2023-10-17 Hamlet Net - SWR - Definition

Announcements:

- Test Session Info
    - Next VE session is Saturday, October 28th in the Clover Building at the Boulder County Fairgrounds, and starts at 10 am. It is an ARRL VEC session, so there is a $15 test fee. For more info, and to pre-register, see the Licensing/Testing page on the club web site, https://w0eno.org/, under the Education menu.

- LARC will be conducting its annual meeting tomorrow, October 18th. Elections for the Board of Directors will be held that night, so all LARC members please plan to attend (at least for the voting at the beginning of the meeting, as we have to get a quorum of members present to conduct the elections). If you are unable to attend in person or via Zoom, please submit a proxy to help us meet the quorum requirements.

- 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

- LARC is running our annual Santa on the Air event again this year, with help from the Northern Colorado Amateur Radio Club. We are planning to have Santa, Mrs. Claus, and Santa's elves operate from Monday, November 27th through Sunday, December 10th.

  Our "professional Santa" has retired this year, so we are in need of some help! We currently have one Mrs. Claus and one Elf, so we need some volunteers to round out our team.

  The only requirement is that you can get into the LARC repeater or the NCARC 447.700 repeater on Mount Buckhorn - you can also use Echolink to get into the LARC repeater. I suppose you should also like kids as well. 🙂

  I believe Chuck has some material put together by our old Santa on how to play the part, so if you are available, please help us out!

  Contact Chuck, K0ITP, at k0itp@w0eno.org to see how you can assist.

- The Boy Scouts are running their Jamboree on the Air, or JOTA, event this weekend. This event occurs annually on the third full weekend in October and is the largest Scouting event in the world. JOTA uses amateur radio to link Scouts and hams around the world, around the nation, and in their own community.

  This event is not a contest, but rather an opportunity for Scouts to get exposure to the world of amateur radio.

  For more information, see their web site at:
  https://www.scouting.org/international/jota-joti/jota/

- 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: SWR

- One thing some hams obsess over is the Standing Wave Ratio, or SWR, of their antenna systems

- Everyone wants that perfect 1:1 SWR, but what does that really represent?
- First of all, what is SWR?
- It is a measure of impedance matching of loads to the characteristic impedance of a transmission line
    a. In the case of a typical amateur radio setup, the load is the antenna and the transmission line is the feedline to the antenna
    b. The most commonly used feedline is coaxial cable with a 50 ohm characteristic impedance
- So what is the characteristic impedance? Does this mean that if I connect an ohmmeter to both ends of a coaxial cable, or across the center conductor and shield at one end, it will read 50 ohms?
- The first thing you may notice is that the term includes the word "impedance." This should be a clue that we're talking about something different from DC resistance, which is what your ohmmeter will read, so no, you won't see 50 ohms with a multimeter.
- Impedance is the opposition to alternating current presented by a combined resistance and reactance - the AC current being the RF signal generated by your transmitter, and the reactance being the opposition to the current by inductance and capacitance
- In your licensing studies, you may have come across the fact that reactance is a function of frequency. You can see this in practice as you will see different SWR values for the same antenna system when tested on different bands.
- The characteristic impedance is based on the distributed capacitance and inductance in a transmission line
    a. It is determined by the geometry and materials of the transmission line (such as the diameter, spacing between conductors, and the type of insulation), and is not dependent on its length (assuming the transmission line is uniform)
- So back to SWR - if the load and transmission line characteristic impedances are equal, then it is said that they are matched, and then the SWR is 1:1
- If there are any impedance mismatches, then reflections will occur, which will cause standing waves along the transmission line
- SWR is defined as the ratio of the standing wave's amplitude at maximum and minimum points
- SWR has an impact on the amount of power that reaches the actual antenna

