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From the Workbench

This issue's thoughts from the Section Manager's workbench

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Welcome to the VERY late Winter 2020 issue of the WCF EXPERIMENTER. Life has gotten in the way once again and we are running very late with this issue.

The good news for you the reader is the Spring 2020 issue will come out in May in about 3-4 weeks from now. So you get two issues almost back to back.

Much has changed in our everyday lives since the last issue. Starting on March 15th, much of everyday society began to respond to the coronavirus or as it is officially known COVID-19 and much of our daily lives began to change. Amateur radio hamfests were cancelled for March and then April. Amateur radio club meetings and social events started to be cancelled shortly after that and the following week. Many of us learned a new term - social distancing. The final "nail in the coffin" so to speak was Governor Desantis Executive Order 20-91, issued on April 3rd with "stay at home" orders to be effective through April 30.

Many have lost their jobs due to the shuttering of parts of the economy and many are hurting. Hopefully the "Coronavirus Aid, Relief, and Economic Security Act" or CARES Act, which comes with a price tag of $2 Trillion dollars (that is $2,000,000,000,000 think about that) will provide checks of $1200 per individual or $2400 per couples to help them through this very rough time. Wearing masks in public and maintaining 6 feet from other people is the new normal. Many are dealing with "cabin fever" from being at home all the time. We will simply have to wait and see when normal social activities and parts of the economy will be restarted.

However this is the time that you as an experimenter, builder, and or designer, can use this time to start and or finish that new project as you are likely to be bound at home or if you are in "essential services" that you have more time at home when you are not working. Or perhaps do research on that new project or finish documenting that project you have completed. If you do not document it, you can forget how you designed it, built it, or problems you solved in development. This may be the time to watch some online videos to learn some new skills and there are even college courses you can take for free that are part of what is called the Massive Open Online Course initiative. Many major universities offer MOOC related classes via video and even have exercises to go with them and they are FREE.

Lastly, consider writing up an article for the next issue of the WCF EXPERIMENTER. The WCF EXPERIMENTER cannot succeed without articles for readers to read. We get articles from writers that have not published in most nationally known journals or would not have otherwise been widely known previously. Your article does not have to be a "finished" product. It can be a reasonably thought out concept for something new or different and that article is the way to ask for feedback. Jim Weslager K3WR, our Assistant Section Manager for Publications, can work with almost any format. I send him these columns you read as an email, for example. Jim's email address is weslager@gmail.com.

This issue has a really good feature article by Andy Corwall VE1COR on an Automatic Antenna Tuner for a Magnetic Loop Antenna. Geoff Haines N1GY has a simple homebrew vesion of a phono jack insertion tool for those phono jacks that do not have a hex nut to mount them. Our Technical Coordinator Dave Birnbaum K2LYV, share thoughts on some ideas for you. Also we have reprinted an article posted on the Electronic Design website by Lou Frenzel W5LEF about the difference between bit rate and baud rate.

Please stay safe, stay well, and continue to follow the social distancing guidelines for your health and the health of your family. 73.

The following article is reprinted by permission from TAPR and the author from Issue #134 of the Packet Status Register published by TAPR.

Automatic Tuner for Small Magnetic Loop Antennas

A small magnetic loop antenna is relatively compact, easily portable, and does not have radials; it is directional, has some gain, and is suitable for use outdoors and indoors or on a balcony

By Andrew Cornwall, VE1COR / KB1RSE

According to the 2010 United States Census 80.7% of the population lives in 'urban' regions. Urban residents account for over 90% of the population in seven states. A trend toward urbanization has happened throughout the country. There is considerable leeway in the definition of an urban area, yet the implication is that an increasing number of U.S. hams live in apartments or in houses with lots too small for a full-size HF antenna. Many U.S. hams with sufficient land reside in neighbourhoods subject to homeowner's association rules that do not allow full size HF antennas[1]. Increasing urbanization is also occurring in other countries. According to United Nations data for 2018, 55% of the world's population now lives in urban areas[2]. The implication for hams is there is a growing need for a small footprint, compact, capable HF antenna. Such an antenna might be an autotuned small magnetic loop.

This article is about making a remote automatic tuner for small magnetic loop antennas. The article explains in some detail how the autotuner functions and is used. Implicit in this description is how to make one. I do not provide a parts list here and catalogue numbers. Fortunately, circuit components are standard electronics as identified in the circuit diagram.

A small magnetic loop antenna is relatively compact, easily portable, and does not have radials; it is directional, has some gain, and is suitable for use outdoors, and (within safe antenna proximity power limits) indoors or on a balcony[3]. The antenna consists of two loops, one within the other, interconnected by inductance. The much smaller loop, called the coupling loop, connects to a transmitter/receiver. The larger, transmitting loop (it also receives), about a metre in diameter for popular HF bands, is connected in parallel with a variable capacitor comprising an LC circuit. Tuning happens, with maximum antenna output, when the variable capacitor is turned until the resonate frequency of the LC loop matches the transmitting frequency. At resonance the variable capacitor is subject to very high voltages, up to about 900 volts when the antenna is transmitting 5 watts, and 4,200 volts at 100 watts. The coupling loop does not experience high voltages. Tuning for optimum transmitting concurrently optimizes the antenna for receiving.

There are numerous Internet sites covering small magnetic loop antenna design and construction. Further, there are several small magnetic loop antenna design calculators. The most accurate calculator for my purposes is KI6GD - Glenn Sperry's Magnetic Loop Antenna Calculator, LoopCalc.exe, which can be downloaded from http://www.iw5edi.com/software/magnetic-loop-calculator.

Picture 1 shows the type of small magnetic loop antenna I use. The autotuner is in the box below the antenna. For my antennas I employ good quality coaxial cable to make the transmitter and coupling loops. It operates on the 40, 30, and 20 metre bands. Other bands may be accessed by changing the transmitting loop size and/or the range of the variable capacitor. The antenna's variable capacitor is a high voltage air

Picture 1. Small Magnetic Loop Antenna with Autotuner

Table 1
Profile of Small Magnetic Loop Antenna

Transmitting Loop	
- Circumference (1)	3.8 metres
- Cable Type	Intecomp 50 Ohm 'Low Loss' Coax (1)
Capacitor	
- Max. Voltage	5 kVolts (2)
- Turning Range	360 degrees
- Max Value	127 pF
- Min Value	22 pF
Resonate Bandwidth /Antenna Efficiency % (3)	
- 40 metres	8.0 kHz / 13%
- 30 metres	12.6 kHz / 33%
- 20 metres	26.1 kHz / 61%
Structure Materials: 5 mm plastic sheet reinforced with 3/4" wood frame to mount variable capacitor and autotuner. PVC electrical conduit: 1" for mast and 3/4" for loop brace	
(1) Only braided shield is used (2) Estimated at plate separation of 3 kV per millimetre (3) Calculated with LoopCalc.exe by Glen Springer, KI6GD	

variable capacitor which can rotate continually 360 degrees[4]. Better amateur radio small magnetic loop antennas have a transmitting loop made of copper pipe or tubing, which is superior because of lower electrical resistance resulting in better performance and lower Q. (The autotuner described here should work well with such a transmitting loop.) Also, a costly vacuum variable capacitor[5] may be employed that can withstand much higher voltages, allowing for greater transmission power. Nevertheless, coax based small magnetic loop antennas with air variable capacitors are fairly popular and quite effective. They are also easy to construct.

Table 1 provides the characteristics of the antenna I used for this article.

Except for portable operation small magnetic loop antennas are rarely found in hams' antenna repertoires. The problem is the antenna's extremely high Q making it difficult to accurately tune. Graph 1 illustrates the minute turning range of a traditional air variable capacitor to achieve anywhere near maximum output. The only significant transmitted signal occurs within a two-degree portion of the 180-degree (half) rotation of a variable capacitor, and successful tuning is within less than a one-half degree range[6]. (At least this is the situation with my small magnetic loop antenna.)

There is another inherent difficulty with small magnetic loop antennas. If the antenna is not equipped with remote tuning the radio operator has to be able to reach the antenna's variable capacitor to tune by hand, limiting where the antenna can be set up and possibly exposing the operator to significant RF energy. There are commercial and DIY devices that make remote tuning possible. These often utilize a stepper motor or geared down DC motor at the antenna to turn the variable capacitor for minimum SWR at the transmitter. One type has a handheld motor control. Another is a logic-based tuner that automatically searches for minimum SWR.

