SPACE DIVERSITY DADE TESTS

This section describes the procedure for performing DADE (differential absolute delay equalization) on space diversity radio receivers. The purpose of the DADE procedure is to equalize the electrical length of the regular and diversity transmission paths up to the input of the IF Combiner. Delay equalization is accomplished by adding coaxial cable in the receiver IF path that is electrically shorter.

Since the absolute delay difference between the two receiver paths depends on the equalizers used for correcting EDD (envelope delay distortion), the DADEing procedures described here must be done after the EDD tests.

Since fading activity can also make it difficult to proceed with the measurements necessary to complete the DADEing process, DADEing tests should be made when normal propagation conditions exist.

Note also that the DADEing procedure requires that a channel be taken out of service.

REASON FOR DADEING

DADEing of the regular and diversity path IF inputs to the IF Combiner is necessary for proper combiner operation. The function of the IF combiner is to switch from the signal on one path to the other without causing hits or errors in the digital payload signal. This switching action, sometimes referred to as "soft switching," is accomplished by a linear combining and attenuating process that requires the two input signals to be within 10 ns to avoid hits.

By removing any delay difference between the two transmission paths during normal propagation conditions, the IF combiner is placed in the center of an approximate 20 ns switching window. Equalizing the delay differences to the center of this window under normal propagation conditions normally makes it possible to achieve the soft switching objective during fading conditions.

In order to achieve satisfactory combiner performance, the objective after DADEing is to have the two transmission paths within 3 ns of each other. Since IF cable has a delay of approximately 1.5 ns/ft., this objective requires that the two IF input paths to the combiner be equalized to within 2 feet of each other.

The spacing between the regular and diversity antenna is typically 30 feet. Since the propagation delay in waveguide is about 1.3 ns/ft., the delay difference between signal paths due to this spacing alone is 39 ns. Thus, if the remaining signal paths of the regular and diversity receivers are equal, the shorter path in such a station would need to be lengthened by approximately 26 feet (i.e., 39 ns/1.5 ns/ft.) to achieve the desired delay equalization.

OUTLINE OF TEST PROCEDURE

Several techniques are available for determining the DADE cable needed for a space diversity receiver. The various procedures depend on whether maintenance personnel are available for both ends of the hop being DADEed and also on test set availability. The DADE procedure described here is designed to be done by a single operator, on a receive-end-only basis, using the over the air digital signal itself.

In this procedure, the radio IF output signals corresponding to the regular and diversity IF inputs to the IF combiner are first combined using an equal-loss hybrid. The resultant IF signal

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is then displayed on an IF spectrum analyzer, and an analysis of the displayed spectrum is used to determine the delay difference between the two signal paths. Using this display technique, measurements and calculations are made to determine which path is the longest, the equivalent length difference, and finally the type and location of the correcting IF cable.

Determining Equivalent Path Length Difference

The procedure for determining the absolute delay difference between signal paths is based on the fact that the phase difference between the corresponding frequency components of the regular and diversity signal spectra is proportional to the delay difference between the two paths. Thus the amplitude of the combined spectrum at the output of the combining hybrid varies as a function of frequency. Wherever the delay difference is enough to create a 180 degree difference, a null will appear in the combined spectrum. If the delay difference is enough to produce multiple nulls in the displayed spectrum, the delay difference between the two paths can be calculated using the equation:

Delay Difference in ns = 1000/null spacing in MHz.

If the delay difference is not enough to produce multiple nulls, a calibrated 59 foot reference cable, which is of adequate electrical length to guarantee multiple nulls within a spectrum width of approximately 22 MHz, is inserted into the "longer" IF path. In any case, the receiver which has the "longer" transmission path is determined using this same reference cable. This is done by inserting the reference cable first in one receiver path and then the other while noting the null spacing. The receiver which produces the closest null spacing with the reference cable present is the longest receiver. If necessary to produce multiple nulls, the reference cable is then left in the "longest" side during measurement. When this is the case, the actual delay difference is determined by subtracting the delay of the reference cable from the calculated value for the combination.

