Instruction Manual
Vari-Notch® Cavity Filter
4” Diameter

Manual Part Number
7-9150

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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 7-9150

First Printing: October 1996

Version Number	Version Date
1	10/18/96
2	07/19/07
3	07/11/12

Symbols Commonly Used

WARNING !!!

High Voltage

CAUTION or ATTENTION

Hot Surface

NOTE *Important Information*

ESD Electrostatic Discharge

VIDEO *Training Video Available*

Electrial Shock Hazard

Heavy Lifting

Safety Glasses Required

Changes to this Manual

We have made every effort to ensure this manual is accurate. If you discover any errors, or if you have suggestions for improving this manual, please send your comments to our Angola, New York facility to the attention of the Technical Publications Department. This manual may be periodically updated. When inquiring about updates to this manual refer to the manual part number and revision number on the revision page following the front cover.

Contact Information

Sales Support at 716-217-3113

Customer Service at 716-217-3144

Technical Publications at 716-549-4700 extension 5019

GENERAL DESCRIPTION

The 4" Vari-Notch® cavity filter is designed to pass a relatively narrow band of frequencies ***(passband)*** while simultaneously rejecting a wide band of frequencies ***(rejection notch)***. A variety of models are available that cover the range of frequencies from 132 to 960 MHz. The portion of the frequency range that each model will tune across is determined by the cavity's physical length.

Two types of 4" Vari-Notch filters are available, lowpass and highpass. Lowpass filters have the passband below the notch frequency while highpass filters have the passband above the notch. The cavity itself remains identical for both types. **Figure 1** shows the response curve of a lowpass filter.

There are two adjustable parameters in a 4" Vari-Notch filter including the **passband frequency** and the **rejection notch frequency.** Both of these parameters are labeled on the response curve shown in figure 1. All of the physical components of the filter are labeled in **Figure 2**, with the adjustable parts shown in emboldened italics. The tuning rod is used to adjust the passband while a variable capacitor is used to adjust the rejection notch.

TUNING

Required Equipment

The following equipment or it's **equivalent** is recommended in order to properly perform the tuning adjustments for the 4" Vari-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. Insulated tuning tool (TX RX Systems Inc. part# 95-00-01).
6. 1/4" open-ended wrench.

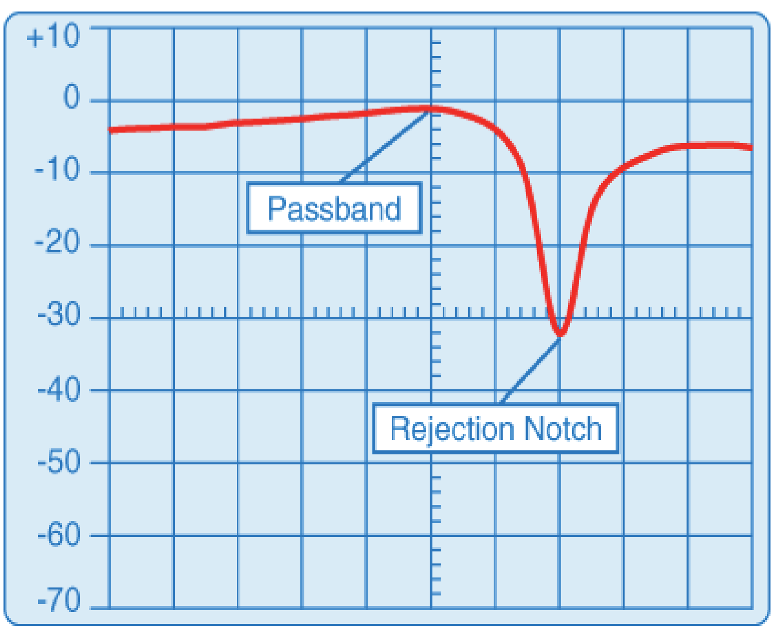


Figure 1: Response curve of the lowpass 4” Vari-Notch filter.
Response curve shown is for model number 15-52-01 (215-250 MHz)

Figure 2: The 4” Vari-Notch filter.

Tuning Procedure

Tuning of the filter requires adjustment of the *pass-band* 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. 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 notch.
3. Final tune the passband.
4. Final tune the notch, always the last adjustment made.

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 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.

Figure 3: Setting the return loss reference.

7. Connect the "load" port on the RLB to one of the input / output ports and make sure the remaining port 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.**

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

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.

