

# **SHL-021 MDS entraNET 220 Interface Specification**

## **MDS entraNET 220 Interface Specification**

**Document Number: SHL-021**

**Version: 1.9**

**Date: 2006-12-19**



# SHL-021 MDS entraNET 220 Interface Specification

## Table of Contents

1	Introduction .....	4
1.1	Access Point .....	6
1.1.1	USB Port Connector Pinout .....	8
1.1.2	RJ Connector Pinouts .....	8
1.1.2.1	LAN (Ethernet) Connector Pinout.....	8
1.1.2.2	COM1 Port Connector Pinout.....	9
1.1.2.3	COM2 (Serial Data) Port Connector Pinout .....	9
1.1.2.4	COM3 (Serial Data) Port Connector Pinout .....	9
1.1.3	DB-25 Connector Pinout .....	10
1.1.4	Power Connector Pinout .....	11
1.2	entraNET 220 OEM Radio Module.....	12
1.2.1	J1 (Ribbon Cable) Connector Pinout .....	14
1.2.2	J4 (Board Mount) Connector Pinout .....	15
1.2.3	RF Connector.....	15
1.3	entraNET 220 Packaged Radio Module.....	16
1.3.1	RJ Connector Pinouts .....	18
1.3.1.1	COM1 Connector Pinout .....	18
1.3.1.2	COM2 Connector Pinout .....	18
1.3.1.3	I/O Connector .....	19
1.3.2	DB-25 Connector Pinout .....	19
1.3.3	RF Connector.....	20
1.3.4	Power Connector Pinout .....	20
2	Features .....	21
2.1	Key Radio Specifications.....	21
2.2	RCL BSP Serial Port Functionality and Configuration .....	21
2.3	Firmware Images Stored In Flash .....	22
2.3.1	Remote-to-Remote OTA Firmware Upgrade procedures .....	22
2.4	Media Access Control.....	24
2.5	Centralized and Distributed Coordination Modes.....	25
2.5.1	Overview .....	25
2.5.2	Switching Between DCM and CCM Modes .....	25
2.6	Basic Serial Protocol .....	25
2.6.1	Overview .....	25
2.6.2	General BSP Message Structure .....	25
2.6.3	BSP Message Data Field Structure .....	26
2.7	Inter-Access Point Protocol .....	26
2.8	RCL Addressing .....	26
2.8.1	RCL System Identifier .....	26
2.8.2	Device Identifiers.....	26
2.8.3	Example .....	27
2.9	Radio Modes.....	27
2.10	Security and Uniqueness.....	28
2.11	End to End Integrity .....	29
3	Version History.....	30

# SHL-021 MDS entraNET 220 Interface Specification

## Table of Figures

Figure 1 entraNET 220 Repeater Block Diagram.....	4
Figure 2 entraNET 220 OCU Unit Block Diagram.....	5
Figure 3 entraNET 220 LCU Unit Block Diagram.....	5
Figure 4 Access Point.....	6
Figure 5 Access Point (Top View) .....	6
Figure 6 Access Point (Front View) .....	6
Figure 7 Access Point (Bottom View) .....	7
Figure 8 Access Point (Side View) .....	7
Figure 9 Mounting Bracket (Can be used with Access Point or Packaged Radio Module) .....	7
Figure 10 entraNET 220 OEM Radio Module (SMB Connector Not Shown).....	12
Figure 11 entraNET 220 OEM Radio Module (Top/Shield View).....	12
Figure 12 entraNET 220 OEM Radio Module (End View).....	13
Figure 13 entraNET 220 OEM Radio Module (Bottom View).....	13
Figure 14 entraNET 220 OEM Radio Module (Side View with PEM detail) .....	14
Figure 15 entraNET 220 Packaged Radio Module.....	16
Figure 16 entraNET 220 Packaged Radio Module (Top View) .....	16
Figure 17 entraNET 220 Packaged Radio Module (Front View).....	16
Figure 18 entraNET 220 Packaged Radio Module (Bottom View).....	17
Figure 19 entraNET 220 Packaged Radio Module (Side View) .....	17

# SHL-021 MDS entraNET 220 Interface Specification

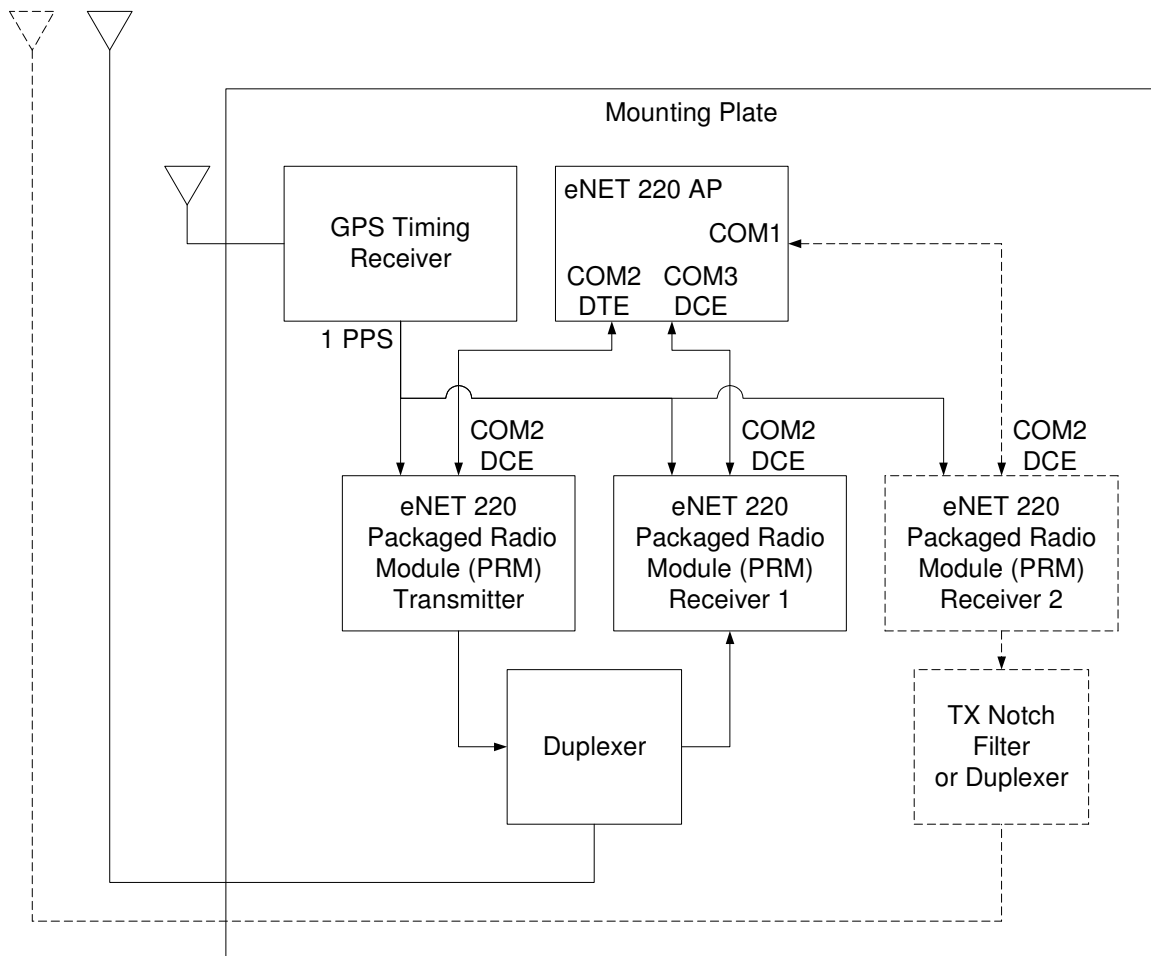
## 1 Introduction

This document provides details of the entraNET 220 System. The entraNET 220 System supports Repeaters, OCUs, and LCUs. Repeaters employ an Access Point and three entraNET 220 Packaged Radio Modules. OCUs employ entraNET 220 OEM Radio Modules while LCUs employ entraNET 220 Packaged Radio Modules.