Normally the actual delay difference is of little interest. Of primary concern is the delay difference in terms of equivalent coaxial cable that must be added in the shorter IF path to eliminate the delay difference between the two paths. For the coaxial cable types used for DADEing (i.e., delay factor = 1.538 ns/ft.), the length of cable which is equivalent to the delay difference is determined using the equation:

Equivalent Length (ft.) = 650/null spacing (MHz).

Again, if this calculation is based on null spacing with the reference cable present in the longest side, the actual cable length required for equalization is determined by subtracting the electrical length of the reference cable from the result.

Determining the DADE Cable Type and Location

DADE cable when required, is normally inserted in the shorter IF path via a pair of DADE access jacks at the top of the radio bay. These access jacks may be inserted into either receiver IF path by connectorized coaxial cables attached to each jack. The first step in determining DADE cable requirements is to determine which of the two paths is the shorter path without the DADE access jacks present in either path. Once the shorter path without these jacks is determined, the DADE jacks are inserted into the IF path of that receiver. The jacks are inserted into the IF path between the IF OUT jack on the down-converter and the IF IN jack on the linear delay equalizer unit. Before further testing, the DADE access jacks are connected together with a patch plug to complete the IF path.

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The type and location of the DADE cable finally deployed depends on the original length difference between paths without the DADE access jacks present in either path. If the original length difference is greater than the length of the DADE jack insertion cables (approximately 10 feet), DADEing is accomplished by inserting additional WESTERN ELECTRIC® 731B coaxial cable between the access jacks. If the total length of the access jack insertion cables exceeds the original path length difference, the patch plug is left between the access jacks and a length of KS-19224, L2 mini-coaxial cable is inserted into the IF path of the opposite receiver. The mini-coaxial cable is cut to a length to compensate for the over-equalization of the DADE access jack insertion. The decision on which procedure must be used is made by repeating the test to determine which receiver path is the shortest with the DADE access jacks present in the originally shorter receiver.

If after inserting the DADE access jacks, the originally shorter receiver path becomes the longer path, the originally shorter receiver is over-equalized by the access jack insertion cables. In this case, DADEing is accomplished by inserting a corrective length of KS-19224, L2 mini-coaxial cable in the IF path of the receiver without the access jacks (i.e., originally longer path).

For either situation, the length of cable required to meet DADEing requirements is determined using the null spacing procedure outlined in the test procedures in the NULL SPACING MEASUREMENT PROCEDURE. Once the length difference is known, the required 731B or mini-coaxial cable is cut to length, assembled with the proper connectors, and installed in the proper path. While the 731B cable is inserted between the DADE access jacks, the mini-coaxial cable is coiled up and installed in the IF path of the receiver without the DADE access jacks. The mini-coaxial coil is installed and inserted into the proper IF path within the LINEAR DELAY EQUALIZER plug-in unit using the cable tie-downs provided for this purpose.

Following the installation of the DADE cable, make a check on equalization accuracy. This is done by making a comparison of null spacing equality with the reference cable first in one side and then the other. A Combiner Performance Check is also made to verify that the inserted delay equalization is satisfactory from a switching point of view.

SUMMARY OF DADE PROCEDURE STEPS

The steps to perform the above DADE procedure are summarized below:

1. If unknown, determine actual electrical length of 59-foot reference cable.
2. Determine the receiver with the longest IF path without DADE access jacks present in either path.
3. Insert DADE access jacks in shorter IF path. Connect jacks with patch plug.
4. Repeat measurement to determine the longest receiver IF path with the DADE access jacks present in originally shorter path.
5. Based on outcome of Step 4, determine if 731B coaxial cable between DADE jacks or mini-coaxial coil in originally longer receiver is required.
6. Measure frequency difference between adjacent nulls. Use the reference cable in longer path to produce multiple nulls if necessary.
7. Determine the delay difference in terms of equivalent cable length using null frequency spacing measured in Step 6.
8. Assemble and install the required length and type of DADE cable.

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9. Check the final electrical length equality by comparing null spacing measurements with the reference cable inserted first in one path and then the other.
10. Perform "Radio Receiver Combiner IF Input Adjustment" (see station operation and maintenance manual).
11. Perform "Combiner Performance Check" (see station operation and maintenance manual).

