GENERAL TUNING INSTRUCTIONS
FOR
HYBRID RING TYPE DUPLEXERS

F- SERIES DUPLEXERS LISTED BELOW:

MANUAL #CM-106

F-201G	F-2B01G	F-150-4G
F-202G	F-2B02G	F-150-4E
F-203G	F-2B03G	F-150-2B
F-204G	F-2B04G	F-225-4E
F-205G	F-3A01G	F-225-2B
F-206G	F-3A02G	F-400-4E
F-207G		F-400-2B
F-301G		
F-306G		

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675 ENSMINGER ROAD PO BOX 23
TONAWANDA, NY 14150

INDEX

THESE INSTRUCTIONS ARE WRITTEN ABOUT A SAMPLE FOUR SECTION DUPLEXER AND A SPECIFIC WIRING DIAGRAM SHOULD BE CONSULTED FOR EXACT HARNESS INTERCONNECTION AND CONNECTORS INVOLVED.

DS NO. 1003	TYPICAL VALUES OF INSERTION LOSS AND ISOLATION FOR HYBRID RING TYPE DUPLEXERS
CI-056	DUPLEXER INSTALLATION PROCEDURE
CI-058	POWER VALUES VS VSWR
TN-1001	THEORY AND OPERATION OF HYBRID RING CIRCUITS
TN-1002	ADJUSTABLE STUB, NOMENCLATURE AND OPERATION WITH HYBRID RING CIRCUITS
DTP NO. 104	DETAILED TUNING PROCEDURE FOR HYBRID RING DUPLEXERS
CI-096	ATTENUATION AND INSERTION LOSS - FIELD MEASUREMENT TECHNIQUES
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THEORY AND OPERATION OF THE HYBRID RING CIRCUIT

THE ISOLATION PROVIDED BY A HYBRID RING DEPENDS ON THE ARRIVAL AT A COMMON POINT OF TWO SIGNALS WHICH ARE EQUAL IN MAGNITUDE AND 180° OUT OF PHASE. THE SIGNAL IS INJECTED INTO ONE TERMINAL OF THE HYBRID RING, SPLITS INTO TWO EQUAL PARTS AND TAKES TWO DIFFERENT PATHS TO THE OUTPUT TERMINAL. IF ONE BRANCH IS ONE-HALF WAVE LENGTH LONGER THAN THE OTHER, HYBRID CANCELLATION OCCURS AND THERE IS NO OUTPUT VOLTAGE. A VOLTAGE NULL OR SHORT CIRCUIT APPEARS AT THE OUTPUT OF THE HYBRID RING.

FOR DUPLEX OPERATION, OR TWO FREQUENCY OPERATION, A SECOND FREQUENCY VERY CLOSE TO THE CANCELLED ONE MUST BE PASSED THROUGH THE SAME TWO TERMINALS OF THE HYBRID RING AT THE SAME INSTANT THE FIRST ONE IS BEING CANCELLED.

A HIGH "Q" NOTCH FILTER OR SHUNT CAVITY IS PLACED AT AN APPROPRIATE POSITION IN THE HYBRID RING AND ACTS AS A SWITCH WHICH EFFECTIVELY ELIMINATES ONE BRANCE OF THE HYBRID RING. THE FREQUENCY TO BE PASSED SEES ONLY ONE BRANCH OR PATH BETWEEN THE INPUT AND OUTPUT TERMINALS AND SO NO CANCELLATION OCCURS.

THE CAVITY IS LOCATED ON THE HYBRID RING SO THAT A QUARTER WAVE LENGTH APPEARS BETWEEN THE CAVITY TEE JUNCTION AND EITHER THE INPUT OR OUTPUT OF THE HYBRID RING, AS SHOWN IN FIGURE 1.

THE CAVITY IS RESONANT ON THE PASS FREQUENCY OF THE HYBRID RING AND CREATES A SHORT CIRCUIT AT ITS POINT OF ATTACHMENT TO THE HYBRID RING. ONE QUARTER WAVELENGTH AWAY IN EITHER DIRECTION, A HIGH IMPEDANCE CONNECTION TO THE INPUT OR OUTPUT JUNCTION RESULTS AND SO HAS LITTLE EFFECT ON THE 50 OHM LOW IMPEDANCE INPUT AND OUTPUT. THE HALFWAVE BRANCH OF THE HYBRID RING CONTAINING THE CAVITY AND THE TWO QUARTERWAVE ARE EFFECTIVELY ELIMINATED AT THE PASS FREQUENCY.

AT THE FREQUENCY TO BE CANCELLED, THE CAVITY IS OFF RESONANCE AND ACTS LIKE A VERY HIGH IMPEDANCE IN PARELLEL WITH THE ONE BRANCH OF THE HYBRID RING AND ELECTRICALLY IS NOT PRESENT. BECAUSE THE IDEAL CAN NEVER BE ACHIEVED, A STUB IS PLACED IN THE OPPOSITE BRANCH OF THE HYBRID RING AND IS ADJUSTED TO OFFSET THE RESIDUAL PHASE SHIFT CREATED BY THE CAVITY IN THE OTHER BRANCH. THIS STUB ADJUSTMENT IS MADE AT THE FREQUENCY TO BE CANCELLED. THE CAVITY RESONANCE IS ADJUSTED AT THE FREQUENCY TO BE PASSED. THE STUB AND CAVITY ARE ADJUSTED ALTERNATELY AT THE PROPER FREQUENCIES UNTIL MAXIMUM LOSS AT THE PASS FREQUENCY OCCUR SIMULTANEOUSLY, THE CANCELLED FREQUENCY OR STUB BEING THE LAST ADJUSTMENT BECAUSE OF ITS CRITICAL BALANCE POINT.

THE HYBRID RING CIRCUIT IS ESSENTIALLY RECIPROCAL AND INPUT AND OUTPUT TERMINALS ARE REVERSIBLE. HYBRID RING CIRCUITS MAY BE CASCADED TO GIVE INCREASED ISOLATION WHEN NECESSARY.

WHEN THE HYBRID RING CIRCUIT IS EMPLOYED IN DUPLEX OPERATION, ONE OR TWO HYBRID CIRCUITS WILL APPEAR IN EACH BRANCH OF THE DUPLEXER, DEPENDING ON THE ISOLATION REQUIRED. THE PASS AND CANCELLATION FREQUENCIES FOR THE HYBRID OF ONE SIDE OF THE DUPLEXER WILL BE REVERSED ON THE OTHER SIDE.

A TYPICAL HYBRID RING DUPLEXER CIRCUIT IS SHOWN IN FIGURE 2.