MDS Radio Unit	Used for OCU	Used for LCU	Used for Repeater
entraNET 220 OEM Radio Module	1	0	0
entraNET 220 Packaged Radio Module	0	1	3
Access Point	0	1	1

*Note that additional information vital to Phase V operation is given in SHL-028, The MDS entraNET 220 Phase V Primer.*

Block diagrams for each unit are shown in the following figures. Note: the cabling shown is for the previous RJ-style versions. Please refer to pinouts for the final DB-25 versions later in this document.



**Figure 1 entraNET 220 Repeater Block Diagram**

# SHL-021 MDS entraNET 220 Interface Specification

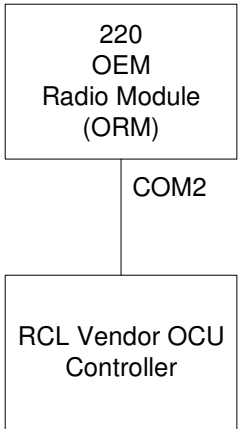


Figure 2 entraNET 220 OCU Unit Block Diagram

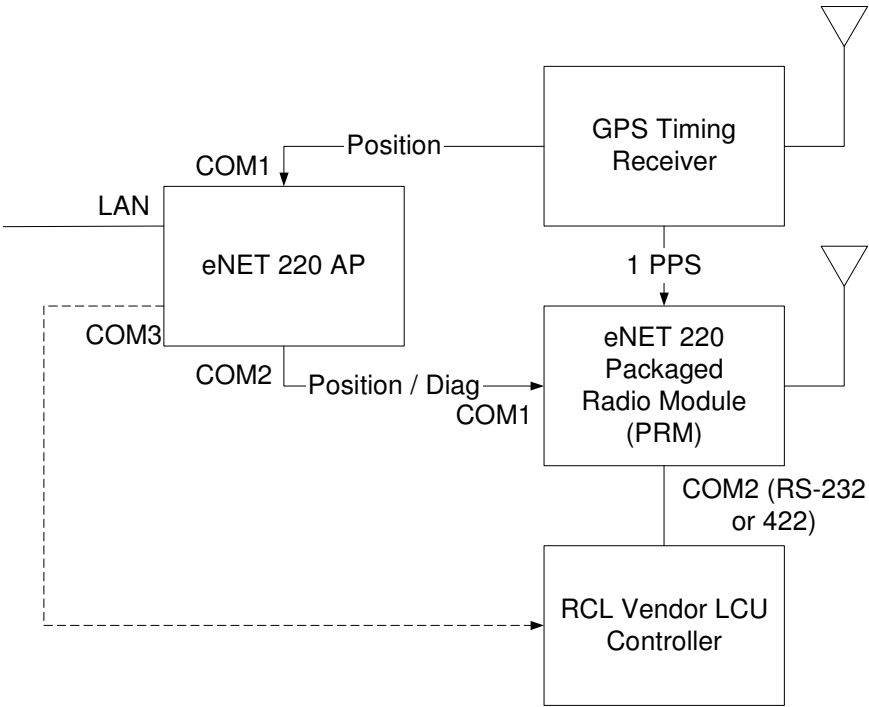


Figure 3 entraNET 220 LCU Unit Block Diagram

# SHL-021 MDS entraNET 220 Interface Specification

## 1.1 Access Point

This unit is used in the repeater and must also fit within the enclosure used at the LCU. Photos and mechanical dimensions of this unit appear below.



Figure 4 Access Point

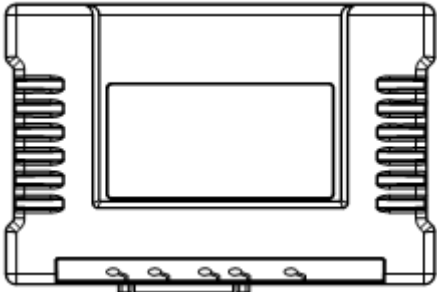


Figure 5 Access Point (Top View)

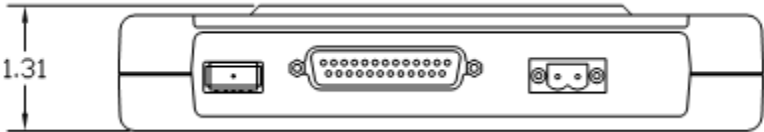


Figure 6 Access Point (Front View)

# SHL-021 MDS entraNET 220 Interface Specification

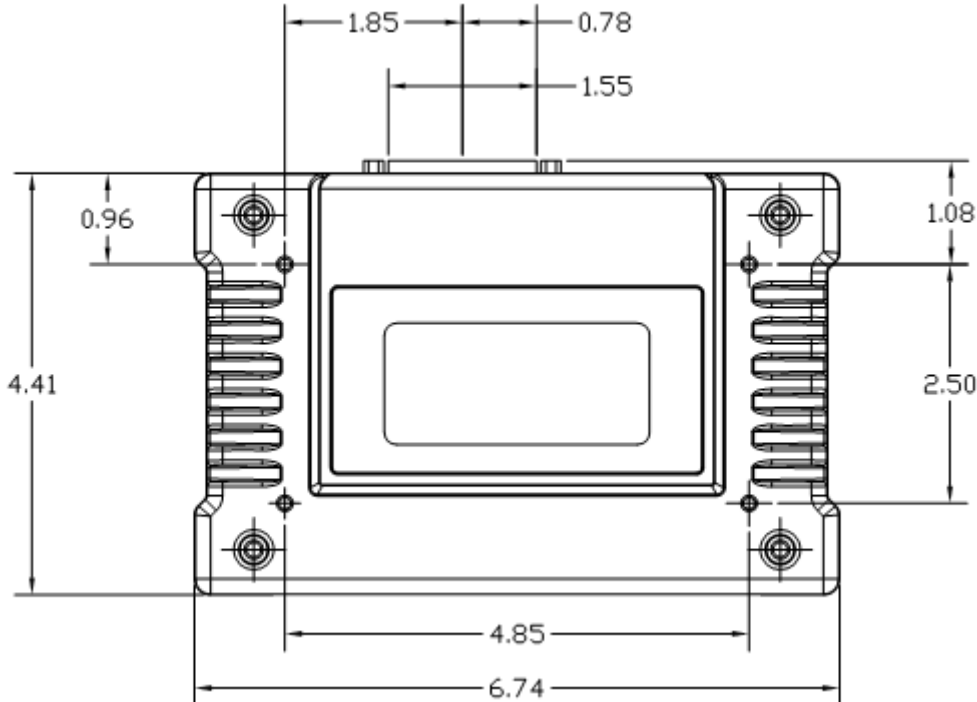


Figure 7 Access Point (Bottom View)

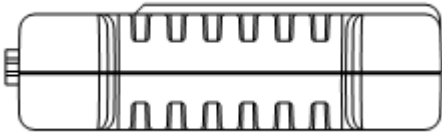


Figure 8 Access Point (Side View)

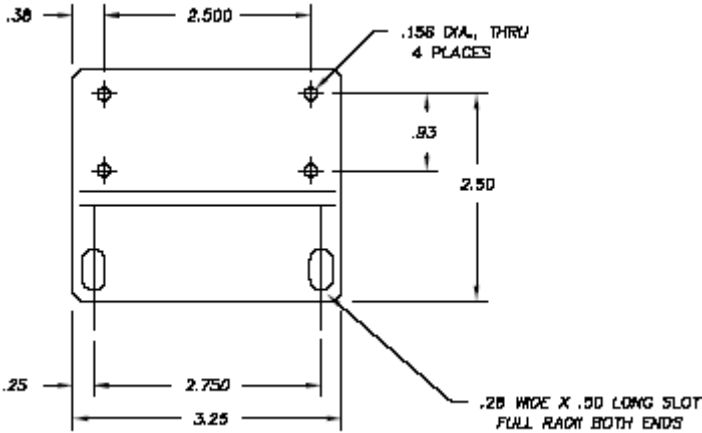


Figure 9 Mounting Bracket (Can be used with Access Point or Packaged Radio Module)

# SHL-021 MDS entraNET 220 Interface Specification

## 1.1.1 USB Port Connector Pinout

The Access Point provides a USB Port conforming to version 1.1 of the USB standard. The pinout for this connector is given in the table below.

