QRP Tuner, Wattmeter, & Dummy Load
MFJ-9219

INSTRUCTION MANUAL

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DISCLAIMER

The information in this manual is for user purposes only and is not intended to supersede information contained in customer regulations, technical manuals or documents, positional handbooks, or other official publications. The copy of this manual provided to the customer will not be updated to reflect current data. Customers using this manual should report errors or omissions, recommendations for improvements, or other comments to MFJ Enterprises, 300 Industrial Park Road, Starkville, MS 39759.

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1 RADIO-FREQUENCY RADIATION

Radio-frequency (RF) radiation is one type of electromagnetic radiation. Electromagnetic waves and associated phenomena are discussed in terms of energy, radiation, and fields. Electromagnetic radiation is defined as waves in electric and magnetic fields moving together, or radiating, through space (Figure 1). These waves are generated by the movement of electrical charge. For example, the movement of charge in a radio station antenna creates electromagnetic waves that are radiated away from the antenna. The waves then induce charge motion in the receiving antenna, which is detected and converted into signal by the radio. The term electromagnetic field refers to the electric and magnetic environment existing at some location due to a radiating source such as an antenna.

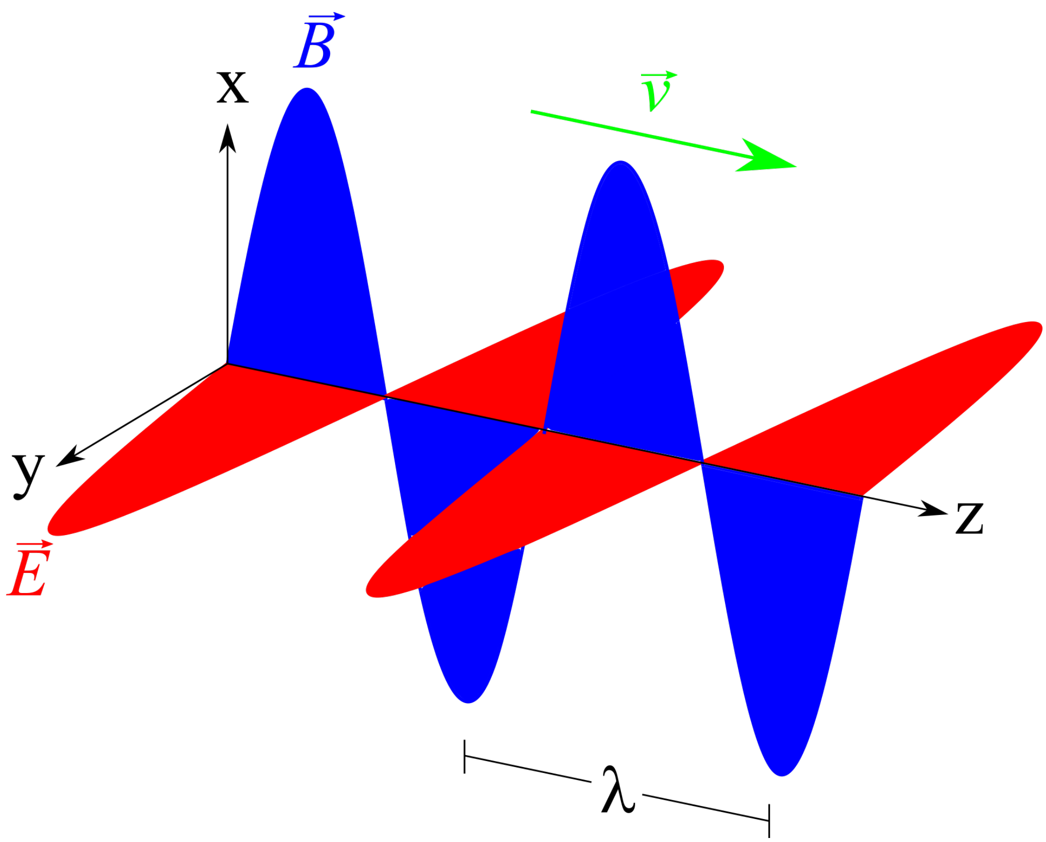


Figure 1: Horizontally-polarized Electromagnetic Plane Wave

An electromagnetic wave consists of oscillating orthogonal electric ($\vec{E}$) and magnetic ($\vec{B}$) fields. These fields propagate together with direction and velocity $\vec{v}$. In a vacuum this is the speed of light, c. In Earth's troposphere, $|\vec{v}| \approx 0.9999997c$. The two defining characteristics of an electromagnetic wave are its wavelength (λ) and frequency (f). The wavelength is the distance between two adjacent peaks in the wave, and the frequency is the number of peaks passing a given point in space during a second. Wavelength and frequency are reciprocal with the speed of light ($f\lambda = c$), so if you know one quantity, you can easily find the other. For example, a typical radio wave transmitted by a 2-meter VHF station has a frequency of about 145 MHz. Dividing the speed of light ($\sim 3 \times 10^8$ m/s) by the frequency in Hz, we find that the wavelength in atmosphere of the signal from our station is 2.06 m. Since wavelength and frequency are reciprocal, an increase in wavelength corresponds to a decrease in frequency, hence, the 160 m band has a rather low frequency of 1.8 MHz.

