Extending High Power Remote Auto-tuners to 160-Meters with a 43-foot vertical antenna
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Introduction

In the “Reviews” section of this website I reviewed the CG-3000, MFJ-927, and the SG-230 auto-tuners specifically for use with the popular 43-foot vertical antenna. As discussed in that review only the SG-230 had enough internal inductance to tune the 43-foot vertical on 160 meters, so I described an external inductor (in the “Articles” section of this website) that could be strapped in to permit the MFJ-927 to tune a 43-footer on top band. I’ve also recently added the MFJ-994BRT 600-watt and MFJ-998RT 1500-watt high power remote auto-tuners to the “Reviews” section. As discussed in that review, the MFJ-2904 is required to permit these auto-tuners to match a 43-foot vertical on 160 meters through manual strapping-in of external inductance. The MFJ-2904 is fine, however I wanted a remote-switched 160-meter extender so an outside trip wasn’t necessary for 160 meter operation.

43-foot vertical 160-Meter Matching Requirements

Approximately 55 uHy of inductance is needed to match a 43-foot antenna on 160 meters, but the MFJ-994BRT and MFJ-998RT only have 17- and 25-uhy maximum inductance respectively. Therefore up to 40uhy of external inductance is needed to tune 160 meters. Further, very high RF voltages occur at the antenna feed-point due to the high reactance of the 43-foot antenna on 160 meters, and to a lesser extent on 80 meters. Theoretically as much as 20KV peak voltage can be found at the antenna feed-point on 160 meters with full legal limit and no ground losses. Of course, any system losses (primarily ground losses) will reduce this voltage. Let’s look at some voltage calculations.

According to EZNEC, the 43-foot vertical has a theoretical impedance of 3-j640 ohms on 160 meters, and 13-j218 ohms on 80 meters over perfect ground. My calculations assume no losses (Rg = 0Ω and infinite inductor Q), and practical losses (Rg = 10Ω and inductor Q = 300) on both bands. A Q of 300 adds about 2Ω of inductor loss on 160 meters, and about 1Ω of inductor loss on 80 meters. Remember, you can only deliver power into a real resistance (radiation resistance plus any losses). Equations used:

Impedance = R + jX, $I_{pk} = \sqrt{(2xPwr/R)}$, $V_{pk} = I_{pk} \times \sqrt{(R^2 + X^2)}$

Band	Power	Antenna Z Theoretical	Vpk	Rr + Rl +10Ω Rg	Vpk
160M	1500W	3-j640	20KV	15-j640	9.1KV
160M	600W	3-j640	13KV	15-j640	5.7KV
80M	1500W	13-j218	3.3KV	24-j218	2.4KV
80M	600W	13-j218	2.1KV	24-j218	1.5KV

Besides providing the inductance necessary for matching, a properly chosen inductor also reduces the RF voltage at the tuner output. I implemented the inductor with a 5.5” length

(46 turns, ~33uHy) of MFJ 404-0700 coil stock in series with a 1.8” length (18 turns, ~11uHy) of the same coil stock. The schematic of the assembly is shown in Figure 1.

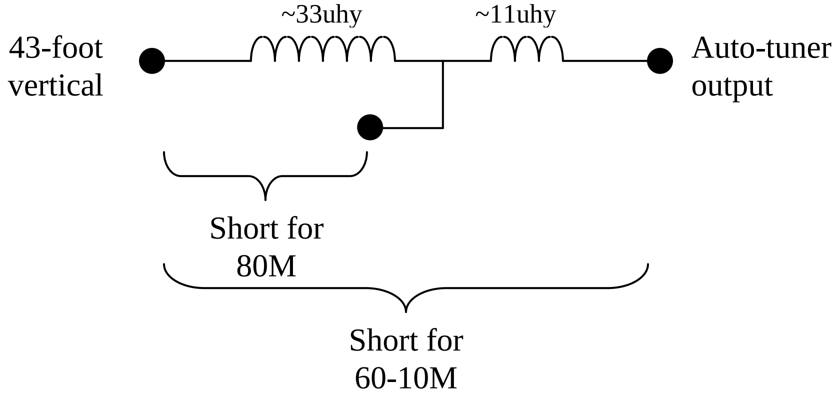

Figure 1: Autotuner range extender

The coil assembly is mounted in a Carlon E987RR 6”x6”x4” outdoor electrical box (Lowes #10030). The smaller inductor is mounted at right angles to the larger inductor to minimize coupling between the inductors. A wire with #10 lugs is used to short the full inductor for 60-10 meters, and the larger inductor for 80 meters. See Figure 2. Three MFJ 606-1006 ceramic feed-thru insulators provide the input, output and shorting positions. An external view of the inductor assembly is shown in Figure 3.

