DUPLEXER TUNING INSTRUCTIONS

Models:
R-101G thru R-116G
R-1C01G, R-1C02G, R-1A01G

CM-169

ATTENTION:

For those of you with older units we include a cross-reference from old model number to new model numbers. The duplexers are identical, the model numbering system was changed for greater flexibility.

Old Number	1st Interim	2nd Interim	New Number
2H-30-4R6A	2H-30-4R6	H-30-6-308S	R-101G
2H-30-3R6A	2H-30-3R6	H-30-6-306S	R-104G
	2H-30-304S	H-30-6-304S	R-107G
2H-30-4R6B	2H-37-4R6	H-37-6-308S	R-102G
2H-30-3R6B	2H-37-3R6	H-37-6-306S	R-105G
	2H-37-304S	H-37-6-304S	R-108G
2H-30-4R6C	2H-43-4R6	H-43-6-308S	R-103G
2H-30-3R6C	2H-43-3R6	H-43-6-308S	R-106G
	2H-43-304S	H-43-6-304S	R-109G
	2H-66-304S	H-66-6-304S	R-1C01G
	2H-77-304S	H-77-6-304S	R-1C02G

DUPLEXER INSTALLATION PROCEDURE

THIS DUPLEXER COMES TO YOU TUNED AND READY TO INSTALL IN THE SYSTEM, NO FIELD TUNING HAS TO BE DONE ON THE DUPLEXER. THE FOLLOWING STEPS SHOULD BE FOLLOWED 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. FROM THE CHART ON THE BACK OF THIS PAGE, USING THESE POWER READINGS, THE VSWR OF THE DUPLEXER CAN BE FOUND. THE TYPICAL VSWR IS 1.25:1 OR LESS, 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 INPUT POWER = INPUT POWER - REFLECTED POWER FROM #3). GO TO PAGE CI-099 AT THE END OF THIS MANUAL AND LOOK DOWN THE HEADING POWER RATIO, FOR A NUMBER THAT IS CLOSEST TO THE CALCULATED VALUE. THEN LOOK TO THE RIGHT OF THIS NUMBER, UNDER THE DB COLUMN, AND READ THE INSERTION LOSS OF THE DUPLEXER. THIS VALUE SHOULD BE EQUAL TO, OR LESS THAN, THE SPECIFICATION OF THE DUPLEXER.

5. TO CHECK THE RECEIVER INSERTION LOSS, INJECT THE RECEIVER 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 RECEIVER 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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DUPLEXER TUNING INSTRUCTIONS

General Description

The duplexer is made up of four, six or eight reject type cavities, depending on the model. Half of the cavities reject the high duplex frequency and pass the low and are interconnected by one-quarterwave cable (RG-213/U). The other half of the cavities reject the low duplex frequency and pass the high. They are also interconnected with one-quarterwave cables. The two halves are connected to the antenna junction with one-quarterwave cables to form the duplexer.

The cavity used in the duplexers is a six inch diameter aluminum shell with a semihelical center resonator. Tuning the cavity is accomplished by a sliding tuning plunger which is locked in position by a 10-32 x ¼" Allen Hex Set Screw. The reject notch is adjusted by tuning the cavity tuning rod. The pass band is positioned by using an open circuited stub on the cavity input, and determined at the factory on order.

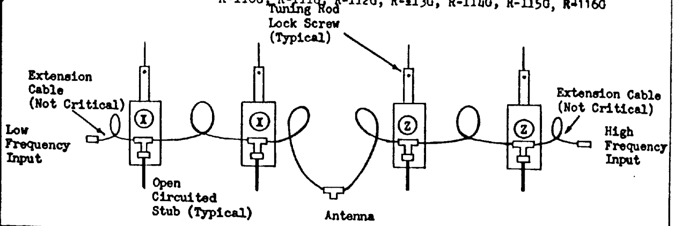
The frequency band of 30 to 50 MHz is divided into three tuning segments because of mechanical limitations of the cavity design. The three sub-bands are 30-37 MHz, 37-43 MHz and 43-50 MHz. Models from one sub-band cannot be tuned to work in another sub-band without extensive factory reworking. The frequency band of 66 to 88 MHz is divided into two sub-bands, 66-77 MHz and 77-88 MHz. The frequency band of 25-30 MHz is covered by one cavity. The table below lists the duplexer models giving the number of cavities, tuning range, minimum duplex frequency separation, and electrical specifications.

