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Ozark QRP BANNER

Index

An Auto-Tuned Mag-Loop Antenna

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On April 16th, 2014, I was fortunate enough to win the "Best of Show" with my auto-tuned loop antenna entry at the annual St. Louis QRP Society's (SLQS) Builders Contest. This article will explain in general terms how it works and my plans for it in the future. Let me begin by saying the entire concept of making loop antennas was brought to my attention by Dave, NF0R, who, many years ago, began using an old bicycle rim as the loop. I pride myself in the fact that one of his loop antennas is made using a rim from my old bicycle. Larry, N0SA, also contributed to the project by pointing out an alternate way to match the loop, using a Gamma match rather than a small coupling loop. He also recommended some of the components I ended up using, specifically the "Big Easy Driver".

One feature of a mag-loop antenna is its very narrow bandwidth. It is essentially a high-Q resonant LC circuit tuned to the frequency of interest that also happens to radiate. Being high-Q is a good thing because the antenna itself becomes a narrow front-end filter, making for very quiet reception. It's also a bad thing when it comes to tuning the loop. Virtually every time you change frequencies on your radio, you need to tweak the antenna tuning to keep it resonant. Tuning is accomplished on my loop by adjusting the other half of the resonant loop circuit, a variable capacitor in parallel with the loop. Tuning is so touchy that stray capacitance from any source such as your hand is enough to detune the loop. Even getting close to the loop can detune it. Therefore, the best way to use most loops is to have them close enough to adjust while scanning the bands but far enough away to keep from detuning them. Having a loop in the backyard or attic while operating from the basement is out of the question, unless there were some way to remotely tune the antenna from the shack. That's what drove me to come up with a way to auto-tune a mag-loop.

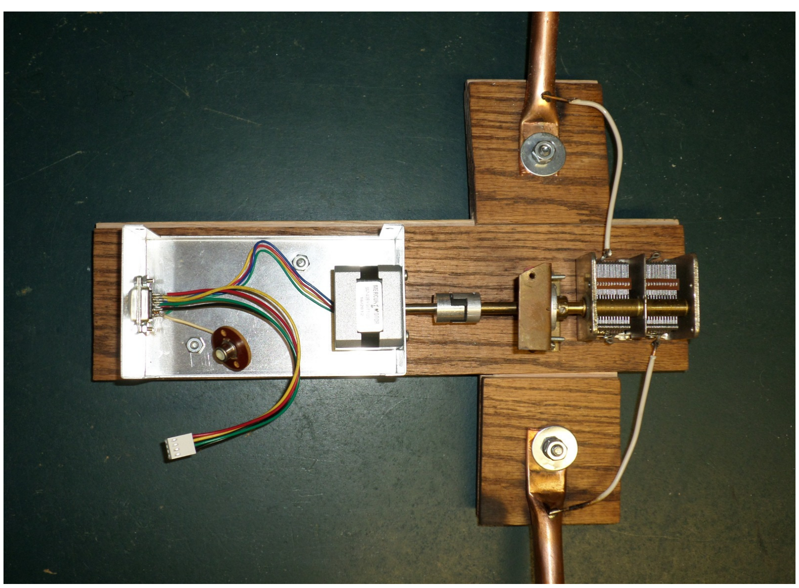


Figure 1. Stepper motor and 6:1 reduction drive attached to variable capacitor.

Antenna Unit. Unlike a typical auto-tuner, which has an array of capacitors, inductors. relays, and a sophisticated program to intelligently and quickly switch in various combinations until a low SWR is obtained, a loop auto-tuner only needs to adjust one component to find resonance, the variable capacitor. I decided to go with a stepper motor rather than a geared-down continuous motor, mainly because stopping the continuous motor without having it overshoot its mark seemed more difficult than using a stepper. The motor I chose has 1.8 degree full steps. The Big Easy Driver stepper controller allows steps as small as one-sixteenth of a full step. Throwing in a 6:1 reduction drive between the motor and capacitor, it is easy to show that 180 degrees of capacitor rotation can be broken down into 9600 discrete steps of the motor if desired. The capacitor is 200 pf (two 400 pf sections in series), which means I can adjust it by as little as 0.02 pf, more than enough for this application. Figure 1 shows a little of the copper loop, the capacitor, the reduction drive, and the stepper motor. I used a universal joint with a rubber spider to both isolate the motor from the capacitor and to allow a little bit of shaft misalignment.