The electromagnetic spectrum (Figure 2) includes all of the various energies of electromagnetic radiation ranging from extremely low frequency (ELF) ranges (with very long wavelengths) to all the way up to x rays and γ rays, which have very high frequencies and correspondingly short wavelengths. In between these extremes lie radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, and the entirety of the FCC spectrum allocation chart. The RF part of the electromagnetic spectrum is generally defined as that part of the spectrum from about 3 kHz to 300 GHz.

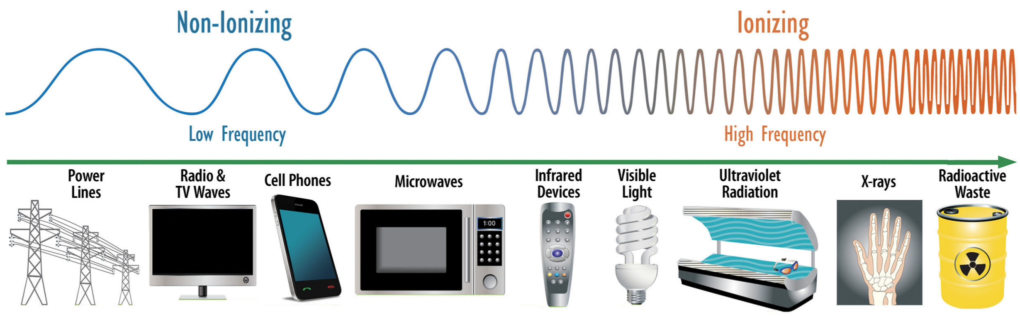


Figure 2: The Electromagnetic Spectrum

2 THE MFJ-9219

2.1 INTRODUCTION

The MFJ-9219 *QRP Tuner, Wattmeter, and Dummy Load*™ (Figure 3), is the logical continuation of MFJ's legendary lineup of QRP products. Combining the features of the MFJ-9201 *QRP Antenna Tuner*™ and the MFJ-9218 *QRP Pocket SWR/Wattmeter*™ into a single, conveniently-sized package provides both the novice and experience QRP operator with a robust addition to their station. Weighing in at only 51 oz and measuring only 5 × 4¹/₄ × 2¹/₂ inches, the MFJ-9219 can slip into almost any pack and won't be a burden down the trail. The MFJ-9219 will work out-of-the-box with the MFJ-9400 series of sideband transceivers, the VEC-1300 series, and for those desiring a true QRP challenge, MFJ's line of Cub transceivers. Which will you choose?

