What is SWR?
and
How Do I Measure It?

Bob Witte, KØNR
bob@k0nr.com
Monument, CO

Bob Witte KØNR

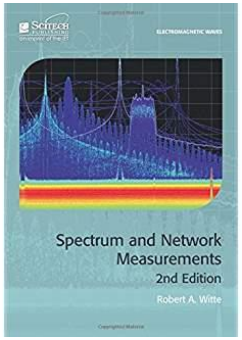
Electrical Engineer

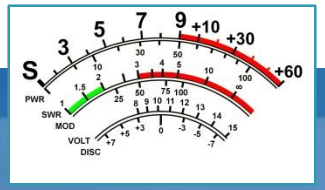
>35 years in the Test and Measurement Industry with Keysight Technologies/Agilent Technologies / HP

Author of

Electronic Test Instruments

Spectrum and Network Measurements





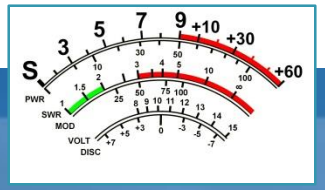
Electronic Test Equipment

- **The Multimeter**

  Measures DC/AC voltage, current and resistance

- **The SWR Meter**
- **The Antenna Analyzer**
- **The Vector Network Analyzer (VNA)**

} Antenna System Measurements



Antenna Measurements

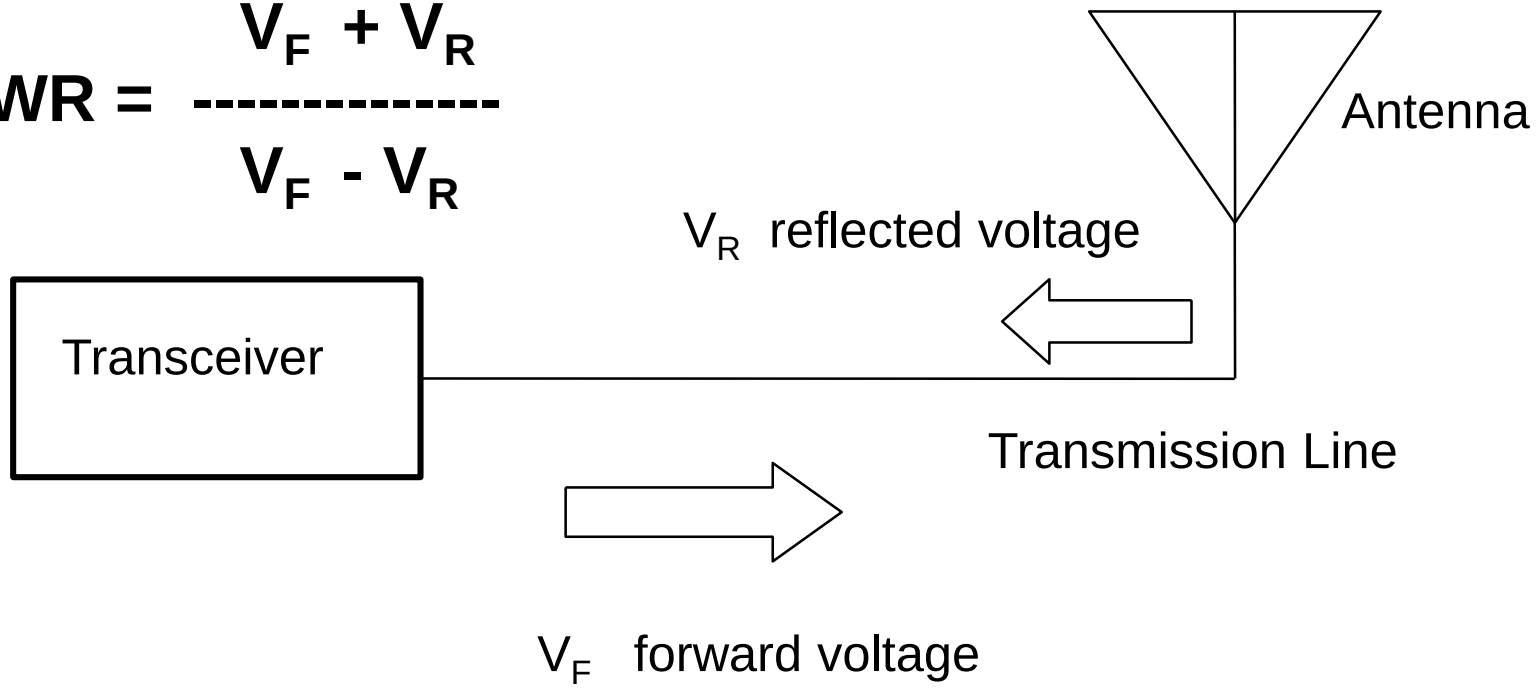
- SWR = *Standing Wave Ratio,* more properly called *Voltage Standing Wave Ratio (VSWR)*
- Measures the match between source (transmitter) and load (antenna).
- Source/Load match (SWR) is important for maximum power transfer
  Get more signal to (and from) the antenna

