FP-1049

DUPLEXER TUNING INSTRUCTIONS

Q-5__D SERIES

MANUAL CM-146

SINCLAIR RADIO LABORATORIES

P.O. Box 23 675 Ensminger Road, Tonawanda, New York 14150 (716) 874-3682 Telex 91-9198

DUPLEXER INSTALLATION PROCEDURE

This duplexer comes to you tuned and ready to install in your system, no field tuning is required. The following steps should be taken to insure proper installation.

1. Verify that your station duplex frequencies are the same as those to which the duplexer is tuned. These frequencies are on the unit identification label.

2. Without the duplexer in the system, tune the transmitter into the station antenna and measure the output and reflected power. These readings will be used as the parameters to which the duplexer is compared.

3. Install the duplexer into the system with the wattmeter between the transmitter and duplexer. Connect the station antenna to the duplexer antenna terminal. Retune the transmitter and read the forward and reflected power. Using these power readings, the VSWR of the duplexer can be determined from the chart titled "Power Values vs. VSWR" (CI-056). The typical VSWR is 1.25:1 or less and the maximum is 1.5:1.

4. Next, measure the output power from the duplexer into the station antenna. Divide this reading by the net input power (net power = input power - reflected power from step 3 above). Turn to the chart titled "Conversion of Voltage and Power Ratios to Decibels" and find your power input in the column titled "Power Ratio", then follow across the chart to the column "Attentuation dB" to locate your duplexer's insertion loss. This value should be equal to, or less than, the specification of the duplexer.

5. To check the receiver insertion loss, inject the receive frequency into the receiver with a signal generator and obtain an unsaturated first limiter reading. Note the generator output level. Next, connect the receiver terminal of the duplexer to the receiver and inject the receive frequency into the antenna terminal of the duplexer. Adjust the generator for the same limiter reading and note the generator output level. The difference between this reading and first reading is the insertion loss of the duplexer.

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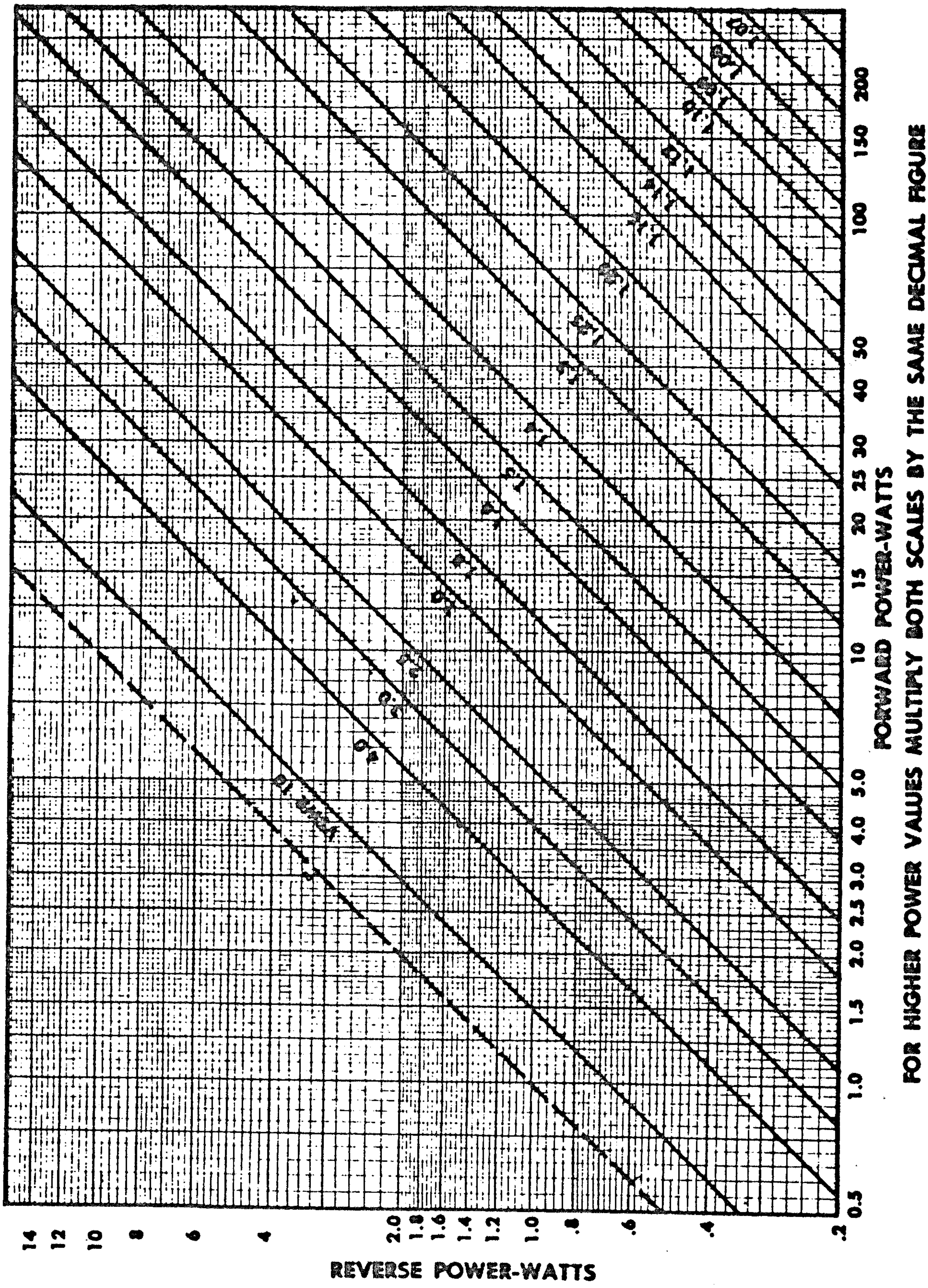

