Telstar

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STARS Antenna Analyzer Build Project 2018

By Ken Pokigo, KC2AYK

The STARS amateur radio club has decided on its 2018 build project. It's an antenna analyzer! The STARS club build projects are meant to bring together our amateur radio club members and allow us to share our knowledge and common interests, work together, and have fun. The project that was selected is an excellent choice since when it is completed, each person will end up with a great little device that is useful and has brought a personal sense of accomplishment. The project is a good choice to pull together several things to learn about in electronics, RF circuits, microcontrollers, programming and of course soldering skills. The remaining discussion in this article is intended to summarize the project and describe the learning experience we can take away from it.

The Antenna Analyzer is based on a design by Beric Dunn, K6BEZ. We have been able to obtain our own PCB to make this build easier and more professional when complete. A special thanks to Owen Torres, KD2LXF for getting the PCB boards ordered.

To make a simple antenna analyzer you must be able to generate a known signal at various frequencies, transmit it into the antenna port and look for any reflected signal coming back from the antenna. If the device is able to sweep a low level signal over a frequency range and capture the reflected signal, we can use this information to determine the antenna performance across this range. If we have a microcontroller operating our device and collecting the data, we can determine a VSWR sweep for the particular frequency range. The analyzer we are building will work to cover a frequency range up to about 40 MHz so it's good for HF antennas. In the following paragraphs I will describe the basic parts of the device and simplified explanation of how it works.

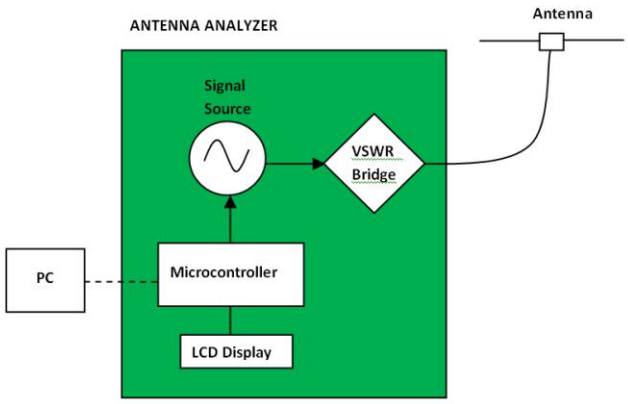

FIGURE 1

Figure 1 shows the main parts of the antenna analyzer system. There is a signal oscillator which generates the source RF signal, a VSWR bridge circuit and a microcontroller. The microcontroller is the heart of the system and controls the sweep of the RF signal oscillator, measures and records the reflected signal from the VSWR Bridge and displays the information on the LCD display. Another advanced feature is the ability of the analyzer to work with special PC software and create plots of the VSWR sweep of the antenna.

The Microcontroller

The microcontroller we are using is an Arduino Pro Micro. Arduino manufactures several microcontroller boards using various Atmel devices. In this case the Pro Micro uses an Atmel Mega32U4. This is a powerful microcontroller that operates at 16MHz, has 32KB of flash memory, a bunch of I/O and several serial

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interfaces. One of its best features is that it has a native USB interface, so no external chips are required. Just a Micro-B USB connector and you can interface this to an external computer directly. The Pro Micro operates on 5V which also makes it simple to use for basic embedded control applications.

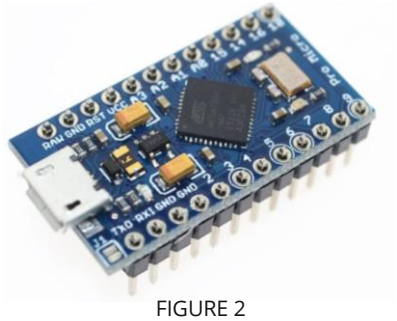

FIGURE 2

The Signal Source

The signal generator consists of a PCB module that uses an Analog Devices AD9850 direct digital synthesizer (DDS). The device is a highly integrated device that uses DDS technology to form a complete, digitally programmable frequency synthesizer. When controlled by the Arduino microcontroller, the AD9850 generates a spectrally pure, analog output sine wave which can be swept over a determined frequency range. This is how the test signal is generated for the antenna being tested.

