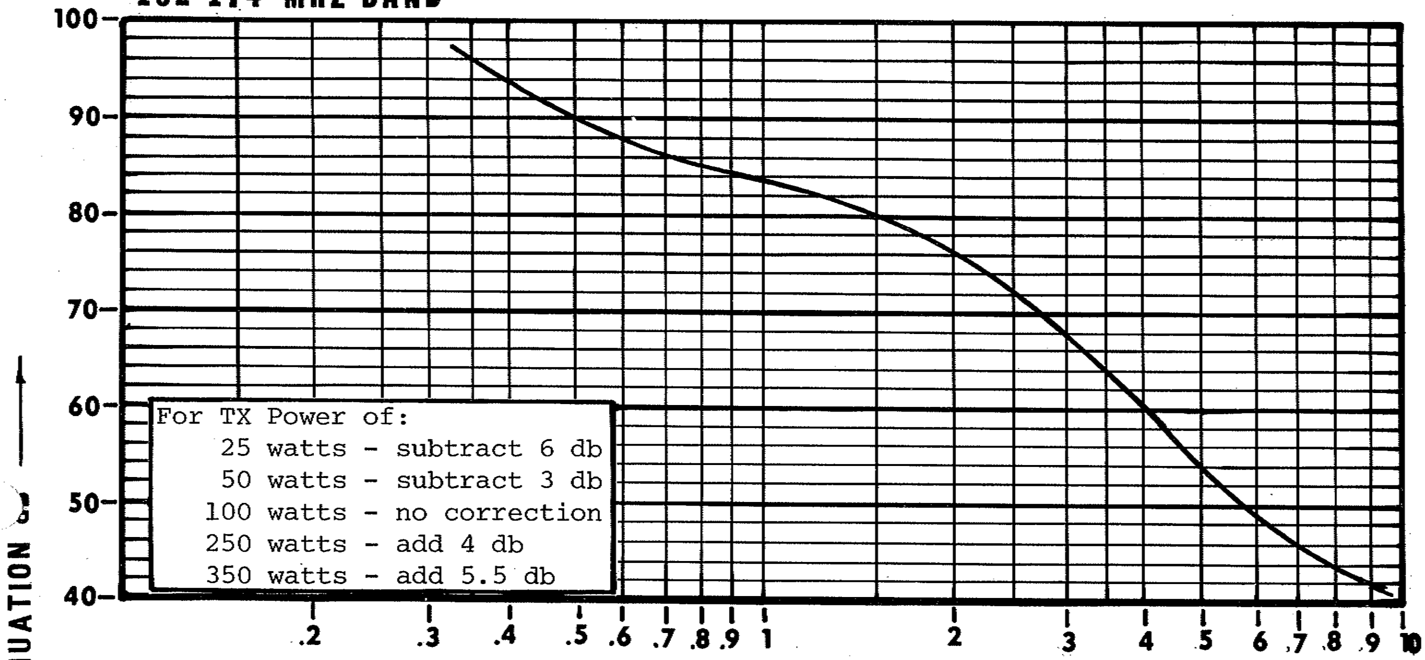
TECH-AID

NO.77001

ISOLATION CURVES FOR... DATA REFERENCE TRANSMITTER/RECEIVER

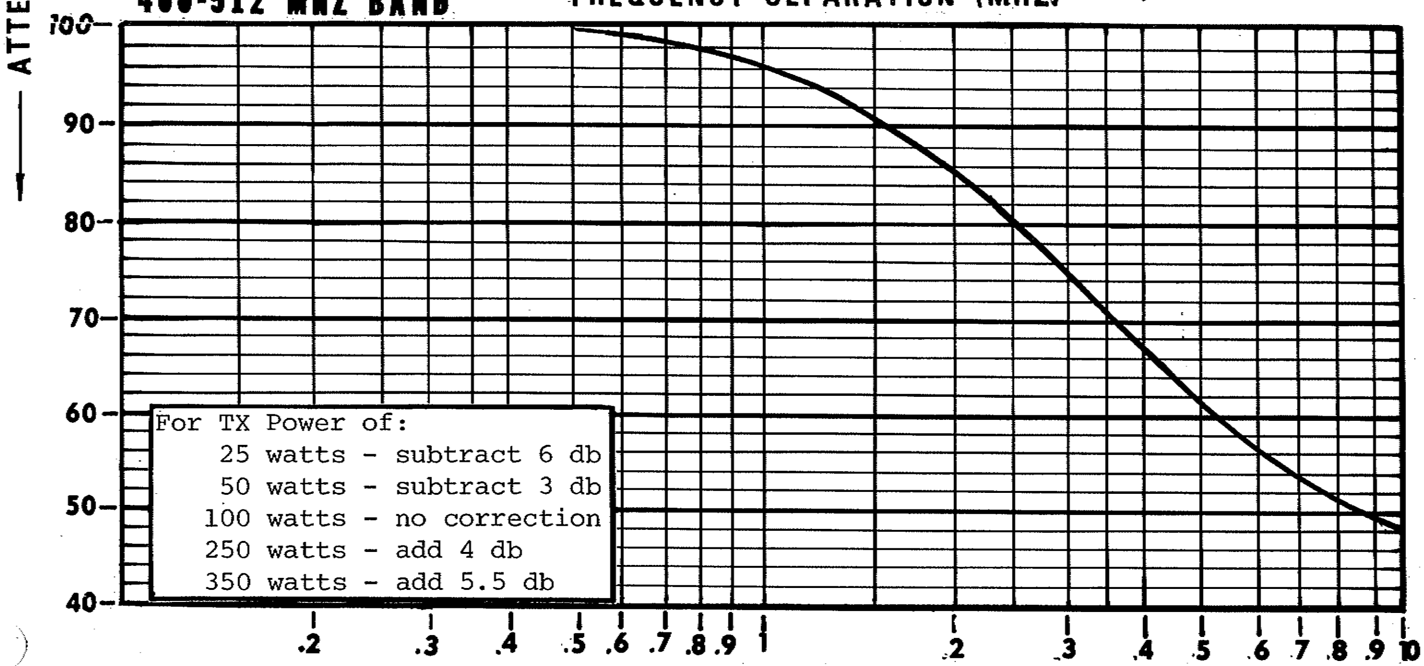
The curves shown below for use with filters, duplexers, and multicouplers, indicate the amount of isolation or attenuation required between a typical 100 watt transmitter and its associated receiver at the Tx (carrier suppression) and Rx (noise suppression) frequency which will result in no more than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

132-174 MHZ BAND



400-512 MHZ BAND

FREQUENCY SEPARATION (MHZ)



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

Z(H)402L8

TX RX SYSTEMS INC. 8625 INDUSTRIAL PARKWAY, ANGOLA, NY 14006-9696
TELEPHONE 716-549-4700 FAX 716-549-4772 (24 HRS.)
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TECH-AID NO.81001

CONVERSION TABLE

POWER AND VOLTAGE RATIOS TO DB

GIVEN: Decibels

TO FIND: Power and {Voltage / Current} Ratios

TO ACCOUNT FOR THE SIGN OF THE DECIBEL

For positive (+) values of the decibel — Both voltage and power ratios are greater than unity. Use the two right-hand columns.

For negative (−) values of the decibel — Both voltage and power ratios are less than unity. Use the two left-hand columns.

