recorder.

Notes : S000 tells the ADCP to operate using the default settings. Disabling serial output is normal for SC-ADCPs, which internally send the data to the recorder. There is no need to send additional data out the serial port because, in the usual underwater deployment, there will not be a terminal to receive the data.

T – SET REAL-TIME CLOCK

Purpose : Used to set the ADCP's internal real-time clock.

Format : T*mmddhhmm*

Range : *mm* = 01 to 12 month
dd = 01 to 31 day (February always has 28)
hh = 00 to 23 hour
mm = 00 to 59 minute

Notes : Seconds automatically set to 0 when last digit of minutes entered. You cannot specify the year. See G-command.

U – TIME OF FIRST PING

Purpose : Sets the time the ADCP wakes up to start data collection.
Format : U*mmddhhmmss*
Range : *mm* = month 01-12
dd = day 01-31 (February always has 28 days)
hh = hour 00-23
mm = minutes 00-59
ss = seconds 00-59

Description: The U-command delays the start of data collection. This lets you deploy an SC-ADCP in STANDBY mode and automatically activate it to the NORMAL mode at a preset time.

Example : If you want the exact time of the first ping to be on November 23 at 13:37:15, you would enter U1123133715. If you want the ADCP to begin pinging immediately after receiving the S-command (see notes), do NOT enter a U-command value.

Notes :
1. Even though the ADCP may receive a U-command, you must also send an S-command before deploying the ADCP.
2. Because you cannot specify the year, do NOT set the U-command to a value earlier than the present time (T-command), or wakeup will not occur until that time NEXT year.

V – TIME BETWEEN PINGS

Purpose : Sets the *minimum* time between pings. Each ping will begin at a precise interval from the last.
Format : V*mmssff*
Range : *mm* = 00 to 59 minutes
ss = 00 to 59 seconds
ff = 00 to 99 hundredths of seconds

Note : The smallest V-command is V000010 (0.1 s). The ADCP may automatically increase the V-command. See Table D-7.

Table D-7. ADCP Ensemble and Ping-Cycle Timing

THIS TABLE LISTS SEVERAL COMMANDS AND THEIR EXECUTION PRIORITY. THIS TABLE IS JUST A REFERENCE FOR THE ORDER IN WHICH THE ADCP EXECUTES COMMANDS. WE DO NOT CONSIDER THE ACTUAL EXECUTION TIME HERE. THE EXECUTION SEQUENCE IS SHOWN FOR BOTH SINGLE-PING (P=1;USUALLY DR/VMs) AND MULTIPLE-PING (P>1;USUALLY SC-ADCPs) OPERATIONS. PRIORITY 1 MEANS THE ADCP EXECUTES THE COMMANDS LISTED IN THIS SECTION FIRST IN THE ORDER SHOWN. AFTER ADCP EXECUTION, THE ADCP DETERMINES THE TIME NEEDED TO DO THE TASKS. THE ADCP THEN DECIDES IF THE TIMING REQUIREMENTS SET BY THE NEXT PRIORITY WILL TELL THE ADCP TO GO TO SLEEP OR TO CONTINUE WITH THE NEXT PING OR ENSEMBLE.

<table>
<tr><th>Single-Ping Operation (P=1; DR/VMs)</th><th>Multiple-Ping Operation (P>1; SC-ADCPs)</th></tr>
<tr><td colspan="2">PRIORITY 1</td></tr>
<tr><td>I-command (Transmit Pulse Length)
L-command (Depth Cell Length)
Q-command (Number of Depth Cells)
J-command (Blank After Transmit)
K-command (Delay After Blank)</td><td>I-command (only during water-track ping)
L-command (" " " " ")
Q-command (" " " " ")
J-command (" " " " ")
K-command (" " " " ")
FA-command (only during bottom-trk ping)
FB-command (" " " " ")
FC-command (" " " " ")</td></tr>
<tr><td>Using these commands, the ADCP calculates what the minimum value for the <i>time between ensembles</i> {R} should be. Since P=1, this time also becomes the minimum <i>time between pings</i> {V}. ADCP data transfer immediately follows the completion of this priority set.</td><td>Using these commands, the ADCP calculates what the minimum value for the <i>time between pings</i> {V} should be.</td></tr>
<tr><td colspan="2">PRIORITY 2</td></tr>
<tr><td>R-command (Time Between Ensembles)
V-command (always ignored when P=1)</td><td>V-command (Time Between Pings)</td></tr>
<tr><td>If the R-command is longer than the time determined by Priority-1 calculations, then Priority-2 sets the minimum <i>time between ensembles</i>. Otherwise, the ADCP uses the time determined by Priority-1.</td><td>If the V-command is longer than the time determined by Priority-1 calculations, then Priority-2 sets the minimum <i>time between pings</i>. Otherwise, the ADCP uses the time determined by Priority-1.</td></tr>
<tr><td colspan="2">PRIORITY 3</td></tr>
<tr><td>NONE</td><td>P-command (no. of water-track pings)
FH-command (no. of bottom-track pings)
H-command</td></tr>
<tr><td></td><td>Using the commands in Priorities 1/2/3, the ADCP calculates what the minimum <i>time between ensembles</i> {R} should be. ADCP data transfer immediately follows the completion of this priority set.</td></tr>
<tr><td colspan="2">PRIORITY 4</td></tr>
<tr><td>NONE</td><td>R-command</td></tr>
<tr><td></td><td>If the R-command is longer than the time determined by Priority 3 calculations, then Priority-4 sets the <i>time between ensembles</i>. Otherwise, the ADCP uses the time determined by Priority-3.</td></tr>
</table>

W – INPUT/OUTPUT CONTROL

Purpose : Allows external selection of serial communication parameters, data output mode, and scale factor of velocity data.

Format : W*nnn*

Range : *nnn* = 000 to 255

Description: This command sets the data I/O control. It overrides the selection of the transmission parameters set by switch S2 on the Peripherals 2 board. When displaying the ?-command help screen, the W-command shows the active system setup. If a zero value is entered for a particular item, the W value will show the actual setting of S2. The W-command uses a binary representation of the entered decimal command. The binary bit assignments are:

7	6	5	4	3	2	1	0	SETTING	
					0	0	0	INTERNAL SWITCH OR PREVIOUS ENTRY (NO CHANGE)	
					0	0	1	300 (1200 WITH @4 COMMAND)	BAUD RATE SELECT
					0	1	0	600 (2400 WITH @4 COMMAND)	
					0	1	1	1200 (4800 WITH @4 COMMAND)	
					1	0	0	2400 (9600 WITH @4 COMMAND)	
					1	0	1	4800 (19200 WITH @4 COMMAND)	
					1	1	0	9600 (38400 WITH @4 COMMAND)	
					1	1	1	19200 (76800 WITH @4 COMMAND)	
			0	0				INTERNAL SWITCH OR NO CHANGE	
			0	1				NO PARITY	
			1	0				EVEN PARITY	
			1	1				ODD PARITY	
	0	0						INTERNAL SWITCH OR NO CHANGE	
	0	1						8-BIT ASCII OUTPUT MODE	
	1	0						BINARY OUTPUT MODE	
	1	1						7-BIT ASCII OUTPUT MODE	
0								SCALE FACTOR PER SWITCH SETTING	
1								SCALE FACTOR COMPLEMENT OF SWITCH SETTING	

Example : W078 (64+8+4+2) = 01001110_2; In this example, W078 would set 9600 baud (38400 with @4 command), no parity, binary output, and default scale factor.

Notes :

1. Bit 7 complements the setting of the velocity scale factor switch (PER2-S2). Bit 7 resets to zero (the default) when power is first applied to the ADCP, during power-on after a RAM failure, and when the Z-command is sent. Bit 7 retains its setting during the automatic wake-up sequence and when a BREAK is sent. No other W-command bits are preserved during the BREAK command. The configuration byte in the leader (Table 4-2) and in the X-command output display show the complement of the velocity scale factor switch when Bit 7 = 1.
2. When the @4 or @1 command is sent, the W-command MUST be the next command issued. When used after the @4 command, the serial baud rate will increase by a factor of four based on the W-command baud rate setting. For example, if you send the @4 and W046 commands, the ADCP will send serial data to the SC-ADCP recorder at 38400 baud rather than the normal 9600. An @4 and W047 command sequence would change the baud rate to 76800 (if a special computer interface board is installed). The @1 command will return the baud rate to its normal W-command setting.

X – TRANSMIT SYSTEM DATA

Purpose : Tells ADCP to send its leader data and system identification data

Format : X

Description: Listed here is an example of the ASCII output format of the X-command. Lines 1 and 2 contain leader data (see Table 4-2). Lines 3 and 4 contain the system identification data.

```
L1 0101200726000100000100090204010000001000993525643496473300000000000230031830
L2 00000000000000000000000000000000000000055355535553555352926000000000000000
L3 1111122333334444444444444444444444444444444444444444444444444444444444445555
L4 566666777888889999900000
```

ASCII DIGITS	BINARY BYTES	SAMPLE DIGITS	CONTENTS
1-5	1,2	ONES	TRANSDUCER SERIAL NUMBER
6,7	3	TWOS	NUMBER OF BEAMS
8-12	4,5	THREES	TRANSDUCER FREQUENCY (kHz)
13-72	6-29	FOURS	BEAM DIRECTIONAL COSINES (NOTE 1)
73-77	30,31	FIVES	ROM 1 SERIAL NUMBER = FIRMWARE VERSION NUMBER
78-82	32,33	SIXES	ROM 2 SERIAL NUMBER = YEAR/MONTH
83-85	34	SEVENS	SYSTEM FIRMWARE FLAGS (NOTE 2)
86-90	35,36	EIGHTS	SYSTEM SERIAL NUMBER
91-95	37,38	NINES	VELOCITY COORDINATE REFERENCE/SCALE FACTOR (NOTE 3)
96-100	39	ZEROS	SPARE

Notes : 1. Contains the XYZ-component beam directional cosines for each beam. Each beam uses 15 ASCII digits (6 binary bytes) and is in two's complement arithmetic.

2. Decode the system firmware flags as follows:

BIT 7 6 5 4 3 2 1 0	CONFIGURATION	
- - - - - - 0 0	EPROM RECORDER	USUALLY SC-ADCPs ONLY
- - - - - - 0 1	60-MB HCR WITH MACROS	
- - - - - - 1 0	60-MB HCR WITHOUT MACROS	
- - - - - - 1 1	1.2 MB RECORDER	
- - - - - 0 - -	KVH FLUX GATE HEADING SENSOR	USUALLY DR/SC-ADCPs ONLY
- - - - - 1 - -	EG&G FLUX GATE HEADING SENSOR	
- - - - 0 - - -	NEW SYNCHRO (STEPPER) BOARD	
- - - - 1 - - -	OLD SYNCHRO BOARD	
- - - 0 - - - -	LONG LEADER, HIGH-RESOLUTION TEMPERATURE SENSOR	
- - - 1 - - - -	SHORT LEADER, LOW-RESOLUTION TEMPERATURE SENSOR	
- X X - - - - -	SPARES (DEFAULTS SET TO 1)	
0 - - - - - - -	FIRMWARE VERSION BEFORE 17.07	
1 - - - - - - -	FIRMWARE VERSION 17.07 OR LATER	

For example, "229" ASCII (11100101_2) in this field would indicate: 60-MB HCR recorder with macros, EG&G flux gate heading sensor, new synchro (stepper) board, long leader, high resolution temperature sensor, and firmware version 17.07 or later.

3. Decode the velocity coordinate reference (set by O-command) and velocity scale factor (set by S2 on Peripherals 2 board) as follows:

DECIMAL VALUE	COORDINATE REFERENCE	SCALE FACTOR
0	BEAM	LOW RANGE
1	BEAM	HIGH RANGE
2	EARTH	LOW RANGE
3	EARTH	HIGH RANGE

Y – PERFORM BIT DIAGNOSTICS

Purpose : Runs built-in ADCP tests
Format : Y*n*
Range : See description
Description: The Y-command values (see below) cause one of two Built-In-Tests to be run once or repetitively and sends the BIT results (see ¶6-3 for more information on the Built-In Tests).

Y1 – SINGLE BIT 3 TEST (INCLUDES MEMORY CHECK)
Y2 – SINGLE BIT 2 TEST (NO MEMORY CHECK)
Y5 – REPETITIVE BIT 3 TEST (18 s BETWEEN TESTS)
Y6 – REPETITIVE BIT 2 TEST (1 s BETWEEN TESTS)

Z – RESET TO FACTORY DEFAULTS

Purpose : Resets the ADCP commands to factory default settings.
Format : Z
Description: The Z-command resets the ADCP by forcing it into the DATA I/O mode, reinitializing the system, discarding data not sent or recorded, and configuring the system to the default settings.

@1 – SET NORMAL SERIAL BAUD RATE (RESET @4)

Purpose : Sets the serial baud rate to its normal W-command setting
Format : @1
Description: The @1-command resets the serial baud rate to the value sent by the next valid W-command (see W-command for more information).
Example : To reset the serial baud rate from 38400 to 9600, you would send the following two commands: @1 and W046.
Note : The baud rate set through @1 is preserved only during the normal data collection wake-up sequence. A <BREAK> or re-initialization command resets the baud rate to the default switch settings.

@4 – SET SERIAL BAUD RATE × 4

Purpose : Increases the W-command serial baud rate by a factor of four
Format : @4
Description: The @4-command increases the serial baud rate of the next W-command by a factor of 4 (see W-command for more information).
Example : To increase the serial baud rate from 9600 to 38400, you would send the following two commands: @4 and W046.
Note : The baud rate set through @4 is preserved only during the normal data collection wake-up sequence. A <BREAK> or re-initialization command resets the baud rate to the default switch settings.

? and / – DISPLAY INPUT COMMAND HELP MENUS

Purpose : Displays a listing of all input commands
Format : ? and /
Description: Pressing <?> displays a listing of all ADCP input commands, their format, and their current settings as stored in the battery-backed RAM. Pressing </> displays a second page of help (currently, only the CF-command is on the second page). An example listing follows. To see help for the bottom-track input commands (Fx-commands), press F?.

Example : ?

```
A =46-             TRACKING FILTER GAIN
B =00:99:01-       ACQUISITION STEPSIZE/THRESHOLD/DELAY
CA=50-             PERCENT OF PINGS IN CTD MEASUREMENT TIME
CB=10000-          ERROR VELOCITY THRESHOLD
CH=00000-          HEADING OFFSET (65536 = 360 DEGREES)
DA=00-             TEST MODES
E =30:00:02:01:99- FIRST BIN TRACKING (%/BINS/1ST BIN/TIME CONSTANT/STEPSIZE
H =000-            DELAY BEFORE DATA OUTPUT (LSB = 0.1 SECOND)
I =01-             PULSE LENGTH (METERS)
J =005-            BLANK AFTER TRANSMIT (LSB = 0.1 METER)
K =00-             DELAY AFTER BLANK (METERS)
L =0-              DEPTH CELL LENGTH (2^L METERS)
M =25-             PERCENT-GOOD THRESHOLD
N =40-             SIGNAL-TO-NOISE THRESHOLD
O =031-            DATA SELECT
P =00001-          PINGS PER ENSEMBLE
Q =128-            NUMBER OF DEPTH CELLS
R =00:00:09:00-    TIME BETWEEN ENSEMBLES (HOURS:MINUTES:SECONDS:SECONDS/100)
S =255-            START DATA COLLECTION
T =11:02:16:24-    SET REAL-TIME CLOCK (MONTH:DAY:HOUR:MINUTE) [SECONDS=0]
U =<<:<<:<<:08:49- TIME OF FIRST PING (MONTH:DAY:HOUR:MINUTE:SECOND) [SEE NOTE]
V =00:00:11-       TIME BETWEEN PINGS (MINUTES:SECONDS:SECONDS/100)
W =046-            INPUT/OUTPUT CONTROL
/                  SHOW SECOND PAGE OF HELP SCREEN
CF =25-            FISH REJECTION THRESHOLD (VALUE DISPLAYED:  AGC COUNTS/2)
```

Note : Time of First Ping (also known as *delay time* or *wake-up time*) is processed correctly by the ADCP; however, the SC-ADCP Deployment Program does not record this value properly. You may see "<" symbols instead of valid values for this readout. If you did not take note of this value when programming the SC-ADCP, you can still determine this value by viewing the ensemble time in the leader data of the first ensemble.

F? – DISPLAY BOTTOM-TRACK INPUT COMMAND HELP MENU

Purpose : Displays a listing of all bottom-track input commands

Format : F?

Description: Pressing F? displays a listing of all ADCP bottom-track input commands, their format, and their current settings as stored in the battery-backed RAM.

Example : F?

```
********
FA=00003- BT TRANSMIT PULSE LENGTH (METERS)
FB=00000- BT DEPTH CELL LENGTH (2^FB METERS)
FC=00128- BT NUMBER OF DEPTH CELLS
FD=00000- BT MODE (00000 = AUTOMATIC)
FE=00013- BT TRANSMIT LENGTH CONTROL (LSD = 1%)
FF=00040- BT DETECTION THRESHOLD (LSD = 1 AGC COUNT)
FG=00000- ENSEMBLES BEFORE BT RE-ACQUIRE
FH=00255- PROFILE PINGS PER BT PING (00255 TURNS BT OFF)
FI=00127- ┐
FJ=00255- │
FK=00255- ├ FOR FACTORY USE ONLY
FL=00255- ┘
END BT COMMANDS 0-
```

BREAK

Purpose : Interrupts ADCP without loosing current user settings
Format : <BREAK>
Description: A BREAK interrupts the ADCP. A BREAK is leading-edge triggered, must be received while in the DATA I/O mode, and must last at least 100 ms. When sent, BREAK initializes the system and places the ADCP in the DATA I/O mode, but does not erase any settings or data. If the ADCP is between pings, two BREAKs (or a character and a BREAK) must be sent. The first tells the ADCP to turn on internal power (wake up); the second sends the power-on message.

RECORDER COMMANDS

The remaining commands are special commands used for communicating directly with the solid-state EPROM recorder in an SC-ADCP. Recorder commands use the @ symbol and a letter/numeric parameter. You send recorder commands the same way as the regular ADCP direct commands. All rules concerning termination, checksum, and capitalization still apply. For example, if you send a correctly formatted recorder command, the ADCP immediately responds with a *<CR><LF>* sequence. If the command string is incorrect, the ADCP responds with an *ERR ###<CR><LF>* sequence. The <CR><LF> response, however, does not necessarily mean you sent the command properly. It only means the ADCP received a valid command string with no transmission errors. The command may still not execute if the recorder cannot be accessed, or if you ask the recorder to do an improper action (e.g., advance the read pointer beyond the end-of-file (EOF)).

Only after the SC-ADCP receives the command-valid <CR><LF> sequence does it try to execute the command. If the ADCP executes the command correctly, it will respond with another <CR> immediately after the <CR><LF> sequence. If there is an error, the ADCP sends the string:

*ERROR *eee CCC ccc sssss bbb*<CR><LF><CR>

Where:

eee = Error code / recorder status byte (0-255)

BIT	FLAG
0	EPRDRS POWER FAILURE
1	EPRDRS BUSY FAILURE
2	EPRDRS WRITE FAILURE
3	BYTE ALREADY WRITTEN
4	CARD IS PRESENT
5	CHIP IS PRESENT
6	EPRDRS IS FULL
7	EPRDRS FAILURE

CCC = Memory card selected when error occurred (001-020) [NOTE: If chips 000 and 001 are bad, *CCC*=021]
ccc = Memory chip selected when error occurred (000-007)
sssss = Chip sector selected when error occurred (00000-00511)
bbb = Byte address selected when error occurred (000-255)

Data within the recorder are organized and stored within two types of files — user files and data files. User files are text files. You create text files using the @W command by typing in your information and terminating each line with a <CR><LF> sequence. User files typically store SC-ADCP configuration data and your comments about the deployment. The ADCP creates a new data file whenever data collection is started with the S-command and the recorder is ON. The ADCP does not overwrite either user files or data files.

You can store as many as 255 files (both user and data) in the recorder. This multiple file capability lets you store several deployments without the need to erase memory each time. Although the recorder can store 255 files, you are limited by the maximum capacity of the recorder (now 40 MB). Typically two files are created for each deployment: a user file for storing the configuration of the SC-ADCP and other user comments, and a data file to store the data collected by the ADCP. When using the SC-ADCP Deployment Program, these files are created automatically, but you are limited to a maximum of 63 deployments.

Recorder data are stored in binary exactly as collected by the SC-ADCP. Ensembles are written to consecutive recorder memory addresses with no gaps or added information. When extracted, the data look as if it were sent from the ADCP in real time. The following paragraphs describe the recorder commands.

@A – ADVANCE READ POINTER WITHIN FILE

Purpose : Advances the read pointer in the current file
Format : @A*sss*
Range : *sss* = 001 to 255 sectors (one sector = 256 bytes)
Description: @A advances the read pointer *sss* sectors in the current file.
Example : @A005 advances the pointer 5 sectors in the current file.
Note : If the advance is beyond EOF, the SC-ADCP reports an error, and the read pointer stays as it was before command execution.

@B – BLANK CHECK

Purpose : Checks erasure status of EPROM memory cards
Format : @B
Description: @B verifies all installed memory cards have been erased. The terminal will display a message similar to the following.

```
CARD 01: 00  01  02  03  04  05  06  07  : GOOD: 8
CARD 02: 00  01  02  03  04  05* 06  07  : GOOD: 7
CARD 03: 00  01  02U 03  04U 05  06  07  : GOOD: 6
CARD 04: NOT PRESENT
     :           :           :           :
CARD 19: 00  01  02  03  04  05M 06  07  : GOOD: 7
CARD 20: 00  01  02  03  04  05  06  07  : GOOD: 8
CAPACITY: 40960 (IN KILOBYTES)
```

where:

* = bad EPROM chip
U = used (unerased) EPROM chip
M = missing EPROM chip
NOT PRESENT = missing card

@D – DUMP SECTORS

Purpose : Dumps *sss* consecutive from current pointer location
Format : @D*sss*
Range : *sss* = 001 to 255 sectors
Description: @D is for factory troubleshooting only. It dumps *sss* consecutive sectors of data starting at the location of the dump pointer. @P initially sets the dump pointer location.
Example : If @P=100200007, @D005 dumps 5 sectors of data starting at card 10, chip 2, sector 7.
Notes : @D does not recognize file, chip, or card boundaries. After dumping *sss* sectors, the dump pointer advances the same number of sectors. If you go beyond the current chip, the dump pointer will wrap-around to sector zero.

@F – FIND FILE NUMBER

Purpose : Finds a specific file in recorder memory
Format : @F*nnn*
Range : *nnn* = 001 to 255
Description: @F moves the read pointer to the beginning of the selected file.
Example : @F005 moves the read pointer to the first sector of file #005.
Notes : If the selected file does not exist, the ADCP reports NOT FOUND, and the read pointer stays as it was before command execution.

@G – GET DATA TO READ WITHOUT ADVANCING POINTER

Purpose : Gets and transmits data last pointed to
Format : @G*sss*
Range : *sss* = 000 to 255
Description: @G reads *sss* sectors starting at the current pointer location but does not advance the pointer. This is useful when you wish to read the same data more than once to verify a good read was executed. To advance to the next read location, you would then use the @A command.
Notes : 1. @G000 reads all data through EOF (end of file).
2. There is also an @g (lower case) command. It differs from @G in that @g increases the EPROM recorder's read voltage. SC-ADCP software uses @g whenever it detects a data error. The voltage increases slightly during the re-read to correct for EPROM charge-leakage, a rare occurrence. @g is for factory troubleshooting only.

@L – LOCATE AND DISPLAY CURRENT READ POINTER POSITION

Purpose : Displays current position of the read pointer
Format : @L
Description: @L is for factory troubleshooting only. It locates the current position of the read pointer and displays its location in the format *CCC ccc sssss bbb* where:

CCC = current card number 001 to 020
ccc = current chip number 000 to 007
sssss = current sector number 00000 to 00255
bbb = current byte address 000 to 255

@P – POSITION DUMP POINTER TO SPECIFIC SECTOR

Purpose : Positions dump pointer to specific card, chip, and sector
Format : @P*CCccsssss*
Range : *CC* = Card number 01 to 20
cc = Chip number 00 to 07
sssss = Sector number 00000 to 00255
Description: @P is for factory troubleshooting only. It positions the dump pointer to a specific card, chip, and sector in EPROM memory.
Example : With @P=100200007, the dump pointer points to card 10, chip 2, sector 7.

@R – READ AND TRANSMIT RECORDER DATA

Purpose : Reads and transmits data sectors from recorder memory
Format : @R*sss*
Range : *sss* = 000 to 255 sectors
Description: @R reads and sends through the serial or parallel interface the next *sss* sectors in the current file (as selected by the @F command). @R automatically advances the read pointer to the next sector until it reaches EOF (end of file).
Example : @R005 reads and sends the next five sectors from the currently selected file (via the @F command).
Notes : 1. @R000 reads all data through EOF.
2. In binary mode, the SC-ADCP sends data in binary; in ASCII mode, the ADCP sends data in ASCII. One exception – the ADCP always sends the configuration block (block 1) in ASCII.
3. If the number of bytes to read is more than the number of bytes left in the file, the ADCP fills the missing bytes with 0FF hexadecimal.

@S – SUMMARIZE (MAP) CONTENTS OF RECORDER MEMORY

Purpose : Displays memory map of recorder contents
Format : @S
Description: @S maps the contents of the recorder and sends a summary of the number of files already recorded, their sizes in kilobytes, and the amount of storage space left in kilobytes. The terminal will display a message similar to the following.

```
USER FILE # 001:   KBYTES: 00008
DATA FILE # 002:   KBYTES: 00020
USER FILE # 003:   KBYTES: 00008
DATA FILE # 004:   KBYTES: 00047
KBYTES LEFT: 19917
```

Notes : USER FILE = Configuration (block 1) data
DATA FILE = Actual deployment data

@T – TEST RECORDER HARDWARE AND CARD INSTALLATION

Purpose : Test recorder hardware and card installation
Format : @T
Description: @T tells the SC-ADCP to test the EPROM recorder hardware. The ADCP runs three different recorder tests.

TEST 1 and TEST 2 check the recorder's control circuitry and DC power. These tests also verify all memory cards are installed correctly (i.e., no shorted lines). If the recorder fails either test, you must fix the problem before deploying the ADCP.

TEST 3 verifies all recorder EPROM chips can be written to and read. During TEST 3 the ADCP shows the card and chip being tested. If a chip fails, the terminal displays an asterisk (*) immediately after the affected chip number. You can still deploy the ADCP even if some chips fail TEST 3. This is because the recorder automatically bypasses missing cards and bad EPROM chips.

Examples : 1. No failures, 10 cards present; deployment can proceed:

```
TEST 1: OK
TEST 2: OK
TEST 3:

CARD 01: 00  01  02  03  04  05  06  07  GOOD: 08
CARD 02: 00  01  02  03  04  05  06  07  GOOD: 08
   :       :           :           :
CARD 11: NOT PRESENT
   :      :     :
CARD 20: NOT PRESENT
TEST 3: OK
CAPACITY: 10180 (IN KILOBYTES)
```

2. No failures, but a few chips are bad; deployment can proceed:

```
TEST 1: OK
TEST 2: OK
TEST 3:
CARD 01: 00  01  02  03  04  05  06  07  GOOD: 08
CARD 02: 00  01* 02  03  04* 05  06  07  GOOD: 06
   :       :           :           :
CARD 11: NOT PRESENT
   :      :     :
CARD 20: NOT PRESENT
TEST 3: OK
CAPACITY: 09162 (IN KILOBYTES)
```

3. TEST 2 failure; deployment must NOT proceed:

```
TEST 1: OK
TEST 2: FAIL
*ERROR xxx: 03 05 00027 092
```

Where xxx = Recorder status byte (see page D-28)
03 = Error occurred when card address 3 selected
05 = Error occurred when chip address 5 selected
00027 = Error occurred when sector address 27 selected
092 = Error occurred when byte address 92 selected

@W - WRITE CONFIGURATION DATA FOR NEW DEPLOYMENT

Purpose : Writes configuration data (block 1) for a new deployment
Format : @W
Description: @W tells the SC-ADCP to store text data at the beginning of the next deployment. Each line of text must end with a carriage return. Text entry is terminated by sending a Ctrl-Z character.
Note : @W forces the creation of a new deployment in the recorder.

APPENDIX F
REPRODUCIBLE FORMS AND CHECKLISTS

F-0. INTRODUCTION

This appendix provides various forms and checklists you can use to make reprodicble copies. Most of these forms are used for each deployment. The following forms are provided.

- SC-ADCP Deployment Checklist (from Table 2-1)
- SC-ADCP Deployment Information Work Sheet (from Table 2-2)
- Battery Capacity Work Sheet (from Table B-1)
- Recovery Checklist (from Table 3-1)
- SC-ADCP Function Test Results Form (for use with Section T-2)
- Write-Erase Record for EPROM Recorder Memory Cards
- Customer Feedback Form

Date: ________ Deployment Name: ________

SC-ADCP Deployment Checklist

Step	Action	Reference
	NOTE Step 1 is application related and can be done independent of steps 2 and 3, which are instrument related. Steps 1 through 3 should be done before step 4.	
__1	PLAN DEPLOYMENT AND DETERMINE TRADEOFFS – Use the Deployment Information Work Sheet (Table 2-2) to gather the following initial information before the actual deployment date and to determine tradeoff requirements.	¶2-1
	__ ADCP instrument configuration	¶2-1.1
	__ Output data requirements	¶2-1.2
	__ Primary profiling parameters	¶2-1.3
	__ ADCP limitations	¶2-1.4
	__ Deployment logistics and postprocessing requirements	¶2-1.5
__2	PREDEPLOYMENT TESTING – Do predeployment testing with enough lead time to allow for correction of problems.	¶2-2
	__ Modular ADCP tests	2-2.1
	__ Practice deployment	2-2.2
__3	PHYSICAL PREPARATION OF THE ADCP FOR DEPLOYMENT – Perform physical instrument preparation with enough lead time to correct problems.	¶2-3
	__ ADCP switch settings	Appendix W
	__ Compass orientation (up/down)	¶5-9
	__ Battery installation	¶5-13
	__ EPROM recorder preparation	¶5-14
	__ Silica-gel air dryer replacement/restoration	¶5-15
	__ O-ring inspection/replacement	¶5-16
	__ Transducer head inspection	¶5-17
	__ Zinc anode inspection/replacement	¶5-18
	__ Mounting bushing inspection/replacement	¶5-19
	__ Protective coating inspection/repair	¶5-20
	__ Sealing the ADCP for deployment	¶5-21
	__ Prevention of biofouling	¶5-22
__4	TRANSFERRING DEPLOYMENT PARAMETERS TO THE ADCP – Transfer all profiling parameters and commands to the ADCP. This process can be done for a real or practice deployment.	¶2-4
__5	PHYSICALLY DEPLOYING THE ADCP – Final recommendations on physically deploying the ADCP.	¶2-5

SC-ADCP Deployment Information Work Sheet

DEPLOYMENT LOGISTICS AND POSTPROCESSING REQUIREMENTS

Deployment name ______________________ Chief scientist ____________________
ADCP serial no. ____________ Mounting method (FIXED/MOORED) ___________________
Location: Depth (m) __________ Latitude __________ Longitude __________
Time reference {T} (i.e. GMT/LOCAL) __________ ADCP wake-up time {U} ____________
Water data: Speed of sound _____ m/s Temperature _____ °C Salinity _____ ppt
Environmental conditions ____

ADCP INSTRUMENT CONFIGURATION

__________ Frequency (75, 150, 300, 600, OR 1200 kHz)
__________ Beam angles (20° OR 30°; MOST COMMON IS 30°)
__________ Transducer/compass orientation (UP OR DOWN)
__________ Range switch setting (LOW OR HIGH)

OUTPUT DATA REQUIREMENTS

Y N 32 Earth-coordinate velocity 〉 SELECT ONLY ONE COORDINATE VELOCITY SYSTEM
Y N 1 Beam-coordinate velocity 〉
Y N 2 Spectral width (NOT SELECTABLE IF EARTH-COORDINATE VELOCITY SELECTED)
Y N 4 Echo intensity
Y N 8 Percent-good pings
Y N +16 Status
____ = O-COMMAND SETTING; IF BOTTOM-TRACKING, SEE O-COMMAND IN APPENDIX D

PRIMARY PROFILING PARAMETERS — LIST ALL OTHER NONDEFAULT SETTINGS (APPENDIX D) ON SEPARATE SHEET

______________ Expected profiling range in meters $\{2^L \times Q\}$
______________{L} Depth cell length (2^L FOR 1, 2, 4, 8, 16, OR 32 METERS)
______________{I} Transmit pulse length (1 TO 99 METERS; USUALLY SET TO EQUAL 2^L)
______________{Q} Number of depth cells (8 TO 128)
______________{P} Pings per ensemble (1 TO 65,535 PINGS)
___:___:___.___{R} Ensemble interval (00:00:01.00 TO 23:59:59.99)

ADCP LIMITATIONS

__________ cm/s Desired/calculated velocity data accuracy (STANDARD DEVIATION)
__________ days Deployment duration
__________ A·h Available V1 battery capacity ┐
__________ A·h Expected V1 power consumption │— FROM APPENDIX B
__________ A·h Available V2 battery capacity │
__________ A·h Expected V2 power consumption ┘
__________ MB Available recorder memory (FROM RECORDER TEST; APPENDIX T)
__________ MB Expected recorder storage requirement

NOTES:

NOTE: APPLICABLE DIRECT COMMANDS ARE SHOWN IN BRACES {x}.

Battery Capacity Work Sheet

Use this work sheet to determine the battery capacity for the battery packs supplying V1 and V2 power. If you are using the CTD interface option, you can compute V4 in the same way.

1. What combination of battery packs will you use? The following is the maximum number of batteries you can place inside an SC-ADCP.

    a. Four D packs
    b. Two D packs and one D+D pack
    c. Two D+D packs

2. Enter V1 and V2 nominal battery capacities (in A·h), temperature derating factor (if necessary), and an estimate of any previous usage for each battery pack you plan to use. See Table B-4 for nominal capacities and derating factors for RDI's standard battery packs. Calculate the total battery capacity for V1 and V2 using the listed formulas.

V1 Computations:	(Nominal Capacity	×	Derating Factor)	-	Previous Use	=	Battery Capacity
Battery pack 1	________		________		________		________
Battery pack 2 (IF USED)	________		________		________		________
Battery pack 3 (IF USED)	________		________		________		________
Battery pack 4 (IF USED)	________		________		________	+	________
	Total expected battery capacity for V1					=	________

V2 Computations:	(Nominal Capacity	×	Derating Factor)	-	Previous Use	=	Battery Capacity
Battery pack 1	________		________		________		________
Battery pack 2 (IF USED)	________		________		________		________
Battery pack 3 (IF USED)	________		________		________		________
Battery pack 4 (IF USED)	________		________		________	+	________
	Total expected battery capacity for V2					=	________

Date: ___________ Deployment Name: ___________

SC-ADCP Recovery Checklist

Step	Action	Reference
__1	<u>SC-ADCP PHYSICAL RETRIEVAL AND MAINTENANCE</u> - Do the following retrieval maintenance:	3-1
	__ Preliminary retrieval check (optional) __ Clean ADCP exterior __ Remove the dummy plug __ Remove the pressure case (optional)	3-1.1 3-1.2 3-1.3 3-1.4
__2	<u>RETRIEVING DATA FROM EPROM MEMORY</u> - This procedure retrieves data from the recorder's EPROM memory using the @S, @F, W, and @R direct commands.	3-2

Date: __________ **SC-ADCP Function Test Results Form**

Test	Data

T-2.1 PRELIMINARY SETUP

_______ V1 power supply setting
_______ V2 power supply setting
_______ V4 power supply setting (if applicable)

T-2.2 COMMUNICATIONS TEST

__________ DTE/DCE switch position on RDI Test Box

T-2.3 SC-ADCP BIT TEST

__________ Pass/Fail If Fail, enter error code: __________

T-2.4 TRANSMIT/RECEIVE TESTS

__________ Displayed Transmit Current value in counts from leader
__________ "Normalized" current [(Display value × 39) / V2]

Receiver continuity (yes/no):
Beam 1:______ Beam 2:______ Beam 3:______ Beam 4:______

Receive beam voltage in mV AC (minimum = 250 mV)
Beam 1:______ Beam 2:______ Beam 3:______ Beam 4:______

T-2.5 INTERNAL SENSOR TESTS

Tilt Test:

Tilt 1 at	Tilt 2 at
0° _________ counts = ______°	0° _________ counts = ______°
+10° _________ counts = ______°	+10° _________ counts = ______°
-10° _________ counts = ______°	-10° _________ counts = ______°

Flux Gate Heading Sensor (Compass) Test:

Heading #1 __________ counts = ________° Actual: ________°
Heading #2 __________ counts = ________° Actual: ________°
Heading #3 __________ counts = ________° Actual: ________°
Heading #4 __________ counts = ________° Actual: ________°

SC-ADCP Temperature Sensor Test:

Temp. #1 __________ counts = ________°C Actual: ________°C
Temp. #2 __________ counts = ________°C Actual: ________°C
Temp. #3 __________ counts = ________°C Actual: ________°C
Temp. #4 __________ counts = ________°C Actual: ________°C

T-2.6 EXTERNAL CTD SENSOR TESTS

CTD Depth Sensor Test:

Depth #1 __________ counts = ________ cycles
Depth #2 __________ counts = ________ cycles
CTD interval __________ counts = ________ ms
__________ f_D [(No. of depth cycles) / (CTD interval)]
Depth change __________

SC-ADCP Function Test Results Form (Continued)

Test | **Data**

T-2.6 (cont)

EXTERNAL CTD SENSOR TESTS (continued)

CTD Temperature Sensor Test:

Temp. #1 __________ counts = ________ cycles Actual: ________°C
Temp. #2 __________ counts = ________ cycles Actual: ________°C
Temp. #3 __________ counts = ________ cycles Actual: ________°C
Temp. #4 __________ counts = ________ cycles Actual: ________°C

CTD interval __________ counts = ________ ms

__________ f_T [(No. of temperature cycles) / (CTD interval)]

CTD Conductivity Sensor Test:

Cond. #1 _________ counts = ________ cycles Actual: ________ S/m
Cond. #2 _________ counts = ________ cycles Actual: ________ S/m
Cond. #3 _________ counts = ________ cycles Actual: ________ S/m
Cond. #4 _________ counts = ________ cycles Actual: ________ S/m

CTD interval __________ counts = ________ ms

__________ f_C [(No. of conductivity cycles) / (CTD interval)]

T-2.7

RECORDER TESTS

Recorder Hardware Tests:

Test 1: Pass/Fail: __________ Error code: ____________________
Test 2: Pass/Fail: __________ Error code: ____________________
Test 3: Pass/Fail: __________ Error code: ____________________
Cards not present: ____
Bad EPROM chips : ____

Memory Map Check:

Number of deployments: __________ Kilobytes left: __________

T-2.8

POWER CONSUMPTION TESTS

__________ mA (V2 Awake Current; 0.40 mA maximum)
__________ mA (V2 Asleep Current; 0.40 mA maximum)
__________ mA (V1 Awake Current; 235 mA maximum)
__________ μA (V1 Asleep Current; less than 280, or 680 μA with CTD)
__________ mA (CTD Depth Current; typically 3 mA)
__________ mA (CTD Temperature Current; typically 11 mA)
__________ mA (CTD Conductivity Current; typically 11 mA)
__________ mA (Total CTD Current)

T-2.9

CONTINUITY AND ISOLATION TESTS

__________ ohms (Zinc Anode Resistance)
__________ megohms (Chassis Isolation Resistance)

Write-Erase Record for EPROM Recorder Memory Card

Serial Number ________

Write-erase cycle number	Date removed	From slot number	Erase time (minutes)	Date inserted	In slot number

RD Instruments

Acoustic Doppler Current Profilers

9855 BUSINESSPARK AVENUE
SAN DIEGO, CA, USA, 92131
TEL: (619) 693-1178
FAX: (619) 695-1459
TLX: 46-7731

CUSTOMER FEEDBACK FORM

Date ____________________

Name ____

Address ____

____

____

____

Phone ____

Instructions

Use this form to report problems with RD Instruments hardware, software, or documentation. You can also use this form to make suggested enhancements to us. Please mail the completed form to RD Instruments at the above address.

Category

__________ Hardware Problem

__________ Software Problem

__________ Documentation Problem

__________ Suggested Enhancement

__________ Other

Hardware/Software Description

__________ Instrument Model (DR, SC, VM)

__________ Instrument Frequency (75, 150, 300, 600, 1200 kHz)

__________ Instrument Serial Number

Software Program ______________________________

Version Number ______________

Please use other side or separate sheet of paper for description.

RD INSTRUMENT USE ONLY

Feedback No. ______________ Routing ____________________

Date Received ______________ By ____________________

Date Resolved ______________ By ____________________

Action Taken:

Description

APPENDIX S
SPECIFICATIONS AND DIMENSIONS

S-0. INTRODUCTION

The ADCP emits an acoustic pulse called a PING. Scatterers that ride on the water currents reflect some of the energy from the ping back to the ADCP. The ADCP uses the return signal to calculate a velocity. The energy in this signal is the ECHO INTENSITY. Echo intensity is sometimes used to determine information about the scatterers.

The velocity calculated from each ping has a STATISTICAL UNCERTAINTY; however, each ping is an independent sample. The ADCP reduces this statistical uncertainty by averaging a collection of pings. A collection of pings averaged together is an ENSEMBLE. The ADCP's maximum PING RATE limits the time required to reduce the statistical uncertainty to acceptable levels.

The ADCP does not measure velocity at a single point; it measures velocities throughout the water column. The ADCP measures velocities from its transducer head to a specified range and divides this range into uniform segments called DEPTH CELLS. The collection of depth cells yields a PROFILE. The ADCP produces two profiles, one for velocity and one for echo intensity.

The ADCP calculates velocity data relative to the ADCP. The velocity data has both speed and direction information. If the ADCP is moving, and is within range of the bottom, it can calculate the absolute velocity of the water. The ADCP can get absolute direction information from a heading sensor.

