MFJ-269 SWR HF/VHF ANALYZER

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Warning: READ SECTION 2.0 BEFORE ATTEMPTING TO USE THIS PRODUCT!

INTRODUCTION 1.0 DESCRIPTION

MFJ-269 SWR HF/VHF ANALYZER

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Warning: READ SECTION 2.0 BEFORE ATTEMPING TO USE THIS PRODUCT

INTRODUCTION

Attention: Read section 2.0 before attempting to use this product. **Incorrect power supply voltages** or excessive **external voltages applied to the ANTENNA connector** will **damage** this unit.

1.0 Description

The MFJ-269 RF analyzer is a compact battery powered RF impedance analyzer. This unit combines five basic circuits; a variable oscillator, frequency counter, frequency multiplier, 50 ohm RF bridge, a twelve-bit A-D converter, and microcontroller. This unit performs a wide variety of useful antenna and RF impedance measurements, including coaxial cable loss and electrical distance to an open or short.

Primarily designed for analyzing 50 ohm antenna and transmission line systems, the MFJ-269 also measures RF impedances between a few ohms and several hundred ohms. An easily accessed user-controlled Zo setting in the **ADVANCED** function menus allows changing SWR and other SWR functions (i.e. return loss, reflection coefficient, match efficiency, etc) to any normalized impedance value between 5 and 600 ohms.

The MFJ-269 also functions as a non-precision signal source and frequency counter. The operating frequency range of this unit extends from 1.8 to 170 MHz in six overlapping bands, and includes SWR measurements on 415-470 MHz.

1.1 Typical Uses

The MFJ-269 can be used to adjust, test, or measure the following:

Antennas: SWR, impedance, reactance, resistance, resonant frequency, and bandwidth
Antenna tuners: SWR, bandwidth, frequency
Amplifiers: Input and output matching networks, chokes, suppressors, traps, and components
Coaxial transmission lines: SWR, length, velocity factor, approximate Q and loss, resonant frequency, and impedance
Filters: SWR, attenuation, and frequency range
Matching or tuning stubs: SWR, approximate Q, resonant frequency, bandwidth, impedance
Traps: Resonant frequency and approximate Q
Tuned Circuits: Resonant frequency and approximate Q
Small capacitors: Value and self-resonant frequency
RF chokes and inductors: Self-resonant frequency, series resonance, and value
Transmitters and oscillators: Frequency

The MFJ-269 measures and directly displays the following:

Electrical length (feet or deg)	Impedance phase angle(degrees)	Resonance (MHz)
Feedline Loss (dB)	Inductance (µH)	Return loss (dB)
Capacitance (pF)	Reactance or X (ohms)	Signal Frequency (MHz)
Impedance or Z magnitude (ohms)	Resistance or R (ohms)	SWR (Zo programmable)

The MFJ-269 is useful as a non-precision signal source. It provides a relatively pure (harmonics better than -25 dBc) signal of approximately 3 Vpp (approximately 20 milliwatts) into 50 ohm loads. The MFJ-269 internal source impedance is 50 ohms. The MFJ-269 is not a stable generator, but has adequate stability for non-critical applications such as alignment of broad bandwidth filters and circuits.

Note: A more complete description of the MFJ-269's features and proper measurement methods can be found by reading the sections on the particular measurement you wish to make. Consult the table of contents for the various applications.

1.2 Frequency Range

The **FREQUENCY** switch selects the following internal oscillator frequency ranges. (A small overlap outside each range is provided):

1.8 - 4 MHz	27 - 70 MHz	415-470 MHz
4 - 10 MHz	70 - 114 MHz	
10 - 27 MHz	114- 170 MHz	

1.3 A Quick Word about Accuracy

The following text details several common problems and reasons they occur. The most likely source of false readings, when measuring antennas, is unintentional external voltages applied to the antenna port of this unit. An optional HF filter, MFJ-731, greatly reduces external interference without modifying impedance or SWR measurements a significant amount.

Measurement errors.

Unreliable readings are rooted in three primary areas:

1.) Signal ingress from external voltage sources, usually strong AM broadcast stations.

2.) Diode detector and A/D converter errors.

3.) The impedance of connectors, connections, and connecting leads.

Broad-band voltage detectors. Narrowband detectors are expensive, since narrowband detector systems must have at least one selective gain-stabilized receiver. Narrowband detectors would price antenna and impedance analyzers far outside the price range of most hobbyists.

Broadband detectors are sensitive to out-of-band external voltages, and solutions to most out-of-band interference are not simple. Common low-pass or band-pass filters behave like transmission lines of varying impedances on different frequencies. Low-pass or high-pass filters change impedance and SWR readings, just as an additional section of transmission line would. This modification of impedance caused by filters severely limits their usefulness when used with impedance measurement devices.

Most RF interference problems occur on lower frequencies, since high power AM broadcast signals and other external voltage sources couple better into large antennas (especially 160 meter verticals). The MFJ-731 is an adjustable filter that attenuates all off-frequency signals. It also contains an adjustable notch covering the AM broadcast band. Properly used on amateur bands between 1.8 and 30 MHz, this adjustable filter reduces external interference and has almost no effect on system measurements.

Note: A solution often suggested by users is to increase internal generator power. Unfortunately the power required to operate a low harmonic-distortion broadband VFO system is the single largest drain on the internal battery. In this unit, more than 70% of the total battery drain (-150 mA) is used to produce the low harmonic-distortion test signal. We have selected the best compromise between battery life and harmonic-distortion.

Component limitations. At low voltage, detector diodes become very non-linear. The accuracy of the MFJ-269 is enhanced by the use of special microwave zero-bias Schottky detectors with matching compensating diodes. Each unit is individually compensated to provide the best possible detector linearity.

Connection lengths. Connection lengths both inside and outside the bridge upset readings, especially when impedance is very high or very low. The MFJ-269 minimizes internal problems by using surface mount low capacitance microwave components with nearly zero lead length. Remember any external leads you add, even short leads, modify the impedance of the load at radio frequencies.

Note: To obtain greatest accuracy, use the minimum possible length of leads and the fewest possible connectors or adapters. Rather than present readings outside the reliable range as exact numbers, the MFJ-269 gives a display warning. If (Z>1500) appears on the display, the impedance is greater than 1500 ohms and outside the reliable instrument range.

2.0 POWER SOURCES

This section describes power supply and battery selection.

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READ THIS SECTION BEFORE CONNECTING THIS DEVICE TO ANY POWER SOURCE. IMPROPER CONNECTIONS OR INCORRECT VOLTAGES MAY CAUSE DAMAGE TO THIS PRODUCT!

2.1 External Power Supply

MFJ has an optional power supply, the MFJ-1315, that satisfies all external supply requirements. We highly recommend using this supply.

Voltage must be more than 11 volts, and preferably less than 16 volts, when the unit is on and operating. Maximum "sleep mode" and "OFF" voltage (when the power supply is lightly loaded by this unit) is 18 volts. The supply must be reasonably well filtered, the case of the MFJ-269 is connected directly to the negative terminal. The supply must *not* have a grounded positive lead.

The MFJ-269 can be used with external low voltage dc supplies (MFJ-1315 AC adapter recommended). The ideal supply voltage is 14.5 volts dc, but the unit will function with voltages between 11 and 18 volts. The current demand is 150 mA maximum on HF and VHF, and 250 mA maximum on UHF).

WARNING: READ SECTION 2.2 THROUGH 2.4 (BATTERY INSTALLATION INSTRUCTIONS) BEFORE INSTALLING BATTERIES.

The MFJ-269 has a recessed 2.1 mm power-type receptacle near the RF connectors. This receptacle is labeled **"POWER 12VDC"**.

The outside conductor of the **POWER** receptacle is negative, the center conductor positive.

Inserting a power plug in the "**POWER 12VDC"** receptacle disables internal batteries as a power source. Internal batteries, although disabled for operating power by inserting a power supply plug, can still be trickle charged.

WARNING: REVERSE POLARITY OR EXCESSIVE VOLTAGE CAN DAMAGE OR DESTROY THE MFJ-269. NEVER APPLY MORE THAN 18 VOLTS, NEVER USE AC OR POSITIVE GROUND SUPPLIES! NEVER ADD OR REMOVE BATTERIES WITH AN EXTERNAL POWER SUPPLY CONNECTED TO THIS UNIT, OR WITH THE POWER SWITCH ON.

2.2 Using Internal Batteries

When batteries are initially installed, a small black-plastic internal jumper must be re-positioned or checked for proper position. The battery setting jumper is located inside the unit at the top of the printed circuit board near the area of the OFF-ON switch and power connector. This jumper is accessed by removing eight screws along the both sides of the MFJ-269. After the cover mounting screws are removed, remove the entire back cover. The black plastic jumper fits over two of three adjacent pins. It must be properly positioned for the type of battery used (either rechargeable or non-rechargeable).

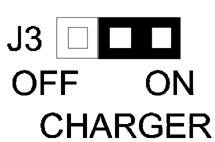
For battery replacement, batteries are accessed by removing the MFJ-269's cover. Be sure the charger switch is in the correct position when replacing batteries.

2.3 Using Rechargeable "AA" Type Batteries

CAUTION: AVOID USING EXTERNAL POWER SOURCES HAVING LESS THAN 13 VOLTS IF RECHARGEABLE BATTERIES ARE INSTALLED. IF EXTERNAL SUPPLY VOLTAGE IS TOO LOW, THE CHARGER WILL NOT WORK PROPERLY AND BATTERIES WILL EVENTUALLY DISCHARGE. WE RECOMMEND RECHARGING DISCHARGED BATTERIES WITH THE MFJ-269 POWER SWITCH OFF, WITH ENOUGH CHARGING TIME TO ESTABLISH FULL BATTERY CHARGE (AT LEAST TEN HOURS). NEVER CHANGE BATTERIES WITH THE POWER SWITCH ON, OR WITH AN EXTERNAL SUPPLY PLUGGED INTO THE MFJ-269.

The internal charger trickle can be used to charge internal batteries. The charger functions any time proper external voltage is applied, even when the MFJ-269 is turned off. Proper charger operation requires an external supply operating between 14 to 18 volts. Whenever the external supply is operating between 14-18 volts, the internal trickle charging circuit will operate correctly. Typical battery charging current is 10-20 mA through the internal charging system. The MFJ-1315 supply fulfills all power supply requirements. Batteries should be removed before shipping this unit.

