Advanced Repeater Measurements and Settings

Lesson Four

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What You Get

- We'll cover the test equipment needed for comprehensive maintenance of a repeater.
- The setup and protocol for these tests.
- Next week we'll go into responses for problems and troubleshooting.
- 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.
- Meet Bill K6KN, president of Berryessa Amateur Radio Klub BARK.

Sessions Summary

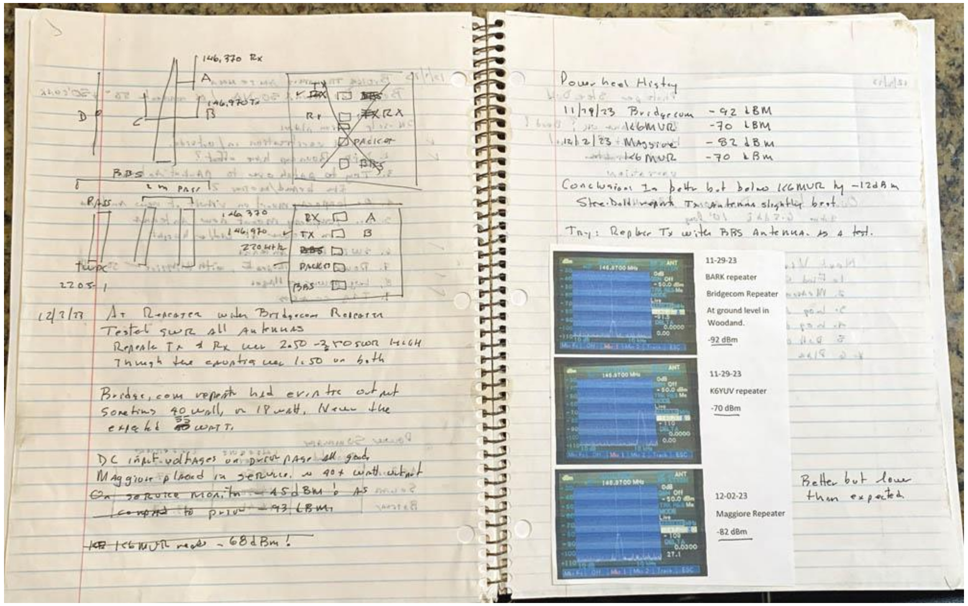
- One: Managing A Ham Repeater
- Two: Repeater Components and Functions
- Three: Repeater Test Equipment and Tests.
- Four: Advanced Repeater Measurements & Settings.
- Five: Repeater Diagnostics
- Optional: Hands on training.

Homework

- Did you down-load and review the data sheet for a Service Monitor?
- What price ranges did you find?
- We’ll discuss your findings in the ending question period.

Your Repeater Log Book

- Log everything.
- When you come back in four months you will need to determine the changes from last time.



Key Terms

- Reflected power
- SWR Standing Wave Ratio
- SINAD Signal Against Noise and Distortion
- Duplex Generator
- Tracking Generator
- Desens

Basic Test Equipment

- Watt Metter (Power Meter) for VHF.
- 50 Ohm dummy loads.
- Doubly shielded cables.
- Graphic antenna analyzer.
- Adapters.

Advanced Test Equipment
Service Monitor

RF transmitter

RF receiver

Duplex transmitter

Spectrum analyzer

Tracking generator

Measures: frequency, power, deviation,

SINAD

Audio generator (2)

DVM. Oscilloscope

Service Monitor Comments

New, about $20,00 to $30,000. Were $70,000.

eBay used $1,000 to $2,500.

Must have tracking generator.

IFR 1200 (1985),   IFR 1900 (1995 on), and ??

IFR 1900 has self-test, very heavy, 50 lbs.

Must have a manual, PDFs on-line.

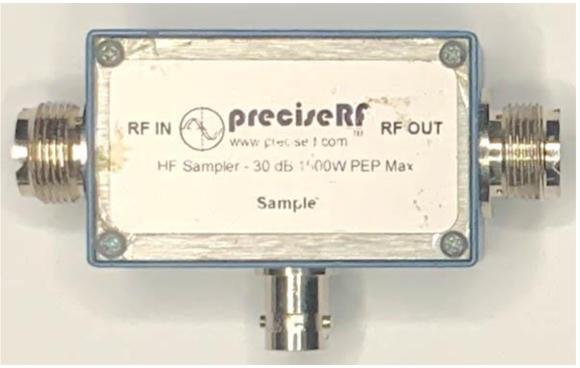
RF Sampler

Extracts a -30 dB replica.

Used to inject or extract low level RF.

To measure sensitivity, noise floor and squelch.

Pass through up to 1.5 kW!



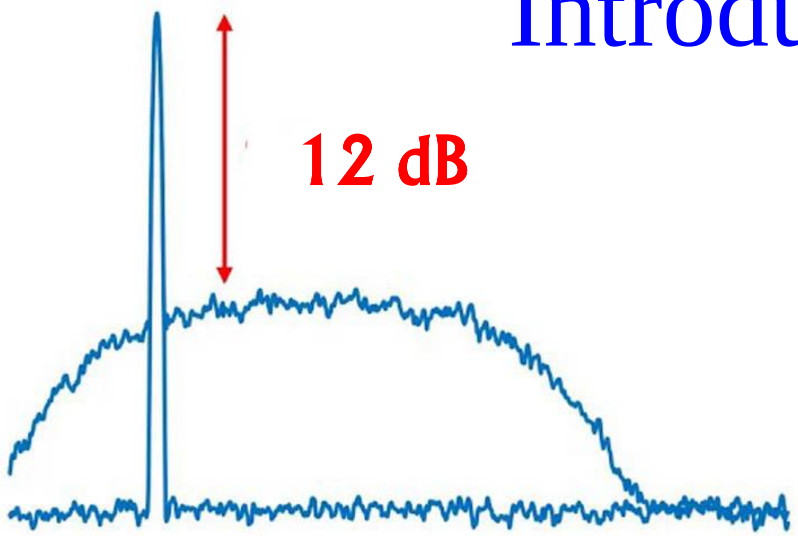
Sampler Based Tests

- Sensitivity, in the -120 dBm range.
- Noise floor, allowing for local RF noise.
- Desens.
- Squelch.
- IF centering.
- CTCSS sensitivity (manufacturer’s method).
- Output RF power and modulation characteristics.

