



**YOU'RE HEARD, LOUD AND CLEAR.**

**Instruction Manual  
Vari-Notch® Duplexers (4" Cavities)**

**Manual Part Number**

**7-9176**



# **Warranty**

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***This warranty applies for one year from shipping date.***

**TX RX Systems Inc.** warrants its products to be free from defect in material and workmanship at the time of shipment. Our obligation under warranty is limited to replacement or repair, at our option, of any such products that shall have been defective at the time of manufacture. **TX RX Systems Inc.** reserves the right to replace with merchandise of equal performance although not identical in every way to that originally sold. **TX RX Systems Inc.** is not liable for damage caused by lightning or other natural disasters. No product will be accepted for repair or replacement without our prior written approval. The purchaser must prepay all shipping charges on returned products. **TX RX Systems Inc.** shall in no event be liable for consequential damages, installation costs or expense of any nature resulting from the purchase or use of products, whether or not they are used in accordance with instructions. This warranty is in lieu of all other warranties, either expressed or implied, including any implied warranty or merchantability of fitness. No representative is authorized to assume for **TX RX Systems Inc.** any other liability or warranty than set forth above in connection with our products or services.

## **TERMS AND CONDITIONS OF SALE**

### ***PRICES AND TERMS:***

Prices are FOB seller's plant in Angola, NY domestic packaging only, and are subject to change without notice. Federal, State and local sales or excise taxes are not included in prices. When Net 30 terms are applicable, payment is due within 30 days of invoice date. All orders are subject to a \$100.00 net minimum.

### ***QUOTATIONS:***

Only written quotations are valid.

### ***ACCEPTANCE OF ORDERS:***

Acceptance of orders is valid only when so acknowledged in writing by the seller.

### ***SHIPPING:***

Unless otherwise agreed at the time the order is placed, seller reserves the right to make partial shipments for which payment shall be made in accordance with seller's stated terms. Shipments are made with transportation charges collect unless otherwise specified by the buyer. Seller's best judgement will be used in routing, except that buyer's routing is used where practicable. The seller is not responsible for selection of most economical or timeliest routing.

### ***CLAIMS:***

All claims for damage or loss in transit must be made promptly by the buyer against the carrier. All claims for shortages must be made within 30 days after date of shipment of material from the seller's plant.

### ***SPECIFICATION CHANGES OR MODIFICATIONS:***

All designs and specifications of seller's products are subject to change without notice provided the changes or modifications do not affect performance.

### ***RETURN MATERIAL:***

Product or material may be returned for credit only after written authorization from the seller, as to which seller shall have sole discretion. In the event of such authorization, credit given shall not exceed 80 percent of the original purchase. In no case will Seller authorize return of material more than 90 days after shipment from Seller's plant. Credit for returned material is issued by the Seller only to the original purchaser.

### ***ORDER CANCELLATION OR ALTERATION:***

Cancellation or alteration of acknowledged orders by the buyer will be accepted only on terms that protect the seller against loss.

### ***NON WARRANTY REPAIRS AND RETURN WORK:***

Consult seller's plant for pricing. Buyer must prepay all transportation charges to seller's plant. Standard shipping policy set forth above shall apply with respect to return shipment from TX RX Systems Inc. to buyer.

## **DISCLAIMER**

Product part numbering in photographs and drawings is accurate at time of printing. Part number labels on TX RX products supersede part numbers given within this manual. Information is subject to change without notice.

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1	09/19/97
2	04/09/98
3	04/26/99
4	06/23/04

### ***Symbols Commonly Used***

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**WARNING**



**ESD Electrostatic Discharge**



**CAUTION or ATTENTION**



**Hot Surface**



**High Voltage**



**Electrical Shock Hazard**



**Use Safety Glasses**



**Important Information**

## GENERAL DESCRIPTION

Vari-Notch® duplexers are used to provide simultaneous operation of a transmitter and receiver (or two transmitters) which are at different frequencies while connected to a common antenna. These duplexers are frequently used in radio repeater systems. This instruction manual (part# 7-9176-1) covers the installation, tuning, and maintenance of Vari-Notch duplexers constructed from 4" diameter cavities. **Table 1** shows the model numbers and electrical specifications of the duplexers covered by this manual. Vari-Notch duplexers are composed of two groups (or sets) of daisy-chained resonant cavity filters, which couple signals to and from the shared antenna. This creates two signal paths, a

high frequency channel and a low frequency channel. The minimum frequency separation between the channels, as well as the isolation in dB's (per channel and between channels) is listed for each model in table 1.

The cavity filters used in a transmit channel will reduce transmitter noise components at the receive frequency, thus preventing noise desensitization of the receiver. Conversely, the cavity filters used in a receive channel will isolate the receiver from the transmitter carrier preventing carrier desensitization of the receiver.

Model Number	Frequency Range (MHz)	Power Rating (Watts)	Min. Freq. Separation (MHz)	Insertion Loss (dB)	Isolation (dB)	
					Per Chan.	Bet Chan
28-38-03A/D	132 - 174	150	0.5	1.9	80	45
28-37-07A/C	144 - 174	400	3	0.7	85	30
28-37-06A/C	144 - 174	125	1	1.2	75	35
28-37-04A/C	144 - 174	125	0.5	1.8	65	30
28-37-81227-A-R2	144 - 174	125	0.5	2	65	30
28-52-02A	215 - 250	250	1.6	1.2	90	55
28-56C-02A	380 - 420	250	5	0.7	100	50
28-65-07A/B	406 - 430	250	3	1.25	85	60
28-65-02A/B	406 - 430	350	3	0.8	80	30
28-66-02A/B	442 - 450	350	5	0.6	100	46
28-70-09A/B	450 - 470	250	5	1.25	100	70
28-70-02A/B	450 - 470	350	5	0.6	100	46
28-69-06A/B	470 - 512	250	3	1.25	86	60
28-69-02A/B	470 - 512	350	3	0.8	80	30
28-89-01A/B	806 - 866	125	45	0.8	90	60
28-88-04A/B	890 - 960	125	39	0.8	90	50
28-88-01A/B	890 - 960	125	3.6	1.25	90	40
28-97-01A/B	1215 - 1300	125	12	1	100	50

**Table 1:** Vari-Notch Duplexer electrical specifications.

Resonant cavity filters are the basic building blocks of the system. Also important, are the interconnect cables between each filter which have cut length's equivalent to either  $1/4 \lambda$  or  $3/4 \lambda$  of that channels pass frequency. The exception is the antenna cable that couples each channels final filter to the antenna port, which is cut to  $1/2 \lambda$  of the other (or remaining) channels pass frequency. This effectively places a relatively large impedance in parallel with the antenna, insuring a good impedance match between the other (or remaining) channel and the antenna. This technique of impedance matching allows both channels to be connected to the same antenna with very little loss due to mismatching. The antenna cables are permanently soldered and crimped to the antenna junction. The combination of the antenna junction and the attached antenna cables is referred to as an "Antenna Junction Assembly".

