

Product Review: MFJ-998 Legal Limit *Intellituner*[™] Automatic Antenna Tuner
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Introduction

I have to admit that I've become an auto-tuner junkie over the past few years. I use an MFJ-929 with my IC-706MKIIG secondary station at home, and a MFJ-925 with the same transceiver when I operate portable. And I have also been using an MFJ-994B auto-tuner with my FT-1000MP MKV and ALS-600 amplifier with great results. So why upgrade to the MFJ-998? Well, partly because I like the latest and greatest. But mostly because the MFJ-998 has some unique new features that make using this auto-tuner with an amplifier a truly simple, user-friendly operation.

MFJ-998 Auto-Tuner Basics

The MFJ-998 *Intellituner*[™] requires just five-watts of transmit power for tuning, and can match impedance ranges from 12-1600 ohms at up to 1500 watts CW and SSB— meaning you can use this auto-tuner from QRP to full legal limit power levels. Of course, like all relay-based auto-tuners you should tune at a low power level (5-30 watts) with the amplifier off-line. Tuning is very fast, usually occurring in less than a second. Unlike typical SWR search algorithms normally used, the MFJ-998 uses MFJ antenna analyzer circuitry and firmware to actually measure the antenna system impedance and then calculate the L/C values needed for matching. The proper L/C values are then snapped in and fine-tuned if necessary. Only if the antenna impedance is outside the analyzer measuring range will the tuner revert to an adaptive search algorithm, which requires a slightly longer tuning time.

Now for some of the MFJ-998 features. First, there are both analog and digital meters which give detailed power and SWR information, and provide the means for setting a variety of parameters. The tuner also has manual tuning capability, A/B antenna switching, and separate coax and wire-output connectors. For an end-fed wire, a high voltage ceramic feed-through connector is provided which is connected in parallel with coax Antenna 1. I.e., you must decide on a long wire or coax feedline for Antenna 1. Antenna 2 is a coax port only. The two antenna ports have four memory banks with 2500 memories each (20,000 memories total), permitting the tuner to memorize up to four different antennas per antenna port. So when you are in the auto-tune mode and you transmit on a frequency used previously, tuning is virtually instantaneous.

For tuning, you can set the target SWR (default is 1.5:1), select between semi-automatic and automatic tuning (default is automatic), and pick the auto-tuning start SWR (default is 2:1). The analog cross needle power/SWR meter can be set to low power (300 watts forward/60 watts reverse power), high power (3000 watts forward/600 watts reverse power), or automatic ranging (default). The digital meter displays forward and reverse power, frequency, and SWR. The digital meter can also display power and SWR on a bar-graph, display the inductance and capacitance values determined for matching (which you can use to make your own external fixed matching network), and is also used for setting the various menu items.

Besides the metering, there is also an audible indicator to let you know the approximate SWR with a series of beeps when tuning is complete, whether you need to increase tuning power (by beeping “QRO” in Morse code), that you are tuning with excessive power (by beeping “QRP” in Morse code), or that you are transmitting with more than 1500 watts (by beeping “QRT” in Morse code). This same information is also displayed on the digital display, and the audible indication can be turned off if desired. If you try to tune with excessive power, tuning will be inhibited. And under the “greater than 1500 watt” transmitting condition, the MFJ-998 automatically bypasses itself.

The MFJ-998 really shines with a couple of well thought -out amplifier interface features. First, you can (and should) feed your amplifier enable keying signal through the MFJ -998 AMP ENABLE IN/OUT ports on the rear panel. This path is then interrupted whenever the MFJ-998 starts tuning, which automatically takes your amplifier off line. At the same time the tuner can control your transceiver through an optional transceiver interface cable, which puts your transceiver into a low power CW tune mode. These features let you leave the MFJ-998 in the fully automatic mode – so it can start tuning whenever the SWR exceeds your programmed set-point without you having to do anything at all! The amplifier is automatically taken off-line, your transmitter outputs a low power tuning signal, the MFJ-998 tunes, and then everything is all restored to normal operation – typically in a fraction of a second. The second amplifier interface feature is a programmable SWR set-point that disables the amplifier when the SWR exceeds a value that you consider safe for your amplifier regardless of whether tuning has occurred or not (default is 2:1)..