DADE WORKSHEET

To help organize the numerical data used throughout the DADE procedure, a DADE Worksheet is provided (Fig. 1). It consists of five sections as follows:

1. *Reference Cable Calibration:* Results of tests to determine the electrical length of the 59-foot Reference Cable.
2. *Initial Long Receiver Determination:* Results of tests which determine which receiver has the longest electrical length without DADE access jacks present.
3. *Final Long Receiver Determination:* Results of tests which determine which receiver has the longest electrical length with DADE access jacks present in originally shorter IF path.
4. *DADE Cable Length Calculation:* Results of tests to determine path length difference with DADE access jacks present in originally shorter IF path.
5. *DADE Test:* Results of tests to verify delay equality of the correcting cable.

A typical example of a filled out worksheet is shown in Fig. 2.

The following test equipment is required to perform this procedure:

1	IF Spectrum Analyzer
1	Marker Tone Generator
1	IF Frequency Counter
1	IF Power Meter
1	Coaxial Connector Adapter Kit
5	Cables, 8 feet, 440 (P) - 448 (P)
1	Cable, 59 feet, 440 (P) - 560 (J) (Reference Cable)
3	Cables, 6 feet, 440 (P) - BNC (P)
2	Cables, 6 inches, SMB (J) - 560 (J)
1	64R Unequal Loss Split Pad
3	2671A Hybrids
1	443A Patch Plug
1	DADE Cable Installation Kit
1	Set of DADE Cable and Connectors per Space Diversity Receiver Pair.

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The following procedures are included in this test:

a. REFERENCE CABLE CALIBRATION PROCEDURE

b. RADIO RECEIVER DADE PROCEDURE
   - Preliminary Preparations
   - Initial Long Receiver Determination
   - Final Long Receiver Determination
   - DADE Cable Length Determination

c. DADE CABLE INSTALLATION PROCEDURE

d. NULL COMPARISON CHECK

e. DIGITAL PERFORMANCE CHECK OF DADED RECEIVER

f. NULL SPACING MEASUREMENT PROCEDURE
   - Preliminary Test Set Adjustments
   - Null Frequency Difference Measurement.

Reference Cable Calibration Procedure

A calibrated reference delay is required with this DADE procedure. The reference delay is provided by a 59-foot reference cable that nominally provides the required delay. Due to variations in physical properties, however, the electrical length of a cable may differ from the mechanical length by as much as 10 percent. Since such a variation is too large for the desired DADEing accuracy, the actual electrical length of reference cable must be known before beginning the RADIO RECEIVER DADE PROCEDURE.

STEP	PROCEDURE
1	If the electrical length of the 59-foot reference cable is known, proceed directly to the RADIO RECEIVER DADE PROCEDURE.
2	If the electrical length of the reference cable is not known, go to Step 3.
3	Establish test setup shown in Fig. 3.
4	Use the NULL SPACING MEASUREMENT PROCEDURE to determine the necessary data for calculating electrical length of reference cable.
5	Record intermediate data and calculate the electrical length of reference cable in the REFERENCE CABLE CALIBRATION section of the DADE Worksheet. Once the reference cable is calibrated, perform the RADIO RECEIVER DADE PROCEDURE.

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Radio Receiver DADE Procedure

STEP	PROCEDURE
Preliminary Preparations	
1	Measure the regular and diversity receiver IF output levels at the REG IF OUT and DIV IF OUT access ports on the LINEAR DELAY EQUALIZER plug-in unit.
2	Adjust the REG and DIV IF output levels at these ports to be approximately equal using the IF LEV ADJ controls on the RECEIVER DOWN CONV & MWV GEN plug-in unit.
3	Establish measurement setup shown in Fig. 4.
4	Set the controls on the IF spectrum analyzer to display a 30-MHz band centered at 70 MHz.
5	Set the controls on the marker tone generator to provide an adjustable clockwise tone between 50 and 90 MHz at approximately 0 dBm.
6	Adjust the spectrum analyzer controls as needed to place the entire digital signal on the display. See Fig. 5 for typical display.
7	Adjust the frequency of the marker tone generator to move the tone away from the digital signal.
Initial Long Receiver Determination	
	The following steps show which receiver path is electrically longer without the DADE access jacks inserted in either IF path. Record the data from this procedure in the INITIAL LONG RECEIVER DETERMINATION section of the DADE Worksheet.
8	With equal length cables from the REG and DIV radio receivers to the combining hybrid, observe the spectrum display and note if any nulls are present. If nulls are present, maximize null depth if possible by slight readjustment of one of the IF LEV ADJ controls on the DOWN CONV. Otherwise, go to Step 9.
9	Insert the reference cable in the regular receiver IF path to the combiner.
10	Adjust the IF level control on diversity receiver to maximize null depth, and record the number of nulls on the worksheet for this condition.