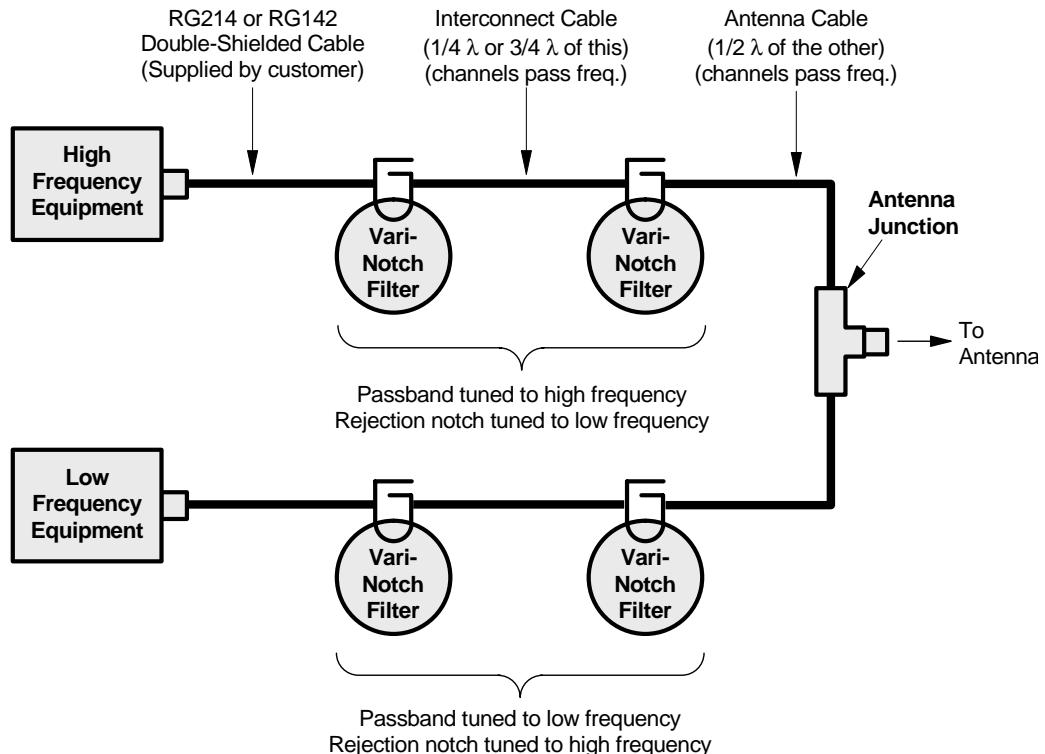
**Figure 1** shows the functional block diagram of a typical four-cavity Vari-Notch duplexer system. Six and eight cavity systems are similar except for the

extra filters in each channel. The photograph shown in **Figure 2** is the front view of a typical four-cavity Vari-Notch duplexer. Each of the physical components in the system is labeled with the field adjustable parts shown in emboldened italics.

## UNPACKING

Care should be used when removing the duplexer from its shipping container to avoid unnecessary damage. It is important to visually inspect the duplexer for any shipping damage as soon as possible after taking delivery. *It is the customers responsibility to file any necessary damage claims with the carrier.*

Vari-Notch duplexers are rugged devices but may become detuned if jostled or dented during shipping. The most easily damaged parts of the duplexer are the tuning rods. These rods are marked where they exit from the locking nut with a dab of red varnish or other color/type of paint. If this seal appears to be broken it may indicate that the system has been detuned in transit.



## TYPICAL FOUR CAVITY VARI-NOTCH FILTER

**Figure 1:** Block diagram of typical four-cavity Vari-Notch Duplexers.

## INSTALLATION

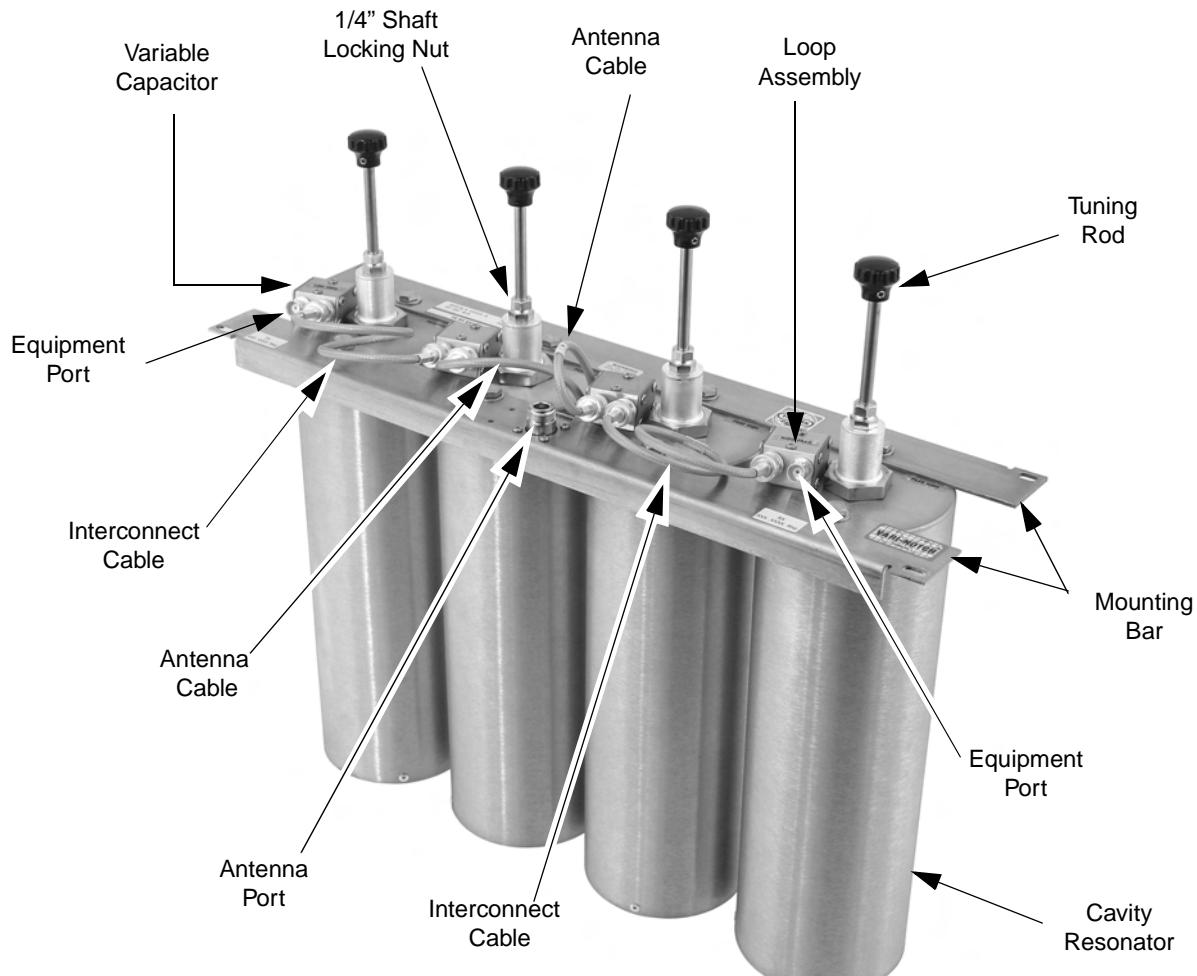
Vari-Notch duplexers should be securely installed in a dry, vibration-free environment. Attachment of the cavity shells to a ground bus is recommended in order to maximize lightning protection. A lightning protection device placed in the antenna feedline, preceding the duplexer, is recommended. High quality double shielded coaxial cable terminated with quality connectors (N-type) are recommended for connecting the transmitter and receiver to the duplexer and are available from TX RX Systems Inc. It is also important to observe the power handling ratings of cables in transmit systems.