I wanted to make a remote automatic tuner that would be precise, easy to use, and inexpensive. Once I settled on the unique strategy for remote automatic tuning, the design of the autotuner was obvious and extremely simple. It is also inexpensive costing about $50, not including metal box and parts for the small magnetic loop antenna. With my design I confidently autotune a small magnetic loop antenna remotely within a fraction of a dB of best possible. There is a limitation to the autotuner's performance, however, and this is noted later.

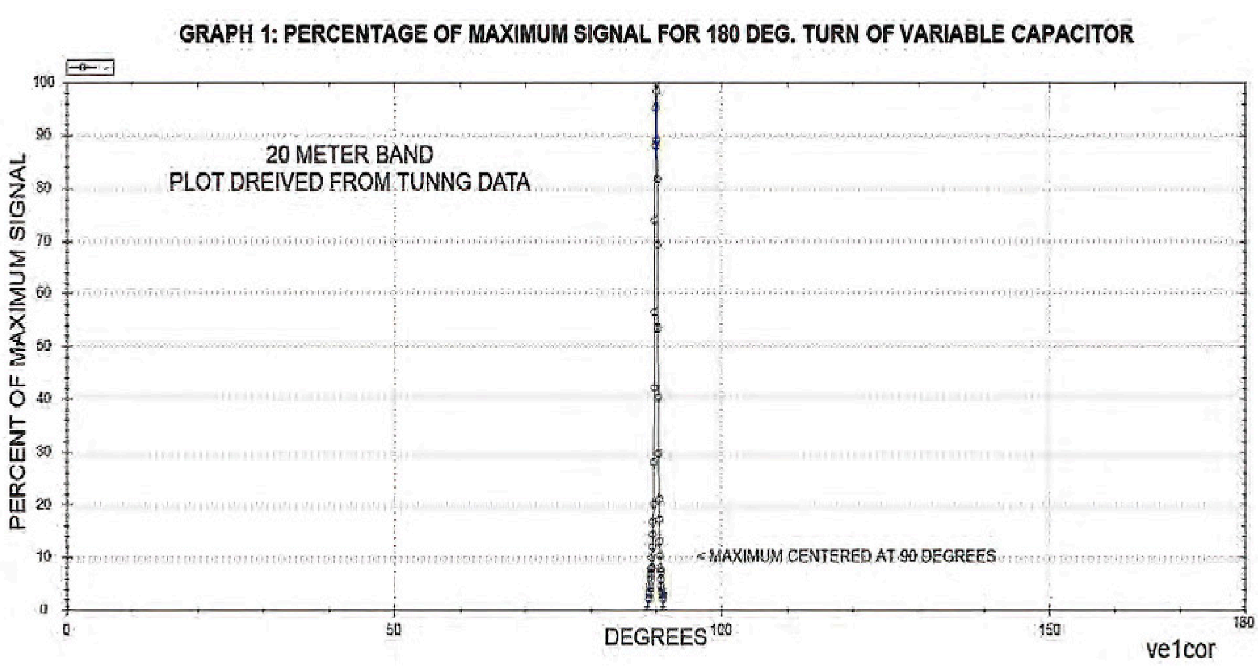
I have constructed several autotuners out of varied parts for the stepper motor, stepper motor driver, and small magnetic loop antenna air variable capacitors. They all did an acceptable job. For guidance, however, specific models of stepper motor and variable capacitor and their suppliers are mentioned in the article. A printed circuit board is available which facilitates assembling the circuit.

Unique Tuning Objective

Usually antenna tuning strives to achieve the lowest SWR measured at the transmitter or the antenna feed point. My autotuner's objective, however, is to achieve the highest possible output at the antenna from the power delivered to it. Maximum transmitted power might not occur at the antenna's lowest SWR, because the impedance of an optimally tuned small magnetic loop antenna may not be 50 ohms, typical transmitter output and transmission line impedances. Tuning the antenna for lowest SWR does not guarantee absolutely highest antenna radiation. Fortunately, in my experience, the highest radiated power of a small magnetic loop antenna is consistent with acceptably low SWR. If this were not the situation high SWR at the antenna can be managed by adding a traditional antenna tuner probably at the transceiver.

Picture 2 shows the autotuner and variable capacitor mounted together on a platform that clamps to the mast of the small magnetic loop antenna. The variable capacitor is housed in a white shield made from PVC pipe, and the autotuner is in the metal box. (The extra holes in the box relate to a former autotuner.) WPicture 3 shows the placement of parts inside the box, and Figure 1 shows the circuit of the autotuner. The circuit has five sections: sampling antenna, wide band receiver, microcontroller, stepper motor driver, and stepper motor. They are described below.

Sampling Antenna



The perceived sensitivity of the sampling antenna increases with frequency. This is mostly because small magnetic loop antennas of a given size are more efficient at higher frequencies, as shown in Table 1 for the prototype antenna.

Picture 2. Autotuner - Sampling Antenna Below Variable Capacitor Protector

The sampling antenna has one important limitation. It can pick up a signal from a nearby relatively high-power transmitter and mislead the autotuner[7]. Although infrequent I have had the embarrassment of demonstrating the autotuner at a transmission laden hamfest with unsatisfactory results. Computer monitoring of the automatic tuning process or autotuner manual mode, described later, can reveal where outside RF is likely to throw off autotuning. Also, extraneous RF interference can be reduced by using a shorter sampling antenna in conjunction with higher tuning power, e.g. 5 watts.

Receiver

The receiver is very wide band, consisting of four 1N34A RF diodes in a bridge rectifier. A 0.002 uF capacitor suppresses non-DC output from the receiver. Indeed, the combination of sampling antenna and receiver comprise a field strength meter.

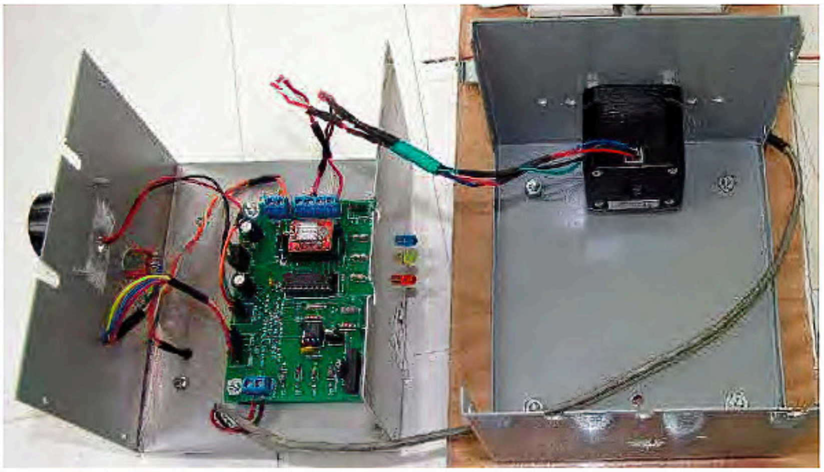
Linking the receiver to the microcontroller is a 4N35 optocoupler which provides a non-inverting path, signal isolation, and limits the voltage to the microcontroller input to 5 volts, its maximum safe level. Output from the bridge rectifier is connected to the LED inside the optocoupler. The optocoupler functions in the linear mode, where current passing through its output transistor varies in conjunction with the amount of current going to the internal LED. Too much current at the LED results in transistor saturation - this is the optocoupler's switching mode. The optocoupler's linear mode sensitivity (before saturation) varies with the value of the output transistor emitter resistor, switchable between R1 and R2 in the circuit diagram. Voltage across the emitter resistor is applied to pin 18 of the microcontroller. A high value for the resistor results in high sensitivity but also early saturation. Conversely, a low value decreases the optocoupler's sensitivity but allows for a greater range for linear operation. In the circuit R1 is 3.0 K-ohm for 'High Sensitivity' and R2 is 1 K-ohm for 'Low Sensitivity', resulting in a scale range of 3:1. By changing the sensitivity setting the autotuner may operate with a tuning signal that is neither too high nor too low, covering several bands given the length and position of the sampling antenna.

