Wave Glider™

Payload Electronics Guide

Version 1.21

13 April 2011

Liquid Robotics, Inc.
1329 Moffett Park Dr.
Sunnyvale, CA 94089
(650) 493-6300

LRI Part Number: 030-00759

This Page Intentionally Left Blank

REVISION HISTORY

Rev	Changes	Author(s)
1.00	Initial Release	FJ, DW
1.10	Add PCOM section 4.2.3	FJ
1.20	Format and Layout Updates	JS
1.21	Updates to Chapter 5	JS, CL

This Page Intentionally Left Blank

Table of Contents

This Page Intentionally Left Blank

1. Overview

This chapter provides a general overview of the Wave Glider™ payload electronics. It is assumed that the reader has reviewed the appropriate chapters in the Wave Glider™ User Manual, and is generally familiar with the Wave Glider™ Vehicle terminology. This chapter is intended as a more extensive description of the system, with an emphasis on information related to doing payload electronics installation and configuration.

1.1 C&C and Payload Dryboxes

The basic control and communications electronics are in the C&C Drybox. Additional electronics may be added as connected payloads, usually interfacing with the C&C Drybox.

1.1.1 C&C Drybox Configurations

The C&C Drybox can be either of two configurations: the “Original” and the “Revised”.

As shown in Figure 1-1, the “Original” C&C Drybox contains 7 connectors; the “Revised” C&C has 10 connectors. In addition, the Revised C&C uses a specific Power-On Key, whereas the Original C&C powers on when one of the solar panels is connected.

The Antenna housings are different in appearance. However, in their standard configurations they contain the same antennas.

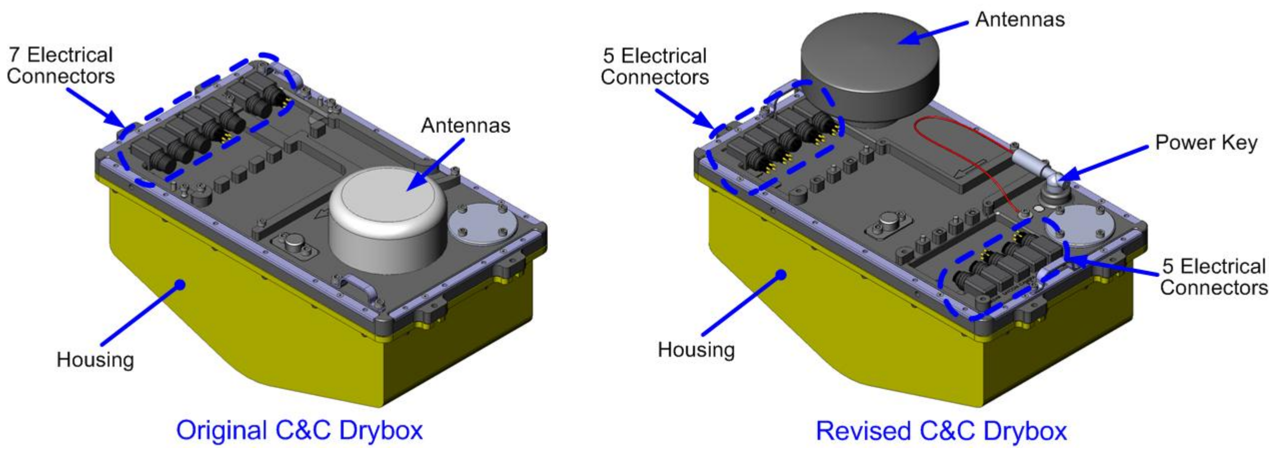


Figure 1-1: Original and Revised C&C Dryboxes

Although the tops of the dryboxes are configured differently, the size of the lids and the housings are identical.

Seven of the connectors on the Revised C&C have exactly the same function as the seven connectors on the Original C&C. The Revised C&C has connectors for three additional functions. The relevant connectors are described in section 5.1 “External Electrical Connections”.

The C&C Drybox and its electronics are neither designed for, nor intended for modification by customers. The only customer interface with the C&C is through the electrical connectors.

Customer electronics is typically mounted inside one or both of the payload dryboxes, described below.

1.1.2 Float Drybox Details

The Fore and Aft dryboxes are used to house user-supplied payloads. The dryboxes shown below are representative of those available from Liquid Robotics Inc. Note that since the aft payload bay is both longer and shallower than the forward bay, the two dryboxes have different shapes.

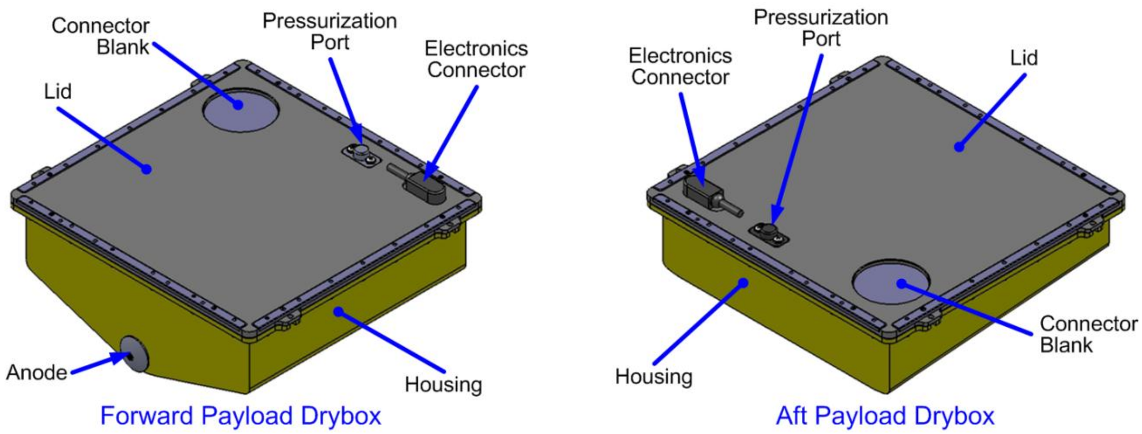


Figure 1-2: Fore/Aft Drybox Principal Components

Electronics Connector: Watertight electrical connector. Used for power and communications.

Anode: Bolted-on sacrificial anode (for corrosion protection).

Connector Blank: Removable plastic panel for adding additional connectors.

Lid: The top of the drybox. Typically, the payload electronics are mounted to the underside.

Pressurization Port: Valve (with cover) for pressurizing the drybox.

Housing: The lower part of the drybox. Typically has no internal attachments.

Valve Cover: Protective cover for the box pressurization valve.

1.1.3 Glider Payloads

The Rudder Module has an 8-pin male connector, which is used for the Umbilical electrical connection. The Rudder module also has an 8-pin female connector for providing communications and power to a Glider payload. Figure 1-3 shows the two rudder box connectors.

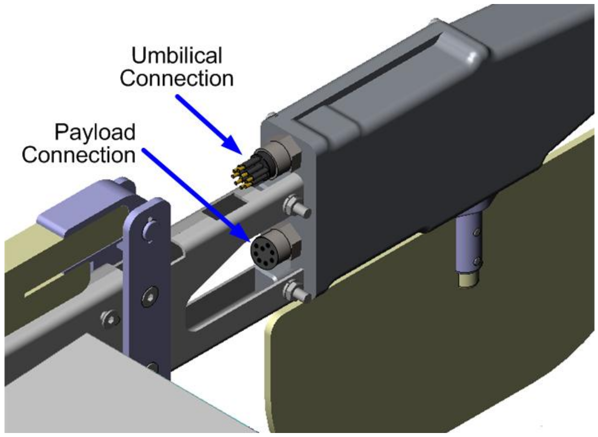


Figure 1-3: Glider Umbilical/Payload Connectors

Figure 1-4 shows an example installation of a glider payload using a custom drybox. Note that the rudder box connectors are enclosed by a cover.

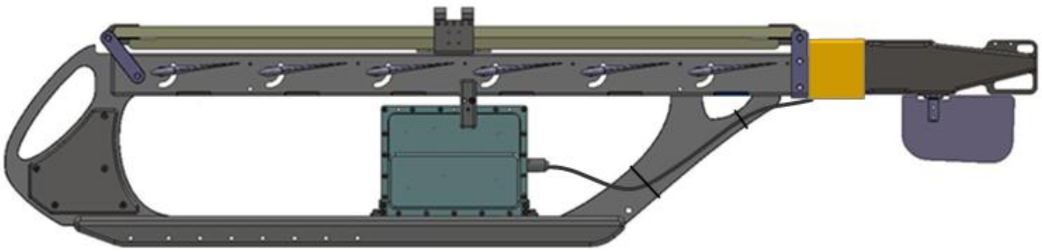


Figure 1-4: Example Glider Payload Installation

A Glider-mounted payload can be connected through the Umbilical to either or both of the Float payloads, but cannot communicate directly with the C&C computer. Any Glider payload datacomm to the C&C computer has to be routed through one of the Float payloads, as described below.

1.1.4 Payload Connectivity

As shown in Figure 1-5 below, each Float payload is connected to the C&C via cables. Communications is via RS-232. Any Glider Payload has to communicate to one of the Float payloads, but connects up through the Umbilical and then through the C&C.

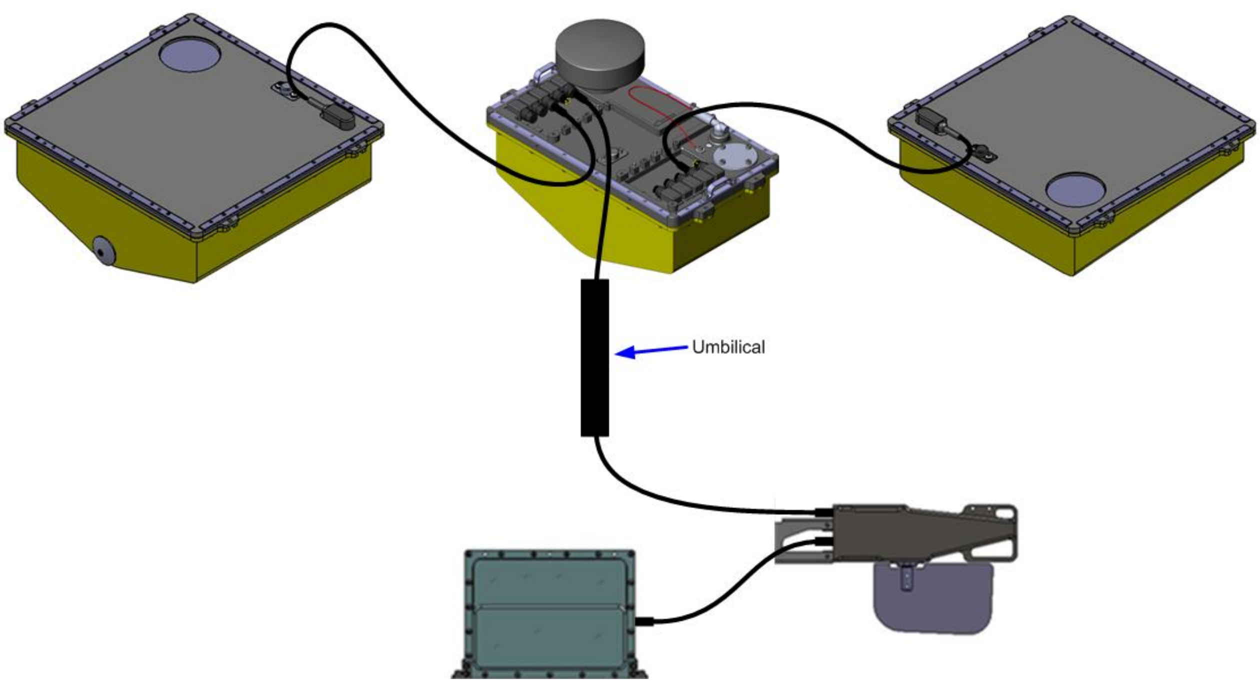


Figure 1-5: Float & Glider Payload Connections

1.1.5 Float Payload Electronics Mounting

The Float Drybox payload electronics are mounted to the underside of the drybox lid, as shown in Figure 1-6. Refer to section 6.2 "Drybox Lids" for more information.

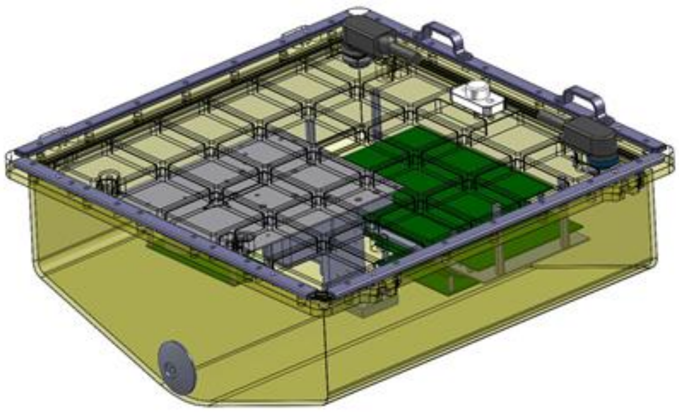


Figure 1-6: Electronics Mounted to Underside of Lid

1.1.6 Glider Payload Electronics Mounting

There is currently no standard drybox for mounting payloads on the submerged Glider. However, a custom drybox has been built that mounts on the Glider frame, as shown above in Figure 1-4.

Figure 1-7 below shows the electronics mounted inside the custom drybox.

Figure 1-7: Glider Drybox Electronics

1.2 Electrical System Overview

1.2.1 Electrical System Schematic

A drawing of the overall Wave Glider™ electrical system is shown in the figure below. This shows a fully-configured system with both Float and Glider Payloads. Each of the schematic components is described in sections following.

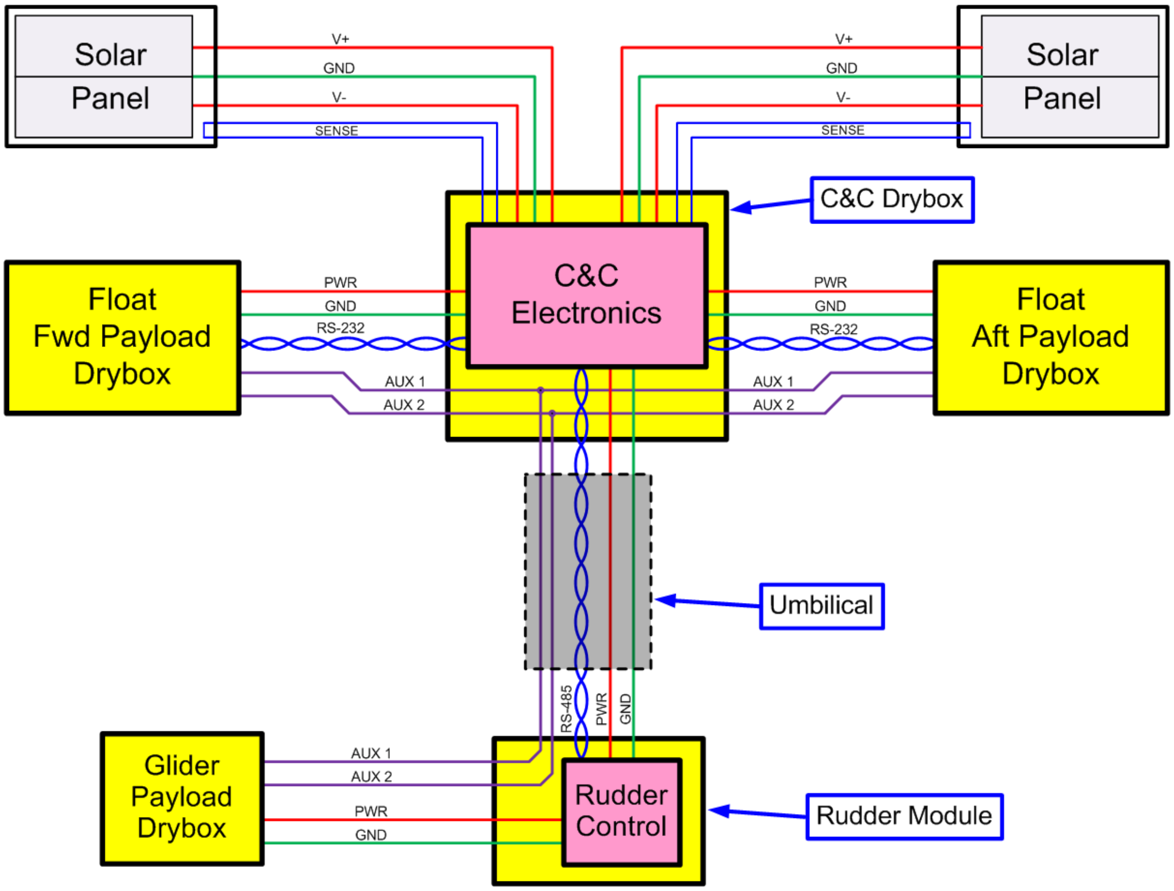


Figure 1-8: Wave Glider™ Overall Electrical Schematic

1.2.2 Solar Panels

Battery charging is via Solar Panels mounted on the Float. The Float can operate with a single solar panel if electrical loads are kept to a minimum.

