How do you choose an Antenna Analyzer?

You are finally getting around to thinking about purchasing an antenna analyzer, but are stumped by all the choices. Just put in "Antenna Analyzer" in a Google search! You will notice that the choices are all over the place!

Options we are going to discuss are Design, Interface, Range, Features, Portability and Price.

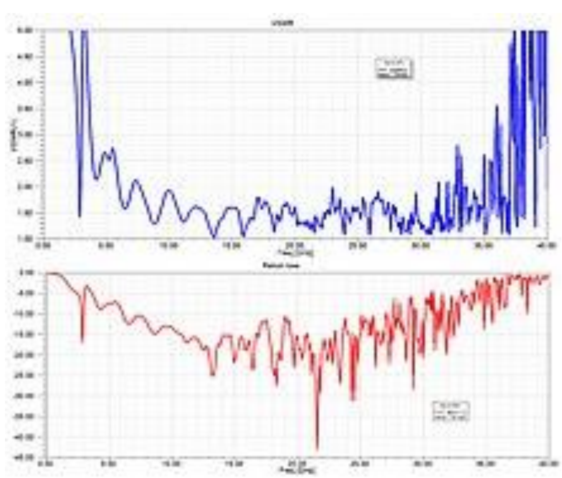
So, how do you choose just one from all that's available? Well, the first thing that you have to ask yourself is how you're going to use the analyzer. If all you're going to do is to check the SWR of your HF dipoles, then most modern Radios already have a SWR meter built in.

How does one decide? Where does one go to find out the differences? Other than asking a fellow ham, how does one find out which one is the best antenna analyzer without paying an arm and a leg unless the features so purchased are deemed worth the cost?

What is an Antenna Analyzer?

An antenna analyzer, also known as an SWR analyzer, RX bridge, noise bridge, or RF analyzer, is a device that helps measure the input impedance of antennas.

In radio communications systems, including amateur radio, an antenna analyzer is a common tool used for fine tuning antenna and feedline performance, as well as troubleshooting them.



Example of estimated bandwidth of antenna according to the schedule VSWR

Practical implications of SWR

The most common case for measuring and examining SWR is when installing and tuning transmitting antennas. When a transmitter is connected to an antenna by a feed line, the driving point impedance of the antenna must match the characteristic impedance of the feed line in order for the transmitter to see the impedance it was designed for (the impedance of the feed line, usually 50 or 75 ohms).

The impedance of a particular antenna design can vary due to a number of factors that cannot always be clearly identified. This includes the transmitter frequency (as compared to the antenna's design or resonant frequency), the antenna's height above and quality of the ground, proximity to large metal structures, and variations in the exact size of the conductors used to construct the antenna.

When an antenna and feed line do not have matching impedances, the transmitter sees an unexpected impedance, where it might not be able to produce its full power, and can even damage the transmitter in some cases. The reflected power in the transmission line increases the average current and therefore losses in the transmission line compared to power actually delivered to the load. It is the interaction of these reflected waves with forward waves which causes standing wave patterns, with negative repercussions.

Matching the impedance of the antenna to the impedance of the feed line can sometimes be accomplished through adjusting the antenna itself, but otherwise is possible using an antenna tuner, an impedance matching device. Installing the tuner between the feed line and the antenna allows for the feed line to see a load close to its characteristic impedance, while sending most of the transmitter's power (a small amount may be dissipated within the tuner) to be radiated by the antenna despite its otherwise unacceptable feed point impedance. Installing a tuner in between the transmitter and the feed line can also transform the impedance seen at the transmitter end of the feedline to one preferred by the transmitter. However, in the latter case, the feed line still has a high SWR present, with the resulting increased feed line losses unmitigated.

The magnitude of those losses are dependent on the type of transmission line, and its length. They always increase with frequency. For example, a certain antenna used well away from its resonant frequency may have an SWR of 6:1. For a frequency of 3.5 MHz, with that antenna fed through 75 meters of RG-8A coax, the loss due to standing waves would be 2.2 dB. However the same 6:1 mismatch through 75 meters of RG-8A coax would incur 10.8 dB of loss at 146 MHz. Thus, a better match of the antenna to the feed line, that is, a lower SWR, becomes increasingly important with increasing frequency, even if the transmitter is able to accommodate the impedance seen (or an antenna tuner is used between the transmitter and feed line).

Certain types of transmissions can suffer other negative effects from reflected waves on a transmission line. Analog TV can experience "ghosts" from delayed signals bouncing back and forth on a long line. FM stereo can also be affected and digital signals can experience delayed pulses leading to bit errors. Whenever the delay times for a signal going back down and then again up the line are comparable to the modulation time constants, effects occur. For this reason, these types of transmissions require a low SWR on the feedline, even if SWR induced loss might be acceptable and matching is done at the transmitter.

Types of Analyzers

There are several different instruments of varying complexity and accuracy for testing antennas and their feed lines. All can also be used to measure other electrical circuits and components (at least, in principle).