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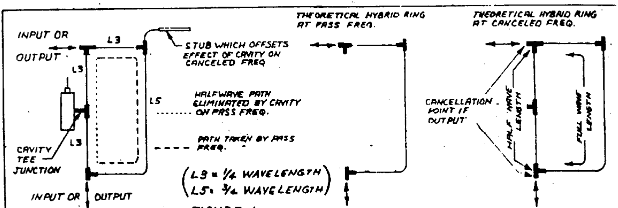


FIGURE 1

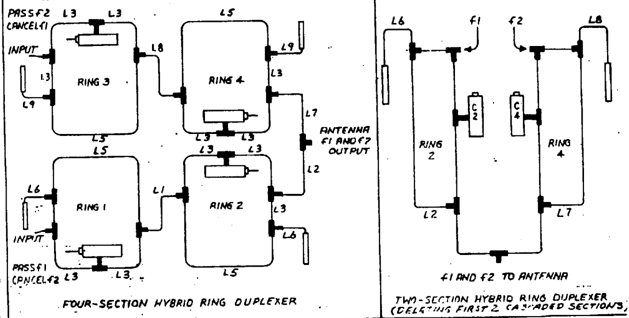


FIGURE 2 TYPICAL HYBRID RING DUPLEXER

THE TYPE OF RESPONSE OBTAINED FROM A HYBRID RING SECTION IS SHOWN IN FIGURE 3. THE RESPONSE WHICH IS OF MOST INTEREST IS BETWEEN THE TWO EQUIPMENT TERMINALS OF THE DUPLEXER WITH A 50 OHM LOAD ON THE ANTENNA TERMINAL. THIS CURVE WILL DISPLAY THE PEAK ISOLATION PROVIDED BY THE HYBRID ON EACH SIDE OF THE DUPLEXER, ALSO THE ATTENUATION AT OTHER FREQUENCIES LYING BETWEEN THE TWO FREQUENCIES OF DUPLEX OPERATION.

THE ISOLATION PROVIDED AT ABOUT MIDWAY BETWEEN THE TWO DUPLEX FREQUENCIES IS OFTEN A LIMITING FACTOR IN DUPLEX OPERATION SINCE TRANSMITTER NOISE GENERATED IN THIS

AREA MAY NOT BE ATTENUATED SUFFICIENTLY TO PREVENT RECEIVER DESENSITIZATION. THE INTERCONNECTING CABLES BETWEEN THE HYBRID RING SECTIONS, AS L1 AND L8, ARE ADJUSTED TO GIVE THE GREATEST PHASE MISMATCH BETWEEN THE INPUT TERMINALS AT THE MIDFREQUENCY. THESE CABLE LENGTHS DO NOT ENTER INTO THE TUNING OF THE HYBRID RING ITSELF AT THE TWO DUPLEX FREQUENCIES.

CABLES L2 AND L7 ARE ADJUSTED FOR THE LEAST INTERACTION OR LOWEST INSERTION LOSS OF THE TWO DUPLEXER BRANCHES. CABLES L2 AND L7 WILL BE APPROXIMATELY ONE QUARTER WAVELENGTH LONG.

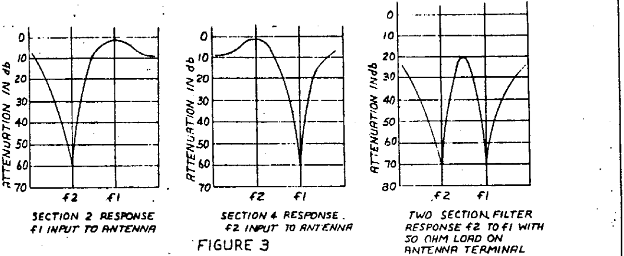


FIGURE 3

DUPLEXERS USING HYBRID RING CIRCUITS ARE ALMOST ALWAYS USED TO PERMIT OPERATION OF A TRANSMITTER AND RECEIVER FROM THE SAME ANTENNA SIMULTANEOUSLY. AT FREQUENCY SEPARATION OF 0.3% IN THE 150 MC BAND, THESE CIRCUITS ARE THE MOST EFFECTIVE AND ECONOMICAL FOR THE ATTENUATIONS REQUIRED. USUALLY, FOUR-SECTION DUPLEXERS WITH ATTENUATIONS OF 100-120 DB AT F_1 AND F_2 ARE REQUIRED AT 0.3% IN 150 MC BAND OR 0.4% IN 450 MC BAND. FOR A TRANSMITTER ON F_1 AND A RECEIVER ON F_2, THE HYBRID RING ON THE TRANSMITTER SIDE WOULD ATTENUATE F_2 TO BLOCK NOISE ON THE RECEIVER FREQUENCY AND THE HYBRID RING ON THE RECEIVER SIDE WOULD ATTENUATE F_1 TO PREVENT RECEIVER DESENSITIZATION BY THE TRANSMITTER CARRIER.

TEST EQUIPMENT REQUIRED

1. FM SIGNAL GENERATOR 100,000 MICROVOLTS OUTPUT AND GOOD FREQUENCY STABILITY MEASUREMENT MODEL 560 FM OR EQUIVALENT.

2. TRANSMITTER ON TX DUPLEX FREQUENCY

3. RECEIVER ON RX DUPLEX FREQUENCY

4. RECEIVER ON TX DUPLEX FREQUENCY (FOR USE AS A DETECTOR)

5. 50 OHM LOAD FOR TRANSMITTER POWER (CAN BE SMALL IF ONLY LOW POWER FOR TUNE IS USED)

6. THRULINE WATTMETER

7. TEST SET FOR MONITORING RECEIVER LIMITER CURRENT OR VOLTAGE

8. INTERCONNECTING CABLES 50 OHM RG-8/U OR RG-58/U AS AVAILABLE. USE A MINIMUM OF ADAPTORS AND UHF CONNECTORS AS THESE WILL INTRODUCE ADVERSE VSWR'S INTO THE TEST CABLES, ESPECIALLY IN THE TRANSMITTER POWER MONITORING CIRCUITS. USE "N" TYPE CONNECTORS WHENEVER POSSIBLE.

OVERALL TUNING PROCEDURE

1. A DETAILED WIRING DIAGRAM OF A SPECIFIC DUPLEXER SHOULD BE CONSULTED FIRST TO DETERMINE EXACT POINTS OF INTERCONNECTION AND HARNESS BREAKDOWN, USING ILLUSTRATIVE SAMPLE IN TUNING PROCEDURE AS A GUIDE. THESE WILL BE THE WIRING DIAGRAMS OR WD DRAWINGS AT THE REAR OF THIS INSTRUCTION.

2. A SMALL ADJUSTMENT MAY BE MADE FOR PEAKING THE REJECTION OF THE CANCELED FREQUENCY ON EACH HYBRID RING IF THE INSERTION LOSS HAS BEEN CHECKED AS SATISFACTORY, USING THE PRE-INSTALLATION CHECK IN CI-096. THE STUBS MAY BE ADJUSTED FOR A PEAK, USING THE FINE TUNING INSTRUCTIONS ON THE TWO SECTIONS COVERING THE ADJUSTMENT OF THE STUBS ON THE CANCELLATION FREQUENCY. THESE WILL BE FOUND ON PAGES 3 THROUGH 5.

