



Repeater Test Equipment & Tests

Lesson Three

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What You Get

- We'll cover a suggested list of must-have and should-have test equipment.
- Basic performance measurements you should make.
- Next week we'll go into advanced testing with a service monitor.
- Sessions: 45 min and 15 minutes Q&A.

Welcome

- The lesson videos are posted at YouTube channel ‘K6KN Bill’.
- Slides PDF posted at our Slack site
- For access to our Slack.com support site visit barkradio.org Training page.
- Introduce Bill K6KN, president of Berryessa Amateur Radio Klub BARK.

Sessions Summary

- One: Managing A Ham Repeater
- Two: Repeater Components and Functions
- Three: Repeater Test Equipment and Tests.
- Four: Advanced Repeater Measurements & Settings.
- Five: Repeater Diagnostics
- Optional: Hands on training.

Homework

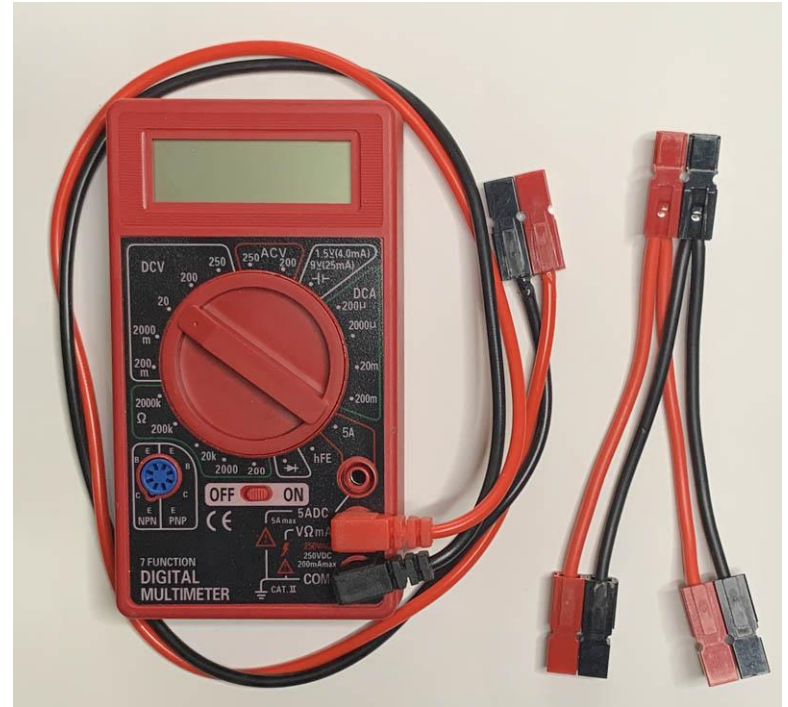
- Did you down-load and review the data sheet for a watt meter such as the Bird Model 43 or the new Model 4410 Series?
- Or the MFJ-264N or similar.

Key Terms

- Reflected power
- SWR Standing Wave Ratio
- SINAD Signal Against Noise and Distortion.
- Watts, the measure of power.
- Decibels dB, a logarithmic scale.
- Service Monitor

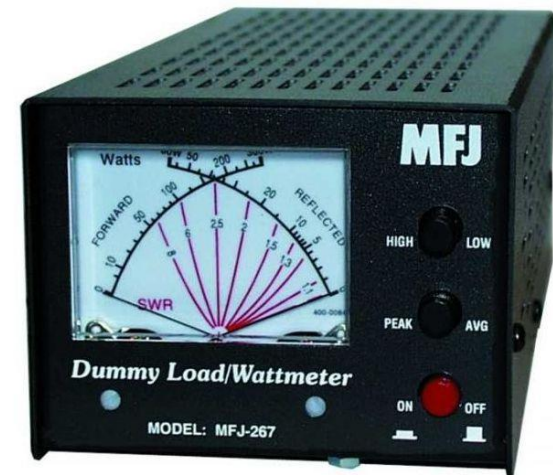
Must Have

- Cell phone for photos and access an offsite testing partner.
- HandyTalkie transceiver as RF generator.
- Digital Volt Meter DVM, cheap Harbor Freight
- Anderson PowerPole test leads.



