HF/VHF SWR Analyzer

Model MFJ-259

INSTRUCTION MANUAL

CAUTION: Read All Instructions Before Operating Equipment

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VERSION 1D

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MFJ-259 HF/VHF SWR ANALYZER

INTRODUCTION

The MFJ-259 SWR Analyzer is an easy to operate, versatile test instrument for analyzing nearly any 50 ohm RF system on frequencies between 1.8 and 170 MHz. In addition the MFJ-259 can be used as signal source and as an accurate frequency counter.

The MFJ-259 combines four basic circuits; a wide range oscillator, a frequency counter, a 50 ohm RF bridge, and a calibrated bridge unbalance indicator. This combination of circuits allows measurement of the SWR (referenced to 50 ohms) of any load connected to the ANTENNA connector. The MFJ-259 FREQUENCY switch selects the following frequency ranges:

1.8	-	4	MHz
4	-	10	MHz
10	-	26.2	MHz
26.2	-	62.5	MHz
62.5	-	113	MHz
113	-	170	MHz

The MFJ-259 can be used to adjust or measure the following:

Antennas:	SWR, resonant frequency, bandwidth, efficiency
Antenna tuners:	SWR, frequency
Amplifiers:	Input and output networks
Coaxial transmission lines:	SWR, velocity factor, losses, resonance
Balanced transmission lines:	Impedance, velocity factor, resonance
Matching or tuning stubs:	SWR, resonant frequency, bandwidth
Traps:	Resonant frequency
Tuned Circuits:	Resonant frequency
Small capacitors:	Value
RF chokes and inductors:	Self resonance, series resonance, value
Transmitters and oscillators:	Frequency

The MFJ-259 is also portable. It can be used with either an external low voltage supply, such the MFJ-1312B AC adapter or with internal AA battery packs.

WARNING: Please read this manual thoroughly before using this instrument. Failure to follow the operating instructions may cause false readings or even damage this unit.

Resistance Meter

The resistance meter section of the MFJ-259 will provide resistance readings for the load connected to the ANTENNA jack. The resistance meter will not give an accurate reading of a reactive load. For example, if an antenna is resonant at 7.1 MHz and you attempt to measure the resistance at 7.3 MHz, the resistance reading will not be accurate. To get an accurate reading the TUNE knob should be adjusted until the lowest SWR reading is obtained. The point of lowest SWR is generally the point of lowest reactance therefore the most accurate point to read the antenna's pure resistance.

If the resistance meter indicates 50 ohms but the SWR meter indicates a high SWR the load is probably reactive. Any time the resistance meter indicates a resistive ratio that disagrees with the SWR reading the load is reactive. For example: If the resistance meter indicates 25 ohms (a 2:1 SWR) but the SWR meter indicates greater than 2:1, the load is reactive. ***For the SWR to be 1:1, the load must be 50 ohms of pure resistance.***

The SWR can not be 1:1 if reactance is present or the resistive component is not 50 ohms. If the SWR meter indicates 1:1 but the resistance meter reads other than 50 ohms you are experiencing an instrument error.

Frequency Counter

The frequency counter in the MFJ-259 will typically measure frequencies between a few hertz and 200 MHz. At frequencies above 1 MHz, the frequency counter is sensitive to 600 mV. Below 1 MHz, the counter is sensitive to TTL input voltage levels (5V peak to peak) with a square wave input. The counter function is accurate to 1 part per million at room temperature.

WARNING: The frequency counter has a CMOS input device that can be easily damaged. To avoid damage to the counter while using the "FREQUENCY COUNTER INPUT" jack the user must observe the following precautions: ***NEVER*** **exceed 5 volts peak input.** ***NEVER*** **apply an input signal with the power switch off.**

To use the frequency counter turn the power "ON" and press the "INPUT" button on the top panel until a "B" appears in the upper right corner of the counter display. The BNC jack is now selected for input to the counter.

The sample time period is selected by momentarily pressing the "GATE" button near the upper left corner of the top panel. The counter displays the average frequency over the sample time period. The red LED in the upper right corner of the front panel flashes when the count cycle is complete and the display is updated.The blinking LED will speed up and/or slow down with the changing of gate settings. At power up, the sample time period normalizes at .01 seconds. Additional count periods of 0.1, 1.0, and 10 seconds can also be selected. Connect the cable with the signal to be counted to the BNC type jack labeled "FREQUENCY COUNTER INPUT".

