Oregon RFID

Low Frequency Installation Guide

WARNING:

Do not turn on the reader without an antenna connected. The reader will be damaged.

Be sure to turn the power off before making any wiring changes.

CONTENTS

ABOUT RFID READERS

An Oregon RFID reader is a self-contained monitoring station that records detections of half duplex (HDX) Passive Integrated Transponders (PIT tags) that pass within range of the antenna. The reader is designed for long term unattended operation. Up to 10 million records can be stored in a database kept on an SD flash memory card.

The reader will operate from a direct current (DC) power source. The current consumption varies between 0.5 to 3 amps. The actual amount depends on the antenna design and reader speed settings.

When operating from batteries, the reader prevents damage by monitoring the supply voltage and it will stop scanning when the power level is too low. The reader will restart again when the power level rises.

Single Antenna Reader

Multiple Antenna Reader

BASIC SYSTEM

The Oregon RFID reader requires a power source and an RFID antenna. The simplest configuration consists of a reader with a deep cycle marine battery in a field box. More elaborate structures are used for long term or permanent stations.

The reader includes tuning capacitors that are mounted near the antenna. These are tuned so that the antenna resonates ("rings") at the proper frequency.

POWER

POWER SOURCE

The reader can be operated from 7 to 20 volts. Higher voltages can increase the reader performance. Most systems will run well at 12 to 14 volts, either from batteries or AC/DC power supplies.

The reader should be placed in an outdoor enclosure along with batteries and tools. The reader electronics can handle wide temperature ranges but it is a good idea to keep batteries from extreme heat or cold. Fans and battery heaters may be necessary in some situations.

Batteries are an inexpensive and dependable power source. With enough batteries a reader can run for many days or weeks.

An AC-DC power supply can be used if AC power is available. It is very important that the power supply be electrically quiet (minimum ripple) or it will interfere with the reader.

Other power sources that can be used are solar panels, gas-powered thermoelectric generators and micro-hydro. power system.

Contact Oregon RFID for help selecting an appropriate power source.

Multiple batteries
for longer runtime

SOLAR POWER

A solar panel generates quiet DC energy but the power level changes with the amount of sun. A solar controller is used to regulate the power from the panel. Controllers need to be chosen that won't generate electrical noise to interfere with the reader.

The controller that is used must provide sufficient power for the reader and charge the batteries simultaneously. The reader consumption is the effective amperage (EA) calculated by the datalogger. Choose a solar power controller that is somewhat higher than the maximum load level expected.

A good reference is USGS Open Report 00-128, "Solar Electric Power for Instruments at Remote Sites," available from usgs.gov.

If the charger noise can't be eliminated there is a circuit that was developed by NOAA/NMFS that charges one set of batteries while the reader operates from another. Relays switch between the banks periodically to maintain the charge on both. A link to more information is available on the Oregon RFID web site.

Contact ORFID for more information on using solar power.

BATTERY POWER

The simplest and most common way to power readers in the field is using deep cycle marine batteries. They supply the quiet ripple-less power that is needed for RFID.

The reader contains a self-resetting fuse at the power inlet to protect against faults. The reader has protection against reverse polarity connections.

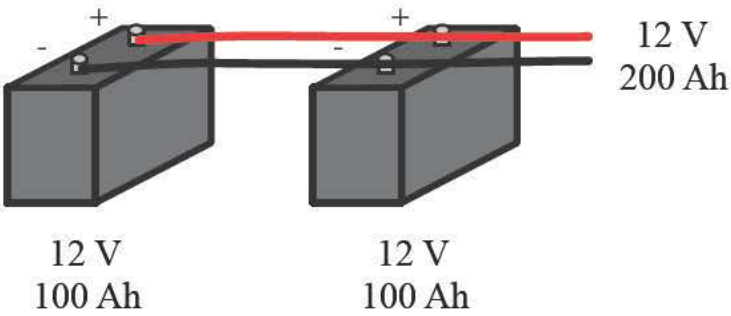
Runtime hours = battery amp hours/reader effective amperage

Example: 130 Ah/1 A = 130 hours

The amount of power that a reader consumes depends on the antenna design. The effective amperage is measured by the datalogger to estimate the battery run time.

For example with a 100 Ah battery, a reader that is drawing 1 amp will run for 100 hours. It will run 50 hours at 2 amps.

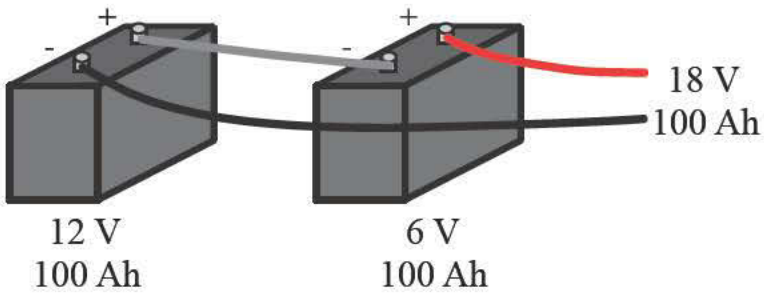
Operating time can be increased by connecting additional batteries in parallel.



Two batteries wired in parallel produce the same voltage and sums the amperages.

HIGHER VOLTAGE OPERATION

Some antennas, particularly very large ones, will perform well if the supply voltage is increased. We recommend using 12 and 6 volt batteries in series. Two 12 volt batteries will damage the reader since the combined voltage (24 volts) is over the maximum allowed (20 volts).



Two batteries wired in series produce the sum of the voltages with the same current capacity.

AC POWER

If AC power is available, an AC-DC supply can be used. The supply should be a linear design (not switcher).

A way to evaluate the quality of the supply is to compare it with a battery,. If the read range and amperage is the same, the supply is sufficiently quiet.

ANTENNAS

TOOLS

These are the tools used to build and test antennas.

Flat blade screwdriver

2.5mm, 3.5mm screwdrivers

Nonmetallic screwdriver

Plastic long tape measure (150’, 50m)

Nonmetallic yardstick or meter measure

Pliers

Thin needlenose pliers

Wire cutters

ANTENNA WIRE

The choice of wire is critical when designing an RFID antenna. In general, thin wire is used for small antennas and thick wire for large. The proper wire size can be determined with antenna design software, by duplicating an existing design, or by using trial and error. Oregon RFID technical support can help choose the appropriate wire size.

American Wire Gauge (AWG)	wire diameter inches	wire diameter mm
1/0	0.325	8.3
2	0.258	6.6
4	0.204	5.2
6	0.162	4.1
8	0.128	3.3
10	0.102	2.6
12	0.081	2.1
14	0.064	1.6
16	0.051	1.3
18	0.04	1.0
20	0.032	0.8
22	0.025	0.6

Source: ASTM B258-96

In North America the nominal size of wire is specified by a gauge. The wire sizes useful for antenna design are shown in this table.

The values shown are for solid wire.

