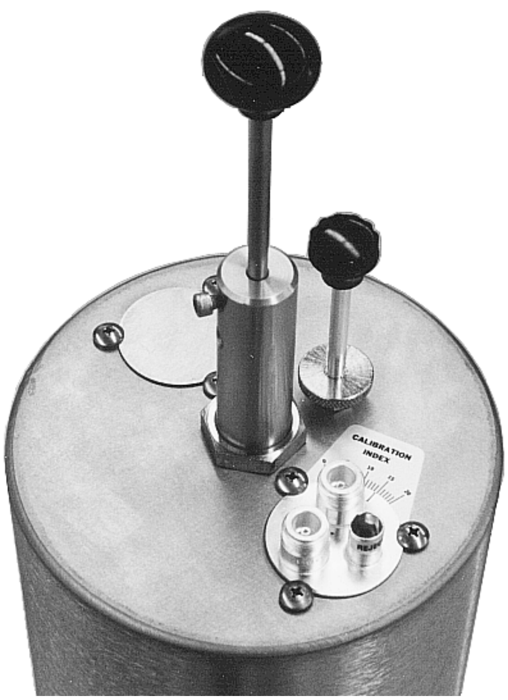
YOU'RE HEARD, LOUD AND CLEAR.

Instruction Manual
Series-Notch® Cavity Filters
6 5/8” and 10” Diameter

Manual Part Number

7-9146



8625 Industrial Parkway, Angola, NY 14006   Tel: 716-549-4700   Fax: 716-549-4772   sales@birdrf.com   www.bird-technologies.com

Warranty

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.

Manual Part Number 7-9146

First Printing: July 1996

Version Number	Version Date
1	07/25/96

Symbols Commonly Used

WARNING

ESD Elecrostatic Discharge

CAUTION or ATTENTION

Hot Surface

High Voltage

Electrical Shock Hazard

Use Safety Glasses

NOTE **Important Information**

GENERAL DESCRIPTION

The Series-Notch® cavity filter passes a relatively wide band of frequencies (***passband***) while simultaneously rejecting a very narrow band of frequencies (***notch frequency***). Minimum separation between passband and notch frequency is 50 KHz. The notch depth is variable from 15 to 25 dB. A variety of models are available that cover the range of frequencies from 30 to 960 MHz. The frequency range that each model will tune across is determined by the cavity's physical length.

Either 6-5/8" or 10" diameter resonator shells may be used to construct the filters. The diameter difference between the two determines the filters selectivity and it's maximum power dissipation. The 10" diameter filters have a slightly higher selectivity (more attenuation at the notch frequency) compared to the 6-5/8" models. Additionally, the 10" filters can safely dissipate up to 40 Watts of RF Power, while the 6-5/8" filters can dissipate up to 30 Watts. Maximum input power for the 6" and 10" diameter filter's is listed in table 1.

Insertion loss	6" diameter power rating	10" diameter power rating
0.3 dB	449 Watts	599 Watts
0.6 dB	230 Watts	308 Watts

Table 1: Input power ratings

There are three adjustable parameters found in a Series-Notch filter including the **passband frequency**, the **notch frequency**, and **notch depth**. Each of these parameters is labeled on the response curve shown in figure 1.

Two types of Series-Notch filters are available, lowpass and highpass. Lowpass filters permit a very narrow separation between the notch and the low frequency portion of the passband. Likewise, highpass filters will permit a very narrow separation between the notch and the high frequency passband. The lowpass filter, unlike the highpass filter, can be tuned for a symmetrical response. The difference between the two types of filters is determined by the loop plate assembly used. The cavity itself remains identical for both types. The part number is stamped on the loop.

Figure 1 shows the response curve of a lowpass filter while figure 2 shows the same filter's return loss curve. A symmetrical response can be seen in figure 3 where the notch is centered between the low frequency passband and the high frequency. A symmetrical response can only be obtained with relatively large separations between pass and notch frequencies. Figure 4 shows the resulting return loss curve.

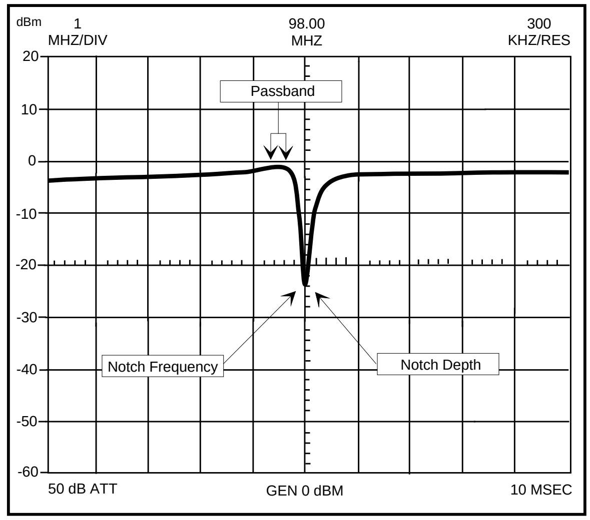


Figure 1:
Spectrum Analyzer / Tracking Generator display of the Series-Notch filter tuned lowpass. Response curve above is for model # 20-29-01 (88 - 108 MHz).