Figure 2: Inductor assembly internal view and shorting cable for 160M,

80M, or 60-10M operation.

Figure 3: Inductor assembly external view

This external inductor box provides several benefits when using remote auto-tuners with a 43-foot vertical.

1) You can now match the 43-foot vertical on 160 meters with any remote auto-tuner, including high power remote auto-tuners.
2) The external inductor reduces the peak voltage that occurs at the auto-tuner output on 160 meters by about 5:1 (Tuner Vpk ≈ Antenna Vpk x external inductance/internal inductance).
3) Because most of the required inductance for matching on 160- and 80-meters is in a large external air-wound hi-Q coil, matching losses are minimized.

Remote Control of the Inductor Extender

Other than improving efficiency a bit, adding external inductance on 80 meters is not really necessary. Therefore, I simplified the remote switching requirements by using a 12VDC-controlled Gigavac G15 vacuum relay rated at 15KV (eBay purchase) to short the entire coil assembly for 80-10 meter operation (0VDC applied), or insert the entire coil assembly for 160 meter operation (+12VDC applied). The vacuum relay is necessary as the majority of the high feed-point voltage will occur across the un-shorted inductor on 160 meters. I also added a second relay to short the auto-tuner output to ground when the tuner is unpowered. While both the MFJ-994BRT and MFJ-998RT include gas discharge tubes and high value resistors across their outputs to provide some protection against nearby lightning strikes and static build-up, a hard short is the best way to protect these auto-tuners. I used the Array Solutions RF-10 DPDT relay for this task. This relay has 1.7KV peak contact-to-contact and 3.1KV peak contact-to-coil voltage break down ratings. I wired the contacts in series to double the contact-to-contact voltage rating to 3.4KV peak when the relay is enabled. This is above expected RF voltages under virtually all conditions. A schematic of the assembly is shown in Figure 4 and an internal view is shown in Figure 5. Figure 6 shows the two 2.1x5.5mm DC jacks used for controlling the relays.