Example — *Given:* ±9.1 dB; *Find:*

	Power Ratio	*Voltage Ratio*
+9.1 dB	8.128	2.851
−9.1 dB	0.1230	0.3508

← −*dB*+ →

Voltage Ratio	*Power Ratio*	*dB*	*Voltage Ratio*	*Power Ratio*
1.0000	**1.0000**	**0**	**1.000**	**1.000**
.9886	.9772	.1	1.012	1.023
.9772	.9550	.2	1.023	1.047
.9661	.9333	.3	1.035	1.072
.9550	.9120	.4	1.047	1.096
.9441	.8913	.5	1.059	1.122
.9333	.8710	.6	1.072	1.148
.9226	.8511	.7	1.084	1.175
.9120	.8318	.8	1.096	1.202
.9016	.8128	.9	1.109	1.230
.8913	**.7943**	**1.0**	**1.122**	**1.259**
.8810	.7762	1.1	1.135	1.288
.8710	.7586	1.2	1.148	1.318
.8610	.7413	1.3	1.161	1.349
.8511	.7244	1.4	1.175	1.380
.8414	.7079	1.5	1.189	1.413
.8318	.6918	1.6	1.202	1.445
.8222	.6761	1.7	1.216	1.479
.8128	.6607	1.8	1.230	1.514
.8035	.6457	1.9	1.245	1.549
.7943	**.6310**	**2.0**	**1.259**	**1.585**
.7852	.6166	2.1	1.274	1.622
.7762	.6026	2.2	1.288	1.660
.7674	.5888	2.3	1.303	1.698
.7586	.5754	2.4	1.318	1.738
.7499	.5623	2.5	1.334	1.778
.7413	.5495	2.6	1.349	1.820
.7328	.5370	2.7	1.365	1.862
.7244	.5248	2.8	1.380	1.905
.7161	.5129	2.9	1.396	1.950
.7079	**.5012**	**3.0**	**1.413**	**1.995**
.6998	.4898	3.1	1.429	2.042
.6918	.4786	3.2	1.445	2.089
.6839	.4677	3.3	1.462	2.138
.6761	.4571	3.4	1.479	2.188
.6683	.4467	3.5	1.496	2.239
.6607	.4365	3.6	1.514	2.291
.6531	.4266	3.7	1.531	2.344
.6457	.4169	3.8	1.549	2.399
.6383	.4074	3.9	1.567	2.455
.6310	**.3981**	**4.0**	**1.585**	**2.512**
.6237	.3890	4.1	1.603	2.570
.6166	.3802	4.2	1.622	2.630
.6095	.3715	4.3	1.641	2.692
.6026	.3631	4.4	1.660	2.754
.5957	.3548	4.5	1.679	2.818
.5888	.3467	4.6	1.698	2.884
.5821	.3388	4.7	1.718	2.951
.5754	.3311	4.8	1.738	3.020
.5689	.3236	4.9	1.758	3.090

← −*dB*+ →

Voltage Ratio	*Power Ratio*	*dB*	*Voltage Ratio*	*Power Ratio*
.5623	**.3162**	**5.0**	**1.778**	**3.162**
.5559	.3090	5.1	1.799	3.236
.5495	.3020	5.2	1.820	3.311
.5433	.2951	5.3	1.841	3.388
.5370	.2884	5.4	1.862	3.467
.5309	.2818	5.5	1.884	3.548
.5248	.2754	5.6	1.905	3.631
.5188	.2692	5.7	1.928	3.715
.5129	.2630	5.8	1.950	3.802
.5070	.2570	5.9	1.972	3.890
.5012	.2512	**6.0**	**1.995**	**3.981**
.4955	.2455	6.1	2.018	4.074
.4898	.2399	6.2	2.042	4.169
.4842	.2344	6.3	2.065	4.266
.4786	.2291	6.4	2.089	4.365
.4732	.2239	6.5	2.113	4.467
.4677	.2188	6.6	2.138	4.571
.4624	.2138	6.7	2.163	4.677
.4571	.2089	6.8	2.188	4.786
.4519	.2042	6.9	2.213	4.898
.4467	.1995	**7.0**	**2.239**	**5.012**
.4416	.1950	7.1	2.265	5.129
.4365	.1905	7.2	2.291	5.248
.4315	.1862	7.3	2.317	5.370
.4266	.1820	7.4	2.344	5.495
.4217	.1778	7.5	2.371	5.623
.4169	.1738	7.6	2.399	5.754
.4121	.1698	7.7	2.427	5.888
.4074	.1660	7.8	2.455	6.026
.4027	.1622	7.9	2.483	6.166
.3981	.1585	8.0	2.512	6.310
.3936	.1549	8.1	2.541	6.457
.3890	.1514	8.2	2.570	6.607
.3846	.1479	8.3	2.600	6.761
.3802	.1445	8.4	2.630	6.918
.3758	.1413	8.5	2.661	7.079
.3715	.1380	8.6	2.692	7.244
.3673	.1349	8.7	2.723	7.413
.3631	.1318	8.8	2.754	7.586
.3589	.1288	8.9	2.786	7.762
.3548	**.1259**	**9.0**	**2.818**	**7.943**
.3508	.1230	9.1	2.851	8.128
.3467	.1202	9.2	2.884	8.318
.3428	.1175	9.3	2.917	8.511
.3388	.1148	9.4	2.951	8.710
.3350	.1122	9.5	2.985	8.913
.3311	.1096	9.6	3.020	9.120
.3273	.1072	9.7	3.055	9.333
.3236	.1047	9.8	3.090	9.550
.3199	.1023	9.9	3.126	9.772

