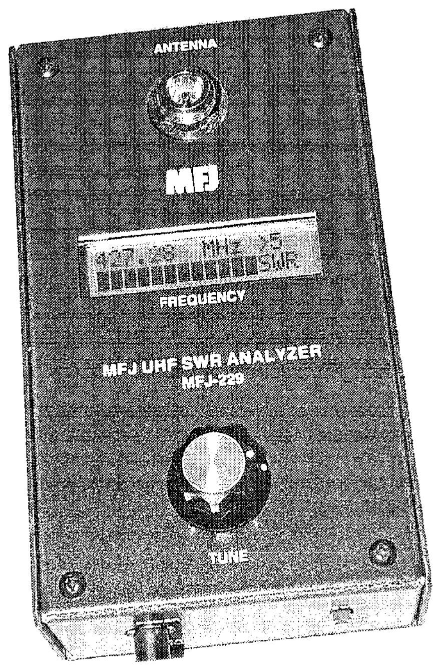
MFJ

440 MHz UHF SWR Analyzer

Model MFJ-229



INSTRUCTION MANUAL

CAUTION: Read All Instructions Before Operating Equipment

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VERSION 1C

INTRODUCTION

The MFJ-229 SWR Analyzer is an easy to operate, versatile test instrument for analyzing nearly any 50Ω RF system on frequencies between 420 and 450 MHz. In addition the MFJ-229 can be used as a UHF signal source. A different frequency range could be customize by adjusting the internal control resistors. The minimum frequency available is around 270 MHz and the maximum frequency is around 480 MHz.

MFJ-229
Rev. 1.00

MFJ-Enterprises
(c) 1999

The MFJ-229 combines three basic circuits; an UHF voltage controlled oscillator, a 50Ω RF bridge, and a calibrated bridge unbalance indicator. This combination of circuits allows measurement of the SWR (referenced to 50Ω) of any load connected to the ANTENNA connector.

The MFJ-229 covers the entire 70 cm amateur band. The actual frequency is displayed on the LCD.

The MFJ-229 has a N-type connector for the antenna.

The MFJ-229 can be used to adjust or measure the following:

- Antennas: SWR, resonant frequency, bandwidth
- Amplifiers: Input and output networks
- Coaxial transmission lines: SWR, velocity factor, losses, resonance
- Networks: SWR, resonant frequency, bandwidth
- Stubs: Resonant frequency

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

POWERING THE MFJ-229

The MFJ-229 requires 15 volts for proper operation. Any power supply used with the MFJ-229 must be capable of supplying 34 mA of current. An optional power supply, the MFJ-1315B (supplying 15 volts for loads driving such a current), is available from MFJ Enterprises, Inc. or authorized MFJ dealers.

The battery level will be indicated by the display in the power up.

Voltage OK

The MFJ-229 has a standard 2.1 mm DC coaxial jack at the bottom of the case. This jack is labeled **15VDC** and has the word **POWER** near it. A pictorial polarity marking appears on the case near the power jack. The outside conductor of the plug must connect to the negative supply voltage and the center conductor of the plug must connect to the positive voltage. If ten AA 1.5 volt batteries are connected, the batteries will be automatically disconnected when an external power plug is inserted in this jack.

SWR measurement will be inaccurate when the supply voltage falls below 15 volts. To avoid false readings maintain fresh batteries and always use the correct power supply. If the power supply falls below the minimum required level, it will be indicated on the display.

Voltage LOW

WARNING: Never apply AC, unfiltered or incorrectly polarized DC to this jack. Peak voltage must never exceed 18 volts.

Power saving

The unit will fall in a power saving mode seven minutes after the power is turned ON. It will be indicated with a blinking **SLP** sign.

447.99 MHz > 5
████████████SLP

The power should be turned back ON again to reinitialize operations.

BATTERY INSTALLATION

To install batteries, first turn the unit **OFF**. Remove the six phillip head screws of the case. Insert the batteries securely into the battery holder.