Physical Characteristics

Being a full legal-limit antenna tuner, the MFJ-998 is the largest in the MFJ auto-tuner line-up at 12-3/4”W x 14-3/4”D x 4”H, and weighing approximately seven pounds. Photo A shows the front panel, and Photo B shows a close-up of the digital meter and pushbutton controls. Of course, I couldn’t wait to take the cover off. Photo C shows an internal view of the MFJ-998. Note the large inductors, which are both soldered and tie-wrapped to the printed circuit board to stabilize them and protect the tuner from damage. The capacitors on the left are high current, low dissipation devices that are stacked to meet the worst-case voltage requirements of the tuner. Also note the aluminum shield between the main pc board and the digital/analog board. This shields the digital/analog board from the high RF fields possible on the main board, and also shields the main board from digital “noise” that may be generated from the analog/digital board. The L/C relays are all high voltage 16-amp relays.

On the rear of the MFJ-998 you’ll find the expected RF connectors, and several non-RF connectors as shown in Photo D. The non-RF connectors are in the left side of the photo and include DC input, the amp -enable feed through ports previously discussed, a RS -232 port for updating the firmware as MFJ adds features over time, and an RJ-45 connector for connecting an optional transceiver interface cable between the tuner and most current HF radios.

With a transceiver interface cable, the MFJ-998 “commands” your transceiver to output a low power CW tune signal when tuning starts, and the tuning process is controlled by either the tuning control on the radio or the TUNE button on the MFJ-998 (depending on the transceiver), or automatically by the MFJ-998. You select the transceiver that you are interfacing with through the menu system.

While you can purchase the appropriate cable from MFJ, you can easily build your own interface cable with the information provided in the MFJ -998 manual. In my case, I built the equivalent of the MFJ-5114Y3 interface cable for my Yaesu MKV. Normally all you need to do is take a short CAT5 cable and cut off the RJ-45 connector on one end. Then solder on the appropriate connector for your transceiver, wiring it as shown in the manual. I bet I spent no more than 10 minutes making this cable.

Using the MFJ-998

The MFJ-998 manual has a “Fast Start” section so you can start using the tuner without getting into the nitty-gritty details of the manual. A simple, yet detailed drawing shows how to connect your rig, antenna and DC power. Then you simply transmit a 5-30 watt constant carrier signal. If the SWR is greater than the default 2:1 “start-tuning” value, the MFJ-998 will auto-tune to an SWR less than 1.5:1. Or you can push the TUNE button while transmitting and the MFJ-998 will auto-tune to less than 1.5:1 regardless of the SWR. But – read the manual! There are a ton of features that you may want to consider based on your particular requirements. And you will need to see how to “tell” the MFJ -998 which type of transceiver you have if a transceiver interface cable is used.

Now on to the testing. The first thing I wanted to do was check the accuracy of the digital power meter. For this, I used my new Tektronix TDS-2022B 2gb/s digital oscilloscope which was calibrated with NIST-traceable test equipment. As you can see in Table 1, the worst case measurement discrepancy between the MFJ -998 power meter and the TDS-2022B oscilloscope was 6%, with most measurements within 4%.

