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MLM-1000 OEM System Reference Manual

RBR Ltd.

CHANGE HISTORY

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1 MLM-1000 System Functional Overview

1.1 INTRODUCTION

The MLM-1000 modem system enables subsurface marine instruments to communicate with a surface communications node while using a jacketed conductor (e.g. steel mooring line, wire) and the water as the transmission medium.

There are two distinct modem circuit cards – namely, the head-end modem (HEM) and the sub-surface modem (SSM). The HEM would be located on the surface, either on a buoy or in a shore mounted installation. It could be connected to a host computer or optionally be operating as an autonomous modem system controller. A remote installation would typically utilize a means of wireless communications to implement connectivity between the HEM/host computer and a control station. An RS232 link provides connectivity between the HEM and the host.

The SSMs are connected to the deployed marine instruments. They would typically be integrated into the instrument enclosure. Connectivity between the SSM and the instrument is via a serial communications link.

Both the HEM and SSM inductively couple the modem data communication signaling onto the jacketed conductor via toroidal transformers. Optionally, the HEM may also utilize a “direct connect” mode.

The physical layer of the communications link is half duplex, 4800 bit per second. The HEM always acts as the “master” in the system. In other words, the HEM always initiates communications with the target SSM(s).

The MLM-1000 implements a packetized communications protocol with CRC error detection over the transmission link.

A communication link between the HEM and target SSM(s) is established using simple ASCII commands. Once the link established, the SSM and HEM provide a transparent link between the host and the target instrument.

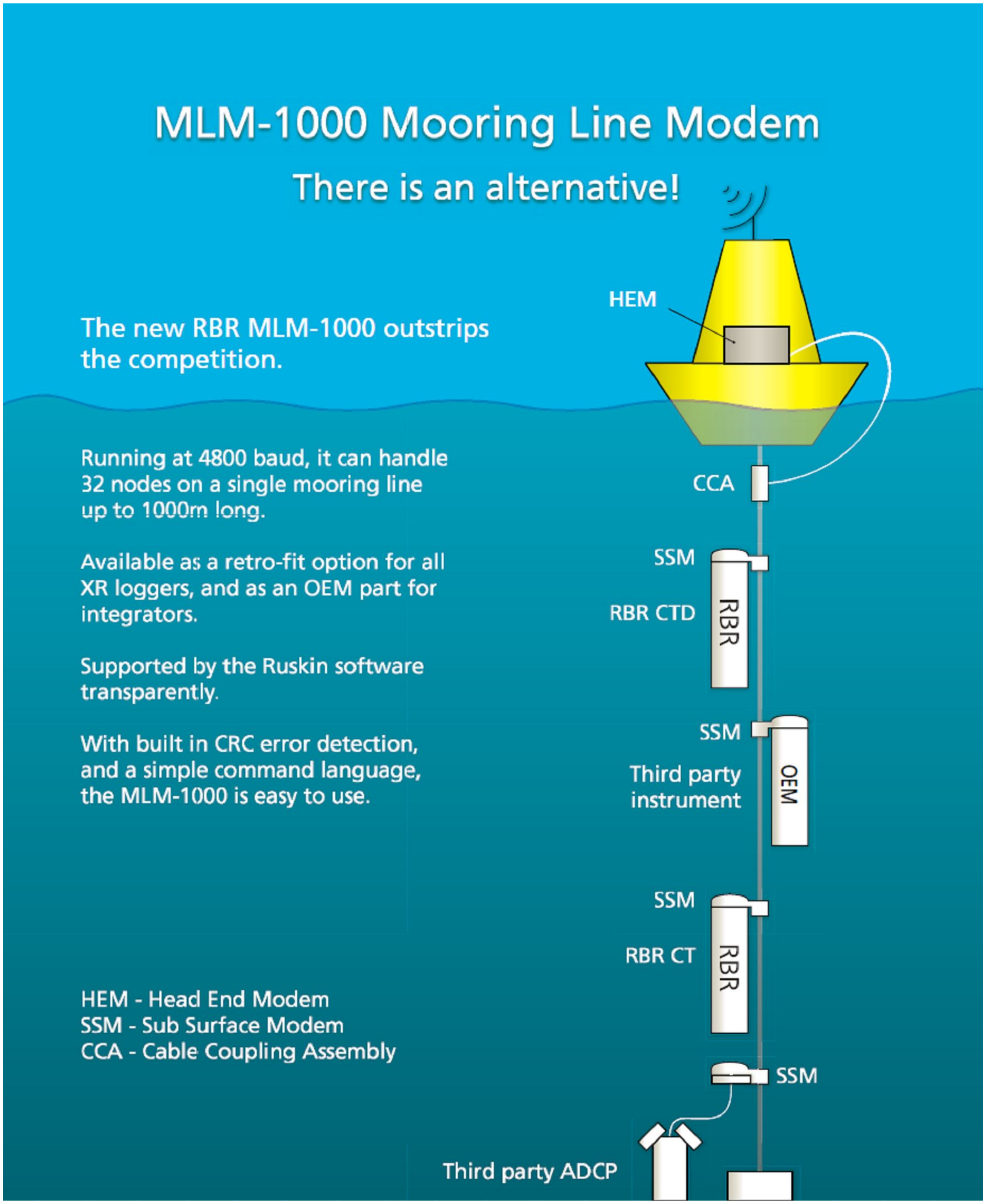

Figure 1 – MLM System Application Overview

2 Quickstart - MLM-1000 Development System

2.1 Connecting Power

A wall adapter is supplied with the MLM-1000 Development System. This universal adapter has an input voltage range of 100-240V AC 50/60Hz and an output of 12V DC.

Plug the output connector of the wall adapter into the power connector on the back panel of the development system box.

2.2 HEM Serial Port - Connecting To A Computer

Connect the 9 pin connector marked "HEM" (Front panel) to a computer using a standard serial.

The default baud rate for this link is 115200 bps

HEM Connector Pin Number	Signal
1	N/C
2	TX;(Data transmitted from Modem to DTE)
3	RX; (Data transmitted from DTE to Modem
4	N/C
5	Signal Reference/Ground
6	N/C
7	Request to Send (From DTE to Modem)
8	Clear to Send (Modem acks RTS back to DTE)
9	N/C

Table 1 – HEM Connector Pinout

2.3 SSM Serial Ports

The connectors for these ports are on the front panel and each is designated with the serial number of the associated SSM.
These ports are configured as "data terminal equipment". The default baud rate is 19200. These ports are normally connected to a subsurface instrument. The connector pinout is shown in the table below.
Note that if these ports are connected to a computer, a null modem cable is required.

SSM Connector Pin Number	Signal
1	N/C
2	RX; (Data transmitted from Instrument to Modem)
3	TX; (Data transmitted from Modem to Instrument)
4	N/C
5	Signal Reference/Ground
6	N/C
7	N/C
8	N/C
9	N/C

Table 2 – SSM Connector Pinout

2.4 USING THE DEVELOPMENT SYSTEM

After the power and serial port connections have been made, commands may be sent to the HEM using a computer and ASCII terminal emulation program (e.g. Realterm) .

Refer to the command reference document for a detailed description of system commands.

2.5 TRANSMITTING COMMANDS - GENERAL POINTS

When sending commands to either the HEM or SSM, it is necessary to include a terminating sequence of either the ASCII carriage-return and/or line-feed characters. Any response from the HEM or SSM will begin with a horizontal-tab, and be terminated by both the ASCII carriage-return and line-feed characters.

Command characters can be upper or lower case. Some commands require hexadecimal input (input characters denoted by X), others require decimal input (input characters denoted by D).

It is possible for the SSM to execute these commands remotely from the HEM over an established modem link. To send a command to the SSM using this method, prefix a '.' to the command in the command mode of the HEM. The response will be displayed on the HEM serial port beginning with a prefixed '.'.