Mount the duplexer in its permanent operating position using suitable hardware. Connect the two transmitters (or transmitter/receiver) and the antenna feedline to the duplexer making sure to

connect the correct equipment to the correct port. Labels are affixed next to each port (port labels) to help you make the right connections. In addition, a specification tag will be found in a plastic bag attached to one of the tuning rods. The frequency that each cavity group is tuned to will appear on either the port labels or the specification tag. The duplexer is now ready for normal operation. No tuning is required if the frequencies (high frequency and low frequency) found on the port labels/specification tag matches the actual operating frequencies.

## MAINTENANCE

No special maintenance is required. Vari-Notch duplexers are passive devices of rugged electrical and mechanical design. They are tuned at the factory for the original design requirements and



**Figure 2:** Typical four-cavity Vari-Notch Duplexer.

require no further adjustment or maintenance. These devices will stay properly tuned unless they have been physically damaged or are tampered with. Check for loose or corroded connectors on the interconnect cables whenever an inspection is performed on other station equipment.

Because duplexers are passive devices, field repairs are rarely required. Field repair of duplexers is limited to the replacement or repair of damaged cables. Cavity damage, when it occurs, is usually due to catastrophic failure from lightning or power far in excess of the duplexers rating. If cavity problems are suspected, the unit should be returned to the factory for repair. Due to the critical alignment of parts inside of the cavity resonators, field repair is not recommended.

### TUNING

Vari-Notch duplexers are originally pre-tuned at the factory to the customers specification. To retune the duplexer, each resonant cavity must be separated from the group and adjusted individually. Then the individual cavities are re-connected and each channel is fine tuned to peak its overall response. When reconnecting the assembly, it is mandatory that each filter and cable be replaced in its original position.

There are two adjustable parameters in a Vari-Notch filter; the *pass frequency* and the *rejection notch*. Adjustment of the tuning rod will allow the filters passband to be centered at the desired frequency. The rejection notch frequency is adjusted by turning the variable capacitor located on the loop assembly.

The insertion loss of each cavity is determined by the design of the loop assembly and is not field adjustable. **The loop assembly on a 4" resonant cavity should never be loosened or moved** from its factory preset position.

It is also important to note that the insertion loss specification in table 1 for each of the different models, is the total insertion loss for each channel of that model. For instance, the specification for model 28-38-03A/D is 1.9 dB, this means both the high and low frequency channels will each have a total of 1.9 dB of insertion loss. The total insertion loss is the sum of losses from each cavity in the channel as well as the interconnecting cables between the cavities.

### Required Equipment

Due to the sensitivity of the adjustments, it is strongly recommended that the proper equipment be used when tuning the individual filters, otherwise the filter should be sent to the factory or an authorized representative for retuning. The following equipment or its equivalent is recommended in order to properly perform the tuning adjustments for the Vari-Notch duplexer.

1. IFR A-7550 spectrum analyzer with optional tracking generator installed.
2. Return Loss Bridge (Eagle model RLB150N3A).
3. Double shielded coaxial cable test leads (RG142 B/U or RG223/U).
4. 50 ohm load with at least -35 dB return loss (1.10:1 VSWR). The JFW Industries model 50T-007 or equivalent.
5. Female union (UG29-N or UG914-BNC).
6. Insulated tuning tool (TX RX Systems Inc. part# 95-00-01)
7. 1/4" open-ended wrench.

### Tuning Procedure

Tuning of the filter requires adjustment of the *passband* and the *rejection notch*. The passband is adjusted while observing the return loss response and the rejection notch is adjusted by monitoring the output of a tracking generator, after it passes through the filter.

All Vari-Notch filters should be temporarily removed from the system and tuned on the bench using test instrumentation only. Do not adjust the filters while they are under transmit power. To insure proper tuning of the 4" Vari-Notch filter, all adjustments should be performed in the following order:

1. Rough tune the passband.
2. Rough tune the rejection notch.
3. Final tune the passband.
4. Final tune the rejection notch, always the last adjustment made.



## WARNING

Tuning while under transmit power can result in damage to the duplexer.

### PASSBAND

The peak of the passband will correspond very closely to the point of minimum reflected energy from the filter and maximum forward power through it. A transmitter connected to the filter will operate best when the reflected energy is lowest, therefore the return loss response will be used to set the passband. The passband can be checked and adjusted using the following procedure.

### Checking the passband

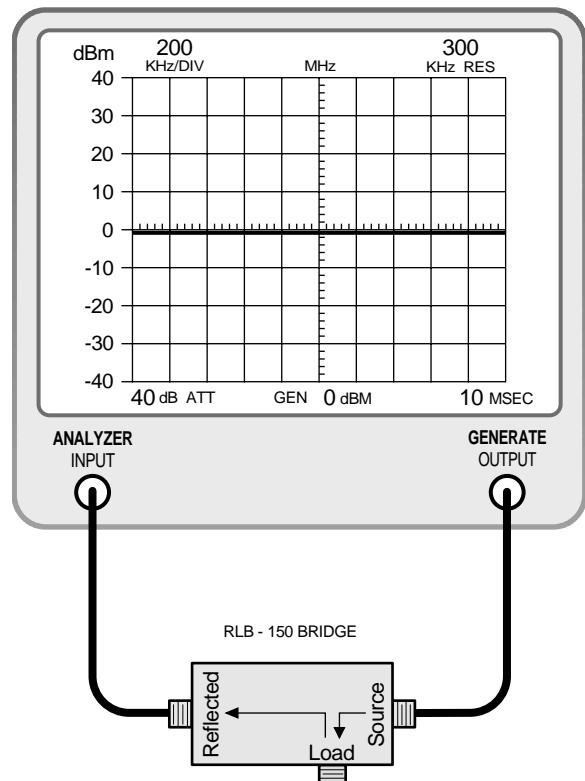
1. A zero reference for return loss must be established at the IFR A-7550 prior to checking the passband frequency, this is done by connecting the return loss bridge to the analyzer / generator as shown in **Figure 3**.
2. Set-up the analyzer / generator for the desired frequency (center of display) and for a vertical scale of 10 dB/div.
3. Do not connect the return loss bridge (RLB) to the cavity, leave the "load" port on the bridge open. This will supply the maximum amount of reflected energy to the analyzer input.
4. Insure that the IFR A-7550 menu's are set as follows:  
DISPLAY - line  
MODE - live  
FILTER - none  
SETUP - 50 ohm/dBm/gen1.
5. The flat line across the screen is the return loss curve. Select the "MODE" main menu item and then choose the "STORE" command.
6. Next select the "DISPLAY" main menu item and choose the "REFERENCE" command. This will cause the stored value to be displayed at the center of the screen as the 0 dB reference value.

7. Connect the "load" port on the RLB to the input of the loop assembly, make sure the output of the loop assembly is connected to a 50 ohm load, refer to figure 4. The display will now present the return loss curve for the 4" Vari-Notch filter being measured. **The passband is that frequency range over which the return loss is 15 dB or greater.**

### Adjusting the Passband

Adjust the passband by setting the peak (maximum negative value) of the return loss curve at the desired passband frequency (should be the center-vertical graticule line on the IFR A-7550's display). Refer to **Figure 4**.

The resonant frequency is adjusted by using the tuning rod, which is a sliding adjustment (invar rod) that rapidly tunes the response curve across the frequency range of the filter. Resonant frequency is increased by pulling the rod out of the cavity and is decreased by pushing the rod into the cavity. For ease in making adjustments, rotate and slide the rod while gently tapping on it with a screwdriver



**Figure 3:** Setting the return loss reference.

handle or other small tool. This will break the surface tension on the probe contact fingers and allow smoother movement of the tuning rod.