IF THE PASS IS ADJUSTED BY ROTATING THE CAVITY PROBES, THE STUBS WILL HAVE TO BE RESET AND A COMPLETE CYCLE MADE OF ALL TUNING ADJUSTMENTS, USING THE FINE TUNING PROCEDURE FOR THE AFFECTED HYBRID RINGS.

3. TUNE THE HYBRID RING OR RINGS ON ONE SIDE OR BRANCH OF THE DUPLEXER AT A TIME. THERE ARE A TOTAL OF FOUR SPEARATE INSTRUCTIONS WHICH COVER TUNING THE PASS AND CANCELED FREQUENCY FOR EITHER SIDE OF THE DUPLEXER. THESE ARE ON PAGES 2 TO 5. SAY, FOR EXAMPLE, YOU WORK WITH HYBRID RING #1 AND #2 ON ONE-HALF OF THE DUPLEXER FIRST. HYBRID RINGS #1 AND #2 WILL BE TUNED SPEARATELY, BUT ARE TUNED IDENTICALLY THE SAME. START BY ALWAYS MAKING THE PASS ADJUSTMENT ON THE HYBRID RING FIRST, THEN PROCEED TO THE ADJUSTMENT OF THE CANCELLATION FREQUENCY OF THAT HYBRID RING. THE OBJECT IS TO ALTERNATE BETWEEN THE TWO ADJUSTMENTS UNTIL EACH IS OPTIMIZED SIMULTANEOUSLY AND CAVITY PROBES AND STUBS LOCKED. THIS IS DONE FOR EACH HYBRID RING FIRST.

4. THE LENGTHS OF L_2 AND L_7, THE ANTENNA JUNCTION CABLES, AND DETERMININED AFTER ALL THE HYBRID RINGS ARE TUNED AND LOCKED. THIS PROCEDURE IS FOUND ON PAGES 5 AND 6.

5. A TOTAL CHECK OF INSERTION LOSS AND ISOLATION CAN BE MADE USING THE PROCEDURE OUTLINED IN CI-096. A TABLE OF TYPICAL VALUES FOR INSERTION LOSS AND ISOLATION FOR SPEARATE HYBRID RING SECTIONS AND COMPLETE DUPLEXERS CAN BE FOUND ON DS NO. 1003.

OVERALL TUNING PROCEDURE (CON'T)

THE MEASUREMENTS ON SEPARATE SECTIONS ARE MADE THE SAME WAY AS ON THE COMPLETE DUPLEXER BY SUBSTITUTING THE HYBRID RING INPUT AND OUTPUT TERMINALS FOR THE DUPLEXER TERMINALS IN THE TEST CIRCUIT.

TUNING TO NEW FREQUENCIES

A CABLE HARNESS WILL WORK OVER ABOUT A 3% CHANGE FROM THE CENTER DESIGN FREQUENCY. THE FREQUENCY SEPARATION OF TX AND RX FREQUENCY IS NOT AS IMPORTANT AS THE GENERAL SHIFT OF THE OPERATING PAIR OF FREQUENCIES. GREATER DEVIATIONS ARE TOLERATED IF THE SEPARATION OF OPERATING FREQUENCIES IS NOT CLOSE TO THE OPERATIONAL LIMIT. THE SAME ANTENNA JUNCTION CABLES L_2 AND L_7 MAY WORK FOR SMALL CHANGES IN FREQUENCY. FOR ANY SPECIFIC INFORMATION, CONSULT THE FACTORY.

WIRING DIAGRAM OF A FOUR SECTION HYBRID RING DUPLEXER

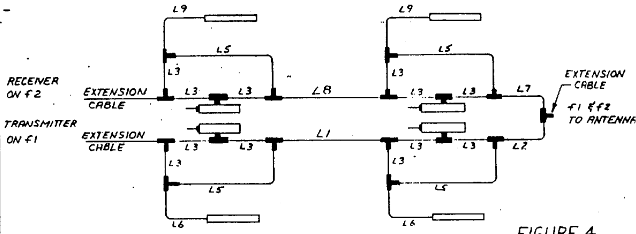


FIGURE 4

THE TUNING PROCEDURE IS ILLUSTRATED USING A TRANSMITTER AND RECEIVER COUPLED TO ONE ANTENNA, BUT TWO TRANSMITTERS MAY BE COUPLED. IF TWO TRANSMITTERS ARE DUPLEXED, USE THE TRANSMITTER PASS ADJUSTMENT PROCEDURE FOR BOTH PAIRS OF HYBRID RING CIRCUITS, USING THE APPROPRIATE FREQUENCY OF EACH PAIR OF HYBRID RINGS.

FOR A TWO SECTION DUPLEXER, DELETE HYBRID RINGS 1 AND 3. THE INPUTS FOR F_1 AND F_2 WILL BE WHERE L_1 AND L_7 ENTER HYBRID RINGS 2 AND 4 RESPECTIVELY.

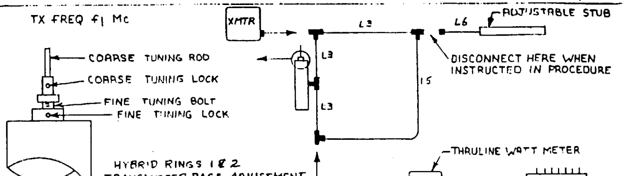
THE INSTRUCTIONS FOR DETERMINING L_2 AND L_7 ARE THE SAME FOR A TWO OR FOUR SECTION DUPLEXER. HYBRID RINGS #1 AND #3 ARE NOT INVOLVED IN THEIR DETERMINATION.

CABLES L_1, L_3 AND L_8 ARE ALL ONE QUARTERWAVE CABLES AT THE HIGHEST OPERATING FREQUENCY. CABLE L_5 IS A THREE QUARTERWAVE AT THE HIGHEST OPERATING FREQUENCY. THE ONLY CABLES ADJUSTED WHEN TUNING THE DUPLEXER ARE L_6, L_9, L_2 AND L_7. THESE ADJUSTMENTS, WHEN REQUIRED, ARE COVERED IN THE FOLLOWING TUNING PROCEDURE.

(THESE PROCEDURES APPLY TO EACH RING SEPARATELY.)

GENERAL TUNING PROCEDURE

IF THE HYBRID RING HAS BEEN TUNED PREVIOUSLY AND NEEDS ONLY MINOR ADJUSTMENT, PROCEED TO THE FINE TUNING PROCEDURE. IF NEW FREQUENCIES HAVE BEEN CHOSEN OR THE HYBRID RINGS BECOME BADLY DETUNED, PROCEED AS FOLLOWS: DISCONNECT THE ADJUSTABLE STUB WHERE NOTED IN THE DIAGRAM ABOVE FOR THE FIRST ADJUSTMENT OF THE PASS FREQUENCY.

