

Long-range Radio Data Link

pMDDLRadio

Technical Manual



Revision list

5/10/2018	Initial version
7/21/2019	Added 4.6 Serial Port Configuration
3/02/2023	2 Connections: pinout edit

1 Introduction

pMDDLRadio is an advanced high-power long-range broadband COFDM communication system for UAV. Based on the new Microhard pMDDLxxxx, the board provides the bandwidth and range needed for complex data intensive UAS applications. The solution implements some communication functions: transmission of FULL-HD video data stream, autopilot control & telemetry data. Featuring an onboard user-accessible STM32F(H)7-series MCU capable of RS422/RS232/2xCAN bus communications, incase temperature&humidity sensing, fan control, IMU data processing. This allows in one case use pMDDLRadio as system controller for antenna tracking system, in other case use pMDDLRadio as the all-in-one system unit for small UAV.

pMDDLRadio available in two versions: OEM module (requires external cooling) (fig.1 & fig.2 & fig.3); module in rugged aluminium case with military Harwin M80 data connectors and Hirose RF connectors (fig.4 & fig.5 & fig.6).



Figure 1



Figure 2

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Figure 3

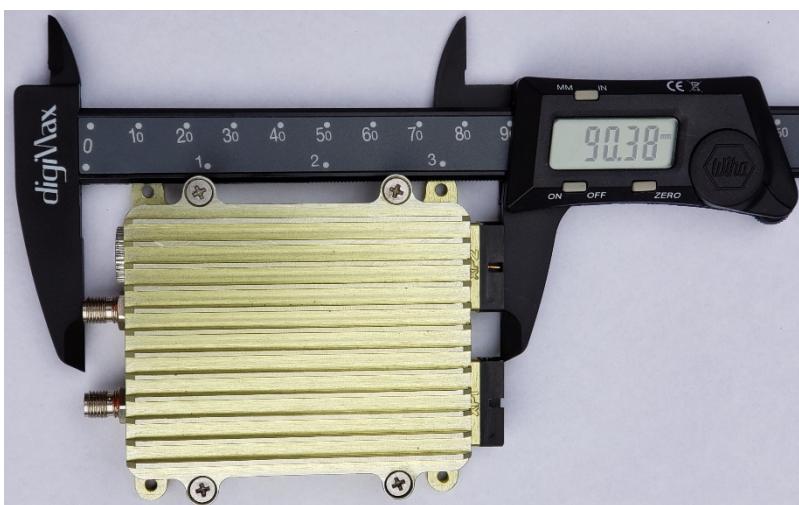


Figure 4

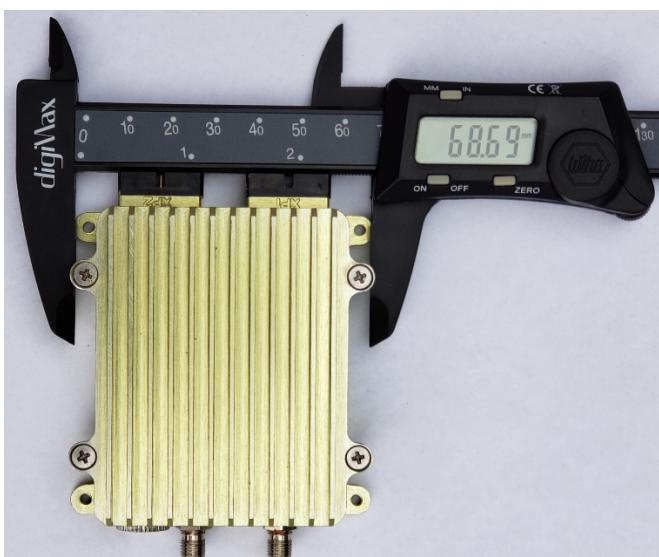


Figure 5



Figure 6

1.1 Application:

- Unmanned long-range missions
- Emergency communication deployment
- Ethernet Wireless Extension
- Wireless Control & Telemetry
- Wireless Video

1.2 Technical specification:

Matching Connectors type for OEM version:

- GPIO x 10 & Analog: Molex 5013300800 (8-pins) (socket: Molex 5011933000)
- SERIAL x 2: Molex PICO-CLASP 5013300600 (6-pins) (socket: Molex 5011933000)
- LAN & WAN: Molex CLIK-Mate 5023800800 (8-pins) (socket: Molex 5023810000)
- CAN x 2 & RS232 & RS422: Molex 5023800600 (6-pins) (socket: Molex 5023810000)
- RF x 2: U.FL

Matching Connectors type for rugged housing version:

- DATA: Harwin M80-9401005
- RF x 2: SMA-RP plug
- Anodized aluminum.
- Fixing type: intermediate bracket