SWR Readings

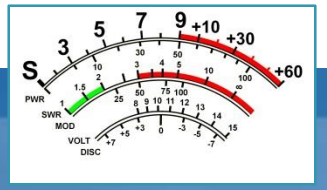
- Perfect match is SWR = 1.0
- Anything greater than 1.0 is less than perfect
- SWR is always ≥ 1.0
- SWR is sometime shown in this format 1:1, 2:1 or even “1 to 1” and “2 to 1”.
- SWR < 2 is a pretty good match
- SWR >3 is a poor match
- SWR >5 is a very poor match

SWR Measurement

$$SWR = \frac{V_F + V_R}{V_F - V_R}$$



Transceiver, transmission line and antenna are all nominally the same impedance (50 ohms for amateur radio work).

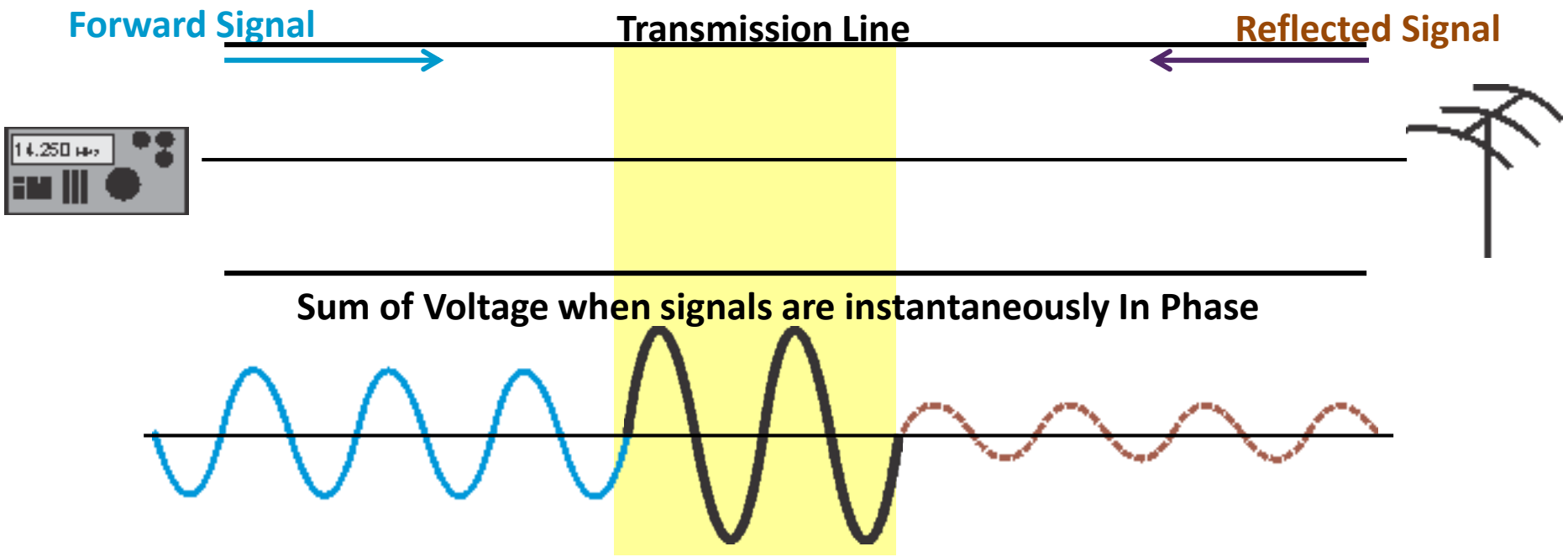


Q. What is SWR?

Slide courtesy of:
HamRadioSchool.com

Standing Wave Ratio (SWR): The ratio of maximum voltage to minimum voltage in an antenna-feed line system.

Properly measured, SWR is an indication of antenna system efficiency.



When impedances are mismatched, some transmission power will be reflected back down the transmission line.

