MFJ 259/259B
Operation & Simplified Calibration

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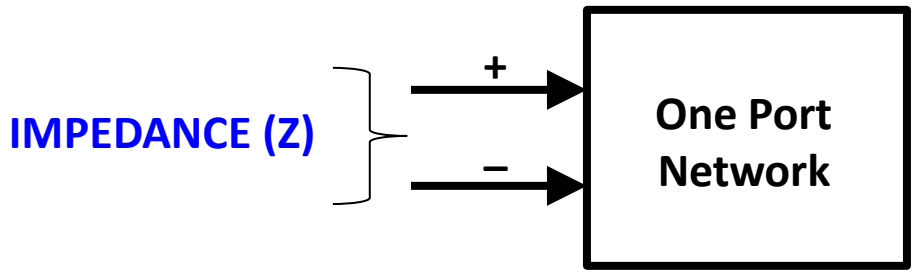
1 March 2014

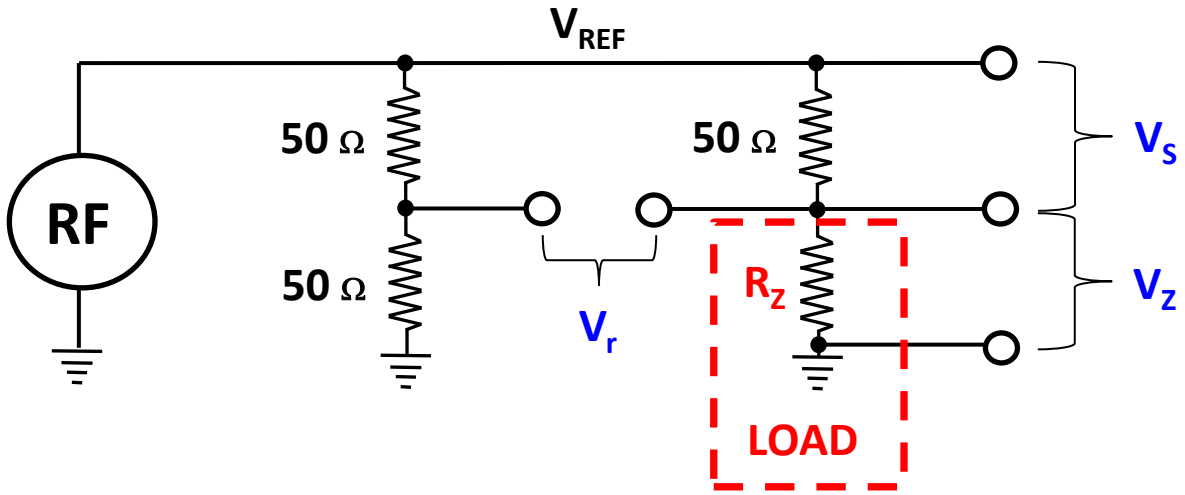
What Is An MFJ-259

- MFJ lists it as a "HF/VHF SWR Analyzer"
- It is essentially a "ONE PORT NETWORK ANALYZER"
  - Measures the electrical parameters of a one port network
  - A port is one complete signal path



How Does The MFJ259 Measure Impedance?

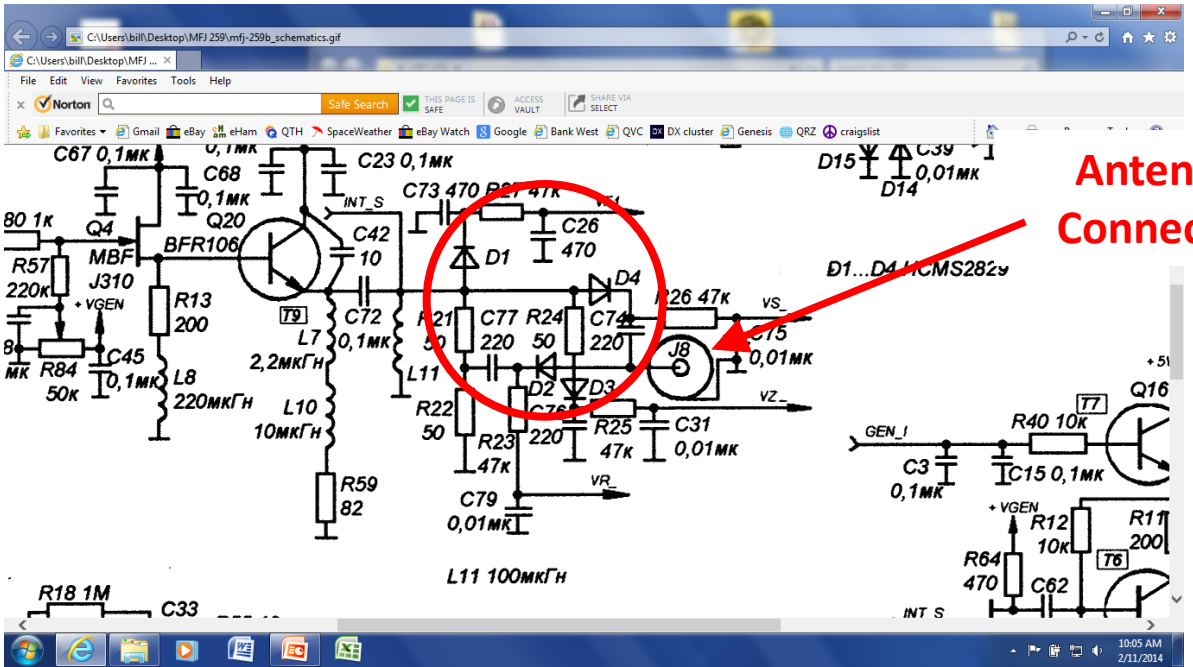
- It generates an RF signal and uses a conventional BRIDGE NETWORK to compare forward & reflected RF signals
  - Three RF voltages are rectified to generate three DC outputs
    - V_Z is the voltage across the load
    - V_r is the voltage indicating bridge balance
    - V_S is the voltage across a series 50Ω resistor between the RF source and the load



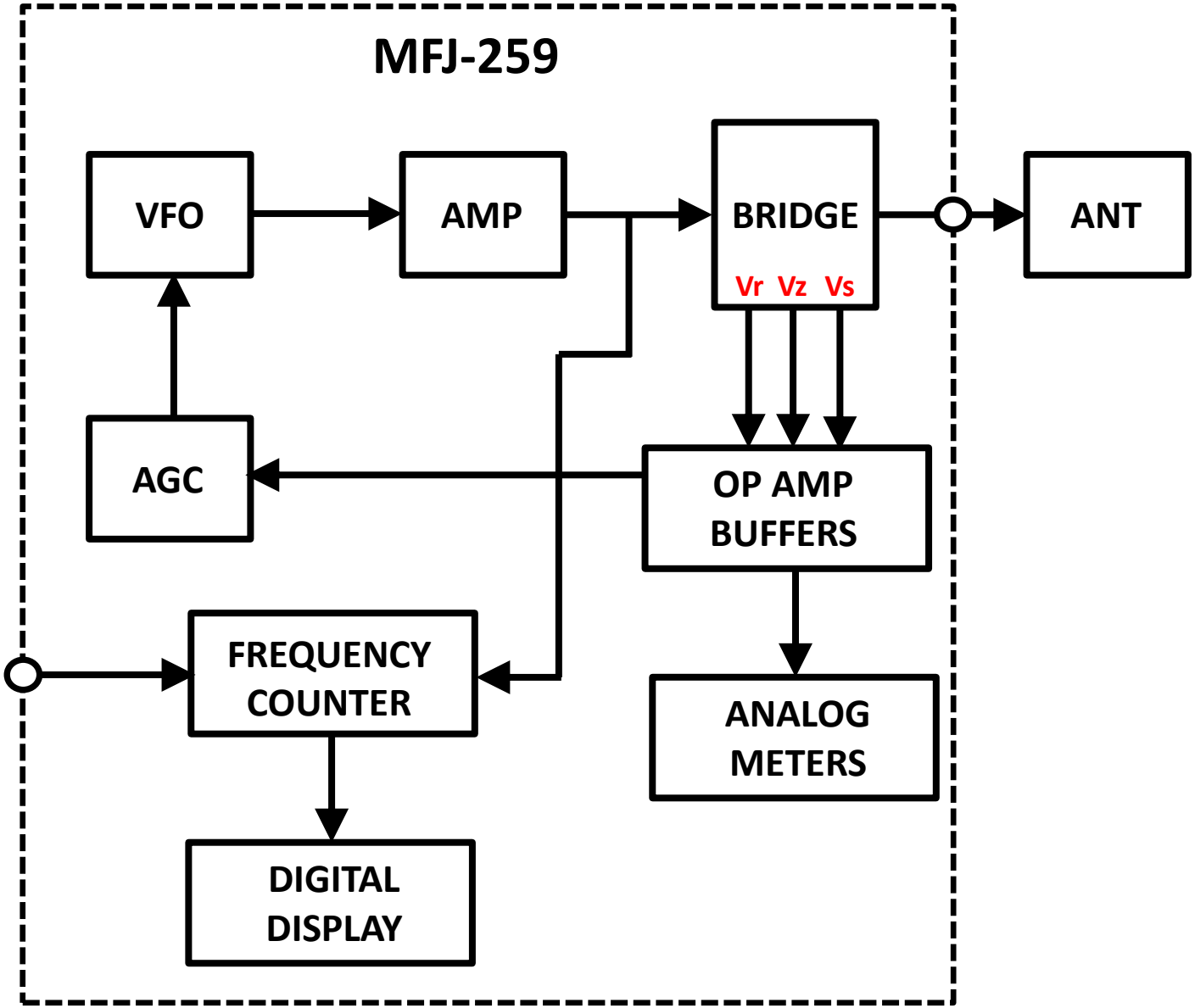
R_Z is the resistance of the load being measured

Caution Notes

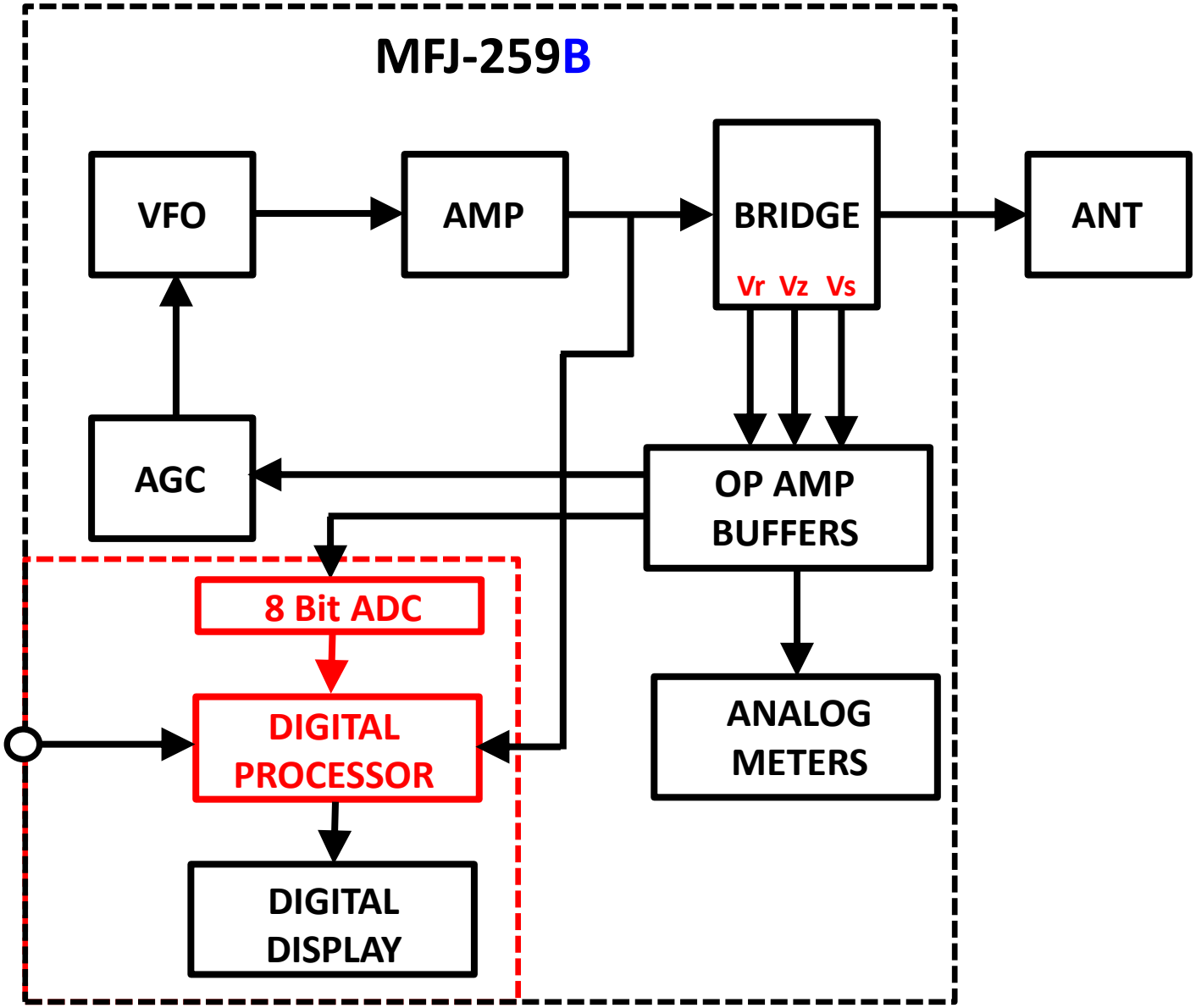
- Bridge diodes:
  - Needed to convert RF to DC voltages (V_S, V_r, V_Z)
  - Easily burned out (**even when powered OFF**)
    - DC voltage above 3 volts (??)
      - ESD:
        - **Discharge antennas** before connecting to analyzer
        - Never touch antenna jack with your hand
    - RF levels above ?? (I use +10 dBm as a max)
  - Wideband => Strong spurious signals can cause erroneous readings
    - MFJ-731 Tunable Analyzer Filter.MFJ



Original MFJ-259



MFJ-259B


MFJ-259B
VFO
AMP
BRIDGE
Vr Vz Vs
ANT
AGC
OP AMP
BUFFERS
8 Bit ADC
DIGITAL
PROCESSOR
ANALOG
METERS
DIGITAL
DISPLAY

How Does The MFJ 259 Display Results?