Carefully check to ensure any wires are not pinched between the cover and the chassis.

After the batteris are installed, reinstall the six cover screws.

MFJ recommends the use of ten 1.5V ALKALINE batteries to reduce the risk of equipment damage from battery leakage. Avoid leaving any batteries in this unit during periods of extended storage. *Remove weak batteries immediately!*

When using a battery with this unit, quickly make a measurement and turn the unit off. If the unit is left on for long periods of time, battery life may be short.

OPERATION OF THE MFJ-229

After the MFJ-229 is connected to a proper power source the red ON/OFF button can be depressed to apply power. When pressed, the red button should lock into position.

The **ANTENNA** connector (N-type) on the top of the MFJ-229 provides the SWR bridge output connection. To measure SWR, this connector must be connected to the load or device under test.

WARNING: Never apply power to the "ANTENNA" connector.

SWR and the MFJ-229

Some understanding of transmission lines and antenna behavior is necessary to use the MFJ-229 properly. For a thorough explanation the ARRL Handbooks or other detailed textbooks can be used for reference.

Since nearly all feedlines and radio equipment used in amateur service are 50Ω, this instrument is designed to measure the system SWR normalized to 50Ω. The SWR will vary with the ratio of source to load impedance. For example a 150Ω resistive load placed across the **ANTENNA** connector will give an SWR reading of 3:1.

The MFJ-229 measures the actual SWR. The load must be 50Ω of pure resistance for a meter reading of 1:1 . The common misconception that 25Ω of reactance and 25Ω of resistance in a load will give a 1:1 SWR is absolutely *not* true. The actual SWR in this condition will be measured as 2.6:1 . The MFJ-229 is not "fooled" by mixtures of reactive and resistive loads.

Another common misconception is that changing a feedline's length will change the SWR. A feedline impedance of 50Ω and a load impedance of 25Ω produces an SWR of 2:1. The SWR will remain 2:1 even if the feedline length is changed. ***If line loss is low*** it is perfectly acceptable to make SWR measurements at the transmitter end of the feedline. The feedline does not have to be any particular length. As line loss increases, and as SWR increases, error is introduced into the SWR reading. The error causes the measured SWR reading to appear ***better*** than the actual SWR at the antenna. Refer to the section on Estimating Transmission Line Loss.

If changing feedline length changes the SWR reading, one or more of the following must be true:

- The feedline is not 50Ω.
- The bridge is not set to measure 50Ω.
- The line losses are significant.
- The feedline is acting like part of the antenna system and radiating RF.

Feedlines with very low losses, such as air insulated transmission lines, will not have much loss even when operating with a high SWR. High loss cables, such as small polyethylene dielectric cables like RG-58, rapidly lose efficiency as the SWR is increased. With high loss or long feedlines it is very important to maintain a low SWR over the entire length of the feedline.

SWR adjustments have to be made at the antenna, since any adjustments at the transmitter end of the feedline can not affect the losses, nor the efficiency, of the antenna system.

Measuring SWR

The MFJ-229 will measure the standing wave ratio (SWR) of any load referenced to 50Ω. The SWR can be measured on any frequency from 420 to 450 MHz. No other devices are required. The maximum SWR read will be five. The SWR measured will be indicated additionally by a bargraph on the display.

425.72 MHz 3.4 ████████ SWR	443.72 MHz >5 ███████████████ SWR

To measure the SWR on a predetermined frequency, adjust the **TUNE** control to the desired frequency. Read the SWR from the graphic display.

To find the lowest SWR, adjust the frequency until the SWR reading reaches the lowest value. Read the frequency of the lowest SWR from the graphic display.

Customizing the Frequency Range

The MFJ-229 uses a variable controlled oscillator to generate a signal source of around 6 dBm. By default the lower frequency limit was set to 415 MHz and the upper to 470 MHz. The available minimum frequency for the unit is 270 MHz and the maximum is around 480 MHz.