Each panel actually has two separate collectors sharing a common ground. Thus, there is both a “V+” and a “V–“ connection to each panel

A continuity sensing circuit is also connected to each solar panel. On the Original C&C, the Vehicle computer is turned on by shorting at least one set of lines (i.e., connecting one panel). On the Revised C&C, the sensing lines are used only to detect solar panel presence.

Out-of-water battery charging is possible through the solar panel connections. Refer to section 5.2 “External Charging" for more information.

1.2.3 Payload Power Connections

The Float and the Glider payloads each have a power (and ground) connection. The "PWR" voltage supplied to each payload depends on the type of C&C (Original or Revised). There are limits on the current that can be supplied to each payload. There is also a limit on the total current that the C&C can supply. Refer to section 5.3 "Current and Power Usage" for more detailed information on the voltages and the current limits.

1.2.4 C&C to Payload Communications

For C&C to Float payload communications there are independent RS-232, 115,200 bps connections to each Float drybox. These RS-232 links can be used for exchanging messages with the C&C. Using an internal messaging system, a Payload can use the C&C to send or receive data using the Iridium or XBee communications.

Refer to the Wave Glider™ ICD document for more information on payload messaging.

1.2.5 Payload to Payload Communications

There are two uncommitted wires (AUX1 and AUX2) that connect to each payload and to the C&C drybox, but do not connect to the C&C computer. These can be used to transfer data between payloads using whatever 2-wire communications method is preferred by the payload designer.

A Glider-mounted payload cannot communicate directly with the C&C computer, but can communicate to the Float payloads using the AUX wires. Thus, any Glider payload messaging with the C&C computer has to be routed via one of the Float payload's RS-232 links.

1.2.6 C&C to Rudder Module Communications

Communication to the Rudder Module is via an RS-485 connection. This connection should not be used for any other purpose.

1.3 PIB and P/COM Overview

1.3.1 Payload Interface Board

The Payload Interface Board ("PIB") is designed to communicate with the C&C, and with other electronics within the payload drybox. It is shown in Figure 1-9.

There are connectors for mounting up to 3 daughter boards, called "Personality Modules" ("PMs"). The PMs are intended as interfaces with the PIB and any devices (sensors, other boards, etc.) within the drybox.

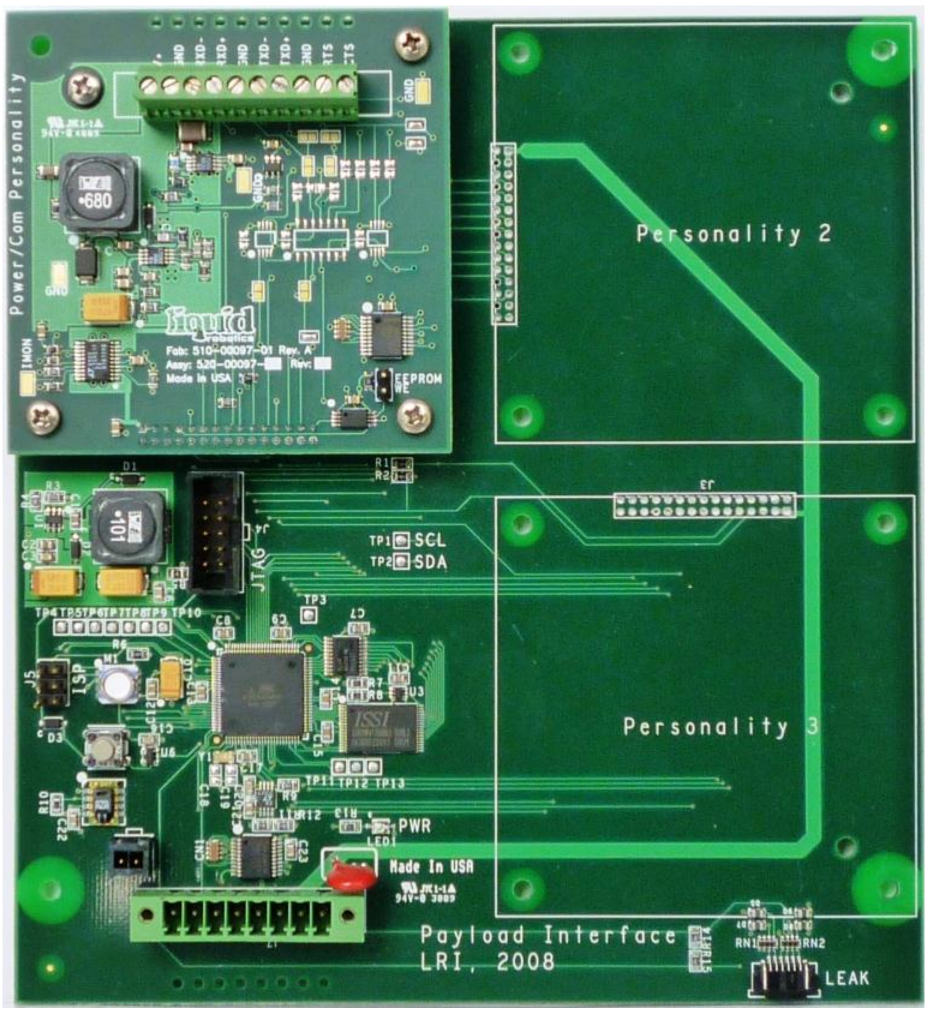


Figure 1-9: PIB with Single P/COM Board

1.3.2 Payload Leak Detection

Note that at one edge of the PIB (bottom-right in Figure 1-9) there is a connection for a water leak sensor. This sensor connects via a cable and rests on the bottom of the drybox.

1.3.3 Power/Communications Board

A standard PM supplied by LRI is the "Power/Communications" ("P/COM") board. As the name implies, this board has both power and communications connections.

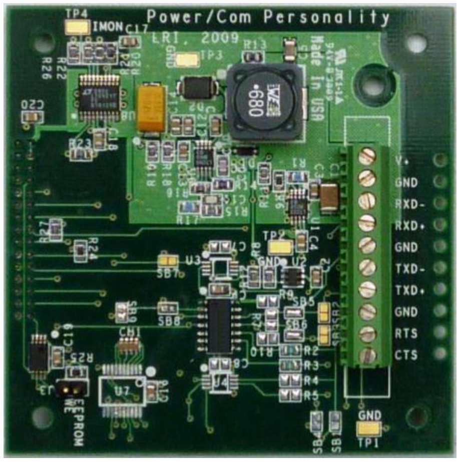


Figure 1-10: P/COM Board

1.3.4 Personality Module EEPROM

Provision is made by the hardware for each PM to contain an EEPROM for future use. Custom PMs should implement their EEPROM using the Atmel AT24C512B used on the P/COM as an example. Refer to the schematic in section 8.2, Figure 8-7.

As a consequence, the I^2C address range 7'b1010_xxx should be considered reserved for addressing the EEPROM.

1.4 Mechanical Mounting Overview

1.4.1 Lid Mounting Points

Figure 1-11 below shows a PIB with a single P/COM mounted to the underside of the drybox lid. Note that there are addition threaded bosses for mounting up to 2 additional PIBs or other customer-supplied electronics.

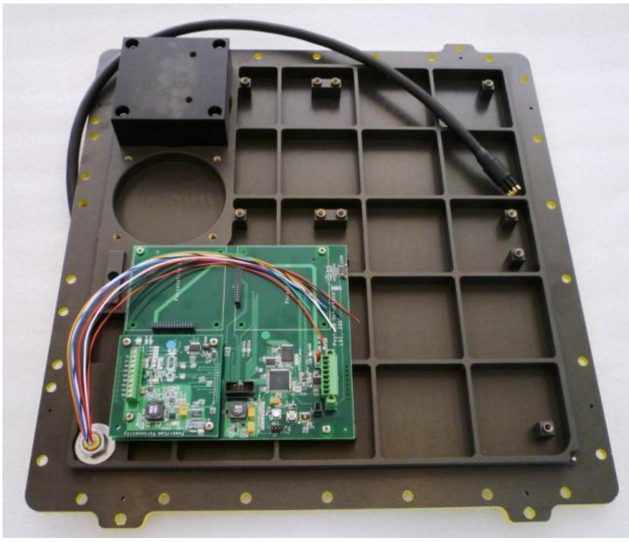


Figure 1-11: PIB Mounted on Drybox Lid

1.4.2 Lid Mounting Examples

Figure 1-12 and Figure 1-13 show two examples of functional electronics mounted to the underside of the lids.

The example shown in Figure 1-12 has 3 PIBs. The orange box is an accelerometer. The blue board is an RF radio link. The white wire is connected to an external antenna.

Figure 1-12: Multiple PIBs + Sensors on Lid

The example shown in Figure 1-13 has no PIB. It connects via a cable to a PIB mounted in the other payload box.

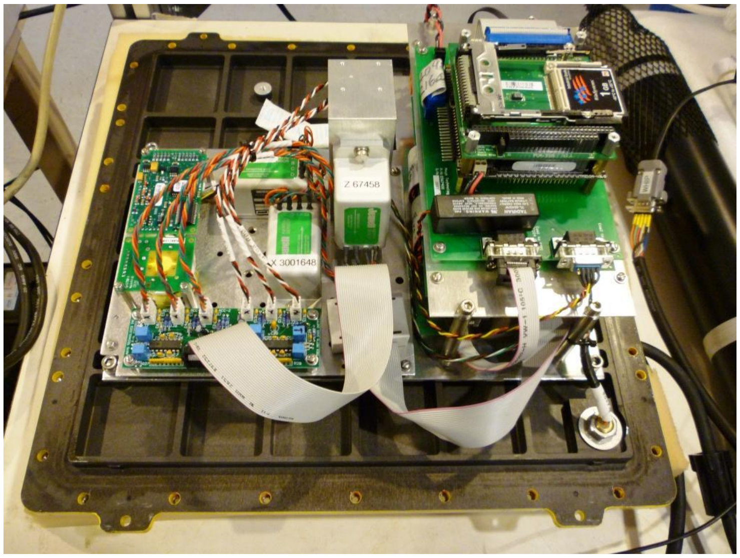


Figure 1-13: Electronics Without PIB on Lid

2. Payload Communications

2.1 Overview

When integrating a payload into the Wave Glider™, it's important to understand all the forms of communication both on-board, as well as Ship-Shore. The following chapters provide the basic information necessary to integrate and test payloads. For more detailed information on Wave Glider™ communications, consult the Wave Glider™ ICD and API documents.

2.1.1 Command and Control

All primary communications to and from the Vehicle are managed by the C&C electronics contained in the center Float Drybox. Likewise, control of the Vehicle systems is handled exclusively by the C&C electronics.

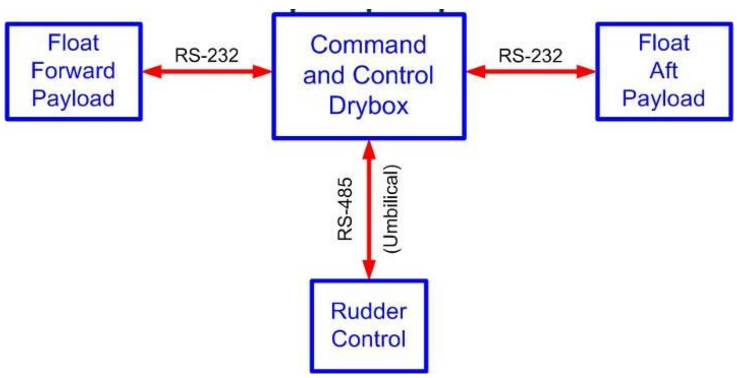


Figure 2-1: Wave Glider™ Command and Control

Thus the communication channels can only request certain actions from the C&C; whether the actions are actually implemented depends upon decisions by the C&C computer.

Also, a Payload can have its own separate communications link to an off-Vehicle location. This can utilize additional antennas or other communications devices that are attached to the Vehicle.

2.1.2 Communications Methods

Each of the Float payloads can communicate by sending messages to the C&C using their respective RS-232 links.

Communications can be C&C-to-payload, payload-to-C&C or payload-to-payload. Payloads can also send messages out through the Iridium link.

Messages are sent using data packets with formats different than the Iridium packets. As with the Iridium packets, the recipient responds with an ACK or NAK.

Payloads send messages only to the C&C, along with the address of the recipient. If the recipient is not the C&C, the message is forwarded to the designated address.

Obviously, there can also be direct analog connections between appropriate devices.

2.2 Communication Hardware

Payload communications hardware can be both of LRI-supplied and customer-supplied/created electronic payload boards and devices.

2.2.1 Payload Interface Board

The Payload Interface Board ("PIB") is a standard LRI-designed circuit board designed to be mounted within a payload box. The PIB is a basic component of the payload architecture.

The Float's C&C computer is connected to the payloads via serial ports. Within each payload is a PIB that manages communications between the payload and the C&C. The PIBs in turn connect to other LRI or customer-designed payload boards and/or devices.

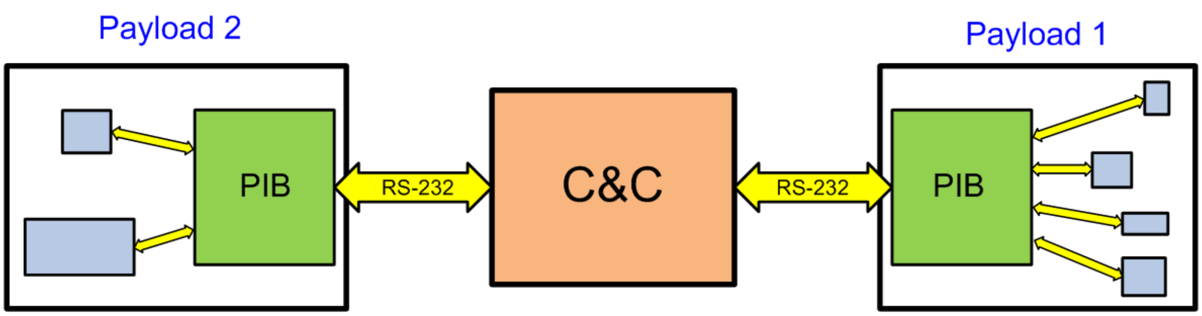


Figure 2-2: Basic Payload Communications

The PIB itself does not connect directly with the additional payload devices. It communicates via "Personality Modules", as described below.

2.2.2 Personality Module

Each PIB is designed to have to up to three daughter boards mounted to it, called "Personality Modules" ("PMs"). The PMs connect to different devices, including other PIBs.

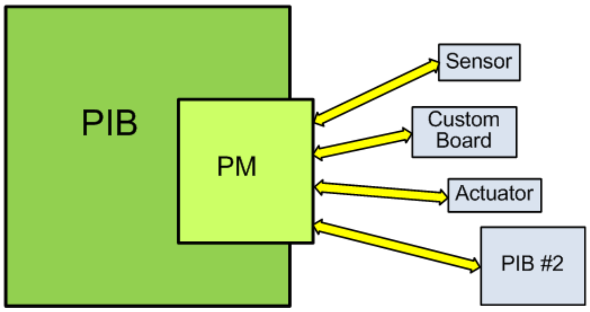


Figure 2-3: Personality Module Connections

Communications between a PM and the other payload devices is typically via RS-232, but is not necessarily restricted to that communication method.

LRI can provide a standard PM called the Power/Communication ("P/COM") board. The P/COM can provide both power and asynchronous serial communications. It is preconfigured for RS-232 communications but may be reconfigured by the customer for either RS-422 or RS-485.

Customers can create their own custom PMs. Detailed hardware descriptions of the PIB and P/COM are provided in Chapters 3 and 4.

2.2.3 Payload Board Devices

Application-specific payload board devices can take many forms. Some possible types of these devices are:

- Standard LRI-supplied PIBs
- Sensors
- Actuators
- Storage devices (e.g., Flash memory)
- External communications devices
- Processing nodes

Since a PM can be connected to additional PIBs through P/COM PMs, it is possible to daisy-chain PIBs, as shown in Figure 2-4 below.

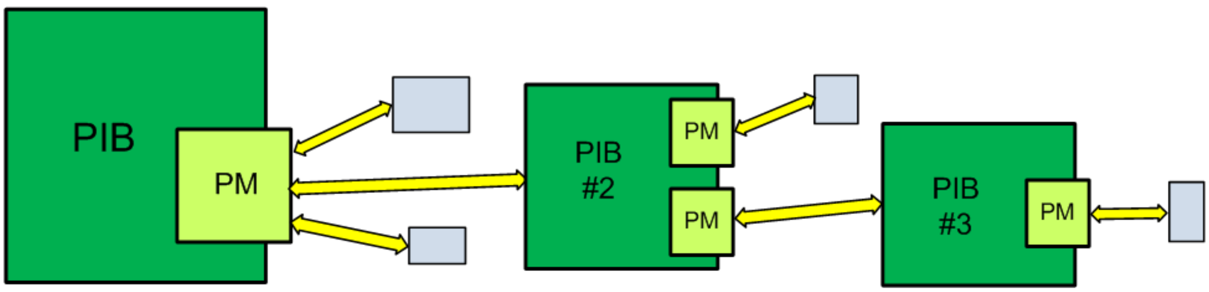


Figure 2-4: Daisy-Chain of PIBs

2.2.4 Configuration Scenarios

Some possible payload configuration scenarios are:

- Payload boards and sensors connected to PIBs via P/COMs.
- PIB acting as a relay
- PIB connected to another PIB as a daisy chain back to the Float C&C PIB port.
- PIB running custom software and with custom PMs and acting as an end device (the "payload board" role is played by the custom PMs.)
- Payload board connected directly to the Float C&C (the "PIB" role is played by Float C&C)

Figure 2-5 below shows a combination of the above-described scenarios. Note that the Float C&C can be connected via radio links to WGMS. Thus, the Iridium and XBee links are considered part of the "configuration".