- MFJ 259:
  - Analog Meters:
    - SWR
    - Resistance **(??)**
      - **Manual is confusing**
        - **"Resistance reading is accurate only if reactance = 0"**
  - Digital Display:
    - Only displays Frequency
- MFJ 259**B**:
  - Analog Meters:
    - SWR
    - Impedance
      - **Manual is confusing**
        - **"The IMPEDANCE " meter displays the complex impedance…"**
        - **Complex impedance is composed of <u>two</u> numbers??**
  - Digital Display:
    - Frequency, **SWR, Resistance, & Reactance**
  - **Digital Processor** generates the values for the Digital Display
    - **Digital Display is more accurate** than the Analog meters

What Does The MFJ 259 Measure?

- **Resistance (??)** **259 only**
- **Impedance**
- **Resistance**
- **Reactance**

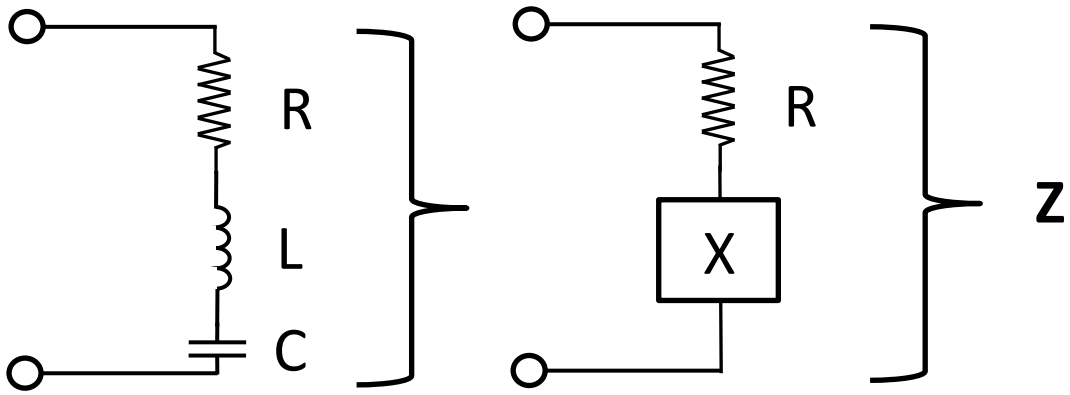
259B only

- **SWR**
- Coax Loss
- Capacitance
- Inductance
- Frequency Counter
- Return Loss
- Reflection Coefficient
- Distance to Fault (on transmission line)
- Resonance
- Percentage Transmitted Power
- Velocity Factor
- Impedance of Transmission Lines

Impedance

- Impedance = **Z** = Resistance + Reactance = **R + jX**
  - Measured in OHMS

Physical Circuit **Equivalent Impedance Circuit**



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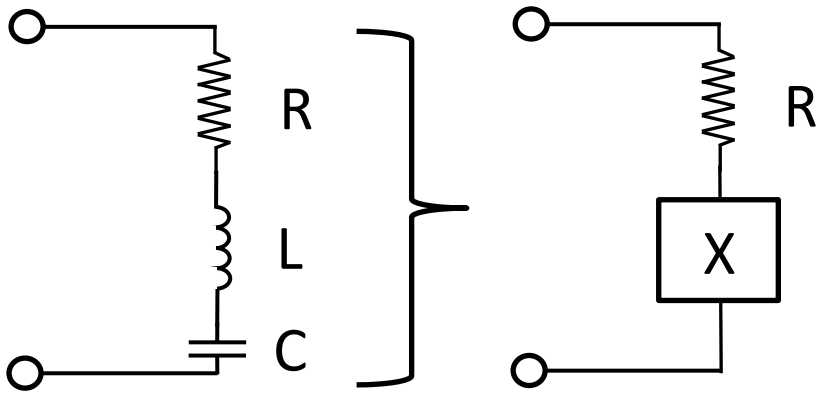

What is the value of X?

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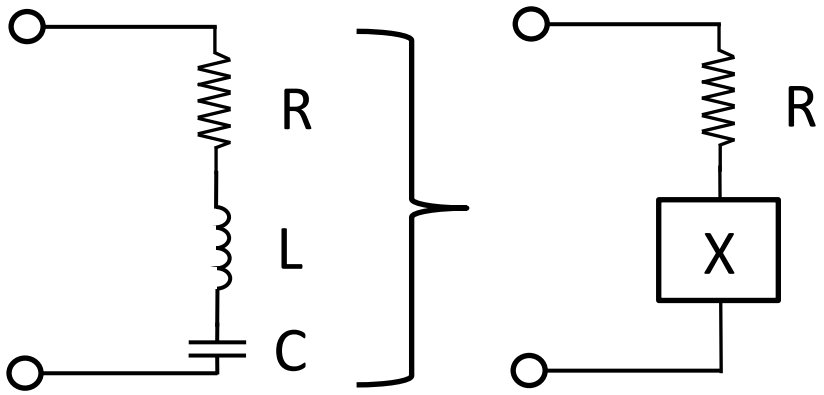

To calculate X, we must specify the frequency

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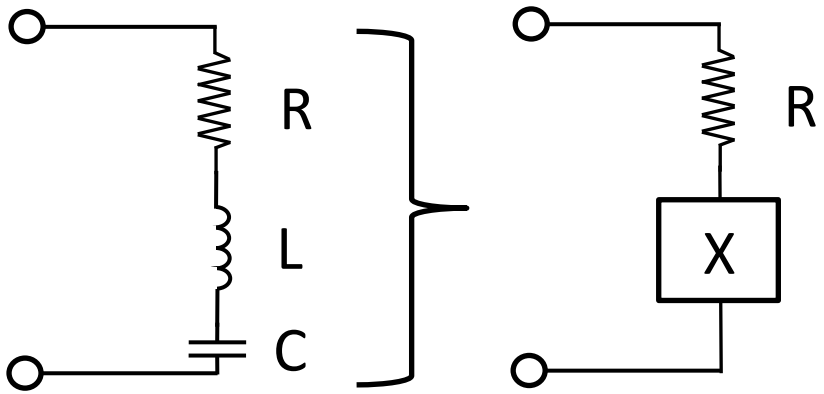

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- Note:
  - At any one frequency, if X is not zero, it is <u>EITHER</u> inductive (+jX) or capacitive (-jX)

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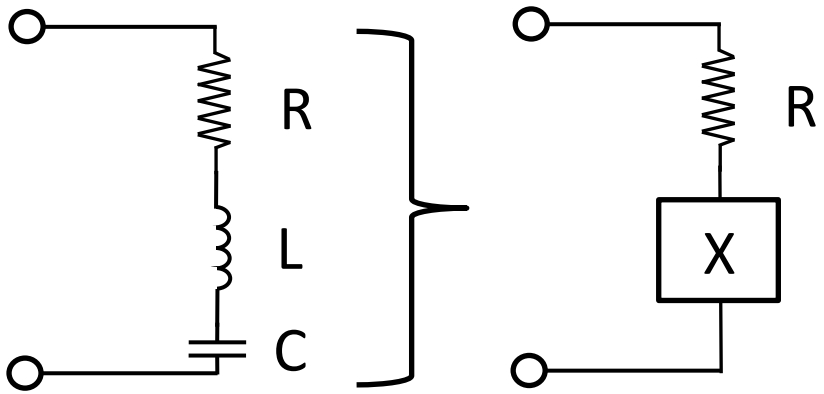

At any specified frequency (F)

X = $j2\pi FL + 1/(j2\pi FC)$

= $j2\pi FL - j[1/(2\pi FC)]$

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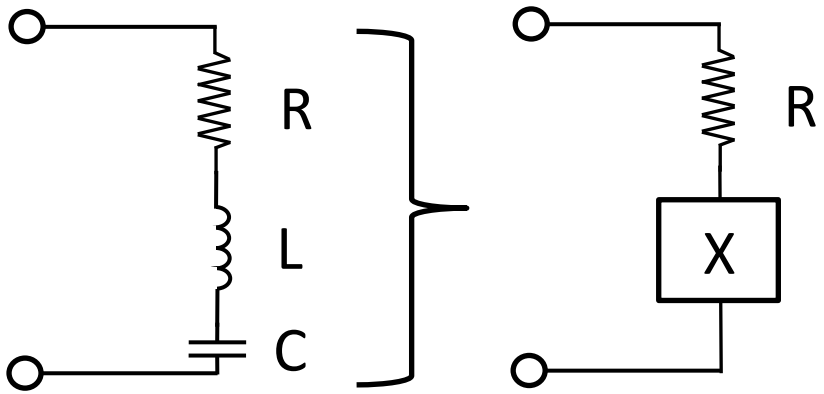

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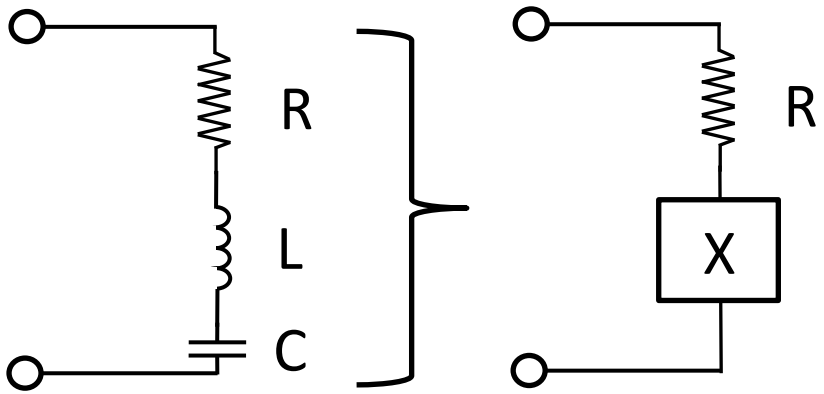

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  - MFJ 259: "Resistance" reading should equal R regardless of X
  - The MFJ 259B "Impedance" meter displays Z as **<u>one</u>** number

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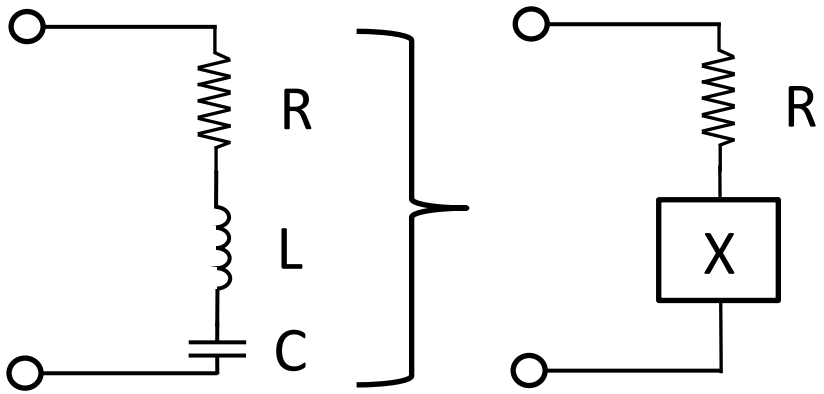

