SWR Meter, Wattmeter, & Dummy Load
MFJ-9218

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.

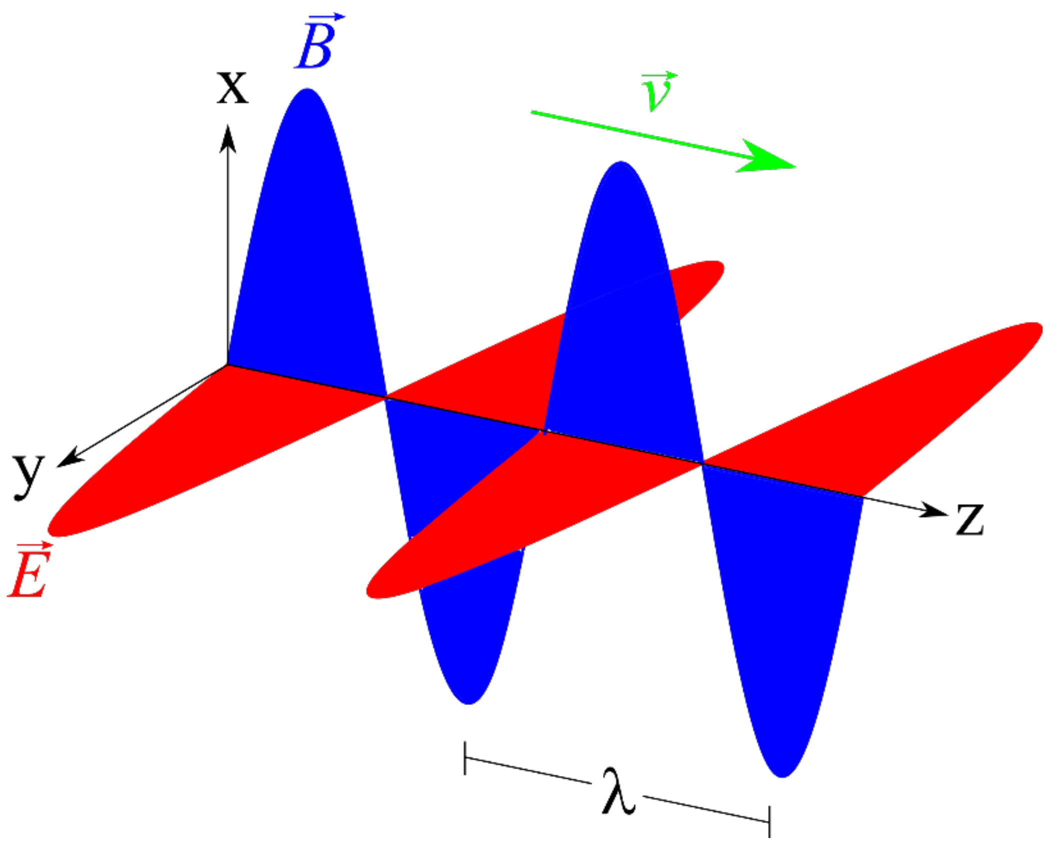


Figure 1: Horizontally-polarized Electromagnetic Plane Wave

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.