- For example, if you have a 50 ohm antenna connected to a 50 ohm lossless coax feedline, then there are no reflections,then close to 100% of the power output by the radio reaches the antenna. This system has an SWR of 1:1
- The SWR is always something to 1 - 1:1, 2:1, 10:1 - it's never 1:5, for example
- Now what if you replace the antenna with one that has a 100 ohm impedance?
    a. The SWR for a purely resistive load can be calculated by dividing the load resistance by the characteristic impedance (or vice-versa - whichever calculation results in a value greater than or equal to 1)
    b. For this system, the SWR would be 100 ohms divided by 50 ohms, or 2:1
    c. For a 2:1 SWR, approximately 33% of the voltage, or 11% of the power is reflected back towards the transmitter
    d. If you could observe the voltage along the transmission line, you would see that instead of a constant AC voltage as is the case for a 1:1 match, it now has standing waves which would appear as peaks and valleys as it interacts with other RF waves from the transmitter
- In the case of a perfect transmission line, which has no losses, this reflected voltage would bounce back and forth in the transmission line until all of it reached the antenna.
- When using a real-world transmission line, there will be losses due resistive heating. The magnitude of these losses will depend on the lossiness of the transmission line used.
- If a very low-loss transmission line is used, then no matter what the SWR, most of the power will eventually reach the antenna.
- On the other hand, if you have a long and very lossy feedline, you may get a low SWR reading, but what you may not be seeing is that the reflected power from the antenna is being lost due to heat.
- Note that these standing waves also mean that your feedline length makes a difference. Your SWR will actually vary based on the length of your feedline.
    a. You may have read antenna information that states a specific length of feedline that needs to be used, or perhaps lengths of feedline to be avoided - usually based on the frequency or wavelength at which the antenna is being used. Note that this is referring to the length of the feedline, not the antenna itself.

- The ARRL Handbook has much more in-depth information, and includes a graph that shows the SWR at the antenna for a given SWR at the transmitter, and a given feedline loss.
- An example of the use of this graph would be a 2 meter station and antenna connected by 120 feet of RG-8X cable.
    a. If the manufacturer's specs for that cable show an expected loss of 4.5 dB and your transmitter's SWR meter reads 2:1, you may think that while this is not optimal, it's not too bad.
    b. Using the chart I mentioned previously, you will find that the actual SWR at the antenna is 20:1, not 2:1. This is due to the mismatch and cable loss.
    c. Your SWR meter is understating the SWR as much of the reflected power is being lost when traveling back to the transmitter and SWR meter.
    d. The 20:1 SWR at the antenna means that less than 1/10 of your transmitter's output power is arriving at the antenna.
- So what can you do about these losses?
    a. One way of addressing them is to use a balanced feedline, such as open wire line, window line, or ladder line
        ■ The loss for this type of feedline is quite low for HF frequencies
    b. For example, 300 feet of 450 ohm ladder line has a loss of less than 0.5 dB at 30 MHz, while a good quality, expensive coax might have around 1 dB of loss for the same length - and cheap coax will have closer to 2 dB of loss
    c. This means that you can use this type of feedline even if you have a high SWR (mismatched) antenna - the lower losses will result in more power being radiated rather than lost in the feedline
    d. This behavior is utilized in the multi-band doublet antenna, which is a wire dipole that is fed by a balanced feedline. The low losses in the feedline allow most of the transmitted power to actually reach the antenna, whereas a coax feedline to the same antenna would suffer high losses.
- The examples I used are all based around purely resistive impedance values. Again, the real world isn't quite so pretty.
    a. To match the impedance of the feedline and antenna (or transmitter), the impedances must be complex conjugates of each other.

    b. In amateur radio applications, this is done by adding inductance and/or capacitance to the antenna system - frequently via an antenna tuner or match box

- Keep in mind that while a low SWR (i.e. close to 1:1) is generally good, it does not mean that your antenna system is radiating effectively

    a. If you connect a 50 ohm dummy load to your radio with a piece of 50 ohm cable, you will get close to a 1:1 SWR, but your station will not radiate very much signal!

- Much of the information in this presentation was based on an article in the November 2006 QST (https://www.arrl.org/files/file/Technology/tis/info/pdf/q1106037.pdf)

- I'll have a bit more information on how to measure the SWR in your station in a later presentation.

Questions:

1. **The question for the week is:** Do you use any non-coax feedline in your station, and if not, do you have a tuner that is capable of using balanced feedline directly?

2. **In my case,** I'm currently using coax for all my antenna feedlines. My main HF antenna is a G5RV Jr. which is a dipole antenna that was designed for 20 meters, but which can be operated on other ham bands with the use of an antenna tuner to overcome the impedance mismatches on those bands. The antenna is a wire dipole with a 15.5 foot feedline made of window line, which then connects to coax to run back to the shack. The ladder line is actually part of the impedance match for the antenna.

   My antenna tuner does have connectors for a balanced feedline, and I plan to eventually try a multi-band doublet which will consist of a wire dipole fed entirely by window line.

Backup Questions:

1. What hobbies do you have other than ham radio? Do you (or could you) use ham radio in these hobbies?

2. Share an "a-ha" moment you had with amateur radio?

More Info:

- Standing Wave Ratio (Wikipedia): https://en.wikipedia.org/wiki/Standing_wave_ratio

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- 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

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7. KN4RD - Russ - Firestone -
8. KF0DGA - Carl - Weld County -
9. KF0FEC - Will - Boulder -

End: 7:58