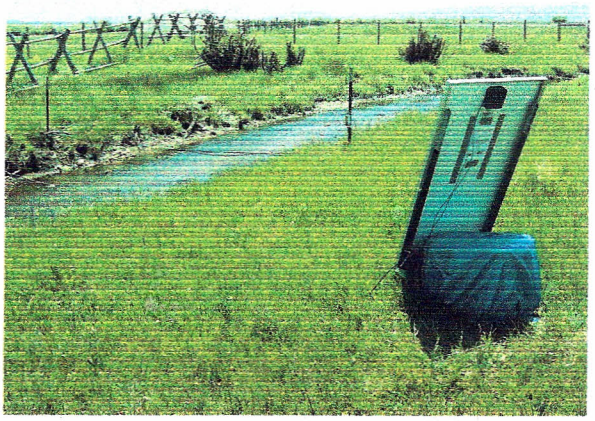
How to Install and Maintain Instream Half-Duplex Passive Integrative Transponder (PIT) Tag Antennas, Readers, and Equipment



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Introduction and Background

Passive integrated transponder (PIT) tags are commonly used to track the movement of individual fishes. PIT tags offer several unique advantages over other tagging methods: the tags last the life of the fish, they do not rely on a battery or internal power source to relay their unique identification code, and the tags can be read passively which helps to minimize potential handling effects. Movement data gathered from individually tagged fish has been used to study entrainment dynamics (Gale, 2005), distribution and migration patterns (Zydlewski et al, 2006), and habitat use (Reagan et al, 2002) in salmonids.

Numerous manufacturers produce PIT tags and PIT tag related equipment and readers, however, most systems can be classified as either half or full-duplex. Half-duplex tags (HDX) and associated equipment are generally less costly and more easily maintained, when compared to full-duplex systems. Fuller and others (2008) offer a review of commercially available PIT tag systems.

This document guides the user through the process of installing an HDX remote antennae site using multiplex readers that are manufactured by Oregon RFID. Much of the information included here can be gathered from the manufacturer; however, this guide offers a consolidated version of details and instructions.

The tags used for this operation are 23mm long, glass-encapsulated transponders that emit a 134.2 kHz signal after being activated by an external power source. The individual code detections are stored on a data card in the Multiplex Reader. Tag number, time, date, and antenna information is stored for each detection. These data are downloaded by connecting a laptop computer to the reader's comport and communicating with the reader. Solar energy is used to power equipment, and installation of this equipment is also discussed in this user guide. A list of tools materials required for installation is included (Appendix 1) along with other technical background material on tuning and programming of antennas and readers (Appendix 2 and 3).

Step 1: Site Selection and Considerations

Antenna sites should be located in or near riffle water to prevent fish from holding immediately next to the antenna and causing repetitive detections. Avoid placing antennas on or near metal objects, as this may create problems with interference. Eighty-five feet is the approximate maximum width of stream for a channel-wide antenna, and max depth is recommended at three feet or less. Be mindful of the potential effects that debris and/or flooding may have on your equipment.

Multiplex readers by Oregon RFID are equipped to read a maximum of four antenna sites per reader. Depending on how and where antennas are installed, different questions can be answered. By pairing antennas and viewing the time of detection, the investigator is able to distinguish direction of travel.

Step 2: Antenna Setup

Figure 1 shows the basic configuration and materials that are used to build a channel-wide stream antenna.

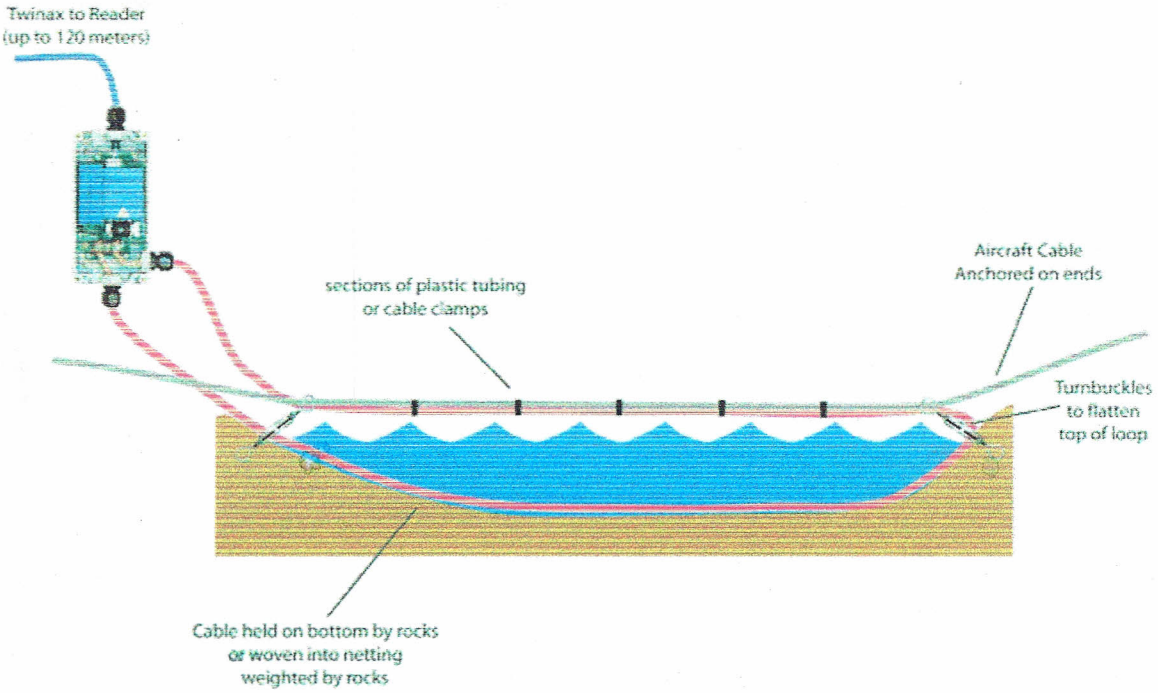


Figure 1. Horizontal view of a channel-wide stream antenna. Speaker wire (8 AWG) is shown in pink, and is looped around the aircraft cable and the bottom of the stream. The looped cable is attached to a tuner box. TwinAx cable is then used to connect the tuner box to the Multiplex Reader. Diagram by Warren Leach, Oregon RFID.