Example:
```
.BV<cr><lf>
.<t>battery voltage: 10.2V<cr><lf>
```

If a link is not established or the modem is busy, the response will be:

`<t>*error* this is not allowed at this time<cr><lf>`

Multiple commands can be sent on a single line (terminated by either a **<cr>** or **<lf>**) by separating them with a semi colon. A limitation to this is that only 250 characters can be entered before a **<cr>** or **<lf>**, and only the first 250 bytes of the command responses will be output. All commands will be executed, however the command responses may be muted. This also applies to sending commands to the SSM from the HEM over an established modem link. Only commands marked with an asterix are capable in executing in this manner; those that aren't will display:

`<t>*error* this command is not allowed now<cr><lf>`

Example:

```
.A; BV; INFO<cr><lf>
.<t>RBR HEM-1000 1.000 051921<cr><lf>
<t>*error* this command is not allowed now<cr><lf>
<t>#051921, HEM-1000 HW rev. B1, FW rev. 1.000 (May 26,
2010)<cr><lf>
```

2.6 Formatting and Other Conventions

Commands to the logger are shown in **BOLD TYPE**.
Responses from the logger are shown in **BOLD TYPE**.
In cases where the actual information varies, a place holder is shown in ***italic type***.
The prefix 0x is used when describing numbers in hexadecimal (base-16) notation.

The following notation is used for some special, non-printing characters:

<cr> ASCII carriage-return: 13, 0x0D, or Ctrl-M.
<lf> ASCII line-feed: 10, 0x0A, or Ctrl-J.
<t> ASCII horizontal-tab: 9, 0x09, or Ctrl-I.

2.7 Error Messages

The generic response to an unrecognized command is:

`<t>*error* unknown command<cr><lf>`

The generic response to a recognized command with an invalid parameter is:

`<t>*error* invalid parameter<cr><lf>`

2.8 Example 1 - Sending "hello" string to SSM serial port:

Using the following default settings for the EEPROM parameters:

TPSNDC	0x0D	(`<cr>` prompts message)
TPSNDEN	1	(sending on character enabled)
TPESCC	0x01	(`<ctrl-A>` is the escape character)
TPESCCCNT	3	(count of escape characters required)

The steps required to do send the string are:

1. Open a connection with the desired SSM
2. Ensure the SSM serial port baud rate is configured correctly
3. Enter transparent mode
4. Send the string
5. Exit transparent mode
6. Close the channel

```
X 223344<cr>
      <t>channel requested (with ssm 223344)...GRANTED<cr><lf>
.EE BAUD 4800<cr>
      .<t>baud rate BAUD: 4800<cr><lf>
TP<cr>
      ***transparent mode***<cr><lf>
hello<cr>
<ctrl-A><ctrl-A><ctrl-A>
      ***command mode***<cr><lf>
X K<cr>
      <t>channel closed<cr><lf>
```

2.9 Example 2 - Getting battery voltages from all SSMs:

The steps required to do this are:

1. Perform discovery to discover all SSMs
2. Open a group connection with all SSMs
3. Open a secondary individual channel with a specific SSM
4. Request battery voltage
5. Open a secondary individual channel with a different SSM
6. Request battery voltage
7. Close the channel

```
DISC<cr>
      <t>discovery requested<cr><lf>
      <t>049509<cr><lf>
```

```
      <t>051959<cr><lf>
      <t>discovery complete OK<cr><lf>
X 00<cr>
      <t>channel requested (with group 00)...GRANTED<cr><lf>
XS 049509<cr>
      <t>channel switch requested (with ssm 049509)...GRANTED<cr><lf>
.BV<cr>
      .<t>battery voltage: 10.2V<cr><lf>
XS 051959<cr>
      <t>channel switch requested (with ssm 051959)...GRANTED<cr><lf>
.BV<cr>
      .<t>battery voltage: 10.6V<cr><lf>
X K<cr>
      <t>channel closed<cr><lf>
```

3 Inductive Modem Application Overview

3.1 Basic Operational Principles of Inductively Coupled Underwater Modems

3.1.1 Inductively Coupled Modem Operation

The modem system utilizes electric current induced in an electrical conductor loop to transmit information between system transmit/receive nodes of the network.

The conductor loop is comprised of the steel core of a jacketed mooring cable as well as the water. The ends of the steel cable are stripped of the insulating jacket and are thus in contact with the water. Between the stripped ends of the cable, the water provides a conduction path for electric current.
Each system node typically utilizes a toroidal transformer that is clamped around the mooring line. One may think of the toroidal transformer as an N:1 (1 being the mooring line) turns ratio transformer. The magnetic coupling between the toroid and the mooring cable is the medium by which information is transferred between the mooring cable and the particular system node.

3.1.2 MultiDrop Networks

A multidrop network refers to a number of instruments that share one transmission medium (i.e. each one is a "drop" from the shared medium). In the case of the mooring line modem system (MLMS), the hardware and data transmission protocols support one active connection between two network nodes at one time over the shared medium. Each instrument has a unique address and may transmit and receive data to/from the surface modem on a "one at a time" basis.

3.2 MLM-1000 System Elements

3.2.1 Overview

The MLMS elements comprise to form a data communications link between subsurface marine instruments and a surface modem (Typically connected to telemetry or a host computer). The physical layer transmission speed for this link is 4800 bps.
The transmission is half-duplex. This means that information is transmitted in only one direction at a time. The instruments are networked in a "multidrop" configuration. Only the surface modem may initiate a communication with a subsurface modem/instrument.

There are 3 main system elements that comprise the MLMS, namely:

- The Head-End Modem (HEM)
- The Cable Coupler Assembly (CCA)
- The Subsurface Modem (SSM)

Other key elements that comprise the full networked logger system include:

- The jacketed oceanographic steel mooring cable.
    - This is a signal transmission medium that is shared by all the instruments
    - In buoy oriented deployments, this cable may also serve as the mechanical element that secures the buoy in-place
- The anchor for the mooring line
    - In addition to the obvious mechanical function of mechanically securing the mooring line, the anchor element must provide the mechanism for the core of the mooring line to be exposed to the water (and thus make the electrical connection to the water from the cable)
- The mooring
    - For a buoy based system that utilizes the jacketed steel cable as a structural member, the mooring system must meet both the structural as well as electrical (for the modem system) performance requirements
- The host computer and communications link
    - The host computer is the one from which commands are sent to the HEM. This computer will also receive logger measurement data transmitted from a deployed logger to the host computer via the MLMS.
    - The communications link is the link between the host computer and the HEM.
        - In a local connection example, this is an RS232 serial link between the computer and the HEM
        - In a remote connection example, this is a satellite link that allows the host computer to intermittently connect to the HEM.

3.2.2 HEAD-END MODEM

Figure 2 depicts the connection points in/out of the Head-End Modem (HEM).

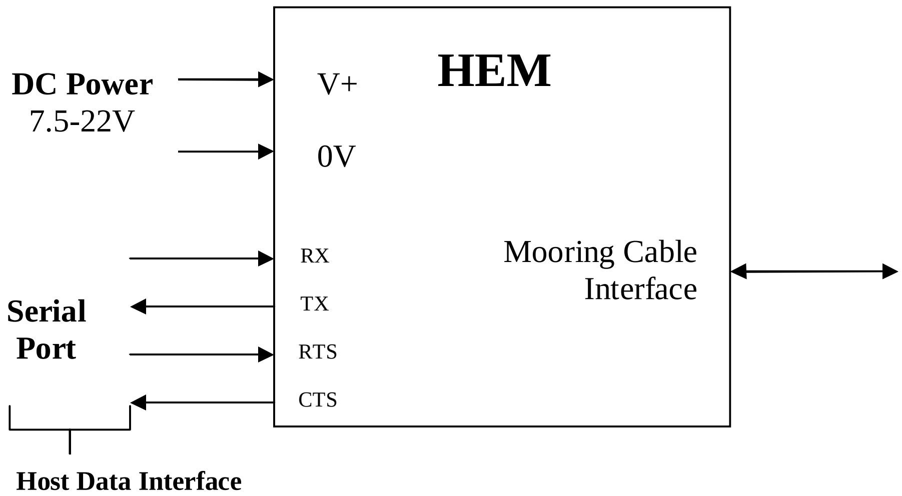

Figure 2 – HEM Input/Output Connections

The HEM is housed in an aluminum case.
There are 3 cables connecting to the unit, as depicted in figure 2.

- The power cable – provides the DC power source – nominally a 12V system
- The serial interface cable – connects to either
  - The host computer directly
  - The host computer via a telemetry modem
  - A data buoy controller

  The serial interface is an RS232 interface with transmission speeds up to 115200 bps. The HEM serial interface optionally supports hardware flow control.