Once I had the capacitor attached to the stepper, I needed to figure out how to tell when the antenna was resonant. I got my idea from the SWR indicator kit sold by www.qrpkits.com and designed by Dan Tayloe N7VE. His indicator design uses a simple bridge circuit, with the antenna acting as one branch of the bridge. If all four branches are 50 ohms, the bridge is balanced and the error voltage is very close to zero. In his implementation, there is a DPDT switch to switch the bridge into and out of the antenna circuit. The AC error voltage goes through a transformer, is rectified, and drives an LED. When you tune the antenna, the brightness of the LED dims as you approach resonance. For my implementation, I replaced the switch with a DPDT relay and eliminated the LED altogether. All I needed was the error voltage, not a visual indication. Figure 2 shows my SWR bridge, including a relay driven by a 2N2222. Other than the coax coming from the rig and going to the antenna, I needed 4 wires to go to this bridge: +5 volts for the relay, ground, a control signal to turn on the 2N2222, and the resulting rectified error voltage. When I want to see what the error voltage is, I turn on the relay, key the rig, and measure the voltage. I can adjust the capacitor for minimum error voltage and then unkey the rig and turn off the relay.

Another good thing about the bridge is the impedance seen by the transmitter is never too far from 50 ohms, which is good for the transceiver finals.

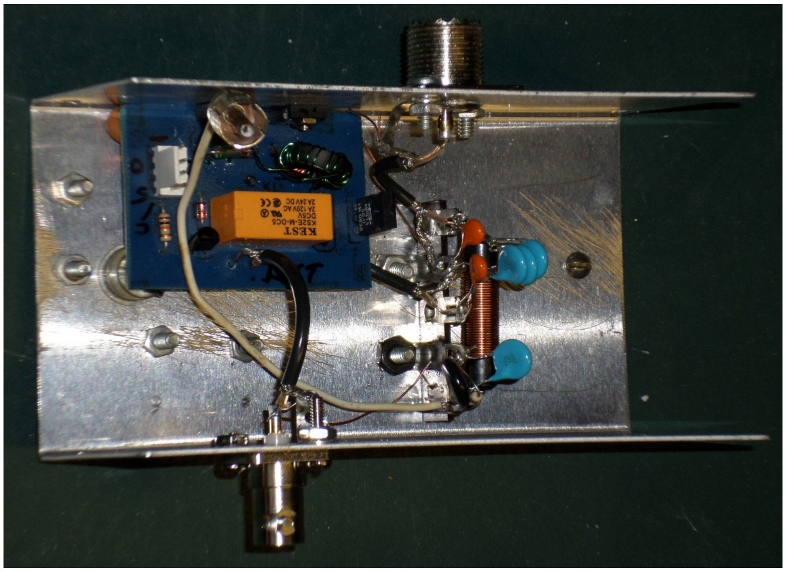


Figure 2. SWR bridge, plus bias-T on the right.

Also evident in Figure 2 is a terminal strip with some capacitors and an inductor attached to it. This is a bias-T circuit which I plan to eventually use to send control signals to the tuner over the coax coming from the rig. That is next year's project and is not used in the current design. The plan for the bias-T, designed by Phil Salas AD5X, is from the January, 2013 issue of QST. The schematic of the bridge circuit is shown in Figure 3. It turns out the transformer secondary can be 10-15 turns, but it works with 25 turns and I didn't want to redo it.

