Measuring 12dB SINAD Sensitivity, Receiver Center Frequency and Modulation Acceptance Bandwidth

Measurement of MODULATION ACCEPTANCE BANDWIDTH while set up to do the normal 12dB SINAD SENSITIVITY test will quickly determine the radio's overall low level signal performance. The RECEIVER CENTER FREQUENCY test will tell you if the local oscillators are close to their design frequency and if the IF is aligned properly.

The 12dB SINAD SENSITIVITY, RECEIVER CENTER FREQUENCY and MODULATION ACCEPTANCE BANDWIDTH all contribute to a receiver's performance at low signal levels.

SINAD SENSITIVITY

SINAD is the acronym for **SI**gnal + **N**oise **A**nd **D**istortion. SINAD is the voltage ratio of signal, noise and distortion to noise and distortion and is expressed in dB. 12dB is the most common SINAD specification point. SINAD is a more accurate method of measuring the *readability* of a signal because it measures distortion in the 1 kHz signal in addition to quieting. A badly distorted audio signal will fail a SINAD test.

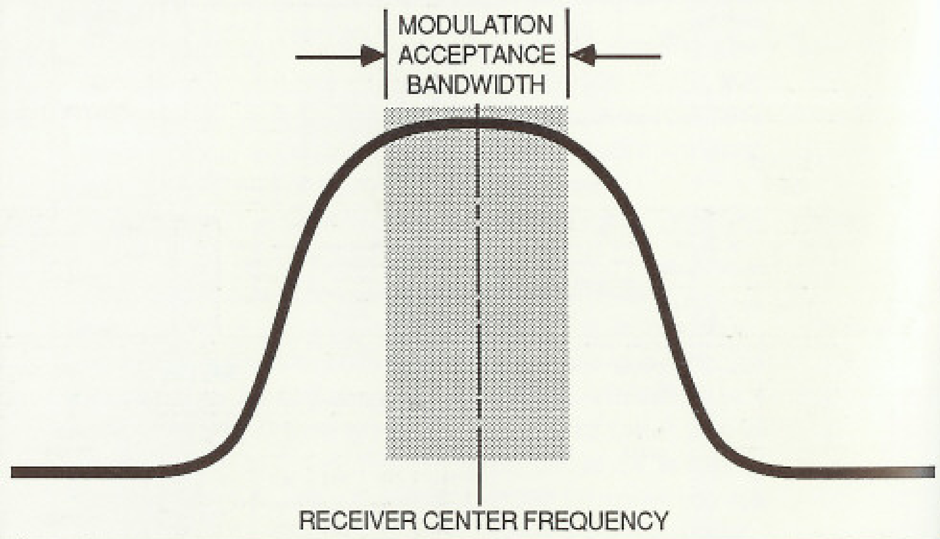
RECEIVER CENTER FREQUENCY

The receiver center frequency is the frequency that produces the best **SINAD** reading.

