Sonardyne
SOUND IN DEPTH

MM-802X

Installation & Maintenance Manual for Type 8021 / 8023 USBL Transceivers

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INSTALLATION & MAINTENANCE MANUAL

FOR THE

TYPES 8021 & 8023 DIGITAL TRANSCEIVERS USBL

ISSUE A

REVISION 1

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Date of Issue	:	04 February 2003

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AMENDMENT RECORD

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A	0	25.07.02	Initial Issue	All	All
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SECTION 1

1. INTRODUCTION AND OPERATING PRINCIPLES

1.1 STRUCTURE OF MANUALS

This manual is divided into five sections, each dealing with a different aspect. In general, these five sections deal with the Standard, 8021 USBL Transceiver. Although the Big Head 8023 version of the Transceiver behaves in much the same way as the standard version, there are some differences in the areas of installation, and Specification. These are covered in their respective sections.

1. INTRODUCTION AND OPERATING PRINCIPLES. Provides a general introduction and a brief description of the operating principles.

2. DESCRIPTION OF USBL ACOUSTIC TRANSCEIVER. Detailed technical description of the Transceiver.

3. INSTALLATION AND CONNECTIONS - Contains all necessary procedures and recommendations for installing and connecting up the Transceiver

4. MAINTENANCE AND FAULT DIAGNOSIS. Description of maintenance principles, dismantling procedures, and trouble-shooting procedures.

5. TECHNICAL SPECIFICATIONS - Full technical specifications of the USBL Transceiver variants.

1.2 PURPOSE OF THE TRANSCEIVER

The Sonardyne 8021 and 8023 USBL Transceivers are used as part of USBL, LUSBL & MRAMS systems. These systems are used for:-

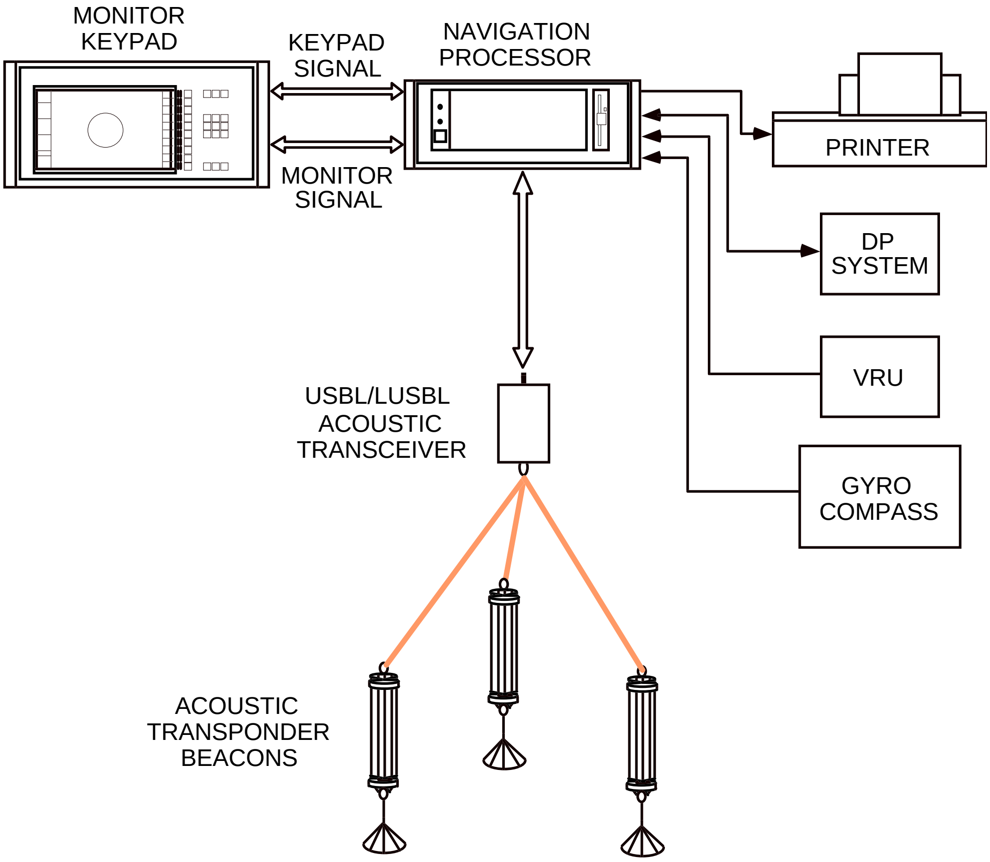
- ❑ USBL - - Remotely Operated Vehicle (ROV) tracking relative to a vessel.
  - - Tow fish tracking relative to a vessel.
  - - Diver tracking relative to a vessel.
  - - Position sensor for a vessel Dynamic Positioning (DP) system.
- ❑ LUSBL - - Use as a more accurate and robust position sensor for a vessel Dynamic Positioning (DP) system.
  - Accurate positioning of underwater structures.
- ❑ MRAMS - When used with a MRAMS (Marine Riser Angle Monitoring System) system, measurement of BOP/Riser Angle/Differential Angles.

1.3 BRIEF SYSTEM DESCRIPTION

The equipment comprising a typical LUSBL system are a Navigation Processor, a Monitor/Keypad unit and a Transceiver.

The key difference between USBL and LUSBL systems is that the basic USBL system utilises only one transponder beacon on the seabed (or on an ROV, etc) and has less accuracy and more limited functionality as a result.

FIG 1.1 SCHEMATIC (CONTEXT) DIAGRAM - BASIC SYSTEM



Operation of the system is controlled by the Navigation Processor, once it has been set up and initiated by the operator. The operator uses the Monitor/Keypad unit as his Man/ Machine Interface. The Processor commands the Transceiver to emit acoustic signals to the Beacon(s) and then interprets the responses received by the Transceiver.

In a typical system, the Processor receives reference information from a VRU and a Gyro Compass and produces outputs to a DP system and a printer. In other system configurations, the vessel's absolute position may be derived by reference to a Radio Navigation system.

The system measures the range and direction of a beacon relative to the known location and orientation of the Transceiver housing:-

- Beacon range is calculated by measuring the elapsed time between the interrogation signal and the detection of the beacon reply.

- Beacon bearing is calculated by measuring the difference in "time-phase" between signals in a number of pairs of acoustic receiving elements on the front face of the Transceiver. (This is sometimes referred to as the Interferometer method). See Appendix C for more detail.

In the case of an LUSBL system, where a number of beacons are in use, greater accuracy of position fixing is possible than with a basic USBL system because the larger volume of data being gathered enables a greater degree of statistical filtering to be carried out.

In a typical navigation cycle:-

- The Navigation Processor commands the Transceiver to transmit an interrogation signal.

- The Beacon reply (or replies in the case of LUSBL) is detected by the Transceiver which measures the elapsed time and the time-phases. The data is reported to the Navigation Processor. Simultaneously, the Navigation Processor will have received the vessel's attitude (roll, pitch) and, possibly, heading data.

- The Navigation Processor computes the position of the beacon relative to the vessel and reports the data to the DP system.

If heading data is present, the processor can compute the position of the vessel (in a North-referenced grid) relative to a beacon fixed to the seabed. Without heading data, vessel position would only be known in terms of range, bearing and elevation from the beacon.

Subsequent navigation cycles may be used to position other beacons up to a maximum of 10 beacons in total. If the positions of the beacons in an array on the seabed (i.e. relative to each other) have previously been calibrated, the position of the vessel (relative to the array) may be calculated to a high degree of accuracy.

1.4 TYPICAL APPLICATIONS OF A USBL/LUSBL SYSTEM

1.4.1 USBL

1.4.1.1 ROV/Tow Fish Tracking

In this application, a beacon is placed on an ROV or Tow Fish as appropriate. The USBL system will then track the position of the ROV/Tow Fish (in terms of depth and bearing) relative to the vessel.

1.4.1.2 Diver Tracking

As for ROV/Tow Fish tracking except that the beacon is attached to the diver.

1.4.1.3 Dynamic Positioning

Dynamic Positioning control of a vessel removes the need to anchor the vessel, which is a time consuming and costly exercise. A DP vessel is fitted with a number of thrusters in addition to the normal main propellers. The thrusters and propellers are managed by a control system to keep the vessel on a constant heading and in a constant position whatever the disturbing forces from wind, current and wave action.

For a DP application, with USBL, a reference beacon is placed on the seabed and the position of the beacon or array in the vessel frame is reported to the DP control system.

A variation of this method is to place a beacon on an ROV which may be following a line feature such as a pipeline. The USBL/DP system will then control the vessel to follow the ROV. This is sometimes referred to as "The dog on a lead" or “Follow the Sub” principle.

1.4.2 LUSBL

1.4.2.1 DP Applications

The most common application of a LUSBL system is as an input to a Dynamic Positioning (DP) system. Dynamic Positioning control of a vessel removes the need to anchor the vessel, which is a time consuming and costly exercise. A DP vessel is fitted with a number of thrusters in addition to the normal main propellers. The thrusters and propellers are managed by a control system to keep the vessel on a constant heading and in a constant position whatever the disturbing forces from wind, current and wave action.

For a DP application, with LUSBL, an array of beacons is placed on the seabed and the position of the beacon or array in the vessel frame is reported to the DP control system.

1.4.2.2 **Accurate Positioning of Underwater Structures**

The greater accuracy afforded by the LUSBL system is valuable when the position of an underwater structure needs to be known more precisely than can be achieved by other means. By deploying more than one beacon, the LUSBL is able to use statistical filtering techniques to reduce the impact of system errors.

1.4.2.3 **Riser Angle Monitoring**

Setup and control functions for a RAMS (Riser Angle Monitoring System) are built into the L/USBL system. RAMS alarm levels may be displayed on the L/USBL's screen while in Navigation mode.

SECTION 2

2. DESCRIPTION OF USBL ACOUSTIC TRANSCEIVER

2.1 OVERVIEW

The Transceiver is a complete microprocessor-controlled interrogator/receiver operating on command from the Navigation Processor. The main functions of the Transceiver are:

- Interpretation of commands from the Navigation Processor.
- Transmission of commands or transponder interrogation signals on any one of 29 frequencies between 19.2 and 31.6 kHz. The transmitted pulse can be variable in length between 1 and 8 mS in steps of 2, 4 and 8 mS. The output power can be adjusted in 3 steps of 6 dB each.
- Reception of transponder reply signals can be on any one of the 29 frequency channels between 19.2 and 31.6 kHz.
- Decoding of Acoustic Telemetry.
- Measurement of time and phase information in the received transponder reply.
- Transmission of measured (range and bearing) data to the Navigation Processor.

The electronics comprises:

- Floating voltage regulation circuits
- A microprocessor subsystem with RS485 comms.
- Six pre-amp channels.
- Six receiver channels including mixers, and other signal conditioning circuits controlled by the processor.
- Sampling and analogue-to-digital conversion circuits.
- Transmit circuit controlled by the processor.

The transducer face comprises an array of a number of ceramic receiver elements arranged evenly around a transmit element. They are recessed into a machined high grade plastic and encapsulated in polyurethane to form a strong smooth acoustic interface to the water.

The electronics chassis is attached to a metal base plate at the transducer face assembly. A cylindrical housing slides over it to mate with the face held together by six recessed bolts. To ensure maximum resistance to corrosion the housing is constructed in Aluminium Bronze.

An underwater connector is provided in the top of the housing for connection with the interface cable.

The microprocessor within the Transceiver runs a program stored in Flash EPROM on the CPU Card. This firmware (a software program stored in EPROM) controls all the functions of the unit.

2.2 FUNCTIONAL DESCRIPTION

Nominally 48V DC power is supplied to the unit using a single pair of conductors. Communications with the Navigation Processor is implemented using a half-duplex RS 485 link. This uses a second pair of conductors. The four conductors linking the Transceiver with the Navigation Processor connect to the PSU/TX Board. The RS 485 communication pair are routed via the motherboard back plane straight through to the Host (CPU) Board. (See Fig 2.3)

All the power supply rails used by the instrument are generated on the PSU/TX Board. The ±12V, ±5V and 3V3 rails are produced by DC/DC converters (five in all).

The transmitter functions of the Board are controlled by the Host Board over an I^2C serial interface. The four levels of the transmitter output power are controlled using a programmable regulator supplied from the ±12V rails. The matching network between the transmitter drive circuit and the transmitting transducer elements is controlled by two tuning lines form the I^2C I/O expander. The Transmit signal is generated by direct digital synthesis (DDR) on the Receiver Board together with the transmitter control (enable) signals. The signals are conditioned locally before being supplied to the transmitter drive circuit.

The Host Board uses a Motorola MCF5206e micro-controller which provides two UARTs and an I^2C controller. Peripheral components on the CPU bus include the RAM and ROM, a daughter board interface to the DAS board and the interface to the DSP devices on the Receiver Board. Two Isolated RS485 drivers are provided.

The DAS Daughter Board supplies reference signals to sensors (PRT, pressure transducer and inclinometer sensors).

The signal from the receiving elements are buffered and filtered by the pre-amplifiers. On the RX Card the six signals are again amplified and digitised before being processed by the three DSP devices. The digital output of the DSPs are collected by the Host CPU for further processing and passing on to the surface equipment.

FIG 2.1 8023-000 ACOUSTIC TRANSCEIVER – BLOCK DIAGRAM

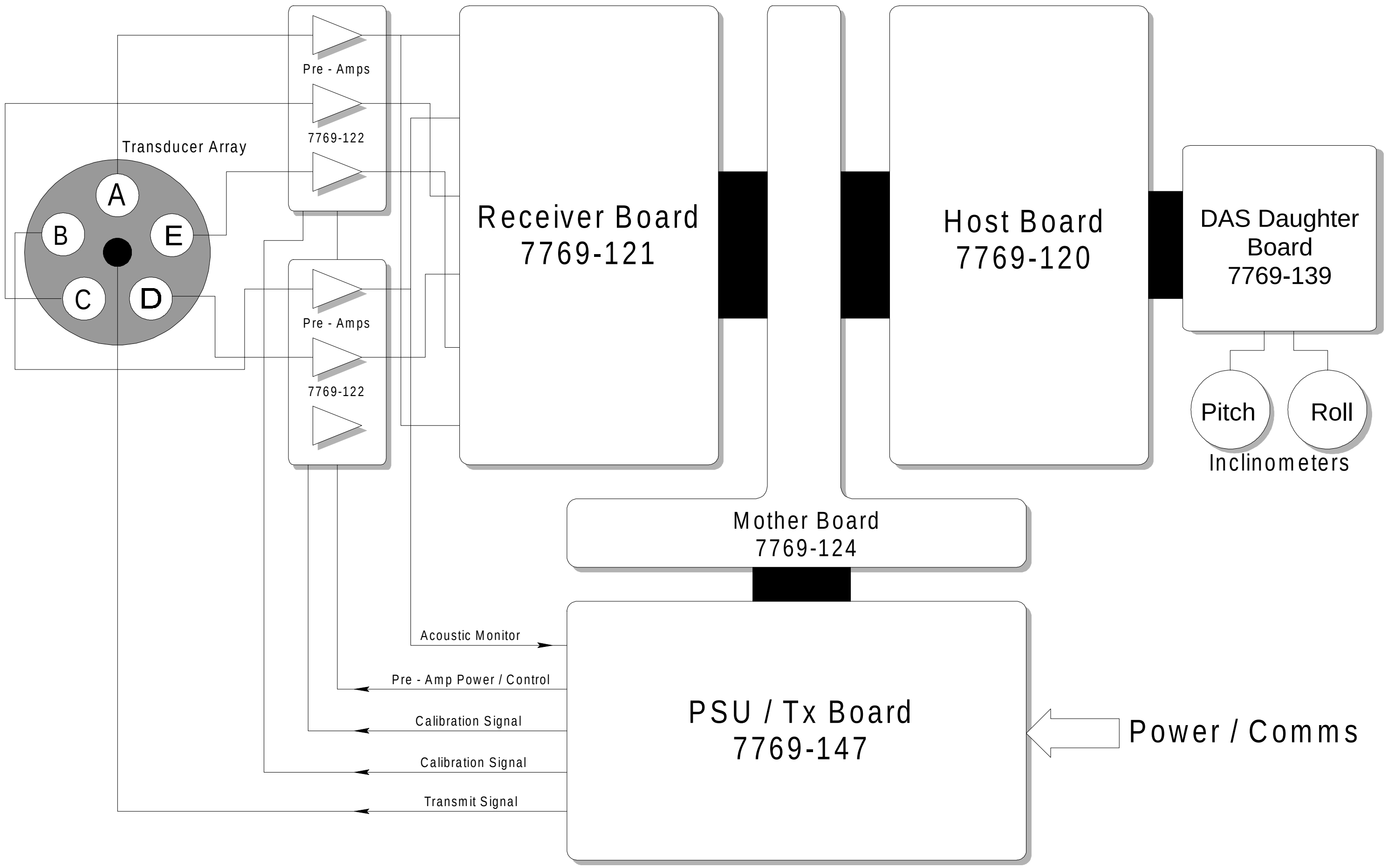


FIG 2.2 7769-121 LUSBL RECEIVER CARD – BLOCK DIAGRAM

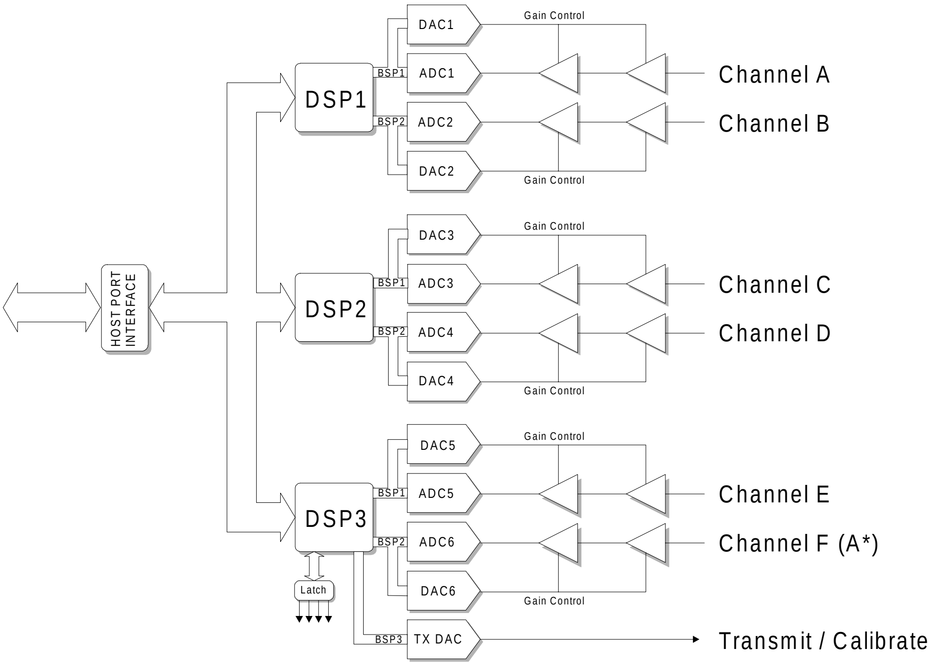
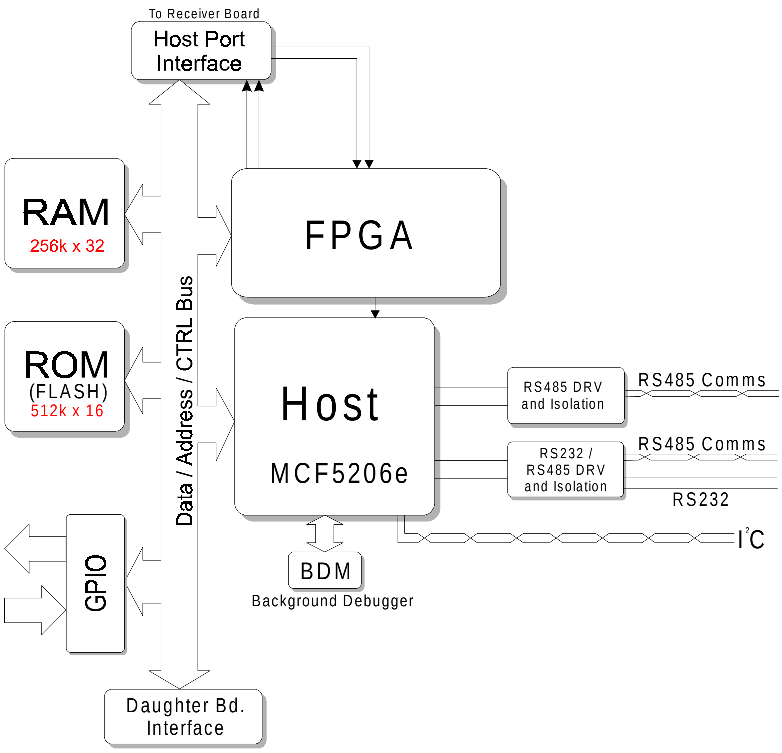