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STEP	PROCEDURE
11	Transfer the reference cable to the diversity receiver IF path.
12	Reoptimize null depth by adjusting IF level control on regular receiver, and record null count under this condition on the Worksheet.
13	Note from the Worksheet which receiver location of the reference cable produced the greatest number of nulls. This is the "longest" receiver and should be so identified in the applicable DADE Worksheet section.
14	Insert DADE access jacks in the shortest receiver IF path by connecting: a. Cable coming from IF IN DADE access jack to the shortest receiver IF OUT port on RECEIVER DOWN CONV AND MWV GEN unit. b. A cable between the shortest receiver DADE IF OUT and the IF IN ports on the LINEAR DELAY EQUALIZER unit. Use the cable provided with each receiver for this purpose.
15	Connect between DADE access jack IF IN and IF OUT ports using a 443A patch plug.

Final Long Receiver Determination

The following steps show which receiver path is electrically longer with the DADE access jacks inserted into the IF path of the receiver determined to be the shortest without the DADE access jacks inserted in either path. Enter the data from this procedure in the FINAL LONG RECEIVER DETERMINATION section of the DADE Worksheet.

STEP	PROCEDURE
16	Insert the reference cable in the regular receiver IF path to the combiner.
17	Adjust the IF level control on the diversity receiver to maximize null depth, and record the number of nulls for this receiver location on the Worksheet.
18	Transfer the reference cable to the diversity receiver IF path.
19	Maximize null depth by adjusting IF level control on regular receiver, and record null count for this location on the Worksheet.
20	Note from the Worksheet which receiver location of the reference cable produced the greatest number of nulls. This is the longest receiver and should be so identified in the applicable DADE Worksheet section.

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STEP	PROCEDURE

DADE Cable Length Determination

This procedure is used to determine the length of 731B or mini-coaxial cable required in the IF path of the receiver determined to be the shortest with the DADE access jacks present in one of the paths.

21 Use the NULL SPACING MEASUREMENT PROCEDURE in conjunction with the setup shown in Fig. 4 to obtain the data necessary to calculate the length of DADE cable required to equalize the delay of the two paths.

Note: While performing the Null Spacing Measurement Procedure, record data and calculations in the DADE CABLE LENGTH CALCULATION section of the Worksheet.

22 Using the measured null spacing data, calculate EQUIVALENT LENGTH OF CABLE.

23 Determine the actual length of DADE cable required per one of the following cases:

a. If the reference cable is used while making the null spacing measurements, subtract the electrical length of the reference cable from the EQUIVALENT LENGTH OF CABLE to determine the actual DADE CABLE LENGTH to use.

b. If the reference cable is not used, use a cable length equal to the EQUIVALENT CABLE LENGTH for the actual DADE CABLE.

24 Proceed to the DADE CABLE INSTALLATION PROCEDURE.

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DADE Cable Installation Procedure

STEP	PROCEDURE
1	Referring to the FINAL LONG RECEIVER DETERMINATION section of the DADE Worksheet, note which receiver path is the shortest.
2	If the receiver with the DADE access jacks present in its IF path is the shortest, go to Step 4.
3	If the receiver without the DADE access jacks present in its IF path is the shortest, go to Step 8.

DADE Cable Preparation and Installation When Path With DADE Access Jacks Is Shorter—731B Coaxial Case

4	Attach 448A plugs to a 731B coaxial cable the length equal to that calculated on the Worksheet.
5	Remove the 443A patch plug connected between the IF IN and IF OUT ports of the DADE access jacks.
6	Install the 731B DADE cable assembly between the DADE jacks. Coil up cable and locate cable in overhead cable racks or other convenient storage location.
7	Go to NULL COMPARISON CHECK.