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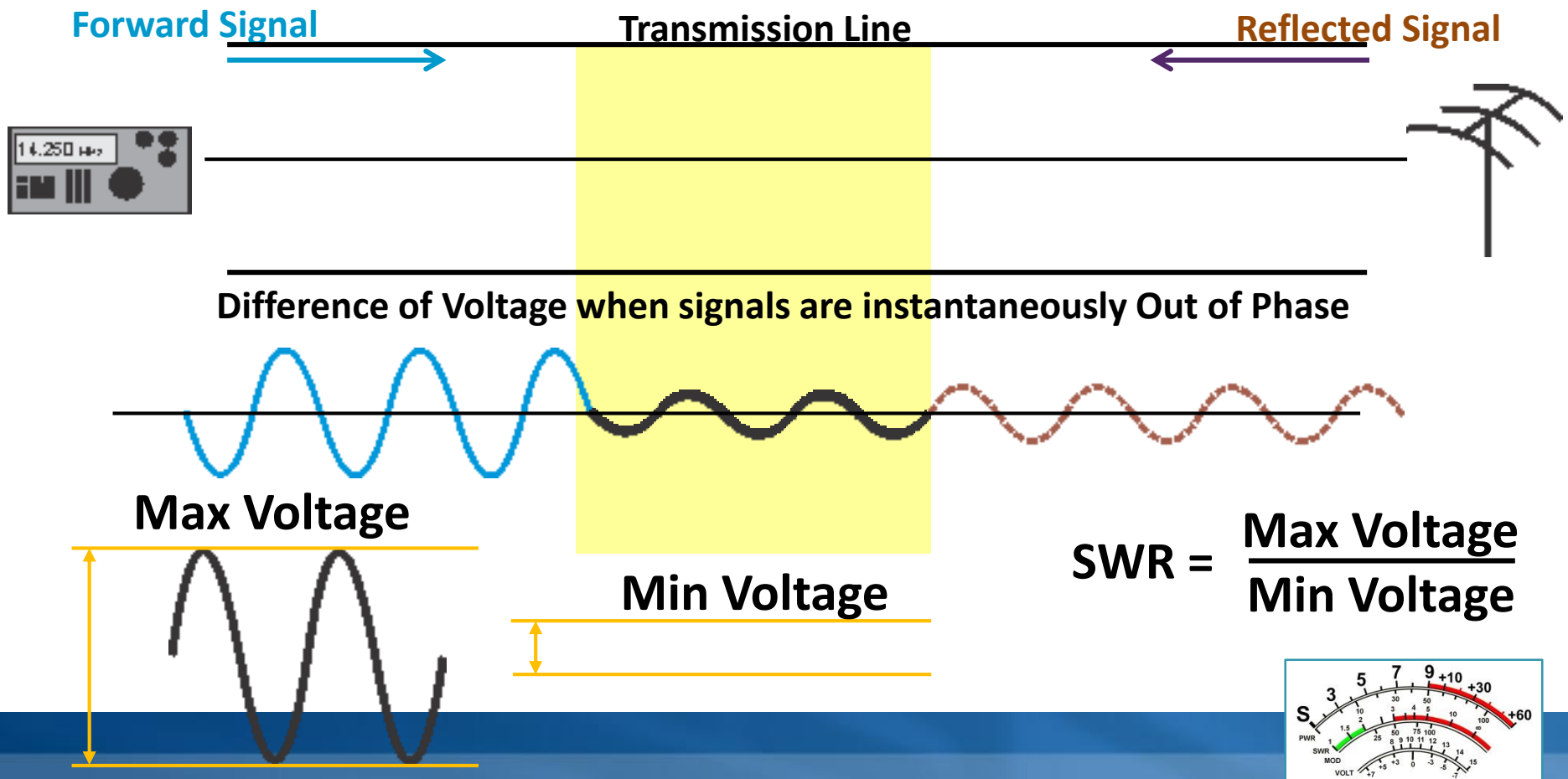
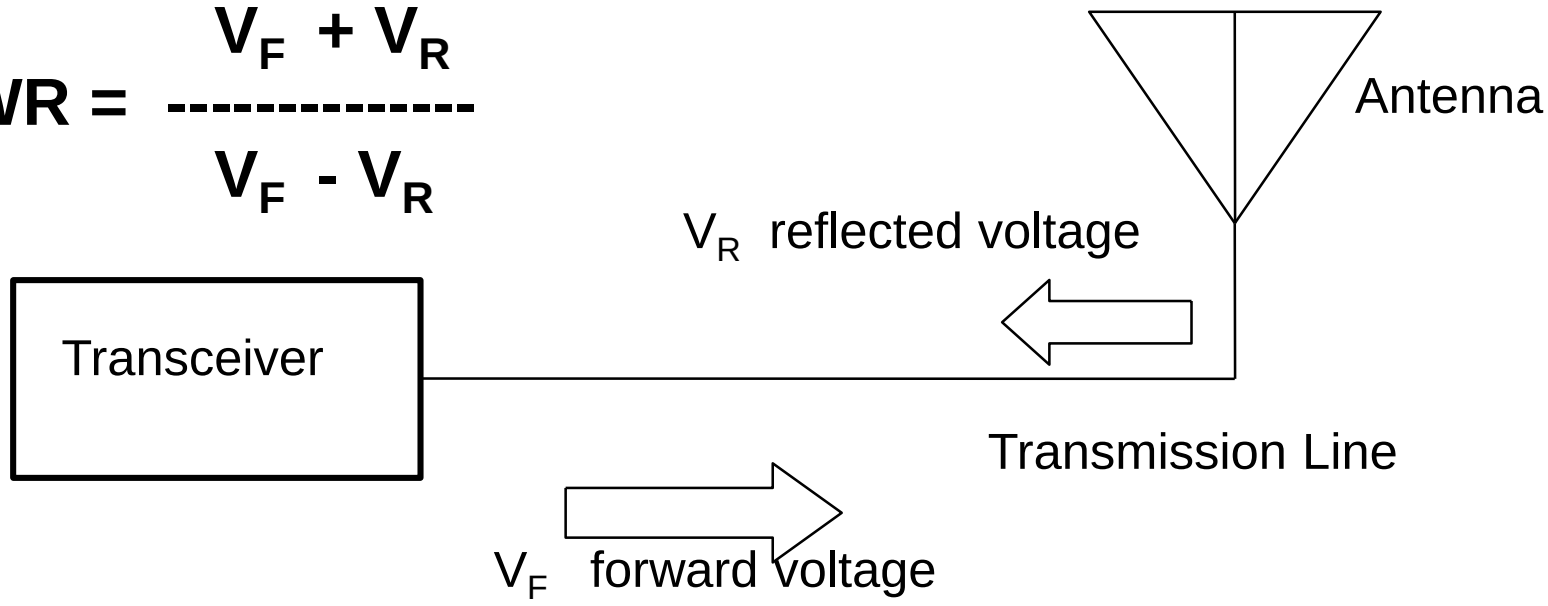
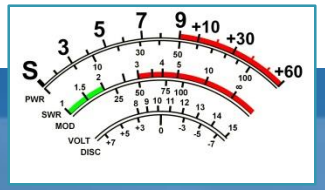