4. Divide the measured frequency by the desired frequency.
5. Multiply the present antenna length by the result of step 4. This is the new length needed.

Note: This method of tuning will only work on full size vertical or dipole antennas that do not employ loading coils, traps, stubs, resistors, capacitors or capacitance hats. These antennas must be tuned according to the manufacturers instructions and re-tested with the MFJ-259 until the desired frequency is obtained.

Measuring the Feedpoint Resistance of Antennas

The approximate feedpoint resistance of a low impedance (0-500 ohms) resonant HF or VHF antenna or load can be measured with the MFJ-259.

1. Connect the MFJ-259 directly across the terminals of the unknown resistance. If the load is unbalanced be sure that the ground is connected to the SO-239 "ANTENNA" connectors outer shell. If the load is balanced it may be necessary to operate the MFJ-259 using internal battery power to allow the case of the unit to float above ground.
2. Set the band switch for the desired frequency measurement range.
3. Adjust the TUNE control until the SWR reads the lowest value.
4. Read the resistance directly from the resistance meter.
5. Double check the meter readings against each other. The SWR ratio should be approximately equal to the ratio between the measured resistance and 50 ohms.

TESTING AND TUNING STUBS AND TRANSMISSION LINES

The proper length of quarter and half wave stubs or transmission lines can be found with this unit and a 50Ω carbon resistor. Accurate measurements can be made with any type of coaxial or two wire line. The line does ***not*** have to be 50 ohms.

The stub to be tested should be attached with a 50Ω noninductive resistor in series to the center conductor of the "ANTENNA" connector with a coaxial line. The shield should be grounded to the connector shell. For two wire lines the 50Ω resistor connects in series between the ground shell of the PL-259 and one conductor. The other conductor of the balanced line connects directly to the center pin of the connector.

Coaxial lines can lay in a pile or coil on the floor, two wire lines ***must*** be suspended in a straight line a few feet away from metallic objects or ground. The lines must be ***open circuited*** at the far end ***for odd multiples*** of 1/4 wave stubs (i.e. 1/4, 3/4, 1-1/4, etc.) and ***short circuited for half wave stub multiples*** (like 1, 1-1/2, etc.)
Connect the PL-259 to the "ANTENNA" connector of the MFJ-259 and adjust the line or stub by the following method. For critical stubs you may want to **gradually** trim the stub to frequency.

1. Determine the desired frequency and theoretical length of the line or stub.
2. Cut the stub slightly longer than necessary.
3. Measure the frequency of the lowest SWR. It should be just below the desired frequency.
4. Divide the measured frequency by the desired frequency.
5. Multiply the result by the length of the stub. This is the necessary stub length.
6. Cut the stub to the calculated length and confirm that it has the lowest SWR near the desired frequency.

Velocity Factor of Transmission Lines

The MFJ-259 can accurately determine the velocity factor of any impedance transmission line. Measure the velocity factor with the following procedure:

1. Disconnect both ends of the transmission line and measure the physical length of the line in feet.
2. Set up the line to measure 1/4 stubs as in the section on Testing and Tuning Stubs, page 8
3. Find the ***lowest*** frequency across all the bands at which the lowest SWR occurs. The dip should occur slightly below the 1/4 wavelength frequency.
4. Read the frequency from the frequency counter display. This is the 1/4 resonant wavelength frequency of your transmission line. Note that you will get low SWR reading at all odd multiples of 1/4 wavelength.
   Example: On a 27 foot line the measured frequency was 7.3MHz
5. Divide 246 by the measured frequency. This gives you the free space 1/4 wavelength in feet.

Example: 246 divided by a dip frequency of 7.3 MHz is 33.7 feet, the free space 1/4 wavelength

6. Divide the physical measured length of the feedline in feet by the free space 1/4 wavelength calculated in number 5.
   Example: 27 feet (physical length) divided by 33.7 feet (calculated length) equals .80 . The velocity factor is .80 or 80%.

$$\text{Free space } 1/4 \text{ wavelength} = \frac{246}{\text{Low SWR frequency}}$$

$$\text{Velocity Factor} = \frac{\text{Actual feedline length}}{\text{Free space } 1/4 \text{ wavelength}}$$

Impedance of Transmission Lines

The impedance of transmission lines between 15 and 150 ohms can be measured with the MFJ-259, a 250 ohm potentiometer, and an ohm meter. Lines of higher impedance can be measured with a higher resistance potentiometer if a broad band transformer is used (see the section on testing transformers) to transform the line impedance to approximately 50 ohms.