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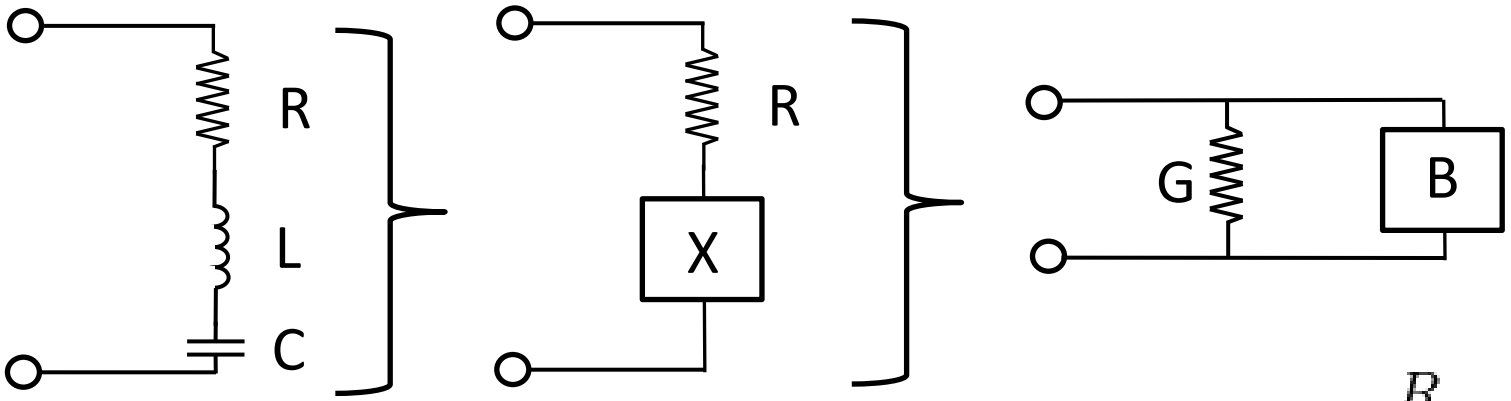
  - MFJ 259: "Resistance" reading should equal R regardless of X
  - The MFJ 259B Impedance meter displays the **<u>Magnitude</u>** of Z

$$\text{Magnitude of } Z = |Z| = \sqrt{R^2 + X^2}$$

Admittance

- Admittance = **Y** = Conductance + Susceptance = **G + jB**
  - Measured in SIEMENS
    - 1 siemen = 1/(1 ohm) = 1 mho

Physical Circuit **Equivalent Impedance Circuit** **Equivalent Admittance Circuit**



$$G = \Re(Y) = \frac{R}{R^2 + X^2} \quad \textbf{mhos}$$

$$B = \Im(Y) = -\frac{X}{R^2 + X^2} \quad \textbf{mhos}$$

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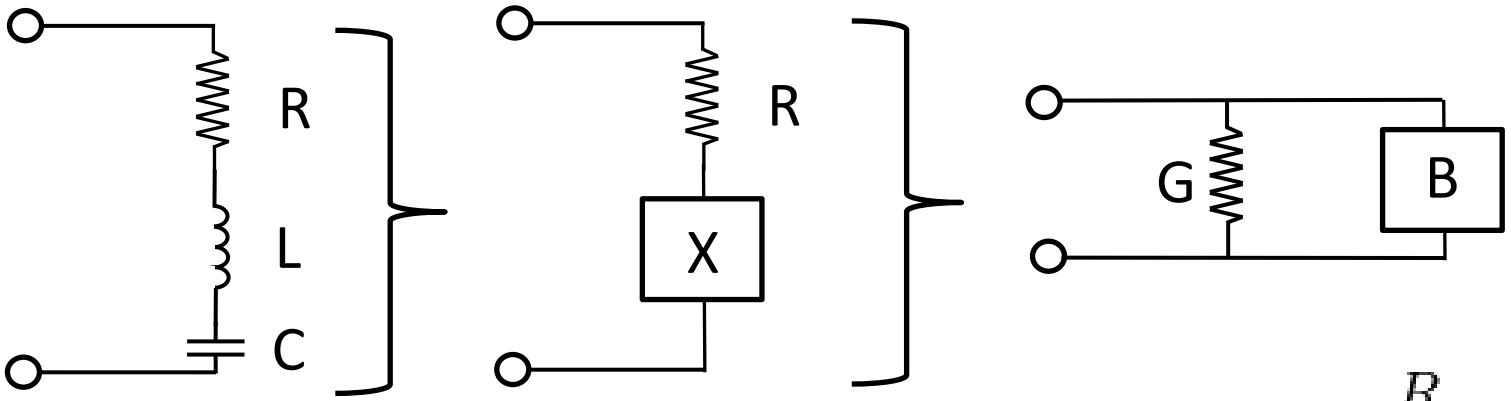

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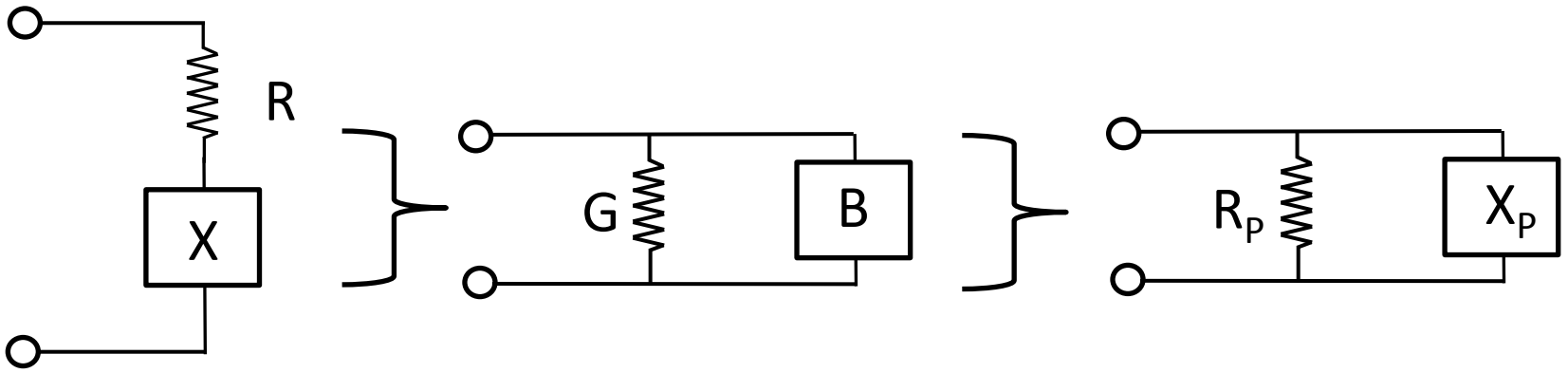
Note: <u>Both</u> G, & B are a function of frequency

Admittance

- **To express G & B in ohms, simply invert:**

$R_P = 1/G$ **ohms**

$X_P = 1/B$ **ohms**



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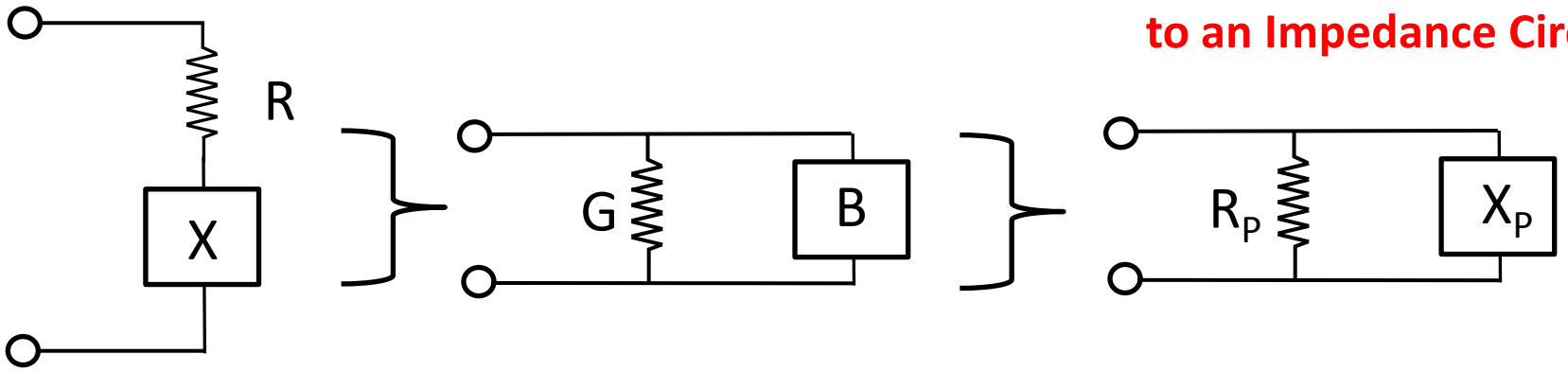

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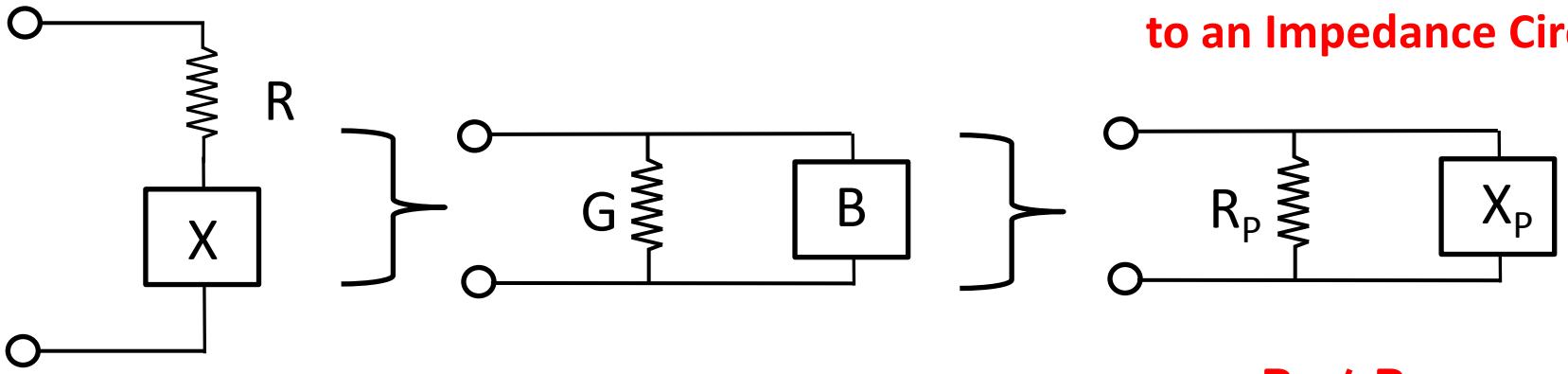
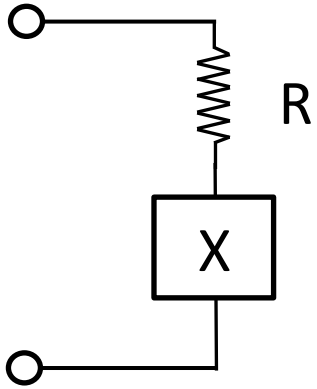


$R_P \neq R$

$X_P \neq X$

Admittance

Equivalent Impedance Circuit



This is what is shown on the MFJ259B digital display

Admittance

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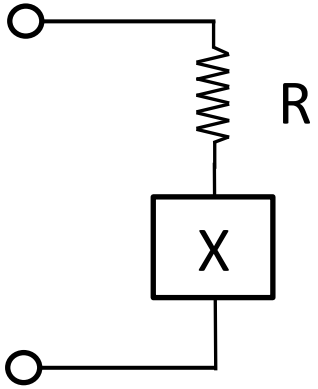

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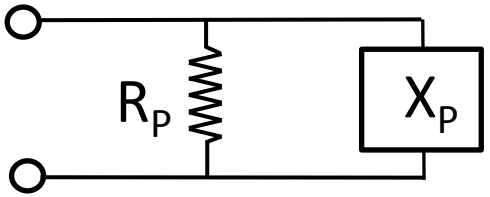
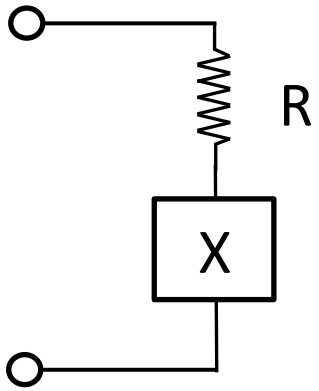


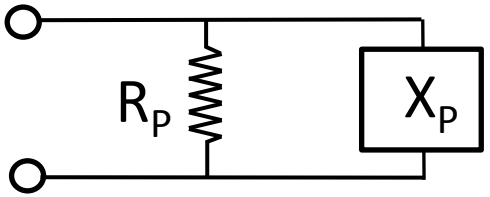
What happens to R_P & X_P as R => 0

Admittance

Equivalent Impedance Circuit



Equivalent Admittance Circuit



As R => 0 :