### Cavity Tuning Tip

When tuning a cavity that has been in service for some time it is not unusual to find the tuning rod hard to move in or out. This occurs because TX RX Systems Inc. uses construction techniques borrowed from microwave technology that provide

large area contact surfaces on our tuning probes. These silver plated surfaces will actually form pressure welds which maintain excellent conductivity. The pressure weld develops over time and must be broken in order for the tuning rod to move. This is easily accomplished by gently tapping the tuning rod with a plastic screwdriver handle or small hammer so it moves into the cavity. The pressure weld will be broken with no damage to the cavity.

Once the desired response is obtained using the tuning rod, it is "locked" into place by tightening the 1/4" shaft lock nut. **Failure to lock the tuning rod** will cause a loss of temperature compensation and detuning of the cavity.

### REJECTION NOTCH

The rejection notch will track with the tuning of the passband and therefore should be the last adjustment made to the 4" Vari-Notch filter. The rejection notch is adjusted by changing the amount of capacitance in the loop assembly. The capacitor is a variable tubular-piston type.

### Checking the rejection notch

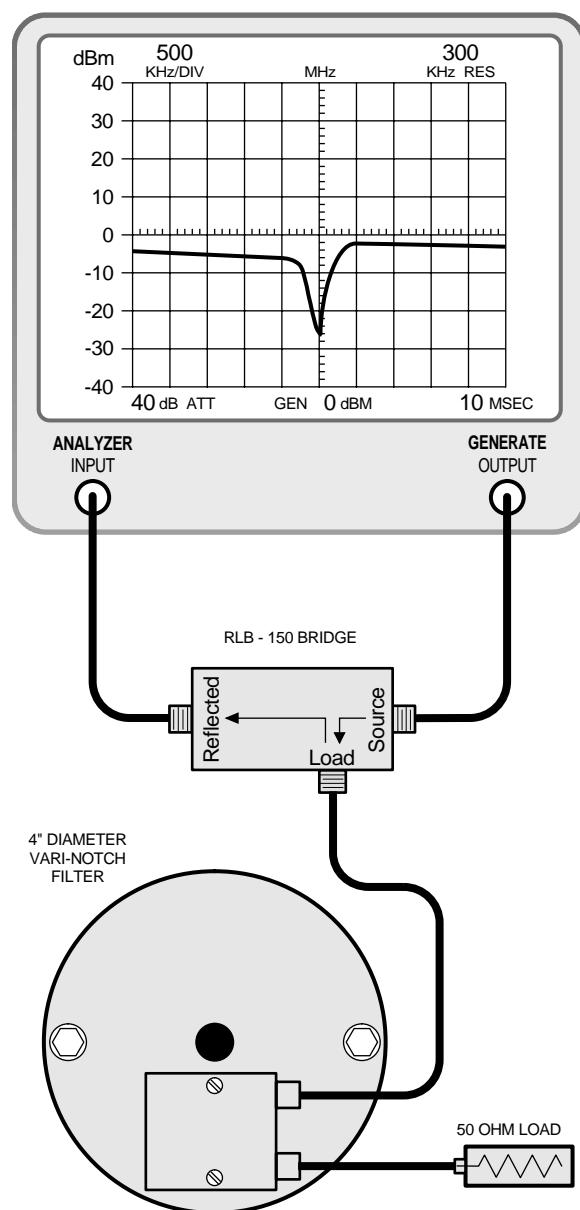
1. The rejection notch is checked by connecting the tracking generator to the input of the cavity filter while the spectrum analyzer is connected to the output, as illustrated in **Figure 5**.
2. Insure that the IFR A-7550 menu's are set as follows:  
 DISPLAY - line  
 MODE - live  
 FILTER - none  
 SETUP - 50 ohm/dBm/gen1.

### Adjusting the rejection notch

The notch is adjusted by turning the variable capacitor. Because of the filters sensitivity to tool contact, an insulated tuning tool must be used to make the adjustment. Access to the capacitor is obtained by removing the small screw or rubber button on the side of the loop assembly.

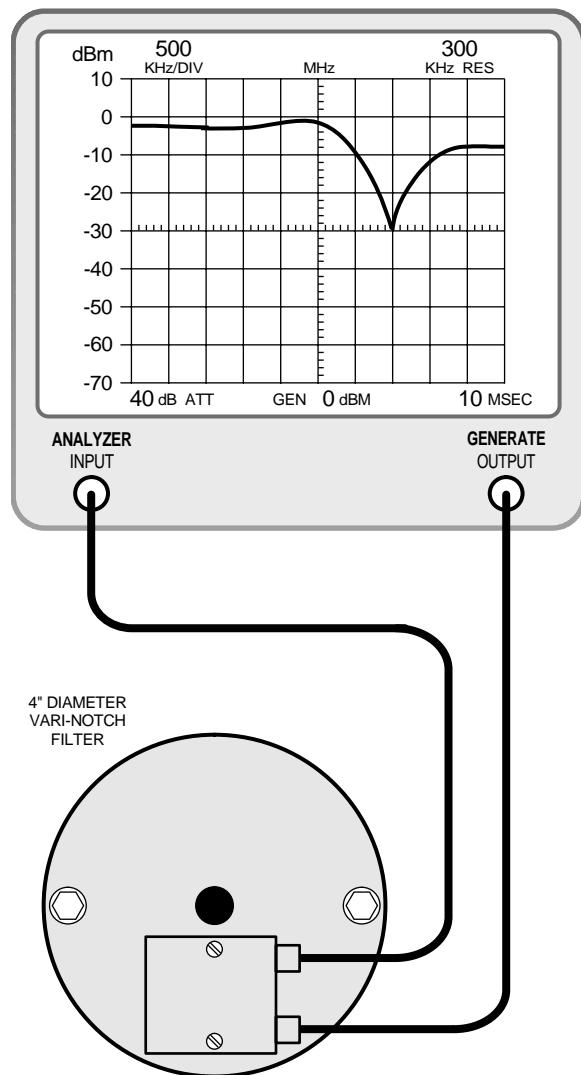
### FINE TUNING THE CHANNELS

Once all of the individual filters have been tuned, each of the channels as a whole must be fine tuned. First the passband for both channels and then the rejection notches. The following is a step by step procedure for fine tuning the channels and completes the re-tuning of the duplexer.