When using rechargeable batteries, the internal black plastic jumper located inside the cover (near the external power jack on the circuit board) must be set to the proper position. If it is not set to the proper position, the batteries will not charge. With rechargeable batteries, the internal charger jumper located on the printed circuit board near the power jack should be set like this:



Charger is now ON

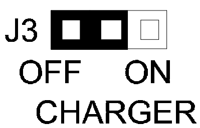
2.4 Using Conventional "AA" Drycell Batteries

If possible, use good quality alkaline batteries. Conventional batteries can be used with the MFJ-269, but high quality alkaline batteries offer slightly less risk of battery leakage generally provide longer service and shelf life.

If you use any type of non-rechargeable dry cell battery, *remove weak batteries immediately*. Batteries must be removed before storing this unit for extended periods of time (longer than one month). Never ship this unit with batteries installed.

WARNING: WHEN USING CONVENTIONAL NON-RECHARGEABLE BATTERIES, THE CHARGING SYSTEM MUST BE DEFEATED! IF YOU FAIL TO FOLLOW THIS WARNING, THE BATTERIES WILL LIKELY LEAK AND RUIN THE ANALYZER!

When using conventional non-rechargeable batteries, the internal jumper located on the printed circuit board near the power jack *must be* set like this:



Charger is now OFF!

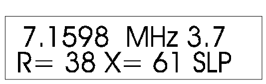
2.5 Blinking "VOLTAGE LOW" display warning

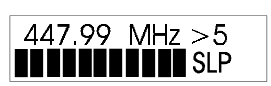
a.) If supply or battery operating voltage is less than eleven volts, a blinking "**VOLTAGE LOW**" warning is displayed. Pressing the "**MODE"** button during a low voltage warning will disable the warning, and allow operation with low supply voltage. Readings might not be reliable when operating with supply voltages of under 11 volts.

2.6 "Power Saving" Mode (sleep mode)

The operating current drain of the MFJ-269 is approximately 135 mA for HF operation.

Battery life is extended by using an internal "Power Saving" mode. "Sleeping" battery drain is less than 15 mA. If you do not make **MODE** switch changes, or change frequency more than 50 kHz during any three minute time period, a power saving (Sleep) mode begins. "Sleeping" is indicated by a blinking **"SLP"** message in the display's lower right corner, as shown here:





To wake the unit up, momentarily press the ''**MODE**'' or ''**GATE**'' button.

Disable the "Power Saving" mode by pressing and holding the **"MODE"** button before power is applied (or before the "**POWER"** button on the unit is turned on). You must hold the **"MODE"** button and only release it after the copyright message appears.

If the "Power Saving" mode is successfully disabled on power up, when the **"MODE"** button is released the display will momentarily indicate:

```
Power Saving   OFF
```

3.0 MAIN MENU and DISPLAY

WARNING: NEVER APPLY RF OR ANY OTHER EXTERNAL VOLTAGES TO THE ANTENNA PORT OF THIS UNIT. THIS UNIT USES ZERO BIAS DETECTOR DIODES THAT MAY BE DAMAGED BY EXTERNAL VOLTAGES. READ SECTION 2.0 BEFORE APPLYING POWER TO THIS UNIT! INCORRECT SUPPLY VOLTAGES CAN ALSO DAMAGE THIS UNIT.

3.1 General Connection Guidelines

The **"ANTENNA"** connector ("N" female) on the top of the MFJ-269 provides the primary RF measurement connection. This connector is used for all measurements except frequency counter measurements.

The **"POWER"** connector (2.1 mm type) is described in section 2.0. Be sure to read section 2.0 before operating this unit. Improper or incorrect power supply voltage or wiring could permanently damage this unit.

The **"FREQUENCY COUNTER INPUT"** connector (BNC type) is for frequency counter use only. Correct use of this connector is described in section 4.5.

3.2 Power-up Display

CAUTION: THERE IS A ''UHF'' SWITCH LOCATED AT THE UPPER LEFT-HAND SIDE OF THE ANALYZER. THIS SWITCH SHOULD BE PRESSED AND LOCKED FOR UHF OPERATION ONLY WHEN UHF OPERATION IS DESIRED AND ONLY AFTER THE UNIT IS POWERED UP. FOR INFORMATION ON UHF OPERATION, SEE SECTION 3.4

Note: The following is a description of the opening or default menu used by the MFJ-269. This unit also has an advanced user section in section 4.0.

After turning on the "**POWER**" switch, or after applying external power with the **"POWER"** switch on, a sequence of messages appears on the display.

The first message is a program version, this "VER" number indicates the software version.

```
MFJ-269
Rev.  1.12
```

The second message is the software copyright date.

MFJ-Enterprises
(c) 1999

Note: Pressing the **"MODE"** button before applying power or turning the **"POWER"** switch on, and continuing to hold the **"MODE"** button down until the copyright message appears, causes a "POWER SAVING OFF" message to appear just as the **"MODE"** button is released. This message appears just before the voltage check. This message confirms the battery saving "sleep mode" has been disabled.

The third message is a voltage check. It displays the operating voltage, indicating battery charge or external power supply voltage.

Voltage Low 9.5V

Voltage OK 14.7V

The final power-up display is the "working" display described in 3.3 (Impedance R&X) below.

Two panel meters indicate SWR and Impedance of loads connected to the **"ANTENNA"** port.

If you press the **"MODE"** button after the operating display is up, the mode changes. After releasing the **"MODE"** button, the display will show the type of data measured in the newly selected mode step. The five main (or opening) measurement modes are described below.

3.3 Main MODE descriptions (HF Functions Only)

CAUTION: THERE IS A ''UHF'' SWITCH LOCATED AT THE UPPER LEFT-HAND SIDE OF THE ANALYZER. THIS SWITCH SHOULD BE PRESSED AND LOCKED FOR UHF OPERATION ONLY WHEN UHF OPERATION IS DESIRED AND ONLY AFTER THE UNIT IS POWERED UP. FOR INFORMATION ON UHF OPERATION, SEE SECTION 3.4

Mode is changed by momentarily pressing the **"MODE"** button during normal operation. As the mode changes, a description of the mode appears on the screen for a few seconds. The five "Main menu" display modes are described below:

1.) The initial power-up mode is **Impedance R&X**. When initialized, the following message appears briefly on the front panel display:

IMPEDANCE
R & X

In this mode, the MFJ-269 LCD (liquid crystal display on front panel) shows frequency in MHz, SWR, the resistive part of load impedance (R=), and the reactive part of load impedance (X=). The IMPEDANCE meter displays the complex impedance (Z in ohms), and the SWR meter displays SWR.

7.1598 MHz 3.6 Rs=153 Xs= 62 SWR	14.095 MHz >31 Rs(Z>1500) SWR

Note: Unless in the advanced modes, this unit displays load impedance in the conventional manner we are all used to seeing. The standard way we describe impedance is a resistance in series with a reactance.

SWR measurements in this menu are referenced or normalized to 50 ohms Zo., the normal impedance used in transmitting systems.

Note: Advanced mode 3 allows measurement of SWR with lines other than 50 ohms Zo.

2.) Coax Loss, the second mode, is reached by pressing the **"MODE"** button once. The liquid crystal display (LCD) indicates the test frequency and approximate loss of any 50 ohm coaxial cable, attenuator pad, or transformer or balun (for differential mode current only). In this mode, the 50 ohm device or cable under test must not be connected or terminated by a load resistance at the far end. If the device under test is terminated in anything that dissipates power, measured loss will be higher than actual loss.

Note: Advanced mode 3 allows measurement of loss in lines other than 50 ohms Zo.

3.) Capacitance in pF is the third mode. The LCD shows measurement frequency, capacitive reactance (Xc=) in ohms, capacitance (C=) in picofarads or pF. The **Impedance** meter indicates reactance in ohms, and the SWR meter displays SWR.

4.) Inductance in µH is the fourth mode. The digital display indicates measurement frequency, inductive reactance (Xl=) in ohms, inductance (L=) in microhenries or µH. The **Impedance** meter indicates reactance in ohms, the **SWR** meter displays SWR.

5.) Freq. Counter is the fifth and final function of the main mode. The BNC connector labeled "**FREQUENCY COUNTER INPUT"** should connect to the RF sample you want to measure. The sensitivity of this port ranges from 10 millivolts at 1.7 MHz to 100 millivolts at 180 MHz. The **"GATE"** button controls the gate time of the frequency counter. Longer gate times are accompanied by additional digits in the display, increasing counter resolution.

 Freq. Counter

14.32 MHz 0.01s Freq. Counter	14.325 MHz 0.1 s Freq. Counter	14.3258 MHz 1 s Freq. Counter

WARNING: NEVER APPLY MORE THAN TWO VOLTS OF PEAK VOLTAGE, OR ANY DC VOLTAGE, TO THE FREQUENCY COUNTER BNC PORT.

3.4 UHF Operation

UHF Operation is selected while the **"UHF"** button on the upper left corner is depressed and locked. UHF frequency adjustment is available by setting the **"FREQUENCY MHz"** switch to **"114-170 UHF"** position and adjusting the **"TUNE"** knob. The display will give a warning if the frequency is outside the correct operating range. Typical operating frequency range is 415 to 470 MHz.

The out-of-range frequency warning displays are:

INCREASE FREQUENCY	DECREASE FREQUENCY

Be sure the **"FREQUENCY MHz"** selector is in the correct extreme counterclockwise position for UHF operation. Adjust the **"TUNE"** control for the correct frequency range.

4.0 Main (or Opening) mode

Main

CAUTION: THERE IS A ''UHF'' SWITCH LOCATED AT THE UPPER LEFT-HAND SIDE OF THE ANALYZER. THIS SWITCH SHOULD BE PRESSED AND LOCKED FOR UHF OPERATION ONLY WHEN UHF OPERATION IS DESIRED AND ONLY AFTER THE UNIT IS POWERED UP. FOR INFORMATION ON UHF OPERATION, SEE SECTION 3.4

WARNING: ***Never apply RF or any other external voltages to the ANTENNA port of this unit. This unit uses zero bias detector diodes that are easily damaged by external voltages over a few volts. Be sure the power supply is correct, as described in section 2.0, before operating this unit.***

A basic understanding of transmission line and antenna behavior and terminology is very important in understanding information provided by the MFJ-269. Most explanations are available in the ARRL Handbooks, and they should suffice for amateur applications. Avoid relying on popular rumor, or unedited, poorly edited, or self-edited handbooks or articles.

4.1 General Connection Guidelines

a.) The **ANTENNA** connector (Type "N" female) on top of the MFJ-269 provides the RF measurement output connection. This port is used to measure SWR or perform other RF impedance measurements, with the exception of the Frequency Counter mode.

