MFJ-259B Calibration

[Home]

MFJ 259B Analyzer

This is an MFJ procedure that does not contain any information that would not be handed out by them. It is easy-access to a test procedure, that is all it is. It is a shortcut to help you.

This information is here only because it is the correct way to calibrate the MFJ-259B analyzer. MFJ's first priority is making sure people who can not send units back to MFJ or who want to verify calibration with a correct reviewed and edited procedure have something easy to access. MFJ gets all the credit for this procedure, no one else.

It is best that no one copy this, and start handing it out in mass. The only reason for this is there should be a point of control of information, so it can be corrected as errors are found.

Common Problems

This family of analyzers is dc-coupled from the bridge to the antenna port. The bridge detectors are NOT frequency selective, and respond to anything from minor dc offsets through microwave signals. This causes a potential problem if there is ***any*** voltage appearing across the antenna port, from dc through microwave. (This is also true for competing analyzers from other manufacturers.) There are multiple reasons why, at the time of design, these units were dc coupled with broadband detectors. Hopefully someday a higher cost-design with selective detectors will become available, but for right now this is all that is available for amateur use.

Because the detector is broadband, and because it is dc coupled to the antenna, any external voltage across the input port causes measurement errors. It is the **accumulated voltage of multiple sources** that is most important, not the strength of any individual signal. Because of that, large antennas should be tested at times when propagated signals in the range of the antenna's response are at minimum strength.

A definite RFI improvement occurs with a bandpass filter, but multiple-section bandpass filters cause impedance measurement problems. Multiple-section filters behave like transmission lines of random line impedances, loss, and lengths as frequency is varied. The best solution is to use a single-stage bandpass filter and dc isolation on large arrays or with long feedlines. I often use a good 1:1 isolation transformer for measurements, and often find a parallel L/C filter (like the MFJ-731 Filter) useful.

The detector **diodes clearly stand out as the most easily damaged devices in the analyzer.** If you have a sudden problem, it is most likely a defective detector diode.

In order for the detectors to be accurate within a fraction of a percent (one bit), detector diodes must have very low capacitance and a very low threshold voltage. This means the diodes, through necessity, must be low-power zero-bias Schottky microwave detector diodes. The same characteristics that make them accurate and linear cause the diodes to be especially sensitive to damage from small voltage spikes. ***ALWAYS discharge large antennas before connecting them to the analyzer! Never apply external voltages greater than 3 volts to the antenna port!***

How This Unit Works

This is a rough summary of how this unit works:

The MFJ-259B, and other digitized MFJ antenna analyzers, compare three major voltages in a 50-ohm bridge circuit. They are:

Vz= Voltage across the load. This voltage is called Z in the alignment display menu

Vr= Voltage indicating bridge balance. This voltage is called R in the alignment display menu

Vs= Voltage across a 50-ohm resistor between the RF source and the load. This voltage is called S in the alignment display menu

All voltages are converted through an eight-bit A-D converter to a 256-bit digitized output with a test-display range of 0-255 bits. By knowing the ratio of these voltages, as compared to the regulated RF source voltage, many different load parameters can be calculated. An antenna analyzer could calculate everything (except sign of reactance) from measuring only Vs and Vz, but at certain impedances any small error in either Vs and Vz becomes critical. This is especially true when voltage is digitized into a 256-bit format (~0.4% steps). At certain impedances, an almost immeasurable voltage change will cause a sudden large jump in the measured impedance parameters.

To reduce display impedance jumps, SWR is weighed into the calculation of reactance and resistance at low SWR values. (An SWR bridge is most accurate when the load is closest to 50 ohms, which is a primary measurement area where impedance measurements through Vz and Vs become critical.) By factoring in a direct SWR measurement from an internal bridge, the analyzer can check and "correct" any small level errors in Vs or Vz. This reduces the impedance jump that would occur with a one-bit jump in voltage. This also why bits must be calibrated for near-perfect accuracy. a one-bit error can cause a resistive load to appear reactive (the total of Vs and Vz must always be 255 bits or less for a load to be considered resistive).