MODULATION ACCEPTANCE BANDWIDTH

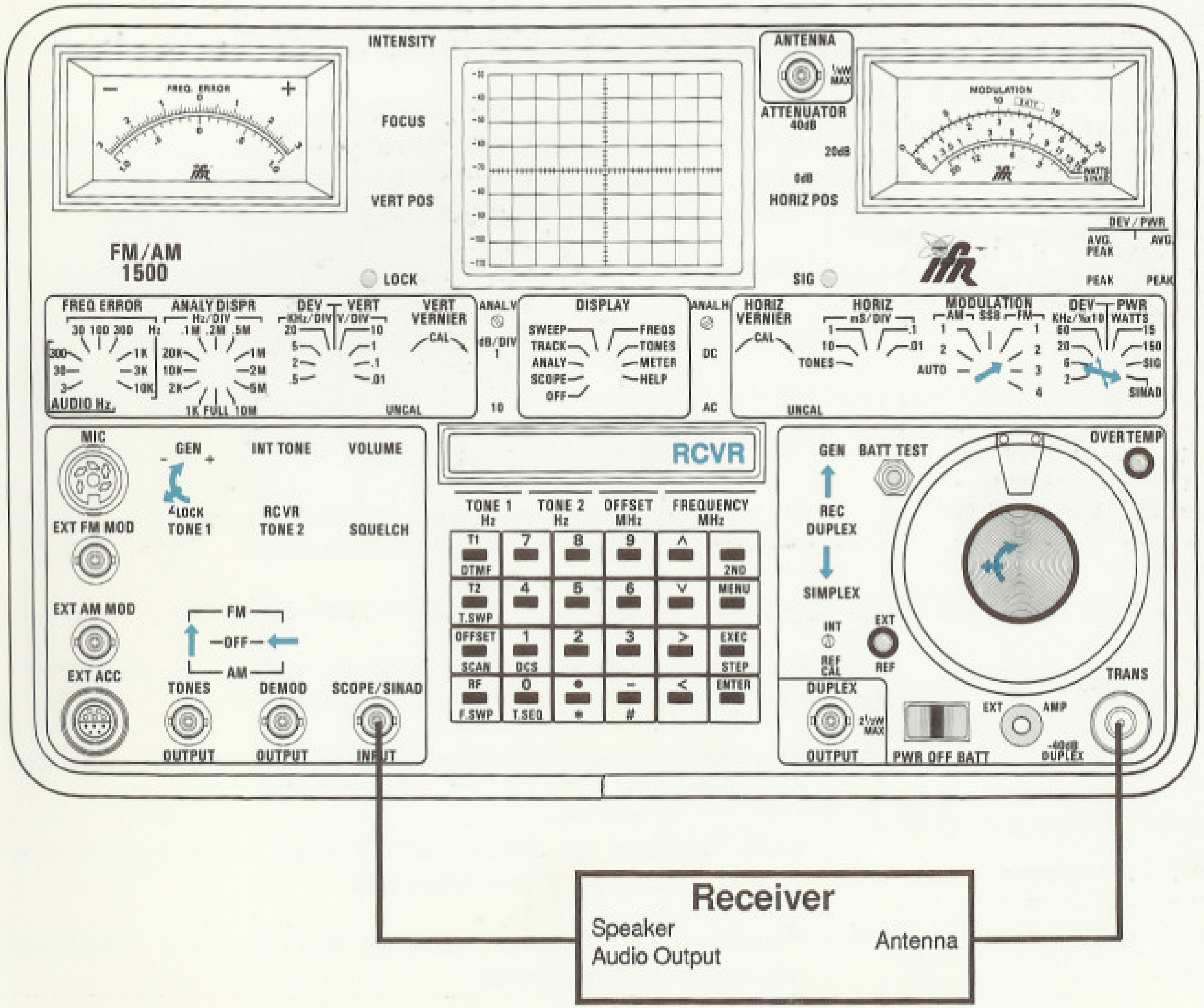
Modulation acceptance bandwidth is measured by increasing the deviation until distortion occurs in the 1 kHz tone due to bandwith limitations.

RECEIVER RESPONSE CURVE



NOTES

Measuring 12dB SINAD Sensitivity, Receiver Center Frequency and Modulation Acceptance Bandwidth



SINAD SENSITIVITY and RECEIVER CENTER FREQUENCY

After setting **TI** to 1000.0 Hz and adjusting **TONE 1** level to 3 kHz of deviation, switch **DEV PWR** to **SINAD.**

Increase RF output from minimum until needle on **SINAD** meter reads about 12dB.

Advance the **GEN** control clockwise from the **LOCK** position to get the highest SINAD reading possible. That is the RECEIVER CENTER FREQUENCY, leave the **GEN** control at that position.

Readjust the **RF** level to get **12dB SINAD,** reading the RF dial at the cursor to determine SINAD SENSITIVITY.

MODULATION ACCEPTANCE BANDWIDTH

With controls in the same position as above, increase the **RF** level **6dB.** The SINAD reading will increase due to the stronger signal.

Increase deviation with the **TONE 1** control until SINAD returns to 12dB as the distortion increases due to bandwidth limitations. The deviation as read on the **MODULATION** meter is the MODULATION ACCEPTANCE BANDWIDTH. Normal readings are in the 6-9 kHz range.

Checking Receiver I.F. Bandwidth and Symmetry

The I.F. filtering network determines the receiver's selectivity. If it is too narrow, audio distortion will be produced. If it is too wide, there is apt to be adjacent channel interference. Symmetry of the I.F. filter is important for recovering audio with the lowest distortion.

TO MEASURE I.F. BANDWIDTH (60dB skirt width)

Open the squelch fully on the receiver under test.