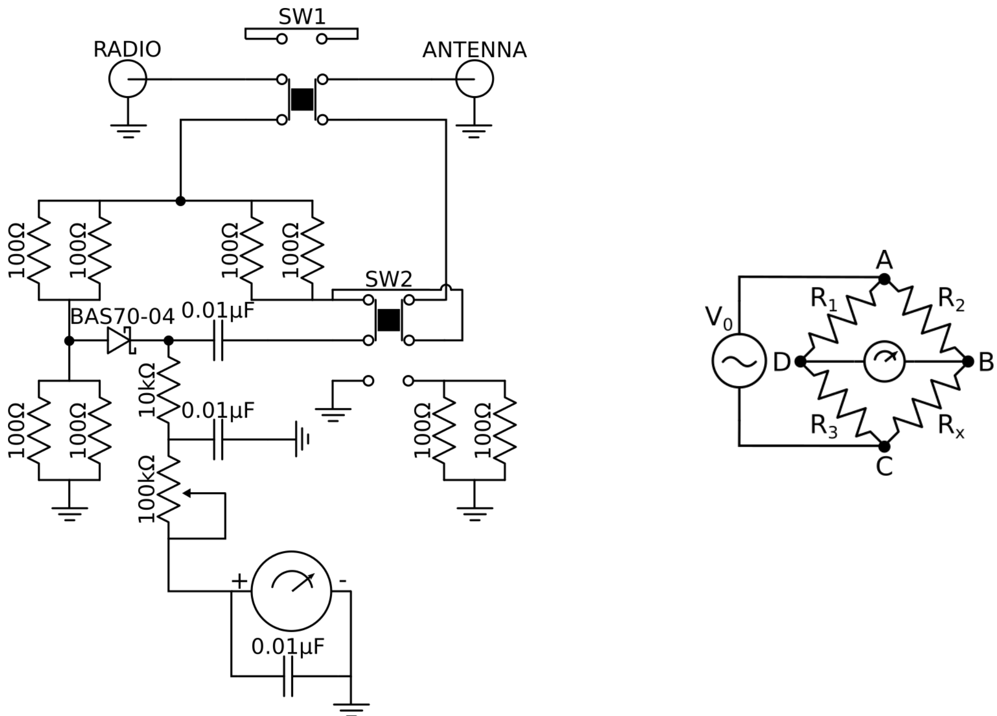
Figure 3: The MFJ-9219

2.2 THE WHEATSTONE BRIDGE

This section is solely for the enjoyment of those who wish to learn some of the theory behind amateur radio. Knowledge or understanding of it is not required to operate and enjoy the MFJ-9219.

The circuit used in the MFJ-9218 is known as a Wheatstone bridge and is shown in Figure 4a. The Wheatstone bridge is a simple circuit that was originally designed to determine an unknown resistance in a DC circuit but also works to determine unknown impedances in RF circuits. Several variants exist, but the one used in the MFJ-9218 can be simplified to the circuit shown in Figure 4b. The Wheatstone bridge works by measuring the current flowing between points B and D (I_{BD}). It is considered balanced when $I_{BD} = 0$, or due to Ohm's Law, $V_{BD} = 0$. In that case, $R_x = \frac{R_2 R_3}{R_1}$. If we define $R_1 = R_2 = R_3 \equiv 50\Omega$, then the value of R_x that will balance the bridge is also 50Ω.

This tells us that in the case of the MFJ-9219 and others like it, any imbalance (i.e. current flowing between points) B and D will occur only if $R_x \neq 50\Omega$. Assuming that the resistance of the ammeter



(a) MFJ-9219 Partial Circuit Schematic (b) A Wheatstone Bridge

Figure 4: Relevant Schematics

is sufficiently large that I_{BD} is negligible (reasonable for most meters and the MFJ-9219), V_{BD} can be written in terms of the source potential V_0 and the resistances. This is shown in Equation 1.

$$V_{BD} = V_0 \left(\frac{R_2}{R_1 + R_2} - \frac{R_x}{R_x + R_3} \right) \tag{1}$$

Finally, if we extend our source to include AC (or RF) potentials and replace R_x with a load, such as an antenna, we can write Equation 1 in terms of reactances to get

$$V_{BD} = V_0 \left(\frac{Z_2}{Z_1 + Z_2} - \frac{Z_x}{Z_x + Z_3} \right). \tag{2}$$

Resistors will have negligible reactances, so Z_1, Z_2, and Z_3 will only carry their resistances of 50Ω. This converts Equation 2 into

$$Z_x = R_3 \left[\frac{V_0 R_2 - V_{BD} \left(R_1 + R_1 \right)}{V_0 R_1 + V_{BD} \left(R_1 + R_2 \right)} \right]. \tag{3}$$

Now that we know the impedance in terms of known quatities ($R_1 = R_2 = R_3 = 50\Omega$, V_{BD} is measured by the meter, and V_0 is "programmed in" during SWR calibration), we can determine the SWR using Equation 4.

$$SWR \equiv \left(\frac{Z_x}{Z_0}\right)^{\pm 1} \tag{4}$$

where in our case, $Z_0 = 50\Omega$.

2.3 FEATURES

For such a small package, the MFJ-9219 is jammed-packed with features. The clear and readable multipurpose meter provides instant feedback regarding the status of your signal and antenna match. The compact and efficient T-network will match just about any load and has a bypass in the event it is not needed. Finally, the resistive wattmeter is coupled to a 20W dummy load that is engaged simultaenously as the wattmeter.

2.4 CONTROLS & CONNECTIONS

Figure 5: MFJ-9219 Controls. 1.) Multipurpose Meter, 2.) SWR Circuit BYPASS Switch, 3.) SWR/PWR Switch, 4.) METER SENSITIVITY Knob, 5.) RADIO Connection, 6.) ANTENNA Connection, 7.) INDUCTANCE Control, 8.) Tuner BYPASS Control, 9.) ANTENNA and TRANSMITTER Controls

1. **Multipurpose Meter:** Displays either SWR or power
2. **Meter BYPASS:** Bypasses the multipurpose meter
3. **SWR/PWR**: Toggles between SWR and wattmeter modes and engages the internal load
4. **METER SENSITIVITY:** Adjusts the sensitivity of the multipurpose meter
5. **RADIO:** Connection to the radio
6. **ANTENNA:** Connections to the antenna
7. **INDUCTANCE:** Adjusts the inductance in the tuner
8. **Tuner BYPASS:** Bypasses the tuner
9. **ANTENNA and TRANSMITTER:** Adjusts the capacitance for the antenna and radio

3 SYSTEM SETUP

Figure 6 shows a basic setup that utilizes the MFJ-9219. The necessary connections are simple: connect the RADIO port of the MFJ-9219 to your radio, and the ANTENNA port to your antenna. The MFJ-9219 does not use any external DC power, so once those connections are made the unit is ready to operate.