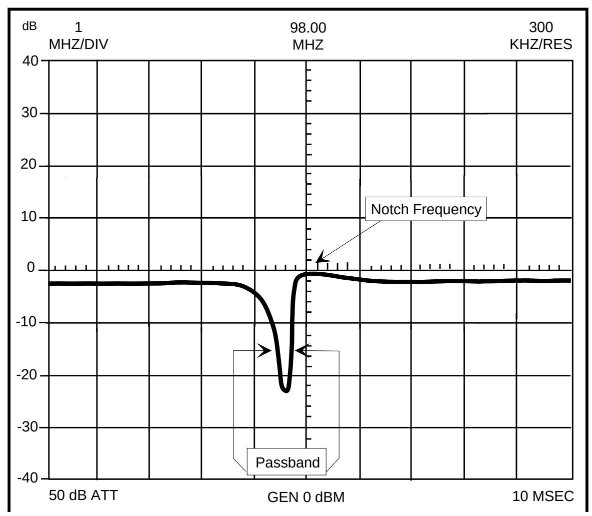


Figure 2:
Return loss response curve for the "lowpass" Series-Notch filter shown in figure 1. Response curve above is for model # 20-29-01 (88 - 108 MHz).

All of the physical components of the filter are labeled in figure 5, with the adjustable parts shown in emboldened italics. Coarse and fine tuning rods are used to adjust the notch (resonant) frequency.

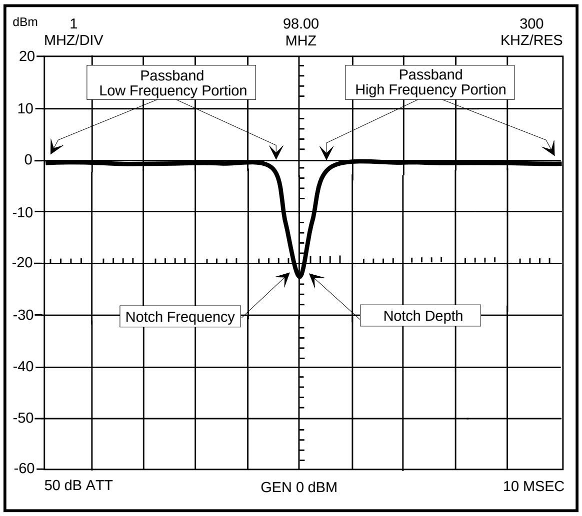


Figure 3:
Spectrum Analyzer / Tracking Generator display of the Series-Notch filter tuned symmetrically. Response curve above is for model # 20-29-01 (88 - 108 MHz).

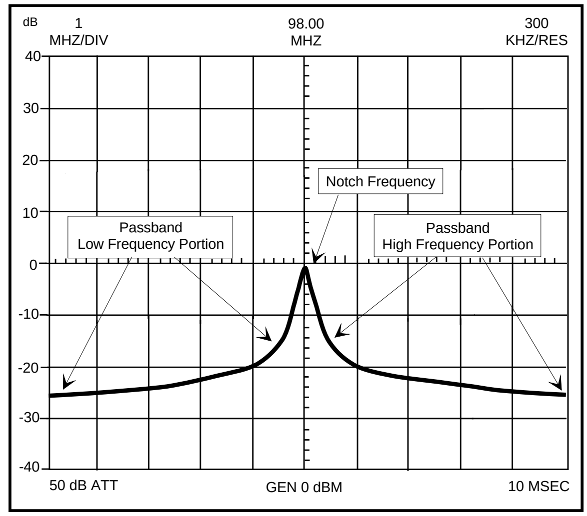


Figure 4:
Return loss response curve for the "symmetrical" Series-Notch filter shown in figure 3. Response curve above is for model # 20-29-01 (88 - 108 MHz).

The passband is adjusted with a variable capacitor and the notch depth is changed by rotating the loop plate assembly. One of two input/output ports will be marked with a red dot to indicate this particular port has the best VSWR characteristics. The marked port should be used as the input port. In multiple cavity systems, the non-red dot port is connected to the next filter's marked port.

