Picoradio Manual

Airborne Innovations LLC

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Revision History

07/26/16	Initial version
02/24/17	Added serial configuration
07/17/17	Updated safety precautions, radio options, serial port info, added mechanical drawing, long range comms, ethernet switch info
08/11/17	Added technical note on J5 serial
08/08/18	Updated serial port pinout diagram

Table of Contents

1   Introduction

This document is a manual covering features and usage of the Airborne Innovations Picoradio OEM board.

Warning: Make sure you read and follow the section 3.2, 'Safety Precautions' to avoid damaging the Picoradio.

2   Picoradio features

The Picoradio is based around the Microhard pDDL radio, an advanced broadband COFDM datalink capable of high speed radio transmission and dual diversity receive. The board includes robust connectors, dual ethernet ports, and a transparent serial port (with switchable RS232/3.3V TTL operation). The board also has an advanced wide input range power system capable of operating from Lithium battery power, aircraft, or Power Over Ethernet voltage ranges as well as an auxiliary power output to drive other devices. It is intended to be a complete full-featured but minimum size replacement for the Microhard radio motherboard. Bandwidth of up to 25 Mbps is possible. Advanced features such as mesh networking will be available in the near future. AES128/256 encryption available (subject to control under the Export Administration Regulations,"EAR")

Figure 2: Picoradio board, approximately actual size
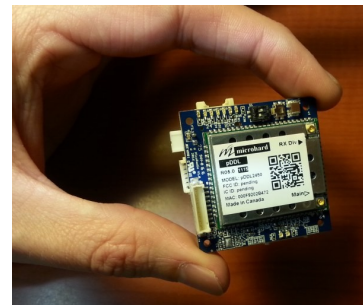
Figure 1: Picoradio size comparision

2.1   Interfaces

Interfaces on the board include:

- Wide range power input: 5-58V
- Auxiliary power output: 12V@2A+ (Some other output voltages may be factory configurable in the range of 6-20V)
- Dual ethernet interfaces (LAN / WAN / bridged). These can act in a bridged configuration (i.e. as an ethernet switch), or as independently configurable IP segments.
- Serial ports (one switchable 3.3V TTL/RS232, and one fixed 3.3V TTL).   Note both ports are functional (and have been since the initial release).
- Full set of LEDs (Power, Tx,Rx, LAN,WAN, RSSI x3)
- Reset button

2.2   Physical

Dimensions: 40x40x10mm

Weight (with radio module) 17.6 grams

2.3   Radio options

We can supply the 2.4 GHz version in an unencrypted version (our default option), or for domestic customers we can supply the encrypted version (at the moment this may require a somewhat longer lead time). We are working on availability of encrypted versions for international customers.

We have also built a limited number of dual 2.4 GHz / 900 MHz radios (without diversity). Contact us for availability if interested.

A 1.8 GHz version may be available in the near future.