1.3 Operating data:

Specification	pMDDL Radio UV01.431329.16.00
Rated voltage	12 VDC & 24 VDC
Absolute supply voltage range (min. – max.)	(5 ¹) (6 ²) 7 ... 58 VDC
Recommended power supply voltage range ³	12 VDC ... 40 VDC
Surge protection range	-80 ... 100 VDC
Current at 24 VDC (RFout = OFF, with LAN link)	0.13 A (2.98 W)
Current at 24 VDC (RFout = OFF, with LAN, w. STM32)	0.18 A (4.2 W)
Current at 24 VDC (RFout = 7 dBm, w/o iperf test, w/o STM32 ⁴)	0.14 A (3.4 W)
Current at 24 VDC (RFout = 7 dBm, iperf test)	0.29 A (6.8 W)
Current at 24 VDC (RFout = 30 dBm, iperf test)	0.45 A (11 W)
Operating Temperature Range	-40°C ... +85°C (-40°F ... +185°F)
Storage Temperature Range	-40°C ... +90°C (-40°F ... +194°F)
Weight OEM version (w/o match connector)	20 g (0.7 oz) ±10%
Weight enclosure version (w/o match connector)	90 g (3.175 oz) ±10%
IP Ratings for enclosure version	IP65
Size OEM version	50 mm x 40 mm x 13 mm
Size enclosure version	90 mm x 70 mm x 19 mm
Available interfaces	LAN & WAN; 2 x UART 3.3 TTL; 2 x CAN; RS485/232; RS422; 10 x GPIO 5.0 V; Analog diff. input; Analog single-ended input.

¹ If RFout = OFF, after starting, the supply voltage can be reduced up to 5 V, while maintaining functionality.

² If RFout = ON, after starting, the supply voltage can be reduced up to 6 V, while maintaining functionality.

³ This input voltage range provides the most optimal heating performance for the device.

⁴ STM32 – on-board microcontroller designed to implement such functions as: tracking antenna control, automatic RFout level control, interface implementation (CAN, RS422, RS485/232, GPIO)

2 Connections

For enclosure version pMDDLRadio pinout example is shown in the Figure 7. Other variants of pinouts with other sets of interfaces are possible at the request of the customer.

XP1		LAN + WAN
	Net	→
LAN	ETH_0_T+	1
	ETH_0_T-	2
	ETH_0_R+	3
	ETH_0_R-	4
Matching connector	RS485A/RS232TX	5
M80-9401005	RS485B/RS232RX	6
M80-4611005	ETH_4_T+	7
WAN	ETH_4_T-	8
	ETH_4_R+	9
	ETH_4_R-	10
	M80-561-10-05	

POWER + CONTROL	
XP2 Version B	
<i>Net</i>	→
<i>FDCAN1_H</i>	1
<i>FDCAN1_L</i>	2
<i>GND_TXRX</i>	3
<i>BDA_CTRL</i>	4
<i>GND</i>	5
<i>5-56V (100V surge)</i>	6
<i>Distance_on/off</i>	7
<i>TX-F_UART_3.3</i>	8
<i>Shield_PE</i>	9
<i>RX-F_UART_3.3</i>	10

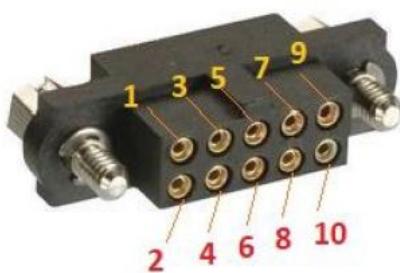


Figure 7

For OEM version pMDDLRadio pinout example is shown in the Figure 8. The first pins are marked with black dots on the connectors. Matched connectors for:

XP1, XP2 - Molex Pico-Clasp 5013300800 (8-pins) (socket: Molex 5011933000)

XP3 - Molex Pico-Clasp 5013300600 (6-pins) (socket: Molex 5011933000)

Tool hand crimper for Pico-Clasp – Molex 0638191500 (28-32 AWG wires)

XS1, XS2 - Molex CLICK-Mate 5023800600 (6-pins) (socket: Molex 5023810000)

XS6, XS7 - Molex CLICK-Mate 5023800800 (8-pins) (socket: Molex 5023810000)

Tool hand crimper for CLICK-Mate – Molex 0638194400 (26-28 AWG wires)

XS3, XS4 – Molex Mini Lite-Trap Wire-to-Board 1042380210 (22-26 AWG solid wires)