There is the opportunity for further autotuner sensitivity adjustment at the two-point gap at X3 in the circuit diagram. Placing a resister here reduces the current going from the diode bridge to the optocoupler LED. A resistor may be needed if tuning wattage is relatively high and cannot be accommodated by shortening or moving the sampling antenna. Otherwise the ends of the gap are connected.

Even when the autotuner is turned off the receiver via the sampling antenna is exposed to the full power being transmitted by the small magnetic loop antenna. There is the possibility that transmitting high power will cause the current handling capacity of the 1N34A bridge rectifier diodes, 50 mA, and the 4N35 optocoupler input LED, 60 mA, to be exceeded, destroying them. The circuit provides for an optional SPST, normally open, relay to disconnect the sampling antenna when the autotuner is not tuning or not in manual mode. It is likely, however, that transmitting high power will arc the variable capacitor before creating sufficient current to damage the receiver diodes or optocoupler LED. A procedure for estimating how much full transmitting power the autotuner can tolerate is described in a short article that may be downloaded from my website. If a relay is not installed then there would be no connections at X1 on pin 17 of the microcontroller, and the gap in the sampling antenna connection, at X2, would be closed. The autotuner program assumes that a relay is present, if not there is no effect.

Microcontroller

The brains of the autotuner is an inexpensive Picaxe



Picture 3. Inside the Autotuner Box

18M2+ microcontroller. Picaxe microcontrollers are entirely self-contained and simple to implement. Support components consist of only two resistors. The built-in oscillator can run up to 32 MHz. Most pins are programmable for input or output, with many having the input option of 10 bit analogue to digital conversion. There is a resident BASIC interpreter having a wide range of built-in functions, including 5- and 10-bit integer mathematics. Program creation in BASIC and uploading it to the 18M2+ is done by means of the Picaxe Development Program; versions of which are downloadable free to work with Windows, Mac, and Linux. For programming and serial data communications the 18M2+ connects to a computer via a serial to USB port adaptor cable made for the Picaxe. A Picaxe chip can be reprogrammed more than 100,000 times - necessary for experimentation.

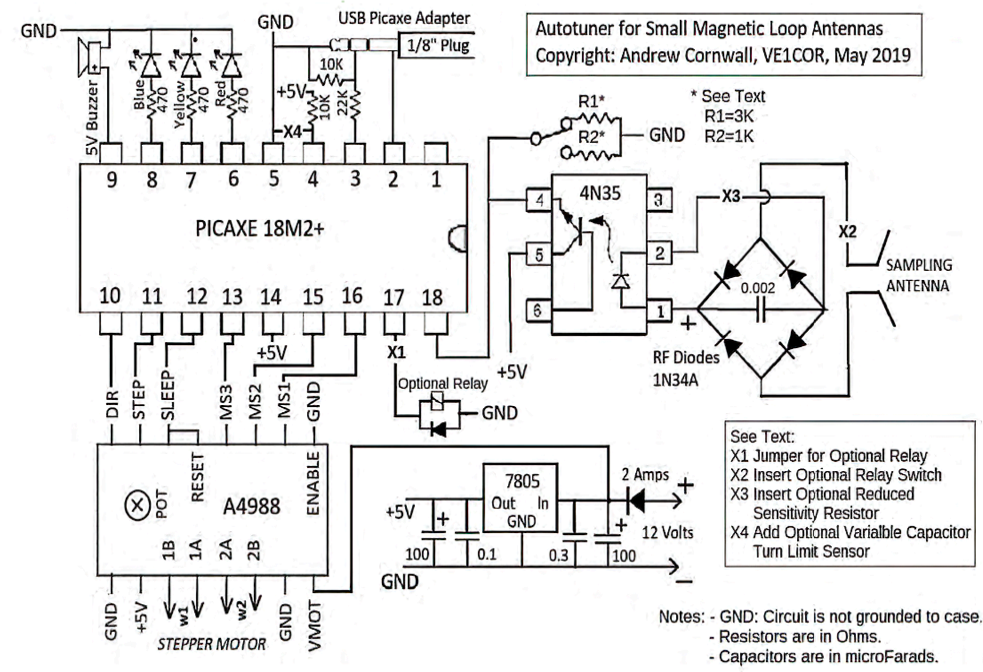


Figure 1. Autotuner Circuit

The circuit diagram shows the digital I/O pin assignments of the 18M2+ connecting to the A4988 stepper motor controller module, three tuning status LEDs, 5 volt status buzzer, and optional 5 volt sampling antenna relay. The LEDs, buzzer, and relay must each draw less than the 20 mA, the per pin I/O current limit of the 18M2+. In the circuit diagram there is also an optional capability at pin 4, with pair of connections at X4 and a 10 K ohm pull-up resistor, for adding a turn-limit sensor to accommodate a 180 degree turn variable capacitor; a modified program is needed for this.

Stepper Motor Driver

The autotuner employs an A4988 modular stepper motor driver that powers and controls a two-phase bipolar stepper motor. Input voltage to the A4988 can range from 8 to 30 volts; my autotuner power source is approximately 12 volts. The A4988 can provide up to one amp (two amps with external heat sink) to each of the two-phase coils of the stepper motor. The A4988 has an on-board adjustable current limiting control to tailor power to the requirements of the stepper motor.

Driving a stepper motor can be complex, and the A4988 module handles this task. Specific pins on the module receive instructions from the microcontroller. Moving a step occurs when the 'Step' pin receives a pulse. Other pins are set high or low to control stepper motor direction, fractional step size, and motor power on or off.

Stepper Motor

The autotuner stepper motor is two phase bipolar type that is commonly available. The stepper motor turns the small magnetic loop antenna's variable capacitor. As the name implies, a stepper motor moves in discrete increments. The motor can start, stop, and go forward and backward. The stepper motor receives power from the A4988 driver through four wires, two for each phase coil (in the circuit diagram these are labelled W1 and W2).

For this project I experimented with stepper motors having full step turning increments of 1.8 degrees, 0.9 degrees, and a geared stepper motor with the equivalent of about 0.25 degrees. The tuning increment Wof the stepper motor can be further reduced by half-stepping, quarter-stepping, eighth stepping, and sixteenth stepping with potentially reduced motor torque. I have had the most success with 0.9-degree stepper motors. The remainder of this article generally assumes the use of a 0.9-degree stepper motor, but a 1.8-degree stepper motor may be easily accommodated by a small change in the program. The present autotuner has a 0.9-degree NEMA 17 cube stepper motor, 'Steperonline' model 17HM15-0904S, shown mounted to the box in Picture 3. This and comparable stepper motors may be obtained from Amazon.com or eBay, and other on-line sources.

Two phase bipolar stepper motors have three power input specifications: voltage, amps per phase, and resistance per phase. For example, the present autotuner's stepper motor specifications are 5.4 volts per phase, 0.9 amps rated current per phase, and 6.0 ohms phase resistance. My experience is that voltage is not an issue when amperage is at or below the stepper motor phase coil rating.

The turning force provided by the stepper motor is related to the amperage it draws. The variable capacitors I've used are fairly easy to turn by hand (i.e. able to turn the bare shaft with fingers without a knob) and can be rotated (even with partial stepping) by a stepper motor drawing 0.9 amps.

Although the stepper motor turns in very small increments the chances of the stepper motor positioning the variable capacitor at exactly maximum radiated power is statistically hit or miss. Near resonance there are substantial changes in radiated power per increment of the stepper motor, as displayed in Graph 1. While landing the variable capacitor exactly on maximum radiated power is never certain, using partial stepping improves the odds that near miss tuning yields an acceptable result. Sixteenth stepping, with 3200 increments per one-half turn of the variable capacitor, is employed by the present autotuner. The success of this strategy is evident in the test results shown at the end of this article. However, with earlier autotuners I have had reasonably satisfactory tuning results with even quarter step tuning.

Microcontroller Automatic Tuner Logic

The autotuner has two modes of operation, 'manual' and 'autotuning'. In both modes the microcontroller can send data through its serial port (converted to USB by the Picaxe connecting cable) to a connected computer[8].