2.4   Connectors
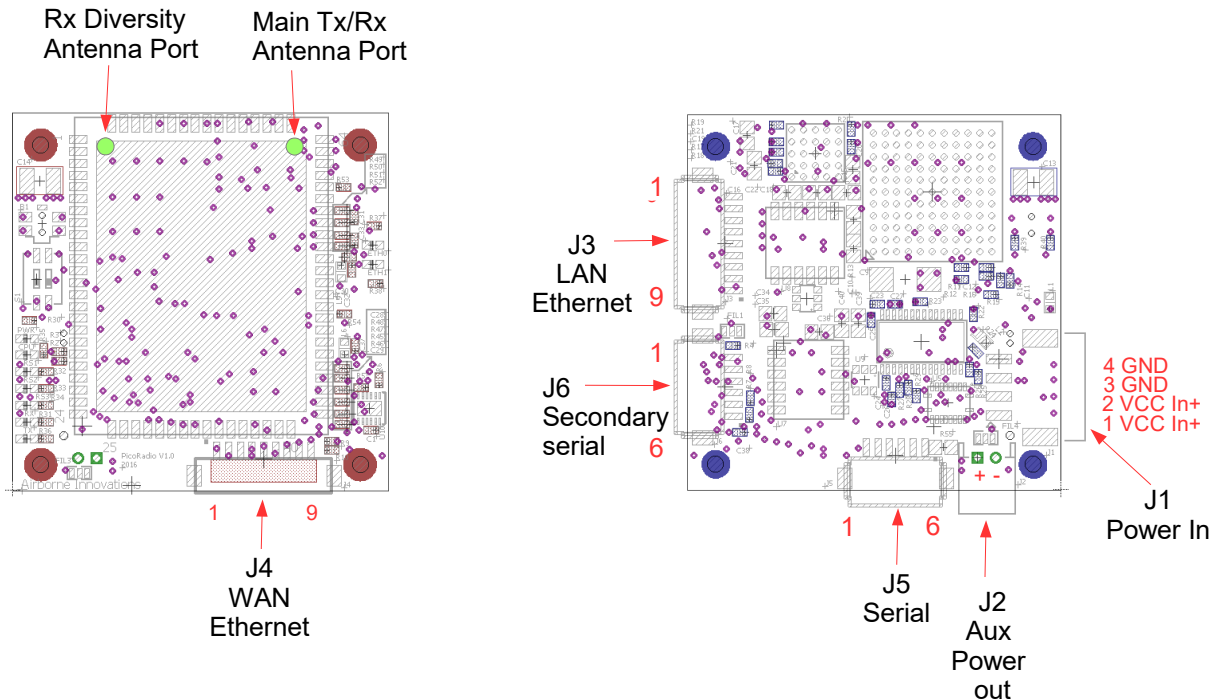
Figure 3: Picoradio Connectors

2.4.1   J1: Power Input

Power input uses a wide input range efficient buck-boost converter (Typical efficiency ~94%). Input voltage range is 5-58V (note for full RF power radio operation the minimum voltage may be limited to about 7-8V). Short pins 1,2 and 3,4 together for full current capacity.

Mating connector is a JST PA series latching connector:

Mating Connector: JST PAP-04V-S

Contacts: JST SPHD-001T-P0.5

(Current rating is 3A per pin)

Pin#	Description
1	VCC In 5-58V
2	VCC In 5-58V
3	GND
4	GND

2.4.2   J2: Auxiliary Power Output

Auxiliary power out is available from this connector. The default output is 12V. Current available depends on the input voltage and RF output power setting of the radio (testing for your desired operating range is recommended).

Current available depends somewhat on voltage input and demand from the radio board. (for example, not including the radio requirements, at 12V/1.7A output @ 6V in. 12V/3.4A output @ 12V in, 12V/5.4A output @ 24Vin).

The radio uses approximately 4.4W of power maximum from the second state regulator (which by default is taken from the 12V supply, and does not take into account that the 2nd stage switcher is about 90% efficient).

The connector may be limited to approximately 2A. You can bypass the connector and solder directly to the board for higher current (or test accordingly).

In some cases and for high volume customers we may be able to factory adjust the output voltage within the range of 8-20 volts (or even leave off this feature for a cost reduced version if you can provide 8-20V regulated input).

Mating connector is a 2mm pitch Molex connector (also compatible with JST PH series such as PHR-2):

Mating Connector: Molex 0873690200

Contacts: Molex 0502128000

Pin#	Description
1	Aux Power Out 12V@ typically 2+ amps
2	GND

2.4.3   Ethernet connectors

       J3: LAN ethernet connector (ETH0)

       J4: WAN ethernet connector (ETH1)

These connectors have identical pinouts. The initial configuration connector is the LAN connector (right angle connector on the board side opposite the radio). The WAN connector is the vertical connector on the same side as the radio.

Mating Connector: JST GHR-09V-S

Contacts: JST MINI-SSHL-002T-P0.2

Pin#	Description
1	ETH_1_T+
2	ETH_2_T-
3	ETH_3_R+
4	POE_Vin+
5	ETH_6_R-
6	POE_Vin-
7	NC
8	Link LED (disconnected by default- to connect a zero ohm resistor needs to be placed)
9	GND

The ethernet connections are also labeled with their typical pin number in an 10/100 RJ45 cable (1,2,3,6).

Note that a power input connection is available which may be capable of powering the radio board in some cases. This is pseudo-POE (Power Over Ethernet)- power is not shared with data lines but it may be sent over the connector, if the voltage is high enough to keep total current low enough for the connector and ethernet cable (typically 48V). Do not connect unless using this feature – note they will also mirror the input voltage if powered from the main input power connector.

2.4.4	J5: Serial connector

This serial port can be configured as a transparent serial connection to a serial device, either with RS232 voltage levels or 3.3V TTL voltage levels (with 5V tolerant inputs).