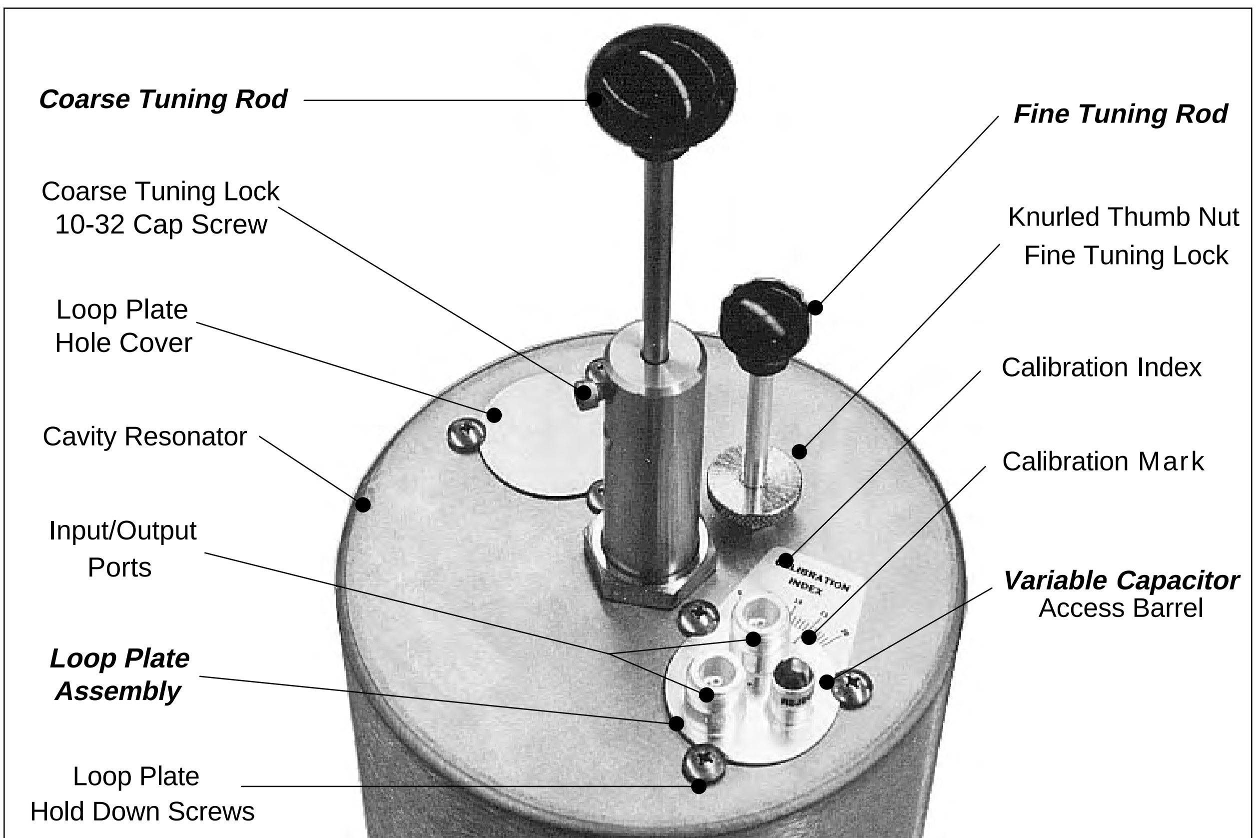


Figure 5: The Series-Notch Filter

TUNING

Required Equipment

The following equipment or it's **equivalent** is recommended in order to properly perform the tuning adjustments for the Series-Notch filter.

1. IFR A-7550 Spectrum Analyzer with optional Tracking generator installed.

2. Eagle Return Loss Bridge 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).

5. Connector - female union (UG 29-N or UG 914-BNC).

6. Insulated tuning tool (TX RX Systems Inc. part# 95-00-01).

7. 5/32" hex wrench.

Tuning Procedure

Tuning of the filter requires adjustment of the *notch frequency* and the *passband frequency*. Adjustment of the *notch depth* is optional because it is usually factory set in most cases. The passband frequency is adjusted using a return loss curve which is generated using a tracking generator and return loss bridge. The notch frequency and notch depth are adjusted by monitoring the output of a tracking generator after it passes through the filter. To insure proper tuning of the Series-Notch filter, all adjustments should be performed in the following order:

1. Adjust the notch depth (optional).

2. Rough tune the notch frequency.

3. Rough tune the passband frequency.

4. Fine tune the notch frequency.

5. Fine tune the passband frequency.

NOTCH DEPTH AND FREQUENCY

Notch depth is not normally adjusted when re-tuning the Series-Notch filter in the field. Notch depth is factory set, at which time a relative index label is attached to the top of the cavity next to the loop plate and a calibration mark is stamped into the loop plate itself. The relative index label is used to log specific filter performance. Changes in the notch depth will cause a shift in both the passband frequency and notch frequency. **Smaller notch depths allow closer spacing of the notch and passband.** Notch depth and notch frequency can both be checked using the procedure listed below.

Checking the notch depth or frequency

1. A zero reference must first be established at the IFR A-7550 before the notch depth or frequency can be measured. This is accomplished by temporarily placing a "female union" between the generator output and analyzer input, refer to figure 6.

2. Setup the analyzer / generator for the desired frequency and bandwidth (center of display) and also a vertical scale of 10 dB/div.

3. Insure that the IFR A-7550 menu's are set as follows; DISPLAY - line
   MODE - live
   FILTER - none
   SETUP - 50 ohm/dBm/gen1.

4. The flat line across the screen is the generator's output with no attenuation, this value will become our reference by selecting the "Mode" main menu item and choosing the "Store" command.

5. 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.

6. Connect the generator output and analyzer input to the input/output ports of the loop plate assembly. The notch depth and notch frequency can be read from the display on the IFR A-7550's screen, see figure 6.

Adjusting the notch depth

Adjustments are made by loosening the three 10-32 screws that hold the loop plate into position and then rotating the plate itself. When the calibration mark is pointed at the relative index setting of 0 the notch depth will be 15 dB