Pin	Signal Name	Description
1	PC_USB_+5V	+5 VDC
2	USBD-	USB Data Minus
3	USBD+	USB Data Plus
4	GROUND	Ground

## 1.1.2 RJ Connector Pinouts

The sections below provide the pinout information for the AP version employing RJ-45 and RJ-12 connectors. This information is provided as reference only. Information on the final DB-25 version appears in section 1.1.3.

### 1.1.2.1 LAN (Ethernet) Connector Pinout

The Access Point provides a 10-BASE-T RJ-45 (Amphenol FRJA-468) Ethernet port for connection to an Ethernet Hub or endpoint. The connector for this port is shielded and filtered to reduce EMI. The signals for this interface are shown in the following table.

Pin	Signal Name	Direction with respect to MDS Equipment	Description
1	ETH_TX_H	Output	Ethernet transmit high
2	ETH_TX_L	Output	Ethernet transmit low
3	ETH_RX_H	Input	Ethernet receive high
4	N/C	N/A	N/A
5	N/C	N/A	N/A
6	ETH_RX_L	Input	Ethernet receive low
7	N/C	N/A	N/A
8	N/C	N/A	N/A



# SHL-021 MDS entraNET 220 Interface Specification

## 1.1.2.2 COM1 Port Connector Pinout

The Access Point provides an RJ-12 (Amp 555165-1) RS-232 port "COM1". This port supports rates from 1,200 bps to 115,200 bps and defaults to 19,200 bps. The pinout for this connector is given in the table below.

Pin	Signal Name	Direction with respect to MDS Equipment	Description
1	N/C	N/A	N/A
2	N/C	N/A	N/A
3	N/C	N/A	N/A
4	COM1_TXD	Output	COM1 Transmit Data
5	COM1_RXD	Input	COM1 Receive Data
6	GROUND	Input	Signal Return

## 1.1.2.3 COM2 (Serial Data) Port Connector Pinout

The Access Point provides an RJ-45 (Amp 555164-1) EIA-561 DCE RS-232 port "COM2". This port supports rates from 1,200 bps to 115,200 bps. The pinout for this connector is given in the table below.

Pin	Signal Name	Direction with respect to MDS Equipment	Description
1	N/C	N/A	N/A
2	COM2_DCD	Output	COM2 Data Carrier Detect
3	COM2_DTR	Input	COM2 Data Terminal Ready
4	GROUND	N/A	Signal Return
5	COM2_RXD	Output	COM2 Receive Data
6	COM2_TXD	Input	COM2 Transmit Data
7	COM2_CTS	N/A	COM2 Clear to Send (shorted to COM2_RTS)
8	COM2_RTS	N/A	COM2 Request to Send (shorted to COM2_CTS)

## 1.1.2.4 COM3 (Serial Data) Port Connector Pinout

The Access Point provides an RJ-45 (Amp 555164-1) EIA-561 DTE RS-232 port "COM3". This port supports rates from 1,200 bps to 115,200 bps. The pinout for this connector is given in the table below.

Pin	Signal Name	Direction with respect to MDS Equipment	Description
1	N/C	N/A	N/A
2	COM3_DCD	Input	COM3 Data Carrier Detect
3	COM3_DTR	Output	COM3 Data Terminal Ready
4	GROUND	N/A	Signal Return
5	COM3_RXD	Input	COM3 Receive Data
6	COM3_TXD	Output	COM3 Transmit Data
7	COM3_CTS	Input	COM3 Clear to Send
8	COM3_RTS	Output	COM2 Request to Send

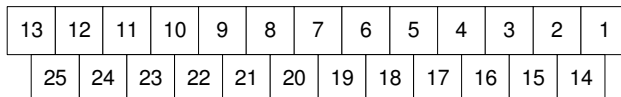
# SHL-021 MDS entraNET 220 Interface Specification

## 1.1.3 DB-25 Connector Pinout

The table below provides the pinout information for the final AP version employing a DB-25 connector.

DB-25 Pin	Signal	Previous AP Connector	Previous AP Pin	Direction WRT MDS Equipment
1	COM3_DCD	J500 (COM3)	2	Input
2	COM2_TXD	J502 (COM2)	6	Input
3	COM2_RXD	J502 (COM2)	5	Output
4	COM2_RTS	J502 (COM2)	8	Input
5	COM2_CTS	J502 (COM2)	7	Output
6	COM3_TXD	J500 (COM3)	6	Output
7	GND	J502 (COM2)	4	Input/Output
8	COM2_DCD	J502 (COM2)	2	Output
9	COM3_CTS	J500 (COM3)	7	Input
10	COM3_RTS	J500 (COM3)	8	Output
11	COM3_DTR	J500 (COM3)	3	Output
12	COM3_RXD	J500 (COM3)	5	Input
13	GND	N/A	N/A	Input/Output
14	ETH_TX_H	J400 (LAN)	1	Output
15	ETH_TX_L	J400 (LAN)	2	Output
16	ETH_RX_H	J400 (LAN)	3	Input
17	ETH_RX_L	J400 (LAN)	6	Input
18	EXT_KEY	N/A	N/A	Output
19	EXT_DET	N/A	N/A	Input
20	COM2_DTR	J502 (COM2)	3	Input
21	ALARM_OUT	N/A	N/A	Output
22	GPS_PPS_L	N/A	N/A	Input
23	GPS_PPS_H	N/A	N/A	Input
24	COM1_RXD	J501 (COM1)	5	Input
25	COM1_TXD	J501 (COM1)	4	Output

The DB-25 connector is female, and the orientation of the connector as looking into the front panel of the unit is as shown below.



# SHL-021 MDS entraNET 220 Interface Specification

## 1.1.4 Power Connector Pinout

The Access Point provides a Phoenix 17 76 69 2 connector for DC power in.

Pin	Signal Name	Direction with respect to MDS Equipment	Description
1 (L)	PWR	Input	10 to 30 VDC input, 125 mA at 13.8 VDC
2 I	GROUND	Input	Power return.

# SHL-021 MDS entraNET 220 Interface Specification

## 1.2 entraNET 220 OEM Radio Module

This unit is used in each OCU. It is a two-board solution (as shown below) that mates with RCL vendor OCU hardware. Mechanical diagrams are provided below as well. The interfaces used by OEM Radio Modules are listed in the tables below.

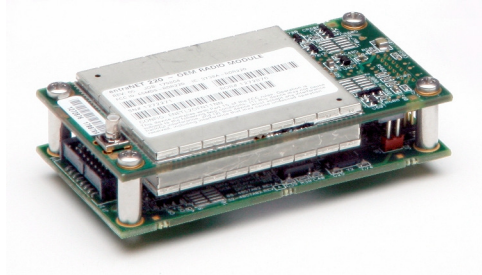


Figure 10 entraNET 220 OEM Radio Module (SMB Connector Not Shown)

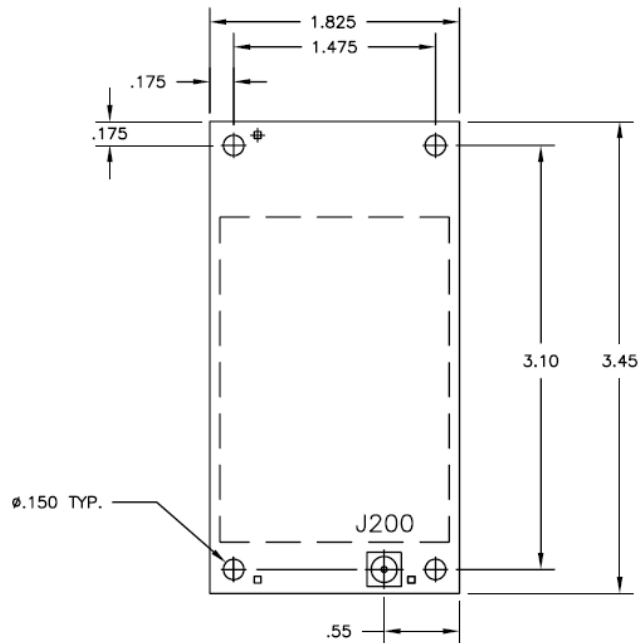


Figure 11 entraNET 220 OEM Radio Module (Top/Shield View)

