Section 1: Reference graphics
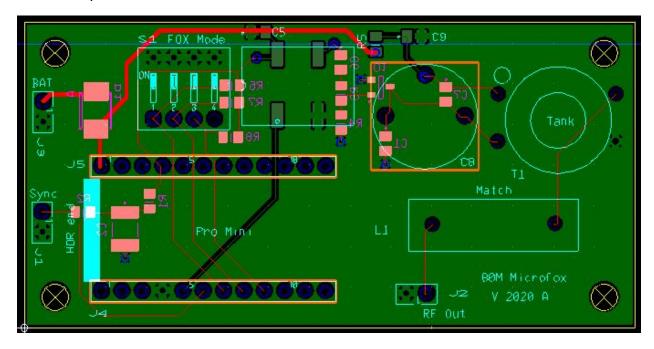
Here is a top view of the circuit board:

Figure 1: Top view of the circuit board

Bottom view of the board looking down from above the top:
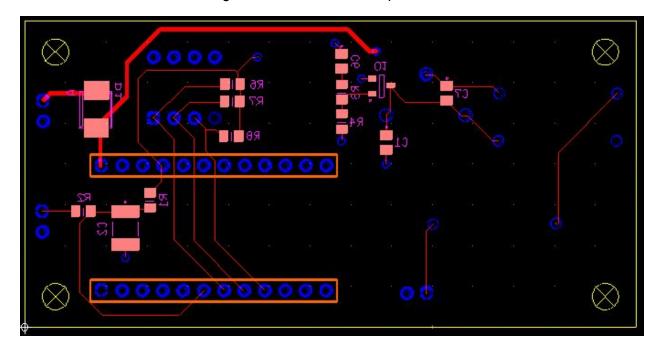

Figure 2: Bottom view of the board looking down from above the top.

Photo of the bottom of the board showing connection to tone output. This is a feature that was added to provide a start timer function, have audio for demo modes, or for modulation.
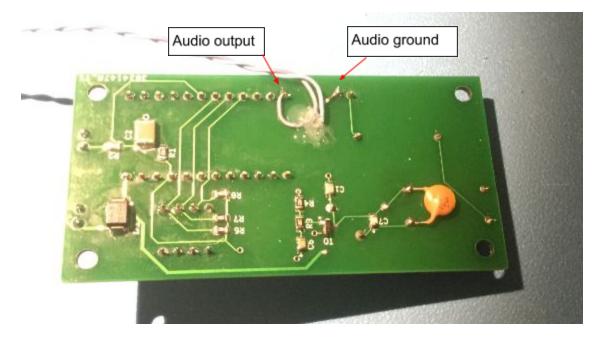

Figure 3: Bottom of the board showing connections for audio output.

Audio output comes from Pin 9 (PB1) of the pro-mini board. Caution: watch out for ESD damage. If an external amp is used add a series resistance between this net and the audio jack (~1K) to help limit ESD current to a value that the on-chip ESD diodes can handle. If driving an audio speaker directly, watch out for ESD damage from charged cables.
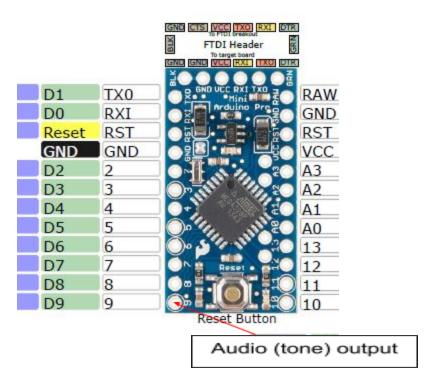
Figure 4: Audio output from Pro Mini.

Section 2: General Assembly Notes

After building 5 units here are some things I have seen.

1. It's best to install the oscillator (U2) first, before installing anything else. This allows free access for soldering to all the pins. Then install the DIP switch.

2. Install the board headers J4 and J5 next. They can then be used as an alignment jig for installing the header pins on the SparkFun Pro Mini. The Pro Mini comes from SparkFun without any headers installed. This will help get into the headers aligned straight up (referenced to the Pro Mini board).