FIGURE 3

The VSWR Bridge

Let's talk for just a brief minute about bridge circuits so that we can understand how the measurements are taken by our antenna analyzer. Do you remember the Wheatstone bridge circuit? It's really nothing more than two simple series-parallel arrangements of resistances connected between a voltage supply terminal and ground. It produces zero voltage difference between the two parallel branches when balanced. The circuit has two input terminals and two output terminals and is usually shown as four resistors configured in a diamond-like arrangement.

On the bottom we see how the bridge is applied to our antenna tester. The antenna completes the bridge and diode detector circuit samples the returning signal. If the antenna produces a 50 ohm resistance, the reflected sample signal will go to a minimum because the bridge becomes balanced. The detector diode changes this to a voltage for the microcontroller to measure.

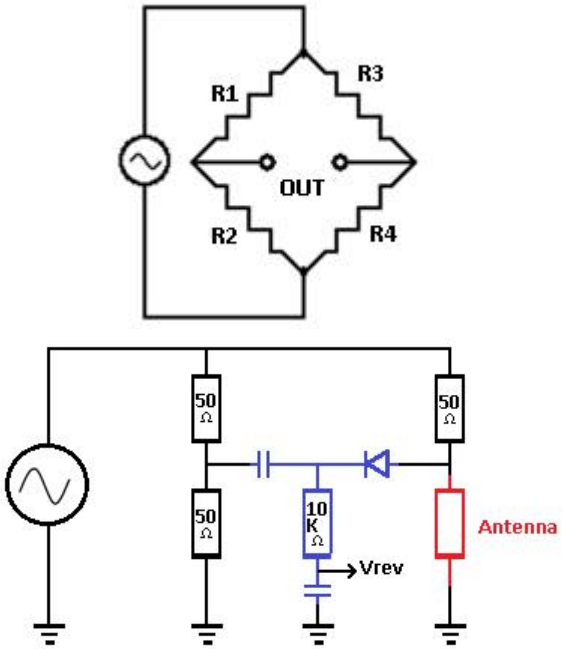

FIGURE 4

The Math

The antenna analyzer uses the resistive VSWR bridge measuring principle. It calculates VSWR by determining the coefficient. If you remember the principle of a balanced bridge, then you'll understand how this works. The bridge routes the signal source to the antenna under test and outputs a signal proportional to the reflection received from the antenna under test. If we know the voltage of the signal sent to the antenna and the voltage of the reflection, the reflection coefficient is the ratio of the reflected signal to the incident signal.

Once we know the reflection coefficient we can calculate VSWR:

$$\mathrm{VSWR} = \frac{1+\Gamma}{1-\Gamma}$$

Using the bridge calculation:

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Z = antenna Impedance, Z_0 = reference impedance (in this case 50 ohms resistance)

$$\Gamma = \frac{Z - Z_0}{Z + Z_0}$$

Another way to look at antenna performance over frequency is to use Return Loss. Return loss is measured in dB and is a nice way to quantify antenna reflected power. Higher return loss is better. After finding the reflection coefficient you can calculate Return Loss.

To determine Return Loss:

$$\text{Return Loss} = -20 \log |\Gamma|$$

Generally, a good rule of thumb is if the antenna has return loss of 20 db or better (higher), it is reflecting so little power (1% of the incident power) that it does not really matter. In a poor performance case, a return loss of 3dB means the antenna is reflecting half of its power.

In Conclusion

Yes the purists will say that we are not really measuring the impedance here and their point is well noted. Ideally, we would want to measure impedance as a vector quantity and be able to determine if our antenna is more capacitive or more inductive, as this is important to know when designing an antenna. The antenna analyzer in this case does a great job determining where our antenna is most resonant over a particular frequency band so we can use it appropriately. It can be a real transmitter savior to know how well your antenna is matched to the band you are using before you apply high RF power! This device does a great job at that.