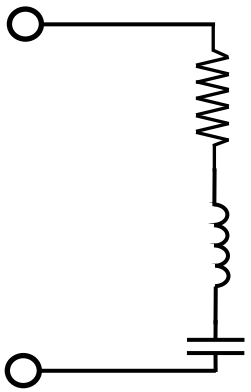
Q => Infinite

R_P => Infinite

X_P => X

MFJ 259B Test Circuit

40M Dipole



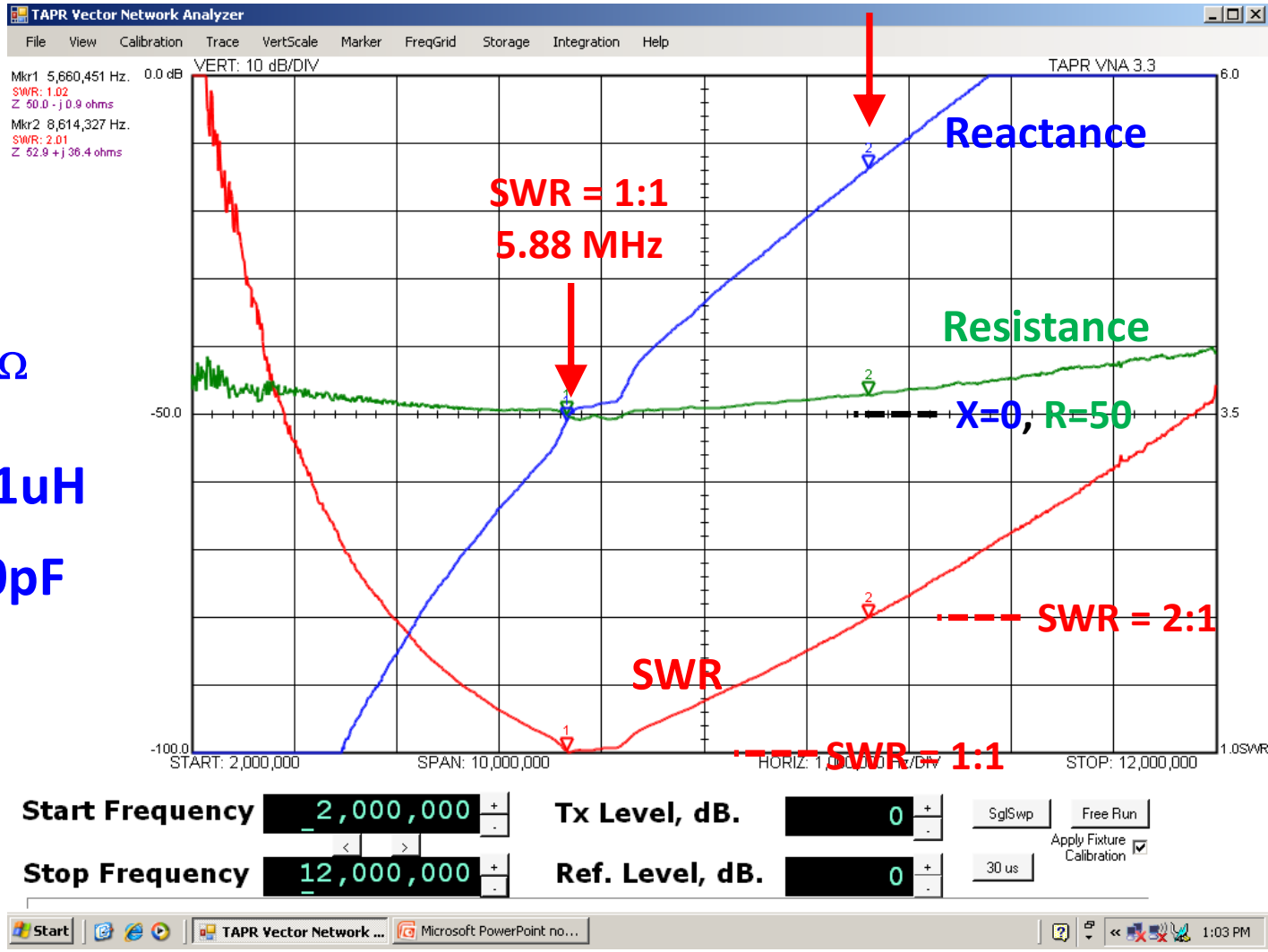
R = 50 Ω

L = 1.31uH

C = 510pF

TenTec VNA

SWR = 2:1
8.61 MHz



What Does The MFJ 259B Measure?

- F (SWR=1:1) = 5.88 MHz:

  Expected values:

  $X = j2\pi FL + 1/(j2\pi FC) = j46.6 + 1/(j18.1x10\text{-}3) = j48.4 - j53.0 \cong 0$

  $Z = R = |Z| = 50\ \Omega$

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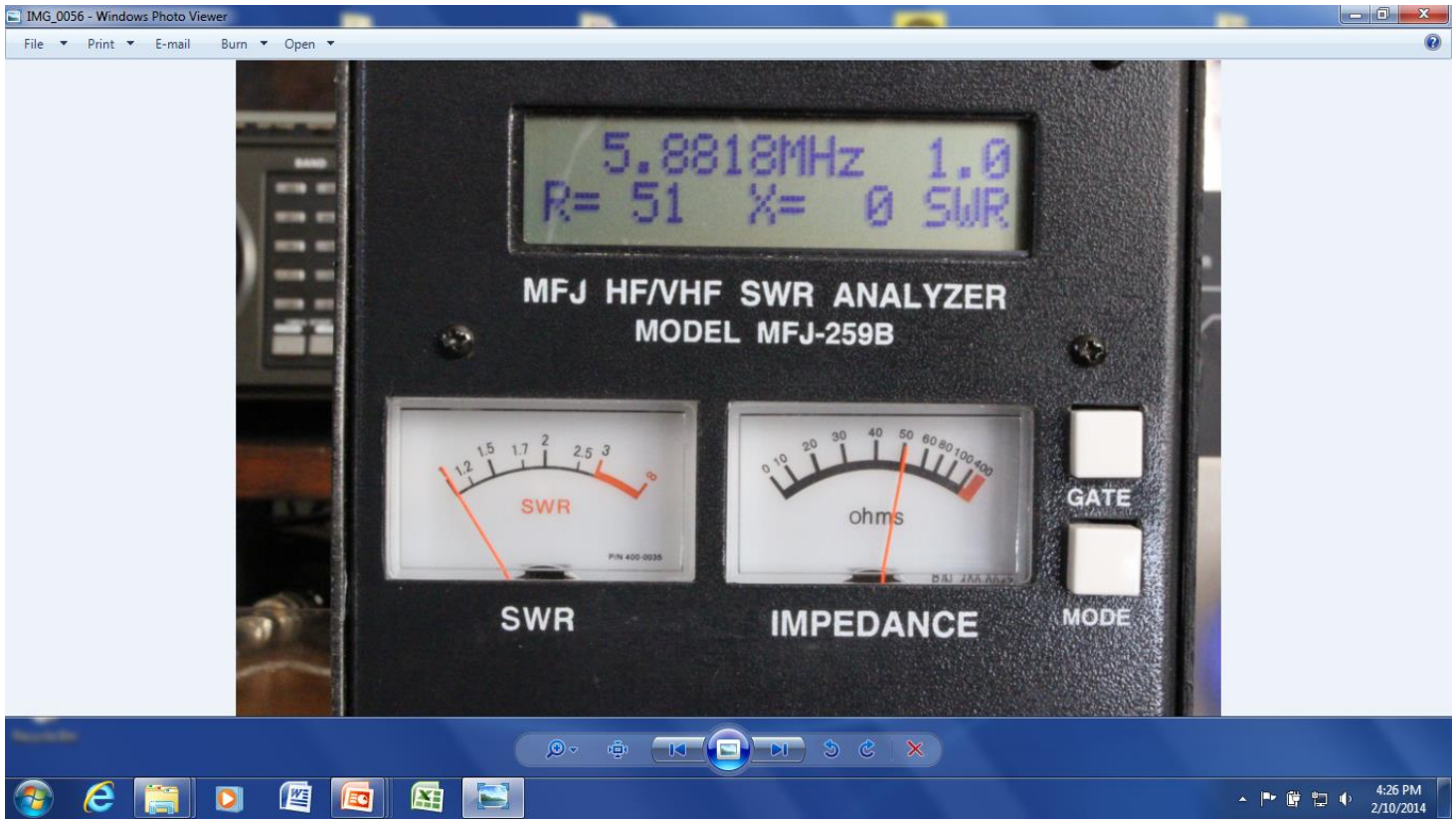

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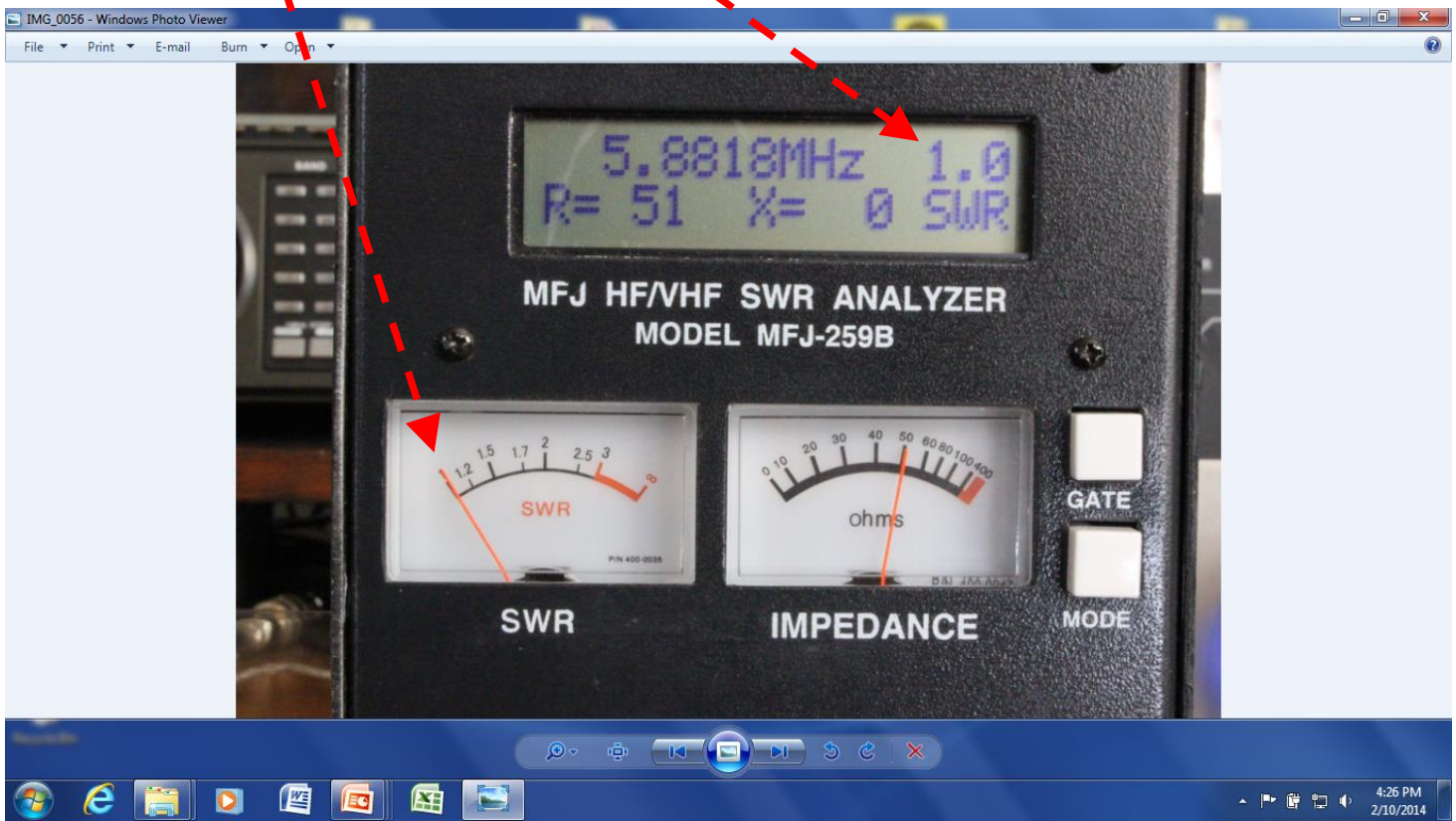