SWR Measurement

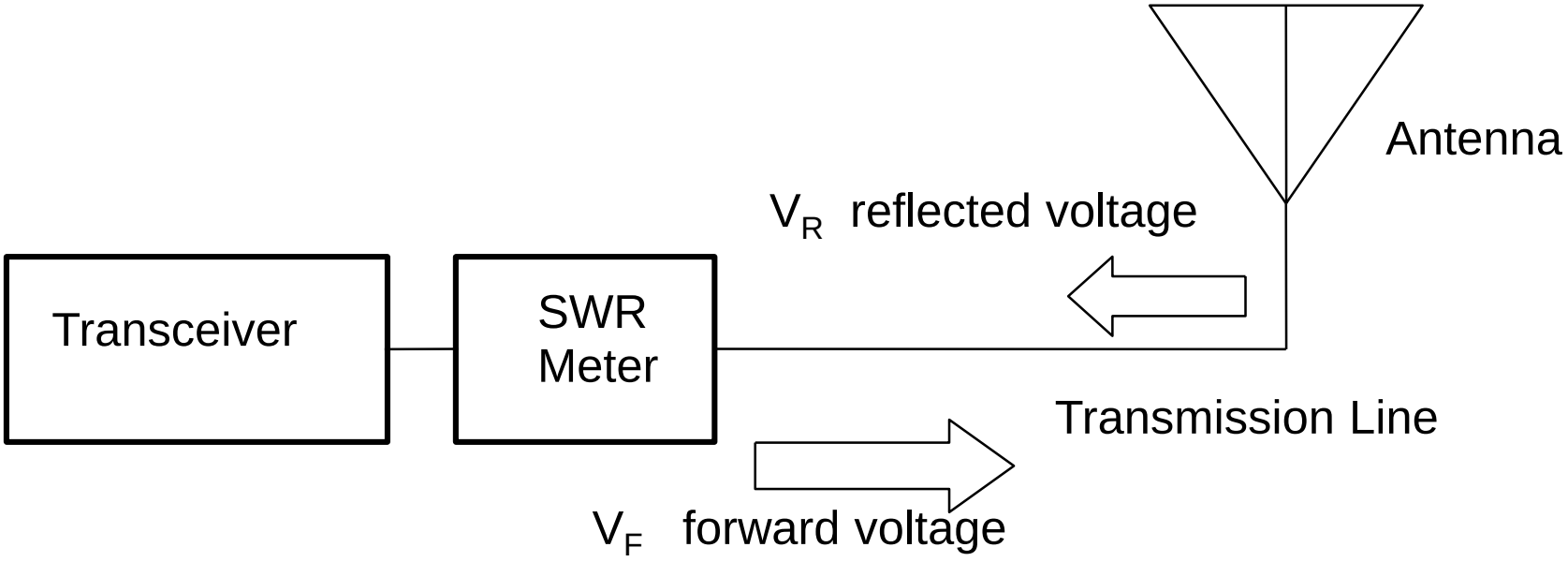
$$SWR = \frac{V_F + V_R}{V_F - V_R}$$



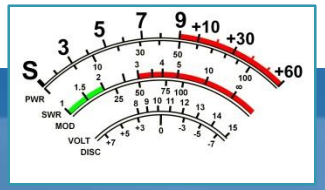
Perfect Match: V_R = 0, no reflection, SWR = 1.0
Small reflection: V_R = 20% of V_F , SWR = 1.5
Large reflection: V_R = 80% of V_F , SWR = 9
Open load: V_R = 100% of V_F , SWR = infinite



Using SWR Meter



SWR meter is inserted into the transmission line, which usually requires an additional cable between transceiver and SWR meter.



SWR Meters

Diamond SX-200 SWR/Power Meter

SWR and Power Meter

Freq Range:
1.8-200 MHz

Power Ranges:
5W, 20W and 200 W

Price: ~$100

Some comments on SWR measurements

- SWR meters measure the match at the point of insertion.
- SWR does NOT indicate the radiating effectiveness of an antenna
- When measuring/adjusting an antenna, put the SWR meter as close to the antenna as possible.
- Make sure the SWR meter is spec'd for the frequency of interest.
- Long, lossy coax makes the SWR look better.
- How low should the SWR be? Depends on the situation...what can be reasonably expected? It might be OK to run high SWR.

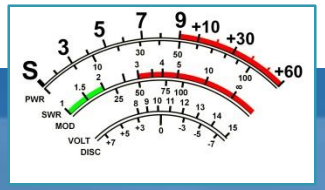
Antenna Analyzers

MFJ-259B Antenna Analyzer

- Frequency Range: 1.8 – 170 MHz
- Price: ~$250
- Measure:
  SWR, Return Loss
  Impedance, Reactance, Resistance

Default measurement mode is:
- Impedance, Z = R + j X
  (R= resistance, X = reactance)
- SWR

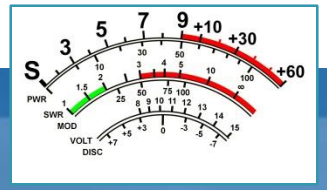
Also:
Impedance, Z = $Z_{mag} \angle\theta$
Reflection coefficient
Return Loss



MFJ-259B Antenna Analyzer

Usage Tips

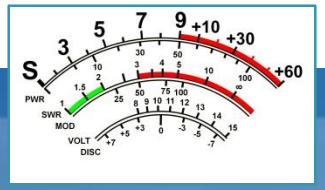
- Best accuracy near 50 ohms (SWR=1)
- Don't use in high RF environment
- Input circuitry is sensitive
- Discharge antennas before connecting
- Do not apply external voltages to test port
- Don't over-interpret the results (the analyzer is just looking at the impedance match against 50Ω)



Comet CAA-500 Antenna Analyzer

Frequency Range:
1.8 to 500 MHz

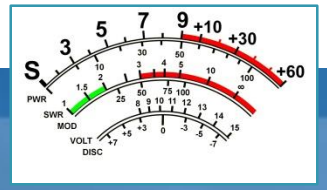
Price: ~$430



Vector Network Analyzer (VNA)

Freq range:
100 KHz to 200 MHz
Range of Z: 1 to 1000 ohm
Dynamic range:
up to 90 dB in Transmission
& 50 dB in Reflection
Two port VNA with S11 and S21