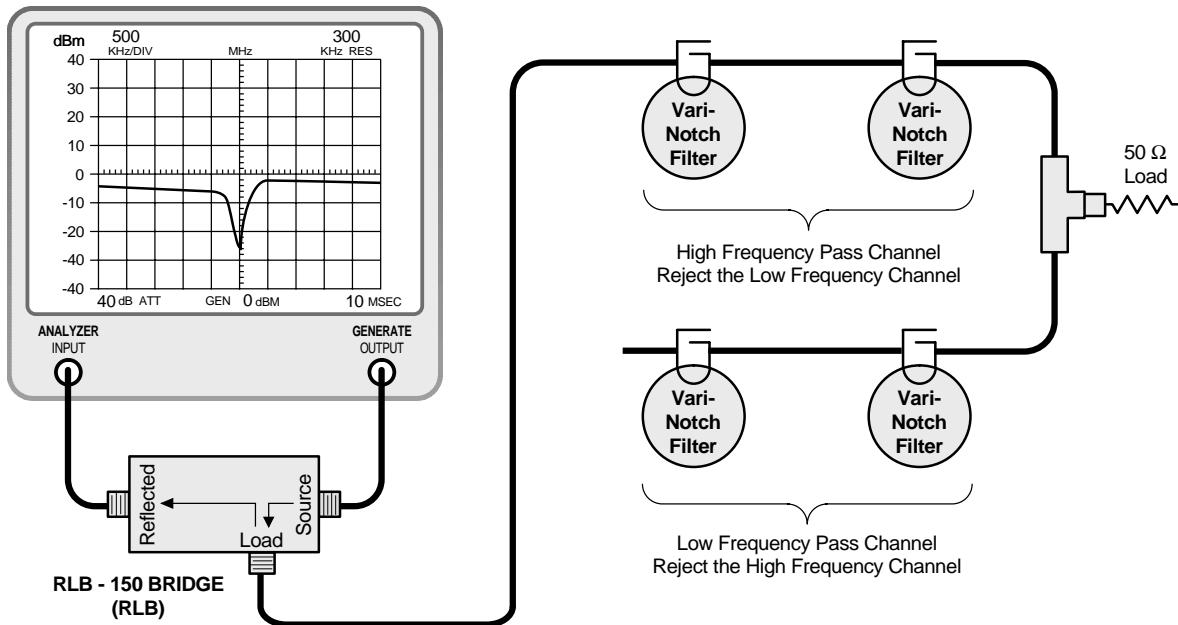
**Figure 4:** Checking the passband.

1. Reassemble the duplexer by reinstalling the cavities and interconnect cables in their original locations.
2. The *passband* for the channels are fine tuned first, in a manner very similar to tuning a single cavity.
3. A zero reference for return loss must be established at the IFR-7550. Connect the RLB to the analyzer / generator as shown in figure 3.



**Figure 5:** Checking the rejection notch.

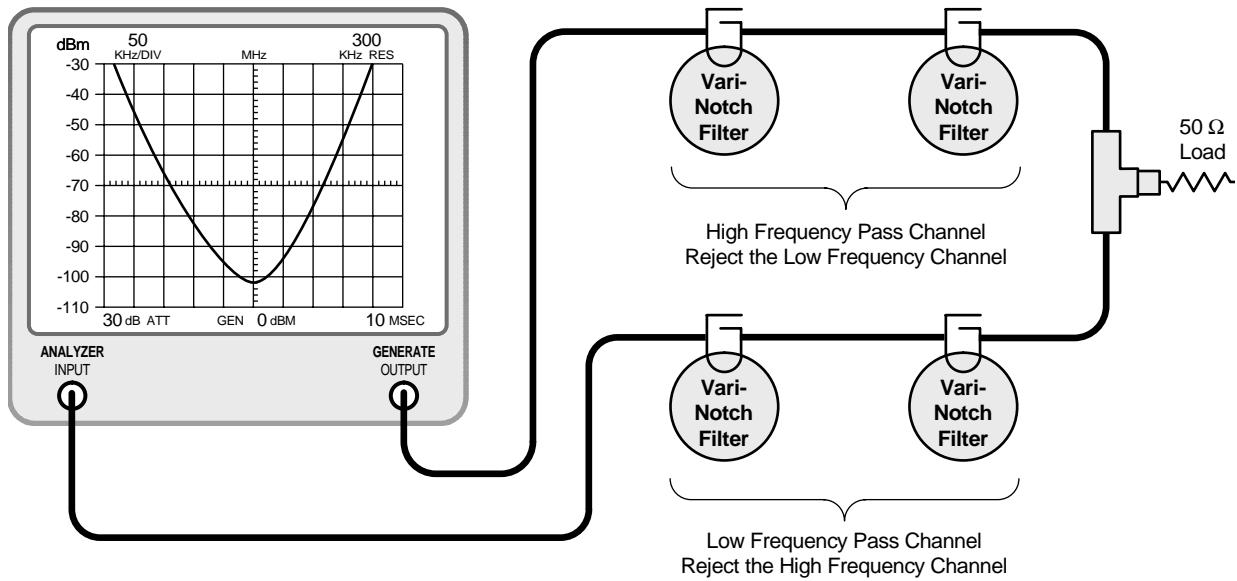
4. Set-up the analyzer / generator to the desired frequency (center of display) and for a vertical scale of 10 dB/div.
5. Do not connect the RLB to the duplexer at this time, leave the "load" port on the bridge open. This will supply the maximum amount of reflected energy to the analyzer input.
6. Insure that the IFR A-7550 menu's are set as follows:  
DISPLAY - line  
MODE - live  
FILTER - none  
SETUP - 50 ohm/dBm/gen1.
7. The flat line across the screen is the return loss curve. Select the "MODE" main menu item and then choose the "STORE" command.
8. Next select the "DISPLAY" main menu item and choose the "REFERENCE" command. This will cause the stored value to be displayed at the center of the screen as the 0 dB reference value.
9. Connect the "load" port on the RLB to the equipment port of the channel to be fine tuned. Terminate the duplexers antenna connector with the 50 ohm load. The equipment port of the remaining duplexer channel is left disconnected, refer to **Figure 6**.
10. The display will now present the combined return loss curve for all of the cavities in the channel. The channels passband is that frequency range over which the return loss is 15 dB or greater.
11. Fine tune the passband (for maximum return loss) for the entire channel by gently adjusting the positions of the tuning rods, moving between cavities as required. Once the desired response is obtained "lock" the tuning rods into place by tightening the 1/4" shaft lock nuts on each filter.
12. Move the cable from the RLB's "load" port to the equipment port of the other channel. This will allow the remaining duplexer channel to be fine tuned. Reset the analyzer / generator center frequency. Repeat steps 10 and 11.



**Figure 6:** Equipment setup for fine tuning the passband of each channel.

13. The *rejection notch* for each of the channels must be fine tuned next.
14. Terminate the antenna connector with a 50 ohm load. Connect the output of the tracking generator to the equipment port of one of the duplexer channels and the spectrum analyzer input to the equipment port of the remaining channel as shown in **Figure 7**.
15. Set-up the analyzer / generator to sweep across the rejection notch frequency of the channel being tuned. The center of the display should be set to the desired center frequency of the rejection notch being adjusted. Set the vertical scale of the analyzer / generator to 10 dB/div.
- Keep in mind that the high frequency channel has its rejection notch set to reject the low frequency signal and vice-versa for the rejection notch of the low frequency channel.
16. Insure that the IFR A-7550 menu's are set as follows:  
DISPLAY - line
- MODE - live  
FILTER - none  
SETUP - 50 ohm/dBm/gen1
17. Set the analyzer's attenuation control so that the "peak" or lowest value on the rejection notch is displayed. The "peak" should be around -100 dB depending upon which model of duplexer you are tuning.
18. The cavities rejection notches are adjusted (for maximum rejection) by gently turning the variable capacitors in the loop assemblies. Move between filters as needed.  
Because of the filters sensitivity to tool contact, an insulated tuning tool must be used to make the adjustment. Access to the capacitors is obtained by removing the small screw or rubber button on the side of the loop assemblies.
19. Adjust the rejection notch of the remaining cavities by changing the sweep frequency of the analyzer / generator to match the new rejection notch frequency. The equipment stays connected as it is.

20. Repeat step 17 and 18 for the remaining channel (cables and equipment stay connected where they are). Remember to replace the small screws or rubber buttons on the side of the loop assemblies.
21. With the tuning completed, reconnect the equipment cables and antenna feedline. Test the system for proper operation.