Set the 1500's **FREQUENCY** to the receiver frequency.

Set **TONE 1** frequency to **1000.0** Hz.

Set **DEV / PWR** to **2 Khz.**

Set **TONE 1** level to produce 1KHz deviation on **MODULATION** meter.
Reset **DEV / PWR** to **SINAD**.

Adjust RF output to achieve a 12dB SINAD reading.

Note the dBm reading on the RF output dial, that's your REFERENCE SENSITIVITY. (typical example: -110dBm)

Raise RF output to 60 dB above REF. SENS. (example: -50dBm)

Move the cursor in the **FREQUENCY** window to the last position on the right, the hundred hertz position.

Jog the frequency up in hundred hertz steps with the ^ key until the SINAD meter again reads 12dB. Note the upper frequency.

Jog the frequency down with the **v** key through center and to the point on the low side where 12dB SINAD is again achieved.

Distortion should begin at approximately the same ± frequency offsets.

The difference between the high and low SINAD points is the 60 dB "skirt width".

By listening to the receiver's audio you can hear the distortion and loss of the recovered 1kHz tone. The tone should be gone at ±15kHz on narrow band FM radios, indicating good adjacent channel rejection.

Distortion should begin at approximately the same ± frequency offsets.

TO MEASURE I.F. SYMMETRY

I.F. symmetry is good if the 1 kHz audio starts breaking up at the same frequency offset either side of the center frequency.

Reset the **FREQUENCY** to the receiver's center frequency.

Advance the frequency to full offset by rotating the **GEN** control clockwise just past the detent. (out of the **LOCK** position)

Reset the squelch on the receiver under test to squelch the audio (just below threshold).

While monitoring the **FREQ. ERROR** meter, swing the frequency either side of center with the **GEN** control.

The receiver should break squelch at about the same ± frequency offsets if the I.F. is symmetrical.

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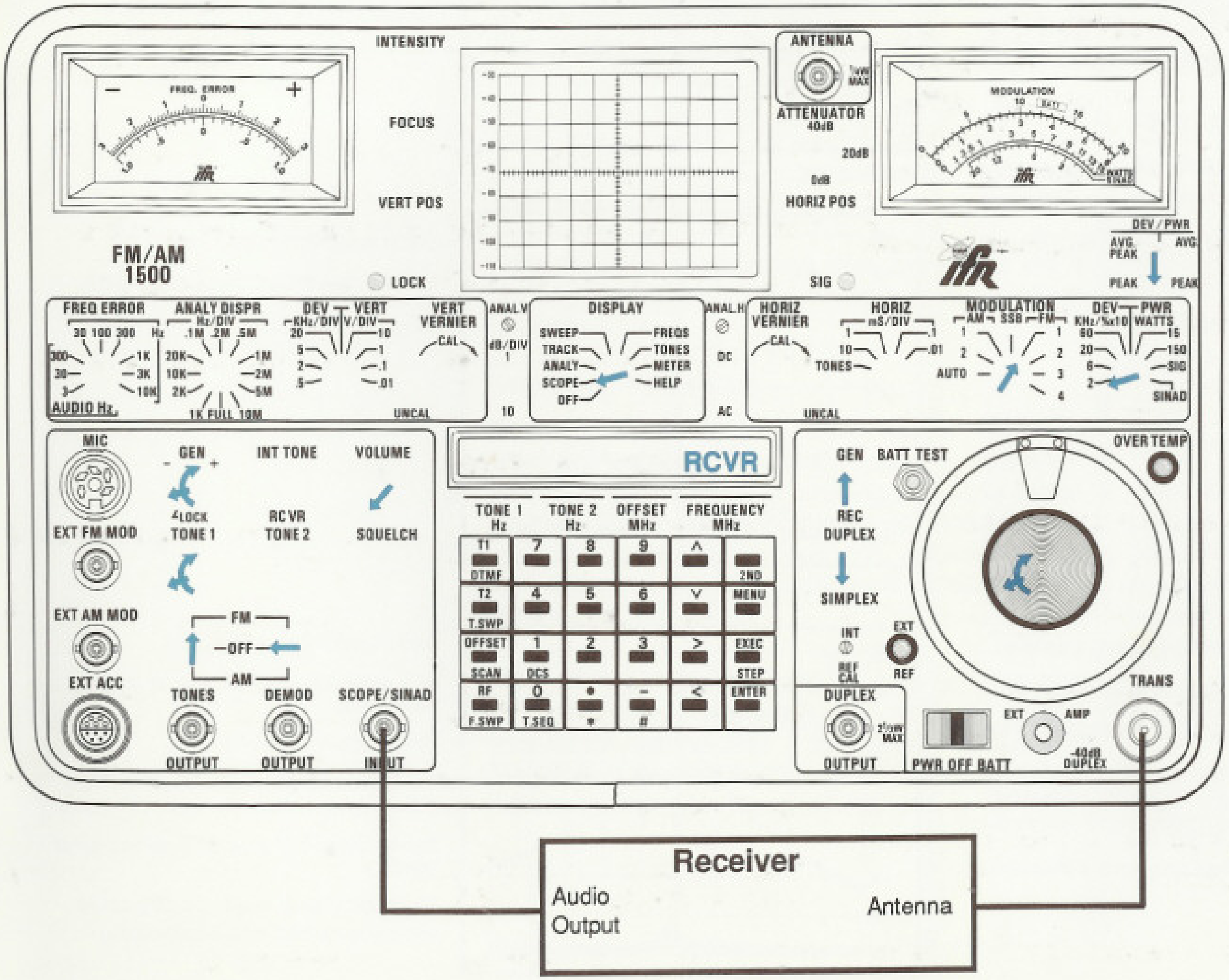
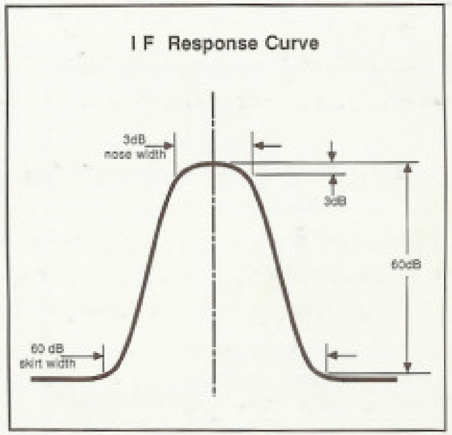
Checking Receiver I.F. Bandwidth and Symmetry