Warning: *Never apply external voltages or RF signals to the antenna connector.*

b.) Remember to use proper RF connections. Keep leads as short as possible when measuring components or any system or device that is not part of the entire system. When measuring 50 ohm coaxial systems or antennas, interconnecting transmission lines may modify impedance and SWR. Use properly constructed 50 ohm coaxial cables of known quality.

c.) Advanced 3 modes allow user selection of custom impedances in case the system under test is not a 50 ohm system.

4.2 HF/VHF Main modes

4.2.1 Antenna system SWR

IMPEDANCE
R & X

Note: 50 ohms is the default SWR impedance. This unit can be set to impedances other than 50 ohms in the Advanced 3 menu.

To measure SWR of an antenna or an antenna tuner input:

a.) If the antenna does not use a dc grounded element and feed system, momentarily short the antenna lead from shield to center. This prevents static charges from damaging the MFJ-269's zero bias detector diodes.

b.) Immediately connect (in the case of a non-dc grounded feed system) the antenna lead to the MFJ-269 **"ANTENNA"** connector.

c.) Set the **"FREQUENCY"** knob to the proper frequency range.

d.) Turn the MFJ-269 **"POWER"** switch on, while watching the display. Battery voltage should be "OK", and indicate more than 11 volts and less than 16 volts.

e.) The main or opening mode opening menu displays frequency, SWR, resistance, and reactance on the LCD, and SWR and impedance on the analog meters. In this mode, the resistance (real part) and reactance (imaginary part) of the system impedance is displayed in ohms.

7.1598 MHz 3.6
Rs=153 Xs= 62 SWR

14.095 MHz >31
Rs(Z>1500) SWR

f.) Adjust the **"TUNE"** knob until the counter displays the desired frequency, or until you find the lowest SWR.

Advanced antenna measurement modes are available and described in section 5.0. Many advanced descriptions are just different ways of displaying the same basic information given in the **MAIN** (or normal opening) mode menu. Unless you fully understand the meaning of terms used in advanced mode measurements, we suggest you avoid them.

Antenna hints:

Display readings are always the SWR, impedance and resonant frequency of the antenna system ONLY at the point in the system the MFJ-269 is connected. The impedance and resonant frequency (frequency where reactance crosses zero) at the point where this unit is connected might not be the resonant frequency of the antenna itself. This happens because a transmission line can add reactance or cancel reactance, and change the impedance and resonant frequency of the antenna system.

This unit displays the antenna's complex impedance, 50 ohm SWR (unless another impedance is selected and measured in Advanced mode 3), and resonant frequency as modified by transmission line "effects" of the feedline and other components between

the antenna and the MFJ-269. If the line is 50 ohms (or the impedance selected in advanced mode 3), this unit will always display the feedline's true SWR, with the exception of a reduction in SWR present in feedlines having appreciable loss.

1.) ***RESONANT FREQUENCY*** is where reactance is zero ohms, or in some cases as close to zero ohms as the MFJ-269 indicates. Lowest SWR is often *not* at the point of lowest reactance, or resonance. That's because the resistance may be wrong where reactance is zero (resonant). The most desirable load is almost always the lowest SWR, even though it may not be resonant.

2.) An ***IMPEDANCE*** of 50 ohms can be composed of both resistance and reactance. If the impedance is 50 ohms (or whatever the meter measures), but the SWR is not 1.0 to 1, reactance is probably making up part or all of the impedance. Contrary to popular misconception, it is impossible to obtain a 1:1 SWR when the load is reactive. This is true even if the complex impedance is exactly 50 ohms.

A good example is a 50 ohm load with almost pure reactance and almost zero resistance. The MFJ-269 LCD will indicate R=0 X=50 while the impedance meter reads 50 ohms or the Z display indicates a 50 ohms impedance. The SWR would overflow (SWR>25) because the nearly-pure 50 ohm reactance and impedance load absorbs almost no power from the source. It has a nearly infinite SWR, despite having an impedance of 50 ohms.

On the other hand if resistance is near 50 ohms and reactance near zero, the impedance would remain 50 ohms. SWR would be 1:1 in this case, since a dissipative resistance readily accepts power from the source.

3.) **Electrical Half-wave lines** only "repeat" the far-end impedance over a narrow frequency range. The line is only "impedance transparent" when lossless and an exact electrical multiple of 1/2 wavelength. On other frequencies, the line will not repeat the true feedpoint impedance of the antenna. The longer the transmission line is when measured in wavelengths, the "more length and frequency critical" it becomes. A longer line has larger errors in repeating load impedance when operated slightly off-frequency, and also has additional errors due to line loss.

4.) **Resonance** at the feedpoint only repeats when a mismatched feedline is an exact multiple of 1/4 wl. If the line is not an exact multiple of 1/4 wl, the resonant frequency of the antenna might be shifted higher or lower by the transmission line. A mismatched line that is not an exact multiple of a quarter-wavelength adds reactance that can either cancel antenna reactance at frequencies where the antenna is not resonant, or add reactance at frequencies where the antenna is resonant.

Multiple antenna-and-feedline-combination resonances commonly occur with antennas, where reactance crosses zero (indicating system resonance) at frequencies other than the antenna's actual resonant frequency. This is a normal effect.

5.) **Line length does not change SWR** if the line is a 50 ohm line (or matches the Zo of the instrument), has no radiation or parallel currents, and if the line has minimal loss. If the line is not perfectly matched, impedance and resonant frequency normally change from line transformation effects but the true SWR will not change.

6.) **If SWR changes** with coaxial line length, line placement, or feedline or equipment grounding, the feedline has one or more of the following shortfalls:

a.) The feedline is carrying common mode current and radiating.

b.) The feedline is not a 50 ohm line, or does not exactly match the impedance the analyzer is programmed for.

c.) The feedline has significant loss.

4.2.2 Coax Loss

The second main (or opening) mode is **"Coax Loss".** Access this mode by turning the MFJ-269 on and stepping to the Coax Loss display with the **MODE** button. In this mode, the MFJ-269 LCD indicates frequency and coax loss in dB. The **IMPEDANCE** meter is disabled. This mode was designed to measure 50 ohm cables, but measures differential mode loss in many types of 50 ohm transmission line transformers and choke baluns, as well as loss in 50 ohm attenuator pads.

Note: An additional coax loss function is available in Advanced 3. Advanced 3 allows user selection of analyzer impedance, and measurement of loss non-50 ohm systems.

Caution: Do not measure loss of conventional transformers, attenuators, or coaxial cables with impedances other than 50 ohms in the **"MAIN"** menu. When making loss measurements, the opposite end of the device-under-test must have an open circuit, a short circuit, or a pure reactance for termination. Any termination loss will make attenuation appear worse than it actually is. The "**ADVANCED 3"** menu allows measurement of devices with impedances other than 50 ohms.

a.) To measure loss, connect the MFJ-269 to the 50 ohm cable, attenuator, or the transmission line type balun or transformer to be measured. Be sure the distant end of the component tested is not terminated in any resistance or other lossy termination.

b.) Turn the MFJ-269 on. After the display reaches the opening **"MAIN"** measurement functions, press the **MODE** switch once.

Note: You can step through other menus and back to this mode by repeatedly pressing the mode button.

c.) The display should momentarily flash **"Coax Loss".**

```
Coax Loss
```

d.) Read the loss in dB at any frequency this unit covers.

```
28.721 MHz
Coax Loss  =  24 dB
```

```
144.23MHz
Coax Loss   = 0.6 dB
```

```
50.157 MHz
Coax Loss  < 0.28 dB
```

4.2.3 Capacitance

Note: The MFJ-269 measures reactance, and converts reactance to capacitance. The MFJ-269 can not determine if the reactance is actually inductive or capacitive. You can usually determine the type of reactance by adjusting frequency. If frequency is increased and reactance (X on the display or Impedance on the meter) decreases, the load is capacitive at the measurement frequency. If frequency is reduced and reactance decreases, the load is inductive at the measurement frequency. This does NOT apply to antennas and also to other loads when they viewed through a transmission line more than a small fraction of a wavelength long.

"Capacitance in pF" is the third mode. It measures capacitance values (in pF) at whatever frequency you select on the display. Normal measurement range is from a few pF to a few thousand pF. The front panel **IMPEDANCE** meter indicates reactance (X in ohms) of the capacitor.

Note: It is normal for the reactance of a capacitor to change gradually with frequency. This effect occurs because series inductance in the leads and sometimes in the capacitor causes *effective* capacitance to change with frequency.

The MFJ-269 becomes inaccurate measuring reactances below 7 ohms or above 1500 ohms. If the reactance of the component is outside reliable ranges, **"C(X<7) [X]"** or **"C(Z>1500)"** will be displayed. When the warning is displayed, capacitance is not measured.

15.814 MHz 51
C= 197 pF Xc

4.0456MHz
C(Z>1500) Xc

4.0456MHz
C(X<7) Xc

4.0456MHz
C(X=0) Xc

To measure capacitance:

a.) Turn the MFJ-269 on and step through with the mode switch until the **"Capacitance in pf"** display appears.

Capacitance
in pF

b.) Connect the capacitor across ANTENNA connector with the shortest leads possible, or with the lead length normally used in the working circuit.

c.) Adjust the MFJ-269 to a frequency near where you plan to use the component, but be sure the unit does not produce a range warning. **"C(Z>1500)"** warning indicates the measurement frequency is too low, and **"C(X<7)"** is a warning that indicates the frequency is too high. **"C(X=0)"** indicates the capacitor appears to be a near perfect short at the operating frequency of the MFJ-269. It means either the capacitor is shorted, the measurement frequency is too high, or the capacitor value is too large to be measured.

Note: At higher frequencies the effective capacitance increases, reaching infinite capacitance when the capacitor and stray inductance becomes series-resonant.

The frequency where the capacitor's impedance, and the leads connecting to the capacitor, becomes (X=0) is the series resonant frequency. Bypass capacitors are sometimes intentionally operated at or near the series or self resonant frequency, but most applications are at frequencies far below the series resonant frequency.

4.2.4 Inductance

Note: The MFJ-269 measures reactance, and converts reactance to inductance. The MFJ-269 can not determine if the reactance is actually inductive or capacitive. You can usually determine the type of reactance by adjusting frequency. If frequency is increased and reactance ("X" on the display or impedance on the IMPEDANCE meter) decreases, the load is capacitive at the measurement frequency. If frequency is reduced and reactance decreases, the load is inductive at the measurement frequency. This does not apply to antennas or to loads measured through a transmission line longer than a fraction of a wavelength long.