MODEL	TUNING RANGE (MHz)	MINIMUM FREQ. SEPARATION (MHz)	NUMBER of CAVITIES	MAX. INSERTION LOSS (db)	MINIMUM ISOLATION (db)	POWER WATTS
R-101G	30-37	0.3	8	1.6	95	350
R-102G	37-43	0.3	8	1.6	95	350
R-103G	43-50	0.3	8	1.6	95	350
R-104G	30-37	0.5	6	1.6	80	350
R-105G	37-43	0.5	6	1.6	80	350
R-106G	43-50	0.5	6	1.6	80	350
R-107G	30-37	0.5	4	1.0	65	350
R-108G	37-43	0.5	4	1.0	65	350
R-109G	43-50	0.5	4	1.0	65	350
R-110G	30-37	1.0	4	1.0	70	350
R-111G	37-43	1.0	4	1.0	70	350
R-112G	43-50	1.0	4	1.0	70	350
R-113G	30-37	1.0	4	1.0	70	350
R-114G	37-43	1.0	4	1.0	70	350
R-115G	43-50	1.0	4	1.0	70	350
R-1C01G	66-77	1.0	4	1.0	65	350
R-1C02G	77-88	1.0	4	1.0	65	350
R-1A01G	25-30	2.0	4	1.0	60	350
R-116G	30-37 37-43 split band	1.0	4	1.0	70	350

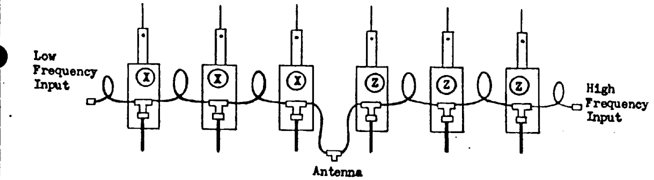
Wiring Diagrams

(X) Cavities Reject High Duplex Frequency and Pass Low
(Z) Cavities Reject Low Duplex Frequency and Pass High

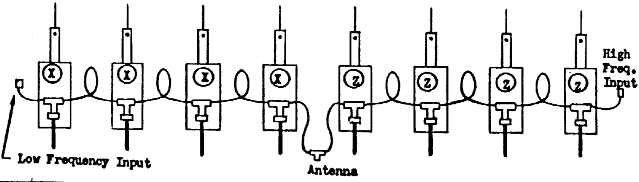
1. Four Cavity Duplexer: R-107G, R-108G, R-109G , R1C01G, R-1C02G, R-1A01G
R-110G, R-111G, R-112G, R-113G, R-114G, R-115G, R-116G



2. Six Cavity Duplexer: R-104G, R-105G, R-106G



3. Eight Cavity Duplexer: R-101G, R-102G, R-103G



Tuning Procedure

Important notice: When retuning, please observe the minimum separation from chart for your model. You CANNOT tune the duplexer closer than stated. AND, you CANNOT tune the reject notch outside the sub-band of the duplexer.

A. PROCEDURE FOR PEAKING UP DUPLEXER TO ORIGINAL FREQUENCIES OR TO SOME WHICH ARE LESS THAN APPROXIMATELY 40 KHz DIFFERENT IN SEPARATION FROM ORIGINALS

Since you are not shifting frequencies much, the open circuited stubs will not have to be changed. Tuning the duplexer consists of setting the rejection notches on each cavity in the unit. Minimum equipment requirements are: FM Signal Generator (Measurements Model 560 M or equivalent), Receivers on each of the duplex frequencies (or one which will tune both) and a first limiter monitor meter. (See CI-096 for basic test circuit).

1. Set the signal generator on the high duplex frequency, inject this signal into the low frequency input terminal and detect it at the high frequency terminal. Terminate antenna port with 50 ohms. Tune the rods on the reject high (pass low) cavities, (X), for minimum signal (attenuate). Adjust the output of the signal generator as necessary to maintain a readable but unsaturated level on the first limiter monitor. The tuning rods are sliding type and are locked in position by a 10-32 HEX socket type Allen Set Screw.

2. Set the generator to the low duplex frequency, inject this signal into the high frequency terminal and detect it at the low frequency terminal. Terminate antenna port with 50 ohms. Tune the rods on the reject low (pass high) cavities (2) for minimum signal (attenuate). Lock rods in position.

The duplexer is now tuned, measurements can be made by techniques described on Sheet CI-096.

B. PROCEDURE FOR RETUNING DUPLEXER TO A DIFFERENT SEPARATION, GREATER THAN APPROXIMATELY 40 KHz OF ORIGINAL, OR SHIFTING TO ANOTHER SET OF FREQUENCIES IN OPPOSITE END OF SUB-BAND.