Note that the DIP switch S1 configures RS232 or TTL mode for this port.

Mating connector: JST GHR-06V-S

Contacts: JST MINI-SSHL-002T-P0.2

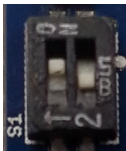| Pin#	Description
1	VCC +5V out
2	RX (Serial input)
3	TX (Serial output)
4	RTS
5	CTS
6	GND

2.4.5	S1: RS232/TTL mode DIP Switch

This DIP switch controls whether J5 operates in RS232 or 3.3V TTL mode.

Only one of the switches should be enabled at a time (do not turn both switches to ON mode).

SW1: Enables RS232 mode
SW2: Enables 3.3V TTL mode

Figure 3: RS232/TTL switch
(RS232 mode shown)

2.4.6   Technical note on the implementation of J5 Serial

J5 uses a TXS0108ERGYR voltage translator / buffer with open drain capability, and a parallel MAX3243EEUI+ for switchable RS232 compatibility (with some added constraints due to this particular implementation). The TXS0108 in particular has some unique features which put some constraints on operation. It can support open drain as well as push-pull operation. The TXS0108 has no fixed input/output direction and so it attempts to auto-detect transmit and receive direction. Pull-up resistors are integrated into the TXS0108, which can dynamically switch the value of the pull-up depending on whether a low or high is being passed. **Current sourcing capability for this port is low (see TXS0108 datasheet)** due to a series 4K resistor inside the IC (see TXS0108 datasheet). Our implementation adds additional 120 ohm resistors in series with the external transmit and receive lines.

For more information please see: http://www.ti.com/lit/an/scea044/scea044.pdf and http://www.ti.com/lit/ds/symlink/txs0108e.pdf

Due to the constraints of this switchable implementation and the TXS0108 hardware implementation, a loopback test between TX and RX of the same serial port will need a pull-up resistor to function properly. A 1K pull-up to 3.3V does allow this test to pass. Connecting the two pins directly without this may cause somewhat increased current draw.

A serial loop between J5 and J6 works fine without a pull-up, as does interfacing to an FTDI interface, or our own SBUS to serial and serial to SBUS interface modules, external GPS modules we have tried, and many other devices we have connected.

We have reports that some Pixhawk hardware does not work with this port (with our original Pixhawk both telem1 and telem2 work fine with both J5 and J6, no pull-up required). Apparently all Pixhawks work fine with J6 (which has simpler serial interface circuitry).

If you do need to get telemetry to a Pixhawk working over J5 (and the J6 workaround is not sufficient for some reason), then you may have success with an external level translator such as those available from Pololu / Sparkfun.

2.4.7   J6: Secondary serial

This connector is a second serial port (3.3V TTL only). The pin outs are the same as J5. The port is designated as 'USB0' in Microhard's interface.

This serial connector functions with the Pixhawk, and has a compatible pinout and identical connector for a Pixhawk avionics to plug in with a straight through cable (disconnecting the VCC 5V output).

2.5   LEDs

A number of status LEDs provide information on the radio status.
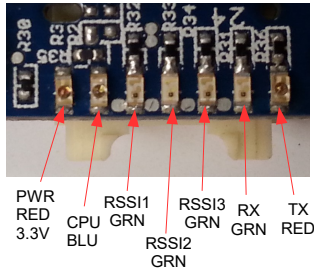
The RSSI LEDs provide a bar graph indication of relative signal strength (and if illuminating in a repeating 1,2,3 sequence indicate the radio is searching for a signal).
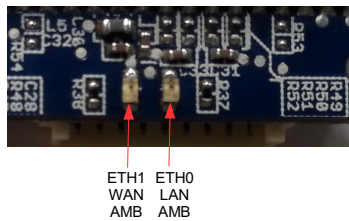
3   Usage and Configuration

The radio has its own IP address.

By default this can be accessed from the LAN ethernet port (ETH0 / J3), which is the right angle 9 pin connector..

The default IP address from Microhard is 192.168.168.1. By convention for Airborne Innovations systems we also use IP addresses 192.168.1.201 (base station) and 192.168.1.210 (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 '99999'

To communicate with the radio it is easiest to set your PC to a fixed IP address such as 192.168.168.100.

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: 192.168.1.201

Base station mode: 'Slave'

Remote unit IP address: 192.168.1.210

Remote unit mode: 'Master'

WAN port set to bridging mode.