- The interface to the mooring cable has two possible termination modes
  - In the first mode, the signals to/from the HEM are coupled to the mooring line via a toroidal transformer that clamps around the mooring line. (See Cable Coupling Assembly).
    - In this case, the cable that plugs into this connector is an undersea cable that goes from the HEM to the toroidal cable clamp. The toroidal cable clamp is located beneath the surface, but not very far from the buoy.
  - In the second mode, the cable that plugs into this connector splits into two leads. This is utilized in direct connect mode.

- The first is a "ground" connection that to the water
- The second is a direct metallic connection to the steel core of the mooring cable. This connection must be made with the core of the cable out of the water. The jacket must be present at the point where the cable enters the water.
- See direct connect mode

- The HEM can operate a in an autonomous controller mode. In this mode it polls and gathers data from the attached subsurface instruments as per a preprogrammed schedule.

3.2.3 Cable Coupling Assembly

As mentioned in the previous section, the cable coupling assembly (CCA) provides a means of securely locating a toroidal transformer around the mooring line and connecting it to the HEM.

3.2.4 Subsurface Modem

The subsurface modem physically connects to a subsurface instrument.

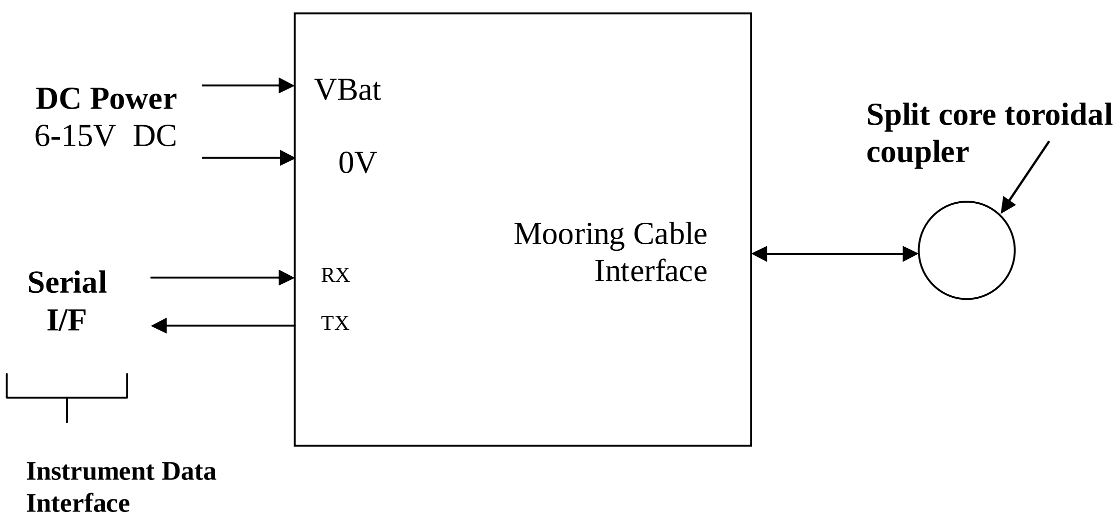

Figure 3 SSM Input/Output Connections

The serial interface hardware on the modem is compatible with RS232, but it is not a full RS232 interface. The serial RX line on the SSM is an RS232 receiver. The serial TX line on the SSM is a 3V logic signal. This is compatible with the RS232 interface chip on the logger and virtually RS232 interface chips.

The maximum baud rate for the serial link between the modem and the logger is currently limited 19200. The default setting is 19200 bps.

The split core toroidal transformer is part of the SSM and functions to inductively couple the signals to/from the SSM onto the steel mooring cable.

3.3 TYPICAL DEPLOYMENT CONFIGURATIONS

3.3.1 TOROID TO TOROID CONFIGURATION

Figure 4 shows the configuration using a toroid at the head end to couple signals to the mooring line. The water forms an electrical return path for current induced in the mooring line – the mooring cable has the jacket removed at both ends – this is where the "electrical connection" from the mooring cable to the water happens.
One may think of the water as "short circuiting" the unjacketed ends of the mooring cable.

The design of the mooring itself forms an integral part of the MLM system. The scope of in the discussion of the mooring and the MLM include:

- whether it is a single point more multipoint mooring
- whether there is a swivel near the buoy or at the anchor; how electrical continuity is maintained if necessary….and where the CCA is located
- perforations in the jacket due to wear, fish bites etc are effectively "resistive" short circuits.

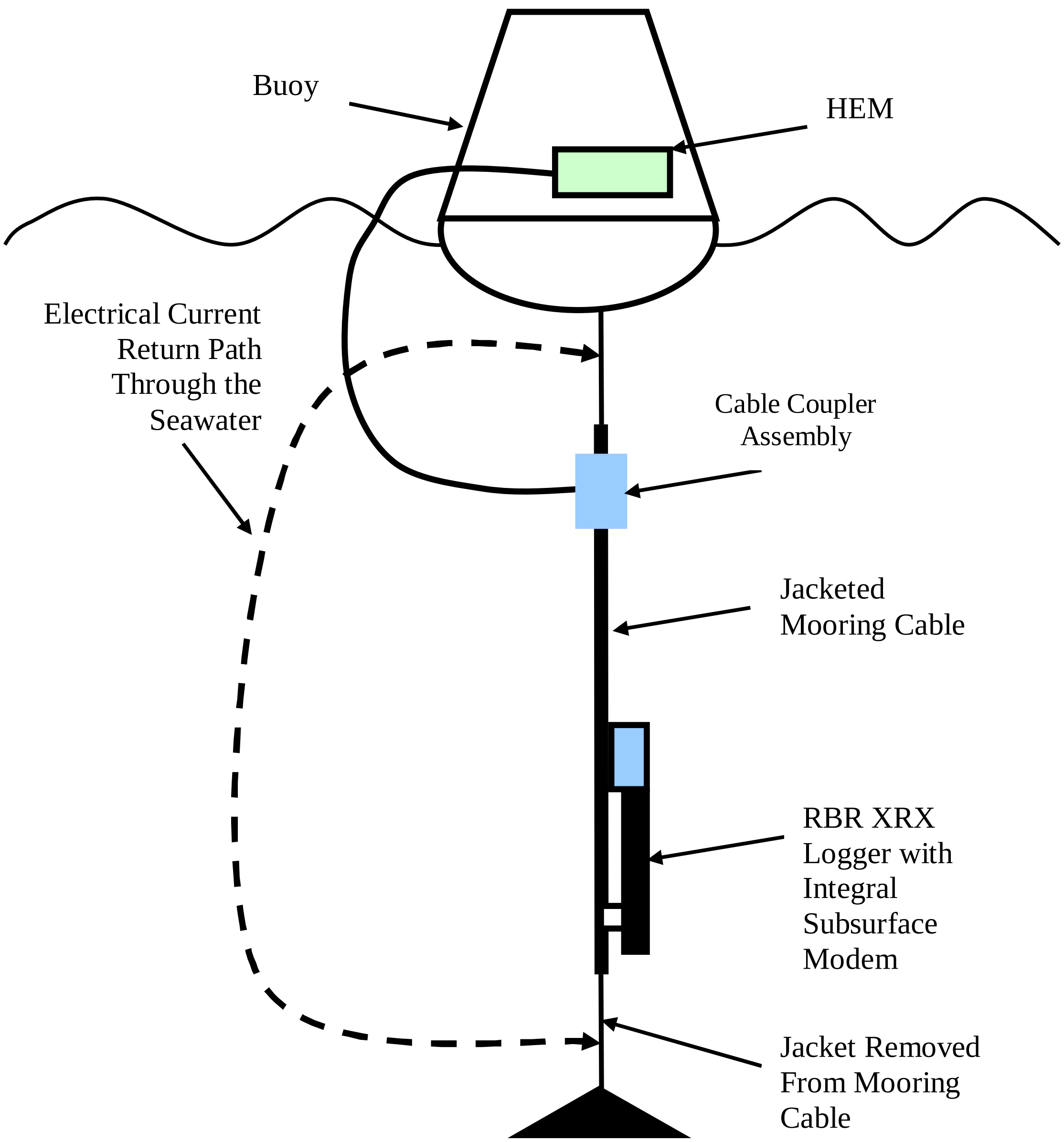

Figure 4 Toroid to Toroid Configuration

3.3.2 DIRECT CONNECT CONFIGURATION

Figures 5 and 6 depict “direct connect” configurations. In direct connect mode, the HEM has a metallic connection to the wire rope core of the mooring cable. This connection is made out of the water.
In this case, the second terminal of the HEM’s mooring line connector must electrically be connected to the water. This connection provides the electrical return path for the signal current that is induced in the mooring line by modems.
The advantage of direct connect mode is that one can achieve much longer deployment loops for a given diameter of mooring cable.