For the manual mode to be useful a computer must be connected to the autotuner. Manual mode is engaged by letting the autotuner run without any tuning power to the antenna during the reconnaissance sweep, described below. After not finding any signal upon which to target tuning, the autotuner reverts to manual mode. Power to the stepper motor is turned off and the variable capacitor can be turned by hand. Then measurements of any radiated power are sent to the computer about three times per second. This data is useful for understanding the nature of the small magnetic loop antenna. Without a transmitted tuning signal, manual mode can be used to assess ambient RF energy from nearby transmitters.

If a computer is connected while in autotuning mode, autotuning information on levels of antenna radiated power and variable capacitor position is communicated after each increment of the stepper motor. (Insignificant measurements, less than '10', are not sent to the computer.) This information is important for understanding autotuning and for experimenting. Autotuning data is the basis of Graph 1. When automatic tuning in the field computer data are not usually needed, and the autotuner is happy to work without a computer connection.

The task of the microcontroller program in autotuning mode is to maximize the small magnetic loop antenna's radiated power at a given frequency. While a low-level tuning signal is being transmitted to the antenna and the stepper motor incrementally turns the variable capacitor, the microcontroller tracks power being radiated until the maximum is achieved. This does not seem complicated, but I've tried several autotune algorithms with varied success. For the present combination of autotuner and small magnetic loop antenna I use the 'direct method' - my terminology.

Direct method autotuning starts with a reconnaissance sweep of the entire turning range (i.e. a full turn) of the variable capacitor to identify a probable maximum signal level. Next one or more active tuning sweeps commence where the objective of the autotuner is to turn the variable capacitor until a signal level is produced that is close to or exceeds the reconnaissance maximum. Because the reconnaissance sweep could have been very lucky in encountering the maximum, its value may not be matched during active tuning. The initial active tuning objective, therefore, is to turn the variable capacitor until a signal level is achieved that is at least 95% of the reconnaissance maximum. Occasionally a 95% value is not encountered whereupon a new active tuning sweep is attempted using a 90% threshold. Before giving up a third and fourth active tuning sweep will be attempted using 85% and 80% thresholds. If tuning is not achieved after the fourth tuning sweep there is likely something wrong that does not involve autotuner operation. Perhaps there is a loose antenna connection, or there may be a high-power ham rig nearby adding its transmitted signal to the autotuner sampling antenna.

The autotuner has to deal with variations in transmitted tuning power when the transmitter's foldback circuit responds to large changes in SWR. Encountering high SWR may cause the foldback function to reduce transmitter tuning power. As tuning approaches antenna resonance SWR declines significantly and the foldback function allows tuning power to increase to the specified level. To give the foldback circuit time to catch up to declining SWR, the stepper motor slows down turning the variable capacitor. In the present program, to speed up the tuning process, the stepper motor turns at half-step until antenna resonance is approached then slows down to sixteenth step.

The autotuner visually and audibly communicates its operating status by means of a buzzer and three LEDs on the box. Table 2 outlines the Buzzer and LED indications.

Mechanical and Shielding Considerations

I suggest two mechanical shortcuts that I found helpful with prototype construction. First, evident in Picture 2, is fastening the two ends of the transmitting loop to the variable capacitor by 1/4-inch stainless steel bolts extending from the variable capacitor protective housing, by means of small hose clamps. The coax braid at the ends of the transmitting loop are stripped for an inch, or so, and tinned to make a firmer connection. Although not elegant the connection is physically and electrically secure. Also, the transmitting loop is easy to set up and take down.

The second shortcut, in Picture 4, is using two short

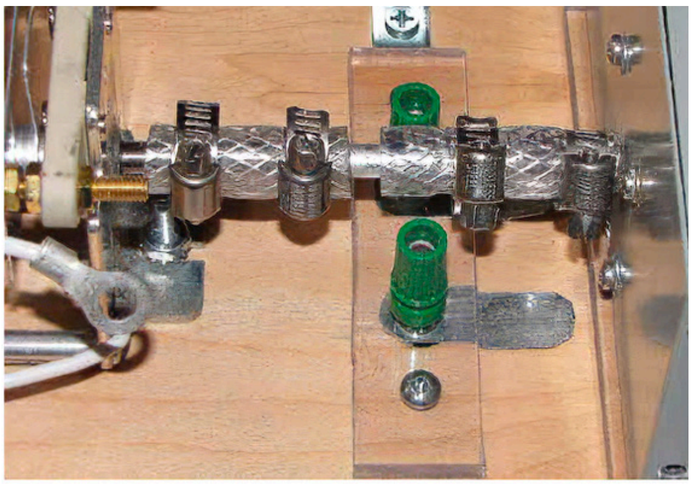
TABLE 2
AUTOTUNER - MEANING OF BUZZER AND LED INDICATIONS

Event	Yellow LED	Buzzer	Blue LED	Red LED
MANUAL MODE (turned on by very low reconnaissance Signal)	ON	-	-	-
AUTOMATIC MODE				
No Problem During Sweep				
- Start Reconnaissance Sweep *	Blink Once	Beep Once	Blink Once	Blink Once
- Start 1st Active Tuning Sweep	-	Beep Once	-	-
- Start 2nd Active Tuning Sweep **	-	Beep Twice	-	-
- Start 3rd Active Tuning Sweep **	-	Beep Thrice	-	-
- Start 4th Active Tuning Sweep **	-	Beep Four Times	-	-
Problem Encountered During Sweep				
-Potential Saturation Occurs	-	-	-	Blink on Occurrence
Successful End	-	Beep Once	ON	ON
Abnormal End				
- Reconnaissance Signal Too Low to Tune (but not too low to to start Manual Mode)	-	Beep 2 Times	Blinking	ON
- Potential Saturation Occurred	-	Beep 2 Times	ON	Blinking
- Unexpected Result ***	-	Beep 2 Times	Blinking	Blinking

Notes: * Start transmitting tuning signal within about 2 seconds
** If additional tuning sweep is needed
*** An unexpected result occurs when final tuning is more than 1 dB below maximum reconnaissance level and no other problem is indicated.

lengths of 1/4 inch PVC, reinforced, flexible hose to attach the stepper motor to the variable capacitor by means of a 1/4-inch aluminum rod drive shaft. The hose is tightly clinched to the shafts of the stepper motor, variable capacitor, and rod by four small hose clamps. The shafts of the stepper motor, variable capacitor, and ends of the rod are roughened to enhance holding power. At each end of the rod there is about a 3 mm gap inside the hose to electrically isolate the stepper motor from the variable capacitor. If the variable capacitor turns relatively easily and the four hose clamps remain tight there is no slippage nor twisting evident with this linkage. Further the flexible hose can accommodate the somewhat different diameters of the shafts of the variable capacitor, aluminum rod, and stepper motor; and overcome minor misalignment.

Although more expensive than the jury-rigged approach described above, stepper motor (CNC) shaft couplers work well to connect the stepper motor and variable capacitor. A coupler must be specified to conform to the diameters of the shafts it is connecting. If electrically conductive (i.e. made of metal) then two couplers are needed, one at the stepper motor and the other at the variable capacitor with a non-conductive drive shaft in between to electrically isolate the variable capacitor from the autotuner. I have used one-quarter inch, stiff plastic rod for a drive shaft.



Picture 4. Connection Between Variable Capacitor and Stepper Motor

The autotuner's circuitry must electrically float inside the metal box. There is no electrical nor power connection between the circuit's components and the box. The metal box shields the autotuner electronics from the potentially significant RF field surrounding the small magnetic loop antenna. Shielding also occurs at the transmission cable from the sampling antenna to the autotuner receiver. (Initially I used RG-174 coax, but the outer braid became part of the sampling antenna.) I use a transmission cable made of shielded audio cable with the two inner wires carrying the signal from the two legs of the sampling antenna. The cable's shield is grounded to the metal box. (The stepper motor is mounted to the box but the motor's coils are insulated from it.)

The method of wiring the electronics and stepper motor is not critical, although a printed circuit simplifies assembly.

Autotuner Platform - Rigidity Rules

A lesson I've learned in building four autotuners with different variable capacitor and autotuner mounting strategies is the variable capacitor and autotuner have to be mutually mounted on a very rigid structure. If there is any flexing a torque will build up during tuning between the variable capacitor and stepper motor which results in the variable capacitor continuing to turn slightly when autotuning is completed. Previously I've finagled this problem by programming the microcontroller to turn the stepper motor backwards a small amount as autotuning finishes. The prototype autotuner now employs a 3/4-inch plywood (16" x 6"). The rigidity this provides allows both the stepper motor and variable capacitor to stop the instant tuning is complete.