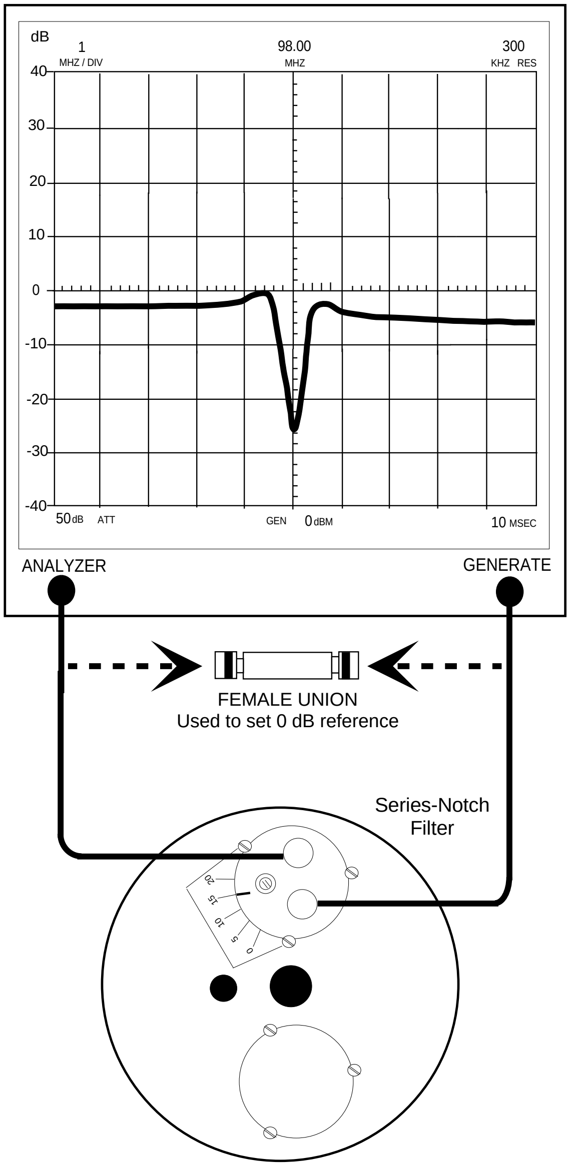


Figure 6: Checking notch depth and notch frequency.

(calibrated by factory). Rotating the loop plate assembly and moving the calibration mark above 0 causes the notch depth to be increased. It is adjustable across a useable range of from 15 dB to 25 dB.

Adjusting the notch frequency

The notch depth should be checked and adjusted prior to adjusting the notch frequency. The procedure for checking the notch frequency appears on page 3. Adjustment is made by first setting the fine tuning knob at it's mid-point. Then setting the peak (minimum value) of the response curve to the desired frequency (should be the center-vertical graticule line on the IFR A-7550's display). See figure 6.

The resonant frequency is adjusted by using the coarse 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. Additionally, the fine tuning rod, also a sliding adjustment (silver-plated-brass rod), allows a more precise setting of the frequency after the coarse adjustment is made. The frequency is increased by pushing the fine tuning rod in and is decreased by pulling it out, the exact opposite of the coarse tuning rod.

Once the desired response is obtained using the coarse and fine tuning rods, they are "locked" in place. The coarse rod is secured by tightening the 10-32 cap screw (5/32 hex wrench required) and the fine tuning rod is held in place by tightening the knurled thumb nut. **Failure to lock the tuning rods** will cause a loss of temperature compensation and detuning of the cavity.

Cavity Tuning Tip

When tuning a cavity that has been in service for some time it is not unusual to find the main 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 actually form a pressure weld that maintains excellent conductivity. The pressure weld develops over time and must be broken in order for the main 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.

PASSBAND

The passband is the frequency range over which the return loss is 15 dB or greater. Because the passband will vary with the tuning of the notch frequency it should be the last adjustment made to the Series-Notch filter. The passband is adjusted by changing the amount of capacitance in the loop plate assembly. The capacitor is variable and is either an air-plate or a tubular-piston type depending upon the frequency range of the filter. The air-plate type has a red mark painted on the access barrel and one-half of the adjusting screw, when the red marks line up the maximum amount of capacitance is achieved.

A transmitter connected to the filter will operate best when the reflected energy is lowest. Therefore a return loss response curve will be used to set the passband. The passband can be checked and adjusted following the procedure listed below.

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 7.

2. Set-up the analyzer / generator for the desired frequency (center of display) and for a vertical scale of 10 dB/div.

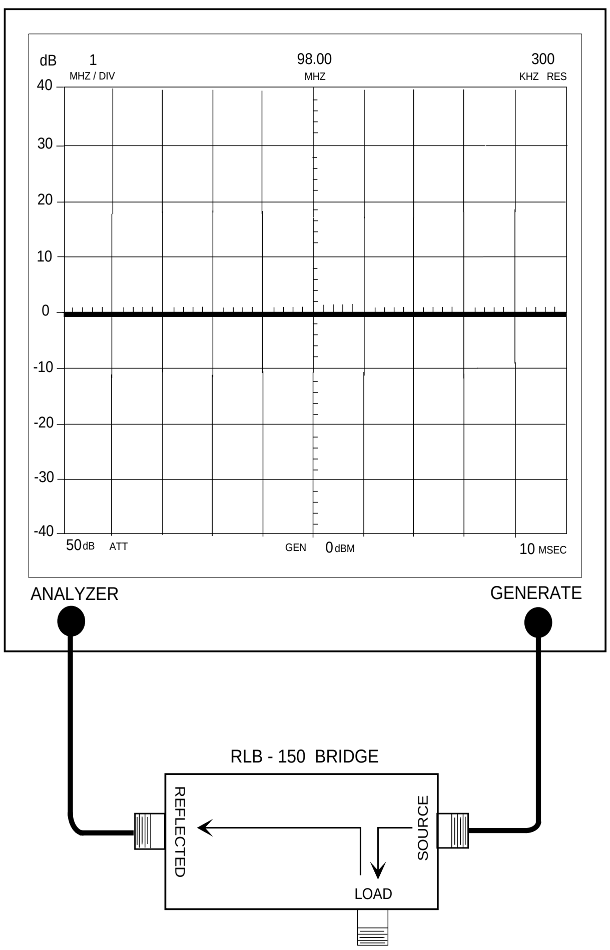


Figure 7: Setting the return loss reference.