Table S-1 lists the specifications for all three models of ADCPs. About the specifications:

a. All these specifications assume minimal ADCP motion - pitch, roll, heave, rotation, and translation. ADCP motion degrades ADCP performance. This is why shipboard and buoy-mounted ADCPs often do not perform as well as moored ADCPs.

b. Except where noted, this specification table applies to typical setups and conditions. Typical setups use the default input values for each parameter (exceptions include Pings Per Ensemble and Number of Depth Cells). Typical conditions assume uniform water velocities at a given depth, moderate shear, moderate ADCP motion, and typical echo intensity levels.

c. The total measurement error of the ADCP is the sum of

   - Long-term instrument error (as limited by instrument accuracy)
   - The remaining statistical uncertainty after averaging
   - Errors introduced by measurement of ADCP heading and motion

d. Because individual pings are independent, the statistical uncertainty of the measurement can be reduced according to the equation

$$\text{Statistical uncertainty for one ping} \, / \, \sqrt{\text{Number of pings}}$$

NOTES

Table S-1. ADCP Specifications

CONFIGURATION

Available Models

Direct-Reading (DR)
Self-Contained (SC)
Vessel-Mounted (VM)

Frequency options (kHz)

System	75	150	300	600	1200
Actual	76.8	153.6	307.2	614.4	1228.8

MEASUREMENT OF WATER VELOCITY RELATIVE TO THE ADCP

Accuracy (long-term)

0.5% of measured velocity ±0.5 cm/s

Statistical uncertainty for one ping (cm/s)

Depth cell length (m)	System frequency (kHz) 75	150	300	600	1200
1	---	---	---	26	13
2	---	---	26	13	6.5
4	---	26	13	6.5	---
8	26	13	6.5	---	---
16	13	6.5	---	---	---
32	6.5	---	---	---	---

VALUES ARE FOR HORIZONTAL VELOCITIES USING THE STANDARD TRANSDUCER. TO CALCULATE THE STATISTICAL UNCERTAINTY FOR VERTICAL VELOCITIES, MULTIPLY THE STATISTICAL UNCERTAINTY FOR THE HORIZONTAL VELOCITY BY A FACTOR OF 0.4.

Ping rate (pings per second)

System	System frequency (kHz) 75	150	300	600	1200	
DR/VM	0.7	1	1.5	1.75	2	(NO PINGS AVGD IN ADCP)
SC	0.75	2	3	5	6.5	(100 PINGS AVGD IN ADCP)

Maximum profiling range (meters)

System (Power)	System frequency (kHz) 75	150	300	600	1200
DR/VM (AC)	665	385	250	90	28
SC (DC)	**500**	**290**	**190**	**70**	**28**

Table S-1. ADCP Specifications (Continued)

MEASUREMENT OF WATER VELOCITY RELATIVE TO THE ADCP (contd)

Minimum range to start of first depth cell (meters)

System frequency (kHz)				
75	150	300	600	1200
4	4	2	1	0.5

Loss of profiling range near a boundary

Standard 30° transducer	13.4% of range to boundary + one depth cell
Special 20° transducer	6% of range to boundary + one depth cell

NOTE: ADCP PITCH AND ROLL MAY REDUCE RANGE.

Number of depth cells	8 to 128
Velocity range	±0.01 to 9.5 m/s (horizontal)

Velocity resolution (cm/s)

System frequency (kHz)				
75	150	300	600	1200
0.25	0.25 or 0.125	0.25 or 0.125	0.25 or 0.125	0.125

NOTE: DATA COLLECTED IN EARTH COORDINATES HAS ONE-HALF THE SPECIFIED RESOLUTION.

MEASUREMENT OF ADCP VELOCITY RELATIVE TO THE BOTTOM AND MEASUREMENT OF BOTTOM DEPTH

Accuracy	0.5% of measured velocity ±0.5 cm/s

Statistical uncertainty for one ping (percent of measured velocity)

System frequency (kHz)				
75	150	300	600	1200
4	3.5	2.5	1.7	1.7

VALUES ARE FOR HORIZONTAL VELOCITIES USING THE STANDARD TRANSDUCER. TO CALCULATE THE STATISTICAL UNCERTAINTY FOR VERTICAL VELOCITIES, MULTIPLY THE STATISTICAL UNCERTAINTY FOR THE HORIZONTAL VELOCITY BY A FACTOR OF 0.4.

Ping rate (pings per second)

	System frequency (kHz)					
System	75	150	300	600	1200	
DR/VM	0.3	0.4	0.7	0.85	1	(NO PINGS AVGD IN ADCP)
SC	0.35	0.9	1.4	2.4	3	(100 PINGS AVGD IN ADCP)

Table S-1. ADCP Specifications (Continued)

<table>
<tr><td>MEASUREMENT OF ADCP VELOCITY RELATIVE TO THE BOTTOM AND MEAS. OF BOTTOM DEPTH (contd)</td><td></td></tr>
<tr><td>Depth range</td><td>Same as for Profiling Range for MEASUREMENT OF WATER VELOCITY
NOTE: THE MAXIMUM DEPTH RANGE CAN BE UP TO 1.5 TIMES GREATER THAN SPECIFIED.</td></tr>
<tr><td>Bottom depth resolution (meters)</td><td><table><tr><th colspan="5">System frequency (kHz)</th></tr><tr><th>75</th><th>150</th><th>300</th><th>600</th><th>1200</th></tr><tr><td>8</td><td>4</td><td>4</td><td>2</td><td>1</td></tr></table></td></tr>
<tr><td>Velocity range</td><td>Same as for MEASUREMENT OF WATER VELOCITY</td></tr>
<tr><td>Velocity resolution</td><td>Same as for MEASUREMENT OF WATER VELOCITY</td></tr>
<tr><td>MEASUREMENT OF ECHO INTENSITY</td><td></td></tr>
<tr><td>Accuracy (with temperature correction)</td><td>Before calibration: ±8 dB (approximately)
After calibration : ±3 dB</td></tr>
<tr><td>Statistical uncertainty for one ping</td><td>Approximately ±5 dB</td></tr>
<tr><td>Ping rate</td><td>Same as for MEASUREMENT OF WATER VELOCITY</td></tr>
<tr><td>Profiling range (meters <i>less</i> than for MEASUREMENT OF WATER VELOCITY)</td><td><table><tr><th colspan="5">System frequency (kHz)</th></tr><tr><th>75</th><th>150</th><th>300</th><th>600</th><th>1200</th></tr><tr><td>112</td><td>64</td><td>36</td><td>10</td><td>5</td></tr></table></td></tr>
<tr><td>Number of depth cells</td><td>Same as for MEASUREMENT OF WATER VELOCITY</td></tr>
<tr><td>Dynamic range</td><td>80 dB</td></tr>
<tr><td>Resolution</td><td>0.45 dB typical (temperature/system dependent)</td></tr>
<tr><td>DATA COMMUNICATION</td><td></td></tr>
<tr><td>Interface</td><td>VM only : GPIB parallel (IEEE-488)
DR/SC/VM: Modified RS-232/422 serial at baud rates of 300 - 19,200
NOTES:
1. MODIFICATIONS TO IEEE STANDARD FOR RS-232 COMMUNICATION ARE:
A. THE MINUS VOLTAGE IS TURNED OFF IN SLEEP MODE FOR THE SC.
B. VOLTAGE LEVELS ARE +4 VDC AND -3.5 VDC NOMINAL UNLOADED. THE STANDARD SAYS MINIMUM VOLTAGE LEVELS SHOULD BE 5 VDC.
2. A MODIFICATION TO IEEE STANDARD FOR RS-422 COMMUNICATION IS THAT THE ADCP COMMUNICATIONS RECEIVER DOES NOT MEET SPECIFICATIONS. AT THE BAUD RATES WE USE, THIS IS NOT A PROBLEM.
3. UP TO 76,800 BAUD IS AVAILABLE UNDER LIMITED CONDITIONS. CALL RDI IF YOU NEED THIS CAPABILITY.</td></tr>
</table>

Table S-1. ADCP Specifications (Continued)

DATA COMMUNICATION (contd)	
Data format	DR/SC/VM: **Binary (8-bit) or ASCII (76-character lines separated by a carriage return/ line feed.** DR/VM : The binary and ASCII formats listed above apply to data taken directly from the ADCP. Our Data Acquisition Software (RD-IBMSOFT) uses a different data format.
Output data for each ensemble	Header (14 bytes): - Sent only when transferring binary data Leader (63 bytes): - Time - Ensemble number - ADCP setup parameters - Bottom depth - ADCP velocity relative to the bottom - Optional CTD data - ADCP heading, pitch, roll, and temp. data - ADCP internal test status and voltages Data for each depth cell: - Radial water velocity components (can be recorded in earth coordinates) - Echo intensity of the return signal - Data quality information (spectral width, percent-good, status) NOTE: THE DATA FORMAT LISTED ABOVE APPLIES TO DATA TAKEN DIRECTLY FROM THE ADCP. OUR DATA ACQUISITION SOFTWARE (RD-IBMSOFT) FOR DR/VM SHIPBOARD INSTALLATIONS USES A DIFFERENT DATA FORMAT.
Data storage requirements in bytes per ensemble	$H + L + V + I + Sp + \% + St$ Binary: $14 + 63 + 6N + 4N + 4N + 4N + 2N$ ASCII : $0 + 150 + 16N + 12N + 12N + 8N + 4N$ where : H = Binary header L = Leader V = Velocity I = Echo intensity Sp = Spectral width $\%$ = Percent good St = Status N = No. of depth cells
SC data storage capacity	2 megabytes (standard); expandable to 40 MB in 1 and/or 2-MB increments

Table S-1. ADCP Specifications (Continued)

POWER REQUIREMENTS

SC (DC powered)

	Power supply desig.	Voltage range (VDC)	Standby current (amps)	Operate current (amps)	Peak current (amps)
ADCP electronics	V1	6-12	0.0002	0.24	0.5
Transmit & EPROM recorder	V2	20-40	0.0001	0.10	2.0
CTD sensors	V4	12-20	0.0001	0.022	0.05

DR/VM (AC powered)

Voltage: 115 VAC, 50 or 60 Hz (220 VAC available for VM systems)
Power : Typical - 100 W average
Maximum - 250 W (very high ping rate, very long depth cells, measuring ADCP velocity relative to the bottom)
Peak current: 5 A during transmit at 115 VAC

NOTE: AT POWER-UP, UP TO 50 A PEAK FOR ONE-HALF CYCLE CAN BE DRAWN. THE TIME CONSTANT IS ABOUT 65 ms.

TEMPERATURE SENSOR

Accuracy	±0.2°C
Time constant	Approximately 2 minutes
Range	-5 to 45°C
Resolution	0.012°C

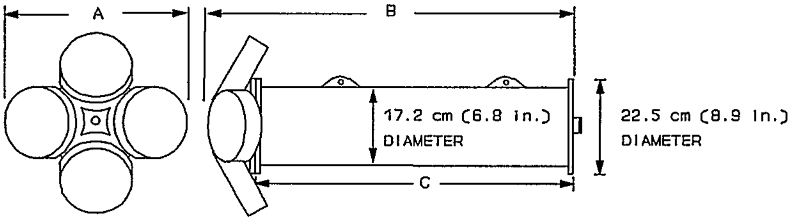
ENVIRONMENTAL

Operating temperature	-5°C to 40°C
Humidity	Must be non-condensing
Depth capability	DR/SC: 1000 meters (1480 psi) VM : 35 meters (transducer only)

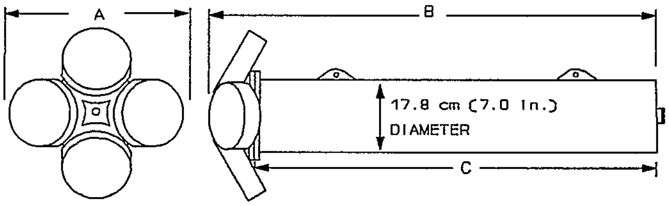
PHYSICAL CHARACTERISTICS Shown on next two pages

Table S-1. ADCP Specifications (Continued)

DR-ADCP

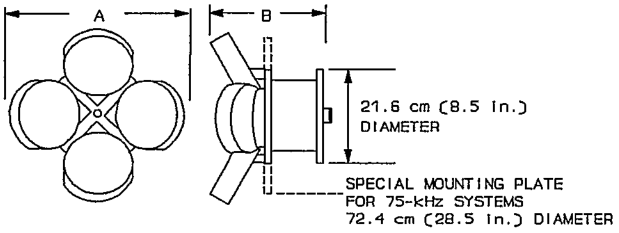


SC-ADCP

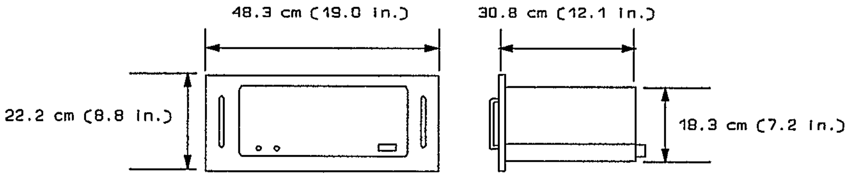


NOTE: THE SC-ADCP HAS ROOM FOR (1) "D" AND (2) "DD" BATTERIES OR THE EQUIVALENT.

VM TRANSDUCER



VM ELECTRONICS



90□ ADAPTOR

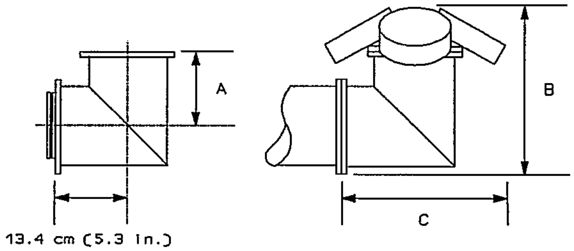


Table S-1. ADCP Specifications (Continued)

Freq	Weight-air		Weight-water		Dim. "A"		Dim. "B"		Dim. "C"	
kHz	kg	lb	kg	lb	cm	in	cm	in	cm	in
DIRECT-READING ADCP										
1200	24.0	53.0	1.6	3.6	22.6	8.9	91.9	36.2	85.9	33.8
600	33.1	73.0	9.3	20.5	37.7	14.9	95.5	37.6	85.9	33.8
300	34.9	77.0	10.0	22.0	39.2	15.5	94.7	37.3	85.9	33.8
150	51.7	114.0	22.2	49.0	45.9	18.1	95.9	37.8	85.9	33.8
75	130.6	288.0	75.8	167.0	84.6	33.3	100.7	39.6	85.9	33.8
SELF-CONTAINED ADCP										
1200	39.9	88.0	4.5	10.0	22.6	8.9	137.4	54.1	131.3	51.7
600	49.0	108.0	12.3	27.0	37.7	14.9	141.0	55.5	131.3	51.7
300	50.8	112.0	12.7	28.0	39.2	15.5	140.2	55.2	131.3	51.7
150	67.6	149.0	25.0	55.0	45.9	18.1	141.4	55.7	131.3	51.7
75	146.5	323.0	78.9	174.0	84.6	33.3	146.1	57.5	131.3	51.7
VESSEL-MOUNTED TRANSDUCER										
1200	14.1	31.0	9.1	20.0	17.2	6.8	21.1	8.3	N/A	
600	35.8	79.0	29.5	65.0	33.9	13.4	23.7	9.3		
300	40.4	89.0	33.1	73.0	39.4	15.5	25.6	10.1		
150	37.6	83.0	29.9	66.0	43.5	17.1	28.2	11.1		
75	211.0	465.0	170.1	375.0	85.7	33.7	36.7	14.4		
VESSEL-MOUNTED ELECTRONICS CHASSIS										
All	9.1	20.0	N/A		N/A		N/A		N/A	
90 DEGREE ADAPTOR										
1200	5.5	12.0	-2.2	-4.8	16.6	6.5	33.8	13.3	24.7	9.7
600	5.5	12.0	-2.2	-4.8	16.6	6.5	37.4	14.7	32.3	12.7
300	5.5	12.0	-2.2	-4.8	16.6	6.5	36.6	14.4	33.0	13.0
150	5.5	12.0	-2.2	-4.8	16.6	6.5	39.9	15.7	36.8	14.5
75	6.2	13.8	-2.8	-6.3	22.9	9.0	48.8	19.2	55.7	21.9

NOTES

APPENDIX T
SC-ADCP TEST PROCEDURES

T-0. INTRODUCTION

This appendix explains how to test the SC-ADCP using our SCTEST.EXE test program with an IBM PC/XT/AT-compatible computer (¶T-1), and how to test the ADCP using direct commands with a dumb terminal or emulator program (¶T-2). Either method checks the ADCP in a laboratory environment, but using SCTEST is quicker, easier, and more thorough than using direct commands. These tests do not calibrate the ADCP, nor are they substitutes for a practice deployment. You should test the ADCP:

a. When you first receive the ADCP.
b. Before each deployment or every six months.
c. When you suspect instrument problems.

These test procedures assume all equipment is working. The tests can help you isolate problems to a major functional area of the ADCP. For troubleshooting information, see Chapter 6.

T-1. TESTING THE SC-ADCP WITH THE SC-ADCP TEST PROGRAM (SCTEST.EXE)

This section explains how to run the SCTEST automated test program using an IBM PC/XT/AT-compatible computer in a laboratory environment. SCTEST thoroughly checks the ADCP. Using SCTEST eliminates the need to write down individual test results. This is because each time you run SCTEST, it automatically creates an ASCII text file and stores the file in the current directory. SCTEST names this file TESTFORM.*nnn*, where *nnn* is a sequential number beginning with 001 that automatically increments with each test run. You can view or print this file using the DOS *TYPE* and *PRINT* commands. This file is also compatible with most text editors. If you delete some, or all, of the TESTFORM files, the program assigns the lowest available sequence number the next time you run SCTEST. You may want to transfer the TESTFORM files to a floppy disk for future reference and test comparisons. The remaining paragraphs in this section provide information on the setup and running of SCTEST.

a. Section T-1.1 - Preliminary Setup
b. Section T-1.2 - Auto-Sequence Tests
c. Section T-1.3 - Establish Communication Test
d. Section T-1.4 - SC-ADCP Built-In Test (BIT)
e. Section T-1.5 - Transmit Test
f. Section T-1.6 - Preamp/Receive Test
g. Section T-1.7 - Receive Continuity Test
h. Section T-1.8 - Internal Sensors Test
i. Section T-1.9 - External CTD Sensors Test
j. Section T-1.10 - Recorder Test
k. Section T-1.11 - Power Consumption Test
l. Section T-1.12 - Continuity and Isolation Test

T-1.1. PRELIMINARY SETUP. This section has information on the equipment connection and general instructions needed to run SCTEST.

a. Connect the SC-ADCP for testing as described in Appendix-A. You can use either batteries or external DC power to run the ADCP. You will need a digital multimeter (DMM), but do not connect it yet. The DMM must be capable of measuring less than one ohm of resistance and currents from 300 μA to 2 A (e.g., Fluke 8050A).

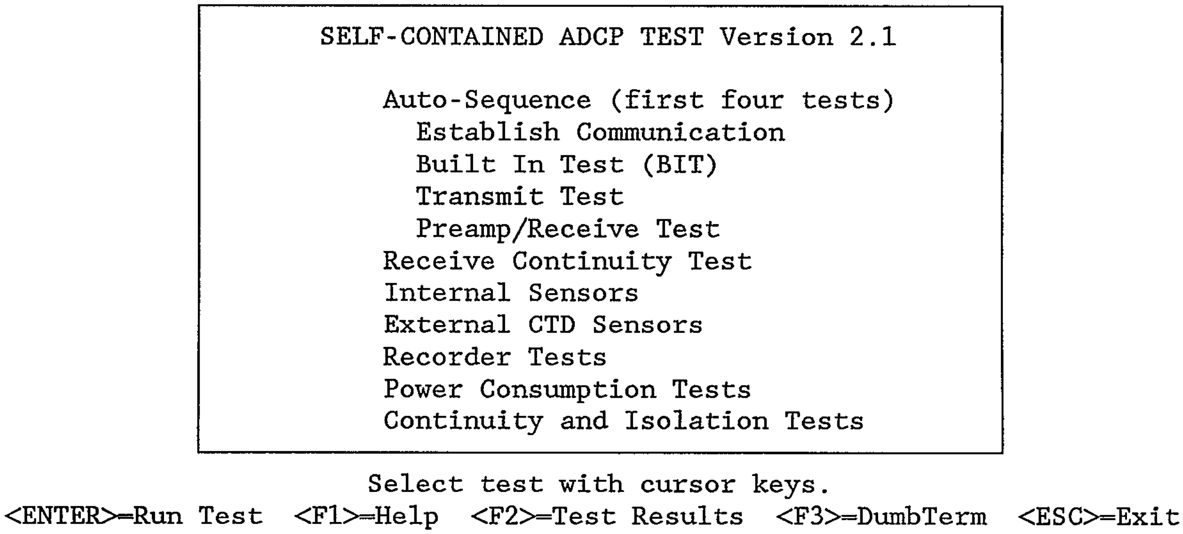
b. Apply power to the system and boot the computer. Access the drive/directory containing the SCTEST program files. To start the program, type in SCTEST <Enter> at the DOS prompt. After a moment, the Main Menu appears (Figure T-1). NOTE: If you have the SC-ADCP Deployment Program, you can select SCTEST from the MAIN MENU.

c. To view help text for a test, use the cursor keys to highlight the desired test. Press the <F1> key. SCTEST will now display help text for the selected test. You can search for text strings using the <F>ind and <A>gain keys. To return to the main menu, press any key.

d. To run a test, use the cursor keys to highlight the desired test and press the <Enter> key. A flashing *RUNNING* message will appear next to the selected test, and test execution will begin.

e. To stop the running of a test, press the <Esc> key. During some I/O operations, it may take several moments before the test stops running. Pressing <Esc> from the main menu when no test is running exits SCTEST. Before exiting, SCTEST asks you to confirm your decision.

f. The lower part of the screen shows the on-going test status and the instructions/prompts to which you must respond. To respond to a prompt, just type in the appropriate information and press <Enter>.



```
            SELF-CONTAINED ADCP TEST Version 2.1

                Auto-Sequence (first four tests)
                  Establish Communication
                  Built In Test (BIT)
                  Transmit Test
                  Preamp/Receive Test
                Receive Continuity Test
                Internal Sensors
                External CTD Sensors
                Recorder Tests
                Power Consumption Tests
                Continuity and Isolation Tests

                 Select test with cursor keys.
<ENTER>=Run Test  <F1>=Help  <F2>=Test Results  <F3>=DumbTerm  <ESC>=Exit
```

Figure T-1. SCTEST Program Main Menu

g. After each test, SCTEST shows a *PASS*, *FAIL*, *DONE*, or *SKIP* message next to the test name. The *PASS/FAIL* message shows the result of the test as determined by the program. A *DONE* message means the test is complete, but you must decide whether the test was successful. A *SKIP* message means you tried to run the External CTD Sensors Test without any sensors installed. If a communication error occurs, or if you stop a test by pressing <Esc>, no message is displayed.

h. After the program completes a test, review the results of the test. To do this, highlight the desired test, and then press <F2>. The screen will now display the results of the selected test.

i. The program automatically records the results of each test in the TESTFORM file. If you run a test more than once, the program will record the results of each test in the same TESTFORM file. This allows you to run one or more tests several times and have the results recorded to the same TESTFORM file for review and comparison.

j. To begin a test run, you must preset two switches on the RDI J-Box. The *ADCP/RECORDER* switch must be in *ADCP*. The *DTE/DCE* switch must be in *DTE* unless previous testing resulted in a setting of *DCE*. The *DTE/DCE* switch reverses pins 2 and 3 of the computer to J-box cable.

k. The first four tests (which also make up the Auto-Sequence test) require you to immerse the transducer faces in water. If you do not, the transmit current portion of the test may fail. Whenever you immerse the transducer head in water, rub the transducer faces with some liquid soap and the palm of your hand to remove air bubbles that can cause a transmit current failure.

l. To communicate directly with the ADCP for troubleshooting, press <F3> to access the DUMBTERM terminal emulator program. DUMBTERM must be in the current directory or a DOS path.

T-1.2. AUTO-SEQUENCE TESTS. This test selection automatically cycles through the first four tests - Establish Communication, Built-In Test, Transmit Test, Preamp/Receiver Test. The first four tests require you to immerse the transducer faces in water (¶T-1.1.1.).

After each test, the program sets a flag showing PASS, FAIL, DONE, or SKIP. These flags appear on the main menu next to the respective test name. If a communication error occurs, or if you abort the test by pressing <Esc>, the test will not set the flag. Pressing <Esc> during the Auto-Sequence test, aborts the current test and automatically starts the next test in the cycle.

After running the Auto-Sequence tests, highlight the tests individually, and then press <F2> to view the results of each test. The program automatically records the results of each test to the TESTFORM file. For more information on each test, use the help screen <F1> or read the appropriate paragraph in this section.

T-1.3. ESTABLISH COMMUNICATION TEST. This test sets up communication with the ADCP, reads ADCP data, and determines the setting for the DTE/DCE switch on the RDI J-Box. SCTEST automatically runs this test before each test that communicates with the ADCP and checks both the COM1 and COM2 serial ports.

NOTE

DURING TESTING, DRTEST FIRST TRIES TO TALK TO THE ADCP ON COM1 AND THEN COM2. IF ANOTHER DEVICE IS ON COM1, DRTEST MAY RESET THE DEVICE'S BAUD RATE. YOU SHOULD USE COM1 FOR THE ADCP SYSTEM.

To begin this test, set the J-Box ADCP/RECORDER switch to ADCP. Set the DTE/DCE switch to DTE unless previous testing resulted in a setting of DCE. The DTE/DCE switch reverses pins 2 and 3 of the computer to J-box cable. After determining the correct setting, do not change it. If SCTEST cannot establish communications with the ADCP:

a. Change the DTE/DCE switch to its opposite setting.
b. Check connections to all equipment.
c. Make sure the ADCP/RECORDER switch is set to ADCP.
d. Check the power supplies or battery packs (Appendix-B).
e. See Appendix-A.

T-1.4. SC-ADCP BUILT-IN TEST (BIT). This test runs the ADCP's "Y1" Built-In Test function. This test checks RAM, ROM, transmit current, receiver operation, Doppler signal processing, and most of the ADCP's electronics. Immerse the transducers in water for this test (¶T-1.1.1.), otherwise the transmit current portion of the test may fail.

Take note of any error messages for troubleshooting purposes. If the transducers are not in water, or if air bubbles exist, the test results may show a VERY LOW, LOW, or HIGH TRANSMITTER CURRENT message. However, these messages also could mean a problem exists with the transmit current. If this test fails, run it several times to make sure the problem is consistent. It is possible that air bubbles could cause an occasional error to occur, but this occasional error is not conclusive that a problem exists. This test also may fail if V2 voltage is low; run the Transmit/Voltage Test to check this.

T-1.5. TRANSMIT TEST. This test checks transmit current. Immerse the transducers in water for this test (¶T-1.1.1.), otherwise the transmit current value may be erroneous. SCTEST reads V1, V2, and Transmit Current Counts from the leader, and then normalizes the counts by:

Normalized Transmit Current Counts = (Transmit Current Counts x 39) / V2.

The normalized count should be between 100 and 250 counts or the test will fail. If V1<6.0 or V2<35.0, SCTEST displays a warning message that indicates the batteries are low. Make a note of these values for future comparisons. NOTE: To pass this test, some older units may need to be calibrated by RDI.

T-1.6. PREAMPLIFIER/RECEIVER TEST. This test checks the ADCP's preamplifiers by testing the Intermediate Frequency bandwidth of each beam for proper noise energy levels. Immerse the transducers in water (¶T-1.1.1.). RDI tunes each beam to operate in water, so the shape of the noise energy is unpredictable in air. If SCTEST finds any beam level to be 4 dB or more below a predetermined value, the "out-of-band" test for that beam will fail. This test also looks at each beam for changes of 6 dB or more between adjacent samples. If a change exceeds 6 dB, the "in-band" test for the beam will fail. If you have problems, shielding the ADCP or isolating devices that radiate frequencies at or near the frequency of the ADCP may help.

T-1.7. RECEIVE CONTINUITY TEST. This test checks the echo intensity of each beam and gives confidence in the transducer-to-preamplifier connections. When asked to rub each transducer face, do so by BRISKLY brushing your hand back and forth across the face as if you are brushing sand from a flat surface.

You MUST run this test with the ADCP's transducer in AIR. If the transducer is in water, the acoustic energy will not decay quickly enough to "see" the rubbing action on the face. You must interpret the results of this test. NOTE: Do NOT run this test with a baud rate of less than 4800.

T-1.8. INTERNAL SENSORS TEST. This test checks the internal ADCP sensors (tilt, heading, temperature), but does NOT calibrate them. The accuracy of this test depends on the accuracy of your input values for roll, pitch, heading, and temperature. You must interpret the results of this test.

Set the ADCP in the position it will be in during deployment (pointing up or down). The factory default is UP. You must provide any fixture needed to position the ADCP. Use Figure C-1 for help in determining tilt directions. Be aware that magnetic interference near the ADCP affects the accuracy of the flux-gate compass readings. You may have to run this test outdoors, away from the influence of buildings and magnetic objects. Take several readings at various positioning angles and temperatures.

CAUTION

PROTECT THE TRANSDUCERS AND I/O CONNECTOR DURING POSITIONING.

The ADCP will average 20 pings per ensemble, and then send its leader data. The screen displays the number of ensembles for reference and the present values of Tilt1, Tilt2, Heading, and Temperature in the following format.

```
ENSEMBLE  TILT1   TILT2  HEADING  TEMPERATURE
NUMBER    DEG.    DEG.   DEG.     DEG. C
       1  -12.6   0.03   275.14   22.7
```

During the test, you can record comments about the test (usually information about actual ADCP positioning and temperature). Pressing <R>, prompts you for comments to add to the TESTFORM file. Pressing <Q> ends this test.

T-1.9. EXTERNAL CTD SENSORS TEST. This test checks external Conductivity, Temperature, or Depth (CTD) sensors connected to the ADCP, but does NOT calibrate them. Test accuracy depends on the accuracy of the sensor input values. You must interpret the results of this test.

The ADCP will average 20 pings, and then send its leader data. SCTEST displays the ensemble number, the present CTD values in kHz, and the CTD Measurement Interval in microseconds in the following format.

```
ENSEMBLE    C kHz    T kHz     D kHz     MI ms
       1    5.000    10.000    40.000    950
```

During the test, you can record comments about the test (usually information about actual ADCP positioning and temperature). Pressing <R>, prompts you for comments to add to the TESTFORM file. If no CTD board is in the ADCP, the file will display *CTD NOT DETECTED*. Pressing <Q> ends this test.

For the CTD sensor tests, connect the sensors to the ADCP using the RD-CTDHARN adapter cable (Figure A-2). Each sensor transmits a frequency that varies as the value it is measuring varies. SCTEST measures these frequencies by counting cycles during a measurement interval. For each sensor, you can get the final measurement value using the manufacturer's sensor-specific calibration data. The calibration sheet lists all coefficients and conversion formulas.

CTD Depth Sensor Test. This test checks the accuracy of the Paroscientific Inc., Model 8000 series or Model 8B000 series depth sensor.

__ a. Connect the depth sensor to P5 of the adapter cable. Place the sensor (not the ADCP) in a container filled with at least one meter of water. Sensor depth should be just below the surface of the water.

__ b. Allow about two minutes for the depth reading to stabilize, and then find the pressure value by converting the calculated frequency using the manufacturer's sensor-specific calibration data.

__ c. Lower the depth sensor in the container of water to one meter and repeat step b.

CTD Temperature Sensor Test. This test checks the accuracy of the Sea-Bird Electronics Inc., Model SBE 3 temperature sensor.

__ a. Connect the CTD temperature sensor to P4 of the adapter cable. Place the sensor (not the ADCP) in a water-filled container or temperature bath. The water should circulate in the container.

__ b. Find the temperature value by converting the calculated frequency using the manufacturer's sensor-specific calibration data.

__ c. Check for reasonable temperature values. If desired, repeat at different water (bath) temperatures.

CTD Conductivity Sensor Test. This test checks the accuracy of the Sea-Bird Electronics Inc., Model SBE 4 conductivity sensor.

__ a. Connect the conductivity sensor to P3 of the adapter cable. Place the sensor (not the ADCP) into a bath with a solution of a known conductivity between 2 and 6 S/m. The solution should circulate in the bath. If you do not know the conductivity, use a container filled with water of a known salinity and temperature. Use a conversion chart to convert from salinity to conductivity.

__ b. Find the conductivity value by converting the calculated frequency using the manufacturer's sensor-specific calibration data.

__ c. Check for reasonable conductivity values. If desired, repeat at different salinity concentrations.

T-1.10. RECORDER TEST. This test confirms recorder operation and ADCP/recorder communications. SCTEST runs several subtests, one of which "reads" how many @T memory locations are free (up to 64). SCTEST then runs the @T recorder test. You must decide if the @T data are correct for your system's configuration. For more information on the @T command, see Appendix-D.

T-1.11. POWER CONSUMPTION TEST. This test measures the electric current required by the SC-ADCP. This relates to the number of battery ampere-hours (A·h) used during a deployment. During these tests, you must connect the DMM in series with battery pack power supplies for accurate readings (see Figure T-2). To do this:

__ a. Turn OFF or DISCONNECT the ADCP power supplies.
__ b. Set the DMM to the DC current range called for during the test.
__ c. Connect the (+) lead of the power supply under test (V1, V2, or V4 if a CTD board is installed) to the (+) DC AMP terminal on the DMM.
__ d. Connect the (-) lead of the power supply under test to the (-) terminal on the J-box for the power supply under test.
__ e. Connect the (-) DMM lead to the (+) J-box terminal for the power supply under test.
__ f. You should use battery pack power supplies to get an accurate reading for this test. Connect the battery pack power supplies.

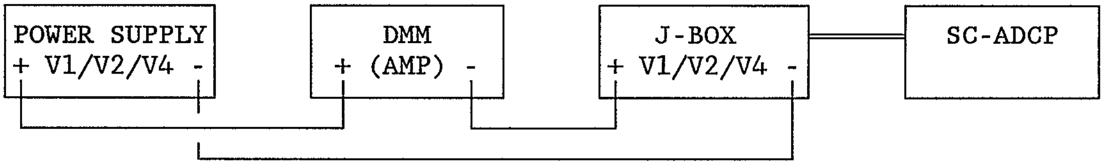


Figure T-2. Power Supply Connections for Power Consumption Tests

T-1.12. CONTINUITY AND ISOLATION TEST. This test measures the continuity between the zinc anode on the transducer head and the zinc anode on the pressure case. It also measures the isolation between the zinc anodes and the electronics chassis. Both anodes and isolation are important to preventing corrosion. Refer to Figure A-2.

__ a. Turn OFF or DISCONNECT all power supplies.
__ b. Install and bolt the pressure case to the transducer head. Connect the RDI J-Box to the I/O connector.

NOTE

ON SOME OLDER UNITS THERE IS NO ANODE ON THE TRANSDUCER HEAD. IN THOSE CASES, YOU MUST CHECK ELECTRICAL CONTINUITY BETWEEN THE ANODE AND THE PRESSURE CASE WITH THE PRESSURE CASE REMOVED (SEE ¶5-17.1).

__ c. Set the DMM to the 200-ohm scale. Connect the DMM leads to the pressure case and transducer head anodes.
__ d. The DMM should measure less than one ohm. Enter the measured value when requested by SCTEST.
__ e. Set the DMM to the two-megohm scale. Connect the DMM leads to the zinc anode on the pressure case and to V1 ground (-) on the RDI J-Box.
__ f. The DMM should read a minimum of one megohm (infinity is acceptable). The initial reading may start low and then slowly increase in value. Enter the measured value when requested by SCTEST.

T-2. TESTING THE SC-ADCP WITH DIRECT COMMANDS

This section explains how to test the ADCP in the laboratory using a dumb terminal or emulator program (e.g., RDI's *DUMBTERM.EXE*). These tests thoroughly check the ADCP, but are more difficult and time consuming to run than the SCTEST program (¶T-1). Appendix-F contains an *SC-ADCP Function Test Results* form. You can copy and use this form to record all test results for future comparisons. This section contains the following tests. We recommend you run the tests in the order listed.

a. Section T-2.1 - Preliminary setup
b. Section T-2.2 - Communications test
c. Section T-2.3 - SC-ADCP Built-In Test (BIT)
d. Section T-2.4 - Transmit/Receive tests
e. Section T-2.5 - Internal sensor tests
f. Section T-2.6 - External CTD sensor tests
g. Section T-2.7 - Recorder tests
h. Section T-2.8 - Power consumption tests
i. Section T-2.9 - Continuity and isolation tests

T-2.1. PRELIMINARY SETUP. This section explains the terminology, equipment connections, and general instructions needed to run the ADCP tests.

Terminology and Data Entry. The following examples show the terminology used throughout these procedures to show command inputs to the dumb terminal. The terminal then sends the command to the ADCP.

a. <BREAK> - This is your prompt to press the key(s) associated with the BREAK signal on your computer/terminal. Most terminals have a BREAK key; simply press that key. On computers used as terminal emulators there may not be a BREAK key. If there is, it does not usually send the correct signal. In these cases, the communications program defines the key(s) that sends the BREAK. If you are using RDI's DUMBTERM program, pressing <End> sends the BREAK signal. Pressing the BREAK pushbutton on the RDI J-Box also sends the BREAK signal. For each BREAK sent, the ADCP should respond with a wake-up message.

```
ACOUSTIC DOPPLER CURRENT PROFILER COPYRIGHT (c) RD INSTRUMENTS
1983-91 ALL RIGHTS RESERVED
```

b. <u>Y5</u> - This is your prompt to press the <u>Y</u> key and then the <u>5</u> key. Do NOT press <Enter> after typing in the entry. When the ADCP accepts the command, it automatically sends a carriage return and line feed.

NOTE

ALL ALPHA CHARACTERS <u>MUST</u> BE IN UPPERCASE. YOU MAY WANT TO SET YOUR TERMINAL IN THE CAPS LOCK MODE.

c. Before the ADCP begins pinging, you must send an S-command (S=Start). Appendix-D describes all ADCP direct commands. These procedures use the command <u>S235</u> to start ADCP processing. This command tells the ADCP to operate for one ensemble (set of pings) and send any associated data. You also can use the command <u>S236</u> instead of <u>S235</u>. The difference is that the ADCP continues to operate and send data at some constant rate. You may find this more convenient. If you use <u>S236</u>, you must send a <BREAK> to stop the ADCP.

Equipment Interconnection. This section explains the equipment connections and general instructions needed to test the ADCP using direct commands.

__ a. Connect the SC-ADCP for testing as described in Appendix-A. You can use either batteries or external DC power to run ADCP. You will need a digital multimeter (DMM), but do not connect it yet. The DMM must be capable of measuring less than one ohm of resistance and currents from 300 μA to 2 A (e.g., Fluke 8050A).

__ b. Apply power to the system.

__ c. You can do most tests with the pressure case on or off. The case must be on for the tests in ¶T-2.3 and ¶T-2.4 because the transducers must be in water for a successful test. Whenever you immerse the transducers, rub the faces with liquid soap and the palm of your hand to remove air bubbles that can cause a transmit current failure.

T-2.2. COMMUNICATIONS TEST. This test determines the proper setting for the DTE/DCE switch on the RDI J-Box. This switch reverses pins 2 and 3 of the computer to J-Box cable. After determining the correct setting, do not change it. See Appendix-A if you cannot establish communications. NOTE: If using RS-422, set the switch to DTE and skip this test.

__ a. Set the ADCP/RECORDER switch on the J-Box to ADCP. This switch must always be in the ADCP position.

__ b. Set the DTE/DCE switch on the J-Box to DTE.

__ c. Send a <BREAK>. If the wake-up message does not appear, change the switch to DCE and resend the <BREAK>.

__ d. Be sure the DTE/DCE switch remains in the correct position for all other tests and operations.

__ e. Record the switch setting on the Test Results form (Appendix-F).

T-2.3. SC-ADCP BUILT-IN TEST (BIT). This built-in, self-test checks RAM, ROM, and most of the ADCP electronics. The BIT also checks transmit current, receiver operation, and Doppler signal processing.

__ a. Install the pressure case for this test. The transducer head must be in water for a successful BIT test. You do NOT have to immerse the ADCP completely. After immersing the transducers, use liquid soap and the palm of your hand to remove air bubbles from the faces.

__ b. On the RDI J-Box, set the ADCP/RECORDER switch to ADCP. Set the DTE/DCE switch to the position determined in the Communications Test.

__ c. Enter the following ADCP commands.

__ (1) <BREAK> (wake-up message displayed)
__ (2) <u>Z</u> (wake-up message displayed)
__ (3) <u>Y5</u> (start BIT processing)

__ d. After about ten seconds, the screen shows the following.

```
NO SELFTEST FAILURES mmddhhmmss     (MONTH, DAY, HOUR, MINUTE, SECOND)
```

__ e. If the transducer is not in water, or if air bubbles exist, the screen may display: 081 mmddhhmmss. NOTE: The screen may display 082 or 083. All three values indicate problems with the transmit current.

__ f. The BIT test result message repeats every ten seconds. Check the message at least four times. Send a <BREAK> to end the test. Record the results of the BIT test on the Test Results form (Appendix-F).

T-2.4. TRANSMIT/RECEIVE TESTS. These tests check the transmit and receive circuits. Although these tests are separate, you must run them consecutively.

Transmit Test. The above BIT measured transmit current within a preset boundary. In this test, you compare the value of the transmit current with past results. A change of 20% may mean a faulty transducer.

__ a. Install the pressure case for this test. The transducer head must be in water for a successful transmit test. You do NOT have to immerse the ADCP completely. After immersing the transducers, use liquid soap and the palm of your hand to remove air bubbles from the faces.

__ b. On the RDI J-Box, set the ADCP/RECORDER switch to ADCP. Set the DTE/DCE switch to the position determined in the Communications Test.

__ c. Enter the following ADCP commands.

```
__ (1) <BREAK>   (wake-up message displayed)
__ (2) Z
__ (3) P00001    (one ping per ensemble)
__ (4) O000      (collect leader data only)
__ (5) S235      (operate for one ensemble)
```

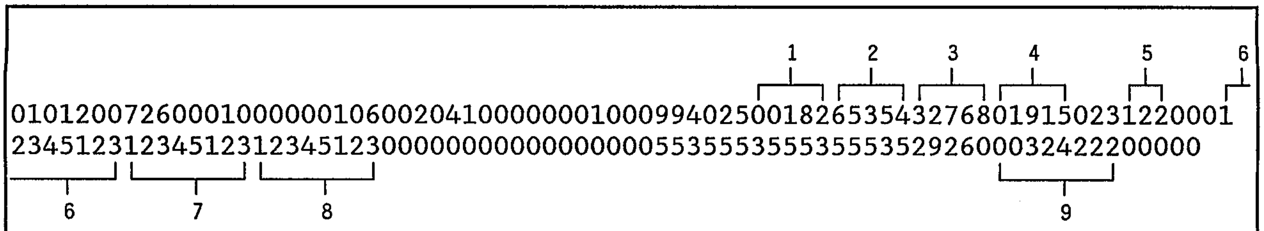
__ d. The screen should display two lines of data called the Leader. Figure T-3 shows the data of interest for the tests in this section. Chapter 4 has a description of all leader data.