Variable Capacitor Considerations

Small magnetic loop antenna air variable capacitors able to withstand high voltage can be expensive to purchase new. This is an issue with small magnetic loop antennas regardless of tuning mechanism. My primary source for high voltage variable capacitors has been ham flea markets. The 27-127 pF variable capacitor used with the small magnetic loop antenna for this article is a flea market find; plate spacing suggests it may be able to withstand 90 watts. Previously I extensively used an available 10-260 pF high voltage variable capacitor, double the capacitance range warranted for the desired bands. This made tuning twice as demanding (i.e. for each stepper motor increment the change in capacitance is double). Despite the added challenge the autotuner consistently tuned within one dB (80%) of optimum. I mention my variable capacitor experience to give heart to small magnetic loop antenna builders who face a compromise when using less than ideal variable capacitors.

Recently I successfully tried a variable capacitor from RF Parts (www.rfparts.com), model 73-175-23, 14pF-145pF, 3.2Kv ($60 US). Based on LoopCalc.exe calculations, the 3.2Kv voltage rating allows my small magnetic loop antenna to handle about 65 watts on 40 meters, and 50 watts on 30 meters and 20 meters. I had to reduce the variable capacitor's turning resistance by slightly loosening the screw (with locking nut) holding the rotor shaft rear pivot point. Once turning resistance was lessened, the 'Steperonline' model 17HM15-0904S stepper motor, specified previously, readily turned the variable capacitor.

Operating the Autotuner

A small magnetic loop antenna is attached to a transceiver with ordinary 50-ohm coax transmission cable. I tend to insert an RF isolator in the transmission line near the antenna. A 12-volt DC power source (a small gel cell will do) with a switch at the operator's position, connects to the autotuner by two conductor hookup wire. The coax and DC power wire may be as long as needed to achieve a satisfactory antenna position. If computer connection to the autotuner is desired it is done by means of the Picaxe serial to USB adapter cable (at the computer) and lengths of stereo headphone extension cables having 1/8-inch female and male end connectors. I've chained together over 30 ft. of headphone extension cables. If there is a traditional tuner between the transceiver and the small magnetic loop antenna, it should be in by-pass mode while the autotuner is actively tuning and in manual mode[9].

TABLE 3 AUTOTUNER TEST RESULTS					
TRIAL	1	2	3	4	5
7.200 mHz					
Percent of Highest Signal for Frequency Group	95%	**92%**	97%	95%	93%
(Percent of Local Maximum)	(96%)	(96%)	(97%)	(96%)	(98%)
SWR	1.2	1.1	1.3	1.1	1.3
Number of Tuning Sweeps	1	1	1	1	1
10.110 mHz					
Percent of Highest Signal for Frequency Group	96%	97%	97%	96%	98%
(Percent of Local Maximum)	(97%)	(97%)	(98%)	(97%)	(98%)
SWR	1.2	1.2	1.2	1.3	1.2
Number of Tuning Sweeps	1	1	1	1	1
14.130 mHz					
Percent of Highest Signal for Frequency Group	94%	94%	94%	**92%**	96%
(Percent of Local Maximum)	(96%)	(97%)	(96%)	(96%)	(96%)
SWR	1.2	1.2	1.2	1.2	1.2
Number of Tuning Sweeps	1	1	1	1	1

Notes: - Frequencies are approximate.
- The tuning signal was 5 watts, CW tone.
- Small magnetic loop antenna was set up outdoors 25 ft from the transceiver, connected by unbranded RG8X transmission cable with a 1:1 current unun.
- 'Percent of Highest Signal for Frequency Group' is the percentage of the highest autotuner signal recorded during the five trials using the specific frequency, see text.

My autotuner on average draws somewhat over one amp when tuning; while 'on' at other times (e.g. manual mode) the draw is less than 20 ma.

Autotuning commences when 12-volt power is switched on. The autotuner beeps once as a reminder to commence transmitting a small, constant tuning signal, which may be an AM or CW carrier, or tone modulated SSB. While tuning progresses the transceiver's SWR indicator dips and rises several times. This is normal. At the end of tuning the SWR meter most likely will be relatively low. The time to complete autotuning with one active tuning sweep is about 50 seconds. Subsequent active tuning sweeps, if needed, add another 20 to 30 seconds each. The tuning signal should not interfere with other hams, because of the antenna's high Q it is effectively transmitting only a few seconds. Once tuning is done, there is a final beep, the stepper motor stops turning, and the red and blue LEDs light up steadily indicating that tuning was successful. Table 2 refers to the LED and buzzer indications for non-successful tuning outcomes. Afterwards 12-volt power to the autotuner can be turned off. Turning the autotuner off before tuning is finished does no harm.

Very infrequently the autotuner misses acceptable tuning within four active tuning sweeps. When miss-tuning occurs, tune again. Repeated failure confirms that there is something wrong operationally with the autotuner, the small magnetic loop antenna, or the antenna's connection with the transceiver.

In manual mode the setup is the same as autotuning except a computer must be attached to the autotuner. Manual mode is activated by turning on 12-volt power but not transmitting any signal to the antenna. After a reconnaissance sweep without any radiated signal the autotuner goes into manual mode and starts providing continual radiated signal data to the computer. Manual mode status is indicated by the yellow LED turned on. Twelve-volt power is kept on as long as manual mode operation is desired. No power goes to the stepper motor and the antenna's variable capacitor can be turned by hand.

Autotuning Results

To illustrate the capability of the autotuner for this article I conducted a total of fifteen trails. The small magnetic loop antenna was set up in the driveway of my home in Nova Scotia. An MFJ-915 RF isolator was inserted in the coaxial cable near the antenna. My operating position was 25 feet away in the garage which had AC power, and a Yaesu FT-897 transceiver and a laptop computer on a makeshift table. The afternoon was sunny with ambient temperature of 68 deg. F.

Table 3 presents the tuning results of fifteen trials. There were five consecutive trails in three groups for frequencies in the 40, 30, and 20 metre bands. The criteria for the frequencies were that they were not special use, not for CW code, and not busy. The Yaesu FT-897 transmitted a CW tone at 5 watts, the lowest possible output[10].

Three parameters were recorded for each trial: SWR, number of tuning sweeps, and percentage of highest signal achieved. SWR was measured by an MFJ-813 QRP, SWR meter. The number of tuning sweeps is the count of 360-degree active tuning turns the autotuner took to (nearly) match the highest signal level found in that trial's reconnaissance sweep. As is typical only one tuning sweep was needed.

"Percent of Highest Signal for the Frequency Group" compares, in percentage terms, the signal level measured at the conclusion of each trial with the highest signal occurring among all five trials in the frequency group. The highest group signal level is that encountered collectively among the five trial reconnaissance maximums and the five autotuned results. The theory is that the highest among these ten values reasonably estimates the maximum signal possible for the frequency group. Also shown in parenthesis in Table 3 is the percentage of 'local' maximum power achieved for just that trail.

The results in Table 3 are self-evident. The individual trial signal values are very close to the probable highest signal value for their frequency group. The lowest are 92% for the second trial in the 40 metre band and 92% for the fourth trail the in the 20 metre band; these trails are bolded in the table. To put this percentage into perspective, 92% is only 0.36 dB (less than one-half dB) below the highest probable signal value. Regarding each trail's local maximum, the autotuned percentage is 96% or higher. These autotuning results are typical. Tuning any antenna to this degree would be considered a success. The relatively low SWRs are encouraging by any standard, but they relate to this particular antenna. It is comforting, nevertheless, to know that after autotuning with this small magnetic loop antenna no further signal treatment is needed to protect the transceiver from high SWR.

Where to Obtain Autotuner Picaxe Programs and Additional Information

I am adding to my website program files and additional information to complement the description in this article. There are two program files. One is a circuit tester that verifies all functions of the circuit are operating correctly. This can be run before the circuit is installed in the autotuner. The second program controls the autotuner. Picaxe programs may be opened in the Picaxe Development Program or any text editor to look at (and edit) the code. Picaxe BASIC is easy to follow and the code tends to be self-documenting. Other information on the website includes a circuit parts list, assembly tips involving the printed circuit board, how to estimate highest tolerable transmitting power, and some project history.