3. Do not connect the return loss bridge 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 response 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 plate, make sure the output of the loop plate is connected to a 50 ohm load, refer to figure 8. The display will now present the return loss response curve for the Series-Notch filter being measured.

Adjusting the passband

The passband is adjusted by turning the variable capacitor in the loop plate assembly to obtain the maximum return loss at the desired frequency or for a maximum return loss across the frequency band. Because of the filters sensitivity to tool contact, an insulated tuning tool must be used to make the adjustment.

MULTIPLE CAVITY SERIES-NOTCH FILTERS

Series-Notch filters can be ordered in multiple cavity arrangements of either two or three combined cavities. In these arrangements, identical filters are connected in a cascaded fashion with the output of each filter fed to the input port of the succeeding filter. The advantage to this arrangement is the amount of attenuation provided by each of the filters is additive.

Also, the interconnecting cable between the two filters, when cut to the correct length (odd multiple of 1/4 λ), will provide up to 6 dB of phase addition due to a mismatch of impedance between the cable and the filters. The 6 dB of mismatch attenuation does not occur at the filters passband but, only at frequencies where moderate to high attenuation occurs, such as at the notch frequency.

Because each of the filters in the multi-cavity arrangement are identical, the passband for the entire arrangement is generally the same as the passband for the individual filters. However, each filters individual insertion loss is also additive.

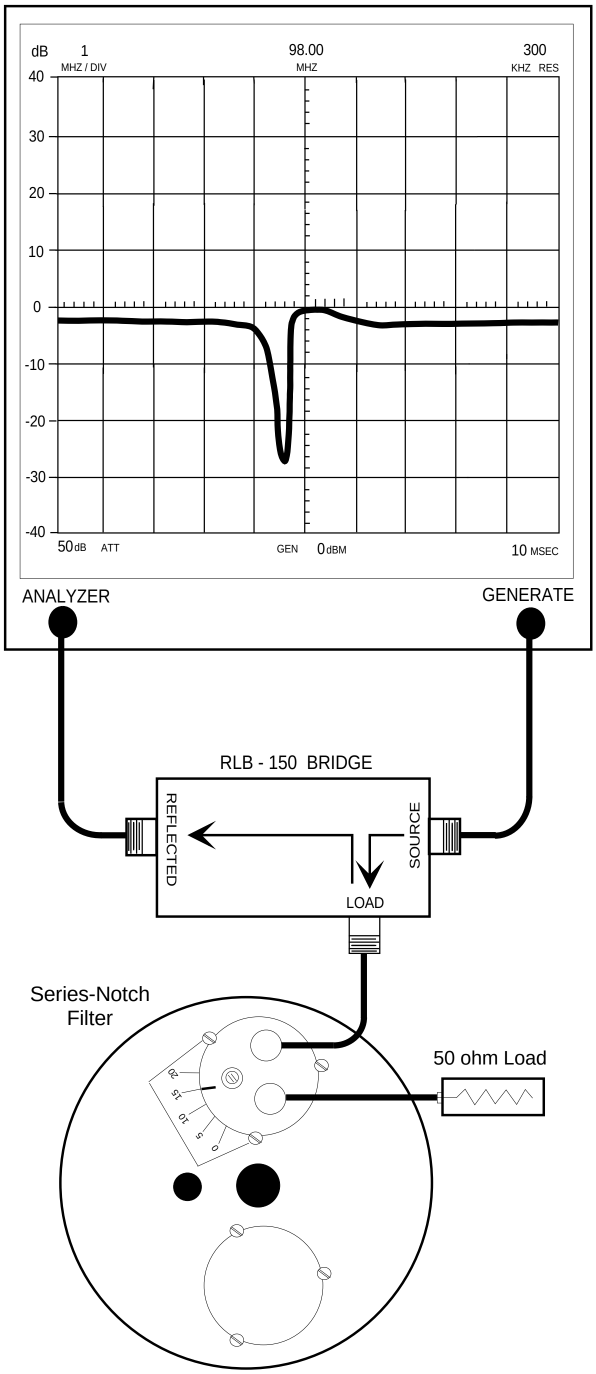


Figure 8: Checking passband frequency.

When tuning a multi-cavity arrangement, each filter is tuned individually prior to interconnecting. Then each is fine tuned to peak the overall response of the arrangement.

CONVERTING CAVITY RESONANT FILTERS

TX RX Systems Inc. produces four types of cavity filters, including the Vari-Notch®, Series-Notch®, Bandpass, and T-Pass®. The cavity resonator shell along with the coarse and fine tuning controls are standard subassemblies found in each type of filter for a specified frequency band. Differences between the types are determined by the loop plate assemblies installed in the filter.

The filter's loop plate assembly may be changed in order to convert the cavity from one type of filter to another. Conversion kits can be ordered which contain all parts required for the conversion. The available kits are listed by part number in table 2. Refer to the appropriate TX RX Systems Inc. manual for the specific filter type once the kit is installed.

