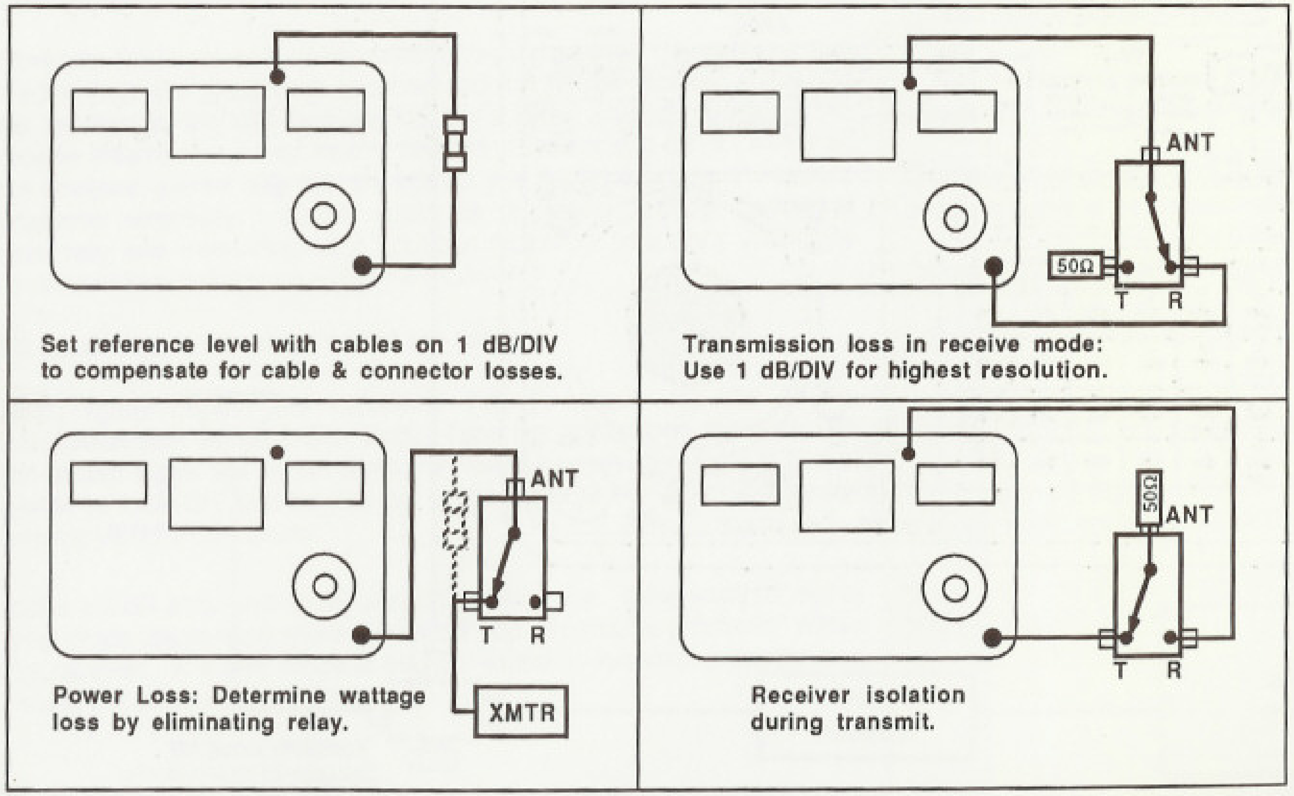
Measuring isolation and insertion loss in Tx-Rx switches

T-R relays can be a source of several problems. Low transmitter power, poor receiver sensitivity and even intermod interference problems.



Set reference level with cables on 1 dB/DIV to compensate for cable & connector losses.

Transmission loss in receive mode: Use 1 dB/DIV for highest resolution.

Power Loss: Determine wattage loss by eliminating relay.

Receiver isolation during transmit.

TRANSMITTER POWER LOSS

Transmit power loss caused by the relay is easily isolated by measuring output power with and without the relay.