1 Measure the 1/4 wavelength frequency of the transmission line to be tested as in Testing and Tuning Stubs on page 8.
2 Terminate the far end of the transmission line with a non-inductive 250 ohm potentiometer.
3 Connect the transmission line to the MFJ-259 "ANTENNA" connector and set the analyzer to the 1/4 wave frequency.
4 Observe the SWR as you vary the "TUNE" from end to end of the "FREQUENCY" range selected.
5 Adjust the potentiometer until the SWR reading varies as little as possible, over the "TUNE" range. Note that the ***value*** of the SWR is not important. Only the ***change*** in SWR as the frequency is varied is important.
6 The value of the potentiometer will correspond closely to the line impedance.

Estimating transmission line loss

The loss of 50 ohm feedlines (between 3 and 10 dB) can be measured with the MFJ-259. It is a simple matter to find the loss at a known frequency and then estimate the loss at a lower frequency.

To measure feedline loss:

1. Connect the feedline to the MFJ-259 "ANTENNA" connector
2. The far end of the feedline is either left unconnected or terminated with a direct short
3. Adjust the MFJ-259 frequency to the frequency desired and observe the "SWR" meter

ADJUSTING AMPLIFIER MATCHING NETWORKS

The MFJ-259 can be used to test and adjust RF amplifiers or other matching networks without applying operating voltages.

The tubes and other components should be left in position and connected so that stray capacitance is unchanged. A non-inductive resistor that equals the approximate driving impedance of the tube is installed between the cathode of the tube and the chassis, or a resistor should be connected between the anode and the chassis that equals the calculated plate impedance of the tube . The appropriate network can now be adjusted.

The antenna relay (if internal) can be engaged with a small power supply so that the coax input and output connectors are tied to the networks.

Caution: The driving impedance of most amplifiers changes as the drive level is varied. Do not attempt to adjust the input network with the tube in an operating condition with the low level of RF from the MFJ-259.

TESTING RF TRANSFORMERS

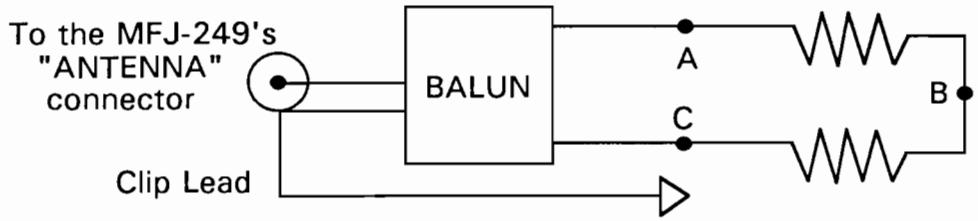
RF transformers that are designed with a 50 ohm winding can be easily and accurately tested with the MFJ-259.

The 50 ohm winding is connected through a short 50 ohm cable to the "ANTENNA" connector on the MFJ-259. The other winding(s) of the transformer is then terminated with a low inductance resistor that is equal to the windings impedance. The MFJ-259 can then be swept through the desired transformer frequency range. The SWR and bandwidth of the RF transformer can be measured.

Testing Baluns

Baluns can be tested by connecting the 50 ohm unbalanced side to the MFJ-259 "ANTENNA" connector. The balun must be terminated with two equal value load resistors in series. The resistor combination must have resistance total that is equal to the balun impedance. A pair of 100 ohm carbon resistors must be used to test the 200 ohm secondary of a 4:1 balun (50 ohm input).

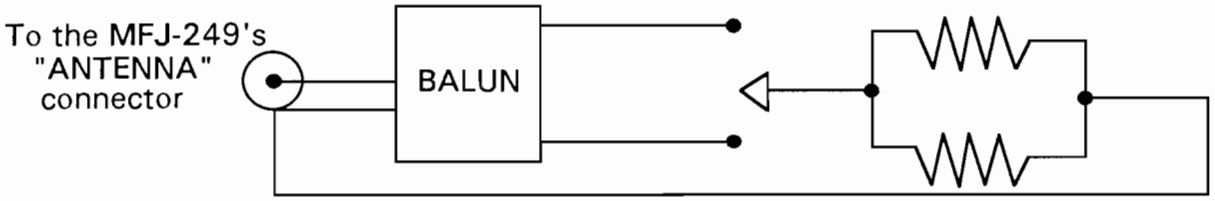
The SWR is measured by moving a jumper wire from point "A" through point "C".