**Figure 7:** Equipment setup for fine tuning the rejection notch of each channel.

## DUPLEXER PROBLEMS AND REMEDIES

Duplexers are passive devices requiring little or no service once installed in a system. The proper design and application of a given Duplexer will give years of trouble free service. When problems do occur in a duplex system it is necessary to identify as many abnormal conditions as possible to zero in on the specific cause of the problem. Unfortunately, there are only a few measurable or observable performance indicators at the disposal of the field serviceman, and any number of conditions may exist, even simultaneously, which are responsible for the observed phenomena. Most Duplexer installation problems fall into three categories. Each of these three conditions will be treated separately, using the typical cause and remedy approach.

- A. High input VSWR**
- B. Excessive loss**
- C. Desensitization of the receiver**

PROBLEM			POTENTIAL CAUSE
A	B	C	The number at right corresponds to the appropriate numbered remedy paragraph
•	•		Reverse labeling of Tx and Rx terminals. 1
•	•		Unit tuned to wrong frequencies. 2
•			Bad antenna or interconnect cables. 3
•	•		Use of between series adapter, especially UHF types. 4
•	•	•	Duplexer detuned in shipment. 5
•	•		Water has entered the Duplexer antenna connector from the antenna feed line. 6
•	•		Spurious Tx output is being reflected by the selective Duplexer input terminal and observed on the wattmeter, the wattmeter being unable to discriminate between on-frequency and off-frequency energy. 7
		•	Bad joint in a cable or antenna system beyond the antenna of the Duplexer. All lines may show zero reflected power, but noise can still be produced when a corroded or indefinite metal-to-metal contact is exposed to RF energy. When this occurs beyond the Duplexer, it cannot be filtered out, and the noise backs up into the receiver. 8
		•	Adverse cable length between Duplexer and transmitter using varactor or broadband hybrid combining type transmitter outputs. Even though the Duplexer VSWR is flat on frequency, the reflected impedance of the Duplexer off resonance, transformed by changing cable lengths, can cause parasitics to be generated. 9
		•	Duplexer transmitter mixing with another outside transmitter, producing intermodulation on or near the receiver frequency. 10
		•	Transmitter cable leading to Duplexer in close proximity to Duplexer antenna or receiver cable. This is usually only a problem on close separation Duplexers, (1.0 MHz or less) where the 85 to 100 dB isolation is decreased by adverse coupling, created by running these cables too close together for too great a distance. 11
		•	Inadequate shielding of transmitter and receiver modules in the repeater. 12
		•	Insufficient duplex isolation for the application. 12
		•	A spurious transmitter response outside of the normal Duplexer isolation band or inadequacy of notch filter type Duplexers to suppress a wide enough band of Tx noise to protect the receiver. 14
		•	Impedance change in antenna due to icing. VSWR increase may be sufficient to reflect back through the Duplexer and upset transmitter tuning, causing parasitics, which are not suppressed by the Duplexer. 15
		•	The addition of a broadband power amplifier to a low power transmitter. The noise floor of the low power radio is raised by an amount equal to the gain of the power amplifier, and in addition, the power amplifier will contribute its own noise. Power amplifiers are just as prone to the generation of parasitics as transmitters, and may be triggered by an adverse cable length between power amplifier and Duplexer, a problem covered above. 16
		•	Excessive loss with changing temperature and apparent Duplexer detuning. 17

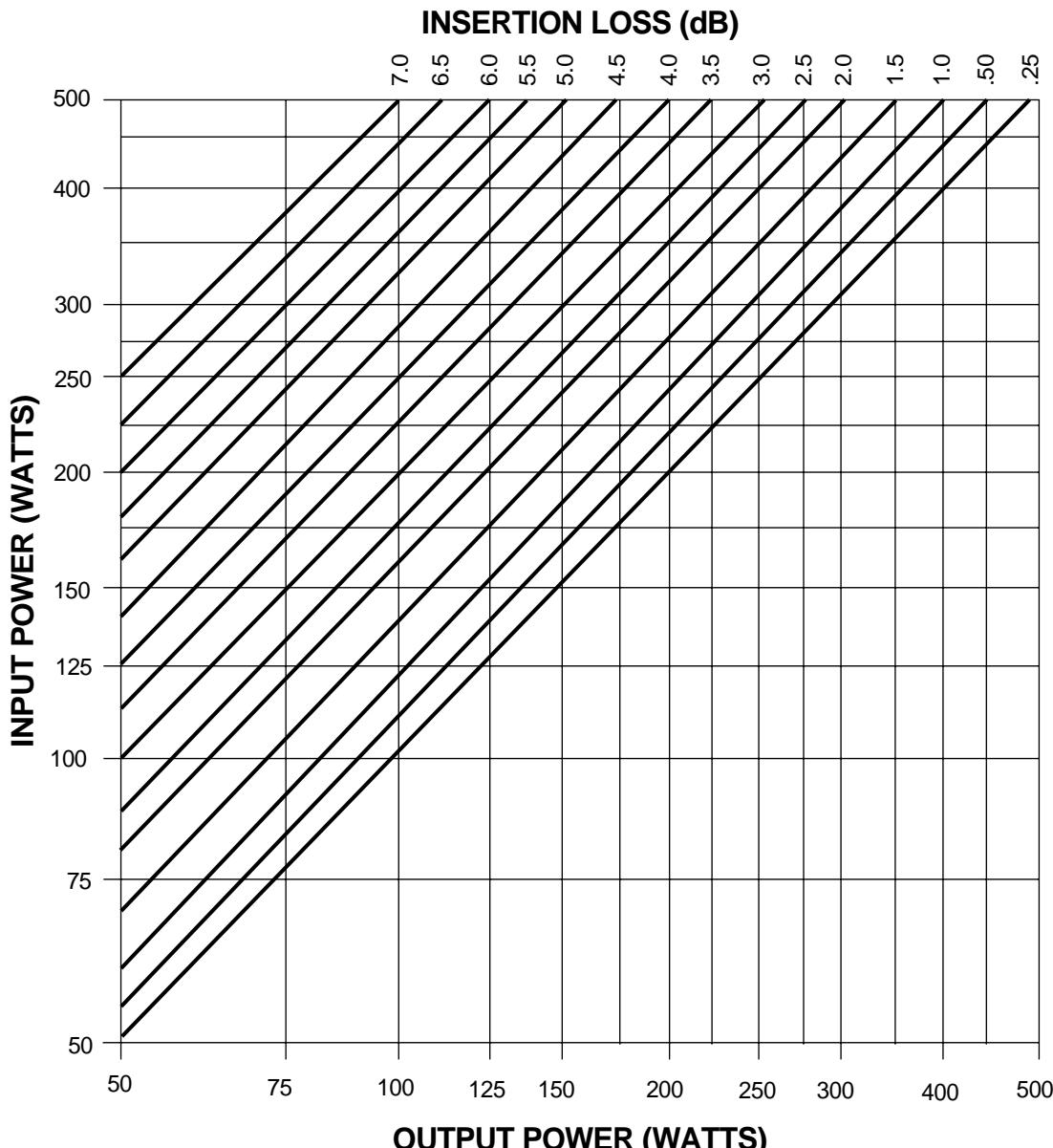
## REMEDIES

1. Tune a signal generator to the receive frequency and inject it into the antenna terminal, sampling for the signal at each equipment terminal. Reverse the labels if necessary. It may be that the unit was ordered to the reverse frequencies. If so, the label will indicate this. If the duplexer is symmetrical in design (usually indicated by the same number of Tx and Rx sections) just reverse the equipment labels and operate. Generally, no damage will be done to the duplexer when operated in reverse for a short period. If other adverse symptoms appear, contact the factory.