FIG 2.3 7769-120 LUSBL CPU CARD – BLOCK DIAGRAM



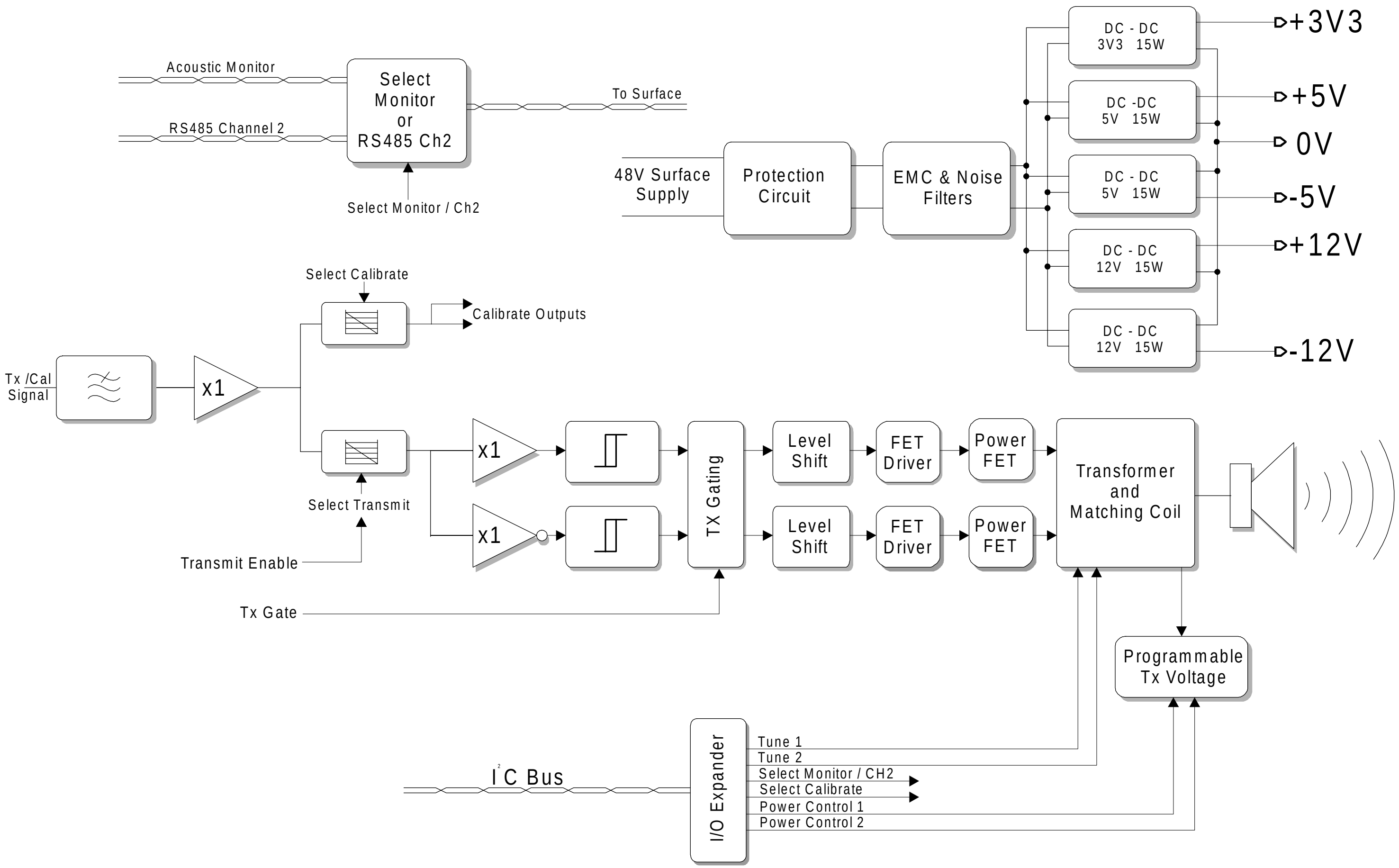


FIG 2.4 7769-147 USBL PSU TX CARD – BLOCK DIAGRAM

SECTION 3

3. INSTALLATION AND CONNECTIONS – HARDWARE

3.1 INSTALLING THE TRANSCEIVER

Outline drawings of the 8021, and 8023 Transceivers can be found in Figs 5.1 and 5.2 respectively. They should be installed vertically, with the connector at the top and the “forward direction” mark pointing forward.

There are several ways of mounting the Transceiver on a ship. The most common are:-

- For the ‘standard’ Transceiver a vertical tube of at least 228.6 mm or 9 inches internal diameter is let into the ship.

- For the ‘Big Head’ Transceiver a vertical tube of at least 305 mm or 12 inches. internal diameter is let into the ship.

  The method detailed below, for mounting the Transceiver is sometimes referred to as the "mini-moonpool" method.

  The Transceiver is mounted on the end of a flanged pole using a purpose designed flange adapter if necessary (see Fig 3.4 - but consult Sonardyne also). The adapter and any intermediate flanges should employ some mechanical means (the Sonardyne supplied adapter has provision for two dowel pins) to maintain the alignment of the Transceivers lubber line mark with the ship’s lubber line. Alignment should be maintained to within 1 degree - which is similar to the accuracy of a typical Gyro-Compass. The pole will normally have a number of flanges with a compliant outer edge that contacts the inside wall of the tube. The alignment with true vertical is not critical, but the pole should not change its vertical alignment with respect to the ship by more than 0.5 degrees. For critical deep water applications, and if good quality VRUs are available, then this tolerance should be tightened.

  If the mounting flange has the correct fixing holes then the transceiver can be bolted on without the use of the adapter ring (see Fig 3.5), the isolation ring must be used if galvanic corrosion is a possibility.

- The second common deployment method is the use of a gate-valve and sea chest assembly that can accommodate the Transceiver. Above this sea chest is a deployment machine that is capable of raising and lowering the Transceiver and stem. The LUSBL Transceiver has been designed to fit to a type 7950 Sonardyne supplied deployment machine and also directly onto a Fixed Head HPR deployment pole (see Fig 3.6).

  The Transceiver housing is made of 10/5/5 Aluminium Bronze and the common material used for the tube and pole etc. is mild steel. It is good practice to isolate the two systems electrically and acoustically. Sonardyne provide an isolation adapter within the Installation kit (see Fig 3.5 for the correct use of the isolation kit). On no account should the Aluminium Bronze be in contact with a material more noble than itself (electro-chemically) - galvanic corrosion would be the result. A blue connector cover is provided to prevent the accumulation of rust etc. (which may fall off the inside of the deployment pole) from collecting on the top of the transceiver.

FIG 3.1 TRANSCEIVER INTERCONNECTIONS

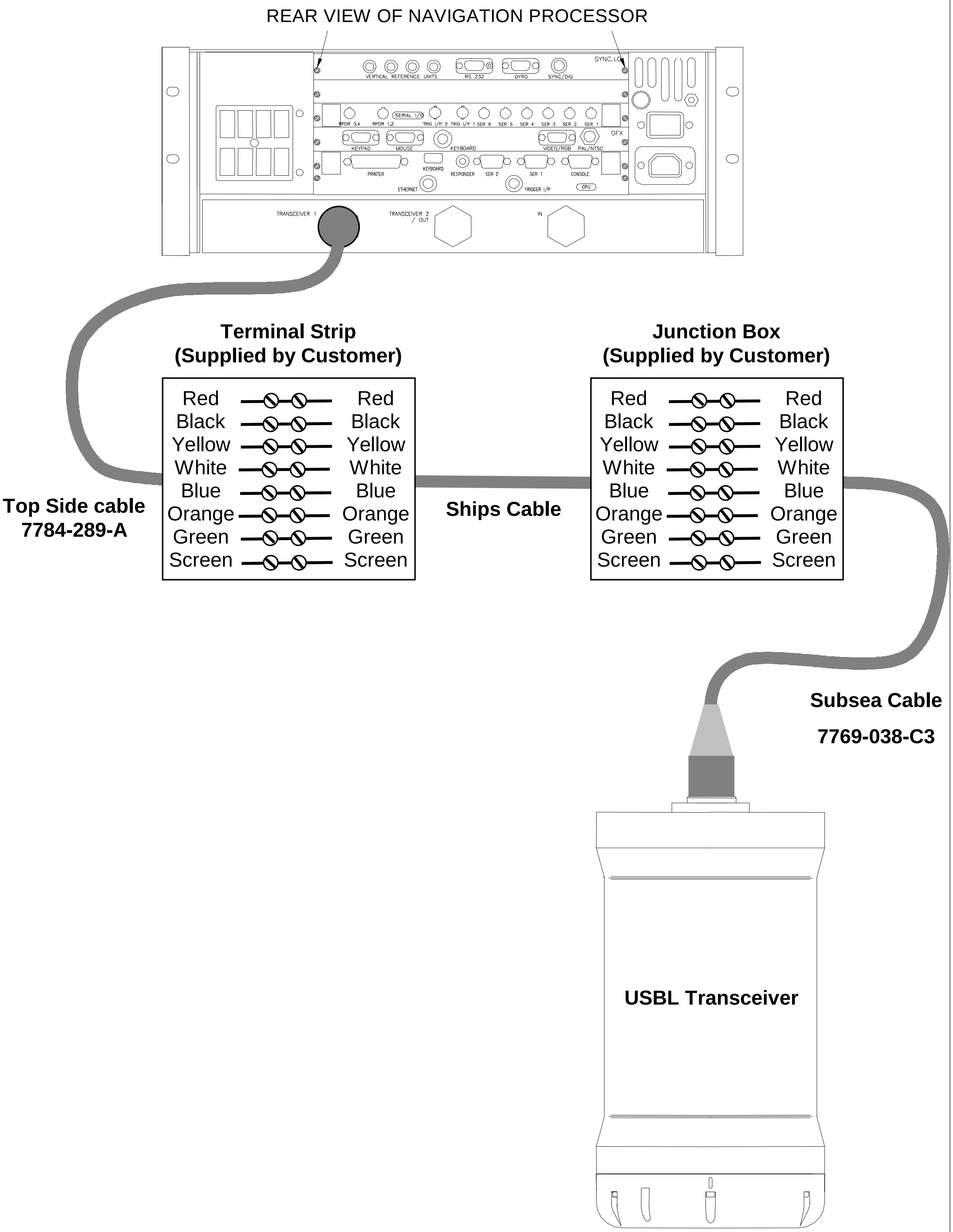
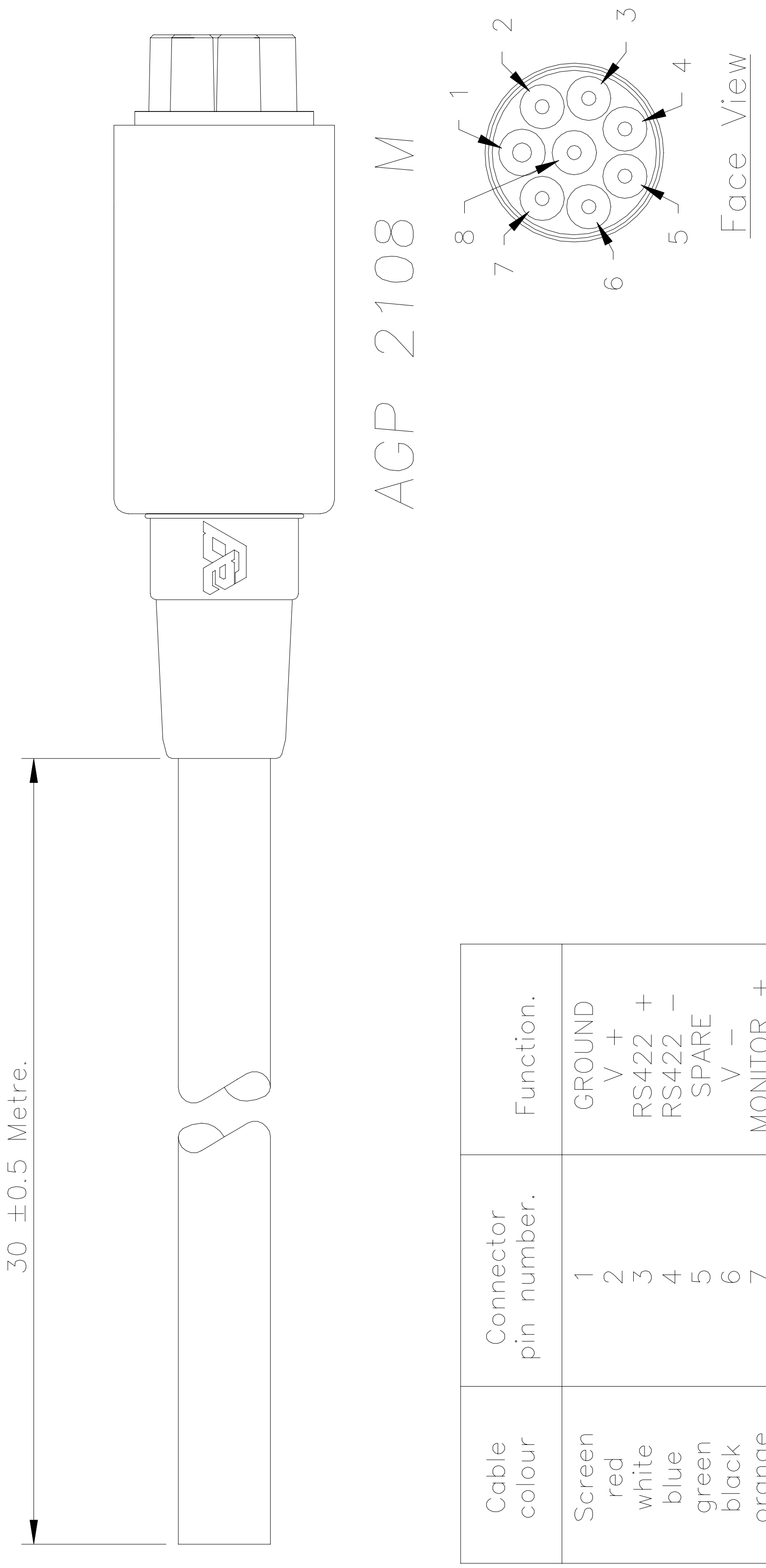
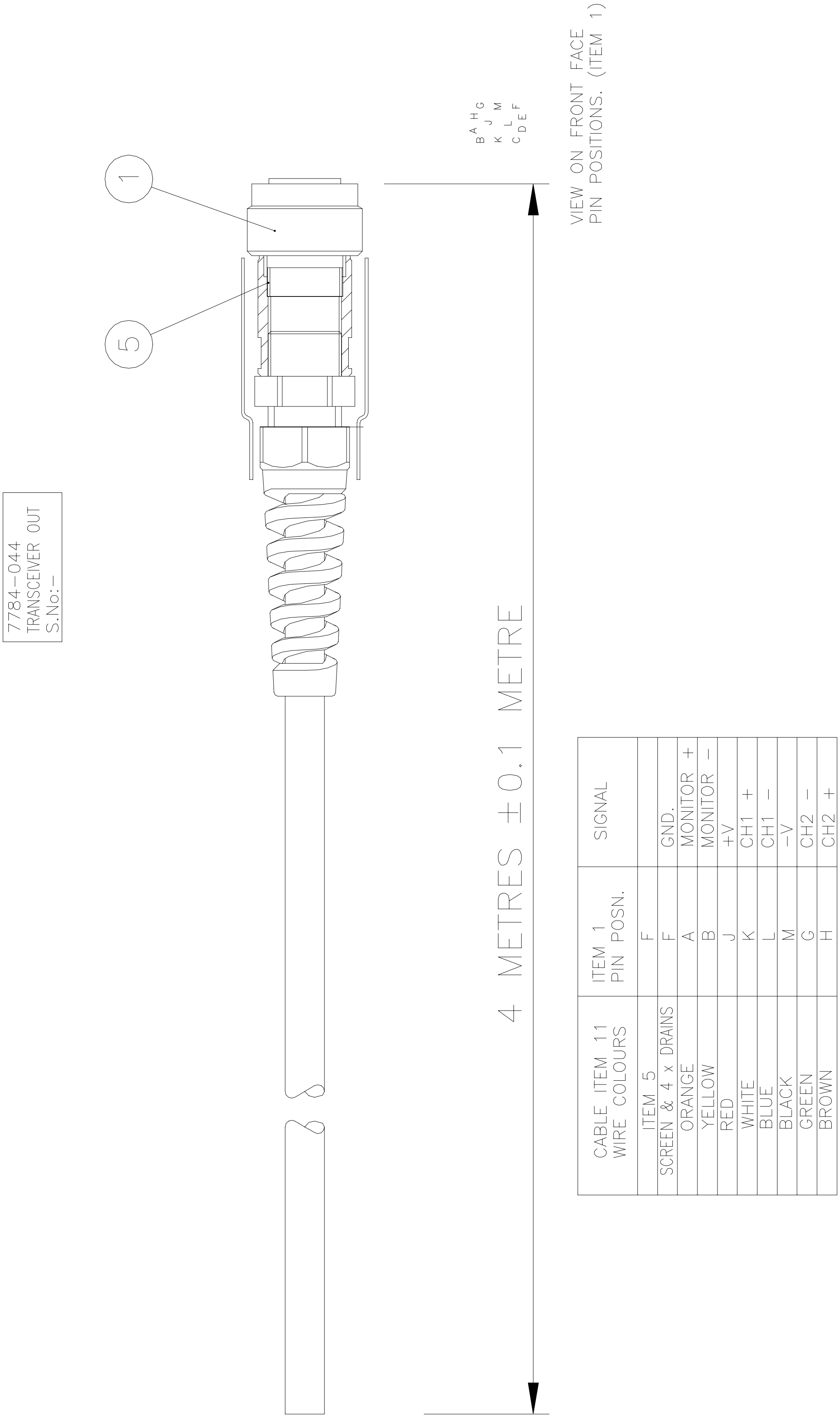