In the land based HEM example (Figure 5), a computer executing host software could be directly connected to the HEM.

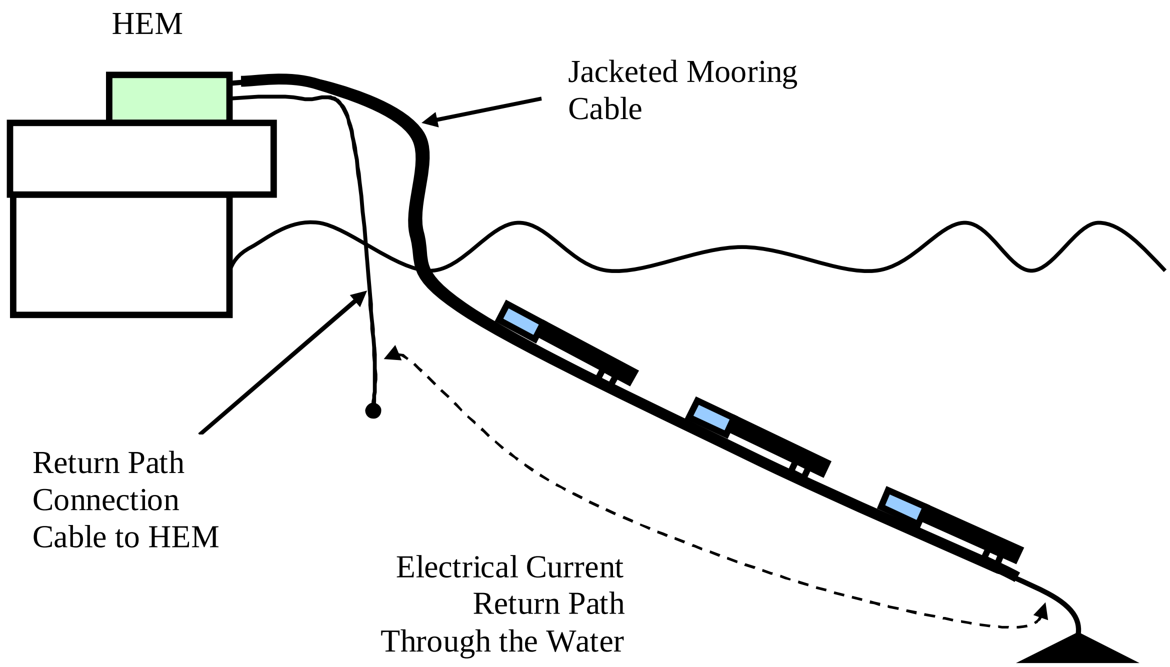

Figure 5 –Direct Connect Configuration with Land Based HEM

A direct connect configuration may also be employed from a buoy based HEM. In this case, the mooring cable must exit the water with the core still insulated from the seawater by the jacket. It may be that in some buoy based direct connect configurations, the mooring cable does not have a structural function but only serves as a transmission medium for modem signaling.

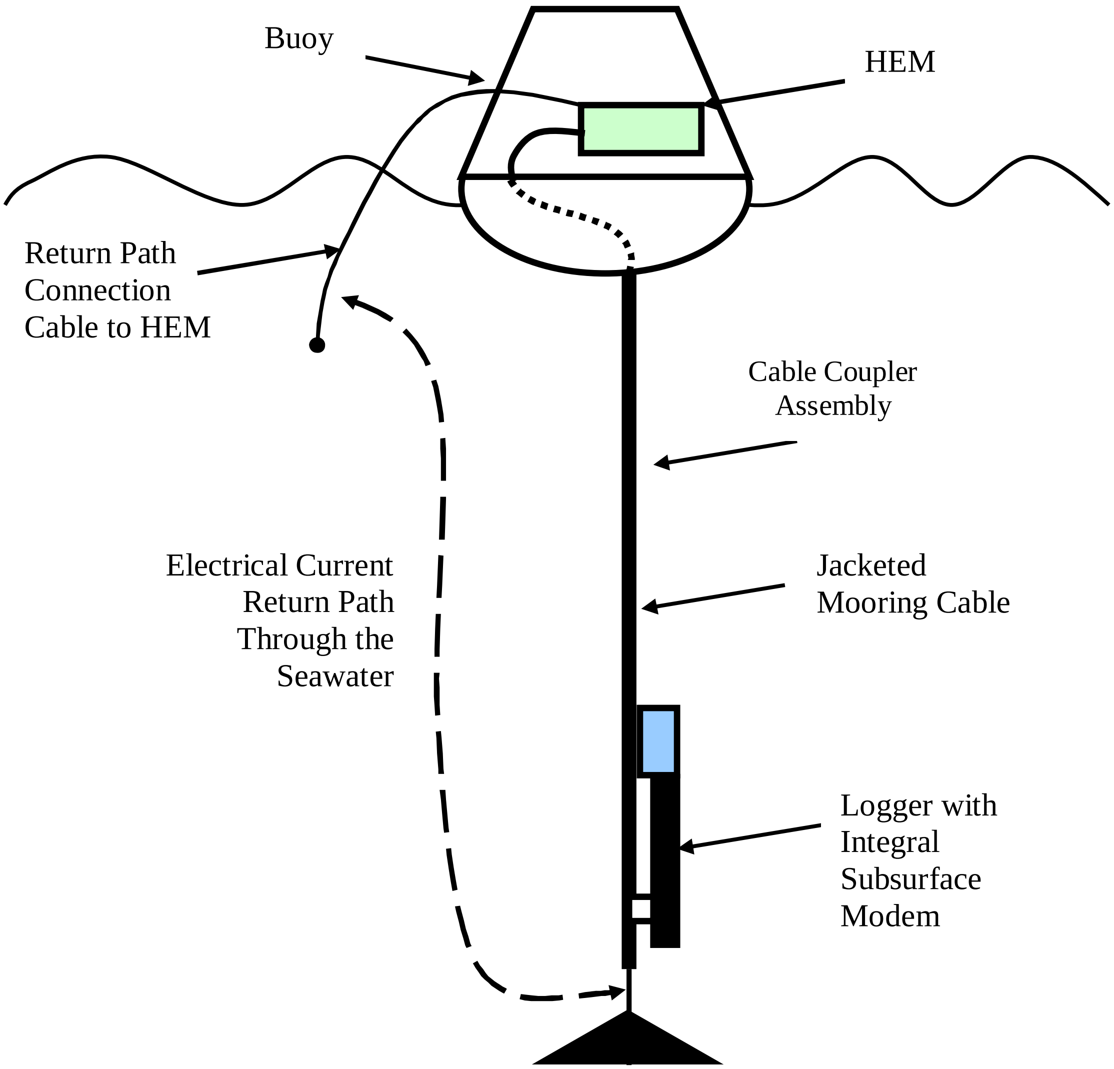

Figure 6 –Buoy Based Direct Connect Configuration

4 MLM-1000 Functional Operation

4.1 Modem Modes

The modems (HEM and SSM) operate in either of two global states – command mode and transparent mode.

4.1.1 Command Mode

This mode is used to send commands to the central processor on either the HEM or SSM. For example, it is most commonly used on the HEM to initiate connections with SSMs in the system. It is also used for configuration and diagnostic purposes. For the complete list of commands, refer to the document **"OEM Command Reference for Mooring Line Modem System".**

Commands are sent to an HEM via the serial port.
Commands to an SSM are sent one of two ways – either via the serial port or from a host via the HEM (serial port and inductive modem link).

4.1.2 Transparent Mode

In transparent mode, the HEM and SSM form a transparent link between the serial port on the HEM and the serial port on an SSM. In other words, all the data that is input on one serial port is appears as output data at the other node.
A transparent mode link results in a deployed, subsurface instrument appear as if the instrument is attached directly to the host.

A modem (i.e. either an HEM or SSM) always enters transparent mode from command mode. Similarly, when a modem exits transparent mode, it reverts to command mode.