TECH-AID

NO.76002

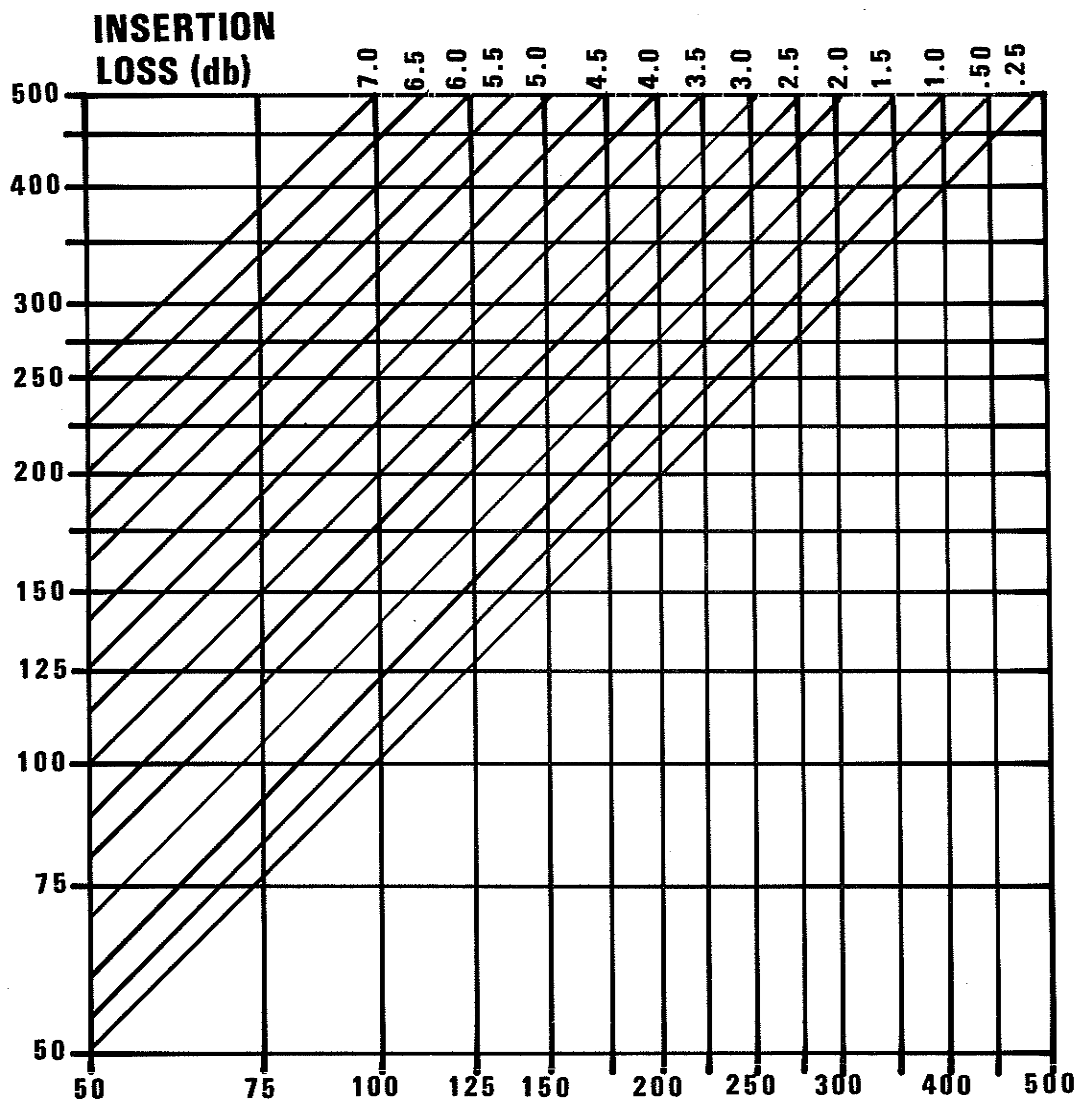
POWER IN/OUT VS. INSERTION LOSS

DATA REFERENCE

POWER FWD./REV. VS. VSWR

TX RX SYSTEMS, INC. offers this convenient means of determining the insertion loss of FILTER, DUPLEXERS, MULTICOUPLERS, and related products.