A properly designed current balun, the type that is the most effective and usually handles the most power, should show a low SWR over the entire operating range of the balun with the clip lead in any of the three positions.

A well designed voltage balun should show a low SWR over the entire operating range when the clip lead is in position "B". It will show a poor SWR when the clip lead is in position "A" and "C".

A voltage balun should also be tested by disconnecting the outer connections of the two resistors and connecting each resistor in parallel. If the balun is operating properly the SWR will be very low with the resistors connected from either output terminal to ground.



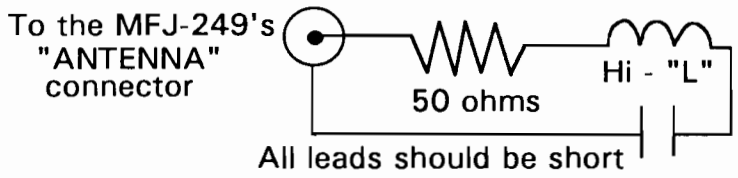
MEASURING INDUCTANCE AND CAPACITANCE

To measure capacitance or inductance you will need some standard value capacitors and inductors. These should be collected and tested for accuracy. MFJ suggests the following sets of values:
Inductors: 330μH, 56 μH, 5.6 μH, .47 μH
Capacitors: 10 pF, 150 pF, 1000 pF, 3300 pF
Readings will be the most accurate if the standard test values used are between 0.5 μH to 500 μH to measure capacitance or 10 pF and 5000 pF to measure inductance.

Take a component of unknown value and connect it in series with a standard component to make a series LC circuit. Attach the series LC circuit to the "ANTENNA" connector in series with a 50 Ω resistor.

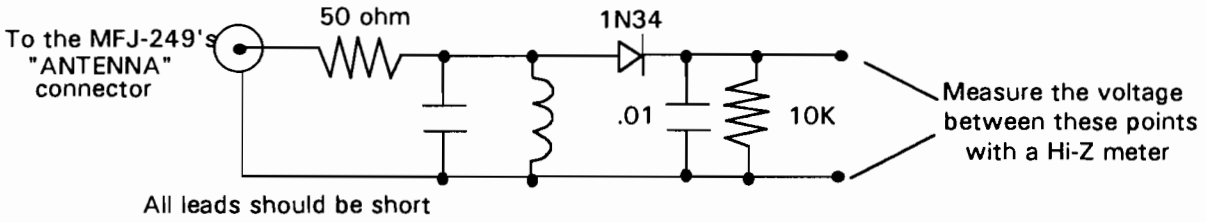
Measure capacitance.

1. Connect an unknown capacitor in series with the highest value standard inductor.
2. Connect the LC circuit to ANTENNA connector with a 50 Ω resistor in series.
3. Adjust the tune knob through the bands until you get the lowest SWR. If you do not get a deep meter deflection change to the next inductor with a lower value and try again. Continue the process until you obtain low SWR.



Tune the MFJ-259's frequency until the "SWR" meter reaches the lowest SWR. This is the resonant frequency of the load.

An external diode detector and volt meter can also be used to measure the resonant frequency of circuits. The maximum meter reading occurs at the resonant frequency.

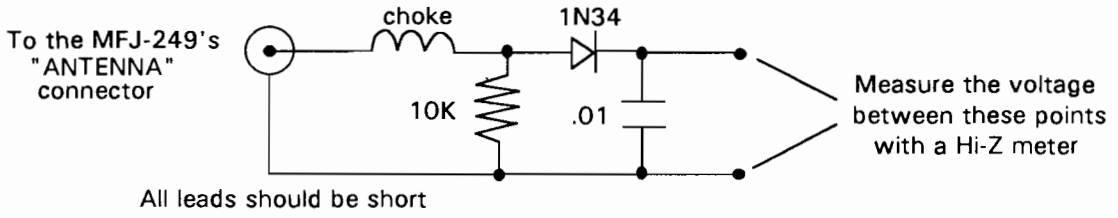


A second method of determining the resonant frequency is by using a small three or four link coil to magnetically couple to a tuned circuit for testing. The coil should be wound around the inductor in the tuned circuit. This magnetically couples the MFJ-259 to the resonant circuit.