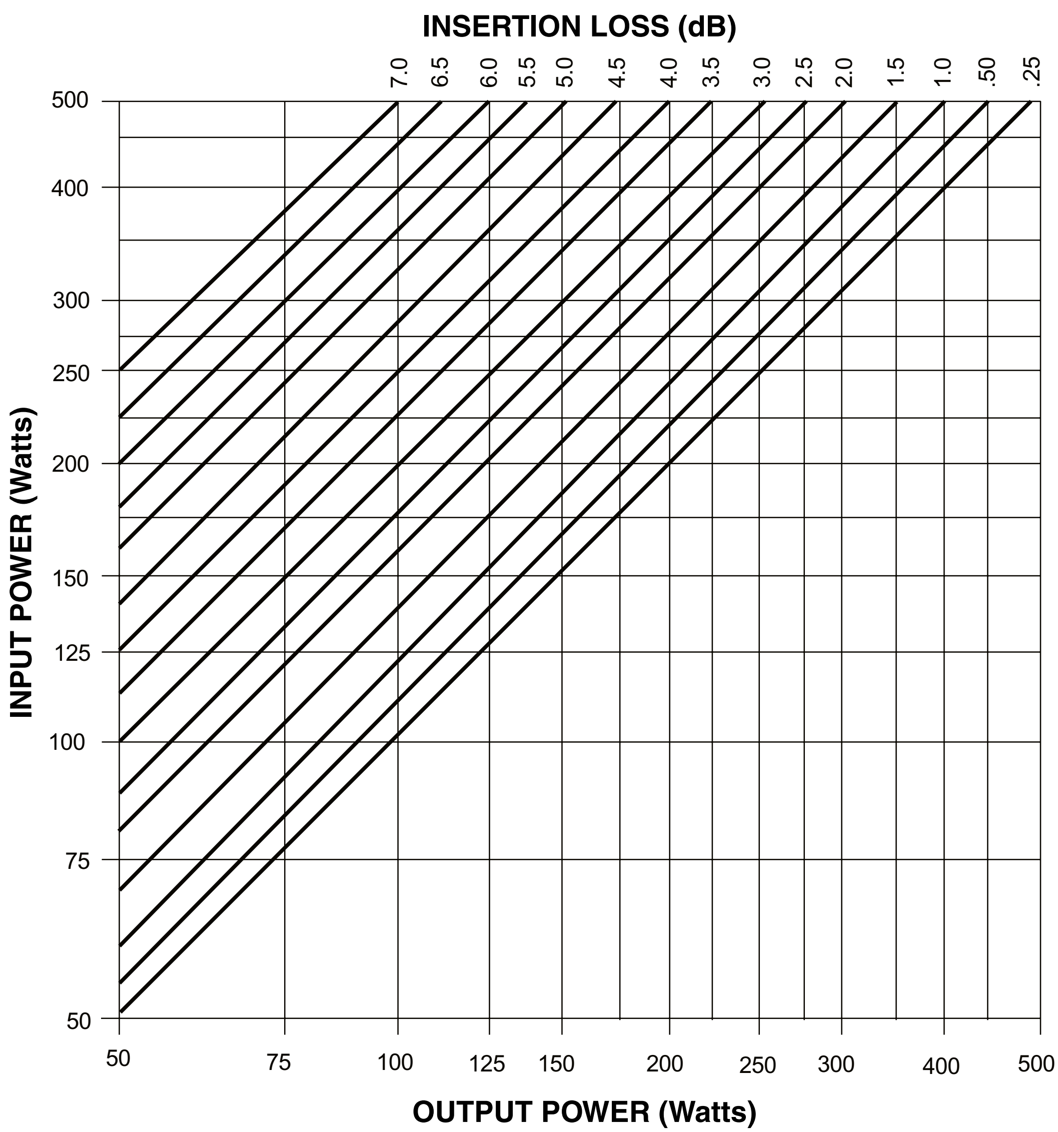
Series- Notch Filter Part #	Vari-Notch (Lowpass) Conversion Kit Part #	Vari-Notch (Highpass) Conversion Kit Part #	Bandpass Conversion Kit Part #	T-Pass Conversion Kit Part #
20-28-01/-11	76-28-02	76-28-03	76-28-01	76-28-07
20-28-05/-25				
20-29-01/-11	76-29-02	76-29-03	76-29-01	76-29-07
20-29-05/-25				
20-35-01/-11	76-35-02	76-35-03	76-35-01	76-35-07
20-35-05/-25				
20-36-01/-11	76-36-03	76-36-04	76-36-01	76-38-01
20-36-05/-25				
20-37-01/-11	76-37-03	76-37-04	76-37-01	76-38-01
20-37-05/-25				
20-65-01/-11	76-65-03		76-65-01	76-67-01
20-65-05/-25				
20-69-01/-11	76-69-03		76-69-01	76-67-01
20-69-05/-25				
20-70-01/-11	76-70-03		76-70-01	76-67-01
20-70-05/-25				

Note: The last two digits of the filters model number indicate it's diameter and wavelength as listed below;
1.) Last digit of "01" indicates 6-5/8" diameter and 1/4 λ.
2.) Last digit of "11" indicates 6-5/8" diameter and 3/4 λ.
3.) Last digit of "05" indicates 10" diameter and 1/4 λ.
4.) Last digit of "25" indicates 10" diameter and 3/4 λ.

Table 2: Conversion kit part numbers.