Return Loss Bridge

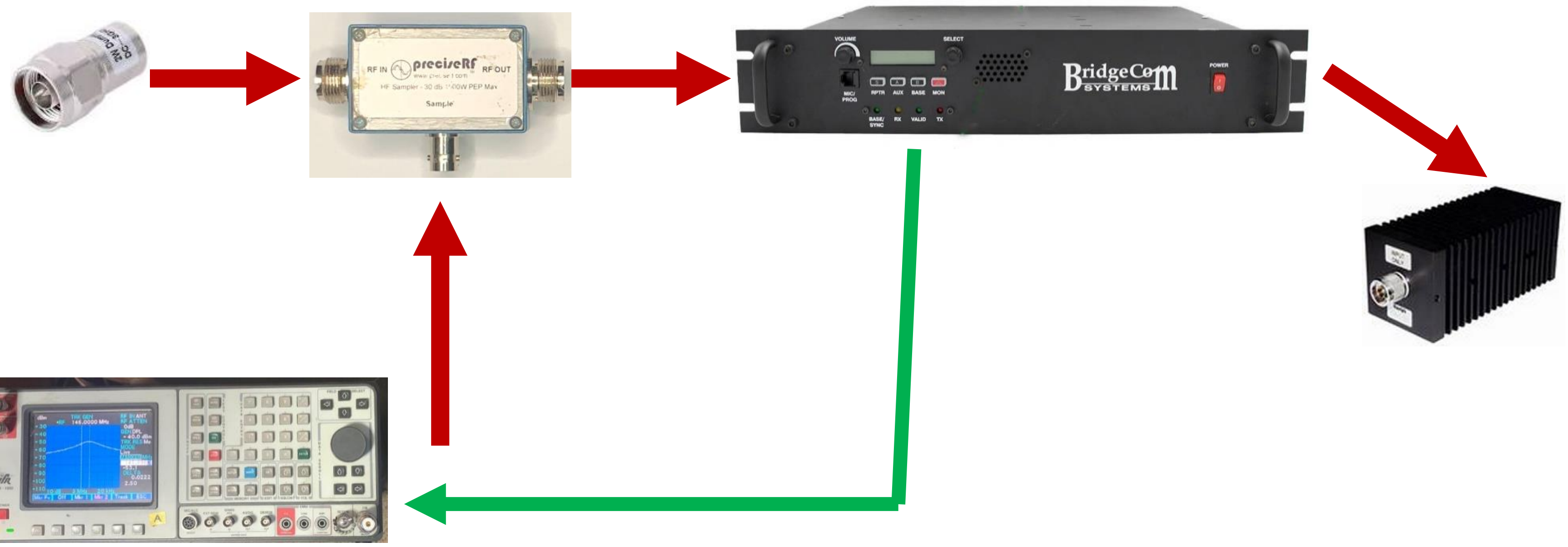
- Samples the reflected RF from antennas, etc.
- Used for SWR calculation.
- Supplies -10 dB of the reflected power.
- For low power, 1.5 watts.

Introduction To SINAD



- How much input signal is sufficient for a repeater to respond?
- SINAD test compares a 1,000 Hz input tone to the underlying noise.
- This provides a uniform point for many receiver tests.
- 12 dB is the accepted reference value.