I leave many details of autotuner assembly to the reader. My platform, 3/4" plywood board about 6" x 18", is suitable for the variable capacitors and autotuner boxes that I have used. The shortcuts described above have facilitated construction, and the way of mounting the autotuner on the mast of a small magnetic loop antenna has worked well. Other than a requirement for rigidity between the stepper motor and variable capacitor, there is nothing vital about my approaches. What they accomplish can be achieved in other ways. Indeed, most aspects of the autotuner are still amenable to experimentation.

Availability of a Printed Circuit Board

To simplify assembling the autotuner circuit I have a printed circuit board, shown in Picture 3. The board was designed to professional standards by Ed Thompson, then a student at the Institute of Technology Campus of the NSCC (Nova Scotia Community College). Ed's ability and diligence are commendable, and he recommended changes that significantly improved the prospective board.

I am planning to have a small supply of printed circuit boards available for sale by February 2020, when this article is scheduled to be published in the 'Packet Status Register'. How to order the board will be posted on my website. If demand exceeds the initial supply of boards, I will attempt to source more.

Acknowledgements

An earlier article of mine describing the experimental nature of this project was published in the May-June 2018 edition of the Radio Amateurs of Canada magazine, TCA (The Canadian Amateur). I wish
to acknowledge the assistance I received from the TCA editor and reviewers of the earlier article. Many of their suggestions helped my approach to the project and writing about it. Since then I have refined the autotuner to make a good device even better. With the present article I was pleased to have the advice of the TAPR reviewer Bruce Raymond, ND8I. Any and all problems associated with the autotuner, however, are entirely my fault.

There remains the need to demonstrate the autotuner's capabilities with a wide range of small magnetic loop antennas used by other hams. Also, the autotuning approach described in this article should be applicable for other kinds of antennas. There are always opportunities for experimenting.

About the Author

Andrew Cornwall resides in Nova Scotia, Canada where he has Basic with Honours amateur radio certification. He was first certified in 1992 and retains the call sign VE1COR. He spends considerable time in
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Footnotes

1. The website www.hoa-usa.com claims that there are 351,000 such home owners associations in the United States. Commonly homeowners' associations ban full size HF antennas.

2. United Nations Department of Economic and Social Affairs, 2018 Revision of World Urbanization Prospects.

3. I have not used a small magnetic loop antenna on a balcony, but others have, for instance: www.qsl.net/kp4md/balconyloop.htm

4. The autotuner circuit design allows for variable capacitors that have an 180 degree turning limit. This requires the addition of a turn limit sensor and a modified microcontroller program.

5. The adjusting mechanism of a vacuum variable capacitor is not suitable for my autotuner mechanism.

6. Some of the peakiness of the small tuning range is due to the very high SWR outside of the vicinity of antenna resonance. This results in transmission line loss and also causes the transmitter's foldback function to reduce power output.

7. There is the possibility of measuring the output signal of the antenna other than a sampling antenna, which would not be subject to extraneous transmissions. The autotuner circuit and logic would not be altered.

8. Measurements of signal strength are relative and range from 10 to about 1000 (anything below 10 is meaningless and not reported). A value of 1000 corresponds to nearly 5 volts from the optocoupler to the microcontroller.

9. The data signal from the autotuner to a computer can be garbled when a fairly high tuning signal (sometimes as low as 5 watts) is being transmitted and the small magnetic loop antenna is close to the computer, or the radio transmission line is in the proximity of the data cable. The solution is to move the antenna, separate the transmission and data cables, and/or lower the power of the tuning signal.

10 Running sequential trials is not as simple as it might seem. Even with the tuning signal reduced to 5 watts, from a 100-watt capable transceiver, holding the key down repeatedly for about a minute heats up the transmitter notably. This eventually reduces tuning power by a small amount. While autotuning is accurate for the trail, the results are not comparable to other trails. The solution for consistency is to allow time for heat to dissipate between trials.

The following article is reprinted from and is courtesy of the Electronic Design website at https://www.electronicdesign.com/

What's The Difference Between Bit Rate And Baud Rate?

Serial-data speed is usually stated in terms of bit rate. However, another oft-quoted measure of speed is baud rate. Though the two aren't the same, similarities exist under some circumstances. This tutorial will make the difference clear.

by Lou Frenzel, W5LEF

BACKGROUND

Most data communications over networks occurs via serial-data transmission. Data bits transmit one at a time over some communications channel, such as a cable or a wireless path. Figure 1 typifies the digital-bit pattern from a computer or some other digital circuit. This data signal is often called the baseband signal. The data switches between two voltage levels, such as +3 V for a binary 1 and +0.2 V for a binary 0. Other binary levels are also used. In the non-return-to-zero (NRZ) format *(Fig. 1, again)*, the signal never goes to zero as like that of return-to-zero (RZ) formatted signals.

BIT RATE

The speed of the data is expressed in bits per second (bits/s or bps). The data rate R is a function of the duration of the bit or bit time (T_B) *(Fig. 1, again)*:

$R = 1/T_B$

Rate is also called channel capacity C. If the bit time is 10 ns, the data rate equals:

$R = 1/10 \times 10^{-9} = 100$ million bits/s

This is usually expressed as 100 Mbits/s.

OVERHEAD

Bit rate is typically seen in terms of the actual data rate. Yet for most serial transmissions, the data represents part of a more complex protocol frame or packet format, which includes bits representing source address, destination address, error detection and correction codes, and other information or control bits. In the protocol frame, the data is called the "payload." Non-data bits are known as the "overhead." At times, the overhead may be substantial—up to 20% to 50% depending on the total payload bits sent over the channel.

For example, an Ethernet frame can have as many as 1542 bytes or octets, depending on the data payload. Payload can range from 42 to 1500 octets. With a maximum payload, the overhead is only 42/1542 = 0.027, or about 2.7%. It would be even greater if the payload was anything smaller. This relationship is usually expressed as a percentage of the payload size to the maximum frame size, otherwise known as the protocol efficiency:

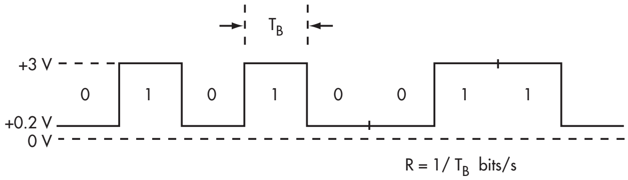
Protocol efficiency = payload/frame size = 1500/1542 = 0.9727 or 97.3%

Typically, the actual line rate is stepped up by a factor influenced by the overhead to achieve an actual target net data rate. In One Gigabit Ethernet, the actual line rate is 1.25 Gbits/s to achieve a net payload throughput of 1 Gbit/s. In a 10-Gbit/s Ethernet system, gross data rate equals 10.3125 Gbits/s to achieve a true data rate of 10 Gbits/s. The net data rate also is referred to as the throughput, or payload rate, of effective data rate.

BAUD RATE

The term "baud" originates from the French engineer Emile Baudot, who invented the 5-bit teletype code. Baud rate refers to the number of signal or symbol changes that occur per second. A symbol is one of several voltage, frequency, or phase changes.

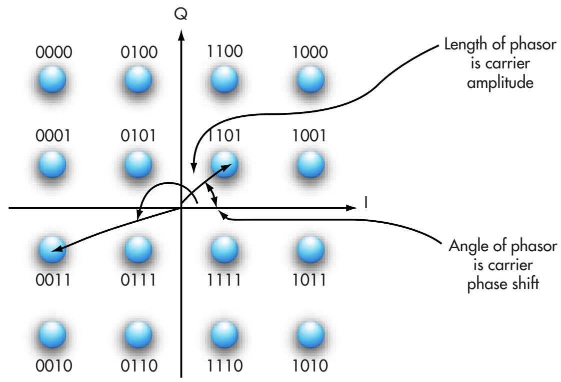
NRZ binary has two symbols, one for each bit 0 or 1, that



1. Non-return to zero (NRZ) is the most common binary data format. Data rate is indicated in bits per second (bits/s).

represent voltage levels. In this case, the baud or symbol rate is the same as the bit rate. However, it's possible to have more than two symbols per transmission interval, whereby each symbol represents multiple bits. With more than two symbols, data is transmitted using modulation techniques.