Price: ~$550



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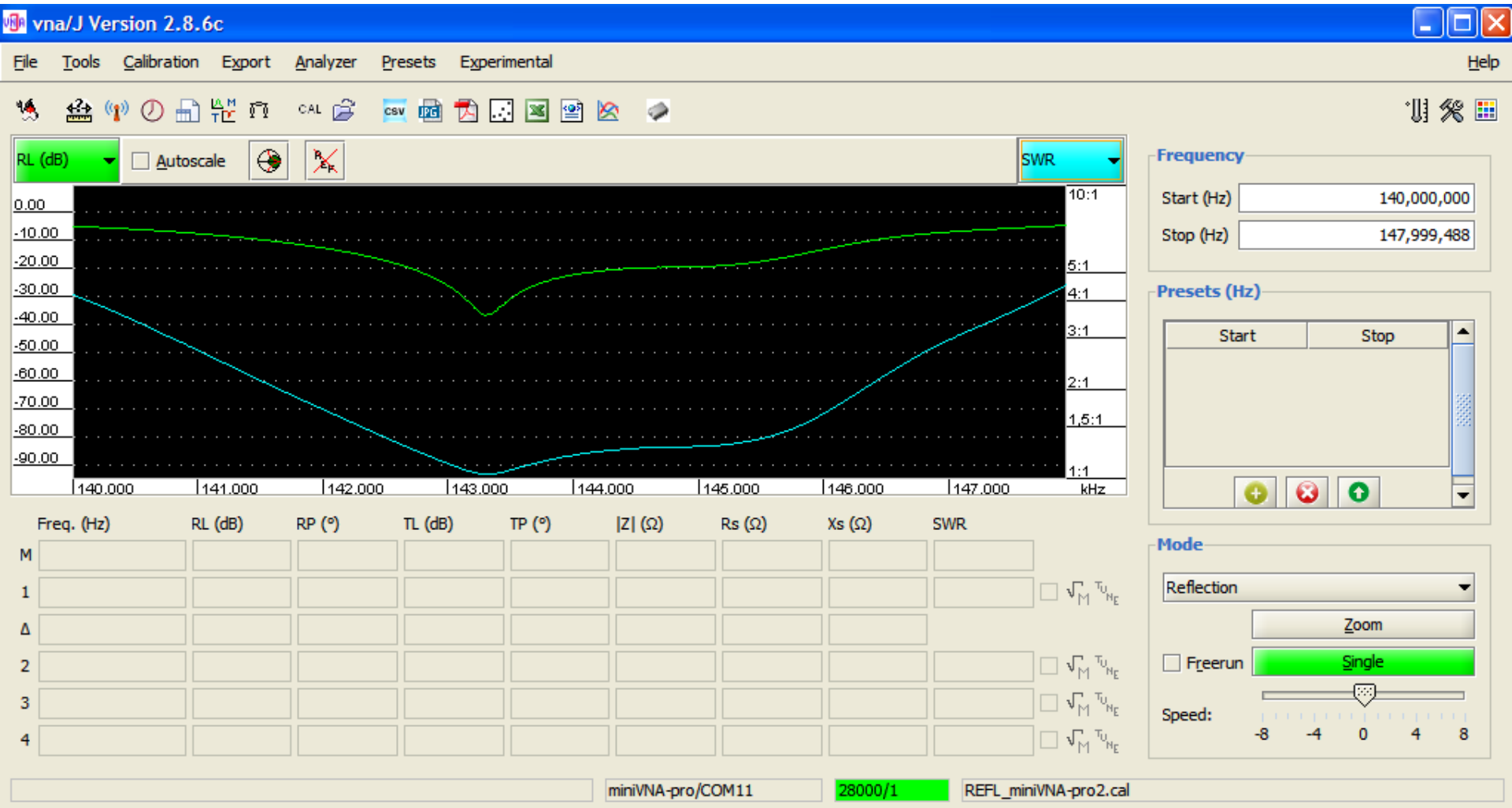