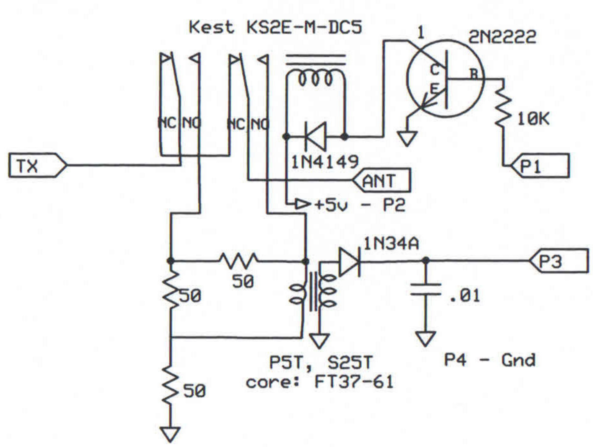


Figure 3. SWR Bridge Schematic

Before leaving this portion of the design, refer to Figure 4, which is the completed loop connected to the stepper motor. Evident in the figure is the SO-239 connector for the coax and a thin piece of coax coming from a BNC connector on the other side of the case and going to a balun at the top of the loop. Barely visible is the gamma match going from the balun to a point on the loop at about the 10:30 position. The optimum gamma match tap location varies with frequency, but the location chosen produces an SWR near 1:1 throughout the tuning range of the loop (40 – 15M).

Figure 4. Loop antenna and stepper motor/swr indicator assembly.

The main controller board. At this point, we have the mechanical means to turn the capacitor and a means to measure the error voltage coming from the SWR bridge. What's needed is a controller to tie these together. I used an Arduino Uno for my initial feasibility study, but didn't want to hard-wire that into my final design, partially due to expense and partially because it has a fairly large footprint. What I ended up choosing was something called an “Ardweeny”. This clever device is essentially an Arduino minus the USB-serial conversion part. A small circuit board contains a few components (LED, crystal, pushbutton, headers, and a few other components) and is mounted piggyback on the Atmega 328.

The problem I found with the Ardweeny is you are required to solder the headers to the very top of the IC pins and I managed to damage the chip with excess heat. My final design incorporates the same schematic but the parts were relocated to my main PCB and the Atmega 328 plugged into a socket after all soldering was finished. Figure 5 shows the completed main PCB attached to a control panel PCB with pushbuttons and LEDs. As is obvious, when I designed the PCB, I didn't spend a lot of time trying to minimize the number of jumpers required. That many jumpers may not look professional, but with a single-sided board and so few components, it is virtually impossible to eliminate all jumpers anyway.