Refer to command: **TP**

4.2 System Addressing

As the MLM-1000 is a multidrop architecture over a shared transmission medium, an addressing scheme is required to access targeted SSM(s)/instrument(s).
On power-up when connected to an RBR instrument, the SSM will automatically acquire the serial number of the RBR instrument. From that point on, the SSM will respond when addressed by either its serial number or the serial number of the RBR instrument.
In an OEM implementation, each SSM would be characterized by a unique address that is the SSM unit's manufacturing serial number.

Furthermore, each SSM may optionally be assigned up to three group identification addresses. A group address enables all the SSMs with the same group address to be awakened by the HEM.

Refer to commands: **GID1; GID2; GID3**

4.2.1 AUTOMATED SYSTEM AND ADDRESS DISCOVERY

The HEM can execute a command that results in an automated discovery of all the serial numbers of the deployed subsurface instruments. This command causes the HEM to query all the SSMs in the system and identify each SSM's serial number. If the SSM is connected to an RBR logger, the discovery process for that node will return the logger serial. The HEM will store the list of serial numbers of these SSMs.

Refer to commands: **DISC; SSM**

4.3 ESTABLISHING A CONNECTION BETWEEN THE HEM AND SSMS WITH A HOST

In the idle state, the HEM and all SSMs are in their respective sleep modes. For an HEM to exit sleep mode, a character must be transmitted over the serial link or the request-to-send (RTS) signal must be asserted if hardware flow control is utilized on the HEM serial port.

Once the HEM is awake, it will be directed by the host to make a connection with an SSM or group of SSMs.

The first part of the connection phase is the seize cycle. Once all the targeted SSM are seized (i.e. awakened) and a channel opened, all modems (HEM and SSMs that are awake) be in command mode with the option to enter transparent mode.

Refer to commands: **X; X K; X S; X?;**

4.4 SEIZE CYCLE

In the idle state, the SSMs and the HEM would be in a power saving sleep mode that is characterized by minimal battery drain.
Typically, the HEM would be "awakened" by activity on the serial port and be commanded to make a connection with an SSM or a group of SSMs.
When creating a link with an SSM, the HEM and target SSM implement a seize and handshaking cycle.
The seize cycle awakens all the SSMs on the line and then sends a message which contains addressing information. This will either result in –

- a one way link being established from the HEM to all SSMs (with no response from the SSMs)
- a link established with one targeted SSM/instrument and all the other SSMs reverting to the sleep state
- a link established with all the instruments that share a targeted group ID address. In this mode, all the SSMs in the group stay awake and the HEM can rapidly poll all the instruments associated with the SSMs in the group

4.4.1.1 Opening a Channel

In the context of the MLM-1000, opening a channel happens whenever the HEM creates a one-way or a two-way link with an SSM or group of SSMs.

The group connection provides a good illustration of the process of opening and closing channels. In this case, the HEM would initially wake up all the SSMs in a group, and open a one-way channel (HEM to SSMs) with the group. At this point in time, the HEM has the option of opening a two-way channel with a specific SSM in the group. If opened, that channel would subsequently be closed and a channel with another SSM in the group would be opened. This could continue until the group channel is closed and all the SSMs go back to sleep mode.
This examples illustrates how the HEM can access a number of SSMs without having to execute the seize cycle each time.

4.4.1.2 Entering and Exiting Transparent Mode

Once a channel has been opened (The HEM and SSM(s) are in command mode), entering transparent mode is accomplished by issuing a command to the HEM.

While in transparent mode, the HEM monitors the data traffic for an escape sequence (The default escape sequence is “<ctrl a > <ctrl a > <ctrl a >”, but is configurable). When the escape sequence is recognized, the modems revert back to command mode.

Refer to command: **TP; TPESCC; TPESCCCNT**

4.4.2 CLOSING A CHANNEL

Closing a channel is accomplished by issuing a command to the HEM that tears down the connection.

A channel would also close if the channel timeout is exceeded. The channel timeout is the amount of time the channel can remain idle (i.e. no traffic) before it is automatically closed by the HEM.

Refer to command: **X K; MDOCDUR**

4.5 HEM TO SSM LINK TYPES

4.5.1 GROUP CONNECTION

Group Connection can be utilized to send a synchronous broadcast message from the HEM to the SSMs and/or to rapidly poll the instruments (That are attached to the SSMs). In the case where it is desired that group of instruments be polled in rapid succession, it is likely that group access mode is the most efficient (Time and battery energy) means of performing this task.

In the group connection mode, the HEM would be awakened by activity on the serial port and be sent a command to connect to a specific group of SSMs. This group could be all or any subset of the SSMs in the system. The HEM would initiate the seize sequence and open a one-way channel connection with the target SSMs (i.e. HEM to all SSMs). The SSMs would all be “awake” and able to receive messages targeted to the specific group from the HEM. At this stage, if the modems are commanded to enter transparent mode, a broadcast message would be transparently passed to the instruments connected to the SSMs. If the “transparent” command is not sent, the broadcast message will be received by all the SSMs.

The synchronous broadcast is a one way message that elicits no response from the SSMs.

For polling during a group connection, the HEM would be commanded to open a channel (establish a two way link) with a specific SSM in the group. During the time that this link is established, all the remaining SSMs in the group remain awake and are monitoring messages over the shared transmission medium. Once the channel between the HEM and the SSM is opened and the transparent command transmitted from the host to the HEM, the host will be transparently connected to the instrument associated with the target SSM. Once the host has completed the communication with the instrument, the HEM can be commanded to immediately establish a link with another SSM in the group (See the Channel Switch command in the OEM command reference). Thus the host (Via the HEM) can rapidly poll through all the SSMs in the group without having to initiate the seize cycle.

This mode is optimal for gathering data from a group of instruments in rapid succession.

Refer to commands: **X; X S; X K; X?**

4.5.2 One-to-One Link

In the idle system state, the HEM and all the SSMs are in "sleep mode".
The HEM would be awakened by activity on the serial port and be sent a command to connect to a specific SSM. The HEM would initiate the seize sequence; establish the connection (i.e. open a channel) with the target SSM. The HEM will report back to the host that the connection has been established. All the other SSMs revert back to sleep mode and remain in sleep for the duration of the one-to-one link. At this point the host sends the HEM a command to put the system in "pass-through" mode. This creates a transparent link between the serial port on the SSM and the serial port on the HEM. The host would then be able to communicate directly with the subsurface instrument that is attached to the SSM.

The HEM continues to monitor the contents of the messages it receives from the host on the serial port. If the escape sequence is detected, the system exits pass-though mode and re-enters command mode. The HEM will tear down the connection if the appropriate command is sent from the host.

This mode is best utilized when instruments have unique data gathering regimes.

Refer to commands: **X; X K**

4.6 Polling Mode

The HEM has the capability to autonomously poll, collect and transmit data from the instruments attached to the system. The minimum and maximum polling intervals are 5 minutes and 65535 minutes respectively, programmable in 1 minute increments.

For attached RBR XR loggers, the HEM will wake up all the SSMs and instruments in the modem system according to the programmed polling interval. All the instruments are synchronously commanded to take a sample with all sensors. The results of this sample are stored in the SSM serial transmit buffer. The HEM subsequently retrieves the stored sample data from each SSM, aggregates it and sends it on to a host (e.g. via a satellite modem).

Refer to commands: **PEN; PINT; PNOW; T**

4.7 PACKET PROTOCOL OVERVIEW

Communications between the HEM and SSM(s) is done utilizing a packet based protocol. The maximum payload size 1024 bytes. The protocol's robustness is enhanced via

- CRC error detection
- Optional intermodem ACK/NACK handshaking protocol
- Optional handshaking protocol between SSM and the instrument and/or HEM and host
- Programmable number of retries when a failed transmission is registered

4.7.1 CRC ERROR DETECTION

Every packetized transmission between the modems is transmitted with associated CRC information. The receiving modem calculates a CRC based on the received transmission and compares it with the CRC that has been transmitted from the other modem. If the CRCs match, the receiving modem will process the packet transmission. If the CRCs do not match there will be no packet processing performed by the receiving modem.

4.7.2 "ACK" PROTOCOL

The user may optionally select to employ the acknowledgement or "ACK" handshaking protocol. This mode applies only when a link has been established by the two modems in transparent mode.

