2023-08-08 Hamlet Net - Test Equipment - Oscilloscope and Spectrum Analyzer

Announcements:

- Test Session Info
    - Next VE session is Saturday, August 26th in the Clover Building at the Boulder County Fairgrounds, and starts at 10 am. It is an ARRL VEC exam session, so there will be a $15 fee to take the exam. For more info, see the Licensing/Testing page on the club web site, https://w0eno.org/, under the Education menu.

- As you may have noticed, we've been experiencing dropout issues on the LARC repeater system lately. Chuck and I did some testing last week in preparation for the Boulder County Fair Parade, and determined that if the repeater equipment on Lee Hill was disconnected, the issues went away. Unfortunately, this does mean that the overall coverage area of the repeater system is greatly reduced, but the larger coverage area doesn't help out if the system is unusable.

  If you are hearing this net, but are not able to get into your usual repeater, you can try using the other repeater (i.e. 2m or 70cm) to see if that's any better. As a fallback, EchoLink will get you into the system.

- Chuck is putting together a special event to celebrate the 105th anniversary of the Peak-to-Peak highway involving multiple area radio clubs on September 30th. They're currently looking for volunteers to work this special event. They will be operating HF SSB voice, CW, and FT8 stations from 8am to 4pm with three operators at each station. There is a signup link on the club web page at https://w0eno.org/, or contact him for more information!

- We have some volunteer opportunities available where you can help out LARC:

    - Photographer / videographer - record team activities and upload to web site / YouTube

    - LARC Fest Coordinator -

    - Newsletter Editor - put together the monthly Splatter newsletter

    - Activities Chairperson - member of the Board of Directors

- Our sister club up in Nederland is looking for some help with events they are running. They have a weekly Monday night net with no predetermined agenda, so you can lead it however you want. They are also planning a Field Day site at Golden Gate State Park and are welcoming anyone who wants to participate. Finally, they are looking for

operators for the Ned Gravel run on July 8th. They have signup links for all these events, so head over to their web site https://w0ned.org/ for more information!

- You can start earning your 2023 membership or future renewal by acting as NCS for at least 5 nets this year. You can run either this Tuesday night net or the Thursday night net (or both). We have scripts available for both, so all you need is a good connection into the repeater, and somewhere to keep track of names and call signs as people check in. If you're going to be on the net anyway, why not save some dough at the same time! There are four free memberships available for 2023, so don't wait to get started!

- Chuck has set a goal for the Club of running at least one activity a month. This can be a hands-on construction activity, an operating activity like Field Day, a fox hunt, or a special event station. The goal is to get people together to have fun with amateur radio! We have multiple locations at our disposal, as well as lots of Club equipment, so if you have an idea for something you think others hams would like to do, please let us know, and if you're willing to run it, even better!

- The Club is also looking for presentation topics for 2023. If you have any ideas, or better yet, would like to present, please let Chuck know and we'll get you on the schedule!

- All club activities are open to anyone - members and non-members. ~~If you have questions, ask them on a net or~~ **send email to elmer@w0eno.org**

Presenter: Bryan, AF0W

Topic: Test Equipment - Oscilloscope and Spectrum Analyzer

- I've covered a few pieces of common test equipment in previous nets. This week, I'm going to cover a couple of more advanced devices

Oscilloscope

- The first piece of equipment I'm going to discuss is the oscilloscope, sometimes referred to as a "scope" or "o-scope"

- At a basic level, they are a device that graphically displays one or more varying signal voltages as a function of time

- The display screen has time on the horizontal axis and voltage on the vertical axis

    a. For example, if you were to feed a sine wave signal into a multimeter, at best, your meter will read some "average value" of the signal - but an oscilloscope will show you the actual waveform