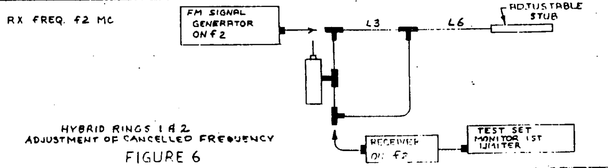


HYBRID RINGS 1 & 2
TRANSMITTER PASS ADJUSTMENT
FIGURE 5

USE LOW POWER ON THE TRANSMITTER AND USING THE COARSE TUNING ROD, SLIDE SLOWLY UNTIL A WELL DEFINED PASS IS INDICATED BY POWER ON THE WATTMETER. LOCK THE COARSE TUNING AND USE THE FINE TUNING BOLT TO PEAK THE POWER OUTPUT. WHEN THE PASS FREQUENCY IS PEAKED, ATTACH THE STUB ASSEMBLY AGAIN SO THAT THE CANCELED FREQUENCY CAN BE ADJUSTED NEXT. PROCEED TO THE ADJUSTMENT OF THE STUB ON THE CANCELED FREQUENCY OF THESE HYBRID RINGS IN FOLLOWING PARAGRAPHS. WHEN RETUNING TO READJUST THIS PASS, USE THE FINE TUNING PROCEDURE.

FINE TUNING PROCEDURE: USE THIS PROCEDURE FOR PEAKING A PRETUNED HYBRID RING OR AS DIRECTED ABOVE IN THE GENERAL TUNING PROCEDURE.

LEAVE THE ADJUSTABLE STUB CONNECTED TO THE HYBRID RING ASSEMBLY AND DO NOT ADJUST THE STUB. LOOSEN THE FINE TUNING SET SCREW AND ROTATE THE FINE TUNING BOLT FOR MAXIMUM POWER OUTPUT. PROCEED TO THE FINE TUNING PROCEDURE FOR THE CANCELED FREQUENCY OF THESE HYBRID RINGS IN FOLLOWING PARAGRAPHS.



HYBRID RINGS 1 & 2
ADJUSTMENT OF CANCELLED FREQUENCY
FIGURE 6

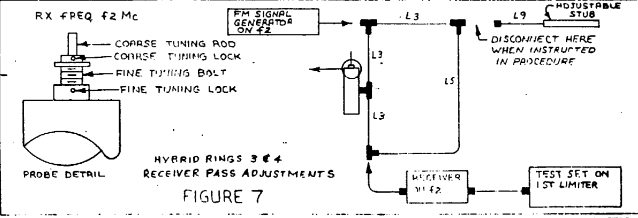
(THESE PROCEDURES APPLY TO EACH RING SEPARATELY.)

GENERAL TUNING PROCEDURE: IF THE HYBRID RING IS BEING TUNED ON THE SAME FREQUENCIES OR NEW FREQUENCIES WITH APPROXIMATELY THE SAME SEPARATION AND LOCATION IN THE BAND, PROCEED TO THE FINE TUNING PROCEDURE SINCE THE EXISTING LENGTH OF L_6 WILL WORK FOR SMALL FREQUENCY CHANGES. IF THE CABLE HARNESS IS CHANGED OR FREQUENCY AND FREQUENCY SEPARATION CHANGED, THE LENGTH OF L_6 WILL BE DIFFERENT TO PLACE THE STUB WITHIN ITS ADJUSTMENT RANGE. REFER TO TN-1002 FOR THE OPERATION OF THE ADJUSTABLE STUB WITH THE HYBRID RING AND HOW TO SET THE LENGTH OF L_6. USING THE FINE TUNING PROCEDURE AND THE INFORMATION IN TN-1002, THE LENGTH OF L_6, IF NOT OPTIMUM, CAN BE FOUND AND THE HYBRID RING TUNED AS NORMALLY OUTLINED IN THE FINE TUNING PROCEDURE.

FINE TUNING PROCEDURE: USE THIS PROCEDURE FOR PEAKING A PRETUNED HYBRID RING OR AS DIRECTED ABOVE IN THE GENERAL TUNING PROCEDURE.

ADJUST THE SIGNAL GENERATOR DRIVE FOR A READABLE, BUT UNSATURATED, LEVEL ON THE FIRST LIMITER MONITOR. LOOSEN THE LOCKING RING AND SLOWLY MOVE THE LOCKING RING AND DIELECTRIC ROD FOR A MINIMUM READING ON THE FIRST LIMITER MONITOR. INCREASE THE SIGNAL GENERATOR DRIVE AS NEEDED SO THAT WHEN THE NULL IS REACHED, IT CAN BE CLEARLY OBSERVED.

IT WILL BE VERY SHARPLY DEFINED. WHEN THE MINIMUM OR NULL IS FOUND, LOCK THE STUB ADJUSTMENT. RETURN TO THE ADJUSTMENT OF THE PASS FREQUENCY OF THESE HYBRID RINGS ON PAGE 3 AND USE THE FINE TUNING PROCEDURE. READJUST THE STUB AGAIN FOR THE NULL ON F_2. THE ADJUSTMENT OF CAVITY PROBE ON THE PASS FREQUENCY AND THE STUB ON THE CANCELED FREQUENCY IS REPEATED UNTIL THE BEST PASS ON F_1 AND THE NULL ON F_2 OCCUR SIMULTANEOUSLY. LOCK THE PASS ADJUSTMENT AS SHOWN ON PAGE 3 AND MAKE THE FINAL STUB ADJUSTMENT AND LOCK. THE STUB IS ALWAYS SET LAST BECAUSE IT IS THE MOST CRITICAL. ANY FURTHER ADJUSTMENT OF THE PROBE ON THE PASS FREQUENCY WILL UPSET THE STUB SETTING. IF A FINAL ADJUSTMENT OF THE PASS IS MADE AFTER THE DUPLEXER HAS BEEN TOTALLY INTERCONNECTED, A FINAL STUB ADJUSTMENT MUST BE MADE ON EACH RING WHEN MEASURING THE ISOLATION ON THE CANCELED FREQUENCY ACROSS THE TOTALLY INTERCONNECTED DUPLEXER.



HYBRID RINGS 3 & 4
RECEIVER PASS ADJUSTMENTS

FIGURE 7

(THESE PROCEDURES APPLY TO EACH RING SEPARATELY.)