Must Have

- Bird 43 or 4410 Watt Meter (Power Meter)
VHF 100 Watt slug,
- Or MFJ-267 Watt Meter with SWR and dummy load.



Must Have

- Dummy load 50 Ohm, 50 or 100 watt. For transmitter testing
- Dummy load 50 Ohm 1 to 5 watts for component testing



Must Have

- Graphic Antenna Analyzer, RigExpert AA-230
- MFJ 226 (discontinued).
- Not MFJ-259. Very popular, non-graphic, but for bench & design. not in the field.
- Graphic view of SWR allows quick evaluation of antenna, feed lines and filters



Should Have

- **AC Line Monitor**
- Nice to have. Measures live voltage, current consumption, power, VAR, and line frequency.



Should Have

- Crimping tools.
- Lots of connector adapters.
- Uninstalled connectors for repair.



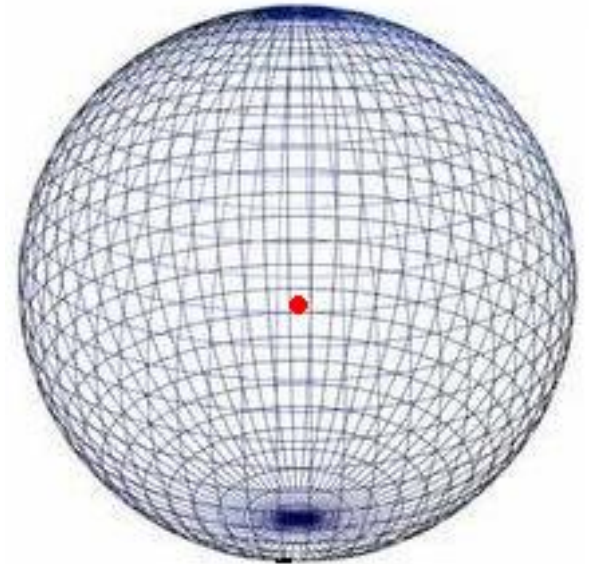
Should Have

- Decade RF attenuator, if possible. Measure sensitivity from the field. JFWindustries.com
- Several Coax RG-400 or RG-214 double silver shielded 98% for critical testing, 18" jumpers, Pasternak RG8X for non-essential testing 95% shielding. More flexible.



Some RF Theory

- VHF is generally line of sight. Earth and buildings attenuate. Trees and rain do a bit.
- An isotropic antennal radiates in all direction equally.
- Real antennas radiate less upward and downward. Called 'gain'.
- Uses a relative measure dBi.



The Flavors Of dB

- dB is a ratio or change between two power levels.
- 10 dB is 10x, Ten times the power.
- 3 dB is 2x, Two times the power.
- -3 dB is $\frac{1}{2}$ x or one-half the power.
- Get the app: dBcalc
- Many calculations; very useful.

Intro to dB

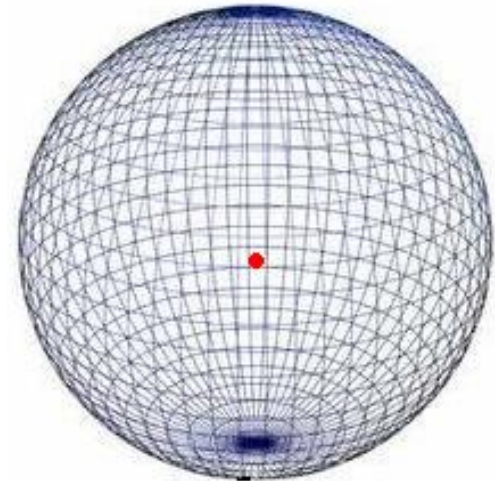
- The attenuation effect of radio devices can't be added and subtracted. Are multiplied.
- A 30% loss and a 30% loss is not 60%.
- It is $1 - (0.7 * 0.7) = 51\%$ result or 49% loss.
- Measures in decibels can be added and subtracted. The equivalent of multiplying.
- $-1.55 \text{ dB} + -1.55 \text{ dB}$ is -3.10 dB
- Which equals 49% loss.

The Flavors Of dB

- dBm is the actual electrical power.
- 0 dBm is .001 Watt or one milliwatt
- An HT with 5 watt output is +37dBm.
- If it loses one-half power (3 dB) the output is $+37 - 3$ or 34 dBm.
- Or 2.5 Watts.