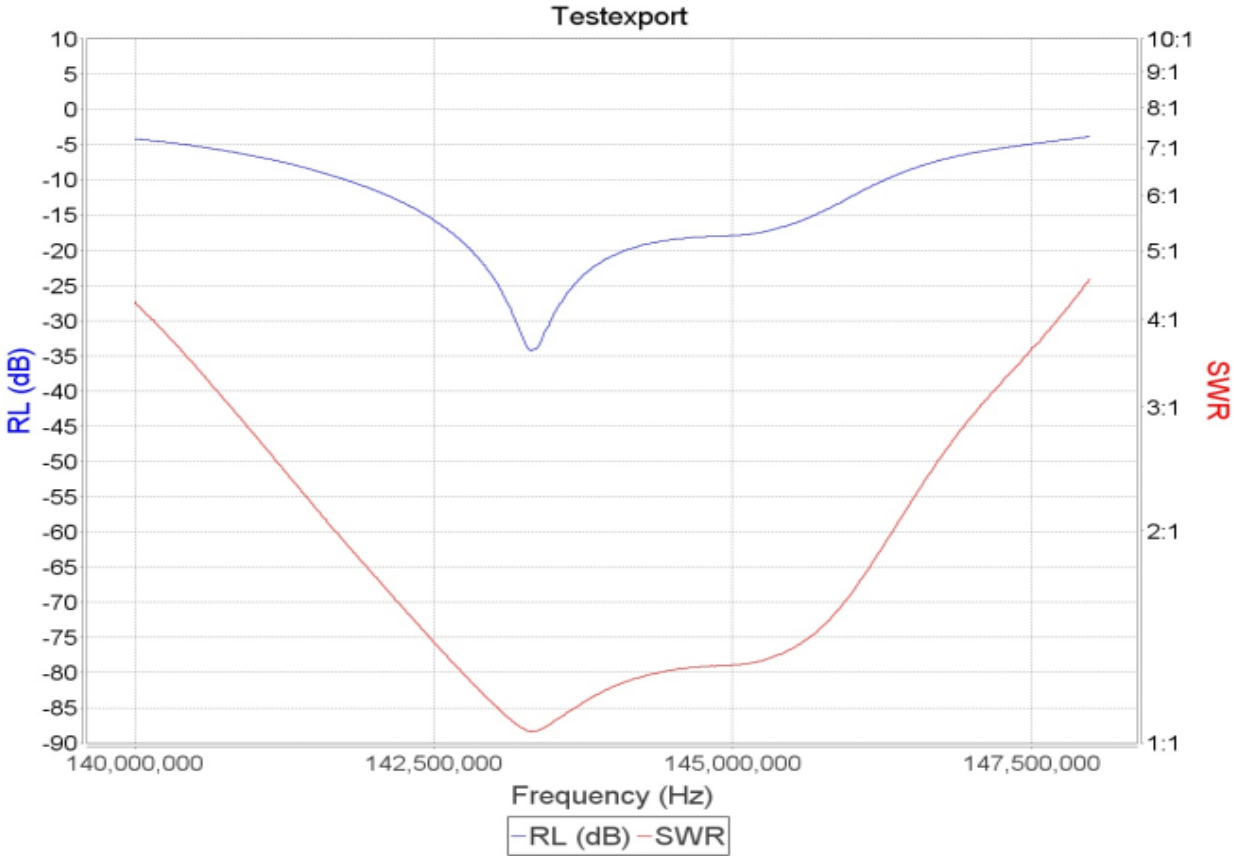
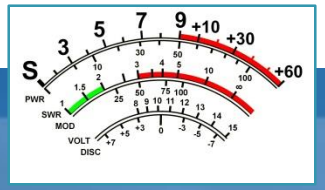
VNA Software