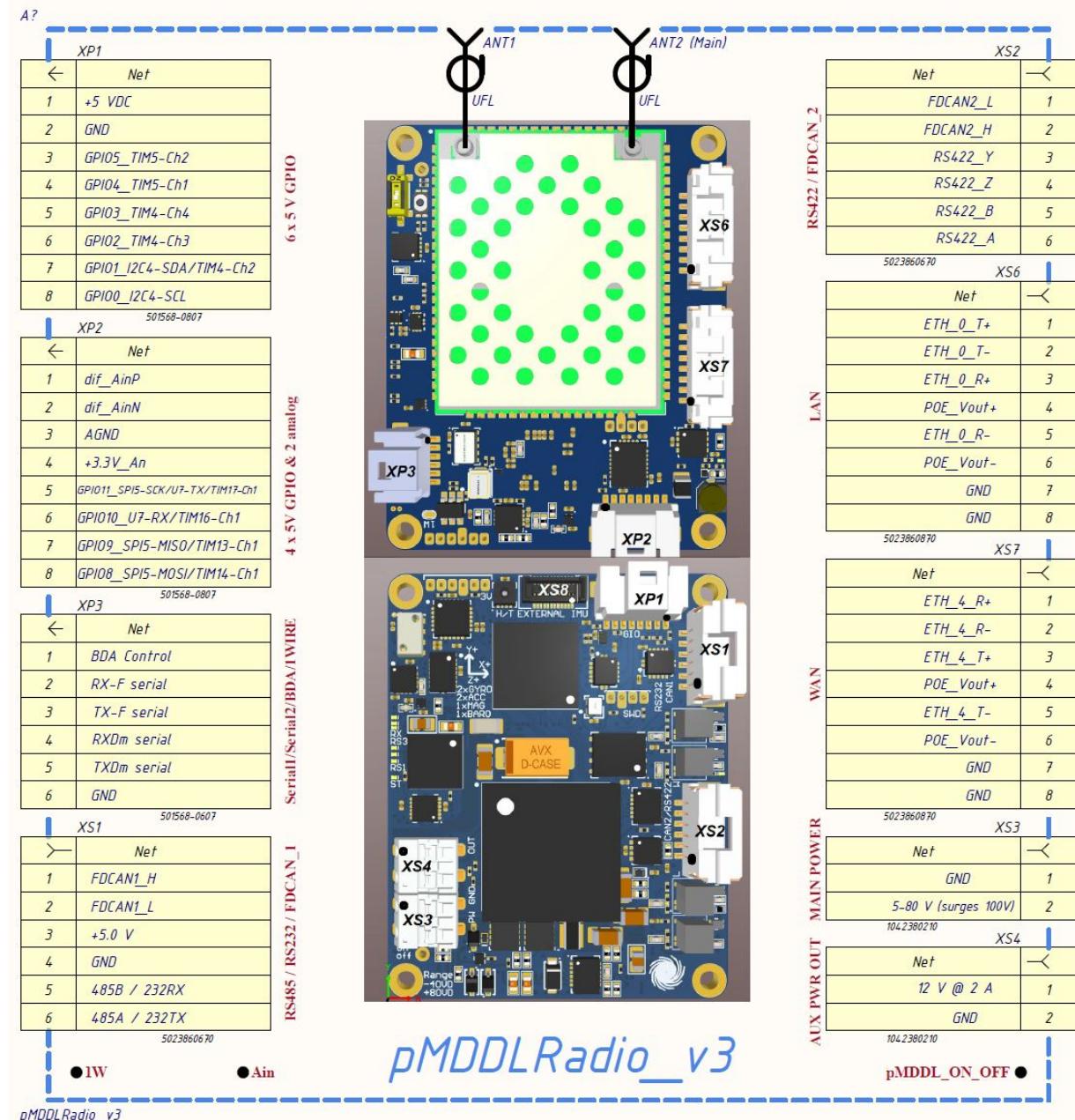


Figure 8

3 LEDs

A number of LEDs on figure 9 provide information on the pMDDLRadio status.