POWER VALUES vs. VSWR

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DETAILED TUNING PROCEDURE

FOR

Q-5__D SERIES DUPLEXERS

TEST EQUIPMENT REQUIRED

1. FM Signal Generator (Measurements Model 612A or equivalent)
2. Receiver on high duplex frequency
3. Receiver on low duplex frequency
4. Receiver test monitor for first limiter or suitable voltmeter
5. 50 ohm 6 dB pad (optional)
6. 50 ohm 10 dB pad
7. Step attenuator in 0.1 dB steps (optional for measurement of low insertion losses) Kay Model 1/432C or equivalent
8. 50 ohm test cables.

GENERAL DESCRIPTION OF CAVITY OPERATION AND TUNING PROCEDURE

The Q-5__D Series Duplexers are constructed using a new and improved notch type filter section. The basic filter section is shown in I.D. 3069, along with the Tuning Procedure.

The interconnection of these two filter sections to produce various model duplexers is shown in the Intercabling Diagram for that model listed on the EMI Sheet with all the enclosures pertaining to the complete instruction.

TUNING PROCEDURE

1. Refer to I.D. 3070 for the intercabling diagram of the Q-5__D duplexers. Isolate the filter sections as shown on I.D. 3069 by removing interconnecting cables.

2. Tune each filter section as outlined in I.D. 3069.

3. Reconnect the filter sections into complete duplexer assembly and measure isolation and insertion loss as described in Field Measurement Techniques, CI-096-1.