APPLICATION NOTE

Receiver RF filter alignment

RF alignment using the tracking generator as a source and the analyzer as an indicator can provide an insight into tuning flaws that are otherwise invisible.

Inside is a case history of how the tracking generator was used to isolate a bad part, the problem that an unavoidable part substitution caused and how it was resolved.

THE SAD STORY

A dual diversity wireless microphone receiver came into the shop with one channel essentially dead.

By using a SNIFFER LOOP with the tracking generator, a bad RF FET was found quickly. It was replaced with the radio manufacturer's *substitute* part. (the original FET was no longer manufactured)

After the FET replacement, the tuning just didn't act right, it was too broad and didn't want to peak-up properly.

THE PLOT THICKENS

Feeding the tracking generator directly into the front end and using the sniffer loop to sniff the RF output coil, the analyzer showed a double hump response. The output coil resonance was too high in frequency when the slug was centered in the coil, indicating that more capacity was necessary to tune it.

After adding a small capacitor across the RF output coil, the output increased as expected as the resonance approached the receive frequency. Resonance was still too high so some more "C" was added.

RF STAGE REGENERATIVE?

As the output coil was tuned toward the receive frequency, the shape of the peak got sharper, an indication that there was regeneration. The stage was about to take-off into self-oscillation.

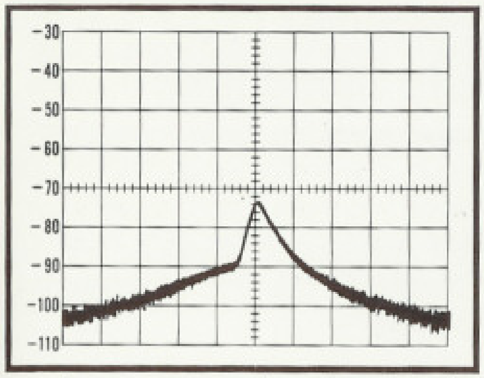
RF STAGE TAKES OFF

As the ouput stage reached resonance at the receive frequency, it went into sustained oscillation. All of this was the result of replacing a FET in the RF stage with a substitute. (Remember, the original part was no longer manufactured) The new FET had considerable more gain and had to be degenerated by raising the drain resistance.