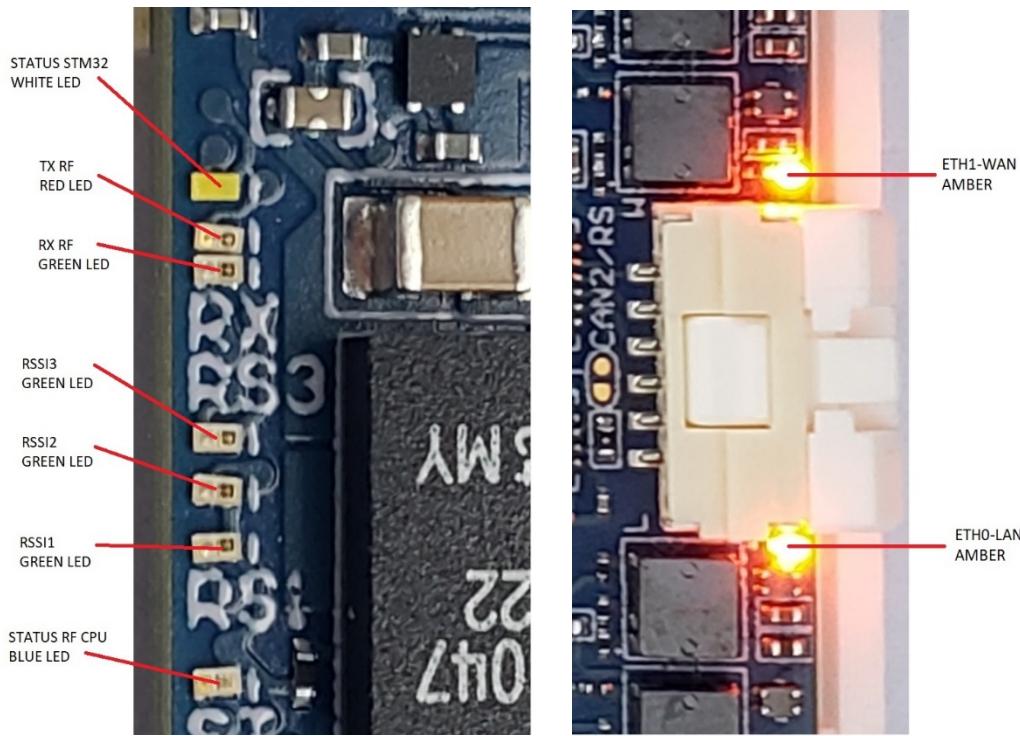


Figure 9

The RSSI LEDs provide a bar graph indication of relative signal strength (if illuminating in a repeating 1,2,3 sequence indicate the radio is searching for a signal, and if when three RSSI LEDs blink at the same time, it indicates that the radio is off).

4 Usage and Configuration

The radio has its own IP address. By default this can be accessed from the LAN ethernet port (XS6), which is the right angle 8 pin connector. The default IP address from Microhard is 192.168.168.1. By convention for UAVOS we also use IP addresses 192.168.168.100 (base station) and 192.168.168.101 (airborne). You can of course change these using Microhard's web interface. When the radios are first powered up the default user and password are both 'admin'. Microhard's firmware insists on changing the password with a minimum of 5 characters so we change it to 'uavos'. To communicate with the radio it is easiest to set your PC to a fixed IP address such as 192.168.168.99. You can then access Microhard's web page which allows changing radio settings. To get two radios to communicate with our default configuration, we make these changes:

Base station IP address: 192.168.1.100

Base station mode: 'Slave'

Remote unit IP address: 192.168.1.101

Remote unit mode: 'Master'

WAN port set to bridging mode.

4.1 Troubleshooting connections

For a successful connection the following conditions must exist:

- Radios set up with different IP addresses (typically on the same subnet)
- One radio set for 'Master' mode (typically airborne/remote side)
- One radio set for 'Slave' mode (typically the base station)

Radios set to the same frequency

- Frequency changed from the default at least once (likely due to a Microhard bug)
- Encryption settings matching (Picoradios are typically supplied in an unencrypted version unless special ordered with encryption so if communicating with an encrypted unit the encryption must be disabled).
- Antennas connected on both ends
- Sufficient RF signal strength (typically we operate at 23 dBm RF output power for lab testing).
- Reasonable RF band availability. Typically, we operate on 2479 MHz or nearby, which is slightly outside the typical wifi band.
- Lastly some antenna separation may be needed (especially if operating at high power).

4.2 Safety Precautions

Please note it is possible to damage Picoradios if they are not properly cooled. Please see the cooling section below.

- It is also possible to damage the radio if you plug or unplug an antenna connection while it is powered (it is very easy to short RF to ground when doing so).
- If using an RF amplifier, it is possible to damage the RF front end of a nearby radio if you have too much RF output power. Appropriate separation physical separation, power setting, and/or attenuation is required.
- Failures for these preventable issues is not covered by warranty.

4.3 Cooling

Some form of cooling should be used with the radio. Active cooling works extremely well. We find a small 40mm fan with 7cfm flow works extremely well. Passive cooling with a properly sized heat sink can also work fine. You may be able to use two smaller fans or find some other suitable method if integrating in a vehicle or enclosure (a thermal pad interface to an enclosure or cool plate would also work). Please note that the RF module surface needs direct heat removal. Also, if you are using accessory power, depending on the input voltage and power demands, the power modules on the opposite side from the RF module can also generate significant heat (they are very efficient but have high load capacity). As a result, we recommend blowing air over both the radio module side (first priority) as well as the opposite (power module) side.

Failure to cool the radios properly can result in radio failure or loss of connection.

