# ANTENNA TUNERS

## AN OVERVIEW

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Antenna tuners always seem to fall into a grey area for SWLs. Hams would tell you that they are not a necessity unless you are transmitting. Others would tell you that they only satisfy the knob-twister's desire to constantly 'tweak' something. I maintain, along with many others, that they are a necessary evil.

Antenna tuners are available in two basic forms: antenna impedance transformation devices and passive preselectors. Either type would give you additional adjustments, if that is all you want. The former type might give you an additional S unit or so to aid in IDing that Indonesian in the 60 mb. The latter might keep the night-time 49 mb slop from IMing your listening to Tahiti on 15,170. Let us dig a bit deeper, first with the latter type, the passive preselector.

The passive preselector is basically a solid state era goodie. Back in the 'hollow state' era, a preselector included a vacuum tube active stage. This was later followed by jFETs and finally MOS-FETs as gain stages. Receivers were not as sensitive then, especially on the higher frequency bands. (Signals were not as strong then either - 50 - 100 kW was about it for even the 'big gun' broadcasters.) The mid - 70's brought the first of the Wadley loop and up-conversion solid state receivers. Sensitivity improved, but front end selectivity went to pot. In fact, most modern-era solid state receivers employ bandpass type circuitry as opposed to tracking tuned circuits in their front end circuitry. Let me briefly explain the difference.

The tuned RF (Radio Frequency) amplifiers of the earliest solid state receivers, like the SX-190 & DX-150/160/200 series, used gang tuning to make their front end tuned circuit 'track' or follow their mixer and local oscillator main tuning control. This was the very same system employed by the vacuum tube receivers as well. Many receiver designs made the RF amplifier tuned circuits externally adjusted by a preselector knob. Both types of tuned RF amplifier maintained a fairly high Q (quality factor - The ratio of a tuned circuits center frequency divided by its bandwidth at a given attenuation.). Even with a very low Q for this type of circuit, one of perhaps twenty, would render a +20db/S9 5 MHz signal down at its 3rd harmonic of 15 MHz to S4 or so. At that level, it would not overdrive the RF amplifier tuned to the desired 15 MHz frequency.

Modern receivers with synthesized front end circuitry use the now common bandpass tuned circuitry and wideband amplifier in place of the tuned RF amplifier previously described. Such tuned circuits generally exhibit much lower Q's with far inferior out-of-band rejection. A typical receiver, like the Kenwood R-1000/2000, Icom R-70/71A, or Yaesu FRG-7700/8800, would use a 3 -5 pole bandpass filter generally covering an octave of response (0.5-1.0, 1-2, 2-4, 4-8, 8-16, & 16-30 MHz). In the previous example of a +20db/S9 signal at 5 MHz, the attenuation this signal would see in a receiver tuned to 15 MHz would likely reduce it to the S9 level, still a substantial signal capable of overdriving the following wideband amplifier and producing both crossmodulation and intermodulation distortion. A preselector, either a passive or a properly designed active type, would improve the ability of such a front end to reduce the level of such an interfering signal.

Passive preselectors are characterized by the frequency specific bandswitch and tuning control. Examples of such devices are the Yaesu FRT-7700, Grove TUN-3, and an MFJ unit. Please note - MFJ makes a wide range of antenna tuners as well as both an active and a passive antenna tuner. Check with any of the usual distributors, or even a recent ham magazine such as QST, 73, or Ham Radio, for their ads.

A few words on the subject of active preselectors are in order. Generally speaking, most modern receivers do not need the gain of an active preselector. In fact, at lower frequencies the very device in the active preselector itself, if not optimized for strong signal handling capabilities, may cause crossmodulation distortion. Such devices as VMOS FETs and FETs and BJTs designed for CATV use, though optimum for such a preselector, seldom find their way into a commercial product. All of the active preselectors I have seen employ standard jFETs or MOSFETs, devices designed for receiver front end use with low noise, high gain, and remotely controlled gain (AGC) capability coming first. The lower noise figure of the better preselectors could be of some benefit with either a low noise antenna, such as a Beverage, or at the higher frequencies now that the sunspots are returning. Thankfully, the gain of most preselectors decreases with increasing frequency, so overloading subsequent stages is less likely where the preselector is needed the most. In addition, the selectivity of the typical active preselector is much greater than that of even the best of the passive types. This enhanced selectivity will require more frequent and more critical adjustment from one end of a band to another.