To custom set the frequency range, first turn the unit **OFF**. Remove the 6 phillips head screws on each side of the case and remove the cover. If the batteries are installed, remove them next. Carefully unscrew the two philips screws that secure the battery holder. As soon the battery holder is released, gently hold the case and the box over a non conductive surface.

The setting procedure is dependent of the relationship between the desired maximum frequency and the current minimum frequency *or* at the same time the desired minimum frequency and the current maximum frequency.

To customize a maximum frequency lower than the minimum frequency already being used follow the procedure establish in **B**.

To customize a minimum frequency higher than the maximum frequency already being used first set the higher frequency as is indicated in **A**.

Your frequency limits setting should be at least in one of the following:

A. The desired maximum frequency is higher than the current lower frequency and/or the desired minimum frequency is higher than the current lower frequency.

Turn the power **ON**. First, set the desired maximum frequency by adjusting the **TUNE** control to the highest available frequency. Find the trimmer resistor labeled **R1. R1** is located near the center of the PC board. With a tuning tool, adjust the trimmer **(R1)** to the desired maximum frequency using the LCD.

Next, set the minimum frequency. Adjust the **TUNE** control to the lowest available frequency. Find the trimmer resistor labeled **R2**. **R2** is located close to R1. With a tuning tool, adjust **R2** to the desired minimum frequency using the LCD.

Note: The wiper on **R1** should always lead or be turned further clockwise than the wiper on **R2.**

Check that the frequency limits set up, match the desired frequencies. If they do not, then reset to the default frequencies.

After the desired limits are obtained, turn the power **OFF**, reinstall the battery holder and the 6 cover screws, while making sure the wires are not pinched between the cover and the chassis.

B. The desired maximum frequency is lower than the current lower frequency and/or the desired minimum frequency is lower than the current lower frequency.

Turn the power **ON**. First, set the desired minimum frequency by adjusting the **TUNE** control to the lowest available frequency. Find the trimmer resistor labeled **R2**. **R2** is located near the center of the PC board. With a tuning tool, adjust the trimmer **(R2)** to the desired minimum frequency using the LCD.

Next, set the maximum frequency. Adjust the **TUNE** control to the maximum available frequency.. Find the trimmer resistor labeled **R1**. **R1** is located close to R2. With a tuning tool, adjust **R1** for the desired maximum frequency using the LCD.

Note: The wiper on **R1** should always lead or be turned further clockwise than the wiper on **R2.**

Check that the frequency limits set up, match the desired frequencies. If they do not, then reset to the default frequencies.

After the desired limits are obtained, turn the power **OFF**, reinstall the battery holder and the 6 cover screws, while making sure the wires are not pinched between the cover and the chassis.

ADJUSTING SIMPLE ANTENNAS

Most antennas are adjusted by varying the length of the elements. Most home made antennas are simple verticals or use a dipole or quad for the driven element. Most types of elements can be easily adjusted.

Dipoles

Dipole elements are balanced radiators. It is a good idea to install a balun at the feedpoint of any balanced dipole element fed directly with coaxial line. The balun can be as simple as a string of very low permeability beads, a low permeability ferrite sleeve, a 1/4 wave sleeve balun, or several turns of miniature coax in a small (less than one inch) diameter coil.

Metallic objects or lossy dielectrics in the immediate vicinity of a dipole and the diameter of the element influences the feedpoint impedance of a dipole and the feedline's SWR. Typically, dipoles have an SWR below 1.5:1.

In general, length is the only adjustment of a dipole antenna. If the antenna is too long it will resonate too low in frequency, and if it is too short it will resonate too high in frequency.

Quad Elements

Quad elements are also balanced radiators. It is a good idea to put a balun at the feedpoint of any quad element that is fed with coaxial line. The balun can be as simple as a string of very low permeability beads, a low permeability ferrite sleeve, a 1/4 wave sleeve balun, or several turns of miniature coax in a small (less than one inch) diameter coil.