In the Figure 10, you can see thermal photo of both sides of the pMDDL Radio. Which worked half an hour outdoors without refrigeration.

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Enclosure version recommended. The enclosure version is preferable because it provides optimal two-side passive cooling of the pMDDLRadio.

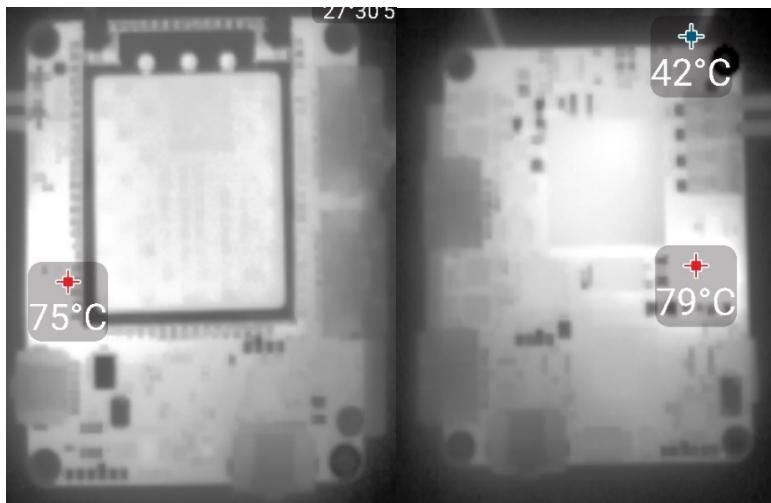


Figure 10

4.4 Radio Data Link usage

4.4.1 Getting Started

Connect an appropriate Antenna to the ANTENNA connector of the pMDDLRadio.

On the top side of the module there is a switch (see Figure 11) that selects the mode “Always ON” or “Distance ON/OFF”.

Connect and/or apply a suitable power source to the unit. And if the switch mode is in position “Distance ON/OFF” it is necessary to give a switch-on signal, for example, connect it to the power line.

To reset to factory defaults, press and hold the CONFIG for 8 seconds with the pMDDL powered up. The pMDDLxxxx will reboot with factory default settings.

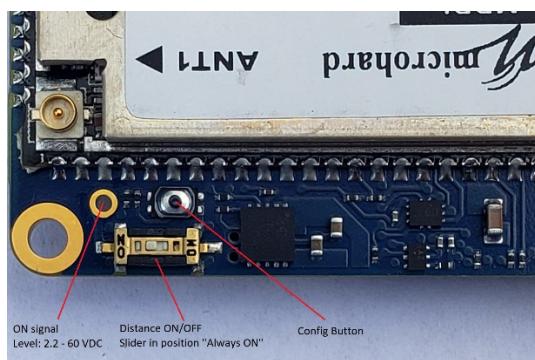


Figure 11

After turning on allow the unit to boot up fully, the STATUS RF CPU LED (Blue) should be on in a solid state (see Figure 12).

Connect A PC to the LAN port, using a custom Ethernet Cable. If the link is established, the orange LED of the port will start blinking (see Figure 12).

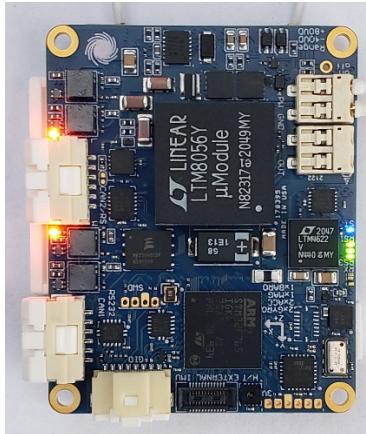


Figure 12

There are some advanced ways to take advantage of the radio.

4.4.2

MIMO mode

If a Microhard pMDDLxxxx is installed in the radio operation mode MIMO (2x2) possible. 2x2 MIMO, sometimes referred to as 2T2R, uses two antennas to establish up to two streams of data with the receiving device. Compared to ordinary single antenna networks, 2x2 offers up to a 100% increase in throughput.

With two spatial streams established, the data payload is divided across both antennas and transmitted over the same frequency band. In order for spatial multiplexing to be effective, the antennas must be well isolated and configured to provide a low correlation coefficient. Typically the most effective way to achieve low correlation in a 2x2 system is to use orthogonal polarisations, for example, using one vertically polarised antenna and one horizontally polarised antenna. You are cutting the power in half to each antenna (3dB down, plus the connector and cable losses), but of course the total power output remains the same. However the net advantage from having two transmission paths can be on the order of 10 to 15 dB, particularly for a vehicle at range which is orbiting around its target and which may be pointing the null of one antenna at a time at the base station, and/or which may be experiencing occlusions from the vehicle itself (i.e. the vehicle itself may at some times block line of sight from one antenna at a time). With 6 dB representing approximately a factor of two in range, the net 7-12 dB improvement can be a huge benefit. More information can be found at www.microhardcorp.com.