"Inductance in µH**"**, the third mode, measures inductor values in microhenries (µH) at an adjustable frequency. Normal measurement range is from less than .1 µH to a maximum of about 120 µH. The front panel **IMPEDANCE** meter indicates reactance (X in ohms) of the inductor. Inductance is calculated using measured reactance (X) and operating frequency, and displayed on the LCD.

The MFJ-269 becomes inaccurate measuring reactance below 7 ohms or above 1500 ohms. If component reactance is in the inaccurate range, **"L(X<7) [X]"** or **"L(Z>1500)"** will be displayed. An inductance value will not be displayed if measurement range is questionable.

```
15.814 MHz   51
L= 0.513 uH  XI
```

```
144.04 MHz
 L(Z>1500)   XI
```

```
3.5456MHz
  L(X<7)      XI
```

```
4.0456MHz
  L(X=0)     XI
```

To measure inductance:

a.) Turn the MFJ-269 on and step the mode switch through until the **"Inductance in** µH**"** display appears.

```
Inductance
  in uH
```

b.) Connect the inductor across **ANTENNA** connector with the shortest leads possible, or with the lead length normally used in the working circuit.

c.) Adjust to a frequency to the working frequency, or a frequency as close to the working frequency as possible that does not produce a range warning. "**L(Z>1500)"** is one warning, and "**L(X<7)"** is another. "**L(X=0)"** indicates the inductor appears as a near perfect short to the MFJ-269, and probably indicates frequency is too low or inductance is too small to measure.

Note: Lead length and placement, as well as inductor design, will affect inductance readings and in-circuit performance. With increasing frequency, measured inductance usually increases because of stray capacitance. At some frequency an inductor often becomes an "open" circuit, with infinite reactance. At others it becomes a short.

4.2.5 Frequency Counter

The **Frequency Counter** mode is the final **MAIN** mode. It is reached by pressing the MODE button four times from the opening menu, or by stepping through the **MAIN** modes until the **"Freq. Counter"** message appears.

Never apply dc, or more than 5 volts peak-to-peak voltage to the **FREQUENCY COUNTER INPUT** BNC jack. In this mode the GATE button controls the frequency counter time window. As a general rule the longer the time window the more accurate the frequency count. The accuracy of this counter is typically better than 0.05 %.

4.3 Main Modes (UHF)

4.3.1 Antenna System SWR (UHF)

```
SWR
SWR
```

The initial (opening) **"MAIN"** mode disables the Impedance meter. The analyzer display reads SWR referenced to 50 ohms. The SWR meter functions normally. The display has a bargraph of SWR, as well as displaying the SWR numbers. Overflow is set at VSWR>5:1.

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

4.3.2 Coax Loss (UHF)

```
Coax Loss
```

A second **"MAIN"** measurement mode, **"Coax Loss"**, is reached by pressing the **MODE** button once. This mode indicates the approximate loss of a 50 ohm feedline. The line must not be terminated, it must remain open at the far end to measure line loss. An overflow indicator in the display ("less than" sign, LOSS<1.76dB) means the loss can not be accurately determined.

```
448.72 MHz            425.82 MHz            450.01 MHz
Coax Loss  =  19 dB   Coax Loss  = 2.7 dB   Coax Loss  < 1.76 dB
```

The analyzer will return to the SWR measurement mode if the **MODE** button is pressed while in the **"Coax Loss"** mode.

5.0 ADVANCED OPERATION

CAUTION: THERE IS A ''UHF'' SWITCH LOCATED AT THE UPPER LEFT-HAND SIDE OF THE ANALYZER. THIS SWITCH SHOULD BE PRESSED AND LOCKED FOR UHF OPERATION ONLY WHEN UHF OPERATION IS DESIRED AND ONLY AFTER THE UNIT IS POWERED UP. FOR INFORMATION ON UHF OPERATION, SEE SECTION 3.4

WARNING: ***Never apply RF or any other external voltages to the ANTENNA port of this unit. This unit uses zero-bias detector diodes that are easily damaged by external voltages over a few volts.***

5.1 Forward

The advanced mode provides several special functions. Some functions are very useful, such as distance to fault (HF/VHF) or transmission line length in degrees.

Caution: Some advanced menus present information in special or uncommon terms. **Advanced 1** includes impedance descriptions such as magnitude and phase of load impedance, series and parallel equivalent impedance, reflection coefficient, and resonance. Most of these terms are useful in special applications, such as in adjusting matching stubs.

The advanced menus also contain uncommon terms describing SWR, such as return loss and match efficiency. These terms can be misleading because their name does not describe what actually happens in most antenna systems. We strongly recommend persons unfamiliar with such terms avoid using them, or at least read the section below that explains what the term actually describes.

The MFJ-269 contains a 50 ohm bridge, with voltage detectors across each bridge leg. A twelve-bit microcontroller processes these voltages and, by applying the proper formulas, displays useful information. The basic calculations are resistance, reactance, SWR, and complex impedance. In some modes, the system cross checks itself and displays a weighted average of the most accurate measurement methods, or searches for certain impedance conditions. System resolution is limited mostly by diode linearity, calibration stability, and external noise or signals.

While we have attempted to make this unit as accurate as possible, most formulas contain squares and other complex functions. A certain amount of error is unavoidable, especially at high or low impedance values and especially at higher VHF or UHF frequencies.

A basic understanding of transmission line and antenna behavior and terminology is very important in understanding **Advanced mode** information provided by the MFJ-269. Many explanations are available in the ARRL Handbooks, and they probably suffice for most amateur applications. Avoid unedited or self-edited amateur handbooks or articles, or at least confirm their accuracy by checking the information against reliable professional sources. For complex questions or critical information, we recommend using textbooks written, reviewed, and edited by professional engineers.

5.2 Accessing Advanced Modes

CAUTION: THERE IS A ‘‘UHF’’ SWITCH LOCATED AT THE UPPER LEFT-HAND SIDE OF THE ANALYZER. THIS SWITCH SHOULD BE PRESSED AND LOCKED FOR UHF OPERATION ONLY WHEN UHF OPERATION IS DESIRED AND ONLY AFTER THE UNIT IS POWERED UP. FOR INFORMATION ON UHF OPERATION, SEE SECTION 3.4

The advanced mode is reached by pressing and holding the **GATE** and **MODE** buttons at the same time for several seconds. After a delay of a few seconds, a series of **“ADVANCED”** messages numbered 1 through 3 appear. When you see the mode you want, quickly release the buttons. If you hold the buttons long enough, the display will eventually loop back through the MAIN menu and repeat the cycle.

**** HF/VHF operation***: The following modes are available from each of these **“ADVANCED”** menus:

"ADVANCED 1"		Magnitude and phase of load impedance
(Section 5.4.1)		Series and Parallel Equivalent Impedances
		Return Loss and Reflection coefficient
		Resonance
		Match Efficiency
"ADVANCED 2"	Velocity Factor setup	
(Section 5.5)		Distance to Fault measurement
		Line length in degrees calculation
"ADVANCED 3"	Charavteristic Impedance setup	
(Section 5.6)		Normalized SWR impedance (display only)
		Coax loss

**** UHF operation:*** The following modes are available from each of these **"ADVANCED"** menus:

"ADVANCED 1"		Return Loss and Reflection coefficient
(Section 5.4.2)		Match Efficiency
"ADVANCED 2"	Velocity Factor setup	
(Section 5.5)		Line length in degrees calculation

5.3 General Connection Guidelines

a.) The **ANTENNA** connector (Type "N" female) on the top of the MFJ-269 provides the RF measurement output connection. This port is used to measure SWR or perform other RF impedance measurements, with the exception of the Frequency Counter mode.

The **ANTENNA** connector supplies about +7 dBm output into 50 ohms (~ .5 volts RMS), and appears like a 50 ohm source resistance (open circuit voltage ~1 volt RMS). Harmonics are at least 25 dB down over the operating range of the MFJ-269. While the VFO is not stabilized, it is useful as a crude signal source.

The **ANTENNA** connector is not dc isolated from the load, external voltages will couple directly into internal detectors.

Warning: *Never apply external voltages or RF signals to the antenna connector. Protect this port from ESD.*

b.) Use proper RF connections. Keep leads as short as possible when measuring components or non-matched systems. Interconnecting transmission lines or wires can modify readings, including impedance and SWR. Use properly constructed coaxial cables of known quality matched to the analyzer impedance to avoid introducing SWR errors.

5.4 Advanced 1 modes

Advanced 1

5.4.1 Advanced 1 (HF/VHF)

ADVANCED 1 mode measures impedance and SWR functions. There are six display functions available in this mode:

- Magnitude and phase of load impedance (5.4.1.1)
- Series Equivalent impedance (5.4.1.2)
- Parallel Equivalent impedance (5.4.1.3)
- Return loss and Reflection coefficient (5.4.1.4)
- Resonance (5.4.1.5)
- Match efficiency (5.4.1.6)

5.4.1.1 Magnitude and Phase of Load Impedance

Magnitude and Phase of Impedance is the first mode in the advanced menu. The opening display first indicates:

```
  IMPEDANCE
Z=mag. θ=phase
```

and then flashes to:

```
28.814  MHz     3.6
Z=87Ω θ=53°    SWR
```

```
4.0456MHz  >31
 (Z>1500)     SWR
```

In this mode, the MFJ-269 LCD displays frequency, impedance or Z magnitude (in ohms), and phase angle (θ) of impedance. The meters indicate 50 ohm referenced SWR and load Impedance. The maximum impedance limit is set at 1500 ohms, exceeding the limit results in an impedance display of (Z>1500).

Note: Stray connector capacitance will be lower than 1500 ohms at frequencies higher than 30 MHz, and lower as adapters and leads are added to the **ANTENNA** port. This small stray capacitance will not affect high frequency measurements, and produces only minor errors in measurement of impedances under a few hundred ohms at VHF.

Phase angle of impedance is another way of expressing R and X. Instead of providing R and X as separate numerical quantities, a vector-type description of measured impedance is presented. Impedance (Z) is still described as the length (magnitude) of a line representing the complex impedance. (This is the same Z as given in other functions.) Besides Z, an angle between zero and 90 degrees is shown. This angle represents the phase difference between current and voltage at the terminals of the analyzer.