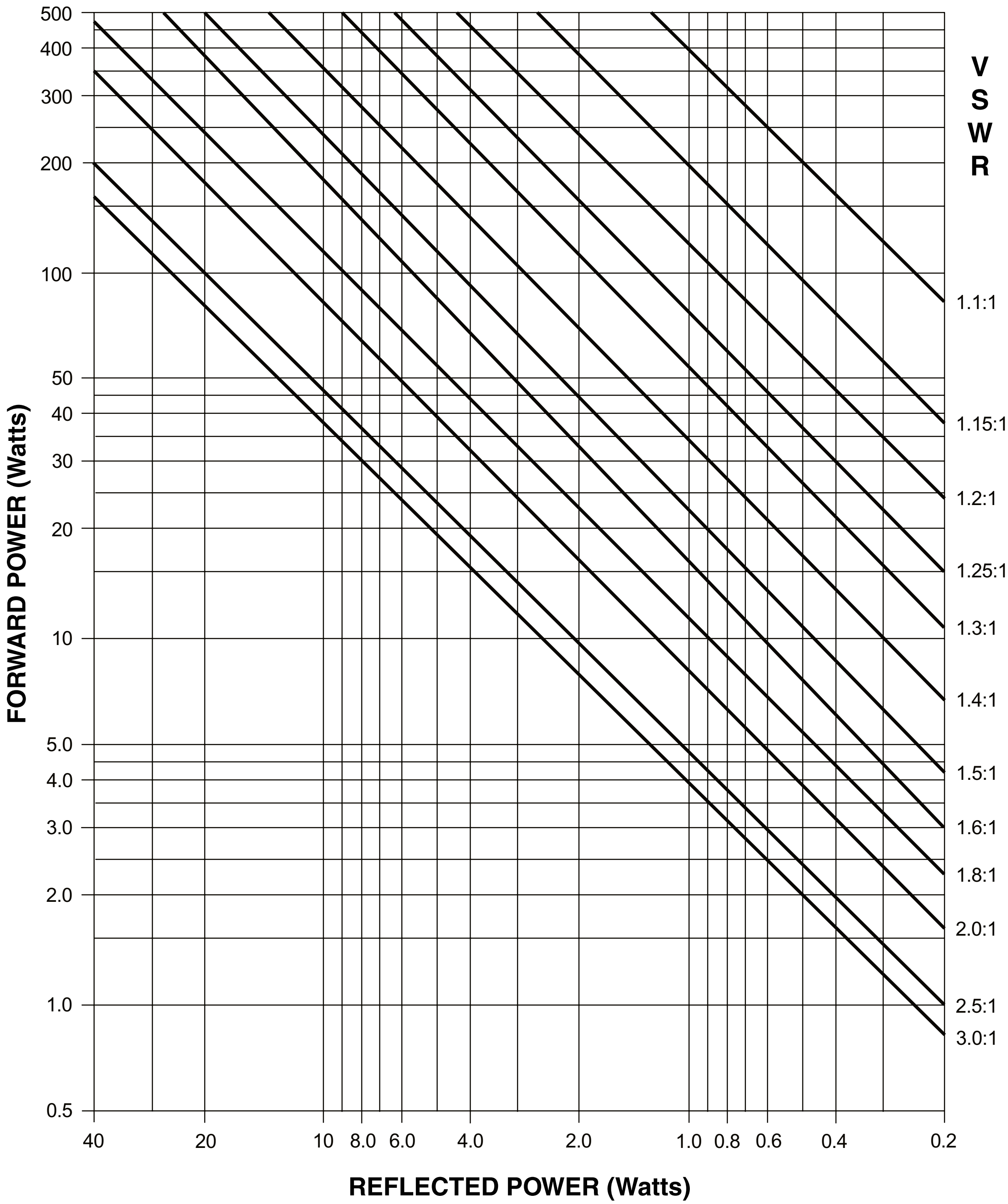
POWER IN/OUT
VS
INSERTION LOSS

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.



FOR LOWER POWER LEVELS
DIVIDE BOTH SCALES
BY 10 (5 TO 50 WATTS)