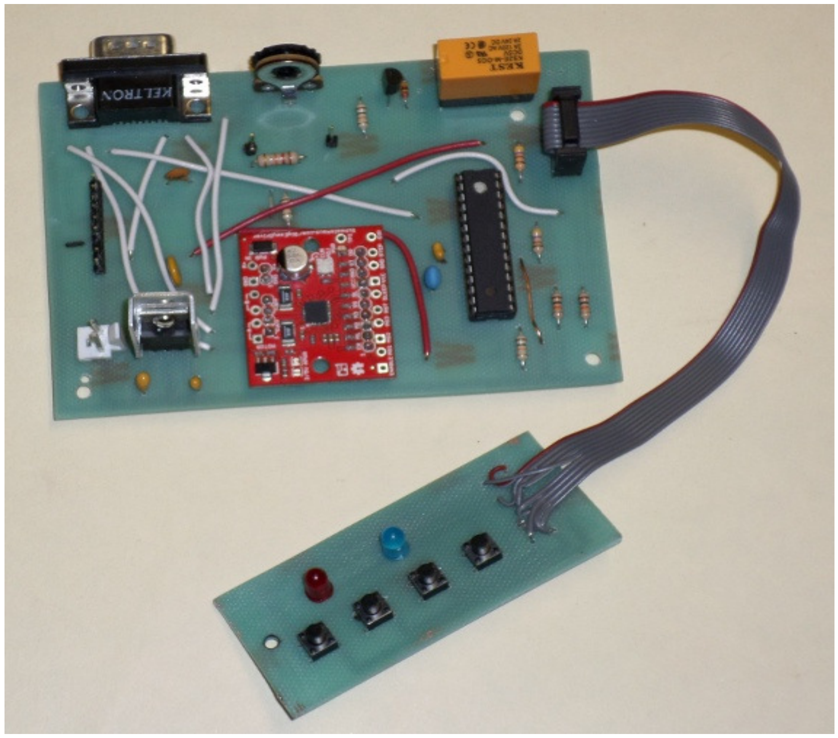


Figure 5. Main board plus front panel

Referring to the figure, near the top of the board are a db9 connector, a trimmer to adjust the voltage coming from the SWR indicator, and a keying relay controlled by a 2N2222. The db9 connects the main board to the stepper motor and SWR indicator located at the base of the antenna. The surface mount board in the middle is the Big Easy Stepper Motor Controller, which I did not build. That board needs 12 volts for the stepper motor and includes its own 5 volt regulator capable of powering the Arduino. I disabled this regulator, fearing it wouldn't be able to handle the Arduino, controller, two relays, and the LEDs. Instead, visible on the lower left is a 7805, which can handle more than enough current for this circuit. The 12 volt power connector is visible to the left of the 7805. The header right above that is where I plug in an FTDI USB-serial programmer. That device allows me to program the 328 (shown on the right on the board) as well as to have the program send debug statements to a terminal on my computer. The FTDI programmer measures a whopping 7/8” x 5/8”. When programming and debugging are finished, the FDTI programmer can be removed and used on my next project, if I don't lose it first.

Main Controller Board Schematic. Figure 6 is the schematic of the main board and control panel.