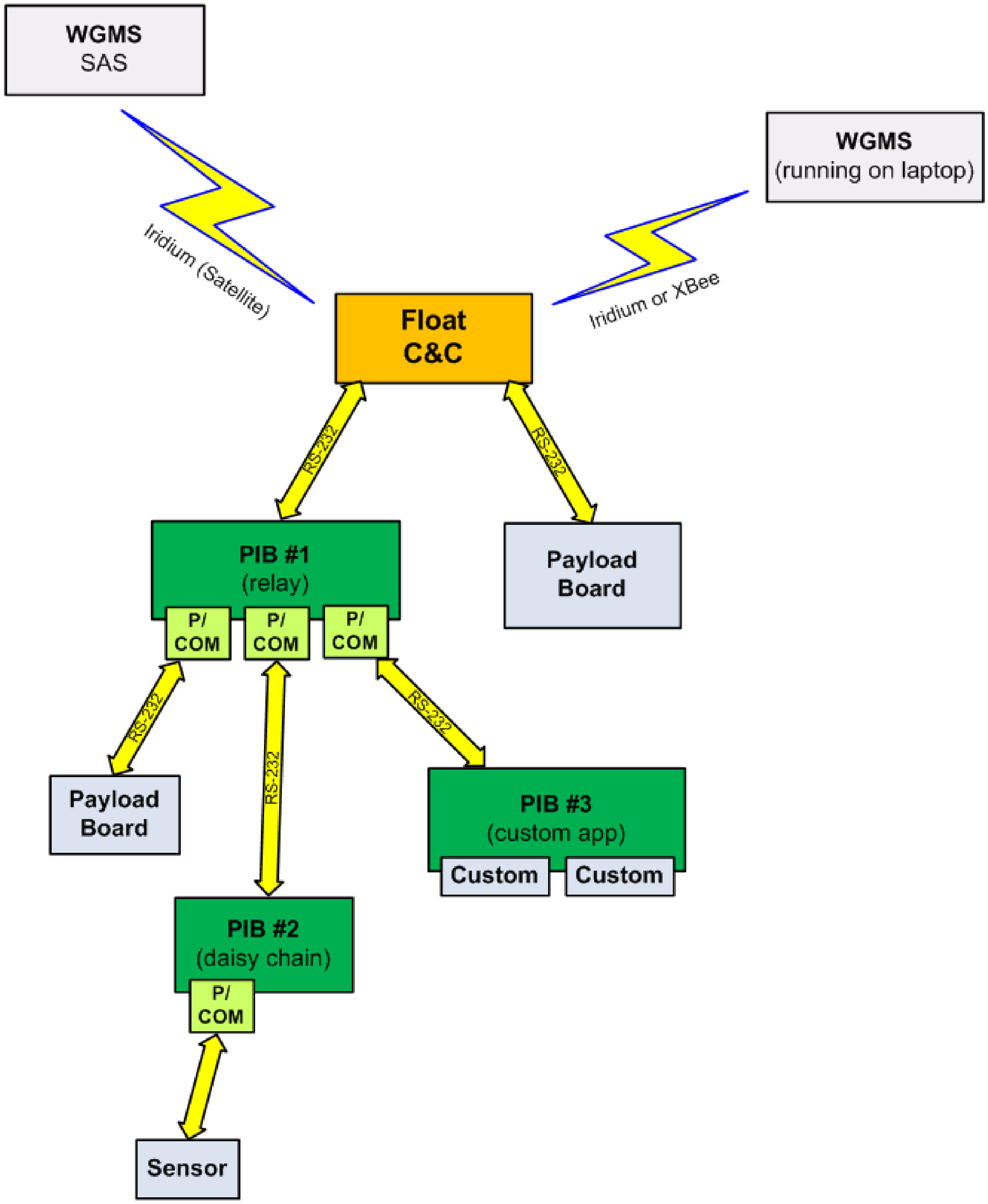


Figure 2-5: Example Payload Hardware Configuration

The above configuration shows most communications below the Float C&C as using RS-232. However, a P/COM can be easily reconfigured for RS-422 or RS-485. A custom PM can use any method required.

2.2.5 Payload Device Connection Example

In the example shown below, the Float C&C connects to a PIB. Two of the three PMs on the PIB connect to other devices (sensors, etc.). The third PM is used to connect to another PIB, which uses PMs to connect to two additional devices.

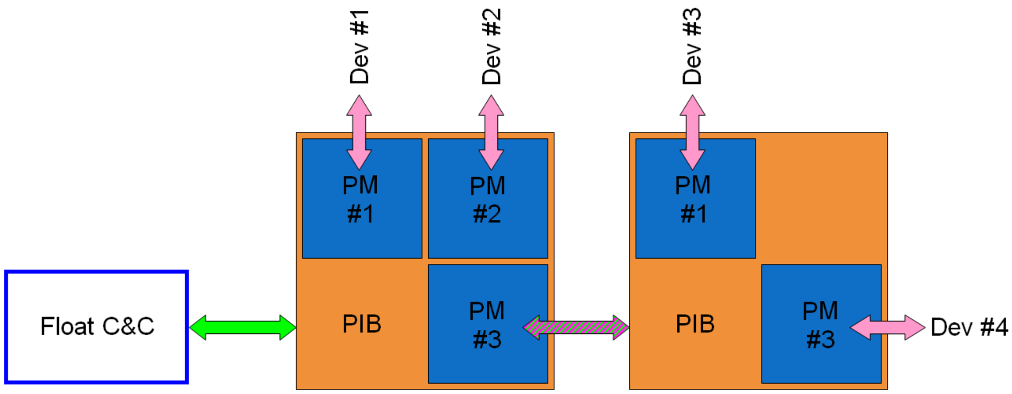


Figure 2-6: Payload Connection Example

2.2.6 Glider Connection Example

In this example, the AUX 1 and AUX 2 lines (ref. Figure 1-8) are used to communicate through the Umbilical and Rudder Box to a PIB on the Glider. PM #3 on the Float manages communications to the Glider PIB.

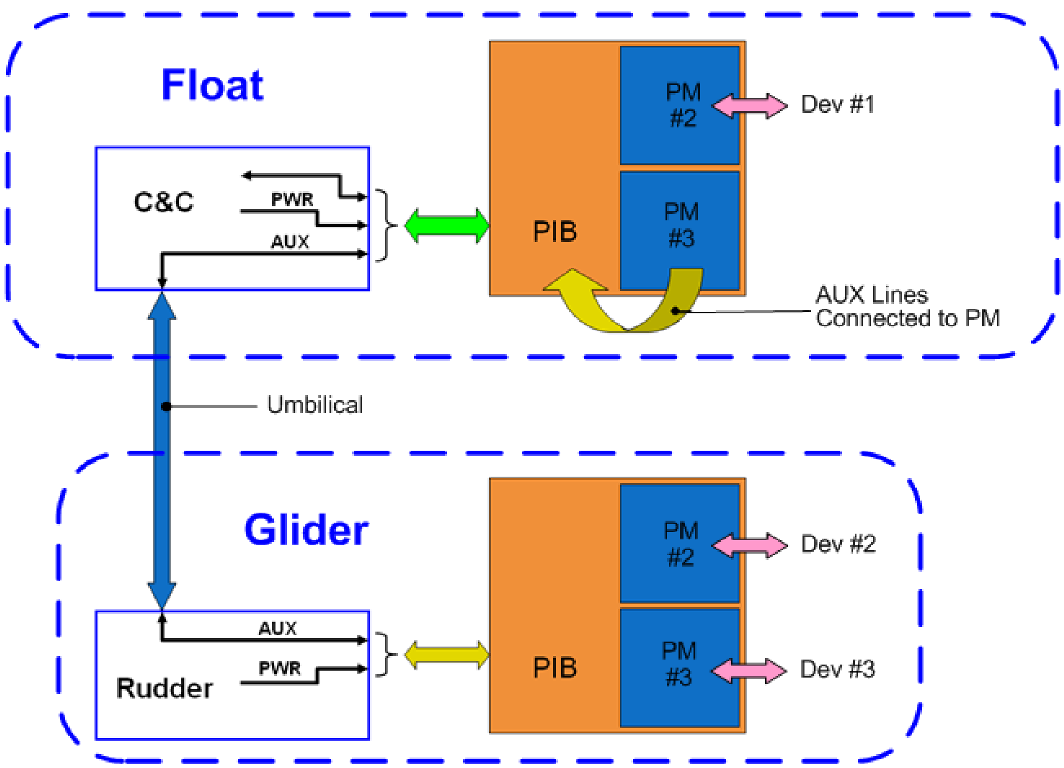


Figure 2-7: Float-Glider Connection Example

This Page Intentionally Left Blank

3. Payload Interface Board (PIB)

3.1 Configuration

3.1.1 PIB Layout

As can be seen in Figure 3-1, the PIB has most of its components grouped into one corner. This allows space for the PMs that plug into connectors J1, J2 and J3.

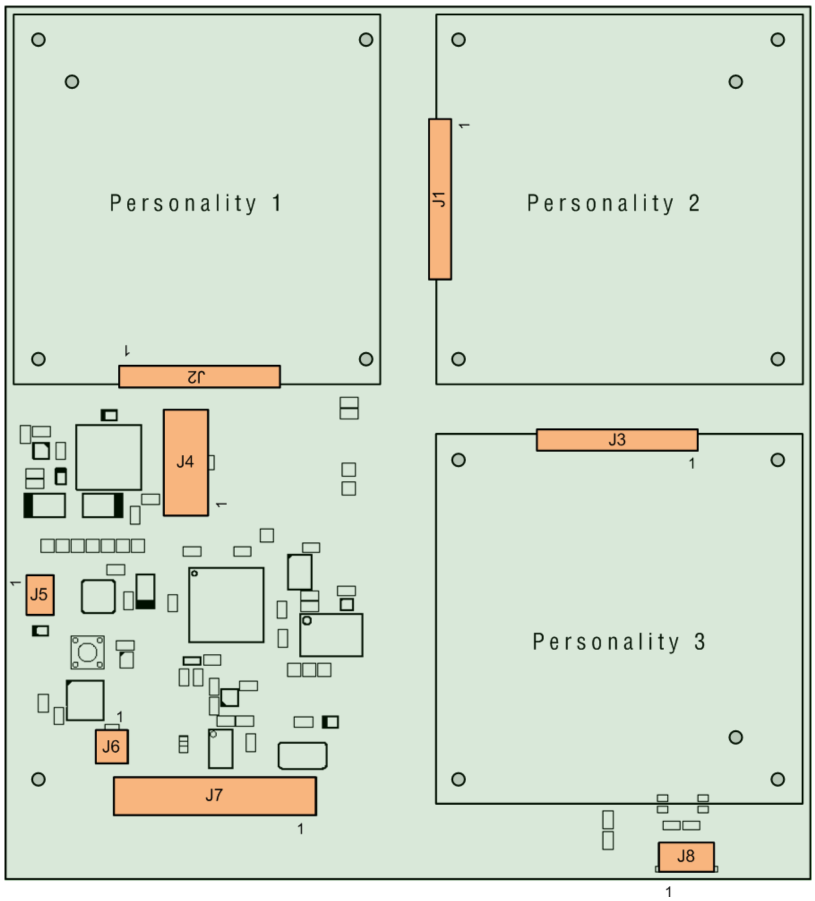


Figure 3-1: PIB Connector Locations

3.1.2 PIB Connectors

Connector	Pins	Type	Function	Ref.
J1, J2, J3	30	Dual Inline Female	Connection to PMs	3.2.1
J4	10	Male Box Header	JTAG connections	3.2.2
J5	6	Dual Inline Male	ISP connections	3.2.3
J6	2	Male Header	AUX lines connecting Float and Glider payloads	3.2.4
J7	8	Terminal Block	Connections to Float C&C	3.2.5
J8	6	Edge Slot	Connection to Leak Sensor	3.2.6

3.2 PIB Connector Details

3.2.1 PIB J1, J2, J3

J1, J2 and J3 are the interface connectors between the PIB electronics and the PMs. All three connectors have the same pin connections. Note that Personality 1 uses J2 and Personality 2 uses J1. Personality 3 uses J3.

Note: Always turn the PIB power off when adding PMs and verify that the PM is inserted properly. Failure to do so may cause permanent damage to the PIB electronics.

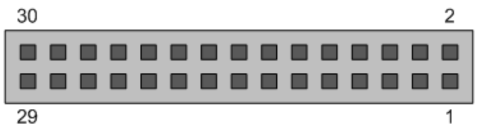


Figure 3-2: PIB J1, J2, J3 Connector Pins

Type: 30 Pin, Dual Row, 2mm Female

Part #: Samtec SQT-115-01-L-D

Pin	Connection	Description	Notes
1	PWR	Power from C&C	[2]
3	PWR	Power from C&C	[2]
5	VCC	Regulated +3.3V	[3]
7	SDA	I^2C Data Line	[4]
9	SCL	I^2C Clock Line	[4]
11	TXD	RS-232 Transmit to PM	
13	RXD	RS-232 Receive from PM	
15	XCK GPIO	Synchronous Serial Clock GPIO (optional)	[9] [10]
17	PON	PM Power-On Enable	[5]
19	POK	PM Power OK Response	[6]
21	GPIO-0	Connection to ATmega	[7]
23	GPIO-1	Connection to ATmega	[7]
25	GPIO-2	Connection to ATmega	[7]
27	GPIO-3	Connection to ATmega	[7]
29	Addr2	PM address 2^{nd} bit	[8]
30	Addr1	PM address 1^{st} bit	

Notes:

[1] Even-numbered pins 2 to 28 are all connected to Ground

[2] For the Original C&C Drybox: Voltage = 11.5 to 16.5 VDC (depends on battery charge)
For the Revised C&C Drybox: Voltage = 13.2 VDC (regulated)

[3] A maximum of 300mA is available for all three PMs together.

[4] I^2C is available to the PM module. It is intended to be connected to an I^2C serial EEPROM (Atmel AT24CxxB [except the AT24C08B]) on each PM, but could be used to control the PM as well. I^2C addresses 7'b1010_xxx should be reserved for EEPROM storage on PMs.

[5] Signal to indicate whether the connected PM is to turn power On. 0V → Off; 3.3V → On

[6] Response from PM indicating its power state. Off → 0V; On → 3.3V. If not required, this signal may be connected to PON.

[7] GPIO connections to the ATMEL ATmega2550V pins are as follows:

	ATMEL Pin		
Pin 21	PK0	PH4	PF0
Pin 23	PK1	PH5	PF1
Pin 25	PK2	PH6	PF2
Pin 27	PK3	PH7	PF3
	J1	**J2**	**J3**

[8] Pins 29 and 30 allow a PM to detect its Personality number.

The Personality numbers are defined as follows:

	Personality		
	#1	**#2**	**#3**
Pin 29	GND	VCC	GND
Pin 30	GND	GND	VCC

[9] XCK connects to the serial SCK signal on the ATMega2560 microcontroller on the PIB. This signal allows the use of SPI communications on the PM.

The ATmega connection depends upon the connector as follows

	ATMEL Pin		
Pin 15	PD5	PH2	PJ2
	J1	**J2**	**J3**

[10]Pin 15 can also be used as a GPIO. This allows selecting between two different voltage regulators on the P/COM board. This is only needed when using the Original C&C Drybox.

The P/COM board provides on-board 12V using either a switching regulator or a low-dropout linear regulator. Normally, the switching regulator is used. If Pin 15 is High, a switch on the P/COM will bypass the switching regulator and use the linear regulator.

On the revised C&C Drybox, the voltage supplied to the P/COM is regulated at 13.2 volts, and thus the switching regulator can always be used.

On the original C&C Drybox, the voltage is the unregulated battery voltage. As the battery voltage gets below about 13 volts, the switching regulator will drop out. Before that happens, the PIB should be programmed to switch over to the linear regulator.

Note: The Vehicle should always initially use the switching regulator. The linear regulator should only be enabled if required.

3.2.2 PIB J4

J4 has the JTAG connections to the ATmega microcontroller. This connector is intended to be connected directly to an Atmel AVR JTAGICE mkII on-chip debugging system.