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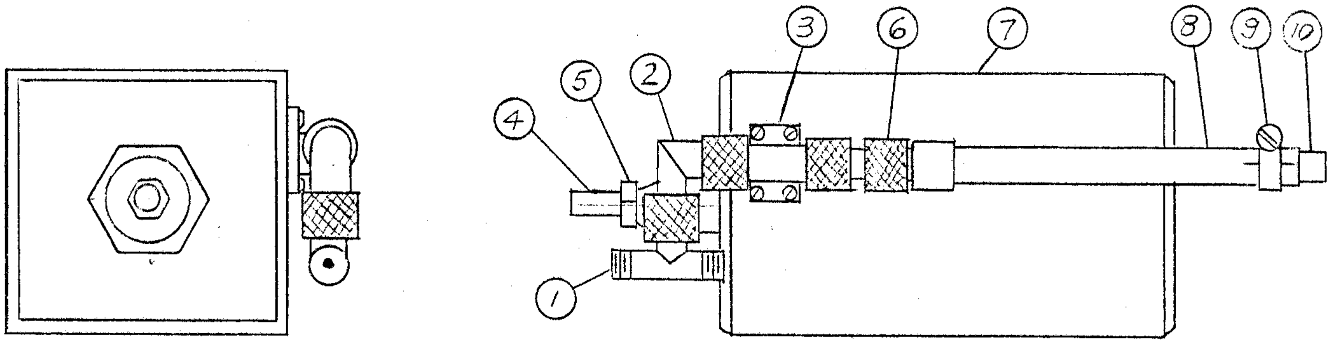
Q-5__D SERIES

CAVITY TUNING PROCEDURE



1. Tee (TNC) across which filter response is observed
2. TNC Elbow Connectors
3. Loop Assembly
4. Cavity Tuning Rod
5. Tuning Rod Locknut
6. TNC Double Male
7. Cavity Body
8. Open Circuited stub (dielectrically tuned). Barrel length for low pass cavity is 4-1/2", for high pass cavity is 3-1/4".
9. Stub Tuning Lock
10. Stub Tuning Rod (dielectric sliding over open center conductor).

GENERAL THEORY

The filter section response appears across tee connector (1). A notch or rejection pull is created at the unwanted frequency with the variable open circuited stub. The cavity probe is adjusted for minimum insertion loss at the desired pass frequency. (It will be noted that this filter operates in a reverse manner as compared with a conventional notch filter where the cavity probe tunes the rejection notch. This method of tuning the pass and the reject is referred to as Q-Switch tuning and is patented.)

TUNING PROCEDURE

1. Isolate the high pass cavities from the low pass cavities. As noted above, the longer stub is on the low pass cavities. In addition, each cavity is marked LOW or HIGH Pass with a label. Tune each cavity separately following the procedure below.
2. Feed the frequency to be passed across Tee (1) and tune cavity probe for minimum insertion loss. The position of the stub has no effect on this step.
3. Feed the frequency to be rejected across Tee (1) and tune the adjustable stub for a maximum attenuation of this signal.
4. Repeat Steps 2 and 3 as a final check. The stub is always set last. The stub has no appreciable effect on the setting of the cavity probe for the pass frequency but the setting of the cavity probe will affect the required setting of the reject frequency. It is for this reason that the stub is set last. Lock cavity probe and stub in place.

The loop coupling in the cavity is set at the factory. Typical performance at 3.6 MHz separation is 29-31 dB attenuation for .35-.4 dB insertion loss.

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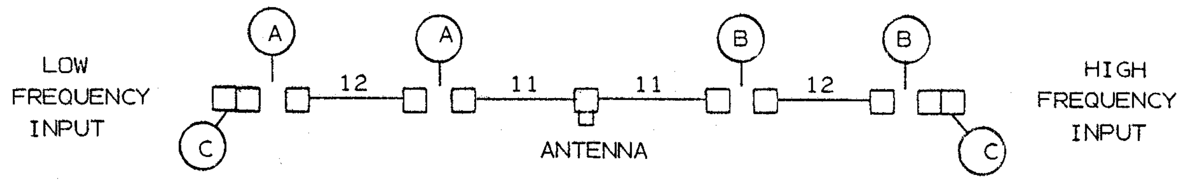
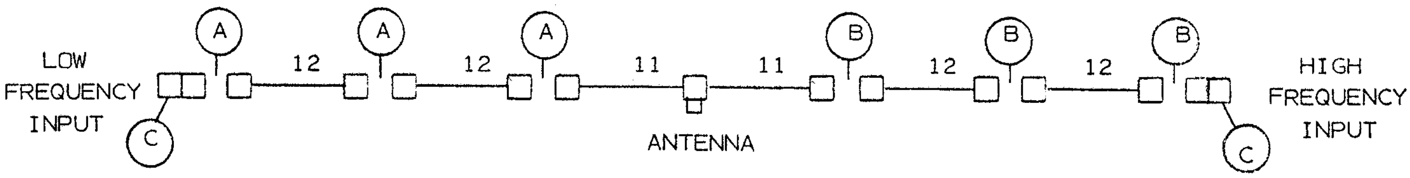
Q-501D AND Q-503D
INTERCABLING DIAGRAM