In MIMO mode total RF power is split between antenna interfaces. MIMO (2X2) features of the pMDDL can be enabled or disabled. Disabling MIMO allows up to 30dBm to be presented to ANT1 connector. When MIMO is disabled, all communication is through ANT1.

4.4.3

Rx diversity mode

The Microhard pDSDLxxxx version of the radio supports dual diversity receive. You can take advantage of this at the receive side with dual antennas on the two different ports. This feature must be enabled in configuration and two antennas must be connected if the feature is enabled.

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Transmit RF is emitted only from the 'Main' antenna port, and both ports are used for receive when diversity is enabled. Note that the Main port is always bidirectional.

4.4.4 Long-Range operation

Please note that the distance parameter on the RF configuration page should be set to a larger value than you are expecting to operate the radios at. It is also desirable for performance reasons not to set this to an excessively large number. 40 km to 100km should be acceptable (but keep it as low as possible). There may also be issues if the number is set too high (120 km). We do have another document which addresses optimization for long-range communications, please contact us for this.

4.5 External Amplifier Support

For ultra-long communication link together with the module, you can use bidirectional amplifiers (BDA) with automatic or manual switching between Tx/Rx modes. In the case of manual control for Tx/Rx switching use BDA-output (3.3 V TTL). Using GPIO and analog inputs pMDDLRadio, you can get additional information about the state of the amplifier - status, temperature and control the BYPASS mode.

Using amplifiers (usually 10W or 25W) and tracking antenna system, a communication range ~120 miles LOS can be achieved.

4.6 Microhard RF modules and Frequencies available

The pMDDLRadio unit is available to order based on the following Microhard modules: pDDL900, pDDL1800, pDDL2450, pMDDL2350, pMDDL2450, pMDDL2550.

4.7 Serial Port Configuration

Two serial ports from Microhard pMDDL2450 are available on the connector XP3 pins. The serial ports are very flexible and can be connected to in a number of ways.

4.7.1 Hardware serial port connection between two units - TCP

This is an easy to configure hardware connection, which connects serial ports on two different radio modules. An advantage is that data will never arrive out of order due to the TCP connection state. It has some potential disadvantages in terms of connection and reconnection since it does have a connection state (connected / disconnected). Below is a sample configuration which sets up a connection between COM1 of both units.

Type : pMDDLRadio Rev. No. : 5
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Client side (base station 192.168.168.100):

Serial Port Configuration

Port Configuration

Port status	<input type="button" value="Data"/>
Escape Sequence	<input type="button" value="Disabled"/>
Data Baud Rate	<input type="button" value="115200"/>
Data Format	<input type="button" value="8N1"/>
Data Mode 	<input checked="" type="radio"/> Seamless <input type="radio"/> Transparent
Character Timeout	<input type="text" value="24"/>
Maximum Packet Size	<input type="text" value="256"/>
No-Connection Data 	<input type="radio"/> Disable <input checked="" type="radio"/> Enable
MODBUS TCP Status	<input checked="" type="radio"/> Disable <input type="radio"/> Enable
IP Protocol Config	<input type="button" value="TCP Client"/>

TCP Configuration

Remote Server IP Address/Host Name	<input type="text" value="192.168.168.101"/>	<input type="button" value="Check"/>
Remote Server port	<input type="text" value="20002"/>	
Outgoing Connection Timeout(seconds)	<input type="text" value="5"/>	
Fast Recovery 	<input checked="" type="radio"/> Disable <input type="radio"/> Enable	

Server side (airborne 192.168.168.101):

Serial Port Configuration

Port Configuration

Port status	<input type="button" value="Data"/>
Escape Sequence	<input type="button" value="Disabled"/>
Data Baud Rate	<input type="button" value="115200"/>
Data Format	<input type="button" value="8N1"/>
Data Mode 	<input type="radio"/> Seamless <input checked="" type="radio"/> Transparent
Character Timeout	<input type="text" value="24"/>
Maximum Packet Size	<input type="text" value="256"/>
No-Connection Data 	<input type="radio"/> Disable <input checked="" type="radio"/> Enable
MODBUS TCP Status	<input type="radio"/> Disable <input checked="" type="radio"/> Enable
IP Protocol Config	<input type="button" value="TCP Server"/>

TCP Configuration

Server Mode	<input checked="" type="radio"/> Monitor <input type="radio"/> Polling
Polling Timeout (seconds)	<input type="text" value="10"/>
Local Listening port	<input type="text" value="20002"/>
Incoming Connection Timeout(seconds)	<input type="text" value="5"/>
Fast Recovery 	<input checked="" type="radio"/> Disable <input type="radio"/> Enable

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4.7.2 Hardware serial port connection between two units: UDP Point to Point

This method would make sense for a connection needing realtime performance and a no-state connection (such as our SBUS modules).

