

Product Review: MFJ-998 Legal Limit 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 also used an MFJ-994B auto-tuner with a FT-1000MP MKV and ALS-600 amplifier for several years with great results. I've since upgraded to the MFJ-998 auto-tuner as it has some unique new features that make using this auto-tuner with any 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 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 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 frequency, SWR, and forward and reverse power. 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 attempting to tune with more than about 125 watts (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 amp-enable keying signal through the MFJ-998 AMP ENABLE IN/OUT ports on the rear panel. This path is interrupted whenever the MFJ-998 starts tuning, which 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. A 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.



Photo A: MFJ-998 Front Panel



Photo B: Close-up of Front Panel 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.



Photo C: MFJ-998 Internal View



Photo D: Rear Panel Connectors

On the rear of the MFJ-998 (Photo D) you’ll find the expected RF connectors, and several non-RF connectors. The non-RF connectors are in the left side of the photo and include DC input, the amp-enable feed through ports, 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 an optional transceiver interface cable, the MFJ-998 “commands” your transceiver to output a low power CW tune signal when tuning starts. Depending on the transceiver, the tuning process is controlled by either the tuning control on the radio or the TUNE button on the MFJ-998, or automatically by the MFJ-998. 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. Just take a short CAT5 cable and cut off the RJ-45 connector on one end. Then solder on the appropriate connector for your transceiver and wire it as shown in the manual.

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. A simple, yet detailed drawing shows how to connect your rig, antenna and DC power. Simply transmit a 5-30 watt constant carrier signal. Then 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 “tell” the MFJ-998 which type of transceiver you have if a transceiver interface cable is used.

My current transceiver is an Elecraft K3 which doesn’t have an external auto-tuner interface yet. So I just leave the MFJ-998 in the full-auto mode and hit the TUNE button on my K3 which puts out 15 watts in the TUNE condition (K3TUNE power is menu

selectable) and the MFJ-998 automatically tunes. I did modify my MFJ-998 so it disables my Elecraft KPA500 amplifier via the amplifier amp-inhibit input as the amplifier reacts in less than <1ms to this. See the “Equipment Modifications” section of this website for details.

Now on to the testing. I first wanted to check the accuracy of the MFJ-998 digital power meter. For this, I used an Array Solutions PowerMaster which was calibrated with NIST-traceable test equipment. I used two convenient power levels for testing (my K3 TUNE power level barefoot and through a KPA500 amplifier). As you can see in Table 1, the worst case measurement discrepancy between the MFJ-998 power meter and the PowerMaster was 8% (this occurred on 10 meters), with most measurements within 3%.

Table 1: PowerMaster vs MFJ-998 Power Meter

Band	<u>Low Power</u>		<u>Med Power</u>	
	<u>PM</u>	<u>998</u>	<u>PM</u>	<u>998</u>
160M	17.3	17.7	330	317
80M	17.8	18.3	343	340
40M	17.3	17.7	322	321
30M	17.3	17.7	314	313
20M	16.7	17.3	338	342
17M	16.6	17.0	345	343
15M	16.2	16.5	375	363
12M	15.9	15.7	396	371
10M	15.3	15.0	349	324

Incidentally, should you ever want to recalibrate the SWR and/or power readings, 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 SWR null capacitor for 1:1 SWR. Next adjust the FWD trim pot for 100 watts forward power indicated on the analog and digital meters. Finally 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.

Now it was time to see how the MFJ-998 would tune my home station antennas. I have a 41-foot vertical with 160- and 80-meter base matching (see the “Articles” section of this website). While my matching section is resonant in the CW end of both 160- and 80-meters, the MFJ-998 easily matched the antenna across the full 160/80 meter bands. And there is absolutely no problem tuning the 41-foot vertical with 1:4 unun on 60-10 meters.

On 40 meters I also tested operation with a MFJ-1775 Rotatable Dipole, a short loaded multi-band dipole resonant at 7.04 MHz. At 7.3MHz the MFJ-998 auto-tuned the 5:1 SWR to 1.5:1 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 antenna to less than a 1.5:1 SWR almost instantly.

One important note: Sometimes when changing bands and attempt a TUNE, the MFJ-998 will “think” it is not getting any transmit power. This occurs if a tuning solution on one band results in a very high SWR when you move to a new band, and so your transceiver folds back power to a very low level. As an example, if you tune a highly reactive antenna on a lower frequency band and then move to a higher frequency band, the MFJ-998 lower-band tuning solution may result in an extremely high SWR on the higher band. If this causes your transceiver to fold back power to less than 5-watts, the MFJ-998 will not be able to sense power or frequency. The solution is to just tap TUNE on the MFJ-998 to bypass the tuner when you change bands. Now when you attempt a tune there will normally be enough transceiver power to start the MFJ-998 tune cycle.

Summary

The MFJ-998 should be a consideration in your decision making process if you are thinking about an auto-tuner for a 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.

MFJ-998 Firmware Upgrade

Go to www.mfjenterprises.com and select “Product Support”. Then select MFJ-998 and find the latest firmware available. Verify that this is a newer version than the version currently loaded in your MFJ-998 (Press TUNE and then POWER on the MFJ-998. The software version will scroll across the screen). Turn off the MFJ-998.

You may use either a direct RS232 interface or a USB-to-serial converter. For the USB-to-serial converter, the latest converters using the FTDI chipset are the best.

1. Press C-UP/L-UP/C-DN/L-DN simultaneously and press POWER. BOOTLOADER READY will appear on the MFJ-998 display.
2. Double-click on the latest MFJ-998 firmware zip file.
3. Open, don't save, the file. Then select “Extract all files”.
4. Double-click on the application file.
5. Select the correct COMM port on the box that appears on your computer screen.
6. Press F4 to begin programming.

If you get the message “Component comctl32.ocx or one of its dependencies not correctly registered: a file is missing or invalid”, go out on the web and find comctl32.ocx. You may also need to find mscomm32.ocx.

1. Copy COMCTL32.OCX file to C:\WINDOWS\SYSTEM32 folder.
2. Restart computer.

If you use Windows 7 you may get an error about missing COMCTL32.OCX even if it is there. Just right-click the executable, then left-click on “Run as Administrator”. The executable wants to make changes to a file that isn't allowed unless it has administrator rights.