HAPPY ENDING (you don't think we'd tell you a sad one do you?)

Once the gain was reduced, both coils could be peaked at the receiver frequency, providing a good RF response curve with stable gain. The regeneration would have been impossible to see without an analyzer. Just peaking for maximum signal wasn't enough to provide proper operation.

A single turn sniffer loop was found to be easier to use in this application at 33 MHz than an RF probe because it could be left in position over each coil form during the tuning process and didn't require an extra hand to hold it in place as the RF probe did.



29.4 33.4 38.4 MHz

Sniffer loop on RF *input* coil as a reference.

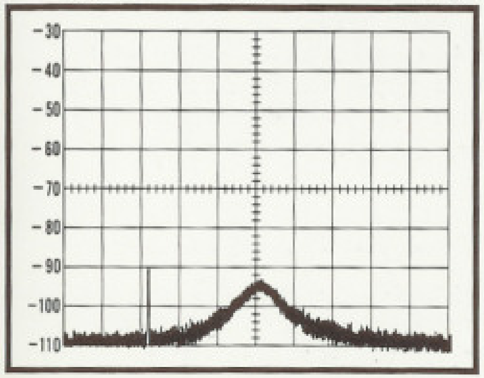
200 µv fed into radio antenna jack.

DISPLAY: TRACK

ANALY DISPR: 1MHz / DIV

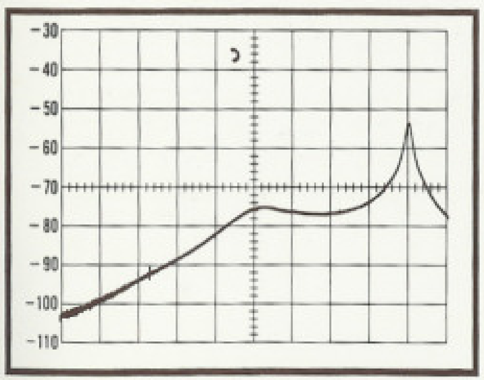
10 dB/DIV

FREQUENCY: 33.4 MHz



Sniffer loop on RF *output* coil.

Obvious loss of gain.



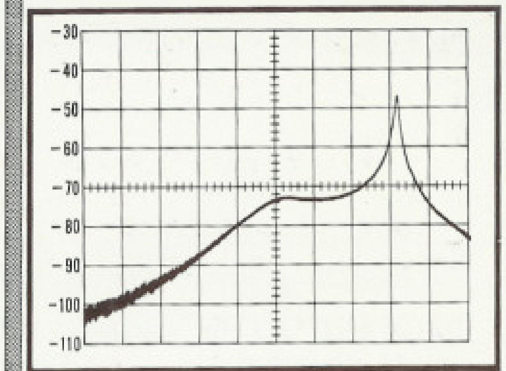
Replaced RF FET with substitute.

Sniffer loop still on RF output coil.

Left hump is RF input coil response.

Right hump is RF output coil response. Output coil tuning slug at maximum inductance in middle of coil.

Output coil resonance 4 MHz too high.

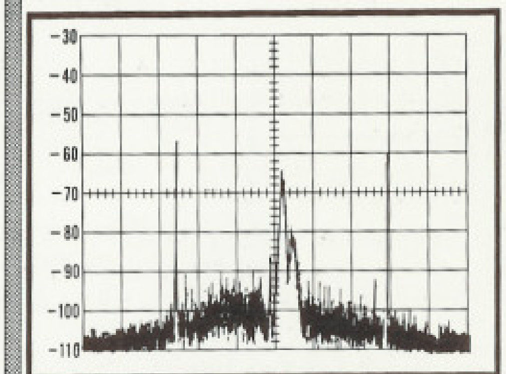


Sniffer loop still on RF output coil.

Added small "C" to output coil to lower resonant frequency.

Output coil resonance closer to 33.4 but peak gets sharper. Why??