3. Then you can install the balance of all other components in any order.

Some other notes: There have been software updates that allow the removal of some components. For example, if you are using the DIP switch there is no longer the need for using R6, R7, and R8 as the software has a compile switch that enables internal chip pull-ups. Yes,

fewer parts! The R1 pull-up for the sync switch can also be omitted if the compile switch is enabled.

Even greater parts reduction is possible. The software allows setting the fox modes without the need of the DIP switch. If you will only be configuring the transmitter via its serial port, then you don't need the DIP switch at all. The serial command "> DIP 0" (the default setting) instructs the software to use the DIP switch.

Notes On The 3D-Printed Case

I mounted my on/off switch so that ON is down. The rationale behind this is that it makes it harder to accidentally turn off the unit after synchronizing.

The following 3D-printed base plate holds the board. It uses 4-40 inserts that are inserted using a soldering iron set to a reduced temperature (~200 deg C).
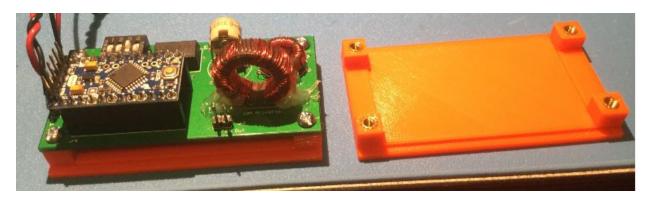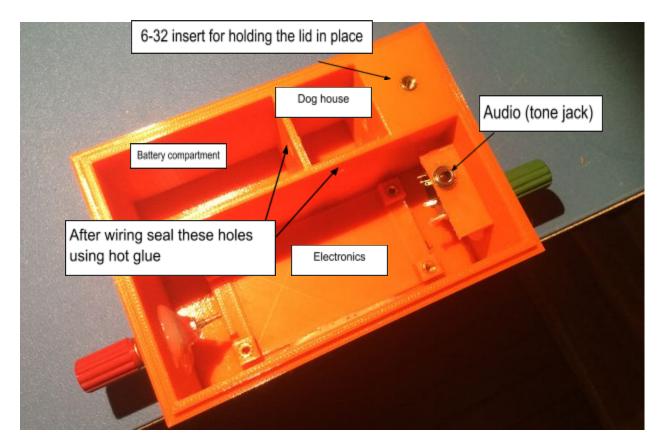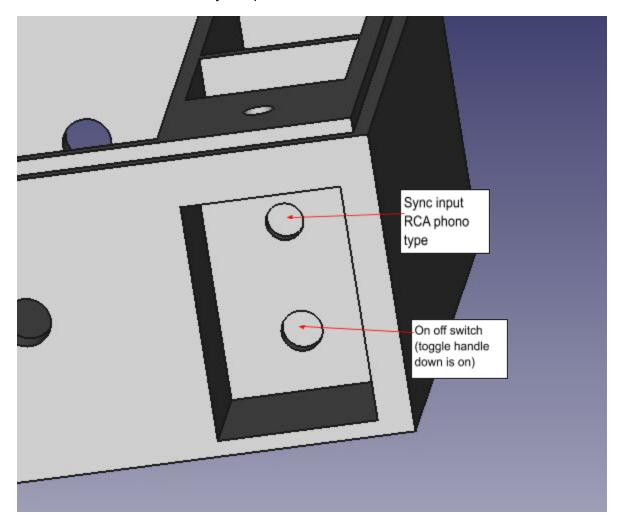

Figure 5: Board and sub-plate.

6-32 insert for holding the lid in place

Dog house

Audio (tone jack)

Battery compartment

After wiring seal these holes using hot glue

Electronics

Figure 6: Sub-plate installed in the case.