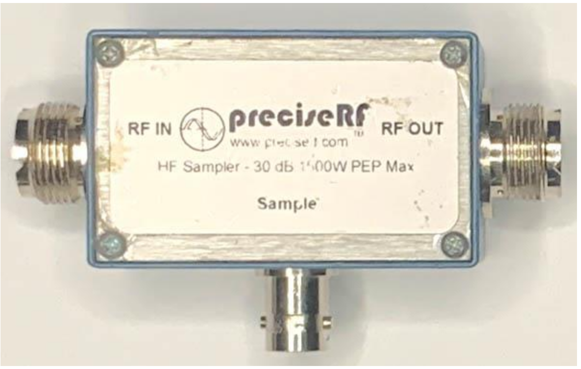
SINAD Setup



RF

Audio

SINAD Setup, Transmitting

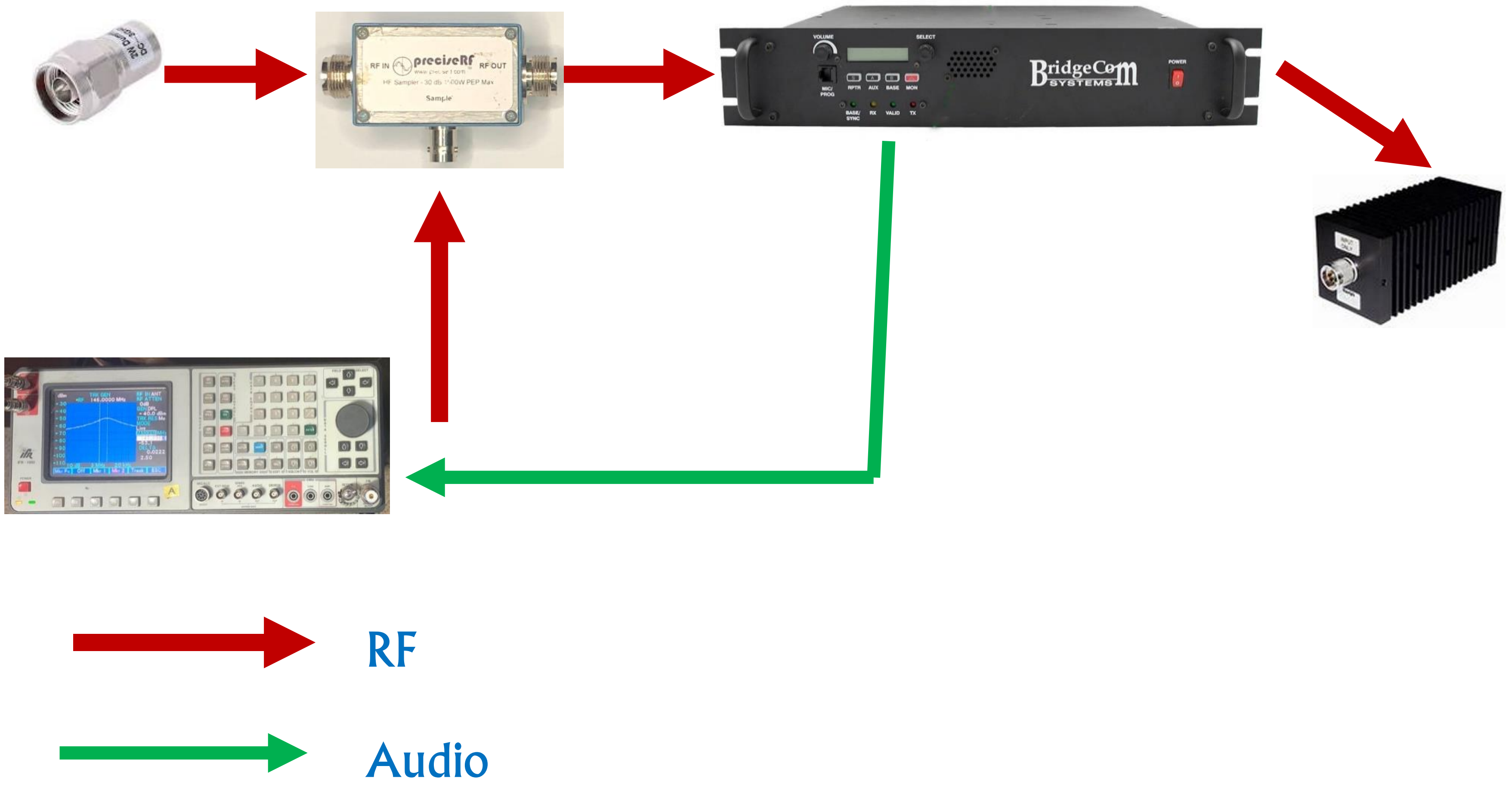


- Set 1,000 Hz modulation at 3 kHz deviation at repeater input frequency.
- 50 Ohm dummy load to the sampler ‘in’ port.
- Sampler ‘out’ port to repeater antenna input.
- Service monitor RF into the ‘sample’ port.
- Repeater audio output to service monitor SINAD input.

SINAD Method

- Remove CTCSS requirement at the repeater.
- Set RF generator to low value, say -90 dBm.
- Set squelch to minimum with the audio tone being heard.
- Increase RF level until SINAD value reaches 12 dB.
- This the reference point for the following measurements.

SINAD Setup



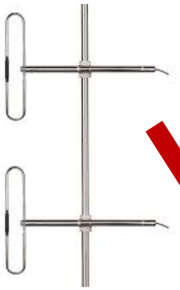
Receiver Sensitivity

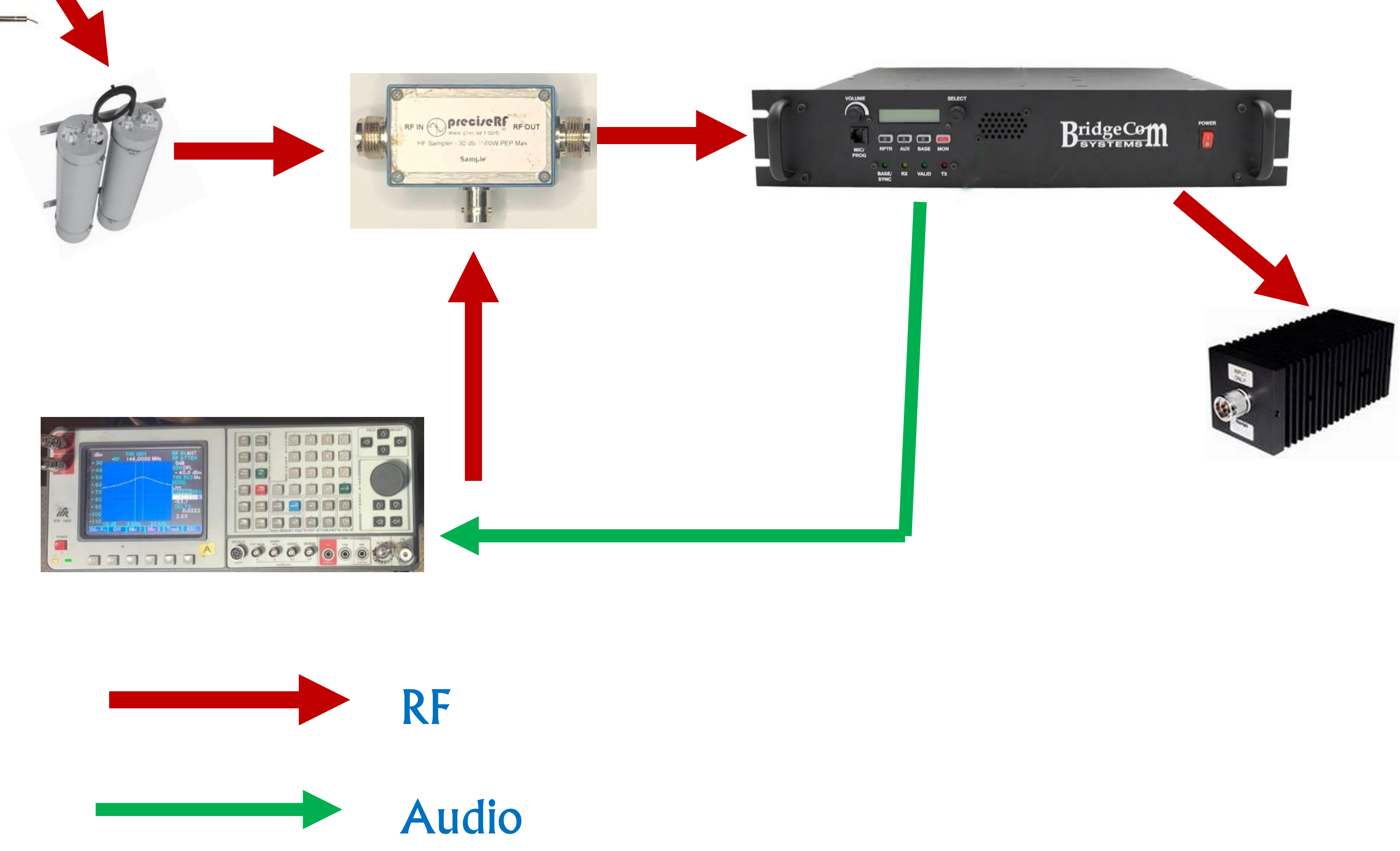
- This measures the ‘raw’ repeater receiver sensitivity based on its design.
- Place a 50 Ohm load as the Sampler Input.
- Reduce squelch to allow audio output of the 1,000 Hz audio.
- Increase the SM output RF out in the -90 dBm range until you get a 12 dB SINAD reading.
- Remember the sampler drops 30 dB.
- Expect a sensitivity of about -120 dBm (-90 -30 to -120 dB total).
- Record your repeater sensitivity.