# SHL-021 MDS entraNET 220 Interface Specification

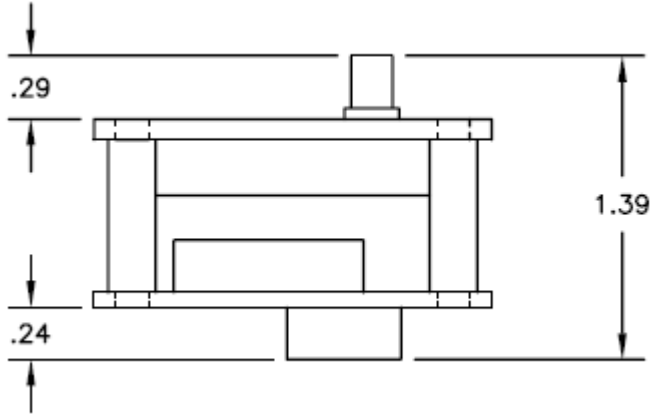


Figure 12 entraNET 220 OEM Radio Module (End View)

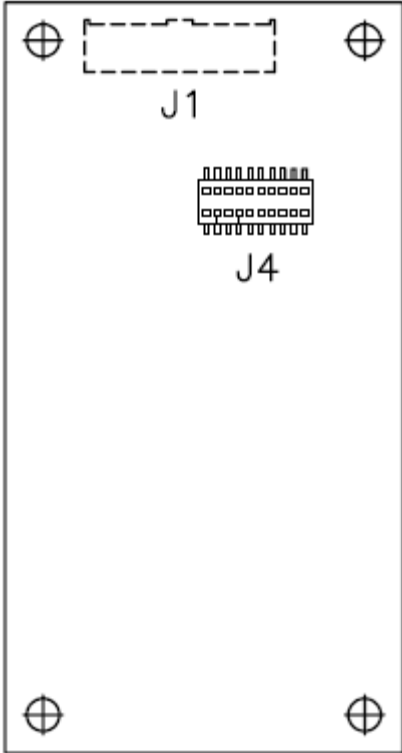


Figure 13 entraNET 220 OEM Radio Module (Bottom View)

# SHL-021 MDS entraNET 220 Interface Specification

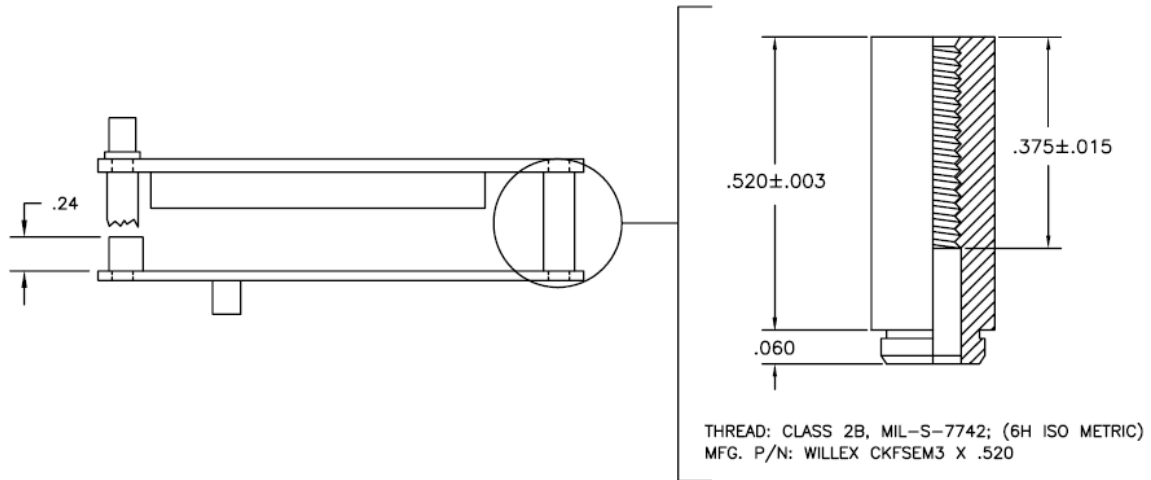


Figure 14 entraNET 220 OEM Radio Module (Side View with PEM detail)

## 1.2.1 J1 (Ribbon Cable) Connector Pinout

The J1 Connector is a Samtec STMM-108-02-T-D-SM-K-TR. The mating connector is a Samtec TCSD-08-D-xx.xx-01-F-N. J1 is the main interface to the OEM Radio Module.

Pin	Function	Direction WRT MDS Equipment	Notes
1	Not Connected		
2	VIN	Input	6 – 12 VDC, 1 A Max.
3	TXD	Input	Serial Data Input, 0 to 5 V.
4	IO1	Output	Slot Timing Signal. 0 to 3.3 V.
5	RXD	Output	Serial Data Output, 0 to 3.3 V.
6	IO2	Output	Reserved. 0 to 3.3 V.
7	Do Not Connect		
8	IO3	Input	ALARM_IN. 0 to 5 V.
9	Do Not Connect		
10	Not Connected		
11	Do Not Connect	Output	Reserved, -6 to +6 V.
12	Not Connected		
13	Do Not Connect	Input	Reserved, -12 to +12 V.
14	Not Connected		
15	GROUND	Input	Return for VIN and signals.
16	Not Connected		

# SHL-021 MDS entraNET 220 Interface Specification

## 1.2.2 J4 (Board Mount) Connector Pinout

The J4 Connector is a SAMTEC RSM-110-02-L-D-TR. J4 is not typically populated on the OEM Radio Module.

Pin	Function	Direction WRT MDS Equipment	Notes
1	Not Connected		
2	Not Connected		
3	Not Connected		
4	Not Connected		
5	IO3	Input	ALARM_IN. Active Low. 0 to 5 V.
6	Not Connected		
7	Not Connected		
8	Not Connected		
9	GROUND	Input	Return for VIN and signals.
10	TXD	Input	Serial Data Input. 0 to 5 V.
11	GROUND	Input	Return for VIN and signals.
12	IO2	Output	Reserved. 0 to 3.3 V.
13	IO1	Output	Slot Timing Signal. 0 to 3.3 V.
14	Not Connected		
15	Not Connected		
16	RXD	Output	Serial Data Output, 0 to 3.3 V.
17	VIN	Input	6 – 12 VDC, 1 A Max.
18	Not Connected		
19	VIN	Input	6 – 12 VDC, 1 A Max.
20	Not Connected		

## 1.2.3 RF Connector

The RF Connector is a straight mount 50 Ohm SMB jack.

# SHL-021 MDS entraNET 220 Interface Specification

## 1.3 entraNET 220 Packaged Radio Module

In the LCU, one entraNET 220 Packaged Radio Module is used. In the Repeater, three are used. Each instance employs identical hardware so that only one configuration must be spared. The packaged module is provided in a cast aluminum housing as shown. Mounting for this unit is shown below. Mechanical dimensions are also given. The interfaces used by Packaged Radio Modules are listed in the tables below.