There are two levels of "ACK" and each one may optionally be selected.

4.7.2.1 "ACK" Between SSM and HEM

If the option to utilize "ACK" between the SSM and the HEM has been selected, the transmitting modem will expect to see a handshaking response from the receiving modem after it has transmitted the data over the mooring line link. If it does not receive the "ACK" response, it will conclude that the message was not successfully transmitted. Furthermore, if the option of the re-try protocol has been selected, the transmitting modem will retransmit the message until it does receive the "ACK" from the receiving modem or until it has retransmitted the message the maximum number of times as set by the system configuration.

Refer to command: **TPACK; MDRTRY**

4.7.2.2 ACK Between Modems and Serially Attached Devices

4.7.2.2.1 "ACK" Between SSM and Instrument

If the option to utilize "ACK" between the SSM and the instrument over the serial line has been selected, the SSM will send the "ACK" character string (<ACK> or <NAK>)

over the serial interface back to the instrument when it believes it has successfully transmitted the data in the transmit buffer.
If the "ACK" protocol between SSM and HEM has also been selected, the SSM will transmit "ACK" back to the instrument only after the buffer contents have been transmitted AND it has successfully received "ACK" from the HEM.
If the "ACK" protocol between the SSM and HEM has NOT been selected, the SSM will transmit "ACK" to the instrument when it has transmitted the contents of the buffer.

Refer to commands: **TPACKDSP; TNAKDSP**

4.7.2.2.2 "ACK" Between HEM and Host

If the option to utilize "ACK" between the HEM and the host over the serial line has been selected, the HEM will send the "ACK" character string (<ACK> or <NAK>) over the serial interface back to the instrument when it believes it has successfully transmitted the data in the transmit buffer.
If the "ACK" protocol between HEM and SSM has also been selected, the HEM will transmit "ACK" back to the host only after the buffer have been transmitted AND it has successfully received "ACK" from the SSM.
If the "ACK" protocol between the HEM and SSM has NOT been selected, the HEM will transmit "ACK" to the instrument when it has transmitted the contents of the buffer.

Refer to commands: **TPACKDSP; TNAKDSP**

4.7.3 SERIAL COMMUNICATIONS BUFFERS

Given that the modem data rate over the shared medium is 4800 bps and that this could differ from the rate on the serial interface, buffering of data is performed by the modems in the system.

4.7.3.1 Transmit Buffering

When data is transmitted from either the HEM or SSM over the serial link, the modems store the data in a transmit buffer. The maximum number of bytes that the transmit buffer can hold is 1024. There are 3 possible ways for the SSM to start transmitting the data held in the buffer

- when a specifically designated (configurable) "send" character is received from the instrument (e.g. a carriage return)
- after a timeout period (configurable). E.g. if the timeout is set for 1 second, then the transmit buffer will start to be emptied 1 second after the last character was received from the instrument.
- after the number of bytes stored in the buffer crosses a (configurable) threshold. E.g. if the threshold is set for 512 bytes, once the buffer has received 512 bytes, it

will start transmitting the data in the buffer.
The default value for this parameter is 1024.

Once the HEM or SSM starts transmitting the data over the mooring line link, refrain from entering any more characters until the SSM has completed transmission (All characters sent or ACK has been received).

Refer to commands: **TPMXC; TPSNDC; TPSNDON; TPSNDC2; TPCTO;**

4.7.3.2 Receive Buffering

When data is transmitted from the one modem to another, the maximum payload size is determined by the size of the receive buffer – 1024 bytes.
When the modem is receiving a message over the mooring line medium, it will continue to fill the receive buffer until it has successfully received the message (i.e. successful end of message and CRC error check). Once it has successfully received the message, it will transmit the data over the serial link to the instrument. After it has completed transmitting, the HEM will be available to receive the next message.

5 MLM-1000 Development System

5.1 Development System Overview

The MLM-1000 Development System (MDS) provides a platform that enables OEM users to develop interface software. Utilizing the development system facilitates integration of MLM-1000 technology with an OEM host as well as subsurface instruments.

Three system components comprise the key elements of the MDS. The unit is comprised of two sub-surface modems (SSM) and one head-end modem (HEM). Each modem provides a serial data connection link which is accessible via the (three) DB-9 connectors on the front panel (One connector for each modem). Inside the unit, a simple transmission line that emulates a jacketed mooring line and seawater connection provides the transmission medium between the modems. Each modem may transmit and receive data on the emulated transmission medium via inductive coupling.

5.2 How To Connect The MLM-1000 Development System

5.2.1 Power

5.2.1.1 12V Power

The unit is powered by the 12V DC output wall adapter shipped with the system. The supplied wall adapter connects to the power connector on the back (beige coloured) panel of the unit.
An LED on the front panel illuminates when system power has been applied to the unit.

5.2.1.2 Power Supply Other Than 12V

5.2.1.2.1 Common External Supply

Should it be desirable to power the unit from a voltage supply other than the 12V adapter supplied with the unit, (e.g. utilizing the supply of the underwater instrument), the user may use a different external supply voltage.
The power connector is a 2.5mm I.D. X 5.5mm O.D. barrel type power connector.
Note that the center conductor is the NEGATIVE supply rail.

5.2.1.2.2 Individual Voltage Supplies to Each Circuit Card

A second option involves opening the unit to access the four position barrier block on the inside of the back panel. The power connection to each circuit board may be accessed individually. This access affords the user the flexibility to alter the input voltage as well as measure the unit’s current consumption.

Figure 7 depicts the barrier blocks as seen from the inside of the rear panel once the top cover has been removed (Remove four screws holding the top cover in place).

The removable jumpers are the point of access if operational current measurements or alternate supply voltages are desired.

5.2.1.3 Current Measurements

It should be noted that current measurements during data transmission taken in the development system will be somewhat lower than an actual deployed MLM-1000 system.