The frequency of the MFJ-259 is adjusted for a dip on the "SWR" meter. The dip occurs at the approximate resonant frequency of the tuned circuit.

Testing RF Chokes

Large RF chokes usually have frequencies where the distributed capacitance and inductance form a low impedance series resonance. The troublesome series resonance can be detected by slowly sweeping the frequency of the MFJ-259 over the operating range of the choke. Peaks in the voltage measured by the RF voltmeter will identify the low impedance series-resonant frequencies.



Refer to the section on measuring the inductance of RF chokes on page 13.

TECHNICAL ASSISTANCE

If you have any problem with this unit first check the appropriate section of this manual. If the manual does not reference your problem or your problem is not solved by following the manual, you may call *MFJ Technical Service* at **601-323-0549** or the *MFJ Factory* at **601-323-5869.** You will be best served if you have your unit, manual and all information on your station handy so you can answer any questions the technicians may ask.

You can also send questions by mail to MFJ Enterprises, INC., 300 Industrial Park Road, Starkville, MS 39759; by FAX to 601-323-6551; through Compuserve at 76206,1763; or by email to 76206.1763@Compuserve.com. Send a complete description of your problem, an explanation of exactly how you are using your unit, and a complete description of your station.

MFJ-259 PARTS LIST

Designator	Description	Part Number
BH1	Battery Holder, 4-AA	730-2342
BS1	Battery, Snap, 9v, 8"	730-3005
C1	Capacitor, Disc Ceramic, 50v, 20%, 22 pF	200-0018
C11,C13,C14,C16, C19	Capacitor, Disc Ceramic, 25/50v, 20%, .01 µF	200-0004
C17,C18,C24	Capacitor, Disc Ceramic, 50/100v, 20%, .1 µF	200-0005
C2,C3,C4,C15,C6, C7,C8	Capacitor, Disc Ceramic, 25/50v, 20%, .01 µF	200-0004
C20,C21,C25,C26, C27	Capacitor, Disc Ceramic, 25/50v, 20%, .01 µF	200-0004
C22,C23,C40,C39	Capacitor, Disc Ceramic, 25/50v, 20%, .01 µF	200-0004
C28	Capacitor, Electrolytic, Radial, 25v, 100 µF	203-0015
C29	Capacitor, Disc Ceramic, 500v, 20%, 75 pF	200-1011
C30	Capacitor, Disc Ceramic, 1 kV, 20%, 470 pF	200-2023
C31	Capacitor, Disc Ceramic, 1 KV, 20%, 33 pF	200-2016
C32	Capacitor, Electrolytic, Radial, 50v, 1 µF	203-0006
C33,C36,C10	Capacitor, Disc Ceramic, 25/50v, 20%, .01 µF	200-0004
C38	Capacitor, Electrolytic, Radial, 35v, 220 µF	203-0019
C44	Cap, Air Var, 6-200pf	204-5160
D2-D4	Diode, Germanium, 1N34A	300-8001
For C44, SW1	Knob, 1/4" Shaft	760-0033
For IC1	Socket, IC, Low Profile, 14 Pin	625-0031
For SW2	Knob, Plastic, Push-Button, Red	760-2140
IC1	IC, Op-amp, Quad Op-amp, 14 Pin, Lm324n	311-0040
IC2	Voltage Regulator, TO-220, 1 Amp, 7805T	307-1011
J2	Connector, Header, 90, 3 Pos	612-0103
J3	Connector, Socket, Dual Row, 7 Pos	612-3307
J4	Connector, UHF, 4-hole Mount, SO-239	610-2005
J5	Jack, 2.1 mm, DC Coaxial Jack	601-6021