When the transmission medium can't handle the baseband data, modulation enters the picture. Of course, this is true of wireless. Baseband binary signals can't be transmitted directly; rather, the data is modulated on to a radio carrier for transmission. Some cable connections even use modulation to increase the data rate, which is referred to as "broadband transmission."



2. A constellation diagram for 16QAM shows the 16 possible carrier amplitude and phase combinations representing four bits per symbol.

BINARY PHASE-SHIFT KEYING	
Bits	**Phase shift (degrees)**
0 0	45
0 1	135
1 1	225
1 0	315

By using multiple symbols, multiple bits can be transmitted per symbol. For example, if the symbol rate is 4800 baud and each symbol represents two bits, that translates into an overall bit rate of 9600 bits/s. Normally the number of symbols is some power of two. If N is the number of bits per symbol, then the number of required symbols is $S = 2^N$. Thus, the gross bit rate is:

$R = \text{baud rate} \times \log_2 S = \text{baud rate} \times 3.32 \log_{10} S$

If the baud rate is 4800 and there are two bits per symbol, the number of symbols is $2_2 = 4$. The bit rate is:

$R = 4800 \times 3.32 \log(4) = 4800 \times 2 = 9600$ bits/s

If there's only one bit per symbol, as is the case with binary NRZ, the bit and baud rates remain the same.

MULTILEVEL MODULATION

Many different modulation schemes can implement high bit rates. For example, frequency-shift keying (FSK) typically uses two different frequencies in each symbol interval to represent binary 0 and 1. Therefore, the bit rate is equal to the baud rate. However, if each symbol represents two bits, it requires the four frequencies (4FSK). In 4FSK, the bit rate is two times the baud rate.

Phase-shift keying (PSK) is another popular example. When employing binary PSK, each symbol represents a 0 or 1 *(see the table)*. A binary 0 equals 0°, while a binary 1 is 180°. With one bit per symbol, the baud and bit rates are the same. However, multiple bits per symbol can be easily implemented.

For instance, in quadrature PSK there are two bits per symbol. Using this arrangement and two bits per baud, the bit rate is twice the baud rate. Other forms of PSK use more bits per baud. With three bits per baud, the modulation becomes 8PSK for eight different phase shifts representing three bits. And with 16PSK, 16 phase shifts represent the four bits per symbol.

One unique form of multilevel modulation is quadrature amplitude modulation (QAM). QAM uses a mix of different amplitude levels and phase shifts to create the symbols representing multiple bits. For example, 16QAM encodes four bits per symbol. The symbols are a mix of different amplitude levels and different phase shifts.

A constellation diagram is typically used to illustrate the amplitude and phase conditions of the carrier for each 4-bit code *(Fig. 2)*. Each dot represents a specific carrier amplitude and phase shift. A total of 16 symbols encodes four bits per symbol, ultimately quadrupling the bit rate over the baud rate.

WHY MULTIPLE BITS PER BAUD?

By transmitting more than one bit per baud, higher data rates can be transmitted in a narrower channel. Recall that the maximum possible data rate is determined by the bandwidth of the transmission channel.

Assuming a worse case of alternating 1s and 0s of data, the maximum theoretical bit rate C for a given bandwidth B is:

$C = 2B$

Or the bandwidth for a maximum bit rate is:

$B = C/2$

Transmitting a 1-Mbit/s signal requires:

$B = 1/2 = 0.5$ MHz or 500 kHz

When using multilevel modulation with multiple bits per symbol, the maximum theoretical data rate is:

$C = 2B \log_2 N$

Here, N is the number of symbols per symbol interval:

$\log_2 N = 3.32 \log_{10} N$

The bandwidth needed with a specific number of different levels for a desired speed is calculated as:

$B = C/2 \log_2 N$

For instance, the bandwidth needed to get a 1-Mbit/s data rate with two bits per symbol and four levels can be determined with:

$\log_2 N = 3.32 \log_{10}(4) = 2$

$B = 1/2(2) = 1/4 = 0.25$ MHz

The number of symbols needed to get a desired data rate in a fixed bandwidth can be calculated as:

$\log_2 N = C/2B$

$3.32 \log_{10} N = C/2B$

$\log_{10} N = C/2B = C/6.64B$

Then:

$N = \log^{-1}(C/6.64B)$

Using the previous example, the number of symbols needed to transmit 1 Mbit/s in a 250-kHz channel is calculated as:

$\log_{10} N = C/6.64B = 1/6.64(0.25) = 0.602$

$N = \log^{-1}(0.602) = 4$ symbols

These calculations assume a noise-free channel. Factoring in the noise requires the well-known Shannon-Hartley law:

$C = B \log_2 (S/N + 1)$

C is the channel capacity in bits per second and B is the bandwidth in hertz. S/N is the signal-to-noise power ratio.

In terms of common logarithms:

$C = 3.32B \log_{10}(S/N + 1)$

What is the maximum rate in a 0.25-MHz channel with a 30-dB S/N? The 30 dB translates to a 1000 to 1 S/N. Therefore, the maximum rate is:

$C = 3.32B \log_{10}(S/N + 1) = 3.32(.25) \log_{10}(1001) = 2.5$ Mbits/s

The Shannon-Hartley law doesn't specifically state that multilevel modulation must be employed to achieve that theoretical result. Using the previous procedure will reveal how many bits per symbol are required:

$\log_{10} N = C/6.64B = 2.5/6.64(0.25) = 1.5$

$N = \log^{-1}(1.5) = 32$ symbols

Using 32 symbols implies five bits per symbol ($2^5 = 32$).

Baud Rate Examples

Virtually all high-speed data connections use some form of broadband transmission. Wi-Fi wireless takes advantage of QPSK, 16QAM, and 64QAM in the orthogonal frequency-division multiplex (OFDM) modulation schemes. The same is true for WiMAX and Long-Term Evolution (LTE) 4G cellular technology. Cable TV and its high-speed Internet access exploit 16QAM and 64QAM to deliver analog and digital TV, while satellites use QPSK and various versions of QAM.

Land mobile radio (LMR) systems for public safety recently adopted standards for voice and data 4FSK modulation. This "narrowbanding" effort is designed to reduce the bandwidth needed from 25 kHz per channel to 12.5 kHz, and eventually 6.25 kHz. As a result, there will be more channels for additional radios without increasing the spectrum allocations.

U.S. high-definition TV employs a modulation method called eight-level vestigial sideband, or 8VSB. This method uses three bits per symbol for eight amplitude levels, which enables the transmission of 10,800 symbols/s. At 3 bits per symbol, that represents a gross bit rate of 3 x 10,800 = 32.4 Mbits/s. When combined with the VSB, which only transmits one full sideband and a vestige of another, high-definition video and audio can be transmitted in a 6-MHz-wide TV channel.

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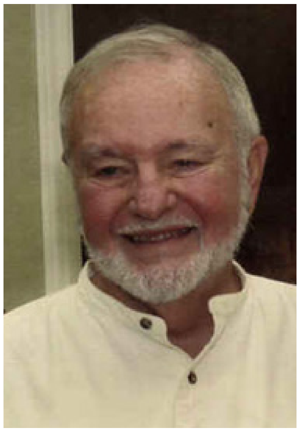

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Formerly, Lou was a college professor teaching electronic technology fundamentals, microcontrollers, communications, and semiconductor manufacturing.

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His education includes a bachelor's degree from the University of Houston and a master's degree from the University of Maryland.

Lou is an author of 25+ books on communications, computers and electronic subjects. His latest projects are self help-success books.

