From the Help Desk – May 2026

Note – this is part of an ongoing series of related articles that will each take a look at some facet of radio selection, installation, or operation as suggested by actual questions received from Club members or other amateur operators.

Q: *"I am confused about exactly how to use a manual antenna tuner with my HF radio setup. I have heard many conflicting procedures, and seen different methods on different online videos. Can you explain the proper procedure for adjusting a manual antenna tuner?"*

A: Understanding how to properly adjust an antenna tuner requires that the user first understand just what the tuner is meant to accomplish, and then further understand that while there are many different approaches to the process, there is really no clear-cut right or wrong procedure to adjusting the tuner. The end goal is the thing that really matters.

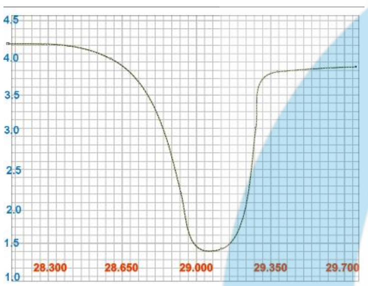

Figure 1 - Narrow SWR bandwidth curve

The basic intent of an antenna tuner is to make an antenna that is resonant at one (and only one) specific frequency appear to be as close to resonance at the various other frequencies at which the radio system is operated as is possible. While it is a truth that any antenna is resonant at only one fixed frequency, how well that antenna will perform at other frequencies above or below the resonant frequency will usually depend upon the *SWR bandwidth* of the antenna system. An antenna system with a very narrow antenna bandwidth will fall off rapidly in performance on either side of its resonant frequency. Conversely, an antenna with a wide SWR bandwidth will maintain a much more acceptable level of performance through a greater variation from the resonant frequency. An antenna tuner simply artificially extends that SWR bandwidth to include the frequency to which the radio is tuned at the time of adjustment of the antenna tuner.

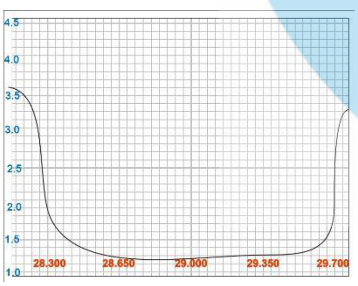

Figure 2 - Wide SWR bandwidth curve

Another point that must be considered is just how much mismatch you are willing to accept in an antenna system, As we all know by now, a perfect match between the radio and the antenna system would show a *standing-wave ratio* or *SWR* of 1:1. What this means is that for a radio with a fifty-ohm output impedance, the input impedance of the antenna system is also right at fifty ohms. This is almost never the case – and really should not be most of the time, based on the physical installation conditions of the antenna. However, any reported SWR greater than a one-to-one match indicates a certain amount of mismatch loss in the antenna system. Note that this loss is *not* the only loss in the antenna system, as the feedline itself also presents a certain predictable amount of loss. Feedline loss is dependent upon three basic factors: 1) the feedline type, 2) the feedline length, and 3) the operating frequency. Feedline loss is given by the cable manufacturers as a certain value in decibels per one-hundred feet of feedline length at a given frequency. The point here is that the feedline losses are *not* related to nor are they changed by changes in reported SWR. Instead, the feedline losses are cumulative to the SWR losses.

So… how much loss is actually imparted by a given SWR value? Look at it this way. A 1.0:1 match results in 100% of the radio's output RF power being transferred into the antenna system. However, a 1.1:1 match results in a 0.2366% loss, a 1.2:1 match gives us a loss of 0.826% of the output RF power, and with a 1.5:1 match, we get a 4% power loss. All of those values are generally considered to be acceptable, though the lower the numeric match is, the better. On the other hand, a 2.0:1 match yields a whopping 11.1% power loss. Of course, it goes up from there.

What exactly does SWR measure or indicate then? Simply put, the standing wave ratio is the ratio of transmitted output power in watts to the power level in watts reflected from the antenna system back to the transmitter.