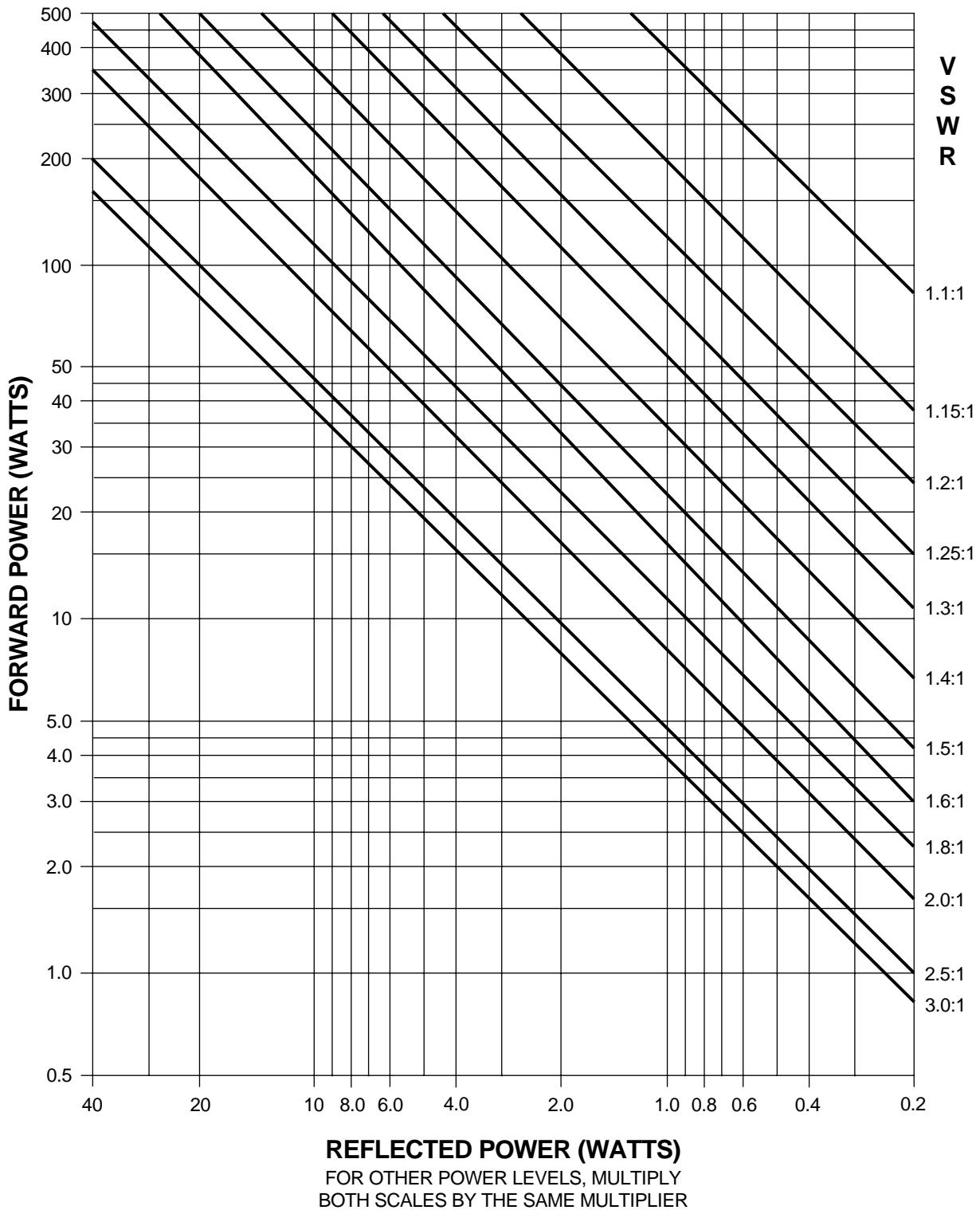
2. Check the unit label. If needed, the duplexer may be field tuned. Consult the instructions and/or the factory if the duplexer is still under warranty or beyond field tuning capability.
3. Check cable, by substitution, using a terminaline wattmeter, or a thruline wattmeter into a known good load. Check the antenna line input for reflected power.
4. To eliminate high input VSWR reduce the number of between series adapters by making up proper interconnect cables. UHF connectors are non-constant impedance, and certain combinations can transform a 1.1:1 VSWR into a 2.0:1, or vice versa.
5. Consult the instruction manual for field tuning procedures, or the factory, if the unit is still under warranty or beyond field tuning capability. (We trust that our products will not be prone to this problem).
6. Consult the factory. The affected antenna cables may be field replaceable, or a "baking out" process may be possible.
7. To prove this condition, place a bandpass filter between the Tx and duplexer to clean up the spurious, and put the wattmeter between the bandpass filter and the duplexer to measure reflected power from the duplexer. The bandpass filter selectivity should be equal to or better than that of the duplexer at about the 3.0 dB points.
8. Operate the duplex system into a dummy load. If no desensitization occurs, check out all line, antennas, and look for potential bad joints close to the radiation antenna where re-radiation of noise may be possible back into the antenna system receiver. Loose metal-to-metal contacts on tower guying systems have also been known to create system noise. Note the effect of vibrating tower guys on system noise.
9. Change the length of cable between the transmitter and duplexer, traversing through half wave in increments of between 1 and 2 inches until the desensitization ceases or is minimal. A ferrite isolator will also cure this condition when it is installed between the transmitter and duplexer. However, this is a much more expensive remedy.
10. If the IM is in the duplex transmitter, a ferrite isolator in the duplex transmitter line (NOT antenna line) will show this by either reducing or eliminating it. More isolation can be obtained by cascading isolators if needed. However, IM of this magnitude indicates the system should be studied for possible revision to reduce the production of the IM.
11. Cables such as RG-8a/u and RG-213/u should be kept at least 3 - 4" apart over 5"-6" runs. Use of double shielded cable will reduce the susceptibility to this problem.
12. Consult the radio manufacturer. This condition can be verified by operating the transmitter into a dummy load while injecting a minimum quieting signal into the receiver. Some radios require special modifications before they are suitable for repeater operation.
13. If this problem is suspected, contact the radio manufacturer for recommended duplex isolation for Tx noise suppression and carrier suppression. Duplexer isolation should be measured first per instruction manual to verify rated specifications are present. If more duplex isolation is required, contact TX RX SYSTEMS for recommended filtering.
14. Consult the factory. Bandpass filter tests can be made to confirm this. In extreme cases, adjustments to the transmitter may be required.
15. Either de-ice the antenna, or use an antenna less sensitive to ice. A ferrite isolator can also be put at the transmitter output to improve the impedance match. Ferrite isolators cannot be put in antenna lines, as they will attenuate Rx signals.
16. A mismatch may possibly be reduced by lengthening the cable which runs between the power amplifier output and the duplexer input until the receiver desensitization disappears, as follows:  
**30 MHz to 512 MHz RANGE;** BNC or N type adapters may be inserted in the original cable, one at a time and not to exceed a total of 1/2 wavelength, until desensitization disappears.  
**800 MHz to 1.3 GHz RANGE;** Prepare a cable length 3/4" longer than the original cable and insert. If desensitization does not disappear, repeat with cables each 3/4" longer than the previous length, not to exceed 1/2 wavelength.
17. We find that this cause most commonly relates to shifting impedance of the transmitter or power amplifier with temperature. The duplexer appears detuned, since a "conjugate match" (canceling reactance, and matching resistance component) is approached by shifting the duplexer passband above or below the 50 ohm point, as determined by an increase in output power on the wattmeter. In this case, temperature control of the room is the only answer, other than upgrading the transmitter.