Q-502D DUPLEXER
INTERCABLING DIAGRAM



DESCRIPTION

The Q-5__D Series filter section (see I.D. 3069) is the basic building block for the Q-5__D Series Duplexers. In the Q-501D and the Q-503D, four of these filters are interconnected as shown above to form the duplexer. The Q-502D duplexer has six filters interconnected to form the duplexer.

IDENTIFICATION

(A) Q-Switch filter sections as described in I.D. 3069. These are low pass filters, tuned to reject the high duplex frequency and pass the low duplex frequency.

(B) Q-Switch filter section as described in I.D. 3069. These are high pass filters, tuned to reject the low duplex frequency and to pass the high duplex frequency.

(C) Input connectors which are attached directly to the first filter on both inputs. These are 'TNC' to 'N' adaptors (Amphenol #79825).

(11) Cables which make up the antenna junction are soldered directly into the special antenna connector ('N' female).

(12) Cables are three quarterwave interconnecting cables (RG 142/u).

SPECIFICATIONS

MODEL	POWER RATING	INSERTION LOSS (B)	*ATTENUATION (B)	INPUT V.S.W.R.*
Q-501D & Q-503D	125 watts	1.3 max.	70 min.	less than 1.5:1
Q-502D	125 watts	1.6 max.	95 min.	less than 1.5:1

* With 50 ohm load on antenna junction

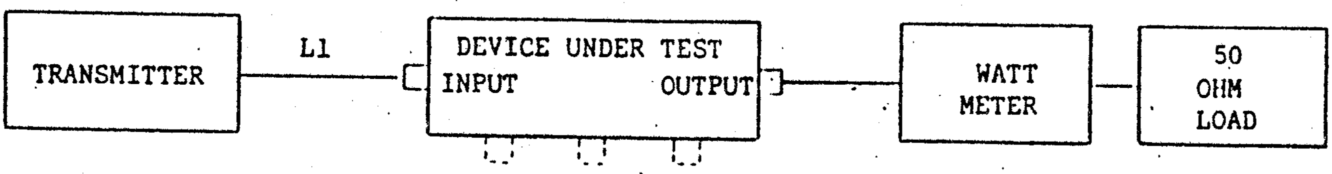
ATTENTUATION AND INSERTION LOSS FIELD MEASUREMENT TECHNIQUES

These instructions are intended to provide reasonably accurate insertion loss and attenuation measurements on filters, duplexers and multicouplers in the field using minimum test equipment.

INSERTION LOSS MEASUREMENTS

Two methods are presented, the first is used for measuring transmitter insertion loss using the transmitter and a wattmeter. The second method is general and can be used for either transmitter or receiver insertion loss measurements.

TRANSMITTER INSERTION LOSS MEASUREMENTS - The VSWR of the wattmeter should be 1.2:1 or less and the use of numerous adaptors in making connections should be avoided because the VSWR of these is often poor and will degrade the measuring system. UHF adaptors and connectors should be avoided when ever possible because their impedance characteristics vary widely with frequency.