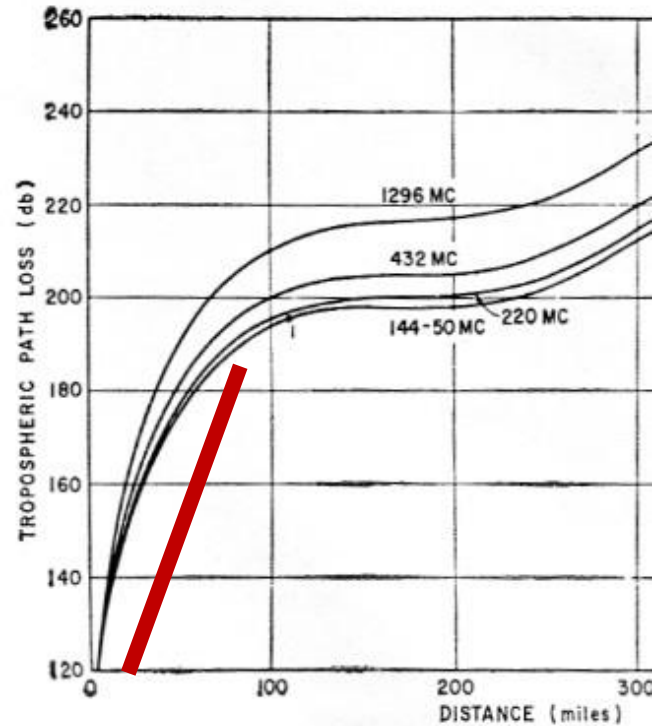
The Flavors Of dB

- dBi is used to express the radiation output from an isotropic antenna, in all directions.
- Saying an antenna has 3 dBi gain means it radiates twice the power directionally.
- Actually it means power usually radiated up and down is now horizontal.



The Importance Of Losses

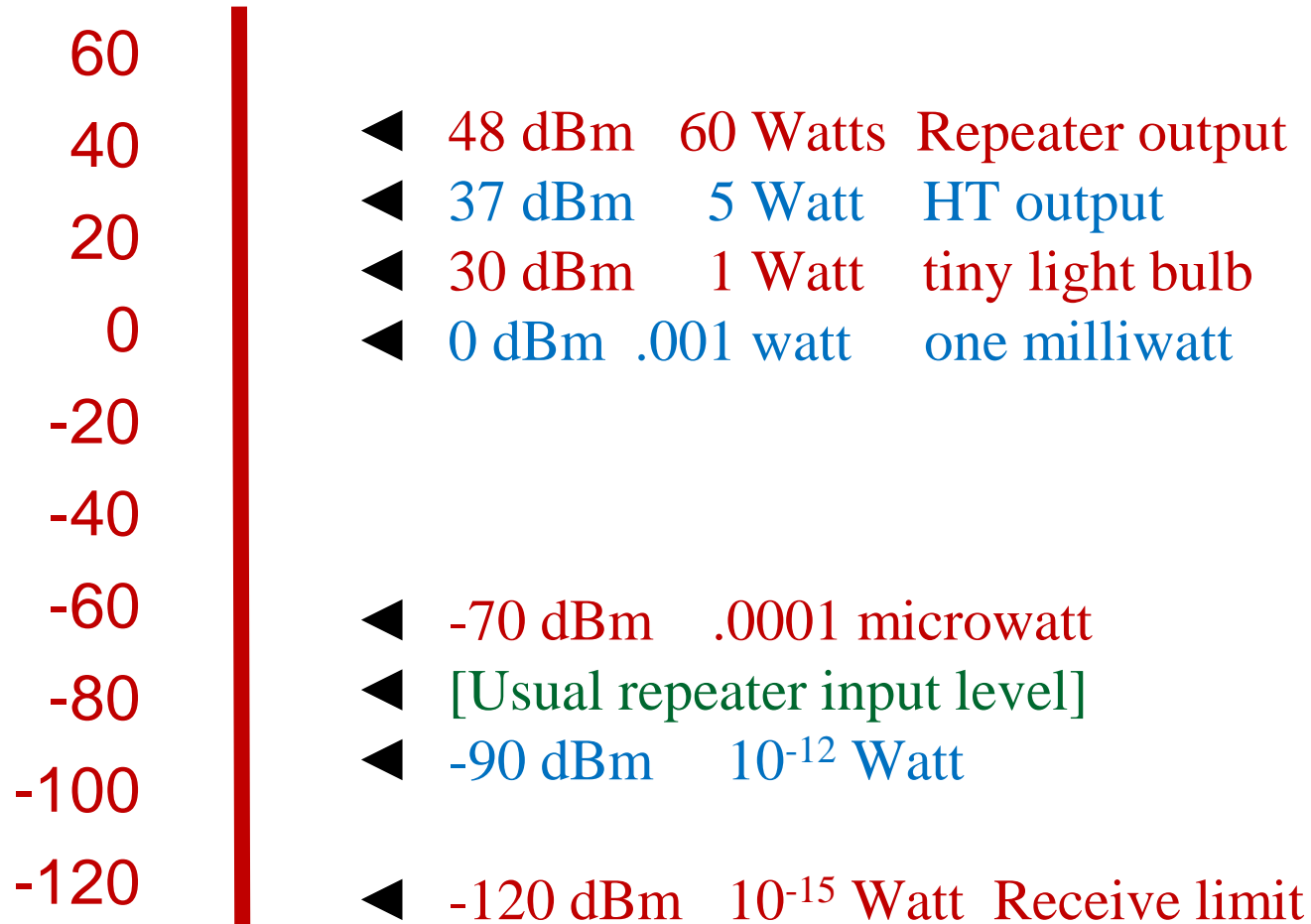
- If they can't hear you they can't work you.
- Repeater operators try to maximize radiated power and minimize receive losses.
- We live with path-loss based on distance.