- The display screen also includes measuring scales that allow voltage and time values to be read from the screen - modern digital oscilloscopes include many built-in measurement capabilities
- Displayed voltage waveforms can be analyzed for properties such as amplitude, frequency, rise time, and distortion
- Early devices used cathode ray tubes for their displays, and linear amplifiers for signal processing.
- Nowadays, most oscilloscopes are DSOs or digital storage oscilloscopes, which feature analog-to-digital converters, digital signal processors, and thin-panel displays, and are much lighter than older CRT-based models
- Both kinds of oscilloscopes include sets of controls for the vertical and horizontal axis as well as triggering.
- The vertical section controls the amplitude of the displayed signal through the selection of the number of volts per screen division. This value may range from 5 millivolts to 5 volts per division
    a. It also typically includes a switch to allow a DC voltage offset to be removed from the displayed signal.
- The horizontal section controls the time base or "sweep" through the selection of the number of seconds per division. This controls how quickly the trace moves from left to right. This value may range from seconds down to picoseconds.
- Both horizontal and vertical sections include a control to allow the vertical or horizontal position of the trace to be shifted. This is handy when making measurements on the screen of an analog scope - one side of the trace can be aligned exactly with the measurements marks on the screen.
- There are also trigger controls that allow the user to adjust the start of the sweep.
    a. For example, a falling zero voltage can be used to start the sweep, which is where the left-hand side of the trace will start. This is useful for observing periodic waveforms such as sine or square waves.
- Oscilloscopes are typically connected to the device under test using probes. These probes connect to the vertical channel inputs on the oscilloscope, and include the ability to account for the capacitance in the probe and connecting cable, and typically use a BNC connector.

- Some characteristics of a scope include the number of vertical channels (i.e. the number of inputs or different values that can be displayed simultaneously), and the bandwidth of the scope (which is the range of frequencies the device can usefully display)
- Scopes can be used for various tasks in amateur radio, for example:
    a. Examining power supply output for noise
    b. Seeing if an RF, AC, or DC signal is present
    c. Tracing signals through the different stages of a radio to troubleshoot malfunctions
    d. Identify clipping or distortion of a signal
    e. Check frequency response, when used in conjunction with a signal generator
    f. Check two signals to see if they are in phase with each other
    g. Monitoring the RF envelope of your signal
- In the "old days," there used to be devices called station monitors that included an oscilloscope display of your outgoing RF waveform
- Because they convert analog signals to digital data, digital oscilloscopes may include capabilities such as on-screen direct measurements, ability to perform calculations on signal information, and the ability to transfer of signals to a computer

Spectrum Analyzer

- The other device I want to cover is the spectrum analyzer
- Whereas oscilloscopes measure voltages over time (called the "time domain"), spectrum analyzers measure the magnitude of an input signal over a range of frequencies (called the "frequency domain")
- By analyzing the spectra of a signal, characteristics such as dominant frequency, power, distortion, harmonics, and bandwidth can be determined
- The display of a spectrum analyzer has frequency on the horizontal axis, and amplitude on the vertical axis
    - Recall that an oscilloscope has time on the horizontal axis, and amplitude on the vertical axis

    - As an example, say you were to generate a 1 MHz sine wave signal on a function generator, and then observe this signal on both an oscilloscope and a spectrum analyzer
        - Assuming the controls are set appropriately, you would see an image of a sine wave on the oscilloscope display, and could measure both the wavelength and amplitude of the signal
            - If you adjusted the frequency of the sine wave to be 2 MHz, the sine wave would appear to get narrower (more cycles would fit on the display)
        - On the spectrum analyzer, you would see a sharp peak at 1 MHz, and could also measure the power of that signal
            - Depending on the quality of your signal generator, and the cabling used between it and the analyzer, you'll likely see other smaller "bumps" around 1 MHz, and possibly some harmonics at 3 MHz and 5 MHz
            - If you adjusted the frequency of the sine wave to 2 MHz, the peak would move to the right
- Controls on the analyzer allow you specify the range of frequencies to be displayed, either via setting the center frequency and span, or by directly setting the upper and lower frequencies
- Additional controls are used to set the gain or attenuation of the input signal, the scan rate at which the range of frequencies are measured, and filter bandwidths.
- As with oscilloscopes, the first spectrum analyzers were analog, while modern analyzers are digital
- Digital analyzers also likely include direct on-screen measurements, min/max capabilities, and on-screen cursor measurements, where you move a vertical line across the frequency range on the screen, and various values are displayed for that frequency
- In amateur radio, spectrum analyzers can be used to:
    - Show harmonics produced by a transmitter
    - Determine the bandwidth of a signal
    - Measuring the distortion of a signal
    - Display spurious emissions from a device such as a Baofeng

    - Measure frequency response of a filter when used in conjunction with a sweep generator, which generates an input signal into the filter

- Either device, oscilloscope or spectrum analyzer comes in various configurations, ranging from a standalone, dedicated piece of test equipment, to a device that is connected to and operated via a computer, to small handheld devices.