None of the aforementioned accessories will do much for 'matching' your antenna to your receiver. You might think that impedance matching is unnecessary - think again! Your stereo would not like a 0.5 Ohm speaker load. That type of mismatch would offer very poor efficiency in conveying the output power of your stereo to your speaker. Your communications receiver's front end (antenna input) is no different. Match your antenna impedance to your receiver's input impedance by one of two methods: either use a resonant antenna or an antenna matcher. I'll try to focus on the latter - search elsewhere for resonant antenna articles!

Antenna matchers are available in three basic forms: impedance matching transformers, low pass filter, and high pass filter design. The impedance transformer is often neglected. The low pass filter design is by far the most common design. It is also the simplest design to construct. It can be implemented as either an L or pi section type design. The L section has a variable capacitor connected from the aerial input to ground with an adjustable (usually by a step type switch) inductor connected between the aerial connection and the receiver coaxial connector with the shield grounded. The pi-section tuner adds another variable capacitor from the receiver coaxial connection to ground.

The pi-section tuner is simple to construct, easy to adjust, but not always the best matcher. Its design helps to reduce the harmonic output of a transmitter due to its inherent low-pass filter design. Unfortunately, if peaked for 19 mb, it will allow a great deal of 49 mb energy through relatively unscathed. To optimize such a tuner for the lower frequencies requires a larger range of input variable capacitance than do the upper SW frequencies. For LW down to 160 kHz for example, one would need a three or four gang tuning capacitor with all of the sections in parallel and large values of inductance, such as available from small RF chokes, to resonate. Additionally, a wideband step-up transformer is necessary for those receivers with 500-1,000 Ohm antenna input impedances in the LW-MW spectrum (Drake SPR-4, Kenwood R-1000,2000, Yaesu FRG-7700, etc.). Check with Ralph Burhans via the Long Wave Club of America for reprints of his excellent articles on LW receiving accessories if you need further help with LW reception.

The other type of matcher, the high pass design, is a bit harder to build. The simplest form places the now grounded inductor as the vertical element of a 'T' with the capacitors as the horizontal elements. This can be a real problem in construction since both 'sides' of both variable capacitors are isolated from ground - a real problem since most variable capacitors have their cases connected to the rotor plates (one side of the capacitor). The problem can be circumvented by mounting everything in a plexiglass (perspex to the British ...) case. This is not normally done in ham designs because of high RF levels, RF burns, and harmonic feed-through (Come to think of it, Okechobe isn't all that far ... I wonder if I could get an RF burn from 'WYFR' ???). For the SWL/DXer, the plexiglass case would be fine.

The high pass design will help to attenuate the lower frequencies and thus reduce the amount of lower frequency interference products. This is a great improvement over the low pass design when the listener is bothered by a local BCB station. It does have some operational problems. One is simple - it is hard to get the proper amount of capacitance to resonate at the lowest part of the SW spectrum, much less into the MW and LW spectrum. I would advise a low pass pi-section for the LW + MW range with the high pass for the SW part of the spectrum. The other problem is simple - it places the center connection (long wire terminal) above ground for DC. That is, there is not a return path to ground (or from ground) to discharge the static charge built-up on the antenna. The resulting static charge can cause rain/snow static and even cause failures in your receiver's front end. This is not a serious omission as far as lightning safety is concerned, since all antennas should be disconnected and grounded under threatening conditions. A simple DC path can be added by placing a 2.5 - 10 mH RF choke from the aerial connector to ground, with little loss in signal resulting.

A tertiary type of matcher is a simple wideband transformer. I have used a quadrifilar wound (four windings wound as one) wide band toroidal transformer for quite some time. I series connect all of the windings with one end grounded. I use 15 turns of #28 enameled wire on an Amidon FT-50-43 ferrite toroidal core (Amidon Associates, 12033 Otsego Street, N. Hollywood, CA 91607). The aerial and receiver connections are then clipped to the different 'taps' until the best signal strength is noted. This is most effective in the lower reaches of the SW spectrum down to the LW spectrum. The other matchers are generally more useful, although this one has merit in impedance transformation following a LW L or pi section tuner when matching to one of the aforementioned higher input impedance receivers.