__ e. Read the transmit current value from the screen (Figure T-3, #5). Convert this value to a 39-volt value as follows.

$$\text{Normalized Current} = (\text{Displayed Value} \times 39) / (\text{V2 Voltage}) \qquad \text{(Eq.T-1)}$$

For example, if V2 is 28 volts and the displayed Transmit Current is 122, then by equation T-1, Normalized Current ≈ 170.

__ f. Record the displayed value and the normalized current on the Test Results form (Appendix-F). Compare the results with previous readings. ADCPs have this value recorded on the System Configuration/Calibration sheet sent in the READ THIS FIRST packet. The sheet lists this value as *Transmit counts*. This value should be between 150 and 190 counts.



```
0101200726000100000010600204100000001000994025001826535432768019150231220001
23451231234512312345123000000000000000005535553555355535292600032422200000
```

LEGEND:
1 - TILT 1
2 - TILT 2
3 - HEADING
4 - SC-ADCP TEMPERATURE
5 - TRANSMIT CURRENT
6 - CTD CONDUCTIVITY (TWO LINES)
7 - CTD TEMPERATURE
8 - CTD DEPTH
9 - CTD INTERVAL

Figure T-3. SC-ADCP Leader Display Data

Receive Test. This test checks that the receivers are active and have reasonably low noise levels. Run this test after the Transmit Test.

__ a. Install the pressure case for this test. The transducer head must be in water run a successful receive test. You do NOT have to immerse the ADCP completely in water.

__ b. Enter the following ADCP commands. You must use a 20-conductor I/O cable for this test.

__ (1) <u>Z</u> (wake-up message displayed)
__ (2) <u>L0</u> (sets depth cell length of one meter)
__ (3) <u>DA08</u> (selects special test mode)
__ (4) <u>DA01</u> (selects beam #1 log AGC for monitoring)
__ (5) <u>S236</u> (operate continuously)

__ c. Set the DMM for 2 VDC full scale. Connect the DMM to the TEST 1 jacks on the J-Box.

__ d. Watch the DMM as you rub each transducer. Figure C-1 shows beam locations. When you rub beam #1, the DMM reading should vary noticeably. This test checks acoustic continuity through the transducer. The value you read is not important, but a variation of at least 100 mV is important. Record the Receiver Continuity results on the Test Results form. NOTE: This test is harder to run on 1200-kHz ADCPs because they are less sensitive to the feedback caused by the rubbing.

__ e. Set the DMM for 2 VAC (not DC) full scale. Connect the DMM to the TEST 2 jacks on the J-Box. Do NOT rub the transducer face for this reading. The DMM should read at least 250 millivolts (mV) RMS. Record the Receive Beam Voltage on the Test Results form.

__ f. Send a <BREAK> to end the test.

__ g. Repeat steps b(4) through f for the other three beams. This is done by replacing <u>DA01</u> in step b(4) with <u>DA02</u>, <u>DA03</u>, or <u>DA04</u> for the appropriate beam. In step d, rub the transducer you are testing.

T-2.5. INTERNAL SENSORS TESTS. These tests check, but do NOT calibrate, the tilt sensors, the flux gate compass, and the ADCP temperature sensor. Before proceeding, set the ADCP in the position it will be in during deployment (pointing up or down). The factory default is UP. You also must provide any fixture needed to position the ADCP. The accuracy of the tilt and compass tests depend on the accuracy and stability of the fixture you provide. The transducer head does not need to be in water for these tests.

CAUTION

PROTECT THE TRANSDUCERS AND I/O CONNECTOR DURING POSITIONING.

<u>Tilt Test</u>. This test checks the accuracy and alignment of the tilt sensors located within the SC-ADCP.

__ a. Set the ADCP in a position of no tilt. The transducer head must be level along both axes (Figure C-1). Beams 1 and 2 form the Y-axis (roll). Beams 3 and 4 form the X-axis (pitch).

__ b. Enter the following ADCP commands.

  - __ (1) <BREAK> (wake-up message displayed)
  - __ (2) <u>P00005</u> (five pings per ensemble)
  - __ (3) <u>O000</u> (collect leader data only)
  - __ (4) <u>S236</u> (operate continuously)

__ c. Read the Tilt 1 and Tilt 2 values from the displayed leader data (Figure T-3, #1 and #2). Convert these values to degrees using:

$$\textit{Degrees of tilt} = (\textit{Display Value} \times 360) / 65536 \qquad \text{(Eq.T-2)}$$

Examples: Display value of 182: $(182 \times 360) / 65536 \approx 1°$
Display value of 65354: $(65354 \times 360) / 65536 \approx 359° \approx -1°$

__ d. If the ADCP is level, Tilt 1 and Tilt 2 should be less than one degree. Record the display values and degree values for Tilt 1 and 2 at 0° on the Test Results form (Appendix-F).

__ e. Check Tilt 1 accuracy and alignment. Tilt the ADCP in each direction and verify the data are correct. For +Tilt 1 readings rotate the ADCP so the I/O connector moves in an arc away from beam #3. For up-facing units, beam #3 moves down. For down-facing units, beam #3 moves up.

__ f. Set the fixture to +10° for Tilt 1. Use equation T-2 to check the reading. Repeat this step using a -10° setting. Record the results.

__ g. Check Tilt 2 accuracy and alignment. Tilt the ADCP in each direction and verify the data are correct. For +Tilt 2 readings rotate the ADCP so the I/O connector moves in an arc away from beam #2. For up-facing units, beam #2 moves down. For down-facing units, beam #2 moves up.

__ h. Set the fixture to +10° for Tilt 2. Use equation T-2 to check the reading. Repeat this step using a -10° setting. Record the results.

Flux Gate Heading Sensor (Compass) Test. This test checks alignment of the internal SC-ADCP compass.

___ a. Before proceeding with this test, be sure there is no magnetic interference near the ADCP. You may have to run this test outdoors, away from the influence of buildings and other magnetic objects.

___ b. Turn beam #3 (Figure C-1) toward magnetic north.

___ c. Enter the following ADCP commands.

- ___ (1) <BREAK> (wake-up message displayed)
- ___ (2) P00005 (five pings per ensemble)
- ___ (3) O000 (collect leader data only)
- ___ (4) S236 (operate continuously)

___ d. Read the Heading value from the displayed leader data (Figure T-3, #3). Convert this value to degrees using the following formula. You should get a heading near magnetic north. Record the results.

$$Heading = (Display\ Value \times 360) / 65536 \qquad \text{(Eq.T-3)}$$

Examples: Display value of 182: (182 × 360) / 65536 ≈ 1°
Display value of 65354: (65354 × 360) / 65536 ≈ 359° ≈ -1°

___ e. Check other headings by positioning beam #3 in various directions. You should see increasing heading values when rotating the ADCP in a clockwise direction while viewing it from above. Record the results.

SC-ADCP Temperature Sensor Test. This test checks the accuracy of the internal ADCP temperature sensor in the transducer head.

___ a. Enter the following ADCP commands.

- ___ (1) <BREAK> (wake-up message displayed)
- ___ (2) P00005 (five pings per ensemble)
- ___ (3) O000 (collect leader data only)
- ___ (4) S235 (operate for one ensemble)

___ b. Read the ADCP Temperature value from the displayed leader data (Figure T-3, #4). Convert this value to °C using the following formula. You should get the room/water temperature. Record the results.

$$ADCP\ Temperature = 45 - (Display\ Value \times 50) / 4096 \qquad \text{(Eq.T-4)}$$

Example: Display value of 01915: 45 - (1915 × 50) / 4096 ≈ 21.6 °C

___ c. Check other temperature readings by changing the temperature at the transducer head. Warming the sensor with your thumb is one way to see if the thermistor responds to change. After changing the temperature, send S235 and note the new value. Record the results.

T-2.6. EXTERNAL CTD SENSOR TESTS. These tests check, but do NOT calibrate, the optional CTD sensors. For these tests, connect the sensors to the ADCP using the RD-CTDHARN adapter cable (Figure A-2). Each sensor transmits a frequency that varies as the value it is measuring varies. The ADCP measures these frequencies by counting cycles during a measurement interval. The leader data stores the cycle count and measurement interval values. For each sensor, you combine these two values to obtain a frequency. You get the final measurement value using the manufacturer's sensor-specific calibration data. The calibration sheet lists all coefficients and conversion formulas.

CTD Depth Sensor Test. This test checks the accuracy of the Paroscientific Inc., Model 8000 series or Model 8B000 series depth sensor.

___ a. Connect the depth sensor to P5 of the adapter cable. Place the sensor (not the ADCP) in a container filled with at least one meter of water. Sensor depth should be just below the surface of the water.

___ b. Enter the following ADCP commands.

___ (1) Z (wake-up message displayed)
___ (2) CA99 (percent of ensemble pings in CTD measurement time)
___ (3) V000100 (time between pings of one second)
___ (4) 0000 (collect leader data only)
___ (5) S235 (operate for one ensemble)

___ c. After about 100 seconds, leader data appears. Read CTD Depth from the leader (Figure T-3, #8). Multiply the 5 left-most digits by 256. Add the result to the 3 right-most digits. This decimal value is the number of depth sensor output cycles for a given CTD measurement interval. For example, a display value of 12345123 gives (12345 × 256) + 123 = 3,160,443 depth sensor cycles. Record the results.

___ d. Read the CTD Interval from the leader (Figure T-3, #9). Multiply the 5 left-most digits by 256. Add the result to the 3 right-most digits. This decimal number is the CTD measurement interval in milliseconds. Record the results. For example, a display value of 00324222 gives a CTD measurement interval of (324 × 256) + 222 = 83,166 ms.

___ e. Calculate the depth sensor's output frequency in kHz using the following formula. Record the results.

$$f_D = \text{(Number of Depth Cycles) / (CTD Measurement Interval)} \qquad \text{(Eq.T-5)}$$

For example, from steps c and d: $f_D = 3{,}160{,}443 / 83{,}166 \approx 38$ kHz.

___ f. Find the pressure value by converting the calculated frequency using the manufacturer's sensor-specific calibration data. Record the results as P1.

___ g. Lower the depth sensor in the container of water to one meter.

| ___ h. Send S235 again. Now repeat steps c-f to compute and record the 1-m depth value as P2. Calculate the depth change between P1 and P2.

$$Depth\ Change = K \times (P2 - P1) \qquad \text{(Eq.T-6)}$$

where K converts pressure to depth. Use the following table to find K based on the unit of pressure. Record the results. The calculated depth change should be close to the actual depth change of one meter.

Units of pressure	Constant K @ 4°C
Pounds per square inch (PSI)	0.70309·
Millibar	0.010197
Newton per square meter (Pascal)	0.00010197

CTD Temperature Sensor Test. This test checks the accuracy of the Sea-Bird Electronics Inc., Model SBE 3 temperature sensor.

___ a. Connect the CTD temperature sensor to adapter connector P4. Place the sensor (not the ADCP) in a water-filled container or temperature bath. The water should circulate in the container.

___ b. Enter the following ADCP commands.

___ (1) Z (wake-up message displayed)
___ (2) CA99 (percent of ensemble pings in CTD measurement time)
___ (3) V000100 (time between pings of one second)
___ (4) O000 (collect leader data only)
___ (5) S235 (operate for one ensemble)

___ c. After about 100 seconds, leader data appears. Read CTD Temperature from the leader (Figure T-3, #7). Multiply the 5 left-most digits by 256. Add the result to the 3 right-most digits. This decimal value is the number of CTD temperature sensor output cycles for a given CTD measurement interval. Record the results (Appendix-F).

___ d. Read the CTD Interval from the leader (Figure T-3, #9). Multiply the 5 left-most digits by 256. Add the result to the 3 right-most digits. This decimal number is the CTD measurement interval in milliseconds. Record the results.

___ e. Calculate the CTD temperature sensor's output frequency in kHz using:

$$f_T = (No.\ of\ Temperature\ Cycles)\ /\ (CTD\ Measurement\ Interval) \qquad \text{(Eq.T-7)}$$

___ f. Find CTD temperature by converting the calculated frequency using the manufacturer's sensor-specific calibration data. Record the results.

___ g. Check for reasonable temperature values. If desired, repeat at different water (bath) temperatures.

CTD Conductivity Sensor Test. This test checks the accuracy of the Sea-Bird Electronics Inc., Model SBE 4 conductivity sensor.

___ a. Connect the conductivity sensor to P3 of the adapter cable. Place the sensor (not the ADCP) into a bath with a solution of a known conductivity between 2 and 6 S/m. The solution should circulate in the bath. If you do not know the conductivity, use a container filled with water of a known salinity and temperature. Use a conversion chart to convert from salinity to conductivity.

___ b. Enter the following ADCP commands.

___ (1) Z (wake-up message displayed)
___ (2) CA99 (percent of ensemble pings in CTD measurement time)
___ (3) V000100 (time between pings of one second)
___ (4) O000 (collect leader data only)
___ (5) S235 (operate for one ensemble)

___ c. After about 100 seconds, leader data appears. Read CTD Conductivity from the leader (Figure T-3, #6). Multiply the 5 left-most digits by 256. Add the result to the 3 right-most digits. This decimal value is the number of conductivity sensor output cycles for a given CTD measurement interval. Record the results (Appendix-F).

___ d. Read the CTD Interval from the leader (Figure T-3, #9). Multiply the 5 left-most digits by 256. Add the result to the 3 right-most digits. This decimal value is the CTD measurement interval in milliseconds. Record the results.

___ e. Calculate the conductivity sensor's output frequency in kHz using:

$$f_c = \textit{(No. of Conductivity Cycles) / (CTD Meas. Interval)} \qquad \text{(Eq.T-8)}$$

___ f. Find the conductivity value by converting the calculated frequency using the manufacturer's sensor-specific calibration data. Record the results.

___ g. Check for reasonable conductivity values. If desired, repeat at different salinity concentrations.

T-2.7. RECORDER TESTS. These tests check the EPROM recorder and the mapping of EPROM memory.

Recorder Hardware Test. This automated test consists of three subtests. TEST 1 and TEST 2 check the recorder's controller circuitry, DC power, and proper installation of the memory cards (no shorted lines). TEST 3 checks the read/write capability of every memory chip in the recorder.

___ a. Enter the following ADCP commands. Figure T-4 lists a sample execution of the recorder hardware test.

___ (1) <BREAK> (wake-up message displayed)
___ (2) @T (begin recorder hardware test)

__ b. If there are no TEST 1 or TEST 2 errors, the screen shows:

```
TEST 1: OK
TEST 2: OK
```

If TEST 1 or TEST 2 errors exist, the screen shows:

```
TEST 1: FAIL  (or TEST 2: FAIL)
*ERROR xxx: CCC ccc sssss bbb
```

If the recorder fails either TEST 1 or TEST 2, you must correct the problem before deploying the SC-ADCP (see Chapter 6). Record the results (Appendix-F).

__ c. During TEST 3, the screen displays each card and chip being tested. If any chip fails, the screen shows an asterisk (*) immediately after the chip number (Figure T-4). If some of the memory chips fail TEST 3, you can still deploy the ADCP because the recorder will automatically bypass all bad chips. Record the results.

Memory Map Check. This check maps the contents of the recorder and displays a summary of the number of deployment files already recorded, the file size in kilobytes, and the amount of storage space left in kilobytes.

__ a. Enter the following ADCP commands. Figure T-4 lists a sample execution of the memory map check.

- __ (1) <BREAK> (wake-up message displayed)
- __ (2) @S (begin memory map check)

__ b. The screen shows all storage files used. Additionally, the screen shows the number of kilobytes remaining in EPROM. NOTE: A *USER FILE* stores user text (block 1) data. A *DATA FILE* stores the raw data collected by the ADCP.

T-2.8. POWER CONSUMPTION TESTS. This test measures the electric current required by the SC-ADCP. This relates to the number of battery ampere-hours (A·h) used during a deployment. During these tests, you must connect the DMM in series with battery pack power supplies for accurate readings. To do this:

__ a. Turn off or disconnect the power supply.
__ b. Refer to Figure T-2. Connect the (+) lead of the power supply under test (V1 or V2) to the (+) DC AMP terminal on the DMM.
__ c. Connect the (-) lead of the power supply under test to the (-) terminal on the J-Box for the power supply under test.
__ d. Connect the (-) DMM lead to the (+) J-Box terminal for the power supply under test.
__ e. Set the DMM to the correct DC current range called for by the test.
__ f. Turn on or connect the power supplies.

```
<BREAK>
@T
TEST 1: OK
TEST 2: OK
TEST 3:
CARD 01: 00  01  02  03  04  05  06  07  GOOD: 08
CARD 02: 00  01  02  03  04  05  06  07  GOOD: 08
CARD 03: 00  01  02  03  04  05  06  07  GOOD: 08
CARD 04: 00  01  02* 03  04  05  06  07  GOOD: 07
CARD 05: 00  01  02  03  04  05  06  07  GOOD: 08
CARD 06: 00  01  02  03  04  05  06  07  GOOD: 08
CARD 07: NOT PRESENT
CARD 08: 00  01  02  03  04  05  06  07  GOOD: 08
CARD 09: 00  01  02  03* 04  05* 06  07  GOOD: 06
CARD 10: 00  01* 02  03  04  05  06  07  GOOD: 07
CARD 11: 00  01  02  03  04  05  06  07  GOOD: 08
CARD 12: NOT PRESENT
CARD 13: NOT PRESENT
CARD 14: NOT PRESENT
CARD 15: NOT PRESENT
CARD 16: NOT PRESENT
CARD 17: NOT PRESENT
CARD 18: NOT PRESENT
CARD 19: NOT PRESENT
CARD 20: NOT PRESENT
@S
RECORDER STATUS:
USER FILE # 001:    KBYTES: 00008
DATA FILE # 002:    KBYTES: 00009
USER FILE # 003:    KBYTES: 00008
DATA FILE # 004:    KBYTES: 00010
USER FILE # 005:    KBYTES: 00008
DATA FILE # 006:    KBYTES: 00092
KBYTES LEFT: 19865
```

Notice in this sample execution:
- No card is present in slot 7 or in slots 12-20
- The following chips are bad:
Card 4, chip 2
Card 9, chips 3 and 5
Card 10, chip 1

Figure T-4. Sample Execution of the Recorder Tests

To run the power consumption tests proceed as follows.

__ a. Check V2 wake Current:

- __ (1) Turn off or disconnect the V1 and V2 power supplies.
- __ (2) Set the DMM for 2 mA DC full scale. Connect the DMM in series between the V2 power supply and the RDI J-Box.
- __ (3) Turn on or connect the V1 and V2 power supplies.
- __ (4) Send a <BREAK>.
- __ (5) @B (runs EPROM erasure check)
- __ (6) The DMM should read 0.40 mA or less. Record this value as V2 Awake Current on the Test Results form (Appendix-F).

___ b. Check V2 Asleep Current:

- ___ (1) V111111 (time between pings)
- ___ (2) S191 (operate and record continuously)
- ___ (3) Change the DMM to 2 mA DC full scale.
- ___ (4) The DMM should read 0.40 mA or less. It may take 2-3 minutes for this value to become stable. Record this value as V2 Asleep Current on the Test Results form.

___ c. Before continuing, turn off the LED display on the CPU PCB. This is necessary only if the pressure case is not on the ADCP. If the case is off, cover the photosensor on the edge of the Power Regulator PCB. With the LEDs lit, V1 awake current can be as much as 150 mA too high.

___ d. Check V1 Awake Current:

- ___ (1) Turn off or disconnect the V1 and V2 power supplies.
- ___ (2) Set the DMM for 2 A DC full scale. Connect the DMM in series between the V1 power supply and the RDI J-Box.
- ___ (3) Turn on or connect the V1 and V2 power supplies.
- ___ (4) Send a <BREAK> (wake-up message displayed).
- ___ (5) DA08 (initial special test mode).
- ___ (6) S236 (operate continuously).
- ___ (7) The DMM should read 235 mA or less. Record this value as V1 Awake Current on the Test Results form.

___ e. Check V1 Asleep Current:

- ___ (1) Send a <BREAK> (wake-up message displayed).
- ___ (2) S236 (operate continuously).
- ___ (3) Change the DMM to 2 mA full scale. You should read less than 280 μA. If the ADCP has a CTD card installed, this value should be less than 680 μA. Record this value as V1 Asleep Current.

___ f. If you have CTD sensors installed, check CTD Current as follows.

- ___ (1) Turn off or disconnect the V4 power supply.
- ___ (2) Set the DMM for 200 mA DC full scale. Connect the DMM in series between the V4 power supply and the RDI J-Box.
- ___ (3) Turn on or connect the V4 power supply.
- ___ (4) Send a <BREAK>
- ___ (5) Z (wake-up message displayed)
- ___ (6) V000100 (time between pings of one second)
- ___ (7) CA99 (percent of ensemble pings in CTD measurement time)
- ___ (8) S235 (operate for one ensemble)
- ___ (9) You have 100 seconds to make the following measurements before the ADCP stops. If you need more time, resend S235.
- ___ (10) The DMM should read the values listed on the manufacturer's data sheet. Typical values are 3 mA for the depth sensor, 11 mA for the temperature sensor, and 11 mA for the conductivity sensor. With all three sensors connected, total current should be about 24 mA. Record this total value as CTD Current.

T-2.9. CONTINUITY AND ISOLATION TESTS. This test measures the continuity between the zinc anode on the transducer head and the anode on the pressure case. It also measures the isolation between the zinc anodes and the electronics chassis. Anodes and isolation are important to preventing corrosion.

__ a. Turn off or disconnect all power supplies.

__ b. Install and bolt the pressure case to the transducer head. Connect the RDI J-Box to the I/O connector.

NOTE

ON SOME OLDER UNITS THERE IS NO ANODE ON THE TRANSDUCER HEAD. IN THOSE CASES, CHECK ELECTRICAL CONTINUITY BETWEEN THE ANODE AND THE PRESSURE CASE WITH THE PRESSURE CASE REMOVED (SEE ¶5-17.1).

__ c. Set the DMM to the 200-ohm scale. Connect one DMM lead to the pressure case and the other lead to the transducer head anodes.

__ d. The DMM should measure less than one ohm. Record this value as Zinc Anode Resistance on the Test Results form (Appendix-F).

__ e. Set the DMM to the two-megohm scale. Connect the DMM leads to the zinc anode on the pressure case and to V1 ground on the J-Box.

__ f. The DMM should read a minimum of one megohm (infinity is acceptable). The initial reading may start low and then slowly increase in value. Record the final value as Chassis Isolation Resistance.

APPENDIX V
CALCULATING ABSOLUTE BACKSCATTER

V-0. INTRODUCTION

This appendix explains how to calculate profiles of absolute backscatter coefficient using echo intensity measurements from an RDI ADCP. It applies to all models of ADCPs delivered after June 1990 or that have implemented Field Service Bulletin 5-7 (August 1, 1990).

NOTE

IN PREVIOUS RDI DOCUMENTATION, WE USED THE TERM ECHO AMPLITUDE TO REFER TO THE ADCP ECHO LEVEL. UNFORTUNATELY, AS NOTED BY FLAGG AND SMITH (1989), OUR INEXACT USE OF THE TERM AMPLITUDE IS CONFUSING, ESPECIALLY IF YOU EXPECT ECHO AMPLITUDE TO REFER TO THE AMPLITUDE OF THE ECHO'S ACOUSTIC PRESSURE. ACCORDING TO URICK (1983), THE POWER PER UNIT AREA OR ENERGY FLUX OF A WAVE IS CALLED ITS INTENSITY, RELATED TO THE SQUARE OF ACOUSTIC PRESSURE. UNITS OF DECIBELS (dB) ARE USED TO COMPARE INTENSITIES, NOT ACOUSTIC PRESSURES. THIS DOCUMENT, AND ALL FUTURE DOCUMENTS, WILL USE THE TERM ECHO INTENSITY INSTEAD OF ECHO AMPLITUDE.

Interest has increased in acoustic studies about the abundance and distributional patterns of the suspended matter (e.g. plankton, sediments) that act as sound scatterers for ADCP measurements (Flagg and Smith, 1989). Supported by careful calibration procedures, acoustic studies using vertical profiles of echo intensity from moored or vessel-mounted ADCPs can provide temporal and spatial information about the abundance of suspended matter that was previously difficult, if not impossible, to obtain. Moreover, combining these data with the simultaneous ADCP current profiles can lead to more informed and insightful interpretation of the distributional patterns of the plankton and suspended sediments. In another application, Schott (1989) reported attempts to measure winds indirectly by using echo intensity measurements from upward-looking ADCPs. This approach is motivated by empirical correlation between wind speed and backscatter energy although the scattering agent, whether it be bubbles or surface roughness, has not been clarified.

This interest in applying ADCPs for purposes that use the backscatter energy motivated RDI to refine the ADCP system further, enabling estimation of the absolute backscatter coefficient (S_v) from ADCP data. Previously, measurements of the echo intensity were relative rather than absolute, so variations in echo strength along a beam could be recorded, but comparison between beams or between instruments was not possible. RDI previously provided an echo intensity calibration service (called Beam Amplitude Calibration) for researchers interested in using this aspect of their ADCP data. Since then, we redesigned some of the electronic circuitry in the ADCP to simplify the calibration process, so much of it can now be completed by the user rather than in the factory. As a result, every new, refurbished, or upgraded ADCP can calculate absolute backscatter.

The main body of this appendix concentrates on calculating absolute backscatter coefficient by applying the sonar equation (¶V-3) via Eq. V-1, a form arranged for estimating S_v. Section V-3 provides a phenomenological presentation of the sonar equation and a description of how it is manipulated.

NOTE

RDI CONSIDERS THE USE OF ECHO INTENSITY DATA FROM AN ADCP TO STILL BE IN DEVELOPMENT. WE WILL CONTINUE TO WORK TO IMPROVE OUR UNDERSTANDING IN THIS AREA. WE WELCOME YOUR INPUT.

V-1. BACKGROUND

A signal emitted from an ADCP is scattered by suspended matter (e.g. plankton, sediments, bubbles) and the seafloor or sea surface. Relating the intensity of an echo to the scatterers in the water requires knowledge of several variables: the power transmitted into the water, the acoustic characteristics of the transducer and the resulting acoustic beam, the power attenuation caused by propagation losses (including absorption and beam spreading), and the strength of the backscattering mechanism (RDI, 1989).

Assigning absolute values to echo intensity requires a reliable reference level, for which the thermal noise of the ADCP electronics was chosen. Several other noise sources such as reverberation and vessel noise (e.g. machinery, propeller, hydrodynamic) can potentially mask the thermal noise and must be avoided when calibrating the reference level. Other background noise sources, such as ambient and man-made noise underwater, occur at much lower frequencies and are therefore less important for this application. To quantify the relationship between the variables affecting the echo intensity, one must apply the sonar equation (¶V-3).

Some of the relevant phenomena for understanding echo intensity cannot be measured independently. Therefore, Eq. V-1, a working version of the sonar equation, has been developed in which some combinations of terms are replaced by quantities that can be measured, some of them at the factory and others by the user. Examples of the variables measured at the factory and supplied to the user include power into the water (K_{1c}) and the system noise factor (K_2). Some system dependent parameters are also combined into a constant variable (K_s) that has a different value for each ADCP frequency. Echo intensity (E) is an AGC circuit output; its real-time reference level is denoted E_r. AGC output is measured in counts that are proportional to the logarithm of power and is converted to dB units by the factor K_c.

Listed below are other important variables in the working version of the sonar equation that have been rearranged to solve for the backscatter coefficient (S_v) in decibels.

c = speed of sound at the scattering layer being measured
P = transmit pulse length
T_x= temperature of the transducer
R = range along the beam to the scatterers
α = absorption coefficient of water

$$S_v = 10 \log_{10} \left[\frac{4.47\times10^{-20}\ K_2\ K_s\ (T_x+273^*)\ (10^{Kc(E-Er)/10} - 1)\ R^2}{c\ P\ K_1\ 10^{-2\alpha R/10}} \right] \quad \textbf{(V-1)}$$

*NOTE: THE CONVERSION FACTOR FROM °C TO °K HAS BEEN ROUNDED TO 273 FROM 273.18.

V-2. STEPS REQUIRED TO CALCULATE ABSOLUTE BACKSCATTER COEFFICIENT

We begin with an overview of the steps and a summary of the variables used in calculating the absolute backscatter coefficient. The following paragraphs then describe each step in detail.

Step 1 – Obtain ADCP characteristics measured at RDI's factory for each beam

K_{1c}	power into the water during calibration at RDI factory (W)
K_2	system noise factor (dimensionless)

Step 2 – Calibrate reference level for echo intensity for each beam

E_{rc}	reference thermal noise of ADCP electronics during calibration (counts)
T_{ec}	temperature of system electronics during calibration of E_{rc} (°C)
T_{xc}	temperature of transducer during calibration of E_{rc} (°C)

Step 3 – Record selected ADCP setup parameters

ADCP model : DR, SC, or VM
Data format: PINGDATA or ADCPDATA
Voltage supply level for VM: 120 or 220 VAC

B	blank after transmit (m)
P	transmit pulse length (m)
D	depth cell length (m)
θ	angle of transducer beams from vertical (degrees)
K_s	system constant, depends on ADCP frequency

Step 4 – Collect pertinent ADCP data

E	echo intensity (counts)
V_s	real-time supply voltage to ADCP transmitter (counts, V)
T_x	real-time temperature of the transducer (counts, °C)
T_e	real-time temperature of system electronics (counts, °C)

Step 5 – Prescribe relevant external variables

α	sound absorption coefficient over profiling range (dB/m, one way)
c	sound speed at each depth cell for each ensemble (m/s)

Step 6 – Evaluate variables in Eq. V-1 for each depth cell

K_c	conversion factor for echo intensity (dB/counts)
E_r	real-time reference level for echo intensity (counts)
K_1	real-time power into the water (W)
R	slant range to depth cell (m)
N	depth cell number of the scattering layer being measured
c'	weighted average of sound speed between transducer & depth cell (m/s)

Step 7 – Calculate profiles of backscatter coefficient using Eq. V-1

S_v	backscatter coefficient (dB, referenced to $[\text{meters} \times 4\pi]^{-1}$)

V-2.1. STEP 1 — OBTAIN ADCP CHARACTERISTICS MEASURED AT RDI's FACTORY. Obtain the values for K_{1c} and K_2 for the four transducer beams. For all new, upgraded, or refurbished systems delivered:

a. Since December 1990, use the system calibration form provided by RDI.
b. Between July 1989 and May 1990, contact RDI to obtain measured values.
c. Before July 1989, contact RDI to arrange for a factory measurement of these ADCP characteristics.
d. In lieu of factory-measured values, an approximation can be obtained using nominal values for K_{1c} and K_2.

Table V-1 lists nominal values for K_{1c} and K_2 by system frequency and model type. Figure V-1 shows a sample ADCP calibration form.

K_{1c} is the power input (in watts) to the water by the ADCP measured during RDI's calibration. This value is sensitive to the voltage supplied to the transducers and must be adjusted for real-time voltage values (Step 6, ¶V-2.6) before being applied in Eq. V-1 as K_1.

K_2 is the system noise factor (dimensionless). This is the ratio of actual noise power to the theoretical noise power of a perfect receiving system.

NOTE

THE CALIBRATED VALUE FOR K_2 IS VALID ONLY IF THE RECEIVER BOARDS REMAIN PAIRED WITH THE SAME BEAM THEY WERE CALIBRATED WITH, SO YOU MUST BE SURE TO KEEP THE RECEIVER BOARDS IN THE FACTORY-INSTALLED POSITION.

Table V-1. Nominal Values for K_{1c} and K_2

Frequency (kHz)	ADCP Model	Nominal values K_{1c}(W)	K_2
75	DR or SC	6.1	2.2
	VM	5.4	2.5
150	DR or SC	3.9	3.6
	VM	3.3	4.3
300	DR or SC	4.1	4.2
	VM	3.6	4.5
600	DR or SC	1.9	7.1
	VM	1.7	9.1
1200	DR or SC	1.3	8.1
	VM	1.2	10.5

ECHO INTENSITY DATA SHEET

ADCP S/N ____________ Customer Name ______________________

XDCR S/N ____________ Technician ______________________

Model No. ____________ Date ____________

Place fully-assembled ADCP in a bucket of water. Let ADCP stand in water for a minimum of 30 minutes (preferably one hour) to allow the preamplifiers in the transducer head to acclimate to the water temperature. After acclimation, send the following commands:

```
V000200
Q128
I01
L4
P00100
O004
S235
```

Record the following information:

Transducer Temperature (T_{xc}) ____________°C

Chassis Temperature (T_{ec}) ____________°C

Beam Echo Intensity Calibration Coefficients:

	$E_{rc(BIN\ 128)}$ (counts)	K_{1c} (watts)	K_2 (dimensionless)
Beam 1	____________	____________	____________
Beam 2	____________	____________	____________
Beam 3	____________	____________	____________
Beam 4	____________	____________	____________

NOTE: Transducer temperature is measured by the internal ADCP sensor. Measure the temperature of the electronics chassis by placing the thermometer next to the SC/DR pressure case or the VM electronics chassis.

Figure V-1. Sample Echo Intensity Data Sheet

V-2.2. STEP 2 — CALIBRATE REFERENCE LEVEL FOR ECHO INTENSITY. For assigning absolute values to echo intensity (E), each beam must be calibrated to determine its reference level (E_{rc}). In the calibration procedure, echo intensity values are taken from depth cells (bins) from which no echo is detected, so only the thermal noise of ADCP electronics contributes to the echo intensity output. Care must be taken to avoid potential contamination of the reference level from interfering noise sources. The calibrated reference level is sensitive to the temperature of the ADCP electronics and must be adjusted for real-time temperatures (Step 6, ¶V-2.6) before being applied in Eq. V-1 as E_r. RDI lists E_{rc} on the ADCP system calibration sheet, but we recommend you recalibrate E_{rc} before each experiment using the following procedure.

NOTE

THIS PROCEDURE ASSUMES THE ABSENCE OF INTERFERING SIGNALS THAT COULD POTENTIALLY MASK THE ECHO INTENSITY OUTPUT BECAUSE OF ADCP THERMAL NOISE. THIS CALIBRATION CANNOT BE DONE WHEN A SHIP IS UNDERWAY. OTHER INTERFERING SIGNALS INCLUDE:

- EMI (ELECTROMAGNETIC INTERFERENCE) FROM OTHER ELECTRONIC DEVICES
- FLOW NOISE GENERATED BY A MOVING SHIP
- PROPELLER NOISE GENERATED BY A MOVING SHIP
- BUBBLE NOISE GENERATED BY ENTRAINED BUBBLES UNDER A MOVING SHIP
- INTERFERENCE FROM OTHER SONAR OR ELECTRONIC DEVICES

___ a. Immerse the transducer head in water deep enough to cover the transducer cups. This assures the receivers are tuned.
___ b. Let the ADCP stabilize to the ambient temperature for 30-60 minutes.
___ c. Turn OFF other equipment that might interfere with the calibration.
___ d. Enter the following ADCP settings:

  ___ (1) Number of bins = 128
  ___ (2) Transmit pulse length = 1 m
  ___ (3) Depth cell length = 16 m
  ___ (4) Time between pings = 2 s

___ e. Obtain the average *echo intensity* (sometimes called *AGC* or *echo amplitude*) for each beam from a minimum of 100 pings. Echo intensity standard deviation is about 5 dB; 100 pings reduces this to 0.5 dB.
___ f. Average the echo intensity values for each beam in depth cell 128. Record this minimum value as E_{rc} for each transducer beam.
___ g. Record the temperature of the transducer (T_{xc}) and the temperature of the system electronics (T_{ec}).
___ h. <u>Additional procedures for VM-ADCP applications only</u>. The reference level (E_r) in Eq. V-1 is attributed SOLELY to thermal noise from ADCP electronics and must NOT be contaminated by additional noise generated by a moving ship, including hydrodynamic (flow), propeller, and bubble noise. Data collected with a VM-ADCP should be checked for this potential problem using the following procedure.

  ___ (1) Find E_{rc} (above) with the ship not moving.
  ___ (2) Find E_{rc} (above) with the ship moving at various speeds.
  ___ (3) Differences between these two E_{rc} values should be attributed to interfering noise. If caused by vessel noise, the interference will probably vary with speed and sea state.
  ___ (4) We recommend you screen data to eliminate values within 10 dB of this interference level (see ¶V-5).

V-2.3. STEP 3 – RECORD SELECTED ADCP SETUP PARAMETERS. Determine the ADCP configuration and setup parameters.

a. **ADCP model:** Direct-Reading (DR), Self-Contained (SC), or Vessel-Mounted (VM)

b. **Data format:**

(1) PINGDATA – data from the DAS (DR and VM users only) already converted to engineering units.
(2) ADCPDATA – data directly from the ADCP; requires conversion to engineering units. SC/direct-command users have data in this format.

c. **Voltage supply level for VM-ADCPs:** 120 or 220 VAC

d. **B:** blank beyond transmit (m) –

(1) In DAS, use BK from the AD menu.
(2) With direct commands, B equals the combination of the J and K-commands, where J is in tenths of meters and K is in meters (see Appendix D for default values).
(3) In SC software, the xxxxBLK1.DAT file lists this value.

e. **P:** transmit pulse length (m) –

(1) In DAS, use PL from the AD menu.
(2) With direct commands, P equals the I-command.
(3) In SC software, P equals the depth cell length and is listed in the xxxxBLK1.DAT file.

f. **D:** depth cell length (m) –

(1) In DAS, depth cell length equals 2^{BL} in the AD menu.
(2) With direct commands, D equals $2^{\text{L-COMMAND}}$.
(3) In SC software, the xxxxBLK1.DAT file lists this value.

g. **Θ:** angle of the transducer beams to vertical (degrees) – This value is determined when the ADCP is built (typically 30°).

h. **K_s:** system constant – The value of K_s varies with ADCP frequency. It is the ratio of system bandwidth to the square of transducer diameter.

K_s	ADCP frequency
1.09×10^5	75 kHz
4.17×10^5	150 kHz
7.69×10^5	300 kHz
1.56×10^6	600 kHz
5.65×10^6	1200 kHz

V-2.4. STEP 4 – COLLECT PERTINENT ADCP DATA. Collect the following data. Procedures and data units vary with ADCP model and data acquisition mode.

a. E: echo intensity (counts) – E is an output for each depth cell along each beam. The ADCP sends a geometric (rather than arithmetic) average of echo intensity if there are multiple pings. Depending on the type of data acquisition used, collect these data as follows:

   (1) <u>DAS users</u> – Echo intensity is called AGC in the DAS. Set Record Last Raw AGC (RRA) = YES in the DR menu; otherwise, the DAS records the average AGC of ALL FOUR BEAMS. Whenever DAS collects RAW data, it records only the last DAS ping (ADCP Ensemble) of a DAS Sample Interval. Therefore, the DAS records echo intensity data only once per sample interval, and this data ARE NOT the average of the interval. If the interval is long, echo intensity samples are taken far apart in time, and perhaps, distance. Additionally, the data will have large variability because each recorded data point has only one DAS ping. The uncertainty of the echo intensity data can be improved by taking multiple pings in the ADCP (PE>1). You can improve the time resolution of the data by shortening the DAS sample interval (SI).
   (2) <u>Direct command users</u> – Echo intensity is obtained using the O-command (see Appendix D).
   (3) <u>SC software users</u> - Set ECHO AMPLITUDE = YES in the Data Recorded section of the Settings and Performance Evaluation menu.

b. V_s: supply voltage to ADCP transmit:

   (1) <u>DR and VM users (VAC)</u> – Measure the RMS AC power supply voltage into the ADCP. Periodically check the supply voltage and note any changes.
   (2) <u>SC users (counts)</u> – This value is called the high voltage input and is found in the leader data (see Table 4-2).

c. T_x: temperature of the transducer:

   (1) <u>DAS users (PINGDATA format: °C)</u> – Set Record Ancillary Data (RN) = YES in the DR menu. You must also use the default settings for OT and ST in the SS submenu of the DP menu.
   (2) <u>SC and direct-command users (ADCPDATA format: counts)</u> – The ADCP records this value in counts in the leader of each ensemble (see Table 4-2). You must convert temperature values in the ADCPDATA format to °C by multiplying by 50/4096.

d. T_e: temperature of system electronics – T_e is used to calculate K_c and E_r. E_r, the real-time reference level for echo intensity, is particularly sensitive to changes in T_e, so it is <u>crucial</u> to obtain an accurate record of T_e.

NOTE

YOU MUST INDEPENDENTLY MEASURE AND RECORD THE TEMPERATURE OF THE SYSTEM ELECTRONICS IF IT DIFFERS FROM THE TEMPERATURE RECORDED AT THE TRANSDUCER.

(1) DR users (ADCPDATA format: counts, PINGDATA format: °C) – For DR-ADCPs that have both the system electronics and transducer assembly immersed, you can substitute T_x for T_e. You must convert temperature values in the ADCPDATA format to °C by multiplying by 50/4096. Temperature in the PINGDATA format is already in °C.
(2) SC users (counts) – For SC-ADCPs that have both the system electronics and transducer assembly immersed, you can substitute T_x for T_e. You must convert temperature values in the ADCPDATA format to °C by multiplying by 50/4096.
(3) VM users (°C) – The ambient temperature for the system electronics usually differs from the temperature recorded at the transducer. Therefore, you must independently measure and record the temperature of the system electronics.

V-2.5. STEP 5 – PRESCRIBE RELEVANT EXTERNAL VARIABLES. You must supply the following variables from Eq. V-1 that vary with the ambient environment:

a. α: sound absorption coefficient (dB/m, one-way) – This variable can be assigned a typical value over the ADCP profiling range. For users seeking higher accuracy, consult Urick (1983) for a discussion of depth and temperature variation of α. Here are some typical values for the sound absorption coefficient of seawater at 4°C based on the ADCP transmission frequency.

Freq (kHz)	75	150	300	600	1200
α (dB/m)	0.027	0.044	0.069	0.153	0.480

b. C: speed of sound (m/s) – For each value of E (echo intensity), a value of sound speed is required for the corresponding ADCP depth cell. Users who seek higher accuracy than can be obtained from atlases having climatological profiles of the speed of sound might consider making occasional XBT profiles.

