Antenna Analyzer

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Overview

- Different types of Antenna Analyzers
- Not much content on theory
- How to troubleshoot antenna system problems
- How to maximize your antenna system performance
- Useful things you can do with an analyzer

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Antenna Analyzers

- Some hams don't care about the SWR.
  - A good Antenna Tuner can fix any SWR problem.
- Some hams only want to know if they have a good SWR.
  - A simple Antenna Analyzer is all that's needed
- Other hams want to know how to maximize their antenna system performance.
  - You probably want an Antenna Analyzer with more advanced features

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Antenna Analyzer

- The #1 tool for a Ham
- All Antenna Analyzers will display SWR
- Most will display the Impedance
- Some analyzers will display the complex products that make up the Impedance.
- Some analyzers have advanced functions to diagnose Antenna System Problems

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Antenna Analyzers

- The introduction of the MFJ low cost Antenna Analyzer has enabled hams to experiment with antenna designs.

- This device was a very significant contribution to the ham community.

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SWR

- If the ***impedance*** of the feed line and antenna match, all the power is transferred.
- If they don't match, some of the power is reflected back to the transmitter (Standing Wave Ratio, SWR).
- SWR is an indicator of how well the feed line is matched to the antenna.
- SWR is a ration between feed point impedance (where the analyzer is inserted) and the characteristic impedance (feed line, antenna).

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SWR Losses (100 watts TX)

SWR READING	% OF LOSS	ERP	WATTS AVAILABLE
1.0:1	0.0%	100.0%	100.00
1.5:1	4.0%	96.0%	96
2.0:1	11.1%	88.9%	88.9
2.4:1	17.0%	83.0%	83
3.0:1	25.0%	75.0%	75
4.0:1	36.0%	64.0%	64
5.0:1	44.4%	55.6%	55.6
6.0:1	51.0%	49.0%	49
7.0:1	56.3%	43.8%	43.8
8.0:1	60.5%	39.5%	39.5
9.0:1	64.0%	36.0%	36
10.0:1	66.9%	33.1%	33.1

SWR

- Point 1: Most amateur transmitters are designed to operate / tolerate a 2:1 SWR or lower.

- Point 2: An antenna Tuner fools a transmitter, making it think it's transmitting into a 50 ohm load. You still have the SWR losses in the feed line and antenna system.

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Impedance

- Impedance represented by: Z
- Impedance formula: $Z = R + jX$
- R = Resistance (real)
- X = Reactance (imaginary)
  - AC resistance caused by Capacitance and/or Inductance
  - X_L is always positive reactance
  - X_C is always negative reactance

- Where does Reactance come from?

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Reactance

- Some analyzers can not determine if the Reactance is capacitive or inductive.
  - If the frequency is increased and the reactance decreases, the load is capacitive.
  - If the frequency is reduced and the reactance decreases, the load is inductive.

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Reactance

- Reactance can be used to electrically shorten or lengthen an antenna
  - Add inductance to lengthen an antenna
  - Add capacitance to shorten an antenna

- This rule can be used to cancel capacitive / inductive reactance.

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When is an Antenna in Resonance?

- When X (reactance) is Zero
- It's not always the lowest SWR
- Feed line can effect the reactance
- The SWR of the system should not substantially change as the feed line length changes.
- Reactance is non-productive resistance.

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Reactance

- If the Impedance is 50 ohms, but the SWR is not 1.0:1. Reactance is probably making up part of the impedance.
- Is the Reactance inductive or capacitive?
- To cancel reactance, apply reactance of the opposite type and the same value.
- Example: using Z = R + jX. If R=35, X=15. Then Z = 50. 15 ohm is Reactance.
- Reactance is non-productive resistance (load).

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Tuning your Antenna
Dipoles

- First short the feed line center conductor and shield. Discharge any static charge. Then connect your analyzer to the feed line.
- With your antenna analyzer find the frequency at the lowest SWR.
- Divide the measured frequency by the desired frequency, yielding a percentage for correction (%).
- Multiply the current antenna length by the correction percentage, yielding the corrected antenna length.
- May need to repeat several times.

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Antenna Trimming Chart

Use this chart as an aid in trimming the length of your antenna. It gives you an idea of the change in wire length needed to move antenna resonance a specific number of KHz.

- Dimensions are for ***each leg*** of a half-wave dipole
- For quarter-wave antennas (i.e. verticals) use the dimensions directly from this chart
- Full-wavelength antennas (loops) - multiply the chart dimensions by four (4) and change the overall length of the antenna by that amount.

Lengths are estimates. Many factors will affect their exact value.

+ value = add to length of antenna - value = shorten antenna

To move	80/75 meters	40 meters	20 meters	15 meters	10 meters
-400 KHz	+6' 8"	+1' 9"	+6.5"	+2.5"	+1.25'
-300 KHz	+5'	+1' 4"	+5"	+1.75"	+1"
-200 KHz	+3' 4"	+10"	+3.25"	+1.25	+5/8"
-100 KHz	+1' 7"	+5"	+1.5"	+1/2"	+3/8
00 KHz	0	0	0	0	0
+100 KHz	-1' 7"	-5"	-1.5"	-1/2"	-3/8"
+200 KHz	-3' 4"	-10"	-3.25"	-1.25	-5/8"
+300 KHz	-5'	-1' 4"	-5"	-1.75"	-1"
+400 KHz	-6' 8"	-1' 9"	-6.5"	-2.5"	-1.25'
+500 KHz	-8' 4"	-2'	-8"	-3"	-1.5"

Problems at Low Freq

- 160M
  - If the SWR / Reactance keep changing (pulsing).
  - Likely there is a problem with local Broadcast Interference.
  - Try using a Broadcast Filter to solve this problem.