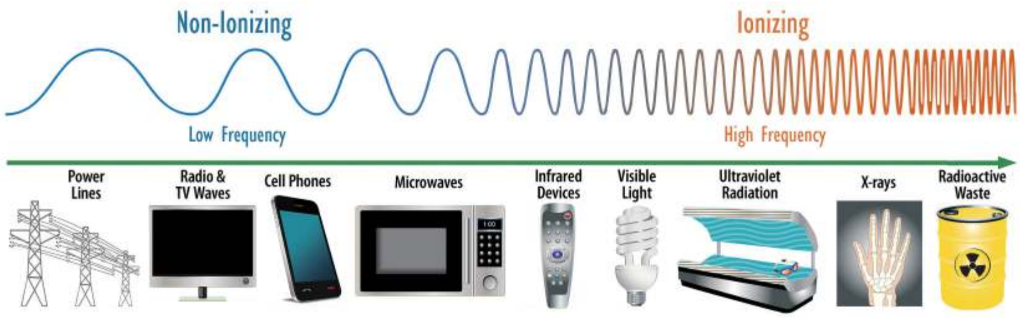


Figure 2: The Electromagnetic Spectrum

2 THE MFJ-9218

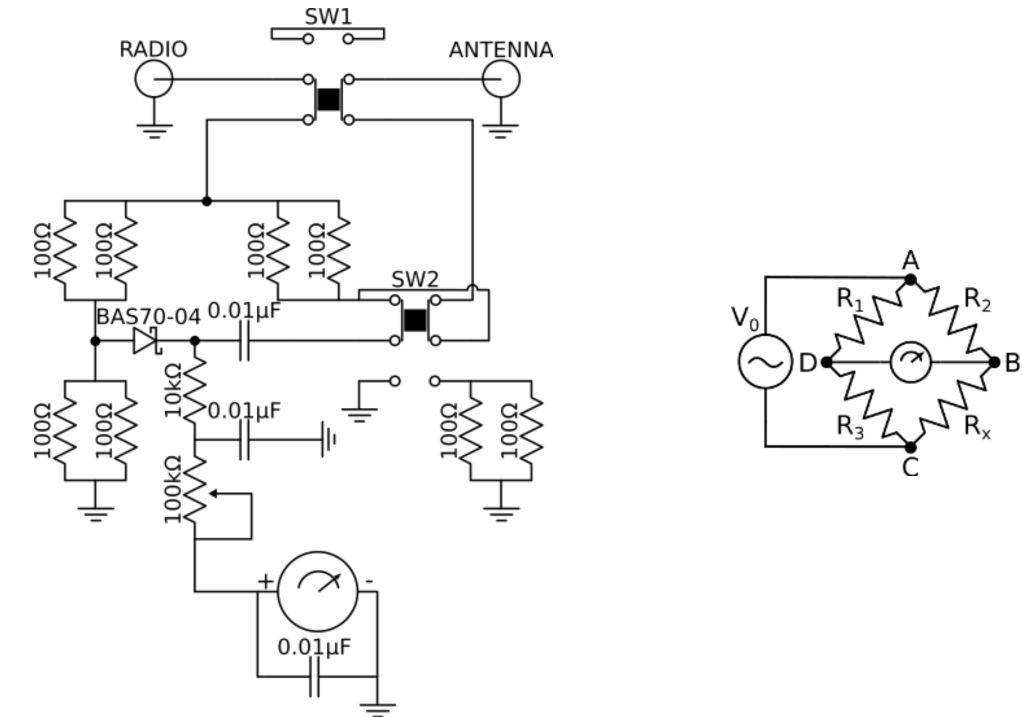
2.1 INTRODUCTION

The MFJ-9218 is a simple resistive QRP SWR Meter, Wattmeter, and Dummy Load. It is designed to be used with QRP transmitters (<5W) but can handle up to 20W for short periods. The MFJ-9218 uses 100Ω 2W surface-mount resistors in the network will work well up to 54MHz with a very low insertion SWR. The power measurement ranges are set by the METER SET pot and the reference marks on the front panel. These ranges are 0.5W, 1W, 5W, and 20W. Note these marks are only for reference and the power readings are only approximate.

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-9218.

The circuit used in the MFJ-9218 is known as a Wheatstone bridge and is shown in Figure 3a. 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



(a) MFJ-9218 Circuit Schematic (b) A Wheatstone Bridge

Figure 3: Relevant Schematics

variants exist, but the one used in the MFJ-9218 can be simplified to the circuit shown in Figure 3b. 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-9218 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 is sufficiently large that I_{BD} is negligible (reasonable for most meters and the MFJ-9218), 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

2.4 CONTROLS & CONNECTIONS

Figure 4: MFJ-9218 Controls. 1.) METER SET, 2.) INPUT, 3.) OUTPUT, 4.)TUNE/BYPASS, 5.) SWR/SET, 6.) Multifuntion Meter

1. METER SET: Adjusts the sensitivity of the multipurpose meter
2. RADIO: Connect to the radio
3. ANTENNA: Connect to the antenna
4. TUNE/BYPASS: Bypasses the MFJ-9218
5. SWR/PWR: Toggles between SWR and wattmeter modes and engages the internal load
6. Multipurpose Meter: Displays SWR and power depending on mode

3 SYSTEM SETUP

Figure 5 shows a basic setup that utilizes the MFJ-9218. The necessary connections are simple: connect the RADIO port of the MFJ-9218 to your radio, and the ANTENNA port to your antenna. The MFJ-9218 does not use any external DC power, so once those connections are made the unit is ready to operate.