Start by stretching aviation cable across the river. Six-foot fenceposts should be used to anchor cable on ends. Cable clamps and turnbuckles help keep the cable tight. After the aviation cable is stretched across the stream and anchored, eight-gage speaker cable (also called power or ground cable) is fastened to it and looped back as shown above. Sandbags can be used to anchor the cable to the bottom when no rocks are available.

Step 3. Tuning the Antenna

After the speaker cable is attached to the aviation cable and anchored to the substrate, measure the inductance (electrical field) of the aviation cable by attaching an inductance meter to each end of the stripped cable loop (Figure 2). Make sure the inductance meter is reading units in microHenries – write this number down. **For optimal detection, the inductance of the cable must be between 8 and 80 microHenries**. Inductance can be increased by adding more loops of cable or by using a thicker cable. Recommended speaker cable is 8 gage, fine-strand copper wire – Metra© and Stinger Custom Pro© brands have been used previously and can be purchased at Radio Shack©. Spools come in 250 and 500 foot rolls.

Figure 2. Using an inductance meter to measure the inductance of a cable loop. Photo by Montana Fish, Wildlife & Parks (FWP).

After making sure the inductance is appropriate, you are ready to attach the speaker cable to a remote tuner box. Insert the stripped ends of the speaker cable into the remote tuner box and fasten down (Figure 3). Each cable loop antenna must have its own remote tuner box in order to communicate with the Multiplex Reader.

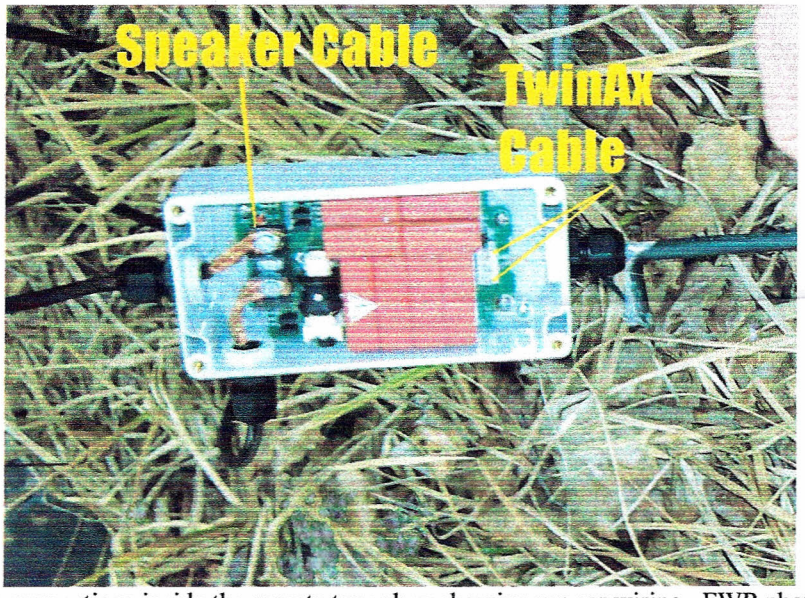


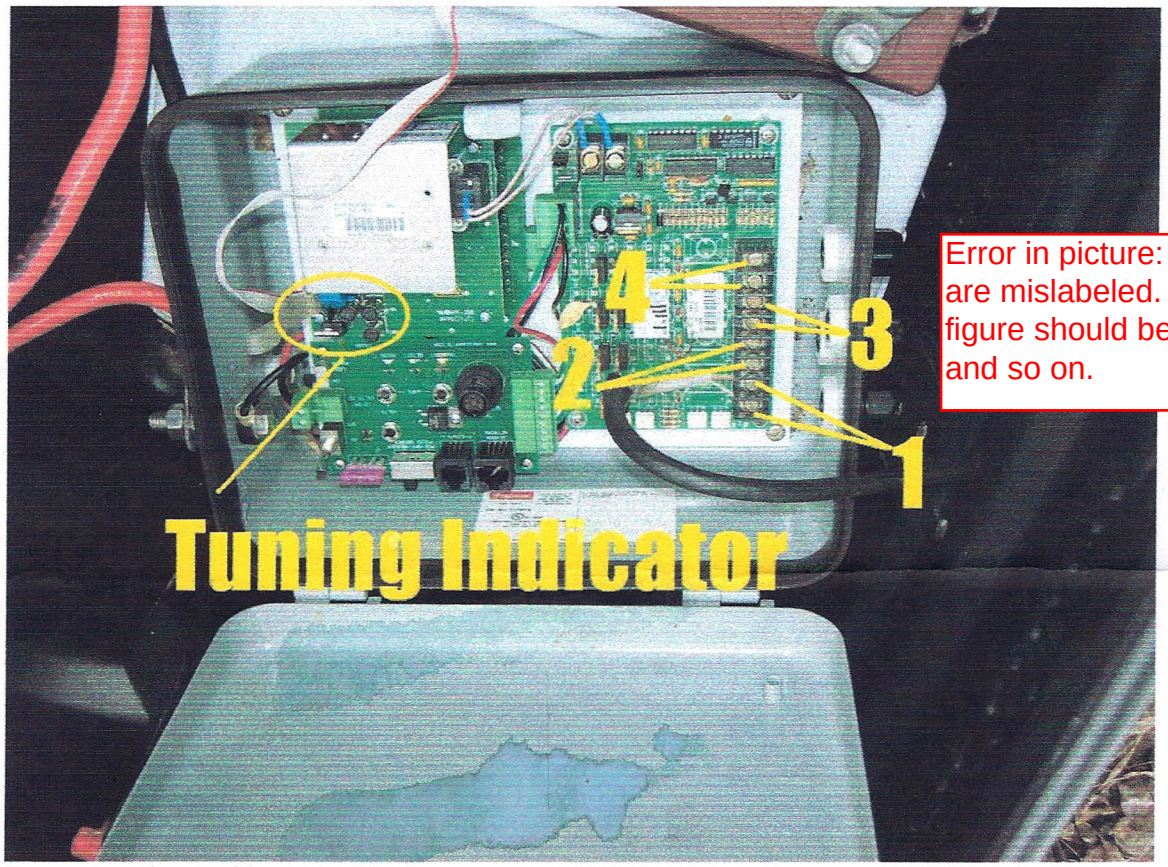
Figure 3. Cable connections inside the remote tuner box showing proper wiring. FWP photo.