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Tuning your Tuner

- This process is intended for a Manual Antenna Tuner, not an Auto Tuner.
- Connect your Analyzer to the TX of the tuner.
- Set the frequency of the Analyzer.
- Adjust the tuner until the SWR read unity (1:1).
- Write the frequency and tuner setting down in a note book or spreadsheet.

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How to test a Dummy Load

- A Dummy Load will show zero reactance and a 50 ohm resistive load over the specified band width.
- SWR of 1.0:1
- Use a very short piece of coax between analyzer and Dummy Load
- Anything other then a small amount of SWR variation indicated a bad Dummy Load.
- This procedure help to validate proper analyzer operation.

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Simple Coax Test

- Connect a 50 ohm load at the far end of the coax.
- 50 ohm load: 50 ohm resistor (not wire wound) or 50 ohm dummy load.
- Sweep the coax with your antenna analyzer.
- The SWR should be very close to 1:1 for the entire usable frequency.
- This only shows the impedance is 50 ohms .
- There maybe other coax losses or problems not being shown.

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SWR changes with coax length

- If the SWR changes with coax line length, line placement, or grounding.
  - Coax is probably carrying common mode current and radiating.
  - Coax is not 50 ohm.
  - Coax has significant loss.
- Start by first testing the SWR using a very short piece of coax at the antenna feed point.
- Then add your long piece of coax. Make sure the SWR does not substantially change.

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How to test a Balun

- If you purchase a balun at a swap meet or if you build your own balun's, how do you know if it is working correctly?
- For a 1:1 balun use a 50 ohm resistor across the output of the balun.
- For a 4:1 balun use a 200 ohm resistor across the output of the balun.
- The SWR should be very low over the entire frequency range of the balun.
- No reactance.
- If the SWR is not flat across the entire frequency range. The balun is questionable.

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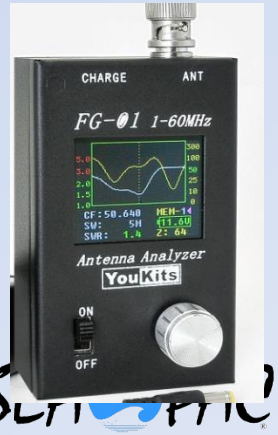
Coax Loss

- Usually under Advanced settings.
- Can be used to test losses in coax and baluns.
- Do not terminate the far end.
- Configure the analyzer for Coax Loss.
- The display will show the loss in dB at a given frequency.

Manufactures

- MFJ
- Comet
- RigExpert
- Palstar
- AIM
- VNA
- Youkits
- Fox Delta
- And many other mfg



Fox Delta Kit
Scan of 20M Beam

SWR Analyzer v.06.02 [f/w v06.02]

File Calibrate SetUp Help

Swr MultiScan Generator

Start Frequency 13,900,000

Stop Frequency 14,450,000

Marker Table Notes NF ON

Scan Time: Fast / Standard / Slow / Very Slow

SWR ref 50ohms

0dB 10.0 20.0 30.0

SWR 10.00 3.00 2.00 1.50 1.20 1.10

M1 21.1 M2 1.19 14,252,000

13.9 MHz 14.2 MHz 14.4 MHz

HF Bands - Region 2: 160 40 17 10 Range 1 / 80 30 15 Range 2 / 60 20 12 FULL Range 3

Cursor: Freq 14,252,000 Swr 1.19 dB 21.1

Power: Loss % 0.8 ERP % 99.2

Analyze

One Shot Start

On Line CONNECTED

Features

- SWR
- Resistance
- Reactance
- Impedance (resistance + reactance)
- Reactance (inductive or capacitive)
- Resonant Frequency
- Bandwidth / Sweep
- Connect to a PC
- Graphics
- Advance features

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Advanced Features

- Velocity Factor of transmission line.
- Impedance of transmission line.
- Coax length.
- Distance to fault.
- Coax Loss
- Reactance in Capacitance / Inductance
- Frequency Counter
- Testing and tuning stubs
- Series/Parallel equivalent of Impedance

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When purchasing an Antenna Analyzer

- Cost $
- Frequency range (HF / VHF / UHF)
- Simple: SWR
- Complex: impedance, reactance, coax (length, velocity factor, Q)
- Power: Battery, AC
- Display: Numbers, Graphical
- PC connection
- Advance features
- Look at reviews on eHam.com and QST

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Summary

- An Antenna Analyzer is more then a SWR meter.
- An Antenna Analyzer can help maximize your antenna system's performance.
- An Antenna Analyzer can help you find problems in your antenna system.
- SWR is an indicator of how well the feed line is matched to the antenna.
- If the Impedance is 50 ohms but, the SWR is not 1.0:1. Reactance is probably making up part of the impedance.

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Summary

- Before connecting coax to your analyzer, first short the center pin to the shield. Discharge any static charge.
- First read the SWR at the antenna feed point.
- Second, if the SWR changed with the coax length or placement. There is a problem with the coax impedance, common mode current, or local RFI.
- Try to keep your SWR to 2.0:1 or less.
- RTFM. Read the manual.
- Take detailed notes and keep them in a safe place.

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End of program

- Any questions ???