FIG 3.2 SUBSEA CONNECTION



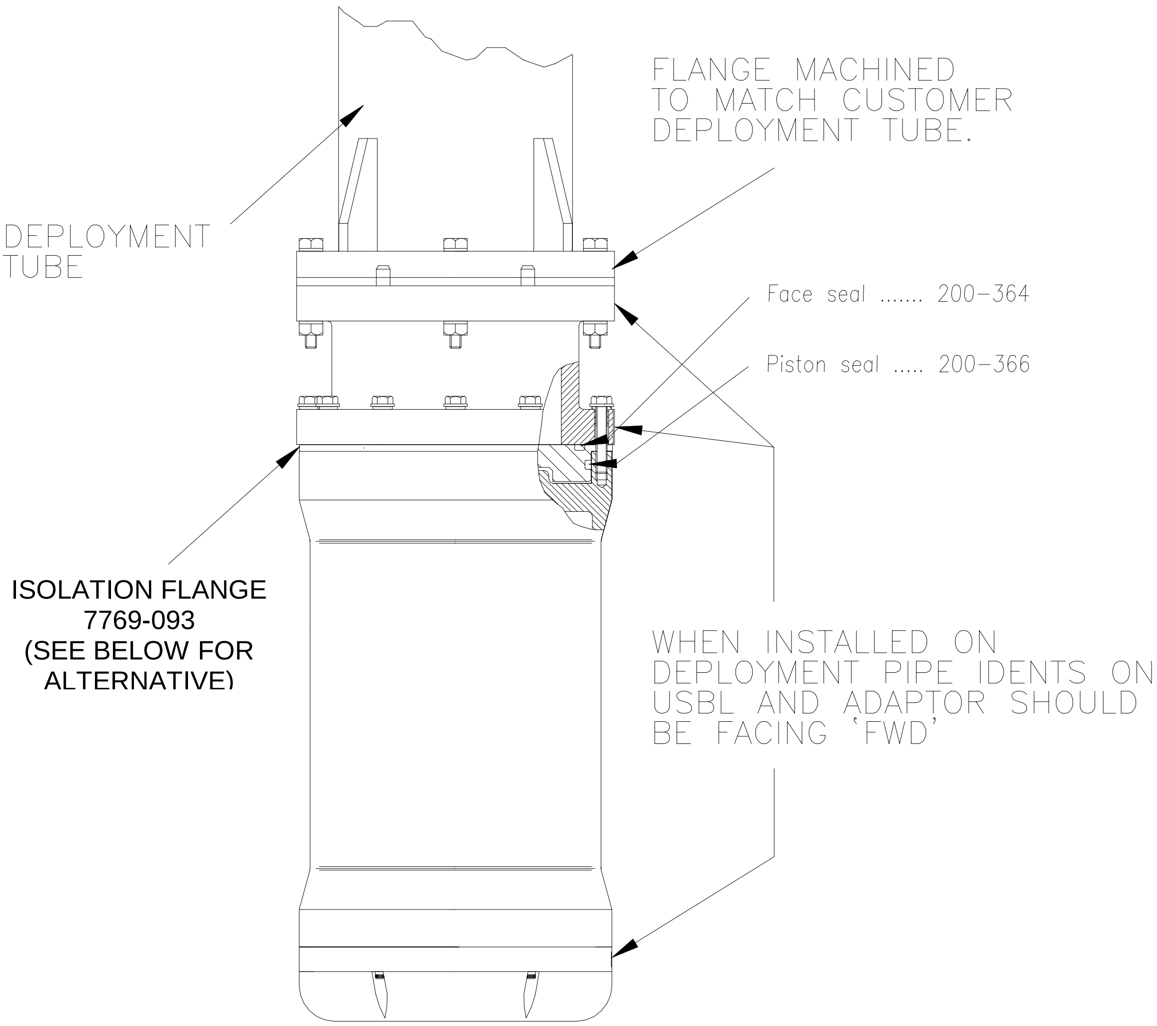
Cable colour	Connector pin number.	Function.
Screen	1	GROUND
red	2	V +
white	3	RS422 +
blue	4	RS422 –
green	5	SPARE
black	6	V –
orange	7	MONITOR +
yellow	8	MONITOR –

FIG 3.3 TOPSIDE CONNECTION



CABLE ITEM 11 WIRE COLOURS	ITEM 1 PIN POSN.	SIGNAL
ITEM 5	F	
SCREEN & 4 x DRAINS	F	GND.
ORANGE	A	MONITOR +
YELLOW	B	MONITOR –
RED	J	+V
WHITE	K	CH1 +
BLUE	L	CH1 –
BLACK	M	–V
GREEN	G	CH2 –
BROWN	H	CH2 +

FIG 3.4 TRANSCEIVER FITTING TO NON-STANDARD BOLT ARANGEMENT POLE



ALTERNATIVE ISOLATION FLANGE 7769-117 (SECTIONAL VIEW)

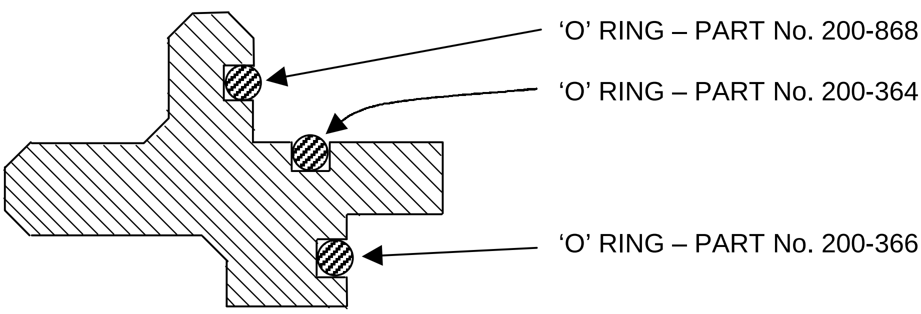
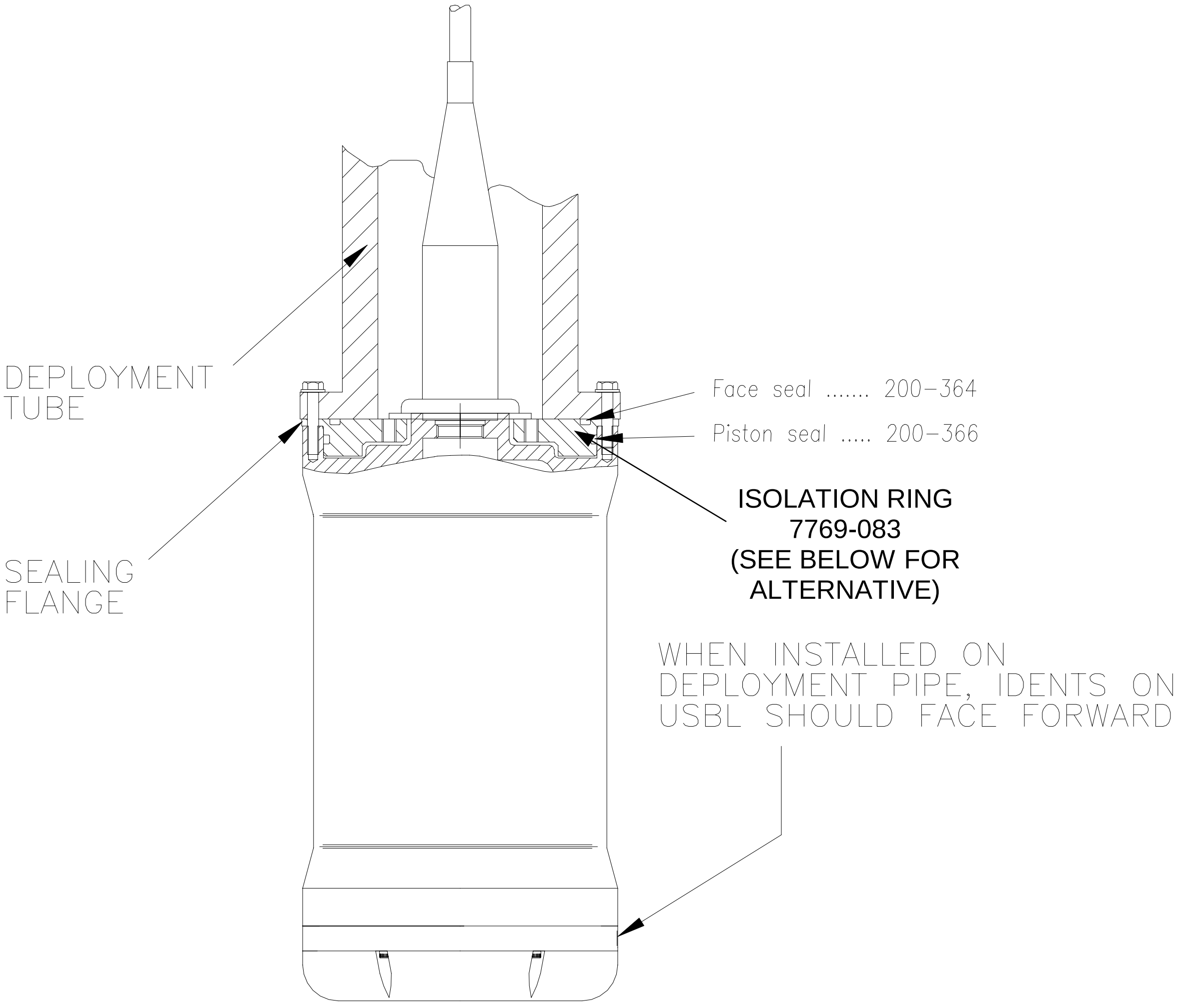


FIG 3.5 TRANSCEIVER FITTING TO POLE WITH A FACE SEAL



ALTERNATIVE ISOLATION FLANGE 7769-117 (SECTIONAL VIEW)

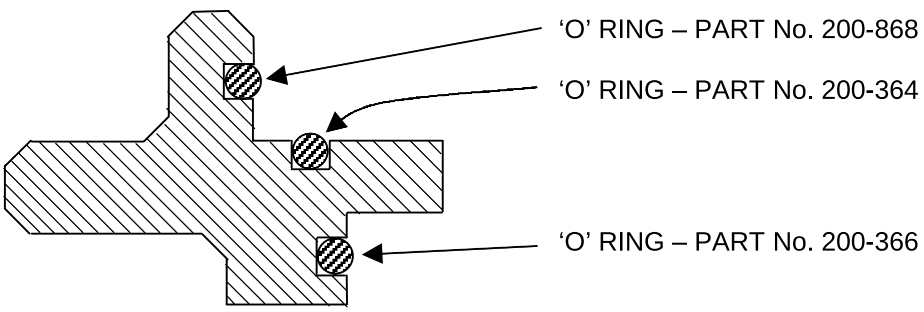
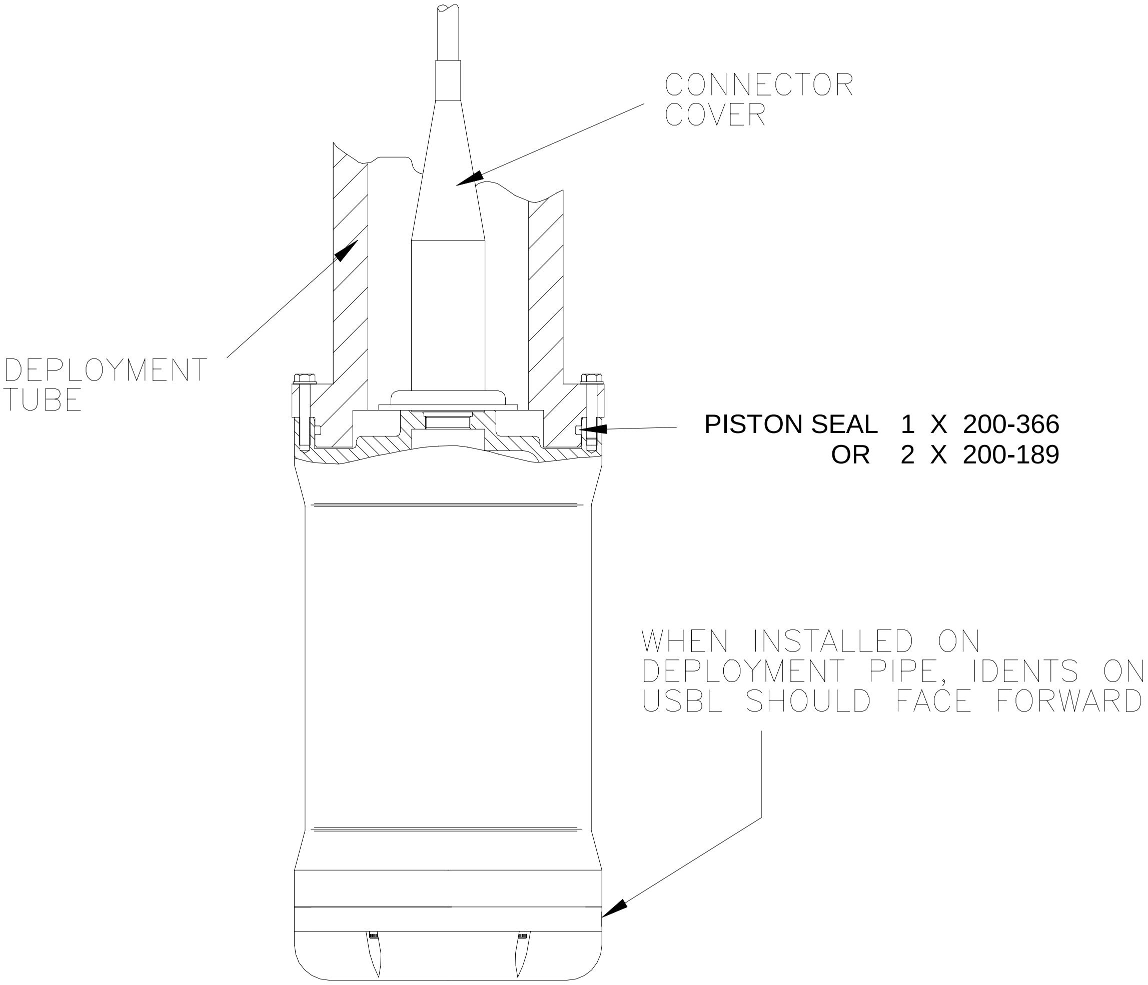


FIG 3.6 TRANSCEIVER FITTING TO A POLE WITH A PISTON SEAL



SECTION 4

4. MAINTENANCE

4.1 GENERAL

This Section defines maintenance strategy, identifies the routine maintenance tasks to be carried out on a periodic basis and also includes a comprehensive set of fault-finding procedures which can be used under failure conditions.

The procedures included in this Section apply equally to the 8021 Standard and 8023 Bighead versions of the Transceiver.

4.2 MAINTENANCE STRATEGY

In an ideal situation, the Sonardyne maintenance strategy is to isolate a fault to a particular system component assembly, in this case the Transceiver, and then replace that component. It is recommended that a complete Transceiver chassis is held as a spare, however, PCB's are available as part of the spares kit. Please refer to Appendix A for the list of available spares.

It is not considered practical to fault find at PCB level with the aim of replacing components on PCBs in the field.

4.3 TRANSCEIVER FAILURE

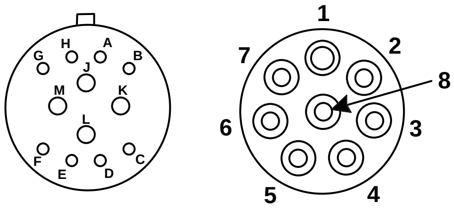
4.3.1 Communication Failure

The Transceiver is an intelligent instrument controlled by a Micro-Controller and without communications between the Navigation Processor and the Transceiver fault finding is virtually impossible and the instrument certainly cannot function.

Before considering this Section of the fault finding procedure, the tests outlined in SM-7707, Section 7. (Transceiver Comms Failure) should be completed to prove the fault to be with the Transceiver.

The connection for power and communications pairs between the Navigation Processor Transceiver connector and the connector for the Power and communication pairs to the Transceiver PSU /TX board is made up of two cables joined at a termination panel.

FIG 4.1 PIN CONNECTIONS FOR TRANSCEIVER CABLE



Transceiver Port			Transceiver	
Pin No.	Colour	Signal	Colour	Pin No.
E	Screen	Ground	Green	1
		Ground	Yellow	
J	Red	+ V	Red	2
K	White	+ Signal	White	3
L	Blue	- Signal	Blue	4
M	Black	- V	Black	6

A full continuity check of the cables can be avoided by doing the following, which should be sufficient to ensure operation. On the connector which plugs into the Transceiver, link skts 3 to 4 and 2 to 6. Using a meter check at the connector to the Navigation Processor Transceiver port that there is continuity between J and M and between K and L. Remove these links and replace them with a link between pins 1 and 4. Check at the connector to the Navigation Processor Transceiver port that there is continuity between L and E. The loop resistance should not exceed 15 ohms. Remake the cabling as necessary.

<u>REMOVE THE LINKS</u>.

Now test each used core (as listed in the following) for insulation resistance using an insulation tester set to 500V. The Transceiver connector MUST NOT be connected. Test for leakage, and remake the cabling as necessary.

J to K	J to L	J to M	J to E
K to L	K to M	K to E	
L to M	L to E		
M to E			

If the above failed to locate the fault, it will be necessary to dismantle the Transceiver. The electronics/transducer module should be removed from the housing.

4.4 <u>DISMANTLING FOR MAINTENANCE</u>

Before dismantling, the unit should be washed in fresh water, dried and brought into a clean, dry area.

There are no parts that can be replaced whilst the unit is powered-up. Whilst dismantling is in progress the unit should be disconnected from the Navigation Processor.

During a fault finding operation, it may be necessary to run the system out of its case. It is recommended that this type of operation is carried out ONLY by qualified personnel.

Many of the electronics components used within the system are liable to damage by static discharge. Work should be carried out at a work station where the unit is earthed or can be placed on an earthed conductive mat. The Maintainer should be electrically connected to the earth of the equipment being worked upon.

When replacing any board, check that the links on the new board match those of the original.

4.4.1.1 Removing the Electronics/Transducer Assembly from the Housing

Undo the 6 M5 socket cap screws (4mm A/F Allen driver) securing the end cap to the housing. Place three of the screws in to the jacking screw positions provided. Screw these in evenly until the end cap is raised enough to be removed. Make sure the assembly is not withdrawn so far and fast that the cable linking the electronics to the connector on the housing is damaged. Undo the connector where indicated in Fig 4.4.

Assembly is the reverse of the above procedure, except that the jacking procedure is not applicable.

4.4.1.2 Replacing the PSU/TX Board

Remove the 12 way Molex Power/Comms connector from PL1, the Pre–Amp power cable from PL3, the Transmitter Cable from PL2 and the 3 Coax SMR connectors (Sk3, SK4 & SK5). (See Wiring Diagram Fig 4.2)

Remove the four Inclinometer fixing screws (M4 x10mm) from the base of the two inclinometer brackets.

Remove the 4 Inclinometer bracket fixing screws (M2.5 x 10mm) and carefully remove the support bracket and Inclinometers clear of the PSU/Tx board without disturbing the settings or the sealed screws on the inclinometers.

Remove the 4 capacitor mounting bracket screws, and support the capacitor assembly to one side.(or disconnect at the Terminal block)

Remove the 4 spacers (M3) and 2 screws to remove the board, being careful not to lose the six nylon spacers from behind the board.

Assembly is the reverse of the above procedure.

NOTE: If the inclinometers have been removed from their bracket, then the Transceiver should be re-calibrated as an inclinometer sensor, as indicated in SM-7707, Section 4.

4.4.1.3 Replacing the Host (CPU) / DAS Board

Remove the two Pre-amp assembly fixing screws (M5 x 12). This will allow the Pre-amp to move sufficiently to allow removal of the Board. (See Fig 4.5)

Remove the Inclinometer cable to the DAS board J1.

Remove the 6 fixing nuts (M3 nyloc) and remove the board, being careful not to lose the six nylon spacers from behind the board.

Assembly is the reverse of the above procedure.

4.4.1.4 Replacing the Receiver Board

Remove the two Pre-amp assembly fixing screws (M5 x 12). This will allow the Pre-amp to move sufficiently to allow removal of the Board. (See Fig 4.5)

Remove the Inclinometer cable to the DAS board J1.

Remove the eight Screen assembly screws (M2.5 x 6) from the Screen assembly under the Host (CPU) board and remove the Board and Screen assembly.

> **NOTE: If you have a screwdriver which grips screws, then the inclinometer will not need to be removed as the screws are accessible through a cut-out in the mounting bracket.**

Remove the eight Receiver board fixing screws (M2.5 x 6).

Carefully remove the six coaxial cables from the base of the board and remove the board.

Assembly is the reverse of the above procedure.

4.4.1.5 Replacing a Pre-amp Card

Undo the 4 screws securing the lid of the pre-amp box and remove the lid. (See Fig 4.6)

If only the top pre-amp is to be replaced then undo the coaxial leads connected to this Card. Note the connections and label them if necessary. Try not to stress the cables and grip the connector bodies using an appropriate pair of pliers.

If the bottom pre-amp is to be replaced remove these connections as well.

Remove the lead with the 5 way Molex connector from the top pre-amp Card.

Undo the 4 M3 hexagonal nuts (5.5mm A/F Socket) securing the pre-amp Card to the box and remove the top pre-amp from the box. If necessary remove the spacers, undo the 5 way Molex connector on the second Card and remove the Card.

Assembly is the reverse of the above procedure. Take care to use all the appropriate spacers etc.