<u>GENERAL TUNING PROCEDURE</u>: IF THE HYBRID RING HAS BEEN TUNED PREVIOUSLY AND NEEDS ONLY MINOR ADJUSTMENT, PROCEED TO THE FINE TUNING PROCEDURE. IF NEW FREQUENCIES HAVE BEEN CHOSEN OR THE HYBRID RINGS BECOME BADLY DETUNED, PROCEED AS FOLLOWS. DISCONNECT THE STUB WHERE NOTED ABOVE FOR THE FIRST ADJUSTMENT OF THE PASS FREQUENCY. USE SIGNAL GENERATOR DRIVE WHICH IS READABLE ON THE FIRST LIMITER MONITOR, BUT NOT SATURATING. LOOSEN THE LOCKING SCREW ON THE COARSE ADJUSTMENT ON THE CAVITY PROBE AND SLIDE THE TUNING ROD SLOWLY FOR A MAXIMUM INDICATION ON THE FIRST LIMITER MONITOR. REDUCE THE GENERATOR DRIVE, IF NECESSARY, AS THE SETTING IS APPROACHED SO THAT THE PEAK IS NOT HIDDEN IN A SATURATED LEVEL. LOCK THE COARSE SETTING AND ROTATE THE FINE TUNING BOLT WHEN NEAR THE MAXIMUM. WHEN THE MAXIMUM PASS IS REACHED, ATTACH THE STUB ASSEMBLY TO THE HYBRID RING SO THAT THE CANCELED FREQUENCY CAN BE TUNED NEXT. PROCEED TO THE ADJUSTMENT OF THE STUBS ON THE CANCELED FREQUENCY OF THESE HYBRID RINGS ON PAGE 5. WHEN RETURNING TO READJUST THIS PASS, USE THE FINE TUNING PROCEDURE.

<u>FINE TUNING PROCEDURE</u>: USE THIS PROCEDURE FOR PEAKING A PRETUNED HYBRID RING OR AS DIRECTED ABOVE IN THE GENERAL TUNING PROCEDURE.

LEAVE THE ADJUSTABLE STUB CONNECTED TO THE HYBRID RING ASSEMBLY AND DO NOT ADJUST THE STUB. LOOSEN THE FINE TUNING LOCK AND USING SIGNAL GENERATOR DRIVE WHICH IS READABLE, BUT NOT SATURATING THE FIRST LIMITER, ROTATE THE FINE TUNING BOLT FOR MAXIMUM INDICATION ON THE FIRST LIMITER MONITOR. PROCEED TO THE FINE TUNING PROCEDURE FOR THE CANCELED FREQUENCY OF THESE HYBRID RINGS, PAGE 5.

(THESE PROCEDURES APPLY TO EACH RING SEPARATELY.)

<u>GENERAL TUNING PROCEDURE</u>: IF THE HYBRID RING IS BEING RETUNED ON THE SAME FREQUENCIES OR NEW FREQUENCIES WITH APPROXIMATELY THE SAME SEPARATION AND LOCATION IN THE BAND, PROCEED TO THE FINE TUNING PROCEDURE SINCE THE EXISTING LENGTH OF L_9 WILL WORK FOR SMALL FREQUENCY CHANGES. IF THE CABLE HARNESS IS CHANGED OR FREQUENCY AND FREQUENCY SEPARATION CHANGED, THE LENGTH OF L_9 WILL BE DIFFERENT TO PLACE THE STUB WITHIN ITS ADJUSTMENT RANGE. REFER TO TN-1002 FOR THE OPERATION OF THE ADJUSTABLE STUB WITH THE HYBRID RING AND HOW TO SET THE LENGTH OF L_9. USING THE FINE TUNING PROCEDURE AND THE

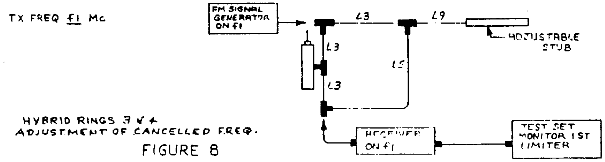


FIGURE 8

INFORMATION IN TN-1002, THE LENGTH OF L_9, IF NOT OPTIMUM, CAN BE FOUND AND THE HYBRID RING TUNED AS NORMALLY OUTLINED IN THE FINE TUNING PROCEDURE.

FINE TUNING PROCEDURE: USE THIS PROCEDURE FOR PEAKING A PRETUNED HYBRID RING OR AS DIRECTED ABOVE IN THE GENERAL TUNING PROCEDURE.

ADJUST THE SIGNAL GENERATOR DRIVE FOR A READABLE BUT UNSATURATED LEVEL ON THE FIRST LIMITER MONITOR. LOOSEN THE LOCKING RING AND SLOWLY MOVE THE LOCKING RING AND DIELECTRIC ROD FOR A MINIMUM READING ON THE FIRST LIMITER MONITOR. INCREASE THE SIGNAL GENERATOR DRIVE AS NEEDED SO THAT WHEN THE NULL IS REACHED, IT CAN BE CLEARLY OBSERVED. IT WILL BE VERY SHARPLY DEFINED. WHEN THE MINIMUM OR NULL IS FOUND, LOCK THE STUB ADJUSTMENT. RETURN TO THE ADJUSTMENT OF THE PASS FREQUENCY OF THESE HYBRID RINGS ON PAGE 4 AND USE THE FINE TUNING PROCEDURE. READJUST THE STUB AGAIN FOR THE NULL OF F_1. THE ADJUSTMENT OF CAVITY PROBE ON THE PASS FREQUENCY AND THE STUB ON THE CANCELED FREQUENCY IS REPEATED UNTIL THE BEST PASS ON F_2 AND THE NULL ON F_1 OCCUR SIMULTANEOUSLY. LOCK THE PASS ADJUSTMENT AS SHOWN ON PAGE 4 AND MAKE THE FINAL STUB ADJUSTMENT AND LOCK. THE STUB IS ALWAYS SET LAST BECAUSE IT IS THE MOST CRITICAL. ANY FURTHER ADJUSTMENT OF THE PROBE ON THE PASS FREQUENCY WILL UPSET THE STUB SETTING. IF A FINAL ADJUSTMENT OF THE PASS IS MADE AFTER THE DUPLEXER HAS BEEN TOTALLY INTERCONNECTED, A FINAL STUB ADJUSTMENT MUST BE MADE ON EACH RING WHEN MEASURING THE ISOLATION ON THE CANCELED FREQUENCY ACROSS THE TOTALLY INTERCONNECTED DUPLEXER.

DETERMINATION OF ANTENNA JUNCTION CABLES L_2 AND L_7.