V-2.6. STEP 6 – EVALUATE VARIABLES IN EQ. V-1 FOR EACH DEPTH CELL. The following equations have all been determined empirically from data collected at RDI as part of its ADCP beam-calibration service.

a. K_c: conversion factor for echo intensity (dB/count)

(1) If E < 200 counts, $K_c = 127.3/(T_e+273)$
(2) If E is 200-230 counts, calibration of K_c must be done at RDI.
(3) If E > 230 counts, K_c cannot be calibrated. These values are not encountered in normal profiling applications.

b. E_r: reference level for echo intensity (counts) – Because the reference level for each beam is sensitive to the temperature of ADCP electronics, you must adjust the calibrated reference value E_{rc} for real-time temperatures before applying it in Eq. V-1 as E_r. Three methods are available. If no interfering signals that mask the thermal noise level are present, the in-situ method (item 3, below) is preferred because the ADCP is measuring the reference value in real-time.

(1) Equation method:

$$E_r = E_{rc}(a) + (1-a)(292 + 0.133T_e) + (1-b)(27.3 + 0.1T_x), \text{ where}$$

$$a = \frac{T_e + 273}{T_{ec} + 273} \qquad b = \frac{T_x + 273}{T_{xc} + 273}$$

(2) Approximation method:

$$E_r = E_{rc} + [\{-0.9 \times (T_e - T_{ec})\} - \{0.1 \times (T_x - T_{xc})\}]$$

(3) In-situ method – You can obtain E_r from the data set if the following conditions are met:

(a) Interfering signals that mask the thermal noise level are not present (see Step 2, ¶V-2.2).

(b) The range of the profile is long enough so propagation losses reduce the signal-to-noise ratio well below unity. At this point, the output in counts for echo intensity has reached and remains at its minimum value, which is E_r.

c. K_1: power into the water (W) – Because the power input to the water by the ADCP is sensitive to the voltage supplied to the transducers, you must adjust the calibrated input power K_{1c} for the real-time voltage as shown below before applying it in Eq. V-1 as K_1.

$$K_1 = \left[\frac{(V_s \times a) - b}{c} \right]^2 \times K_{1c}$$

where

Model	V_s	a	b	c
DR	VAC	1.397	6.30	35.10
VM (110V)	VAC	1.397	4.27	37.14
VM (220V)	VAC	0.699	4.27	37.14
SC	counts	0.170	5.76	34.24

d. R: slant range to a depth cell (m) – This value is the range to the relevant scattering layer along the beam.

$$R = \left[\frac{B + |(P - D) / 2| + (N \times D) + (D / 4)}{\cos \Theta} \right] \times \frac{c'}{1475.1}$$

(1) The ADCP samples the echo intensity in the last quarter of each depth cell, not the center. The term D/4 accounts for this.

(2) The ADCP assumes the speed of sound is 1475.1 m/s in determining depth cell size. The term c'/1475.1 m/s corrects for variations from this value.

V-2.7. STEP 7 — CALCULATE PROFILES OF BACKSCATTER COEFFICIENT. For each ensemble, calculate S_v at each depth cell along each beam.

$$S_v = 10 \log_{10} \left[\frac{4.47\times10^{-20}\ K_2\ K_s\ (T_x+273)\ (10^{Kc(E-Er)/10} - 1)\ R^2}{c\ P\ K_1\ 10^{-2\alpha R/10}} \right]$$

Here are some "order of magnitude" values of S_v measured off San Diego:

Freq (kHz)	75	150	300	600	1200
S_v (dB*)	-92	-86	-80	-74	-70

*NOTE: REFERENCED TO [METERS × 4π]$^{-1}$

Figure V-2 is a sample plot of S_v. The data were taken by a 1200-kHz ADCP crossing a sediment plume in Mobile Bay (Alabama, USA).

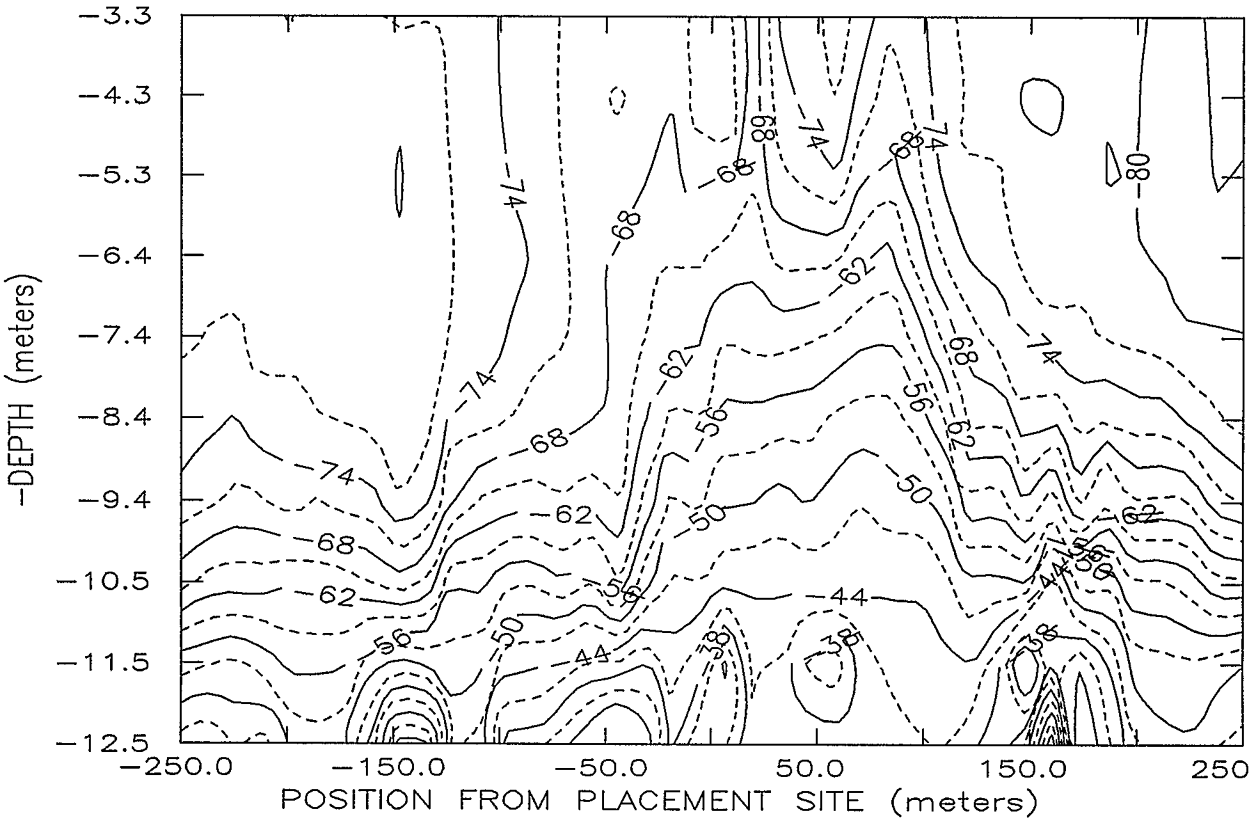


Figure V-2. Sample Plot of Mobile Bay Sediment Plume

V-3. THE SONAR EQUATION

In this conceptual presentation of the sonar equation, the variables affecting the power of the echo are introduced in chronological sequence for the round-trip passage of an ADCP ping. We consider, in turn, transmission (1), radiating signal (2,3), backscattering (4,5,6), returning echo (6,7), and reception (8,9). Some of the relevant phenomena introduced here cannot be measured independently, so a working version of the sonar equation is developed in which some combinations of terms are replaced by quantities that can be measured, some of them at the factory and others by the user. Table V-2 describes the terms in Eq. V-2.

$$\begin{array}{lcccccccccccc}
S/N & = & \dfrac{P_E E_x}{4\pi} & \dfrac{G}{R^2} & 10^{-\alpha R/10} & \dfrac{\pi[R\phi]^2}{4} & \dfrac{ct}{2} & \dfrac{10^{S_v/10}}{R^2} & 10^{-\alpha R/10} & \dfrac{G\lambda^2}{4\pi} & E_x & \dfrac{1}{KTB_N F} & \textbf{(V-2)} \\
\text{Term:} & & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 &
\end{array}$$

Where: S/N = Signal-to-Noise ratio
P_E = Electrical power to transducer (W)
E_x = Transducer efficiency
G = Transducer gain or directivity
R = Range to scatterers along the beam (m)
α = Water absorption (dB/m)
ϕ = Effective 2-way beam width (radians)
c = Speed of sound (m/s)
t = Transmit pulse length (s)
S_v = Backscatter coefficient (dB, referenced to $[\text{meters} \times 4\pi]^{-1}$)
λ = Wavelength of transmitter (m)
K = Boltzmann's constant (joules/°K)
T = Temperature at the transducer (°K)
B_N = Noise bandwidth (Hz)
F = Receiver noise factor

Table V-2. Description of Equation V-2 Terms

Term	Description
1	Power density of a spherically-spreading pulse on the surface of a one-meter sphere
2	Corrects for directivity of transducer; adjusts for range (one-way)
3	Corrects for absorption of the out-going pulse
4	Instantaneous ensonified area of water
5	Instantaneous ensonified depth of water
4 × 5	Gives instantaneous ensonified volume of water
6	Corrects for backscatter strength and adjusts for range (one-way)
7	Corrects backscattered signal for absorption
8	Capture area of the transducer
9	Corrects for transducer efficiency
1 thru 9	Give signal power (S)
10	Noise power (N)

To begin the derivation of the equation for S_v:

1. For a circular piston, the transducer gain or directivity, G, and the resulting beam width, ϕ, which are inversely related, can be quantified in terms of the ratio of effective transducer diameter, d, and transmission wavelength (λ) according to Urick (1983):

$$G = (\pi d/\lambda)^2$$
$$\phi^2 = (4\lambda/\sqrt{2}\pi d)^2 \tag{V-3}$$

Substituting for G and ϕ^2 and combining terms:

$$S/N = \frac{P_E E_x \; \pi c t}{4\pi R^2} \; 10^{S_v/10} \; 10^{-2\alpha R/10} \; \frac{\pi d^2 E_x}{4} \; \frac{1}{KTB_N F} \tag{V-4}$$

$$S/N = \frac{P_E E_x \; \pi c t}{16R^2} \; 10^{S_v/10} \; 10^{-2\alpha R/10} \; d^2 E_x \; \frac{1}{KTB_N F} \tag{V-5}$$

$$S_v = 10 \log_{10} \left[\frac{5.09 \; S/N \; R^2 \; KTB_N F}{P_E E_x \; ct \; 10^{-2\alpha R/10} \; d^2 \; E_x} \right] \tag{V-6}$$

2. Defining – $P_E E_x$ as K_1 (power into the water), F/E_x as K_2 (system noise factor), $K_s = B_N/d^2$ (system dependent parameters; see table V-3), and K = 1.38E-23 joules/°kelvin:

$$S_v = 10 \log_{10} \left[\frac{7.02\times10^{-23} \; S/N \; R^2 \; T \; K_s \; K_2}{K_1 \; ct \; 10^{-2\alpha R/10}} \right] \tag{V-7}$$

3. Defining P as the transmit pulse length in meters, projected into the vertical, two-way:

In the general case: $t = (P/\cos\theta) \times (2/c)$
For the ADCP : $t = 0.00157P$

Substituting for t:

$$S_v = 10 \log_{10} \left[\frac{4.47\times10^{-20} \; S/N \; R^2 \; T \; K_s \; K_2}{K_1 \; cP \; 10^{-2\alpha R/10}} \right] \tag{V-8}$$

Table V-3. K_s and System Dependent Parameters B_N and d^2

System Frequency	d^2	B_N	K_s
75 kHz	5.90×10^{-2}	6.45×10^{3}	1.09×10^{5}
150 kHz	2.04×10^{-2}	8.52×10^{3}	4.17×10^{5}
300 kHz	1.64×10^{-2}	1.26×10^{4}	7.69×10^{5}
600 kHz	9.03×10^{-3}	1.41×10^{4}	1.56×10^{6}
1200 kHz	2.60×10^{-3}	1.47×10^{4}	5.65×10^{6}

NOTE: THE DIAMETER (d) USED IN THE ABOVE TABLE IS THE EFFECTIVE DIAMETER (BASED ON BEAM-WIDTH MEASUREMENTS). IT IS SMALLER THAN THE PHYSICAL DIAMETER.

4. The term S/N can be determined from the ADCP AGC output. Figure V-3 shows a block diagram of AGC processing. The signal (S) from the transducer is amplified - this is where the system noise is introduced. The total power (S+N) is then filtered by a band-pass filter. The term B_N in the above equations is determined by this filter. The output of the filter is regulated to a fixed level by the AGC circuitry. The ADCP echo intensity output (E) is proportional to the LOG of S+N power and is in counts.

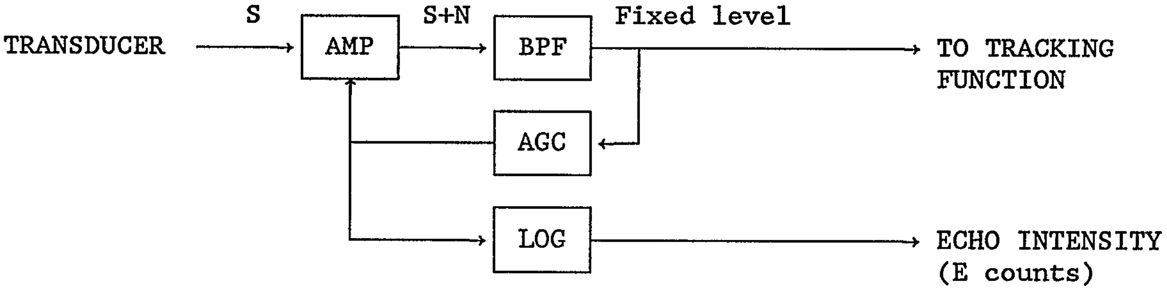


Figure V-3. Simplified Block Diagram of AGC

5. Defining E as counts representing S+N power,
defining E_r as counts representing N power (no signal present), and
defining K_c as the conversion factor dB/count:

$$E = 10 \log_{10}[(S+N)/K_c] \quad \text{(in counts)} \tag{V-9}$$

$$S+N = 10^{K_c E/10} \tag{V-10}$$

$$S = 10^{K_c E/10} - N \tag{V-11}$$

$$N = 10^{K_c E_r/10} \tag{V-12}$$

$$S/N = 10^{K_c (E-E_r)/10} - 1 \tag{V-13}$$

6. Substituting equation V-13 into equation V-8 and substituting T_x + 273 for T because the transducer temperature is recorded in °C:

$$S_v = 10 \log_{10} \left[\frac{4.47\times10^{-20}\ K_2\ K_s\ (T_x+273)\ (10^{Kc(E-Er)/10} - 1)\ R^2}{c\ P\ K_1\ 10^{-2\alpha R/10}} \right] \tag{V-14}$$

V-4. ACCURACY, UNCERTAINTY, AND CALIBRATION ISSUES

This section discusses the accuracy, uncertainty, and calibration issues for some of the terms used to calculate absolute backscatter coefficient.

V-4.1. K_{1c} AND K_2.

Accuracy. These values are measured relative to a calibrated hydrophone in RDI's test tank and are believed to be accurate within ±2 dB. Tests have not yet been conducted on the effects of temperature, pressure, biofouling, and long-term exposure to water on these parameters. We believe these values are relatively insensitive to temperature and pressure, but we suspect severe biofouling has major effects on both of these parameters.

Recalibration Recommendations. We now believe calibrating an ADCP every two to three years is enough. This coincides with the recommended time between refurbishments. We also recommend recalibration be done after a critical backscatter experiment.

V-4.2. E_r AND E_{rc}.

Accuracy. The equation for E_r has been tested against 16 beams, and the standard deviation of error from the actual value is 1.7 counts (≈0.77 dB).

Recalibration Recommendations. E_{rc} should be calibrated before and after each deployment using the procedures described in ¶V-2. If an in-situ calibration of E_r can be done, errors introduced by the equation for E_r can be eliminated. This type of calibration is discussed in ¶V-2.

V-4.3. E.

Accuracy. The statistical uncertainty of one ping is ±5 dB. Note: The AGC circuit will sometimes yield values less than 10 counts. These values are not valid; do not use them in these calculations.

Recalibration Recommendations. Calibration is not available at this time.

V-4.4. K_c.

Accuracy. The equation for K_c has been tested against 16 beams and the standard deviation of the error from the actual value is 0.0065 dB/count for $E < 200$ counts. This equation has been tested between 0 and 30°C. We believe it will work to -5°C, but not to more than 30°C.

Recalibration Recommendations. Calibration of this value is not required unless E is greater than 200 counts, which is not encountered in normal profiling situations. Calibration at values above 200 counts must be done at RDI. K_c cannot be calibrated for $E > 230$ counts.

V-5. USING DATA AT LOW SIGNAL-TO-NOISE RATIOS

Figure V-4 shows that the echo intensity output will be biased high when the signal is close to the noise level. This is because the minimum value of echo intensity is the noise level and therefore signal levels below this are rounded UP to this value.

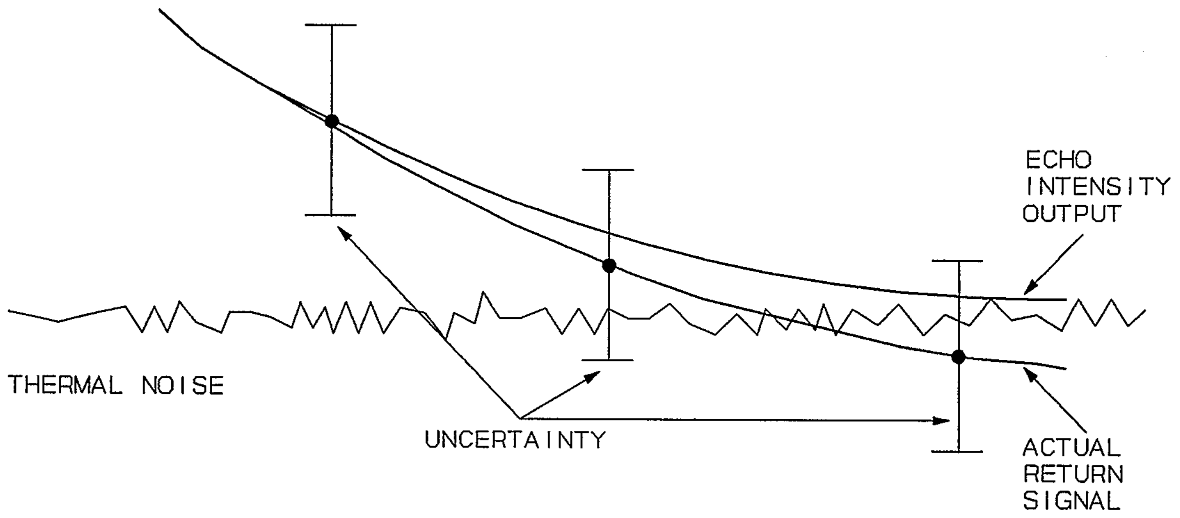


Figure V-4. Sample Echo Intensity Output when Noise Level is Low

V-6. REFERENCES

Flagg, C. N., & Smith, S. L. (1989). On the use of the acoustic Doppler current profiler to measure zooplankton abundance. Deep-Sea Research, Vol. 36, No. 3, pp. 455-474.

RD Instruments (1989). Acoustic Doppler Current Profilers - Principles of Operation: A Practical Primer.

Schott, F. (1989, June 15). Measuring winds from underneath the ocean surface by upward looking acoustic Doppler current profilers. Journal of Geophysical Research, Vol. 94, No. C6, pp. 8313-8321

Urick, R. J. (1983). Principles of Underwater Sound. 3rd ed. New York: McGraw-Hill.

APPENDIX W
ADCP SWITCH SETTINGS

W-0. INTRODUCTION

This appendix describes all ADCP internal switch settings. We strongly suggest you double check all switch settings before you deploy or troubleshoot the ADCP.

The ADCP uses DIP switches on several of the Printed Circuit Boards (PCBs) to set many of the operating parameters and characteristics of the system. Table W-1 lists all boards having switches. This information will help you determine the settings needed for your particular system and application. The combination of switch settings is not universal because we usually set them based on the customer's requests before shipping. Therefore, we do not provide default settings. Appendix Y shows switch locations for each board.

NOTE

THROUGHOUT TABLE W-1, 0 = OPEN AND C = CLOSED.

Table W-1. ADCP Switch Settings

<table>
<tr><th>Board / Location</th><th>Switch Description</th></tr>
<tr><td>POWER AMPLIFIER
Chassis J2
Fig. Y-7</td><td>SWITCH S1 – Sets the transmit frequency of the Power Amplifier. S1 must match the frequency of transformer T2. The Power Amplifier is made for a specific frequency; it is not interchangeable with other transducer frequencies.
<table>
<tr><th rowspan="2">FREQ. (kHz)</th><th colspan="8">POLE</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th></tr>
<tr><td>1228.8</td><td>C</td><td>0</td><td>0</td><td>0</td><td>C</td><td>0</td><td>C</td><td>0</td></tr>
<tr><td>614.4</td><td>0</td><td>C</td><td>0</td><td>0</td><td>C</td><td>0</td><td>C</td><td>0</td></tr>
<tr><td>307.2</td><td>0</td><td>0</td><td>C</td><td>0</td><td>C</td><td>0</td><td>C</td><td>0</td></tr>
<tr><td>153.6</td><td>0</td><td>0</td><td>0</td><td>C</td><td>C</td><td>0</td><td>C</td><td>0</td></tr>
<tr><td>76.8</td><td>0</td><td>0</td><td>0</td><td>C</td><td>0</td><td>C</td><td>0</td><td>C</td></tr>
</table>
SWITCH S2 – (On older boards only; newer boards use resistors instead.) Sets system frequency. S2 is used as a reference by the CPU and other modules to determine the variables used for processing. The frequency settings for S1 and S2 must match; otherwise, the Power Amplifier may be damaged (see S1).
<table>
<tr><th rowspan="2">FREQ. (kHz)</th><th colspan="6">POLE</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th></tr>
<tr><td>1228.8</td><td>C</td><td>0</td><td>C</td><td>0</td><td>0</td><td>C</td></tr>
<tr><td>614.4</td><td>0</td><td>C</td><td>0</td><td>C</td><td>C</td><td>0</td></tr>
<tr><td>307.2</td><td>C</td><td>0</td><td>0</td><td>C</td><td>C</td><td>0</td></tr>
<tr><td>153.6</td><td>0</td><td>C</td><td>C</td><td>0</td><td>C</td><td>0</td></tr>
<tr><td>76.8</td><td>C</td><td>0</td><td>C</td><td>0</td><td>C</td><td>0</td></tr>
</table>
</td></tr>
</table>

Table W-1. ADCP Switch Settings (Continued)

Board / Location	Switch Description
PERIPHERALS 2 Chassis J9 Fig. Y-11	SWITCH S1 – Sets collection and output criteria. P1 depends on the CPU clock's oscillator frequency. This setting must match the frequency setting on S1 of both the CPU and RAM/Multiplier boards. S1 also determines default modes for output, cycle, internal recorder operation (SC-ADCPs), and serial I/O disable. You can override these four settings through commands from a dumb terminal or external software program.

POLE	SETTING	FUNCTION
P1	OPEN	10-MHz CPU CLOCK OSCILLATOR FREQUENCY (MOST COMMON)
	CLOSED	5-MHz CPU CLOCK OSCILLATOR FREQUENCY
P2	—	NOT USED
P3	—	NOT USED
P4	OPEN	FACTORY USE ONLY
	CLOSED	THIS POLE MUST BE CLOSED
P5	OPEN	AUTOMATIC OUTPUT OF COLLECTED DATA
	CLOSED	COMMANDED OUTPUT OF COLLECTED DATA
P6	OPEN	ADCP REPEATS COLLECTION CYCLE AUTOMATICALLY
	CLOSED	ADCP MUST BE COMMANDED TO REPEAT CYCLE
P7	OPEN	ENABLES INTERNAL RECORDER (SC-ADCPs ONLY)
	CLOSED	DISABLES INTERNAL RECORDER
P8	OPEN	SENDS COLLECTED DATA TO SERIAL I/O
	CLOSED	DOES NOT SEND COLLECTED DATA TO SERIAL I/O

SWITCH S2 – Sets communications protocol, transfer mode, and velocity scale factor.

POLE	SETTING	FUNCTION
P1-3	SEE TABLE	BAUD RATE
P4-5	SEE TABLE	PARITY

BAUD	P1	P2	P3
300	O	C	C
600	C	O	C
1200	O	O	C
2400	C	C	O
4800	O	C	O
9600	C	O	O
19200	O	O	O

PARITY	P4	P5
NONE	–	C
EVEN	C	O
ODD	O	O

POLE	SETTING	FUNCTION
P6	OPEN	OUTPUT DATA ARE IN ASCII CHARACTERS
	CLOSED	OUTPUT DATA ARE IN BINARY DIGITS
P7*	OPEN	VELOCITY SCALE FACTOR = 0.25 cm/s (HIGH RANGE)
	CLOSED	VELOCITY SCALE FACTOR = 0.125 cm/s (LOW RANGE)
P8	OPEN	7-BIT ASCII DATA
	CLOSED	8-BIT ASCII DATA

*NOTE: 75-kHz MODELS CAN USE ONLY HIGH RANGE; 1200-kHz MODELS CAN USE ONLY LOW RANGE. IN HIGH RANGE, THE MAXIMUM CURRENT VELOCITY OUTPUT IS HIGHER; IN LOW RANGE, THE VELOCITY RESOLUTION OF THE OUTPUT DATA IS HIGHER. THESE OUTPUTS ALSO DEPEND ON WHETHER THE ADCP COLLECTS VELOCITY DATA IN EARTH OR BEAM COORDINATES. LISTED BELOW ARE THE MAXIMUM OUTPUT VELOCITY AND THE LEAST-COUNT RESOLUTION OF THE OUTPUT DATA.

RANGE SWITCH	COORDINATES	LEAST-COUNT VELOCITY	MAXIMUM VELOCITY
HIGH	EARTH	0.50 cm/s	10 m/s
HIGH	BEAM	0.25 cm/s	5 m/s
LOW	EARTH	0.25 cm/s	5 m/s
LOW	BEAM	0.125 cm/s	2.5 m/s

WHEN VELOCITY IS IN BEAM COORDINATES, THE ADCP STILL MEASURES RADIAL VELOCITIES SUCCESSFULLY EVEN WHEN VELOCITIES ARE LARGER THAN THE MAXIMUM BEAM-COORDINATE OUTPUT VELOCITY. FOR EXAMPLE, IF P7 = HIGH, VELOCITY IS IN BEAM COORDINATES, AND ACTUAL CURRENT VELOCITY IS 6 m/s, THE ADCP WOULD "WRAP" AND MEASURE 1 m/s (6 m/s - 5 m/s).

Table W-1. ADCP Switch Settings (Continued)

<table>
<tr><th>Board / Location</th><th>Switch Description</th></tr>
<tr><td>PERIPHERALS 1
Chassis J10
Fig. Y-12</td><td>
SWITCH S1 – Selects specific components to match the local oscillator (LO1) frequency. The frequency settings must match the Power Amplifier settings. Change the S1 settings only if you change the system frequency.
<table>
<tr><th>FREQ.</th><th colspan="8">POLE</th></tr>
<tr><th>(kHz)</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th></tr>
<tr><td>1228.8</td><td>C</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>614.4</td><td>0</td><td>C</td><td>0</td><td>0</td><td>0</td><td>C</td><td>C</td><td>C</td></tr>
<tr><td>307.2</td><td>0</td><td>0</td><td>C</td><td>0</td><td>0</td><td>C</td><td>C</td><td>C</td></tr>
<tr><td>153.6</td><td>0</td><td>0</td><td>0</td><td>C</td><td>0</td><td>C</td><td>C</td><td>C</td></tr>
<tr><td>76.8</td><td>0</td><td>0</td><td>0</td><td>0</td><td>C</td><td>C</td><td>C</td><td>C</td></tr>
</table>
SWITCH S2 – Selects mode and voltages for the serial communications port. When using AC power, you also must set S1 (if present) on the AC Power Supply. NOTE: Poles P3 and P4 of PER1-S2 are alternative choices when using an AC Power Supply. If P4 is closed, set S1 on the AC Power Supply as shown below. To avoid shorting the -5V supplies, close only one pole (P2, P3, P4) on PER1-S2. Similarly, close only P1 or P2 on S1 of the AC Power Supply.
<table>
<tr><th colspan="6">PERIPHERALS 1 – S2</th><th colspan="2">AC POWER–S1</th></tr>
<tr><th>MODE</th><th>POWER</th><th>P1</th><th>P2
GND</th><th>P3
-5V</th><th>P4</th><th>P1
-5V</th><th>P2
GND</th></tr>
<tr><td>RS232</td><td>DC</td><td>0</td><td>0</td><td>C</td><td>0</td><td>–</td><td>–</td></tr>
<tr><td></td><td>AC</td><td>0</td><td>0</td><td>0</td><td>C →</td><td>C</td><td>0</td></tr>
<tr><td>RS422</td><td>–</td><td>C</td><td>C</td><td>0</td><td>0</td><td>–</td><td>–</td></tr>
<tr><td>RS423</td><td>DC</td><td>C</td><td>0</td><td>C</td><td>0</td><td>–</td><td>–</td></tr>
<tr><td></td><td>AC</td><td>C</td><td>0</td><td>0</td><td>C →</td><td>C</td><td>0</td></tr>
</table>
</td></tr>
<tr><td>RAM/MULTIPLIER
Chassis J11
Fig. Y-13</td><td>
SWITCH S1 – Sets the system clock divider. Set S1 to match the CPU clock oscillator frequency used on S1 of both the CPU and PER2 boards.
<table>
<tr><th>POLE</th><th>SETTING</th><th>FUNCTION</th></tr>
<tr><td>P1</td><td>OPEN</td><td>5-MHz CPU CLOCK OSCILLATOR FREQUENCY</td></tr>
<tr><td></td><td>CLOSED</td><td>10-MHz CPU CLOCK OSCILLATOR FREQUENCY</td></tr>
<tr><td>P2</td><td>—</td><td>NOT USED</td></tr>
</table>
</td></tr>
<tr><td>CPU
Chassis J12
Fig. Y-14</td><td>
SWITCH S1 – P2 of S1 must be set to match the CPU clock oscillator frequency. This setting (usually 10 MHz) must match the frequency setting on S1 of both the Peripherals 2 and RAM/Multiplier boards.
<table>
<tr><th>POLE</th><th>SETTING</th><th>FUNCTION</th></tr>
<tr><td>P1</td><td>OPEN</td><td>ALWAYS OPEN FOR NORMAL USE</td></tr>
<tr><td></td><td>CLOSED</td><td>FOR FACTORY USE ONLY</td></tr>
<tr><td>P2</td><td>OPEN</td><td>10-MHz CPU CLOCK OSCILLATOR FREQUENCY</td></tr>
<tr><td></td><td>CLOSED</td><td>5-MHz CPU CLOCK OSCILLATOR FREQUENCY</td></tr>
<tr><td>P3</td><td>OPEN</td><td>FOR FACTORY USE ONLY</td></tr>
<tr><td></td><td>CLOSED</td><td>ALWAYS CLOSED FOR NORMAL USE</td></tr>
<tr><td>P4</td><td>OPEN</td><td>ALWAYS OPEN FOR NORMAL USE</td></tr>
<tr><td></td><td>CLOSED</td><td>FOR FACTORY USE ONLY</td></tr>
</table>
</td></tr>
</table>

Table W-1. ADCP Switch Settings (Continued)

<table>
<tr><th>Board / Location</th><th>Switch Description</th></tr>
<tr><td>PERIPHERALS 3
Chassis J13
Fig. Y-15</td><td>SWITCH S1 – Pole 1 sets the up/down transducer orientation to compensate for the corresponding heading sign change and coordinate transformations. The transducer orientation selected must agree with the setting on the Transducer Compensation board. Pole 2 enables/disables the flux gate heading sensor (compass) interface.
<table>
<tr><th>POLE</th><th>SETTING</th><th>FUNCTION</th></tr>
<tr><td>P1</td><td>OPEN</td><td>TRANSDUCER FACING UP</td></tr>
<tr><td></td><td>CLOSED</td><td>TRANSDUCER FACING DOWN</td></tr>
<tr><td>P2</td><td>OPEN</td><td>COMPASS INTERFACE DISABLED (P1 HAS NO EFFECT; DEFAULTS TO UP)</td></tr>
<tr><td></td><td>CLOSED</td><td>COMPASS INTERFACE ENABLED</td></tr>
</table></td></tr>
<tr><td>SYNCHRO
INTERFACE
Chassis J15
Fig. Y-17</td><td>NOTE: Available as an option in AC-powered systems only.
SWITCH S1 - Sets the turns ratio of the external heading input. This input can be a synchro voltage or a stepper voltage. Appendix U explains how to set up and use the Synchro Interface board.
<table>
<tr><th>TURNS</th><th colspan="8">POLE</th></tr>
<tr><th>RATIO</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th></tr>
<tr><td>1:1</td><td>C</td><td>O</td><td>C</td><td>O</td><td>O</td><td>C</td><td>C</td><td>C</td></tr>
<tr><td>36:1</td><td>C</td><td>O</td><td>C</td><td>O</td><td>O</td><td>O</td><td>C</td><td>C</td></tr>
<tr><td>90:1</td><td>C</td><td>O</td><td>C</td><td>O</td><td>O</td><td>C</td><td>O</td><td>C</td></tr>
<tr><td>360:1</td><td>C</td><td>O</td><td>C</td><td>O</td><td>O</td><td>O</td><td>O</td><td>C</td></tr>
<tr><td>STEPPER</td><td>O</td><td>C</td><td>O</td><td>C</td><td>O</td><td>O</td><td>O</td><td>O</td></tr>
</table></td></tr>
<tr><td>AC POWER SUPPLY
Chassis J17
Fig. Y-18</td><td>NOTE: Present only in AC-powered systems.
SWITCH S1 - (On older boards only; newer boards use a jumper.) See Peripherals 1, switch S2 for explanation.</td></tr>
<tr><td>TRANSDUCER
COMPENSATION
Transducer Head
Fig. Y-2</td><td>SWITCH S1 – Sets the up/down transducer orientation to compensate for the corresponding heading sign change and coordinate transformations. The transducer orientation selected must agree with the setting on the PER3 board.
<table>
<tr><th>POLE</th><th>SETTING</th><th>FUNCTION</th></tr>
<tr><td>P1</td><td>OPEN</td><td>TRANSDUCER FACING DOWN</td></tr>
<tr><td></td><td>CLOSED</td><td>TRANSDUCER FACING UP</td></tr>
<tr><td>P2</td><td>—</td><td>NOT USED</td></tr>
</table></td></tr>
</table>

APPENDIX X
SC-ADCP FUNCTIONAL DESCRIPTION AND BLOCK DIAGRAMS

X-0. INTRODUCTION

This appendix presents a functional description of SC-ADCP operation and contains the system and printed circuit board (PCB) block diagrams. You can use this appendix with Chapter 6 to troubleshoot the system.

X-1. OVERVIEW OF NORMAL ADCP OPERATION

Refer to Figure X-1. An internal microprocessor (CPU) controls normal ADCP operation as directed by commands received through the serial I/O cable (see Chapter 2 and Appendix D). During a typical data collection cycle, the following events occur.

a. The user or a controlling software program sends data collection parameters to the ADCP. The user/program then sends an S-command to start the data collection cycle.

b. The CPU initializes all internal functions.

c. The POWER REGULATOR sends a transmit command to the POWER AMPLIFIER, initializing acoustic transmissions (pinging) on all four TRANSDUCERS.

d. The TRANSDUCERS receive echoes from the backscatter. Four PREAMPLIFIERS and RECEIVERS then amplify and translate the echoes into a baseband frequency.

e. The BUTTERFLY and CPU modules process the four pairs of received baseband echoes (SIN and COS of each beam).

f. After echo reception, the ADCP injects a self-test signal into the RECEIVERS and processes the signal as normal data for test purposes.

g. The TEMPERATURE SENSOR measures water temperature at the transducer head and sends it to the CPU via the PERIPHERALS 2 module.

h. Pitch and roll from the PENDULUMS, and ADCP heading from the FLUX GATE COMPASS are digitized by the PERIPHERALS 2 and PERIPHERALS 3 modules and sent to the CPU.

i. External conductivity, temperature, and depth (pressure) sensors send data to the optional CTD module.

j. The CPU continually executes steps b through i for a user-defined number of "pings." Data from each ping are averaged together to produce an ensemble data set.

k. At the end of the ensemble (or sampling) interval, the resulting data ensemble is recorded on the internal EPROM RECORDER and/or sent to the ADCP I/O connector through the serial data I/O port.

X-2. FUNCTIONAL DESCRIPTION OF OPERATION

The following paragraphs provide a functional description of how the ADCP operates and the interaction of its modules. This information will help you understand the diagnostic self-tests used to isolate faults to a plug-in module (see Chapter 6 for extensive troubleshooting information). Refer to Figures X-1 and X-2 throughout this description.

X-2.1. DC POWER DISTRIBUTION AND REGULATION. The DC POWER SUPPLY filters DC power from internal battery packs (or an external DC power supply through the I/O connector). The ADCP uses three major power supplies (V1, V2, V4). V1 (≈7-12 VDC) provides primary power to ADCP electronics. V2 (≈25-40 VDC) provides transmitter and recorder power. V4 (≈6-20 VDC) provides power to the optional CTD interface. Figure X-3 shows how DC power is distributed throughout the SC-ADCP. NOTE: V3 was used on SC-ADCPs that had a 60-MB internal tape recorder. V3 is not used in systems with EPROM recorders.

Connectors P1/J1 and/or P2/J2 on the DC POWER SUPPLY receive V1/V2 power from the internal BATTERY PACKS; connector P3/J3 receives V4 power. The V1/V2 terminals of P1/J1 and P2/J2 are connected together on the DC POWER SUPPLY. Separate connections for the I/O connector can supply V1/V2 power from an external DC power supply. A resistor-diode buffer connected in series with the V1/V2 outputs provides current limiting protection against externally applied shorts to ground. Fuses F1, F2, and F4 on the DC POWER SUPPLY provide circuit protection.

As a convenience, you can use the I/O connector to measure internal battery pack voltages without removing the pressure case. Additionally, lithium BATTERY PACKS are configured with protective diodes that let you apply external voltages for pre/post-deployment setup and maintenance without disconnecting the internal batteries or removing the pressure case.

The POWER REGULATOR uses V1 to create and regulate five +5 VDC voltages (VCC1-VCC5). The 5V voltages operate the ADCP electronics and provide control logic and a transmit frequency clock (CLK2) to the POWER AMPLIFIER. The CPU selectively enables these 5V voltages to apply power to ADCP functions only when that particular function is operating.

VCC1 and VCC2 turn ON and OFF under CPU control during various ADCP operating modes. VCC1 supplies power to the CPU and primary logic functions; it is ON during all ADCP operating modes except STANDBY. The ADCP enters the STANDBY mode during the interval between pings when multiple pings are averaged within the ADCP during a single measurement ensemble (P-command greater than 1). VCC2 provides power primarily to the RECEIVERS and to the TRANSDUCER modules. VCC2 turns ON only during the receive interval.

VCC3 provides power to part of the RAM on the RAM/MULTIPLIER PCB and to other control logic. VCC4 supplies power to part of the RAM located on the RAM/MULTIPLIER PCB and to the real-time clock on the PERIPHERALS 2 PCB. VCC4 is at +5 VDC whenever power is ON and drops to +3 VDC when power is OFF. The 3V comes from a button battery on the DC POWER SUPPLY. VCC5 supplies power to the LED displays on the CPU module.

During start-up, VCC3 and VCC4 turn ON when power is applied. VCC1 turns ON when the ADCP "wakes up" upon receipt of a BREAK command through the I/O connector. The WAKE-UP mode can also be manually initiated by temporarily shorting to ground (TP0) and releasing the WAKE-UP test point (TP11) on the POWER REGULATOR. VCC1 remains ON during all operating modes except STANDBY during multiple-ping ensemble measurements. CLK2 (TP7) on the POWER REGULATOR has a 5V logic level square wave signal at a frequency of 2,457,600 Hz initially after the ADCP wakes up, during data I/O modes, and during transmit intervals. VCC2 turns ON during echo reception.

The POWER AMPLIFIER uses V2 to supply the electrical power needed to drive the transducers for acoustic transmission. Auxiliary power (VCC7) of 18V is generated on the DC POWER SUPPLY from V2. V2 also supplies power to a V1 backup regulator on the DC POWER SUPPLY. The backup regulator is connected to V1 and will supply 5.2V to V1 when the V1 BATTERY PACK (through its internal series diode) or V1 external voltage (through the buffer diode) is less than 5.2V. This feature helps sustain ADCP operation should the V1 battery pack happen to discharge before V2.

X-2.2. PULSE TRANSMISSION. The CPU controls ADCP operation and data collection using firmware programming and operator input commands. After receiving its commands, the CPU sequences power application to the ADCP subsystems and sends a transmit command to the POWER AMPLIFIER. During transmit, the POWER REGULATOR sends a 5V logic pulse (transmit) to the POWER AMPLIFIER (TP2). CLK2 (TP7) on the POWER REGULATOR is at a frequency of 2,457,600 Hz. The S1 settings on the POWER AMPLIFIER divide the CLK2 frequency. A 5V logic level gate (TP4 on the POWER AMPLIFIER) tells the POWER AMPLIFIER to generate a 40V pk-pk drive signal at the transmit frequency. The transmit current flowing to the TRANSDUCERS is sensed and measured by the PERIPHERALS 2 PCB. Transmit current can be monitored by observing pulse amplitude proportional to current on TP1 of the POWER AMPLIFIER. Transmit power is passed from the POWER AMPLIFIER, through a power transformer in the TRANSDUCER ASSEMBLY, and routed to each TRANSDUCER through a diode switching network inside the transducer.

X-2.3. ECHO RECEPTION. Shortly after the four transducers emit the acoustic signal (ping), they switch to the receive mode to accept the backscattered echoes used in determining water current motion. Four PREAMPLIFIERs, one for each transducer beam, increase the signal level of these echoes and pass them on to the four RECEIVERs.

Further amplification and signal conditioning occur in the RECEIVERs using Automatic Gain Control (AGC) circuitry to control the signal level. The AGC circuit sends a linear AGC (LIN AGC) voltage to the PREAMPLIFIERs to control gain and a logarithmic AGC (LOG AGC) voltage to the PERIPHERALS 2 module for sampling and output as part of the data set.

The RECEIVER outputs of SIN and COS are in-phase quadrature 22 components of the received echo that have been translated in frequency from the transmit carrier frequency to the base-band (zero average) frequency. These quadrature pairs help determine the Doppler frequency shift of the echoes.