4.4.1.6 Replacing an Inclinometer Sensor

Remove the hexagonal headed screws retaining the appropriate inclinometer sensor bracket to the base plate. Disconnect the lead running between it and the CPU Card and remove the sensor and bracket. (See Fig 4.5)

Undo the 2 pan head screws securing the sensor to the bracket and remove the sensor. The new sensor wires will have to be incorporated into the loom (see Fig 4.2 for wiring details).

Assembly is the reverse of the above procedure. Take care to use all the appropriate spacers etc.

> **NOTE: After the inclinometers have been replaced the Transceiver should be re-calibrated as an inclinometer sensor as indicated in SM-7707, Section 4.**

4.4.2 Servicing by Replacing Electronics/Transducer Module

Servicing the unit by replacing the entire Electronics/Transducer module with a known working spare is the simplest way of servicing the unit. If the tests above have failed to clear the fault then replace the entire module.

The faulty module should be returned to Sonardyne for repair.

4.4.3 Servicing by PCB Replacement

Before any PCBs are replaced, the tests at the start of this section should be carried out.

If the fault has been proved to be in the Transceiver, then failure of communication must be due to: -

- Failure of power to the Host (CPU) board
- Loss of continuity of the RS485 lines
- Fault on the Host (CPU) Board.

Remove the Transceiver Housing and using the test cable 7784-290 connect from the Transceiver connector on the Navigation Processor to PL1 on the Transceiver PSU / Tx board.

Switch on the navigation processor and check that the RED led D4 (adjacent to PL1 on the PSU / Tx board) is on.

Measure the following voltages on the PSU / Tx board.

TP1 with respect to (wrt) TP2 for 48V (36V to 72V)

TP3 wrt TP5 for +3V3 ± 0.1V

TP4 wrt TP5 for +5V ± 0.25V

TP6 wrt TP5 for –5V ± 0.25V

TP7 wrt TP5 for +12V ± 0.5V

TP8 wrt TP5 for –12V ± 0.5V

If any of the above voltages are unsatisfactory replace the PSU / Tx board and on re-powering the system check for the transceiver found message on the display.

If the transceiver is still not found, check the RS485 comms LEDs D5 and D6 on the Host board. D6 will flash if the downward message is being seen by the RS485 driver, (D5 will flash when a reply is sent) indicating that the Host board is probably faulty, replace the host board. If the LED does not flash: power down the system and check for continuity of the RS485 connections: -

PL1 pins 9 or 10 on the PSU Tx boards and pin 9 of IC U6 on the Host (CPU) board

PL1 pins 7 or 8 on the PSU Tx boards and pin 10 of IC U6 on the Host (CPU) board

If the continuity is OK then Host board is at fault. Replace the Host board.

4.4.3.1 **Transducer Tests**

NOTE:	**Servicing the unit by replacing the entire Electronics/Transducer module with a known working spare is the simplest way of servicing the unit. If the tests above have failed to clear the fault then if possible replace the entire module and return the faulty module to Sonardyne for repair.**

Before the tests in this Section are carried out, all the tests outlined in earlier in this Section should have been carried out and communications must be operational.

The transducer assembly should as far as possible be eliminated as a cause of failure first:-

- Disconnect the transmitting element from the PSU/TX PCB by disconnecting the 3 pin Molex connector (PL 1 at the transducer end of the board).
- Disconnect the receiving elements by disconnecting the RX inputs A through E from the pre-amp box.
- Measure the capacitance of each element @ 1 kHz using an LCR meter
- The TX element should read:- Min 0.8nf to Max 1.2nf - with a Loss factor D $<$ 0.01
- The RX elements should read:- Min 0.3nf to Max 0.6nf - with a Loss factor D $<$ 0.05
- Next check the insulation resistance of the TX element @ 1000V and the RX elements @ 50V. It is particularly important to be sure of the TX element as this is constantly stressed electrically.

4.4.4 <u>Receiver/Transmitter Functional Tests</u>

The following is a logical sequence of tests to check the functions of the receivers and the transmitters. In the process the vital functions of the CPU board will be tested.

All of the tests are to be found by selecting "**System Setup**" from the top level menu and then selecting the "**System Test Programs**" option. Appendix E should be referred to for further information on these System Test Programs.

If the Transducer test described in Section 4.4.3.1 above has been carried out and the unit found to be OK, re-connect all leads.

Switch off the Navigation Processor.

4.4.4.1 **TX Tests - Synthesiser and TX Gate Output**

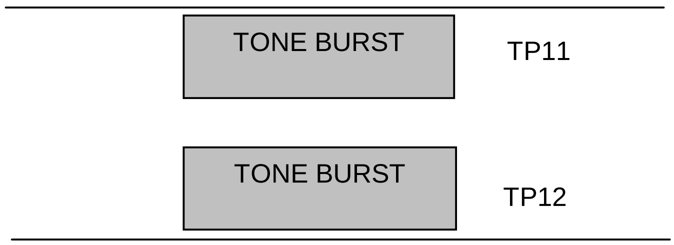
Connect the Transceiver Test lead (7784-290) between the 12 way Molex (PL1) connector on the PSU / TX board and the Transceiver output connector of the Navigation Processor.

- From the "**System Test Programs**" menu, select "**Transceiver Test Utilities**". This option tests the transmitter at various Frequencies and Power Levels.
- Use the "**Setup Transmit Parameters**" option to set up the Transmitter to LOW MEDIUM or LOW power, the pulse width to 4 ms and the frequency to CH1.
- Use the "**Setup Receive Pulse Parameters**" option to set up the Receiver to LINEAR / 0dB / 14dB / 12dB / 7kHz / 125ms / ±200Hz / 1s / 1500m/s / TRANSPONDER / CRF.

- ❑ Using an Oscilloscope (5V & 2ms per division) monitor the signals on the Tx card on TP 11 & 12 (connect the ground of the scope probe to TP 5). A Storage or Digital Storage Scope would be a great advantage here as the repetition rate will be very slow.

- ❑ Select the "**Range Test**" option.

- ❑ With no replies and zero range, all QB should be blank. On TP 11 & 12, check for a logic signal of ~ 4 ms duration swinging between -12V and 0V, as illustrated in the diagram which follows.



- ❑ Expanding the time base should reveal a square wave inside the grey areas shown above. The period of the Square Wave should be ~ 50µs.

If this is all OK, the Synthesiser and the TX gate signal are OK.

4.4.4.2 TX Tests - TX Output

Power down the Unit while the following connections are carried out.

To monitor the Transducer Output connector PL1 (this is hidden behind the Pre-Amplifier box at the base of the board), connect the scope probe across pins 1 and 3 of PL2 (do not remove the connector as the TX circuit needs a load to operate correctly).

N.B.	**The transmitter can produce > 2000V p/p across the transducer when operated in High Power. If you wish to check this voltage, make sure you are using a high voltage (x100 - 4kV or greater) probe and be careful not to touch the PSU / TX board during High Power tests.** **The unit should not be operated for too long at high power in air, as the matching of the Transducer will be incorrect when out of the water.**

Switch on the unit.

- ❑ Using the Transmit Setup facility again, select the CIF frequency (24.752kHz) and set the Transmit power to LOW.

  - Select the Range Test option and check for a 4ms long tone burst with an amplitude of > 200V peak to peak.

  - Repeat with the Transmit frequency set to CH14.

- ❑ Using the Transmit Setup facility again to change the Transmit power to HIGH MEDIUM and the frequency to CH1.

  - Select the Range Test option and check that the output voltage is > 800V peak to peak.

  - Repeat with the Transmit frequency set to CIF and then CH14.

- Using the Transmit Setup facility again to change the Transmit power to HIGH and the frequency to CH1.

  - Select the Range Test option and check that the output voltage is > 2000V peak to peak.

  - Repeat with the Transmit frequency set to CIF and then CH14.

Power the unit down, remove the probe and ensure the TX connector is correctly mated.

4.4.4.3 **TX Tests - Audible Response**

If an Oscilloscope is not available, the Transmitter can be checked (to a very limited extent) audibly.

Switch on the unit and return to the Transmitter test as described above.

- Select LOW power and listen for a click at the face of the Transducer - this will fall in volume as the voltage of the storage capacitor falls to the correct value. Once this value is attained you may have to place your ear fairly close to the Transducer face to hear the click. If no click can be heard at the transducer face then the transmitter is faulty.

- Select HIGH MEDIUM power and listen for a much large volume click at the Transducer Face.

- Select HIGH power and listen for a very much larger volume click at the Transducer Face. This should be audible from a reasonable distance (say 1 to 2m) from the face. If not then the Transmitter is faulty.

Power the unit down.

4.4.4.4 **Receiver Tests**

From the "**System Test Programs**" menu select the "**Transceiver Test Utilities**", and select "**Transceiver Calibration Test**".

This test starts by requesting which Transceiver is to be tested. Respond to the prompt and press <ENTER>. The procedure is then run automatically over the full range of channels and the full range of transducer elements, producing the following display:-

Sonardyne SOUND IN DEPTH
Current Level:
Top->System Setup->Test Menu->
TCVR Calibrate Test

15:34:47 24 Sep 05
File: 0
TCVR:PORT

Acoustic Channel	Avrge Phase	Element A	Element B	Element C	Element D	Element E	Element F	Phase Span
1	0.2	-0.2	-0.6	0.9	0.7	-0.5	-0.3	1.5
2	0.2	-0.2	-0.6	0.9	0.8	-0.6	-0.3	1.5
3	0.2	-0.2	-0.6	0.9	0.8	-0.6	-0.3	1.5
4	0.2	-0.2	-0.6	0.9	0.8	-0.7	-0.3	1.6
5	0.3	-0.3	-0.5	1.0	0.9	-0.7	-0.4	1.7
6	0.3	-0.3	-0.5	1.0	0.9	-0.7	-0.4	1.7
7	0.3	-0.3	-0.5	1.0	1.0	-0.8	-0.4	1.8
8	0.3	-0.3	-0.5	1.0	1.0	-0.8	-0.4	1.8
CIF	0.4	-0.4	-0.4	1.1	1.0	-0.9	-0.5	1.9
CRF	0.5	-0.5	-0.3	1.1	1.1	-0.9	-0.5	2.1
0	0.5	-0.5	-0.3	1.2	1.2	-1.0	-0.6	2.1
H6	0.5	-0.5	-0.3	1.2	1.2	-1.0	-0.6	2.2
SQUARE	0.5	-0.5	-0.3	1.2	1.2	-1.0	-0.6	2.2
9	0.5	-0.5	-0.3	1.2	1.2	-1.0	-0.6	2.2
H7	0.5	-0.5	-0.3	1.2	1.2	-1.0	-0.6	2.2
H8	0.6	-0.6	-0.2	1.2	1.2	-1.0	-0.6	2.3
CIRCLE	0.6	-0.6	-0.2	1.2	1.2	-1.0	-0.7	2.3
10	0.6	-0.6	-0.2	1.2	1.3	-1.1	-0.7	2.3
H9	0.6	-0.6	-0.2	1.3	1.3	-1.1	-0.7	2.4
11	0.6	-0.6	-0.2	1.3	1.3	-1.1	-0.7	2.4
H1	0.6	-0.6	-0.1	1.3	1.3	-1.1	-0.7	2.4
DELTA	0.6	-0.6	-0.1	1.3	1.3	-1.1	-0.7	2.4
12	0.7	-0.7	-0.1	1.3	1.3	-1.1	-0.7	2.5
H2	0.7	-0.7	-0.1	1.3	1.3	-1.2	-0.8	2.5
13	0.7	-0.7	-0.1	1.3	1.4	-1.2	-0.8	2.5
H3	0.7	-0.7	-0.1	1.3	1.4	-1.2	-0.8	2.6
X	0.7	-0.7	-0.1	1.3	1.4	-1.2	-0.8	2.6
14	0.7	-0.7	0.0	1.4	1.4	-1.2	-0.8	2.6
H4	0.7	-0.7	0.0	1.4	1.4	-1.2	-0.8	2.6
Y	0.8	-0.8	0.0	1.4	1.4	-1.2	-0.8	2.7
H5	0.8	-0.8	0.0	1.4	1.4	-1.2	-0.8	2.7

Phase span should be less than 10 degrees.

Test complete. Press Print Screen for hardcopy or any key to exit

For each channel, the set of phase angles measured on all transducers is displayed on the screen and should lie within about 10° of each other. If any phase angle is significantly different from its peers in the same channel, a transducer channel error may be indicated. Sonardyne should be contacted for advice if this should happen.

If one channel is suspect then the problem could be a faulty ceramic in the transducer array, a pre-amplifier channel or receiver channel or connections between boards. Check all cables for this channel for possible breaks or damage. Channel F of the pre-amp is unused and can be used by removing the input and output connection from the suspect channel and connecting to channel F.

If two or more channels are suspect then it is unlikely that the problem is the transducer or the cables. As the Pre-amps have 3 channels per board it is possible to narrow down the problem. The Pre-Amps have A, C & E on one board and B, D on the other. Thus if channels B & D give suspect readings the problem is likely to be the Pre-Amp board with B, D and if channels A,C,E are suspect then the problem is the other Pre-amp.

Power down the unit.