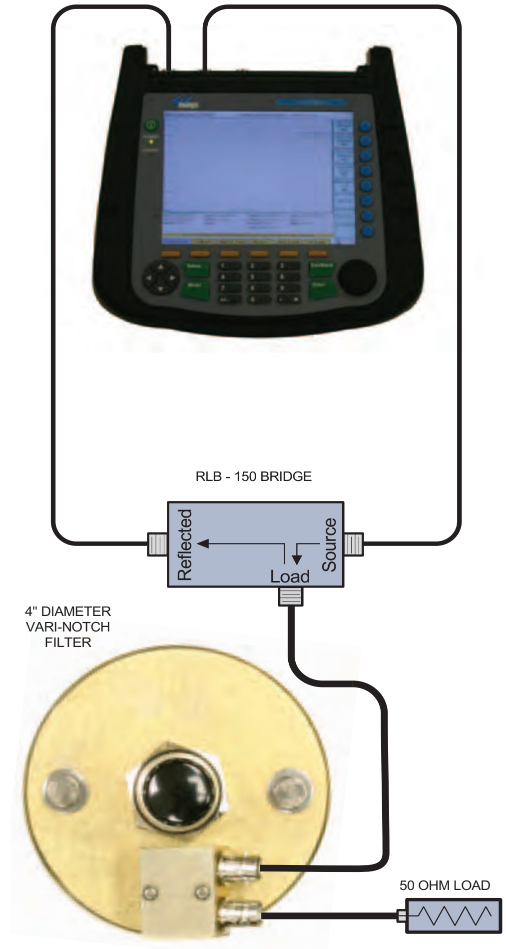


Figure 4: Checking the passband.

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

Figure 5: Checking the rejection notch.

Adjusting the rejection notch

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

MULTIPLE CAVITY VARI-NOTCH FILTERS

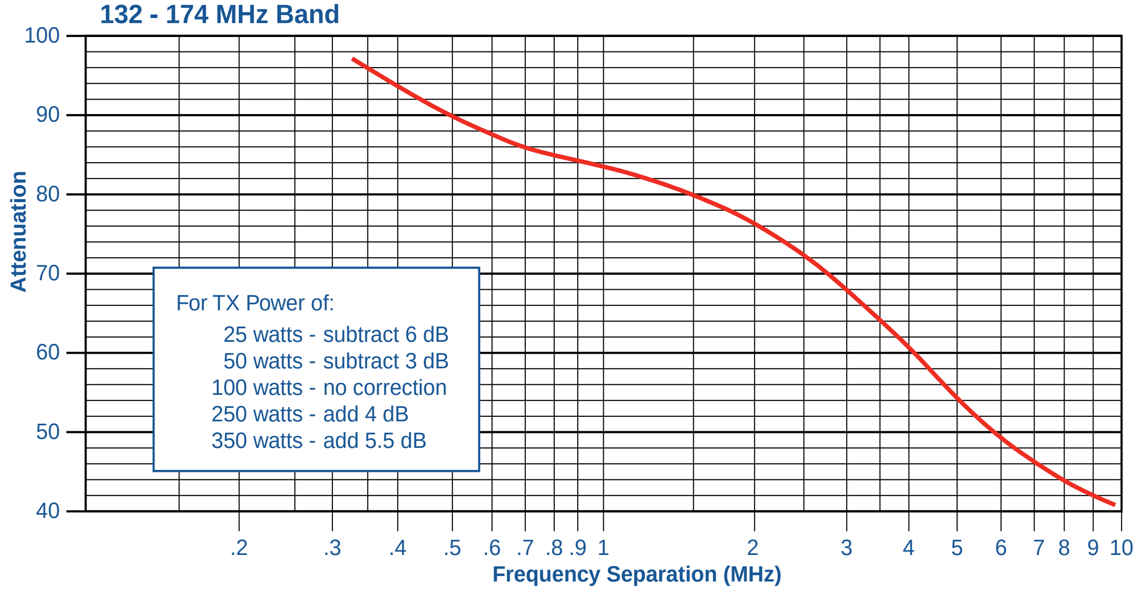
Vari-Notch filters can be ordered in multiple cavity arrangements of either two or three combined cavities. In these arrangements, identical filters are connected in a cascaded fashion with the output of each filter fed to the input port of the succeeding filter. The advantage to this arrangement is that the amount of attenuation provided by each of the filters is additive. In the case of the rejection notch frequency, the dual cavity can provide attenuation of over 60 dB (30 dB for each filter).

Also, the interconnecting cable between the two filters, when cut to the correct length (odd multiple of a 1/4 λ), will provide up to 6 dB of additional attenuation 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 rejection 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. When tuning a multi-cavity arrangement, each filter is tuned individually prior to interconnecting them. Then each is fine tuned to peak the overall response of the multi-cavity arrangement.