3.1   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).

3.2   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.

3.3   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.

3.4   Radio usage

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

3.4.1   Rx diversity

The 2.4 GHz 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. 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.

However there is a way to create two transmission paths:

3.4.2   Dual transmission path and dual diversity

With a COFDM radio you can split the transmit power into two paths by simply adding a splitter and running the signal to two antennas. 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

3.4.3   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.

3.5   Serial Port Configuration

The serial ports are very flexible and can be connected to in a number of ways.

3.5.1   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.

Client side (base station 192.168.168.1):   Server side (airborne 192.168.168.2):

3.5.2   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 192.168.168.1:   Airborne 192.168.168.2:

3.5.3   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. 192.168.168.2:

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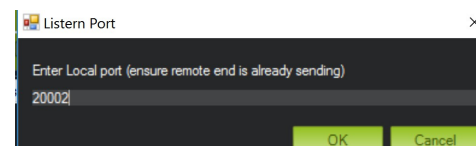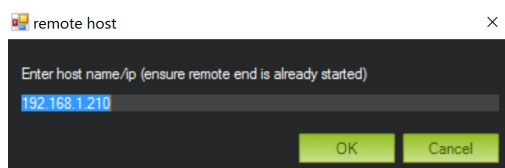
3.5.4   Logical Point to Point UDP connection to one remote serial port

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.

3.5.5   Other serial connection methods

There are also methods to connect via point to multipoint.

3.5.6   Virtual Com Port drivers

For applications which only understand hardware serial connections, you can use a virtual com port driver (which would typically run on Windows or Linux). There are freeware and commercial drivers available. This makes the logical connection and creates a virtual serial port on the PC which can be connected to exactly like a hardware serial port on the PC.

3.6   RF Amplifier Support

The Picoradio may be used with a number of different RF amplifiers (regulatory issues apply and must be addressed by the user). AI can supply an 8W bidirectional RF amplifier which can be used, and which autodetects the TX/RX direction. We do have support for RF amplifiers which require TX/RX directional control as well (contact us if you need this feature).