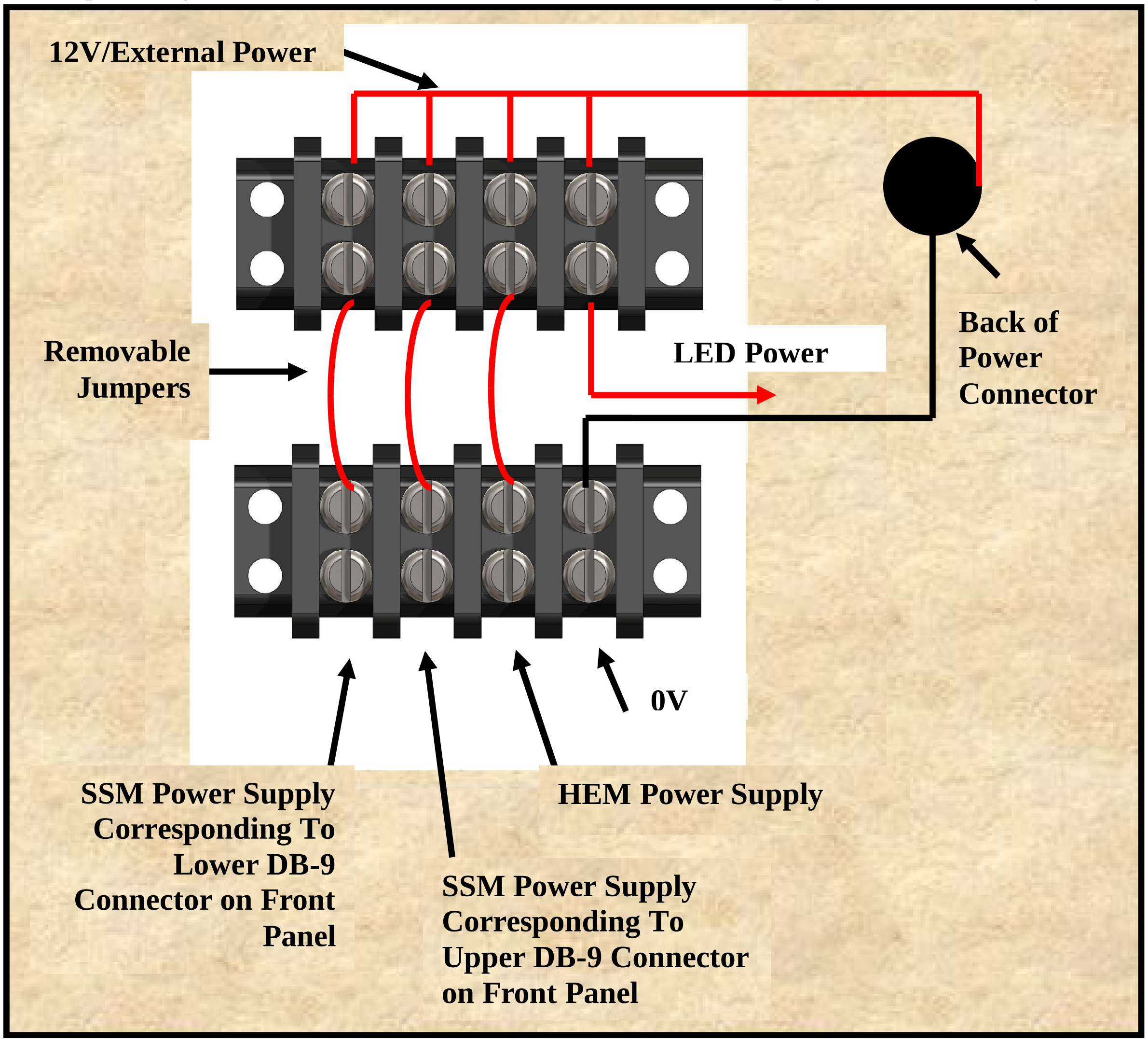

Figure 7 – Barrier Blocks on the Inside of the Development System

5.2.2 SERIAL CONNECTION TO THE HEAD-END MODEM

5.2.2.1 Connector Pinout

The head-end modem's serial port is accessible via the female 9 pin D-shell on the front panel. This serial interface connector is configured so that a serial port of a computer (Or any other DTE) may be directly connected to the HEM connector with a standard serial cable. (The HEM connector is configured as a DCE).

The HEM optionally supports the RS232 hardware flow control signals of DTR and CTS.

HEM Connector Pin Number	Signal
1	N/C
2	TX;(Data transmitted from Modem to DTE)
3	RX; (Data transmitted from DTE to Modem
4	N/C
5	Signal Reference/Ground
6	N/C
7	Request to Send (From DTE to Modem)
8	Clear to Send (Modem acks RTS back to DTE)
9	N/C

5.2.2.2 Interface Electrical Specification

The HEM electrical interface is fully compliant with RS232 signaling levels.

5.2.2.3 Baud Rate

The default (and maximum) baud rate for the HEM serial interface is 115200 bps. The supported baud rates are: 300; 1200; 2400; 4800; 9600; 19200; 38400, 57600, 115200.

5.2.3 SERIAL CONNECTION TO THE SUBSURFACE MODEMS

5.2.3.1 Connector Pinout

Each subsurface modem's serial port is accessible via a male 9 pin D-shell connector on the front panel. The serial connection for each SSM is configured as a DTE (Opposite polarity of RX/TX to the HEM). E.g. they may be connected directly to an RBR instrument via the standard RBR DB-9 to RJ11 cable.

The SSMs do not support hardware flow control and thus do not have any pins reserved for that purpose.

SSM Connector Pin Number	Signal
1	N/C
2	RX; (Data transmitted from Instrument to Modem)
3	TX; (Data transmitted from Modem to Instrument)
4	N/C
5	Signal Reference/Ground
6	N/C
7	N/C
8	N/C
9	N/C

5.2.3.2 Interface Electrical Specification

The serial RX (Pin 2 of the DB 9 connector) signal is fully compliant with RS232 electrical specifications.
The serial TX line is a logic-level inverted representation of the UART output (Same logic sense as an RS232 implementation). However, the signal is a 0-3V swing digital signal.

5.2.3.3 Baud Rates

The default baud rate for the SSM serial interface is 19200. The supported baud rates are 300; 1200; 2400; 4800; 9600; 19200.

In the Command Reference document, refer to command: **BAUD**

6 SSM Specifications

6.1 External Connections to the SSM

6.1.1 Serial Port/Power

Connection to the SSM is via a 4 pin connector (Designated J3 on the SSM circuit card). The four signals are:

- J3-1 - DC battery supply
- J3-2 - Serial port transmit line
- J3-3 - Serial port receive line
- J3-4 - 0V power reference/serial port ground

6.1.2 Mooring/Transmission Line Connection

The split core toroidal transformer that couples the modem output to the mooring line is connected to the two pins of J1.

6.2 DC Power Supply

The DC power supply voltage range for the SSM is 6-15V.

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Typical current consumption figures for the SSM (All at 12V supply):

SSM State	Typical Consumption
Sleep Current	35µA
Receive Mode	900µA
Transmit Mode (Data onto the mooring line)	4.4mA

6.2.1 Battery Voltage Monitor

The SSM provides a monitor that can be used to report the battery voltage without having to wake the target instrument.

Refer to command: **BV**

6.3 Serial Interface

6.3.1 Electrical Interface

The serial port on the SSM consists of two signal lines – one transmit and one receive line. The receive line is fully compliant with RS232 signaling levels and is enabled at all times. The transmit line provides an output signal with 0-3V level swing. This is compatible with the receive circuitry of virtually all commercial RS232 components.

6.3.2 BAUD RATES

The default baud rate for the SSM serial interface is 19200. The supported baud rates are 300; 1200; 2400; 4800; 9600; 19200.

6.4 PHYSICAL SPECIFICATIONS

Operating Temperature Range: -10°C to 50°C

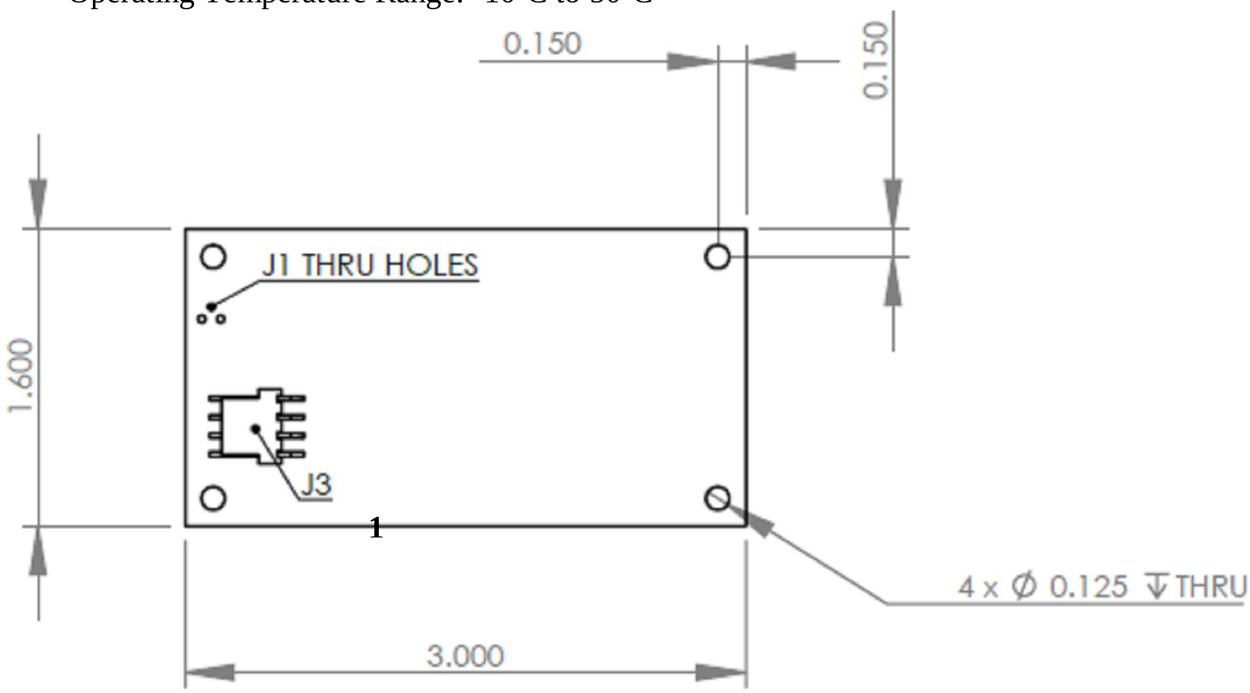

Figure 8 - SSM Circuit Board Dimensions (Inches)