The sub-plate was glued in place using Gorilla Glue. Note the audio jack that was installed for providing tone output from Pin 9. The red banana is for the vertical antenna wire and the green one is used for the two antenna counterpoise wires. Note: use hot glue to seal the two through-case holes to keep water out of the battery and electronics compartments as it could get into the dog house form the sync connector.

Controls Installation

Here are the locations for the sync input and on/off switch:

Sync input
RCA phono
type

On off switch
(toggle handle
down is on)

Calibration

Due to the broad tolerance of the ceramic resonator used for the clock oscillator, Pro Mini boards exhibit significant frequency drift over time. I have observed tens of kHz differences in the 16 MHz master oscillator frequency. The software allows setting a calibration value to correct the 1-second timer to account for the clock frequency drift.

It is important to perform a calibration after the board is installed in the case, as I noticed that bending (putting the board under stress) can shift the oscillator frequency. So, perform the calibration after everything is mounted and wired in place.

Calibration can be performed using an accurately-calibrated radio receiver capable of receiving at 16 MHz or using an oscilloscope or frequency counter capable of accurately measuring the frequency of a 600 Hz square wave.

Receiver Method

Use an HF receiver and a small loop sensor. With the receiver in CW mode (narrow bandwidth setting) zero beat the master oscillator signal and note the frequency indicated by the radio.
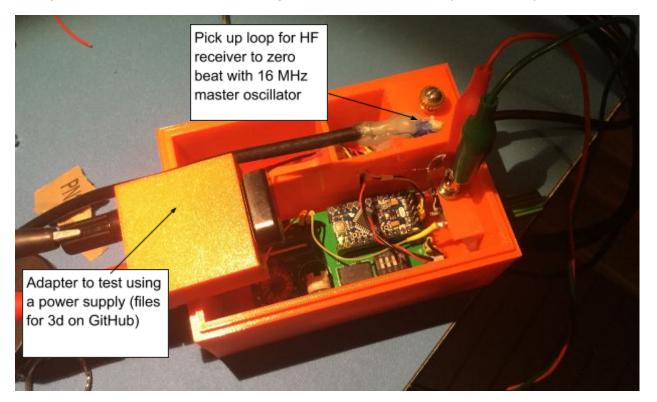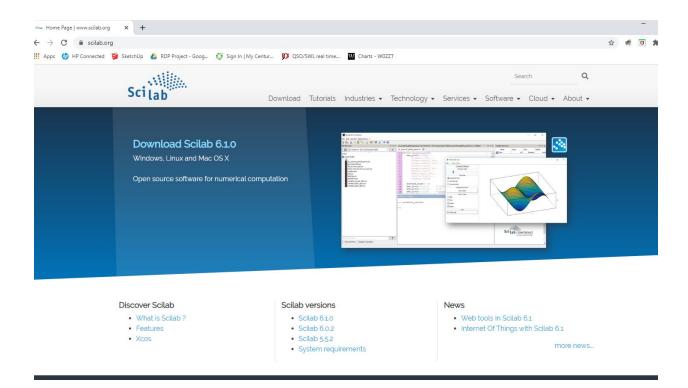

Figure 7: Receiver calibration method.

After obtaining the frequency of the oscillator, use the following script, or manually compute the calibration value using the equations in the script. The script is written in SCILAB, an open-source version of MATLAB scientific scripting software.

To download SCILAB go to https://www.scilab.org/

The calibration script starts below.

```
clc;
//
// Oscillator calibration calculator
//
// Enter measured frequency of Oscillator in MHz using CW
receiver to zero beat
mprintf("Enter frequency of the Oscillator in MHZ?\n");
FREQ = mscanf("%f");
FREQ_for_calc_IN_HZ = FREQ*1E6;
//
//
CALIBRATE = (FREQ_for_calc_IN_HZ/1024)-1;
//
```

```
// Now display it for printing a label
// Cut and paste the output into Notepad and print the label
//
mprintf('Oscillator Frequency = %2.5f MHz \n',FREQ);
mprintf('Calibration = %1.3f  \n',CALIBRATE);
mprintf('Calibration = %d  \n',round(CALIBRATE));
mprintf('Use CAL command CAL<sp>%d to enter
n',round(CALIBRATE));
```

After running the script or manually computing the calibration value, use the > CAL serial command to enter the calibration into non-volatile storage. It is recommended to print a calibration tag and tape it inside the unit. I copy the output from the script into a Notepad document and print it.