DADE Cable Preparation and Installation When Path Without DADE Access Jacks Is Shorter—Mini-Coaxial Coil Case

8	Attach right angle female (KS-20864, L3) and right angle male (KS-20863, L3) snap-on SMB connectors to a KS-19224, L2 mini-coaxial cable the length equal to that calculated on the DADE Worksheet.
9	Coil up the mini-coaxial cable assembly into an approximate 4-inch diameter coil, and tie into this shape using the cable ties provided.
10	Install the mini-coaxial coil within the LINEAR DELAY EQUALIZER plug-in unit using the cable coil tie-downs provided. See Fig. 6 for mounting details.
11	Insert the mini-coaxial cable coil into the IF path of the shortest receiver. This is accomplished by inserting the mini-coaxial coil in the appropriate path within the LINEAR DELAY EQUALIZER unit. See Fig. 6 for installation and connection details.

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STEP	PROCEDURE
12	Go to NULL COMPARISON CHECK.

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Null Comparison Check

This procedure checks the accuracy of the completed DADE process. During this test, record the data and calculations in the DADE TEST section of the DADE Worksheet.

STEP	PROCEDURE
1	With the DADE cable in place and using the setup shown in Fig. 4, insert the reference cable in the regular receiver IF path.
2	Adjust the diversity receiver IF LEV ADJ on the DOWN CONV to produce the best nulls on the spectrum analyzer display.
3	Using the NULL SPACING MEASUREMENT PROCEDURE, measure and record the null spacing data in the appropriate column of the DADE Worksheet.
4	Insert the reference cable in the IF path of the diversity receiver, and maximize the null depth by adjusting the IF LEV ADJ in the regular receiver.
5	Using the NULL SPACING MEASUREMENT PROCEDURE, measure and record the null spacing data in the appropriate column of the DADE Worksheet.
6	Calculate the cable length from the null spacing data for the two reference cable locations and compare results. *Requirement:* The calculated values of cable length for the two cases should be within 2 feet of each other. If the requirement is met, go to DIGITAL PERFORMANCE CHECK OF DADED RECEIVER. If the requirement is not met, repeat the DADE TEST from the beginning to determine where error was made.

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Digital Performance Check of DADEd Receiver

STEP	PROCEDURE
1	Perform Radio Receiver Combiner IF Input Adjustment procedure in applicable station operation and maintenance manual.
2	Perform Combiner Performance Check procedure in station operation and maintenance manual.
	If requirements of the performance check are met, the DADE procedure is complete.
	If requirements of the performance check are not met, follow troubleshooting procedures recommended in Combiner Performance Check chart.

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Null Spacing Measurement Procedure

This procedure is applicable to the REFERENCE CABLE CALIBRATION PROCEDURE, the RADIO RECEIVER DADE PROCEDURE, and the NULL COMPARISON CHECK. Record the data taken during this procedure in the appropriate section of the DADE Worksheet.

STEP	PROCEDURE

Preliminary Test Set Adjustments

1 Set the controls on the IF spectrum analyzer to display a 30-MHz band centered at 70 MHz.

2 Set the controls on the marker tone generator to provide an adjustable clockwise tone between 50 and 90 MHz at approximately 0 dBm.

3 Adjust the spectrum analyzer controls as needed to place the entire digital signal on the display. See Fig. 5 for a typical display.

4 Adjust the frequency of the marker tone generator to temporarily move the tone away from the digital signal.

5 Proceed in accordance with one of the following:

a. If test is being done in conjunction with REFERENCE CABLE CALIBRATION or NULL COMPARISON CHECK, go to Step 6.

b. If test is being done in conjunction with RADIO RECEIVER DADE PROCEDURE, observe displayed spectrum for presence of multiple nulls.

If multiple nulls do not exist, insert reference cable in IF path of longer receiver and adjust IF LEV ADJ of opposite receiver to maximize null depth; then go to Step 6.

If multiple nulls exist, go to Step 6.