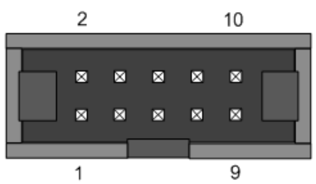


Figure 3-3: PIB J4 Connector Pins

Type: 10 Pin, Dual Row, 0.10 Male

Part #: 3M N25 10-6002RB

Pin	Connection	Description
1	TCK	Clock
2	GND	Ground
3	TDO	Data Out
4	VCC	+3.3 VDC
5	TMS	Test Mode Select
6	RESET	Pin 6 Grounded → Reset
7	VCC	+3.3 VDC
8	N/C	
9	TDI	Data In
10	GND	Ground

3.2.3 PIB J5

J5 is for In-System-Programming connections to the ATmega. This connector is intended to be connected directly to an Atmel AVRISP mkII in-system programmer.

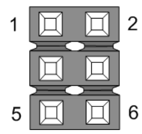


Figure 3-4: PIB J5 Connector Pins

Type: 6 Pin, Dual Row, 0.10 Male

Part #: Samtec TSW-103-07-G-D

Pin	Connection	Description
1	MISO-ISP	Master In – Slave Out
2	VCC	+3.3 VDC
3	SCLK	
4	MOSI	Master Out – Slave In
5	RESET	
6	GND	Ground

3.2.4 PIB J6

J6 is a 2-wire connector that can be used to route the external AUX1 and AUX2 lines (ref. 1.2.5) to a PM or other device.

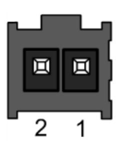


Figure 3-5: PIB J6 Connector Pins

Type: 2 Pin, 0.10 Male

Part #: Samtec IPL1-102-01-S-S

Pin	Connection	Description
1	AUX1	Payload Common 1
2	AUX2	Payload Common 2

3.2.5 PIB J7

J7 connects to the 8 wires that come in through the drybox lid pass-thru.

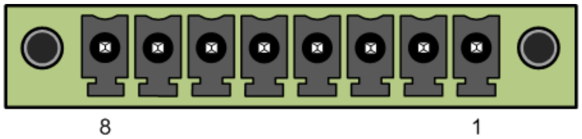


Figure 3-6: PIB J7 Connector Pins

Type: 8 Pin, 3.5mm Male

Part #: Tyco 284516-8

Pin	Connection	Specifications	Wire Color	Notes
1	GPS NMEA Data	4800 Baud GGA, ZDA, and VTG messages at RS-232 levels	Black	[3]
2	PWR	DC power from C&C	White	[1]
3	TX	RS-232 Transmit	Red	
4	RX	RS-232 Receive	Green	
5	AUX1	Payload Common 1	Orange	[2]
6	AUX2	Payload Common 2	Blue	[2]
7	GND	Ground	Yellow	
8	GPS PPS	GPS PPS (pulse-per-second) at RS-232 levels	White/Black	[3]

Notes:

[1] For the Original C&C Drybox: PWR = 11.5 to 16.5 VDC (depends on battery charge)
For the Revised C&C Drybox: PWR = 13.2 VDC (regulated)

[2] Connected to J6 Pins 1 & 2

[3] This signal is only available for the Revised C&C Drybox. Currently, the PIB does not connect to these signals. To use these signals, use the connector to add another wire to the desired location.

3.2.6 PIB J8

J8 is a 6-pin edge connector that connects to the leak detector at the bottom of the drybox.

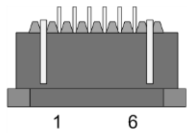


Figure 3-7: PIB J8 Connector Pins

Type: 6 Pin, 1.0mm Female

Part #: FCI SFW6R-4STE1LF

Pin	Connection	Specifications	Notes
1	LEAKCO	Leak Continuity Out	[1]
2	LEAKCI	Leak Continuity In	[1]
3	GND	Grounded thru 1K	
4	LEAK1	0V → Leak	[2]
5	GND	Grounded thru 1K	
6	LEAK0	0V → Leak	[2]

Notes:

[1] Connected together within the leak sensor.

[2] Shorted to GND (through seawater) if a leak is detected.

This Page Intentionally Left Blank

4. Personality Modules

4.1 PM Types

LRI offers the P/COM module for general use. Other possible types of Personality Modules include:

- Load Cell Measurement
- SD Flash Storage
- Alternate Global Positioning System
- Alternate Iridium

4.2 Power/Communications Daughterboard

4.2.1 P/COM Layout

The P/COM board primary connectivity to other electronics is via connector J2.

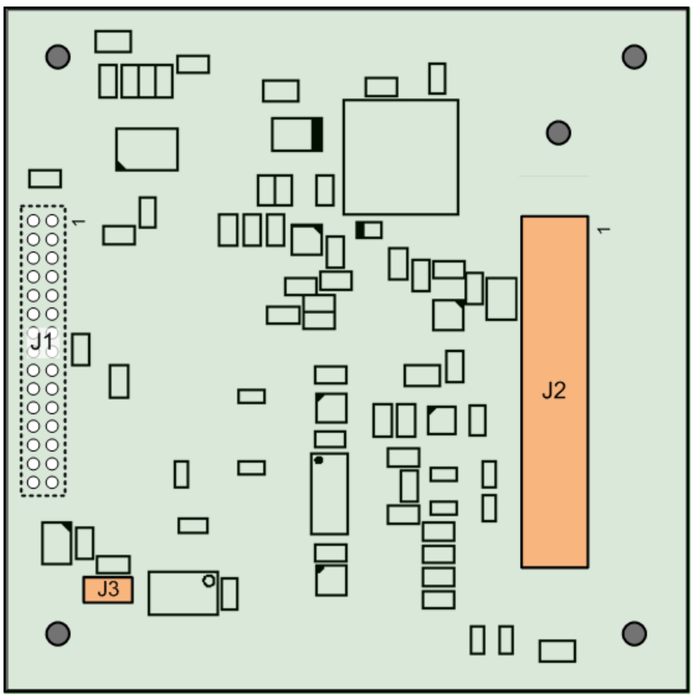


Figure 4-1: P/COM Connector Locations

4.2.2 P/COM Connectors

The two primary connectors on the P/COM are the connection to the PIB (J1) and the connection from the P/COM to other devices in the drybox (J2). J3 is a basic jumper.

Connector	Pins	Type	Function	Ref.
J1	30	Dual Inline Male	Connection to J1, J2, J3 of PIB	4.2.2.1
J2	10	Screw Terminal	P/COM connection to devices	4.2.2.2
J3	2	Jumper	For writing to the EEPROM	4.2.2.3

4.2.2.1 P/COM J1

Connector J1 is a dual male pin strip on the bottom side of the board, designed to connect to J1, J2 or J3 of the PIB.

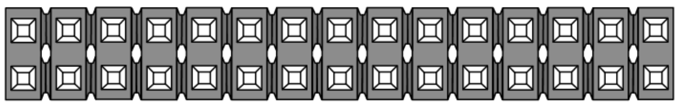


Figure 4-2: P/COM J1 Connector Pins (Viewed from bottom of board)

Type: 30 Pin, Dual Row, 2mm Male

Part #: Samtec TMM-115-03-G-D

Pin	Connection	Description	Notes
1	PWR	DC Power from C&C	[2]
3	PWR	DC Power from C&C	[2]
5	VCC	Regulated +3.3V	
7	SDA	I^2C Data Line	
9	SCL	I^2C Clock Line	
11	TXD	RS-232 Transmit to PM	
13	RXD	RS-232 Receive from PM	
15	XCK GPIO	Synchronous Serial Clock GPIO (optional)	[7] [8] [9[
17	PON	Power-On Enable	[3]
19	POK	Power OK Response	[4]
21	GPIO-0	RXEn Pull this signal Low to enable the serial receiver.	[5]
23	GPIO-1	TXE Pull this signal High to enable the serial transmitter.	[5]
25	GPIO-2	RTS Controls the RTS signal on J2 if TXE is high.	[5]
27	GPIO-3	CTS From the CTS signal on J2 if RXEn is low.	[5]
29	Addr2	PM address 2nd bit	[6]
30	Addr1	PM address 1st bit	

Notes:

[1] Even-numbered pins 2 to 28 are all connected to Ground

[2] For the Original C&C Drybox: PWR = 11.5 to 16.5 VDC (depends on battery charge)
For the Revised C&C Drybox: PWR = 13.2 VDC (regulated)

[3] Signal from PIB indicates whether to turn on this P/COM's 3.3V power.
0V → Off; 3.3V → On

[4] Response sent to PIB indicating this P/COM's power state.
Off → 0V; On → 3.3V

[5] Connections to the PIB ATmega2550 pins. The ATmega connections depend upon the Personality board number as follows:

	21	23	25	27
Personality 1	PK0	PK1	PK2	PK3
Personality 2	PH4	PH5	PH6	PH7
Personality 3	PF0	PF1	PF2	PF3

[6] Pins 29 and 30 allow the P/COM to detect its Personality number.

The Personality numbers are defined as follows:

	29	30
Personality 1	GND	GND
Personality 2	VCC	GND
Personality 3	GND	VCC

[7] Set High to enable a low-dropout linear regulator to bypass the switching regulator.

[8] XCK connects to the serial SCK signal on the ATMega2560 on the PIB. This signal allows the use of SPI communications on the P/COM.

The ATmega connection depends upon the Personality board number as follows:

	15
Personality 1	PD5
Personality 2	PH2
Personality 3	PJ2

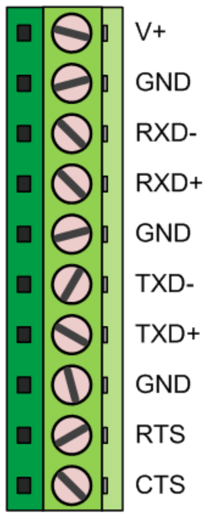
[9] Pin 15 can also be used as a GPIO. This allows the PIB to select the use of the low-dropout regulator on the P/COM board (ref. 3.2.1, Note [10]). This feature is not required for the Revised C&C Drybox.

4.2.2.2 P/COM J2

J2 is an 8-connection terminal block, used to connect to other electronics.

Type: 10 Pin, 3.5mm Screw Terminal Block

Part #: Tyco 284516-8



Pin	Connection	Specifications	Notes
1	VREG	12.0 V Regulated	[1]
2	GND	Ground	
3	RXD–	RS-232 Receive or RS-422 Receive –	[2]
4	RXD+	RS-422 Receive +	[2]
5	GND	Ground	
6	TXD–	RS-232 Transmit or RS-422 Transmit –	[2]
7	TXD+	RS-422 Transmit +	[2]
8	GND	Ground	
9	RTS	RS-232 Ready-to-Send Output	[3]
10	CTS	RS-232 Cleared-to-Send Input	[3]

Figure 4-3: P/COM J2 Connections

Notes:

[1] Max current: **1 Amp**. By selecting different values of R15 and R16, different output voltages can be set. Please consult the LT3505 datasheet.

[2] As shipped, the P/COM is configured for RS-232 operation. These signals can be configured to be RS-232, RS-422 or RS-485. Refer to section 8.2, Figure 8-9 for details on how to configure the P/COM for RS-422 or RS-485 operation.

[3] RTS/CTS are available only when the MAX3224 is present and always use RS-232 levels.

4.2.2.3 P/COM J3

J3 is a 2-pin jumper used to allow writing to EEPROM. When the Jumper is inserted, the EEPROM may be written.

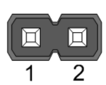


Figure 4-4: P/COM J3 Jumper

Type: 2 pin, 0.10 Male

Part #: FCI 90120-0762

Pin	Connection	Specifications
1	WP	0 → Write to EEPROM
2	Ground	

4.2.3 Configuring PCOM Communications

By changing connections on solder bridges, the PCOM connector J2 can be configured for 3 types of communications, as shown below. Refer also to the schematic Figure 8-9.

4.2.3.1 RS-232 Configuration

This is the default setting. Bridges SB1 and SB4 are shorted. The other four are open.

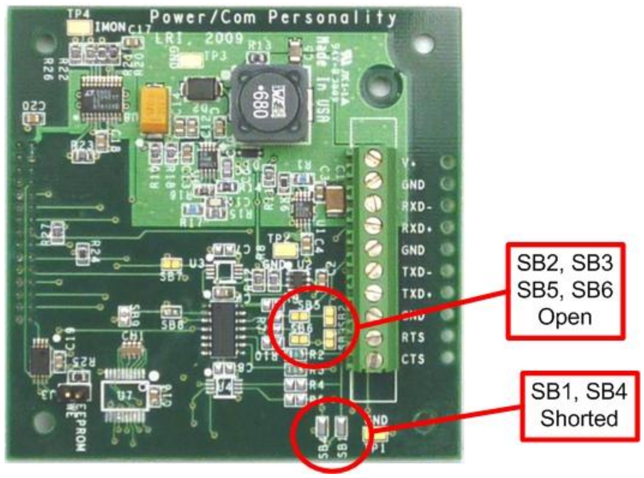


Figure 4-5: RS-232 Configuration

4.2.3.2 RS-422 Configuration

Bridges SB5 and SB6 are shorted. SB1 and SB4 must be open.

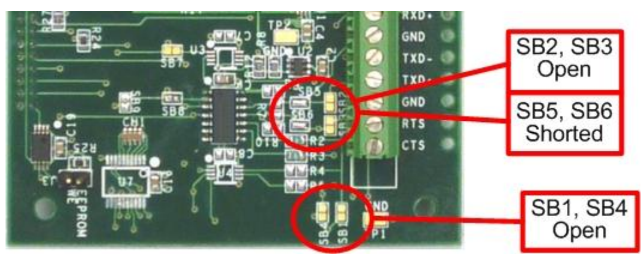


Figure 4-6: RS-422 Configuration

4.2.3.3 RS-485 Configuration

Bridges SB2, SB3, SB5 and SB6 are shorted. SB1 and SB4 must be open.

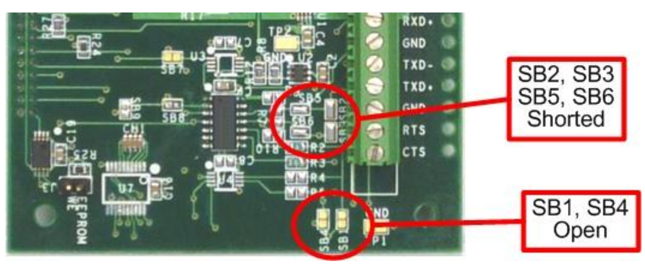


Figure 4-7: RS-485 Configuration

This Page Intentionally Left Blank

5. Vehicle Electrical System

5.1 External Electrical Connections

There are basically three different types of watertight connectors used on the Wave Glider™, depending upon location. The tables below describe the connector types and pinouts for each.

5.1.1 C&C Solar Panel Connections

The two SOLAR1 and SOLAR2 connectors on the top of the C&C Drybox are SubConn 5-pin Male type. These connections can be used with an external charger to recharge the batteries. Refer to section 5.2 "External Charging".

Pin #	SOLAR Function	Description	Notes
1	V+	Positive Solar Panel voltage	
2	V–	Negative Solar Panel voltage	
3	V_{CT}	Center-tap for Solar Panel	
4	Sense	Continuity Sensor for Solar Panel	[1] [2]
5	Sense Ref	Reference for Continuity Sensor	[1] [2]

SubConn MCBHRA5M

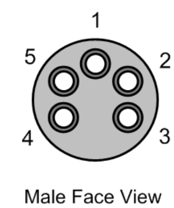


Table 5-1: Solar Panel Connector Specifications

[1] On the Original C&C drybox, the **Sense** and **Sense Ref** are used to turn the C&C on or off.

[2] On the Revised C&C, the **Sense** and **Sense Ref** are used to verify that the solar panel is connected. Thus, no solar panels are required to be connected for power to be turned on.

Note: If the Vehicle is deployed without one or both solar panels, a dummy plug should be used on the unused connector to prevent damage to the exposed pins.

5.1.2 C&C Payload Connections

The two Float PAYLD1 and PAYLD2 connectors on the top of the C&C Drybox are SubConn 8-pin female type, with the following connections:

Pin #	PAYLD Function	Description	Notes
1	GPS NMEA Data	4800 Baud GGA, ZDA, and VTG, using RS-232 levels	[4] [5] [6]
2	PWR	Original C&C: 11.6 – 16.6 Volts Revised C&C: 13.2 Volts regulated	[1] [2]
3	Tx	RS-232 Transmit Line	
4	Rx	RS-232 Receive Line	
5	AUX 1	Payload common #1	[3]
6	AUX 2	Payload common #2	[3]
7	GND	Ground reference for all pins	
8	GPS PPS	GPS pulse-per-second, using RS-232 levels	[5] [6]

SubConn MCBHRA8F

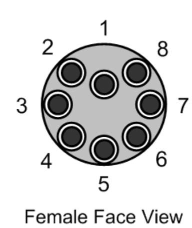


Table 5-2: C&C Payload Connector Specifications

[1] For Original C&C Drybox, the maximum allowed current is **1.0 Amps**. See also section 5.3 "Current and Power Usage".

[2] For the Revised C&C Drybox, the maximum current is **3.5 Amps**. See also section 5.3.

[3] **AUX 1** and **AUX 2** connect also to pins 5 and 6 on the Glider rudder box payload connector (ref. 5.1.3).

[4] GPS: 4800 baud GGA (position), ZDA (date/time) and VTC (velocity) messages. These GPS signals are on the Revised C&C only.

[5] For the Original C&C, Pins 1 and 8 are No-Connects.