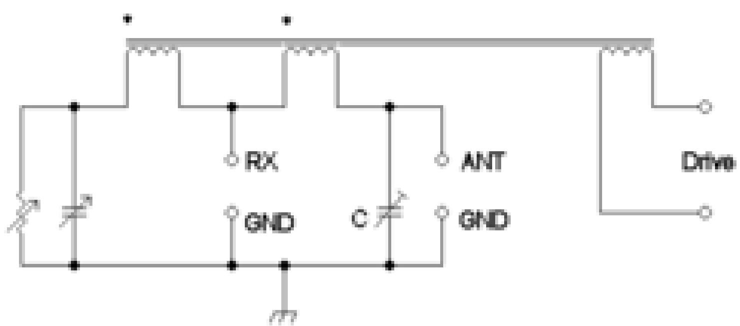
SWR Meters

The simplest is an SWR meter, which only indicates the degree of mismatch; the actual mismatched impedance must be inferred by measuring several nearby frequencies and performing a few simple calculations. The SWR meter requires a transmitter or signal generator to provide a few watts power test signal.

Many transmitters include an SWR meter in the output circuits which works by measuring the reflected wave from the antenna back to the transmitter, which is minimal when the antenna is matched. Reflected power from a badly tuned antenna can present an improper load at the transmitter which can damage it. The SWR meter requires about 5–10 watts of outgoing signal from the radio to register the reflected power (if any), and then only indicates the relative degree of mismatch, not the reactive and resistive impedance seen at the end of the antenna's feedline.

Antenna Bridge

Antenna bridges have long been used in the broadcast industry to tune antennas. A bridge is available which measures complex impedance while the transmitter is operating, practically a necessity when tuning multi-tower antenna systems. In more recent times the direct-reading network analyzers have become more common.



A typical antenna bridge, the trimmer capacitor (C) is adjusted to make the bridge balance when the variable capacitor on the left is half meshed. Hence the bridge will be able to detect if an antenna is either a capacitive or inductive load.

An antenna bridge is able to measure at low power, but also requires a supplied test signal; depending on the bridge circuit, it can be used to measure both reactance and resistance by reading values marked on knobs that have been adjusted for a match.

Noise Bridge and Network Analyzer

The noise bridge and network analyzers both supply their own very low-power test signals. Both are able to measure both resistance and reactance, either by calculation or by reading knobs adjusted for a match. Modern analyzers directly display resistance and reactance, with the calculations done internally by a microprocessor.

A bridge circuit has two legs which are frequency-dependent complex-valued impedances. One leg is a circuit in the analyzer with calibrated components whose combined impedance can be read on a scale. The other leg is the *unknown* – either an antenna or a reactive component.

To measure impedance, the bridge is adjusted, so that the two legs have the same impedance. When the two impedances are the same, the bridge is balanced. Using this circuit it is possible to either measure the impedance of the antenna connected between ANT and GND, or it is possible to adjust an antenna, until it has the same impedance as the network on the left side of the diagram below. The bridge can be driven either with *white noise* or a simple carrier (connected to drive). In the case of white noise the amplitude of the exciting signal can be very low and a radio receiver used as the detector. In the case where a simple carrier is used then depending on the level either a diode detector or a receiver can be used. In both cases a null will indicate when the bridge is balanced.

Complex voltage and current meters

A second type of antenna analyzer measures the complex voltage across and current into the antenna. The operator then uses mathematical methods to calculate complex impedance, or reads it off a calibrated meter or a digital display. Professional instruments of this type are usually called network analyzers.

Modern analyzers do not require the operator to adjust any R and X knobs as with the bridge-type analyzers. Many of these instruments have the ability to automatically sweep the frequency over a wide range and then plot the antenna characteristics on a graphical display. Doing this with a manually-operated bridge would be time-consuming, requiring one to change the frequency and adjust the knobs at each frequency for a match.

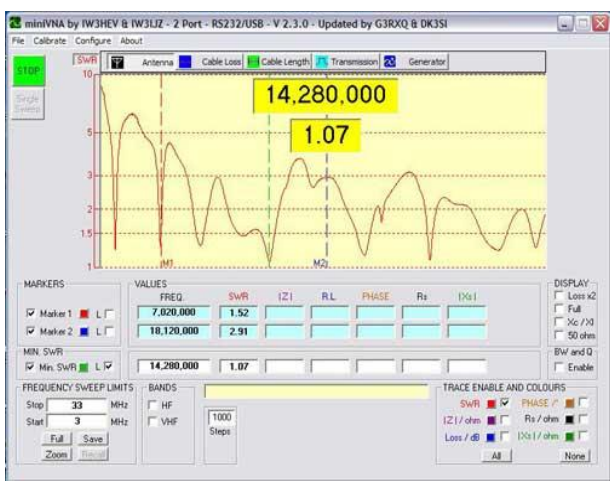
High and low power methods

A complex-impedance antenna analyzer typically only requires a few milliwatts of power be applied to the antenna, and typically provides its own signal, not requiring any test signal from a transmitter. Using a low-power test signal avoids damaging the analyzer when testing a badly-matched antenna, In addition, because its signal power is very low, the analyzer can be used for frequencies outside of the transmit bands licensed to its operator, and thus measure antenna performance over an unrestricted range of frequencies.