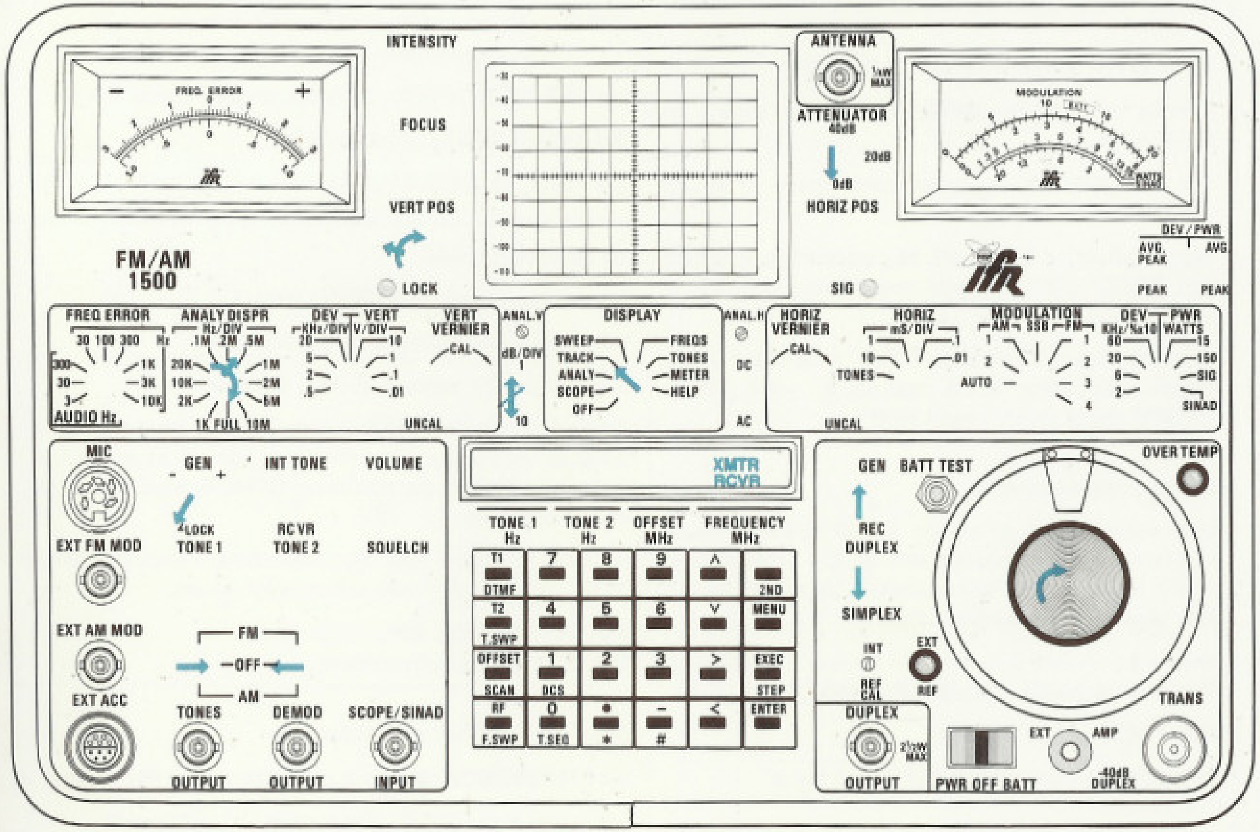
RECEIVER SENSITIVITY LOSS

Receiver sensitivity loss is isolated by measuring the transmission loss at the receiver frequency. Sensitivity loss is more apt to be an intermittent problem due to the lack of power to punch through the thin corrosion layer on the receive contacts.

T-R RELAY MAY BE AN INTERMOD SOURCE

Corrosion on contacts may act as a diode, creating an unwanted mixer when excited by strong RF signals from the antenna.

Measuring isolation and insertion loss in Tx-Rx switches



See facing page for actual connections.

Use **10dB/DIV** for loss measurements of10dB or more.

Use **1dB/DIV** for higher resolution measurements.(≤10dB)
Use **VERT POS** to re-center reference.

Always "calibrate out" cable and connector loss at each frequency of interest.

APPLICATION NOTE

Monitoring SSB & ACSB testing

SSB

Single Sideband signals are easily monitored with the 1500's **MODULATION** switch in the **SSB** position. An accurate phase locked beat frequency signal [BFO] is automatically injected on the 1500's last IF frequency.

SSB Frequency error

Setting the frequency of a SSB transmitter is easiest when the transmitter can be switched or jumpered into a CW mode. Sometimes the carrier balance control can be misadjusted slightly to produce a small CW signal. The frequency can then be read conventionally on either the digital or analog Error Meter. (See pages 34-35 for 0.1 Hz resolution method.)