FIG 4.2 802X-000 USBL ACOUSTIC TRANSCEIVER - WIRING DIAGRAMS

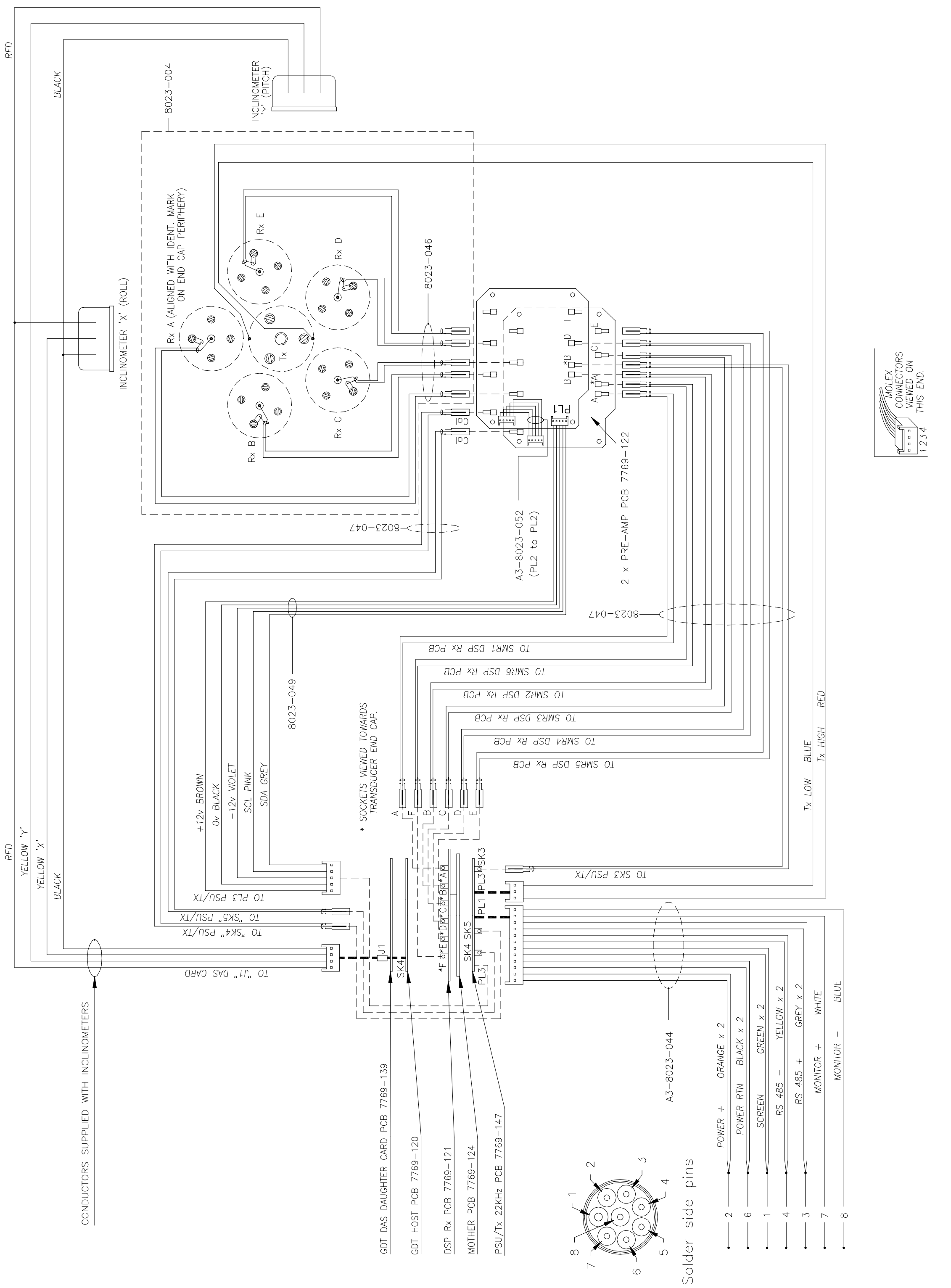


FIG 4.3 TRANSCEIVER HOUSING

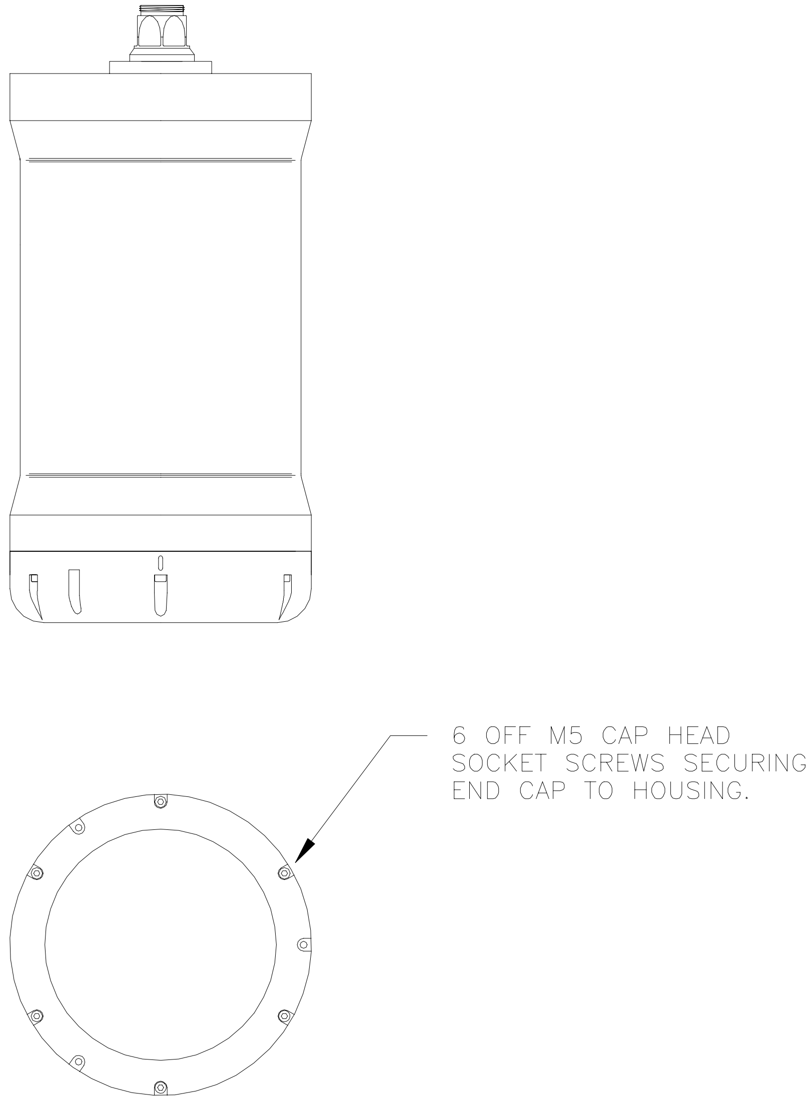


FIG 4.4 REMOVING ELECTRONICS/TRANSDUCER FROM HOUSING

DISCONNECTING CABLE

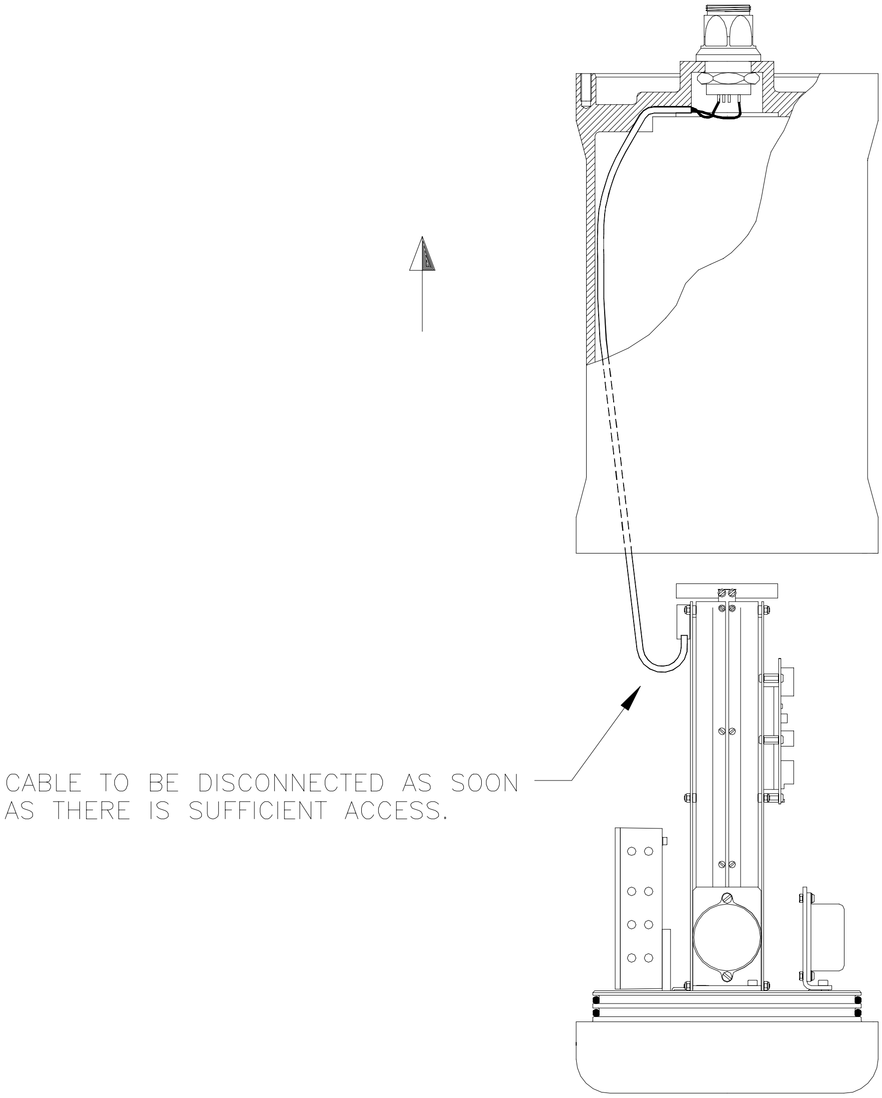
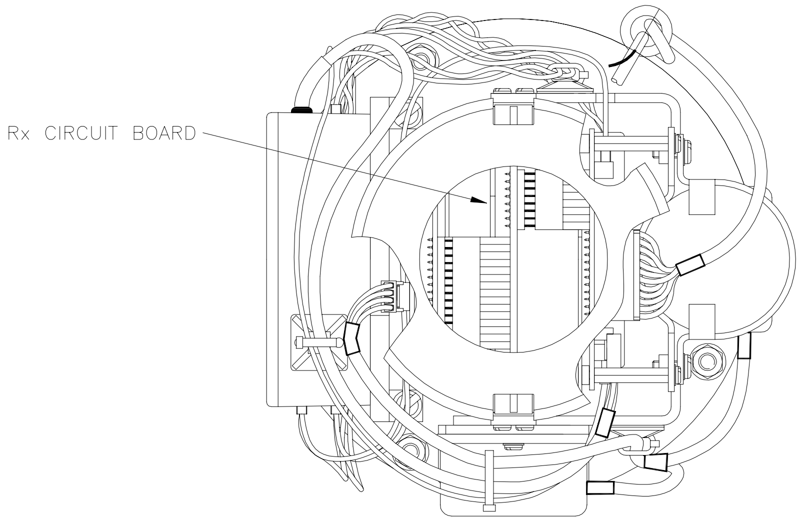


FIG 4.5 8023-009 ELECTRONICS CHASSIS



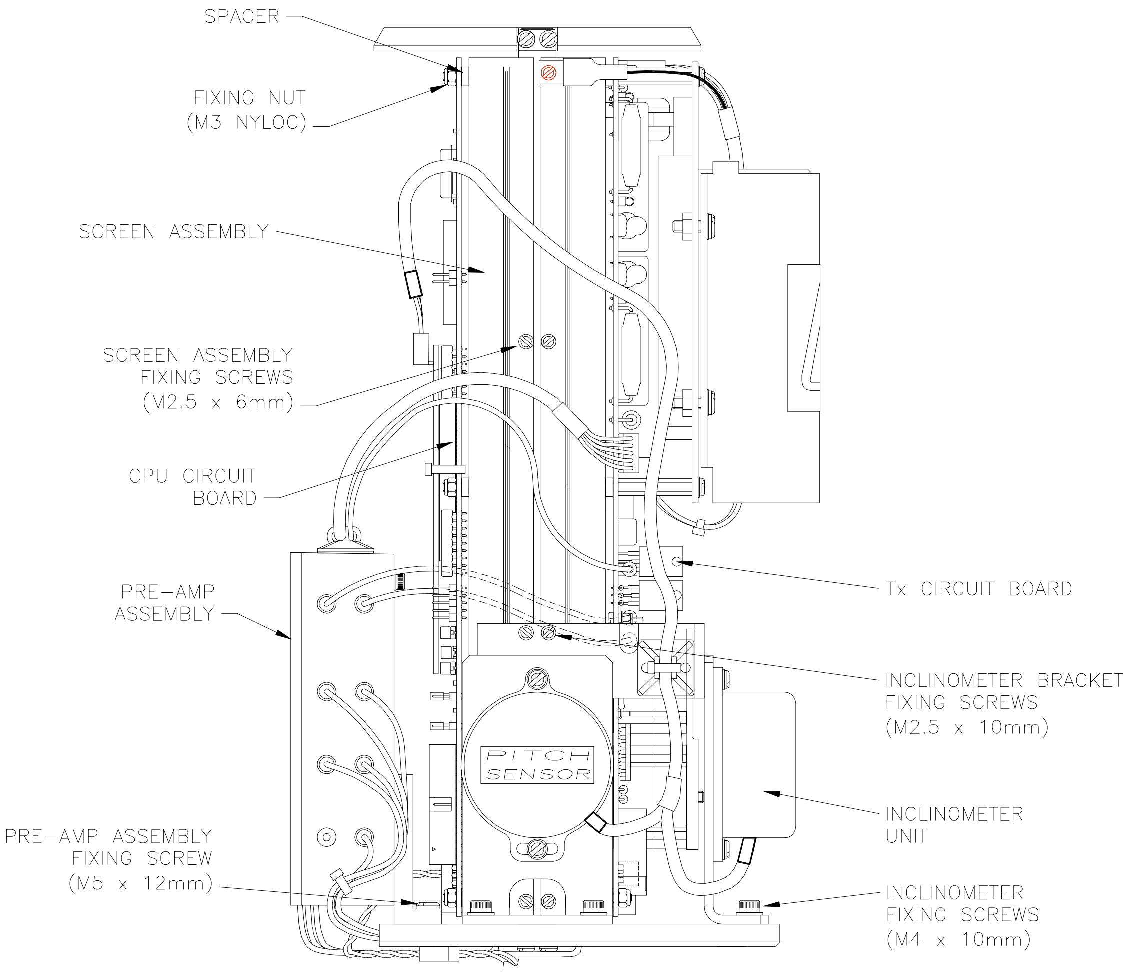


FIG 4.6 8023-008 PRE-AMPLIFIER ASSEMBLY

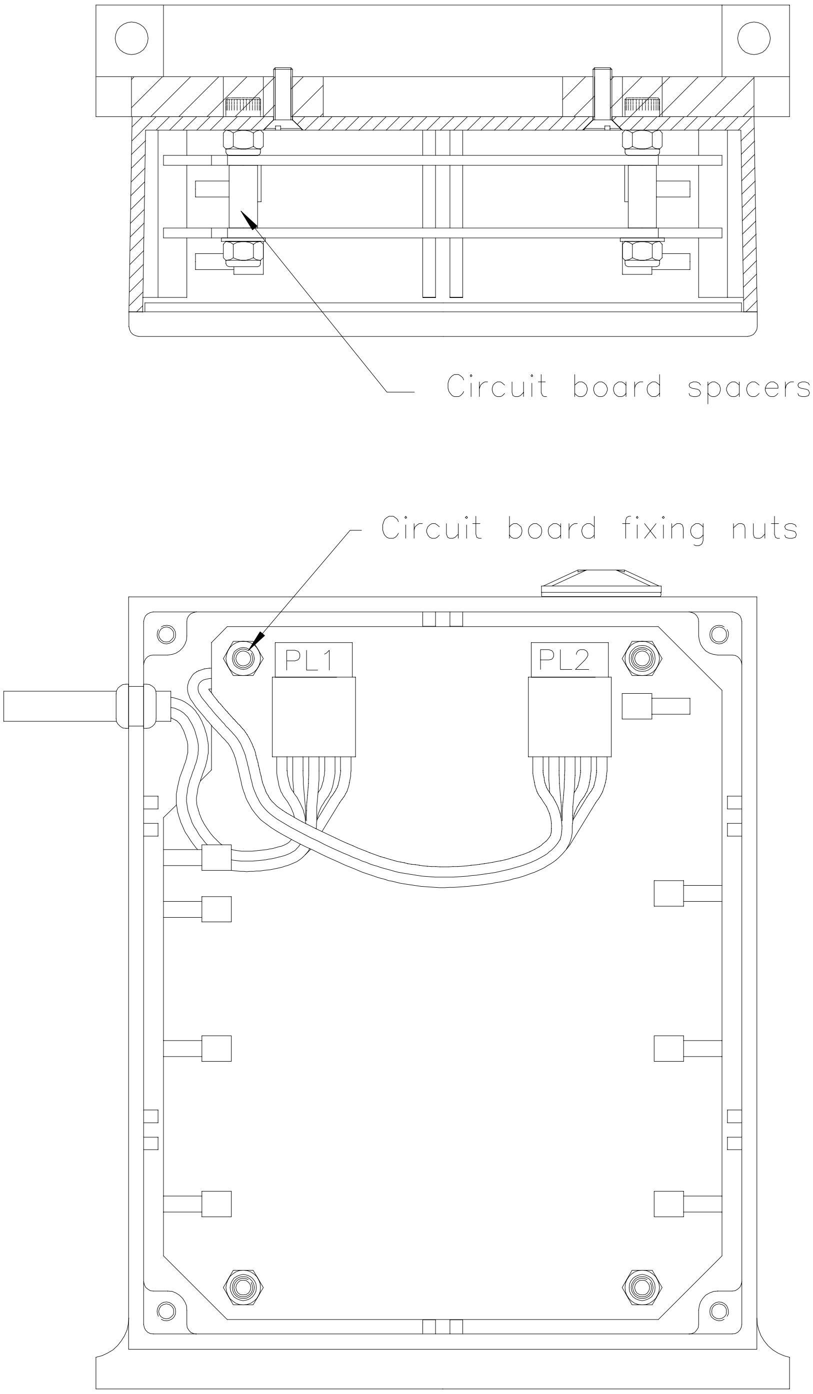
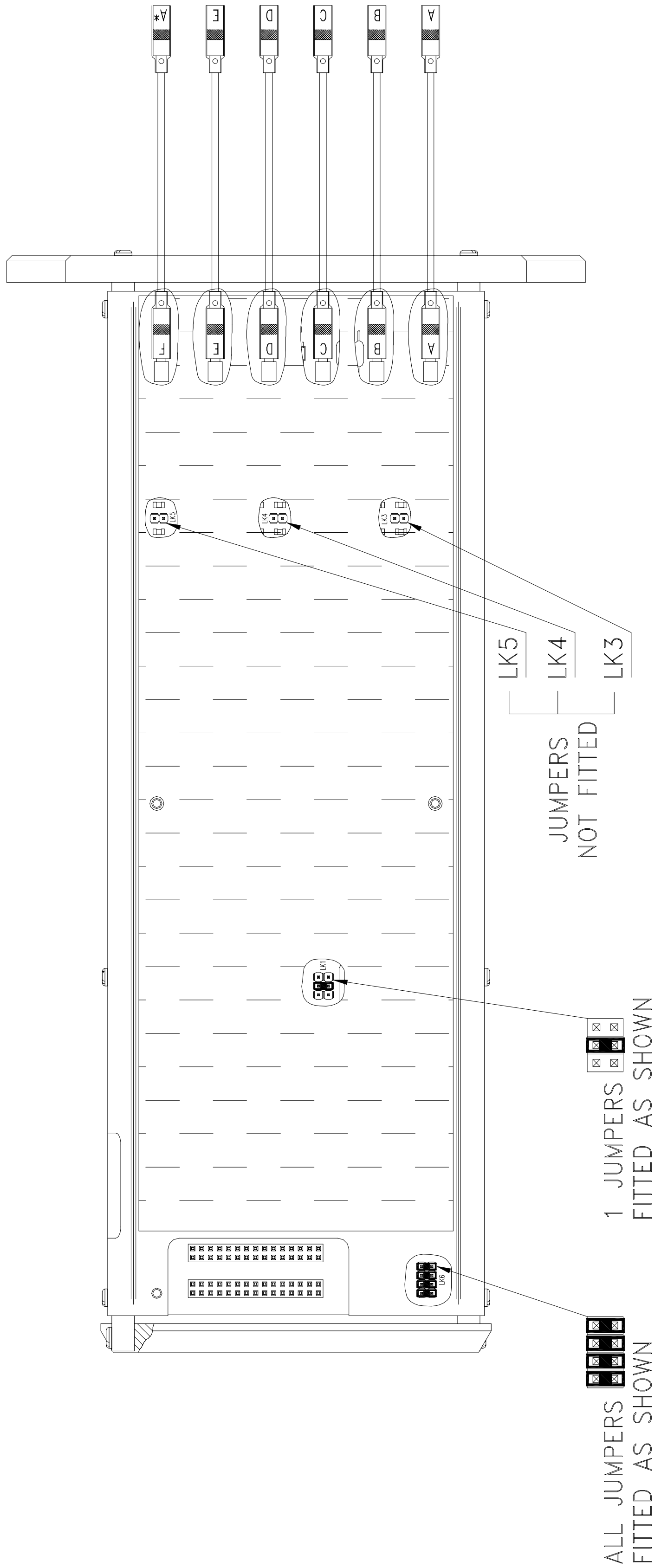


FIG 4.7 7769-121 LUSBL RECEIVER CARD – JUMPER SETTINGS



SECTION 5

5. TECHNICAL SPECIFICATIONS

5.1 SPECIFICATION FOR TYPE 8021-000 L/USBL 'STANDARD' TRANSCEIVER

5.1.1 Mechanical

Diameter (main body)	8.9 ins	225 mm
Diameter (over transducer)	8.9 ins	225 mm
Overall length	17.94 ins	456 mm

Note: An additional 7ins (180mm) should be allowed for flange and connector to fit into a sea chest.

It is recommended that Sonardyne be contacted prior to fitting to existing deployment machines to ensure correct installation.

Weight in air	62 lbs	28 kgs
Weight in water	30 lbs	13.5 kgs

5.1.2 Electrical

Maximum power	36-72V DC - 25 W continuous	
Communication	RS 485 baud rate switchable	9600 - 115200
Processor	32 bit micro controller	
A/D Converter (ADC)	multi-channel 16 bit	

5.1.3 Acoustic

Transmitting:

Directivity Index	8 dB approx.
Power	50 watts acoustic
Source Level	195 dB//1µPa·m (dB ref 1 micro pascal @ 1 m)

Receiving:

Operating envelope	±80° (160 deg) min
Sensitivity Threshold	100 dB ref 1 micro pascal
Directivity Index	10 dB
Repeatability	One standard deviation <0.5% of range for a signal/noise ratio (SNR) of 25dB measured as a spectrum level by an omnidirectional hydrophone <0.2% if SNR >35dB as measured by an omnidirectional hydrophone or SNR >20dB at phase meter
Accuracy	Better than 1% of range

5.1.4 Environmental

Operating Temperature:	-1 to 45°C in water

5.2 SPECIFICATION FOR TYPE 8023-000 L/USBL 'BIG HEAD' TRANSCEIVER

5.2.1 Mechanical

Diameter (main body)	8.9 ins	225 mm
Diameter (over transducer)	11.8 ins	300 mm
Overall length	19.14 ins	486 mm

Note: An additional 7ins (180mm) should be allowed for flange and connector to fit into a sea chest.

It is recommended that Sonardyne be contacted prior to fitting to existing deployment machines to ensure correct installation.

Weight in air	90 lbs	41 kgs
Weight in water	44 lbs	20 kgs

5.2.2 Electrical

Maximum power	36-72V DC - 25 W continuous	
Communication	RS 485 baud rate switchable	9600 - 115200
Processor	32 bit micro controller	
A/D Converter (ADC)	multi-channel 16 bit	

5.2.3 Acoustic

Transmitting:

Directivity Index	8 dB approx.
Power	50 watts acoustic
Source Level	195 dB//1µPa·m (dB ref 1 micro pascal @ 1 m)

Receiving:

Operating envelope	±90° (180 deg) at 24kHz to ±48° (96 deg) at 32kHz
Sensitivity Threshold	85 dB ref 1 micro pascal
Noise Rejection Index @90°	20 - 40 dB generally rising with frequency
Repeatability	<0.15% of slant range D_{RMS} for a 30 dB signal/noise ratio (SNR) in the receiver bandwidth. This Signal to Noise Ratio in the receiver can be maintained in the presence of intense noise in the water provided that the noise sources lie well outside the beam. (See the Noise Rejection figure above.)
Accuracy	Better than 1% of range