## **POWER IN/OUT VS. INSERTION LOSS**

The graph below offers a convenient means of determining the insertion loss of filters, duplexers, multicouplers and related products. The graph on the back page will allow you to quickly determine VSWR. It should be remembered that the field accuracy of wattmeter readings is subject to considerable variance due to RF connector VSWR and basic wattmeter accuracy, particularly at low end scale readings. However, allowing for these variances, these graphs should prove to be a useful reference.



**POWER FWD./REV.  
VS.  
VSWR**



## Power Ratio and Voltage Ratio to Decibel Conversion Chart

Loss or Gain	Power Ratio	Voltage Ratio
+9.1 dB	8.128	2.851
-9.1 dB	0.123	0.351

← - dB + →

← - dB + →

Voltage Ratio	Power Ratio	dB	Voltage Ratio	Power Ratio
1	1	0	1	1
0.989	0.977	0.1	1.012	1.023
0.977	0.955	0.2	1.023	1.047
0.966	0.933	0.3	1.035	1.072
0.955	0.912	0.4	1.047	1.096
0.944	0.891	0.5	1.059	1.122
0.933	0.871	0.6	1.072	1.148
0.923	0.851	0.7	1.084	1.175
0.912	0.832	0.8	1.096	1.202
0.902	0.813	0.9	1.109	1.23
0.891	0.794	1	1.122	1.259
0.881	0.776	1.1	1.135	1.288
0.871	0.759	1.2	1.148	1.318
0.861	0.741	1.3	1.161	1.349
0.851	0.724	1.4	1.175	1.38
0.841	0.708	1.5	1.189	1.413
0.832	0.692	1.6	1.202	1.445
0.822	0.676	1.7	1.216	1.479
0.813	0.661	1.8	1.23	1.514
0.804	0.646	1.9	1.245	1.549
0.794	0.631	2	1.259	1.585
0.785	0.617	2.1	1.274	1.622
0.776	0.603	2.2	1.288	1.66
0.767	0.589	2.3	1.303	1.698
0.759	0.575	2.4	1.318	1.738
0.75	0.562	2.5	1.334	1.778
0.741	0.55	2.6	1.349	1.82
0.733	0.537	2.7	1.365	1.862
0.724	0.525	2.8	1.38	1.905
0.716	0.513	2.9	1.396	1.95
0.708	0.501	3	1.413	1.995
0.7	0.49	3.1	1.429	2.042
0.692	0.479	3.2	1.445	2.089
0.684	0.468	3.3	1.462	2.138
0.676	0.457	3.4	1.479	2.188
0.668	0.447	3.5	1.496	2.239
0.661	0.437	3.6	1.514	2.291
0.653	0.427	3.7	1.531	2.344
0.646	0.417	3.8	1.549	2.399
0.638	0.407	3.9	1.567	2.455
0.631	0.398	4	1.585	2.512
0.624	0.389	4.1	1.603	2.57
0.617	0.38	4.2	1.622	2.63
0.61	0.372	4.3	1.641	2.692
0.603	0.363	4.4	1.66	2.754
0.596	0.355	4.5	1.679	2.818
0.589	0.347	4.6	1.698	2.884
0.582	0.339	4.7	1.718	2.951
0.575	0.331	4.8	1.738	3.02
0.569	0.324	4.9	1.758	3.09

Voltage Ratio	Power Ratio	dB	Voltage Ratio	Power Ratio
0.562	0.316	5	1.778	3.162
0.556	0.309	5.1	1.799	3.236
0.55	0.302	5.2	1.82	3.311
0.543	0.295	5.3	1.841	3.388
0.537	0.288	5.4	1.862	3.467
0.531	0.282	5.5	1.884	3.548
0.525	0.275	5.6	1.905	3.631
0.519	0.269	5.7	1.928	3.715
0.513	0.263	5.8	1.95	3.802
0.507	0.257	5.9	1.972	3.89
0.501	0.251	6	1.995	3.981
0.496	0.246	6.1	2.018	4.074
0.484	0.234	6.3	2.065	4.266
0.479	0.229	6.4	2.089	4.365
0.473	0.224	6.5	2.113	4.467
0.468	0.219	6.6	2.138	4.571
0.462	0.214	6.7	2.163	4.677
0.457	0.209	6.8	2.188	4.786
0.452	0.204	6.9	2.213	4.898
0.447	0.2	7	2.239	5.012
0.442	0.195	7.1	2.265	5.129
0.437	0.191	7.2	2.291	5.248
0.432	0.186	7.3	2.317	5.37
0.427	0.182	7.4	2.344	5.495
0.422	0.178	7.5	2.371	5.623
0.417	0.174	7.6	2.399	5.754
0.412	0.17	7.7	2.427	5.888
0.407	0.166	7.8	2.455	6.026
0.403	0.162	7.9	2.483	6.166
0.398	0.159	8	2.512	6.31
0.394	0.155	8.1	2.541	6.457
0.389	0.151	8.2	2.57	6.607
0.385	0.148	8.3	2.6	6.761
0.38	0.145	8.4	2.63	6.918
0.376	0.141	8.5	2.661	7.079
0.372	0.138	8.6	2.692	7.244
0.367	0.135	8.7	2.723	7.413
0.363	0.132	8.8	2.754	7.586
0.359	0.129	8.9	2.786	7.762
0.355	0.126	9	2.818	7.943
0.351	0.123	9.1	2.851	8.128
0.347	0.12	9.2	2.884	8.318
0.343	0.118	9.3	2.917	8.511
0.339	0.115	9.4	2.951	8.71
0.335	0.112	9.5	2.985	8.913
0.331	0.11	9.6	3.02	9.12
0.327	0.107	9.7	3.055	9.333
0.324	0.105	9.8	3.09	9.55
0.32	0.102	9.9	3.126	9.772

### **Return Loss vs. VSWR**

Return Loss	VSWR
30	1.06
25	1.11
20	1.20
19	1.25
18	1.28
17	1.33
16	1.37
15	1.43
14	1.50
13	1.57
12	1.67
11	1.78
10	1.92
9	2.10

### **Watts to dBm**

Watts	dBm
300	54.8
250	54.0
200	53.0
150	51.8
100	50.0
75	48.8
50	47.0
25	44.0
20	43.0
15	41.8
10	40.0
5	37.0
4	36.0
3	34.8
2	33.0
1	30.0

dBm =  $10\log P/1\text{mW}$   
Where P = power (Watt)

### **Insertion Loss**

Input Power (Watts)

	50	75	100	125	150	200	250	300
3	25	38	50	63	75	100	125	150
2.5	28	42	56	70	84	112	141	169
2	32	47	63	79	95	126	158	189
1.5	35	53	71	88	106	142	177	212
1	40	60	79	99	119	159	199	238
.5	45	67	89	111	134	178	223	267

Output Power (Watts)

### **Free Space Loss**

Distance (miles)

	.25	.50	.75	1	2	5	10	15
150	68	74	78	80	86	94	100	104
220	71	77	81	83	89	97	103	107
460	78	84	87	90	96	104	110	113
860	83	89	93	95	101	109	115	119
940	84	90	94	96	102	110	116	120
1920	90	96	100	102	108	116	122	126

Free Space Loss (dB)

Free space loss =  $36.6 + 20\log D + 20\log F$

Where D = distance in miles and F = frequency in MHz





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