Receiver Sensitivity

-125 dBm receiver sensitivity. (Without sampler.)

Receiver Noise Floor, And Squelch

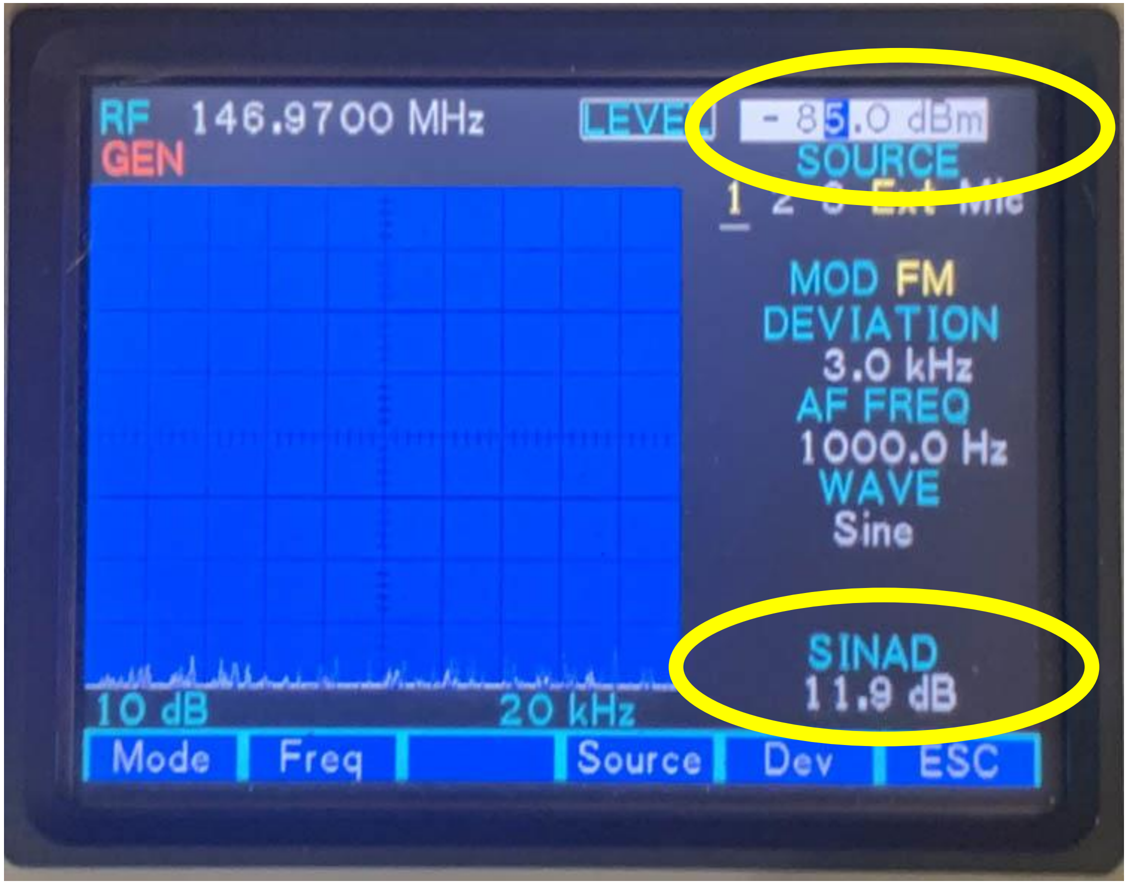




Receiver Noise Floor

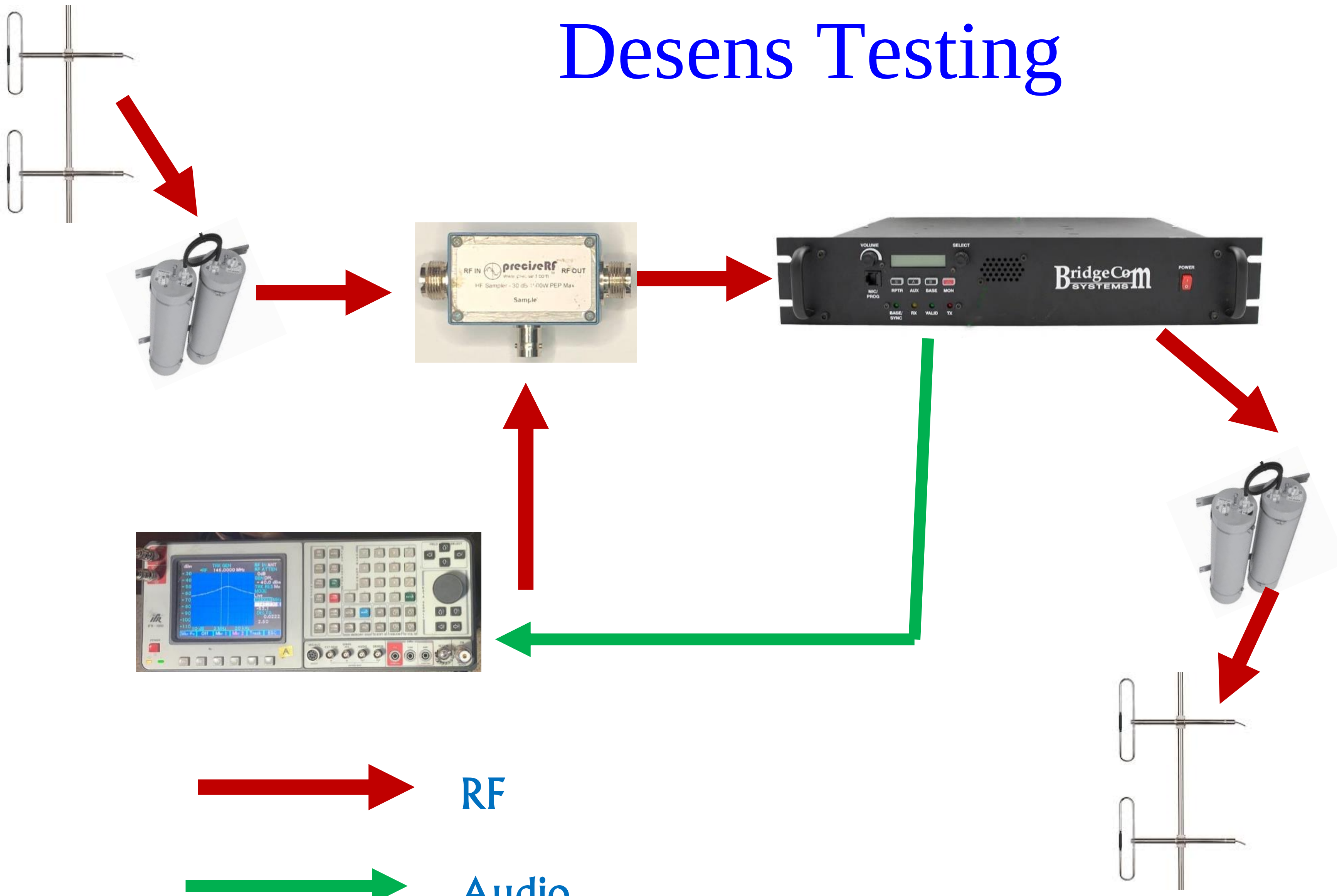
- This measurement gives an indication of the RF environment at your site. Record for future comparisons.
- From the Sensitivity Test replace the sampler input with the cavity filters, feed-line and antenna.
- Repeat the SINAD test.
- Expect the RF level to be a few dB above the prior sensitivity value; say, -118 dBm.
- This difference is due to local RF noise.
- If significantly greater, investigate.

Receiver Noise Floor



- Noise Floor: -85 dBm -30 dB = -115 dBm