5.2.4 Environmental

Operating Temperature:	-1 to 45°C in water

FIG 5.1 OUTLINE DRAWING TYPE 8021-000 'STANDARD' USBL

Acoustic Transceiver

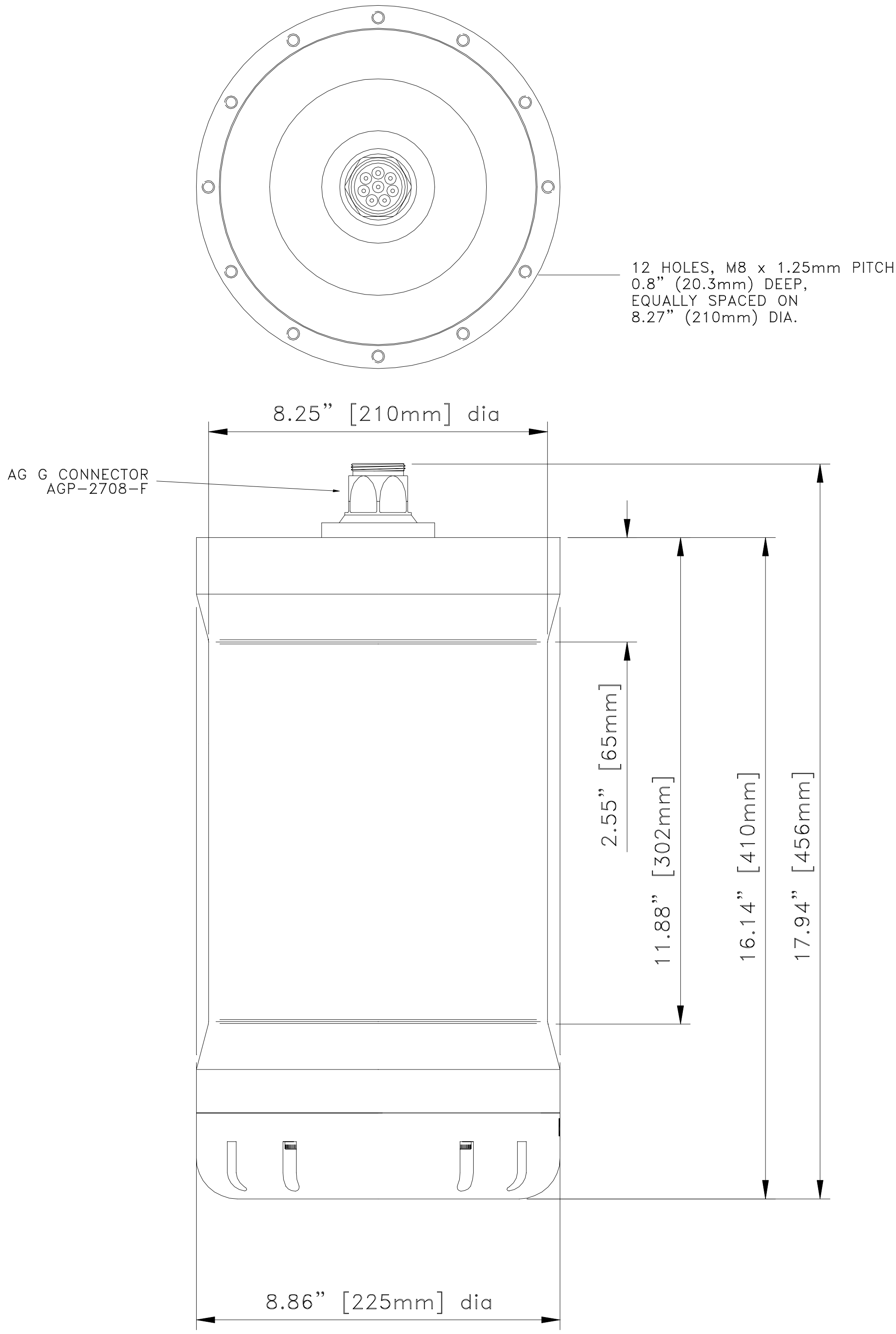
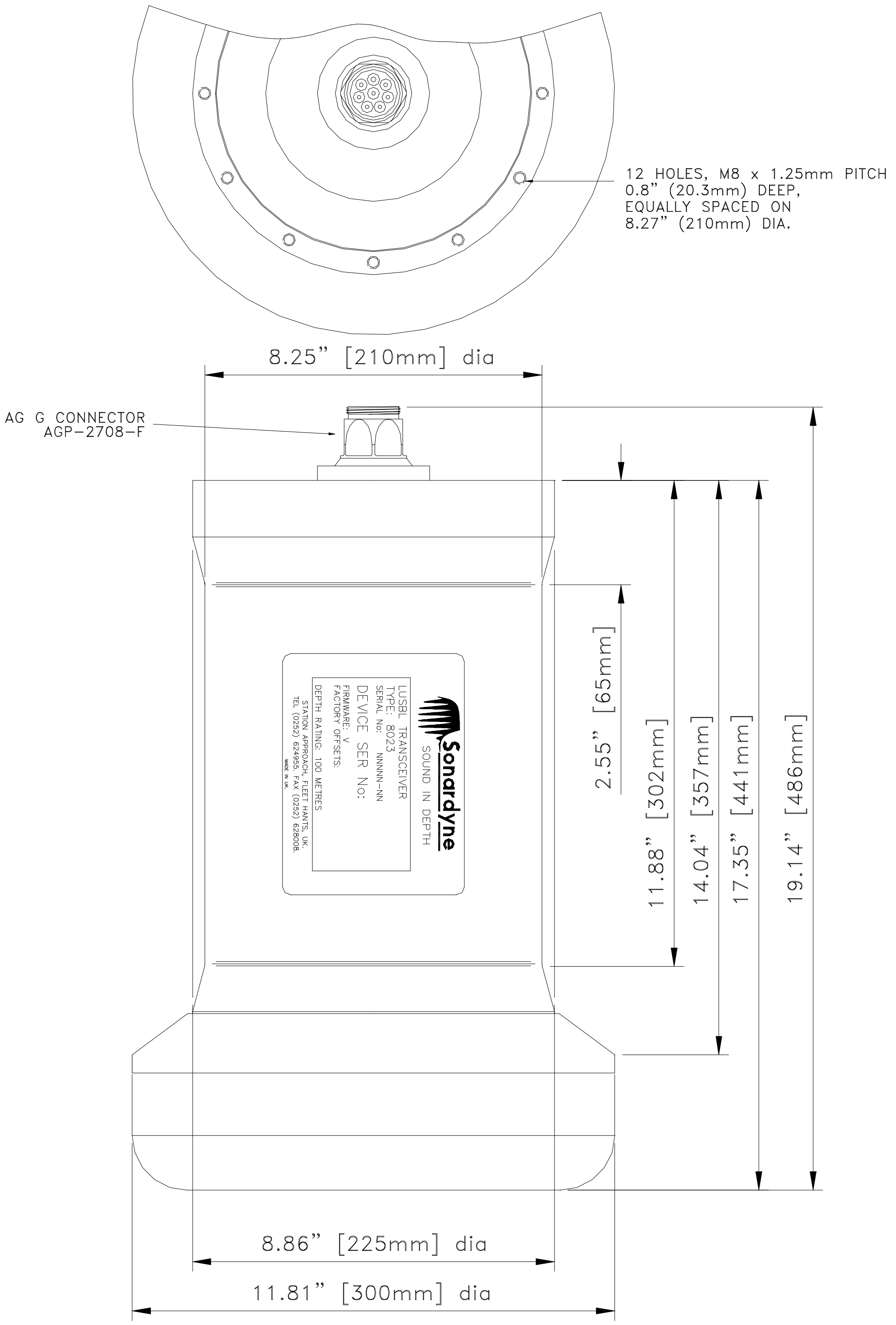


FIG 5.2 OUTLINE DRAWING TYPE 8023-000 'BIG HEAD' USBL

Acoustic Transceiver



APPENDIX A

A.1 SPARES LIST - USBL TRANSCEIVER

Part No.	Dwg No	Description	QTY
PCB'S			
631-5855	7769-147	GDT PSU Tx PCB Assembly	1
631-5699	7769-122	GDT Pre-Amp PCB Assembly	2
631-5685	7769-121	GDT Receiver PCB Assembly	1
631-5678	7769-120	GDT Host PCB Assembly	1
631-5841	7769-139	GDT DAS Daughter PCB Assembly	1
631-5712	7769-124	GDT Mother Board PCB Assembly	1
		(Note:- If Motherboard is replaced, Sonardyne must be Contacted to obtain Motherboard Identity software)	
ASSEMBLIES			
641-1572	8023-009	Chassis Assy GDT USBL (Complete Assembly)	1
641-1568	8023-008	Pre-Amp Assembly	1
HOUSING			
710-2493	8021-014	Housing USBL	1
TRANSDUCERS			
641-2020	8021-002	Transducer Assy GDT USBL - (8021 Standard Transceiver)	1
641-1559	8023-004	Transducer End Cap Assy USBL – (8023 Bighead Transceiver)	1
200-367B	200-367-5570	Seal 'O' Ring	2
581-3181	02110002-000	Inclinometer 02110002-000 Accustar	2
CABLES			
820-5947	7784-289-A	Nav Processor – Ship Cable (Topside cable)	1
820-3427	7769-038-C3	AGP Tail Cable Assy 30mt (Subsea Cable)	1
MISCELLANEOUS			
345-4913	-	Capacitor 20v / 150mF	1

A.2 SPARES LIST - USBL TRANSCEIVER (CONTINUED)

Part No.	Dwg No	Description	QTY
INSTALLATION			
640-6792	7769-063	Transceiver Installation Kit (USBL)	1
		(This kit contains all of the following parts)	
206-064C	-	Insulation Bush 015-0986 M8.0 Nylon	12
230-1462	-	Washer Spring S/S M8 Din 7980 small O/D	12
212-1362	-	Screw Socket Cap S/S M8 X 50	12
755-1409	7769-117-B	Insulator Flange Ring	1
200-3661	200-366-5570	Seal ‘O’ Ring	1
200-3647	200-364-5570	Seal ‘O’ Ring	1
820-4808	7009-304-A3	Test Cable Assy	1
200-8088	200-868-5570	Seal ‘O’ Ring	1
800-4889	7769-118-A	Washer Plate	6
212-133B	-	Screw Socket Cap S/S M8 X 30	6
200-1896	1895:30-043	Seal ‘O’ Ring Nit	2
200-4399	200-439-5570	Seal ‘O’ Ring	1

APPENDIX B

B. FIRMWARE HISTORY

GDT-USBL firmware is separated into two distinct types, the **Kernel** and the **Application**.

The **Kernel** firmware is programmed in the factory and can not be upgraded in the field via a serial downloaded. Kernel firmware can therefore only be upgraded by returning to the factory. The Kernel provides the functionality required to install or upgrade application firmware via serial download and boot the application firmware on power-up or reset.

The **Application** firmware can be upgraded in the field via a serial download, using a suitable PC programming utility such as the GDT Programmer. The software package for this is included at the rear of this manual, on CD.

Kernel Firmware History

VERSION	DATE	DESCRIPTION
1.00.00.05	17/04/01	First Release

Application Firmware History

VERSION	DATE	DESCRIPTION
6.00.00.12	*21/04/2001*	*Beta Release – Initial*
6.01.00.02	*08/05/2001*	*Beta Release – Revised*
6.02.00.00	08/05/2001	Corrected Telemetry Timing Issues
6.05.00.06	03/05/2002	Corrected Binary Command Timing Issues Corrected Noise Measurement Levels Added Support for HPR-400

APPENDIX C

C. ACOUSTIC NAVIGATION SYSTEM PRINCIPLES

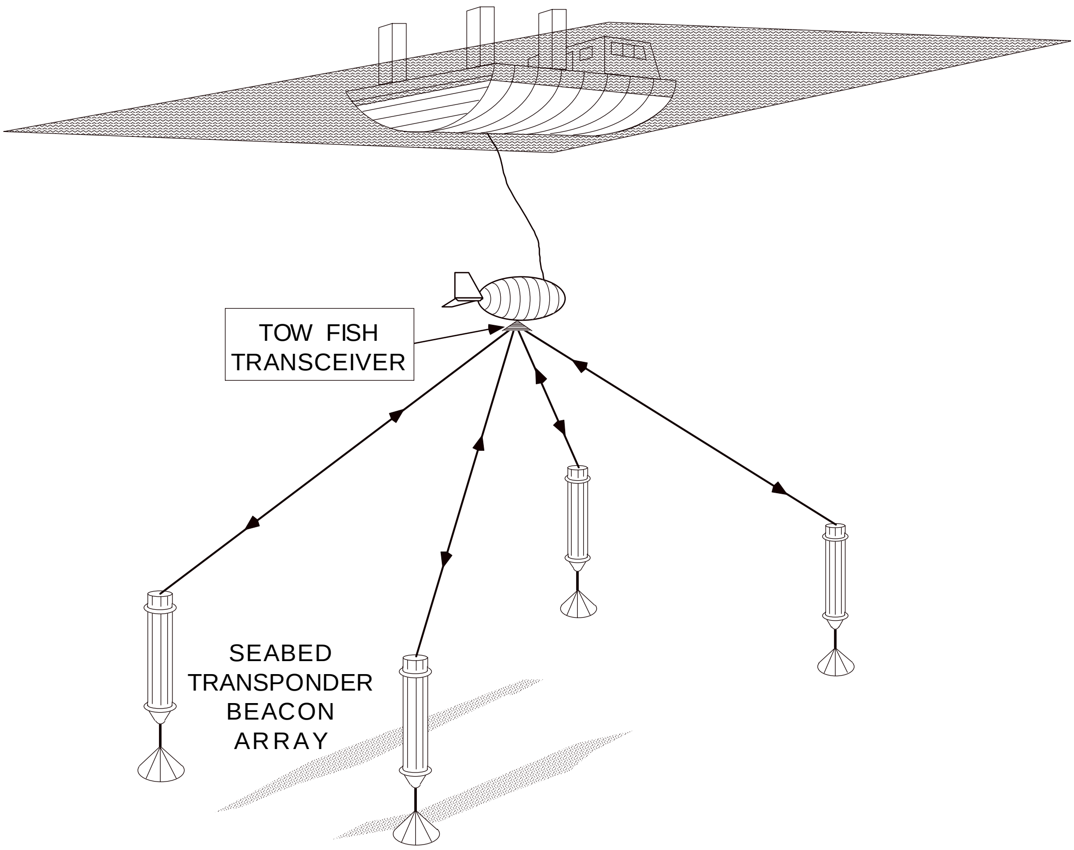
C.1 LBL PRINCIPLES

A "Long-Base-Line" system has two parts or segments.

The first segment comprises a number of acoustic transponder beacons moored in fixed locations on the seabed - see Fig C.1. The positions of the beacons are described in a co-ordinate frame fixed to the seabed. The distances between them form the “baselines” used by the system.

The second segment comprises an acoustic transducer on a transceiver which is normally temporarily installed on the vessel - or on a Tow Fish in the example shown in Fig C.1. The distance from a transducer to a transponder beacon can be measured by causing the transducer to transmit a short acoustic signal which the transponder detects and causes it to transmit an acoustic signal in response. The time from the transmission of the first signal to the reception of the second is measured. As sound travels through the water at a fixed speed, the distance between the transducer and the beacon can be estimated. The process is repeated for the remaining beacons and the position of the vessel relative to the array of beacons is then calculated or estimated.

FIG C.1 A CLASSICAL LBL SYSTEM



In principle, navigation can be achieved using just two seabed transponder beacons but in this case there is a possible ambiguity as to which side of the baseline (a line drawn between the beacons) the vessel may be. In addition, the depth or height of the transducer has to be assumed. Three transponder beacons is the minimum required for unambiguous navigation in three dimensions; four is the minimum number required for some degree of redundancy - which is useful for checks on the quality of navigation.

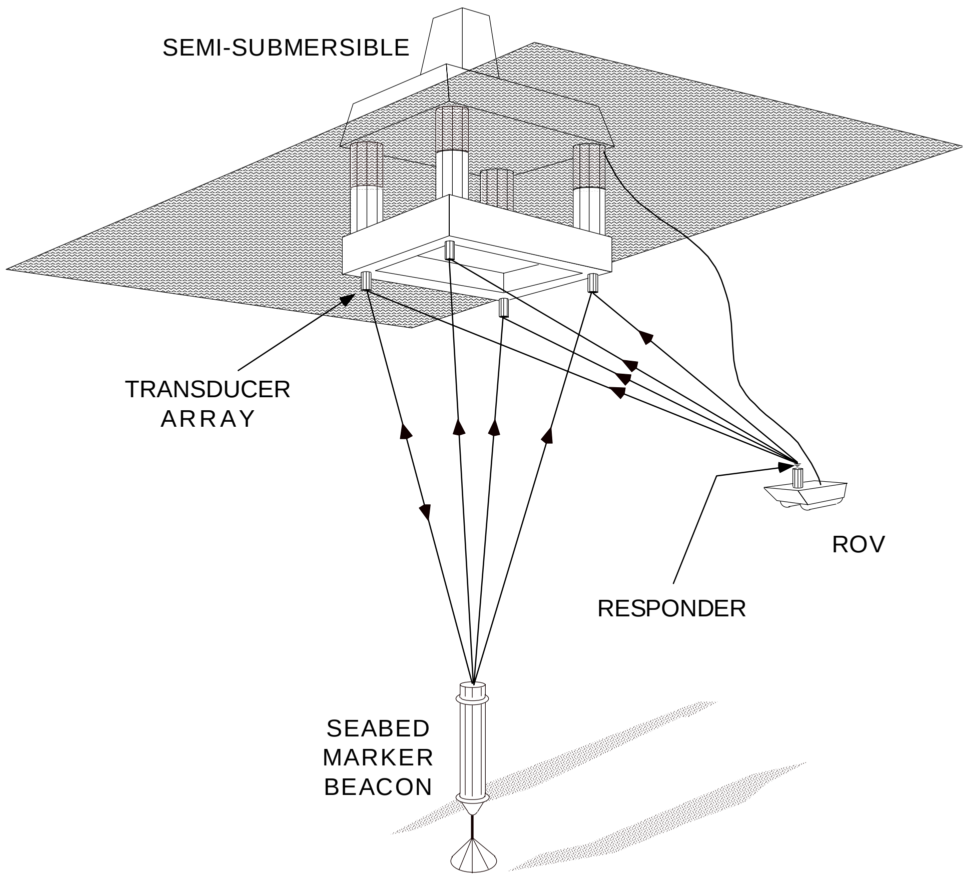
The term "Long-Base-Line" is used because in general the baseline distances are much greater for LBL than for SBL (Short Base-Line) and certainly for USBL (Ultra Short Base-Line)! Because the baselines are much larger, an LBL system is very accurate compared with the SBL and USBL versions and also has the advantage of positioning the vessel (or any other object) directly in a "fixed" or an inertial frame. This removes most of the problems associated with vessel motion.

The array of seabed beacons needs to be calibrated and there are several techniques available for achieving this. The most appropriate technique depends on the requirements of the task or job in hand and the available hardware. With the continuing integration of LBL, SBL and USBL systems, intelligent transponder beacons (that measure baselines directly) and satellite navigation systems, the calibration of seabed arrays is becoming a quick and simple operation. The operator will be free to choose the techniques appropriate to the requirements and the task.

C.2 SBL PRINCIPLES

A "Short-Base-Line" system is normally fitted to a vessel such as a barge, semi-submersible or a large drilling vessel - see Fig C.2. A number of (at least three but typically four) acoustic transducers are fitted in a triangle or a square on the lower part of the vessel. The distances between the transducers (the "baselines") are made as large as is practical, typically they are at least 10 metres long. The position of each transducer within a co-ordinate frame fixed to the vessel is determined by conventional survey techniques or from the "as built" survey of the vessel.

FIG C.2 A CLASSICAL SBL SYSTEM



The term "Short" is used as a comparison with "Long-Base-Line" techniques where, in general, the "baselines" are much bigger.

If the distances from the transducers to an acoustic beacon are measured as described for LBL, then the position of the beacon, within the vessel co-ordinate frame, can be computed. Moreover, if redundant measurements are made, a best estimate can be determined which is, statistically, more likely to be more accurate than the basic position calculation.

It is impractical to transmit a signal from each SBL transducer in turn. Therefore systems that use transponder beacons transmit from one transducer but receive simultaneously on all transducers. The result is one distance (or range) measurement and a number of range (or time) differences.

With an SBL system, the co-ordinate frame is fixed to the vessel - which is subject to roll (change in list), pitch (change in trim) and yaw (change in heading) motion. This "disadvantage" can be overcome by using additional equipment such as a VRU (Vertical Reference Unit - see glossary) to measure roll and pitch and a Gyro-compass to measure heading. The co-ordinates of the beacon can then be transformed mathematically to remove the effect of these rotational motions.

If the requirement is to estimate the position of the vessel in some "fixed" or "inertial" frame such as one fixed to the seabed, then at least one beacon should be placed in a fixed position on the seabed and used as a reference point. It is this principle that is used for "DP" vessels. Fig C.2 illustrates a system having a transponder beacon fixed to the seabed and a responder beacon located on an ROV (Remotely Operated Vehicle). In such a case, the system can calculate the position of both the vessel and the ROV in a seabed-fixed frame.

C.3 USBL PRINCIPLES

USBL (Ultra-Short-Base-Line) techniques are very similar to SBL techniques except that the transducers are all built into a single transceiver assembly - or the array of transducers is replaced by an array of transducer elements in a single transceiver assembly - see Fig C.3, which follows.