VNA Measurement – 2M Antenna

Measured
SWR
and
Return Loss





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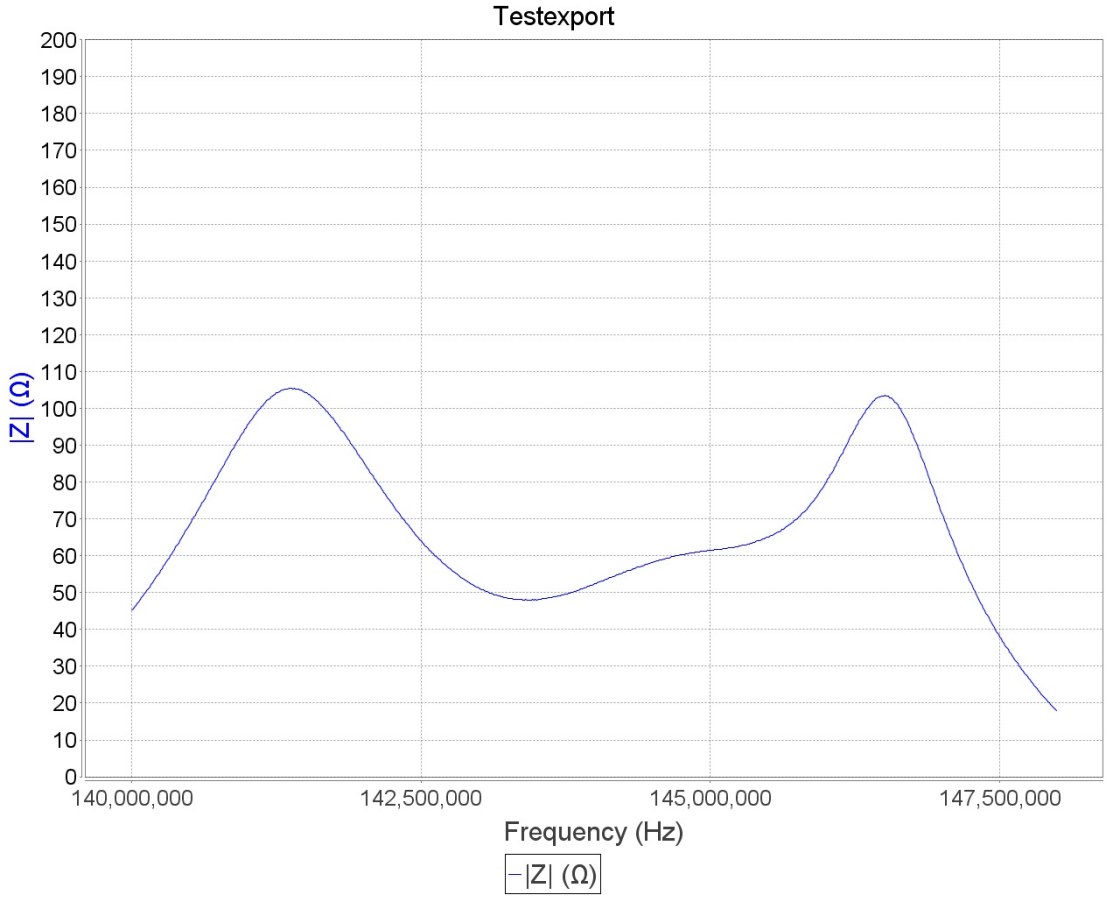
VNA Measurement – 2M Antenna