Final Summary

The completed version of the board will look pretty much like the picture shown in figure 5. The whole design including the hardware schematics, layout, firmware and optional PC software will all be open source. The required input voltage is between 7-36 VDC and the unit can be powered using a 12 V source

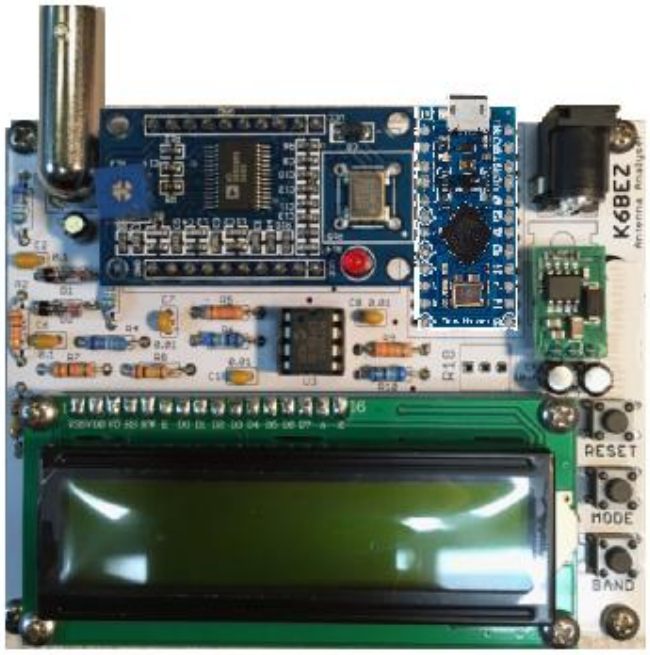


FIGURE 5

from a wall adaptor or a battery.

The antenna analyzer will provide VSWR measurements for any antenna from 1 to 40 MHz. There is a 2 line x 16 character LCD display and there are three push buttons to the right which are use to select the mode and band. It can be programmed to scan several bands any sub band and has built in ranges for 160m, 80m, 60m, 40m, 30m, 20m, 17m, 15m, 12m, 10m. Frequency and VSWR are shown on the LCD display. Data can optionally be sent over the USB cable to a PC running a program that will plot the VSWR on a graphical window display.

Now you know how the antenna analyzer we're building actually works! I hope this gives you a great feeling of satisfaction after completing your project and a handy tool to use to test all of those new antennas that you'd like to try.

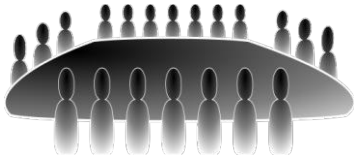
VE Session Results

Two candidates passed technician exams at the STARS exam session last month, but their callsigns haven't come in yet!

Name	Call	Class
Richard Burns	???	Tech
Brian Hembrook	???	Tech

Club Officers

President	Ken Pokigo, KC2AYK
Vice President	Allen Mitzo, WA2TTT
Secretary	Joe Claus, KB2JDB
Financial Secretary	Patrick Groom, KC2VWG
Treasurer	John Leitten, KA2RFT
Director (1 yr.)	John Dilivio, K2CF
Director (2 yr.)	Jon Hall, AA2CC
Clubhouse Chair	Allen Mitzo, WA2TTT
Fundraising Chair	Jon Hall, AA2CC
Hospitality Chair	Richard Neubeck, W2RLN
Net Control Stations	Scott Barto, KB2KOL (VHF) Bob Lehning, WA2YSJ (HF)
NYQP Chair	John Leitten, KA2RFT
Photographer	Richard Neubeck, W2RLN
Program Chair	Larry Plumb, WA2TLY
Repeater Chairs	Pat Groom, KC2VWG Ken Pokigo, KC2AYK
Special Events Chairs	Joe Claus, KB2JDB Bob Koster, KA2WYE
Telstar Editor	Owen Torres, KD2LXF
VE Team Liaison	Richard Neubeck, W2RLN
Webmaster	Don Niles, K2PMC



Club Nets

STARS holds two nets every week -- one on 2 meters and one on 75 meters. All are welcome to participate.