NanoVNA

NanoVNAs are compact VNA devices that are as tiny as credit cards. They flaunt an LCD panel that helps display insightful graphs such as Smith charts and SWR charts. These gizmos can be connected to computers and managed via the NanoVNA software for Windows.

If you want to do some more serious frequency analysis, then you should be looking at the NanoVNA or, if you have more cash, the Timewave TZ-900. These instruments can help you do a lot more in-depth analysis of your antenna system. The figure below, for example, shows a plot generated by the NanoVNA software. It shows the SWR of a multi-band vertical antenna from 3 – 33 MHz.



For more sophisticated frequency analysis, consider the NanoVNA. It can use a computer.

How to Choose an Antenna Analyzer

Even after learning about the best antenna analyzers on the market, choosing one can still be a bit challenging, especially if you don't know what to look for. The following paragraphs shed light on the different factors that must be considered before purchasing an antenna analyzer.

Design

When we speak of design, we're mainly talking about whether the unit is shielded or unshielded. Shielded devices like the Hima NanoVNA-F Vector Network Analyzer tend to flaunt metal casing that's usually made of aluminum.

Shielded devices have two main advantages over their unshielded counterparts. Firstly, they're way sturdier and offer better protection for their internal components. And secondly, these units are highly resistant to disturbances.

Shielded VNAs are excellent choices for beginners who don't have much hands-on experience with antenna analyzers. However, if you're an expert, you'll probably need access to the VNA's internal components for things such as changing the transceiver's wiring. In this case, you'd be better off with an unshielded device since it'll offer you easier access to internal components.

Range

The frequency range is arguably the most important factor to consider when in the market for an antenna analyzer. The selection should be based mainly on the application with which you'll use the VNA.

For example, if you need the device for a ham radio system, you need an analyzer with a range that covers the area just above the AM band all the way to the Citizens band. More specifically, you need a device that can cover the 2-30MHz range.

If you're looking for an analyzer for weather tracking radio systems, you need a unit that's able to cover higher frequencies.

We strongly recommend getting an antenna analyzer that features a broad frequency range so that you're able to use it for a wide range of activities.

Interface

Make sure to invest your money in a device that has a user-friendly interface and that's easy to navigate. Most NanoVNAs feature touchscreens of small size that allow for easy navigation, but you may need to connect it to a computer to get a larger screen.

There are also units like the RigExpert Zoom HF Analyzer that combine touchscreen navigation with physical buttons or switches for a more user-friendly experience.

When picking an analyzer, you want to consider the size of the screen. Anything between 2-4 inches should be sufficient. Also, you want to consider the screen's brightness. Of course, the brighter, the better, especially if you're going to use your antenna analyzer outdoors.

Portability

The great thing about VNAs is that they're very compact and lightweight, especially NanoVNAs. However, there are units that are pretty bulky and heavy. Not to take anything away from these units, it's just better to invest in an analyzer that's small and light for easy handling.

Features

Some units are more feature-packed than others, but that doesn't necessarily make them better. The more features a device has, the steeper the learning curve will be, so make sure you invest your money in a device that offers just the features you need so you don't get lost in the sauce.

It's worth noting, however, that most of the analyzers are backed by plenty of YouTube tutorials that help explain and demonstrate their features. So even if you were to go for a device that flaunts more features than you need, you'll find it somewhat easy to get over their learning curve.

Are Antenna Analyzers Necessary?

An antenna analyzer is handy, but it's not necessary. If you're trying to boost the performance of a ham radio system, you ought to consider an antenna analyzer, as it's going to help you achieve your goal a lot easier.

Some antenna analyzers do more than just SWR. For example, what sold me first on the MFJ-259 was that it also measured reactance. So, you can use the antenna analyzer as an LC meter as well. Other features include using it as a low-level signal source, frequency meter, cable analyzer, and short finder.

If you're new to the hobby, starting out small and working your way up might be a good strategy. You could buy one of the less expensive models and get used to how they work, then sell it and make the leap to a more sophisticated unit. The way things are going, you should be able to sell your first antenna analyzer for at least 80% of what you paid for it.

Whatever you do, don't fall victim to "paralysis by analysis." Go ahead and buy one and start using it. This is a "learn by doing" hobby after all.

Final Thoughts

There you have it, the best antenna analyzers available today. We're quite confident that one of the above-reviewed devices will meet your needs and budget.

If we were to choose a winner, we'd probably lean towards the NanoVNA because it's the most well-rounded of the bunch in terms of functionality and pricing.

The RigExpert Zoom HF Analyzer is a close second because of its impressive range of features. The MFJ-259 Analyzer coming in third place. Feel free to let us know which of the above-mentioned products you think are the best.

Nano VNA RigExpert MFJ-259

For the Bella Vista Radio Club

From heavily modified, various sources off the internet.

Glenn Kilpatrick – WB5L