Oscilloscope or Frequency Counter Method

Enable the compile switch in *defs.h* to turn on the calibration signal on Pin 11 (PB3). Compile the project software and install it in the transmitter to be calibrated.

Measure the frequency of the signal on Pin 11. It should be close to 601 Hz. The calibration value is derived using the following formula:

CAL = 26f -1

Where f is the frequency measured on Pin 11.

Use the > CAL *nnnnn* serial command to apply the clock calibration value.

3D box parts

Here are the components that make up the 3D printed case

The following files are in the GitHub repository for this project.

1. **case_lid.stl** the lid for the transmitter case.

2. **bottom_half.stl** the bottom main part of the case.

3. **80mbase.st**l the sub-chassis that the PCB mounts on. Glue to the inside of the case.

4. **audio_jack_holder.stl** a bracket to hold optional audio jack for tone output.

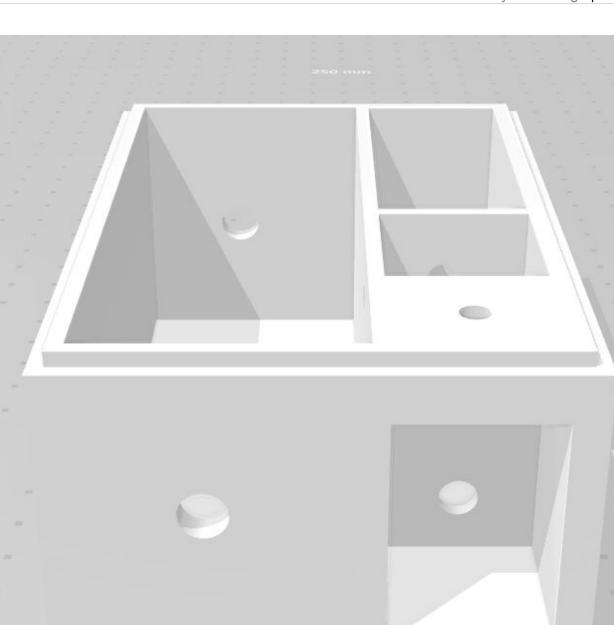5. **9vbattery_adaptor.stl** an optional test adaptor for bench testing with a power supply.
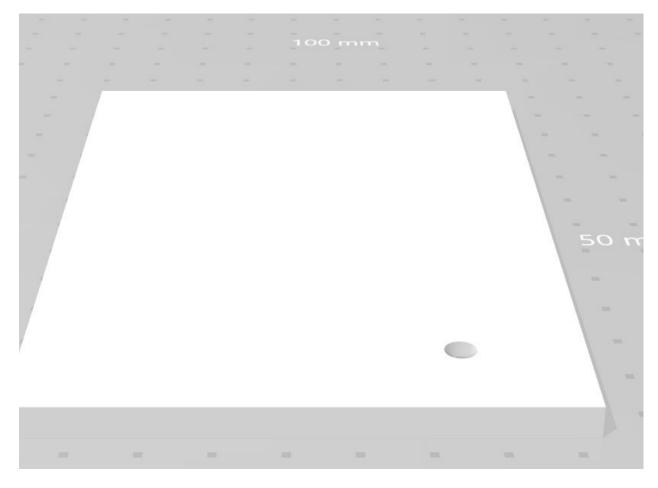
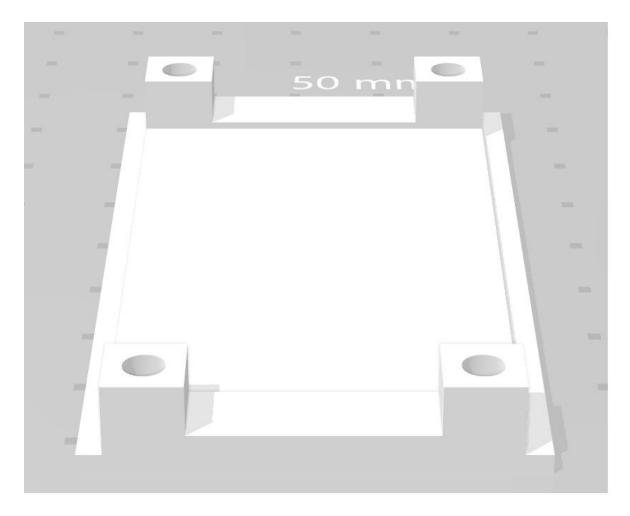*Figure 8: Main case.*