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, this graph should prove to be a useful reference.



OUTPUT POWER (WATTS)

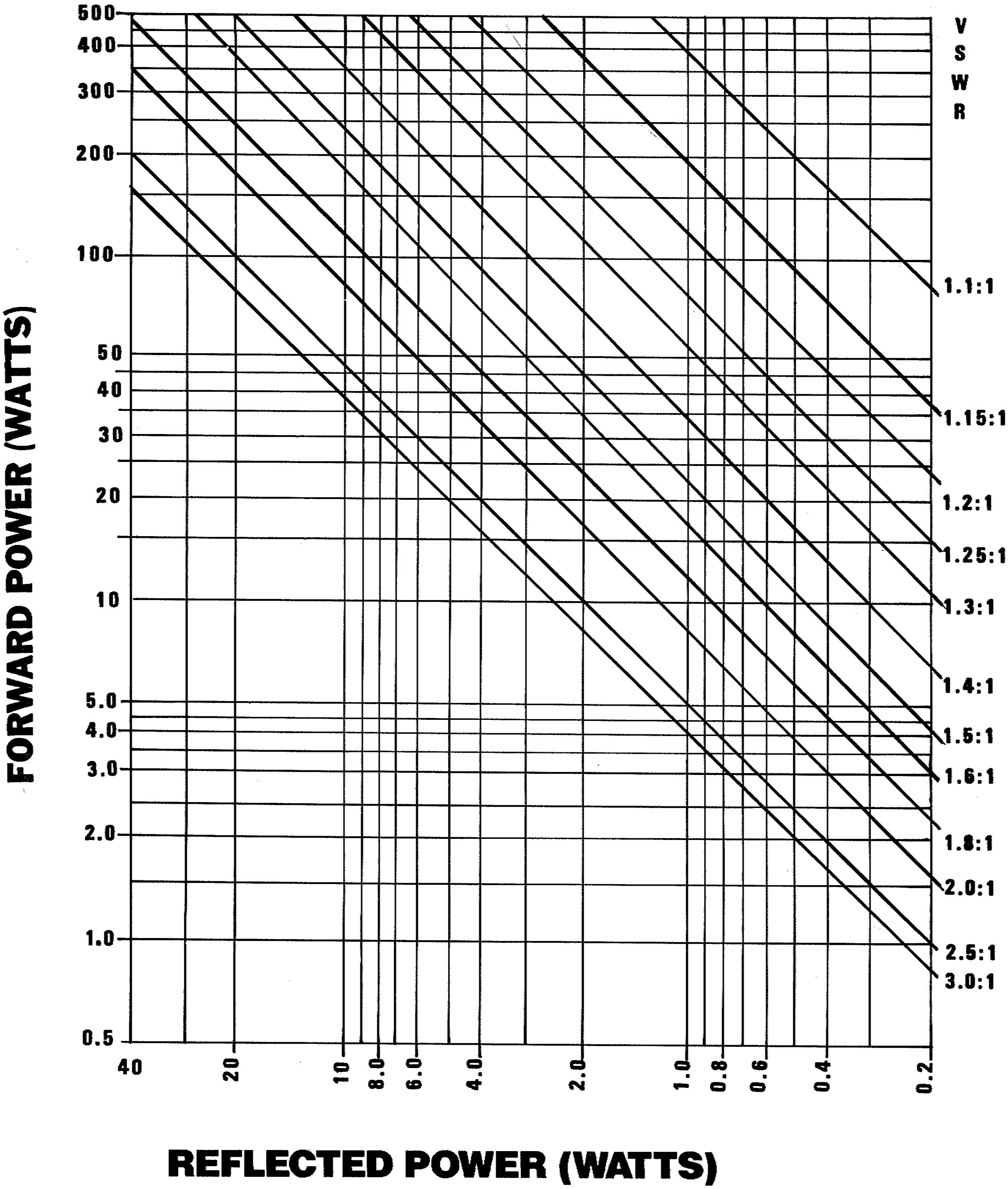
FOR LOWER POWER LEVELS, DIVIDE BOTH SCALES BY 10 (5 TO 50 WATTS)