When a reactance is present, voltage and current are no longer in phase (or exactly out-of-phase) and so the phase angle increases from 0 degrees to a maximum angle of 90 degrees. The angle becomes 90 degrees when the load is a pure reactance, and zero degrees when the load is a pure resistance.

This analyzer will determine the angle in degrees, but it will *not* describe the load reactance specifically as either capacitive or inductive. It is a simple matter to determine the direction by adding a small amount of reactance in series with the load and watching the angle change. If the angle decreases, the load reactance is opposite to the sign or type of test reactance. If the angle increases, the load reactance is the same sign as the added reactance.

5.4.1.2 Series Equivalent Impedance

This **"ADVANCED 1"** display sub-mode is reached by pressing the **GATE** button once while in the **"Magnitude and Phase of Load Impedance"** mode. This mode displays the series equivalent impedance of the load. This is the most common form used to describe antenna system impedance. In this mode, the load impedance is described as a resistance in series with a reactance. In order to cancel the reactance without changing the resistance, a reactance of the opposite type and same reactance value must be connected in *series* with the load at the point of measurement.

The digital display shows SWR, resistive part of load impedance (Rs=), and reactive part of load impedance (Xs=). The **IMPEDANCE** meter displays the impedance (Z in ohms) while the **SWR** meter displays 50 ohm referenced SWR.

Series equivalent impedance display examples:

```
7.1598 MHz 3.2          14.095 MHz > 31
Rs= 50  Xs= 62 SWR       Rs(Z> 1500)  SWR
```

With impedances in the above left-hand display, resistance would remain 50 ohms, reactance would go to zero, and SWR to 1:1 if an opposite-sign reactance of 62 ohms was connected in *series* with the feedline at the point where the measurement was made.

Note: Every series impedance has a parallel equivalent counterpart. A series impedance of Rs 50 Xs 62 is equal to the parallel equivalent impedance of Rp 126 Xp 102 ohms. This analyzer can make that conversion in this mode by pressing the GATE button. See 5.4.1.3

5.4.1.3 Parallel Equivalent Impedance

Pressing the **GATE** button twice from the **Magnitude and Phase of Load Impedance** mode toggles the analyzer into a parallel equivalent impedance sub-mode.

Parallel equivalent display examples:

```
7.1598 MHz 3.2          14.095 MHz > 31
Rs= 126 Xs= 102 SWR      Rs(Z> 1500)  SWR
```

In the left hand display example, the equivalent parallel resistance is R=126 ohms. That resistance appears to be in *parallel* with 102 ohms. If we *parallel* connect an opposite-sign reactance of 102 ohms, the *parallel* equivalent reactance is canceled. Only the 126 ohm resistance remains.

This is a powerful tool used in matching antennas. The MFJ-269 places that tool at your fingertips. By checking a load for both Rp and Rs, you can see if either is close to the desired resistance. If one resistance value is close to the desired value, adding only one component will match the load by canceling reactance.

5.4.1.4 Return Loss and Reflection Coefficient

Return Loss and Reflection Coefficient mode is the second measurement mode in the **Advanced 1** mode menu. This mode is reached by pressing and releasing the **MODE** button one time after entering the **Advanced 1** mode menu. You can also reach it, an all other modes, by stepping through Advanced modes with the **MODE** button until the display indicates **"Return Loss and Reflection Coeff"** .

```
Return Loss &
Reflection Coeff
```

The **"Return Loss and Reflection Coeff"** mode measures and displays return loss in dB and voltage reflection coefficient on the LCD. These terms describe SWR. The meters indicate 50 ohm SWR and the impedance.

To use this mode, connect the load to be measured to the ANTENNA connector, adjust the frequency to the desired frequency range, and read the results on the MFJ-269 LCD and panel meter displays.

```
14.159 MHz      1.0
RL=48 dB ρ=.0 SWR
```

```
144.23MHz      1.9
RL=9.6 dB ρ=.32  SWR
```

```
14.159 MHz     >31
RL=0 dB  ρ=1  SWR
```

```
21.450MHz      >31
RL<0.5 dB ρ >0.93 SWR
```

5.4.1.5 Resonance Mode

Resonance mode is reached by pressing the **MODE** button twice while in the opening menus of the **Advanced 1** function. Like all other mode functions, you can step back to this mode as long as you are in the **Advanced 1** menu by stepping through the other modes. When this mode is initialized, the display briefly indicates:

```
Resonance mode
 tune for X=0
```

The **Resonance Mode** primarily draws attention to reactance, displaying reactance on the **IMPEDANCE** meter. In this mode, the MFJ-269 measures frequency, SWR, resistance (Rs=), and reactance (Xs=). When reactance is *zero* in a system that has selectivity, the *system* is said to be *resonant*.

```
15.814  MHz 2.4
Rs= 63 [Xs= 51]
```

```
1.8950MHz  >31
 Rs(Z>1500) [X]
```

NOTE: Because of transmission line effects, zero reactance or resonance can occur on frequencies where the antenna is ***not*** actually resonant. Conversely, the antenna may appear to contain reactance even at its true resonant frequency when measured through a feedline.

A less than perfectly matched antenna and feedline, when used with a feedline that is not an exact multiple of 1/4 wavelength (0, 1/4, 1/2, 3/4, etc.), will have reactance added by the feedline. Reactance added by a non-quarter wave multiple mismatched feedline may coincidentally cancel a non-resonant antenna's reactance, making the system resonant.

The SWR of the system, if the feedline is a 50 ohm feedline (or any impedance feedline that matches the impedance setting of the instrument) with minimal loss and free from common mode currents, will not change as the feedline length is changed. This is true even if the resonant frequency or reactance changes.

This mode functions like other SWR and impedance modes, with the exception the IMPEDANCE meter measures reactance. This allows the operator to easily locate frequencies where system reactance crosses zero.

5.4.1.6 Match Efficiency

Match Efficiency is the final measurement mode available in the **Advanced 1** menu. This mode is reached (after entering the **Advanced 1** menu) by pressing and releasing the **MODE** button three times. It can also be reached (as all other advanced modes are) by stepping through **Advanced 1** modes with the **MODE** button until the display indicates **"Match Efficiency**".

```
Match
Efficiency
```

Match efficiency is only another way of describing SWR. It is similar to mismatch loss, but SWR data is expressed as a "percentage of forward power" compared to the "reactive" or "circulating power" of the system.

CAUTION: "Match efficiency" may mislead those unfamiliar with SWR and energy transfer in a system. Power "transmitted" or transferred to a load can be nearly 100% even when a match efficiency calculation or display indicates a system has *nearly zero percent match efficiency*. Conversely, match efficiency can measure nearly 100%, and the actual power at the load might be very low due to system losses.

Match efficiency ONLY applies to the loss in power transfer from a perfect 50 ohm fixed tuned source to the input of the feedline or system where the measurement is made. It is mostly useful in laboratory situations. It is not a description of antenna system or feedline efficiency. Even with nearly zero percent match efficiency, an antenna system can radiate applied power with good efficiency. With any given amount of match efficiency your antenna system can be near 100% or near zero percent efficient.

```
1.8963   MHz   3.1
Power = 74 % SWR
```

```
50.097 MHz  1.3
Power =98%  SWR
```

```
53.34 MHz   >31
Match< 12%   SWR
```

5.4.2 UHF Advanced 1

Advanced menus are reached by pressing and holding the **GATE** and **MODE** buttons for an several seconds.

As in HF/VHF operation, the **"MAIN"** mode can be reached by continuing to hold both **GATE** and **MAIN** buttons for an extended period. Doing so will cycle the analyzer through all available menus.

5.4.2.1 Return Loss and Reflection Coefficient (UHF)

"Return Loss and Reflection Coefficient" is the first measurement mode in the **Advanced 1** UHF menu. This menu is reached by pressing and holding the **GATE** and **MODE** buttons simultaneously until the "**Advanced 1"** UHF menu appears on the screen. The display will briefly indicate:

Return Loss &
Reflection Coeff

NOTE: You can also cycle through the **Advanced 1** UHF menu by holding the **MODE** button until the display indicates the desired function.

After a few seconds, the display changes to:

437.12 MHz 1.1 RL= 23 dB ρ=.06 SWR	462.09MHz 2.8 RL=6.6 dB ρ=.46 SWR

The **"Return Loss and Reflection Coeff"** mode measures and displays return loss in dB and voltage reflection coefficient on the LCD. These terms are another way of describing SWR. The SWR meter indicates 50 ohm SWR and the impedance meter is disabled.

420.86 MHz >5 RL= 0 dB ρ = 1 SWR	449.78 MHz >5 RL<3.5 dB ρ >0.66 SWR

To use this mode, connect the load to be measured to the ANTENNA connector, adjust the frequency to the desired frequency range, and read the results on the MFJ-269 LCD and panel meter displays.

5.4.1.6 Match Efficiency (UHF)

Match Efficiency is the second and final measurement mode available in the **Advanced 1** UHF menu. This mode is reached (after entering the **Advanced 1** menu) by pressing and releasing the **MODE** button one time. It can also be reached (as all other advanced modes are) by stepping through the other **Advanced 1** modes with the **MODE** button until the display indicates **"Match Efficiency"**.

Match
Efficiency

Match efficiency is another way of describing SWR. It is similar to mismatch loss, but SWR data is expressed as a "percentage of forward power" compared to the "reactive" or "circulating power" of the system.

CAUTION: "Match efficiency" may mislead those unfamiliar with SWR and energy transfer in a system. Power "transmitted" or transferred to a load can be nearly 100% even when a match efficiency calculation or display indicates a system has *nearly zero percent match efficiency*. Conversely, match efficiency can measure nearly 100%, and the actual power at the load might be very low due to system losses.

Match efficiency ONLY applies to the loss in power transfer from a perfect 50 ohm fixed tuned source to the input of the feedline or system where the measurement is made. It is mostly useful in laboratory situations. It is not a description of antenna system or feedline efficiency. Even with nearly zero percent match efficiency, an antenna system can radiate applied power with good efficiency. With any given amount of match efficiency your antenna system can be near 100% or near zero percent efficient.

```
420.16   MHz   4.7
Match  = 58 % SWR
```

```
441.82 MHz  1.9
Match  =90%   SWR
```

```
435.64 MHz   >5
Match< 55%    SWR
```

5.5 Advanced 2

CAUTION: THERE IS A ''UHF'' SWITCH LOCATED AT THE UPPER LEFT-HAND SIDE OF THE ANALYZER. THIS SWITCH SHOULD BE PRESSED AND LOCKED FOR UHF OPERATION ONLY WHEN UHF OPERATION IS DESIRED AND ONLY AFTER THE UNIT IS POWERED UP. FOR INFORMATION ON UHF OPERATION, SEE SECTION 3.4

This mode measures physical or electrical distance to a fault (a short or open or large impedance bump), electrical length in degrees, and also calculates the length of a wavelength.