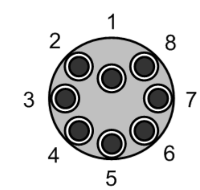
[6] This functionality is only available with at least one payload turned on.

5.1.3 Glider Rudder Box Connections

The payload (lower) connector on the Glider's Rudder Module is a SubConn 8-pin female type. It has the connections:

Pin #	Rudder Box Function	Description	Notes
1	N/C	Not Used	
2	PWR	Original C&C: 11.6 – 16.6 Volts Revised C&C: 13.2 Volts regulated	[1]
3	(reserved)	DO NOT USE	[2]
4	(reserved)	DO NOT USE	[2]
5	AUX 1	Payload common #1	[3]
6	AUX 2	Payload common #2	[3]
7	GND	Ground reference for all pins	
8	Open	Not Used	

SubConn MCBHRA8F



Female Face View

Table 5-3: Glider Payload Connector Specifications

[1] The maximum allowed current is **1.0 Amps**. See also section 5.3 "Current and Power Usage".

[2] Pins 3 and 4 are reserved for use by the Wave Glider™. These pins must not be connected to any Glider payload.

[3] **AUX 1** and **AUX 2** connect also to pins 5 and 6 on the Float Payload connectors (ref. 5.1.2).

5.1.4 Revised C&C "WEATHER" Connections (Original "I/O 1")

The "WEATHER" connector on the Revised C&C and the "I/O 1" connector on the Original C&C have the same pinouts.

Both use a SubConn 8-pin female type, with the connections:

Pin #	WEATHER Function	Description	Notes
1	N/C	Not Used	
2	PWR	Original C&C: 11.6 – 16.6 Volts Revised C&C: 13.2 Volts regulated	
3	RXD-	RS-422 receive from station	
4	RXD+	RS-422 receive from station	
5	TXD-	RS-422 transmit to station	
6	TXD+	RS-422 transmit to station	
7	GND	Ground	
8	N/C	Not Used	

SubConn MCBHRA8F

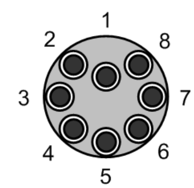


Table 5-4: Revised C&C Weather Connector Specifications

5.1.5 Revised C&C "SPEED" Connections (Original "I/O 2")

The "SPEED" connector on the Revised C&C and the "I/O 2" connector on the Original C&C have the same pinouts.

Both use a SubConn 8-pin female type, with the connections:

Pin #	SPEED Function	Description	Notes
1	GND	Ground	
2	N/C	Not Used	
3	PWR	Regulated 8V supply	
4	Data	Speed Data	[1]
5	N/C	Not Used	
6	N/C	Not Used	
7	N/C	Not Used	
8	N/C	Not Used	

SubConn MCBHRA8F

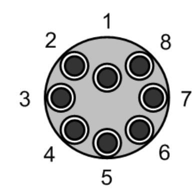


Table 5-5: Revised C&C Speed Connector Specifications

[1] Speed data is a variable-frequency square wave.

5.1.6 “LIGHT” Connections

The lIGHT connector on the Revised C&C Drybox is a SubConn polarized 2-pin female type, with the following connections:

Pin #	LIGHT Function	Description	Notes
1	PWR	13.2 Volts regulated	
2	GND	Ground reference	[1]

Table 5-6: Light Connector Specifications

5.1.7 “Aux PWR” Connections

The AUX PWR connector on the Revised C&C Drybox is a SubConn 6-pin female type, with the connections:

Pin #	Aux PWR Function	Description	Notes
1	V-Aux	Auxiliary charging input	[1]
2	AIS	AIS data stream	
3	PWR	13.2 Volts regulated	[2]
4	PWR	13.2 Volts regulated	[2]
5	GND	Ground reference	
6	GND	Ground reference	

Table 5-7: Aux PWR Connector Specifications

[1] Must be externally limited.

[2] 3 Amps continuous per pin.

5.2 External Charging

5.2.1 Charger Connections

An external charger can be connected to either or both of the C&C solar panel connectors. This allows charging or "topping-off" of the batteries pre-mission, or when bench testing.

The maximum charging current for each connection will be internally limited to 2.5 Amps, regardless of what the charger is capable of supplying. For faster charging, connect a charger to each of the two solar panel connectors.

5.2.2 LRI-Supplied Charger

Liquid Robotics Inc. offers a pre-made external charger specifically designed for the Wave Glider™.

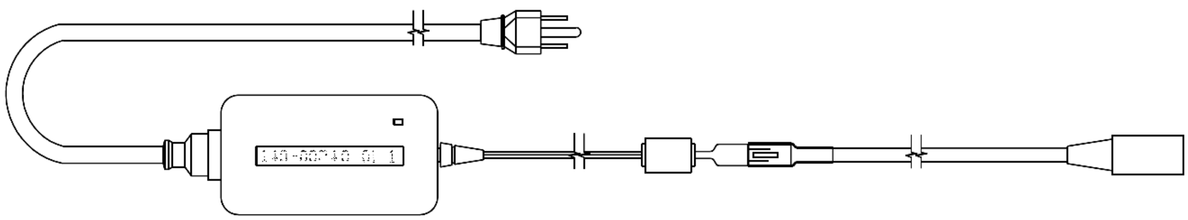


Figure 5-1: LRI External Charger

Contact Liquid Robotics for more information.

5.2.3 Custom-Made Charger

A custom Wave Glider™ battery charger can be made from a commercial power supply and a SubConn connector.

The power supply voltage must be **9-12 VDC**. In order to minimize charging time, the charger should be capable of delivering at least **2 Amps.**

The connector required to mate with the solar panel connector is a MCBHRA5F SubConn 5-pin Female type, with the following connections:

Pin #	Function	Description
1	V+	To P/S Positive (+9VDC)
2	GND	To P/S Negative
3	GND	To P/S Negative
4	Sense	Connected Together
5	Sense Ref	

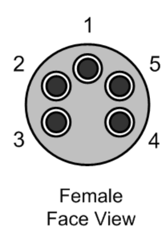


Table 5-8: External Charger Connections

With the Original C&C, the Wave Glider will power-up when the charger is connected.

With the Revised C&C, the power must be turned on (via the key) during charging.

5.3 Current and Power Usage

The Wave Glider has some specific limitations on the power used by the payloads.

5.3.1 Maximum Current Limits

Table 5-9 below summarizes the maximum allowed currents for connections to both the Original and the Revised C&C Drybox. If any of these limits is exceeded, the C&C will shut down power to the offending component.

Max Current	Original Drybox	Revised Drybox	Notes
Total to all External	5.0 A	5.0 A	[1] [2]
PAYLD 1	1.25 A	3.5 A	[3]
PAYLD 2	1.25 A	3.5 A	[3]
PAYLD 3	1.25 A	3.5 A	[3]
Glider Payloads (all)	1.0 A	1.0 A	[4]
WEATHER (I/O 1)	0.2 A	0.2 A	
SPEED (I/O 2)	0.2 A	0.2 A	
Aux PWR Out	n/a	6.0 A	[3] [6]
AIS	0.2 A	0.2 A	[5]
LB	n/a	0.5 A	[3] [5]

Table 5-9: Maximum Currents for C&C Connections

[1] For the Revised Drybox, the sum of the allowed payload currents exceeds the maximum current draw.

[2] If the total current for all connections is exceeded damage to the batteries or electronics may result.

[3] If the payload current exceeds this limit, power will be shut down to the payload.

[4] If the total Glider payload current exceeds this limit, power will be shut down to both the payload and the rudder control.

[5] Internal to C&C drybox but able to be controlled externally.

[6] Aux PWR in 17-28 Volts is not available. 3.0 A externally limited.

5.3.2 Transient Power Surges

It is extremely important that start-up and other transient currents be taken into consideration, as the C&C has very limited ability to absorb excess power when currents exceed the maximum values.

For the Revised C&C:

- Each Float payload source can dissipate 30 Watts for up to 160 ms (4.8 joules)
- The Glider payload source can dissipate 13 Watts for 1.5ms (19.5 millijoules)

For the Original C&C, the limits are lower:

- For a Float payload connection: 0.5 joules
- For the Glider payload connection: 0.2 millijoules

Large transient start-up currents can be caused by a high-capacitance load on the payload input. For the Revised C&C, the maximum capacitance loads would be:

- For a Float payload: ~50,000uF (4.8 J, 13.2V)
- For the Glider payload: ~200uF (19.5mJ, 13.2V)

Transients during normal operation can be caused by devices that use large amounts of energy for relatively short periods of time, such as active acoustic transducers (SONAR), or high-power satellite transceivers (BGAN).

If a payload's transient current value will exceed the limit, some kind of local energy storage (batteries or super-caps) is required.

5.3.3 Determining Surge Energy

If a payload will be operating near its current limit, transient currents (start-up or intermittent) should be checked to verify that it is not close to exceeding its over-current energy limit.

Figure 5-2 below shows a screen shot of the load voltage and current measured during the start-up of a 25W power supply. The current was measured using a Tektronix A622 current probe.

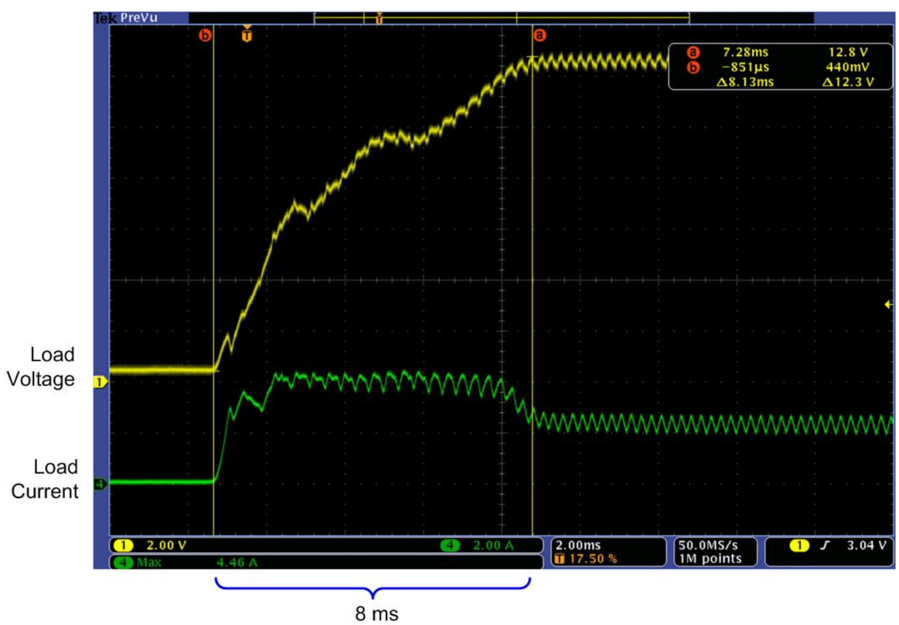


Figure 5-2: Screen Shot of Start-up Transients

In the Figure, the turn-on time is 8ms – well within the time allowance.

As a general rule for the Revised Drybox, if the voltage is stable within 160ms, then the payload should power-up reliably.

5.4 Power Consumption

Since the Wave Glider™ derives all of its long-term operating power from the solar panels, the average energy usage by the C&C Drybox plus payload(s) should not exceed the average energy input from the solar panels. Allowance also has to be made for the possibility that, due to storms and cloud cover, the solar energy may be considerably less than average for several days at a time.

5.4.1 Sustainable Payload Power

Figure 5-3 shows the computed power available to a Wave Glider™ at different Northern latitudes and dates. The graph assumes that cloud cover reduces the solar flux by 25%. However, it does not take into account the larger atmospheric absorption at far-North latitudes.

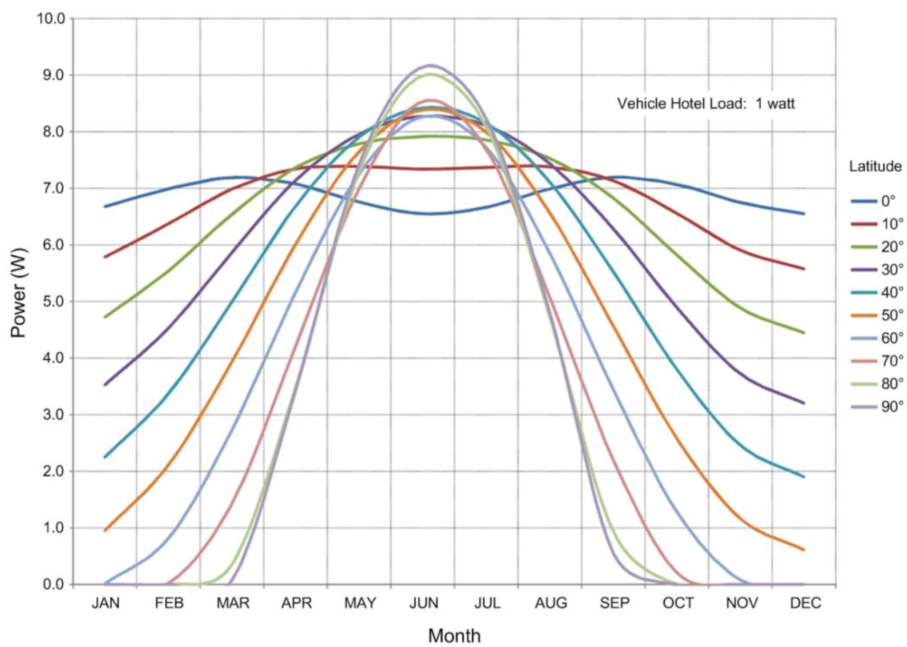


Figure 5-3: Solar Power vs. Time and Location

5.4.2 C&C Drybox Average Power Loads

The C&C Drybox runs off the internal battery pack with a theoretical maximum capacity of 650 Wh. The amount of power draw from the C&C depends upon the electrical activity, as shown in Table 5-10.

Operation	Average Power	Notes
Idle	1000 mW	
Iridium On (9601, 9602)	500 mW	[1]
Iridium On (9522)	1500 mW	[1]
XBee On	250 mW	
RS-232 to Float Payload	5 mW	
WS	2500 mW	[2]
AIS	1100 mW	[2]
Speed	1100 mW	[2]

Table 5-10: C&C Drybox Current Draw

[1] Telemetry rate of 5 minutes and power reporting at 60 minutes with modem duty cycling enabled. Telemetry report rates and payload data rates will affect these numbers.

[2] Optional sensors.

5.4.3 Battery System Power

The Wave Glider™ fully-charged Lithium-Ion battery pack has the following characteristics:

Battery Max Voltage	16.6 Volts
Maximum Continuous Current	42 Amps
Energy Capacity (fully charged) [theoretical maximum]	665 Watt-hours

Table 5-11: Battery Pack Characteristics

The above numbers assume that seven fully-charged batteries are installed in the C&C Drybox. However, note that the Maximum Continuous Current is not available on any external connections.

5.4.4 Battery Charge Level

The figure below shows how the battery voltage indicates the charge level. Note the characteristic rapid drop-off near full discharge.

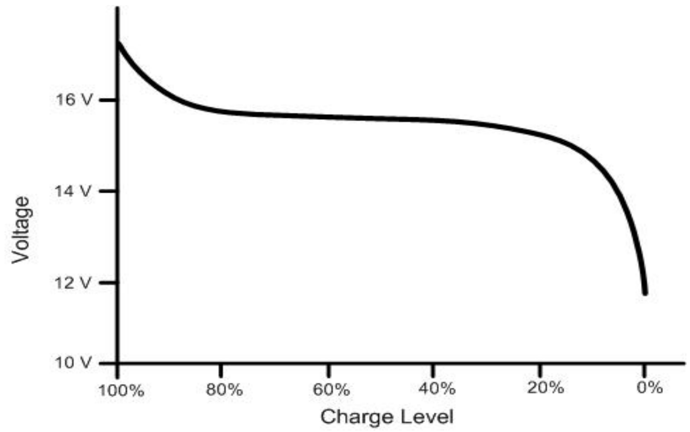


Figure 5-4: Battery Charge Level vs. Voltage

5.4.5 Battery Discharge Characteristics

Assuming the batteries are fully charged, but there is no input from the solar panels, the discharge time will depend upon the Wave Glide power draw as follows:

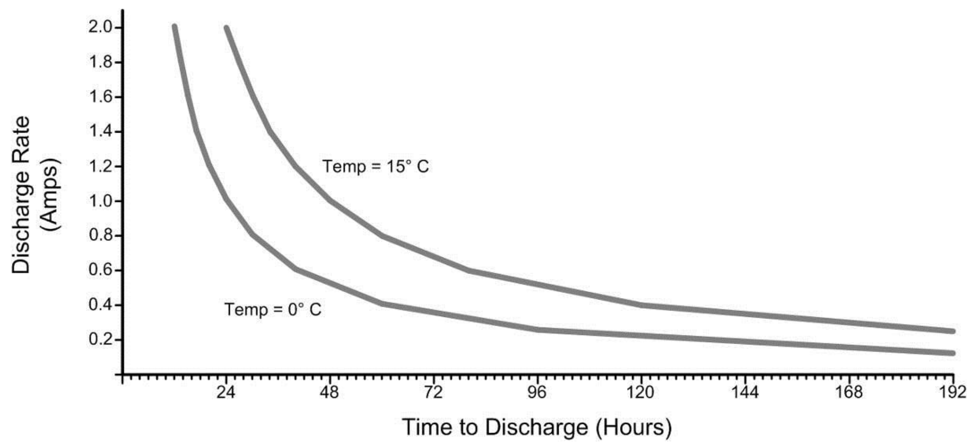


Figure 5-5: Battery Discharge Time vs. Current Draw

6. Drybox Mechanical Specifications

6.1 Payload Dryboxes

The forward payload drybox is deeper than the aft drybox. However, the lids for both the fore and aft dryboxes are interchangeable.