Calibrating the MFJ-259B Antenna Analyzer

This calibration procedure is the correct procedure for later MFJ-259B's. Disregard any other information. Since MFJ-259B software has been changed under the same model number, you may find some final performance test steps not valid. These steps will involve parameters that do not appear on the display.

Be sure you have printed a copy of the board layout showing adjustment points, have read all this, and have suitable loads before proceeding.

Adjustments

This unit has tracking and gain adjustments for Vz, Vs, and Vr. Tracking is set at low voltages (low bits). Gain is set at high voltages or bits. Together they make the detector voltage output closely track the actual RF voltage.

This unit also has meter calibration adjustments. The analog meters almost certainly suffer from some scale linearity problems, they will be somewhat less accurate than the digital display. These adjustments only affect analog meter readings. The meter adjustments do not affect the display.

Quiescent current (bias) in the RF amplifier section is adjustable. This adjustment directly affects output signal harmonic content. Harmonics are worse with low supply voltages, and with low impedance loads. ***Be sure you check the harmonics as outlined below, with a 1/4 wl open-circuit stub!!***

Excessive harmonics can cause severe errors in measurement of frequency-selective loads, even when dummy-load SWR tests appear perfect. Loads most sensitive to harmonic-induced errors include, but are not limited to, antenna tuners, tank circuits, very short resonant antennas, and distance to fault and stub length measurements. If you notice something "funny" going on with a stub measurement, it may be a fault of incorrect bias.

Warning: Never calibrate around a sudden "problem" that appears. If a detector suddenly shifts voltage, the problem is almost certainly a defective detector diode. If the meter is recalibrated with a defective (leaky) diode, the meter will probably NOT track correctly with frequency.

Alignment

Tools and Equipment:

[ ] #2 and #1 Phillips-head screwdrivers

[ ] Digital meter or accurate analog meter for checking supply voltage

[ ] Small set of non-metallic alignment wands for coils, or small jeweler's screwdrivers for controls

[ ] Power supply, regulated to 12-volts + - 5%

[ ] General-coverage receiver with level meter or Spectrum Analyzer (these are optional with additional work and use of a stub)

[ ] ~10 MHz 1/4wl open-stub, for example 15' good-quality solid-dielectric RG-8, UHF connector at on end, open on other (not needed with analyzer or receiver)

[ ] 2.2-ohm 1/4 or 1/2 watt film resistor (not needed with stub)

[ ] Accurate load set to include:

A. Short

B. 12.5-W load

C. 50-W load

D. 75-W load

E. 100-W load

F. 200-W load

Note 1: Loads must be constructed using physically small 1% carbon-film resistors.

- **DO NOT use large resistors. Acceptable results will be obtained when load resistors are mounted in the very bottom of a UHF-male connector.**

- **The ideal load resistors are surface-mount precision-resistors, but other styles will work. It is acceptable to parallel multiple resistors to obtain low resistances, but don't series connect more than two resistors!**

- **Never use physically large resistors, such as 1-watt or larger resistors, unless you are absolutely positive they are composition-types (very rare).**

- **Since the loads are used to set the number of bits in critical calculations, the maximum reactance error will always be worse than the percentage of resistive load error. A one bit error in calibration (~ .4%) can shift a resistive load to read reactance.**

Quick-connect loads can be made with surface mount resistors on a BNC male chassis mount connector with the bayonet removed. This makes a "quick connect" connector that will slide directly into a type-N female. In this case, use a good UHF to BNC female adaptor for the 259 units. With a 269, the load will plug directly in to the N female.

Note 2: The power source should be the LOWEST expected operating voltage. DO NOT use a standard "wall-wart" or batteries! You can reduce voltage from a conventional 13.8v regulated supply by adding a few series diodes. Silicon diodes will normally drop about 0.6volts or so per diode. Three or four diodes will reduce place the voltage below 12 volts.

WARNING: The MFJ-1315 AC adapter or other "wall-warts" should NOT be used to power the unit for most alignment steps.