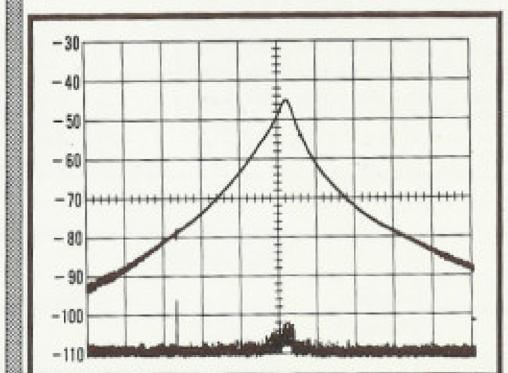
Suspect regeneration.



Sniffer loop still on output coil.

More "C" is added to output coil to tune it.

RF stage goes into sustained oscillation.



Sniffer loop still on output coil.

FET degenerated with higher drain resistance.

Double exposure photo:

Top trace = RF output coil with 200µv into antenna.

Bottom trace = RF output coil with no signal input.

Slight noise hump shows amplifier stable with some normal noise amplification.

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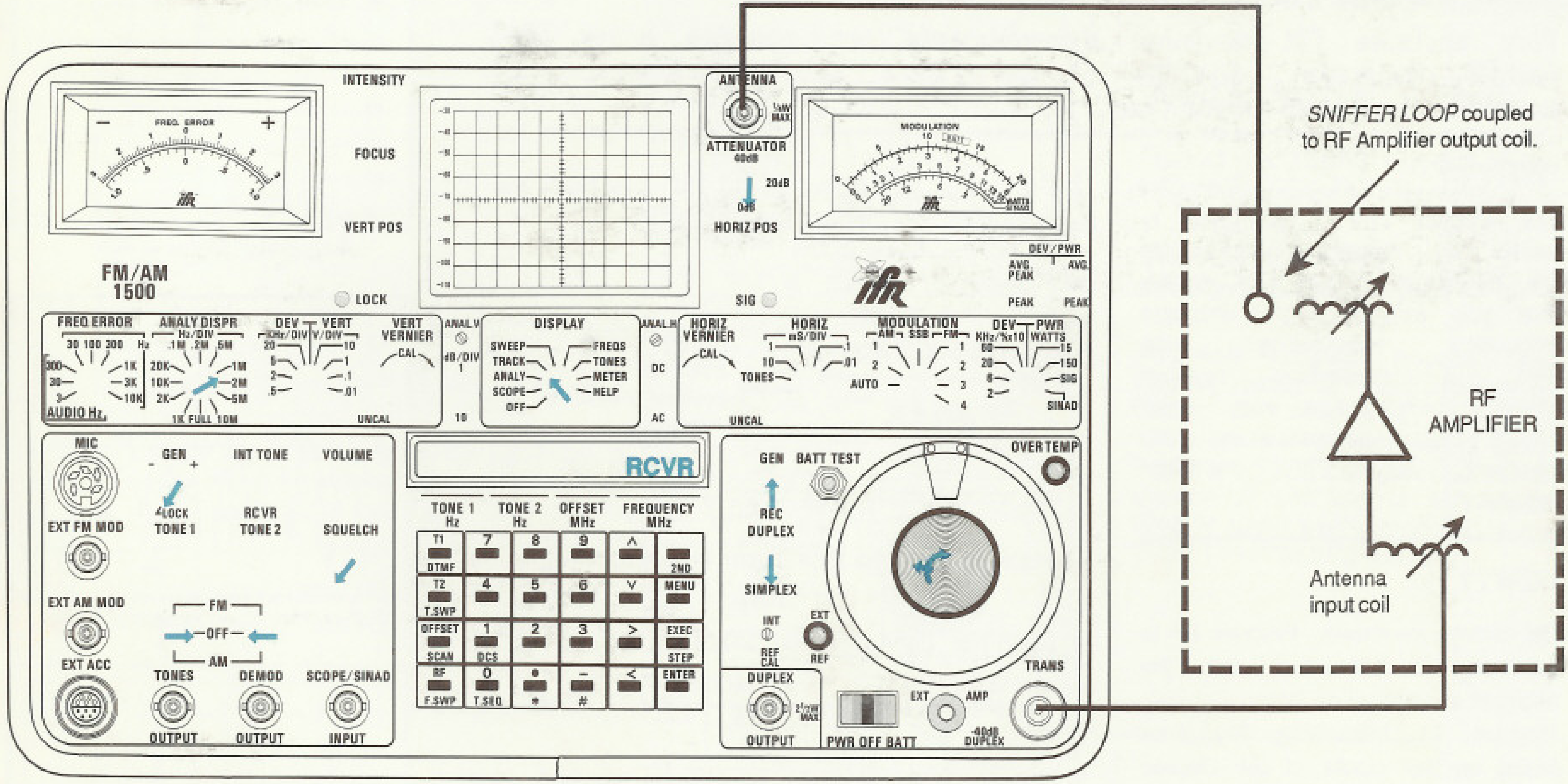
Receiver RF filter alignment



High accuracy FM deviation measurements using the Bessel null technique.