0/1 AWG

10 AWG

22 AWG

STRANDED WIRE

Stranded wire can be made from many thin wires or a few thick ones. Stranded wire for a gauge will usually be larger than the solid wire size. A complete description includes three numbers: the overall gauge, the number of strands and the gauge of one strand. For example, a common 10 AWG wire is 19/24 which is made from 19 strands of 24 gauge wire.

INDUCTANCE

An antenna loop must have an inductance value that falls within the tuning range determined by the RFID reader. Inductance is the magnetic capacity that the loop can store and is measured in units of Henries.

For antennas to be used with the Oregon RFID HDX readers the inductance range is 8 and 80 µH. Inductance is measured with a handheld meter.

These are the primary factors that determine loop inductance:

Increase inductance	Decrease inductance
more turns	fewer turns
closer turn spacing	wider turn spacing
decrease loop size	increase loop size

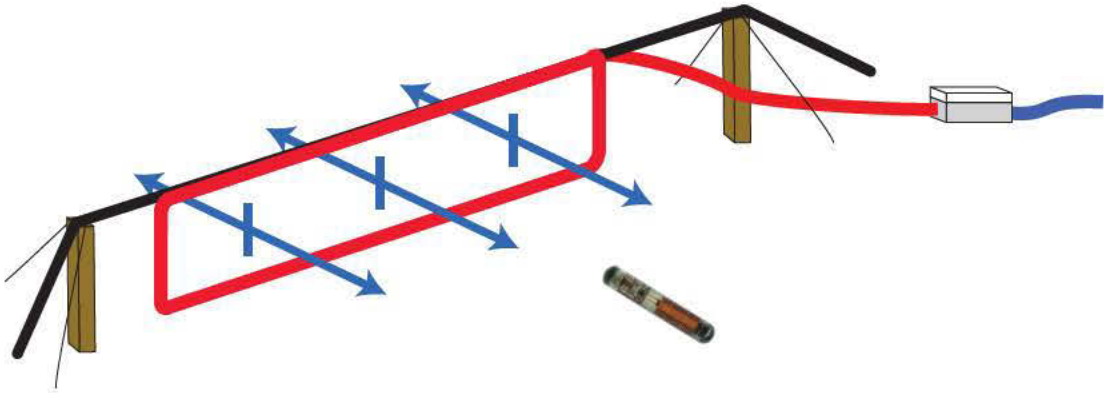
ANTENNA DESIGN

An antenna for low frequency RFID must be a loop in order to generate the magnetic field that charges the tag.

The starting point for a new antenna design is to define the loop size and shape needed. This is usually determined by where the antenna will be located.

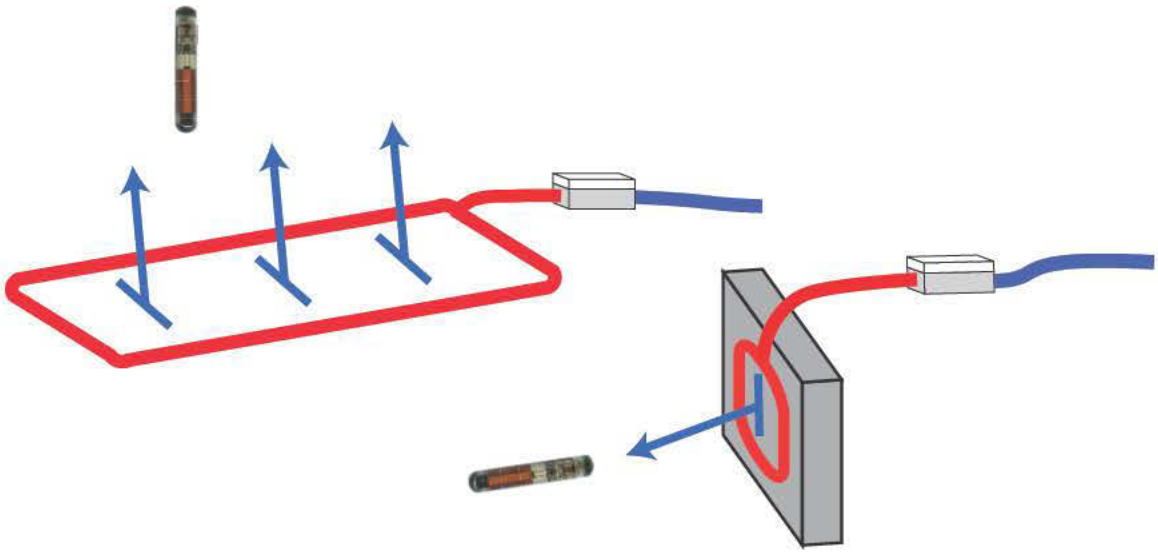
The antenna can be mounted vertically (pass-through or pass-by) or horizontally (pass-over). The sense zone in a pass-through antenna extends in front and behind the loop.

Large pass-through loops can cover a wide stream or passageway. The zone size is twice the read range of the tag from the wire.

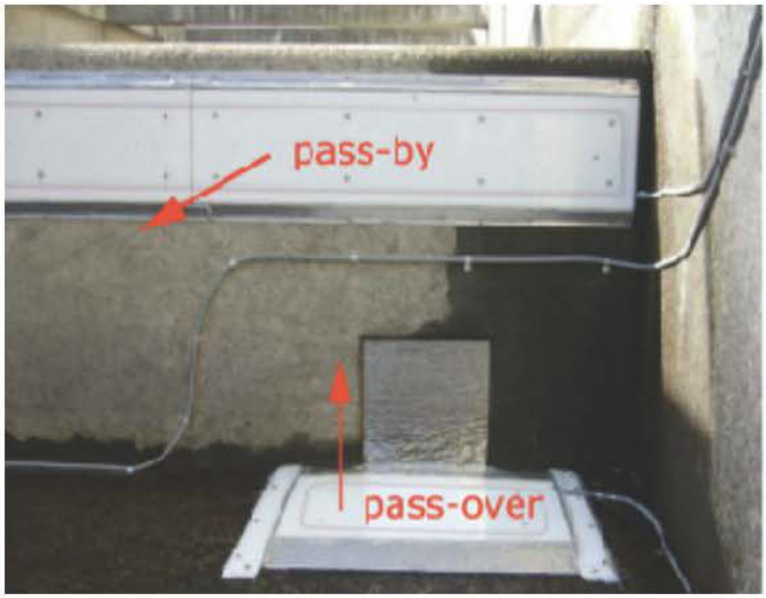


PASS-BY, PASS-OVER

Pass-by and pass-over antennas lie on the bottom or side of a channel. They can only use half of the available magnetic field since the other half is behind or under the antenna.