Figure 5: MFJ-9218 Basic Setup

4 SYSTEM OPERATION

1. Connections
   (a) Connect the transmitter to the IN connector.
   (b) Connect the antenna or antenna tuner to the OUT connector
2. SWR Measurements
   (a) To measure SWR set the SWR/SET switch to OUT and transmit.
   (b) Adjust the meter with the METER SET pot to full scale on the meter.
   (c) Place the SWR/SET switch IN and read the SWR on the SWR scale of the meter. The resistive network will temper the SWR on the transmitter to less than 2:1 and depends on the antenna impedance. Only a fraction of the transmitted power reaches the antenna in this mode, so be sure to switch back to BYPASS when ready to operate.
   (d) Above 5W limit the transmitter time to the time indicated in Figure 6.
3. Power Measurements and Dummy Load
   (a) To use as a DUMMY LOAD set the SWR/SET switch OUT. The internal resistive network is a 50 ohm load which will handle 5W power continuous or higher power for short periods of time.
   (b) To measure POWER the SWR/SET switch is OUT.
   (c) Set the marker on the METER SET pot to the scale mark desired.
   (d) Key the transmitter and measure the power on the meter RF PWR scale.
   (e) Above 5W limit the transmitter time to the time indicated in Figure 6.

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 the 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 6 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.

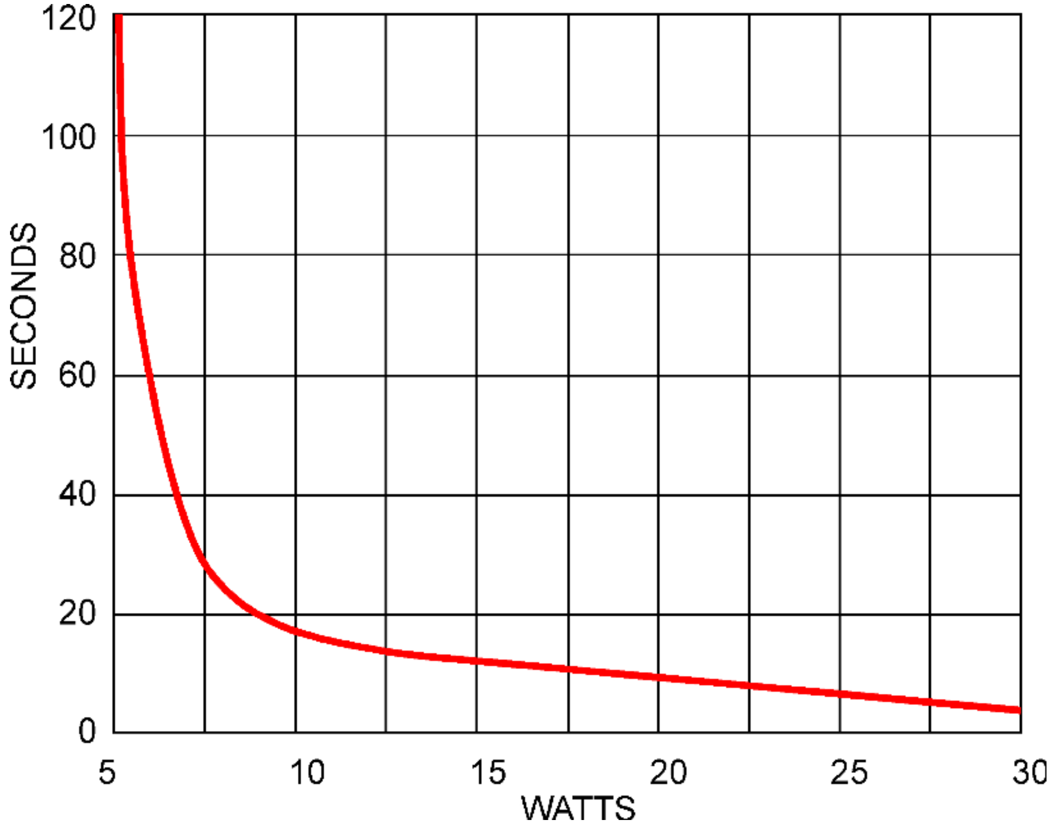


Figure 6: Safe transmitting times as a function of RF power

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