- As with many things, you "get what you pay for" - spectrum analyzers can run into the tens of thousands of dollars, but this level of accuracy is not needed for amateur applications

- Recently, a device called the tinySA has become available which combines a spectrum analyzer and signal generator into a small, handheld package with a built-in battery and display that retails for around $60

- Regardless of the instrument, make sure you do not exceed the input specifications or you will damage the device

    - For example, the tinySA lists +10 dBm as the maximum input power

        - Recall that dB is a comparison of two values - in this case, the power of the input signal compared to one milliwatt

        - 100W of power equals 50 dBm and 1W of power equals 30 dBm, so external attenuators must be used if connecting directly to a transmitter, or you will damage the device

        - 10 dBm is only 10 mW of power - this is lower than the maximum wireless transmitter power for 802.11 a/b/g/n WiFi, cellular and BlueTooth signals on cell phones

- You also need to be careful to protect measurement equipment from things like static electricity and nearby RF

    - If 1W of power equals 30 dBm, and the TinySA maxes out at 10 dBm, then attaching a 2m antenna (even a rubber duck antenna) to your spectrum analyzer and transmitting with your 4W radio nearby can potentially damage it

- Neither an oscilloscope nor a spectrum analyzer are required pieces of amateur radio equipment, and if you aren't troubleshooting or repairing radios, you may never need to use one, but they can come in very handy if you need to observe signals that vary with time or frequency

Questions:

- **The question for the week is:** Have you used either an oscilloscope or spectrum analyzer, and if so, what kind and what did you use it for?

- **In my case,** I've used them for demos in licensing classes - a signal generator connected to an oscilloscope allows students to easily see the relationship between frequency (both audio via a speaker and on the oscilloscope) and wavelength.

  The spectrum analyzer can be used to show the difference in the spectral purity of transmissions from a Baofeng handheld as compared to a Kenwood.

  I haven't really used either of these devices other than to play around with them, but I did use a USB RTL-SDR receiver stick and SDR Sharp software the other night to try to figure out the frequencies programmed into an older Kenwood radio I purchased from the Silent Key sale a couple of weeks ago.

  I planned to use it for GMRS, so I first tried to use it with some cheap FRS/GMRS handheld radios, but could neither hear them on the new radio, or hear it on them. I did hear what sounded like repeater tones and IDs.

More Info:

- TinySA: https://tinysa.org/wiki/pmwiki.php
- Oscilloscope (Wikipedia): https://en.wikipedia.org/wiki/Oscilloscope
- Spectrum analyzer (Wikipedia): https://en.wikipedia.org/wiki/Spectrum_analyzer

- If you have ideas for net topics or general meeting topics / presenters, please let us know! Tell us on a net, or send email to k0itp@w0eno.org

Email to elmer@w0eno.org

1. K0BDL - Don - Mead
2. W7PGF - Phillip - Frederick
3. AF0W - Bryan - Longmont
4. KF0MXH - Art - Longmont
5. WG5X - Chuck - Frederick
6. KN6CFI - John - Longmon

ARRL lab test articles show oscilloscope and spectrum analyzer outputs for things like CW keying envelopes

LARC Solder Sniffers - Used to meet once a month, work on a kit over time

TDR can be used to find break in cable

WG5X - coming Saturday morning at 9am - Chuck and him are having class/demo on DX Commander. Solder Sniffers - Leonard was running it. He was radio maintenance guy for Denver Fire Department. Will try to put together a little presentation on that. Was Net Control for Security Forces in Military.

NOTES - Net procedures (directed, roundtable, NTS traffic, etc.)