Step 1

Visual Inspection: Before, during, and after calibration, be mindful of physical condition. Watch for missing or loose hardware. Do not tug, stress, or repeatedly flex leads, or carelessly flop or toss things about. Keep your bench clean. Follow these rules the entire time you have the unit apart!

Step 2

Battery Tray Removal: This step provides access to trim-pots and most inductor adjustments.

[ ] Remove last two batteries at each end of the tray.

[ ] Remove two screws (right side) and extract the tray.

[ ] Always position the battery tray to minimize strain on wires.

Refer to the board layout pictorial for specific control locations.

Step 3

Band Overlapping: Each band should overlap the next by a small amount to ensure gap-free coverage from 1.8 MHz to 170 MHz. While viewing the *LCD Frequency Display*, wiggle the bandswitch from side-to-side gently. Watch for any display or meter dropout. Check each band as follows:

[ ] **114-170 MHz:** Oscillator tunes from below 114.0 MHz to above 170.0 MHz. Check tune for dead spots.

[ ] **70-114 MHz:** Oscillator tunes from below 70.0 MHz to above 114.0 MHz

[ ] **27-70 MHz:** Oscillator tunes from below 27.0 MHz to above 70.0 MHz.

[ ] **10-27 MHz:** Oscillator tunes from below 10.0 MHz to above 27.0 MHz.

[ ] **4-10 MHz:** Oscillator tunes from below 4.0 MHz to above 10.0 MHz.

[ ] **1.8-4 MHz:** Oscillator tunes from below 1.8 MHz to above 4.0 MHz. Check tune for dead spots.

While verifying overlap, check at least the lowest and highest bands carefully for dead spots. The LCD Display will indicate 000.000MHz if a dead spot occurs. Dead spots generally indicate a defective tuning capacitor (TUNE).

If you find the switch causes a dropout the switch may have dry or dirty contacts, or poor solder joints. Check the solder joints first. If you must clean and lubricate the switch, be aware it is a difficult task. The entire board needs to be lifted from the case front. Dirty band-switch contacts may be restored with spray tuner cleaners. The best place to spray the switch is from the front side (shaft side), right below the nut. You must remove the switch indexing tab retainer nut and the metal switch retainer (stop) under the nut. Be sure the stop goes back exactly as removed.

To correct overlap problems, locate and retune the appropriate VFO coil (see Pictorial for coil locations). Note that L1-L4 are slug-tuned and require an insulated hex-head tuning wand. If you use the wrong size wand or a worn wand, it will break a slug!

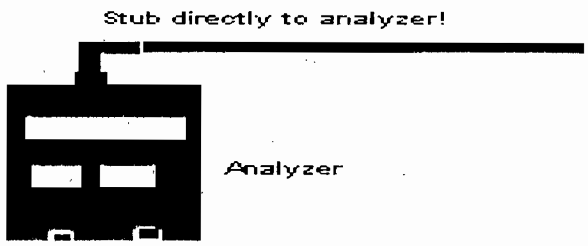
Inductors L5 and L6 are located on the component side of the board and are compression-tuned (press turns closer together to lower frequency or spread apart to raise frequency). Make only very small corrections--*especially to L5 or L6*--and recheck the band you are adjusting. You should also check the *next lower band* after each adjustment to ensure that the lower band hasn't moved excessively.

Important Warning: VFO coils MUST be aligned from highest frequency to lowest frequency. The next higher range affects next lower band the greatest amount. Do not attempt VFO coil adjustment unless you are experienced working with VHF-LC circuitry or complex alignment procedures.

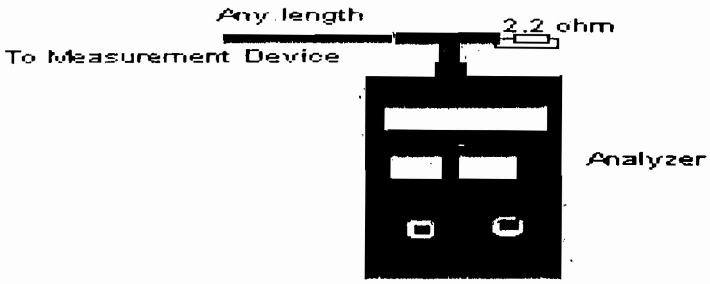
Step 4

Harmonic Suppression/ Bias: Connect the analyzer *exactly* as shown below.