This mode is reached by pressing and holding the **MODE** and **GATE** buttons until **"Advanced 2"** appears on the display. It can also be reached (and all other advanced modes) by stepping through **Advanced** modes by holding the **MODE** and **GATE** button until the display indicates **"ADVANCED 2"** (or other desired function).

```
Advanced 2
```

The opening display of **Advanced 2** is:

```
VELOCITY FACTOR?
     VF= 0.66
```

This display prompts the operator to set the correct feedline velocity factor. Velocity factor is increased by pressing the **GATE** button, and decreased by pressing the **MODE** button. When the correct Vf is reached, press both buttons at the same time to lock the value in. Set the Vf to the known Vf of the transmission line. This setting will affect the ***physical length*** of the line displayed later. If you want to know the ***electrical length*** in feet, set Vf for to unity (1.00).

NOTE: Incorrect Vf settings do not cause errors in electrical measurements, such as **"Length in Degrees"**. Incorrect Vf settings will cause an error in physical length calculations, such as **"Dist. to Fault"** displayed in feet.

At UHF, internal capacitance of the diodes and lead lengths through the connector and connections create errors in other measurements, so only SWR and SWR related functions are displayed. Unfortunately there is now way to cure these problems without causing the MFJ-269 to become unreliable at HF, and any cures would require a calibration fixture to be used at UHF every time a series of measurements are made.

5.5.1 Distance to fault (DTF) (for HF/VHF only)

The next display menu is:

Distance to
fault in feet

This function will measure any type or impedance of line, including the length of Beverage or other antenna antennas (if the termination is removed). Section 5.5.1.4 outlines the measurement procedures, or *HOW* to measure something. Sections 5.5.1.1 through 5.5.1.3 describe a few things that can be measured.

5.5.1.1 DTF balanced lines

If a balanced line is used, operate the MFJ-269 *only* from internal batteries. Keep the MFJ-269 a few feet away from other conductors or earth, and do not attach any wires (other than the balanced line) to the analyzer. Use the **ANTENNA** connector's shield for one lead and its center pin for the other. Two wire balanced lines ***must*** be suspended in a reasonably straight line a few feet away from other objects by using good insulators. Avoid laying the line against anything, including insulators, for any distance. Be sure to keep the line several conductor spacings away from other conductors, even poor conductors like earth or concrete.

5.5,1.2 DTF Coaxial lines

Coaxial lines can lay in a pile or coil on anything, including a floor. Either battery or external power supplies can be used to power the analyzer, and the MFJ-269 can be placed on or near large metallic objects with no ill effects. Coaxial lines must connect normally, with the shield grounded to the outside of the connector.

5.5.1.3 DTF Antenna Length

Antenna length, such as the electrical length of longwires, dipoles, or Beverages, can be measured. Measurements should ideally be made either through a good broadband matching transformer or by directly connecting the antenna to the **ANTENNA** port of the analyzer.

To guarantee the most reliability and accuracy, it is a good idea to avoid appreciable lengths of feedline (more than 1/32 wl) between the analyzer and the antenna. While measurements can be made with a transmission line connected between the antenna and analyzer, false zero reactance crossings will be introduced from line mismatch. Watching the SWR meter can help weed-out false reactance nulls when measuring antennas through a transmission line.

To measure antenna length, treat the antenna like a transmission line and follow the procedure for measuring distance to fault. With a dipole antenna, the result will be the length of one side of the antenna. With a longwire or Beverage, it will be the entire antenna electrical length.

5.5.1.4 DTF measurement procedures

"Distance to Fault" is the first measurement mode in the **"Advanced 2"** menu. This menu is reached by pressing and holding the **MODE** and **GATE** buttons until **"Advanced 2"** appears on the display. It can also be reached (and all other advanced modes) by stepping through **Advanced** modes by holding the **MODE** and **GATE** button until the display indicates **"Advanced 2"** (or other desired function).

CAUTION: THERE IS A ''UHF'' SWITCH LOCATED AT THE UPPER LEFT-HAND SIDE OF THE ANALYZER. THIS SWITCH SHOULD BE PRESSED AND

LOCKED FOR UHF OPERATION ONLY WHEN UHF OPERATION IS DESIRED AND ONLY AFTER THE UNIT IS POWERED UP. FOR INFORMATION ON UHF OPERATION, SEE SECTION 3.4

1.) The first menu that appears is:

```
VELOCITY FACTOR?
    VF= 0.66
```

The **GATE** button increases the Vf, the **MODE** button decreases the Vf. Set the Vf to the known Vf of the transmission line. This setting will affect the ***physical length*** of the line (in feet) displayed later. If you want to know the ***electrical length*** in feet, set Vf to unity (1.00).

NOTE: Incorrect Vf settings do not cause errors in electrical measurements, such as **"Length in Degrees"**. Incorrect Vf settings will cause an error in physical length calculations, such as **"Dist. to Fault"** .

2.) After setting the Vf, press **GATE** and **MODE** simultaneously to lock-in the desired Vf. The display will indicate:

```
Distance to
fault in feet
```

and after a few seconds change to:

```
15.814  MHz 1st
DTF  Xs= 51
```

This display prompts you to find a frequency of lowest reading on the **IMPEDANCE** meter that coincides with Xs as close to Xs=0 as possible. When you find that frequency, press the **GATE** button firmly until the flashing **"1st"** on the display stops flashing. Release the **GATE** button quickly.

```
21.324  MHz 1st
DTF  Xs= 0
```

3.) The display now indicates the first frequency data point and the blinking **"1st"** will change to a blinking **"2nd"**:

```
21.324  MHz 2nd
DTF   Xs= 0
```

4.) Slowly tune the analyzer higher or lower in frequency until the Impedance meter indicates the very *next* low **IMPEDANCE** meter reading, and reactance (**Xs=**) is zero or the lowest possible value near zero.

```
68.511 MHz  2nd
 DTF   Xs= 1
```

5.) Press the **"GATE"** button again, and the display will indicate distance in feet:

```
Dist. to fault
  6.6 ft
```

The Dist. to Fault reading shows the physical distance in feet to a transmission line fault or mistermination. To obtain the true physical distance, the analyzer multiplies electrical distance by feedline velocity factor entered in step 1. This reading will be only as accurate as the velocity factor you enter allows. To find the electrical length in feet, you must program the velocity factor as **"Vf=1.00"** in step 1.

6.) Pressing the MODE button once (after finding a valid DTF) displays the distance to fault in feet and the electrical length of the line (in degrees) at the frequency the analyzer is set on:

```
68.511  M hz
   L= 6.6 ft =251 °
```

As the displayed frequency is changed, the electrical length of the line is re-calculated. Note that **electrical length repeats at 360 degrees**, and returns to zero. Because of this, it is impossible to obtain a reading larger than 359 degrees. This feature helps you trim long lines to desired multiples of 1/4 or 1/2 wavelength.

7.) Pressing the **MODE** button again causes the analyzer to calculate the length of one wavelength of line for the velocity factor and at the frequency of the display. Remember, this is the length of a full wavelength (360 degrees) at the frequency selected and with Vp selected in step 1. If you select a Vp of .5, the result will be the physical length of a half wavelength in freespace.

```
146.51   MHz
l=360°= 4.0 ft
```

To confirm reliability, make two or more groups of measurements on different starting frequencies at least one octave apart. If measured distances agree, the distances measured are confirmed.

If a different wavelength is required see .

As with other modes, pressing the **MODE** button steps back to the beginning.

5.5.2 Calculator Functions (direct access)

The MFJ-269 performs calculator functions. These functions can also be accessed from Distance to Fault modes.

This functions:

1.) Calculates length in feet of a transmission line or conductor for the number of electrical degrees (up to 359 degrees) of a transmission line or conductor for the velocity factor and length entered and the frequency selected (see **5.5.2.1**).

2.) Calculates electrical degrees (up to 359 degrees, at which point it repeats again at zero) for the velocity factor entered, the electrical length programmed, and the frequency selected (see **5.5.2.2**).

5.5.2.1 Line Length in Degrees

This mode tells you length of a line in electrical degrees if you know the physical length and velocity factor. You can also directly measure the electrical length using the distance to fault mode (sec 5.5). This mode is useful for calculating the length in degrees of matching sections and phasing lines.

If this mode is entered after using distance to fault (sec 5.5), VF and length will be programmed automatically using distance to fault data. The physical or electrical length of the line can also be programmed manually. If a length is not programmed, a default length of 100 feet is selected automatically.

When changing UHF frequency with a 100 foot line, the display rotates through 360 degrees rapidly. This demonstrates how highly frequency sensitive a long (in terms of wavelength) transmission line is. With lines that are very long in terms of wavelength, cutting the line to an exact electrical degree is almost impossible. This is true over extremely narrow frequency ranges.

1.) Simultaneously press and hold **GATE** and **MODE** buttons until Advanced 2 appears. The display will show the velocity factor (factory default to 0.66):

VELOCITY FACTOR?
VF= 0.66

2.) Set VF to the desired value. **GATE** increases VF, **MODE** decreases VF. When the desired VF is reached simultaneously press and hold the **GATE** and **MODE** buttons until "Distance to Fault" appears.

VELOCITY FACTOR?
VF= 0.70

Note: If you know the true electrical length in feet, set VF to VF=1.0 and enter the electrical length in feet.

3.) Press the **MODE** button. A display showing length in feet and length in degrees will appear.

14.315 MHz
L= 100.0 ft= 73°

4.) The display will now show the electrical degrees for the line length entered (default is 100 feet) at the velocity factor you entered in step 1. By adjusting the frequency controls, the analyzer will recalculate the results for any frequency desired.

14.315 MHz
l=177.2 ft = 326°

437.52 MHz
l=177.2 ft = 153°

5.) Pressing **MODE** takes the display to section 5.5.3.2. Pressing **GATE** takes the display to a line length adjustment function.

```
Line length ?
l= 100.0 ft         °
```

6.) To increase line length, press the **GATE** button. To decrease line length, press the **MODE** button. When the desired length appears, simultaneously press and hold **GATE** and **MODE** buttons. The display will now change to:

```
Line length ?
l= 67.2. ft         °
```

7.) Pressing **MODE** takes the display to length in feet for the degrees programmed at Vf selected.