Figure 15 entraNET 220 Packaged Radio Module

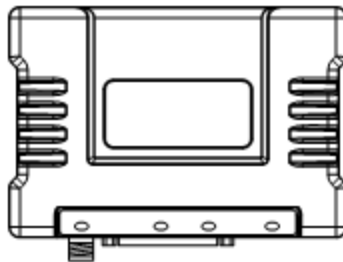


Figure 16 entraNET 220 Packaged Radio Module (Top View)

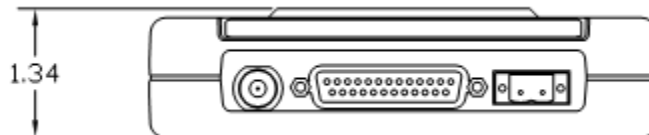


Figure 17 entraNET 220 Packaged Radio Module (Front View)



# SHL-021 MDS entraNET 220 Interface Specification

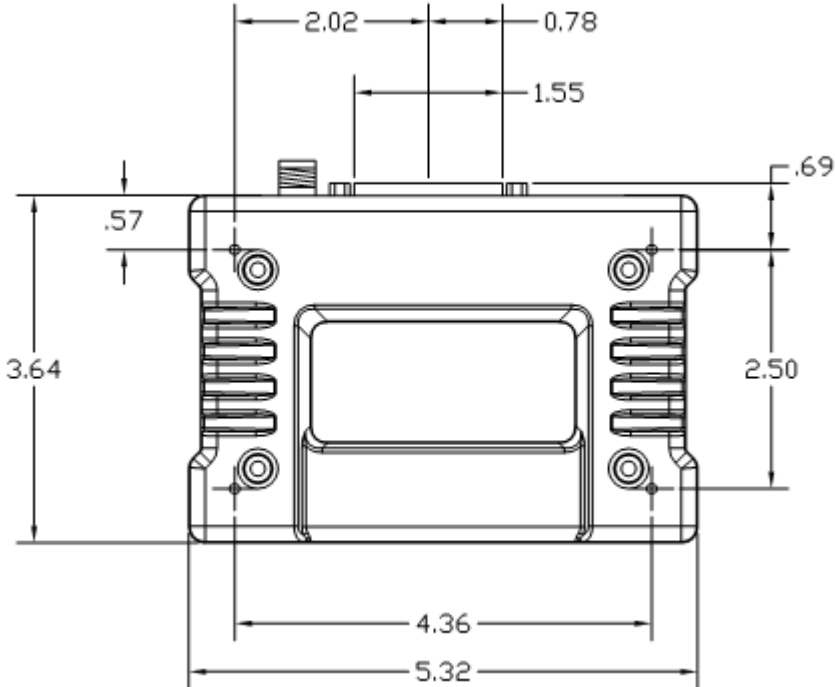


Figure 18 entraNET 220 Packaged Radio Module (Bottom View)

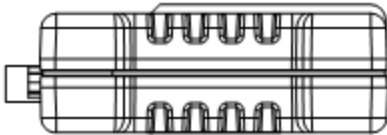


Figure 19 entraNET 220 Packaged Radio Module (Side View)

# SHL-021 MDS entraNET 220 Interface Specification

## 1.3.1 RJ Connector Pinouts

The following sections describe the pinouts for the previous RJ-45 and RJ-12 version of the PRM. The pinouts for the final DB-25 version are given in section 1.3.2.

### 1.3.1.1 COM1 Connector Pinout

The Packaged Radio Module provides an RJ-12 (Amp 555165-1) RS-232 port "COM1". This port supports rates from 1,200 bps to 115,200 bps. The pinout for this connector is given in the table below.

Pin	Signal Name	Direction WRT MDS Equipment	Notes
1	Not Connected		
2	Not Connected		
3	Not Connected		
4	RXD	Output	Serial Data Out. -6 to +6 V.
5	TXD	Input	Serial Data In. -12 to +12 V.
6	GROUND	Input	Signal Return

### 1.3.1.2 COM2 Connector Pinout

The Packaged Radio Module provides an RJ-45 (Amp 555164-1) EIA-561 DCE RS-232 or RS-485 port "COM2". This port supports rates from 1,200 bps to 115,200 bps. The pinout for this connector is given in the table below.

#### RS-232 Mode

Pin	Signal Name	Direction WRT MDS Equipment	Notes
1	Not Connected		
2	Do Not Connect	Output	Reserved. -6 to +6 V.
3	Do Not Connect	Input	Reserved. -12 to +12 V.
4	GROUND	Input	Signal Return.
5	RXD	Output	Serial Data Output. -6 to +6 V.
6	TXD	Input	Serial Data Input. -12 to +12 V.
7	CTS	Output	Slot Timing Signal. -6 to +6 V.
8	Do Not Connect	Input	Reserved. -12 to +12 V.

#### RS-485 Mode

Pin	Signal Name	Direction WRT MDS Equipment	Notes
1	Not Connected		
2	RXD-	Output	Data Output Low. Diff +/- 2 V.
3	DTR	Input	-12 to +12 V.
4	GROUND	Input	Signal Return.
5	RXD+	Output	Serial Data Output High. Diff +/- 2 V.
6	TXD+	Input	Serial Data Input High. -7 to +12 V CM.
7	CTS	Output	Slot Timing Signal. -6 to +6 V.
8	TXD-	Input	Data Input Low. -7 to +12 V CM.

# SHL-021 MDS entraNET 220 Interface Specification

## 1.3.1.3 I/O Connector

The I/O Connector is an 8-pin Molex MicroFit 3.0 connector (mates with customer-supplied 43025-0800 jack with 43030-0007 pins) and is located between the LINK and COM1 connectors on the front panel. It employs the following signals.

Pin	Signal Name	Direction WRT MDS Equipment	Notes
1	EXT_KEY	Output	Power Amplifier TX Key. 0-3.3 V.
2	EXT_DET	Input	Power Amplifier Feedback. 0-5 V.
3	ALARM_OUT	Output	Discrete Output. Active Low. 0-3.3 V.
4	GROUND	Input	Signal Return.
5	GPS_PPS_L	Input	GPS 1 PPS timing. RS-422 Low In.
6	GPS_PPS_H	Input	GPS 1 PPS timing. RS-422 High In.
7	Reserved		
8	Reserved		

Note: Looking into the front of a packaged radio module, the connector is wired as shown below.

8	6	4	2
7	5	3	1

## 1.3.2 DB-25 Connector Pinout

The following table describes the pinout for the DB-25 version of the PRM.

New DB-25 Pin	Signal	Previous PRM Connector	Previous PRM Pin	Direction WRT MDS Equipment
1	COM3_DCD	N/A	N/A	Input
2	COM2_TXD/TXD+	J3 (COM2)	6	Input
3	COM2_RXD/RXD+	J3 (COM2)	5	Output
4	COM2_RTS/TXD-	J3 (COM2)	8	Input
5	COM2_CTS	J3 (COM2)	7	Output
6	COM3_TXD	N/A	N/A	Output
7	GND	J3 (COM2)	4	Input/Output
8	COM2_DCD/RXD-	J3 (COM2)	2	Output
9	COM3_CTS	N/A	N/A	Input
10	COM3_RTS	N/A	N/A	Output
11	COM3_DTR	N/A	N/A	Output
12	COM3_RXD	N/A	N/A	Input
13	GND	N/A	N/A	Input/Output
14	ETH_TX_H	N/A	N/A	Output
15	ETH_TX_L	N/A	N/A	Output
16	ETH_RX_H	N/A	N/A	Input
17	ETH_RX_L	N/A	N/A	Input
18	EXT_KEY	I/O	1	Output
19	EXT_DET	I/O	2	Input

# SHL-021 MDS entraNET 220 Interface Specification

New DB-25 Pin	Signal	Previous PRM Connector	Previous PRM Pin	Direction WRT MDS Equipment
20	COM2_DTR	J3 (COM2)	3	Input
21	ALARM_OUT	I/O	3	Output
22	GPS_PPS_L	I/O	5	Input
23	GPS_PPS_H	I/O	6	Input
24	TXD*	J5 (COM1)	5	Input
25	RXD**	J5 (COM1)	4	Output

\* TXD is called COM1\_RXD on the AP. It truly is an input to the MDS unit.

\*\* RXD is called COM1\_TXD on the AP. It truly is an output from the MDS unit.

The DB-25 connector is female, and the orientation of the connector as looking into the front panel of the unit is as shown below.

13	12	11	10	9	8	7	6	5	4	3	2	1
25	24	23	22	21	20	19	18	17	16	15	14	

## 1.3.3 RF Connector

The RF connector is TNC.