- The impedance of the cable to the measurement device should match the impedance of the measurement device.
- The "T" must be connected either directly to or placed within a few inches of the analyzer.
- The power source must be the lowest expected operating voltage.
- The measurement device must be well-shielded, and not pick up any substantial signal from the analyzer when the "T" is disconnected from the analyzer.



Test Setup Using Internal Vz for Harmonics



Test Setup using External Analyzer and resistor for Harmonics

Step 5

Harmonic Suppression (bias R89): This adjustment reduces oscillator harmonics. Harmonics will cause incorrect readings under some load conditions.

WARNING: ***Incorrect adjustment of R89 will NOT show when checking with resistive dummy loads!!! The unit will appear to calibrate correctly, but will produce errors in stub length, distance-to-fault, and other frequency selective functions.***

When R89 is set properly, harmonic suppression of -30 to -35dBc should be possible across most of the analyzer's tuning range. This particular adjustment must be made at the lowest expected operating voltage. Proper alignment requires a 12.0-volt regulated supply as a power source. NEVER use an AC adapter or any supply voltage higher than 12-volts when making this adjustment. A calibrated spectrum analyzer works best for monitoring harmonic output, but a well-shielded general-coverage receiver with signal-level meter will also work. The receiver MUST be "T'd" into the analyzer just as the spectrum analyzer is, and the Tee and resistor must be located at the analyzer connector. If you do not have a good-quality receiver or spectrum analyzer, use the test mode of the analyzer with a stub. Watch MFJ analyzer test-mode Vz. Test-mode Vz will roughly indicate total harmonic voltage when the analyzer is set at the stub's exact resonant frequency. Entering the test mode is described in Detector Calibration (Step 6).

[ ] a. Install either a 15' RG-8 open stub, or resistor and measurement device, and tune analyzer to approximately 10 MHz.

[ ] b. (stub and internal Vz use only) Observing Vz on the data display (analyzer test mode), adjust frequency until the *lowest* fundamental output reading (or lowest impedance) is obtained. You should clearly see the MFJ analyzer's fundamental frequency output voltage (Vz) go through a deep null.

[ ] c. Observe the analyzer frequency reading. This is the approximate resonant frequency of the stub, and the test frequency.

[ ] d. Without changing the analyzer test frequency setting, observe the second harmonic level. This harmonic will be at twice the MFJ analyzer frequency counter reading..

[ ] e. Adjust R89 for lowest 2nd harmonic meter reading on the receiver, lowest Vz test-menu reading, or lowest harmonic level on the spectrum analyzer. Be SURE the fundamental frequency level remains nulled in the analyzer.

WARNING: Always repeat steps (b) through (e) at least one extra time when relying on display Vz. The original null point of any stub will shift if there is a substantial reduction in harmonics after R89 is adjusted. The original stub frequency, as observed at (c), will probably change slightly. It is NOT necessary to recheck when doing a resistor load test with a good-quality spectrum analyzer or receiver. With a resistor, exact test frequency is NOT critical.

NOTE: If you have a poorly performing spectrum analyzer or receiver with limited dynamic range, use a stub with the spectrum analyzer or receiver instead of a 2.2 ohm resistor. If you have a reasonable quality spectrum analyzer or receiver (at least 50dB dynamic range) use a 2.2-ohm

[ ] 50-W

[ ] Tune to 1.8 MHz

[ ] Verify Z=50 W, q=0°, SWR=1

[ ] Advance to Return Loss

[ ] Verify RL=>42dB, r=0, SWR=1

[ ] Advance to Match Efficiency

[ ] Verify ME @ 100%

[ ] Restore Main Modes

[ ] Open

[ ] Verify Z=>650

End of Procedure

Pictorial Diagram of Analyzer Board

Locations for trimpots and inductors