Designator	Description	Part Number
J6	Connector, BNC, Chassis Mt. Female, UG-652/U	610-1016
JMP1-JMP3	Wire, Jumper, 1/4"-2"	870-5000
L1	Inductor, Var, 66 µH	402-3412
L2	Inductor, Xformer, 1 7.8 µH	402-3406
L3	Inductor, Xformer, 1.8 µH	402-3402
L4	Inductor, .211 µH	402-2728
L5	PCB Coil, Air Wound, 4 Turn	10-01014
L6	PCB Coil, Air Wound, .5 Turn	10-01011
L7	Pick-up Coil, #61 Pre-wound	10-01003
M1	Meter, 100 uA, SWR Meter	400-0035
M2	Meter, Resistance	400-0045
MOD1	Counter Module, LCD	50-247-3
P2	Connector, IDC, Socket, 3 Positions	612-2003
PCB	PCB, 2-side, MFJ-259	862-0249
Q1,Q2,Q4	Transistor, FET, To-92, Siliconix, J310	305-6310
Q3	Transistor, FET, Switching, VN10KM	305-6005
Q5	Transistor, HF Wide Band, To-39, NPN, 2N5109	305-0017
R1	Resistor, 1/4 Watt, 5%, Film, 18 Ohm	100-1180
R10	Resistor, 1/4 Watt, 5%, Film, 39k Ohm	100-4390
R15,R24,R29,R30	Resistor, 1/4 Watt, 5%, Film, 10.0k Ohm	100-4100
R17,R32	Resistor, Trimpot, Sub. Horz., 10 K	133-4100
R18	Resistor, Trimpot, Sub. Horz., 100 K	133-5100
R2,R21,R22	Resistor, 1/4 Watt, 5%, Film, 1M Ohm	100-6100
R26,R27,R28	Resistor, 1/8 Watt, 1%,49.9 Ohm	102-1499
R3,R8	Resistor, 1/4 Watt, 5%, Film, 100 Ohm	100-2100
R33	Resistor, 1/4 Watt, 5%, Film, 620 Ohm	100-2620
R4,R7	Resistor, 1/4 Watt, 5%, Film, 10 Ohm	100-1100
R5,R6	Resistor, 1/4 Watt, 5%, Film, 1.0k Ohm	100-3100
R9	Resistor, 1/4 Watt, 5%, Film, 100k Ohm	100-5100
SW1	Switch, Rotary, 2p6p	500-1565
SW3,SW4	Switch, Push Button, spst	504-1003
SW2	Switch, Push-Button, 2p2p	504-0022

FULL 12 MONTH WARRANTY

MFJ Enterprises, Inc. warrants to the original owner of this product, if manufactured by MFJ Enterprises, Inc. and purchased from an authorized dealer or directly from MFJ Enterprises, Inc. to be free from defects in material and workmanship for a period of 12 months from date of purchase provided the following terms of this warranty are satisfied.

1. The purchaser must retain the dated proof-of-purchase (bill of sale, canceled check, credit card or money order receipt, etc.) describing the product to establish the validity of the warranty claim and submit the original or machine reproduction of such proof of purchase to MFJ Enterprises, Inc. at the time of warranty service. MFJ Enterprises, Inc. shall have the discretion to deny warranty without dated proof-of-purchase. Any evidence of alteration, erasure, or forgery shall be cause to void any and all warranty terms immediately.

2. MFJ Enterprises, Inc. agrees to repair or replace at MFJ's option without charge to the original owner any defective product under warrantee provided the product is returned postage prepaid to MFJ Enterprises, Inc. with a personal check, cashiers check, or money order for **$7.00** covering postage and handling.

3. This warranty is **NOT** void for owners who attempt to repair defective units. Technical consultation is available by calling the Service Department at 601-323-0549 or the MFJ Factory at 601-323-5869.

4. This warranty does not apply to kits sold by or manufactured by MFJ Enterprises, Inc.

5. Wired and tested PC board products are covered by this warranty provided **only the wired and tested PC board product is returned.** Wired and tested PC boards installed in the owner's cabinet or connected to switches, jacks, or cables, etc. sent to MFJ Enterprises, Inc. will be returned at the owner's expense unrepaired.

6. Under no circumstances is MFJ Enterprises, Inc. liable for consequential damages to person or property by the use of any MFJ products.

7. **Out-of-Warranty Service:** MFJ Enterprises, Inc. will repair any out-of-warranty product provided the unit is shipped prepaid. All repaired units will be shipped COD to the owner. Repair charges will be added to the COD fee unless other arrangements are made.

8. This warranty is given in lieu of any other warranty expressed or implied.

9. MFJ Enterprises, Inc. reserves the right to make changes or improvements in design or manufacture without incurring any obligation to install such changes upon any of the products previously manufactured.

10. All MFJ products to be serviced in-warranty or out-of-warranty should be addressed to:

    MFJ Enterprises, Inc.,
    300 Industrial Park Road
    Starkville, Mississippi 39759 USA

    and must be accompanied by a letter describing the problem in detail along with a copy of your dated proof-of-purchase.

11. This warranty gives you specific rights, and you may also have other rights which vary from state to state.