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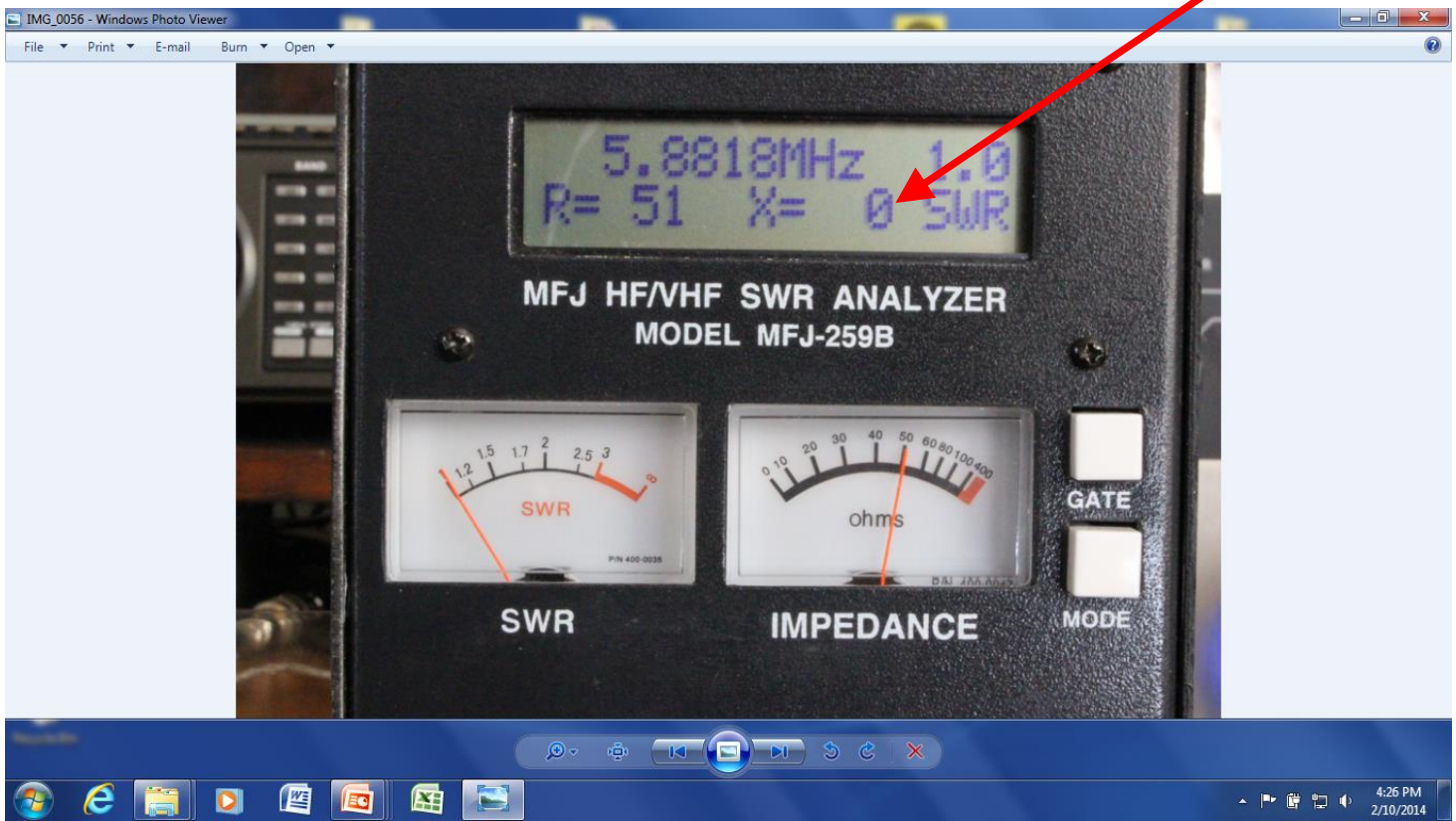

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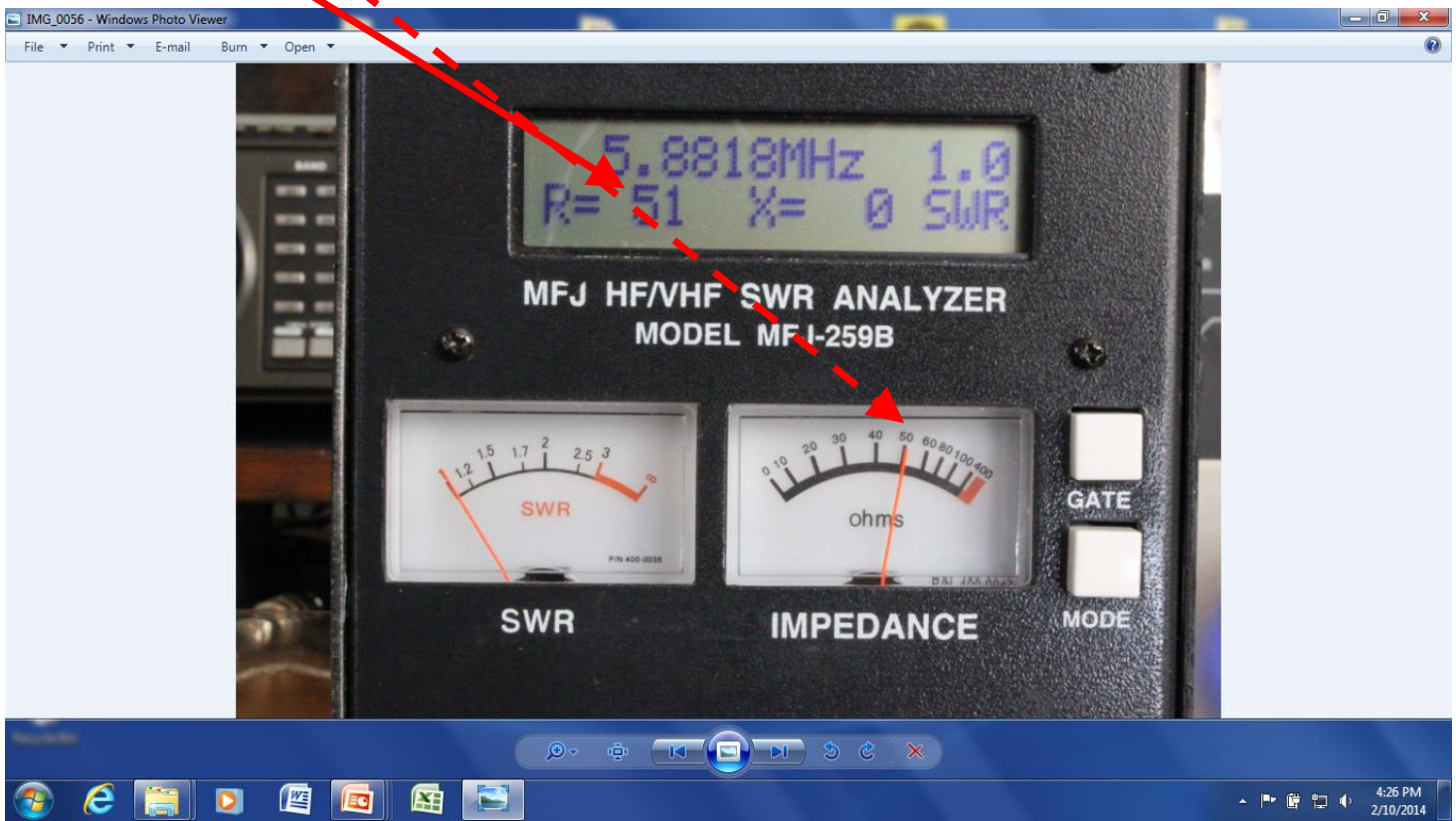

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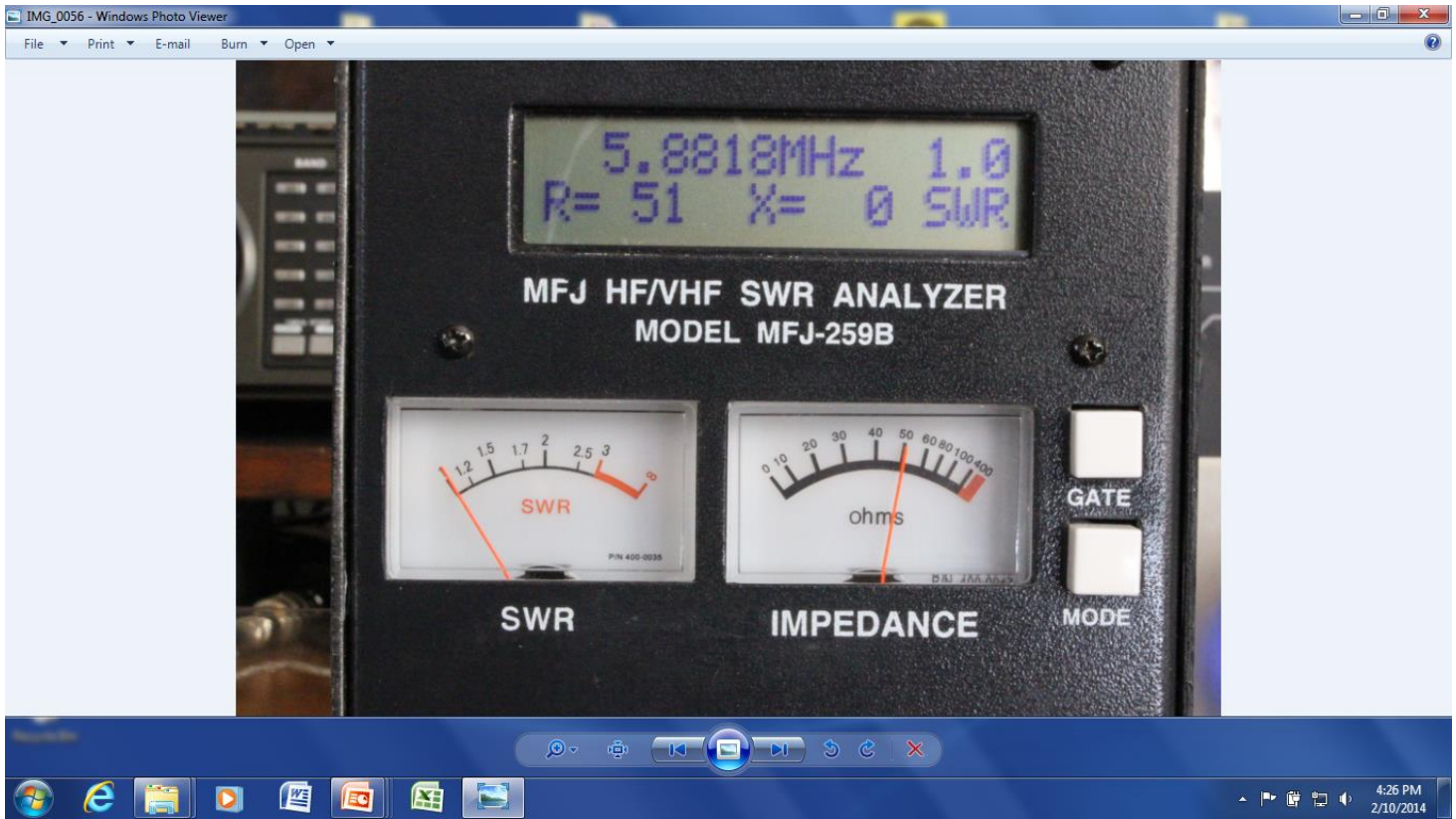
VNA Results: SWR = 1.02 & Z = 50.0 – j0.9 ohms