- Compares to -125 dBm sensitivity with no antenna.

Desens Testing



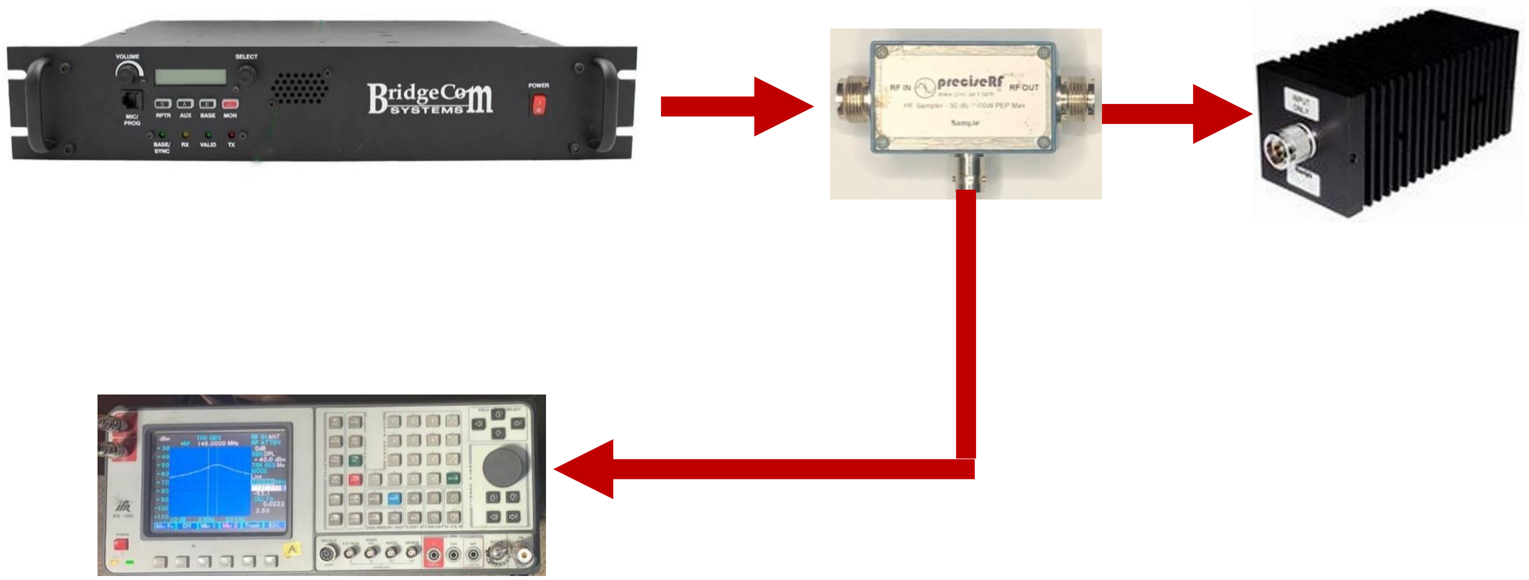
Desens Detection

- The dreaded ‘desens’ means a reduction in receiver sensitivity upon its transmitter activation. Due transmitter RF reaching the receiver input.
- From the noise floor setup replace the output dummy load with the transmit cavity filters, feed line and antenna.
- Key the transmitter while repeating the noise floor test. If the service monitor output must be increased above the prior noise floor value you have desense.
- Most often caused by inadequate feed-line shielding, insufficient cavity filter isolation, connectors, intermodulation from incompatible metal surfaces, and ??