Next, attach 20 AWG TwinAx Cable to the other set of screws in the tuner box (Figure 3). Recommended brands of 100 ohm, 20 gage cable are Belden© 9207 and IBM© 7362211. Capacitance of the TwinAx cable should be 15 pF/ft (50pF/meter).

Run a length of TwinAx cable from the remote tuner box to the Multiplex Reader station and attach the TwinAx into PORT 1 on the Multiplex Reader (Figure 4). Maximum TwinAx cable length is 400 feet. To properly 'tune' the reader to the electrical field of the cable, the TwinAx cable must be connected to PORT 1(Figure 4). After being tuned, the TwinAx cable can then be moved to any of the 4 ports on the Multiplex Reader, and another antenna can be tuned in its place at PORT 1.

'Tuning' the cable will require that you attach a 'Tuning Indicator' (Figure 5) to the Multiplex Reader (Figure 4). Basically what you are doing here is matching the capacitance of the TwinAx cable to the inductance of the speaker cable.

Connect the power terminals on the Multiplex Reader to a DC battery using 2/0 battery cables and turn the power on. After the Multiplex Reader has warmed up for several minutes, turn the tuning indicator on. The LED light either flashes "IN", "OUT", or "OK". You are aiming for "OK".



Error in picture: Ports 1-4 are mislabeled. Port 1 on figure should be Port 4, and so on.

13.9

Figure 4. TwinAx cable connected to port 1 and antenna tuning indicator connected to the inside of the Reader. FWP photo.

Figure 5. Antenna tuning indicator. Indicator plugs into connector J2 near the corner of the reader board (Figure 4). Photo by Warren Leach, Oregon RFID.

Refer to the "Remote Tuner Jumper Settings" sheet (Appendix 2). This sheet indicates complimentary capacitance settings in relation to inductance. Based on your initial reading of inductance (microHenries), adjust the Jumper Settings in the tuner box to the nearest corresponding reading on the sheet. You will need a needlenose pliers to move the small black fuses (jumpers) from one setting to the next in the remote tuner box (Figure 6a). The antenna-tuning indicator will allow you to visually assess whether the adjusted setting has brought you 'in tune'. Macro adjustments are made to the remote tuner box by moving the jumpers. Fine-tuning adjustments may also be needed. To access the fine-tune, remove the rubber plug on the outside of the remote tuner box. Adjustments can be made by moving a plastic screw in or out (Figure 6b) until the "OK" button flashes on the antenna-tuning indicator. When the antenna is tuned, the antenna tuning indicator light should remain green, for "OK". Reattach the rubber plug when finished.

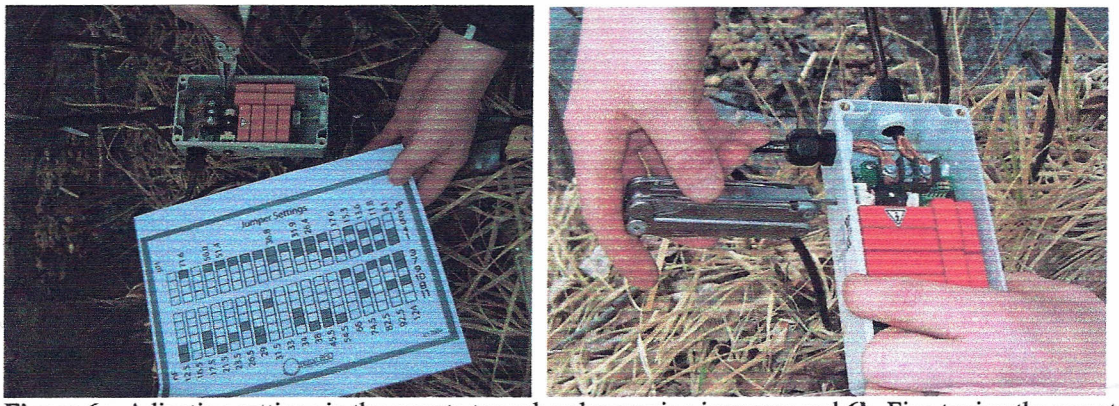


Figure 6a. Adjusting settings in the remote tuner box by moving jumpers; and **6b.** Fine tuning the remote tuner box using a small screwdriver.

Now you can test to see if the antenna is able to detect a tag. Attach a pizometer to the plug-in on the reader and remove the antenna-tuning indicator (Figure 7a). A pizometer is an audio device that emits a loud chirp when activated by electrical stimulation. When a tag passes near the antenna, the pizometer should chirp loudly. Attaching a tag to a stick, pole, or plastic bottle and passing it through the cable loop is a good way to test if the antenna is able to detect a passing tag (Figure 7b). Tags must be oriented parallel to the stream bottom in order to be detected. Read range of 23mm tags is expected to be approximately 18 inches, however, read range at each site may vary depending on size of antenna. To quantify detection efficiency of each antenna, an advanced test is recommended (see Connolly et al, 2008). Once the antenna is tuned and able to detect passing tags, reattach the cover on the remote tuner box and attach to a sturdy fencepost.