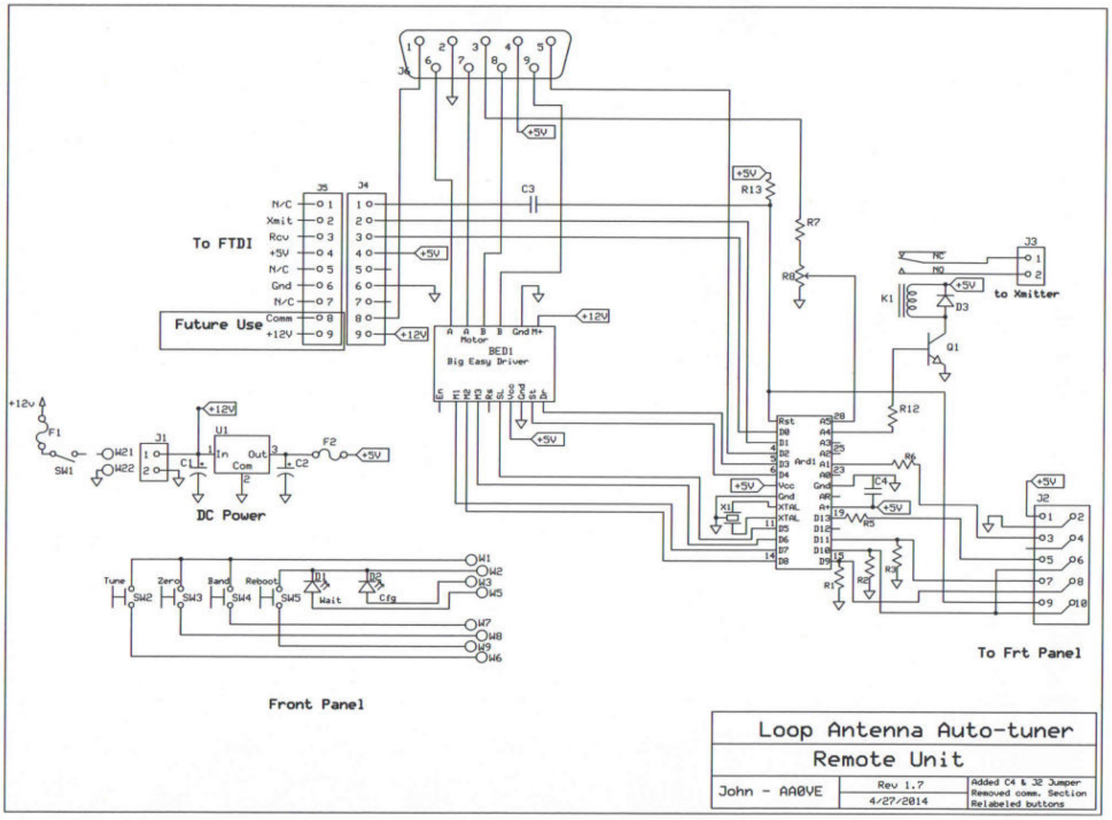


Figure 6. Main Board/Front Panel Schematic

I don't intend to discuss the entire schematic in gory detail, but will point out a few things to help explain how it works. The DC Power section sends 12 volts to the Big Easy Driver (BED) and provides 5.0 volts for the rest of the circuit. The front panel consists of 4 pushbuttons and 2 LEDs. The "Tune" button tells the program to commence tuning. The "Zero" button tells it to bring the capacitor back to the "home" position, plates fully meshed. The "Band" button selects which band the antenna is to be tuned to. The "Reboot" button grounds the reset pin of the Atmega 328 Main Processing Unit (MPU) to restart the program. When any of the other three buttons is pressed, 5 volts is sent to a pin of the MPU. If the MPU happens to be watching that pin, the 5 volts is a signal telling it to do something. The red LED lights mainly to tell the operator that something is indeed happening. The blue one blinks to tell which band you have selected. They will light whenever the MPU sends 5 volts to the pins the LEDs are connected to. Notice the pushbuttons are inputs to the MPU while the LEDs are outputs from the MPU.

The main purpose of the MPU can be summarized as follows:

1) It watches the 3 digital input ports (D9-D11), to see if a pushbutton has been pressed.

2) It sends either 0 or 5 volts to the digital output ports (D2-D8, D13, A1, and A4).
3) It watches an analog input port (A5), to measure the SWR error voltage coming in.
4) It runs the program that tells it when to do all these things.

There are two digital pins, D0 and D1, which connect directly to the FTDI interface. They are the serial communications ports, responsible for loading the program from my desktop computer to the MPU. During debugging, they also send data back to the desktop, to a terminal program that allows me to see what the program is doing. This is invaluable during the programming/debugging phase, but not necessary once all is working properly.

The program operation will be described in general terms a little bit later. We will first quickly discuss the Big Easy Driver (BED), shown as a rectangle in the middle of the schematic. The output of the BED has two terminals labeled A and two terminals labeled B, which go directly to the stepper motor via the db9 connector at the top of the schematic. Other than the terminals labeled Vcc and Gnd, all the terminals at the bottom of the BED are inputs which tell it what to do. For example, “SL” is the sleep pin. If grounded, the BED is turned off, preventing any processor noise from making it to the antenna. +5 volts turns it back on. “Dr” is the direction pin. If grounded, the motor turns in one direction. If +5 volts are applied, it turns in the other direction. The signals on M1, M2, and M3 tell the BED how big of a step is desired. If all are grounded, it takes a full step, which is 1.8 degrees. If some or all are at +5 volts, it takes various smaller step sizes, down to 1/16th of a full step. Finally, “St” is the step command. Whenever a 5 volt pulse is sent to this pin, the motor takes one step, determined by M1-M3, in the direction indicated by the “Dr” pin. That's about all you need to know about the BED.

Pin 3 of the db9 contains the error voltage from the SWR indicator. That voltage goes to the voltage divider R7 and R8, the output of which goes to an analog pin on the MPU. The voltage at that pin must be within the range of 0 to +5 volts and when read is internally mapped to a number from 0 to 1023. If I know the power output of the transceiver will be 5 Watts or less, I can adjust the trimmer such that no more than 5 volts will ever show up at the analog pin. I don't know if the variable capacitor or the SWR relay can handle much more than 5 Watts and I don't intend to do any destructive testing to find out. As a result, I'm rating this antenna at 5 Watts maximum and have adjusted the voltage divider accordingly.

The remaining circuit in the schematic is a relay, K1, which will key the rig when told to. Figure 7 shows the finished unit with the cover removed. The eagle-eyed readers might notice a slight change from Figure 5. The resettable fuse, located just above the 7805 regulator, is no longer soldered directly onto the board. I put a small header there in order to remove the fuse if desired. Five volts are available from the FTDI USB interface when it is plugged in. I didn't like the idea of 5 volts coming from two independent sources, so I made the fuse removable, to disable the internal 5 volt supply.