X-2.4. DATA PROCESSING. ADCP data processing operates under control of the microprocessor program stored in the CPU firmware EPROM via the tri-state, bidirectional data bus. After RECEIVER processing, the RECEIVERs pass the amplified and conditioned echoes to the BUTTERFLY module, where the initial digital signal processing occurs. The BUTTERFLY module passes this digital information to the CPU module. The CPU uses information from the RAM/MULTIPLIER, PERIPHERALS 1, and PERIPHERALS 2 modules to further process the echo data, do calculations, and format data for output.

The RAM/MULTIPLIER module temporarily stores data and does math processing.

The PERIPHERALS 1 module controls the serial input/output interface. On SC-ADCPs, data are also sent to the recorder through the serial I/O.

The PERIPHERALS 2 module digitizes the pitch and roll signals from the PENDULUMS, logarithmic AGC signals from the RECEIVERs, and transmit current (XMIT CUR) signals from the POWER AMPLIFIER. The ADCP also uses LOG AGC and XMIT CUR for internal tests and performance verification checks. The results of the internal tests are digitized for output and sent through the serial interface as BIT and leader output data.

A sensor in the transducer head provides the water temperature as output data in the leader (see Chapter 4). The TRANSDUCER COMPENSATION module digitizes the measured temperature data and passes it to the PERIPHERALS 2 module for sampling by the CPU. The TRANSDUCER COMPENSATION module also stores system-specific compass corrections and transducer configuration information.

The PERIPHERALS 3 module digitizes heading signals from the FLUX GATE COMPASS, controls the test multiplexer (TEST MUX) output, controls the bottom-track threshold monitor and bottom-track gain switch circuits, and contains recorder control circuits.

The EPROM RECORDER is an intelligent read/write device. Communication with the recorder and retrieval of data can be done through the serial interface.

The optional CTD module digitizes signals from external conductivity, temperature, and depth (pressure) sensors.

At the end of every data collection cycle, the ADCP runs an end-to-end self-test (BIT). CPU control logic injects a test signal of known frequency and amplitude into the RECEIVERs, which process the signal as a normal echo. The CPU compares the results with stored limits to determine GO/NO GO status.

After completion of the echo processing and the BIT, the resulting data are stored on the internal EPROM RECORDER or sent through the serial interface to an external device.

X-3. SYSTEM AND PCB BLOCK DIAGRAMS

The following SC-ADCP block diagrams are in this appendix. In general, the printed circuit board block diagrams are listed by slot location.

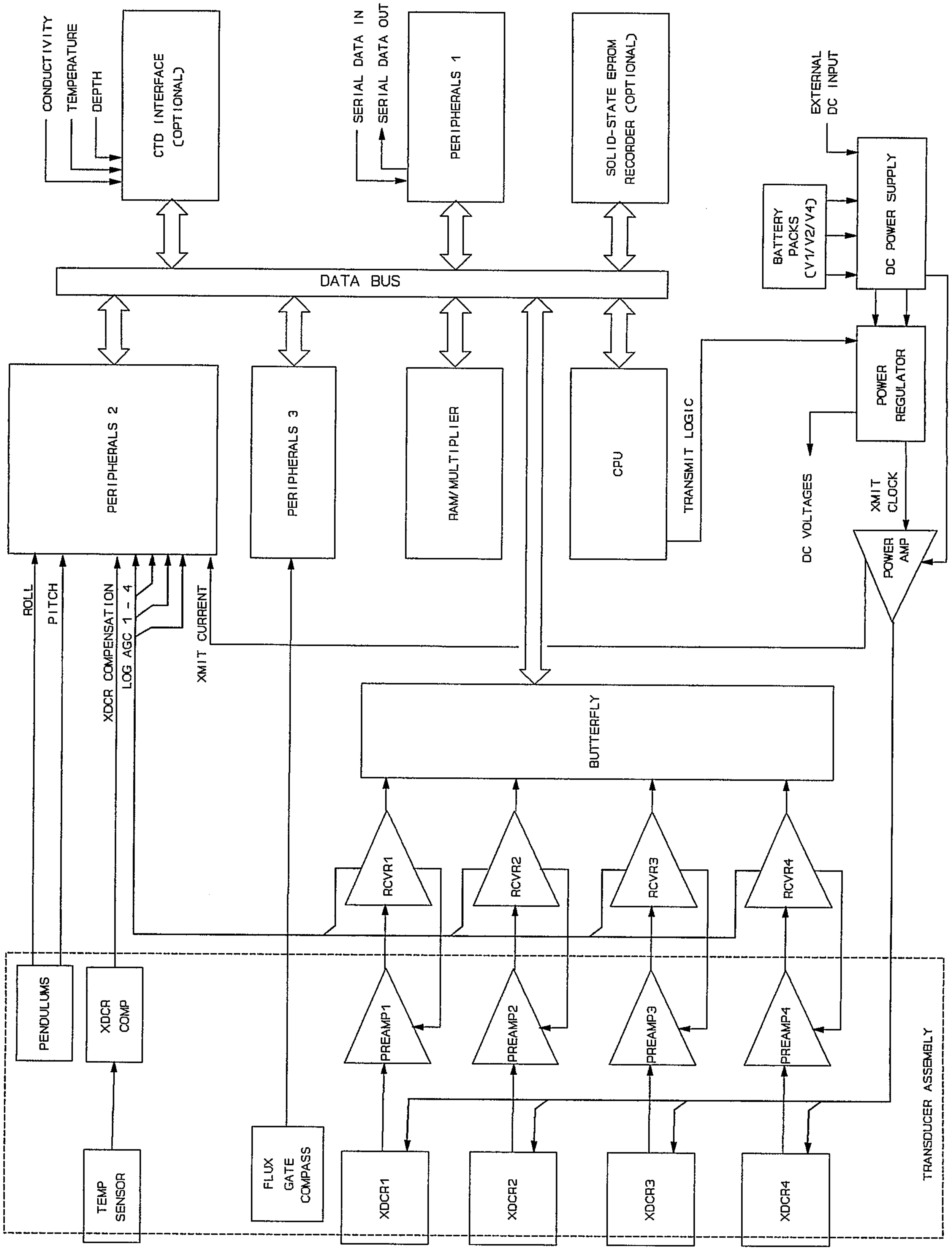


Figure X-1. SC-ADCP Functional Flow Block Diagram

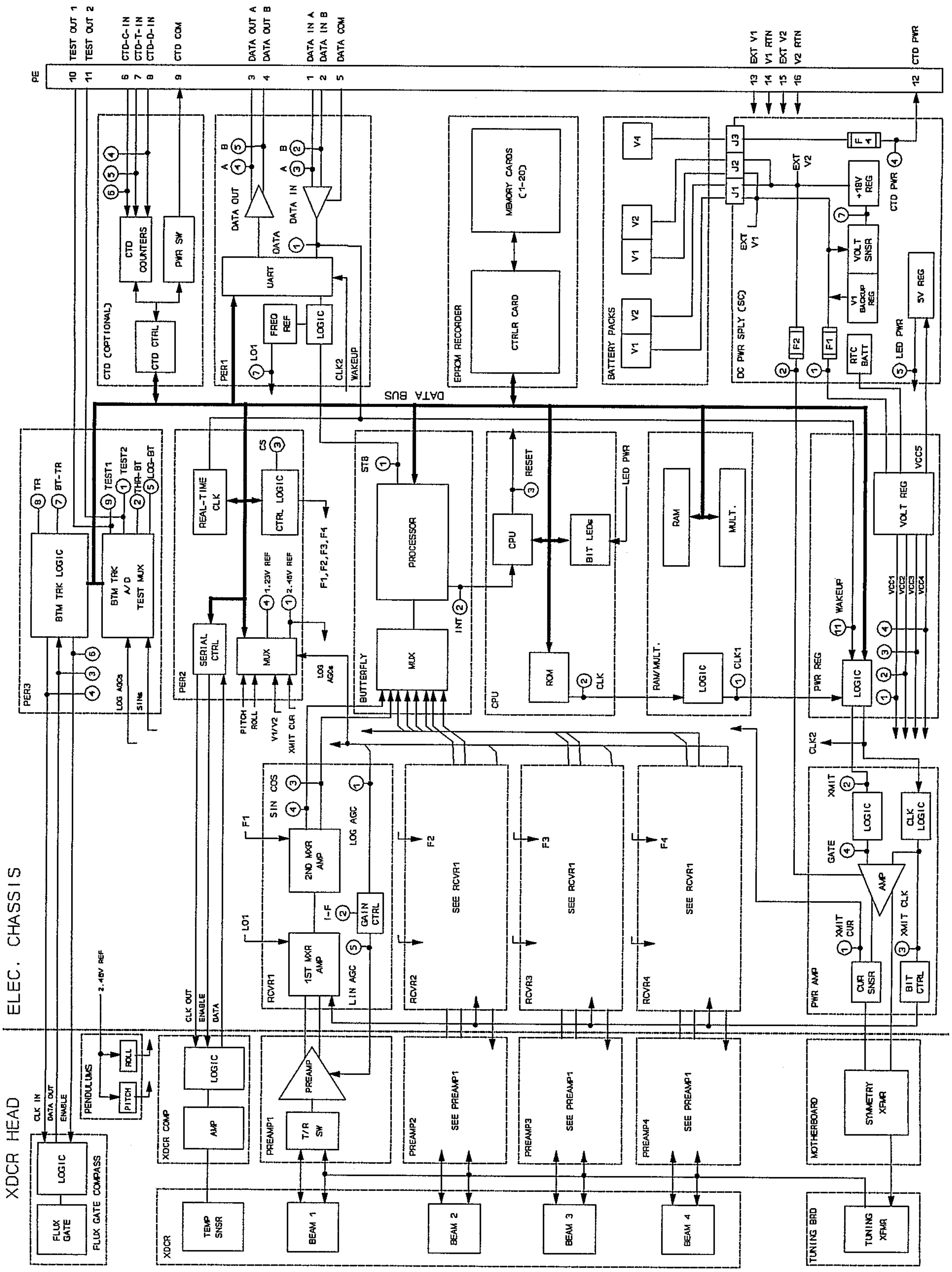
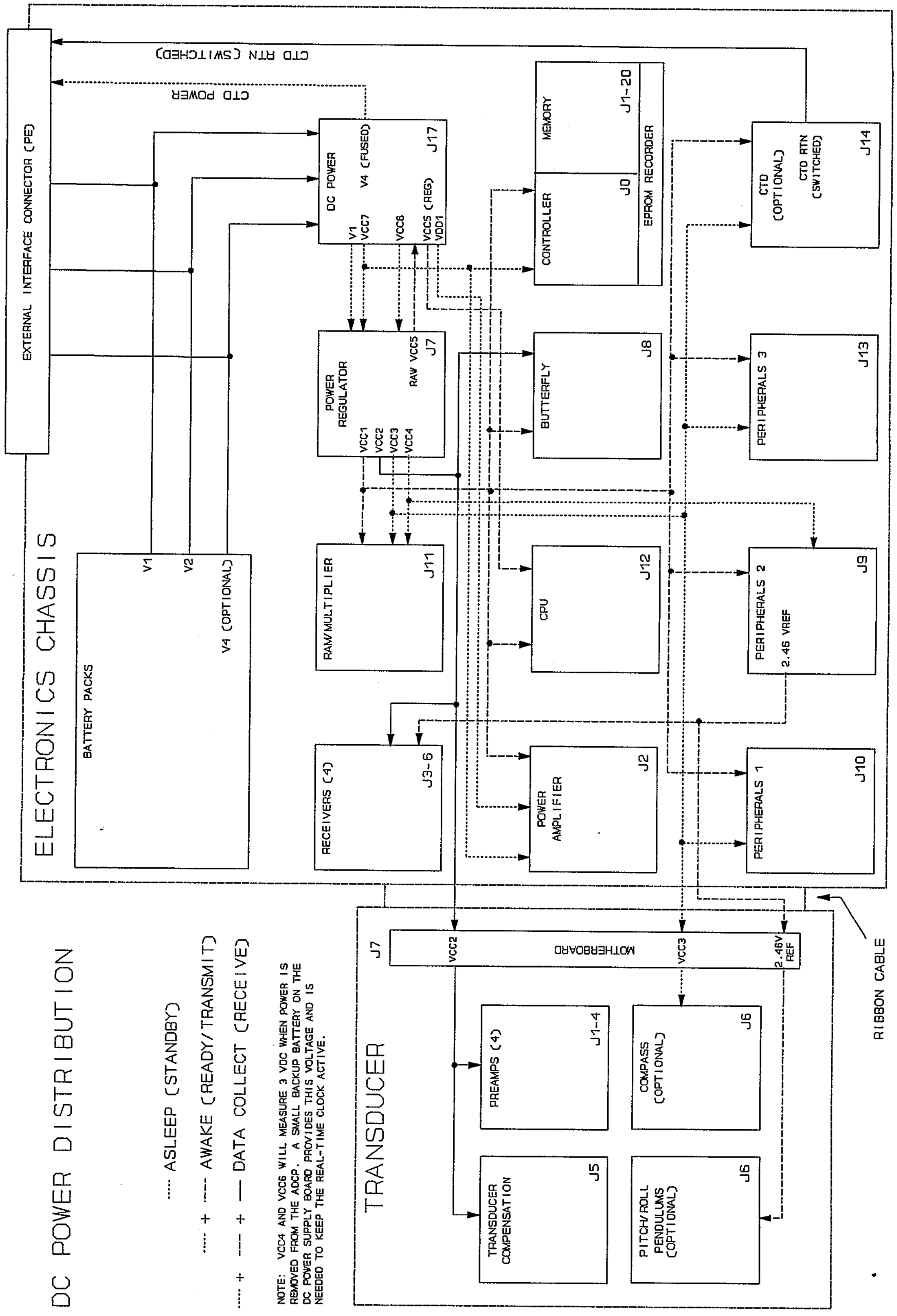


Figure X-2. SC-ADCP System Block Diagram



NOTE: VCC4 AND VCC6 WILL MEASURE 3 VDC WHEN POWER IS REMOVED FROM THE ADCP. A SMALL BACKUP BATTERY ON THE DC POWER SUPPLY BOARD PROVIDES THIS VOLTAGE AND IS NEEDED TO KEEP THE REAL-TIME CLOCK ACTIVE.

