MFJ-935B Loop Tuner: Review and Modifications
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While wandering around the MFJ area at Dayton 2005, I saw several new products that got my attention. One series of products that I found very interesting were the MFJ loop tuners. These are manual tuners designed to tune small loop antennas, and are particularly useful for antenna restricted and/or portable operation.

There are three models of loop tuners available: The MFJ-933B, MFJ-935B, and MFJ-936B. The actual loop tuner circuitry is identical in the three tuners. The difference is in size and features. Both the MFJ-933B and MFJ-935B tuners are fairly compact (6 ¼" x 9 ¼" x 5 ¼") and cover 60-10 meters. They are probably better for portable operation due to their smaller size. The MFJ-933B has no built-in metering, so an external SWR meter is needed for tuning. The MFJ-935B has a built-in RF current meter for tuning. The MFJ-936B is physically larger than the other two tuners (10 ¼" x 9 ¼" x 5 ¼"), but includes both a built-in RF current meter and a built-in SWR/RF Power Meter – and also adds 80 meters to the band coverage. The dimensions given include all projections (knobs and connectors) and the carrying handles.

Some Basic Loop Information

The ARRL Antenna Book has plenty of information on these antennas, and I recommend that you review that information. But suffice it to say, small transmitting and receiving loops, when properly designed, can approach the performance of a full-size antenna. Also, due to their high-Q nature, a well designed loop antenna system can provide pretty significant rejection of undesired signals and noise. Height above ground is not that critical, especially on the higher frequency bands (20-10 meters), and no ground or radials are needed. However, TANSTAAFL (There Ain't No Such Thing As A Free Lunch). Tuning will generally be very sharp. And there are design considerations that must be followed or significant efficiency penalties can occur.

A loop antenna is a very high-Q circuit, and therefore very high voltages will be generated across the tuning capacitor – on the order of many thousands of volts. Also, because the loop is small compared to a full-size antenna, it has very low radiation resistance. As an example, a loop with 10-foot circumference will only have a radiation resistance of about 0.1 ohms on 20 meters. So very high current will flow in the ideal loop. At 100-watts, there would be about 32 amps of RF current flowing. Even at 10-watts, you would have 10-amps of RF current flowing in the loop. So it is CRITICAL that significant attention be paid to minimizing losses in the antenna conductor and the tuning circuit itself. This means that you must use the largest conductor you can for an antenna, minimize all loop connector interfaces, and use air-variable tuning capacitors with no mechanical wiping contacts in series with the loop.

The MFJ Tuner Design

Butterfly capacitors eliminate any wiping contacts in series with the RF, and MFJ builds their own butterfly air-variable capacitors for loop tuner use. You can purchase these separately from MFJ if you want to build your own tuners (MFJ-19 and MFJ-21). In

order to reduce losses in the capacitor, MFJ uses #10 brass screws to both hold the capacitors together, and to extend through the case and also serve as antenna connectors (see photo "CapAntIntfc"). This makes the capacitor as close as possible to being part of the antenna. Additionally, MFJ also parallels the entire capacitor plate connectors on all four sides, and the brass screw, with separate bus wires to further reduce losses. And finally, the only matching necessary to the loop is another air-variable capacitor. Therefore, only high-Q air variable capacitors are used in the design – no inductors necessary. Photo "Inside" shows the butterfly and matching capacitors.

Mechanically, the MFJ loop tuners are all very similar. These tuners are designed to be directly connected to the base of the actual antenna loop. Therefore, the positioning of the rear antenna connectors and the PVC top mount are identical on all models so the optional MFJ-58B Cross Antenna Kit (more discussion below) will fit all the different tuners. Also, since tuning can be very sharp due to the high-Q nature of a well-designed tuner, MFJ includes a vernier drive on the butterfly capacitor.

The MFJ-58B Cross Antenna Kit

The MFJ-935B Loop Tuner manual does a great job pointing out the best loop lengths for different frequency ranges so that the user can build his own wire loop. Generally, a specific wire antenna length can be tuned over a 1.5:1 frequency range. In my case, I opted for a convenient solution to the loop question and obtained the MFJ-58B loop antenna kit. The antenna kit includes a PVC cross mount assembly which mounts directly to the top of any of the loop tuners. Also included are 10-gauge flexible copper wire lengths of 28-feet (60 & 40 meters), 13-feet (30 & 20 meters), 7-feet (20-15 meters), and 4-feet (17-10 meters). The 13-, 7-, and 4-feet wires fit on the PVC cross mount assembly which mounts to the top of the loop tuners as previously stated. The 28-foot wire, used for 60 and 40 meters, does not fit on the PVC cross mount due to its length.