Metallic objects or lossy dielectrics in the immediate vicinity of a quad element and the diameter of the material used to construct the element will influence the feedpoint impedance of the quad and the feedline's SWR. Typically unmatched quad elements have an SWR below 2:1.

The only matching adjustment of a quad is the length of the loop. If the antenna circumference is too long it will resonate too low in frequency, and if it is too short it will resonate too high in frequency. The impedance can be modified with stubs or "Q" sections.

Verticals

Verticals for UHF are generally unbalanced ground plane types. They usually have a main vertical element and at least three radials or counterpoises. Verticals are tuned in a manner similar to dipoles, lengthening the element moves the frequency lower, and shortening the element moves the frequency higher.

Tuning an Antenna

Tuning basic antennas fed with 50Ω coaxial cable can be accomplished with the following steps:

1. Connect the feedline to the MFJ-229.
2. Adjust the MFJ-229 until the SWR reaches the lowest reading.
3. Read the MFJ-229's frequency.
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 may not work on loaded or electrically shortened antennas. They must be tuned by adjusting and re-testing until the proper frequency is obtained.

Measuring the Feedpoint Resistance of Antennas

The approximate feedpoint resistance of a low impedance (10-100 ohm) resonant UHF antenna or load can be measured with the MFJ-229. An assortment of low value non-inductive resistors can be used to make these measurements.

Note: Remember that all lead lengths must be extremely short on UHF !

1. Connect the MFJ-229 directly across the terminals of the unknown impedance. If the load is unbalanced be sure that the ground is connected to the **ANTENNA** connector's ground.
2. Adjust the MFJ-229 until the SWR reads the lowest value.
3. If the SWR is not unity (1:1), place different resistors in parallel with the load. Adjust the potentiometer until the SWR is as good as possible.
4. If the SWR only becomes worse go to step 7.
5. If the SWR reaches unity, note the value of the resistor.
6. The resistance of the load is found by using the formula below.

$$R_A = \frac{50R}{R-50}$$

R_A = Antenna resistance

R = Resistor

7. If the earlier steps did not work put the resistor in series with the center pin (ungrounded terminal) of the **ANTENNA** connector.
8. Adjust the value of the resistor until the SWR is unity (1:1).
9. Subtract the value of the resistor used in step 8 from 50 to determine the load resistance.

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 non-inductive resistor. Accurate measurements can be made with any type of coaxial or two wire line. The line does ***not*** have to be 50Ω.

Note: Remember that all lead lengths must be extremely short on UHF !

The stub to be tested should be attached through a series 50Ω non inductive resistor 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 is connected in series with the ground shell of the connector and one feedline conductor. The other conductor of the balanced line connects directly to the center pin of the connector.

Coaxial lines can lie in a pile or coil on the floor, two wire balanced 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*** (i.e., 1, 1-1/2, etc.)

Connect the coaxial line to the **ANTENNA** connector of the MFJ-229 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-229can accurately determine the velocity factor of any transmission line. Measure the velocity factor with the following procedure:

Note: Remember that all lead lengths must be extremely short on UHF !

1. Cut a sample of the transmission line to a length of seven inches.
2. Set up the line to measure a 1/4 wavelength stub (as in the section on Testing and Tuning Stubs).
3. Cut off pieces of the open end of the stub until the lowest SWR occurs within the range of the **TUNE** control. This dip will occur slightly below the 1/4 wavelength resonant frequency.

4. Read the frequency of the MFJ-229. This is the 1/4 resonant wavelength frequency of your transmission line.
   example: On a four inch line the measured frequency was 433 MHz.

5. Divide 2950 by the measured frequency. This gives you the free space 1/4 wavelength in inches.
   example: 2950 divided by a dip frequency of 433 MHz is 6.81 inches. This is the length of a free space 1/4 wave.