Very accurate FM deviation measurements are possible using the narrow dispersion capability of the 1500's Spectrum Analyzer to determine the Bessel function null.

WHY??

The Bessel null technique is useful to determine accurately the deviation of any FM device that you can feed an accurate frequency modulating tone into... a transmitter, another signal generator, even the 1500's signal generator may be checked for FM deviation accuracy.

HOW??

Set controls as shown. Program **RF** to transmitter frequency so that the analyzer is centered on transmitter freq. Program **T1** Modulating Frequency based on the results of the Desired Deviation formula. Increase **TONE 1** level from zero until first null appears. Crosscheck on analog **MODULATION** meter or on digital readout by switching **DISPLAY** to **METER.**

The first null will occur when the deviation is 2.4048 times the modulating frequency.

$$\frac{\textbf{Desired Deviation}}{\textbf{2.4048}} = \textbf{Modulating Frequency}$$

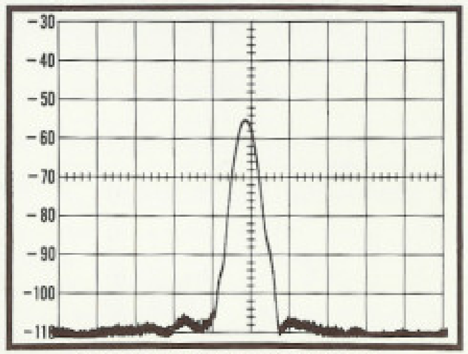
(required to produce first null.)

Example: **Desired Deviation = *5 kHz***

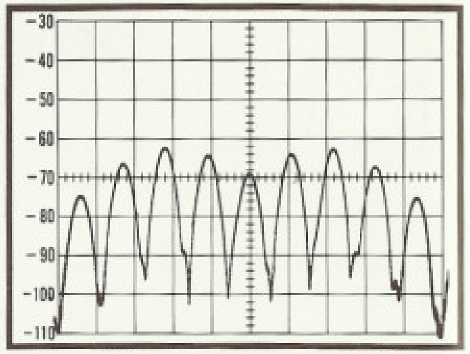
$$\frac{\text{5000 Hz Deviation}}{\textbf{2.4048}} = \begin{array}{l}\text{2079.2 Hz} \\ \text{Modulating freq.}\end{array}$$

Caution:

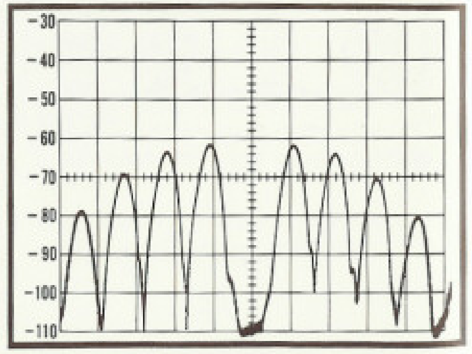
Some transmitters' deviation limiters are fooled when they are set up with a continuous sine wave signal. Recheck peak deviation by viewing **DEV**iation on **SCOPE** with speech input.