Note too that there is another peculiarity to SWR measurement. For example, there are two scenarios that both result in a 2:1 SWR. If the transmitter output impedance is fifty ohms, an antenna system input impedance of either twenty-five ohms or one-hundred ohms will result in a 2:1 SWR match. This is because SWR, when it is *not* a perfect 1:1 ratio, is *always* reported with the antecedent as a value greater than one, and the consequent as a unity value, or a value of *one.* Thus, either way, we get a 2:1 ratio from the impedance pairs of fifty ohms and twenty-five ohms, which is naturally a 2:1 ratio, or fifty ohms and one-hundred ohms, which is naturally a 1:2 ratio, but as an SWR value is expressed as a 2:1 value. Again, the antecedent, or "first" number is always greater than the consequent, or "second" number, when it is not a 1:1 match.

The next thing that must be understood is what happens to the reflected power once it enters the feedline after being reflected by the mis-matched antenna. Remember what I said about feedline loss? Well, it works both ways. The reflected power will make the reverse trip up the feedline towards the transmitter, where it will again be reflected back down the feedline towards the antenna. This will occur repeatedly until the reflected power has all been dissipated by the ohmic resistance of the feedline – or in other words by the feedline loss. Each trip through the feedline consumes a certain percentage of the power, until it is all gone, *having been converted to heat in the feedline.*

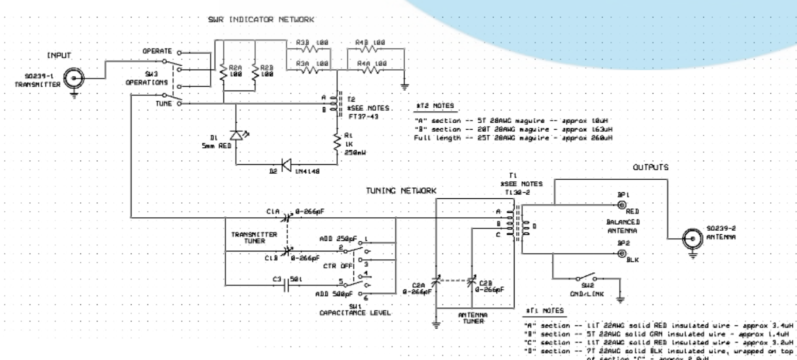

Figure 3 - Emtech ZM2 ATU tuner schematic

OK – let's move on to the antenna tuner itself. Antenna tuners are made with various architectures, which will directly affect the number of controls to be manipulated on the front panel of the tuner unit. For example, the Emtech

ZM-2 ATU tuner (Figure 3) uses a single toroid with a complex winding system as its inductor, and it uses two air-gap variable dual capacitors as the tuning controls. Its architecture is basically a CL/C “L” filter, having a series capacitor and inductor and a second shunt capacitor. This is a QRP tuner, meant strictly for low-power systems.

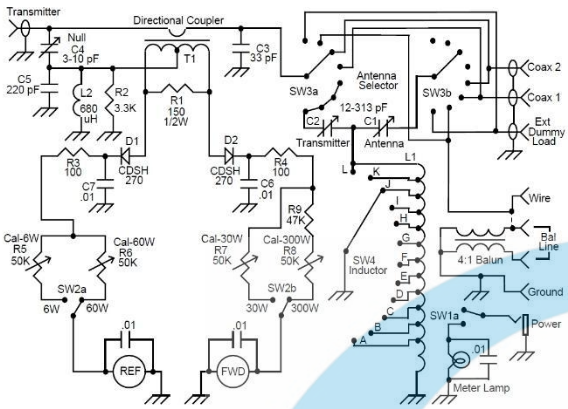

Figure 4 - MFJ-941 Versa-Tuner schematic

Another example is the MFJ-941 Versa-Tuner, whose schematic is shown in Figure 4. This tuner uses a slightly different arrangement of two air-gap variable capacitors and a step-selectable coil as the inductor. In this case, the capacitors are both in series, and the inductor is in shunt, forming a CLC “T” filter.