Figure X-3. SC-ADCP DC Power Distribution Block Diagram

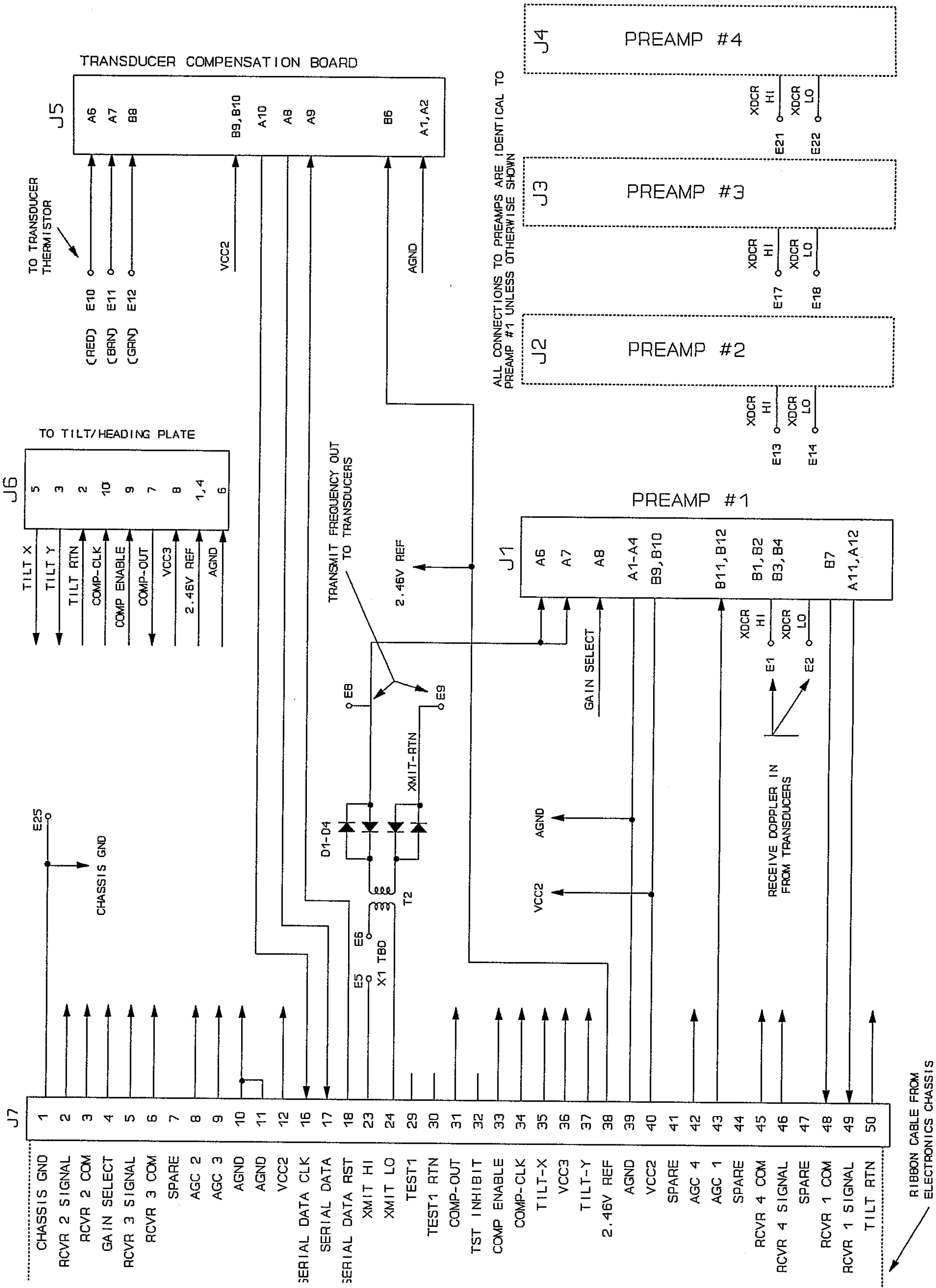


Figure X-4. Transducer Motherboard Block Diagram

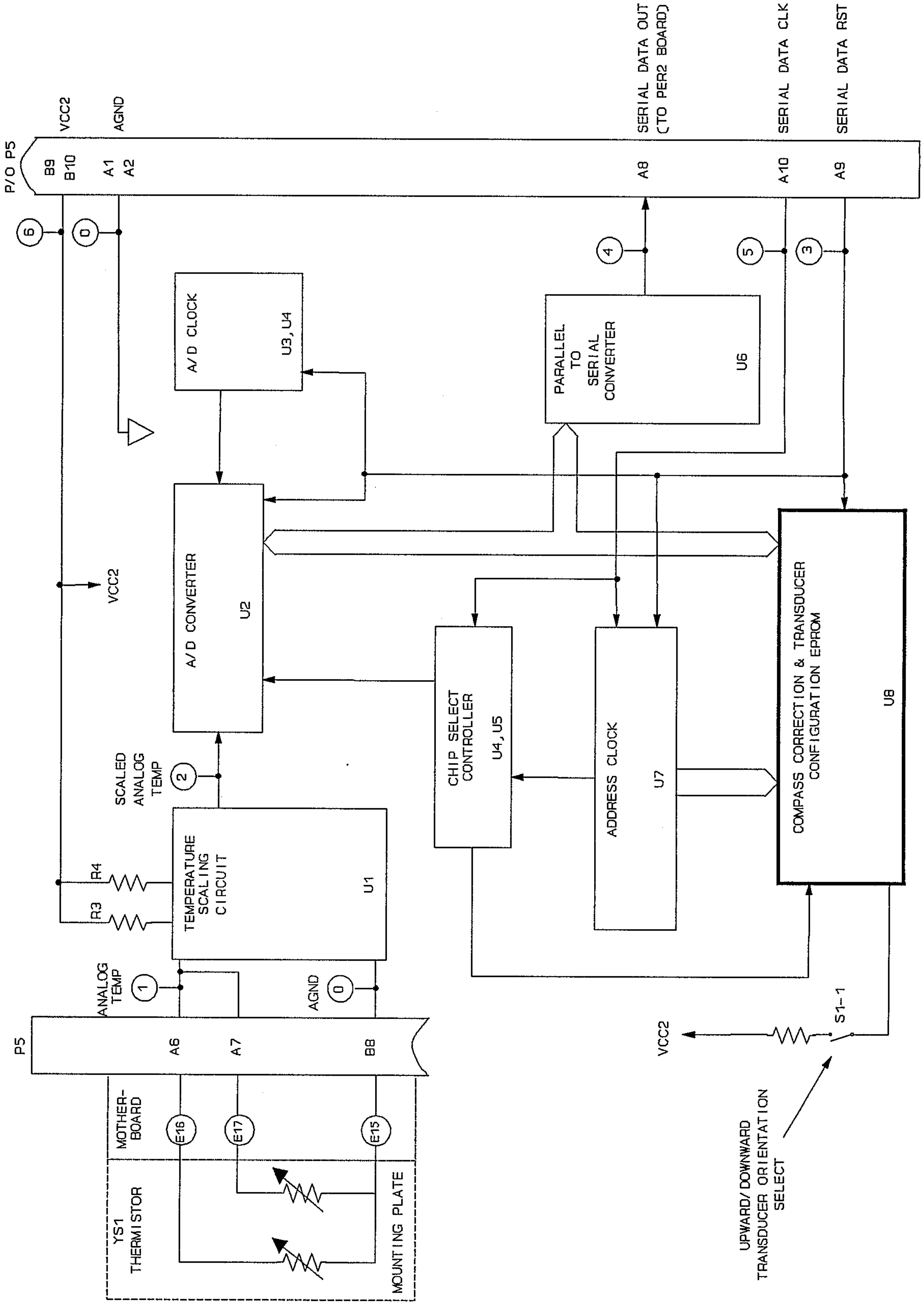


Figure X-5. Transducer Compensation PCB Block Diagram

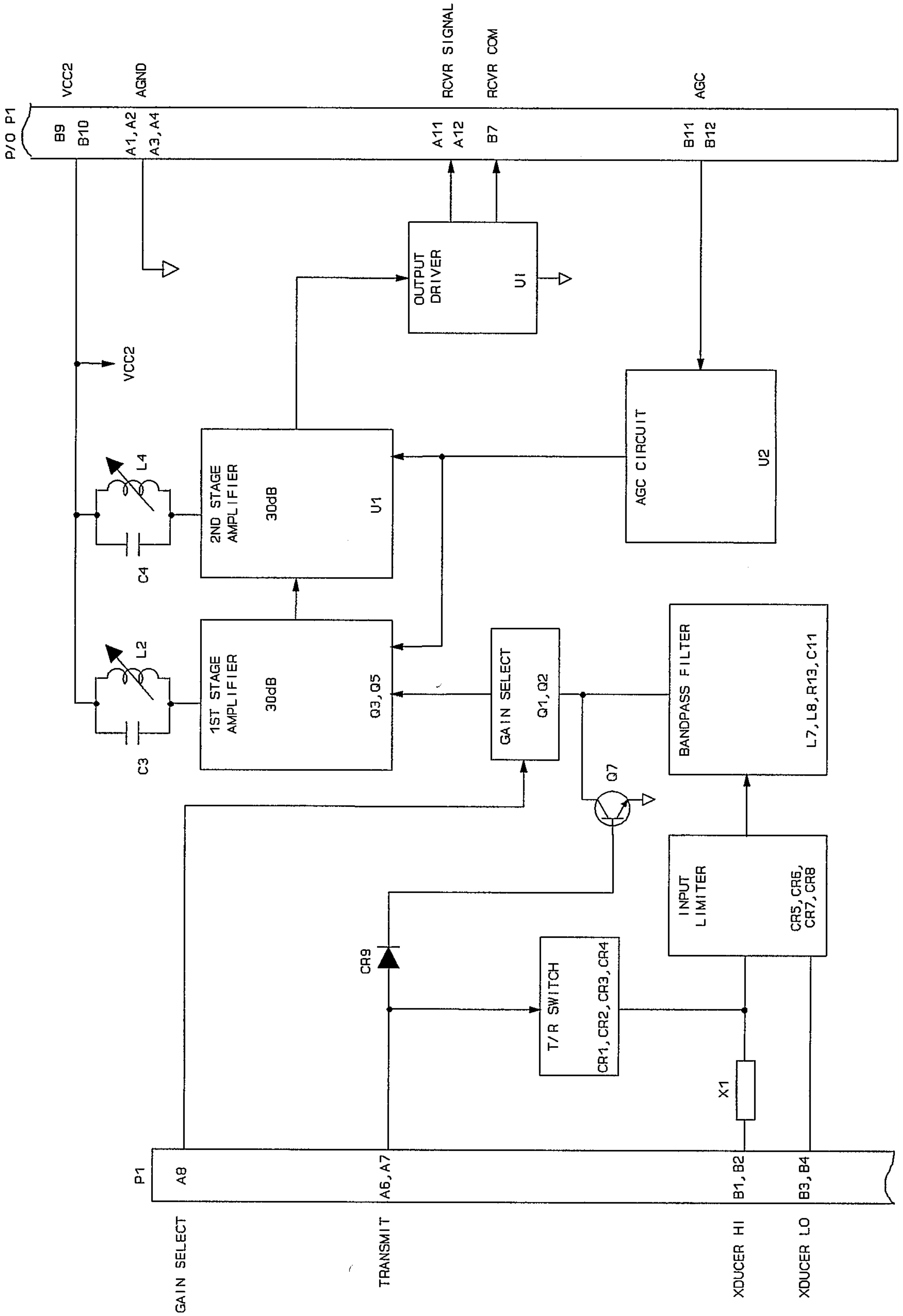


Figure X-6. Preamplifier PCB Block Diagram

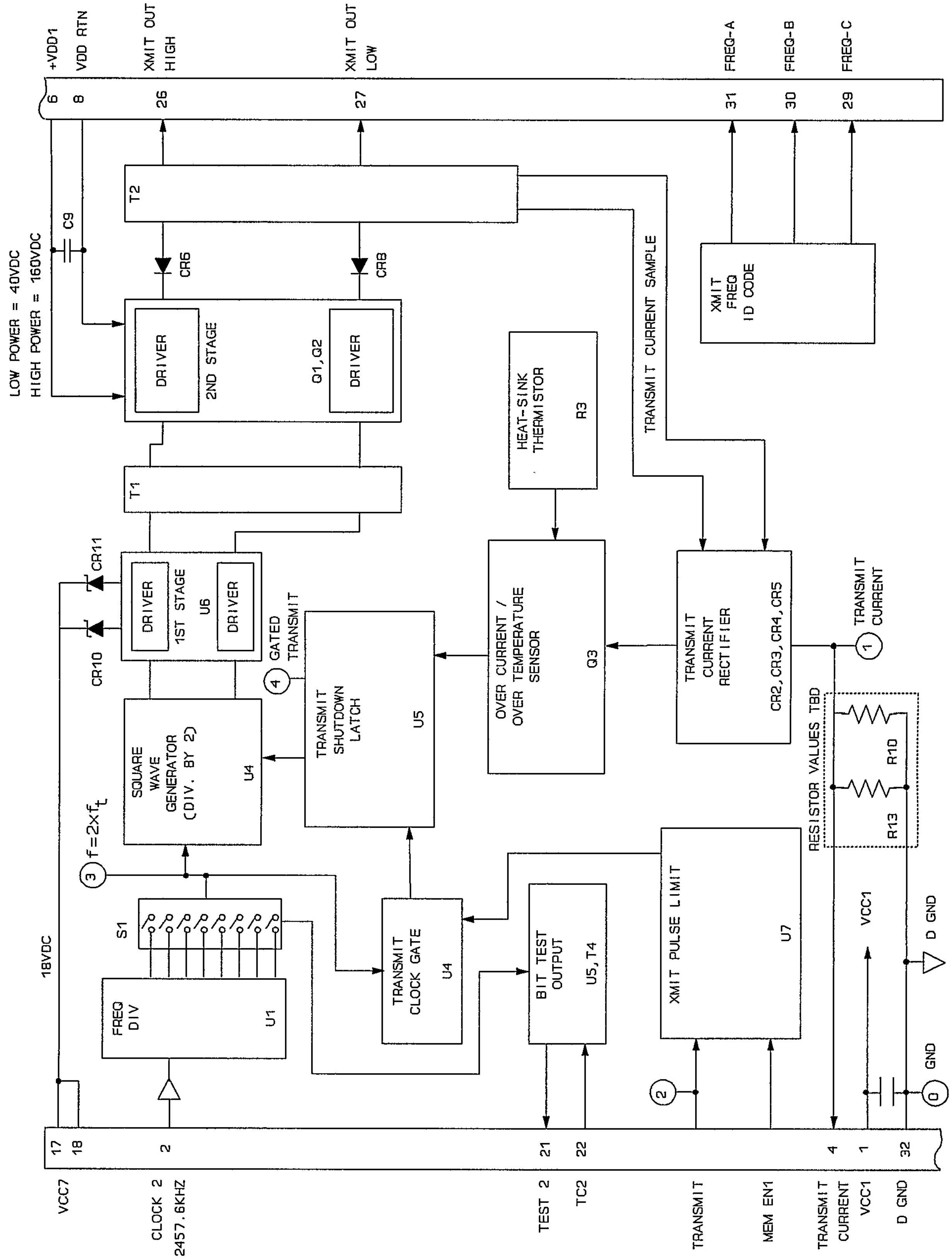


Figure X-7. Power Amplifier PCB Block Diagram

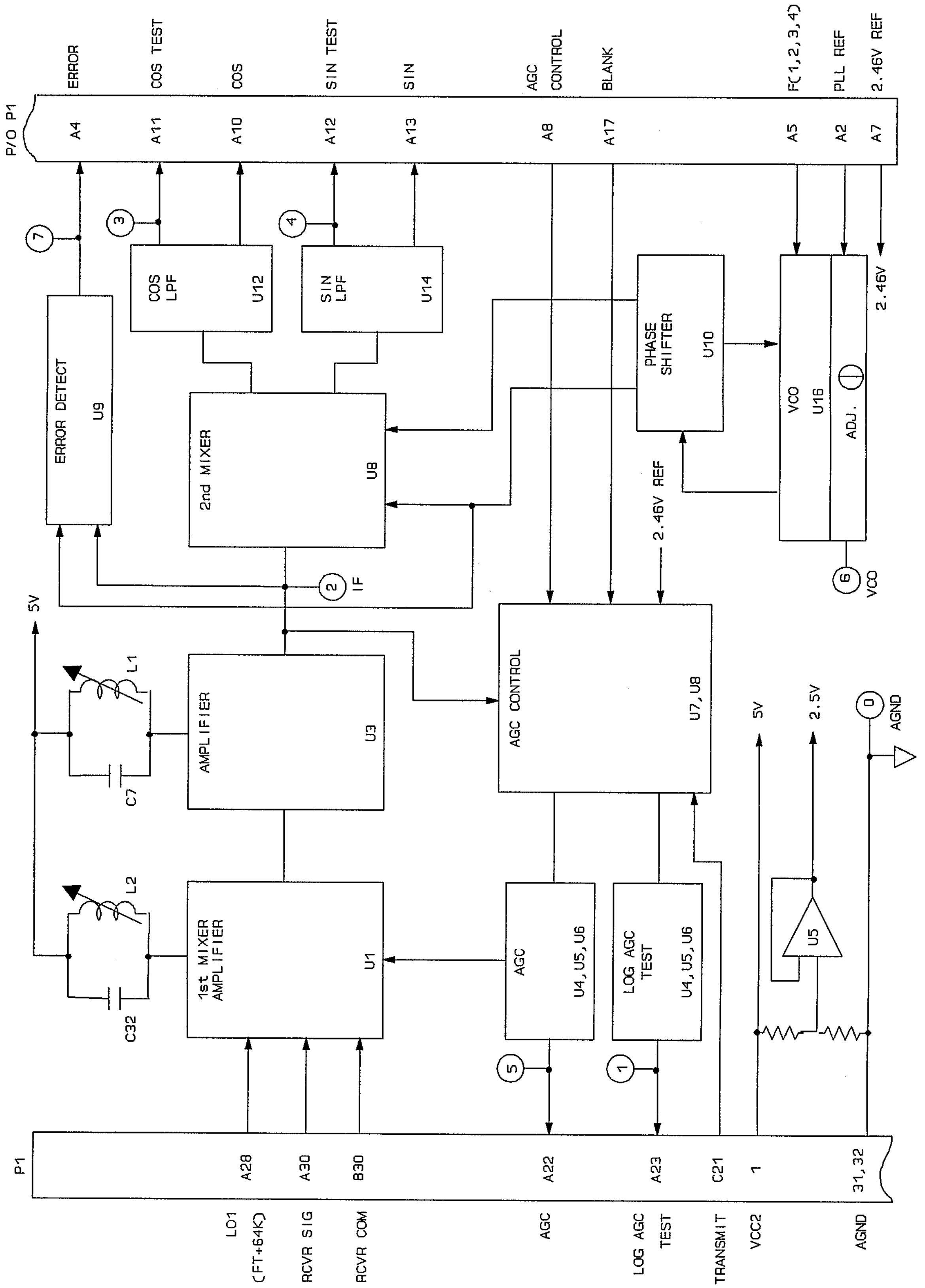


Figure X-8. Receiver PCB Block Diagram

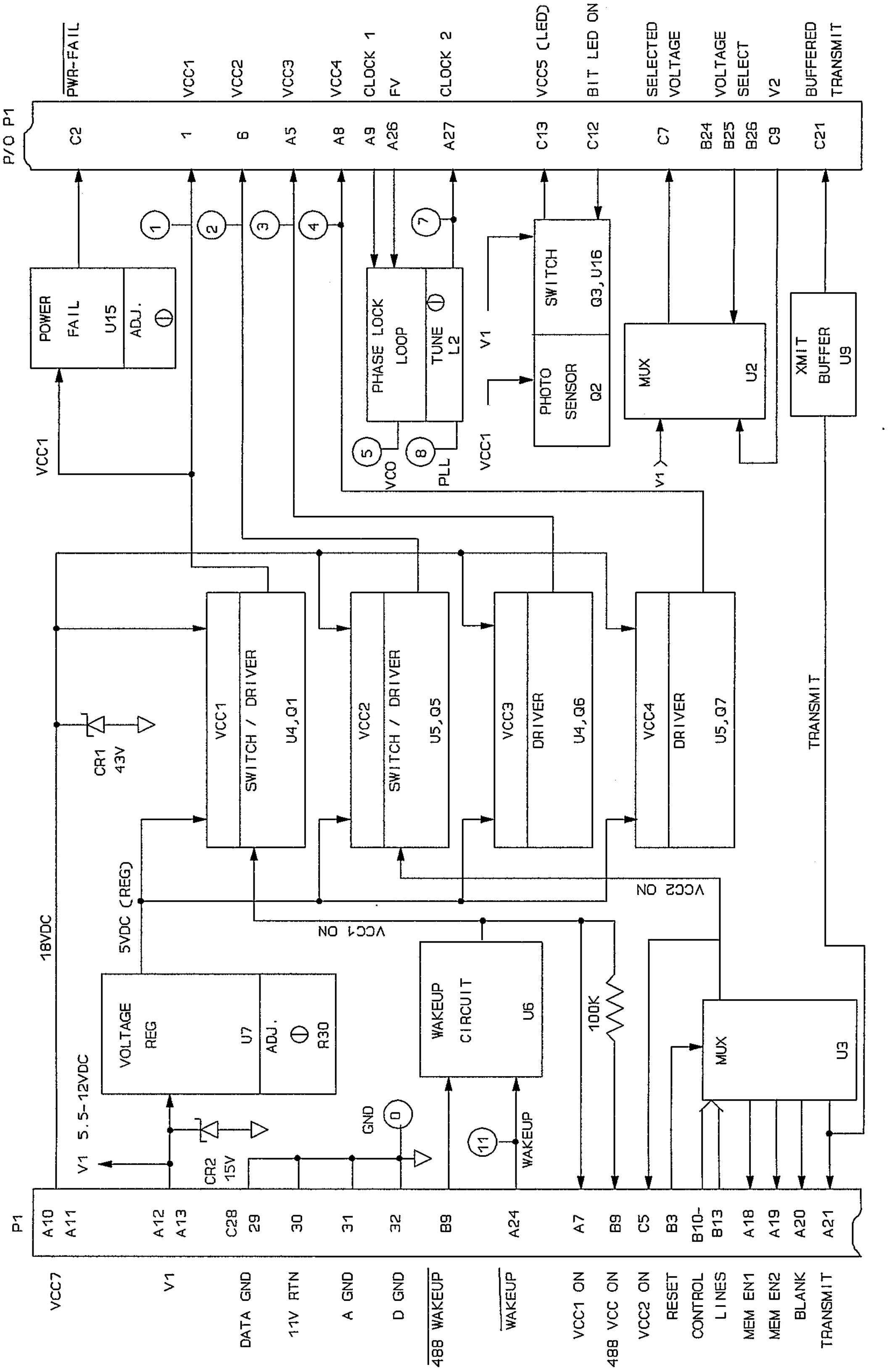


Figure X-9. Power Regulator PCB Block Diagram

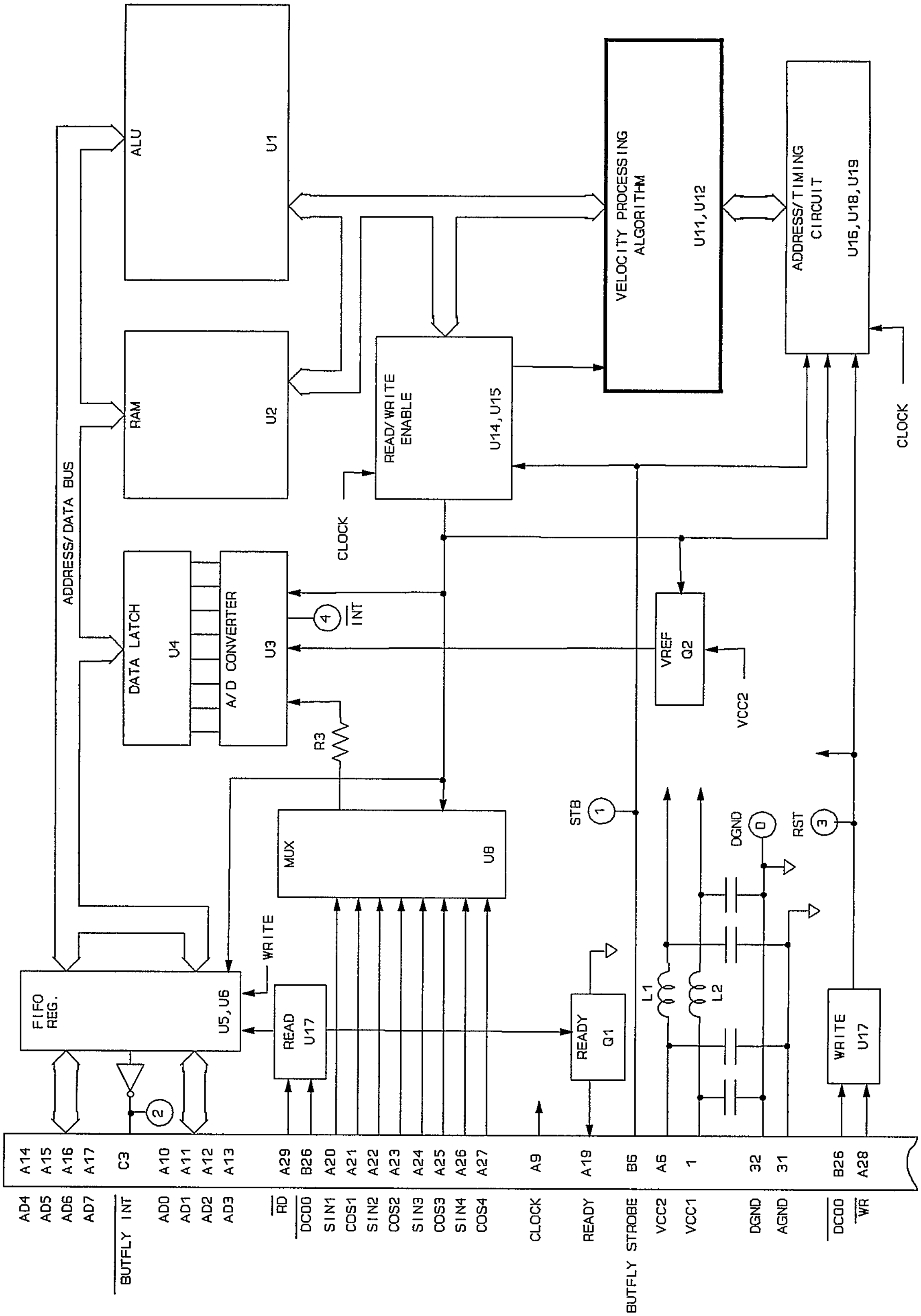


Figure X-10. Butterfly PCB Block Diagram

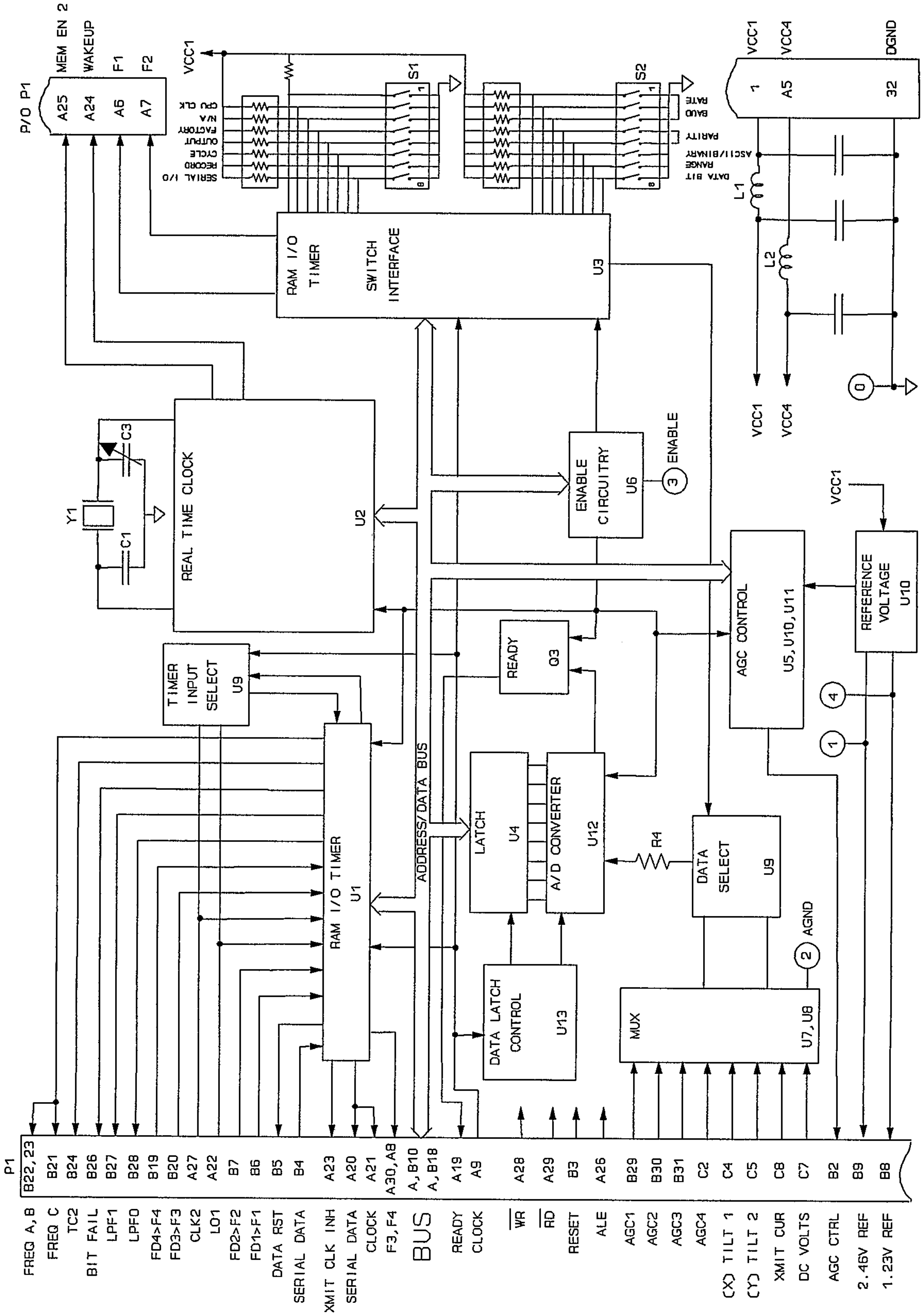


Figure X-11. Peripherals 2 PCB Block Diagram

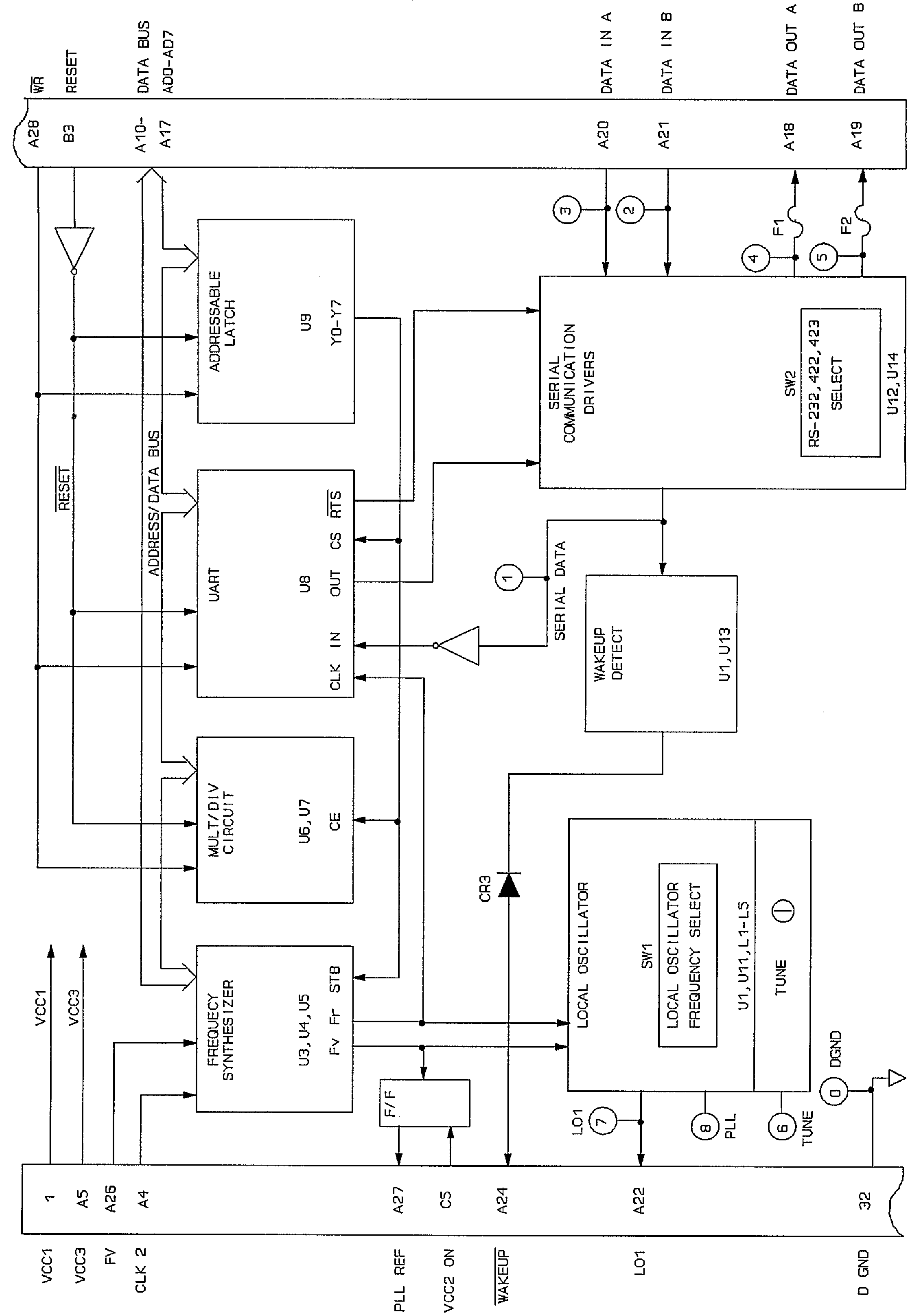


Figure X-12. Peripherals 1 PCB Block Diagram

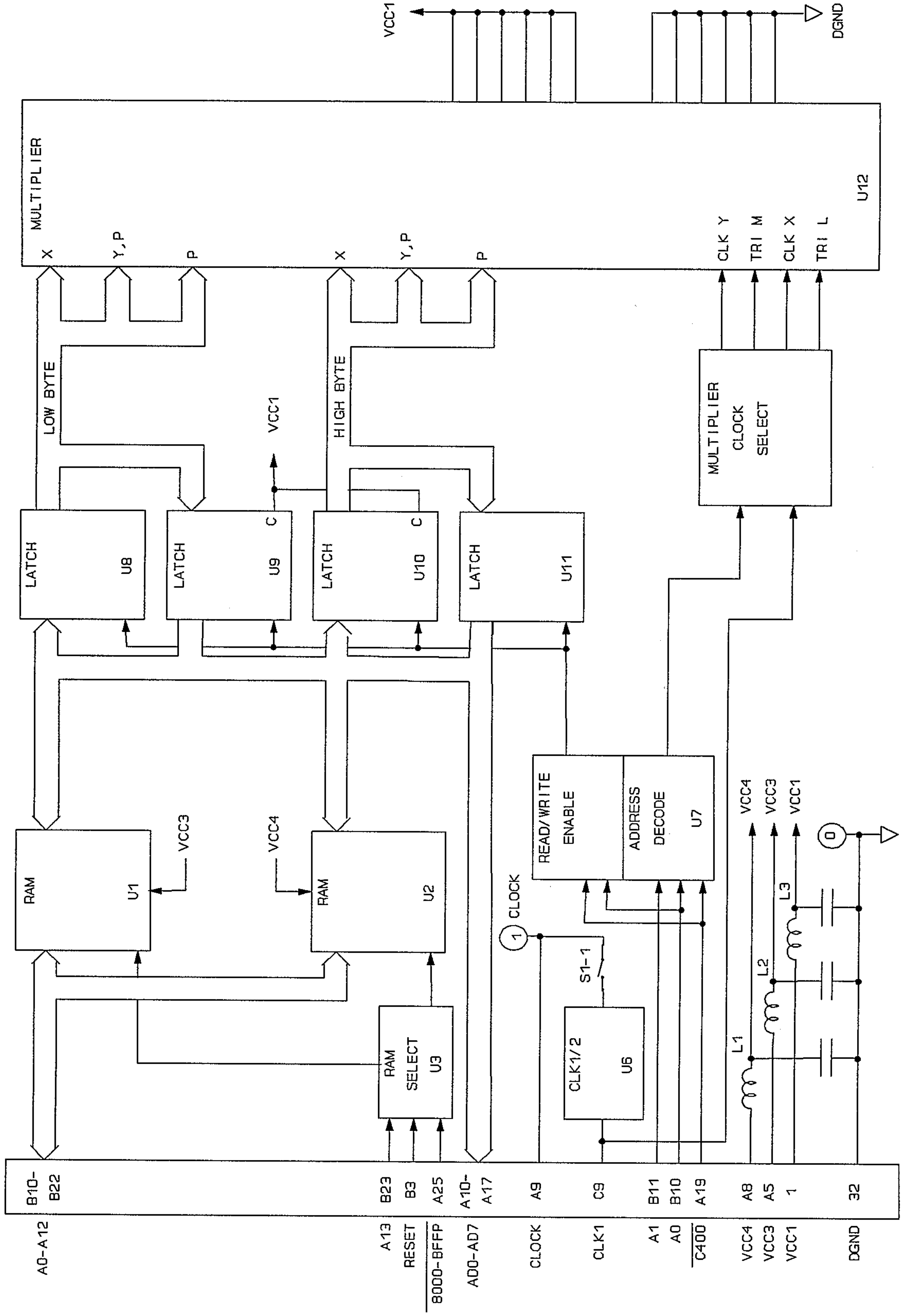


Figure X-13. RAM/Multiplier PCB Block Diagram

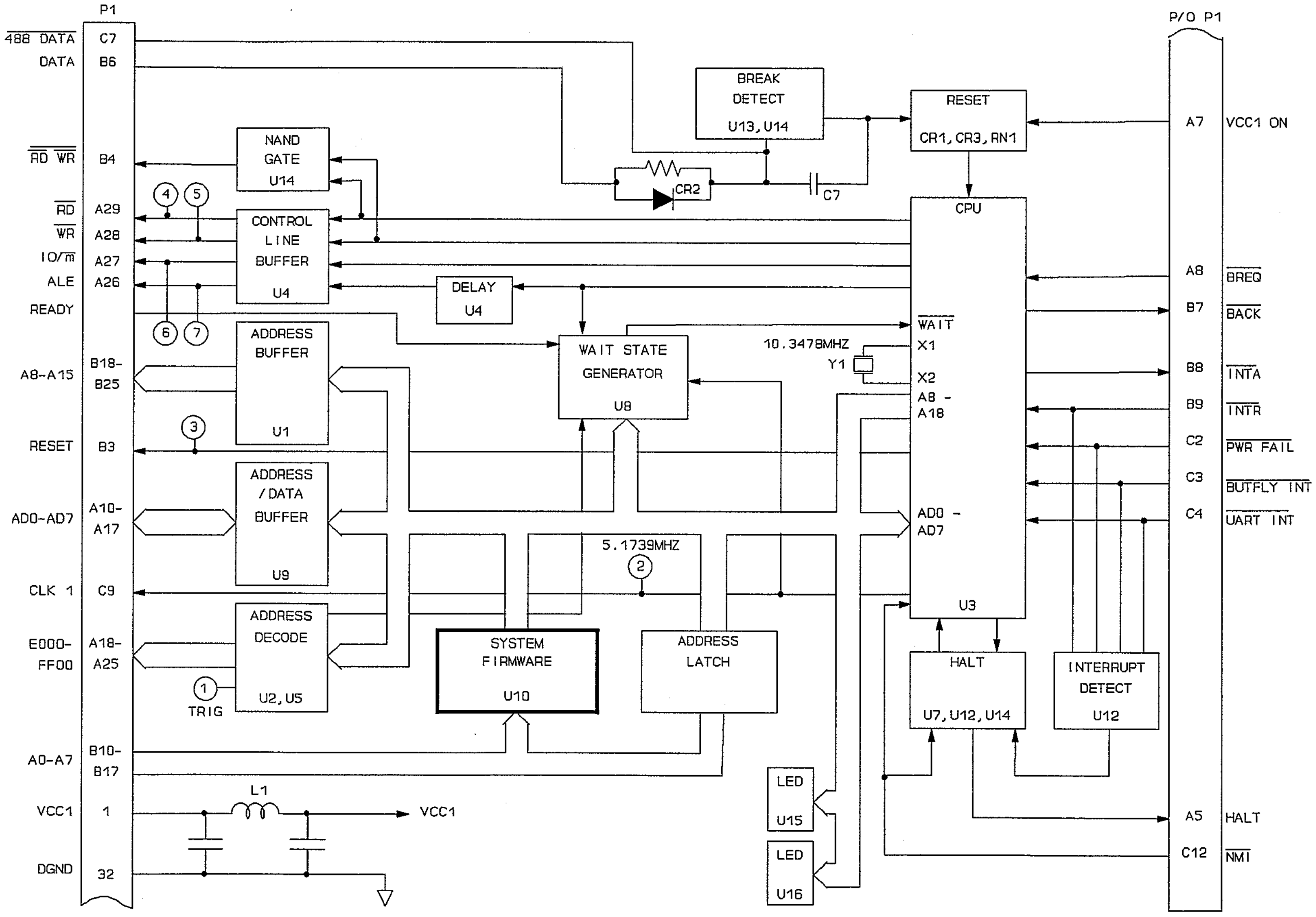


Figure X-14. CPU PCB Block Diagram

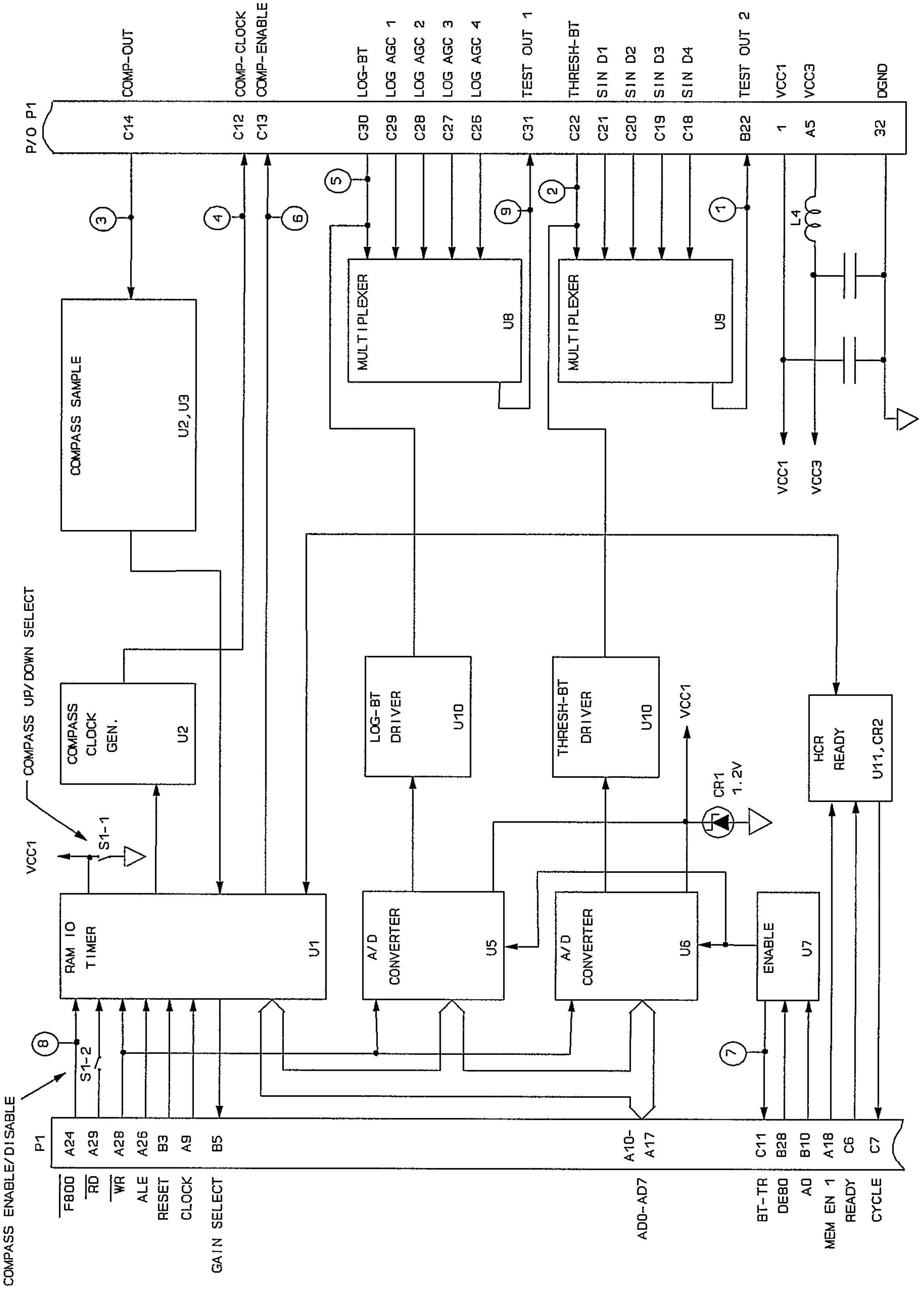


Figure X-15. Peripherals 3 PCB Block Diagram

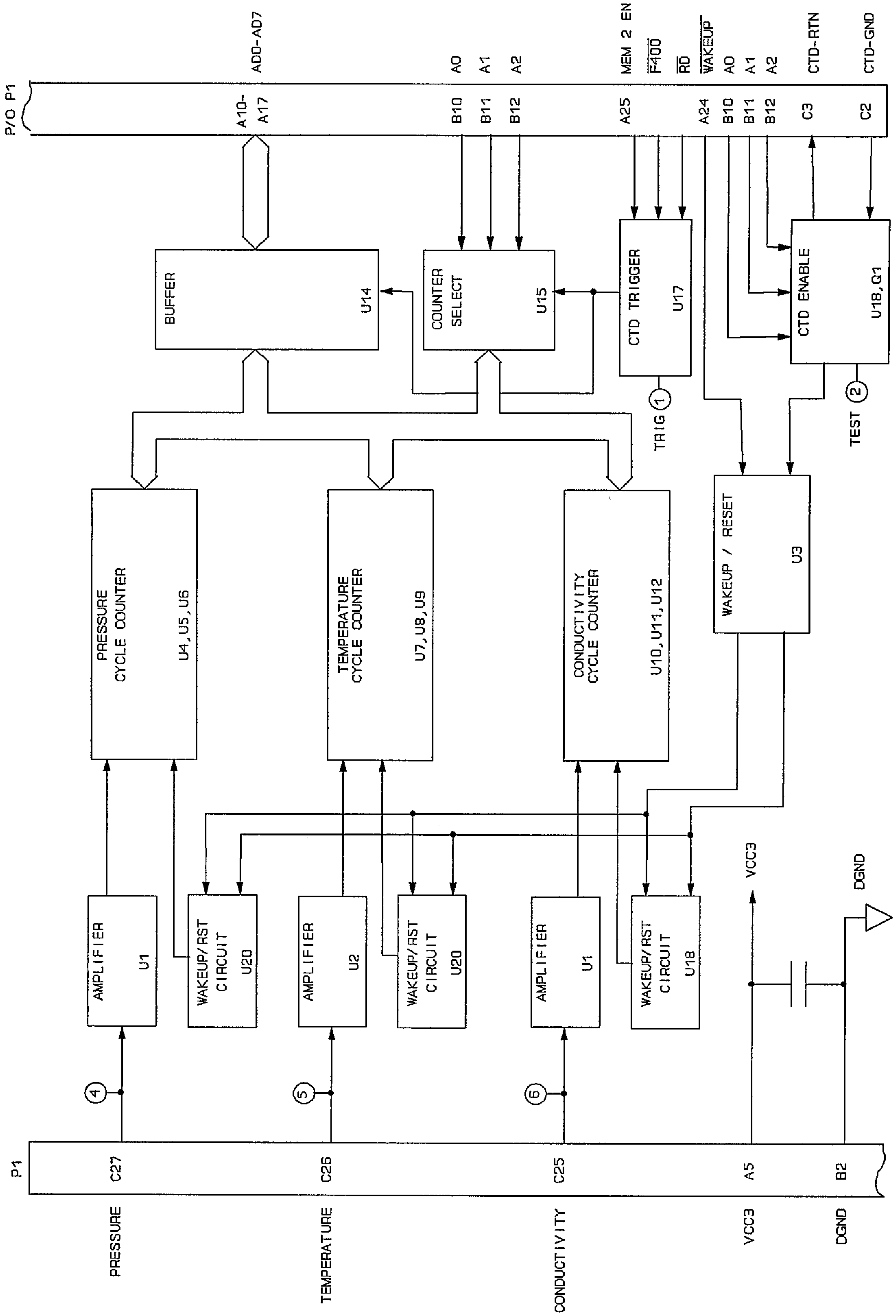


Figure X-16. CTD Interface PCB Block Diagram (Optional)

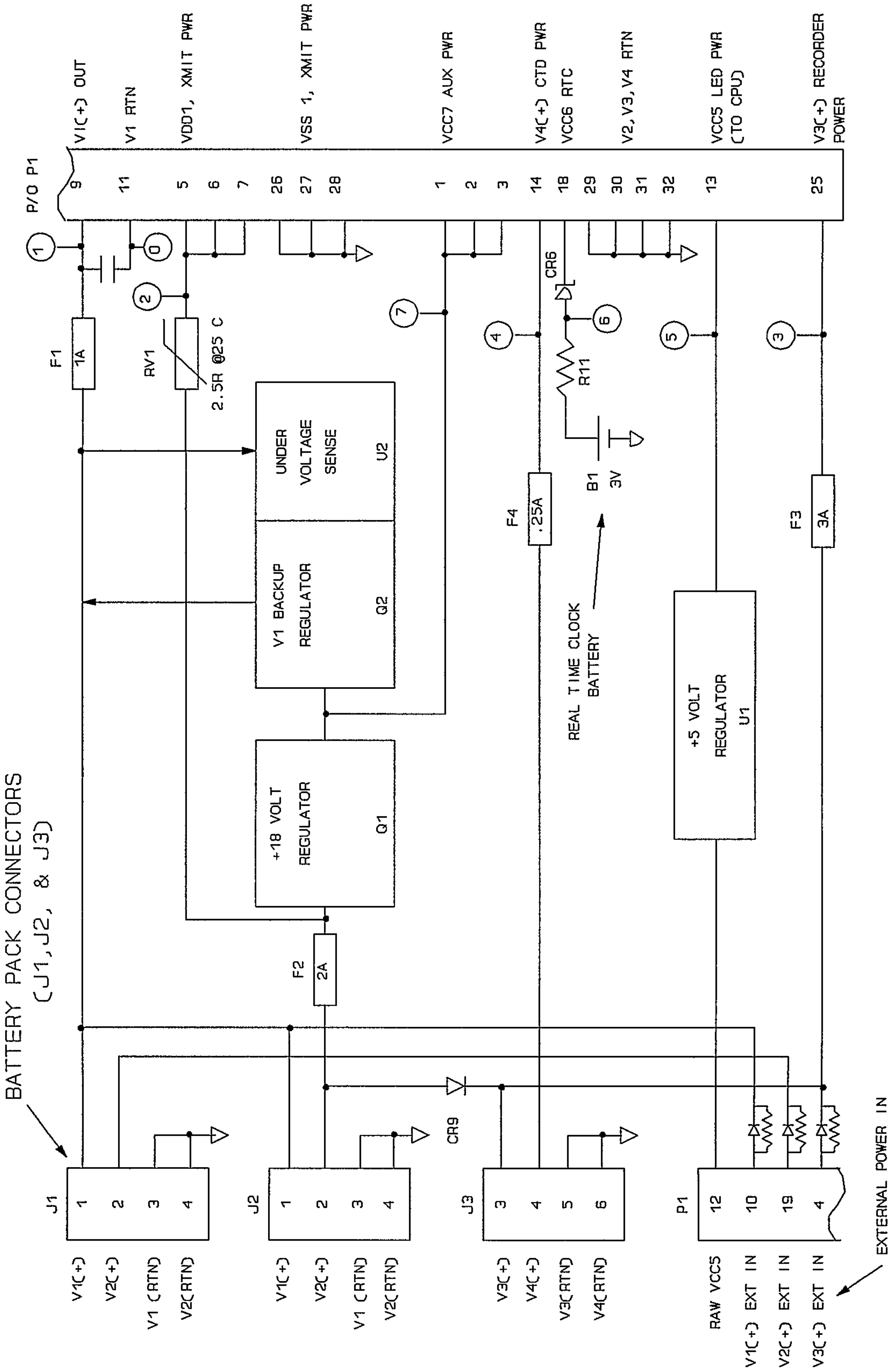


Figure X-17. SC-ADCP DC Power Supply PCB Block Diagram

APPENDIX Y
SC-ADCP PRINTED CIRCUIT BOARD LAYOUTS

Y-0. INTRODUCTION

This appendix contains several figures that show the layout of the major components on the SC-ADCP Printed Circuit Boards (PCBs). The following PCB layouts are in this appendix. In general, they are listed by slot location.

Figure	Description / Location	
Y-1	Transducer Motherboard	Transducer Head
Y-2	Transducer Compensation	
Y-3	Preamplifier (Old)	
Y-4	Preamplifier (New)	
Y-5	Tilt Pendulums [Optional]	
Y-6	KVH Flux Gate Heading Sensor (Compass) [Optional]	
Y-7	Power Amplifier (J2)	Chassis
Y-8	Receiver (J3 through J6)	
Y-9	Power Regulator (J7)	
Y-10	Butterfly (J8)	
Y-11	Peripherals 2 (J9)	
Y-12	Peripherals 1 (J10)	
Y-13	RAM/Multiplier (J11)	
Y-14	CPU (J12)	
Y-15	Peripherals 3 (J13)	
Y-16	CTD Interface (J14) [Optional]	
Y-17	DC Power Supply (J17)	
Y-18	EPROM Recorder Controller (J1)	EPROM Recorder
Y-19	EPROM Recorder Memory (J2 – J21)	

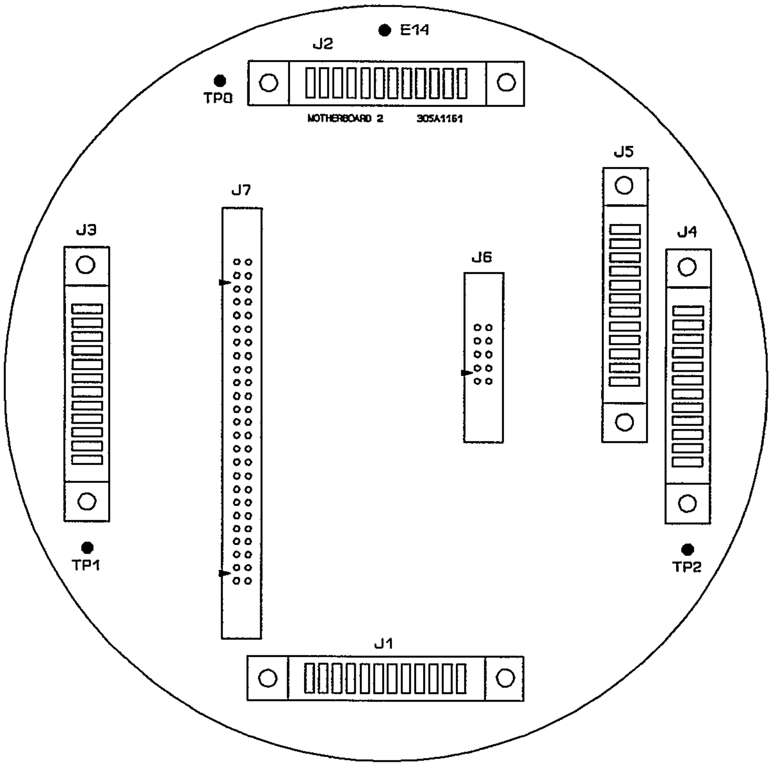


Figure Y-1. Transducer Motherboard PCB Layout

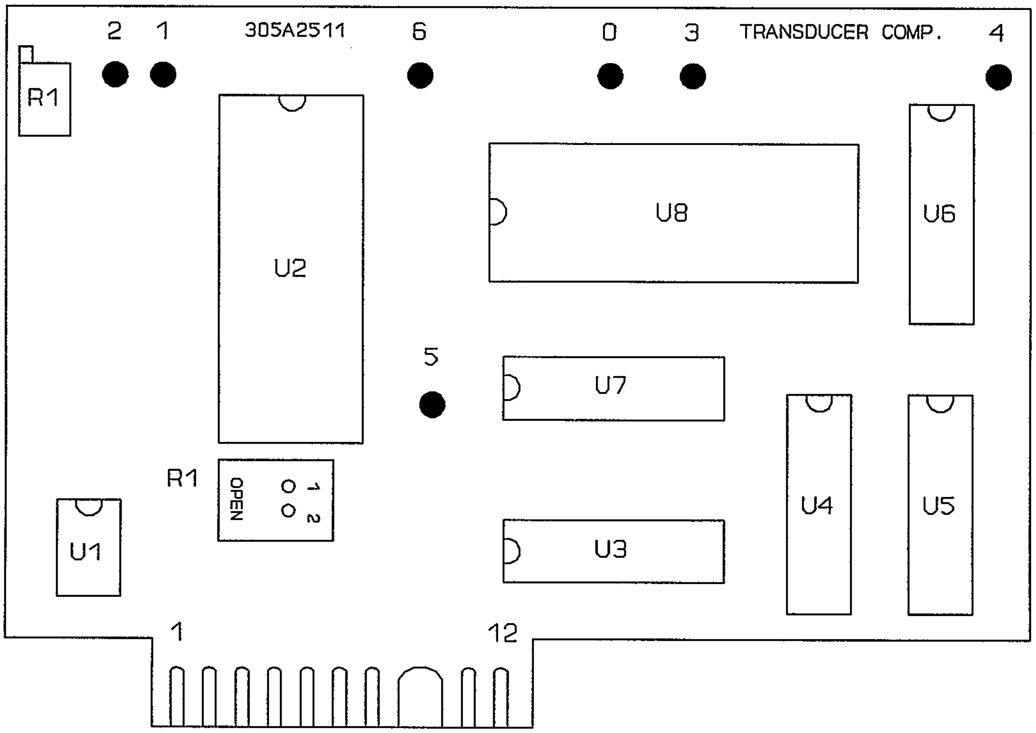


Figure Y-2. Transducer Compensation PCB Layout

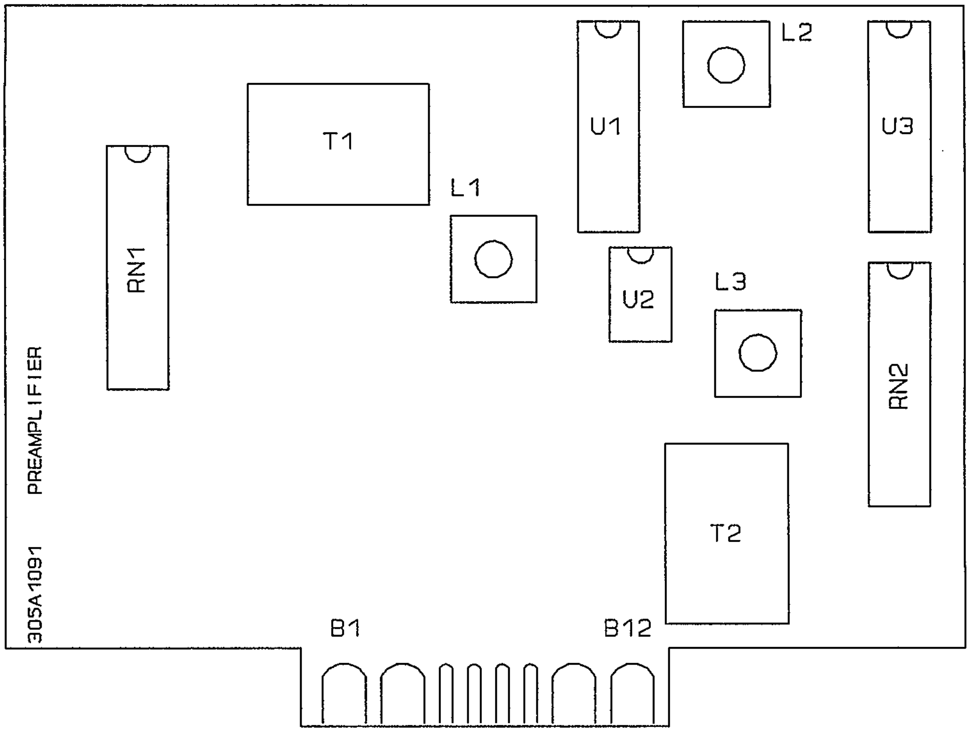


Figure Y-3. Preamplifier PCB Layout (Old)

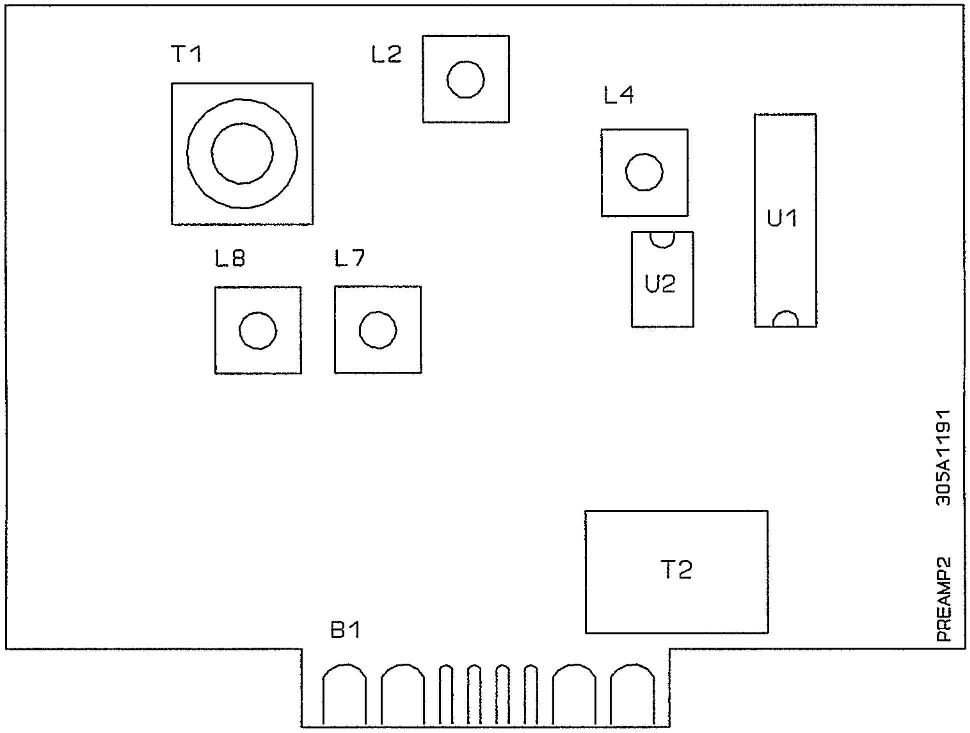
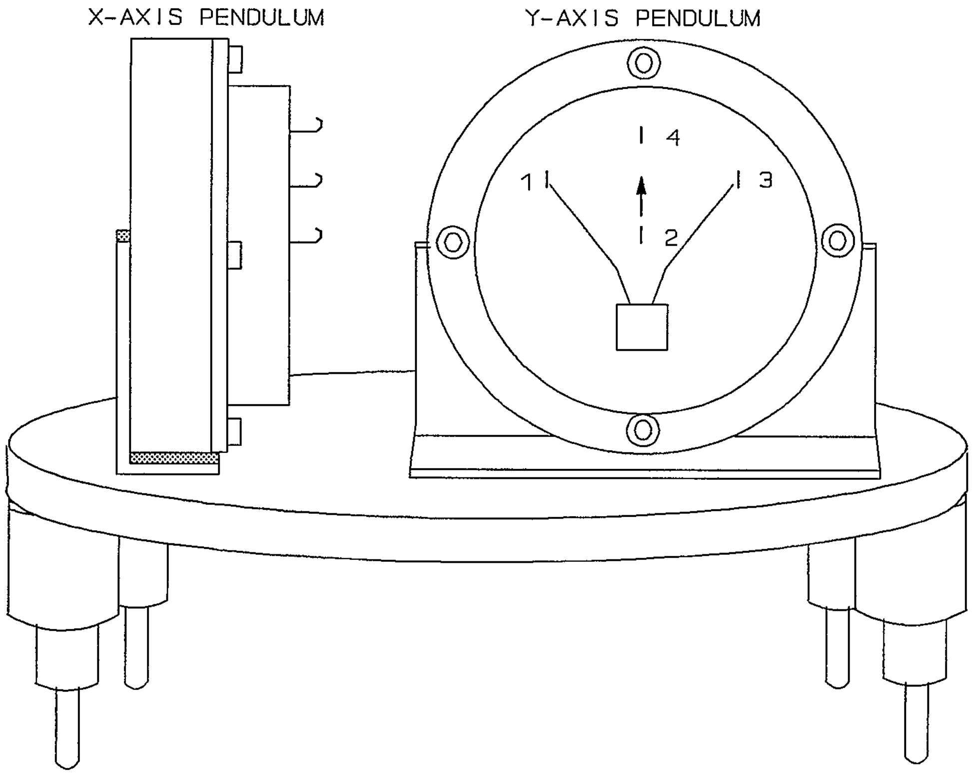


Figure Y-4. Preamplifier PCB Layout (New)



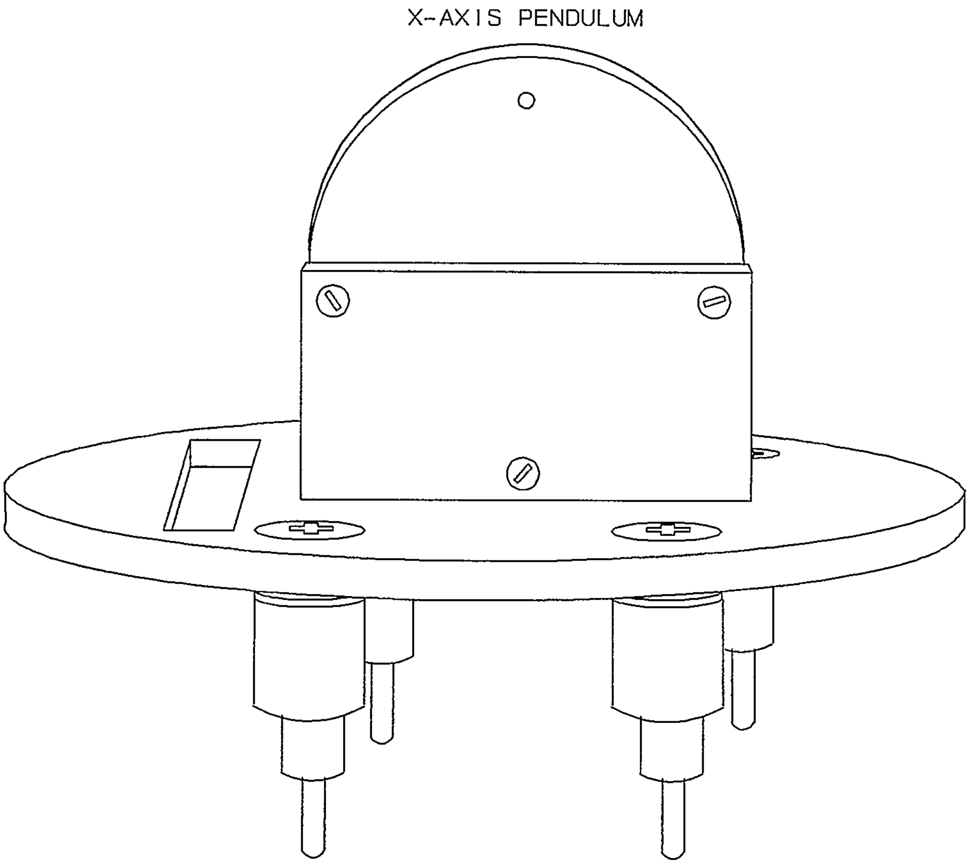


Figure Y-5. Tilt Pendulums PCB Layout (Optional)

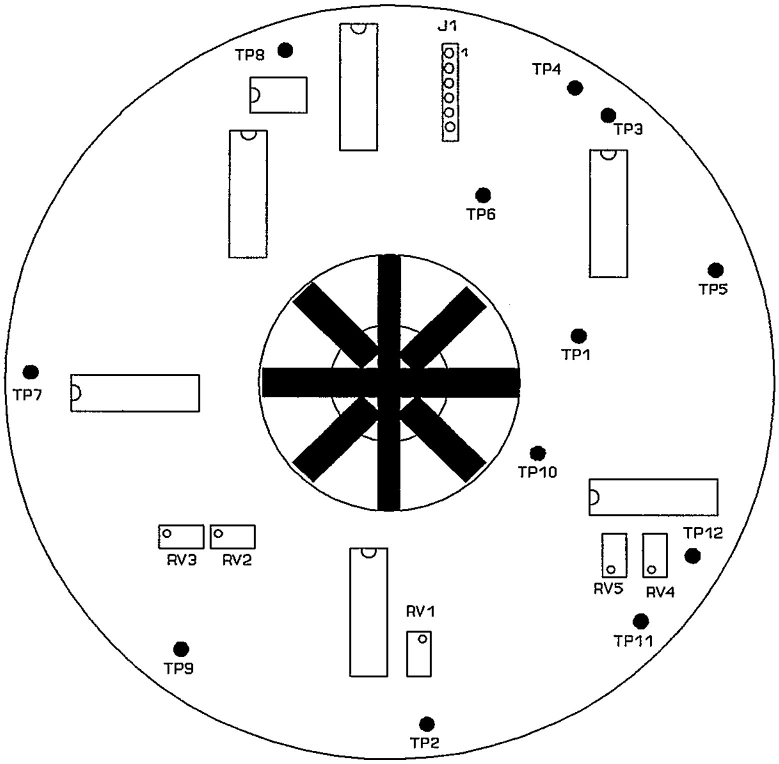


Figure Y-6. KVH Flux Gate Heading Sensor (Compass) PCB Layout (Optional)