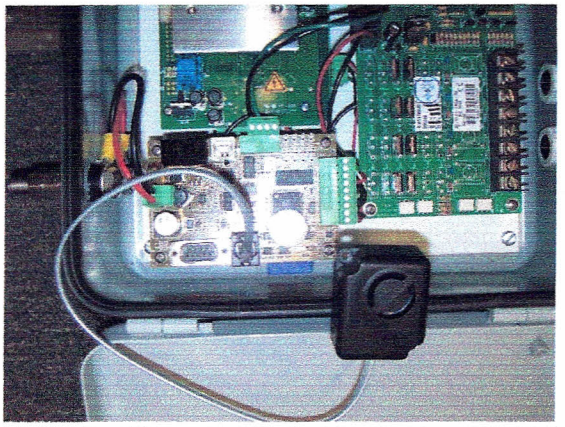



Figure 7a. Pizometer attached to plug-in on Multiplex Reader; and **7b.** Testing the detection ability of an antenna. FWP photos.

Step 4. Adding additional antennas

Up to four antennas can be used per Multiplex Reader. To add antennas, follow the installation steps outlined above. Spacing of antennas should be such that a time delay can be detected when a fish passes through both upstream and downstream antenna stations. Increasing distance between antennas may also reduce interference. Tradeoffs do exist, however. Be mindful that increasing distance between antennas may also increase the amount of TwinAx cable needed for connecting remote tuner boxes to the Multiplex Reader. More power may also be required for additional antennas, so be mindful of power issues and check these stations frequently.

When adding antennas to the Multiplex Reader, the antenna can only be tuned when the TwinAx cable is connected to PORT 1. After all antennas have been tuned, reattach the TwinAx cable from each antenna to any of the four PORTS (Figure 4). When all antennas are tuned and capable of detecting passing tags, solar power can be added to energize the system.

Step 5. Adding power to the station

Each Multiplex Reader station will be powered by two deep-cycle 12 Volt batteries with a reserve capacity of 100 Amp Hours. Connecting the two batteries in parallel will increase the storage, whereas connecting the batteries in series will increase the voltage. We want to increase storage by connecting the batteries in parallel. Therefore, connect battery terminals with cable connections from negative to negative, and positive to positive.

The batteries can be connected to the solar panel and charge controller, which is shown on the diagram as the charger (Figure 8).

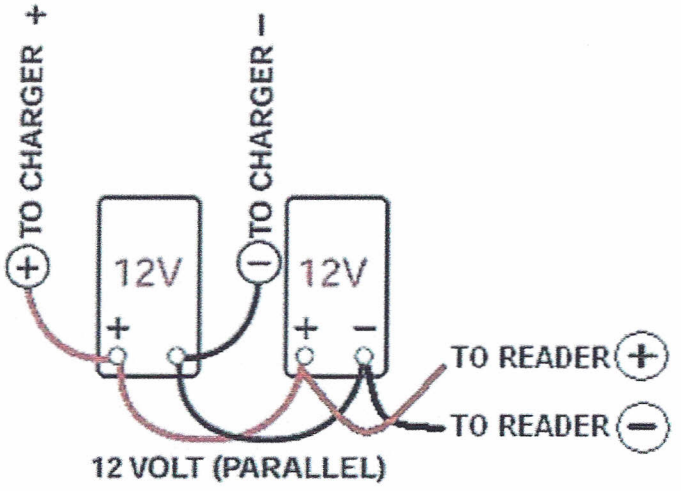
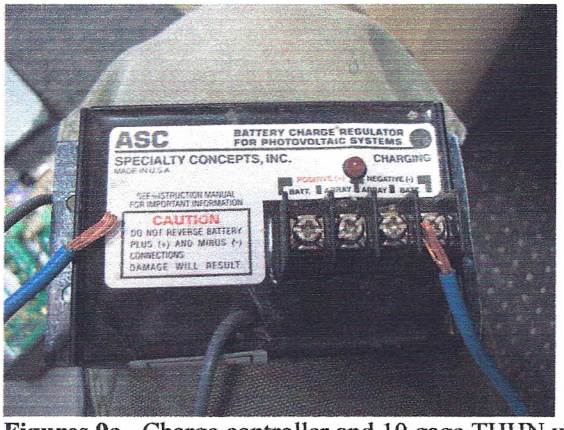


Figure 8. Parallel connection showing proper configuration of battery bank and connections to solar panel and charge controller (charger) and Multiplex Reader.

Use 2/0 gage battery cables to connect batteries to each other and to the Multiplex Reader. Connections to the solar panel, the charge controller, and the battery can be made using large strand electrical wire (THHN) in a 10 gage (Figure 9). The charge controller can be housed inside the storage tub, so run a short line of 10 gage wire from the battery to the charge controller. A longer length of wire can then be used to connect the solar panel to the charge controller (Figure 9b). Pay attention to the positive and negative labels on both the charge controller and solar panel terminals.



Figures 9a. Charge controller and 10 gage THHN wire; and **9b**. A mounted solar panel showing appropriate wiring of solar panel to charge controller, which is housed inside the tarp-covered tub.

When wiring the solar panel, **avoid initially exposing the crystal side of the solar panel to the sun.** Sun exposure will cause energy production and storage that may create a sudden surge or discharge when wiring connections are finally made. After the connections are made, the solar panel can then be positioned upright and mounted to

either fenceposts or a crow's nest structure. When the connection from the solar panel to the charge controller to the battery is made correctly, the LED light on the charge controller will stay red, indicating the unit is charging. No light or a flashing light on the charge controller indicates a possible problem with the connection(s). Make sure all nuts are tight. You can apply a light coat of petroleum jelly on the battery terminals to help prevent corrosion and maintain a good connection.