Measured

|Z|



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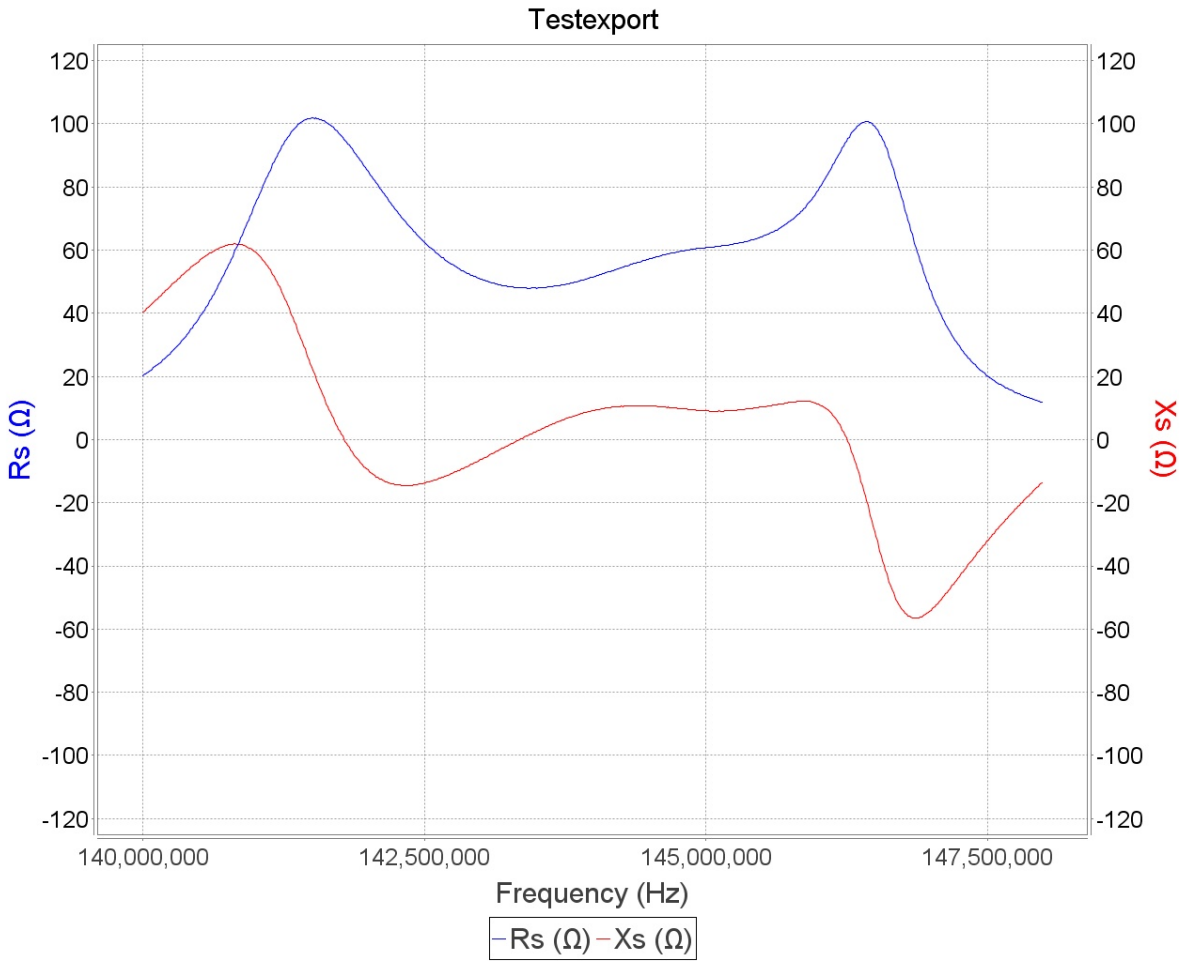
VNA Measurement – 2M Antenna

Measured
R and X



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Demonstration

Comet CAA-500 antenna analyzer

70 cm halfwave vertical antenna

We want it tuned to:

446.0 MHz
SWR = 1.0 and Z =50Ω

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Summary

Antenna Test Equipment for Ham Use

- SWR Meter
- Antenna Analyzer
- Vector Network Analyzer