REFERRING TO THE WIRING DIAGRAM FOR A FOUR SECTION DUPLEXER ON PAGE 2, THE LENGTH OF L_2 WILL BE APPROXIMATELY ONE QUARTERWAVE AT THE CONCELLATION FREQUENCY OF HYBRID RING #2 AND L_7 WILL BE APPROXIMATELY ONE QUARTERWAVE AT THE CANCELLATION FREQUENCY OF HYBRID RING #4. THE FORMULAS FOR CUTTING THE CABLE BEFORE ATTACHING CONNECTORS ARE AS FOLLOWS:

ONE QUARTERWAVE IN POLYETHYLENE CABLE (INCHES) $= \frac{1946}{\text{FREQ MC}} - 1.54 =$ ________

(1.54 INCHES = 'N' TYPE CONNECTOR ALLOWANCE)

ONE QUATERWAVE IN TEFLON CABLE (INCHES) $= \frac{2060}{\text{FREQ MC}} - 1,54 =$ ________

IN UHF DUPLEXERS, A THREE QUARTERWAVE IS OFTEN USED TO OBTAIN MORE PHYSICAL LENGTH. THEIR LENGTH CAN BE CALCULATED AS FOLLOWS:

THREE QUARTERWAVE IN POLYETHYLENE CABLE (INCHES) $= \frac{5838}{\text{FREQ.MC}} - 1.54 =$ ________

THREE QUARTERWAVE IN TEFLON CABLE (INCHES) $= \frac{6180}{\text{FREQ MC}} - 1.54 =$ ________

THE LENGTH OF L_2 AND L_7 MAY DEVIATE SLIGHTLY FROM THE THEORETICAL QUARTERWAVE OR THREE QUARTERWAVE BY 10-20% FOR LOWEST INSERTION LOSS THROUGH THE DUPLEXER. THIS IS BECAUSE THERE MAY BE SOME RESIDUAL VSWR THROUGH THE HYBRID CIRCUITS ON THE PASS FREQUENCY AND A SMALL PHASE CHANGE CAN BE INTRODUCED AT THE ANTENNA JUNCTION BY ALTERING THE QUARTERWAVE JUNCTION CABLE ON THE OPPOSITE SIDE OF THE DUPLEXER. THE PROCEDURES FOR OPTIMIZING THE LENGTHS ARE AS FOLLOWS: CUT FOUR CABLES, TWO 10 AND 20% SHORTER AND TWO 10 AND 20% LONGER THAN THE THEORETICAL QUARTERWAVE. IN ACTUAL PRACTICE, THEY WILL BE THE SAME FOR L_2 AND L_7 SINCE THE TWO DUPLEXER FREQUENCIES USUALLY DIFFER BY LESS THAN 1-2% OF EITHER DUPLEX OPERATING FREQUENCY AND THESE SMALL DIFFERENCES CAN BE NEGLECTED.

THE FOLLOWING CIRCUIT, FIGURE 9, IS USED FOR OPTIMIZING THE TRANSMITTER INSERTION LOSS. THE METHOD IS ILLUSTRATED USING THE SAMPLE CIRCUIT AND FREQUENCIES ON PAGE 2 (FIGURE 4).

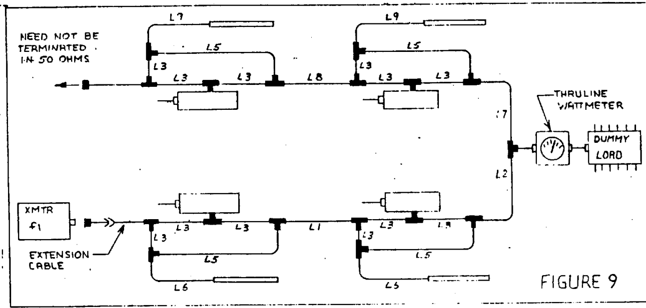


FIGURE 9

FIRST, ADJUST THE EXTENSION CABLE FROM THE TRANSMITTER TO SOME MULTIPLE OF HALF WAVELENGTHS AT F_1. THIS CAN BE DONE BY DOUBLING THE QUARTERWAVE CONSTANT IN THE PREVIOUS FORMULAS FOR L_2 AND L_7. LEAVE OFF L_7 AND TUNE THE TRANSMITTER FOR MAXIMUM POWER OUTPUT. NOW, CONNECT THE THEORETICAL QUARTERWAVE FOR L_7 AND TUNE TRANSMITTER FOR MAXIMUM POWER OUTPUT AGAIN. SUBSTITUTE LENGTHS FOR L_7 WHICH VARY ±10-20% IN LENGTH, EACH TIME RETUNING THE TRANSMITTER. CHOOSE THE LENGTH WHICH GIVES THE MAXIMUM POWER OUTPUT FOR LOWEST PLATE CURRENT.

TOTAL TRANSMITTER INSERTION LOSS CAN BE DETERMINED USING THE PROCEDURE OUTLINED IN CI-096.

THE FOLLOWING CIRCUIT, FIGURE 10, IS USED FOR OPTIMIZING THE RECEIVER INSERTION LOSS:

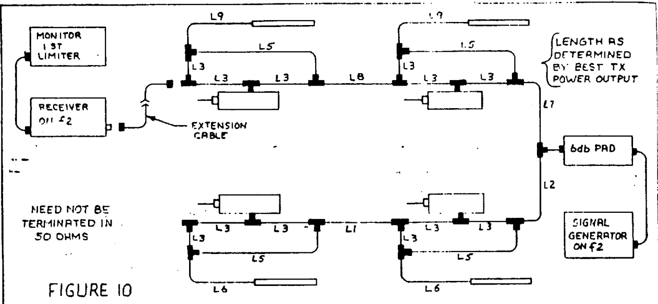


FIGURE 10

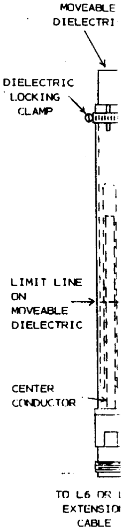
FIRST, ADJUST THE EXTENSION CABLE FROM THE RECEIVER TO SOME MULTIPLE OF HALF WAVELENGTHS AT F_2. THIS CAN BE DONE BY DOUBLING THE QUARTERWAVE CONSTANT IN THE PREVIOUS FORMULAS FOR L_2 AND L_7. LEAVE OFF L_2 AND USING SIGNAL GENERATOR DRIVE WHICH GIVES A READABLE, BUT UNSATURATED, LIMITER READING, TUNE THE RECEIVER INPUT FOR MAXIMUM LIMITER READING. NOW, CONNECT THE THEORETICAL QUARTERWAVE FOR L_2 AND RETUNE RECEIVER, OBSERVING THE LIMITER READING FOR A REFERENCE. SUBSTITUTE LENGTHS FOR L_2 WHICH VARY ±10–20% IN LENGTH, EACH TIME RETUNING THE RECEIVER INPUT. CHOOSE THE LENGTH WHICH GIVES THE HIGHEST LIMITER READING.

TOTAL RECEIVER INSERTION LOSS CAN BE DETERMINED USING THE PROCEDURE OUTLINED IN CI-096.

SINCLAIR RADIO LABORATORIES INCORPORATED
675 ENSMINGER ROAD PO BOX 23
TONAWANDA, NEW YORK 14150

ADJUSTABLE STUB NOMENCLATURE AND OPERATION WITH HYBRID RING CIRCUITS

THE ADJUSTABLE STUB IS AN OPEN CIRCUITED SECTION OF TRANSMISSION LINE WHOSE ELECTRICAL LENGTH IS VARIED BY THE INSERTION OF A DIELECTRIC ROD OVER THE OPEN END OF THE LINE. IN THE HYBRID RING CIRCUIT, IT ACTS AS A VARIABLE CAPACITOR. TO VARY THE ELECTRICAL LENGTH OF THE STUB, LOOSEN THE CLAMP AND MOVE THE DIELECTRIC. THIS PLACES VARYING AMOUNT OF DIELECTRIC OVER THE OPEN ENDED CENTER CONDUCTOR. THE STUB IS LENGTHENED BY MOVING THE DIELECTRIC IN AND SHORTENED BY MOVING THE DIELECTRIC OUT.



THE TOTAL STUB LENGTH USUALLY CONSISTS OF A VARIABLE PORTION PICTURED HERE, PLUS A CERTAIN FIXED LENGTH INSERTED BETWEEN THE VARIABLE STUB AND THE HYBRID RING. THIS FIXED LENGTH OF CABLE MUST BE ADJUSTED SO THAT THE DESIRED PHASE ADJUSTMENT REQUIRED IN THE HYBRID RING TUNING FALLS WITHIN ADJUSTMENT RANGE OF THE STUB. THESE PATCH CABLES ARE THOSE DESIGNATED AS L6 AND L9 IN TN-1001.

UP TO THE TIME OF THIS PUBLICATION, HYBRID RING DUPLEXERS SUPPLIED BY SINCLAIR RADIO LABORATORIES, INC. HAVE UTILIZED SHORTED STUBS TO PROVIDE THE NECESSARY PHASE ADJUSTMENT. THE CABLE WAS PREPARED IN SUCH A MANNER THAT A HOLLOW SHORTING TUBE WOULD SLIDE OVER THE CABLE BRAID AND THE STRIPPED CABLE CENTER CONDUCTOR THROUGH A HOLE IN THE CLOSED END OF THE TUBE, SHORTING OUT THE CENTER CONDUCTOR. THIS ALLOWED ADJUSTMENT OVER A 2" RANGE. THE BRAID AND CENTER CONDUCTOR WERE SOLDERED TO THE BRASS TUBE WHEN THE FINAL POSITION WAS DETERMINED. THIS SYSTEM MADE FIELD ADJUSTMENT DIFFICULT. UNSOLDERING THE BRASS TUBE IS VERY TEDIOUS WORK, IF NOT IMPOSSIBLE. IT IS RECOMMENDED THAT, SHOULD A UNIT IN SERVICE NEED RETUNING, THE PURCHASE OF FOUR ADJUSTABLE STUBS FOR ABOUT $35.00 WOULD SAVE MUCH TIME, DUE TO THE EASE OF ADJUSTMENT.

THE OPEN CIRCUITED STUBS WILL BE ONE-QUARTER WAVE LONGER THAN THE SHORTED STUBS, SO THAT THE PHASE SHIFT INJECTED INTO THE HYBRID RING WILL BE THE SAME.

THERE IS A CHARACTERISTIC LONG AND SHORT PATCH CABLE BETWEEN THE ADJUSTABLE STUB AND THE HYBRID RING; THE SAME AS THERE IS A LONG AND SHORT SHORTED STUB.

THE LONGEST PATCH CABLE WILL APPEAR ON THE HYBRID RING TUNED TO PASS THE HIGH FREQUENCY AND REJECT OR CANCEL THE LOW FREQUENCY. THE SHORTER PATCH CABLE WILL BE ON THE HYBRID RING, TUNED TO PASS THE LOW FREQUENCY AND REJECT THE HIGH FREQUENCY.

THE PATCH CABLE IS ADJUSTED SO THAT THE TUNING RANGE OF THE DIELECTRIC STUB FALLS SLIGHTLY ABOVE AND BELOW THE ACTUAL NULL OR CANCELLATION POINT, ALLOWING SMALL ADJUSTMENTS TO BE MADE IN THE FUTURE. THE NULL POSITION OF THE STUB MAY CHANGE IN TIME DUE TO CABLE FATIGUE, RESULTING IN SLIGHT STRETCHING OF THE HYBRID RING AND ASSOCIATED PHASE CHANGES.

SINCLAIR RADIO LABORATORIES INCORPORATED
675 ENSMINGER ROAD PO BOX 23
TONAWANDA, NY 14150

THE PATCH CABLE IS ADJUSTED DURING TUNING (OR STUB REPLACEMENT) SO THAT THE NULL POSITION OCCURS WHEN ABOUT 1" OF DIELECTRIC IS OUT OF THE STUB. THE SPACING IS A GUIDE TO THE FINAL POINT OF LOCKING, TO ALLOW FOR FUTURE ADJUSTMENT WITHOUT CHANGING PATCH CABLE LENGTH.

WHEN TUNING THE HYBRID RING, STARTING FROM A COMPLETELY UNTUNED CONDITION, THE STUB AND PATCH CABLE ARE COMPLETELY REMOVED AND THE HYBRID RING SECTION IS TUNED FOR THE PASS FREQUENCY BY ADJUSTING THE CAVITY PROBE, AS STATED IN THE DETAILED TUNING PROCEDURE (DTP). THE STUB AND PATCH CABLE ARE THEN ATTACHED TO THE HYBRID RING. UPON PLACING THE FREQUENCY TO BE CANCELLED THROUGH THE HYBRID RING, THE PATCH CABLE IS SUBSTITUTED IN INCREMENTS OF ½" IN LENGTH UNTIL THE DIELECTRIC IS OUT ABOUT 1".

FOR HYBRID RINGS IN THE 148-174 MHZ REGION, INITIAL TRIAL LENGTHS OF PATCH CABLE (CUT CABLE LENGTH) ARE 17" ON HYBRID RINGS, HAVING A HIGH PASS FREQUENCY AND 10-½" ON HYBRID RINGS HAVING THE LOWER OF THE TWO FREQUENCIES AS THE PASS FREQUENCY.

WHEN ADJUSTING THE PATCH CABLE FOR THE LOCATION OF THE NULL, THE MOTION OF THE DIELECTRIC ROD INDICATES WHETHER THE PATCH CABLE NEEDS TO BE LONGER OR SHORTER, USING THE FOLLOWING RULE: IF THE NULL IS APPROACHED WHEN THE DIELECTRIC IS FULLY INSERTED, THE PATCH CABLE NEEDS TO BE LONGER. IF THE NULL IS APPROACHED WHEN THE DIELECTRIC IS FULLY RETRACTED, THE PATCH CABLE NEEDS TO BE SHORTER. THE DIELECTRIC HAS A LIMIT LINE TO INDICATE THE MAXIMUM IT CAN BE RETRACTED. A NUMBER OF PATCH CABLES IN ½" INCREMENTS FROM 8" TO 18" ARE VERY USEFUL FOR THIS PURPOSE.