If CW operation is not practical, the precision frequency audio generator capability of **TONE 1** is used to modulate the SSB transmitter with a 1,000.0 Hz tone.

The 1500's **FREQUENCY** is then set 1 kilohertz above or below the suppressed carrier frequency depending upon whether the upper or lower sideband is used.

The frequency error can then be read directly on the digital **DISPLAY** in the **METER** position or on the analog **FREQ. ERROR** meter.

Marine radio note: To achieve the ±20 Hz accuracy required by FCC for marine HF radios, the oven option must be installed in the 1500.

ACSB TRANSMITTER TESTS

To confirm compressor performance:

Monitor through the **ANTENNA** port as shown on facing page.

Set **FREQUENCY** to suppressed carrier of ACSB signal.

With modulation turned off, key transmitter and note that **FREQ ERROR** meter reads the frequency of the pilot tone.

Modulate transmitter with **TONE 1** at **1000.0 Hz.** When modulation is at maximum, the **FREQ ERROR** meter should read 1 kHz.

ACSB Frequency error

Use either digital or analog **FREQ ERROR** meter to measure the frequency error of the *unmodulated* ACSB signal. The unmodulated signal will be 3.1 kHz *above* the suppressed carrier.

Viewing transmitter modulation envelope

Reset **DISPLAY** to **SCOPE.**

Modulate the transmitter with **TONE 1** set at **1800 Hz.**

Adjust **TONE 1** level to display a modulation envelope. Adjust **HORIZ VERNIER** for a stable display.

Overdriving the transmitter output causes flattening of peaks. Watch for parasitic oscillations which appear as a fuzzy halo on the envelope.

ACSB RECEIVER TESTS

SRTM (Standard Receiver Test Modulation)
[test signal with pilot and 1 kHz test tone.]

Set **FREQUENCY MHz** to the suppressed carrier +1kHz.

Set **MODULATION** switch to **AM1.**

Set **TONE 1** to **2100.0** Hz. Set the modulation level to 63%.

To measure SINAD:

Connect audio output to **SINAD** input.

Increase RF level to achieve 12 dB SINAD.

Checking pilot capture & AFC tracking

After achieving 12 dB SINAD, vary **TONE 1** frequency in hundred hertz steps from 1400 Hz to 3000 Hz to make sure that receiver tracks the pilot tone. SINAD indication should remain constant.

Receiver capture of pilot: Set radio squelch to threshold with no RF. Increase RF level until squelch opens.

Vary **FREQUENCY MHz** ±500 Hz.
SINAD should remain constant.

Checking receiver expander

Set **FREQUENCY MHz** to suppressed carrier frequency.