Figure 9: Case lid.

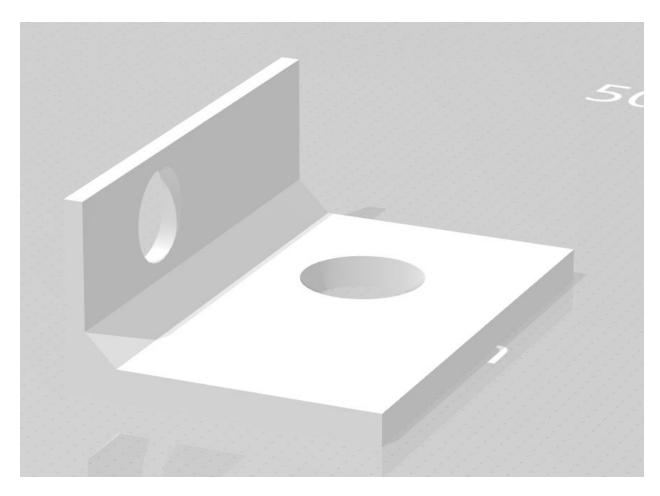*Figure 10: The sub-base for mounting the PCB.*
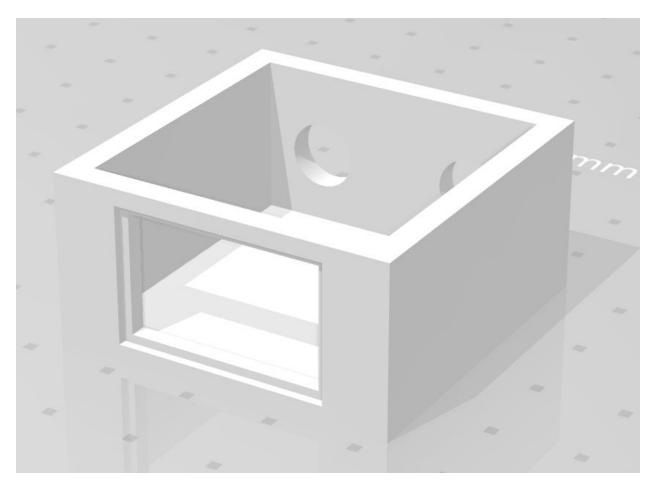
Figure 11: Audio jack holder.

Figure 12: Test jig for testing without batteries.

Note: for the test jig the battery connector was harvested from expired 9-volt batteries.

Section 3: Other Notes

Battery Installation Tips

To make it easy to remove the battery from the battery cavity, make a tape tag as shown below. Otherwise, the battery may be somewhat tricky to remove.

Figure 13: Tag on battery before installation.

Figure 14: Battery installed.

Note about syncing and transport

The transmitter was designed to run without an antenna load attached. So, after syncing, just put the active transmitter(s) into a backpack. You can continue to monitor foxes as you place them in the field. Foxes in the backpack lacking antennas, and those placed on the course, can all be monitored to confirm that all is well during field installation.

Note about antennas

The original transmitter was designed to work with a 25-foot vertical wire and counterpoise. If your antenna provides matching then you should be able to omit L1 (match). In that case install an insulated jumper in place of L1.