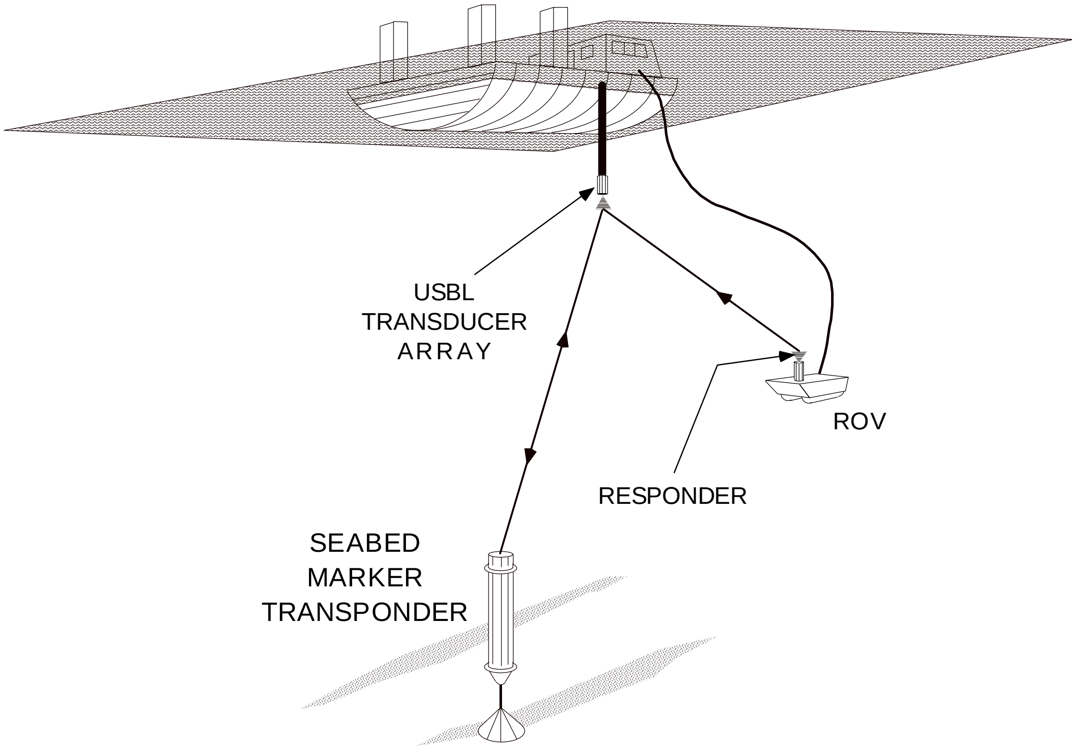
The distances or ranges are measured as they are in an SBL system but the time differences are now much less. Systems using sinusoidal signals measure the "time-phase" of the signal in each element with respect to a reference in the receiver. The "time-phase differences" between transducer elements are computed by subtraction and then the system is equivalent to an SBL system.

Similar rules apply in that systems using three elements (or groups of elements) have the same restrictions as SBL systems with three transducers. USBL systems using four elements have the same restrictions as SBL systems using four transducers and so on.

An additional restriction is that if an unambiguous position within a hemisphere is required and there are only three elements or element groups in use, then the element spacing must be less than one-half wavelength of the signal. Alternatively, a prior set of measurements must have been made with an element spacing of less than one-half wavelength.

Another practical difference is that the transducer elements are in a Transceiver assembly that is placed somewhere in the vessel frame. The attitude of the assembly in the vessel frame must be measured during installation. It should be remembered that, intrinsically, a USBL system positions a beacon in a frame fixed to the Transceiver assembly, not directly in a vessel-fixed frame as in the SBL case.

FIG C.3 A CLASSICAL USBL SYSTEM



C.4 LUSBL PRINCIPLES

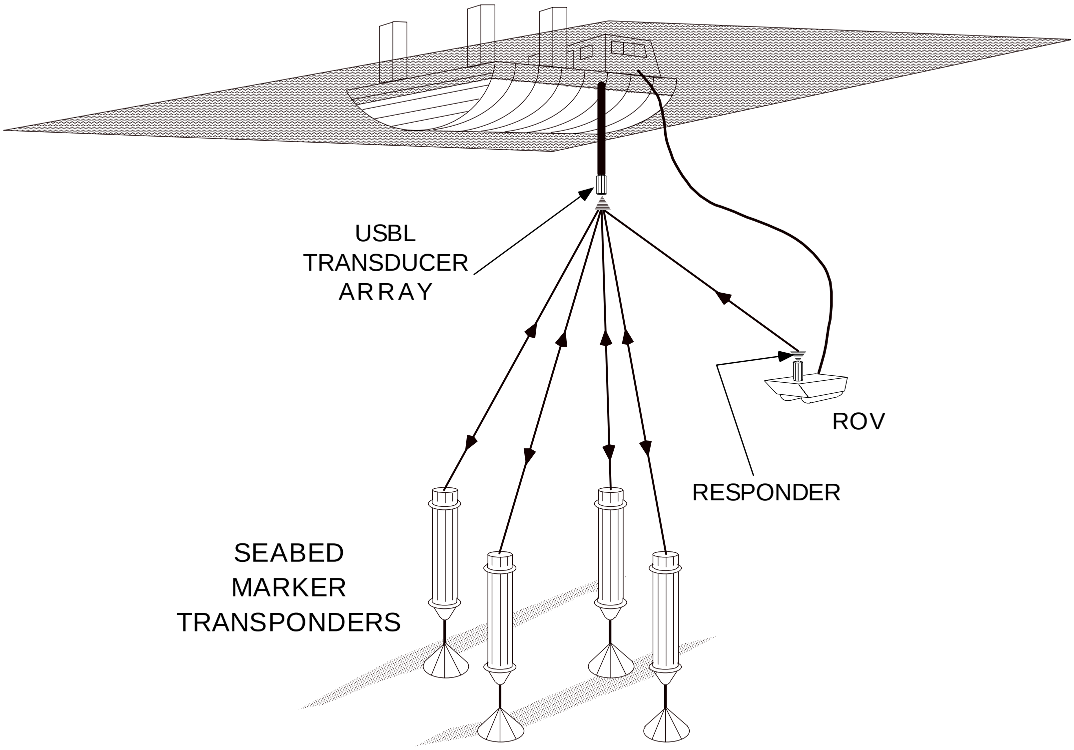
The LUSBL system is a special case of a USBL system. It utilises USBL hardware in a configuration similar to the one described for the LBL system - see Fig C.4 which follows.

Range and bearing in an LUSBL system are still measured as described for a basic USBL system. However, because a larger number of beacons is deployed on the seabed, a considerable improvement in accuracy may be achieved.

In a basic LUSBL system as illustrated in Fig C.4, the seabed array must be calibrated separately and the resultant baseline data entered manually into the LUSBL Navigation Processor. If, however, a Radio Navigation input is available to the LUSBL system, it is feasible to locate each seabed beacon directly in an earth-referenced frame to an accuracy determined by the accuracy of the Radio Navigation system. Thus, in this case, there would be no need for separate calibration of the seabed beacon array.

Similarly, if beacons of the COMPATT type (see Glossary) are used on the seabed, the potential exists for the seabed array, under command from the LUSBL system, to be self-calibrating. Using COMPATT beacons has the advantage also of affording the system considerably more flexibility in that they can be commanded to respond on any of a variety of frequencies and with any desired delay time. Thus, from the operator's point of view, the COMPATT version of the system becomes simpler and faster to set up and use.

FIG C.4 A CLASSICAL USBL SYSTEM



Two complete sets of LUSBL equipment (Navigation Processor, Monitor/Keypad and Transceiver) may operated in tandem to form a dual-redundant version of the System. The two sub-systems are cross-linked in such a way that, in the event of a failure of any major element, system operation will continue without the need for operator intervention. From the operator's point of view, operation of the dual-redundant version is essentially identical to that of the standard version.

In operation, one sub-system or the other operates as the "master" and performs all normal system functions. The second sub-system monitors the function of the "master" and will commandeer system operation if it detects that the erstwhile "master" is not functioning.

APPENDIX D

D. USBL TRANSCEIVER HEADING ALIGNMENT

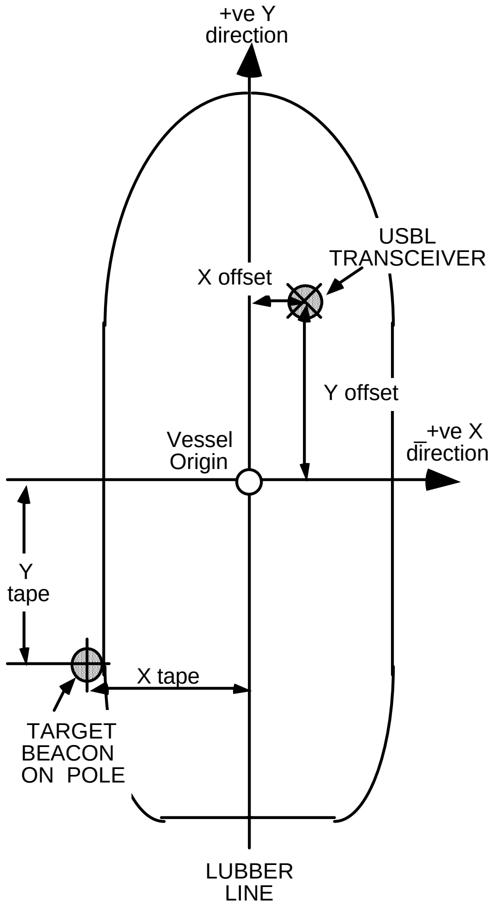
D.1 GENERAL CASE

The procedure given below enables the Transceiver to Ship Grid correction to be derived with the Transceiver installed in its normal operating position.

Suspend a Transponder over the side of the ship on a pole, taking care to ensure that the pole is clamped parallel to the Ship's Z axis as accurately as possible. The actual bearing of the Transponder from the Transceiver may then be determined from the relationship:-

$$\text{Actual Bearing } \alpha = \tan^{-1}\left(\frac{x_{tape} + \text{Xoffset}}{y_{tape} + \text{Yoffset}}\right)$$

where x_{tape} and y_{tape} are tape measurements, as shown on the diagram. Measurements to Starboard are positive and to Port are negative. Measurements forward are positive and aft are negative. From the position of the transceiver in the diagram, both the measurements would be negative



Before using this information, work through the menu structure to the Set-Up / Installation / Transceiver Positions page and ensure that there are no Transceiver Offsets entered on the page.

Then go to Navigation/Chart Co-ord Frame / Ship Frame/Bows Up page and calculate the USBL Transceiver version of the bearing as follows:-

$$\text{USBL Bearing } \beta = \tan^{-1}\left(\frac{x_{display}}{y_{display}}\right)$$

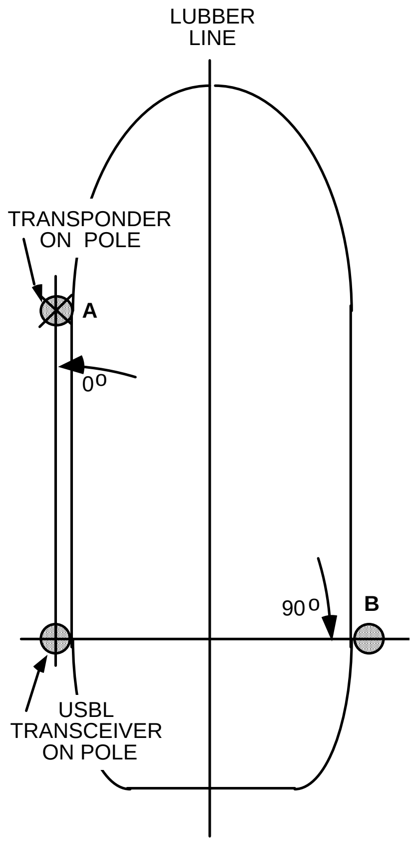
where $x_{display}$ and $y_{display}$ are taken from the data box on the "Bows Up" page. The correction to be applied can now be calculated as:-

Correction Angle = $\alpha - \beta$

Enter this value as the "Transceiver to Ship Grid Heading" on the Set-Up/Installation/Roll-Pitch and Heading Sensors/Corrections page. Go back to the data box on the "Bows Up" page and recalculate the USBL Bearing, β. It should now be very close to the Actual Bearing, α, as determined from the tape measurements. If it is not, repeat the correction procedure.

Once the transceiver to ship frame rotation has been determined, re-enter the Transceiver offsets from the reference point to the Transceiver. In the example above, X & Y are both positive.

D.2 SPECIAL CASE - PREFERRED



Correction of Transceiver alignment errors may be achieved more conveniently by positioning the Transponder, on its pole, either directly forward of the Transceiver (at A on the diagram) or, if this is difficult for some reason, directly athwartships (at B on the diagram). Note that, for this procedure to work, position A must lie on a line from the Transceiver parallel to the lubber line (or position B must lie on a similar line at right angles to the lubber line). As before, the Transponder pole must be clamped parallel to the ship's Z axis as accurately as possible and the Transceiver offsets are set to zero.

Greater accuracy will be achieved by positioning the Transponder pole as far as possible away from the Transceiver. For this reason, position A is preferred to position B.

For position A, the actual bearing will be 0° and the $x_{display}$ value on the "Bows Up" page should also be zero if the Transceiver is correctly set up. If $x_{display}$ is not zero, calculate the correction angle again as described in Appendix D.1 and enter this value on the Corrections page. Repeat the process as necessary to achieve an acceptably small error.

If position B is used, the procedure will be the same, but the actual bearing will be 90° and $y_{display}$ on the "Bows Up" page should be zero once the Transceiver is correctly set up.

APPENDIX E

E. TRANSCEIVER TESTS

To test the Transceiver it is necessary to test as a complete USBL system.

From the top level menu on the USBL system, select “System Setup” followed by “System Test Programs”. Seven System Tests are available under this heading. The two tests that are relevant to Transceiver testing are:-

E.1 TRANSCEIVER CALIBRATION TEST

Start by selecting “**Transceiver Calibration Test**” from the “**System Test Programs**” menu.

When the system is installed, the receivers should be given a functional test to make sure that the calibration values for the transducer elements have not changed in transit. The Transceiver system can inject a test signal into all transducer elements and measure the electrical phase angle in each case with respect to the reference.

This test starts by requesting which Transceiver is to be tested. Respond to the prompt and press <ENTER>. The procedure is then run automatically over the full range of channels. For each channel, the set of phase angles measured on all transducers is displayed on the screen and should lie within about 5° of each other (ie, the largest angle minus the smallest angle should be less than 5°). If any phase angle is significantly different from its peers in the same channel, a transducer channel error may be indicated. Sonardyne should be contacted for advice if this should happen.

If testing a dual-redundant version of the LUSBL, repeat the test for the other Transceiver.

Having completed this test, return to the “**System Test Programs**” menu.

E.2 TRANSCEIVER TEST UTILITIES

Select “**Transceiver Test Utilities**”.

There are five utilities available on this page. Pressing <ESC> terminates any utility. This test also starts by requesting which Transceiver is to be tested. Respond to the prompt and press <ENTER>. Then proceed through the test procedures in the following order.

1. **Setup Transmit Parameters.** This routine enables transmit parameters to be edited as necessary in preparation for Test No 3. Common settings are:

   - **TX POWER**

   - Use LOW Power for shallow water or in-air testing
   - LOW MEDIUM Power is not very different in output power from LOW Power and is therefore generally not used
   - Use HIGH MEDIUM Power in shallow water if the target is suspected to be deaf or in air
   - Use HIGH Power for deep water. NOT FOR USE IN AIR.

   - **TX PULSE WIDTH**

   - If dealing with COMPATTs, set to 4ms.

- If dealing with SIMRAD Beacons or SONARDYNE Beacons operating on SIMRAD channels, select 8ms.

- ❑ **TX FREQUENCY**

- For SIMRAD Beacons or SONARDYNE Beacons operating on SIMRAD channels, select the required channel from G21 to G29 (for SIMRAD HPR309 channels 1 to 9) or G31 to G35 (for the SIMRAD HPR205 symbol channels).

- For SONARDYNE channels, select the desired channel in the ranges G0 to G14 and G16 (CIF).

2. **Setup Receive Pulse Parameters.** This routine enables receive parameters to be edited as necessary also in preparation for Test No 3. Common settings are:

RECEIVER MODE	Normally Linear
SENSITIVITY	In shallow water, or in a reverberant environment, start at 30dB attenuation. Otherwise set at 0dB attenuation.
DETECTION THRESHOLD	Start with 12dB
VALIDATION THRESHOLD	Start with 14dB
SAMPLE RATE	Start at 7kHz but adjust to (say) 6kHz if the channel to be received is close to a multiple of 7kHz.
TURN AROUND TIME	Use 125ms (Default) or the appropriate TAT set in the Compatt in use, (Multiples of 62.5ms). or 30ms for the Simrad channels.
BANDWIDTH	Start with ±200Hz
REPLY PERIOD	Start with 1 second but increase in deep water.
SOUND VELOCITY	Use a sound velocity meter or make an educated guess based on knowledge of the area you are working in.
BEACON TYPE	Select appropriate option.
RX FREQUENCY	Select required channel. For Sonardyne COMPATTs and DMTs, the RX channel name/number is <u>different</u> from the TX channel name/number. For SIMRAD and Sonardyne Simrad-compatible Transponders and USBL/LUSBL Transponders, the RX channel name/number matches the TX channel although different frequencies are used.

3. **Range Test.** This routine interrogates a beacon and displays the received pulse graphically. This test uses the transmit and receive parameters set up in options 1 and 2 but makes those two pages accessible for editing, if required.

4. **Noise Test.** This routine is very useful for trouble-shooting acoustic noise problems at sea. It causes the system to go through a transmit/receive sequence on each channel and displays the results as total noise and in-band noise for each channel. A line graph is displayed showing current trace, peak hold trace, and average trace. Wait until at least three runs have taken place to stabilise the data.

In a reasonably quiet environment, the average trace peaks and troughs will be within a 6dB spread and will be in the region of 55dB to 70dB. If a particular frequency shows a high level, avoid using transponders on that channel. The Sonardyne and Simrad HPR309 and HPR205 channels are shown at the bottom of the graph.

This test makes no reference to the transmit/receive parameters set in options 1 and 2.

5. **Transceiver Commands Interface.** This routine enables command mnemonics to be sent manually to the Transceiver. This process requires specialist knowledge and should not be attempted except with Sonardyne help.

If testing a dual-redundant version of the LUSBL, select option 6 (Escape) and repeat the whole test sequence for the other Transceiver.

Having completed these procedures, return to the "**System Test Programs**" menu.

APPENDIX F

F. ANT PROGRAMMING

F.1 INTRODUCTION

The programme given in this Appendix enables the ANT to act as a Transponder.

F.2 ANT TRANSPONDER PROGRAMME

KEY	LABEL	COMMENTS
ON	POWER UP	
3	MULTI	
3	OLD PAN	PAN MODE
2	INTERROGATE	
2	SET	
4	SWAP	ANT BECOMES TRANSPONDER
2	TX REPLY	
6	MF	
3	CRF	
3	RX INT'G'N	
6	MF	
2	CHAN	
5	<ENTER>	TRANSPONDER INT'G'N CHANNEL
4	TRT	TURN AROUND TIME
250	<ENTER>	
1	EXIT	
3	STORE	
1	<ENTER>	SAVE IN STORE 1

APPENDIX G

G. GLOSSARY OF TERMS

This appendix contains two glossaries:

- User Operator Terms
- Signal Processing and Communication Terms

G.1 USER OPERATOR TERMS

G.1.1 Acoustic (Beacon)

An instrument that emits acoustic signals. It is used to mark a point on the seabed or is fixed to a Mobile so that it can be tracked or positioned in space.

The major types of beacon are described below but some beacons can be configured as several or any of the types.

- **Acoustic (Transponder) Beacon**

  A particular type of beacon that emits an acoustic signal when it detects an interrogating acoustic signal.

- **Acoustic (Responder) Beacon**

  A particular type of beacon that emits an acoustic signal in response to an electrical signal carried to it by cable.

- **Acoustic (Pinger) Beacon**

  A particular type of beacon that emits signals regularly without an interrogating signal. A SYNCHRONOUS pinger is one that can be synchronised to an external master signal. A PRECISION pinger is one with an accurate internal time standard.

- **Acoustic Transducer**

  A device that converts electrical signals into acoustic signals and vice-versa. A HYDROPHONE is a device used to convert acoustic signals into electrical signals only.

  Note: Often the term is applied to a complete instrument that contains pre-amplifiers, matching networks etc.

- **Acoustic Transceiver**

  An instrument that can generate electrical signals suitable for conversion to acoustic signals by a transducer. It can detect received signals and extract information from them.

  For example some transceivers can measure the time it takes a signal to travel from a transducer to a transponder and return. Some can encode and send data in a message and extract digital data from a message (Acoustic Telemetry).