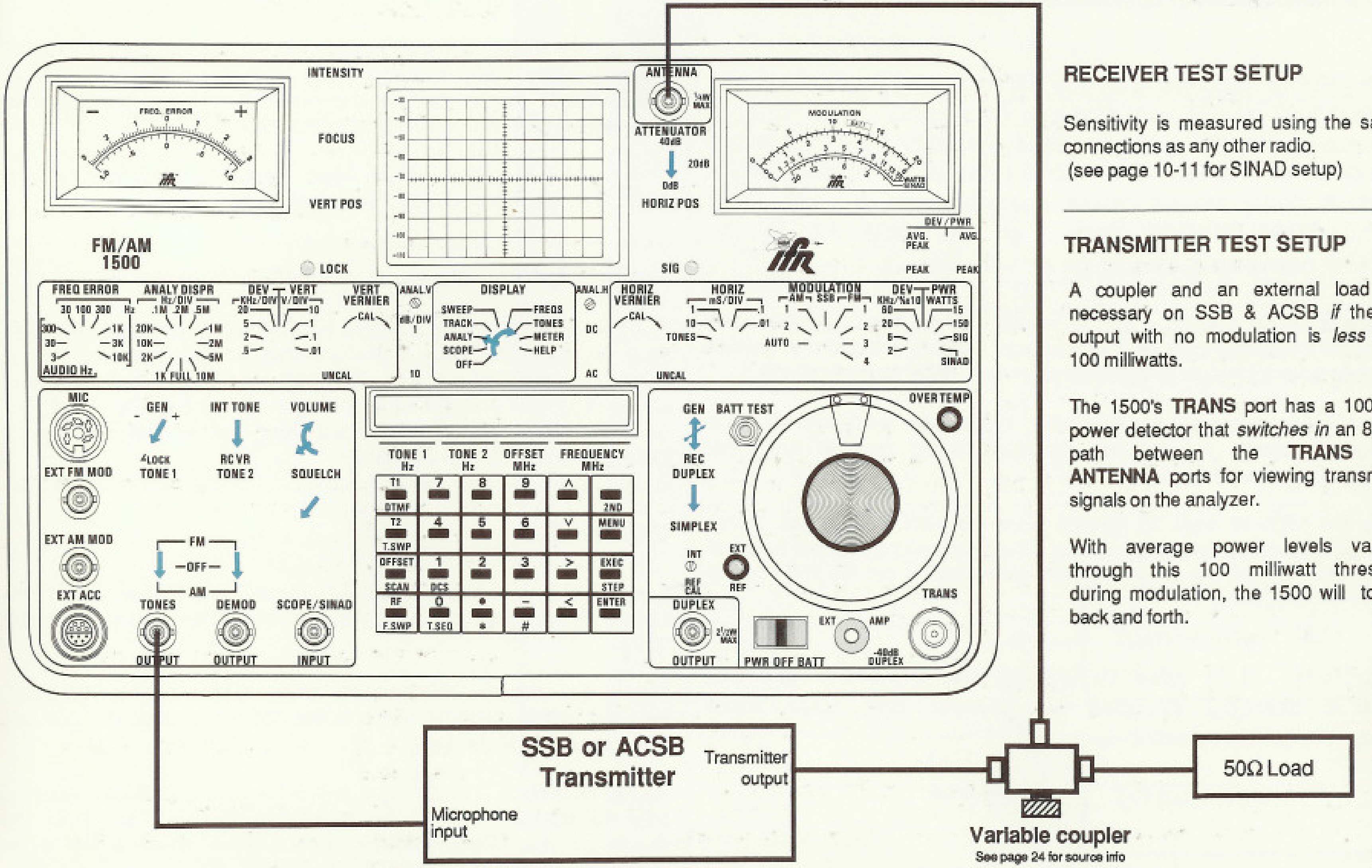
Set **TONE 2** to **1000** Hz. Set modulation to 20% with **TONE 2** level control.

Set **TONE 1** to **3100.0** Hz. Increase **TONE 1** to obtain 40% *total* modulation.

View radio's 1 kHz speaker audio on **SCOPE.**

Increase / decrease 1 kHz (**TONE 2**) level. Audio level should change correspondingly.

Monitoring SSB & ACSB testing



RECEIVER TEST SETUP

Sensitivity is measured using the same connections as any other radio.
(see page 10-11 for SINAD setup)

TRANSMITTER TEST SETUP

A coupler and an external load are necessary on SSB & ACSB *if* the RF output with no modulation is *less* than 100 milliwatts.

The 1500's **TRANS** port has a 100 mw power detector that *switches in* an 80 dB path between the **TRANS** and **ANTENNA** ports for viewing transmitter signals on the analyzer.

With average power levels varying through this 100 milliwatt threshold during modulation, the 1500 will toggle back and forth.

Synchronizing Simulcast Transmitters

Simulcasting requires that the RF frequency of all of the transmitters be set very close to each other. The 1500 is capable of measuring the frequency direct or off the air with a resolution of ± .1 Hz. The needle trend of the analog **FREQ. ERROR** meter makes coarse frequency setting easy. The digital **FREQ ERROR** shown on the **DISPLAY** in the **METER** position provides ±1 count resolution.

Off-the-air checking would of course require that you have control of each individual transmitter from the measurement site or be able to discriminate between received signals so you know which transmitter you're receiving.

Note: The standard 1500 will resolve RF signals to 0.1 Hz, but the frequency stability required for simulcast testing requires the oven oscillator option be installed.

Allow the 1500 at least 15 minutes warm-up from a cold start before attempting accurate frequency setting. The oven can be kept hot between transmitter sites by using the cigarette lighter plug to run the 1500 on the service vehicle battery.

CAUTION: It is wise to unplug the cord during the vehicle starting process to protect the 1500 from those brutal transients!