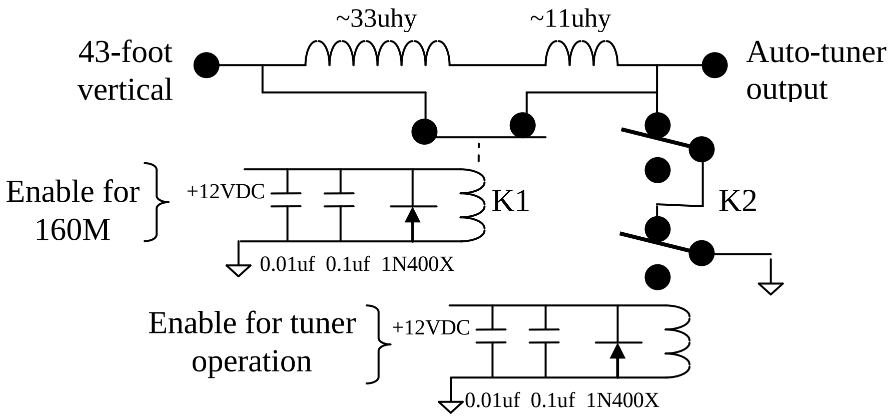

Figure 4: Remote switchable range extender/tuner protector

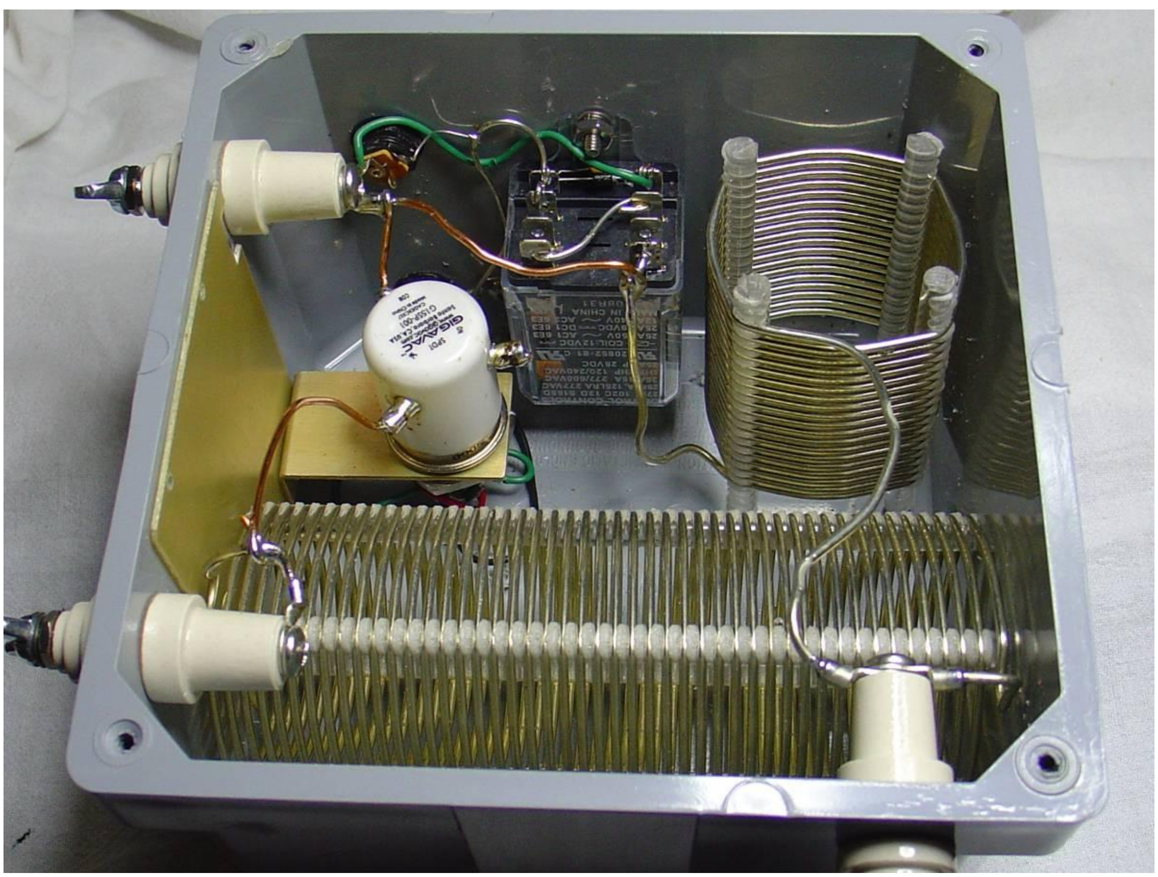

Figure 5: Gigavac 15KV relay (left), and RF-10 relay (middle) installed in extender.

Figure 6: Auto-tuner Range Extender/Protector DC control jacks

Figure 7 shows the extender mounted with a MFJ-998RT using short lengths of wire between the high voltage connections on the tuner and extender. One switched DC interface parallel-feeds both the MFJ-998RT and the extender upper DC input so the shorting relay opens when the MFJ-998RT is powered.


Figure 7: MFJ-998RT and remote-switched inductor extender at base of 43-foot vertical

One Final Note

As discussed in this article, the voltages at the feed-point of an electrically short antenna can be very high. It is always a good idea to provide a fence around a ground-mounted vertical antenna if children or pets could come in contact with the antenna while you might be operating. With the especially high voltages available on electrically short antennas, a fence is even more prudent!

Conclusion

Most remote auto-tuners are unable to tune 160-meters due to component limitations. The tuner range expander described here solves both value range issues and voltage breakdown issues at up to full legal limit, provides for remote switching of the extender circuit, and provides improved lightning and static protection for the auto-tuner when it is unpowered.