Table 1: MFJ-998 Power Meter vs TekTronix TDS-2022B Oscilloscope

Band	<u>Low Power</u>		<u>Nom Power</u>		<u>Med Power</u>		<u>High Power</u>	
	<u>2022B</u>	<u>998</u>	<u>2022B</u>	<u>998</u>	<u>2022B</u>	<u>998</u>	<u>2022B</u>	<u>998</u>
160M	31.1	33.0	82.4	82.7	272	268	592	574
80M	30.8	33.3	81.0	83.3	293	293	452	440
40M	29.8	33.0	77.5	81.3	220	228	481	482
30M	29.3	32.7	75.4	79.3				
20M	31.0	34.0	78.7	82.7	212	222	523	527
17M	32.4	35.0	80.3	83	242	244	515	511
15M	28.7	30.7	71.3	72.7	266	269	522	522
12M	28.6	29.7	70.2	70.0	245	239	487	475
10M	25.8	26.5	65.8	64.5	264	249	500	480

Incidentally, should you ever want to recalibrate the SWR circuitry for any reason, the MFJ-998 has an excellent software-based calibration procedure. You just need to call up the internal SWR cal procedure, transmit into a dummy load at 100 watts, and adjust the

FWD trim pot for 100 watts forward power indicated on the analog and digital meters. You then reverse the transmitter and dummy load, transmit in the reverse direction through the MFJ-998, and adjust the REV trim pot for 100 watts reverse power indicated on both the analog and digital meters.

Finally it was time to see how the MFJ-998 could tune my home station antennas. My Butternut vertical has very narrow bandwidths on 160- and 80-meters since the antenna is electrically short on these bands. My 160 meter resonance point is 1817 KHz, and the SWR rises to 20:1 at 1856 KHz. I set my FT-1000MP MKV to 1856 KHz and pushed the TUNE button, and in less than ½-second I had an SWR of 1.2:1. I also have a 41-foot vertical fed with a 4:1 balun and a short piece of LMR-400 coax. The SWR on this antenna was greater than 25:1. Tuning on this antenna took about five seconds and resulted in an SWR of 1.5:1.

Next I went to 80 meters, where my Butternut resonates at 3560 KHz. The SWR was 20:1 at 3960 KHz. After I enabled tuning, the SWR dropped to 1.4:1 in a fraction of a second. On 40 meters I switched to my MFJ-1775 Rotatable Dipole. This is a short, loaded multi-band dipole resonant at 7.04 MHz. At the top of the 40 meter band, the SWR is 5:1. Again, no problem auto-tuning to a 1.5:1 SWR in a fraction of a second. Finally, I went to 20 meters where the MFJ-1775 antenna is resonant on 14.02 MHz. At the top end of 20 meters the SWR rises to 3:1. The MFJ-998 auto-tuned this impedance almost instantly to less than a 1.5:1 SWR.

My normal operation is a snap. I leave the MFJ-998 in the automatic mode, and just transmit when and where I want to without thinking about anything. And when my amplifier is on, I know it is fully protected from both high SWR and tuning damage at high power.

Summary

The MFJ-998 *Intellituner*[™] should be one of the considerations in your decision making process if you are thinking about an auto-tuner for your high power station. Its amplifier-interfacing features, wide matching range, wide selection in transceiver interface cables, accurate digital metering, upgradeable firmware, and low tuning power requirement make this a very flexible auto-tuner for most any station.



Photo A: MFJ-998 Front Panel



Photo B: Close-up of Front Panel Controls

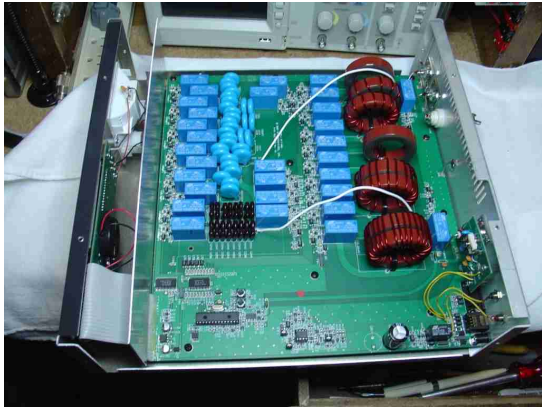


Photo C: MFJ-998 Internal View



Photo D: Rear Panel Connectors