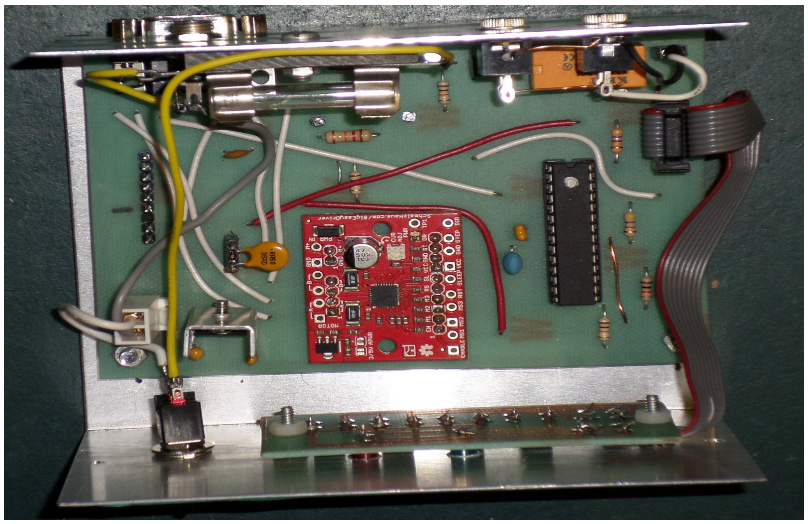


Figure 7. Finished control unit, cover removed.

<u>Putting it all together.</u> When switched on, the MPU begins to run the tuner program. It first sits there, patiently waiting for one of the 3 pushbuttons to be pressed. If the 4^{th} button is pressed, it's the same as switching the device off, then on again, so we won't discuss that further. When pressed once, the “band” button tells the MPU we are interested in the lowest band (40M). If pressed again, we are interested in the next band (30M). The loop works up to 15M, so I currently allow 5 bands. As you press that button, the blue LED flashes to indicate which band has been chosen (1-5). If you press the button 6 times, it goes back to band 1, etc. The program is calibrated to know about where the tuning capacitor needs to be for the lowest part of each defined band. It also knows about where each band ends. For example, out of the 9600 capacitor settings possible (microsteps), let's assume the 40M CW band goes from location 1000 to 1100, corresponding to 7.000 MHz to 7.150 MHz. To allow for reduction gear slippage and imperfect motor stepping, I might define the 40M CW band as going from 900 to 1200 microsteps. The “band” button doesn't make the motor move. It just makes a note of which band is desired.

When the “tune” button is pressed, the first thing the program does is see if the desired band is the same as the current band. After all, it's possible that the “band” button was pressed enough times that it ended up set to the same band the antenna was already tuned to. If it is a different band, the capacitor is quickly moved to the lower end of that band. Then it performs the following steps:

1) Turns on the SWR indicator relay and delays to make sure the contacts have closed.
2) Keys the transmitter and delays to make sure the transmitter keying relay contacts have closed.
3) Waits to make sure the transmitter has reached maximum power.
4) Steps the capacitor a little, checks the SWR bridge voltage, determines if the voltage is decreasing.
5) Keeps track of the lowest SWR bridge voltage and stores the setting that produced it.
6) Continues to step the capacitor until it is sure it has tuned through the resonant point and is on its way back out of resonance.
7) Unkeys the transmitter and turns off the SWR indicator relay.
8) Moves the capacitor back to where the SWR bridge voltage was lowest.
9) Turns off the Big Easy Controller, to eliminate receiver noise.

If the band hasn't changed, it is considered a “fine tune” only. The capacitor is moved down a few steps, then the above process is pretty much repeated. Modifications that are currently in work include using a finer motor step, especially for 17 and 15M. Tuning gets more touchy as the frequency increases and a finer motor step will be able to get closer to resonance. A quarter step is sufficient to tune 40M through 20M, although a finer step won't hurt. The “zero” button is used to park the capacitor with the plates fully meshed, to protect it while in transit or to prepare for a reboot. Whenever rebooted, the program assumes the plates are in the starting position, i.e., fully meshed.