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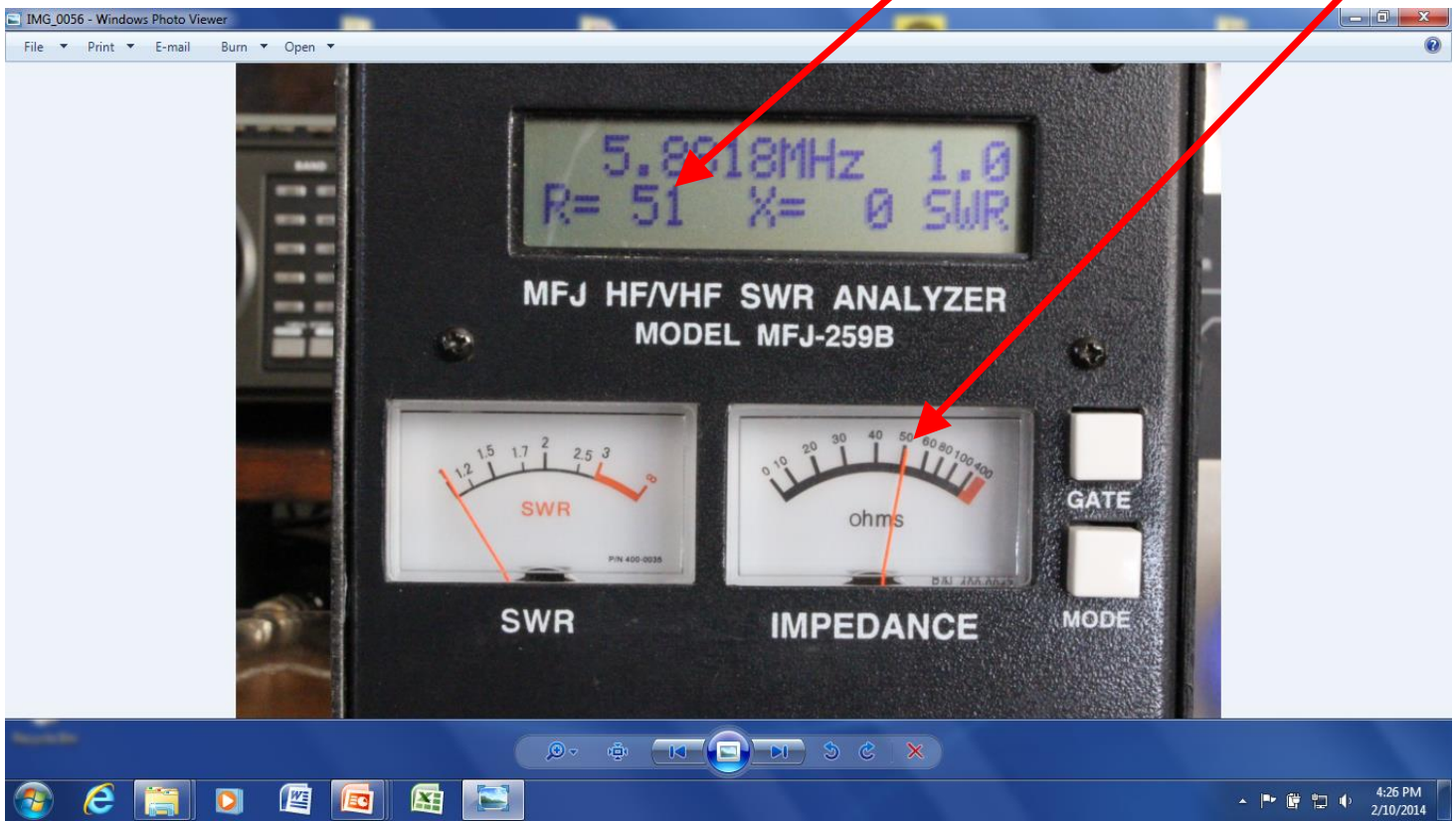
Before CAL: R measured 37Ω & |Z| measured 61Ω



What Does The MFJ 259B Measure?

- F (SWR=2:1) = 8.61 MHz:

Expected values:

$X = j2\pi FL + 1/(j2\pi FC) = j71.3 + 1/(j27.8x10\text{-}3) = j71.3 - j36.0 = j35.3$

$Z = 50 + j35.3$

Magnitude of $Z = |\mathbf{Z}| = \sqrt{R^2 + X^2} = \sqrt{50^2 + 35.3^2} =$ **61.2**

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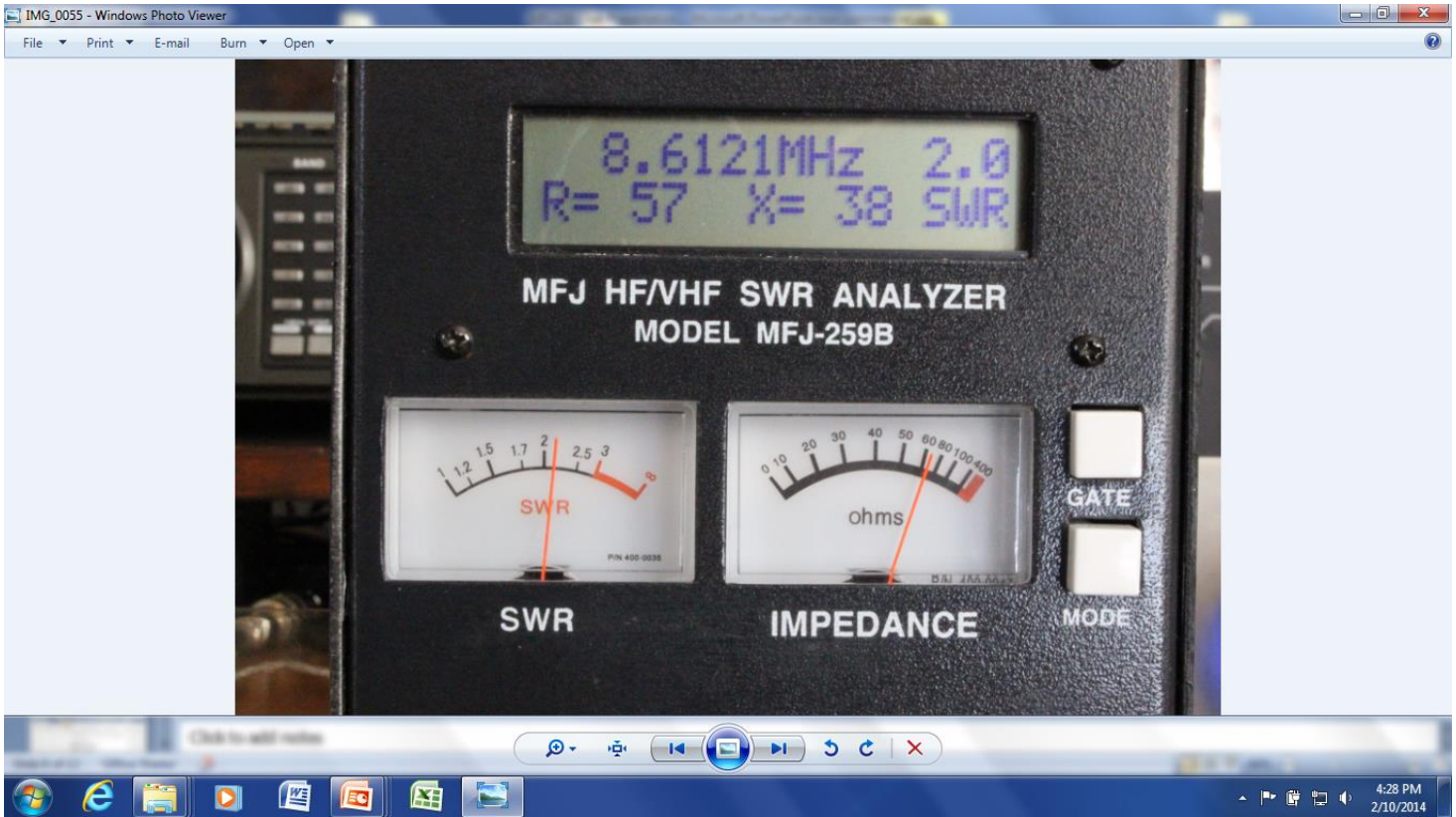

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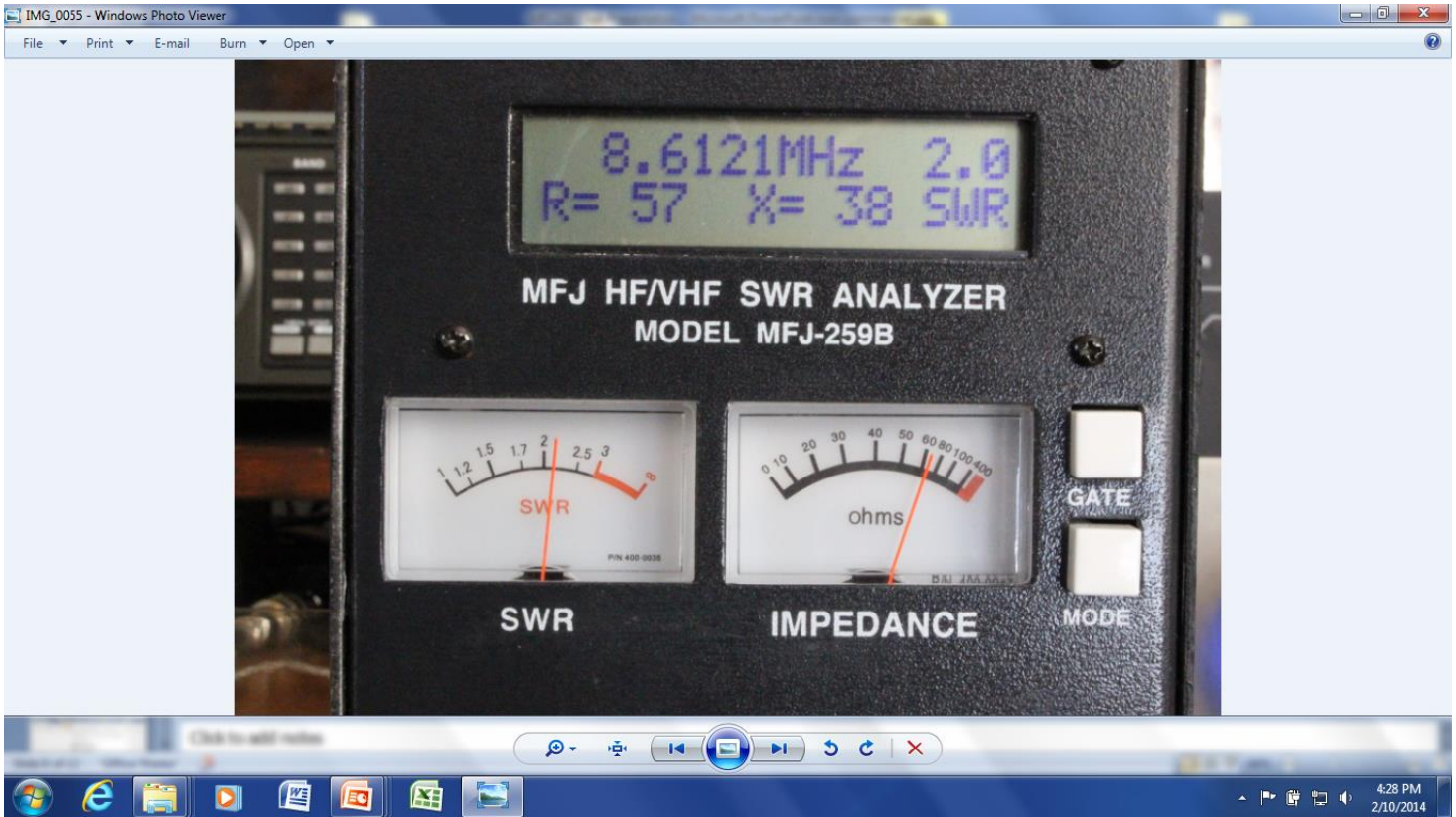
VNA Results: SWR = 2.01 & Z = 52.9 – j36.4 ohms



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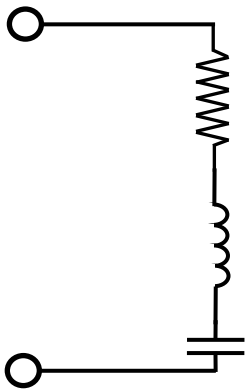
MFJ 259B Test Circuit