5.5.3.2 Line Length in Feet

This mode displays the length in feet required to obtain a certain number of electrical degrees for the velocity factor (VF) and frequency selected. It is useful for determining the physical length required for matching sections, phasing lines, or antennas if the velocity of propagation, electrical length required, and frequency are known.

This mode is useful for calculating the required length in feet of matching sections and phasing lines if you know the required variables, velocity factor and electrical degrees. The analyzer can also directly measure and display length using the distance to fault mode (sec 5.5.1 for HF/VHF).

If this mode is entered after using distance to fault (sec 5.5.1), VF and length will be programmed automatically using distance to fault data. The physical or electrical length of the line can also be programmed manually. If a length is not programmed, a default length of 360 degrees is selected automatically.

1.) Simultaneously press and hold **GATE** and **MODE** buttons until "Advanced 2" appears. The display will show the velocity factor (factory default to 0.66):

```
VELOCITY FACTOR?
VF= 0.66
```

2.) Set VF to the desired value. **GATE** increases VF, **MODE** decreases VF. When the desired VF is reached simultaneously press and hold the **GATE** and **MODE** buttons until "Distance to Fault" appears.

```
Distance to
fault in feet
```

Note: If you know the true electrical length in degrees, set velocity factor to VF=1.0 and enter the electrical length in degrees as indicated in step 5.

3.) Press and release the **MODE** button. The display will flash "Line Length in Degrees".

```
Line length
in degrees
```

After a moment, a display appears showing:

```
14.315  MHz
l=100 ft=  73°
```

4.) Press the **MODE** button again. A display appears showing "Line length in feet" appears and quickly changes to:

```
Line length
  in feet
```

5.) The display will now show line length for the electrical degrees entered (default is 360 degrees) for the velocity factor entered in step 1. By adjusting the frequency controls, the analyzer will recalculate the correct length for any frequency desired.

```
146.51  MHz
l=360°= 4.0 ft
```

6.) Pressing **MODE** takes the display back to the "Velocity Factor" adjustment screen in step 2. Pressing **GATE** takes the display to a line length adjustment function that allows you to change the length in degrees.

```
Line length ?
l= 360°
```

°

7.) To increase line length in degrees, press the **GATE** button. To decrease line length in degrees, press the **MODE** button. When the desired length in degrees appears, simultaneously press and hold **GATE** and **MODE** buttons. The display will now change to:

```
Line length ?
l= 78 °
```

°

7.) Pressing **MODE** takes the display to the "Velocity Factor" adjustment in step 2.

5.6 Advanced 3 (HF/VHF only)

CAUTION: THERE IS A ''UHF'' SWITCH LOCATED AT THE UPPER LEFT-HAND SIDE OF THE ANALYZER. THIS SWITCH SHOULD BE PRESSED AND LOCKED FOR UHF OPERATION ONLY WHEN UHF OPERATION IS DESIRED AND ONLY AFTER THE UNIT IS POWERED UP. FOR INFORMATION ON UHF OPERATION, SEE SECTION 3.4

This mode is reached by pressing and holding the **MODE** and **GATE** buttons until **“Advanced 3”** appears on the display. This mode allows you to set the SWR reference impedance to values other than 50 ohms, and measure line loss and SWR in systems other than 50 ohms.

```
Advanced 3
```

Note: The SWR meter does not change reference impedance in this mode. It displays the 50 ohm SWR value, not the value selected from the display. Only the display SWR changes with the new reference impedance setting.

5.6.1 Z Characteristic

A few moments after entering Advanced 3, the display changes to **“Z Characteristic Zo= 75”:**

```
Z Characteristic?
   Zo = 75
```

1.) When the message shown above appears, Zo can be adjusted by pressing either the **GATE** (increase) or **MODE** (decrease) buttons.

2.) After the correct Zo is reached, press both **MODE** and **GATE** at the same time for a very short time. The display will show:

```
Z Characteristic?
   Zo = 35
```

3.) The flashing “swr” on the display means the display is indicating SWR referenced to a new Zo. The meter continues to indicate 50 ohm SWR.

```
21.273 MHz   9.1        21.273 MHz   9.1
Rs= 16 Xs= 72 SWR       Rs= 16 Xs= 72
```

4.) Pressing the **GATE** button alone changes the function back to the Zo setup mode. Pressing the **MODE** button alone changes the **MODE** to **5.6.2 Coax Loss**.

5.6.2 Coax Loss

Please read and use the method section 4.2.2, Coax loss before using this advanced function. That section explains loss measurement in great detail.

This mode is reached from the Z Characteristic mode (5.6.1) by pressing the **MODE** button. In this mode, **“Zo”** flashes and **“Coax Loss”** appears on the display.

```
50.832 MHz    Zo
Coax Loss  =  18 dB
```

This mode measures coax loss for the line Zo selected in 5.6.1. it is important that the line is not terminated in any sort or dissipative load when making this measurement.

To use this mode, sweep the desired measurement frequency range. Watch the loss reading carefully, and tune for minimum loss. The minimum loss reading obtainable near the desired frequency range is the correct loss reading.

To return to Z Characteristic, push the **MODE** button one time. Pressing the **GATE** button returns the analyzer to the Zo setup menu.

Pressing and holding both **GATE** and **MODE** buttons for a long time cycles the analyzer back to the **"MAIN"** or **"Advanced"** modes.

6.0 Adjusting Simple Antennas

CAUTION: THERE IS A ''UHF'' SWITCH LOCATED AT THE UPPER LEFT-HAND SIDE OF THE ANALYZER. THIS SWITCH SHOULD BE PRESSED AND LOCKED FOR UHF OPERATION ONLY WHEN UHF OPERATION IS DESIRED AND ONLY AFTER THE UNIT IS POWERED UP. FOR INFORMATION ON UHF OPERATION, SEE SECTION 5.7

Most antennas are adjusted by varying the length of the elements. Most home made antennas are simple verticals or dipoles that are easily adjusted.

6.1 Dipoles

Since a dipole is a balanced antenna, it is a good idea to put a balun at the feedpoint. The balun can be as simple as several turns of coax several inches in diameter, or a complicated affair with many windings on a ferromagnetic core.

The height of the dipole, as well as it's surroundings, influence the feedpoint impedance and feedline SWR. Typical heights result in SWR readings below 1.5 to 1 in most installations when using 50 ohm coaxial cable.

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

Remember feedline length, when the antenna is not exactly the same impedance as the feedline, modifies the ***impedance*** along the feedpoint. **SWR** will remain constant (except for a small reduction in SWR as the feedline is made longer) if the feedline is a good quality 50 ohm cable. If feedline length changes SWR at any one fixed frequency, the feedline either has common mode currents that are detuning the antenna or the feedline is not a true 50 ohm cable. Common mode currents are caused by lack of a balun or other installation errors, such as a feedline paralleling the antenna.

Note: Advanced 3 allows you to change the SWR Zo reference. If 75 ohms Zo is selected, and SWR is measured along a 75 ohm cable, SWR referenced to 75 ohms shown on the display will remain nearly constant regardless of line length. SWR referenced to 50 ohms (shown on the meter) will vary wildly.

The 75 ohm Zo SWR on the display is the true SWR on the 75 ohm cable, the SWR on the meter is the SWR when a 50 ohm system is connected to the 75 ohm cable.

6.2 Verticals

Verticals are usually unbalanced antennas. Many antenna manufacturers incorrectly downplay the need for a good radial system with a grounded vertical. With a good ground system, the SWR of a directly fed quarter-wave vertical can be nearly 2 to 1. SWR often improves if the ground system (and performance) is poor, so a low SWR with a directly fed Marconi might be a sign of inefficiency.

Verticals are tuned like dipoles, lengthening the element moves the frequency lower, and shortening the element moves the frequency higher.

6.3 Tuning a simple antenna

Select any mode that indicates SWR. Tuning basic antennas fed can be accomplished with the following steps:

1. Momentarily short the feedline center conductor and shield, then connect the feedline to the MFJ-269.

2. Adjust the MFJ-269 frequency to the desired frequency.

3. Read SWR, and adjust the MFJ-269 frequency until the lowest SWR is found. (Be sure cable Zo matches Analyzer Zo).

4. Divide the measured frequency by the desired frequency.

5. Multiply the present antenna length by the result of step 4. This will be close to the antenna length actually needed.

Note: This method of tuning will only work on full-size vertical or dipole antennas with uniform diameters. This method will not work with antennas that employ loading coils, traps, stubs, resistors, capacitors or capacitance hats, and these antenna types should be tuned according to the manufacturer's instructions while tested with the MFJ-269, until the desired SWR is obtained.

7.0 Testing and Tuning Stubs and Transmission Lines

7.1 Testing Stubs

Resonant frequency of any impedance stub or transmission line can be measured. Select the first (or opening) measurement mode in the **MAIN** menu, or use the protocol in **5.5 Advanced 2**.

Connect the stub under test to the "ANTENNA" connector of the MFJ-269 .

NOTE: The line 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 all half-wave stub multiples*** (like 1/2, 1, 1-1/2, etc.).:

1.) If a balanced line is used, operate the MFJ-269 *only* from internal batteries. Keep the MFJ-269 a few feet away from other conductors or earth, and do not attach any wires (other than the feedline) to the unit. Use the **ANTENNA** connector's shield for one lead and its center pin for the other. Two wire balanced lines ***must*** be suspended in a fairly straight line a few feet away from metallic objects or ground.

2.) Coaxial lines can lay in a pile or coil on the floor. Internal or external power can be used, and the MFJ-269 can be placed on or near large metallic objects with no ill effects. Coaxial lines connect normally, with the shield grounded.

When tuning critical stubs, **gradually** trim the stub to frequency. Adjust the feedline or stub using the following method:.

1. Determine the desired frequency and theoretical length of the feedline or stub.

2. Cut the stub 20 percent longer than calculated.

3a. Measure frequency of lowest resistance and reactance, or lowest impedance for odd quarter wave stubs. For fine tuning look only at the “X=?” display. Adjust for X=0, or as close as X=0 as possible. The frequency should be about 20% below the desired frequency if everything worked as planned during the length calculation.

3b. For 1/2 wavelength stubs, measure the frequency of highest Zo where the analyzer overflows and Z>1500 appears.

4. Divide the measured frequency by the desired frequency.

5. Multiply the result by the length of the feedline or stub to find the required length.

6. Cut the stub to the length calculated in step 5, and confirm lowest “X” is on he desired frequency.

The Distance to Fault mode can also be used. It will directly display the line length in degrees at any frequency you choose. See section **5.5 Advanced 2** .