While I described the algorithm in a few short paragraphs, the actual program is around 600 lines of code.

Future plans. This is part I of a two part (at least) project. I currently have a 6' cable going from the control unit to the antenna. That allows 6' of remote operation, enough to help if the antenna is on the same picnic table as the radio, but hardly enough if the antenna is in the attic. See Figure 8. The 6' cable was used because I could buy one with ferrites on each end for less than $2.00. I couldn't buy the connectors, let alone the cable and ferrites, to make my own cable for $2.00. I doubt the device will work with a 50-75' cable, but even if it did, I don't want to run an extra cable between the antenna and the shack.

Figure 8. Finished auto-tuner in operating position, plus Best of Show plaque.

There are other shortfalls as the design currently stands. For one thing, the transceiver needs to be set for hand key operation. When keyed in paddle mode, producing a string of dits or dahs will only confuse the program and certainly won't find the proper resonance point. So at this point, I am stuck with using an external keyer.

My future plans will include at least the following:

1) Make a second unit that will be sitting in the shack, connected to the K2 (or other smart transceiver).
2) That local unit can communicate with the K2 as well as with the control unit near the antenna. Communications with the K2 would be via the serial port. Communications with the unit at the antenna will be through the coax via two bias-T circuits, one in the local unit and one in the control unit at the antenna.
3) When a tune is requested, the local unit can switch the K2 to hand key input. After tuning, it will switch the K2 back to paddle input. This will all happen rather quickly and won't inconvenience the operator at all. Furthermore, the K2 can be queried as to which band it is on, to eliminate having to manually set the tuner to the correct band.
4) A hardware mod that needs to be made is isolating the key jacks from ground. I plan to accomplish that by eventually mounting those jacks on a piece of acrylic.

Conclusions. This has been a fun project. I've worked on it part-time for about 18 months and have learned a lot about the Arduino in the process. I don't expect my future plans to be implemented by Field Day 2014, but I'll make sure it can do a good job of tuning when the radio is 6' away from the antenna and hope to use it at least a little during that weekend. As of this writing, the software hasn't been cleaned up, but if anyone is interested in seeing the nitty gritty details of how it was done, he is welcome to contact me and request the latest version of the C-code that is available (no warranties expressed or implied).
73, John Lonigro, AA0VE - jonigro@gmail.com

Stephen Szabo, WB4OMM

New Northern Florida SM

Stephen Szabo, WB4OMM, QCWA Member #32402, of Port Orange, FL, is the new ARRL Section Manager for the Northern Florida Section. Szabo begins his term on July 1, 2014.

A retired Daytona Beach Police captain, Szabo is currently the Northern Florida Section Emergency Coordinator and District Emergency Coordinator as well as an instructor/mentor and a DXCC/WAS/VUCC card checker. **(*Courstesy ARRL Bulletin Service)***

Second Sunday Sprint

SSS

June 8th ..watch the 4sqrp reflector

HAM HIJINKS

HAM RADIO NEWS OF THE FUNNY VARIETY

From the Award-Winning
Noise Blankers News Team

By WBØRUR, on the scene

WELLSBURG, Missouri – Famous for the grossly underperforming Peanut Whistle 250 and 500 model transmitters, Missouri electronics manufacturer "Peanut Whistle" is announcing a new transceiver will be unveiled at the Dayton, Ohio, Hamvention.

Director of Marketing Erastus Pflemming says the company hopes to align its product offering with current pop culture trends to sell units and get more people involved in ham radio.

"We looked at the marketplace and analyzed what people are buying right now. Based on the pervasive nature of 'DUCK DYNASTY' logo merchandise, we brokered a deal with the Robertson family. You can't go anywhere that the 'DUCK DYNASTY' brand isn't slapping you in the face with everything from plastic drink glasses to toolboxes to cooking tools. Why not an amateur radio transceiver?"