A Homebrewed Earphone Jack Nut Driver

AKA audio jack tool

By Geoff Gaines, N1GY
ARRL Technical Specialist

Ever since I began building ham radio projects, I have been looking for a tool that would allow me to tighten and secure the 3.5mm stereo and mono audio jacks that are part of so many projects in amateur radio. I spent way too much money having a pair of modular screwdriver tips modified by a commercial machine shop to fit the two little slots that are cut into the "ring" style nut that is found on most of the audio jacks today. The modified tips never worked really well, in part because the space between the small tips was too wide to properly position the tool. When I saw a picture of a tool made by a gentleman in Japan which only one small shop in the electronics district sold for him, I had to at least try to duplicate it. It turns out that the gentleman who used to make them retired many years ago and the tools have not been available for many years. So, on to the build:

I decided to begin with the 3.5mm or 1/8» shaft as this would not only position the tool around the jack but also form the shaft and part of the handle for the tool. I drilled out two small hexagonal nuts to fit onto the brass rod which I got at a local hobby shop. The first of these nuts was placed in a vice and the corners of the nut were filed down to permit it to slip inside a UG-176 coax adapter. The adapter usually goes inside a PL-259 to permit the PL-259 to be used with RG-8X coaxial cable. However, it also matches almost exactly the diameter of the «ring» nut of a 3.5mm or 1/8» audio jack. While I was at the hobby shop I also purchased a small ZONA razor saw, so I used that to cut away material from the end of the UG-176 so as to create the two small tips or pins that engage the slots in the «ring» nut. All of this cutting and shaping was done with the saw and small files until I was satisfied with the size and shape of the projecting tips.

Next it was time for assembly. The shaft with the modified nut was slipped into the UG-176 and positioned so that the shaft projected just the right length beyond the tips. I wanted the shaft to position the tool on the jack but not go into the jack so far that it might damage the internal connections of the jack itself. The modified nut was positioned suitably and then a butane powered hand torch was applied to heat the assembly and solder was applied to the inside of the UG-176 to secure the nut inside it. The unit was allowed to cool and then inverted and the second (less modified) nut was slid down the shaft to rest on the back end of the adapter. It was also soldered to the adaptor and the shaft. With the working end of the tool completed, I turned my attention to the handle end of the shaft. First it was cut down to a suitable length of about 5» overall. I spent about an hour testing various ideas for an operating handle and eventually decided to build one using the left over piece of 1/8" brass rod. I cut six pieces about 1 1/2" long and wrapped them around the handle end of the tool. I used wire ties to hold them initially and then augmented those with enameled copper wire. The wire ties were then removed and using my 140 watt soldering gun I soldered all six pieces of rod to the central shaft. A couple of vacuum caps from the auto parts store (actually from my junque box) were pressed into service as a hand friendly cover over the assemblage of brass rod and the job was done.

I built the tool in this manner because trying to modify say a nut driver or my previous attempts would mean attempting to drill through hardened tool steel (never an easy task). The end result is a tool that, while quite crude and obviously home made, does the task it was built for in fine fashion.

Below are some photos of the tool.

The overall picture of the finished tool. The handle is a bit crude and my soldering could be better, but the tool works and that is all I asked it to do.

This is an extreme close up of the working end of the tool. The shaft only protrudes enough to enter the jack just far enough to position the two tips to engage the ring nut of the jack. Positioned this way, there is no possibility of the tool slipping off the nut and or damaging the surface of the panel in which the jack is being mounted.

The soldering job is a bit sloppy but the view is of the second hex nut soldered to the back end of the UG-176. The second nut together with the one inside the adapter serves to properly orient the shaft concentric to the modified UG-176. It was a very happy coincidence that the diameter of the inner end of the UG-176 just happened to be the same as the diameter of the ring nut on the 1/8" audio jack.

I can only hope that some tool making company will someday make a commercial version of this tool. In the meantime I will use the home brewed version to its fullest. I have emailed the owner of the web site where I found a picture of the original tool in hopes that he will permit me to add the photo to this page. For now I wish you, as usual 73.

This evening, I took another look at the new tool and decided that the handle, while functional was not how I wanted to leave it. I took another look around the shop and found a handle from one of those mini screwdriver sets that discount stores sell. I made a few modifications to the handle removing a long dead battery and the associated lamp and wiring. I actually had to drive the battery out with a hammer and nut driver as a prod. Once the battery was clear and the handle cleaned out the end of the headset jack nut driver (its new name) fit snugly inside the handle. The remainder of the space in the handle was filled with hot glue because I did not have any epoxy on hand. This tool does not have to stand too much torque so the hot glue should be fine. The tool now looks almost of commercial caliber (at least in my opinion). Of course I am a bit biased having constructed it in the first place.

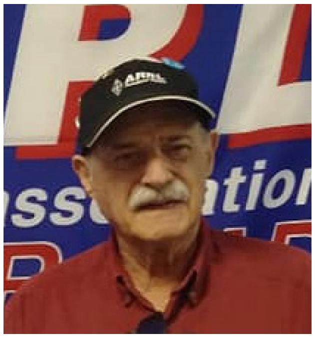
Having received permission from the original author, Alan Kastner, here is a photo of the tool that started this entire project. Since I do not have the tools nor skills to duplicate this marvelous tool, I resorted to the ham radio operator's special skill set: building it out of what I had on hand.

Source:http://www.n1gy.com/homebrewed-audio-jack-tool.html

Some things to do while you're staying home.

Learn, build and expend your testing capability during downtime

By David Birnbaum, K2LYV
ARRL Technical Coordinator - ARRL West Central Florida Section



Hoping all of you are staying well and keeping safe. While you're at home perhaps it's an opportunity to do some ham projects that you've been putting off for lack of time. So, here are a few ideas:

1. Learn something new

If you've been thinking that you'd like to upgrade your license (Tech to General, General to Extra) now's an opportunity to work on it. There are a number of online sites that have practice tests and lessons that can help you with the process. Then there's always books. The first few chapters of the ARRL Handbook contain almost everything that you need to know. And even an old Handbook will be fine.

Of course, now would be a good time to brush up or learn CW. There are programs – my favorite is from G4FON – that will systematically teach you Morse code. If you've got an HF rig you have CW capability for free, why not use it? There are sections of the bands – usually around 50kHz up from the bottom of the band, especially on 40 and 20M where there are slow speed QSOs going on. It's a great way to get on the air and learn - and have fun.

How about doing something with an Arduino? Raspberry Pi? They can be bought online often together with some helpful extras like a breadboard and some discrete components. There's lots of online tutorials on getting started. There's also a lot of ideas for ham related use of these computers.

2. Build something

If you either have the experience or want to gain some, there are a lot of simple yet useful kits available for you to build. If you have some more experience, there are some more advanced kits that are really worth the time. Several of us at TARC have built the QCX transceiver from qrp-labs (qrp-labs.com). It's a complete single band CW transceiver (it can be built for 40,30 or 20M as you choose). The receiver is a direct SDR and is quite sensitive and can be tuned across the band (or beyond if you want). The transmitter is only 5W but the thrill of working someone with only 5W is really cool.

How about building a beam for your 2M handheld to expand the range over which you can reliably hit one of the local repeaters? Have an old tape measure (or a cheap one from Harbor Freight)? Look up the directions for a 2M beam built using pieces of tape measure and PVC pipe.

How about a satellite antenna? Check out the directions at https://www.wa5vjb.com/references/Cheap%20Antennas-LEOs.pdf

You can build one of these using simple parts – I had one I made from a 1"x1" piece of lumber and pieces of #8 copper wire. The design described is similar to the commercial versions made by Arrow and others. Even a simple dual band handheld combined with one of these antennas will let you explore communication using the beam.

There are a number of apps and PC programs that will tell you when and where to look for satellite passes. For some of the passes you can even hear the QSOs with your handheld – it helps to hold the antenna horizontally. Ham radio satellites were some of the first (literally) communications satellites available. The development of the CubeSat configuration has given rise to a large number of satellites, some of which have interesting telemetry in addition to ham radio communication.

3. Expand your testing capability

As I mentioned in my last column, there are now several pretty cheap (< $100) RF testing devices that greatly expand the range of things that we can measure. The nanoVNA for example is around $50 and allows you to actually measure your antenna impedance, not just its SWR. It can also be used to measure the performance of filters and other similar devices.

There are several "very broadband" receiver options available – I have an SDRPlay RSP1 which covers 1kHz to 2 GHz. There are also a variety of USB dongles that cover similar frequency ranges – see rtl-sdr.com for examples. There are several software packages that allow you to explore the RF spectrum and demodulate and analyze a wide variety of signals. There are also software packages that use the device as a spectrum analyzer. Most (all?) of this software is free.

I just read a column that showed how you could use a spectrum analyzer and a wide-band noise source to work similarly to a spectrum analyzer with a tracking generator.

I'd love to hear from any of you with ideas for these columns or things that you've been doing that other folks in the WCF section would be interested in. Drop me a line k2lyv@arrl.net