Carrier with no modulation



First null begins to appear at 3 kHz



Deep null appears at exactly 5 kHz

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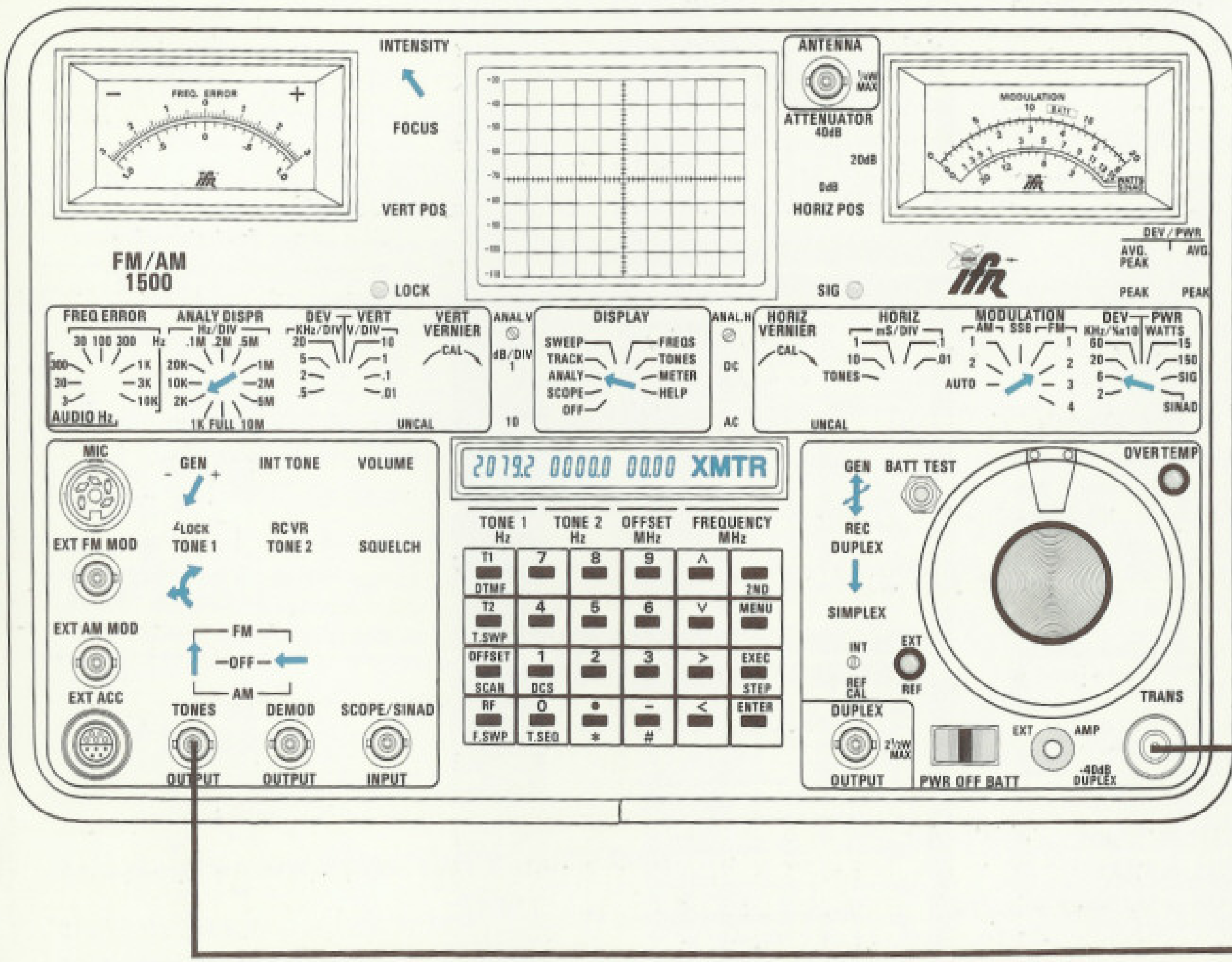
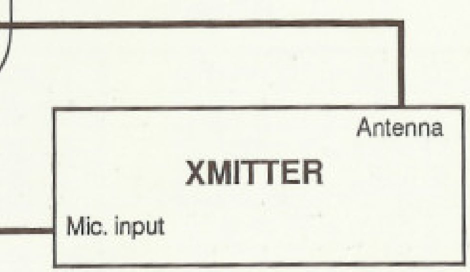
High accuracy FM deviation measurements using the Bessel null technique.





Direct connection

Connect the **TONES OUTPUT** to the microphone input of the transmitter.

Optional acoustical coupling to microphone

Acoustical coupling provides non-invasive testing of the transmitter by holding the microphone up to the 1500's speaker (on right side of case). Feed the 1500's tone generator to the speaker by switching to **INT TONE.** Speaker output level is controlled by the **TONE 1** and **VOLUME** controls.