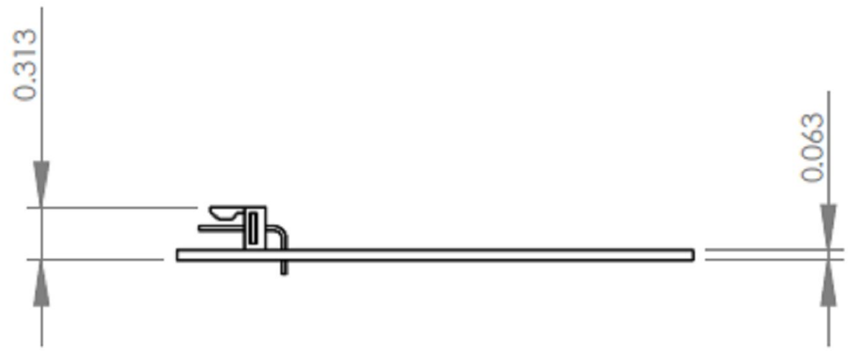

Figure 9 - SSM Circuit Board Dimensions (Inches)

7 HEM Specifications

7.1 External Connections to the HEM

7.1.1 Power Connections

The 4 pin connector J1 provides the power input to the HEM.
J1-1 – DC Power
J1-2 – DC Power
J1-3 – 0V Reference
J1-4 – 0V Reference

7.1.2 Serial Interface

The 6 pin connector J2 provides the serial interface to the HEM
J2-1 – Serial Port Transmit Line
J2-2 – Serial Port “Clear to Send”
J2-3 – Serial Port Receive Line
J2-4 – Serial Port Request to Send
J2-5 – 0V Reference
J2-6 – 0V Reference

7.1.3 Mooring/Transmission Line Connection

The 5 pin connector J4 provides the connections to interface the HEM either to a split core toroidal inductive coupler to the line or to establish a metallic connection with the mooring line.
J4-1 – Direct Connect +
J4-2 – Direct Connect -
J4-3 – N/C
J4-4 – Toroidal Coupler+
J4-5 – Toroidal Coupler-

7.2 DC Power Supply

The DC power supply voltage range for the HEM is 7.5-22V.

Typical current consumption figures for the SSM (All at 12V supply):

HEM State	Typical Consumption
Sleep	50µA
Receive Mode	4.2mA
Transmit Mode (Data onto the mooring line)	6mA

7.2.1 Battery Voltage Monitor

The HEM provides a monitor that can be used to report the battery voltage without having to wake the target instrument.

Refer to command: **BV**

7.3 Configuration Jumpers

There are two shorting jumpers on the HEM PCB. For countries where the power grid operates at 50Hz, remove the jumpers. For 60Hz countries, ensure that the jumpers are installed.

7.4 Serial Interface

7.4.1 Electrical Interface

The serial port on the HEM consists of two signal lines – one transmit and one receive as well as two hardware handshaking lines – Request to Send (RTS - Originating at the host connected to the HEM) and the Clear to Send (CTS – Originating from the HEM). The handshaking lines may optionally be utilized if desired.

All four lines are fully compliant with RS232 signal levels.

Refer to command: **HWF**

7.4.2 Baud Rates

The default (and maximum) baud rate for the HEM serial interface is 115200 bps. The supported baud rates are: 300; 1200; 2400; 4800; 9600; 19200; 38400, 57600, 115200.

7.5 Connection To the Mooring Line

7.5.1 Toroid To Toroid

The HEM is most commonly coupled to the mooring line via a split core toroidal transformer. The system reach of 1000m is readily achievable utilizing toroids at both the HEM and SSM ends of the system.

7.5.2 Direct Connect Mode

In some applications, it may be desirable to utilize the direct connect mode of the HEM. This mode enables a larger signal to be injected onto the mooring line resulting in longer system reach. In direct connect mode, an optional PCB mounted transformer is mounted on the HEM PCB. The transformer is connected between the core of the mooring line and the seawater return path.

7.6 Physical Specifications

Operating Temperature Range: -30^{o}C to 60^{o}C

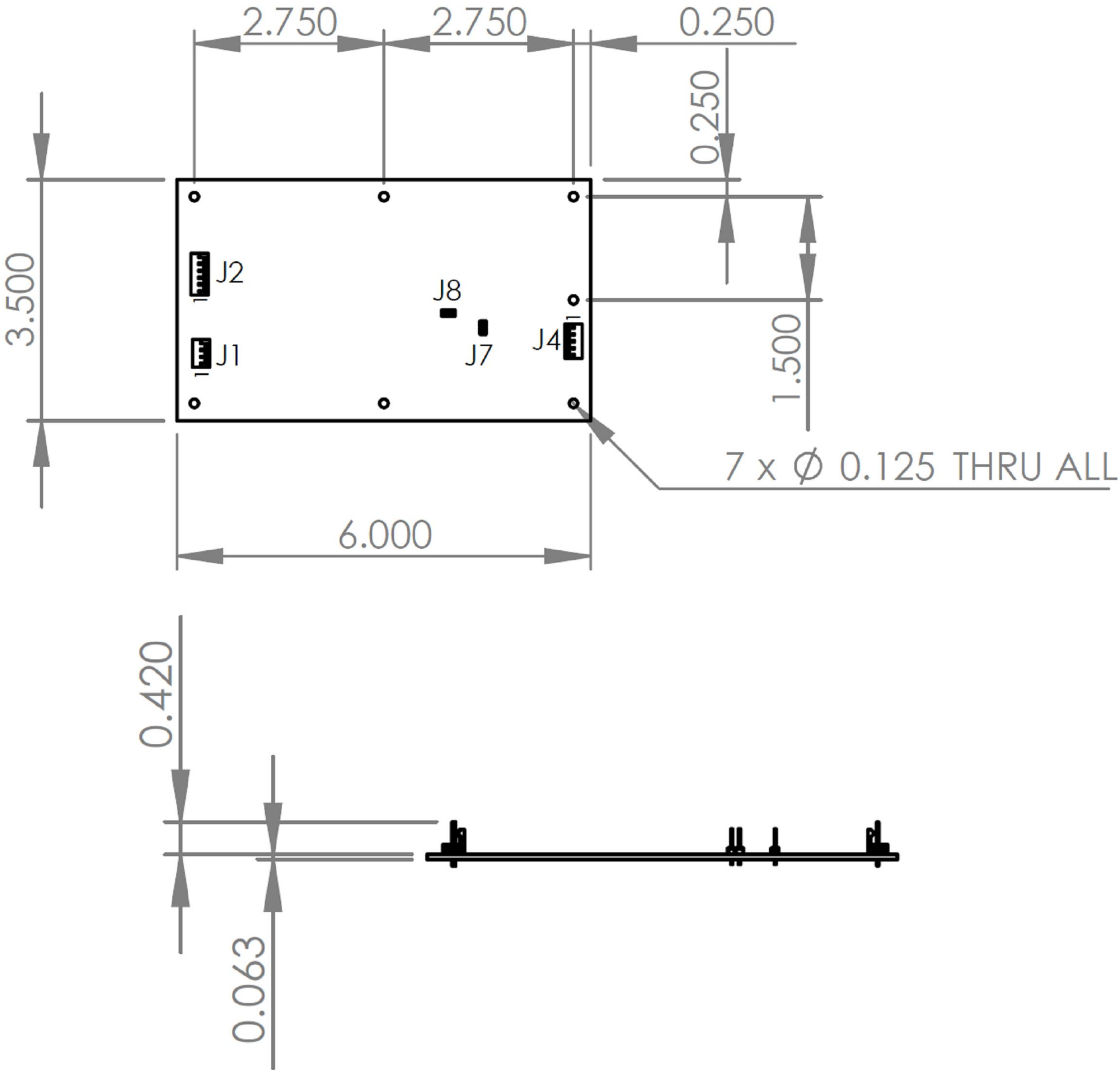

Figure 10 - HEM Circuit Board Dimensions (Inches)

8 Glossary of Terms and Abbreviations

CCA – Cable Coupler Assembly

CTS – Clear to Send

DCE – Data Communications Equipment

DTE – Data Terminal Equipment

DTR – Data Terminal Ready

HEM – Head End Modem

MDS – MLM-1000 Development System

MLMS – Mooring Line Modem System

SSM – Subsurface Modem