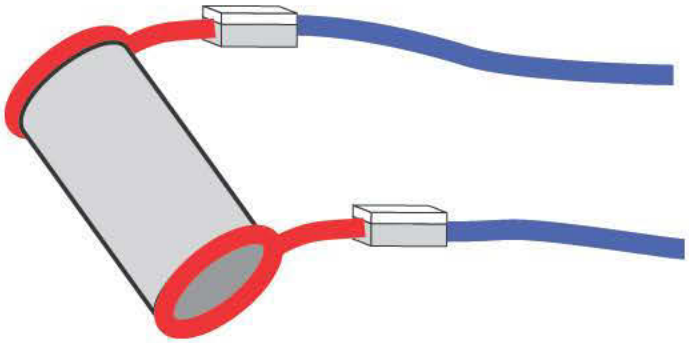
Optimum tag orientation



CIRCULAR ANTENNAS

Culverts make ideal locations for antennas since they are a clearly defined channel that an RFID antenna can encircle. Two antennas can be used to determine direction of motion by comparing detection times.

Antennas can be made from plastic tubing or pipe and placed at the edge. Culverts made from metal present special challenges.

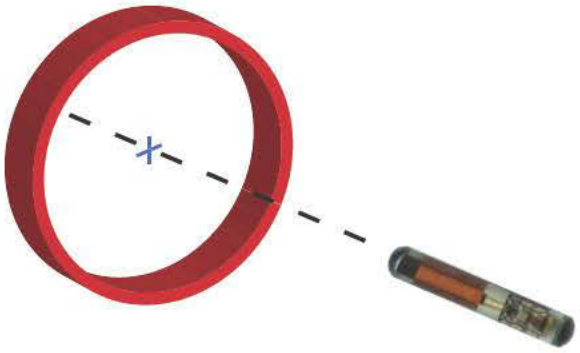


TAG ORIENTATION

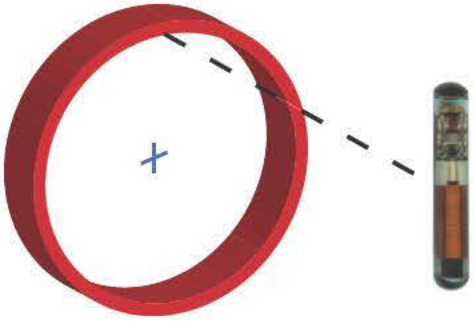
It is important to consider the orientation of the tag's long axis to the antenna loop plane. The angle of intersection can significantly change the tag's read range.

When testing read range these two detection positions should be measured.

The orientation tag for the best read range is over the center of the loop and the long axis perpendicular to the antenna plane (Z axis).



The tag can also be read when it is over the wire and the long axis is parallel to the antenna plane. The read range will be a little shorter than the optimum orientation.



Other tag orientations will have greatly reduced read range or will not be read at all.

TAG SPEED AND SCAN RATE

The tag must remain in the read field long enough to be interrogated. If the tag velocity is too fast the reader will not have sufficient time to read it. For reliability it is a good idea to make sure there is enough time to scan the tag at least twice while in the field.

The number of scans a tag will receive in a zone is calculated thus:

10 scans per second, 3' zone and 5 feet/second tag speed

$$\frac{10 \times 3}{5} = 6$$

10 scans per second, 1 meter zone and 2 meters/second tag speed

$$\frac{10 \times 1}{2} = 5$$

Multiplexer readers with two antennas will read at half the read rate at each antenna. With four antennas the rate at each antenna is one fourth of the reader speed. If the scan rate with a multiplexer is too slow then multiple synchronized readers can all operate simultaneously, allowing full read speed on all antennas.

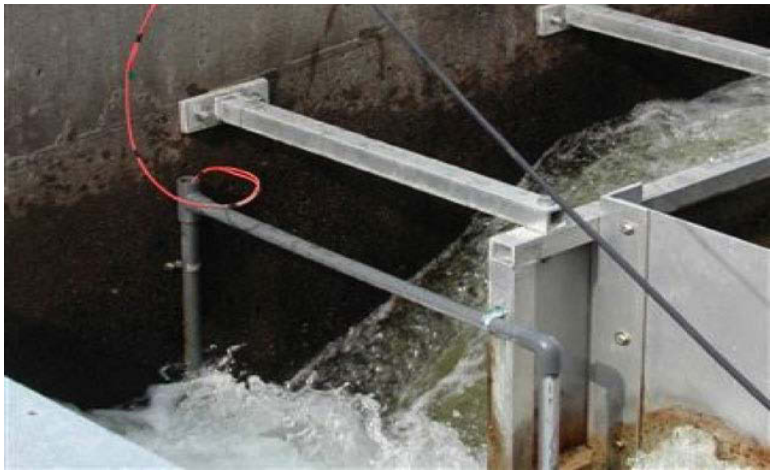
It is possible to increase the reader speed by shortening the listen and charge pulse timings. Contact Oregon RFID for read rate questions and issues.

CONSTRUCTION

It greatly simplifies things if an antenna can be made from a single turn of wire. To do this the proper wire size needs to be selected so that the inductance will fall within the tuning range. Most medium to small antenna sizes require multiple turns.

Antennas wires for HDX can be placed directly in water. The wire can be placed in plastic tubing or hose for extra protection.

Rigid housings can be fabricated from PVC plastic or fiberglass. Materials that can absorb water such as wood should be avoided since it can effect tuning over time as the moisture content changes.



SYNCHRONIZATION

Multiple readers that are within operating range can interfere with each other. When this happens the yellow noise LED will flash brightly and the read range will be greatly decreased.

If the antennas are fairly close the readers should be synchronized so that they will transmit and receive simultaneously. Some interference can be reduced by moving antennas further apart and placing the loops perpendicular to each other. Metal shielding can be used to limit the signal to the vicinity of the antenna.

Contact Oregon RFID technical support for help with synchronizing multiple readers.

READERS

RFID READERS

The single antenna reader can connect to one antenna while the multiple antenna reader shares one reader across up to four antennas.

The multiple antenna reader is useful for determining direction at multiple antennas. The scan rate is lower since one antenna at a time is read in sequence. If the maximum read rate is needed on multiple antennas, use multiple single readers and synchronize. them.

The backpack reader uses an industrial strength plastic enclosure with waterproof external connectors.

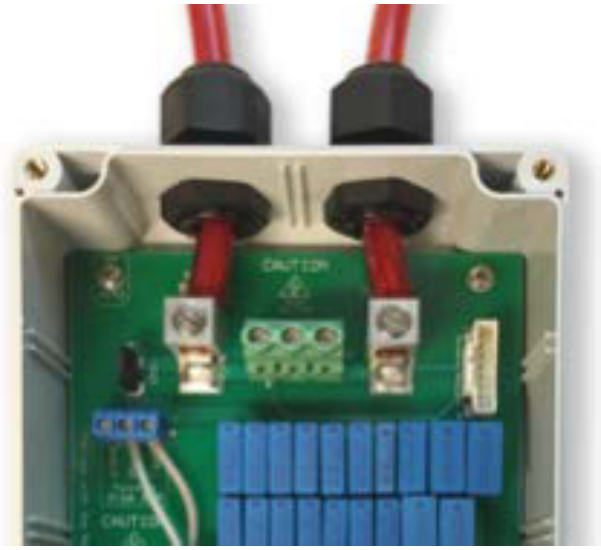
It has the same performance as a single reader and can be used with stream-width antennas.