I could go on and show other approaches, especially as related to the auto-tuner types, but my point is sufficiently made already. With multiple architectures and circuit designs, and with different control arrangements, how can there possibly be one single procedure for tuning these devices?

The first step in adjusting your manual antenna tuner is to determine what the indicated forward power is like when you have as close to a 1:1 SWR as is possible, and this is best done at a low power setting – as low as your particular radio will adjust is fine. In some cases that will be five watts, but in others, like some Alinco models, it is ten watts. Whatever your lowest power setting is, set the radio to that output RF power level, and set the radio to a carrier-type of output. In most cases, this may well be the CW mode. Tune the set to the desired output frequency. Finally, place the SWR meter directly in line after the transmitter, and connect the feedline to a fifty-ohm *resistive* dummy load. Perform any calibration steps that your SWR meter calls for. Then, trigger the RF output into the dummy load and note both the forward and the reflected power levels while also noting the indicated SWR. When the SWR and power meters are integrated into the antenna tuner, often as a single meter, this is a bit easier as it is often just a matter of setting the proper output selection and then setting the meter function to SWR to read the standing-wave ratio, or to POWER to read the indicated power levels. Remember that in the case of a dual-needle (or *cross-needle)* meter, all three levels are read at once. One needle indicates the forward power, the opposite needle indicates the reflected power, and the point where the two needles cross each other indicates the SWR.

OK – you now have a baseline reading to start with. You know that your radio had RF output, and you know what power level to expect as you tune further. Now, select (or connect to) the antenna output for the antenna that you want to tune. Then, if your antenna tuner includes an inductor control, select the lowest inductance level to start with. Next, alternating between the two capacitor controls, make small adjustments in the capacitor mesh and note the indicated SWR when you trigger the RF output. Do this quickly so as not to be tuning excessively on the air. If you cannot adjust the SWR to an acceptable low value, change the inductance selector position by one step and repeat the capacitor manipulation, again alternating back and forth between the two capacitors, making *small* adjustments each time. Small adjustment increments are important, as with a large capacitor change, you can tune right through the optimal position and never know that you did so.

Repeat this entire process until you achieve the lowest SWR possible. Then, once you have reached an acceptable SWR match for that frequency, do yourself a favor and record the specific inductor and capacitor control positions that resulted in that match. Over time, if you do this each time you tune to a new frequency, you will develop a table of control positions that will allow you to very rapidly tune the system for a given frequency. It is for this reason that the inductor positions and the capacitor dial ranges have incremental markings. They really do not mean anything other than to give the user a means of quickly repeating a tuned position that was determined earlier. With time and experience, you will develop the skill to quickly and accurately tune the system for any frequency that you choose to use.

If your particular antenna tuner does not, for example, have an inductor control like the Emtech ZM2 ATU mentioned earlier, it is simply a matter of alternating capacitor adjustments until you reach the desired SWR value. That particular tuner actually incorporates a “tuned” indicator in the form of an LED that illuminates when a low SWR value is reached.

OK – so what do you do when (not “if”) you cannot achieve a sufficiently low SWR with which you are comfortable? At some point this is very likely to occur, and with frequent occurrences for certain types of antennas. For example, what happens when that ice storm hits and it pulls down one side of your wire dipole? Or, what happens when that pesky squirrel or chipmunk chews right through your feedline coaxial cable? Or, how about when the ice load and/or repetitive wind action on your dipole stretches the wire to some unusually long length? All of these events will show up as variations in the SWR attainable with your system. The fact of this matter is that when you cannot achieve the expected results, look for *something* about your antenna system to have changed. Similarly, when the control positions that once worked for a given frequency no longer do so, once again look for a physical change in the antenna system.

I hope that this has given you some insight into the workings and operation of common antenna tuners as used with typical HF radios. The bottom line is that there is no real *“one size fits all”* method to antenna tuner operation – but it really doesn’t matter – so long as you ultimately attain the lowest SWR value that you can get.