## 1.3.4 Power Connector Pinout

The Packaged Radio Module provides a Phoenix 17 76 69 2 connector for DC power in.

Pin	Signal Name	Direction with respect to MDS Equipment	Description
1 (L)	PWR	Input	6 to 30 VDC input, 800 mA at 13.8 VDC
2 I	GROUND	Input	Power return.

# SHL-021 MDS entraNET 220 Interface Specification

## 2 Features

### 2.1 Key Radio Specifications

Transmitter Parameter	Spec
Frequency Error	1.5 ppm
Carrier Output Power	33 dBm
Power Adjustment Range	10 dB

Receiver Parameter	Spec
Useable sensitivity @ 9.6 kbps	-110 dBm

Power Requirements	Spec
Operational Power Consumption	425 mW
Sleep power Consumption	25 mW
Operating Voltage Range	5.5 to 16 VDC

Note that the MDS equipment will automatically reduce power during times when it is not active.

### 2.2 RCL BSP Serial Port Functionality and Configuration

The serial port used as the communication link between the RCL vendor equipment and the MDS equipment operates in one of two modes, Console mode or Data mode.

In Console mode, the MDS radio provides a command line type interface, whereas in Data mode, the MDS radio accepts BSP messages as described in section 2.6 for transmission over the air. To enter Data mode from console mode, issue the following command:

```
COM2 MODE=DATA
```

To return from Data mode to Console mode, send the following sequence:

```
“+” 10 ms delay “+” 10 ms delay “+”.
```

Console mode is indicated by the entraNET> prompt.

CTS pulses indicate that it is time for the user to send its latest BSP message. CTS pulses will not occur in CONSOLE mode, nor will they occur when an OCU radio is not connected to the associated LCU radio.

The minimum steps required to put an LCU or OCU radio into operation are as follows:

```
+++  
LOGIN  
ADMIN  
ADMIN  
RADIO UNITADDR=t BFREQ1=u MFREQ1=v TIMESLOT=w  
ENCRYPT LCU=x OCUA=y OCUB=z  
RADIO MODE=NORMAL  
COM2 MODE=DATA
```

where

# SHL-021 MDS entraNET 220 Interface Specification

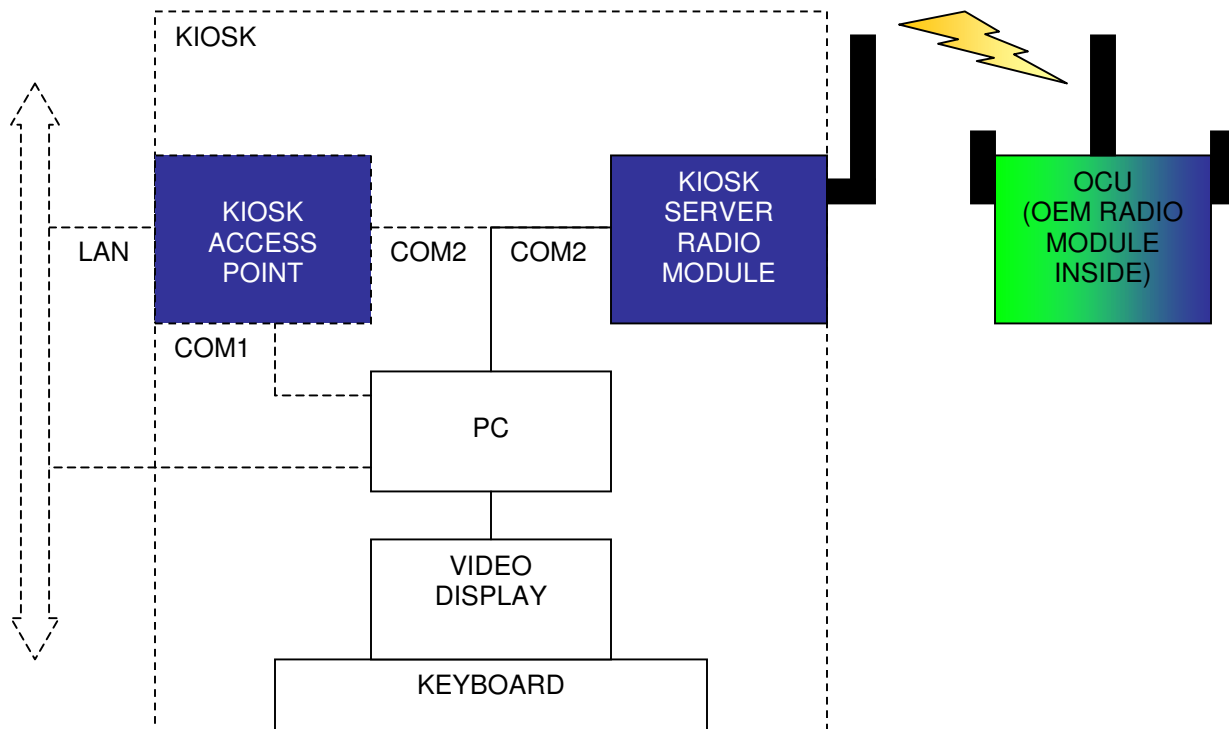
- t is equal to the 32-bit RCL Unit Address as described below (also configures unit as OCU radio A or B, or LCU radio,
- u and v are floating point numbers indicating the base and mobile 220 MHz frequencies for the selected channel, e.g. 220.10625 and 221.10625.
- w is an integer indicating the preferred time slot to use, 0 to 14 (for Phase IV only), and
- x, y and z are the scrambling keys described in section 2.10 below.

## 2.3 Firmware Images Stored In Flash

Each entraNET 220 radio stores two copies of the operating firmware in Flash to allow one image to be upgraded while the other is in use. This ensures that if corruption occurs when reprogramming, there is always a valid image to fall back to. The upgrade process will not allow upgrading the active image. Upgrading units within the LCU is accomplished via the unit's serial port. Upgrading OCU units is performed over the air in a special maintenance mode or via the unit's serial port. Upgrading the units within the repeater is performed over the LAN interface. Within a repeater or locomotive configuration, the AP upgrades the attached PRMs.

### 2.3.1 Remote-to-Remote OTA Firmware Upgrade procedures

There are two radio modules involved in the upgrade procedure, the OCU radio module (the client, the unit GETTING the upgrade) and the Kiosk radio module (the server, the unit SENDING the upgrade). See the diagram below.



In the OCU, the RCL vendor software must issue console commands to put the MDS radio into the mode to await an upgrade. The RCL vendor must implement a button and/or switch sequence the operator can use to initiate this mode.

The radios also support a low-power, off-channel "Test" mode where the RCL vendors can write testware to put an OCU through its paces as prompted at the Kiosk (simulating an LCU). This is

# SHL-021 MDS entraNET 220 Interface Specification

something the RCL vendors can design and build. The radios simply provide the over-the-air support.

At the Kiosk end, a PC application commands the Kiosk Server radio to begin serving firmware downloads.

The following notes must be considered in the upgrade process.