Figure 6: MFJ-9219 Basic Setup

4 SYSTEM OPERATION

Operating the MFJ-9219 is accomplished in two broadly-defined stages. First, set the SWR/Wattmeter for your radio and antenna. Second, engage the tuner and make necessary adjustments.

STAGE 1

Step 1 Bypass the tuner (Switch 8) and set the SWR/Wattmeter to TUNE (Switch 2).

Step 2 Set the SWR/PWR switch (Switch 3) to PWR.

Step 3 Set your radio to the desired transmit power (<20W) and key down. Adjust the METER SENSITIVITY knob until the needle on the multipurpose meter is pointing at full power (5) but is not pegged against the side. The wattmeter is unitless with power levels being displayed on a one to five scale. This means that in order to determine the displayed power, you need to multiply the reading by the appropriate scaling factor. For example, at 20W the scaling factor would be 4W ($20W \div 5 = 4W$).[*]

Step 4 Set the SWR/PWR switch to SWR.

[*] At higher power be sure to keep your transmissions into the internal load to less than 10 seconds to prevent overheating and damage to the unit.

STAGE 2

Step 1 Engage the tuner (Switch 8).
Step 2 Set the TRANSMITTER control to 5.
Step 3 Set the ANTENNA control to 0.
Step 4 Apply just enough RF power to obtain a noticeable deflection on the multipurpose meter.
Step 5 Adjust the INDUCTANCE control to find the lowest SWR.†
Step 6 Slowly adjust the TRANSMITTER control until the lowest SWR is obtained, then repeat with the ANTENNA control. These controls interact, so it will be necessary to switch back and forth between adjusting controls until a minumum is found.
Step 7 After the lowest SWR is obtained, use the INDUCTANCE switch to reduce the inductance by one switch position. Adjust the TRANSMITTER and ANTENNA controls for the lowest SWR. Continue this process until the lowest SWR cannot be repeated, then use the INDUCTOR switch to increase the inductance by one switch position. Tune for lowest SWR.
Step 8 Set the SWR/Wattmeter to bypass.

4.1 THERMAL WARNING

The resistor network in the MFJ-9218 is made up of eight 100Ω 2W surface-mount resistors. Six are used in SWR mode and all eight in Dummy Load and Power mode. Due to the small size of the devices the temperature increase is substantial. Above 5W limit the transmit time in SWR, Wattmeter, and Dummy Load mode to less than the time listed in Figure 7 and allow the resistors to cool for 2 to 5 minutes between transmissions. It is recommended to keep the power below 100W in BYPASS mode.

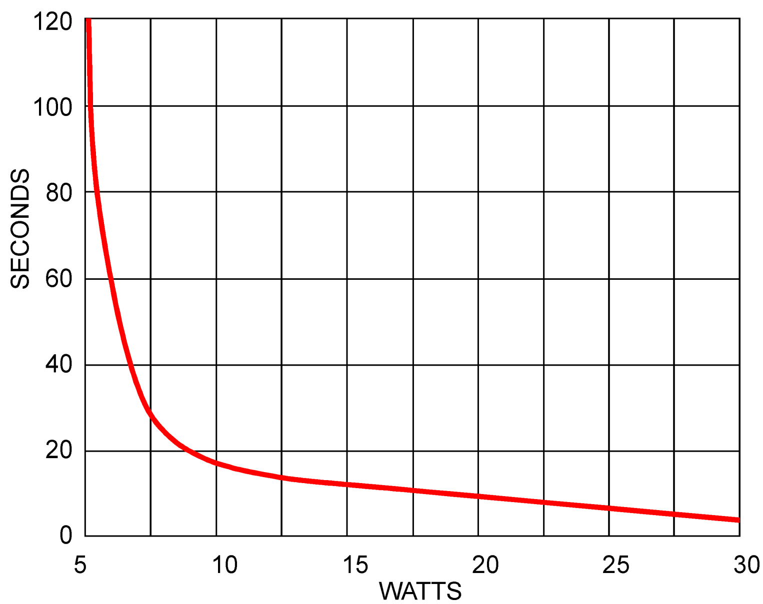


Figure 7: Safe transmitting times as a function of RF power

†Never transmit while adjusting the INDUCTANCE switch.

5 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 reading the manual does not solve your problem, 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 Facsimile (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.

USER NOTES