DUPLEXERS • CAVITY FILTERS • MULTICOUPLER SYSTEMS • SIGNAL BOOSTER SYSTEMS • RF SYSTEM PRODUCTS

TX RX SYSTEMS INC. 8625 INDUSTRIAL PARKWAY, ANGOLA, NY 14006-9696
TELEPHONE 716-549-4700 FAX 716-549-4772 (24 HRS.)
A MEMBER OF BIRD TECHNOLOGIES GROUP

REFLECTED POWER (WATTS)

FOR OTHER POWER LEVELS, MULTIPLY BOTH SCALES BY THE SAME MULTIPLIER



TECH-AID

No. 93001

Measuring Insertion Loss with Wattmeters

Introduction

Passband insertion loss is a primary specification of a wide variety of passive RF devices. Typical insertion loss values are relatively small and therefore difficult to measure with anything but laboratory-quality instruments. At TX RX Systems Inc., we measure insertion loss with modern Hewlett Packard network analyzers. The calibration of our instruments is traceable to the National Bureau of Standards, and we take pride in the consistency and accuracy of our measurements.

It is not easy to *accurately* measure low values of insertion loss at high power, using ordinary radio transmitters as signal sources and RF wattmeters such as Bird Model 43s or similar. In fact, insertion loss under power cannot be measured directly: it must be *calculated* as a ratio of measured RF power at the output and input of the device under test, using the formula

IL (dB) = 10 x log(Po/Pi)

where Pi and Po are RF power at the input and output of the device, respectively.

This **Tech-Aid** explains why indirect insertion loss measurements made with a single wattmeter are prone to significant errors, and describes a two-wattmeter method that is more likely to be in agreement with measurements made with laboratory-quality instruments.

Single-Wattmeter Method

In general, it is <u>not</u> possible to use a single wattmeter to measure device input and output power with sufficient accuracy to verify factory insertion loss specifications. There are just too many possible sources of error.

Figure 1 describes a common method of performing the required power measurements. The device under test has a factory-measured insertion loss of -1.5 dB at the pass frequency. The wattmeter is a Bird Model 43 with a 50-watt element, and the transmitter is a 30-watt mobile transceiver. Random-length coaxial cables are used for equipment connections.

In **Figure 1A**, the transmitter is connected to the device under test via the wattmeter and test cables 1 and 2. The output of the device is connected to a 50-ohm load via cable 3. When the transmitter is keyed, the wattmeter indicates 32.3 watts forward power. We record Pi = 32.3 W.