ASSEMBLY

CONNECTING THE ANTENNA TO THE TUNER

The tuner box contains capacitors that attach to ends of the antenna loop to form a resonant circuit.

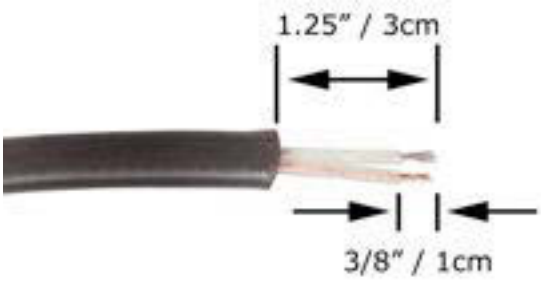
Connect the antenna cable to the two outside screws of the terminal strip. Pass them through the grip holes first, then tighten to make a watertight seal.



CONNECTING THE TUNER TO THE READER

Twinax cable connects the tuner box to the reader. A single antenna reader can be up to 130 meters from the antenna. The multiple antenna reader with up to 4 antennas can each be up to a distance of 30 meters away.

Cut off 1.25” from the outer sheath, removing the metal shield layer completely. Then cut 0.375” from the end of the two wires.



Pass the twinax through the grip and tighten. Attach the wires to the terminals marked RFM1 and RFM2 on the circuit board. The polarity is not significant. It doesn’t matter which wire is connected to RFM1 or RFM2.

WIRING A SINGLE ANTENNA READER

The twinax from the tuner box is attached to the antenna connector on the reader board as shown in the photographs. The third terminal on the connector is for the ground and is usually left open.

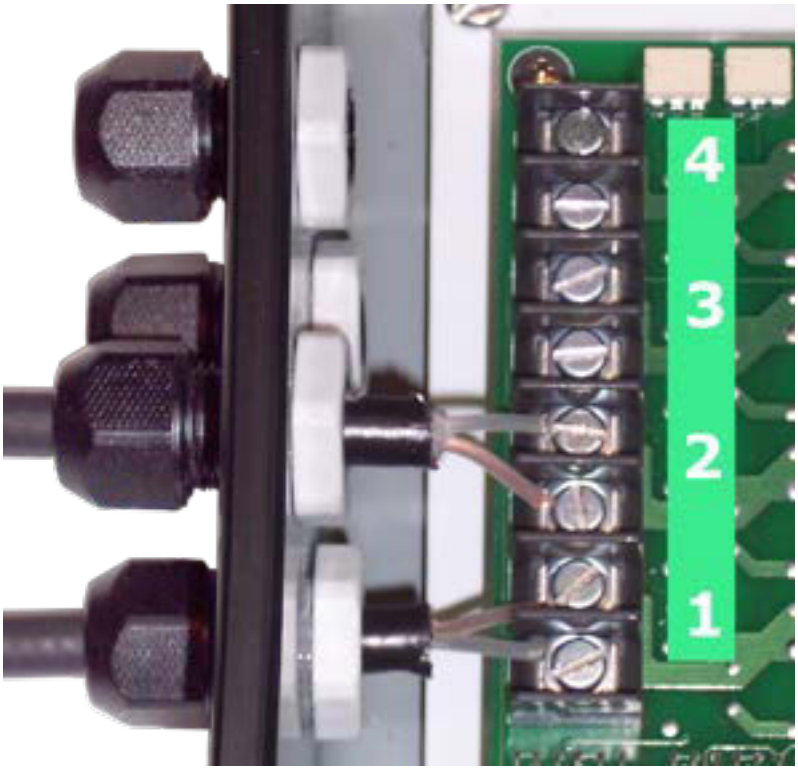
Make sure the connector is properly plugged in and seated firmly. Look at the side of the connector as in the photo and press down until it is completely seated. Make sure the two plastic fingers on the underside of the connector clip around the bottom ridge.

Align connector and press all the way down

WIRING A MULTIPLE ANTENNA READER

The twinax from up to four tuner boxes is attached to the terminal strip on the antenna multiplexer board as shown below.

The sequence for a new reader is configured before shipping to read only antenna number 1. You must change the multiplexer sequence to enable the other channels.



TUNING

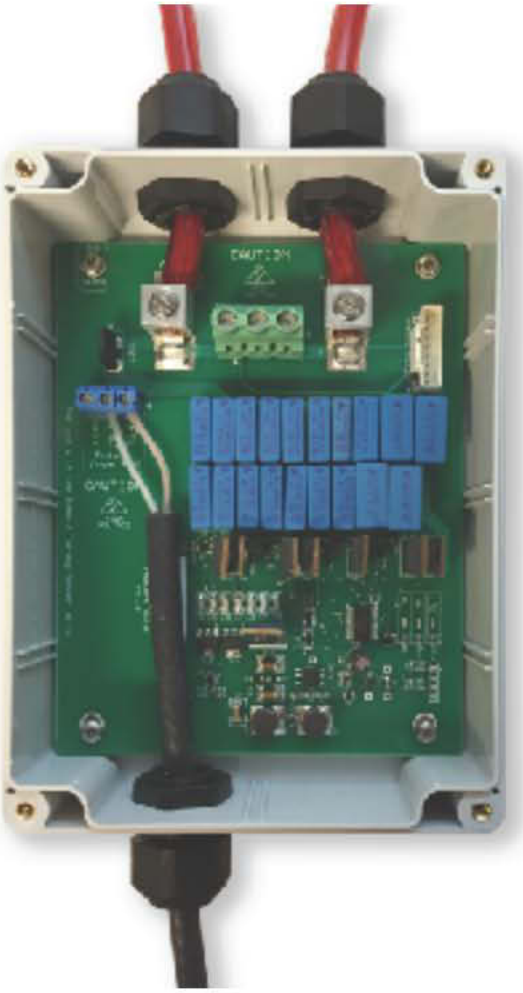
ATC AUTOTUNER AND RTS TUNING INDICATOR

The ATC Auto Tuner and the RTS Tuning Indicator/Sender automatically tune antennas for our HDX Single Antenna, Multiple Antenna and Backpack readers.

Commands are sent by the RTS Tuning Indicator/Sender over the twinax feedline to adjust the ATC Auto Tuner over an inductance range of 24 and 102 µH.

After attaching the Auto Tuner to the antenna, the RTS Tuning Indicator/Sender is plugged into the reader. With the Multiple Antenna reader one channel is selected with the MX command. After the green OK LED is on in a few seconds, the antenna is in tune and the RTS Tuning Indicator/Sender can be removed. The tuning settings are saved in flash memory while the reader is turned off.

ALWAYS REMOVE THE TUNING INDICATOR IMMEDIATELY AFTER TUNING.