- **Acoustic (Intelligent Transponder Beacon)**

  A particular type of transponder beacon that is managed by a micro-controller. It is commonly referred to as a COMPATT . It can decode acoustic telemetered commands from a transceiver and can send telemetered data to the transceiver. It can measure the distance between itself and other transponder beacons and then telemeter the data to a transceiver.

  Usually the instrument is capable of measuring its depth and the temperature of the water and may be commanded to telemeter its own internal state back to the surface. It may be used to measure a variety of underwater parameters and telemeter these back to the surface. It is used, for example, as an intelligent angle-measuring device in a Riser Angle Monitoring System . Very often is fitted with a release mechanism enabling it to be returned, on command, back to the surface at the end of a mission (or if battery power is low).

  The intelligent beacon can be developed to the state where it becomes a remotely operated transceiver.

G.1.2 Acoustic Signal

A message carried by sound pressure waves through the water. In the Sonardyne case, the message has finite length in time.

G.1.3 COMPATT

COMPuting And Telemetry Transponder (see Acoustic Intelligent Transponder Beacon). A range of COMPATTs is available from Sonardyne to perform a variety of tasks.

G.1.4 Co-ordinate Frame

A system that is used to define the position of body in space. The system used is a right-handed Rectangular Cartesian co-ordinate system in three dimensions where the three axes used are orthogonal.

[Sometimes "polar" co-ordinates may be used. The z co-ordinate is the same as above but the position reflected in the x-y plane is expressed as a radius from the z axis and a bearing in degrees measured clockwise from the y axis].

A frame with its z axis vertical and stationary with respect to the seabed is known as a SEABED FRAME or an INERTIAL FRAME. (Normally for convenience the x,y plane where z = 0 is at or just below the lowest point on the seabed in the area. Positions above this plane have a positive z co-ordinate or height. Depth is considered as negative height and is measured from the sea-surface or from a height close to it).

A vessel frame is a frame that is fixed to a vessel.

An RPH (Roll, Pitch and Heading) compensated vessel frame is a frame sharing the same origin as the vessel frame but with the z axis vertical and the y axis parallel with a meridian passing through the origin (points true north).

G.1.5 Database

A Database is a body of data stored in a computer memory or on magnetic disc media such as an embedded hard disc or on portable floppy disc.

G.1.6 DPS (Dynamic Positioning System)

A system that automatically maintains a vessel with a constant heading, and in a fixed position in an inertial frame, or with respect to a mobile. It avoids the need to anchor a vessel and provides more flexibility in operation.

G.1.7 DP Reference

A number of position inputs such as GPS receivers, taut wire sensors, LBL, SBL or USBL acoustic positioning sensors, wind speed indicators etc.

G.1.8 DP Telegram

The report an acoustic positioning system sends to a DP system over a serial interface.

G.1.9 Geodetic Co-ordinates

The earth is modelled by a reference spheroid (of which there is a large selection). The position of any point on or near the earth surface is defined by an angle of latitude and an angle of longitude.

For a point on the spheroid P:-

Latitude is defined as the angle between the normal plane at P and the plane of the spheroidal equator.

Longitude is defined as the angle between the meridian plane through P and the arbitrarily defined zero meridian plane or the "Greenwich" plane. (See Geodesy, fourth edition, Bomford, Oxford, sections 2.03 and 4.10(d) for more precise definitions.)

Note: This co-ordinate system is not the same as the astronomical co-ordinate system.

G.1.10 GPS (Global Positioning System) Attitude Sensor

A system based on the GPS system and a receiver using three or more antennae with known baselines. It is able to computed the instantaneous attitude of a vessel about the roll, pitch and yaw axes.

G.1.11 GPS (Global Positioning System)

A multi-user, 24 hour, world-wide radio navigation system using the NAVSTAR constellation of satellites. GPS receivers are capable of tracking and decoding the data from the satellites and computing the position and velocity of a vehicle in space. The system uses the WGS 84 Geodetic Co-ordinate system.

G.1.12 Gyro Compass

A North-seeking Gyroscope uses the properties of a gyroscope when its spin axis is maintained horizontal. The gyroscope senses the spin axis of the earth and will align itself with true north.

G.1.13 Inclinometer

An analogue device, usually fitted into a COMPATT, which measures the angle of the transponder in which it is mounted with respect to the local vertical.

G.1.14 Mobile

A body that is free to move relative to the seabed through the space between the sea surface and the seabed.

G.1.15 Monitor/Keypad

An instrument that contains a 12 inch colour graphics display monitor and has a keypad in close proximity suitable for operator input to the system.

Note that, in a later version of this unit, incorporating a 17 inch high resolution monitor, the Monitor and Keypad are split into two separate units - Type 7940 Monitor unit and the Type 7941 Keyboard unit. Both are designed for 19 inch rack mounting.

G.1.16 Navigation Processor

An instrument that:-

- Acts as the system controller.
- Accepts operator input from the keypad.
- Generates the display signals for the Monitor.
- Processes the data from the transceiver into a form suitable for display to the operator and output to a DP system.
- Interfaces to various "attitude" sensors and other navigation systems.

G.1.17 Riser Angle Monitoring System (RAMS)

Used for measuring the differential angle between a BOP (Blow-Out Preventer) on the seabed and the Riser, connecting the BOP to the rig. Comprises a COMPATT type transponder which is rigidly mounted to the BOP and an external inclinometer unit mounted on the Riser and connected by cable to the COMPATT. On command, the system measures the angle of the BOP with respect to the local vertical and reports this back to the surface and can then repeat this process for the Riser using the external inclinometer, or the difference between the Compatt and the remote can be reported.

G.1.18 ROV (Remotely Operated Vehicle)

A vehicle controlled and powered over a cable connection so that it can travel in the space between the sea surface and the seabed.

G.1.19 Seabed

The surface of the earth covered by water or sea. The seabed is considered stationary.

G.1.20 Sonardyne Systems

- **LBL (Long-Base-Line) System**

  A system where there are two or more (typically four) transponders on the seabed. The positions of the transponders are established by a calibration process in a seabed frame. The distances from a transducer to each transponder are measured using a transceiver. The position of the transducer can be computed in the seabed frame.

  It takes its name from the "baselines" joining each transponder. It is sometimes referred to as a range-range system.

- **SBL (Short-Base-Line) System**

  A system where three or more transducers are fixed to a vessel and connected to a single transceiver. The position of each transducer is measured and co-ordinated in the vessel frame. By measuring the time of arrival of the signal from a beacon at each transducer the position of the beacon in the vessel frame can be computed.

- **LSBL System**

  A hybrid of an LBL and an SBL system.

- **USBL (Ultra-Short-Base-Line) System**

  A system similar in principle to an SBL system except the system uses three or more elements in a single transducer array. The measurements it makes are the differences in "time-phase" of the signals from each element.

  The co-ordinate frame is fixed to the transducer array which must be oriented in the vessel frame to be equivalent to the SBL system.

- **LUSBL System**

  A hybrid of an LBL and a USBL system. It utilises USBL equipment in an LBL configuration.

- **Dual-redundant LUSBL System**

  Two complete sets of LUSBL equipment working in tandem on a master/slave basis. The two sub-systems are cross-linked in such a way that, in the event of a failure of any major element, system operation will continue without the need for operator intervention. From the operator's point of view, operation of the dual-redundant version is essentially identical to that of the standard version.

G.1.21 Sound Speed

For seawater, for constant temperature, salinity and pressure the speed at which sound travels in seawater is constant.

G.1.22 Sound Speed Profile

At different depths the temperature, salinity and pressure vary; therefore the local sound Speed varies.

In practice the depth cannot be measured directly. Therefore pressure measurements are made, and depth computed, using a knowledge of density. Derivation of density requires a knowledge of temperature and salinity. Salinity cannot be measured directly but conductivity can be measured. Therefore a popular method of measuring the sound Speed profile is from a profile of pressure, temperature and conductivity and the use of empirically derived formulae to compute depth and sound Speed.

Sound Speed can be measured directly using a dedicated and calibrated instrument called a sound Speed sensor (Frequently referred to as a velocimeter). (One still needs a set of depth measurements.)

G.1.23 Submersible

A vehicle that operates below the sea surface, carries men in a one atmosphere environment. One man pilots the craft. It carries a supply of air for the men and a supply power for propulsion etc. It is capable of autonomous operation form a vessel for a limited time.

G.1.24 True North

The direction of the shortest line that can be drawn, across the surface of the earth, from the observer and the north pole. (The north pole is where the north end of the spin axis of the earth meets the surface.)

G.1.25 UTM (Universal Transverse Mercator)

A Projection system that is used to transform Geodetic co-ordinates into an orthogonal two dimensional system suitable for representation on a plane such as a chart. Normally the co-ordinates are called easting and northing which are equivalent to x and y respectively.

The UTM system is a world wide system. Each projection covers 6 degrees of longitude with the central meridian at 3, 9 degrees etc east of Greenwich and from 84 degrees north to 80 degrees south. The scale factor on a central meridian is 0.9996 (with some exceptions).

The projection is orthomorphic which means that at a point the scale in all directions is the same and there is no LOCAL distortion. However it should be noted that the scale factor changes with distance from the central meridian. For points away from the central meridian grid north and true north diverge. The difference is called the CONVERGENCE which is positive when grid north is east of true north.

Usually, the point where the central meridian meets the spheroid equator is given a false easting of 500,000 m.

Many countries' mapping systems are based on the same system but use a particular reference spheroid, non standard central meridians, scale factors and different false eastings and northings.

The polar regions are covered by two Zenithal orthomorphic projections.

G.1.26 VRG (Vertical Reference Gyroscope)

A gyroscopically stabilised VRU.

G.1.27 VRU (Vertical Reference Unit)

An instrument that measures the instantaneous roll and pitch of a vessel.

G.1.28 Vessel

A body floating in the sea with at least part of it penetrating the surface. It is free to move and rotate relative to the seabed.

SIGNAL PROCESSING AND COMMUNICATIONS TERMS

G.1.29 Bore-sight

The axis about which the transducer maximum power gain is being directed.

G.1.30 Capture Area

The effective aperture size of the array. It is directly related to the array gain.

G.1.31 Carrier to Noise Density

This is the ratio of the signal power(C) to noise power (No) in unit bandwidth (C/No); generally quoted in dBHz.

G.1.32 Directivity Index

This is the ratio of the radiation intensity in the direction of interest compared with an isotropic radiator.

G.1.33 False Alarm

An invalid signal has satisfied all of the detection criteria and the detection process incorrectly declares the presence of a valid signal

G.1.34 False Alarm Probability

The resultant probability of ALL the false alert probabilities.

G.1.35 False Alarm Rate

Predicts the number of false alarms that will occur in a specified time.

G.1.36 False Alarm Number

Predicts the average number of possible decisions between false alarms.

G.1.37 False Alert

An invalid signal has satisfied ONE detection criterion and the detection process incorrectly declares the presence of a valid signal.

G.1.38 False Alert Rate

Predicts the number of false alerts that will occur in a specified time.

G.1.39 Front to Back Ratio for a Transducer

It refers to the ratio of power transmitted in the forward hemisphere of the polar diagram to that transmitted in the reverse hemisphere of the polar diagram.

G.1.40 Kalman Filter

An adaptive filter that provides optimum filtering of a signal that has been subjected to a non-stationery environment (i.e. when the data is significantly changing during the filter convergence time).

G.1.41 Translinear Mode

The system operates in linear mode for signals within specified dynamic range. Once the input signal level is larger than the upper limit set by the input dynamic range, hard limiting occurs.

APPENDIX H

H. ACOUSTIC FREQUENCY CHANNELS

Frequency clashes with a USBL or LUSBL system can be avoided by prudent choice of interrogate and reply channels for the COMPATTs being interrogated by the system. This is particularly true in the case of an LUSBL system (which tends to utilise more COMPATTs) and where other acoustic systems are in use in the same area of sea.

The general rule is "choose frequencies which are well separated from those being used by other Beacons in the vicinity". For an LUSBL with (say) four COMPATTs, it is safest to pick four separate IIFs and a different four separate IRFs. However, in many cases, it is possible to economise on frequencies and still achieve sufficient discrimination by setting one CIF and four different IRFs together with four different turn-around times.

The diagrams which follow summarise the range of Sonardyne and SIMRAD frequencies associated with HPR 309 acoustic transmissions refer to fig H1, and HPR 418 acoustic transmissions refer to Fig H2. Assuming other frequencies being used in the area are known, it is possible, using these diagrams, to select frequencies for the current job which are well separated from each other and all other known frequencies.

FIG H.1 SONARDYNE AND SIMRAD CHANNEL FREQUENCIES - HPR 309

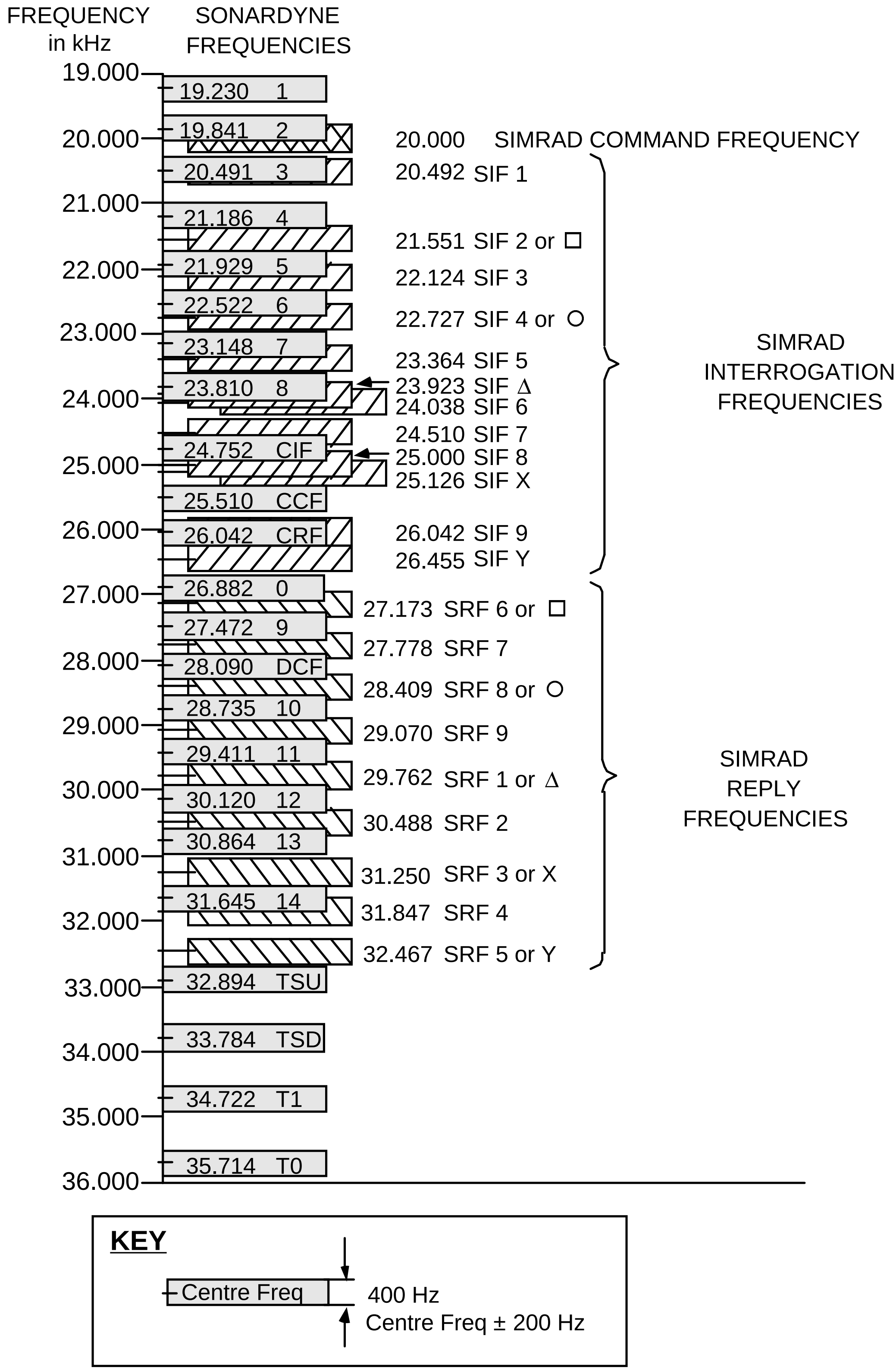
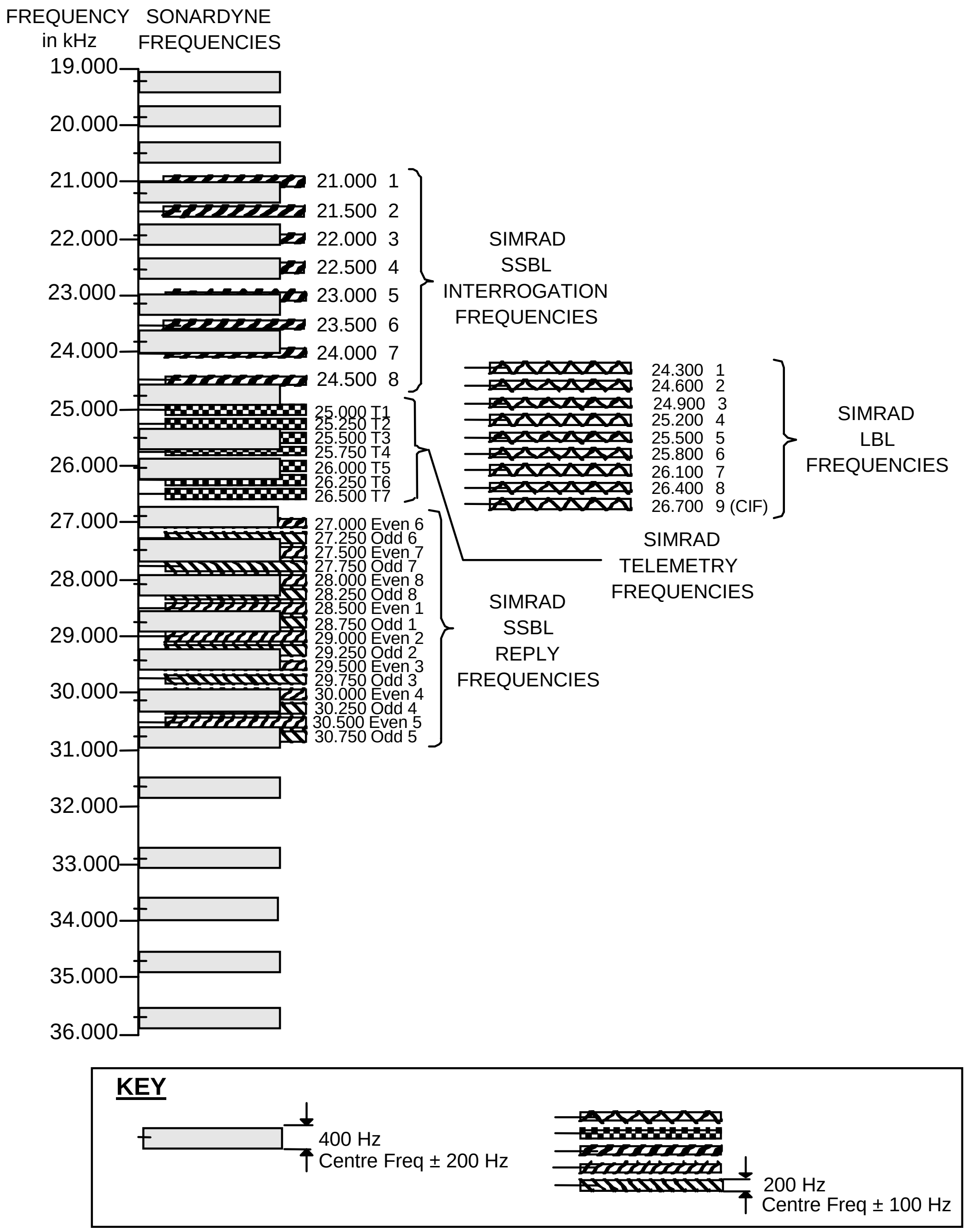


FIG H.2 SONARDYNE AND SIMRAD CHANNEL FREQUENCIES - HPR 418



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