Transmission Loss To A User

- Transmitter 60 Watts out is 48 dBm
- - 0.5 to -2.0 dB cavity filter loss.
- +3 to +9 dB antenna gain.
- -120 to -190 dB path loss.
- Yields -86 dBm power to the user.
- -5 dB user's antenna loss
- -91 dBm into user's transceiver.

The dB Power Scale



The Visit

- Two-person rule, 3000' drive to help.
- Log book, record keeping essential.
- Key to the vault,
AA batteries,
flashlight,
water, paper
towels.
- Chainsaw?



Pre and Post Checks

- The first and last tests you make on arrival and before leaving.
- Add power meter. Test transmitter output power.
- Last step on leaving: repeater power test.
- After locking the door, one last check. It's a long hike back.

Utility Power

- Measure voltage of utility, battery, solar open circuit.
- Then voltage input to repeater from one source at a time; keyed and unkeyed.

	Isolated	Input Unkeyed	Input Keyed
Utility Power	13.70 V	13.50 V	13.27 V
Battery	13.50 v	13.41 V	13.07 V
Solar	22.60 V	13.41 V	13.10 V

Overall RF Performance

- Do most testing with RF off or into a dummy load. Avoid kerchunks to the users.
- Otherwise make an announcement.

Overall RF Performance

Voltage Standing Wave Ratio	Reflected Power (percent)
1.4 to 1	2.78
1.5 to 1	4.00
1.75 to 1	7.40
2 to 1	11.00
2.5 to 1	18.00
3 to 1	25.00
3.5 : 1	31.00
4 to 1	36.00
5 to 1	44.50
6 to 1	50.80

- Check forward power and reflected power. An alternate check on SWR.



RF Specific Tests

- Graphic view of SWR allows quick evaluation of antenna, feed lines and filters. And and trouble shooting.
- Graphic Antenna Analyzer, RigExpert AA-230, MFJ 226 (discontinued).
- Not MFJ-259. Very popular, non-graphics, for bench/design use not in the field.