STANDARD TUNING

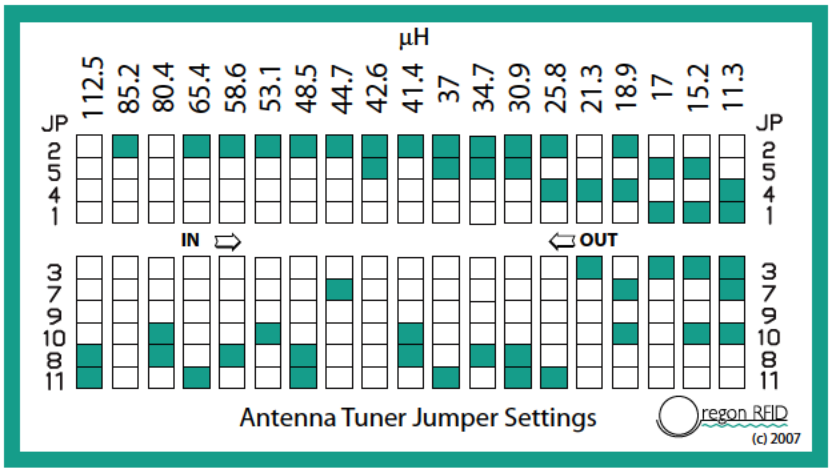
Standard antenna tuning is performed by adjusting the capacitance attached to the loop until it resonates at the proper frequency. The approximate tuning is determined using the inductance meter. The Tuning Indicator shows when the antenna is precisely tuned.

With a multiple antenna reader, change the antenna sequence to select just one antenna at a time. When all antennas are individually tuned, enter the full scan sequence to enable the other antennas.

Plug the flat cable into J2 so that it extends away from the reader board.

STEP-BY-STEP STANDARD TUNING

- Turn off the reader and plug the Antenna Tuning Indicator into J2.
- Loosen the screw on the side of the tuner box holding the black rubber plug. Remove plug.
- Insert a nonmetallic screwdriver through the hole and turn the core of the coil counterclockwise until it reaches the inside edge of the tuner box.
- Turn the reader on, the red "Transmit" light should start flashing.
- Select the column from the jumper chart that is closest to the value that is higher than the measured antenna inductance (e.g. meter reads 55.2µH, use 62µH).
- Find the highest inductance jumper setting that turns the "IN" LED on.
  - If "OUT" is on, try jumper settings to the left.
  - If "IN" is on, select next jumper setting to the right until "OUT" is on, then back up one.
- When jumpers have been set, fine tune by adjusting the coil screw until "OK" is on.
- Replace the black rubber plug and tighten the screw.



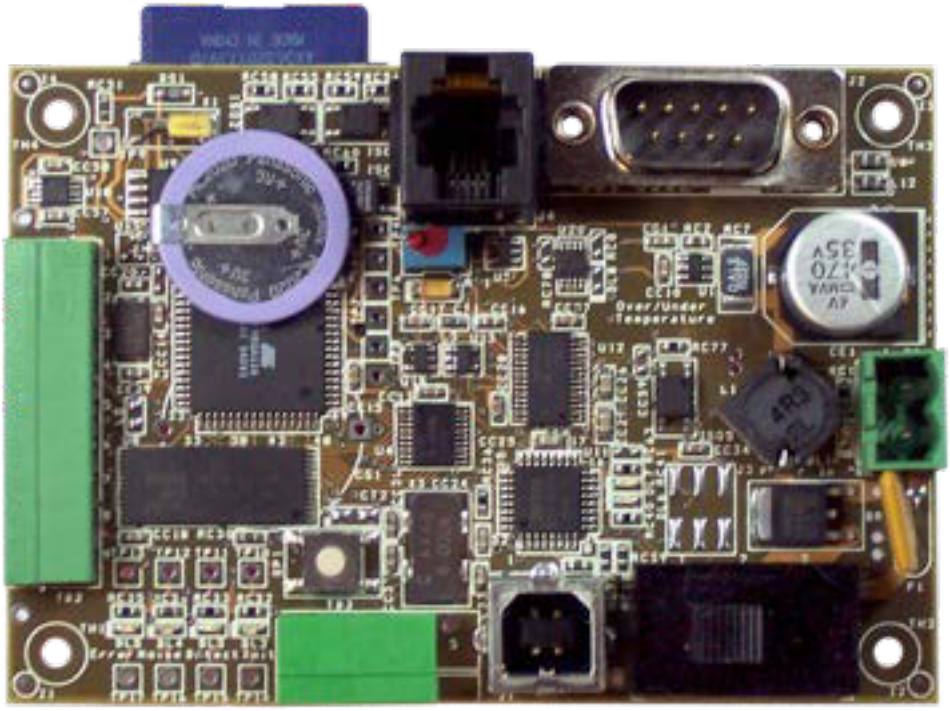
DATA

LOGGING DATA

The datalogger board maintains a large database on an SD memory card. This card is intentionally difficult to remove since the datalogger accesses it whenever the power is on.

The database is accessed using a bluetooth adapter or a computer via serial link.

Since the database is very large records are not deleted until the entire file is erased. When accessing log files using the serial port the latest readings can be accessed or selected data from the archive.



STATUS LIGHTS

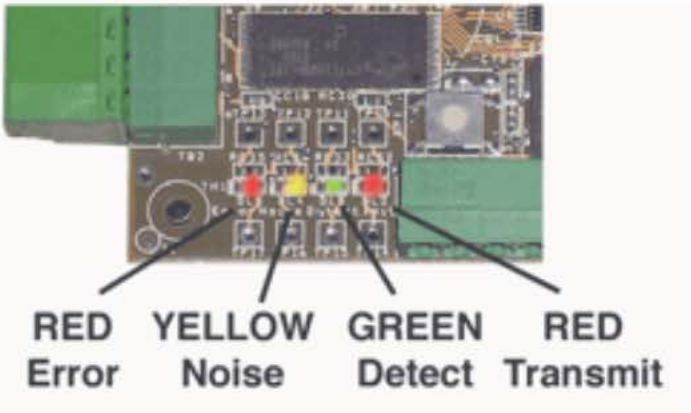
There are 4 LEDs on the datalogger board that indicate the current system status.

The **red** error LED on the left indicates a problem has occurred and messages have been written to the log file.

The **yellow** noise LED will flicker occasionally. If the LED is bright then a strong noise source is present on the RFID frequency.

The **green** LED shows that a tag has been detected. Each occurrence will be logged in the database.

The **red** transmit LED on the right flashes to show the charge pulse is active on the antenna. When the LED is off the reader is listening for a tag.



Special light patterns are used to indicate the reader status. When the lights flash left-to-right continuously, the reader is sleeping either due to a timer setting or low battery voltage. A constant red error LED indicates the database cannot be opened, either because the card is not plugged in correctly or the file is corrupt.

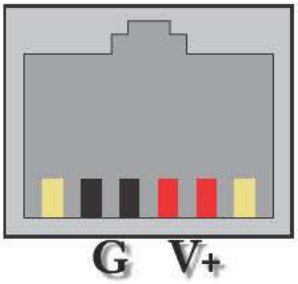
Two other patterns are less common. If all lights flash on and off simultaneously the datalogger has detected a hardware memory error. If the lights flash erratically (1-3-2-4) the firmware needs to be rewritten. Contact Oregon RFID for assistance.