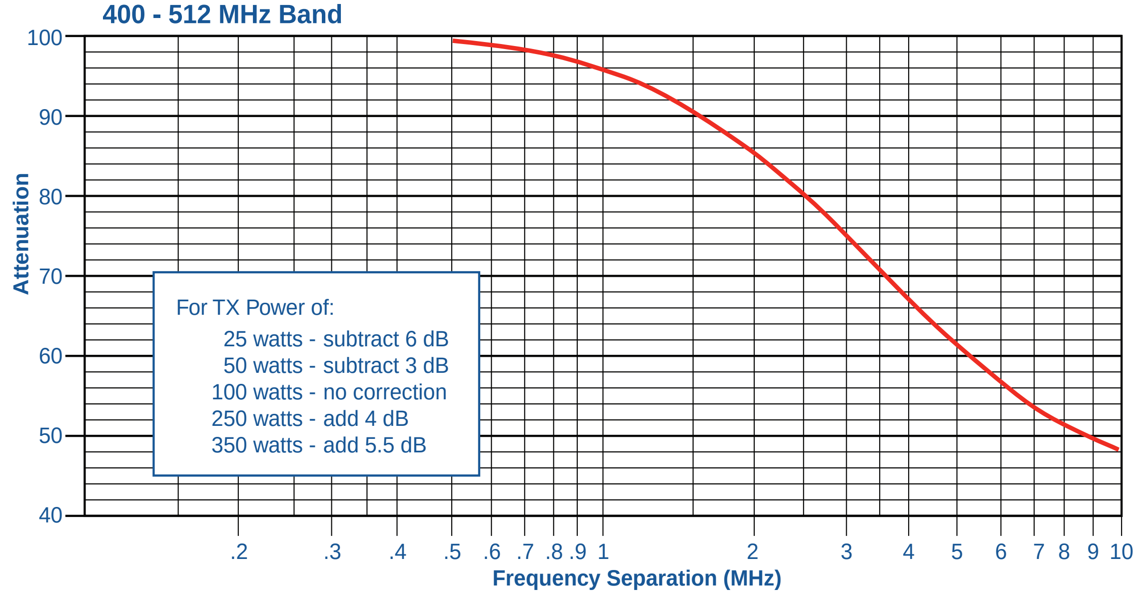
Isolation Curves for Transmitter/Receiver