For 1 Hz resolution

The 30 Hz **FREQ. ERROR** position on the analog **FREQ. ERROR** meter provides 1 Hz resolution so it's as easy as setting the 1500's **FREQUENCY** to the desired and tweaking first one transmitter to zero and then the other to zero on the error meter.

The digital error display shown when the **DISPLAY** switch is in the **METER** position will also reflect the frequency error ±1 Hz.

For 0.1 Hz resolution.

Tenth Hertz resolution is available by switching the **MODULATION** to **SSB**. In the **SSB** position a phase locked beat frequency oscillator is injected into the 1500's last IF. This BFO produces an audio beat note which may then be compared to TONE 1 with the difference displayed on the **FREQ. ERROR** meter and read out on the CRT digital **DISPLAY** in the **METER** position.

EXAMPLE

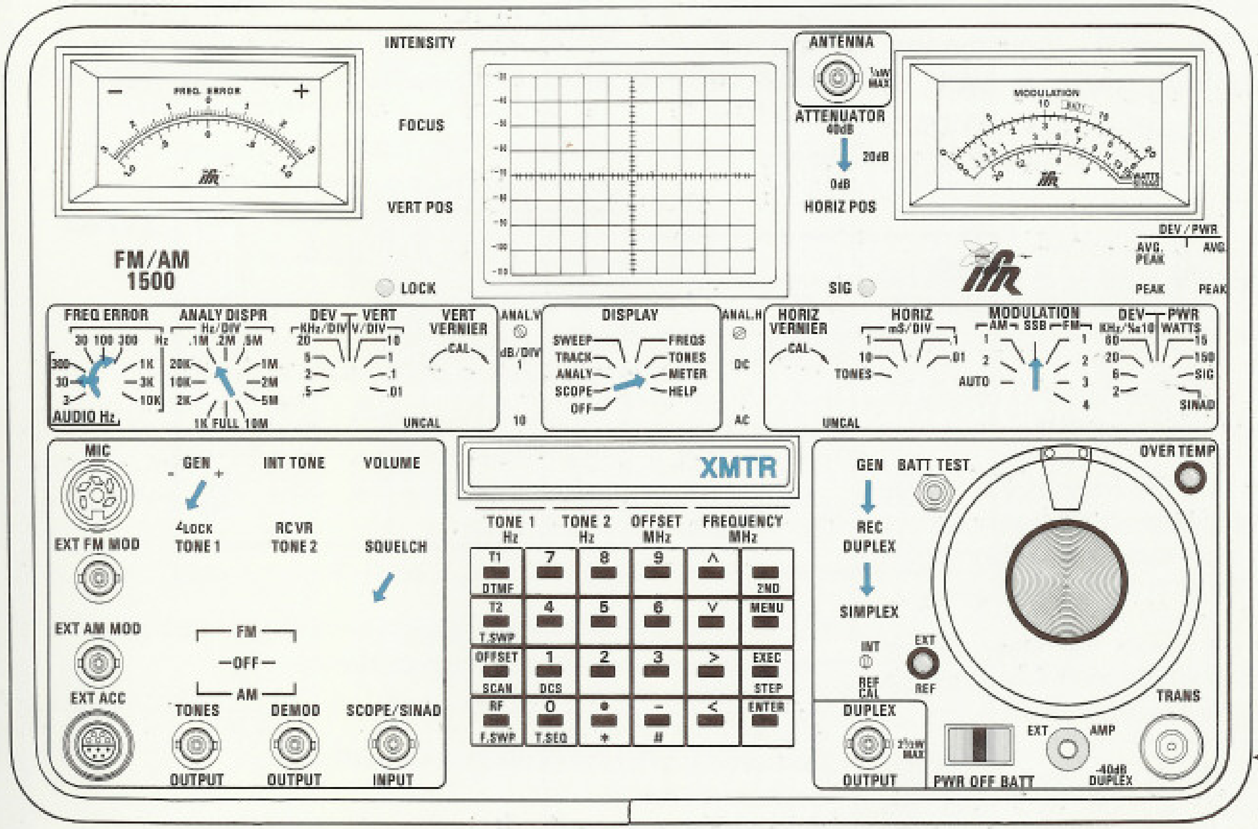
Suppose that you wanted to set a transmitter to a frequency that was not on an even hundred hertz step, say 155.500145. 145 Hz above 155.5.