PIEZO BEEPER

The piezoelectric buzzer makes a very loud sound whenever a tag is detected. It plugs into the RJ11 jack on the datalogger board.

There are two different beeper modes. In mode 1, a sound will be made whenever there is a detection. In mode 2 the initial detection will be long and remaining ones short. This is used with Tagtracker mode to know when a new tag has been found when scanning with mobile antenna.

Other devices can be plugged into the connector but they must be limited to 150 mA or less or the datalogger can be damaged. Two pins are ground and two are the same voltage as the reader supply.



RJ11 pinout looking into the connector on the datalogger board

Oregon RFID can provide technical assistance to use the connector with other kinds of indicators (buzzers, LEDs, relays, lights, etc).

LED indicator

RETRIEVING DATA

The Aceeca Meazura and PTLogger have been the graphic interface to Oregon RFID's long range reader for many years. However Aceeca has discontinued the Meazura and there is no replacement.

The recommended replacement is to use a Bluetooth Serial adapter with threader to connect with an Android phone or tablet and the free application Blue Term.

BLUETOOTH ADAPTERS

Oregon RFID's web store has two Bluetooth serial adapters Both are powered by the DB9 serial port (5 volts on pin 9) when they are plugged in to any of our long range readers so no power cable is needed.

The Bluetooth Serial Adapter for the Mobile reader has an embedded antenna.

The Bluetooth Serial Adapter with External Antenna can be installed inside the metal reader enclosure with the antenna mounted on the outside.

ANDROID PHONE OR TABLET

An Android phone or tablet with Bluetooth can be used to connect to the reader. An iPhone cannot be used because Apple iOS will not allow Bluetooth serial connections.

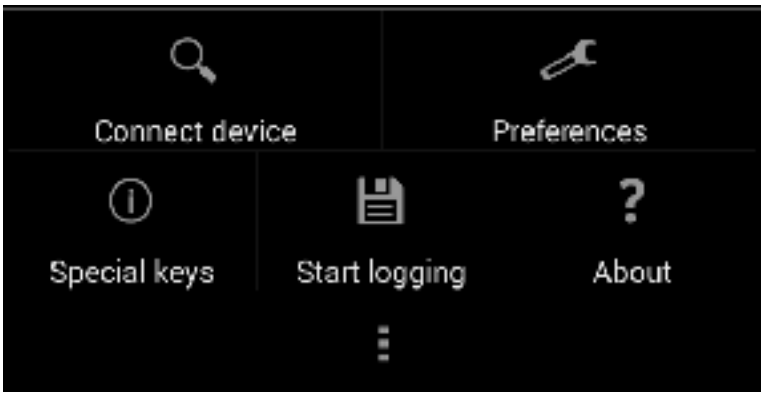
Waterproof Android devices are available from Kyocera, Sony, Samsung, and other retailers.

BLUETERM

BlueTerm is a free app available at on Google Play.
https://play.google.com/store/apps/details?id=es.pymasde.blueterm&hl=en

USING BLUETERM

Press the three vertical dots at the bottom of the screen to show the menu.



Change the **Preferences** according to page 6.

Press **Connect device** to open a wireless channel. The first time you do this the device will need to be paired. See page 5.

To save data to the SD card, press **Start logging**. It will open a file with a name of the current date and time. Everything that appears on the screen will also be saved to the file. Pressing the button again will **Stop logging** and close the file.

With many Android devices, connecting it to a computer with a USB cable will allow copying the files from the phone.

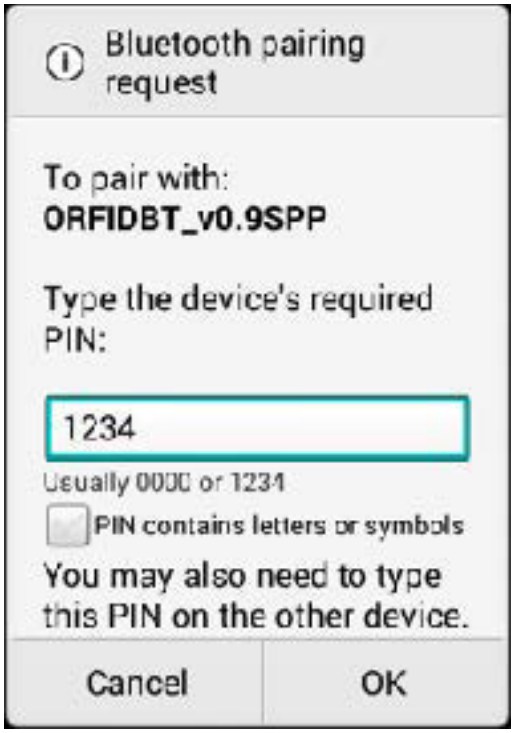
OPERATING THE READER

Once the connection is made with the reader, the command line interface is used to change settings and upload data to the SD card on the Android device.

To collect the detection log data from the reader, press **Start logging**, type UP to upload the newest data and when it is complete, press **Stop logging** to close the file.

PAIRING BLUETOOTH (FIRST TIME)

After starting BlueTerm, scan for nearby Bluetooth devices and select the Serial Adapter. Oregon RFID adapters have the name ORFIDBT.



After the device is connected, a PIN is needed to pair. This number only needs to be entered the first time. The Android device will remember the PIN.