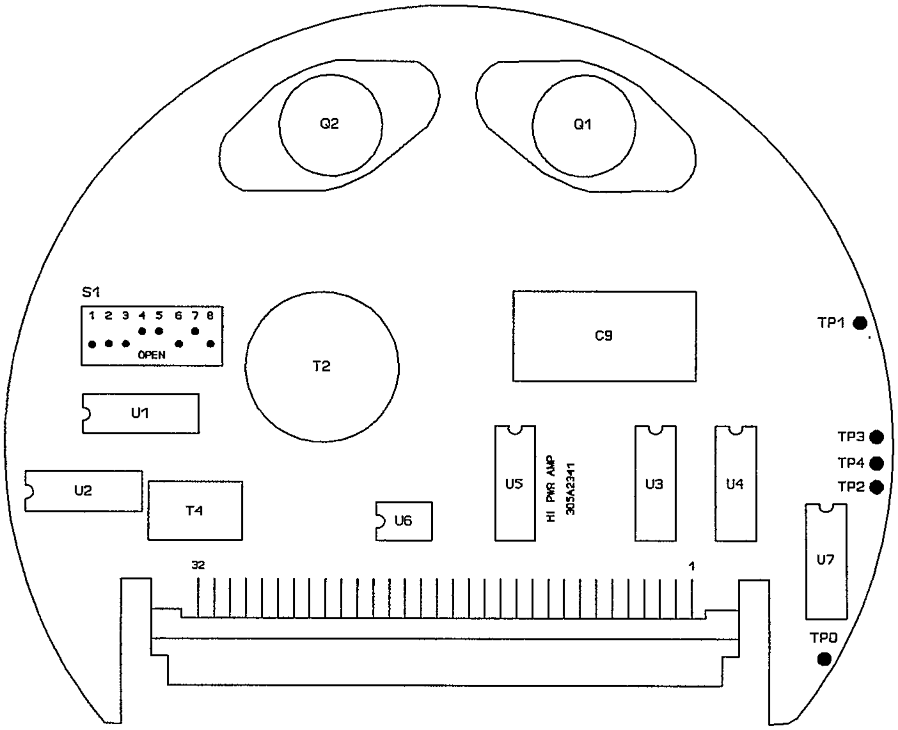


Figure Y-7. Power Amplifier PCB Layout

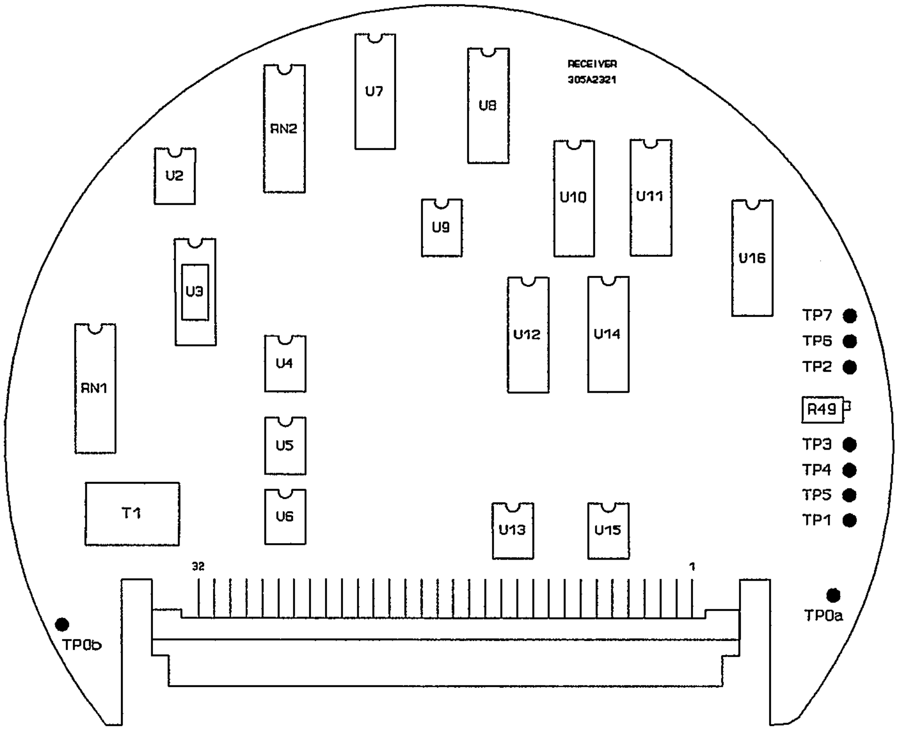


Figure Y-8. Receiver PCB Layout

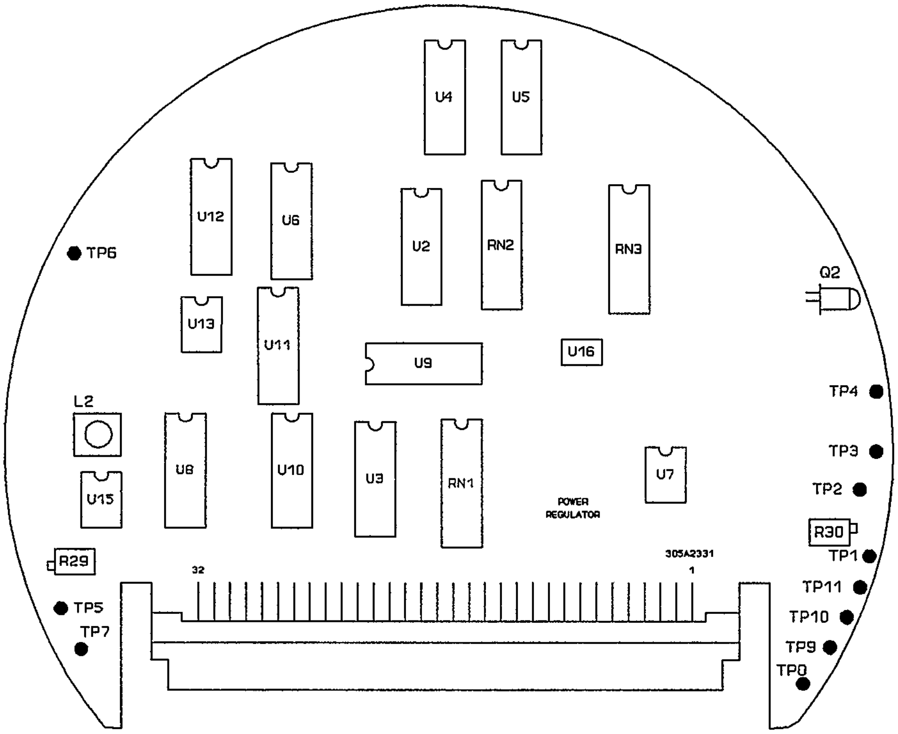


Figure Y-9. Power Regulator PCB Layout

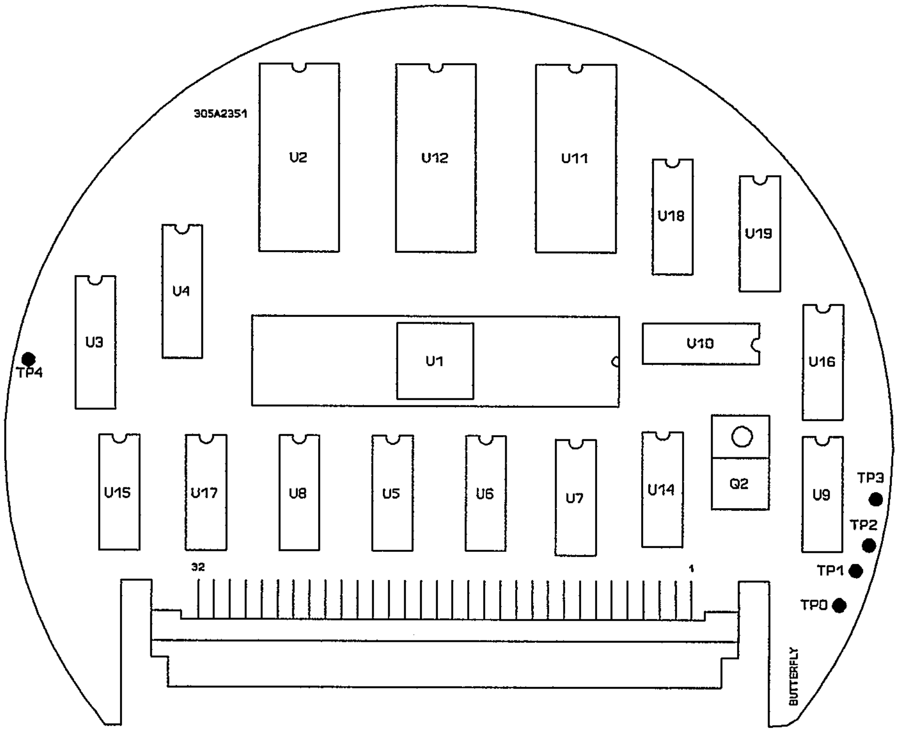


Figure Y-10. Butterfly PCB Layout

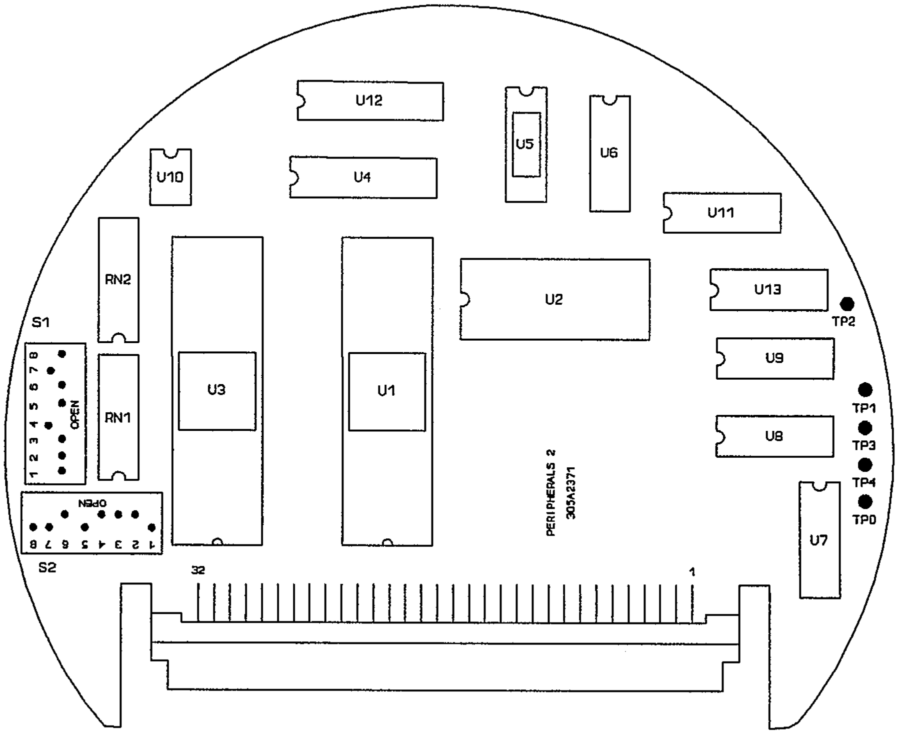


Figure Y-11. Peripherals 2 PCB Layout

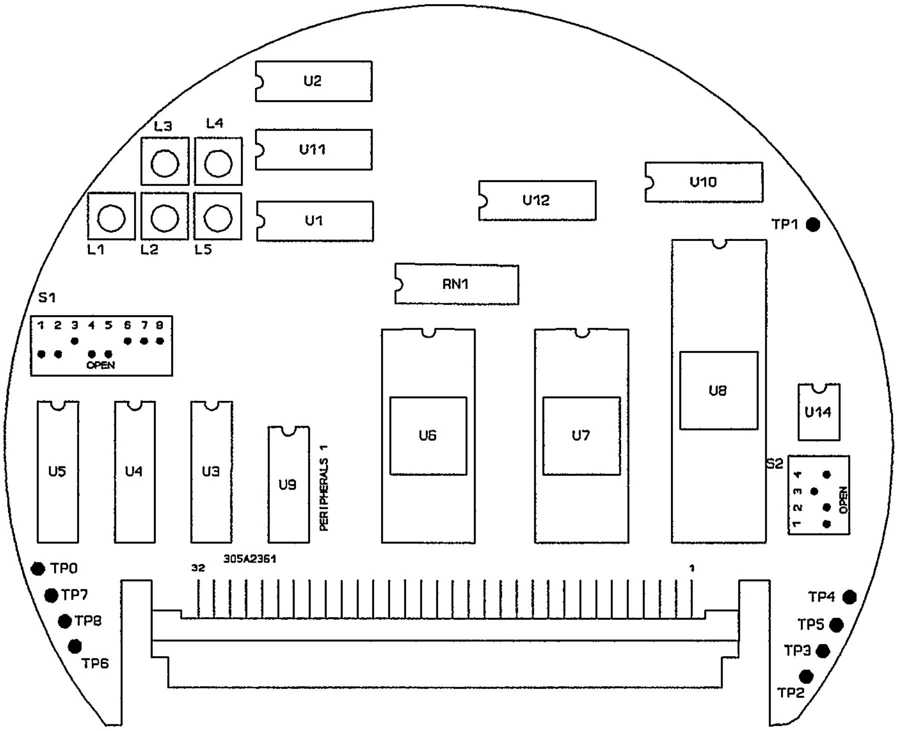


Figure Y-12. Peripherals 1 PCB Layout

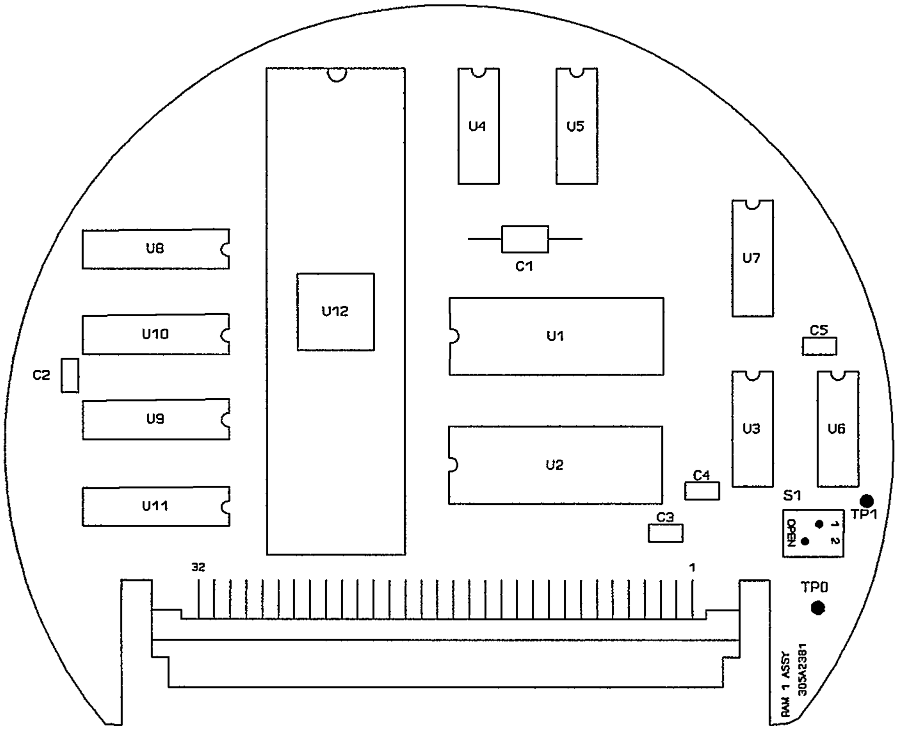


Figure Y-13. RAM/Multiplier PCB Layout

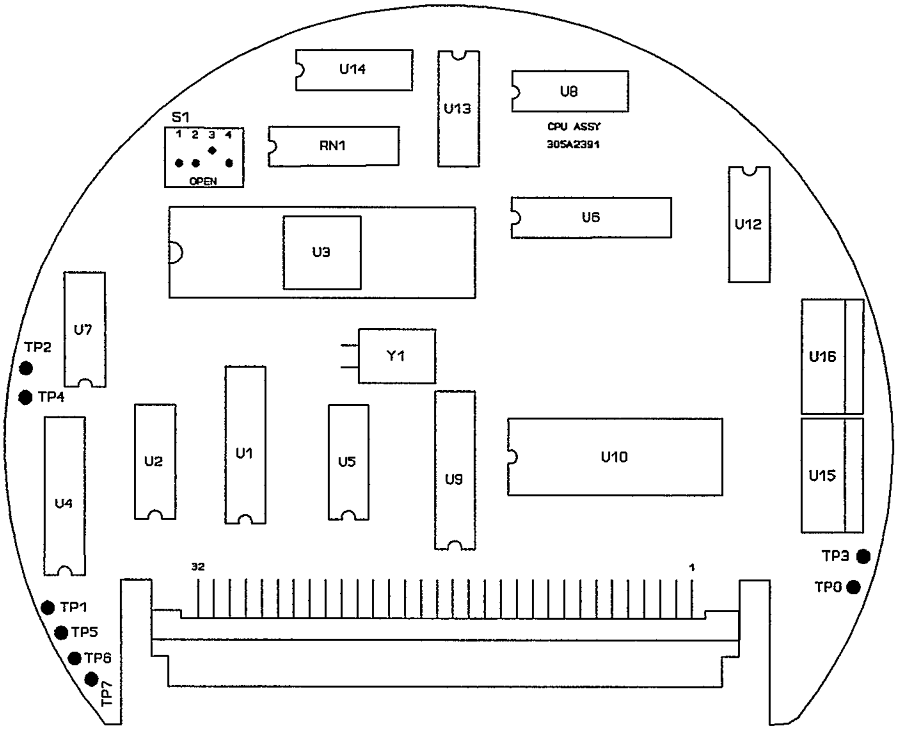


Figure Y-14. CPU PCB Layout

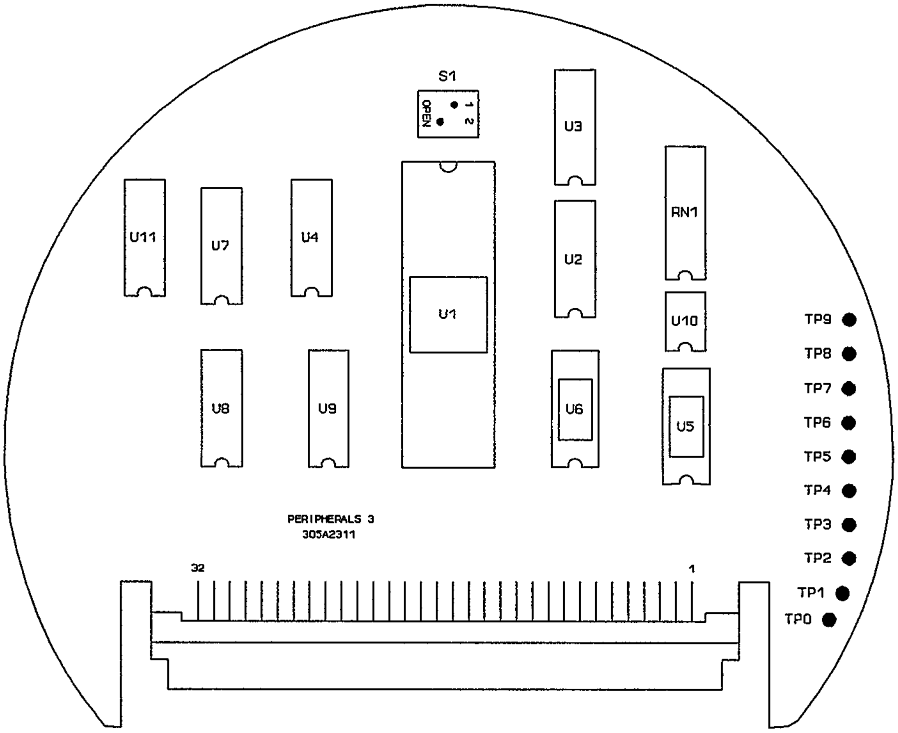


Figure Y-15. Peripherals 3 PCB Layout

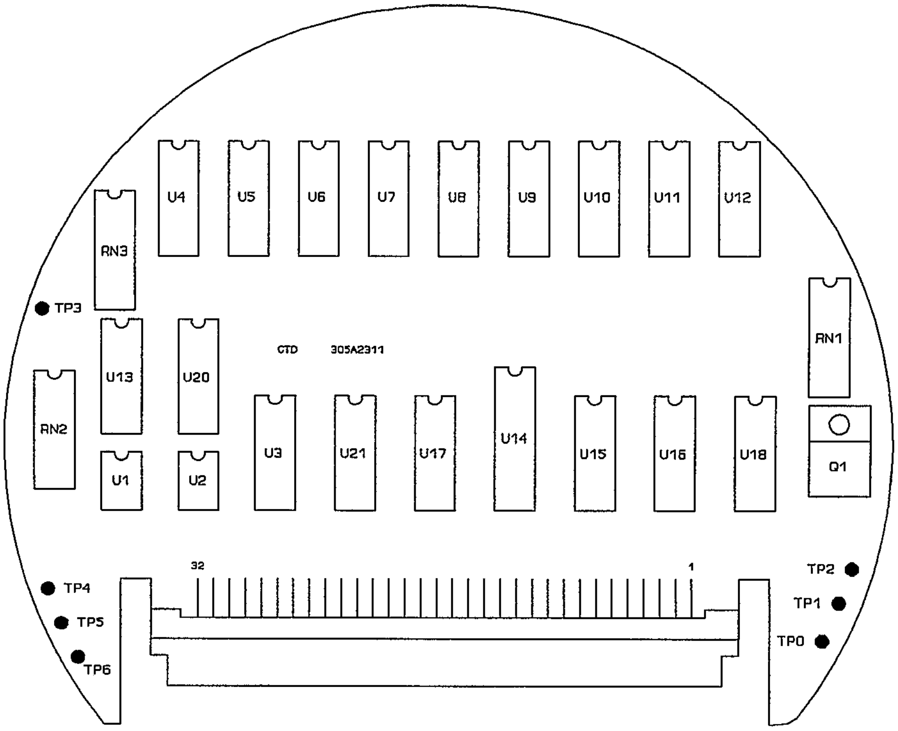


Figure Y-16. CTD PCB Layout (Optional)

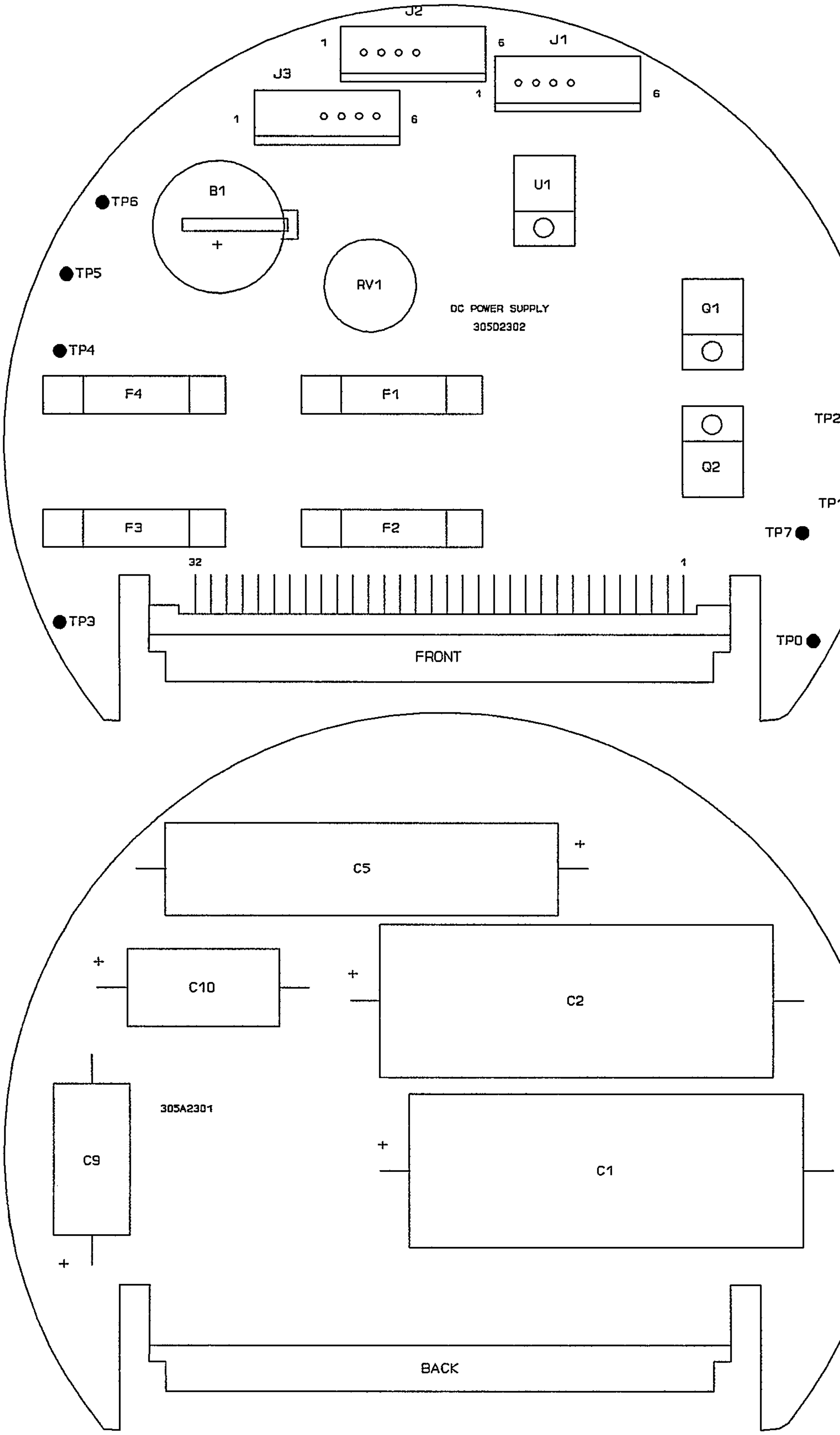


Figure Y-17. DC Power Supply PCB Layout (Front and Back)

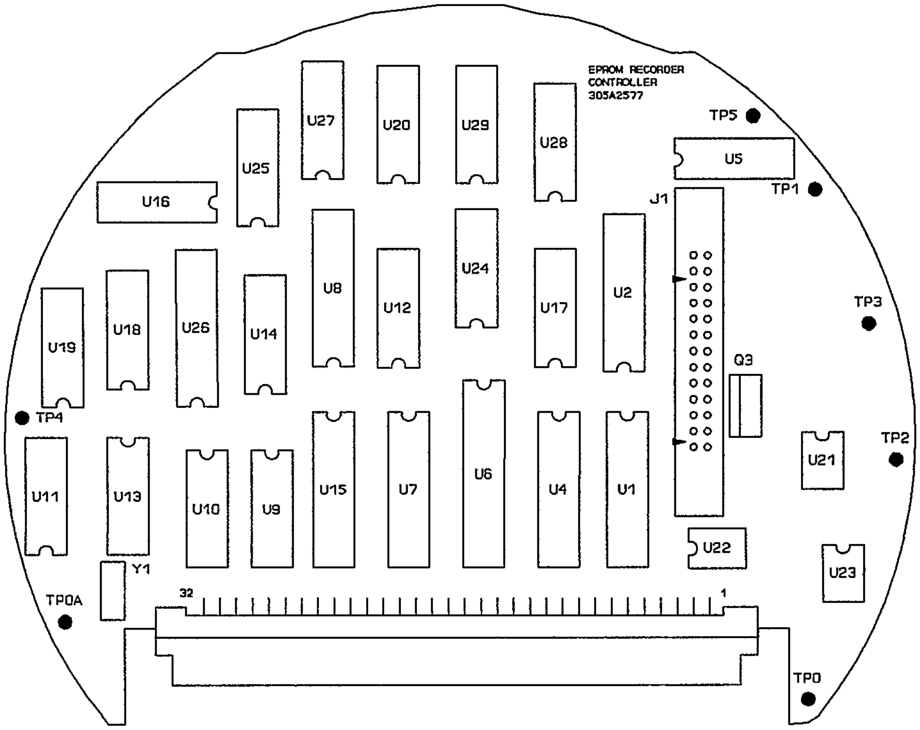


Figure Y-18. EPROM Recorder Controller PCB Layout

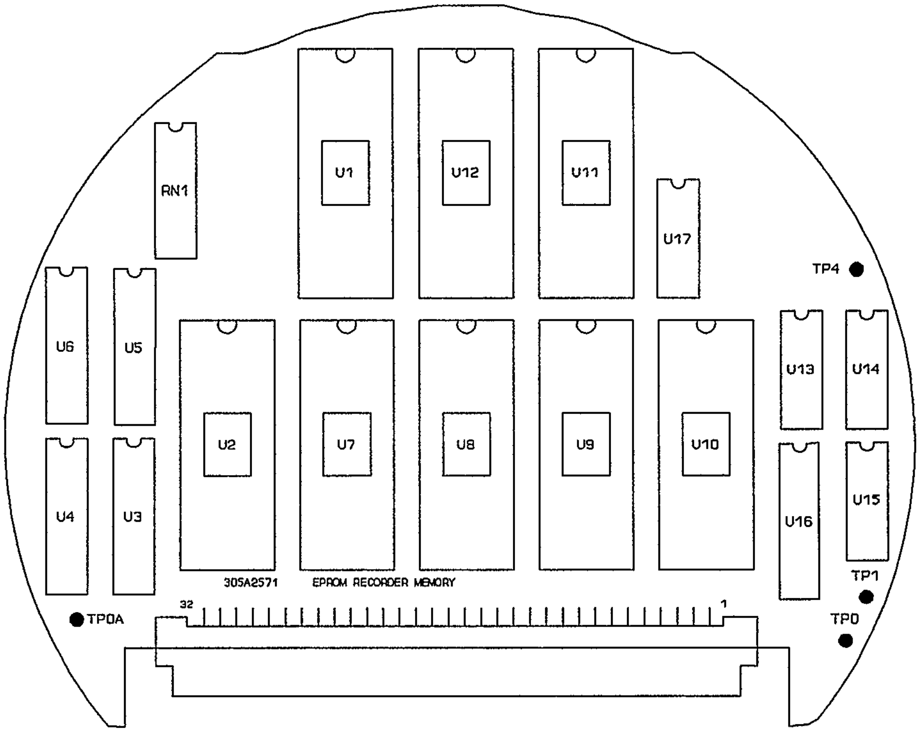


Figure Y-19. EPROM Recorder Memory PCB Layout

APPENDIX Z
SC-ADCP WIRE LIST AND CABLE/CONNECTOR PINOUTS

Z-0. INTRODUCTION

This appendix provides the SC-ADCP internal wiring list and cable/connector pinouts. This list also applies to our DR-ADCPs. We do not guarantee this wiring list to be accurate for all production models. Special user-requests might cause changes to the basic wiring system and might not be reflected here. We provide this list solely as a guide in troubleshooting and repairing the SC-ADCP. If you feel there is a conflict, please contact RDI for specific information about your system.

Z-1. SC-ADCP WIRING LIST

This wiring list is identified as follows.

Description : 305DR/SC-WIRE LIST
Specification: 305P4200
Revision : 21
Item : 1
Date : July 30, 1990

CARD RACK ASSIGNMENT

CONNECTOR	ASSEMBLY
PE	END-BELL CONNECTOR
P1	RECORDER INTERFACE CONNECTOR
P1A	AC POWER 1 ELECTRONICS POWER
P2A	AC POWER 2 POWER AMPLIFIER SUPPLY
J1	TRANSDUCER CONNECTOR
J2	POWER AMPLIFIER
J3	RECEIVER 1
J4	RECEIVER 2
J5	RECEIVER 3
J6	RECEIVER 4
J7	POWER REGULATOR
J8	BUTTERFLY
J9	PERIPHERALS 2
J10	PERIPHERALS 1
J11	RAM/MULTIPLIER
J12	CPU
J13	PERIPHERALS 3
J14	CTD-INTERFACE
J15	S/D-CONVERTER/SWITCH PLUG
J17	POWER SUPPLY, AC OR DC
J18	INPUT/OUTPUT RECEPTACLE
P18	INPUT/OUTPUT PLUG

AC POWER CONNECTIONS

COLOR	AWG	FROM	TO	COMMENT
BLK	22	PE-20	P1A-2	LINE (AC HIGH)
WHT	22	PE-19	P1A-1	LINE (AC LOW)
BLK	22	PE-20	P2A-2	LINE (AC HIGH)
WHT	22	PE-19	P2A-1	LINE (AC LOW)

RIBBON CABLE CONNECTIONS

COLOR	COND#	FROM	TO	COMMENT
BLK	20	P18-20	CHASSIS	CHASSIS
WHT	19	P18-19	CHASSIS	CHASSIS GND
GRA	18	P18-18	PE-18	REC. DATA OUT / RH
VIO	17	P18-17	PE-17	V3 (+), REC. PWR IN / RL
BLU	16	P18-16	PE-16	V2, V3, V4 RTN / S3
GRN	15	P18-15	PE-15	V2 (+), AUX. PWR IN / S2
YEL	14	P18-14	PE-14	V1 RTN, D-GND / S1
ORN	13	P18-13	PE-13	V1 (+), ELECTRONICS PWR IN
RED	12	P18-12	PE-12	V4 (+), CTD-POWER OUT
BRN	11	P18-11	PE-11	TEST OUT 2
BLK	10	P18-10	PE-10	TEST OUT 1
WHT	9	P18-9	PE-9	CTD-RTN
GRA	8	P18-8	PE-8	CTD-PRESSURE
VIO	7	P18-7	PE-7	CTD-TEMPERATURE
BLU	6	P18-6	PE-6	CTD-CONDUCTIVITY
GRN	5	P18-5	PE-5	DATA-GND
YEL	4	P18-4	PE-4	ADCP DATA OUT-B
ORN	3	P18-3	PE-3	ADCP DATA OUT-A
RED	2	P18-2	PE-2	ADCP DATA IN-B
BRN	1	P18-1	PE-1	ADCP DATA IN-A
BRN	21	P18-21	P1-26	AD7
RED	22	P18-22	P1-25	AD6
ORN	23	P18-23	P1-24	AD5
YEL	24	P18-24	P1-23	AD4
GRN	25	P18-25	P1-22	AD3
BLU	26	P18-26	P1-21	AD2
VIO	27	P18-27	P1-20	AD1
GRA	28	P18-28	P1-19	AD0
WHT	29	P18-29	P1-18	VM
BLK	30	P18-30	P1-17	GND
BRN	31	P18-31	P1-16	WR
RED	32	P18-32	P1-15	RD
ORN	33	P18-33	P1-14	A1
YEL	34	P18-34	P1-13	A0
GRN	35	P18-35	P1-12	GND
BLU	36	P18-36	P1-11	DEC0
VIO	37	P18-37	P1-10	VCC1
GRA	38	P18-38	P1-9	RESET
WHT	39	P18-39	P1-8	GND

COLOR	COND#	FROM	TO	COMMENT
BLK	40	P18-40		NC
BRN	41	P18-41		NC
RED	42	P18-42		NC
ORN	43	P18-43		NC
YEL	44	P18-44		NC
GRN	45	P18-45		NC
BLU	46	P18-46		NC
VIO	47	P18-47		NC
GRA	48	P18-48		NC
WHT	49	P18-49		NC
BLK	50	P18-50		NC

WIRE WRAP CONNECTIONS

COLOR	AWG	FROM	TO	COMMENT
GRN	26	J15-C24	J18-14	V1 RTN, D-GND / S1
GRN	26	J15-B24	J18-15	V2 (+), AUX. PWR IN / S2
GRN	26	J15-A24	J18-16	V2, V3, & V4 RTN / S3
GRN	26	J15-B23	J18-17	V3 (+), REC. PWR IN / RL
GRN	26	J15-A23	J18-18	REC. DATA OUT / RH
GRN	26	J2-C26	J1-23	XMIT
GRN	26	J2-C27	J1-24	XMIT-RTN
YELLOW	22	J2-B8,C8	J17-B6,C6	VDD 1, TRANSMIT PWR
GRAY	22	J2-B6,C6	J17-B27,C27	VSS 1, TRANSMIT PWR

WIRING CONNECTIONS

COLOR	AWG	FROM	TO	COMMENT
BLUE	26	J17-A10	J18-13	V1 (+), ELECTR. PWR IN
BLUE	26	J17-B10	J18-13	
BLUE	26	J15-B25	J7-A29	V1 RTN, D-GND
BLUE	26	J15-B25	J7-B29	
BLUE	26	J15-A25	J17-A19	V2 (+), AUX. PWR IN
BLUE	26	J15-A25	J17-B19	
BLUE	26	J17-C19	J7-C9	V2 TO MUX
BLUE	26	J15-A22	J17-A4	V3 (+), REC. PWR IN
BLUE	26	J15-A22	J17-B4	
BLUE	26	J17-A25	J18-49	V3 (+), PWR TO RECORDER
BLUE	26	J17-B25	J18-50	
BLUE	26	J17-A14	J18-12	V4 (+), CTD PWR (+) OUT
BLUE	26	J17-A30	J15-A29	V2, V3, V4 RTN
BLUE	26	J17-B30	J15-C30	
BLUE	26	J17-C30	J18-47	
BLUE	26	J17-A29	J18-48	
BLUE	26	J14-C3	J18-9	CTD-RTN
BLUE	26	J14-C2	J17-C29	CTD-GND
BLUE	26	J7-A12	J17-A9	V1 (+)
BLUE	26	J7-A13	J17-B9	
BLUE	26	J15-A2	J17-C9	

COLOR	AWG	FROM	TO	COMMENT
BLUE	26	J7-A30	J17-A11	V1 RTN
BLUE	26	J7-B30	J17-B11	
BLUE	26	J7-C30	J17-C11	
BLUE	26	J7-A30	J15-C32	
WHT	30	J1-15	J3-A31	AGND
WHT	30	J4-A31	J5-A31	
WHT	30	J3-A31	J4-A31	
WHT	30	J6-A31	J7-A31	
WHT	30	J5-A31	J6-A31	
WHT	30	J8-A31	J9-A31	
WHT	30	J7-A31	J8-A31	
WHT	30	J1-11	J3-B31	
WHT	30	J4-B31	J5-B31	
WHT	30	J3-B31	J4-B31	
WHT	30	J6-B31	J7-B31	
WHT	30	J5-B31	J6-B31	
WHT	30	J7-B31	J8-B31	
WHT	30	J1-39	J3-C31	
WHT	30	J4-C31	J5-C31	
WHT	30	J3-C31	J4-C31	
WHT	30	J6-C31	J7-C31	
WHT	30	J5-C31	J6-C31	
WHT	30	J8-C31	J9-C31	
WHT	30	J7-C31	J8-C31	
WHT	30	J1-50	J9-C31	
WHT	30	J2-A32	J7-A32	DGND
WHT	30	J7-A32	J8-A32	
WHT	30	J9-A32	J10-A32	
WHT	30	J8-A32	J9-A32	
WHT	30	J11-A32	J12-A32	
WHT	30	J10-A32	J11-A32	
WHT	30	J13-A32	J14-A32	
WHT	30	J12-A32	J13-A32	
WHT	30	J2-B32	J7-B32	
WHT	30	J8-B32	J9-B32	
WHT	30	J7-B32	J8-B32	
WHT	30	J10-B32	J11-B32	D-GND
WHT	30	J9-B32	J10-B32	
WHT	30	J12-B32	J13-B32	
WHT	30	J11-B32	J12-B32	
WHT	30	J13-B32	J14-B32	
WHT	30	J2-C32	J7-C32	
WHT	30	J8-C32	J9-C32	
WHT	30	J7-C32	J8-C32	
WHT	30	J10-C32	J11-C32	
WHT	30	J2-C32	J18-39	
WHT	30	J9-C32	J10-C32	
WHT	30	J12-C32	J13-C32	
WHT	30	J11-C32	J12-C32	
WHT	30	J13-C32	J14-C32	
WHT	30	J14-C32	J18-35	
WHT	30	J7-C28	J18-5	DATA COMMON
WHT	30	J18-5	J18-46	

COLOR	AWG	FROM	TO	COMMENT
WHT	30	J18-19	J1-1	CHASSIS GROUND
WHT	30	J18-20	J1-1	
WHT	30	J2-A1	J7-A1	VCC1
WHT	30	J8-A1	J9-A1	
WHT	30	J7-A1	J8-A1	
WHT	30	J10-A1	J11-A1	
WHT	30	J9-A1	J10-A1	
WHT	30	J12-A1	J13-A1	
WHT	30	J11-A1	J12-A1	
WHT	30	J13-A1	J14-A1	
WHT	30	J14-A1	J18-37	
WHT	30	J2-B1	J7-B1	
WHT	30	J8-B1	J9-B1	
WHT	30	J7-B1	J8-B1	
WHT	30	J10-B1	J11-B1	
WHT	30	J9-B1	J10-B1	
WHT	30	J12-B1	J13-B1	
WHT	30	J11-B1	J12-B1	
WHT	30	J13-B1	J14-B1	
WHT	30	J2-C1	J7-C1	
WHT	30	J8-C1	J9-C1	
WHT	30	J7-C1	J8-C1	
WHT	30	J10-C1	J11-C1	
WHT	30	J9-C1	J10-C1	
WHT	30	J12-C1	J13-C1	
WHT	30	J11-C1	J12-C1	
WHT	30	J13-C1	J14-C1	
WHT	30	J3-A1	J4-A1	VCC2
WHT	30	J5-A1	J6-A1	
WHT	30	J4-A1	J5-A1	
WHT	30	J7-A6	J8-A6	
WHT	30	J6-A1	J7-A6	
WHT	30	J1-12	J3-B1	
WHT	30	J4-B1	J5-B1	
WHT	30	J3-B1	J4-B1	
WHT	30	J6-B1	J7-B6	
WHT	30	J5-B1	J6-B1	
WHT	30	J1-40	J3-C1	
WHT	30	J4-C1	J5-C1	
WHT	30	J3-C1	J4-C1	
WHT	30	J6-C1	J7-C6	
WHT	30	J5-C1	J6-C1	
WHT	30	J7-A5	J1-36	VCC3
WHT	30	J10-A5	J11-A5	
WHT	30	J13-A5	J14-A5	
WHT	30	J7-A5	J10-A5	
WHT	30	J11-A5	J13-A5	
WHT	30	J7-A8	J9-A5	VCC4
WHT	30	J11-A8	J14-A8	
WHT	30	J9-A5	J11-A8	
WHT	30	J7-C12	J17-C12	RAW VCC5, BIT LED ON
WHT	30	J7-C13	J17-C13	VCC5, BIT LED ON
BLUE	26	J12-C6	J17-B13	