In **Figure 1B**, the transmitter is connected to the device under test via cable 1. The output of the device under test is now connected to the load via cable 3, the wattmeter and cable 2. The wattmeter now indicates 20 watts forward power. We record Po = 20.0 W.

With the above power measurements, insertion loss is calculated as follows:

IL (dB)=10xlog(20/32.3)=10x(-0.21)=-2.1 dB

Is the filter out of specification? Before we reach any conclusions, let us take a close look at the possible sources of error inherent to the single-wattmeter method.

Sources of Measurement Error

1. Transmitter Load Impedance Changes

Substantially different lengths of cable are used to connect the device under test to the transmitter in **1A** and **1B**. If filter input impedance is not purely resistive and equal to 50 ohms, changing the length of cable between it and the transmitter can change the magnitude and phase of the load impedance presented to the transmitter. Transmitter output power may therefore change, due to the load impedance changes caused by moving the wattmeter and one cable from the input to the output of the device under test.

2. Wattmeter Position

Standing waves exist in a transmission line

3. Key the transmitter again and record forward power readings P3 and P4.
4. Calculate insertion loss as follows:
   IL (dB) = 10xlog[(P1xP4)/(P2xP3)]

Alternatively, calculate (P1xP4)/(P2xP3) as a numerical ratio and look up the equivalent loss in dB on **Tech-Aid** No. 81001, TX RX literature No. J(H)408D1.

The following measurements are obtained with the cavity filter in the previous example:

P1 = 28.7 W   P3 = 28.0 W

P2 = 24.0 W   P4 = 16.8 W

Computed insertion loss is:

Po/Pi = (28.7x16.8/24.0x28.0) = 0.7175

IL = 10xlog(0.7175) = -1.44 dB

This is within less than 0.1 dB of the factory specification for the filter under test.

In Case of Discrepancy

If you use the suggested two-wattmeter method and your insertion loss measurement does not agree with ours, there are two likely causes: either your transmitter is oscillating, or our equipment is indeed out of specification.

With the equipment arranged as in **Figure 2B**, insert a -30 dB RF sampler on the transmitter output and check transmitter spectral purity with a spectrum analyzer. Carefully scan a broad frequency range, as spurious outputs may sometimes appear at frequencies far removed from the carrier. If the transmitter is clean, it is safe to conclude that the equipment is out of specification. You should then file a warranty claim.

Other Precautions

1. Use wattmeter elements that produce a wattmeter reading at mid-scale or higher.
2. Use the best cable and connectors money can buy. If possible, connectors should be crimped and soldered. A bad connector will ruin your measurement.
3. Do *NOT* use UHF connectors or adapters! UHF connectors are notorious for their very bad impedance characteristics, even at VHF frequencies. Put type N connectors in your wattmeter .
4. Check the spectral purity of your test transmitter. All spurious products and harmonics must be at least 60 to 70 dB below the carrier when the transmitter is loaded as in **Figure 2B**.