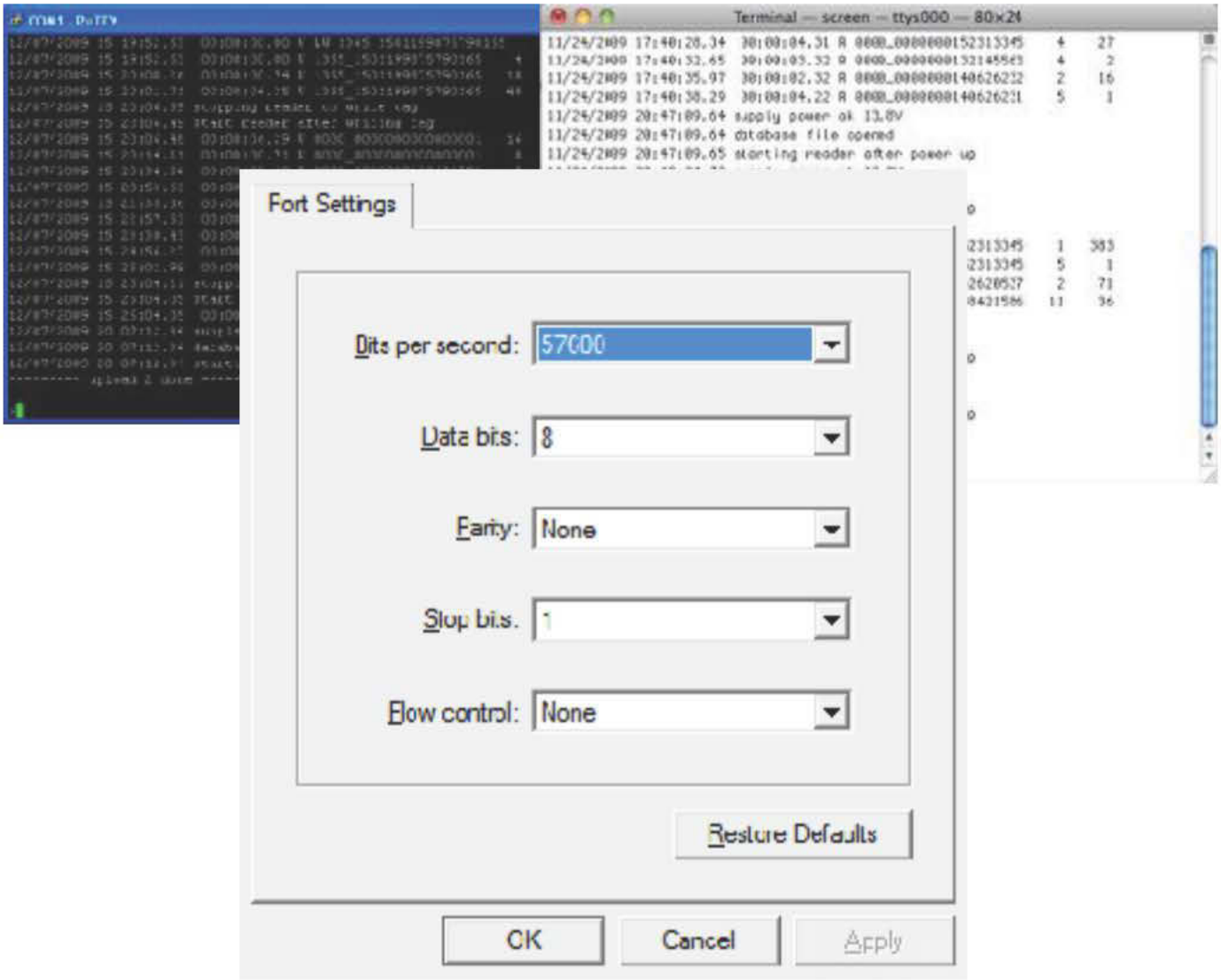
BLUETERM SETTINGS

Here are the settings to use with the Oregon RFID datalogger. Be sure to select the four options at the bottom of the page to define the incoming and outgoing end of line characters.

TERMINAL INTERFACE

The reader can be operated using a terminal program such as Tera Term, Hyperterminal (XP), PuTTY (Vista, Windows 7) or Terminal (OSX) with a serial cable, USB converter or a Bluetooth link with a serial adapter. Port settings are below.

The command line interface is the simplest solution for for remote operation over a long distance wireless link.



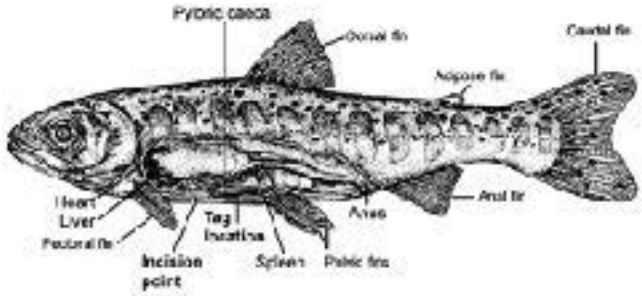
TAGS

USING PIT TAGS

Larger sized tags will absorb more of the magnetic field than small ones and therefore will have a longer read distance. Use the largest practical tag for best performance.

Tags can be attached externally or internally. When inserting tags into animals the tag dimensions will determine the smallest organism that tagged without harm. Syringes are used with small animals for proper placement within the body. Larger specimens can be tagged by making a small incision with a scalpel and pushing in a sterilized tag.

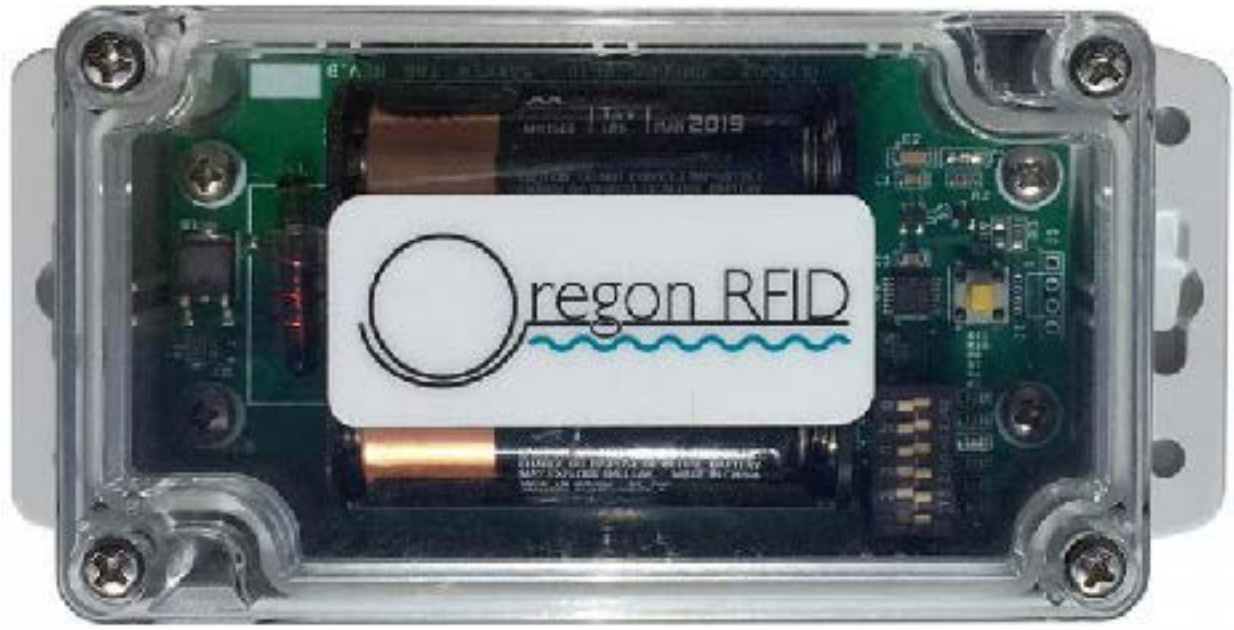
The Pacific States Marine Fisheries Commission has developed standard procedures and methods for tagging salmon in the Columbia River. Their excellent guide "PIT Tag Marking Procedures Manual" can be obtained from the web site *ptagis.org*.



MARKER TAG

There can be gaps in the log files where no tags are seen for long periods. The marker tag is used to verify that the reader was operational during these data gaps.

It contains an RFID tag wrapped in a coil that will hide the tag at periodic intervals. These regular detections should appear at fixed intervals in the log file. Missing entries indicate a that the reader was not detecting tags.