The drybox electronics are usually mounted to the underside of the lid. There are different lid options, as described below.

6.1.1 Forward Drybox

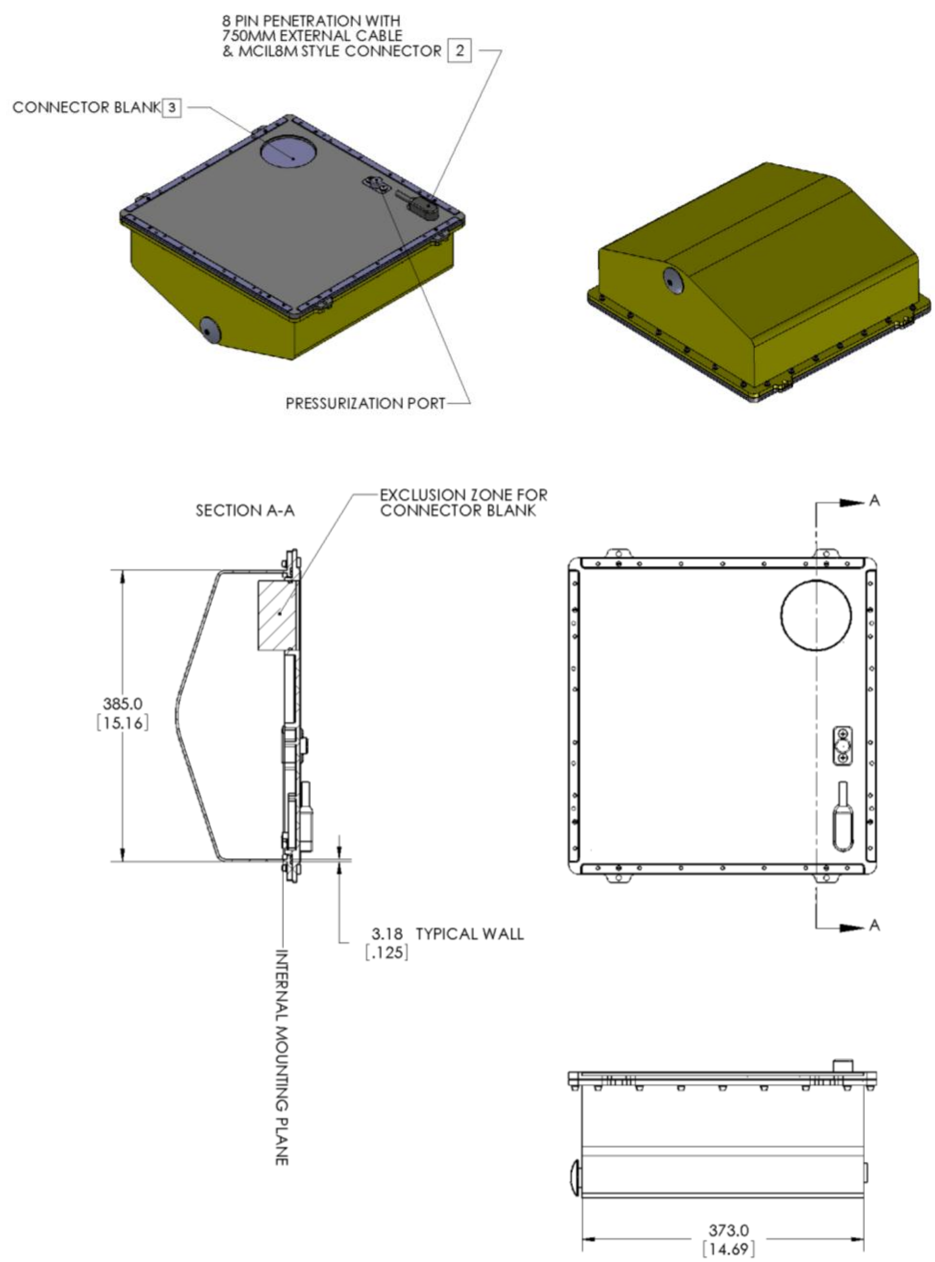


Figure 6-1: Forward Drybox Overall Dimensions

6.1.2 Aft Drybox

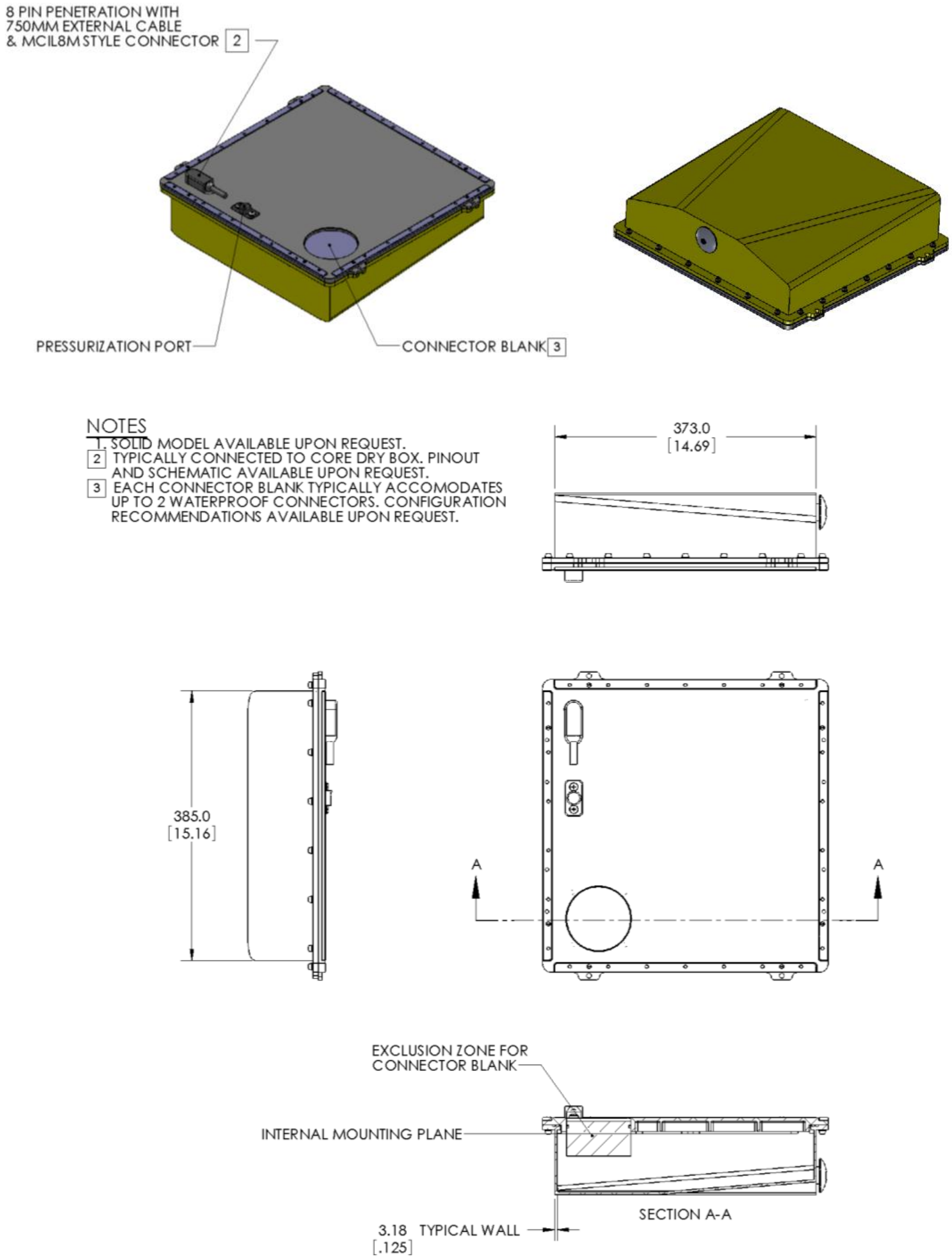


Figure 6-2: Aft Drybox Overall Dimensions

6.2 Drybox Lids

Since the electronics are mounted to the underside of the drybox lids, their mechanical specifications need to be considered.

The PIBs are designed for mounting to the lids. Custom electronic designs need to consider not only the positions of the mounting holes, but also clearance for the lid seals and the connector pass-thrus.

6.2.1 Underside Dimensions

The drybox lid underside has several bosses for mounting electronics and other equipment. There is also a removable panel for adding additional pass-thru connectors.

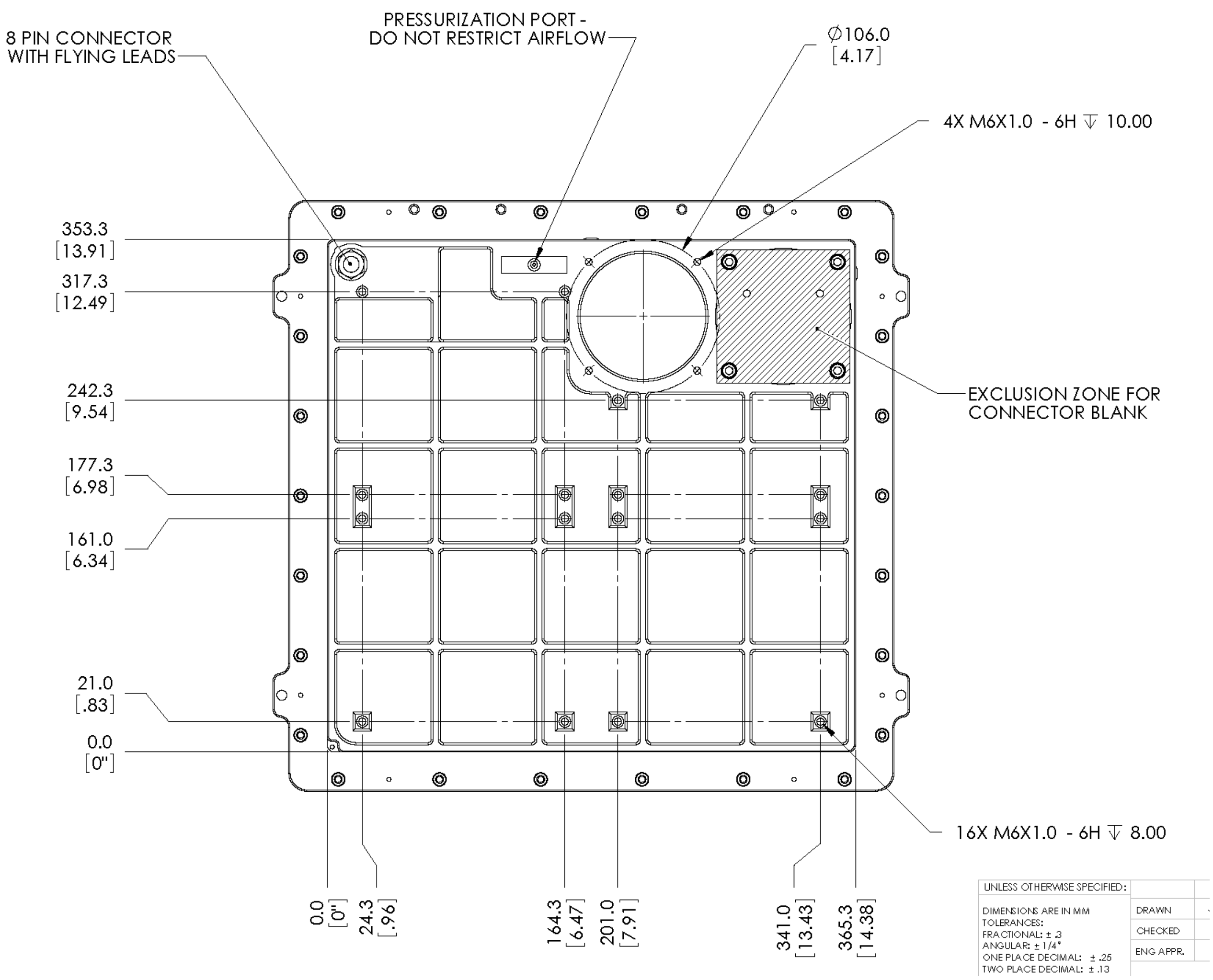


Figure 6-3: Drybox Lid Underside Dimensions

6.2.2 Drybox Lid With Payload Interface

The drybox lid can be optionally shipped with a Payload Interface Board. This board will use some of the available real-estate, as shown in the figure.

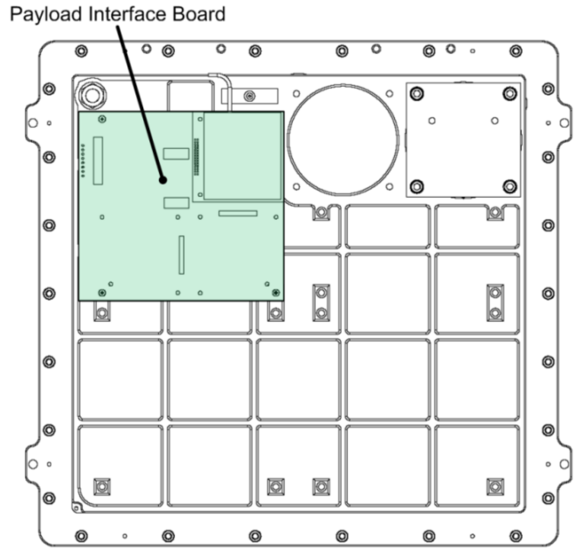


Figure 6-4: Drybox Lid With Payload Interface Board

6.2.3 Drybox Lid With Dual Connector Blanks

The drybox lid can be optionally equipped with two Connector Blanks for pass-thrus. The exclusion areas are shown below.

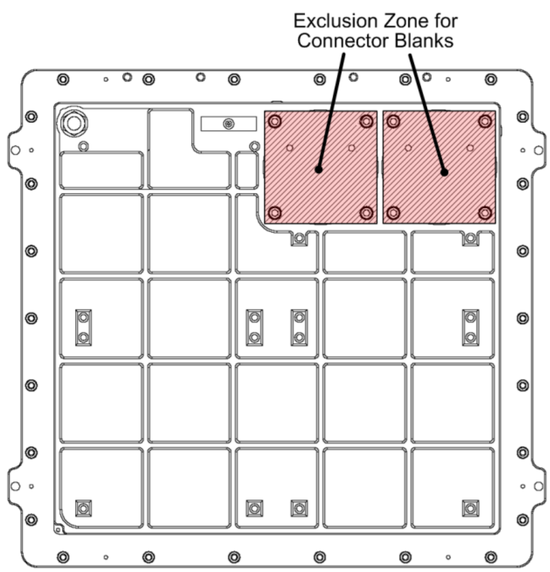


Figure 6-5: Drybox Lid With Two Connector Blanks

7. Troubleshooting

7.1 Overview

On-Shore troubleshooting falls into two general categories:

1) Fixing non-functioning systems

2) Diagnosing and correcting error conditions

7.1.1 Re-Booting

Generally, re-booting the system is a solution of last resort. Re-booting may temporarily fix the problem, but not address the root cause.

A re-boot can be initiated by powering OFF (removing solar panel connectors), waiting a few seconds, and then re-connecting a solar panel to turn the system back ON.

7.1.2 Contacting Liquid Robotics

If you've tried the solutions suggested here, and the problem persists, collect the pertinent data and contact LRI, as described in "7.3 Contacting Liquid Robotics Inc.".

7.2 Problems and Responses

7.2.1 No Float Payload Power From C&C

When the system is powered up (or re-booted), power to the payloads is turned OFF. The power needs to be explicitly turned ON

Also, the maximum current that can be supplied to any payload is limited to **1 Amp** (Original C&C) or **4 Amps** (Revised C&C). Any attempt to use more current will result in power to that payload being shut off.

Responses:

1) Check that the payload is connected to the correct connector on the C&C Drybox.
2) Check the connectors on C&C and Payload Dryboxes.
3) Check for an over-current alarm.
4) Check the power status for low batteries.

7.2.2 No Sub Payload Power From C&C

As with Float payloads, Rudder power is initially Off when the Vehicle power is turned On. Also, the max current that can be supplied to both the Rudder and any Glider payload combined is **1 Amp**.

Responses:

1) Verify that rudder can move. If not, check both the Float and Rudder Module Umbilical connectors. Also check the Umbilical for cracks or tears.
2) Check for an over-current alarm.
3) Check the power status for low batteries.

7.2.3 No C&C-to-Payload RS-232 Communications

Lack of RS-232 communications can be caused by a problem with the C&C electronics, the Payload electronics, and/or the connection between them.

If communications were previously established, but no longer work, the best response is to try re-booting the system.