Setting the 1500's **FREQUENCY MHz** will get you to 155.5001. With the **FREQ. ERROR** switch in the **100 Hz** position you can see the +45 Hz error on the meter.

Key in 45.0 Hz in **TONE 1** and switch the **FREQ. ERROR** switch to **300 Hz AUDIO**. Tweak the transmitter frequency to center the needle on the **FREQ. ERROR** meter. Switch down to the **3 Hz** position to center it within a tenth hertz.

IFR FM/AM-1500

Synchronizing Simulcast Transmitters



Transmitter "A"

Transmitter "B"

Measuring Antenna Isolation

With antenna site space a valuable commodity, multiple antennas in close proximity are a fact of life. Isolation between antennas becomes important to reduce the possibility of intermod interference.

To measure the isolation between antennas, one antenna is fed with the tracking generator (**TRANS** port) and the 1500's receiver / spectrum analyzer (**ANTENNA**) is connected to the other antenna.

The transmission loss versus frequency curve is then displayed directly on the analyzer.

For most UHF and low gain VHF antennas, one measurement is usually sufficient because the antenna selectivity doesn't affect the measurement appreciably. In the adjacent example, there was essentially no difference in the measurement curves because both antennas were cut the same.

When high gain/narrow band antennas are used, the measurement procedure should be done twice. Swap coax lines and re-measure the loss. The curves will be different due to the selectivity of each antenna.

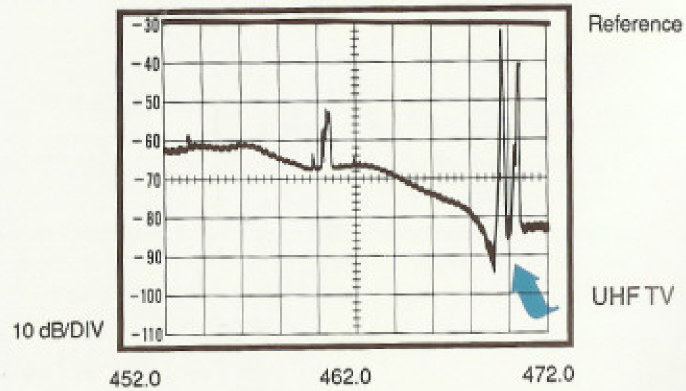
Check for possible front end overload levels before making this measurement by setting the **FREQUENCY** to **500 MHz** and the **ANALY DISPR** to **FULL**. Look for any signals that exceed the top of the display. If there are any, switch in the **20dB ATTENUATOR.**

Re-couple the connecting coax test cables to each other and increase the RF output to re-establish a "top of the screen" reference.

EXAMPLE

A single four stack collinear array was split into two 2 stack collinear UHF arrays, separated by about 10 feet vertically.

DOUBLE EXPOSURE PHOTO TO ILLUSTRATE REFERENCE



The 35-40 dB isolation between these two antennas proved to be marginal and created some intermod problems.

Control settings for the above measurements:

DISPLAY: TRACK

FREQUENCY: 462.0 MHz

ANALY DISPR: 2 MHz/DIV

DB/DIV: 10

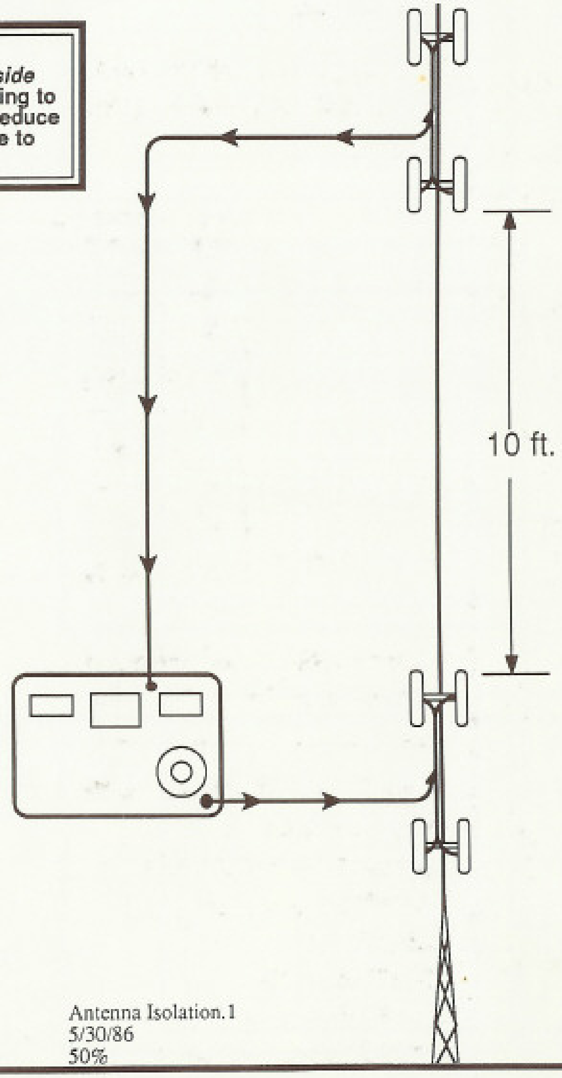
GEN/REC: GEN

ATTENUATOR: 0dB

RF OUTPUT:= -30 dBm

IFR FM/AM-1500

CAUTION:
Be sure to discharge *any outside* antenna coax before connecting to the 1500's ANTENNA port to reduce the possibilty of static damage to the front end.

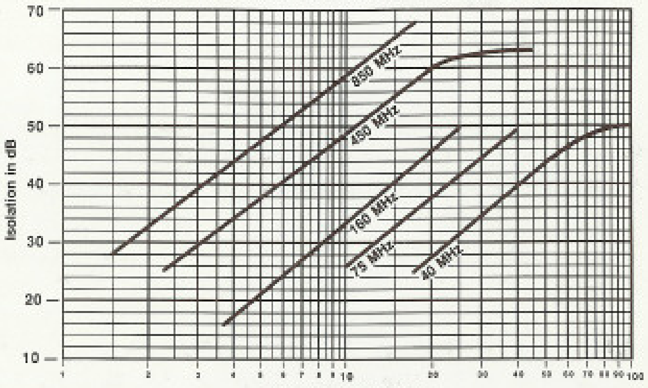


Antenna Isolation.1
5/30/86
50%

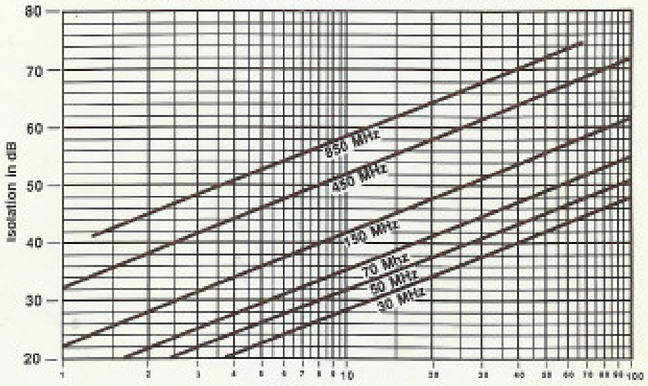
Measuring Antenna Isolation

APPROXIMATE ISOLATION PROVIDED BY ANTENNA SEPARATION

ATTENUATION PROVIDED BY VERTICAL SEPARATION OF DIPOLE ANTENNAS



ATTENUATION PROVIDED BY HORIZONTAL SEPARATION OF DIPOLE ANTENNAS



Tuning Antennas for Minimum VSWR

APPLICATION NOTE

Using a VSWR BRIDGE

A VSWR bridge[1] used with the tracking generator / spectrum analyzer can provide more useful antenna information than a directional wattmeter. The VSWR bridge method will tell you the frequency where resonance occurs. By knowing the resonant frequency, you'll know *which way* to tune it. You won't have to tell the boss, "I cut it off and cut it off and it's still too short."

NORMAL procedure

The bridge method is simple, just connect the bridge as shown leaving the DUT ("DEVICE UNDER TEST") port *open.* Raise the RF output to set the trace to the top line at the center of the screen for your REFERENCE. Connect the antenna to the DUT port and read the return loss at center screen. The deeper the dip, the more power is being absorbed. The width of the dip is determined by the bandwidth of the antenna. A "broadbanded" antenna will have more than one tuned element and will display more than one dip.