Squelch Setting

- Use the desense setup: all antennas, cavities and feed lines in place.
- Remove CTCSS requirement at the repeater.
- Set RF generator to low value, say -90 dBm.
- Set squelch to minimum with the audio tone being heard (open).
- Increase service monitor RF level until SINAD value reaches 12 dB.
- Increase squelch until audio silences (closes).
- Finally, decrease squelch until audio reappears.

Transmitter Frequency



Transmitter Frequency

- Set service monitor to receive.
- Read the transmitter frequency & error.
- Most repeaters have a frequency trim.

Transmitter Power Out

- Three Methods.
- Into a Watt Meter, quick, best.
- Into T/R connector of service monitor with a 50 watt limit.
- Into T/R connector of service monitor using 30 dB sampler.

Transmitter Power Out

Forward 60 Watts

Reverse 2 Watt

SWR By Watt Meter

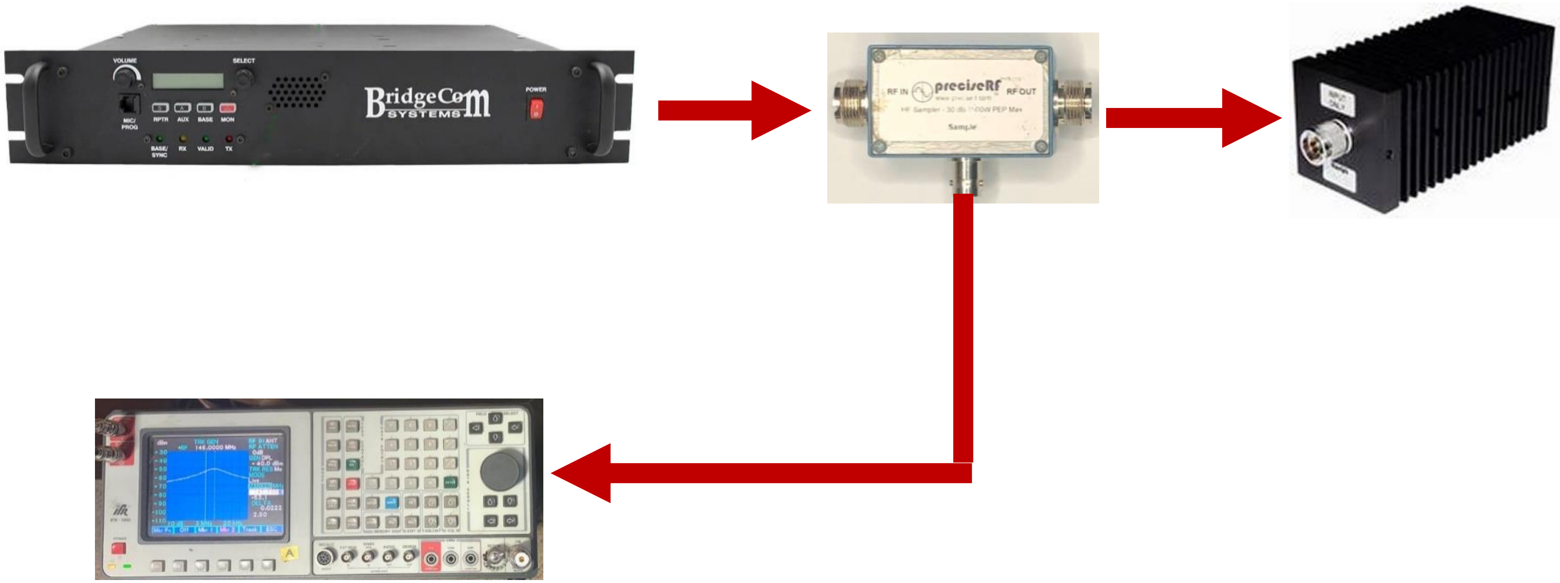
SWR Example:.

60 W forward; 2 W backward

2/60 x 100 = 3.3% about 1.4: 1

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

Transmitter Power Out



Return Loss Setup

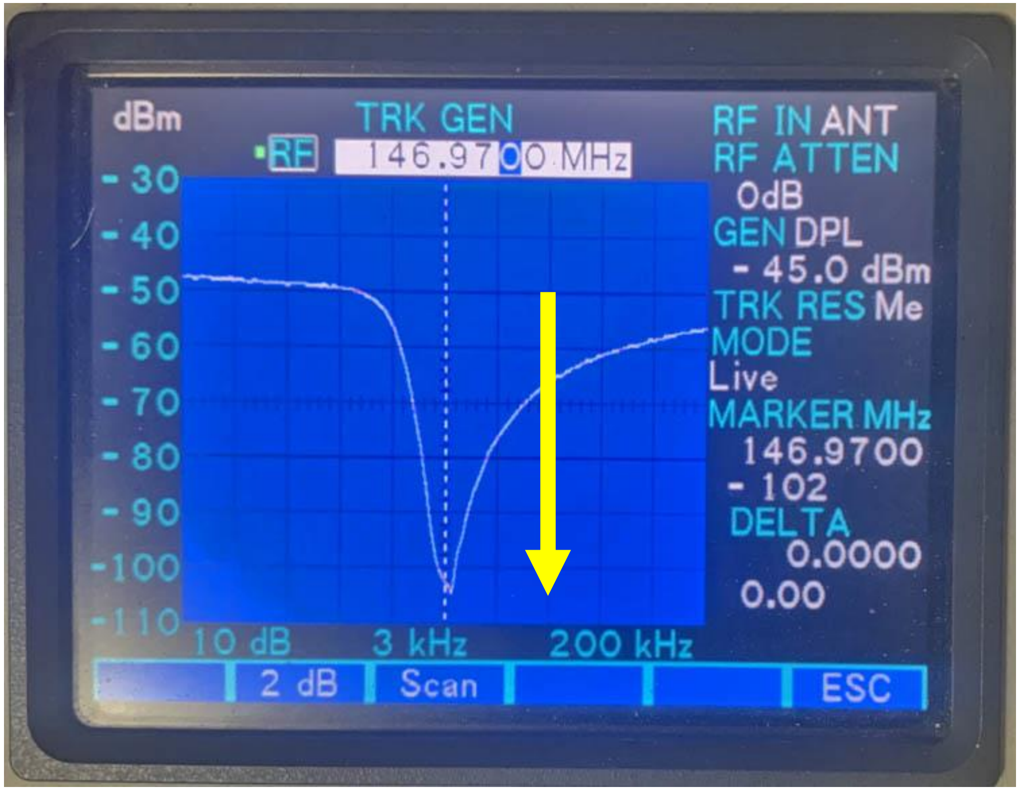
Note: Using an antenna analyzer is much easier.