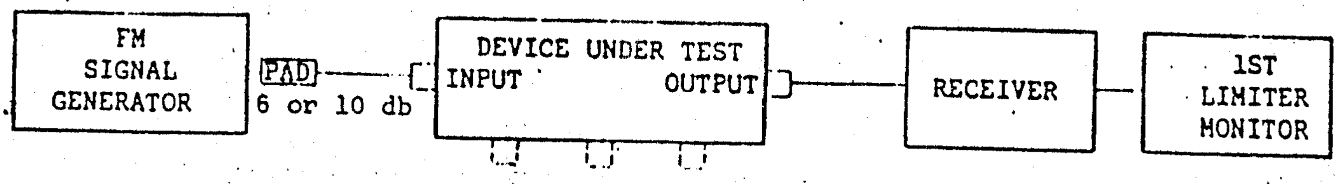
Install the device to be measured in the circuit as shown above, tune the transmitter for maximum power out. If the reflected power is not zero or near zero, then cable L1 should be adjusted to give the highest output power (lowest reflected power) when tuning the transmitter into the device. There will be some VSWR looking into the device and length L1 will determine the reactive component reflected to the transmitter. Because the adjustment range of the transmitter output is limited, it has been found that adjustment of L1 for maximum output can prove advantageous for lowest insertion loss.

An arbitrary length for L1 may be chosen and then varied by the addition of 1/8, 1/4, or 3/8 wavelengths, each time retuning the transmitter. The addition of one of these lengths, or the initial length of L1 will give maximum power out with a minimum of plate current. The trial lengths for polyethylene dielectric (solid) cables can be computed from these formulas.

$\lambda g/8$ = 973/freq. in MHz, $\lambda g/4$ = 1946/freq. in MHz, $3\lambda g/8$ = 2919/freq. in MHz

When maximum power output has been obtained through the device, note this power, then disconnect the device from the final length of L1 and connect directly to the wattmeter and load. Retune the transmitter, maintaining the same coupling and note the power output. You can now compute the power ratio, which is equal to power out (with device)/power out (without device). Page CI-099 will give the insertion loss value for the calculated power ratio.

SUBSTITUTION METHOD FOR INSERTION LOSS MEASUREMENT - Assemble the test set up as shown on the next page. The remaining terminals need not be terminated if the device under test is a duplexer or multicoupler. Inject the frequency and obtain a reference level on the first limiter monitor, taking care not to saturate the limiter circuit. Note the microvolt signal level and the generator output (dbm). Next, inject the signal directly into the receiver and decrease the signal generator output until the same reference level is obtained. The insertion loss is the difference in dbm as taken from the generator dial or the ratio of microvolts, using the following relationship,



and then referring to the table on CI-099.

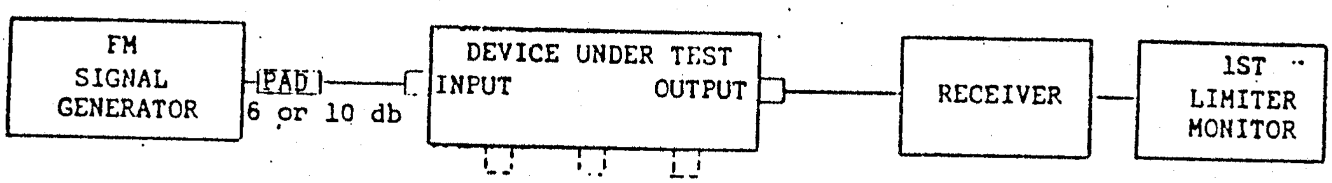
Voltage ratio = microvolts (w/o device)/microvolts (w/device)

A step attenuator providing small db increments (0.1, 0.2, 0.5, 1.0) can be used to provide more accurate readings. The attenuator should be connected to the generator output. Snap in and leave in about 6 db to pad the generator output. Take the reading with the device in the circuit, then remove the device and connect the two leads together. Snap in attenuation to bring the level down to the same reference level. The insertion loss is the equal to the amount of dbs snapped in (do not count in the value you had for padding purposes).