This configures a connection between COM1 of both units.

Base station 192.168.168.100:

Serial Port Configuration

Port Configuration

Port status	Data
Escape Sequence	Disabled
Data Baud Rate	115200
Data Format	8N1
Data Mode 	<input type="radio"/> Seamless <input checked="" type="radio"/> Transparent
Character Timeout	24
Maximum Packet Size	256
No-Connection Data 	<input type="radio"/> Disable <input checked="" type="radio"/> Enable
MODBUS TCP Status	<input checked="" type="radio"/> Disable <input type="radio"/> Enable
IP Protocol Config	UDP Point to Point

UDP Configuration

Remote IP Address/Host Name	192.168.168.101	Check
Remote port	20002	
Allow Multipoint	<input type="checkbox"/>	
Listening port	20002	
UDP Timeout(s)	10	

Airborne 192.168.168.101:

Serial Port Configuration

Port Configuration

Port status	Data
Escape Sequence	Disabled
Data Baud Rate	115200
Data Format	8N1
Data Mode 	<input type="radio"/> Seamless <input checked="" type="radio"/> Transparent
Character Timeout	24
Maximum Packet Size	256
No-Connection Data 	<input type="radio"/> Disable <input checked="" type="radio"/> Enable
MODBUS TCP Status	<input checked="" type="radio"/> Disable <input type="radio"/> Enable
IP Protocol Config	UDP Point to Point

UDP Configuration

Remote IP Address/Host Name	192.168.168.100	Check
Remote port	20002	
Allow Multipoint	<input type="checkbox"/>	
Listening port	20002	
UDP Timeout(s)	10	

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4.7.3 Logical TCP connection to one remote serial port (easiest method to test with Pixhawk bidirectional telemetry)

This could make sense for an application which connects to the serial port using a TCP style connection (such as MissionPlanner's TCP mode, or the telnet commandline tool).

To configure this method simply use the server side connection from 'Hardware serial port connection between two units – TCP' above. Note that the base station serial configuration should remain unconfigured, i.e. should not connect as a TCP client to the airborne port. To connect to the serial stream you make a direct TCP connection to the airborne radio on the TCP server port.

Recent versions of firmware also have a TCP timeout, it may be necessary to increase this value somewhat from the default.

Airborne i.e. 192.168.168.101:

Serial Port Configuration

Port Configuration	
Port status	<input type="button" value="Data"/>
Escape Sequence	<input type="button" value="Disabled"/>
Data Baud Rate	<input type="button" value="115200"/>
Data Format	<input type="button" value="8N1"/>
Data Mode 	<input type="radio"/> Seamless <input checked="" type="radio"/> Transparent
Character Timeout	<input type="button" value="24"/>
Maximum Packet Size	<input type="button" value="256"/>
No-Connection Data 	<input type="radio"/> Disable <input checked="" type="radio"/> Enable
MODBUS TCP Status	<input checked="" type="radio"/> Disable <input type="radio"/> Enable
IP Protocol Config	<input type="button" value="TCP Server"/>

TCP Configuration	
Server Mode	<input checked="" type="radio"/> Monitor <input type="radio"/> Polling
Polling Timeout (seconds)	<input type="button" value="10"/>
Local Listening port	<input type="button" value="20002"/>
Incoming Connection Timeout(seconds)	<input type="button" value="5"/>
Fast Recovery 	<input checked="" type="radio"/> Disable <input type="radio"/> Enable

Then you can telnet to the port, for example:

telnet 192.168.168.2 20002

or in the case of MissionPlanner you can the TCP connection method.

4.7.4 Logical Point to Point UDP connection to one remote serial port

This method is also connectionless and allows an application to make a logical connection to a remote unit with a serial port. Each side must be configured to communicate with the remote IP address and port number, and a listen port which must match. Each side sends a packet to the other unit, with an IP address and destination port, and also listens on a listen port. These port numbers can match or can be different. The key is the packet that is sent has a destination address and port number. So each unit has to know the other side's IP address and listen port.

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4.8 Mechanical Drawing

Below are the drawings for the two available versions of the pMDDLRadio unit.