Solar panels should always face true south. Solar panels should be positioned in a sunny area, away from willows and strong shadows. At latitude 45 degrees (Dillon), the panel should be oriented at a 42.5-degree angle in the spring (March –April) and autumn (September - October) for optimal exposure. **The panel should be oriented at a 17-degree angle in the summer (May – August) for optimal sun exposure.**

Step 6. Programming the Multiplex Reader

Now that the antenna(s) and Multiplex Reader station are receiving power, and the antennas are properly tuned, the Multiplex Reader can be programmed to store tag information. With the Multiplex Reader turned off, open the Multiplex Reader enclosure and connect a ComPort cable to the appropriate terminal (Figure 10). Connect the other end of the computer to a laptop computer – typically at ComPort 1.

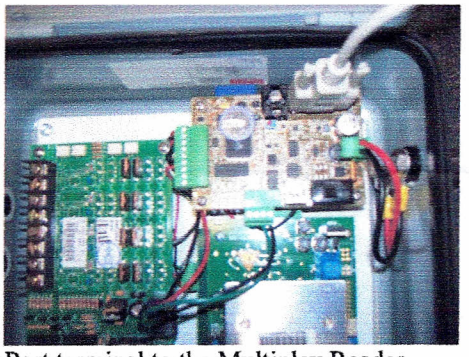
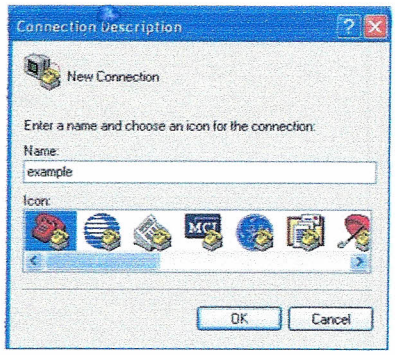


Figure 10. Connecting the ComPort terminal to the Multiplex Reader.

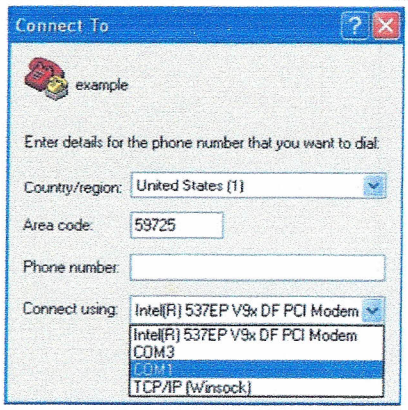
Start a "HyperTerminal" connection on the laptop computer. Hyperterminal is a communications program that will allow the user to send and receive information to the Datalogger on the Multiplex Reader. Hyperterminal is found on most computers in the following path:

Start Menu→All Programs→Accessories→Communications→Hyperterminal

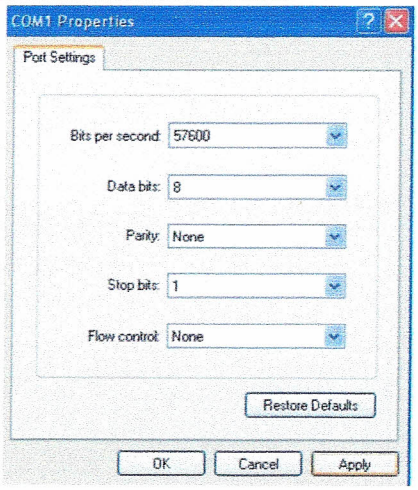
A dialog box appears when the Hyperterminal program is started. Any name can be given for the connection



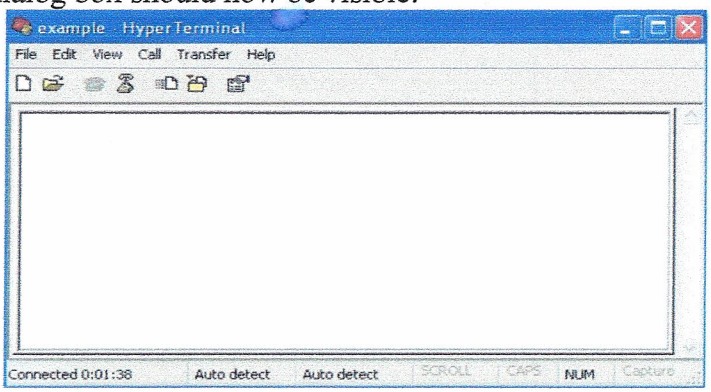
The next dialog box prompts the user to choose a connection port. Choose Com1.



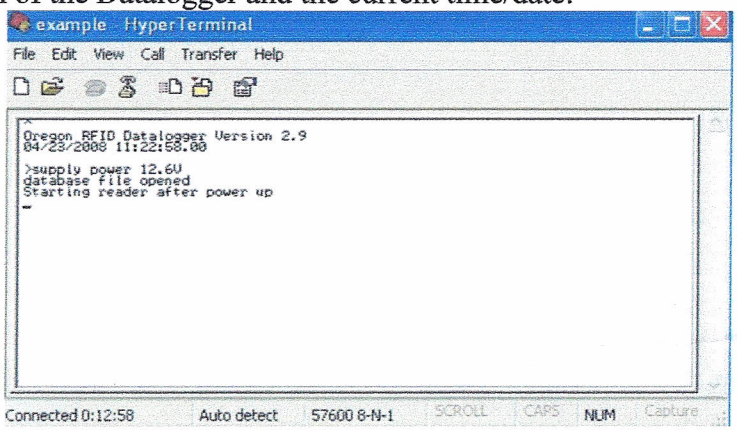
Apply the Port Settings of the connection to Com1:



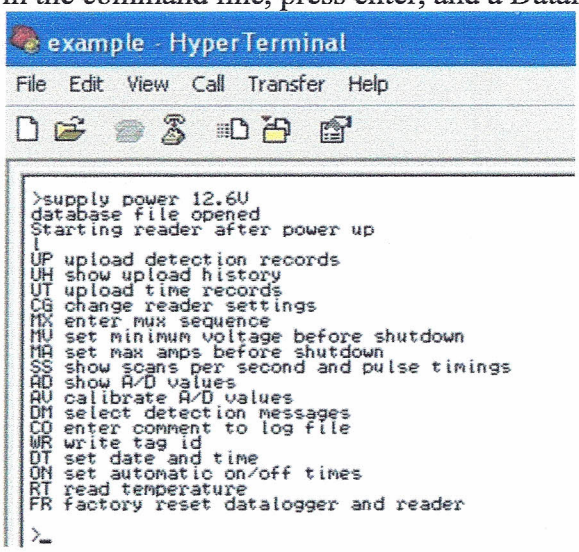
The Multiplex Reader and laptop computer are now able to communicate. A HyperTerminal dialog box should now be visible:



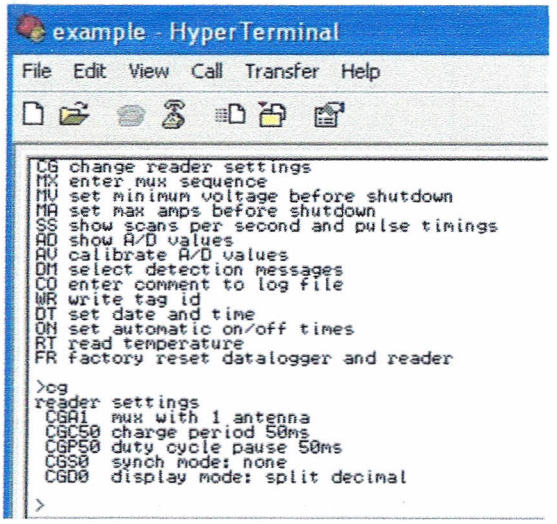
Turn the Multiplex Reader on and the following message will appear, showing the software version of the Datalogger and the current time/date:



Type any single key in the command line, press enter, and a Datalogger menu appears:

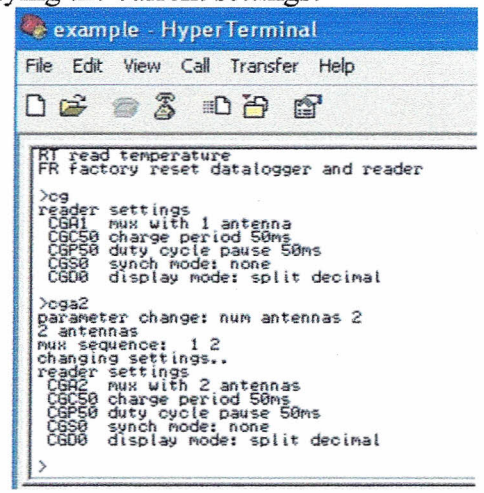


To change the settings on the Datalogger, type CG in the command line. The current reader settings will appear:



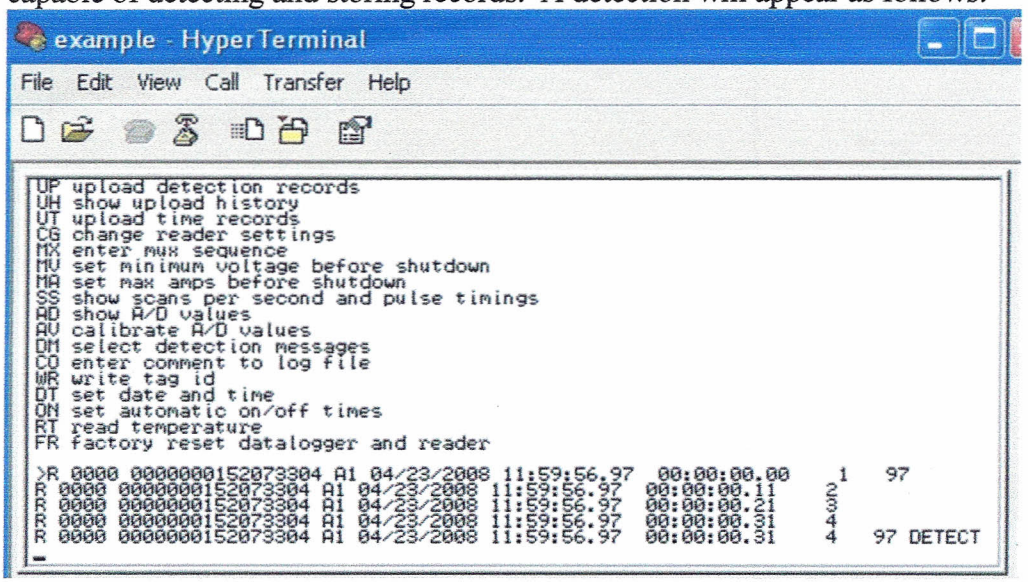
The settings for this reader, shown above, are currently set at CGA1 - "mux with 1 antenna". This means the unit is a multiplex unit, currently operating with only one antenna 'ON' – Antenna 1.

The number of antennas can be changed by typing the command "CGA_" – fill in the blank for the number of antennas desired. For example, CGA2 means "multiplex with two antennas". CGA3 means "multiplex with three antennas". Adjust the reader settings to the number of antennas desired. A change in reader settings will produce the following message, displaying the current settings:



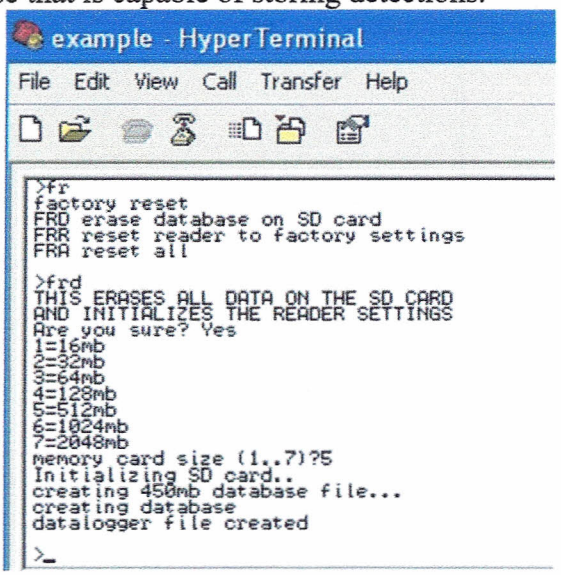
Antennas that are currently operating are shown by the line - "mux sequence". The above example shows that antennas 1 and 2 are currently operating. The user could change the operating antenna numbers by typing the command "mx_ _" - fill in the blank with the antenna numbers to be turned ON. For example, if PORT 1 and 4 were currently wired with TwinAx, but 2 and 3 were not, the user could type "mx14", and antennas 1 and 4 would be turned ON.