40M Dipole

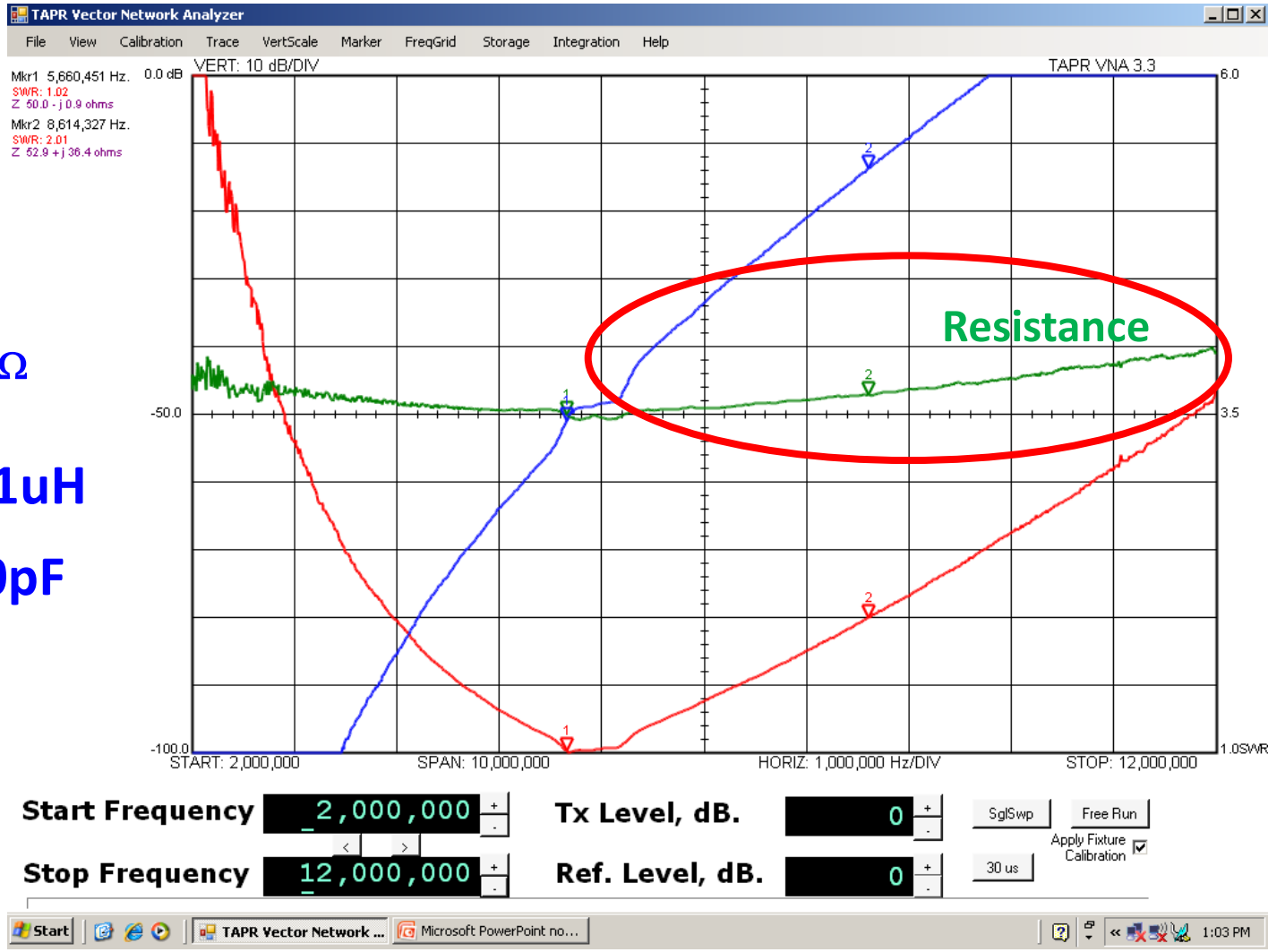


R = 50 Ω

L = 1.31uH

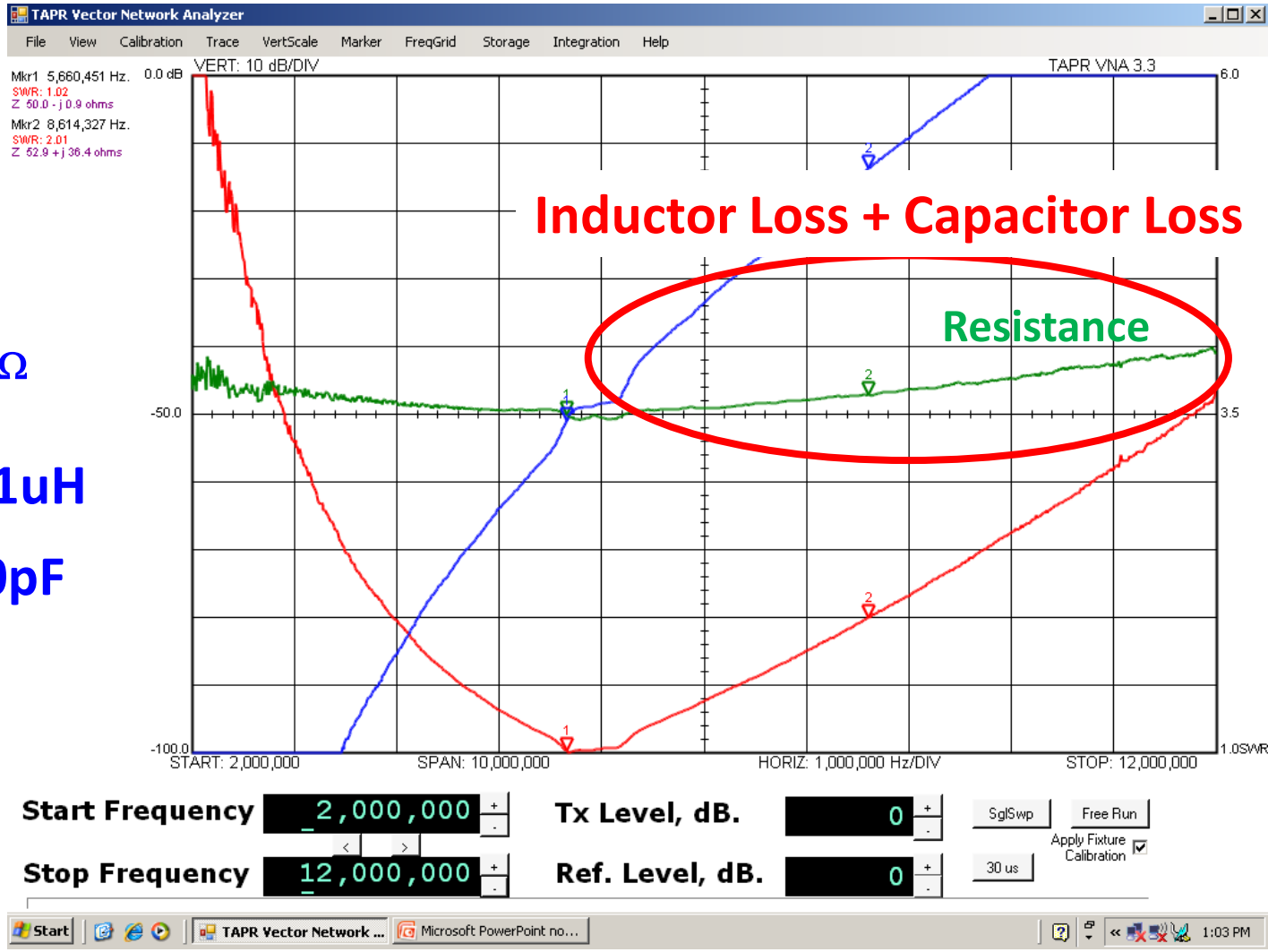
C = 510pF

TenTec VNA

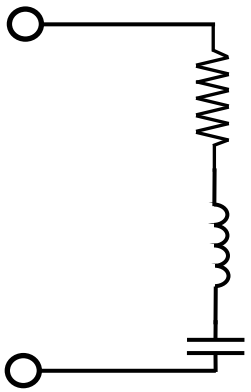


MFJ 259B Test Circuit

TenTec VNA



40M Dipole



R = 50 Ω

L = 1.31uH

C = 510pF

Simplified MFJ259/B Calibration

Calibration Information

- MFJ259:

http://www.radioaficion.com/HamNews/reviews/accesorios/11341-mfj-259-calibrating.html

  - Full Calibration Only Includes:
    - AGC Set to 0.4 VDC (CAL instructions are confusing?)
    - SWR meter set with 100Ω load
    - Resistance meter set with 50Ω load

- MFJ259B:

http://www.w8ji.com/mfj-259b_calibration.htm (don't use factory instructions)

  - Full Calibration Includes:
    - Adjust bias for minimum harmonic levels
    - Adjust VFO Ranges for band overlap
    - Calibration of Impedance & SWR at four different load values
      - Both analog and digital displays
  - **Simplified** Calibration Includes:
    - Check output power and harmonic levels
      - Adjust bias only if the harmonic levels are too high
    - Calibration of Impedance & SWR at four different load values
      - Both analog and digital displays

Calibration Information - continued

- Caution:
  - **ESD**: Do not touch any part of the PC board (or antenna jack) with your hands
  - Do not stress the wires to the battery holder
- Do not use wall warts when calibrating??

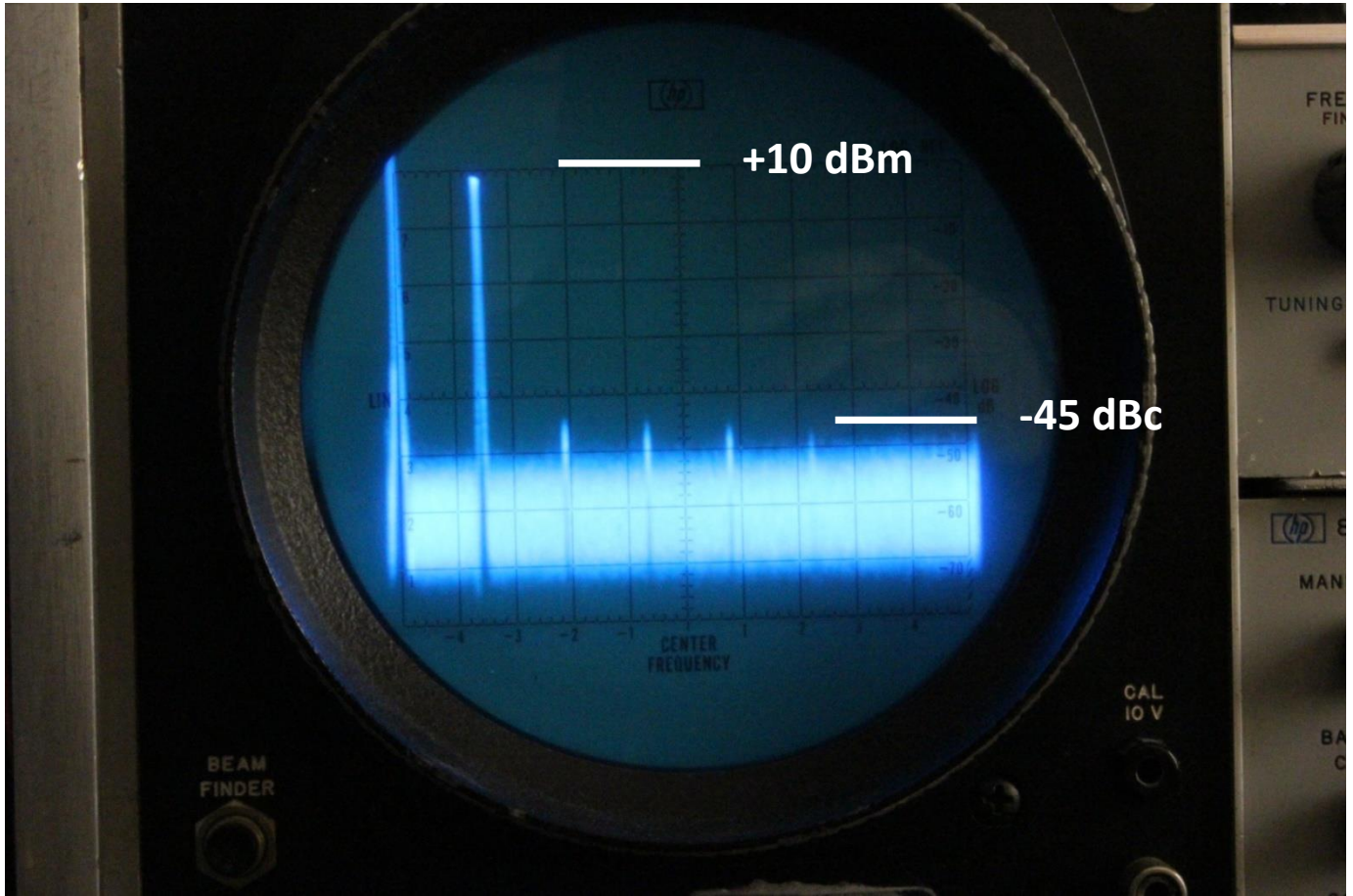
Parts Needed for Simplified Calibration

- RF loads: 12.5, 50, 75, 200 ohms
  - Use the **smallest METAL FILM** resistors you can find
- Philips screwdriver (#1 or #2)
- Non-metallic(??) alignment tool
- Spectrum analyzer or HF receiver with S meter

MFJ259/B Calibration

1- Check output RF level and harmonic content

- Output level should be ~ +10 dBm
- Harmonics must be < -25 dBc (< -35 dBc desired)
  - **Use 2.7 ohm load**
  - Adjust R84 later only if necessary