3.7   Additional Ethernet Switch

Picoradio has two ethernet ports which can function as an ethernet switch to connect and multiplex data from multiple ethernet devices. However if you need more we can supply a miniature 5 port ethernet switch which can be used with other devices such as our Pico series HD video encoders.
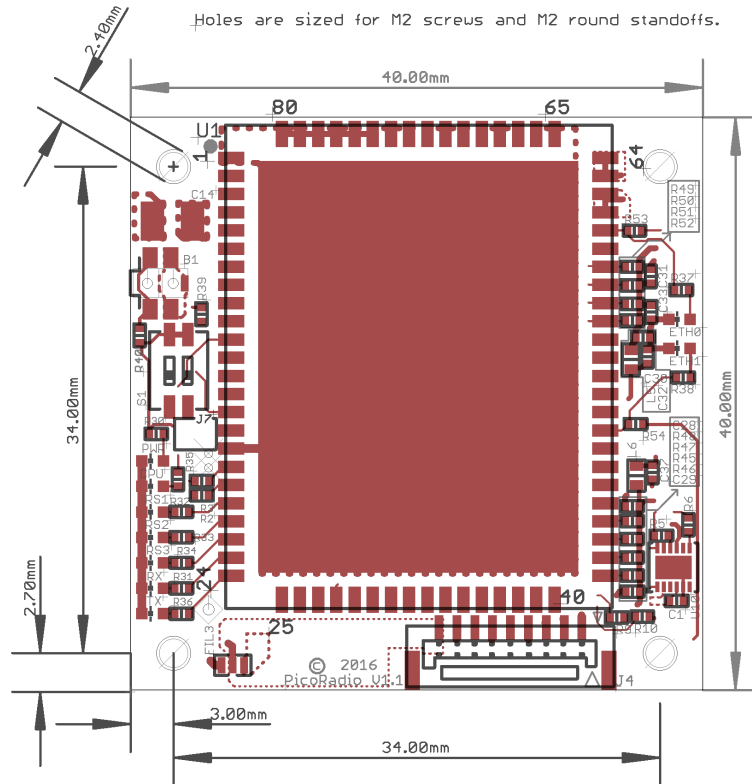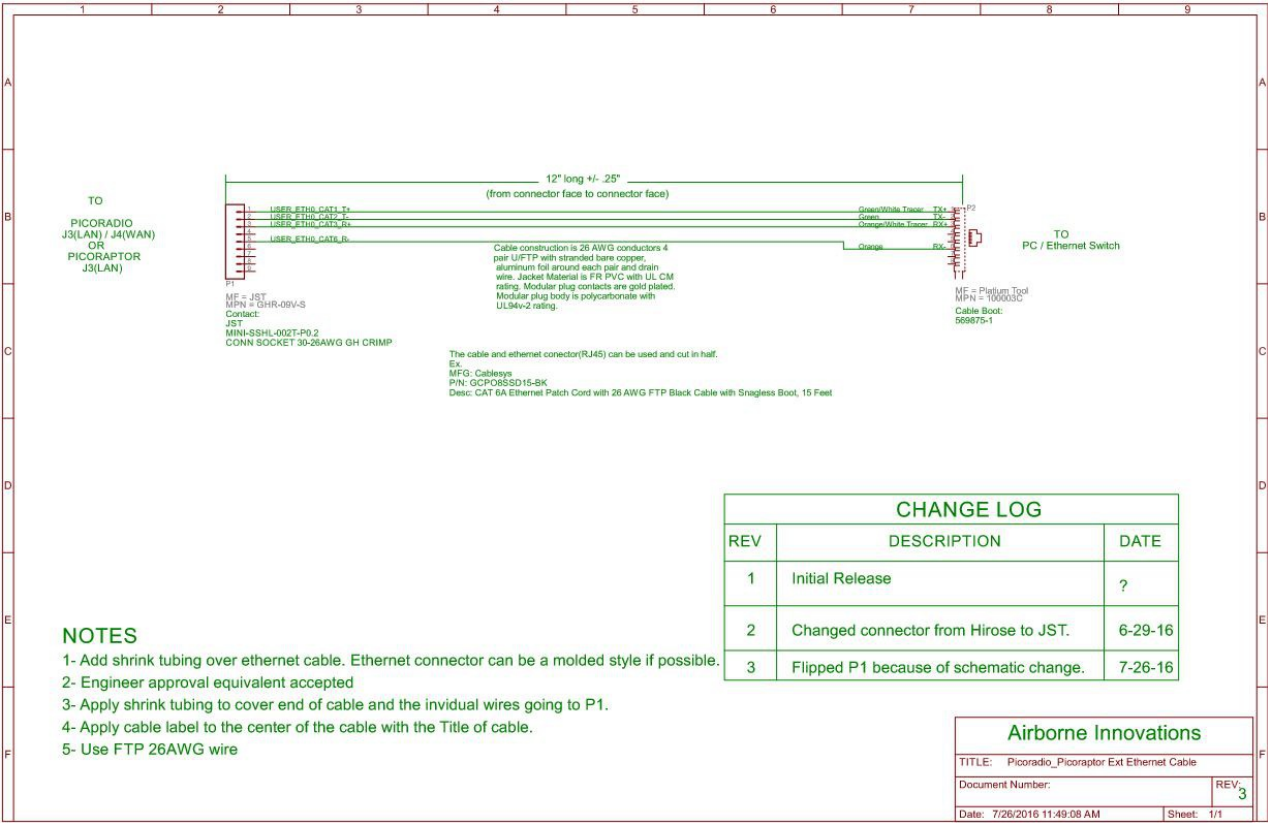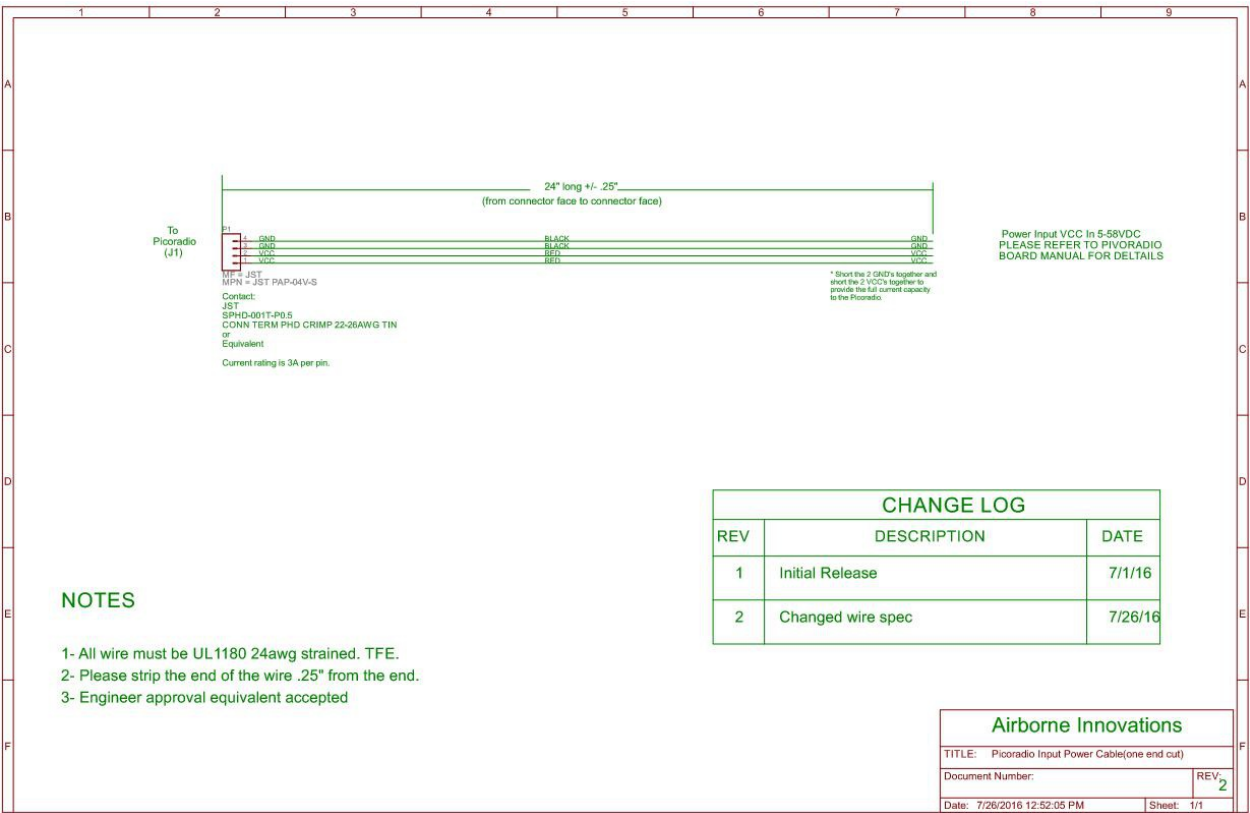
3.8   Mechanical Drawing