POWER FWD./REV.
VS
VSWR

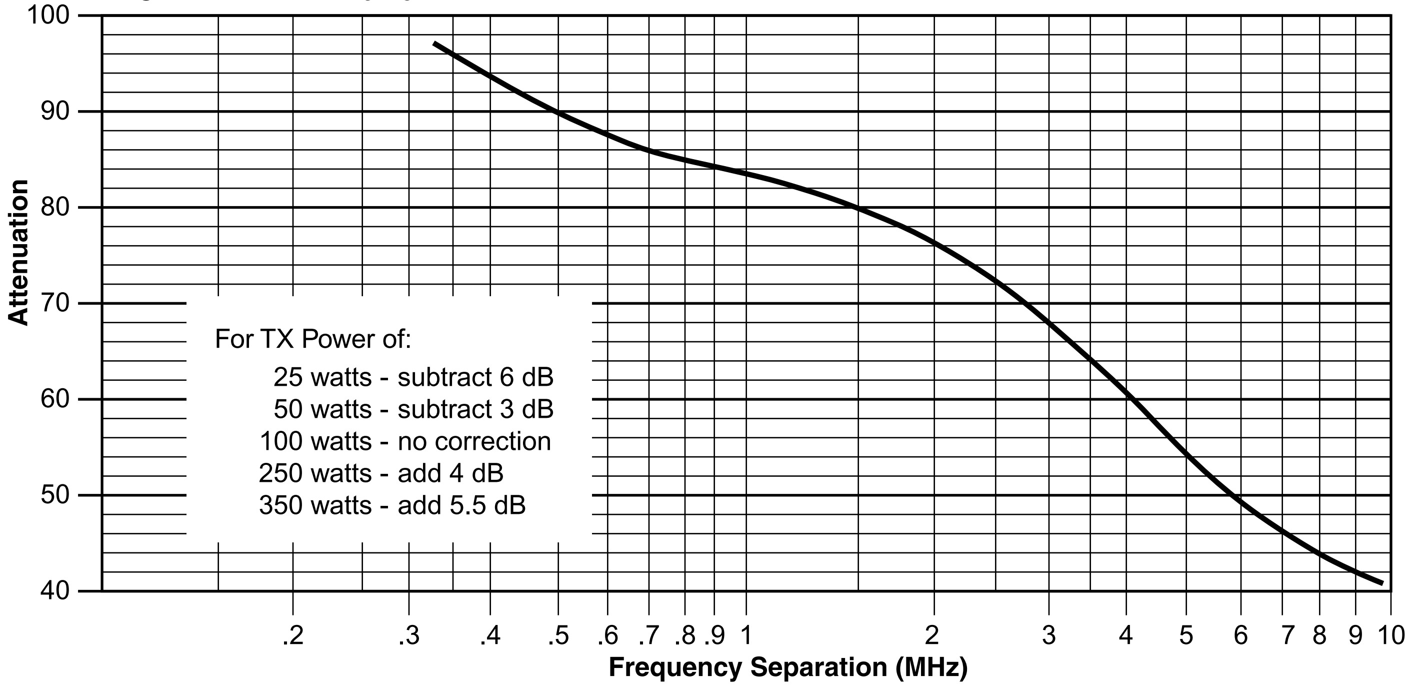


FOR OTHER POWER LEVELS
MULTIPLY BOTH SCALES
BY THE SAME MULTIPLIER

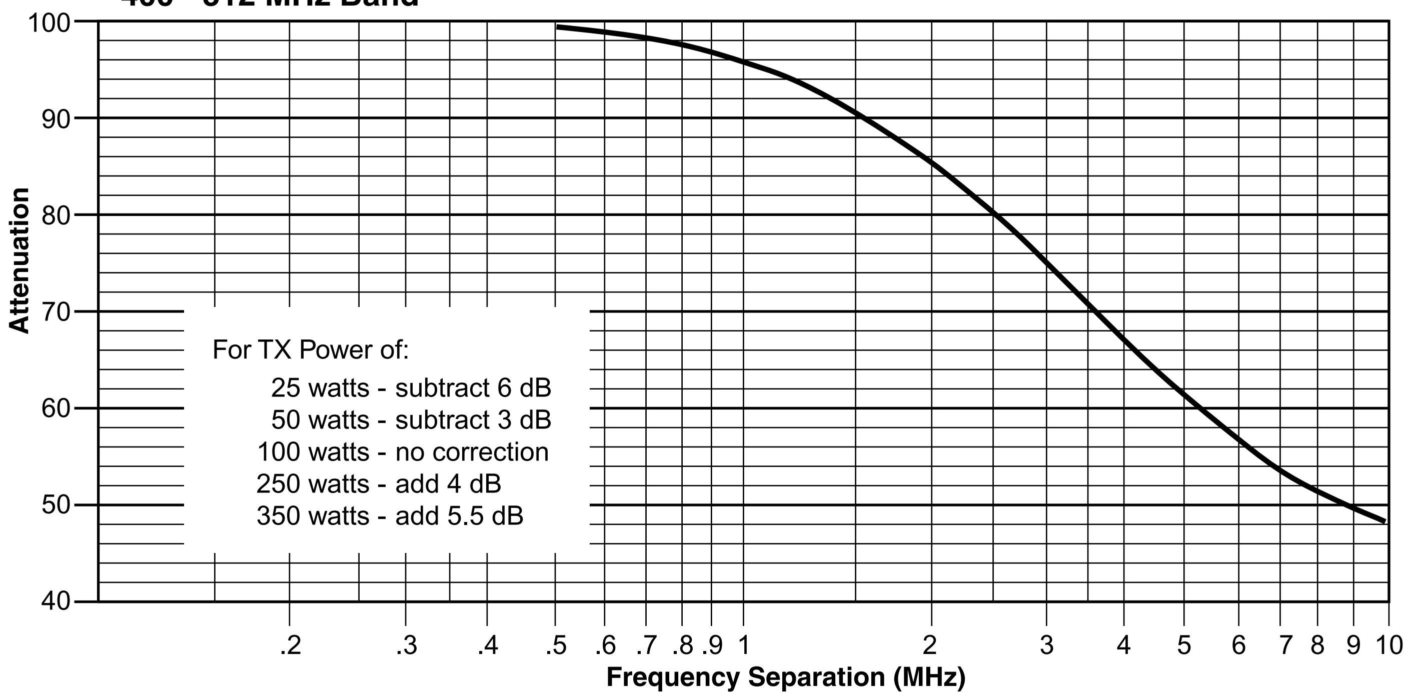
Isolation Curves for Transmitter/Receiver

The curves shown below for use with filters, duplexers, and multicouplers, indicate the amount of isolation or attenuation required between a typical 100 watt transmitter and its associated receiver at the TX (carrier suppression) and RX (noise suppression) frequency which will result in no more than a 1 dB degradation of the 12 dB SINAD sensitivity.

132 - 174 MHz Band



400 - 512 MHz Band



NOTE

These are only "typical" curves. When accuracy is required, consult the radio manufacturer.

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 + →

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

← - dB + →

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
0.49	0.24	6.2	2.042	4.169
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 = 10log P/1mW
Where P = power (Watt)

Insertion Loss

Input Power (Watts)

Insertion Loss	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)

Frequency (MHz)	.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 + 20log D + 20log F
Where D = distance in miles and F = frequency in MHz