6. Divide the physical measured length of the feedline in feet by the free space 1/4 wavelength calculated in step 5.
   example: 4 inches (physical length) divided by 6.81 inches (calculated free space length) equals .587 . The velocity factor is approximately .6 or 60%.

$$\text{Free space } 1/4 \text{ wavelength} = \frac{2950}{\text{Low SWR frequency}}$$

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

Impedance of Transmission Lines

The impedance of transmission lines between 10Ω and 250Ω can be measured with the MFJ-229 and an assortment of non-inductive resistor.

__Note:__ Remember that all lead lengths must be extremely short on UHF !

1. Measure the 1/4 wavelength frequency of a small sample of the transmission line to be tested as in Testing and Tuning Stubs section.
2. Terminate the far end of the transmission line with a non-inductive resistor.
3. Connect the transmission line to the MFJ-229 **ANTENNA** connector and set the analyzer to the 1/4 wave frequency.
4. Observe the SWR as you vary the **TUNE** control from end to end of the frequency range selected.
5. Select a resistor that produces the smallest SWR reading change over the entire **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 resistor will correspond closely to the line impedance.

Estimating Transmission Line Loss

The loss of 50Ω feedlines (between 3 and 10 dB) can be measured with the MFJ-229. 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-229 **ANTENNA** connector.
2. The far end of the feedline is either left unconnected or terminated with a direct short.
3. Adjust the MFJ-229 frequency to the frequency desired and observe the **SWR**.

SWR	LOSS
5.0 : 1	1.7 dB
4.5 : 1	1.9 dB
4.0 : 1	2.2 dB
3.5 : 1	2.5 dB
3.0 : 1	3.0 dB
2.5 : 1	3.6 dB
2.0 : 1	4.7 dB
1.7 : 1	5.8 dB
1.5 : 1	6.9 dB
1.2 : 1	10.3 dB
1.1 : 1	13.2 dB

ADJUSTING MATCHING NETWORKS

The MFJ-229can be used to adjust matching networks. Connect the MFJ-229 **ANTENNA** connector to the network's 50Ω input and the desired load to the network output.

WARNING: RF Power Must Never Be Applied To The MFJ-229.

1. Connect the MFJ-229 to the matching network input.
2. Turn on the MFJ-229 and adjust it to the desired frequency.
3. Adjust the matching network until the SWR becomes unity (1:1).
4. Turn off the MFJ-229 and re-connect the transmitter.

Adjusting Amplifier Networks

The MFJ-229 can be used to test and adjust RF amplifiers or other matching networks without applying operating voltages.

The tubes or transistors and the other components should be left in the same physical position. They should remain connected so the circuit's stray capacitance is not changed. A non-inductive resistor with a value equal to the approximate driving impedance of the tube or transistor is installed at the input of the amplifying device. This resistor should have very short leads and be connected between the device input and the chassis. To align the output circuit connect a resistor with a value equal to the anode (or output) impedance of the amplifying device between the anode (or output) of the device and the chassis. The appropriate network can now be adjusted for lowest SWR on the MFJ-229.

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 amplifier in an operating condition. The RF level from the MFJ-229 is too low.

USING THE MFJ-229 AS A SIGNAL SOURCE

The MFJ-229 can provide a crude signal source for testing and alignment. Signal is produced by the internal voltage controlled oscillator and can be taken from the **ANTENNA** jack. The MFJ-229 provides around 6dBm from the antenna jack.

An attenuator pad or variable resistor can be used to reduce the output level of the MFJ-229.

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 reading the manual, you may call *MFJ Technical Service* at **662-323-0549** or the *MFJ Factory* at **662-323-5869**. You will be best helped 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 662-323-6551; or by email to techinfo@mfjenterprises.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.

NOTES

LIMITED 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 662-323-0549 or the MFJ Factory at 662-323-5869.

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.

MFJ ENTERPRISES, INC.
300 Industrial Park Road
Starkville, MS 39759

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