Figure 4: Picoradio mechanical drawing

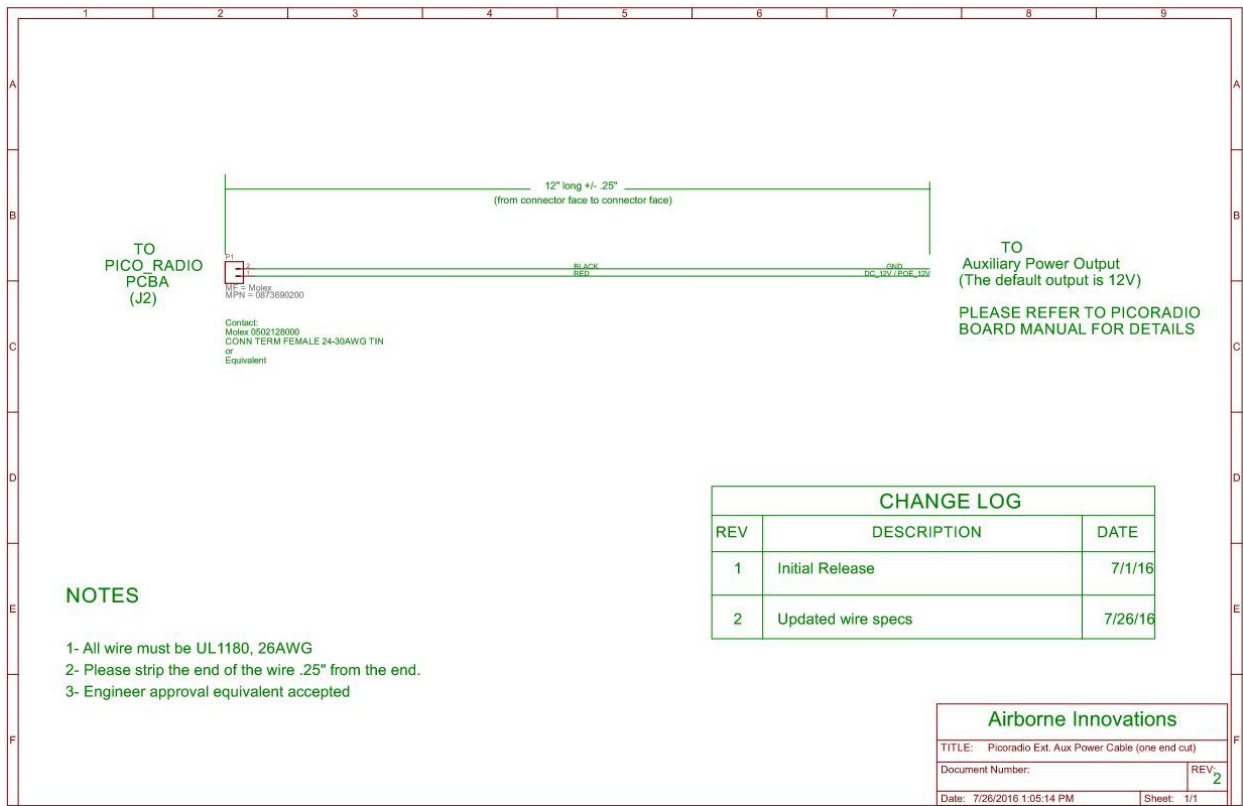## 3.9   Picoradio Cable/Antenna Kit

3.9.1   Picoradio_Picoraptor Ext Ethernet Cable

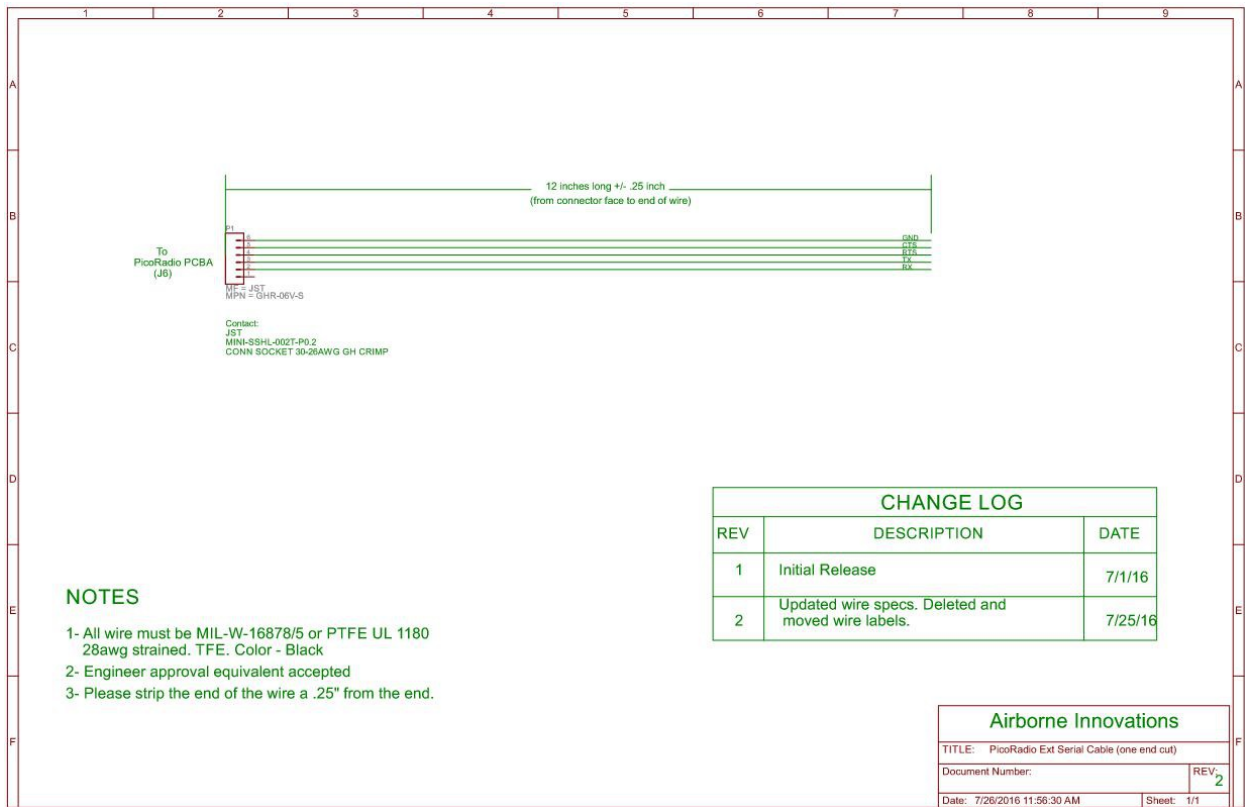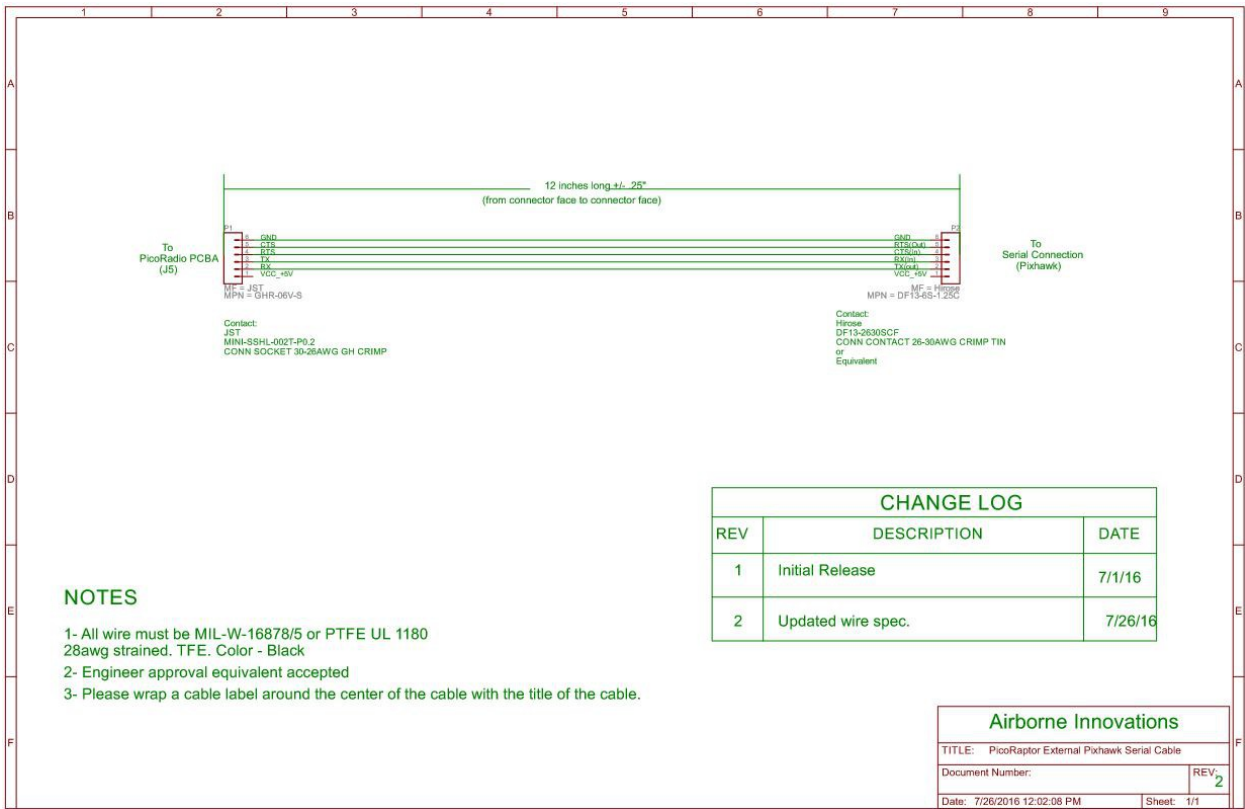### 3.9.2   Picoradio Input Power Cable(one end cut)

3.9.3 Picoradio Ext. Aux Power Cable (one end cut)

PicoRaptor External Pixhawk Serial Cable

3.9.4   Antenna Cable, U.FL to RP-SMA-Female

No Drawing Available

3.9.5   2.4 GHz. Dipole ¼ wave Antenna, Connector, RP-SMA Male *

No Drawing Available

*Antenna provided is for short range and bench testing.

3.9.6   DC Power Female Jack to Terminal Block Adapter

No Drawing Available