EQUIPMENT NOTES:

1. Quick slip connectors can be made by sawing off the outer barrel of male plugs. They can then be inserted in a variety of female contacts such as "N", "BNC", or "TNC" jack.
2. Use a minimum of adaptors in test cables, especially UHF and conversion types between "N", "UHF", or "BNC". The VSWR and associated phase shift of "UHF" type connectors can cause erroneous readings, especially when measuring low values of insertion loss.
3. FM signal generator may be measurements model 560 M or equivalent. The step attenuator is one providing 0.1 db increments for measurement of low insertion losses using the substitution method. This may be omitted and the attenuator on the signal generator substituted, but with substantial loss of resolution. (Kay model 1/432 C or equivalent).
4. The length between the duplexer and the receiver may have some effect on insertion loss and may be adjusted if desired, but it has been found that the receiver is not as sensitive or as easily disturbed by slight mismatches.

ATTENUATION MEASUREMENTS



Insert the two terminals, between which the attenuation is to be measured, into the test circuit above. If the device has more than two terminals, as a duplexer or multi-coupler, terminate all remaining terminals with 50 ohms before making measurements.

Using a signal generator and receiver on the test frequency, set the signal generator drive for a readable but unsaturated level on the list limiter monitor. Note a reference level on the first limiter monitor and the dbm level on the signal generator attenuator or the microvolt reading on the generator attenuator. Remove the filter terminals and connect leads of the test circuit together. Reduce the output on the signal generator until the reference level on the 1st limiter monitor is obtained. Note the dbm level on the signal generator attenuator. The difference between this and the previous level represents the filter attenuation in db. If the microvolt readings are used, the attenuation can be obtained from the ratio of the two readings, then referring to the chart on CI-099 using the closest tabulated value.

Voltage ratio = microvolts (w/o device)/microvolts (w/device)

Consult the data Sheet or Detailed Tuning Procedure of the particular model under test for typical values of Insertion loss and attenuation.

PRECAUTIONARY MEASURES FOR MORE RELIABLE MEASUREMENTS - RF leakage is occasionally a problem when measuring filter attenuations in the area of 60 db or greater. When measuring attenuations over 80 db, RG-58/u cable should not be used because of excessive radiation. RG-8A/u or RG-213/u cable will permit measurements of 100-110 db only if input and output filter cables are not in close proximity. Double shielded cable, as RG-9/u or RG-142/u, is advised for measurements over 80 db. Occasionally, RF leakage occurs because of excessive radiation from the signal source, insufficient shielding of the receiver or a combination of all the above. If the measurements of a filter section indicates a lower level of attenuation than expected, a parallel path of lower attenuation (RF leakage) may be the reason. If this occurs, you will not be able to measure attenuations greater than the leakage path. If leakage is suspected, a simple test can be made as follows: insert the terminals of the filter under test and obtain a reference level on the first limiter monitor, using sufficient generator drive for a readable but unsaturated level. Note the dbm level of drive on the signal generator. Now insert a known level of attenuation in series with the filter section, as a 6 or 10 db pad. It should be necessary to increase the signal generator drive, in dbm, by the amount of attenuation added to obtain the previous reference level on the first limiter monitor. If RF leakage is occurring, the signal generator drive will be practically the same, indicating a path for RF other than thru the filter section. It can be easily shown if the filter section is responsible for the RF leakage. The results of the leakage test should be unaffected by placing the additional attenuation before or after the filter section in the test circuit, allowing for slight variation due to possible VSWR level of the attenuator. The 10 db pad should be left on the generator output at all times since the generator is looking into an unmatched line at this frequency. In actual practice, the cable length connecting the transmitter to the duplexer will affect the total amount of noise suppression, since the transmitter is an unmatched source of receiver noise power on the receiver frequency and is looking into a reflective load. The cable length which gives the greatest mismatch at the receiver frequency will provide the best noise suppression. Likewise, an adverse length can be chosen which will actually reduce the noise suppression by about 6 db less than the value measured, using a padded signal source. Unfortunately, this length is already adjusted for the best transmitter output through the duplexer. Since there are a few other uncontrollable factors affecting noise suppression such as varying frequency separations and internal extension cable lengths in the duplexer, the best solution is to provide an adequate safety margin of 10-15 db above the theoretical value specified by the manufacturer or systems supplier.