CURVE FORMAT FOR TECH-AIDS

ALL PRODUCT LINES

NETWORK ANALYZER RESPONSE CURVE FORMAT

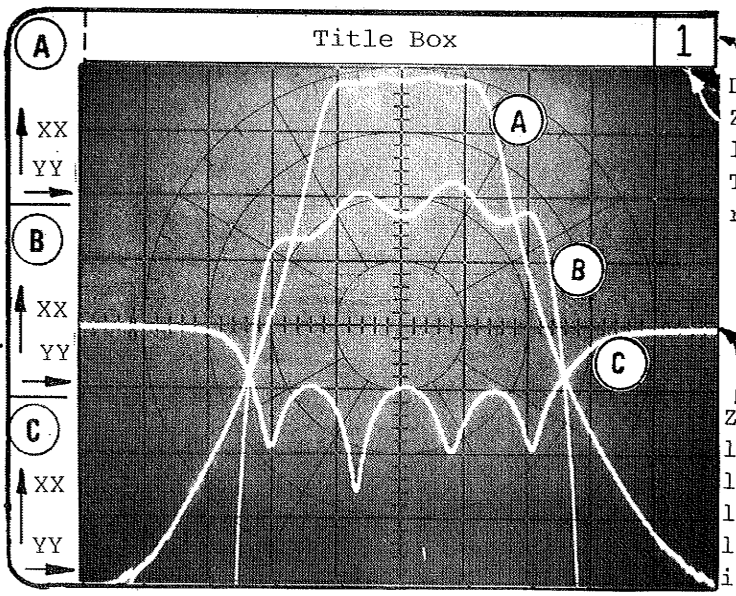
In order to adequately document the performance of our extensive line of filter and multicoupler products, we have created a pictorial series of Tech-Aids, using the power of our camera equipped network analyzer. A "sweep display" provides comprehensive performance data on any RF device by plotting its transmission and reflection characteristics, as illustrated by the receiver multicoupler preselector curves below. A glossary of terms and a description of the various product displays is provided on the back page.

(A)(B)(C)

Curve identification letters. Each data sheet contains its own key.

XX indicates vertical scale sensitivity in db/Div. for each curve.

YY indicates horizontal scale sensitivity in MHz/Div. for each curve



Display number. Zero dB reference line for all Transmission response curves.

Zero dB reference line for return loss and preamplifier gain, unless otherwise indicated.

ZZZ

Center Frequency

CONVERSION OF RETURN LOSS TO EQUIVALENT VSWR

dB	VSWR	dB	VSWR	dB	VSWR	dB	VSWR	dB	VSWR
46	1.01	27	1.09	21.5	1.18	14	1.50	6	3.01
40	1.02	26.4	1.10	20.7	1.20	13	1.58	5	3.57
37	1.03	26	1.11	20	1.22	12	1.67	4	4.42
34	1.04	25	1.12	19	1.25	11	1.78	3	5.85
32	1.05	24	1.13	17.7	1.30	10	1.92	2	8.72
30.4	1.06	23.5	1.14	17	1.33	9	2.10	1	17.40
29	1.07	23	1.15	16	1.38	8	2.32	.5	34.78
28	1.08	22	1.17	15	1.43	7	2.61	0	∞

Y(H)305L0

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MEASUREMENT TERMINOLOGY

RETURN LOSS: This display indicates how well a terminal is matched to 50 ohms. Expressed in db, it is a measure of reflected energy with reference to the forward energy. A zero db return loss indicates all the energy is reflected back to the source. A perfect match would be indicated by an infinite return loss, meaning all the energy has been transferred and no energy has been reflected. A chart is provided on page one for easy conversion from return loss to VSWR. No direct relationship exists between return loss, and insertion loss through a device, though a poor match or return loss will add to the overall insertion loss.

TRANSMISSION LOSS: A measure of signal reduction though a device, relative to the input signal level, expressed in db. In the passband, this loss is referred to as insertion loss, and in the stop band, as attenuation or isolation. If amplifiers are present in the system, a transmission gain may also be indicated above some 0 db reference line, usually, the center of the display.

DISPLAY FORMATS

PRESELECTORS (Factory set passbands)

Three response curves are generally sufficient: an expanded passband transmission response, a total transmission response, and a passband return loss response. These are generally shown on a single display.

BANDPASS FILTERS (Narrowband, adjustable insertion loss)

One display may be used to show one set of response curves for a single insertion loss setting. Two displays per filter are used to show a "family" of selective responses, one for expanded passbands and return loss, and one for companion total transmission responses.

DUPLEXERS

There are three types of filter designs used having distinctly different response characteristics, these being T-pass (bandpass), VARI-NOTCH (pseudo-bandpass), and SERIES NOTCH (band reject or standard notch). In all cases, two displays are used. One shows expanded passbands and related return loss. The second shows overall high pass and low pass response curves. The pseudo-bandpass (VARI-NOTCH) and bandpass (T-pass) duplexers also have a third response showing overall broadband attenuation between Tx and Rx terminals with antenna terminated in 50 ohms.