The Peanut Whistle Duck Dynasty "Grass Shadow" pattern, complete with duck call knobs.

The transceiver – which looks eerily similar to vintage Heathkit rigs in both design and color – will operate on ham bands 80-10 (except WARC) and is a "throwback" to a by-gone era with its use of vacuum tube circuitry.

Additionally, Pflemming says the unit will be available in two types of camouflage patterns: "Forest Concealment" and "Grass Shadow." Each unit will also be sold with duck call knobs, a heavy duty beard comb and a set of hunting overalls.

Pflemming says hams who purchase units

at the Dayton Hamvention will receive the

special bonus of a pre-programmed

voicekeyer which transmits "HEY!

I'M CALLING CQ AND THAT'S A FACT,

JACK!" in the voice of the family's famous Uncle Si.

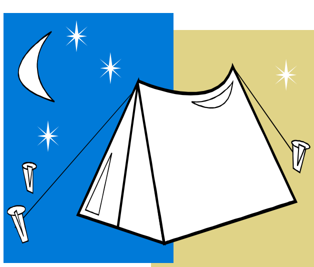
The Peanut Whistle Duck Dynasty "Forest Concealment" pattern is perfect for operating in the woods. Can you spot the radio?

Peanut Whistle officials say if the Duck Dynasty unit does not sell well, it won't be too difficult to rebrand the devices as "'DAPPER DAN' O' BROTHER WHERE ART THOU" limited edition transceivers.

hamhijinks.com

AARRL Field Day June 28 – 29, 2014

Start: 1800 UTC Saturday ..... End 2100 UTC Sunday



Always the fourth full weekend in June

WARNING to all FD outings

FD Reports of clubs and individual reservations to camp out in parks overnight are being required to provide proof of insurance for overnight events. Please contact your park or site location for any requirements ASAP. It may take time to purchase the needed insurance.........de K5EST.

Four State QRP Group

is meeting at the Country Cupboard Restaurant in downtown Seneca, Mo. This is one of the locations that 4SQRP folks gather.

The Country Cupboard has a nice menu and they have a separate meeting room we can use.

The Country Cupboard restaurant is located in the first block north of the blinker light in downtown Seneca. From Barney's, head north on Cherokee Street (that's the main street of town). Go across the railroad tracks and keep going past the blinker light stop.
The restaurant is located at 1038 Cherokee street, on the west side of the street.

Caution: If you are headed north, do not make a left "J turn" into a parking spot. "J turns" are illegal in the downtown area. Keep going north past the restaurant till you reach the residential area north of downtown where a "U turn" is permitted. Make a U turn there (it's a wide street) and come back to the parking in front of the restaurant.

Our group is an informal organization with no officers, no rules, no dues or any other things to get in the way of having fun with QRP. **We get-together monthly for lunch and the sharing of ideas and information, parts swapping and just plain fun on our normal third Saturday of a month.**

All ham radio amateurs (or prospective hams) are invited to participate.

via Terry - WAØITP

David Cripe, NM0S, has been inducted into the ARCI QRP Hall Of Fame.

He also won category 200 of the Homebrew contest with his soon to be famous MenthoDyne transceiver.

Many well deserved congratulations to Dave!!

The Four State QRP Comfortable nets meet each Wednesday night beginning at 7:30 PM CDT, 0030z.

Note: on Nov 6 we'll be on CST.

If we have to QSY, I like to move up, Wayne likes to move down, and Dick doesn't have to move much at all.

Add anything to the exchange that you wish, temp rig, ant, etc. Checking into all sessions is encouraged.

7:30 CDT 0030z ... 40M CW Net on 7122, KCØPMH NCS
8:00 CDT 0100z ... 80M CW Net on 3564, WAØITP NCS.
8:30 CDT 0130z ... 40M CW Net on 7122, KCØPMH NCS
9:00 CDT 0200z ... 80M PSK Net on 3580.5, NØTGR

Thursday mornings ~ 8 to 8:30am
A gathering of CW ops are having fun on
7.122 MHz
....and you are invited!

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