CONVERSION OF VOLTAGE AND POWER RATIOS TO DECIBELS

VOLTAGE RATIO	POWER RATIO	DB
1.0000	1.0000	0.0
.9886	.9772	0.1
.9772	.9550	0.2
.9661	.9333	0.3
.9550	.9120	0.4
.9441	.8913	0.5
.9333	.8710	0.6
.9226	.8511	0.7
.9120	.8318	0.8
.9016	.8128	0.9
.8913	.7943	1.0
.8810	.7762	1.1
.8710	.7586	1.2
.8610	.7413	1.3
.8511	.7244	1.4
.8414	.7079	1.5
.8318	.6918	1.6
.8222	.6761	1.7
.8218	.6607	1.8
.8035	.6457	1.9
.7943	.6310	2.0
.7852	.6166	2.1
.7762	.6026	2.2
.7674	.5888	2.3
.7586	.5754	2.4
.7499	.5623	2.5
.7413	.5495	2.6
.7328	.5370	2.7
.7244	.5248	2.8
.7161	.5129	2.9
.7079	.5012	3.0
.6998	.4898	3.1
.6918	.4786	3.2
.6839	.4677	3.3
.6761	.4571	3.4
.6683	.4467	3.5
.6607	.4365	3.6
.6531	.4266	3.7
.6457	.4169	3.8
.6383	.4074	3.9
.6310	.3981	4.0
.6237	.3890	4.1
.6166	.3802	4.2
.6095	.3715	4.3
.6026	.3631	4.4
.5957	.3548	4.5
.5888	.3467	4.6
.5821	.3388	4.7
.5754	.3311	4.8
.5689	.3236	4.9
.5623	.3162	5.0

VOLTAGE RATIO	POWER RATIO	ATTENTUATION DB
.5012	.2512	6
.3162	1×10^{-1}	10
.1778	$.3162 \times 10^{-1}$	15
1×10^{-1}	1×10^{-2}	20
$.5623 \times 10^{-1}$	$.3162 \times 10^{-2}$	25
$.3162 \times 10^{-1}$	1×10^{-3}	30
$.1778 \times 10^{-1}$	$.3162 \times 10^{-3}$	35
1×10^{-2}	1×10^{-4}	40
$.5623 \times 10^{-2}$	$.3162 \times 10^{-4}$	45
$.3162 \times 10^{-2}$	1×10^{-5}	50
$.1778 \times 10^{-2}$	$.3162 \times 10^{-5}$	55
1×10^{-3}	1×10^{-6}	60
$.5623 \times 10^{-3}$	$.3162 \times 10^{-6}$	65
$.3162 \times 10^{-3}$	1×10^{-7}	70
$.1778 \times 10^{-3}$	$.3162 \times 10^{-7}$	75
1×10^{-4}	1×10^{-8}	80
$.5623 \times 10^{-4}$	$.3162 \times 10^{-8}$	85
$.3162 \times 10^{-4}$	1×10^{-9}	90
$.1778 \times 10^{-4}$	$.3162 \times 10^{-9}$	95
1×10^{-5}	1×10^{-10}	100
5623×10^{-5}	$.3162 \times 10^{-10}$	105
$.3162 \times 10^{-5}$	1×10^{-11}	110
$.1778 \times 10^{-5}$	$.3162 \times 10^{-11}$	115
1×10^{-6}	1×10^{-12}	120