The responses below assume that communications has never been established using a specific payload.

Responses:

1) Check for correct cable connection to C&C Drybox.
2) Check that C&C has turned on power to the Payload.
3) Check for an over-current alarm.
4) Check payload electronics UART.

7.2.4 Float Continuously Re-Boots

This indicates a serious electronics problem. Contact LRI.

7.2.5 Sub Continuously Re-Boots

This indicates a serious electronics problem. Contact LRI.

7.3 Contacting Liquid Robotics Inc.

If you cannot determine or correct the cause of a problem, contact LRI. To expedite resolving the problem, make a brief list beforehand with the following information.

1) Wave Glider™ Model Number
2) Any special or added payloads on the Vehicle
3) Time/date when problem occurred
4) Location of Vehicle when problem occurred
5) Initial indication of problem
6) Any other indications or unusual readings
7) Attempts at corrective actions and their results

For time-critical problems, call LRI at:

(650) 493-6300

and select the option for Customer Service

For non-critical problems, send the above information via email to:

support@liquidr.com

8. Schematics

8.1 Payload Interface Board

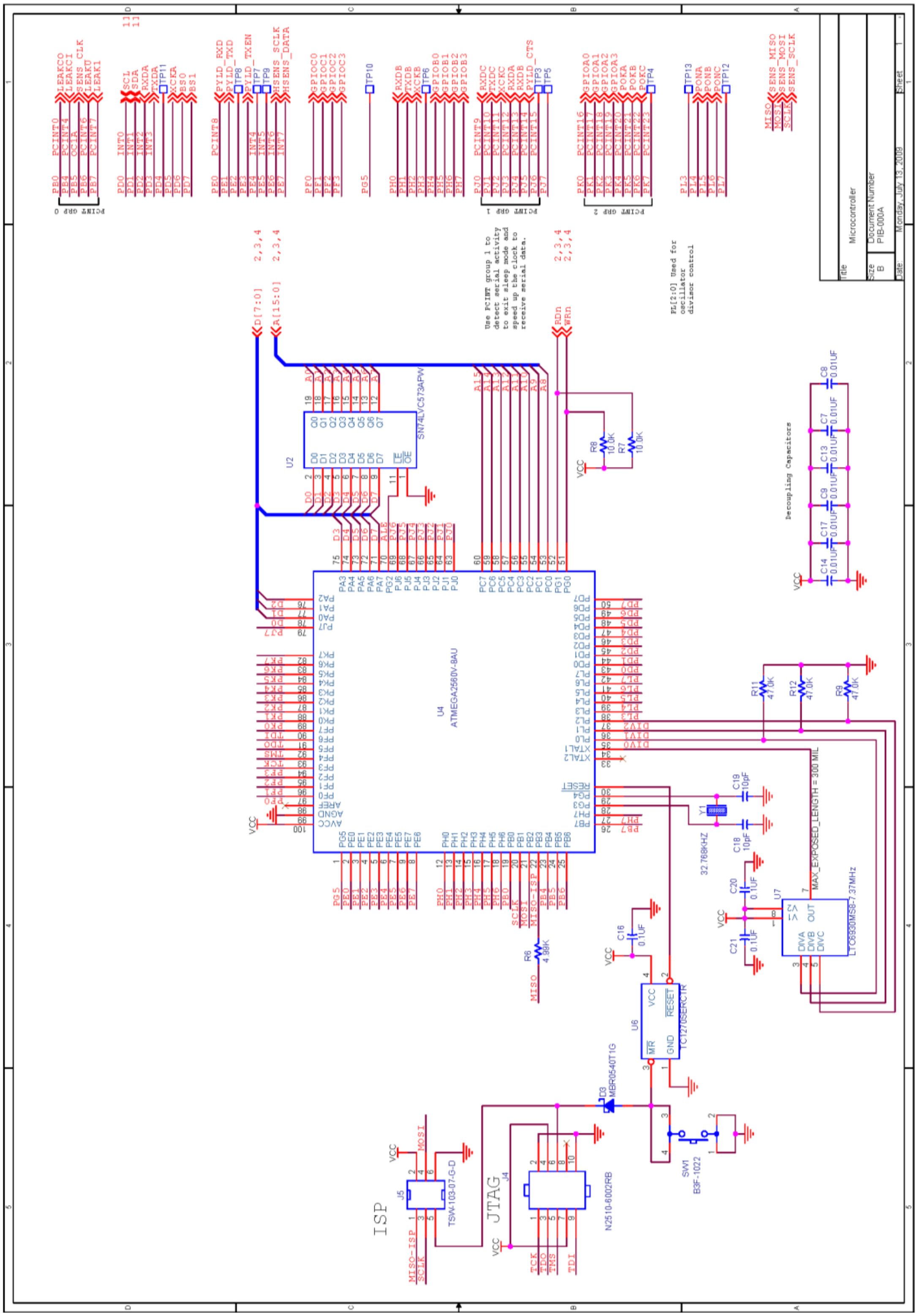


Figure 8-1: PIB Schematic Page 1

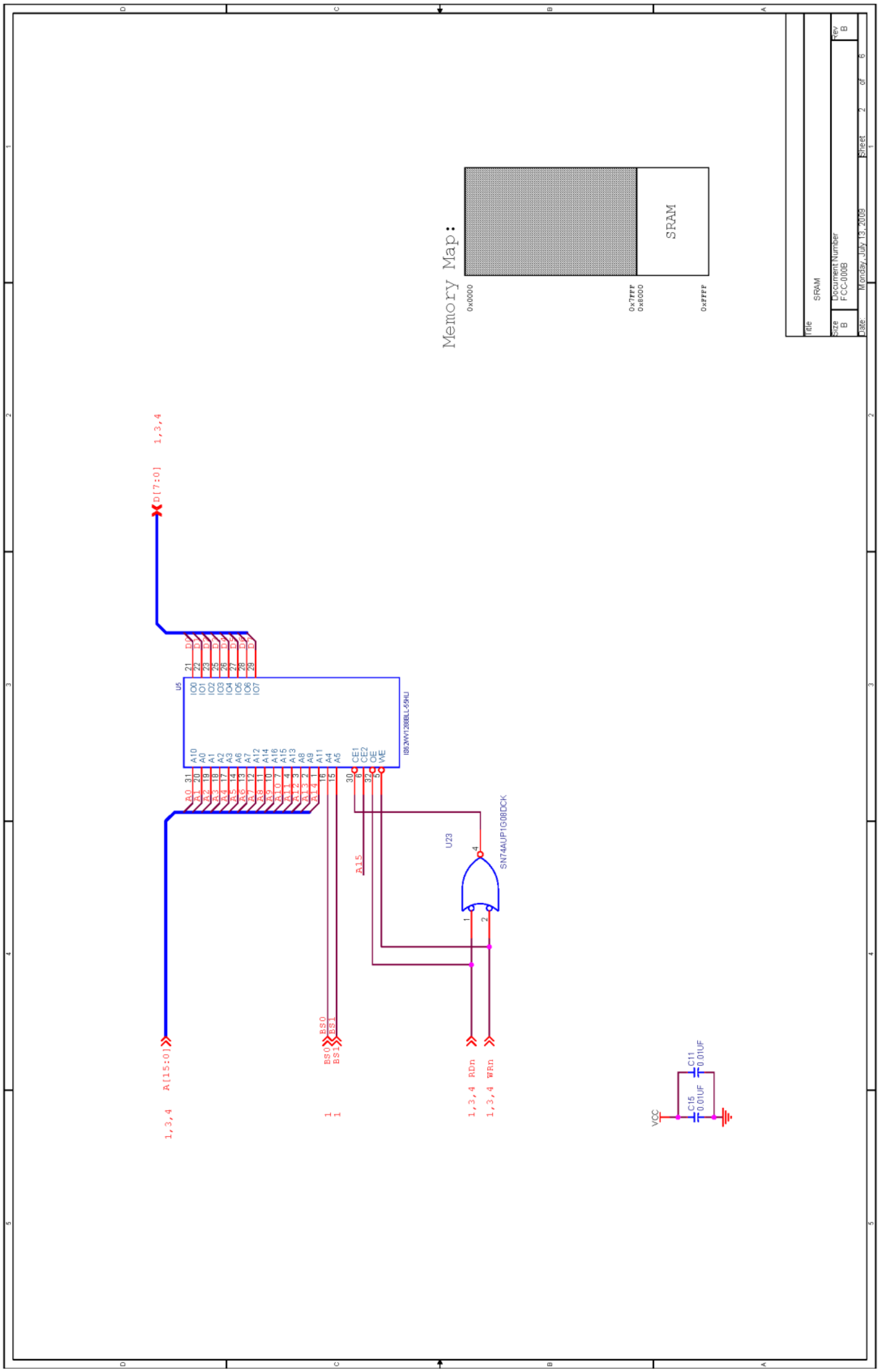


Figure 8-2: PIB Schematic Page 2

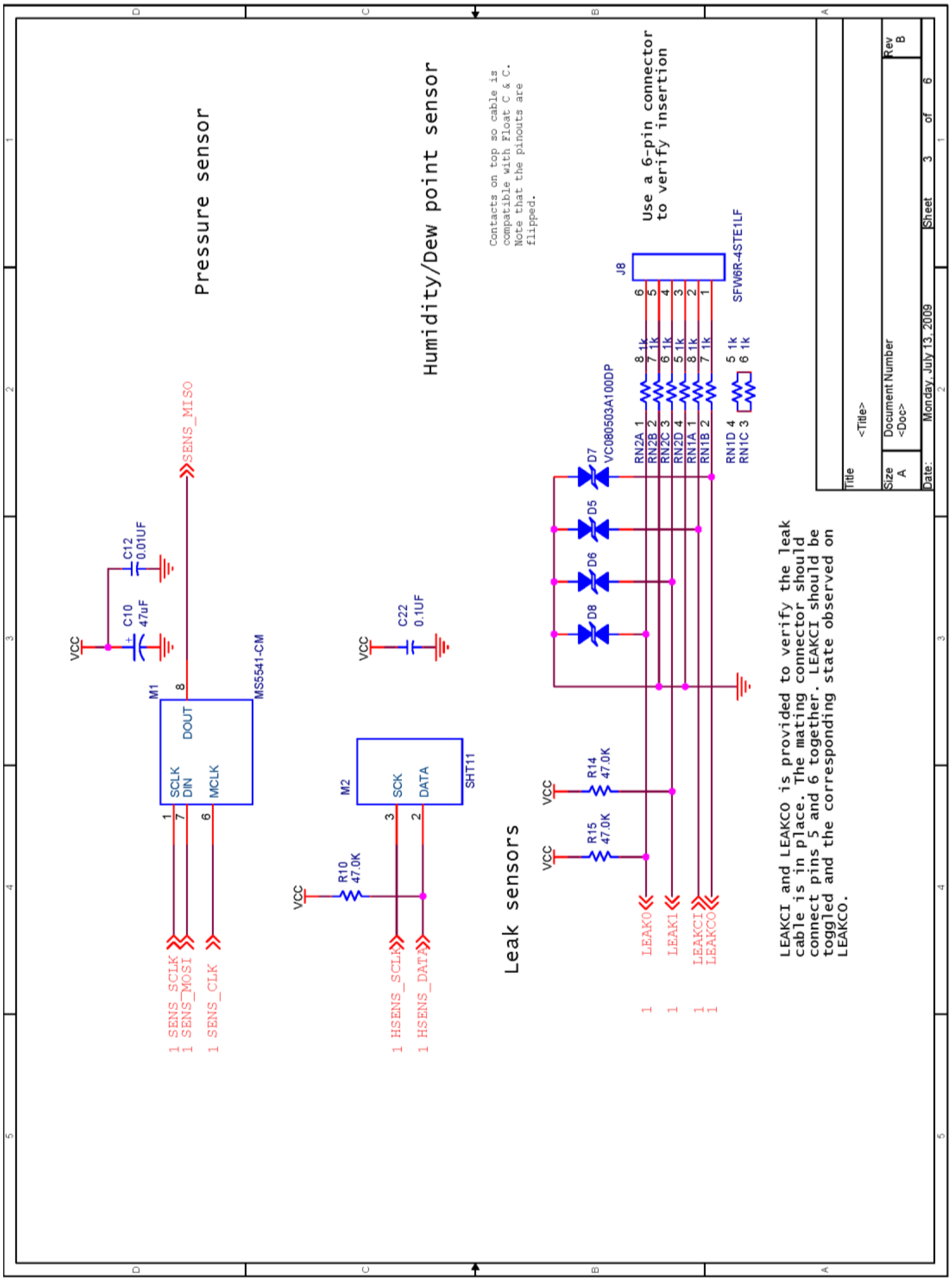


Figure 8-3: PIB Schematic Page 3

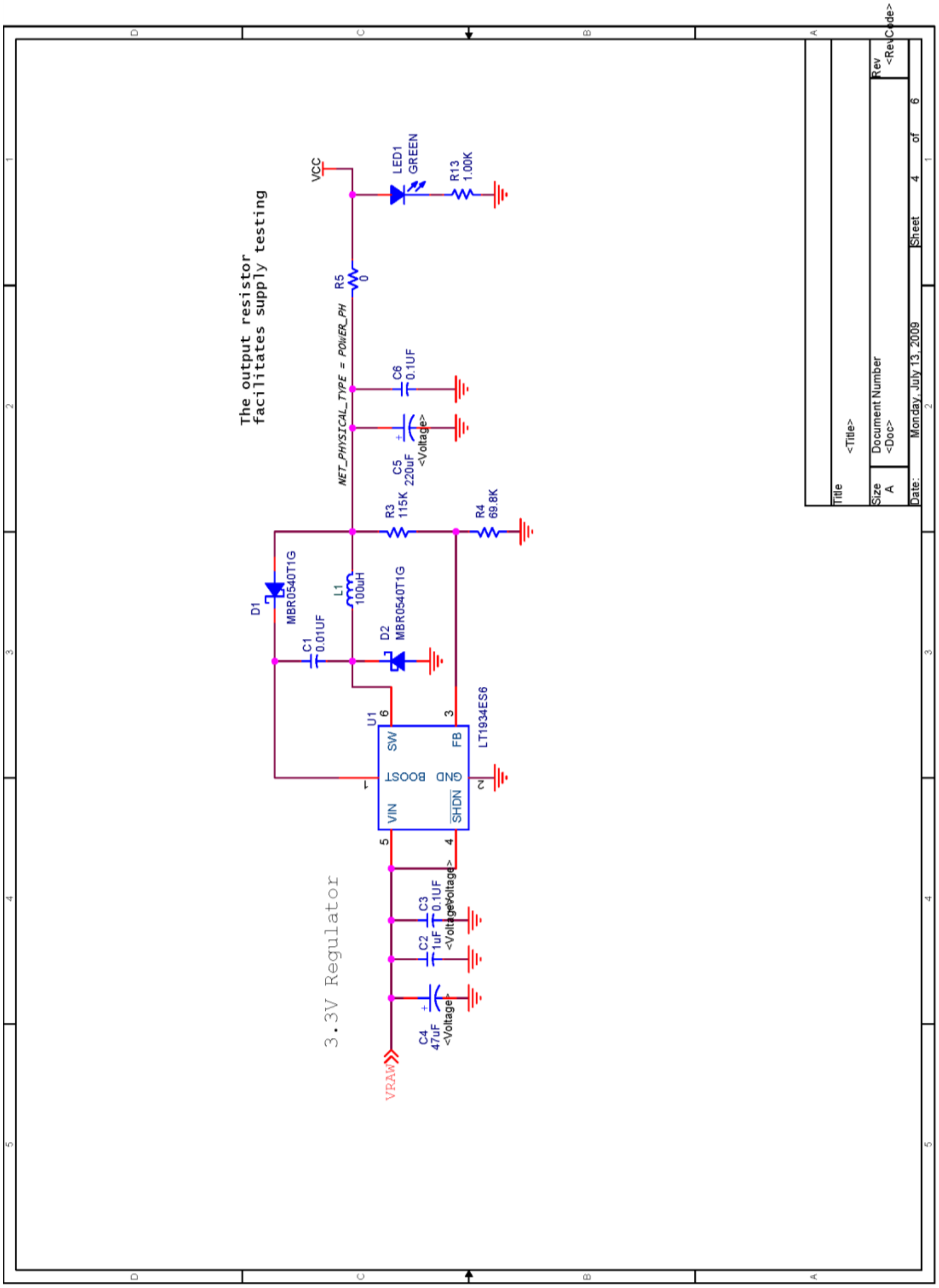


Figure 8-4: PIB Schematic Page 4

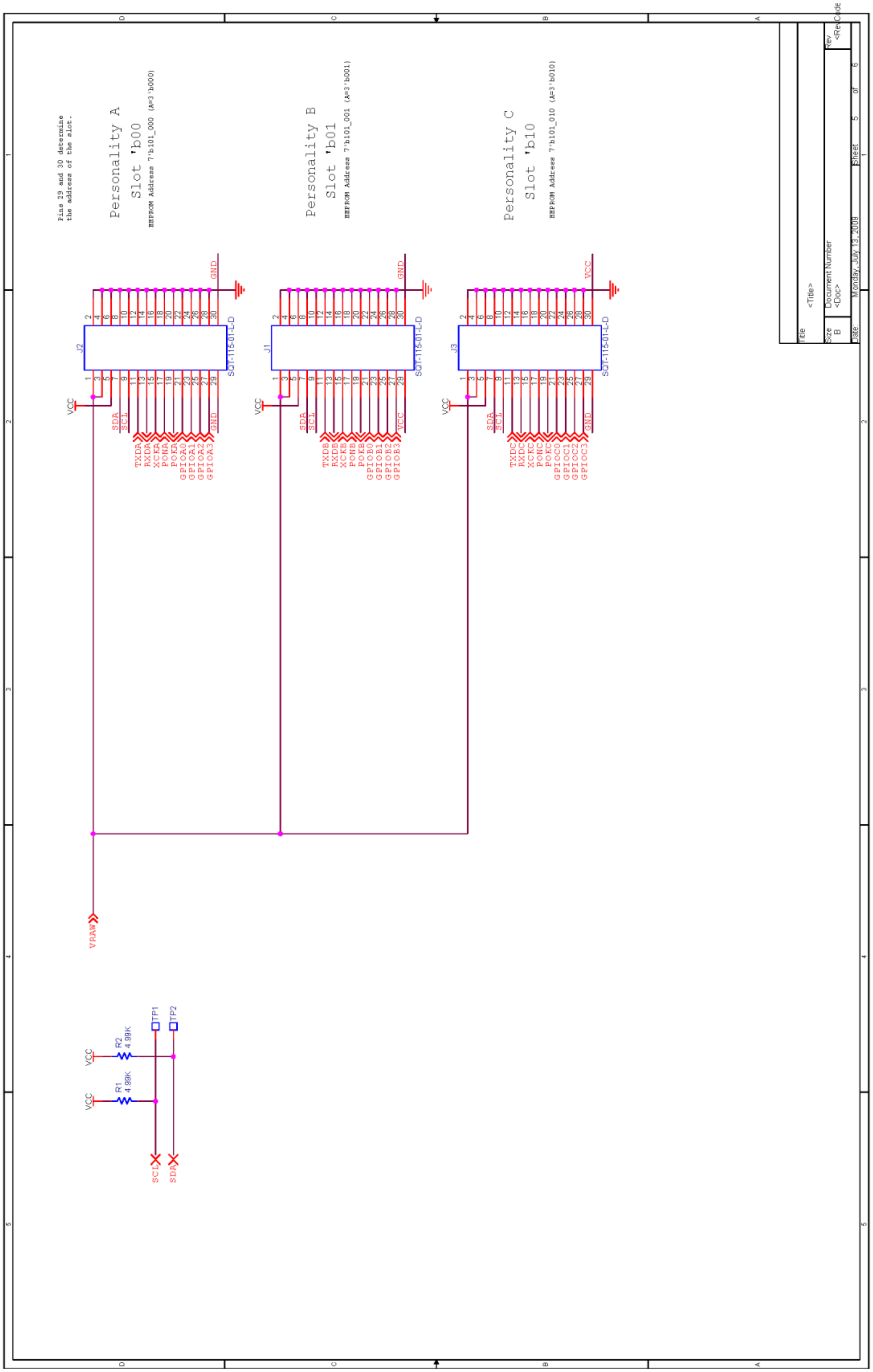


Figure 8-5: PIB Schematic Page 5

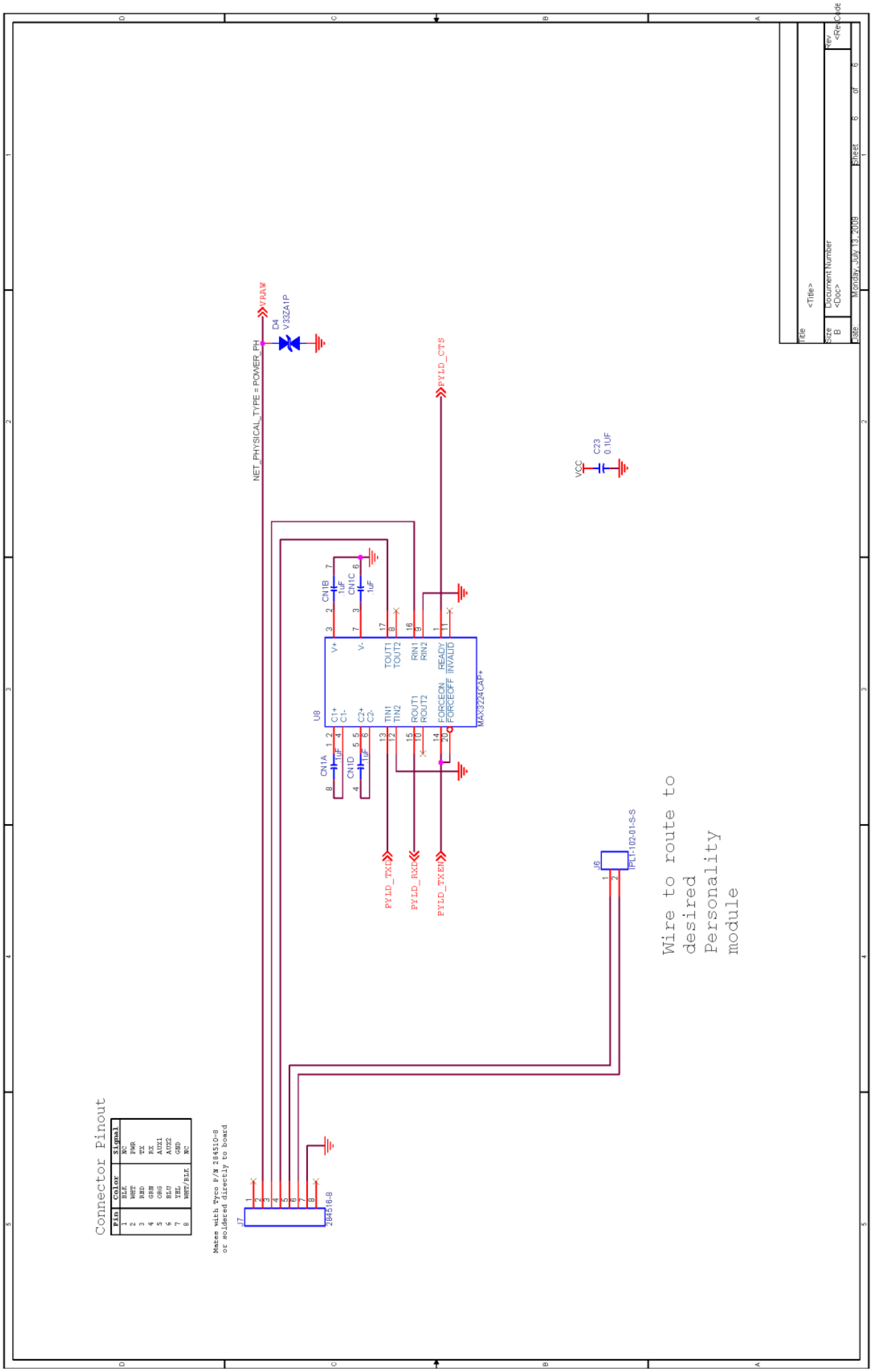


Figure 8-6: PIB Schematic Page 6

8.2 Power/Communications Board

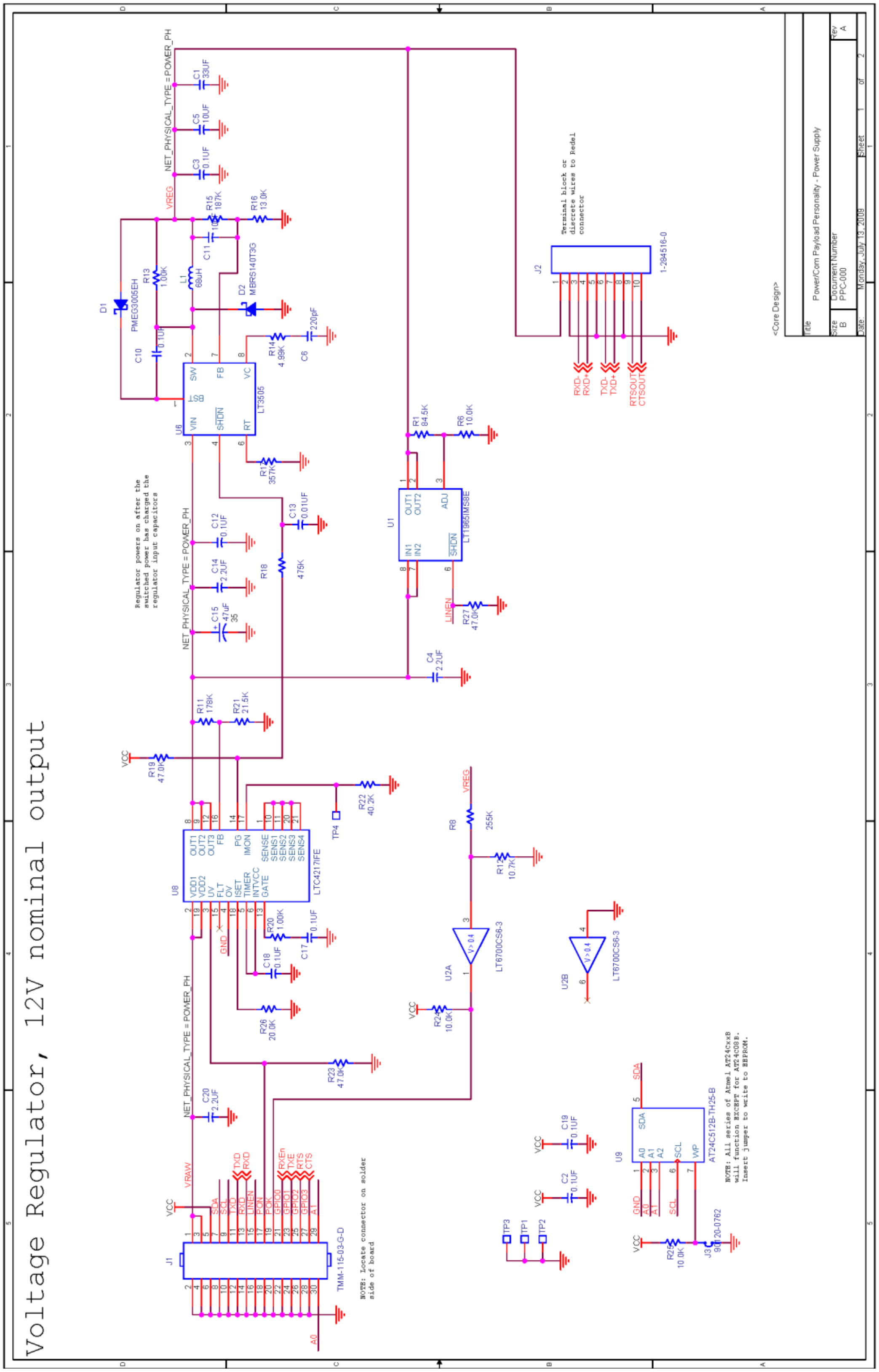


Figure 8-7: P/COM Schematic Page 1

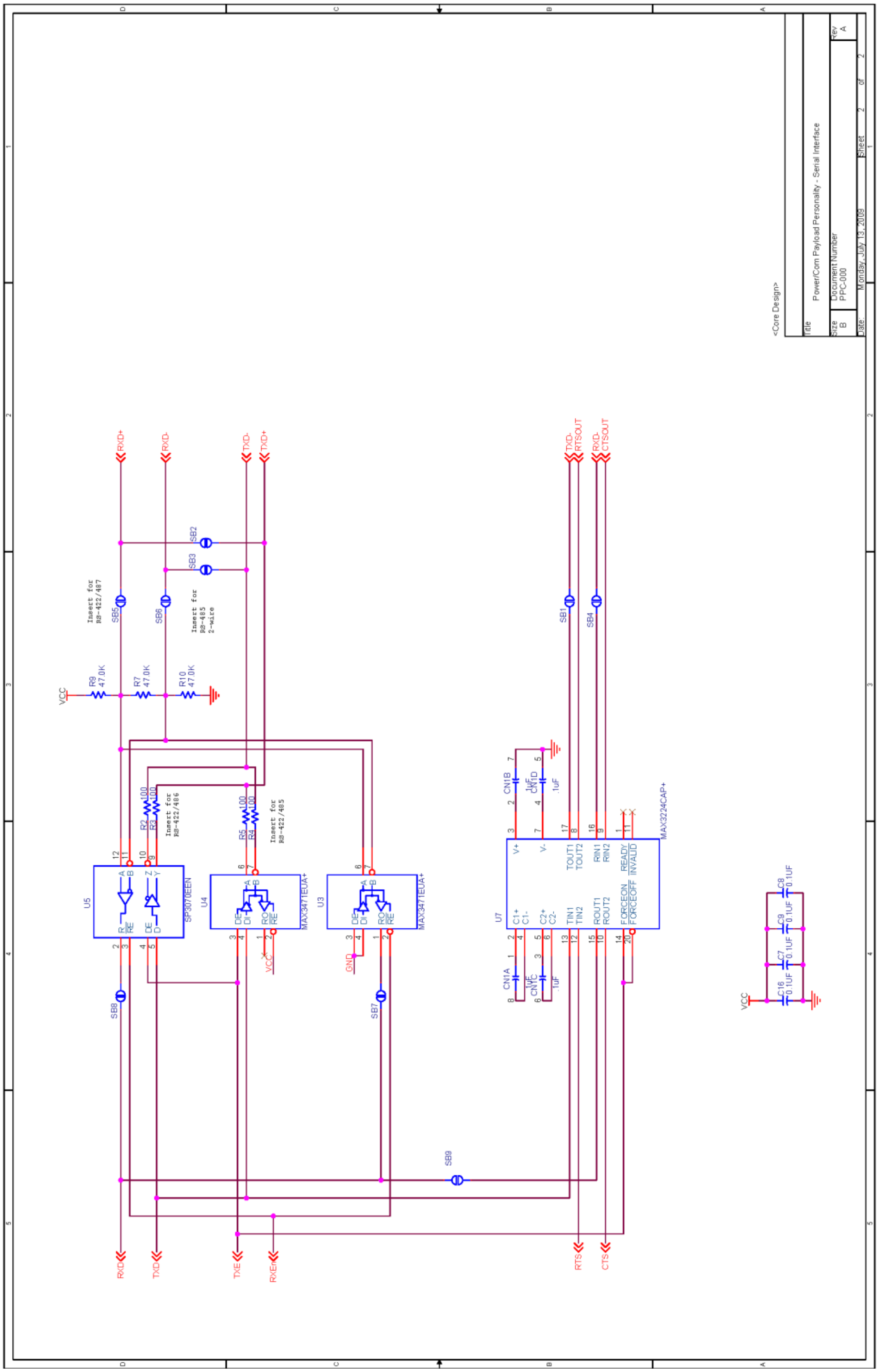


Figure 8-8: P/COM Schematic Page 2

Figure 8-9 shows the communications conversion detail from the schematic in Figure 8-8.

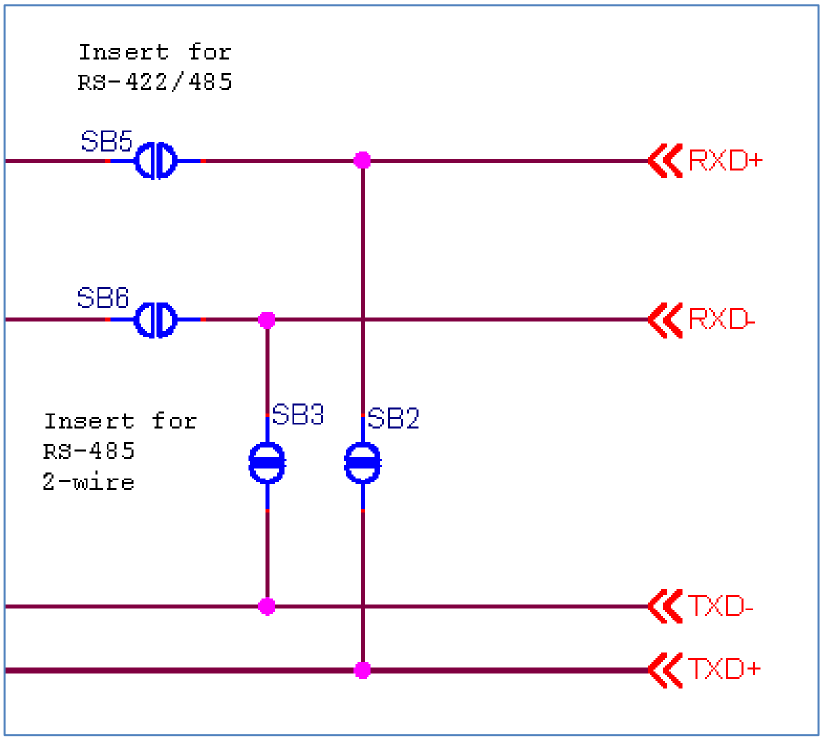


Figure 8-9: P/COM Comm Configuration Detail

See also the figures in section 4.2.3.