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

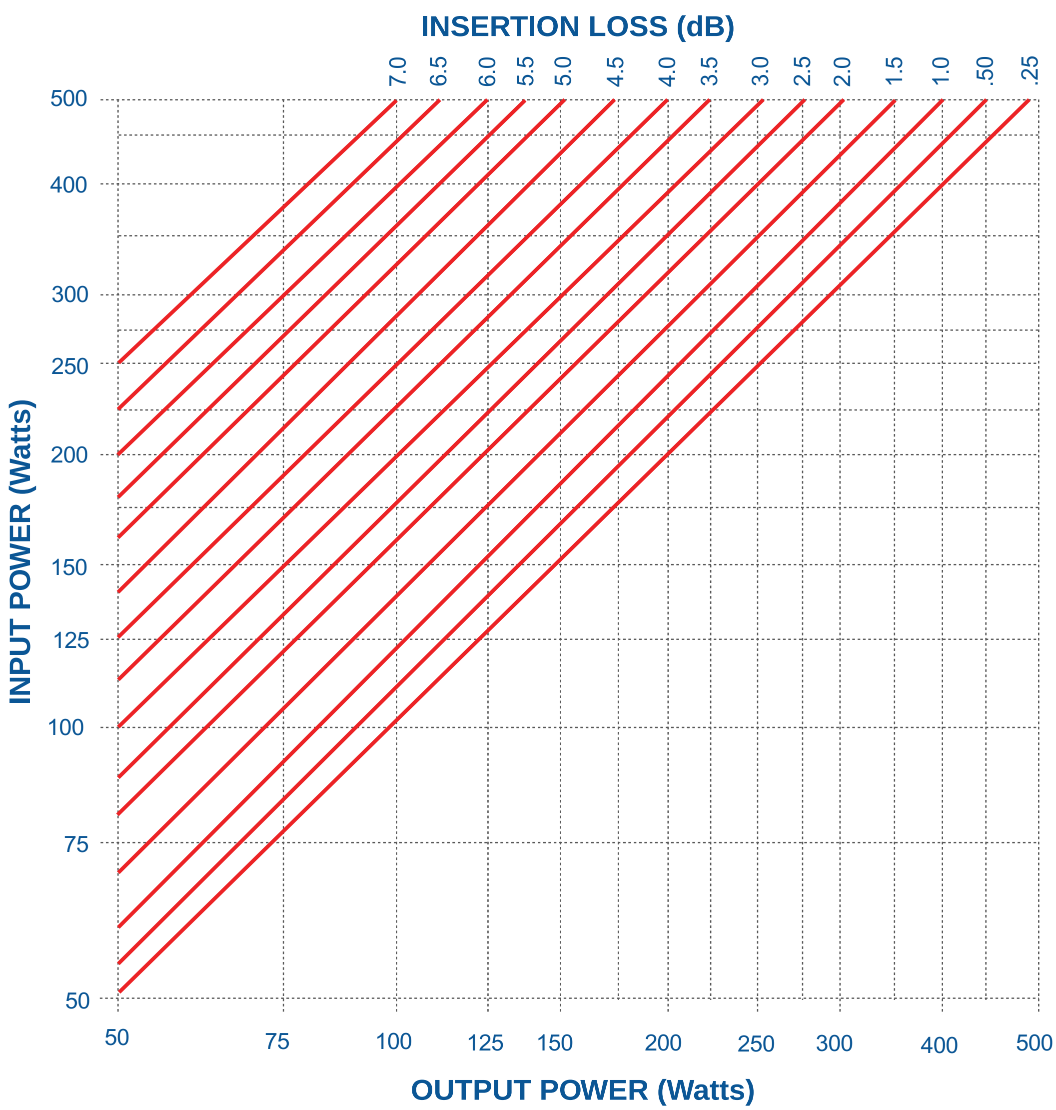


NOTE

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

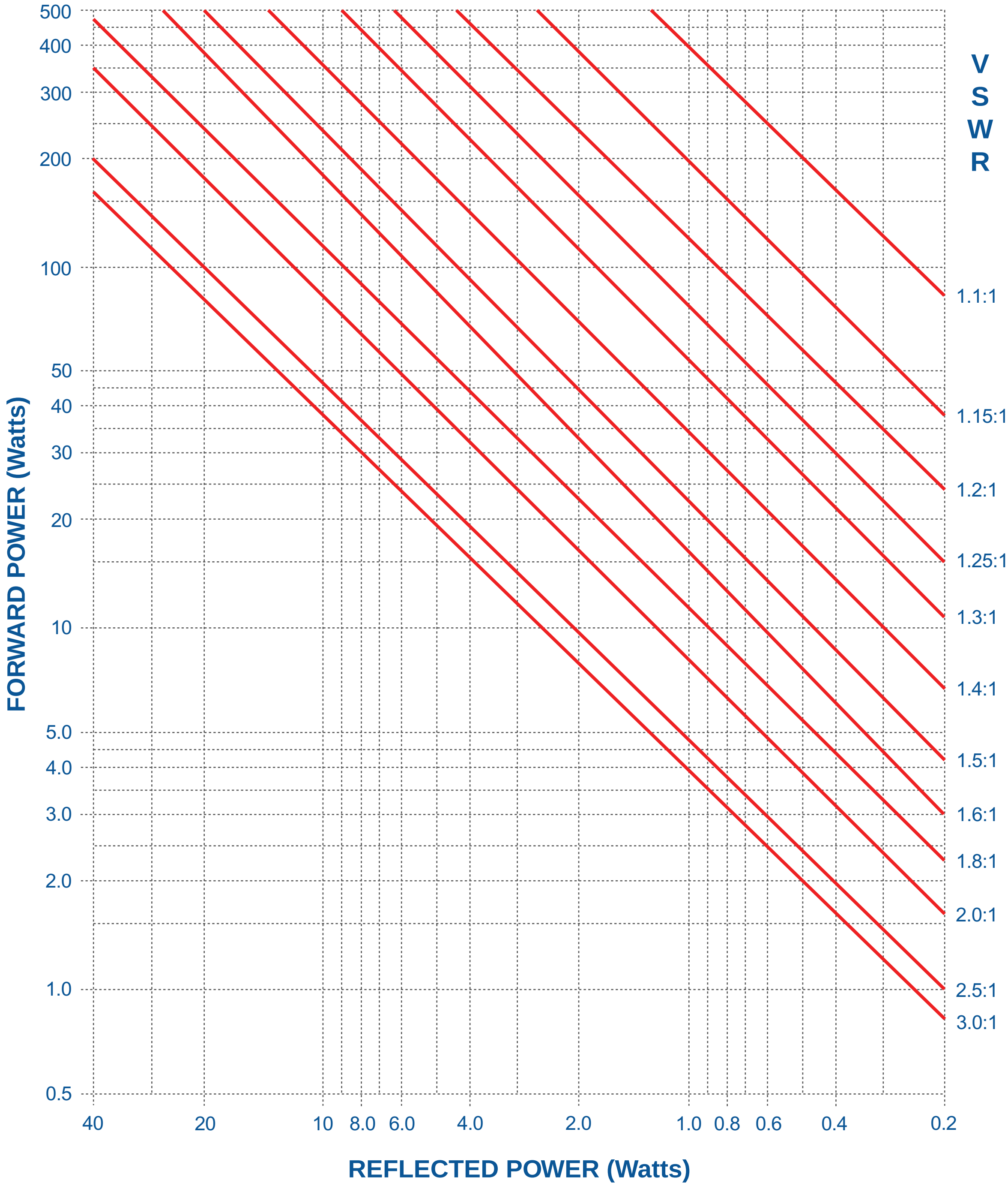
POWER IN/OUT
VS
INSERTION LOSS

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

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

Power Conversion Chart

dBm to dBw to Watts to Volts

dBm	dBw	Watts	Volts 50
80	50	100kW	2236
75	45	31.6 kW	1257
70	40	10.0 kW	707
65	35	3.16 kW	398
60	30	1000	224
55	25	316	126
50	20	100	70.7
45	15	31.6	39.8
40	10	10.0	22.4
38	8	6.31	17.8
36	6	3.98	14.1
34	4	2.51	11.2
32	2	1.58	8.90
30	0	1.00	7.07
29	-1	0.79	6.30
28	-2	0.63	5.62
27	-3	0.50	5.01
26	-4	0.40	4.46
25	-5	0.32	3.98
24	-6	0.25	3.54
23	-7	0.20	3.16
22	-8	0.16	2.82
21	-9	0.13	2.51
20	-10	0.10	2.24
19	-11	79 mW	1.99

dBm	dBw	Watts	Volts 50
18	-12	63 mW	1.78
17	-13	50 mW	1.58
16	-14	40 mW	1.41
15	-15	32 mW	1.26
14	-16	25 mW	1.12
13	-17	20 mW	1.00
12	-18	16 mW	0.890
11	-19	13 mW	0.793
10	-20	10 mW	0.707
9	-21	7.9 mW	0.630
8	-22	6.3 mW	0.562
7	-23	5.0 mW	0.501
6	-24	4.0 mW	0.446
5	-25	3.2 mW	0.398
4	-26	2.5 mW	0.354
3	-27	2.0 mW	0.316
2	-28	1.6 mW	0.282
1	-29	1.3 mW	0.251
0	-30	1.0 mW	0.224
-5	-35	316 uW	0.126
-10	-40	100 uW	0.071
-15	-45	31.6 uW	0.040
-20	-50	10 uW	0.022
-25	-55	3.16 uW	0.013
-30	-60	1 uW	0.007