1. The upgrade process occurs on the AUXTX and AUXRX frequencies. These are intended to be out of band (default 223.6 MHz). It is illegal to operate on these frequencies at full power, so a "RADIO MODE=MAINT" command must be issued before beginning the process.
2. Type "ver" to compare Active image versions on both the Kiosk Server radio and the OCU sides. The APP, DSP and MCU software versions running on both sides must be identical to insure a reliable RF modem link. If necessary, downgrade the Kiosk Server radio's software to match the remote OCU side.
3. The Kiosk Server radio can only serve the *inactive* image firmware update data to the OCU unit. Therefore, make sure that the Kiosk Server radio's inactive image number equals the OCU unit's inactive image number and that the inactive image on the Server is the desired upgrade version. Type "ver" on both sides to verify the information before proceeding to the next steps. If necessary, reprogram and/or reboot to the other Kiosk Server image.
4. Login as "admin" user at both sides (Kiosk Server and OCU Client).
5. At the Kiosk Radio Module's console prompt, type "program mode=radio\_send".

```
EntraNET> program mode=radio_send  
MODE=Serve reprogramming requests over the air
```

6. At the OCU radio console prompt, type "program mode=radio\_receive".

```
EntraNET> program mode=radio_receive  
MODE=Request reprogramming over the air
```

7. Use "program status" to monitor progress status at the OCU side. The IMAGENUM should indicate the inactive image that is being upgraded.

```
EntraNET> program status  
Displays image reprogram status  
MODE=Request reprogramming over the air  
START_COUNT=1  
IMAGENUM=1  
STATUS=Receiving over the air reprogramming  
APP%=2  
DSP%=0  
MCU%=0
```

```
entraNET> program status  
Displays image reprogram status  
MODE=Request reprogramming over the air  
START_COUNT=1  
IMAGENUM=1
```

# SHL-021 MDS entraNET 220 Interface Specification

*STATUS=Receiving over the air reprogramming  
APP%=20  
DSP%=0  
MCU%=0*

8. At the OCU side, when 100% completed, the program mode should automatically go back to "COM1\_RECEIVE".
9. Reboot to the upgraded image by typing "reboot other" and then "y".
10. Repeat step 3 through 5 if the other image requires the same firmware upgrade.
11. If anything goes wrong (unreliable link, etc...), just restart by typing "program mode=com1\_receive" and then back to the desired "radio\_send" or "radio\_receive" mode on the Server or Client radio, respectively.

## **Example:**

Server Image 1: 1.7.6 (inactive) ←- this is where the upgrade comes from.  
Server Image 2: 1.6.9 (active)

OCU Image 1: whatever (inactive) ←- this is where the upgrade will go.  
OCU Image 2: 1.6.9 (active)

## **This will not work:**

Server Image 1: 1.7.6 (inactive) ←- this is where the upgrade comes from.  
Server Image 2: 1.7.6 (active) ←- Error: this version does not match the OCU unit's active version.

OCU Image 1: whatever (inactive) ←- this is where the upgrade will go.  
OCU Image 2: 1.6.9 (active)

## **Neither will this:**

Server Image 1: 1.6.9 (active) ←- Error: the OCU's active image is 2, not 1.  
Server Image 2: 1.7.6 (inactive)

OCU Image 1: whatever (inactive) ←- this is where the upgrade will go.  
OCU Image 2: 1.6.9 (active)

## **2.4 Media Access Control**

Because this radio product employs a TDMA media access control algorithm, each of the 45 remotes per channel can send up to seven bytes of payload data per second.

At the LCU, the RCL vendor must supply a 0-5 Volt GPS one Pulse Per Second signal and GPS position data in NMEA format.

To indicate to the RCL vendor that the unit's time slot is approaching and it is time to send a message into the MDS equipment, a "Slot Timing Signal" is provided at the LCU and the OCU. The amount of advance time of this signal is programmable.



# SHL-021 MDS entraNET 220 Interface Specification

## 2.5 Centralized and Distributed Coordination Modes

### 2.5.1 Overview

Centralized Coordination Mode (CCM) is defined as the mode where each entraNET Remote is associated with the repeater infrastructure. CCM mode allows up to 15 locomotives to simultaneously share a single 12.5 kHz channel. Distributed Coordination Mode (DCM) is defined as the mode where entraNET Remotes abandon their connection with the Repeater and instead move to a self contained LCU and OCU A/B network cluster. In this mode up to 15 or more locomotives can simultaneously share a channel in the same area with no coordination.

### 2.5.2 Switching Between DCM and CCM Modes

Switching between CCM and DCM Modes is handled by the entraNET communication system.

## 2.6 Basic Serial Protocol

### 2.6.1 Overview

The entraNET supports a Basic Serial Protocol (BSP) that can be used to specify routing of serial message frames from one Remote to another. Messages framed with BSP are always passed transparently so that the message received at the destination Remote's serial port is identical to the message sent into the source Remote's port. In addition, messages sent when in CCM or DCM Mode appears identical, so the application does not need to parse these messages differently.

BSP routing is performed by the RCS functionality in the repeater infrastructure. In DCM mode, BSP packets sent directly between the OCUs and LCU with no additional infrastructure. BSP packets not destined for a given OCU/LCU address will be filtered so they do not appear at that Remote.

### 2.6.2 General BSP Message Structure

BSP messages use a simple data framing structure based on the following generic protocol fields:

1. SYNC (1 byte): This allows fast and easy synchronization.
  - a. Fixed value "0xA5".
2. TYPE (1 byte): This specifies the type of BSP message.
  - a. "0x02" Seven byte standard RCL Frame (Length = 0x0010)
  - b. New types may be defined in the future as needed
3. LENGTH (2 bytes): This specifies the length of the BSP message; bytes are packed in little endian order (least significant byte first)
4. DATA (n bytes): The BSP message content where n=LENGTH including address and flags in hex see below

General BSP Message Structure

SYNC (8 bits)	TYPE (8 bits)	LENGTH (16 bits)	BSP Message DATA (Length bytes)
------------------	------------------	---------------------	------------------------------------

# SHL-021 MDS entraNET 220 Interface Specification

## 2.6.3 BSP Message Data Field Structure

The BSP Message Data Field for BSP Application Data Packets is formatted as follows:

1. Destination Address (3 bytes): Indicating the Unit ID of the target Remote. The bytes are packed in "little endian" order (least significant byte first, most significant byte last).
2. Source Address (3 bytes): Indicating the Unit ID of the source Remote. The bytes are packed in "little endian" order (least significant byte first, most significant byte last).
3. Flags are reserved for future use. Set as "0x00".
4. Packet Data (X bytes): The information portion of the packet. Length X is determined by taking the BSP message length and subtracting the packet header length of 9 bytes.

### BSP Application Data Packet Structure

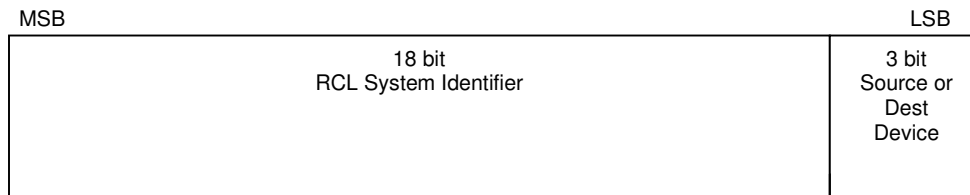
Destination Address (21 bits)	Not Used 11 Bits	Source Address (21 bits)	Not Used 11 Bits	Flags (8 bits)	Packet Data (X bytes)
-------------------------------------	---------------------------	--------------------------------	---------------------------	-------------------	--------------------------

## 2.7 Inter-Access Point Protocol

In CCM Mode, messages that are sent from one remote and destined for another (via the BSP protocol) are routed through RCS. The ability of a message sent from a remote to be routed to a remote on a *different* AP is called Inter-Access Point Protocol (IAPP). IAPP Traffic is passed from repeater to repeater over a backbone via the RCS LAN infrastructure. This backbone may be hard-wired or a Wireless Ethernet LAN. The repeater infrastructure must have the RCS functionality installed to route packets.

## 2.8 RCL Addressing

The format for the 21-bit frame address follows:



### 2.8.1 RCL System Identifier

The RCL System Identifier is an 18-bit number as specified by the AAR's CAI-12 specification.

### 2.8.2 Device Identifiers

The 3-bit device identifiers are used to identify the source and destination devices for each packet

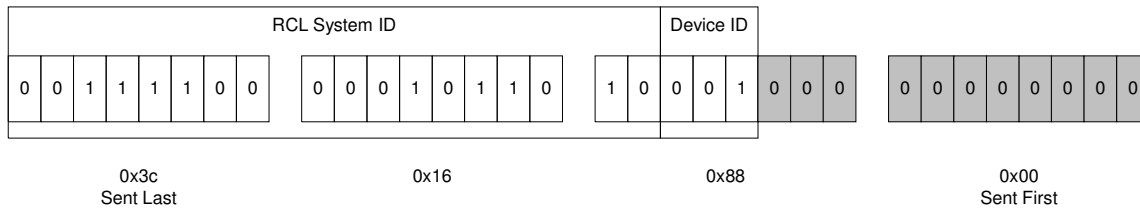
- 000 (0) = NUL\*
- 001 (1) = OCUa
- 010 (2) = OCUb
- 011 (3) = OCUa & OCUb (Destination only)
- 100 (4) = LCU or Test Device

# SHL-021 MDS entraNET 220 Interface Specification

- 101 (5) = RCS\*
- 110 (6) = AUX controller (e.g. Hump controller)\*
- 111 (7) = Broadcast (Destination only)\*
  
- Not yet implemented.