Pass a tag through each antenna that has been turned ON in order to show that the unit is capable of detecting and storing records. A detection will appear as follows:



The above detection shows tag number 152073304 passing Antenna 1 on April 23, at 11:59. If the time or date is wrong, now is the time to change it using the DT command. Make a note of which antenna (A1, A2, A3) corresponds to each PORT.

Create a database to store your detection records. Type the command "FR" on the command line. Three options will appear – FRD, FRR, and FRA. FRD erases the current data card and opens a new database. FRR erases the settings that have been applied to the Datalogger. FRA erases both the Datalogger settings and the database. Type FRD to create a new database. After entering the command, an option box will appear prompting the user to select an SD card size. Type '5', and the Datalogger will initialize a new database that is capable of storing detections.



The Datalogger is now operational and capable of storing tag detections. The SD card is capable of storing over a million tag detections. Check for new detections periodically, about once every few weeks. Detections can be uploaded to the HyperTerminal program by typing the command, 'UP'. Previous uploads can be viewed by typing the command, 'UP1', 'UP2', and so on. After the current detections are uploaded to the screen, select all the lines in the HyperTerminal session and copy them to Microsoft Word. Store the Word document in a folder with Station information and Date of Upload. Detections will continue to be stored on the SD card after each upload session. Do NOT reset the factory settings on the Datalogger after uploading detections.

Numerous other commands are available in the Datalogger program. A complete list of HyperTerminal commands is included (Appendix 3).

Step 6: Site Maintenance and Asset Protection

After assuring the antennas are tuned and the Multiplex Reader is capable of storing tag detections, the area can be secured. Make sure there are no items capable of short-circuiting the unit in the plastic tote. Close the NEMA enclosure on the Multiplex Reader. Screw down the remote antenna tuners with their plastic covers. Place the cover on the plastic tote and cover with a tarp, if appropriate. Place a lock on the handles, if appropriate. Ventilation should also be provided to the tub and reader to avoid condensation and shorting the circuit boards.

In areas where cattle may have access to exposed wires, solar units, and readers, place a small section of barbed wire around the area. Cows love to chew on plastic wire and they will rub on any posts, panels, or tubs that are left out!

Place signs on all equipment, warning people of electric shock. Use both English and Spanish. Signs should also identify a contact person and display the purpose of the project.

Step 7: Ongoing Maintenance

Although PIT tag stations are meant to passively monitor fish movement, there are several maintenance related issues that should be periodically addressed by the user. Wash solar panels about four times a year to remove dirt and debris.

Deep cycle batteries must be maintained. Check charge and fluid levels on each battery every six months. Fluid levels should be kept approximately ¼ to ½ inch below the bottom of the well of each cell tube (Figure 10). The production and escape of hydrogen and oxygen gas from a battery causes water loss and water must be regularly replaced in lead acid batteries. Add distilled water periodically, at a minimum every six months. During hot weather, the deep cycle battery will need water more frequently. Water should be added after the charging has been completed. If the tops of the internal plates are exposed, water should be added before charging.

If batteries have been deeply discharged and used heavily, check the state of charge of each cell using a hydrometer. Charge levels correspond to a specific gravity that can be

read on the meter. If charges between cells differ greater than .030, the battery must be equalized by placing the battery on a charger. If battery acid is spilled while testing specific gravity, dilute the battery acid using a solution of 1/4 cup baking soda to 1.5 gallons of clean water.

Periodically check to see that the Multiplex Reader is getting charged in the day and maintaining power through the night. Do this by connecting to the Reader through the HyperTerminal program and typing the command "AD". A good battery should read over 12 volts. Avoid discharging the battery below 70 to 80%. If deep discharge is occurring regularly, more energy will be needed to power the system. The Reader is programmed to shut off when voltage drops below a certain point – 10 Volts on the Default setting. Adjusting the "MV" setting using HyperTerminal program can change this. Realize, however, that deeply discharging a deep-cycle battery will shorten its lifespan.

Contact information related to PIT tag equipment

- Oregon RFID - manufacturers of HDX tags, readers, and equipment. Warren Leach (503)788-4380 www.oregonrfid.com