Tenna-Tune Modification

I've recently begun worrying about protecting the finals in my radios during tuning operations, probably because I'm now retired and so I want my radios to last a long time! Let's face it, until you get that antenna tuner or screwdriver antenna close to the proper point, a high SWR will be presented to your radio during the tuning process. I know – most current transceivers have power turn-down circuitry so as to protect the output devices under high SWR conditions. However, why not be absolutely safe? I recently added a resistive SWR bridge into my MFJ-902 antenna tuner just for this reason (October 2004 QST). Additionally, I described the Tenna-Tune, a stand-alone resistive SWR meter, in the December 2004 QST Hints & Kinks. Since there is plenty of room inside the MFJ-935B, I decided to add this circuitry to my unit as well. Figure 1 shows an updated Tenna-Tune circuit which simultaneously permits monitoring of SWR, protecting the finals on my transceiver during tuning, and keying my IC-703 or IC-706MKIIG in the CW "tune" mode. The "Key" output to the IC-703/706G is through a 1/8" mono-jack mounted on the back of the MFJ-935B. This is all accomplished with the 4PDT slide switch (3PDT used) shown in the parts list and schematic. Photos "Front", "Back", and "TennaTune" show details of this modification. Note that I located the SWR monitoring LED adjacent to the RF current meter on the front panel.

Loop Tuner Use

As pointed out in the MFJ-935B manual, you need to take RF exposure precautions due to the high RF power density of a small loop antenna system. The manual includes two tables that show the distances one must stay away from the actual wire loop in order to meet the current FCC guidelines. Basically, a distance of about 4-feet seems to resolve RF exposure problems at the 100-watt power level.

Actual tuning and operation is quite simple. With the correct wire in place, set the MATCHING capacitor to minimum capacitance, and peak the TUNING control for maximum receiver noise. Then apply low power and re-adjust both controls for maximum RF current, or minimum SWR. Maximum RF current corresponds to minimum SWR in all the models due to the essentially lossless design of the tuners. I found that I could easily achieve a 1.5:1 or less SWR with very little effort.

Performance

The actual performance of the unit has been amazing to me. The first time I used the unit, I just had it set up in my work area in the center of my home (ground floor). I was just playing with tuning the unit and checking SWR. But then I heard K7AO in Reno calling CQ on 20 meters, and just for the heck of it, I answered him. To my amazement, he came back to me and we had a pleasant QSO. Not only was I using the loop antenna system inside my home, I was just using my IC-703 at 10-watts output! Since then I've made numerous contacts with the loop antenna system set-up on a table in my back yard.

Conclusion

There is no perfect antenna system, especially for portable use. And generally, the more wire you can get into the air, the better your performance. However, the MFJ Loop Tuners seem to work very well, especially in antenna restricted or portable applications. Take a look at these units and see if they may be applicable to your situation.

TABLE 1 – Tenna-Tune Parts

| Qty | Description | Source | Cost |
|---|---|---|---|
| 3 | 50 Ω 15-watt resistor | Mouser 684-MP915-50 | $2.78 ea |
| 1 | 4PDT Slide Switch | Mouser 629-GF6426010 | $1.02 |
| 2 | 0.01 uf 500V capacitor | Mouser 75-5HKSS10 | $0.26 ea |
| 2 | 10K ¼-watt resistor | Radio Shack 271-1335 | 5/$0.99 |
| 1 | 1N4148 switching diode | AllElectronics 1N4148 | 15/$1.00 |
| 1 | 6000mcd red LED | AllElectronics LED-94 | $0.75 |
| 1 | Heat sink grease | Radio Shack 276-1372 | $1.99 |
| 3 | #2 screws | Radio Shack 64-3010 | $1.49/pk |
| 3 | #2 nuts | Radio Shack 64-3017 | $1.49/pk |
| 1 | 4-pin Molex plug | Radio Shack 274-224 | $1.19 |
| 1 | 3.5mm Mono Jack | AllElectronics MJW-7 | $0.45 |
| 1 | 3.5mm Mono Plug | AllElectronics PMP | $0.40 |