## 2.8.3 Example

For an RCL System Identifier of 0x0f05a and Device Identifier 0x1 (OCUa), the following bytes would be sent into the BSP serial port of the MDS equipment in sequence: 0x00 0x88 0x16 0x3c. In the following diagram, note that the bytes are sent from right to left, but the bit order of each byte is retained.



## 2.9 Radio Modes

The table below describes the different Radio Modes that can be set in the eNET 220 Radio Module.

The Radio Module will start up in CAL mode by default so that it does not key until it is either set to another mode or is keyed explicitly.

After a timeout set by RADIO TXSTART=x (in seconds) the radio will automatically change from CAL mode to NORMAL mode to allow operation to begin.

If RADIO TXSTART=0 is set, the radio will never automatically change to NORMAL mode, and a command must be given to make this transition (RADIO MODE=NORMAL). This is the intended practice.

# SHL-021 MDS entraNET 220 Interface Specification

RADIO MODE=	Description	Frequency	Power	TDMA?	Interface
NORMAL	Normal operation for Railroad work. Go to data mode and pass BSP messages.	Licensed, M/BFREQs	High	Yes	BSP (COM2 MODE=DATA)
TRAFFIC	Stand-alone traffic generator for system checkout. Go to data mode on the other end to see traffic, or use console to get stats.	Licensed, M/BFREQs	High	Yes	Command Line (COM2 MODE=CONSOLE)
TEST	Low power test operation for simulated Railroad work. Go to data mode and pass BSP messages.	Unlicensed, Customer must program out of band M/BFREQs for duration of test	Extra Low	Yes	BSP (COM2 MODE=DATA)
CAL	Calibration mode for RSSI and Power Out measurements. For power measurements, use RADIO TXKEY=ON.	Unlicensed, AUXTX/AUXRX	High	No	Command Line (COM2 MODE=CONSOLE)
MAINT	OTA Reprogramming. Use PROGRAM command.	Unlicensed, AUXTX/AUXRX	Extra Low	No	Command Line (COM2 MODE=CONSOLE)

## 2.10 Security and Uniqueness

The LCU determines and sets the operational parameters for an RCL System. The initialization process requires that each OCU be “linked” to its controlling LCU so that the OCUs have all RCL system-specific information necessary for operation, and will recognize and act on transmissions from their own LCU exclusively. This initialization process occurs outside the radio link used for locomotive control.

The designation of an OCU device as “OCUA” or “OCUB” is established during the out-of-band link-up process and remains static during RCL system operation. The “A” or “B” status of an OCU device should not be confused with the “Primary” or “Secondary” dynamic logical status of an OCU, which determines the subset of locomotive control functions available to a particular OCU.

At the time of linking the OCUs and LCU pairs agree on an encrypted data stream to be sent over the air for each connection. The MDS equipment scrambles and descrambles the data for over the air transmission and recreation of the original packet. It is up to the RCL vendor or Railroad equipment to discard BSP messages that do not exhibit the correct CRC after the descrambling operation. A security violation can be logged by the BSP logging server collecting repeater traffic, or to the event recorder at the LCU. This mechanism prevents cloning and creation rogue OCUs or playback of recorded TDMA traffic. In addition it prevents accidental creation of multiple OCUs with identical operational addresses.

The RCL vendor LCU is responsible for assigning 5-bit keys to the MDS radios at IR Link time. The MDS equipment will use these keys to scramble and descramble each message behind the

# SHL-021 MDS entraNET 220 Interface Specification

scenes. In other words, the RCL vendor equipment does not need to scramble or descramble. The following keys are used.

- LCU key (for messages from the LCU to either OCU)
- OCU A key (for messages from OCU A to the LCU)
- OCU B key (for messages from OCU B to the LCU)

The LCU key can be fixed for a given locomotive.

The OCU A key should rotate every time a new OCU links as OCU A.

The OCU B key should rotate every time a new OCU links as OCU B.

The command to set the keys is as follows:

```
ENCRYPT LCUKEY=x OCUAKEY=y OCUBKEY=z
```

where x, y, and z are numbers from 1 to 32 or zero to turn scrambling off.

## ***2.11 End to End Integrity***

For all mission critical and safety critical messages the RCL vendor message should include a 16-bit CRC reducing the actual payload to five bytes. This in addition to the error detection employed in the entraNET over the air protocol provides data integrity of less than one RCL miscommunication in every  $1 \times 10^{12}$  years were an error is consider 2 bad transmissions received as valid in a five second window.

# SHL-021 MDS entraNET 220 Interface Specification

## 3 Version History

Version	Date	Modified By	Notes
0.6	2004-01-13	T. Mayo	Corrected OEM Radio Module J1 connector definition for RXD and TXD.
0.7	2004-01-14	T. Mayo	Added information for Access Point connectors. Added information for Packaged Radio Module power connector.
0.8	2004-01-14	T. Mayo	Added Access Point photo.
0.9	2004-01-20	T. Mayo	Added correct Access Point mechanical drawings.
0.10	2004-01-22	T. Mayo	Added Login to initialization sequence for PSRM.
0.11	2004-02-06	T. Mayo	Corrected current requirement for OEM unit. Updated block diagrams for Repeater and LCU unit. Updated RADIO command. Updated I/O Connector definition. This is likely to change again.
0.12	2004-02-23	T. Mayo	Updated I/O Connector definition. Updated Security description.
0.13	2004-02-25	T. Mayo	Added ALARM_IN and ALARM_OUT signals to OCU and LCU unit connector descriptions. Changed gateNET to Access Point. Changed port connections for LCU eNET AP.
0.14	2004-03-09	T. Mayo	Changed Serial Remote to Radio Module. Corrected COM1, COM2, and COM3 descriptions. Added BSP addressing example. Updated OCU Unit J1 connector to the proper manufacturer and part number. Updated OCU Unit RF connector to straight instead of right angle SMB.
1.0	2004-05-07	T. Mayo	ALARM I/O Signal is active low. Pins 11 and 13 on J1 are RS-232 levels. RADIO subcommand is TIMESLOT, not PREFSLOT. ENCRYPT subcommands are LCU, OCUA, and OCUB, not LCUKEY, OCUAKEY, and OCUBKEY. Corrected OEM Radio Module Power Supply Requirements. Corrected RADIO MFREQ1 and BFREQ1 argument descriptions.
1.1	2004-07-21	T. Mayo	Replaced incorrect unit photos with correct photos. Added RADIO MODE=NORMAL step to initialization. Corrected I/O Connector numbering. Added a description of RADIO modes.
1.2	2004-12-02	T. Mayo	Added Over the Air Radio Module Reprogramming procedure.
1.3	2005-05-16	T. Mayo	Added information for DB-25 versions of AP and PRM.
1.4	2006-09-14	T. Mayo	Refined references, made DB-25, reprogramming, and addressing information clearer.
1.5	2006-09-26	T. Mayo	Added RS-485 pin designations to PRM DB-25 pinout table.
1.6	2006-11-06	T. Mayo	Added notes for PRM DB-25 COM1 signals.
1.8	2006-12-18	T. Mayo	Corrected photos of the entraNET 220 family members. Added description of RADIO MODE=MAINT to over the air upgrade instructions.

# SHL-021 MDS entraNET 220 Interface Specification

1.9	2006-12-19	T. Mayo	Updated line drawings to show DB-25 versions.
-----	------------	---------	---

Notes: