DUPLEXER PROBLEMS AND REMEDIES

TECH-AID NO. 76007

FOR BROCHURES : 30-136 MHz, 132-250 MHz, 406-512 MHz, 806-1300 MHz
LIT. ORDER NO. : A1004, A1104, A1204, A1304

ALSO AVAILABLE:
TECH-AID 80009 (LIT. ORDER NO. C3104H9) DUPLEXER RESPONSE CURVES

INTRODUCTION:

As an aid to those in the field concerned with servicing Duplexers, TX RX SYSTEMS INC. offers this field service guide along with our thanks for their contributions to its contents. Advice from our customers is always most welcome and is a prime source for designs and applications.

Duplexers are passive devices requiring little or no service once installed in a system. The proper design and application of a given Duplexer will give years of trouble free service. When problems do occur in a duplex system it is necessary to identify as many abnormal conditions as possible to zero in on the specific cause of the problem.

Unfortunately, there are only a few measurable or observable performance indicators at the disposal of the field serviceman, and any number of conditions may exist, even simultaneously, which are responsible for the observed phenomena.

Most Duplexer installation problems fall into three categories. Each of these three conditions will be treated separately, using the typical cause and remedy approach:

A. HIGH INPUT VSWR B. EXCESSIVE LOSS C. DESENSITIZATION OF THE RECEIVER WHEN TRANSMITTER IS KEYED

PROBLEM A	PROBLEM B	PROBLEM C	POTENTIAL CAUSE THE NUMBER AT RIGHT CORRESPONDS TO THE APPROPRIATE NUMBERED REMEDY PARAGRAPH ON THE REVERSE	
●	●		Reverse labeling of Tx and Rx terminals.	1
●	●		Unit tuned to wrong frequencies.	2
●			Bad antenna or interconnect cables.	3
●	●		Use of between series adaptors, especially UHF types.	4
●	●	●	Duplexer detuned in shipment.	5
●	●		Water has entered the Duplexer antenna connector from the antenna feed line.	6
●	●		Spurious Tx output is being reflected by the selective Duplexer input terminal and observed on the wattmeter, the wattmeter being unable to discriminate between on-frequency and off-frequency energy.	7
		●	Bad joint in a cable or antenna system beyond the antenna terminal of the Duplexer. All lines may show zero reflected power, but noise can still be produced when a corroded or indefinite metal-to-metal contact is exposed to RF energy. When this occurs beyond the Duplexer, it cannot be filtered out, and the noise backs up into the receiver.	8
		●	Adverse cable length between Duplexer and transmitter using varactor or broadband hybrid combining type transmitter outputs. Even though the Duplexer VSWR is flat on frequency, the reflected impedance of the Duplexer off resonance, transformed by changing cable lengths, can cause parasitics to be generated.	9
		●	Duplexer transmitter mixing with another outside transmitter, producing intermodulation on or near the receiver frequency.	10
		●	Transmitter cable leading to Duplexer in close proximity to Duplexer antenna or receiver cable. This is usually only a problem on close separation Duplexers, (1.0 MHz or less) where the 85 to 100 dB isolation is decreased by adverse coupling, created by running these cables too close together for too great a distance.	11
		●	Inadequate shielding of transmitter and receiver modules in the repeater.	12
		●	Insufficient duplex isolation for the application.	13
		●	A spurious transmitter response outside of the normal Duplexer isolation band or inadequacy of notch filter type Duplexers to suppress a wide enough band of Tx noise to protect the receiver.	14
		●	Impedance change in antenna due to icing. VSWR increase may be sufficient to reflect back through the Duplexer and upset transmitter tuning, causing parasitics, which are not suppressed sufficiently by the Duplexer.	15
		●	The addition of a broadband power amplifier to a low power transmitter. The noise floor of the low power radio is raised by an amount equal to the gain of the power amplifier, and in addition, the power amplifier will contribute its own noise. Power amplifiers are just as prone to the generation of parasitics as transmitters, and may be triggered by an adverse cable length between power amplifier and Duplexer, a problem covered above.	16
		●	Excessive loss with changing temperature and apparent Duplexer detuning.	17

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TELEPHONE 716-549-4700 TELEX 755770 FAX 716-549-4772 (24 HRS.)

FIELD SERVICE REMEDIES FOR PAGE ONE PROBLEMS

1. Tune a signal generator to the receive frequency and inject it into the antenna terminal, sampling for the signal at each equipment terminal. Reverse the labels if necessary. It may be that the unit was ordered to the reverse frequencies. If so, the label will indicate this. If the duplexer is symmetrical in design (usually indicated by the same number of Tx and Rx filter sections) just reverse the equipment labels and operate. Generally, no damage will be done to the duplexer when operated in reverse for a short time period. If other adverse symptoms appear, contact the factory.

2. Check the unit label. If needed, the duplexer may be field tuned. Consult the instructions and/or the factory if the duplexer is still under warranty or beyond field tuning capability.

3. Check cable, by substitution, using a termaline wattmeter, or a thruline wattmeter into a good load. Check the antenna line input for reflected power.

4. To eliminate high input VSWR reduce the number of between series adaptors by making up proper interconnect cables. UHF connectors are non-constant impedance, and certain combinations can transform a 1.1:1 VSWR into a 2.0:1, or vice versa.

5. Consult the instruction manual for field tuning procedures, or the factory, if unit is still under warranty or beyond field tuning capability. (We trust that our products will not be prone to this problem).

6. Consult the factory. The affected antenna cables may be field replaceable, or a "baking out" process may be possible.

7. To prove this condition, place a bandpass filter between the Tx and duplexer to clean up the spurious, and put the wattmeter between the bandpass filter and the duplexer to measure reflected power from the duplexer. The bandpass filter selectivity should be equal to or better than that of the duplexer at about the 3.0 dB points.

8. Operate the duplex system into a dummy load. If no desensitization occurs, check out all lines, antennas, and look for potential bad joints close to the radiating antenna where re-radiation of noise may be possible back into the antenna system receiver. Loose metal-to-metal contacts on tower guying systems have also been known to create system noise. Note the effect of vibrating tower guys on system noise.

9. Change the length of cable between the transmitter and duplexer, traversing through a half wave in increments of 1 to 2 inches until desensitization ceases or is minimal. A ferrite isolator will also cure this condition when installed between the transmitter and duplexer. However, this is a much more expensive remedy.

10. If the IM is in the duplex transmitter, a ferrite isolator in the duplex transmitter line (NOT antenna line) will show this by reducing or eliminating it. More isolation can be obtained by cascading isolators if needed. However, IM of this magnitude indicates the system should be studied for possible revision to reduce the production of this IM.

11. Cables such as RG-8a/u and RG-213/u should be at least 3-4" apart over 5'-10' runs. Use of double shielded cable will reduce the susceptability to this problem.

12. Consult the radio manufacturer. This condition can be verified by operating the transmitter into a dummy load while injecting a minimum quieting signal into the receiver. Some radios require special modifications before they are suitable for repeater operation.

13. If this problem is suspected, contact the radio manufacturer for recommended duplex isolation for Tx noise suppression and carrier suppression. Duplexer isolation should be measured first per instruction manual to verify rated specifications are present. If more duplex isolation is required, contact TX RX SYSTEMS for recommended filtering.

14. Consult the factory. Bandpass filter tests can be made to confirm this. In extreme cases, adjustments to the transmitter may be required.

15. Either de-ice the antenna, or use an antenna less sensitive to ice. A ferrite isolator can also be put at the transmitter output to improve the impedance match. Ferrite isolators cannot be put in antenna lines, as they will attenuate Rx signals.

16. A mismatch may possibly be reduced by lengthening the cable between the power amplifier output and the duplexer input until the receiver desensitization disappears, as follows:
    30 MHz to 512 MHz RANGE; BNC or N type adaptors may be inserted in the original cable, one at a time and not to exceed a total of 1/2 wavelength, until desensitization disappears.
    800 MHz to 1.3 GHz RANGE; Prepare a cable length 3/4" longer than original cable and insert. If desensitization does not disappear, repeat with cables each 3/4" longer than the previous length, not to exceed 1/2 wavelength.

17. We find this cause most commonly relates to shifting impedance of the transmitter or power amplifier with temperature. The duplexer "appears" detuned, since a "conjugate match" (cancelling reactance, and matching resistance component) is approached by shifting the duplexer passband above or below the 50 ohm point, as determined by an increase in output power on the wattmeter. In this case, temperature control of the room is the only answer, other than upgrading the transmitter.

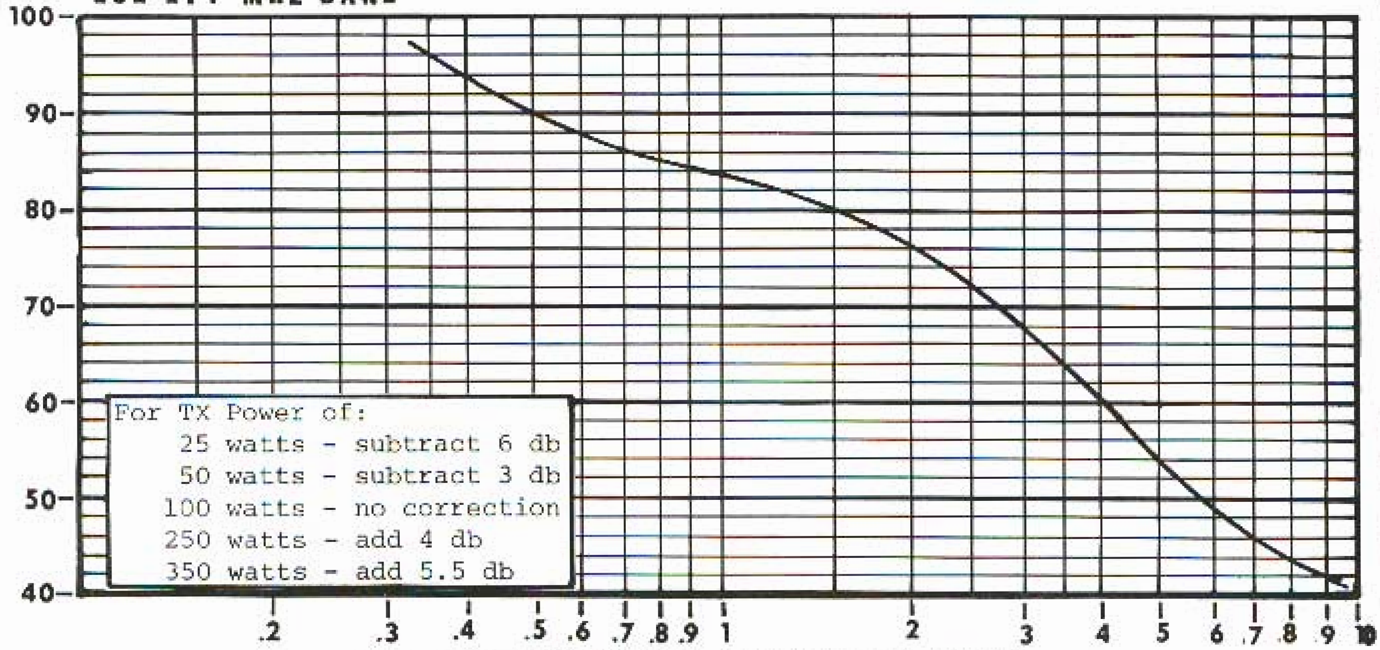
TECH-AID

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

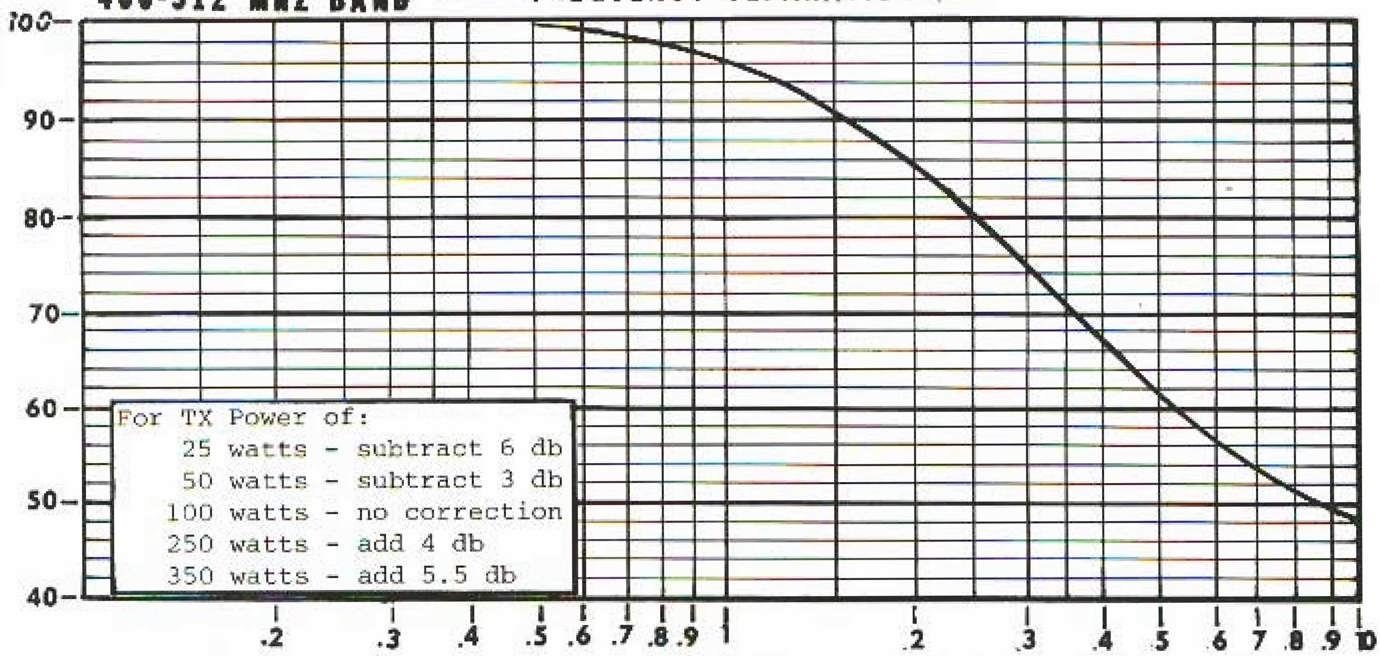
132-174 MHZ BAND



ATTENUATION db

FREQUENCY SEPARATION (MHZ)

400-512 MHZ BAND



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

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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

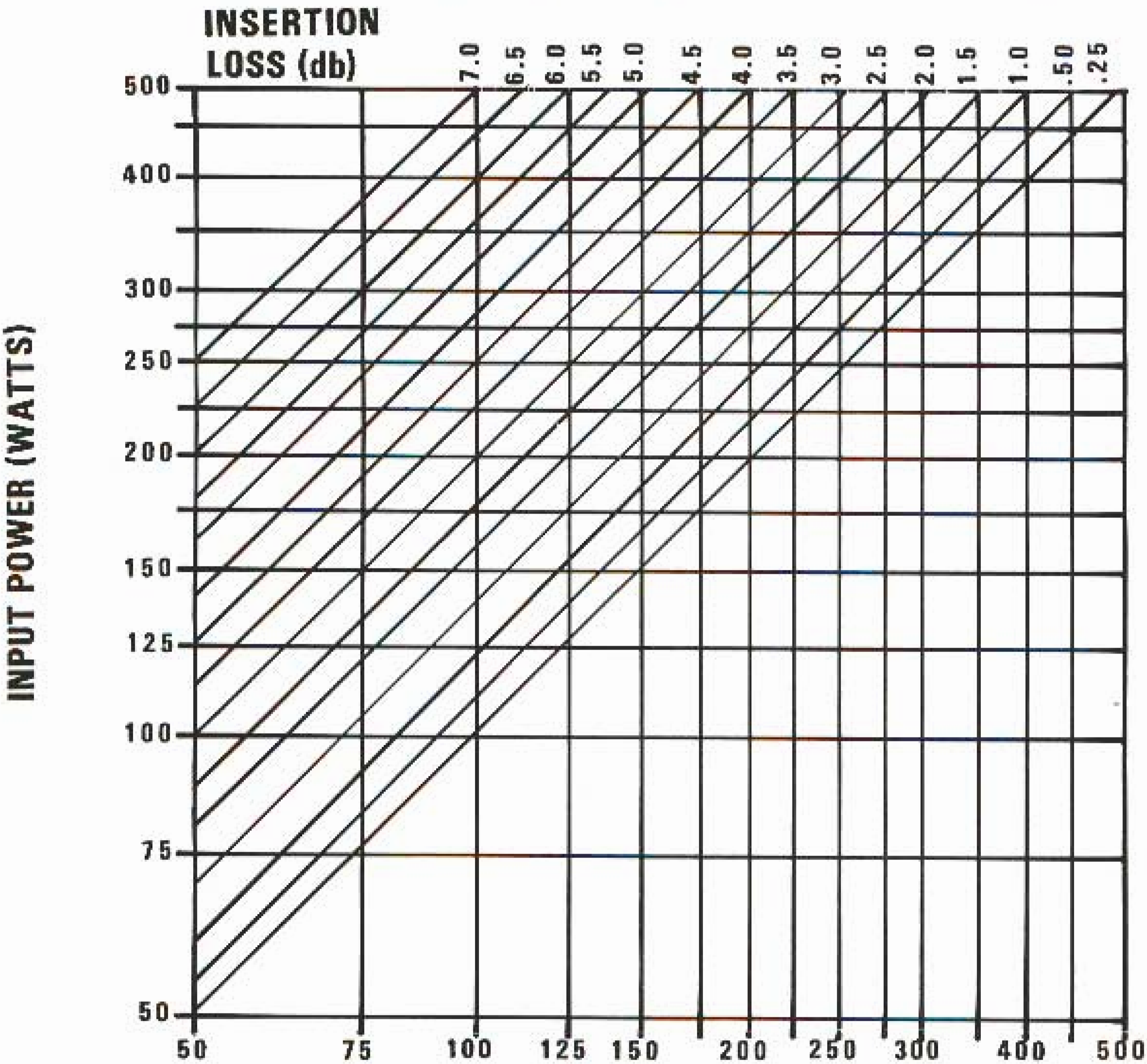
POWER IN/OUT VS. INSERTION LOSS

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.



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

TX RX SYSTEMS INC. 8625 INDUSTRIAL PARKWAY, ANGOLA, NY 14006
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BASIC
VARI-NOTCH FILTER TUNING PROCEDURE
For 4" Dia. Cavities covering 132-960 MHz

Applicable to Filters, Duplexers, or Multicouplers containing same.

PATENT No. 4186359, VARI-NOTCH®

GENERAL

These cavities are usually of quarterwave design, and have a small aluminum enclosure mounted to the end cap, containing the small tuned circuit which is inductively coupled to the cavity resonator. This small enclosure is attached to the cavity end cap by two 4-40 screws, visible on the top surface. Some frequency bands have a number of these "Vari-Notch box" assemblies which look similar, but have varying coupling factors controlling the frequency separations they will tune, which also affects the insertion loss.

These versions all tune identically, and specific performance data should be obtained from the product specification sheets.

The circuit in the enclosure is parallel resonant, and connected in series with the connector center pins. You should measure DC continuity between the center pins,but not center pin to ground, with all other cabling disconnected .

The cavity center probe tunes the passband of this filter, while a small air variable capacitor inside the "Vari-Notch box" tunes the reject notch. The passband tuning overrides the notch tuning, so your notch adjustment must be the last one made. The cavity resonance "punches" the passband into the wide notch produced by the lower 'Q' parallel resonant circuit. The notch, however, is not infinitely wide, and if the notch resonance is greatly off frequency and isolation is low in the desired area, the passband tuning will appear overly broad until the notch has first been tuned to the general area desired.

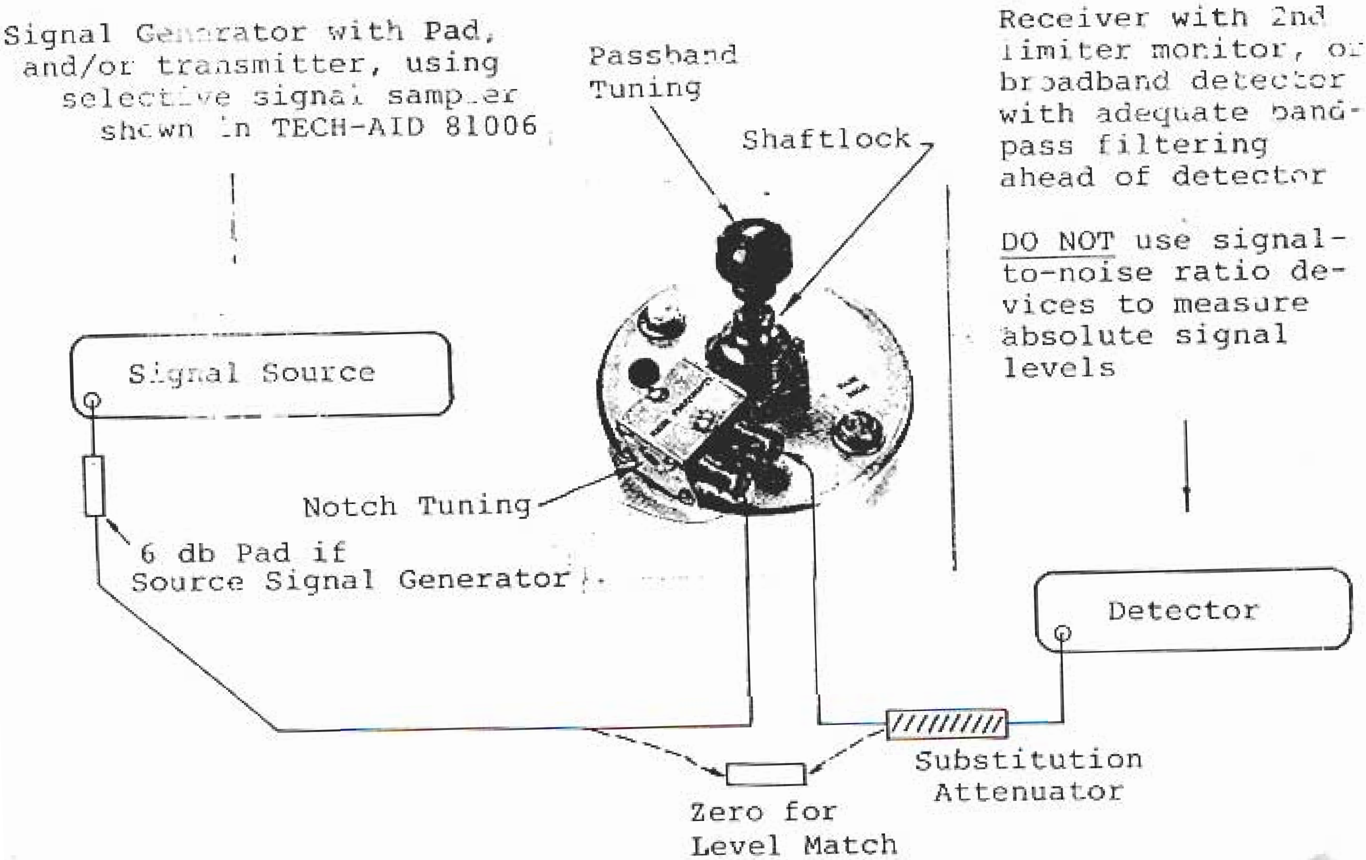
Access to the notch tuning is obtained by removing the small screw or rubber button in the side of the "Vari-Notch box".

A small insulated tuning tool must be used to make the notch adjustment. Where isolations obtained are high, (over 40db) some sensitivity to tool contact on the capacitor rotor may be seen, but is easily taken care of by "offset tuning" the notch. (A tuning tool is available under our model 95-00-01.)

The passband tuning is a sliding adjustment, held securely by a ¼" shaftlock. Should the tuning appear to stick while sliding, rotate and slide the probe while tapping on the rod with a screwdriver or other small tool. The shock will break the surface tension on the probe contact fingers, aiding fine tuning adjustments.

We prefer shaftlocks to threaded locking devices, as tightening the lock nut causes axial tension and a resulting shift in frequency.

BASIC FILTER TEST CIRCUIT



1. Rough tune Notch on reject frequency
2. Tune passband
3. Retune notch
4. Final tune passband
5. Final tune notch, always the last adjustment.

Attenuation is determined by substituting attenuator for filter and matching detector levels.

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VARI-NOTCH DUPLEXERS

TUNING INSTRUCTIONS

T1-3

MODELS: 28-52-02 (220-225 MHz)
28-65-02, 28-70-02, 28-69-02 (406-512 MHz)
28-37-04, 28-37-05, 28-37-06 (144-174 MHz)

Associated Instruction Material: TECH-AIDS 76002, 76007

GENERAL

These instructions apply to the above models, consisting of four cavities in a symmetrical circuit configuration.

The VARI-NOTCH circuit, an exclusive design of TX RX Systems, Inc. produces a wide, deep notch of isolation with selective passband characteristics within the band of operation.

The VARI-NOTCH circuit in the above models is contained in the small housing attached to the cavity end cap. One circuit assembly tunes the high pass or low pass response as required. The insertion loss of each VARI-NOTCH assembly is fixed per the design specifications for each model, but may be factory adjusted to satisfy other specification requirements.

The passband of the vari-notch circuit is tuned by adjusting the cavity probe. The isolation notch is tuned by adjusting a capacitor located in the vari-notch enclosure, access being through a thread port normally closed by a 10-32 screw in the side of the housing. An insulated tuning tool must be used when adjusting this capacitor. A sketch of the type of tool required is shown at the end of this instruction. (The factory can also supply such a tool at a nominal charge.)

BASIC TUNING PROCEDURE

1. Isolate each filter section for individual tuning.
2. Tune the cavity probe for the circuit pass frequency.
3. Tune the capacitor, using an insulated tuning tool as shown, for the circuit reject frequency.
4. Repeat steps 2 and 3 at least once for each filter section.
5. Completely interconnect the duplexer filter sections, and repeat steps 2 and 3, making the isolation adjustments (capacitor) last. In this case, you will inject the test signal into the antenna port and detect at the TX or RX port as determined by the particular adjustment being made. Load the opposite port (TX or RX) in 50 ohms when making this adjustment.

TEST EQUIPMENT REQUIRED

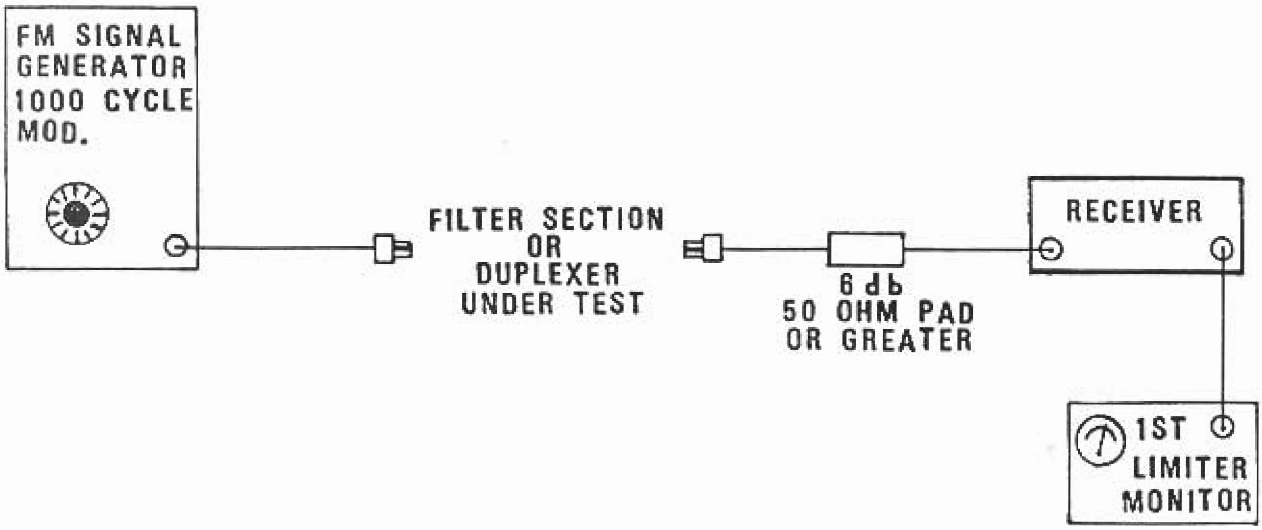
1. A receiver on each duplex frequency to act as a detector.
2. A metering circuit for the receiver 1st limiter level.
3. A 6 dB or greater 50 ohm pad for the receiver input.
4. A signal generator capable of an output at least 95 dB above the receiver sensitivity, including input pad.

401.1020

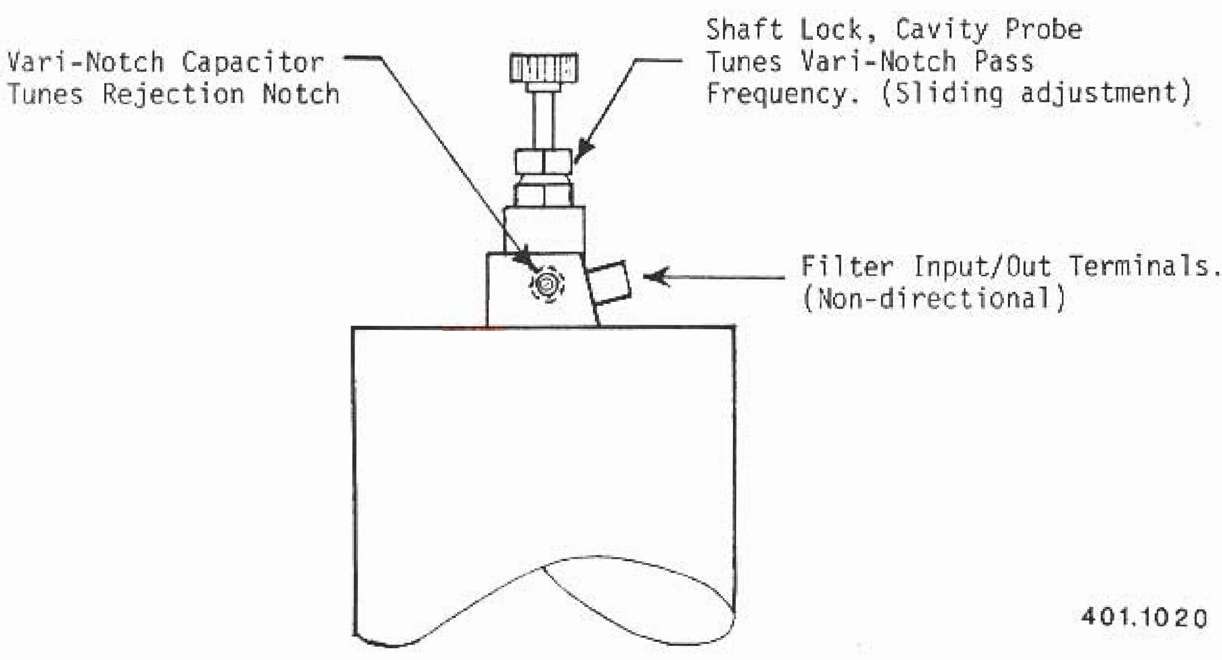
Isolation is measured by the substitution method using the calibrated attenuator of the signal generator. Match signal levels, with and without the filter section, using the 1st limiter reading as a level indicator. The difference in attenuator settings is the filter isolation. Take care not to saturate the 1st limiter and use a 6 db or greater pad on the receiver input for forced 50 ohm reference.

Insertion loss is difficult to measure using the rough dbm calibration of signal generator attenuators. A substitution step attenuator calibrated in 0.1 db increments is the best method. A wattmeter input and output reading, taking certain precautions, will also give a reasonable indications of insertion loss, referring to TX RX Systems Tech-aid TA No. 76002, a graph of the insertion loss vs. power in and out.

TYPICAL MEASUREMENT CIRCUIT

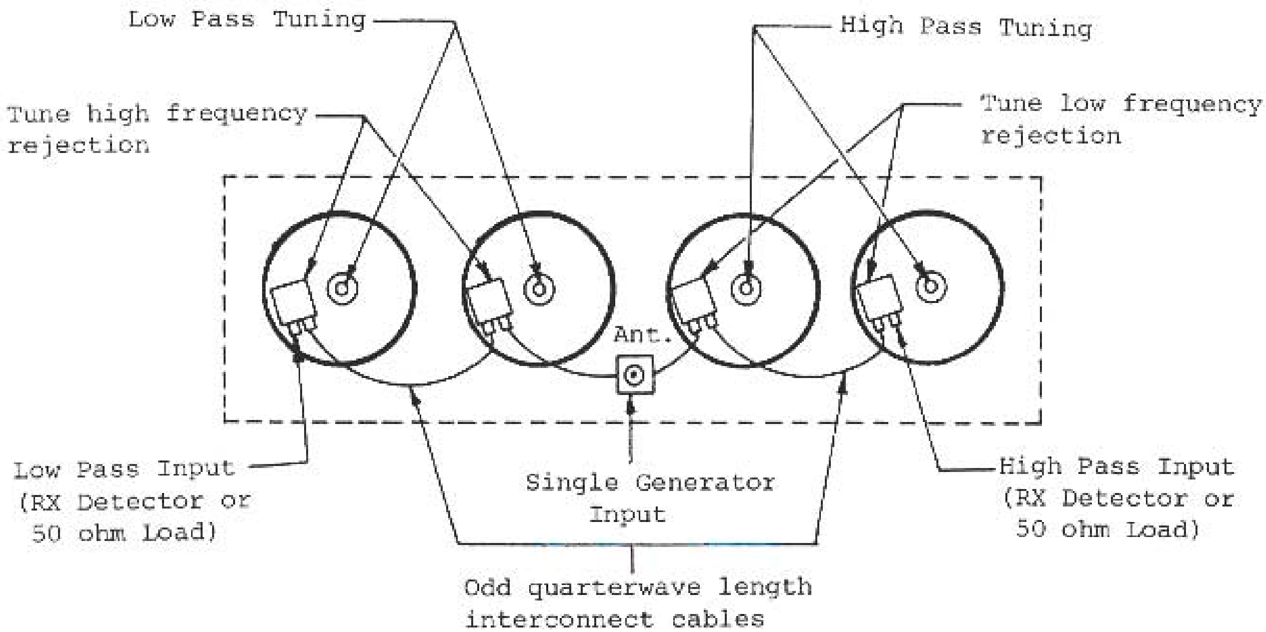


SINGLE FILTER SECTION



401.1020

FINAL TUNING CONFIGURATION



NOTE: Low Pass Input on left of unit is strictly a convenient convention. Follow labeling of unit is marked in reverse, as filter sections may be tuned either as low pass or high pass sections.

TUNING PROCEDURE

1. Inject the low frequency into the antenna terminal and detect with a low frequency receiver at the low pass input. Terminate the high pass input in 50 ohms. Tune the low pass probes for minimum loss and lock shaft locks.
2. Inject the high frequency into the antenna terminal and detect with a high frequency receiver at the high pass input. Terminate the low pass input in 50 ohms. Tune the high pass probes for minimum loss and lock shaft locks.
3. Inject the high frequency into the antenna terminal and detect with a high frequency receiver at the low pass input. Tune the capacitors in the vari-notch housings for maximum high frequency rejection.
4. Inject the low frequency into the antenna terminal and detect with a low frequency receiver at the high pass input. Tune the capacitors in the vari-notch housings for maximum low frequency rejection.

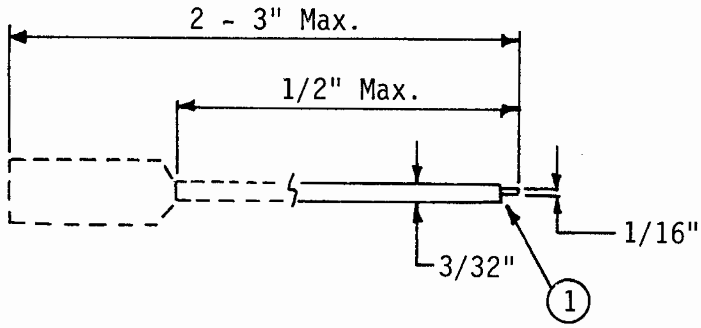
Your duplexer is now tuned and should meet the minimum published specification as shown in the enclosed chart.

VARI-NOTCH DUPLEXER SPECIFICATIONS

GENERAL SPECIFICATIONS		MTG. CODE
TEMP. RANGE :	-40°C to +80°C	C: CABINET
IMPEDANCE :	50 ohms	R: RACK
VSWR :	1.3:1	I: INTERGRAL

MODEL	FREQUENCY RANGE MHZ	MIN. FREQ. SEP. TX TO RX MHZ	POWER RATING WATTS	INSERTION LOSS db TX	INSERTION LOSS db RX	ATTEN. AT db TX FREQ.	ATTEN. AT db RX FREQ.	MIN. ATTEN. BETWEEN FREQS. db	MOUNTING	DIMENSIONS H"	DIMENSIONS W"	DIMENSIONS D"	CONNECTORS STD.	CONNECTORS OPT.
28-65-02	406-420	3.0	350	0.6	0.6	75	75	15	R	5.25	19	+3,-9	N	UHF
28-70-02	450-470	5.0	350	0.6	0.6	85	85	30	R	5.25	19	+3,-9	N	UHF
28-69-02	470-512	3.0	350	0.6	0.6	75	75	15	R	5.25	19	+3,-9	N	UHF
28-52-02	220-225	1.6	150	1.5	1.5	90	90	40	R	5.25	19	+3,-15	N	UHF
28-37-04	144-174	0.5	125	1.7	1.7	65	65	30	R	5.25	19	+5,-15	N	UHF
28-37-05	144-174	0.5	125	2.2	2.2	90	90	40	R	8.75	19	+5,-15	N	UHF
28-37-06	144-174	1.0	125	1.2	1.2	75	75	35	R	5.25	19	+5 -15	N	UHF
ABOVE	144-174	2.0	125	1.2	1.2	90	90	45	R	5.25	19	+5 -15	N	UHF

TUNING TOOL, critical dimensions



(1) Blade must be narrower than 3/32" insulated shank so as not to create metal shavings from blade scraping on inner threaded barrel of capacitor.