THE PATCH CABLE LENGTHS WILL CHANGE WHEN THE FREQUENCY SEPARATION OF THE PASS AND CANCELLED FREQUENCIES CHANGE. IN GENERAL, AS THE FREQUENCY SEPARATION DECREASES, THE LONG PATCH CABLE WILL GET LONGER AND THE SHORT PATCH CABLE WILL GET SHORTER. THE REVERSE WILL OCCUR FOR INCREASES IN FREQUENCY SEPARATION WHERE THE LENGTHS OF BOTH STUBS TEND TOWARD THE THEORETICAL HALF-WAVE LENGTH WHICH, IN THE CASE OF THE OPEN STUB, IS A REPEATING OF THE STUB OPEN CIRCUIT TO THE POINT OF HYBRID RING ATTACHMENT. THE STUB APPEARS ELECTRICALLY ABSENT AND SO CAN BE, THEORETICALLY, PHYSICALLY REMOVED. IN ACTUAL PRACTICE, THERE IS ALWAYS SOME PHASE IMBALANCE AND A STUB IS REQUIRED.

GENERAL (HARNESS APPLICABLE TO F-2016, F-2076, F-150-4G, F-150-4E)

THE CABLE LENGTHS SHOWN ON THE DIAGRAM ON PAGE TWO ARE CUT CABLE LENGTHS BEFORE THEY ARE PREPARED FOR CONNECTOR INSTALLATION. THESE LENGTHS (EXCEPT FOR L6 & L9) DO NOT CHANGE FOR OPERATION IN THE 144-146 MHZ AREA AT ANY FREQUENCY SEPARATION FROM 500 KHZ ON OUT. CABLES L6 & L9 WILL VARY WITH CHANGES IN FREQUENCY [illegible] AND MANUAL CM-106 COVERS THE PROCEDURE FOR DETERMINING NEW LENGTHS. THE CHART PROVIDED BELOW GIVES INITIAL LENGTHS FOR L6 & L9 VS. FREQ. SEPARATION BASED ON PAST HISTORY AND SHOULD BE YOUR STARTING POINT.

PARTS LIST

45 FT	RG-214/U 50 OHM CABLE
12 EA.	CRIMP/SOLDER 'N' FEMALE TEE CONNECTORS
1 EA	" " " " PANEL MOUNT TEE CONNECTOR (ANTENNA JUNCTION)
66 EA.	CRIMP/SOLDER 'N' MALE CONNECTORS
4 EA.	UG-107 B/U TEES

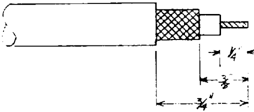
OPTIONAL!

4 EA. ST-2 STUBS

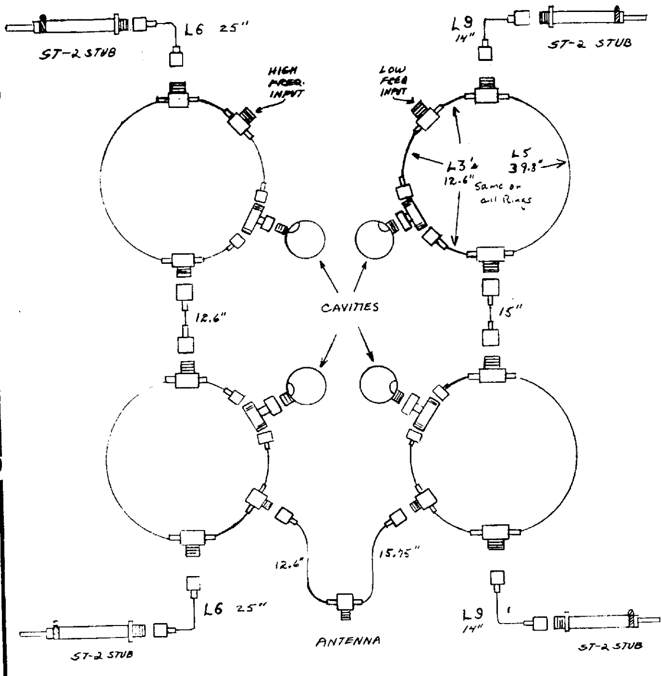
TRIAL LENGTHS FOR L6 & L9

FREQ. SEP.	L6 (INS.)	L9 (INS.)
500 KHZ	26"	13.5"
600 KHZ	24"	15"
700 KHZ	22"	16.5"

CABLE PREPARATION DIMENSIONS - ALL CONNECTORS



NOTE:
THE 1/2" DIA. CRIMP FERRULE MAY BE SOLDERED TO BRAID INSTEAD OF CRIMPED. DRILLING A 3/16" DIA. HOLE MIDWAY ACROSS THE TUBE WILL FACILITATE SOLDERING.



CIRCUIT DIAGRAM

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.

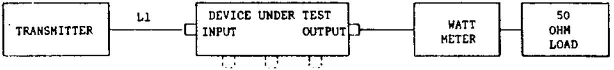
ATTENTUATION AND INSERTION LOSS
FIELD MEASUREMENT TECHNIQUES

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.



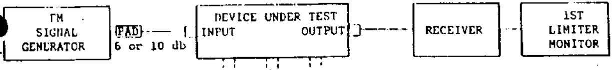
Install the device to be measured in the circuit as shown above, tune the transmitter for maximum power out. If the reflected power is not zero or near zero, then cable L1 should be adjusted to give the highest output power (lowest reflected power) when tuning the transmitter into the device. There will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

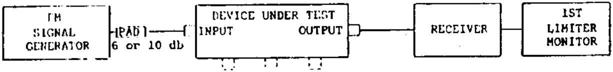
Voltage ratio = microvolts (w/o device)/microvolts (w/device)

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)

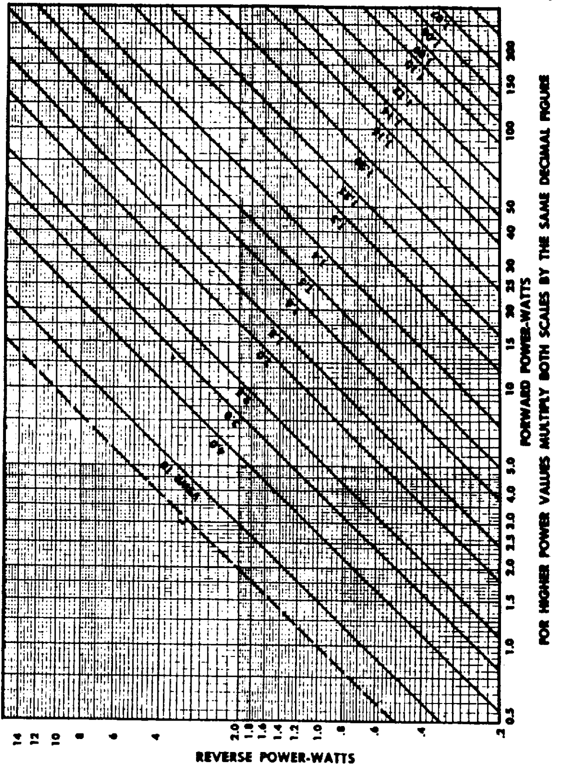
Consult the data Sheet or Detailed Tuning Procedure of the particular model under test for typical values of Insertion loss and attenuation.

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