7.2 Velocity Factor of Transmission Lines

The MFJ-269 accurately determines velocity factor of any transmission line. Select the **Distance to Fault** mode in **5.5 Advanced 2**.

Distance to
fault in feet

1.) If a balanced line is used, operate the MFJ-269 *only* from internal batteries. Keep the MFJ-269 a few feet away from other conductors or earth, and do not attach any wires (other than the stub) to the unit. Use the ANTENNA connector’s shield for one lead and its center pin for the other. Two wire balanced lines ***must*** be suspended in a straight line a few feet away from metallic objects or ground.

2.) Coaxial lines can lay in a pile or coil on the floor. Internal or external power can be used, and the MFJ-269 can be placed on or near large metallic objects with no ill effects. Coaxial lines connect normally, with the shield grounded.

The Distance to Fault mode measures the *electrical length* of a transmission line if a Vf of 1 is entered. To obtain velocity factor, you must know the electrical and physical length of the line. If the length in feet displayed (with a

Vf entry of 1.0) is 75 feet, and the transmission line is actually 49.5 feet long, the velocity factor is 49.5 divided by 75, for a result of 0.66 Vf.

NOTE: The far end of the line can be either ***open circuited*** or ***short circuited.*** The line can not be terminated in any impedance other than an open or short.

To confirm reliability, make two or more groups of measurements on different starting frequencies at least one octave apart. If measured distances agree, they are almost certainly very reliable.

Use the following method:

1.) Using procedures in 5.5 Advanced 2, measure distance to fault with Vf set at 1.00.

2.) Measure the physical length of the line in feet.

3.) Divide the actual physical feedline length by the display reading.

Example: 27 feet (actual physical length) divided by 33.7 feet (measured electrical length) equals .80. The velocity factor is .80 or 80%.

4.) If the analyzer is now set to Vf= .80 and the line measured, the result should be the correct physical length.

7.3 Impedance of Transmission Lines or Beverage antennas

The impedance of transmission lines between a few ohms and 1500 ohms can be directly measured with the MFJ-269. Lines of higher impedance can be measured if a broadband transformer or resistance is used to extend the MFJ-269's range. Select any measurement mode that indicates resistance (R=) and reactance (X=).

1.) If a balanced line is used, operate the MFJ-269 *only* from internal batteries. Keep the MFJ-269 a few feet away from other conductors or earth, and do not attach any wires (other than the feedline) to the unit. Use the ANTENNA connector's shield for one lead and its center pin for the other. Two wire balanced lines ***must*** be suspended in a fairly straight line a few feet away from metallic objects or ground.

2.) Coaxial lines can lay in a pile or coil on the floor. Internal or external power can be used, and the MFJ-269 can be placed on or near large metallic objects with no ill effects. Coaxial lines connect normally, with the shield grounded.

3.) Beverage antennas can be directly connected to the MFJ-269.

Using fixed resistances:

1. Terminate the line or antenna in a non-inductive resistance somewhere around the expected value.

2. Connect the transmission line or antenna directly to the MFJ-269 "ANTENNA" connector. Adjust the frequency (near the expected operating frequency) until the lowest resistance and lowest reactance is measured.

3. Record the impedance value.

4. Adjust the frequency until the highest resistance and *lowest* reactance is measured.

5. Multiply the highest resistance by the lowest resistance, and find the square root of the result.

Example:

The highest resistance is 600 ohms, the lowest is 400 ohms. 400 x 600 = 240,000. The square root of 240,000 is 490. The impedance is 490 ohms.

Using a potentiometer or resistor decade box:

1. Connect the MFJ-269 to one end of the system (in this case you can use a broadband matching transformer).

2. Adjust the frequency and note *only* the SWR change.

3. Adjust the termination resistance until the SWR remains as constant as possible with very large frequency changes around the operating frequency range.

4. The resistance of the termination resistor is the surge impedance of the system.

The electrical length of the Beverage can be determined by using procedures outlined in Advanced 2.

7.4 Adjusting Tuners

The MFJ-269 can be used to adjust tuners. Connect the MFJ-269 "ANTENNA" connector to the tuner's 50 ohm input and the desired antenna to the normal tuner output. This connection can be made with a manual RF switch to facilitate rapid changeover, provided that switch has better than 50 dB port isolation.

WARNING: Always connect the common (rotary contact) of the switch to the tuner. The switch must connect either the MFJ-269 or the station equipment to the tuner. ***Transmitting Equipment Must Never Be Connected To The MFJ-269.***

1. Connect the MFJ-269 to the tuner input.

2. Turn on the MFJ-269 and adjust it to the desired frequency.

3. Adjust the tuner until the SWR becomes unity (1:1).

4. Turn off the MFJ-269 and re-connect the transmitter.

7.5 Adjusting Amplifier Matching Networks

The MFJ-269 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.

1.) To measure input circuits, a non-inductive resistor equaling the approximate driving impedance of each individual tube is installed between the cathode of each tube and chassis.

2.) To measure tank circuits, a resistor equaling the calculated tube operating impedance is connected from the anode to the chassis with short leads.

3.) The antenna relay (if internal) can be engaged with a small power supply. The amplifier's external RF input and output connectors are now connected to the amplifier's RF matching networks.

The appropriate network can now be adjusted. When the analyzer shows 50 ohms and a 1:1 SWR at the operating frequency with the proper amounts of capacitance to set the system Q, the networks are working.

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-269.**

7.6 Testing RF Transformers

RF transformers designed to operate with 10-1000 ohm termination on one of the windings can be tested with the MFJ-269.

The 10 to 1000 ohm winding is connected through very short (less than one electrical degree long) leads to the **"ANTENNA"** connector on the MFJ-269. The other winding(s) of the transformer is terminated with a low inductance resistor equal to the desired load impedance. The MFJ-269 can then be swept through the desired transformer frequency range. The impedance and bandwidth of the RF transformer can be measured.

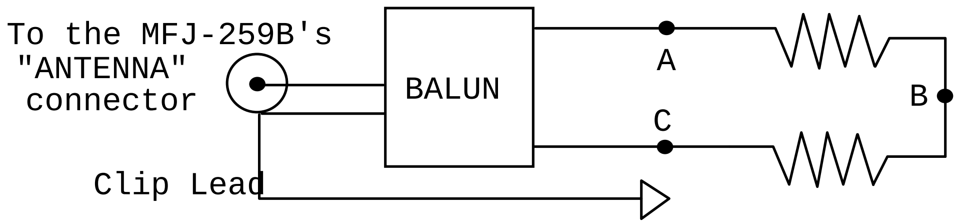
Transformer efficiency can be measured by comparing the source voltage from the MFJ-269 to the load voltage, and using standard power level conversions. A second method is to NOT terminate the transformer and measure the winding at it's design operating impedance in Advanced 2's Coax Loss mode. Set the analyzer at the winding operating Zo value. Approximate loss can be measured using the same method as measuring a transmission line.

7.7 Testing Baluns

Baluns can be tested by connecting the 50 ohm unbalanced side to the MFJ-269 "ANTENNA" connector. The balun must be terminated with two equal value load resistors in series. The resistor combination must have total resistance equal to balun load impedance. For example, a pair of 100 ohm carbon resistors are required to properly test the 200 ohm secondary of a 4:1 balun (50 ohm input).

Measure SWR while moving a jumper wire from point "A" through point "C".

Voltage and current balun test:

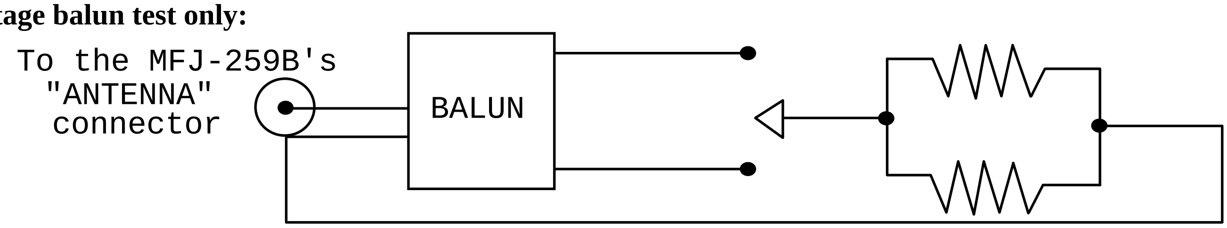


A properly designed **current balun** is the type most effective for maintaining current balance. It has the highest power capability and lowest loss for given materials. It should show a low SWR over the entire operating range of the balun with the clip lead in ***any*** of the three positions.

A well designed **voltage balun** should show a low SWR over the entire operating range when the clip lead is in position "B". That SWR should not change when the clip lead is removed. It will show a very poor SWR when the clip lead is in position "A" and "C". SWR should be about the same in either position "A" or "C". If the balun does not follow these rules, the balun has poor balance and is of questionable benefit.

A 4:1 voltage balun should also be tested by disconnecting the outer connections of the two resistors and connecting each resistor in parallel. If the voltage balun is operating properly the SWR will be very low with the resistors connected from either output terminal to ground.

Voltage balun test only:



7.8 Testing RF Chokes

Large RF chokes usually have frequencies where the distributed capacitance and inductance form a low impedance "series-resonance". This series resonance occurs because the choke acts like a series of back-to-back L networks. This causes three problems:

First, impedance from end to end in the choke becomes very low.

Second, the voltage at the center of the resonant point becomes very high, often causing severe arcing.

Third, the current in the winding becomes very high, often resulting in severe heating.

Troublesome series-resonances can be detected by installing the choke in the operating location, and connecting ***only*** the MFJ-269 from end-to-end of the choke through a short 50 ohm jumper cable. By slowly sweeping the operating frequency range of choke, dips in impedance identify low impedance series-resonant frequencies.

By moving a small insulated screwdriver's blade close to and along the choke, you will find a point where the series-resonant impedance suddenly changes. This is the area that has the highest voltage and also the area where adding or subtracting a tiny amount of capacitance has the largest effect. By removing turns to reduce capacitance or adding a small capacitive stub at this point, resonance can be shifted out of the desired frequency range.

A small change in stray capacitance has a much larger effect than a small change in turns, because the ratio of L to C is so high. It is often possible to move the series-resonance a large amount without greatly affecting the overall inductance.

8.0 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 **601-323-0549** or the *MFJ Factory* at **601-323-5869**. 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 601-323-6551; or by e-mail to mfj@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.