TAGGING ROCKS

RFID tags can be inserted into hard nonmetallic objects like gravel and rocks by drilling holes and sealing with a pliable adhesive sealant.

Glass tags should have protection against forces that can break them. Tag sleeves provide a cushion that can absorb quite a bit of mechanical shock.

TROUBLESHOOTING

BASIC TROUBLESHOOTING

Whenever there are problems:

- check all wiring
- tighten wire connections
- look for loose wires
- clean pins on electrical connectors
- check voltages and amperages

If the reader won't tune or the read range is poor:

- disconnect the power supply and only use a battery
- make sure the antenna loop inductance is in range
- check to see that the capacitor jumpers in the tuner box are seated correctly
- check for metal near the antenna
- turn off all devices in the vicinity that are potential noise sources (these include other RFID readers, florescent lights, wall switch dimmers and computer laptop power supplies)

To locate a problem, change one thing at a time to determine if that changes the problem. Try swapping antennas, a reader, a tuner boxes, see if problem stays or follows the part.

If the reader stops working, try swapping circuit boards with a good reader. Change one at a time to determine which board the source of the problem.

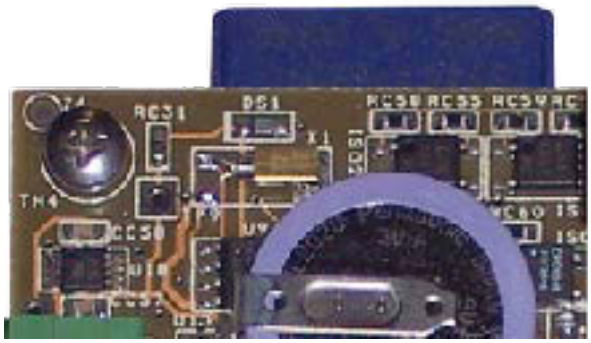
ERROR MESSAGES

The reader constantly monitors the system to log errors when they occur. The red error LED indicator on the datalogger will turn on when errors occur.

A PDA or PC is used to look through the most recent database records to find the error records. These messages are stored in the same database with the detection records along the time and date. Scrolling through the log file will show a history of what happened.

The datalogger will attempt to resolve some problems if it can. It will try to restart the reader if stops scanning. These will appear in the log file as “Kick start” messages. Occurrences of this message are usually rare and occasional ones can be ignored. If this message appears many times then the reader should be examined to find the problem.

The error light will also go on when there is a problem with the database itself but the explanation cannot be logged. A common problem that occurs is when the SD card isn’t inserted properly in the memory slot and the file cannot be accessed. This will cause a “Database not open” error that will be displayed on power up.

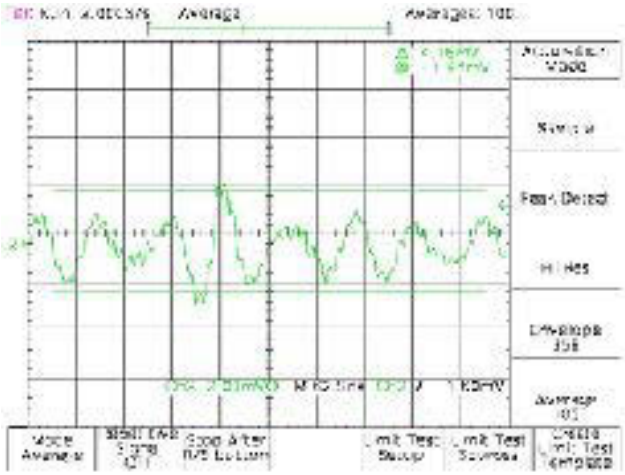


Make sure the SD card is inserted properly

If the card can be read but the database file cannot be found it will display “Database not found”. This usually happens when a new card is being used. The file can be re-created by initializing it with the utility on the Setup screen of the PDA or using the “FRD” command.

NOISE

Low frequency electrical noise can affect the performance of an RFID reader. Noise can be conducted through the power lines into the reader or it can be radiated by a nearby device and detected at the antenna.



A chemical storage battery (lead acid, lithium, nickel, etc) is a very quiet source and generates no power ripple.

Here is a list of possible LF noise sources that can interfere:

Reader power supply
- AC-DC supply (especially switching types)
- battery chargers
- solar panel controllers
- automotive, wind and hydro electric generators

Signals transmitted by unsynchronized reader

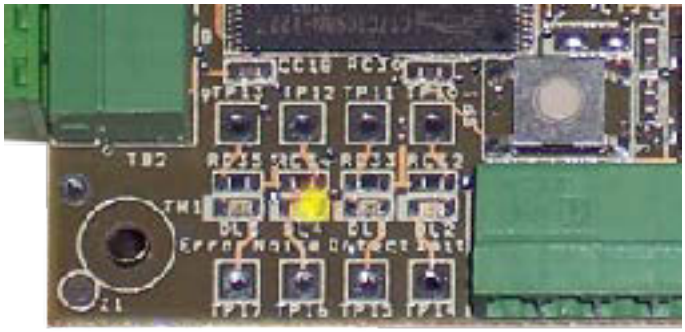
Interference from electrical transformers in vicinity
- fluorescent or other high voltage light ballast
- wall transformers, particularly laptop chargers
- computer video monitors
- light dimmers

Electrical motors, power tools

Radiated from metal connected to a noise source
- rebar and railing at a power dam
- metal doors and gates

FINDING NOISE PROBLEMS

There are a few ways to tell when noise is present. The yellow LED on the datalogger board is an immediate visual indicator. It flickers when a signal is detected while listening for a tag. The noise is also displayed as a number on the main screen of the PDA handheld or using the AD command.



The reader can get quite hot if connected to a noisy power source. If you can't hold your hand on the aluminum heat sink, the reader is too hot. The reader will automatically shut down if it overheats and restart after it cools down.

The average noise value for every operating minute is kept by the datalogger and can be accessed using the UT command. This is not yet available for display on the PDA.

The simplest test for conducted noise is to measure the read range when connected to the power source and then operate from battery. Since the battery is a quiet source, any difference would be due to conducted noise.

If there is still noise when using battery power, identify the source by turning electrical devices off one at a time while watching noise levels to see when they drop.

NOISE FROM SOLAR POWER SYSTEMS

A solar power system can operate well most of the time but data could be lost for a few mid-day hours due to noise blocking the tag signals.

When the sun is brightest it is drives the panels to their highest power. If the level reaches the controller's maximum limits then the electronics will generate noise. Watched for increased noise levels on sunny days around local noon to make sure this isn't a problem.

SOLVING NOISE PROBLEMS

- use a clean power source
- make sure power supply can handle the peak levels
- orient antennas at 90 degree angles from each other
- shield antennas to block interfering signals
- synchronize all readers within range
- ground the twinax shield at the reader

Oregon RFID manufactures equipment for tracking fish and wildlife (and rocks!) using low frequency passive RFID tags and readers. Our products are used worldwide for scientific research and commercial operations.

We provide toll-free technical support by phone or email to help you design and build your monitoring system.

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