In general we advise that the above type of retuning be done at our plant because of the critical length changes in the open circuited stubs which set the pass bands. The techniques used for determing the correct stub length requires equipment which must be able to measure insertion losses of 0.2 to 0.4 db . For those of you who have such equipment available, and would try this procedure the following discussion is offered.

The cavities you have are set for a certain separation in some part of the sub-band. If you are staying in the same part of the sub-band and only changing separation the length of the stubs will change according to the following rule:

A. For reject low cavities (high pass) - the greater the separation the shorter the stub length.

B. For reject high cavities (low pass) - the greater the separation the longer the stub length.

Example:

You have an R-1010 working at 31.40 and 31.70. You wish to retune to new frequencies of 31.80& 32.50. The old separation was 300 KHz. The new one is 700 KHz. Therefore, the high pass cavity (rejection) stub will want to be shorter, and the low pass cavity (reject high) will want to be longer.

To determine the actual length needed you will be working with one cavity from each side of the duplexer. First tune a reject high cavity to reject your new high frequency, leave the existing stub on. Now go to your low frequency (pass) and read the insertion loss. It should be fairly high 0.5 to 1.5 db. This stub will want to be longer. Either add elbows to lengthen it, or cut a new piece of Rg 213/u or RG 8 A/u about 10" longer than that stub. Put the new stub on and trim it off about ½" at a time, until the insertion loss is minimized (.2-.4db). Now go back to the reject frequency and peak up the notch. Then read the insertion loss at pass frequency again, it should not have changed. You can now cut more stubs for each of the other reject high cavities the same length as the one you just worked out.

Next do the same tuning procedure on the reject low cavity (high pass). In this case the stub will want to become slightly shorter. First tune to new reject low frequency then read insertion loss with existing stub. Then trim back on stub until insertion loss is minimized. Then repeak reject notch and check insertion loss. You can now cut more stubs the same length for the other reject low cavities.

After cutting and installing new stubs on all cavities in the duplexer, follow the previously outlined procedure for tuning.

When shifting from one end of sub-band to the other, it may require stub length changes even though the separation is the same. The reason for this is that percentage-wise, the .300 MHz or .500 MHz minimum separations are different from one end of the sub-band to the other (an example of this is a .300 MHz separation at 37 MHz is equivalent to a .405 MHz separation at 30 MHz)

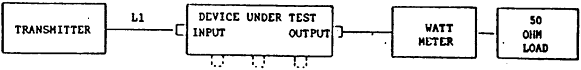
ATTENTUATION AND INSERTION LOSS
FIELD MEASUREMENT TECHNIQUES

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.



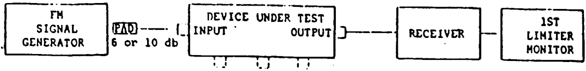
Install the device to be measured in the circuit as shown above, tune the transmitter for maximum power out. If the reflected power is not zero or near zero, then cable L1 should be adjusted to give the highest output power (lowest reflected power) when tuning the transmitter into the device. There will 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.

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

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.

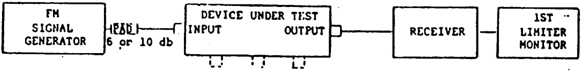
Voltage ratio = microvolts (w/o device)/microvolts (w/device)

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 multicoupler, 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)

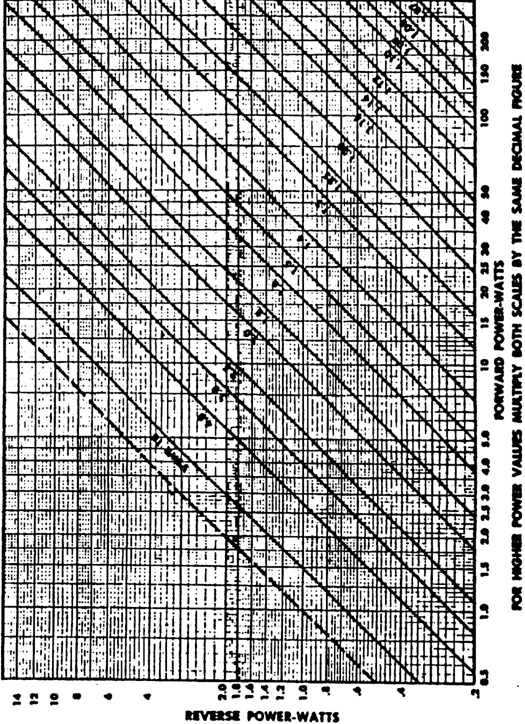
Consult the data Sheet or Detailed Tuning Procedure of the particular model under test for typical values of Insertion loss and attenuation.

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



POWER VALUES vs. VSWR