8 7 6 5 4 3 2 1

F

F

E

E

D

D

C

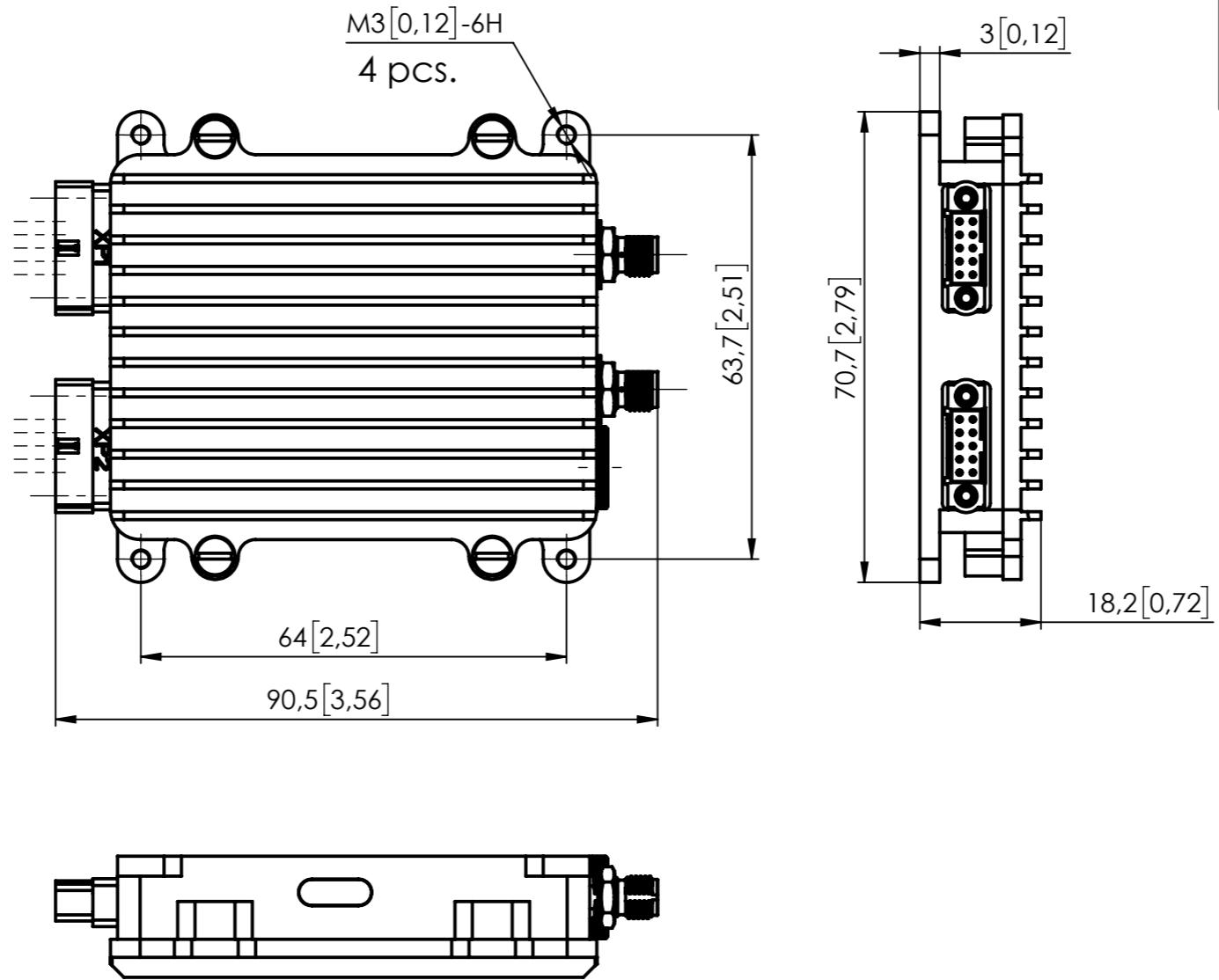
C

B

B

A

A



Technical information:

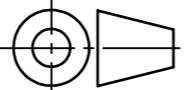
1. Operating temperature from -40 to 65 °C;
2. Power supply - from 7 to 58VDC;
3. Power consumption max - 12W;
4. Matching connectors Harwin M80-4611005 Socket- 2 pcs.

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UNLESS OTHERWISE SPECIFIED
DIM ARE IN MILLIMETERS
[DIM ARE IN INCHES]
TOL ON ANGLES $\pm 0.5^\circ$
0 PLACE ± 0.5 1 PLACE ± 0.1
INTERPRET DIM AND TOL
PER ASME Y14.5M
Surface Finish: Ra3.2

THIRD ANGLE PROJECTION

NEXT ASSY USED ON
APPLICATION



DRAFTER

CHECKER

DEV ENGR

CONTRACT NO.

UAVOS FUNDED

MATERIAL

**UAVOS Inc.****Data link**

TITLE

SIZE

A3

CAGE CODE

DRAWING NUMBER

UV01.431329.16.00

REV

10

SCALE

1:1

WEIGHT, g

90

SHEET

1 OF 1

8

7

6

5

4

3

2

1