MFJ259B Calibration

2- Check CAL accuracy first with 50 & 100 ohms

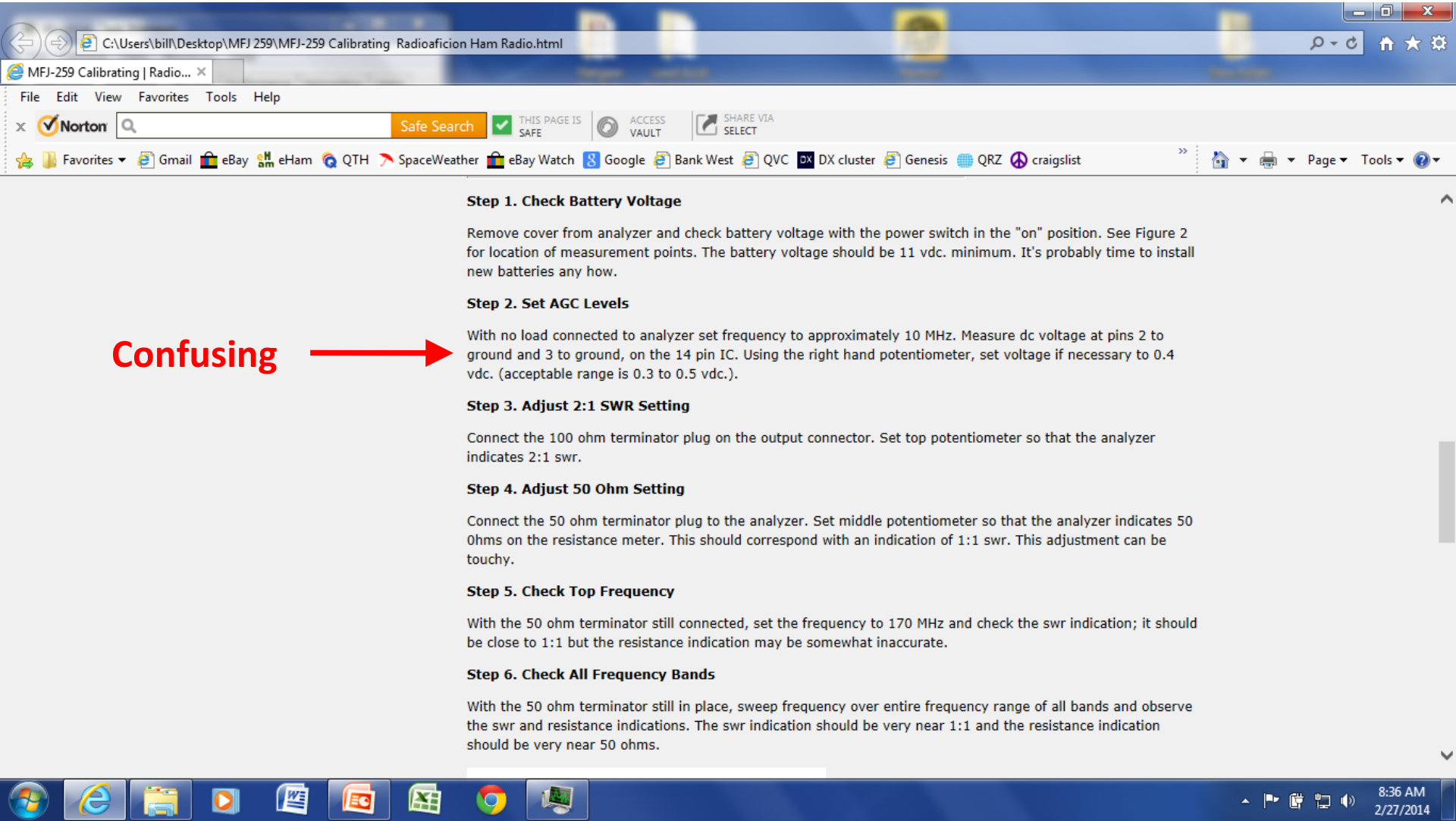
- Don't fix it if it ain't broke

3- Open case:

- Remove 8 screws on sides of cabinet
- Remove batteries 1, 2, 9, & 10
- Remove **2 screws on right side** of battery tray
- Replace batteries
  - **Tape off battery tray contacts**
- **Mark original settings with pen**

MFJ259 Calibration

4- Calibration procedure:



MFJ259 Calibration

http://www.radioaficion.com/HamNews/reviews/accesorios/11341-mfj-259-calibrating.html

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Step 6. Check All Frequency Bands

With the 50 ohm terminator still in place, sweep frequency over entire frequency range of all bands and observe the swr and resistance indications. The swr indication should be very near 1:1 and the resistance indication should be very near 50 ohms.

Ignoring AGC, there are only two adjustments

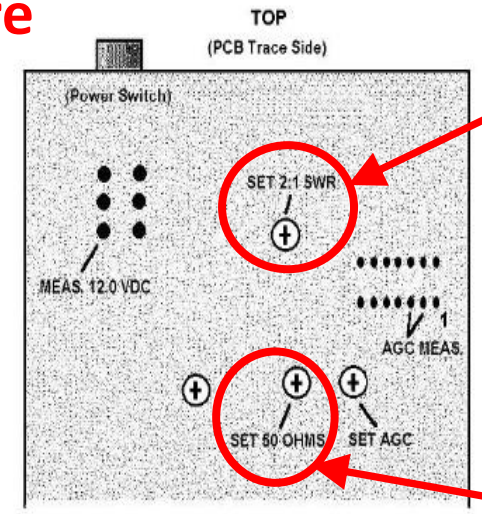


Figure 2. PCB Locator

1) Set SWR meter for 2:1 reading with 100Ω load

2) Set Resistance meter for 50Ω reading with 50Ω load

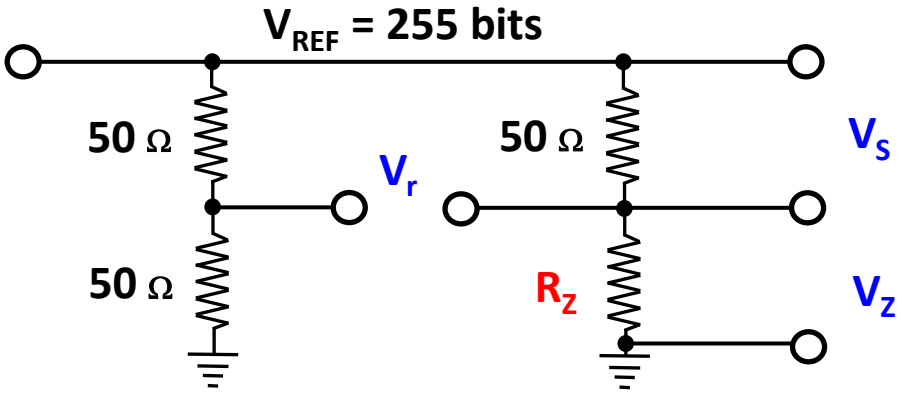
Summary

This procedure works well assuming that the analyzer is in otherwise good condition. If after carefully performing the preceding procedures, your unit is still not operating properly, consider sending the unit back to MFJ for repairs. It has been my experience that they give good service at reasonable prices.

8:52 AM
2/10/2014

MFJ259B Calibration

- Digital alignment involves settings based upon "**bits**"
  - 8 bit A/D converts all voltages to a 0-255 bit number



- R_Z is the resistance of the load being measured
- Voltage Vz in bits = $R_Z/(50+R_Z)$ * 255 bits

MFJ259B Calibration

4- Detector calibration procedure:

- **Set digital impedance tracking at 12.5 and 200 ohms**
- **Set digital SWR tracking between 1.5:1 and 4:1 SWR**
- **Set the Impedance analog meter for 50 ohms**
- **Set the SWR analog meter for 1.5:1 SWR (75 ohms)**

Note: There is no analog SWR meter tracking adjustment.

You may want to compromise R56 with several SWR test loads. R56 will not affect anything except the analog SWR meter reading.

MFJ259B Calibration

4-Set up "TEST MODE" (This can be tricky the first time)

To enter "*Test Mode*":

[ ] Turn power off.
[ ] Hold down ***MODE*** and ***GATE*** buttons while turning power on.
[ ] As display comes up, slowly (about 1 second period) rock between applying finger-pressure on the **MODE** and **GATE** switches. The best method is to use two fingers, rocking your hand from side-to-side to alternate your fingers between the two buttons.
[ ] Confirm analyzer has entered test mode **(it may take more than one try)**.
[ ] Using the **MODE** button, advance display to the **R-S-Z** screen (shown below).

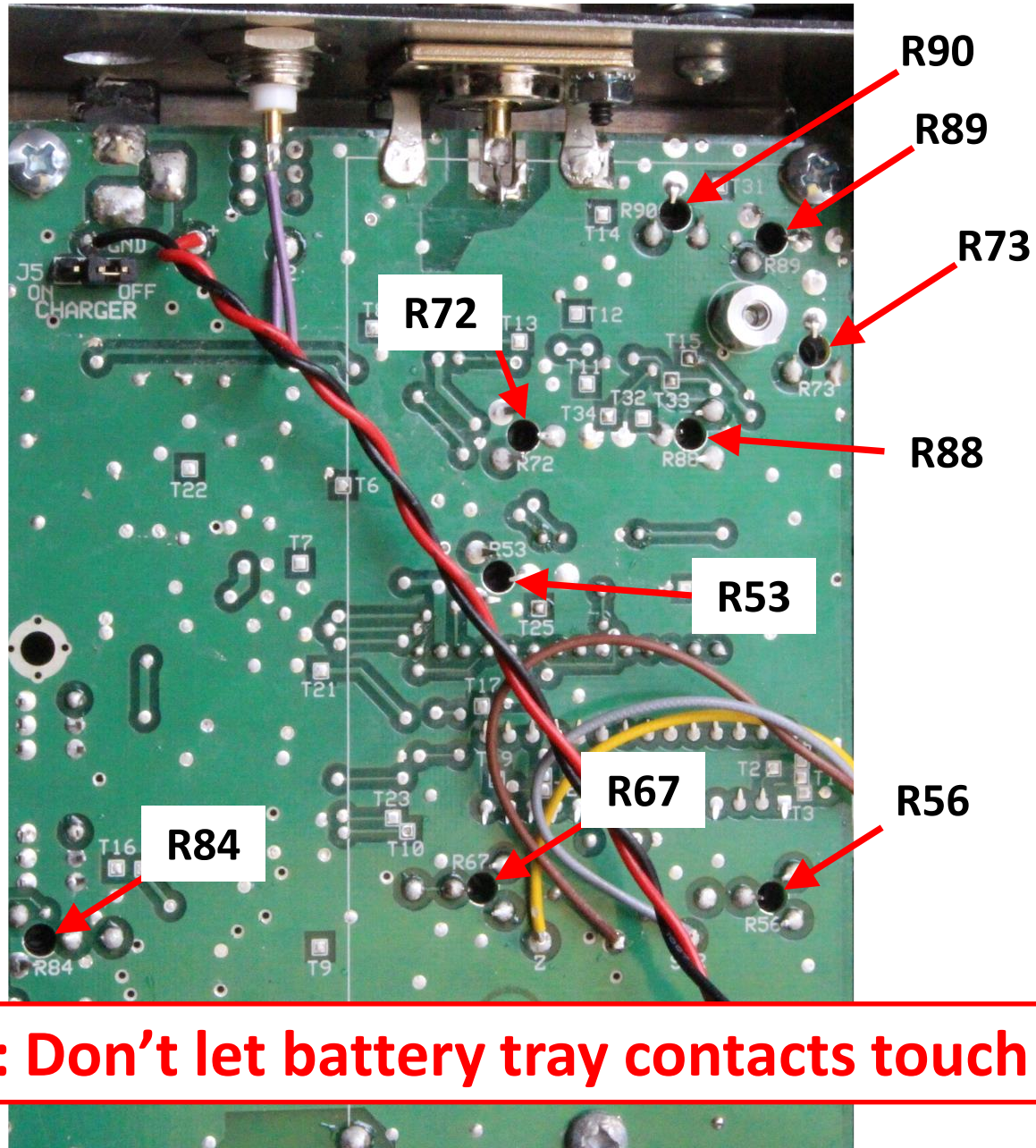
Note: If you go past the R-S-Z screen, you can still see R-S-Z by pushing and holding the MODE button. } **WRONG!**

R-S-Z Mode Digital Display

xx.xxx MHz

Rxxx Sxxx Zxxx

MFJ259B Calibration Points



Caution: Don’t let battery tray contacts touch case!!!

MFJ259B Calibration

5- **Impedance Calibration** (Ignore "First Time Adjustments")

Set Frequency to **14.000 MHz**

[ ] Install **12.5-Ω** load

[ ] Set **R90** for **Z=051**

[ ] Set **R73** for **S=204**

[ ] Set **R53** for **R=153** (for 4:1 digital SWR)

This reading should be compromised with the 12.5 ohm load.

(I set R=160 with 12.5 ohm load)

R-S-Z Mode Digital Display

14.000 MHz

R153 S204 Z051

MFJ259B Calibration

5- Impedance Calibration – (continued)

[ ] **Change Load** to **200-Ω**
[ ] Set **R88** for **S=051**
[ ] Set **R72** for **Z=204**

[ ] **Change Load** to **12.5-Ω**
[ ] Reset **R90** for **Z=051**
[ ] Reset **R73** for **S=204**
[ ] Reset **R53** for **R=153**

[ ] **Change Load** to **200-Ω**
[ ] Verify or reset **R88** for **S=051**
[ ] Verify or set **R72** for **Z=204**
[ ] Verify or set **R53** for **near R=153**

Probably won't need to readjust.

MFJ259B Calibration

6- SWR Calibration (Digital & Analog)

[ ] **Change Load** to **75-Ω**
[ ] Set **R89** for **R=051** (digital 1.5:1 SWR)
[ ] Set **R56** for **SWR Meter** reading of **1.5:1**

7- Impedance Meter (Analog) Calibration

Note: Error in W8JI instructions. Analyzer must be in "Impedance" mode to CAL Impedance meter!

[ ] **Cycle analyzer power OFF and then ON. Using the Mode button, set to analyzer to Impedance mode.**
[ ] **Change Load** to **50-Ω**
[ ] Set **R67** for an **Impedance Meter** reading of **50-Ω**