Free Space Path Loss Estimator

		Frequency in MHz						
		50	150	170	450	500	800	900
Path Length (miles)	0.1	50.58	60.12	61.21	69.66	70.58	74.66	75.68
	0.25	58.54	68.08	69.17	77.62	78.54	82.62	83.64
	0.5	64.56	74.10	75.19	83.64	84.56	88.64	89.66
	1	70.58	80.12	81.21	89.66	90.58	94.66	95.68
	2	76.60	86.14	87.23	95.68	96.60	100.68	101.71
	3	80.12	89.66	90.75	99.21	100.12	104.20	105.23
	4	82.62	92.16	93.25	101.71	102.62	106.70	107.73
	5	84.56	94.10	95.19	103.64	104.56	108.64	109.66
	6	86.14	95.68	96.77	105.23	106.14	110.22	111.25
	7	87.48	97.02	98.11	106.57	107.48	111.56	112.59
	8	88.64	98.18	99.27	107.73	108.64	112.72	113.75
	9	89.66	99.21	100.29	108.75	109.66	113.75	114.77
	10	90.58	100.12	101.21	109.66	110.58	114.66	115.68
	12	92.16	101.71	102.79	111.25	112.16	116.25	117.27
	14	93.50	103.04	104.13	112.59	113.50	117.58	118.61
	16	94.66	104.20	105.29	113.75	114.66	118.74	119.77
	18	95.68	105.23	106.31	114.77	115.68	119.77	120.79
	20	96.60	106.14	107.23	115.68	116.60	120.68	121.71
	30	100.12	109.66	110.75	119.21	120.12	124.20	125.23
	40	102.62	112.16	113.25	121.71	122.62	126.70	127.73
	50	104.56	114.10	115.19	123.64	124.56	128.64	129.66

Formula: Path Loss (dB) = 36.6 + 20 log (MHz) + 20 log (miles)

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

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