Cavity, feed-line and antenna testing with a return loss bridge and tracking generator.

Return Loss

1. Measures the RF power reflected back from the feedline, cavity and antenna due to impedance mis matches. Leads to the SWR value.
2. Use tracking generator setup with a return loss bridge.
3. Replace the feed-line, cavities and antenna with a 50 Ohm resistor. Measure dBm as the baseline.
4. Replace the resistor with the feed-line, cavities and antenna. Measure the dBm signal level.
5. The difference is reverse attenuation in dB. 20 or larger is the desired range (SWR 1.2: 1).
6. Refer to a chart for the SWR value.

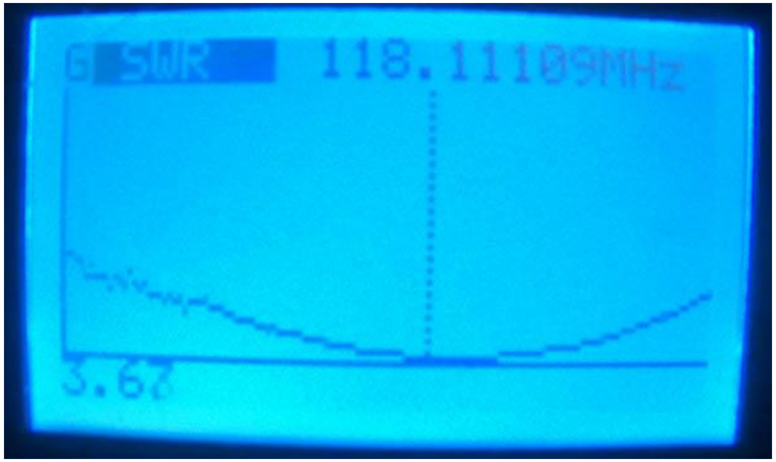
Return Loss Plot For SWR



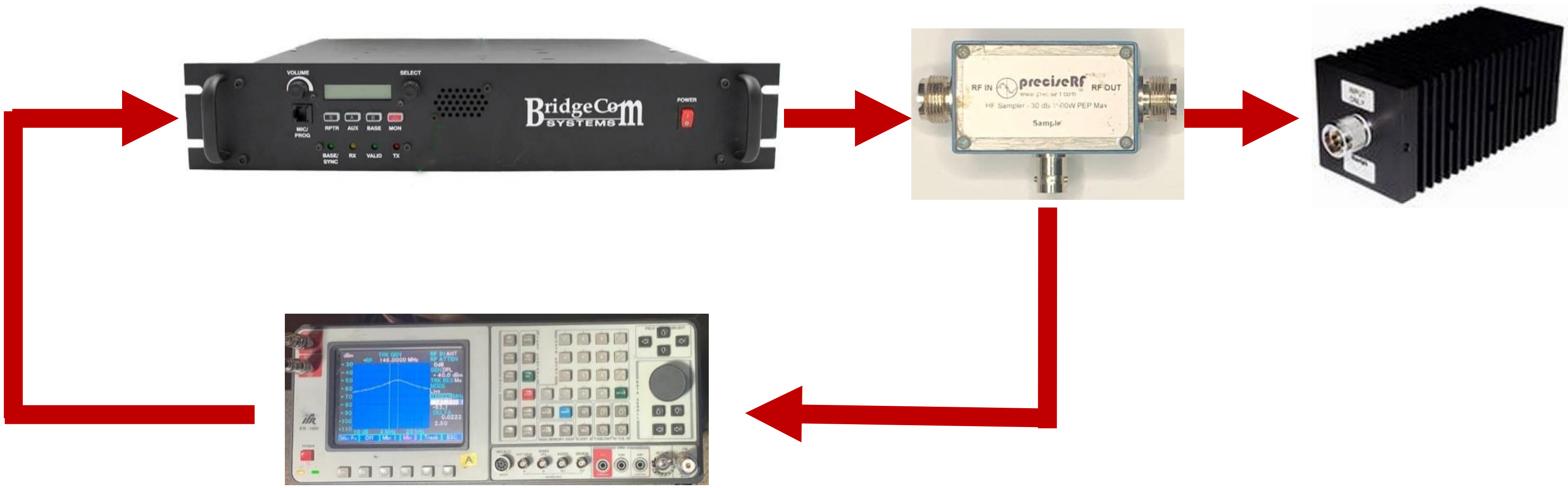
Return Loss, dB	SWR
5	3.57
8	2.32
10	1.92
15	1.43
20	1.22
25	1,12
30	1.07

SWR Test, By Antenna Analyzer

- Easiest SWR test.
- Follow setup for your antenna analyzer..



Transmitter Deviation Setup



Transmitter Deviation

- Set service monitor to Duplex.
- Service Monitor out: RF at -50 dBm FM 1,000 Hz, 3 kHz deviation. -50 -30 dBm into repeater.
- Service Monitor in: Sampled repeater RF.
- Adjust repeater deviation setting to reach 3 kHz, matching its input.