Tuesdays	7:30 PM	147.09 MHz (Repeater)
Saturdays	10:00 AM	3.925 MHz ± QRM

2018 Goals

Participate in Field Day.	🔴
Participate in NYS QSO Party.	🔴
Attend mini-maker faire.	🔴
Set up a digital station.	🔴
Conduct fundraising events.	🔴
Conduct a club build project.	🟡
Present 4 monthly programs.	🔴
Conduct training on club equipment.	🔴
Conduct general and extra classes.	🔴
Install satelite antennas.	🔴
Reinstall Colden repeaters.	🔴

School Club Roundup February 12-16 2018

By Joe Claus, KB2JDB

Pioneer High School Amateur Radio Club, KC2AIF, will participate in School Club Roundup Feb 12-16 during school hours, 9-3 each day. Kids and advisors will attempt to contact schools, clubs, and individuals locally, nationally, and worldwide.

This is our annual contest event. The club has had a radio presence in Pioneer HS since its first advisor, Joe Claus, KB2JDB, got licensed in 1990, 28 years ago.

It is possible no other school club has been active this long in WNY.

Club members include student hams and non-hams working toward their Tech license. All Radio Club members are also part of a larger Computer Club that meets on a different day. KB2JDB is a volunteer advisor who travels to Pioneer twice weekly to present radio lessons and teach hands-on tech skills.

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Our most recent project was the installation of a new Hustler 6-BTV trap vertical antenna. Students from both clubs climbed to the roof, painted a platform on a rooftop AC unit and placed the antenna near a VHF-UHF antenna. Both antennas are working well and we hope to QSO with local hams. Please listen for us calling CQ School Club Roundup on several bands, with 40 and 20 meters being our first choice:

Phone (MHz): 1.855-1.865; 3.850-3.880; 7.225-7.255; 14.250-14.280; 21.300-21.330; 28.440-28.460

Colden Repeater Work

As you may have noticed, one of our goals this year is to refurbish and reinstall the Colden repeaters. Club members have started investigating the current state of the repeaters and think that it may be best to replace them with some newer ones that were donated. The donated repeaters are not designed for high power continuous duty however, so a setup involving the old power amplifiers is being looked into.

STARS Meetings

STARS meetings are usually at 7:00 PM on the first Thursday of each month, at the Hamburg Memorial Youth Center, 200 Prospect Avenue in Hamburg.

During July and August the youth center is closed and meetings are held at the Nike Base Clubhouse at 2982 Lakeview Road in Hamburg.

This month's meeting will be on February lst, at 7:00 PM, at the Hamburg Memorial Youth Center. All those interested in amateur radio are welcome.

The STARS board usually meets at 7:00 PM on the fourth Thursday of each month, at the Nike Base Clubhouse.

The next board meeting will be on February 22nd at 7:00 PM. All members are welcome.

STARS Licensing Exams

STARS offers licensing exams at 9:00 AM on the third Saturday of each odd-numbered month. The exams are conducted at the Hamburg Memorial Youth Center at 200 Prospect Avenue in Hamburg. Walk-ins are allowed.

Candidates must bring the following items to the exam:

- Legal photo ID (a driver's license is excellent).
- Your SSN or FRN. FRNs can be obtained on the FCC website.
- Current license and/or CSCE, if any, with a non-returnable photocopy of each.
- $15 in cash.
- Two #2 pencils with erasers, and a pen.

Calculators are permitted, so long as any programming has been cleared.

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