References

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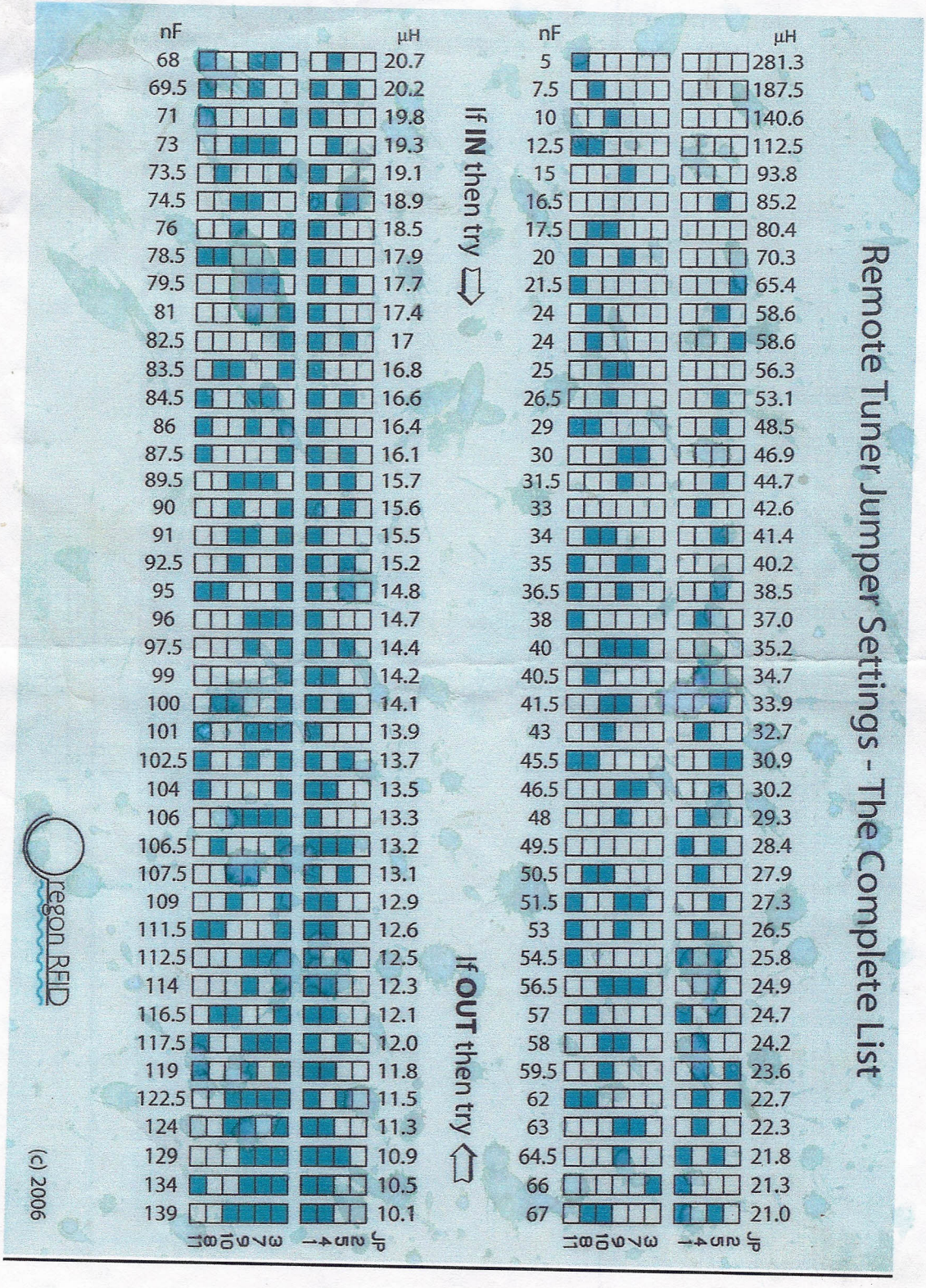
Appendix 2 – Remote Tuner Jumper Settings



Appendix 1 - Materials Checklist for HDX PIT Tag Antenna Installation

- Small screwdrivers
- Wrenches
- Wire cutters / Stripper
- Inductance Meter
- Tags
- Laptop Computer
- Comport cable
- 20 AWG TwinAx Cable
- Remote tuner boxes
- Batteries / Cables
- Notebook / Pencils
- 64 W Solar Panel
- Charge Controller
- 100 Ah Marine Batteries
- Box cutter
- Clippers
- Needlenose pliers
- Pizometer
- Voltmeter
- 3/16" Cable Clamps
- Zip ties
- 3/16" Aviation Cable
- Multiplex Readers
- 8 AWG Speaker cable
- Barbed wire
- 10 AWG Electrical wire
- Totes and locks
- E-Warning Signs
- Backup power for laptop computer
- PIT tags
- Fenceposts
- **Cheat Sheets:**
  Jumper Settings
  Terminal Commands

MGX

MGS allows for 5 Readings to be Averaged together

Terminal Commands

Set date and time
DT
(cr) Show date and time
mm/dd/yyyy hh:mm:ss

Show stored detections
UP
(cr) Send all since last upload
n By upload history list number
-n For nth previous upload
Type control-c to stop

Show stored time records
UT
(cr) Send all since last upload
n By upload history list number
-n For nth previous upload
Type control-c to stop

Show detection upload history list
UH
(cr) Show detection history
n Start with nth entry
-n Start with nth entry from end
n m Start with nth entry for m items
-n m Start with nth entry from end for m items
Type control-c to stop

Show scans per second, charge pulse timings
SS
(cr) Average of last few seconds
Runs until any character typed

Change reader settings
CG
(cr) Show current settings
An Number of antennas
Cn Charge period (15 to 255 ms)
Pn Pause to read tag (20 to 16384 ms)
Dn ID display mode
0=split decimal (manufacturer code plus ID)
1=hexadecimal
Sn Synch mode
0=None
1=Wireless
2=Wired
3=Wired/wireless
4=Master
5=Slave
I Full reader EEPROM initialization

Multiplexer scan sequence
MX
(cr) Show current sequence
dddd Sequence of up to 16 digits (1..4)
0 Clears sequence, uses 1 to number of antennas

Set minimum voltage before shutdown
MV *v d*
(cr) Show current setting
v Enter value in tenth volts (e.g. 100)
d Difference to startup (e.g. 15)
Reader restarts when value *d* volts above *v*

Set maximum voltage before shutdown
MA *a*
(cr) Show current setting
a Enter value in tenth amps (e.g. 30)

Select detection messages (see other side)
DM
(cr) Show current setting
I Send initial detection
C Send consecutive detections
F Send final detection
E Send event messages
A All
0 None

Show analog values once per second
AD
(cr) Show supply and clock battery voltages, transmit and receive amperages (by antenna on mux)
Runs until any character typed

Reset datalogger and reader to factory settings
FR
D Erase SD card, initialize database file
R Reset reader EEPROM settings
A All

Interactive mode with reader serial port
TI
Type control-c to exit

Enter comments into log file
CO *text*
Enter one line of text into log file

Oregon RFID