Cavity Filter Tuning

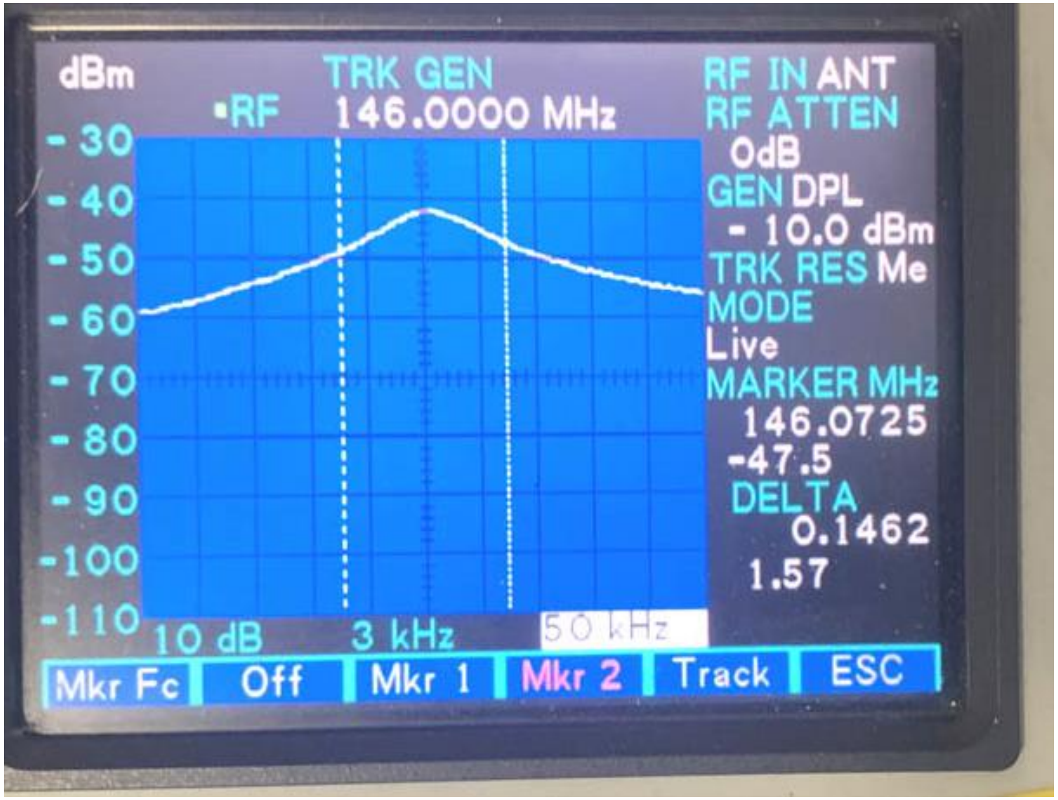
A tracking generator gives you visually the dB response over a range of frequencies.

Cavity Filter Tuning.

1. Note: It is highly unlikely you will have to make field adjustment to cavity filters from their factory settings.
2. Adjust the cavities individually. Then verify operation with their series connection.
3. Connect the SM Duplex output to the cavity input.
4. Connect the cavity output to the SM Antenna input.
5. Set for Tracking Generator operation centered in the desired cavity frequency.
6. For a pass filter, adjust the cavity settings for your tradeoff of loss vs. bandwidth. The desired loss range is 0.5 dB to 1.5 dB.
7. For a notch filter similarly adjust for the lowest (most negative) dBm at the same frequency.

Cavity Filter Tuning

Markers at -3 dB points. BW = 41 kHz.



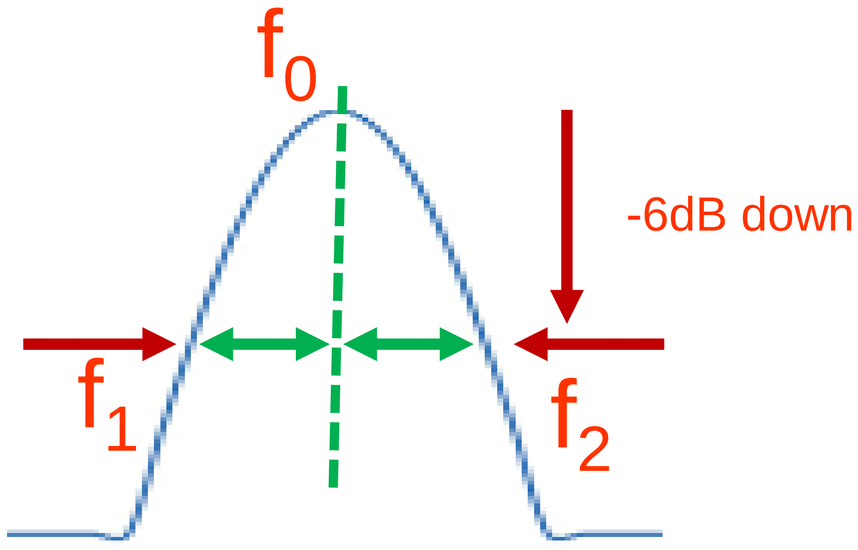
IF Centering

- This is included for reference. It is very unlikely you will have to make the adjustment in a modern repeater, or can it be possible.
- From heterodyne theory we know the repeater input is translated and passed through two IF stages.
- It is desirable your user’s input RF is centered within that IF bandwidth.

IF Centering, Method

- Setup for SINAD.
- Adjust the RF output to produce SINAD 12 dB.
- Increase the RF power by 6 dB. (Subtract 6 dB.)
- Adjust the transmit frequency up and down to the new 12 dB SINAD points.
- Average the two frequencies by adding together and dividing by two.
- This is the IF pass band center frequency.
- Trim the repeater's local oscillator (IF trim) until the calculated average frequency is (close to) the receiver's announced frequency.

IF Centering, Method



$(f_1 + f_2) / 2 = f_0$ IF center frequency.

(146.9683 + 146.9713) / 2 = 146.9698

146.970 - 146.9698 = .0002 or 200 Hz.

Next Lesson

- What can go wrong?
- Simple diagnostic tests.
- Systematic trouble-shooting.

Assignment

- Make a list of the top three (or more) items that could go wrong at a repeater?

References

- 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.