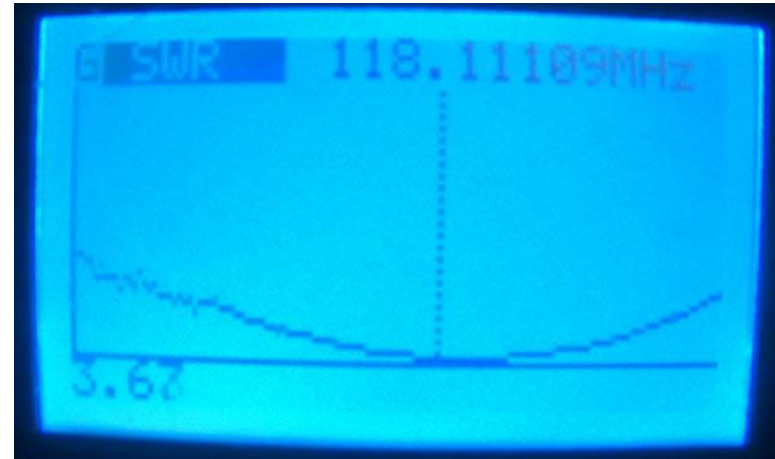
SWR Measurement

- SWR measures the reflected energy back to the instrument over a range of frequencies.
- Good for quick, hand checks. More appropriate is by return loss bridge with service monitor.
- Cavities via feedline to antenna.
- Cavities alone. Terminate with 50 Ohm.



SWR Test

- First, test overall.
- If problems, test one item at a time.



SWR Interpretation

- Under 1.4:1 Great.
- Under 1.7:1 Tolerate.
- Over 1.7:1 Fix.
- Analyzers also can locate cable opens and shorts plus much more.

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3.5 : 1	31.00
4 to 1	36.00
5 to 1	44.50
6 to 1	50.80

Squelch

- Several methods of increasing precision.
- SWAG: Turn off receive CTCSS.
- Decrease squelch until noise appears (squelch opens).
- Increase a bit to silence.
- Restore CTCSS.

Squelch from RF Source

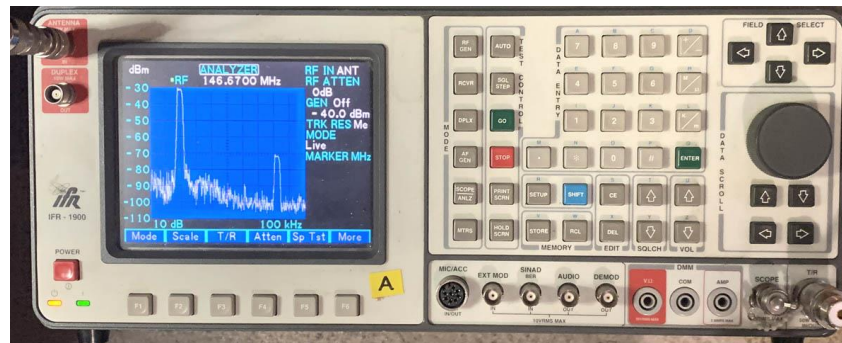
- Turn off CTCSS. [Diagram on next slide.]
- Handheld transceiver set to low power.
- Into a calibrated attenuator.
- Into an RF sampler.
- Between cavities and repeater.
- Increase RF signal until noise begins to decrease.
- Add 5 dB to signal. (?)
- Increase squelch until repeater mutes.
- Restore CTCSS.

Squelch from RF Source



Squelch from Service Monitor

- More detail next week.
- SINAD Signal Above Noise and Distortion.
- RF input with a 1,000 Hz tone via a sampler into the repeater.
- Service monitor analyzes tone vs. noise.
- Increase RF level to -12 dB SINAD reading.
- Set squelch to just open at the point.



Next Lesson

- Service monitors.
- Product generations.
- Buying new or used.
- Measurements with a service monitor.
- Transmitter frequency accuracy.
- Deviation
- Receiver IF centering.
- Squelch.
- Desens.
- Cavity filter tuning.

Assignment

- Find one or more service monitors. Review their features and cost.
- Brands:
 - Marconi/IFR
 - Agilent/HP
 - Rigol
 - Or?
- New or used. Try eBay.com.

References

- [Barkradio.org/training](https://barkradio.org/training) to register for Slack
- ke6yuv.slack.com. For PDFs, questions, discussion & YouTube links.
- YouTube.com channel: “K6KN Bill”
- www.repeater-builder.com
- The ARRL Handbook For Radio Communications.
- The ARRL Antenna Book.

Discussion

- Anyone wish to comment on the homework for this session?
- Your field experience and measurements?
- How do you set squelch?
- Any comments or questions?

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