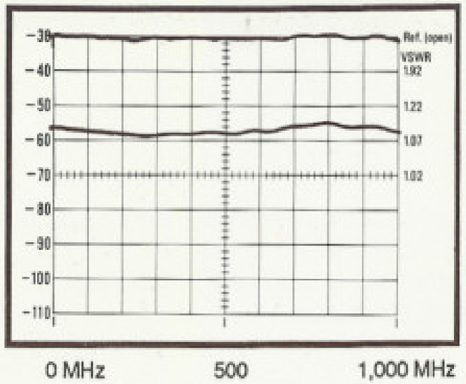
HIGH RESOLUTION procedure

The **10 dB/DIV** scale will show major antenna deficiencies. Definitive measurement of VSWR of less than 2 to1 is best accomplished by using the **1 dB/DIV** setting to increase the display resolution. The return loss is then read using the dB scale of the RF output dial.

Connect the bridge as shown leaving the DUT port open. Set the RF output to **-40dBm**. Bring the trace back to mid-screen with the **VERT POS** control, this becomes your REFERENCE POSITION . Connect the device being tested to the DUT port. Bring the trace back to the REFERENCE POSITION by increasing the RF level to compensate for the RETURN LOSS. Subtracting the ***new*** RF dial reading from the -40 dBm reference gives you the RETURN LOSS. Use the CONVERSION CHART to determine VSWR.

RETURN LOSS - VSWR - REFLECTED POWER
CONVERSION CHART

Return Loss dB	VSWR	Reflected Power %REFL	Return Loss dB	VSWR	Reflected Power %REFL
1.0	17.4	79.4	16.0	1.38	2.5
2.0	8.72	63.1	17.0	1.33	2.0
3.0	5.85	50.1	18.0	1.29	1.6
4.0	4.42	39.8	19.0	1.25	1.3
5.0	3.57	31.6	20.0	1.22	1.0
6.0	3.01	25.1	22.0	1.17	.6
7.0	2.61	20.0	24.0	1.13	.4
8.0	2.32	15.8	26.0	1.11	.3
9.0	2.10	12.6	28.0	1.08	.16
10.0	1.93	10.0	30.0	1.07	.10
11.0	1.78	7.9	32.0	1.05	.06
12.0	1.67	6.3	34.0	1.04	.04
13.0	1.58	5.0	36.0	1.03	.03
14.0	1.49	4.0	38.0	1.03	.02
15.0	1.43	3.2	40.0	1.02	.01



Reference = Bridge with open N to BNC adaptor.

Scope photos are double exposures to show both reference and unknown VSWR.

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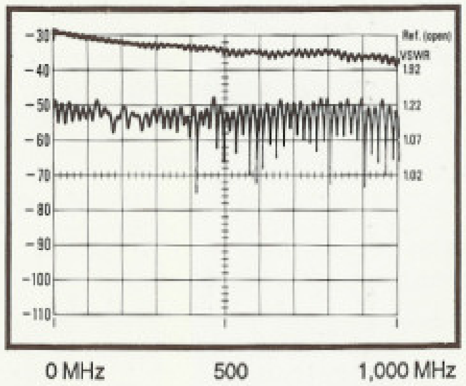
50 Ω BNC termination connected directly through N to BNC adaptor.

FREQUENCY = 500 MHz
ANALY DISP = FULL

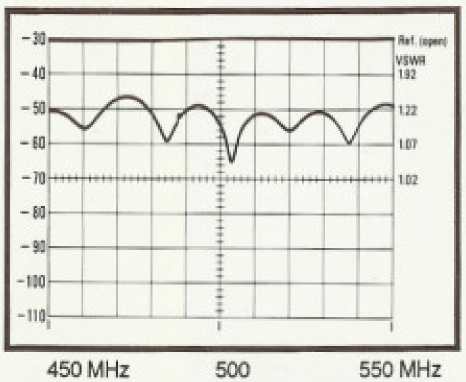


Reference = 17 ft. RG-58 with open BNC barrel.
Reference droop due to coax loss.

Same 50 Ω termination as above except it's on the end of 17 ft. of RG-58 coax.

Reflected power ripples, caused by summing of reflection vectors, must be averaged to approach accurate VSWR.

MORAL: Connect bridge DIRECT to antenna if possible.



Reference = 17 ft. RG-58 with open BNC barrel.
Reference droop due to coax loss.

Same 50 Ω termination at the end of 17 ft. of RG-58 coax.

ANALYzer **DIS**Persion set at **10 MHz / DIV.**

Dotted line indicates average of ripple.