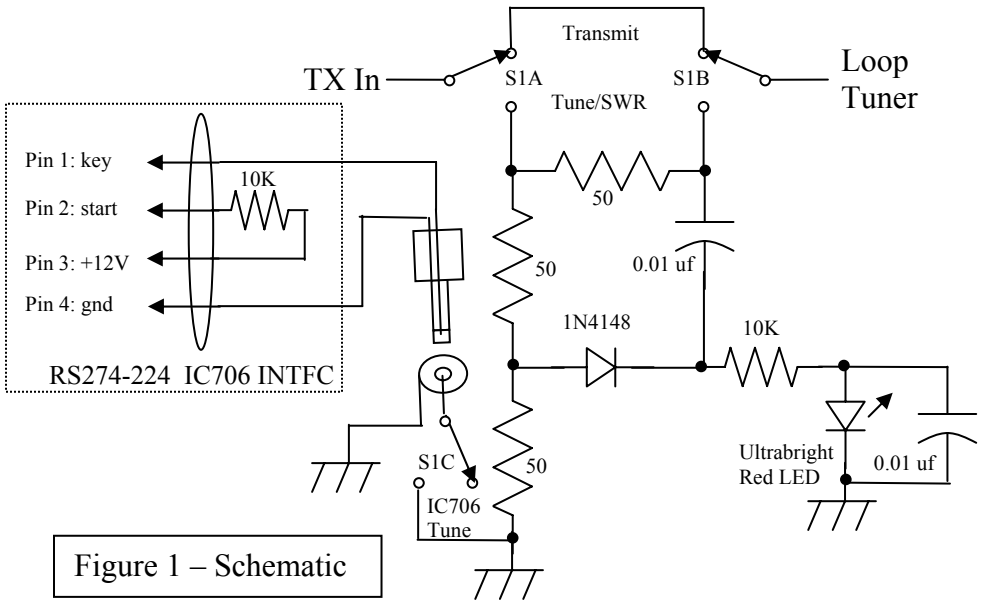
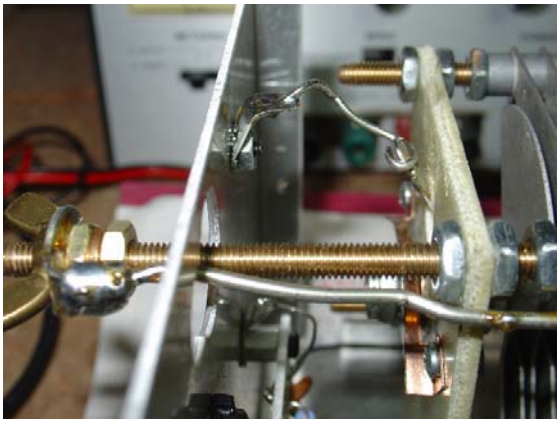
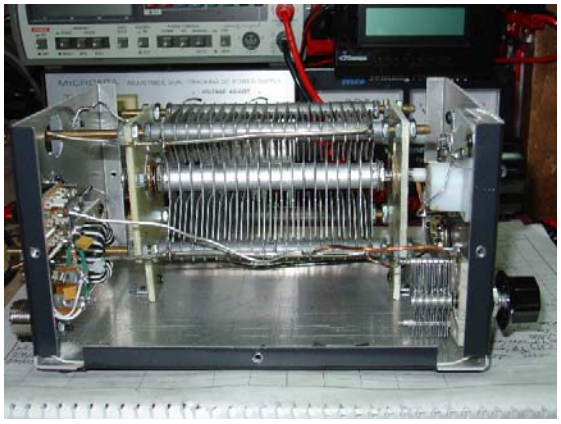



Figure 1 – Schematic



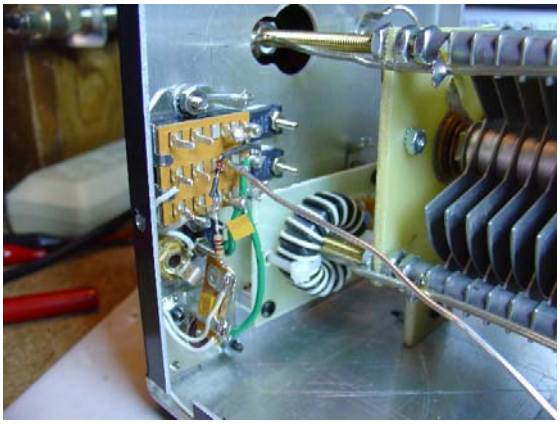
Antenna terminal interface to capacitor



Inside: tuning (center) & matching caps


MFJ-935B showing SWR LED added


Back showing Tenna-Tune interface



Tenna-Tune circuitry