COLOR	AWG	FROM	TO	COMMENT
BLUE	26	J7-A25	J17-C18	VCC6; BAT +
BLUE	26	J2-A17	J17-A1	VCC7, AUXILIARY PWR +18VDC
BLUE	26	J2-B17	J17-B1	
BLUE	26	J2-C17	J17-C1	
BLUE	26	J7-A10	J17-A3	
BLUE	26	J7-A11	J17-B3	
BLUE	26	J17-A1	J18-29	
BLUE	26	J2-A14	J17-A31	VCC7 RTN
BLUE	26	J2-B14	J17-B31	
BLUE	26	J2-C14	J17-C31	
BLUE	26	J2-A15	J17-A32	
BLUE	26	J2-B15	J17-B32	
BLUE	26	J2-C15	J17-C32	
BLUE	26	J17-C32	J18-30	
WHT	30	J1-38	J3-A7	VREF1 2.46V REF
WHT	30	J4-A7	J5-A7	
WHT	30	J3-A7	J4-A7	
WHT	30	J6-A7	J9-B9	
WHT	30	J5-A7	J6-A7	
WHT	30	J2-A20	J9-B25	TC1 (PREAMP TEST INHIBIT)
WHT	30	J2-A20	J1-32	
WHT	30	J2-A22	J9-B24	TC2 (RCVR TEST INHIBIT)
WHT	30	J2-A23	J1-29	TEST 1
WHT	30	J2-A24	J1-30	TEST 1 COM
WHT	30	J3-A2	J4-A2	PLL REF
WHT	30	J5-A2	J6-A2	
WHT	30	J4-A2	J5-A2	
WHT	30	J6-A2	J10-A27	
WHT	30	J3-A8	J4-A8	AGC CONTROL
WHT	30	J5-A8	J6-A8	
WHT	30	J4-A8	J5-A8	
WHT	30	J6-A8	J9-B2	
WHT	30	J13-B5	J1-4	GAIN SELECT
WHT	30	J3-A14	J4-A14	LPF0/VOLT SEL A
WHT	30	J5-A14	J6-A14	
WHT	30	J4-A14	J5-A14	
WHT	30	J7-B24	J9-B28	
WHT	30	J6-A14	J7-B24	
WHT	30	J3-A16	J4-A16	LPF1/VOLT SEL B
WHT	30	J5-A16	J6-A16	
WHT	30	J4-A16	J5-A16	
WHT	30	J7-B25	J9-B27	
WHT	30	J6-A16	J7-B25	
WHT	30	J3-A17	J4-A17	BLANK
WHT	30	J5-A17	J6-A17	
WHT	30	J4-A17	J5-A17	
WHT	30	J6-A17	J7-A20	
WHT	30	J2-A21	J3-A27	TEST 2
WHT	30	J4-A27	J5-A27	
WHT	30	J3-A27	J4-A27	
WHT	30	J5-A27	J6-A27	

COLOR	AWG	FROM	TO	COMMENT
WHT	30	J3-A28	J4-A28	LO1
WHT	30	J5-A28	J6-A28	
WHT	30	J4-A28	J5-A28	
WHT	30	J9-A22	J10-A22	
WHT	30	J6-A28	J9-A22	
WHT	30	J3-A4	J9-B6	FD1 > F1
WHT	30	J3-A5	J9-A6	F1
WHT	30	J3-A10	J8-A21	COS D1
WHT	30	J3-A13	J8-A20	SIN D1
WHT	30	J3-A12	J13-C21	SIN D1 TEST
WHT	30	J3-A22	J1-43	AGC 1
WHT	30	J3-A24	J9-B29	LOG AGC 1
WHT	30	J3-A23	J13-C29	LOG AGC 1 TEST
WHT	30	J3-A30	J1-48	RCVR 1 COM
WHT	30	J3-B30	J1-49	RCVR 1 SIG
WHT	30	J4-A4	J9-B7	FD2 > F2
WHT	30	J4-A5	J9-A7	F2
WHT	30	J4-A10	J8-A23	COS D2
WHT	30	J4-A13	J8-A22	SIN D2
WHT	30	J4-A12	J13-C20	SIN D2 TEST
WHT	30	J4-A22	J1-8	AGC 2
WHT	30	J4-A24	J9-B30	LOG AGC 2
WHT	30	J4-A23	J13-C28	LOG AGC 2 TEST
WHT	30	J4-A30	J1-3	RCVR 2 COM
WHT	30	J4-B30	J1-2	RCVR 2 SIG
WHT	30	J5-A4	J9-B20	FD3 > F3
WHT	30	J5-A5	J9-A30	F3
WHT	30	J5-A10	J8-A25	COS D3
WHT	30	J5-A13	J8-A24	SIN D3
WHT	30	J5-A12	J13-C19	SIN D3 TEST
WHT	30	J5-A22	J1-9	AGC 3
WHT	30	J5-A24	J9-B31	LOG AGC 3
WHT	30	J5-A23	J13-C27	LOG AGC 3 TEST
WHT	30	J5-A30	J1-6	RCVR 3 COM
WHT	30	J5-B30	J1-5	RCVR 3 SIG
WHT	30	J6-A4	J9-B19	FD4 > F4
WHT	30	J6-A5	J9-A8	F4
WHT	30	J6-A10	J8-A27	COS D4
WHT	30	J6-A13	J8-A26	SIN D4
WHT	30	J6-A12	J13-C18	SIN D4 TEST
WHT	30	J6-A22	J1-42	AGC 4
WHT	30	J6-A24	J9-C2	LOG AGC 4
WHT	30	J6-A23	J13-C26	LOG AGC 4 TEST
WHT	30	J6-A30	J1-45	RCVR 4 COM
WHT	30	J6-B30	J1-46	RCVR 4 SIG
WHT	30	J7-A9	J8-A9	CLOCK
WHT	30	J9-A9	J10-A9	
WHT	30	J8-A9	J9-A9	
WHT	30	J11-A9	J12-A9	
WHT	30	J10-A9	J11-A9	
WHT	30	J13-A9	J14-A9	
WHT	30	J12-A9	J13-A9	
WHT	30	J11-C9	J12-C9	CLK 1

COLOR	AWG	FROM	TO	COMMENT
WHT	30	J7-B3	J9-B3	RESET
WHT	30	J10-B3	J11-B3	
WHT	30	J9-B3	J10-B3	
WHT	30	J12-B3	J13-B3	
WHT	30	J11-B3	J12-B3	
WHT	30	J13-B3	J14-B3	
WHT	30	J14-B3	J18-38	
WHT	30	J8-A19	J9-A19	READY
WHT	30	J9-A19	J12-B5	
WHT	30	J7-A28	J8-A28	$\overline{\text{WR}}$
WHT	30	J9-A28	J10-A28	
WHT	30	J8-A28	J9-A28	
WHT	30	J11-A28	J12-A28	
WHT	30	J10-A28	J11-A28	
WHT	30	J13-A28	J14-A28	
WHT	30	J12-A28	J13-A28	
WHT	30	J14-A28	J15-A28	
WHT	30	J15-A28	J18-31	
WHT	30	J8-A29	J9-A29	$\overline{\text{RD}}$
WHT	30	J11-A29	J12-A29	
WHT	30	J9-A29	J11-A29	
WHT	30	J13-A29	J14-A29	
WHT	30	J12-A29	J13-A29	
WHT	30	J14-A29	J15-A3	
WHT	30	J15-A3	J18-32	
WHT	30	J10-B4	J12-B4	$\overline{\text{RD-WR}}$
WHT	30	J9-A26	J12-A26	ALE
WHT	30	J13-A26	J15-C6	
WHT	30	J12-A26	J13-A26	
WHT	30	J12-A27	J14-A27	IO/$\overline{\text{M}}$
WHT	30	J7-B10	J9-B10	A0
WHT	30	J10-B10	J11-B10	
WHT	30	J9-B10	J10-B10	
WHT	30	J12-B10	J13-B10	
WHT	30	J11-B10	J12-B10	
WHT	30	J14-B10	J15-B10	
WHT	30	J13-B10	J14-B10	
WHT	30	J15-B10	J18-34	
WHT	30	J7-B11	J9-B11	A1
WHT	30	J10-B11	J11-B11	
WHT	30	J9-B11	J10-B11	
WHT	30	J12-B11	J13-B11	
WHT	30	J11-B11	J12-B11	
WHT	30	J14-B11	J15-B11	
WHT	30	J13-B11	J14-B11	
WHT	30	J15-B11	J18-33	
WHT	30	J7-B12	J9-B12	A2
WHT	30	J10-B12	J11-B12	
WHT	30	J9-B12	J10-B12	
WHT	30	J12-B12	J13-B12	
WHT	30	J11-B12	J12-B12	
WHT	30	J14-B12	J15-B12	
WHT	30	J13-B12	J14-B12	

COLOR	AWG	FROM	TO	COMMENT
WHT	30	J7-B13	J9-B13	A3
WHT	30	J10-B13	J11-B13	
WHT	30	J9-B13	J10-B13	
WHT	30	J12-B13	J13-B13	
WHT	30	J11-B13	J12-B13	
WHT	30	J14-B13	J15-B13	
WHT	30	J13-B13	J14-B13	
WHT	30	J7-B14	J9-B14	A4
WHT	30	J10-B14	J11-B14	
WHT	30	J9-B14	J10-B14	
WHT	30	J12-B14	J13-B14	
WHT	30	J11-B14	J12-B14	
WHT	30	J14-B14	J15-B14	
WHT	30	J13-B14	J14-B14	
WHT	30	J7-B15	J9-B15	A5
WHT	30	J10-B15	J11-B15	
WHT	30	J9-B15	J10-B15	
WHT	30	J12-B15	J13-B15	
WHT	30	J11-B15	J12-B15	
WHT	30	J14-B15	J15-B15	
WHT	30	J13-B15	J14-B15	
WHT	30	J9-B16	J10-B16	A6
WHT	30	J11-B16	J12-B16	
WHT	30	J10-B16	J11-B16	
WHT	30	J9-B17	J10-B17	A7
WHT	30	J11-B17	J12-B17	
WHT	30	J10-B17	J11-B17	
WHT	30	J9-B18	J11-B18	A8
WHT	30	J11-B18	J12-B18	
WHT	30	J11-B19	J12-B19	A9
WHT	30	J11-B20	J12-B20	A10
WHT	30	J11-B21	J12-B21	A11
WHT	30	J11-B22	J12-B22	A12
WHT	30	J11-B23	J12-B23	A13
WHT	30	J8-A10	J9-A10	AD0
WHT	30	J10-A10	J11-A10	
WHT	30	J9-A10	J10-A10	
WHT	30	J12-A10	J13-A10	
WHT	30	J11-A10	J12-A10	
WHT	30	J14-A10	J15-A10	
WHT	30	J13-A10	J14-A10	
WHT	30	J15-A10	J18-28	
WHT	30	J8-A11	J9-A11	AD1
WHT	30	J10-A11	J11-A11	
WHT	30	J9-A11	J10-A11	
WHT	30	J12-A11	J13-A11	
WHT	30	J11-A11	J12-A11	
WHT	30	J14-A11	J15-A11	
WHT	30	J13-A11	J14-A11	
WHT	30	J15-A11	J18-27	

COLOR	AWG	FROM	TO	COMMENT
WHT	30	J8-A12	J9-A12	AD2
WHT	30	J10-A12	J11-A12	
WHT	30	J9-A12	J10-A12	
WHT	30	J12-A12	J13-A12	
WHT	30	J11-A12	J12-A12	
WHT	30	J14-A12	J15-A12	
WHT	30	J13-A12	J14-A12	
WHT	30	J15-A12	J18-26	
WHT	30	J8-A13	J9-A13	AD3
WHT	30	J10-A13	J11-A13	
WHT	30	J9-A13	J10-A13	
WHT	30	J12-A13	J13-A13	
WHT	30	J11-A13	J12-A13	
WHT	30	J14-A13	J15-A13	
WHT	30	J13-A13	J14-A13	
WHT	30	J15-A13	J18-25	
WHT	30	J8-A14	J9-A14	AD4
WHT	30	J10-A14	J11-A14	
WHT	30	J9-A14	J10-A14	
WHT	30	J12-A14	J13-A14	
WHT	30	J11-A14	J12-A14	
WHT	30	J14-A14	J15-A14	
WHT	30	J13-A14	J14-A14	
WHT	30	J15-A14	J18-24	
WHT	30	J8-A15	J9-A15	AD5
WHT	30	J10-A15	J11-A15	
WHT	30	J9-A15	J10-A15	
WHT	30	J12-A15	J13-A15	
WHT	30	J11-A15	J12-A15	
WHT	30	J14-A15	J15-A15	
WHT	30	J13-A15	J14-A15	
WHT	30	J15-A15	J18-23	
WHT	30	J8-A16	J9-A16	AD6
WHT	30	J10-A16	J11-A16	
WHT	30	J9-A16	J10-A16	
WHT	30	J12-A16	J13-A16	
WHT	30	J11-A16	J12-A16	
WHT	30	J14-A16	J15-A16	
WHT	30	J13-A16	J14-A16	
WHT	30	J15-A16	J18-22	
WHT	30	J8-A17	J9-A17	AD7
WHT	30	J10-A17	J11-A17	
WHT	30	J9-A17	J10-A17	
WHT	30	J12-A17	J13-A17	
WHT	30	J11-A17	J12-A17	
WHT	30	J14-A17	J15-A17	
WHT	30	J13-A17	J14-A17	
WHT	30	J15-A17	J18-21	
WHT	30	J7-B27	J12-B27	DD00
WHT	30	J8-B26	J12-B26	$\overline{\text{DC00}}$
WHT	30	J9-A18	J12-A18	$\overline{\text{C000}}$-$\overline{\text{E000}}$
WHT	30	J10-B28	J12-B28	$\overline{\text{DE00}}$
WHT	30	J10-C19	J13-B28	$\overline{\text{DE80}}$ (1.2 MB-TAPE, BT MONITOR)

COLOR	AWG	FROM	TO	COMMENT
WHT	30	J10-C18	J18-36	$\overline{\text{DECO}}$
WHT	30	J11-A19	J12-A19	$\overline{\text{C400}}$
WHT	30	J11-A25	J12-A25	$\overline{\text{8000}}$-$\overline{\text{BFFF}}$
WHT	30	J12-A23	J14-A23	$\overline{\text{F400}}$
WHT	30	J12-A24	J13-A24	$\overline{\text{F800}}$ COMPASS, S/D-CONV.
WHT	30	J15-C3	J13-A24	
WHT	30	J10-B6	J12-B6	$\overline{\text{DATA}}$
WHT	30	J10-C4	J12-C4	$\overline{\text{UART}}$ $\overline{\text{INT}}$
WHT	30	J8-B6	J10-A23	BUTFLY STROBE
WHT	30	J8-C3	J12-C3	$\overline{\text{BUTFLY}}$ $\overline{\text{INT}}$
WHT	30	J7-A23	J9-A23	XMIT CLOCK INHIBIT
WHT	30	J2-A3	J7-A18	MEM EN 1
WHT	30	J11-A18	J13-A18	
WHT	30	J7-A18	J11-A18	
WHT	30	J14-A18	J15-A7	
WHT	30	J13-A18	J14-A18	
WHT	30	J7-A19	J9-A25	MEM EN 2
WHT	30	J9-A25	J14-A25	
WHT	30	J6-C21	J7-A21	TRANSMIT
WHT	30	J4-C21	J5-C21	
WHT	30	J5-C21	J6-C21	
WHT	30	J2-A12	J3-C21	
WHT	30	J3-C21	J4-C21	
WHT	30	J7-A24	J9-A24	WAKE UP
WHT	30	J14-A24	J10-A24	
WHT	30	J9-A24	J10-A24	
WHT	30	J7-A26	J10-A26	FV
WHT	30	J7-B26	J9-B26	VOLT SEL C
WHT	30	J7-C2	J12-C2	$\overline{\text{PWR}}$ $\overline{\text{FAIL}}$
WHT	30	J7-A7	J12-A7	VCC1 ON
WHT	30	J7-C5	J10-C5	VCC2 ON
WHT	30	J7-C7	J9-C7	DC VOLTAGES
WHT	30	J2-A4	J9-C8	XMIT CURRENT
WHT	30	J2-A29	J9-B21	FREQ C
WHT	30	J2-A30	J9-B22	FREQ B
WHT	30	J2-A31	J9-B23	FREQ A
WHT	30	J2-A2	J7-A27	CLK 2
WHT	30	J9-A27	J10-A4	
WHT	30	J7-A27	J9-A27	
WHT	30	J9-C28	J14-C28	CLK 3
WHT	30	J9-A20	J9-A21	SERIAL DATA CLOCK
WHT	30	J1-16	J9-A21	
WHT	30	J9-B4	J1-17	SERIAL DATA
WHT	30	J9-B5	J1-18	SERIAL DATA RESET
WHT	30	J10-A7	J17-C15	RS-232/422
WHT	30	J10-A18	J18-3	DATA OUT A
WHT	30	J10-A19	J18-4	DATA OUT B
WHT	30	J18-4	J18-44	RECORDER DATA IN
WHT	30	J10-A20	J18-1	DATA IN A
WHT	30	J10-A21	J18-2	DATA IN B
WHT	30	J9-C3	J1-13	TEMP
WHT	30	J9-C4	J1-35	TILT 1 (X)
WHT	30	J9-C5	J1-37	TILT 2 (Y)

COLOR	AWG	FROM	TO	COMMENT
WHT	30	J13-C12	J1-34	400 HZ
WHT	30	J13-C13	J1-33	HEADING ENABLE
WHT	30	J13-C14	J1-31	HEADING OUT
WHT	30	J13-C31	J18-10	TEST OUT 1
WHT	30	J13-B22	J18-11	TEST OUT 2
WHT	30	J14-C25	J18-6	CTD-CONDUCTIVITY
WHT	30	J14-C26	J18-7	CTD-TEMPERATURE
WHT	30	J14-C27	J18-8	CTD-PRESSURE
WHT	30	J15-C22	J18-45	REC. DATA OUT
WHT	30	J13-C6	J18-43	RECORDER READY
WHT	30	J13-C7	J18-42	RECORDER CYCLE

Z-2. SC-ADCP CABLE/CONNECTOR PINOUTS

The following figures show SC-ADCP cable/connector pinouts.

P1	P2		CONNECTIONS FOR A			
			20-WIRE CABLE	10-WIRE CABLE	7-WIRE CABLE	5-WIRE CABLE
1	K	ADCP DATA IN - A	*	*	*	
2	A	ADCP DATA IN - B	*	*	*	*
3	J	ADCP DATA OUT - A	*	*	*	
4	B	ADCP DATA OUT - B	*	*	*	*
5	L	ADCP DATA GND	*	*	*	*
6	C	CTD - CONDUCTIVITY IN	*			
7	E	CTD - TEMPERATURE IN	*			
8	H	CTD - PRESSURE IN	*			
9	U	CTD GND	*			
10	M	TEST OUT 1	*	*		
11	N	TEST OUT 2	*	*		
12	S	V4 (CTD PWR)	*			
13	F	V1	*			
14	G	V1 GND	*	*		
15	P	V2	*			
16	T	GND	*			
17	R	V3	*			
18	D	RECORDER DATA OUT	*			
19	r	AC-PWR LO	*	*	*	*
20	t	AC-PWR HI	*	*	*	*

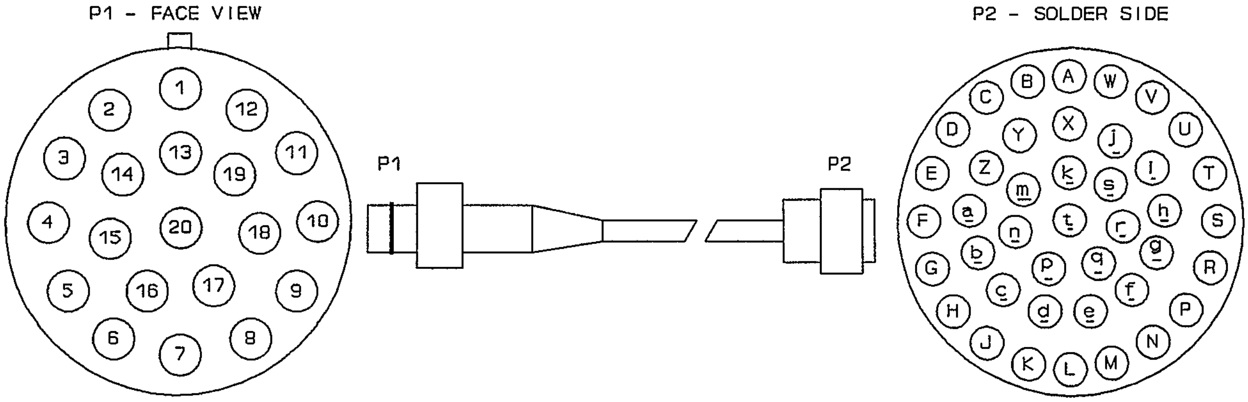


Figure Z-1. SC-ADCP to J-Box Cable Pinouts

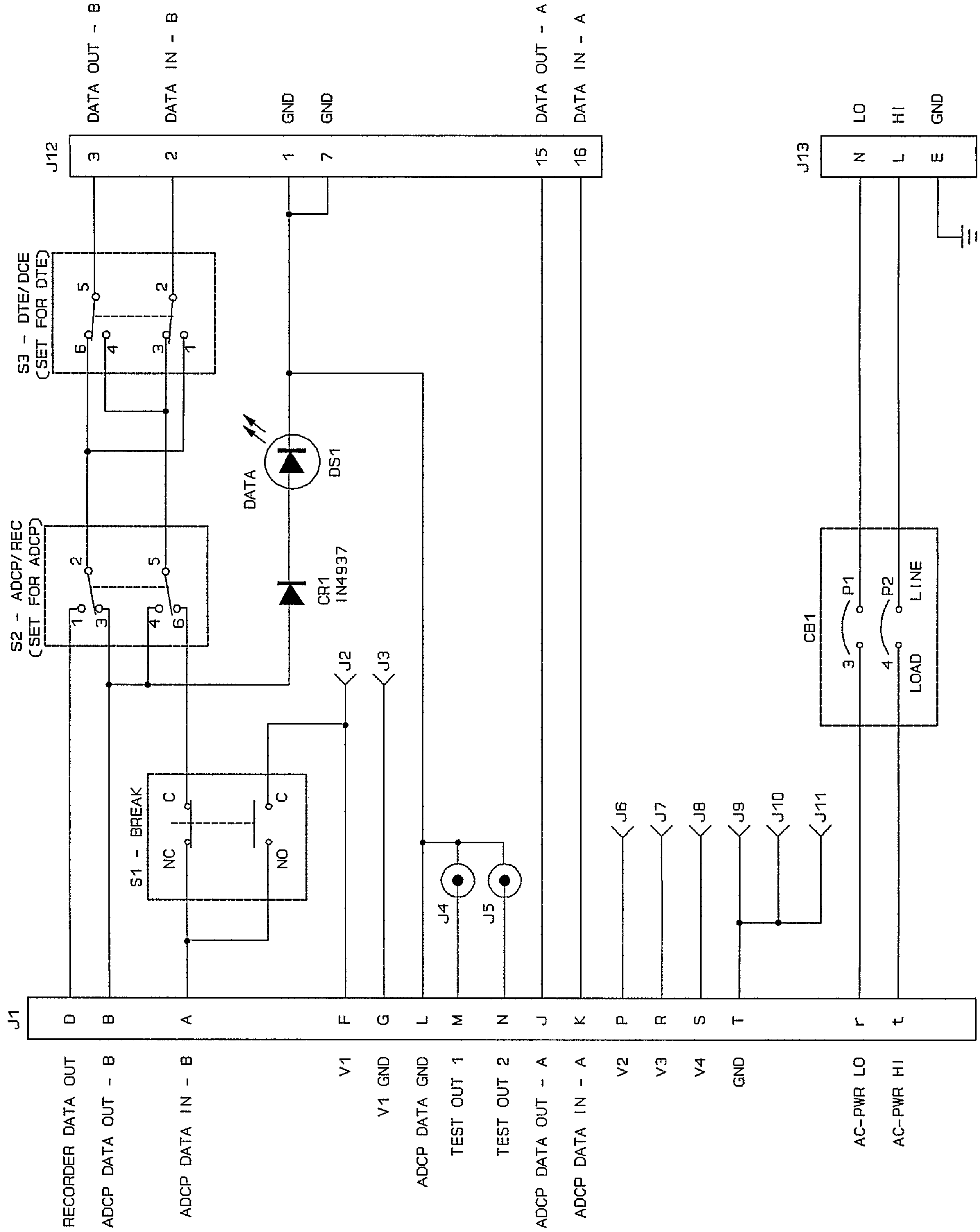


Figure Z-2. SC-ADCP J-Box Wiring Schematic

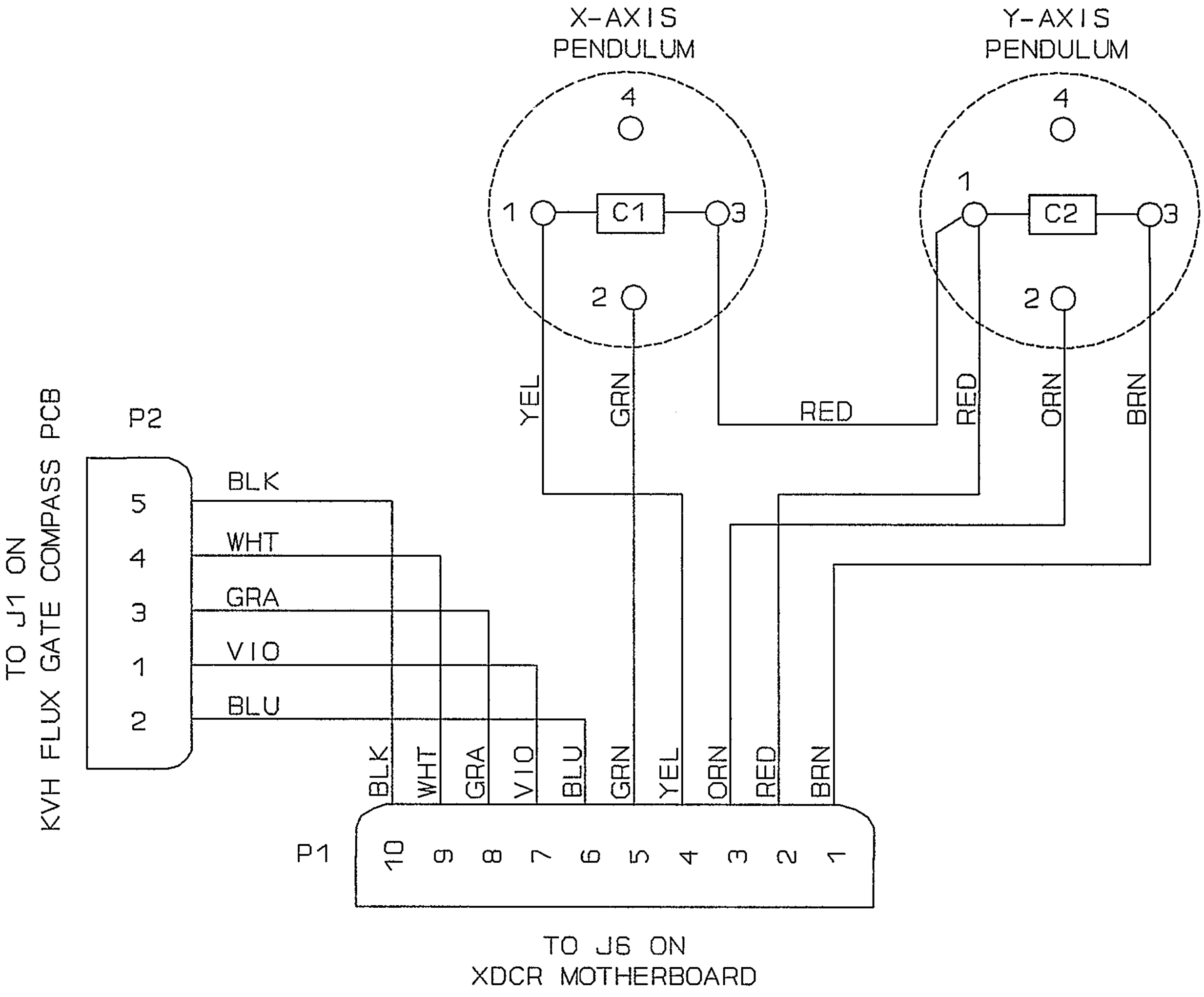


Figure Z-3. KVH Compass Cable Pinouts

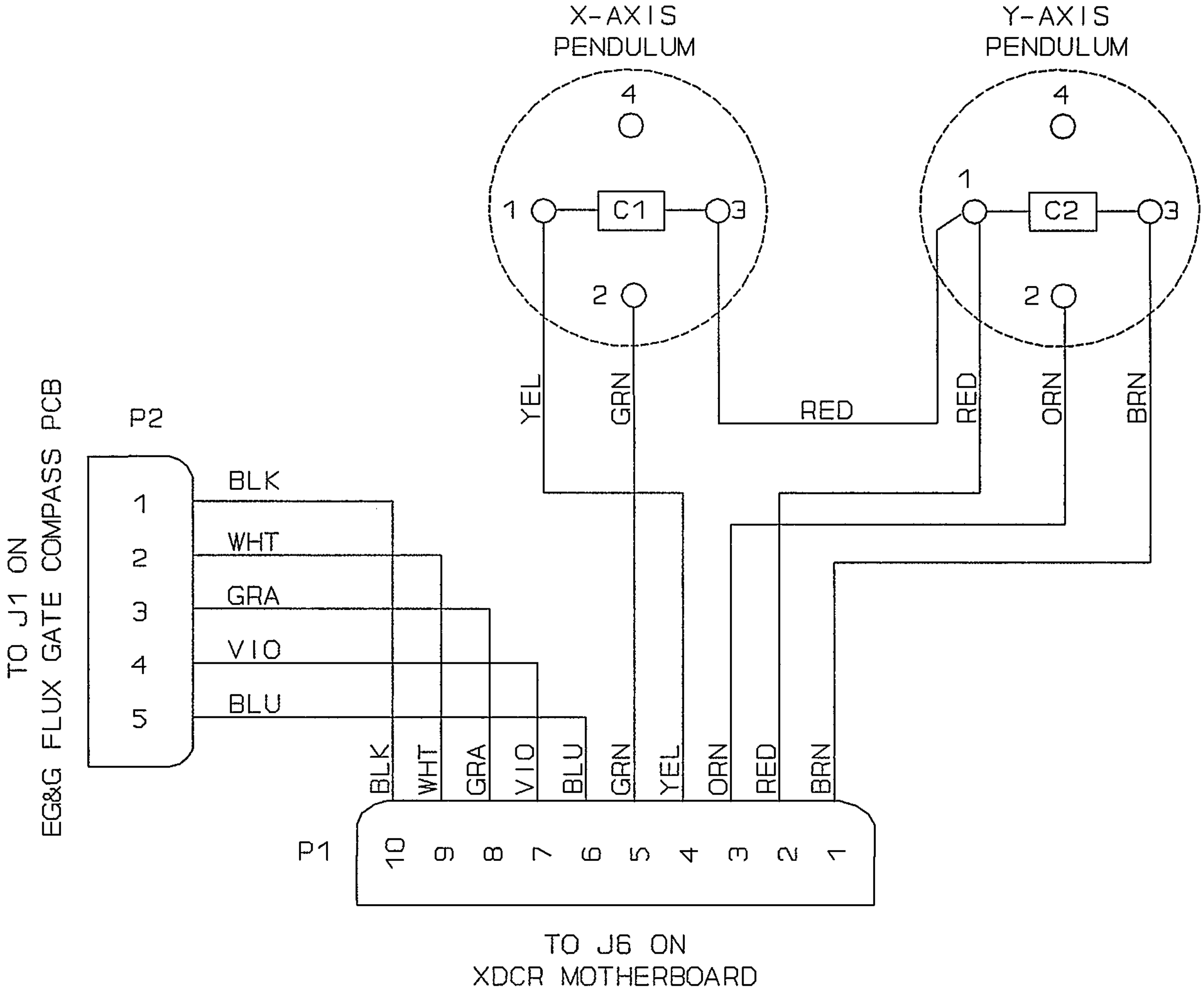


Figure Z-4. EG&G Compass Cable Pinouts

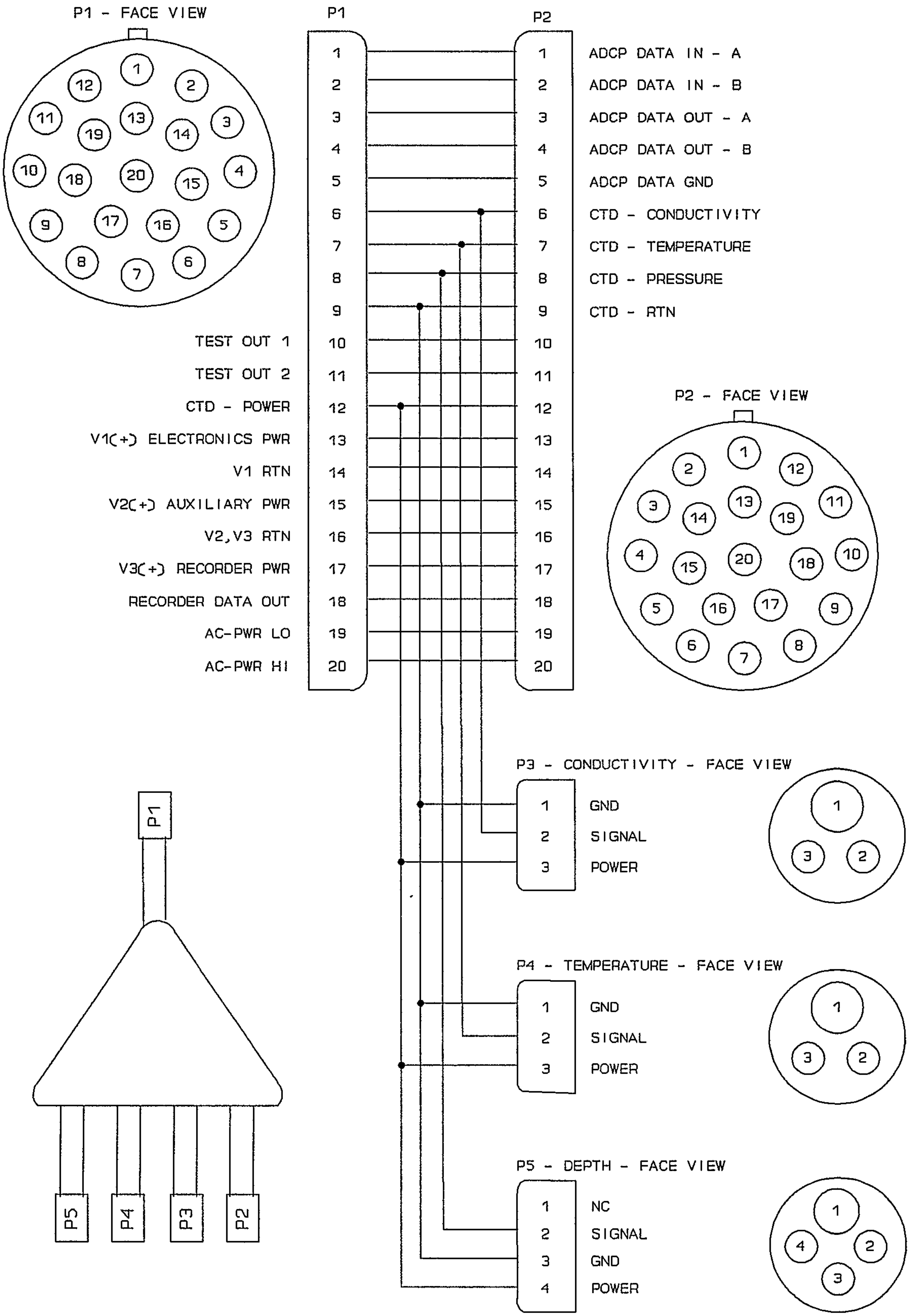


Figure Z-5. CTD Cable Pinouts

NOTES

GLOSSARY

absolute backscatter coefficient	A value used to compare echo intensity levels between instruments, or between different beams of the same instrument
accuracy	See standard deviation
acoustic doppler current profiler	An instrument used to measure the speed and direction of water currents at multiple locations throughout a water column. The ADCP operates by transmitting acoustic pulses from a transducer assembly along four beams. The transducers receive backscattered sound from plankton and small particles riding the water currents. By applying the Doppler principle, the ADCP transforms the backscattered sound into water-current velocity components.
ADCP	See acoustic doppler current profiler
amplitude	See echo intensity
ASCII	American Standard Code for Information Interchange – A code for representing alphanumeric information
averaging interval	See ensemble interval
beam angle	Angle of each of the ADCP's transducer beams relative to the vertical. The most common transducer beam angle is 30 degrees.
beam coordinates	The orientation system used by the ADCP for referencing the water-current data. We define the instrument-coordinate system such that without any roll, pitch, or heading change, the instrument's X, Y, and Z components are the same as XE, YE, and ZE in the earth-coordinate system. See Figure C-1. The ADCP's X and Y planes pass through the centers of the four transducers. The X-axis runs through transducer beams 1 and 2; the Y-axis runs through beams 3 and 4. When you look at the faces of the transducer head, the transducers are clockwise in the order 3-1-4-2. This means that for upward-facing ADCPs beam 1 is in the +X direction, and beam 3 is in the +Y direction. For downward-facing ADCPs, beam 2 is in the +X direction, and beam 3 remains in the +Y direction. The directions fore, aft, port, and starboard refer to the instrument-coordinate system and are in the +Y, -Y, -X, and +X directions, respectively.
beam orientation	Refers to the up/down orientation of the transducer beams
beam pattern	Refers to the concave/convex arrangement of the transducer beams
bin	See depth cell
biofouling	Refers to the buildup of organic sea life to objects deployed within about 100 meters (328 feet) of the surface, especially in warm water. In relation to the ADCP, soft-bodied organisms usually cause no problems, but the hard shells of barnacles can cut through the soft urethane transducer face causing failure to the transducer and, eventually, leakage into the ADCP.
BIT	Refers to the Built-In Test function that continually checks ADCP operation

GLOSSARY (CONTINUED)

bottom-track	Refers to the ADCP's ability to "track" the sea floor when it is within range. Bottom-tracking more accurate and more stable estimates of water-current velocities than does the normal ADCP operating mode.
break	A signal sent to the ADCP to interrupt its operation. The BREAK signal must be 100-400 milliseconds long.
canister	See pressure case
checksum	A value computed by the ADCP by summing all the bytes in the binary output data buffer, excluding itself. It is used to verify data transmission.
concave/convex	Refers to the arrangement of the transducer beams as mounted on the ADCP. A concave pattern has beams 3 and 4 crossing each other, and beams 1 and 2 crossing each other. Most concave beam patterns are on vessel-mounted ADCPs because this arrangement allows the transducer head to be mounted inside a sonar well. A convex pattern avoids crossing beams and are usually found on direct-reading and self-contained ADCPs.
CTD	Refers to the optional Conductivity, Temperature, and Depth (pressure) sensors that can be attached to the ADCP.
depassivation	Refers to the method of removing the internal resistive film on the anodes of lithium cells
deployment	Refers to the act of positioning and using the ADCP to collect data
depth cell	Refers to the volume of water in the water column from which current data are being extracted. The ADCP can collect data for up to 128 depth cells (sometimes called bins). All depth cells in the water column can be from 1 to 32 meters in length.
direct commands	Refers to those instructions manually sent to the ADCP from an external computer/dumb terminal that tell the ADCP how to collect data.
direct-reading ADCP	An ADCP similar in appearance to the self-contained ADCP, but which operates in real-time using AC power. Both commands and power are supplied to the DR-ADCP through a water-proof cable.
DR-ADCP	See direct-reading ADCP
dumb terminal	A method of communicating with the ADCP that uses a CRT monitor and keyboard. A dumb terminal does no internal processing.
dumb terminal emulator program	A method of communicating with the ADCP that uses a personal computer running a program that emulates a dumb terminal. When used this way, the computer does no internal processing of ADCP data or information.
earth coordinates	The ADCP collects data in beam coordinates, but can transform the data to earth coordinates. The earth-coordinate system has its +Z axis pointing up, +X axis pointing east, and +Y axis pointing north.

GLOSSARY (CONTINUED)

echo intensity	Refers to the echo level returned to the ADCP from the scatterers within the ADCP beams. (formerly called echo amplitude)
ensemble	An ensemble is a collection of data. It can consist of the header, leader, velocity, echo intensity, spectral width, percent-good, status, and checksum data collected by the ADCP after averaging the ping-to-ping data during the ensemble interval.
ensemble interval	This is the period of time during which the ADCP samples and averages ping data. It is sometimes called the sampling interval or averaging interval.
header	This information is sent only when the ADCP is collecting data in the binary mode. It is the first data item sent by the ADCP at the end of the ensemble interval. Header data simply sends buffer size information. It contains buffer size information for the output data buffer, the leader data buffer, the velocity data buffer, the spectral width data buffer, the echo intensity data buffer, the percent-good data buffer, and the status data buffer.
housing	See pressure case
leader	This relatively fixed information is sent by the ADCP at the end of the ensemble interval. It contains information that is ALWAYS recorded with every ADCP ensemble.
passivation	Refers to the chemical reaction within lithium cells that cause an internal resistive film to form on the anode.
percent-good	This ADCP output is a data qualifier representing the percent of pings having good data based on the signal-to-noise threshold.
ping	Refers to the acoustic transmission emitted from the ADCP
pressure case	The container that covers and protects the internal ADCP electronics
profiler	See acoustic doppler current profiler
radial beam coordinates	See beam coordinates
retrieval	The process of recovering the ADCP from its deployment
sampling interval	See ensemble interval
SC-ADCP	See self-contained ADCP
self-contained ADCP	A stand-alone, battery-operated instrument that is pre-programmed with operating instructions before it is deployed. Once deployed, the SC-ADCP collects data and stores it on its internal recorder. After retrieval, this data can then be processed and analyzed. The SC-ADCP is similar in appearance to the direct-reading ADCP.

GLOSSARY (CONTINUED)

vessel-mounted ADCP	An AC-powered ADCP mounted on a moving vessel. The transducer head is usually mounted in a sonar well. The electronics and real-time computer interface are usually mounted in a central operations room aboard the vessel. External gyroscope and navigation information can be interfaced with the data collected by the ADCP.
VM-ADCP	See vessel-mounted ADCP
wakeup	The process of energizing and initializing the ADCP

INDEX

INDEX (CONTINUED)

INDEX (CONTINUED)

INDEX (CONTINUED)

INDEX (CONTINUED)

INDEX (CONTINUED)

INDEX (CONTINUED)

INDEX (CONTINUED)

NOTES

NOTES