Okay, now that I have a matcher, where do I put it? Simple. Put it as close to your antenna as possible. Everything connected to its input is considered as part of the 'source' impedance to be matched to your receiver as a load. I leave mine on the window sill where my long wire aerial enters the house, about 20' from the actual end of the antenna itself. The output is fed via RG-58 50 Ohm coax to my receiver some 15 feet away. The tuner's function, recall, is to match one impedance to another. If I were to have the tuner at the receiver site, it would be a good bit easier to adjust. Unfortunately, the feedline to the tuner is then 'part' of the antenna. Besides picking up more electrical noise from your house wiring, the feedline will couple additional capacitance to ground to the input of the tuner, thus making high frequency high antenna impedance (low capacitance) matching impossible with the pi-network tuner. Placing the antenna tuner in a window is not such a bad idea - most adjustments are fairly broad and can be made with the receiver 10-20 feet away.

What about using the matcher with a coaxial cable fed antenna? If the antenna is of the resonant type, i.e. a 1/2 wave dipole fed by a 70 Ohm cable, the matcher will do little if any good. There is little to be gained by attempting to match a 70 Ohm line to a 50 Ohm line. Just run the 70 Ohm line all the way! CBers have used small matchers to lower the SWR at the transmitter for years. They definitely will lower the VSWR (Voltage Standing Wave Ratio - a measure of load matching in transmission line jargon with 1:1 being ideal.) between them and the transmitter - but they still do not affect a mismatch between the aerial and the remainder of the feedline. Most hams know better than to use a matcher in between their coaxial feedline and the transmitter - the complex impedances can result in an RF hot coax shield under certain conditions. Take the lesson from the ham community - do not use your antenna tuner in series with a coax fed antenna and your receiver.

What if you feed a long wire aerial with coax to 'shield' it from noise pick-up? Simple. The coax feedline adds a great deal of capacitance to ground, rendering the tuner's ability to match a high impedance antenna as nil at the upper parts of the HF spectrum. 20' or so of coaxial cable will have about the same capacitance to ground as the usual input tuning capacitor of a pi-network tuner will have at maximum capacitance, allowing no room for adjusting the capacitance under such conditions. You could leave the coax's shield ungrounded, that would lessen the capacitance by a bit, but lessen the noise source shielding ability of the cable as well. Always have the matcher grounded, however. In fact, a separate RF ground for your tuner with the radio grounded only at that point will usually improve reception. Experiment - it is relatively inexpensive to drive a ground rod (Unless you find your gas or water service!) and run out a few 1/4 wave radials cut for your favorite bands and 'pushed' under the surface of the ground, all bonded together at the rod and carried into the shack via a short but large diameter ground wire. I personally use old coaxial cable shield (RG-58,59 or bigger) for ground wire since its usefulness as feedline is shortened by UV exposure, moisture, etc. As long as the shield isn't ripped up, it should still be quite serviceable for ground wire use!

Where can you buy a matcher? MFJ makes a multitude of examples. Many other amateur equipment vendors sell other makes as well. Try a hamfest - there should be a selection to choose from there. If all else fails, build one! Borrow a recent A.R.R.L. Handbook - there are several construction articles for antenna matchers in each edition. The current availability of receiver type variable capacitors dictates a premium price for them - shop at 'hamfests' if at all possible. It could be your first 'project', and a most worthwhile one at that!

What, then are my recommendations? Simple. If your receiver is easily overloaded or shows evidence of severe crossmodulation, you need the passive preselector type of tuner. Unless you have a dipole for each band, or, perhaps, use an Eavesdropper, you could also use a matching type of tuner. You could certainly use both in some instances. Feed the antenna to the matcher first with the passive preselector second and the receiver third. Some means of bypassing the passive preselector would be nice. Active preselectors do offer some benefits, although they generally can cause overloading problems in modern receivers on the lower frequency bands, especially when fed from large aperture antennas. They can still be beneficial under certain conditions. Cautious experimentation is the key here. Generally speaking, I have had less than favorable results in using active preselectors and tuneable active antennas with outside antennas and thus do not recommend their use. The last comment is based on my experience over the years with several homebrew designs as well as a few borrowed (or bartered) commercial examples in conjunction with my R390A and Icom R-70 and 65' - 160' outside inverted L's (long wire antennas). In fairness, all of my examples have employed low level type active devices. I must try a more crunchproof device, such as the CATV type transistors, V-MOS and FETs, etc. I still have some equipment to build and test! Good listening!

Common Antenna Tuner Designs