Null Frequency Difference Measurement

In the following steps, the marker tone generator and a frequency counter are used to measure the difference in frequency between adjacent nulls (see *Note* in Step 10).

6 Adjust the marker tone generator frequency and output power to center a visible tone on a null in the displayed digital signal spectrum. See Fig. 7 for a typical display.

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STEP	PROCEDURE
7	Measure the injected tone frequency, and record this value as the *first frequency* on the DADE Worksheet.
8	Adjust the marker tone generator frequency to center the injected tone in a null adjacent to the first one measured.
9	Measure the injected tone frequency, and record this value as the *second frequency* on the DADE Worksheet.
10	Calculate the difference between the *first frequency* and *second frequency*, and record this value as the *frequency difference* on the DADE Worksheet. *Note:* On a display with many nulls, the frequency difference between adjacent nulls may differ across the band. This is caused by a delay response that is not flat. In this case, use an average of the null spacing values across the band.
11	Once the null spacing measurements are complete, return to the step that called for this procedure.

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DADE WORKSHEET		
REFERENCE CABLE CALIBRATION		
First Frequency (MHz) F1		
Second Frequency (MHz) F2		
Frequency Difference (MHz) FD=F2-F1		
Cable Length (Feet) L=650/FD		
INITIAL LONGER RECEIVER DETERMINATION (W/O DADE Jacks Present)		
	Ref Cable Position	
	Reg	Div
Nulls with 59' Cable		
Longer Receiver (Most Nulls)*		
FINAL LONGER RECEIVER DETERMINATION (W/DADE Jacks Present) In: ( )		
	Ref Cable Position	
	Reg	Div
Nulls with 59' Cable		
Longer Receiver (Most Nulls)*		
DADE CABLE LENGTH CALCULATION		
First Frequency (MHz) F1		
Second Frequency (MHz) F2		
Frequency Difference (MHz) FD=F2-F1		
Equivalent Length of Cable (Feet) L=650/FD		
DADE Cable Length L-59' (Feet)†		
DADE TEST		
	Ref Cable Position	
	Reg	Div
First Frequency (MHz) F1		
Second Frequency (MHz) F2		
Frequency Difference (MHz) FD=F2-F1		
Cable Length (Feet) L=650/FD		

* If there are an equal number of nulls, the longer or shorter side can be determined by measuring the spacing between nulls. The path with closer spacing between nulls is the longer side.

† Use only if Reference Cable was required in longer path to produce multiple nulls.

Fig. 1—DADE Worksheet Format

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DADE WORKSHEET		
REFERENCE CABLE CALIBRATION		
First Frequency (MHz) Fl	67.376	
Second Frequency (MHz) F2	78.300	
Frequency Difference (MHz) FD=F2-Fl	10.924	
Cable Length (Feet) L=650/FD 650/10.924	59.5'	
INITIAL LONGER RECEIVER DETERMINATION (W/O DADE Jacks Present)		
	Ref Cable Position	
	Reg	Div
Nulls with 59' Cable	3	1
Longer Receiver (Most Nulls)	Long	Short
FINAL LONGER RECEIVER DETERMINATION (W/DADE Jacks Present) In: (DIV)		
	Ref Cable Position	
	Reg	Div
Nulls with 59' Cable	3	1
Longer Receiver (Most Nulls)	Long	Short
DADE CABLE LENGTH CALCULATION		
First Frequency (MHz) Fl	66.592	
Second Frequency (MHz) F2	74.123	
Frequency Difference (MHz) FD=F2-Fl	7.531	
Equivalent Length of Cable (Feet) L=650/FD	86.3'	
DADE Cable Length L-59' (Feet)* 86.3'-59.5'	26.8'	
DADE TEST		
	Ref Cable Position	
	Reg	Div
First Frequency (MHz) Fl	64.710	62.295
Second Frequency (MHz) F2	75.821	73.219
Frequency Difference (MHz) FD=F2-Fl	11.111	10.924
Cable Length (Feet) L=650/FD	58.5'	59.5'

* Use only if Reference Cáble was required in longer path to produce multiple nulls.

Fig. 2—DADE Worksheet Example

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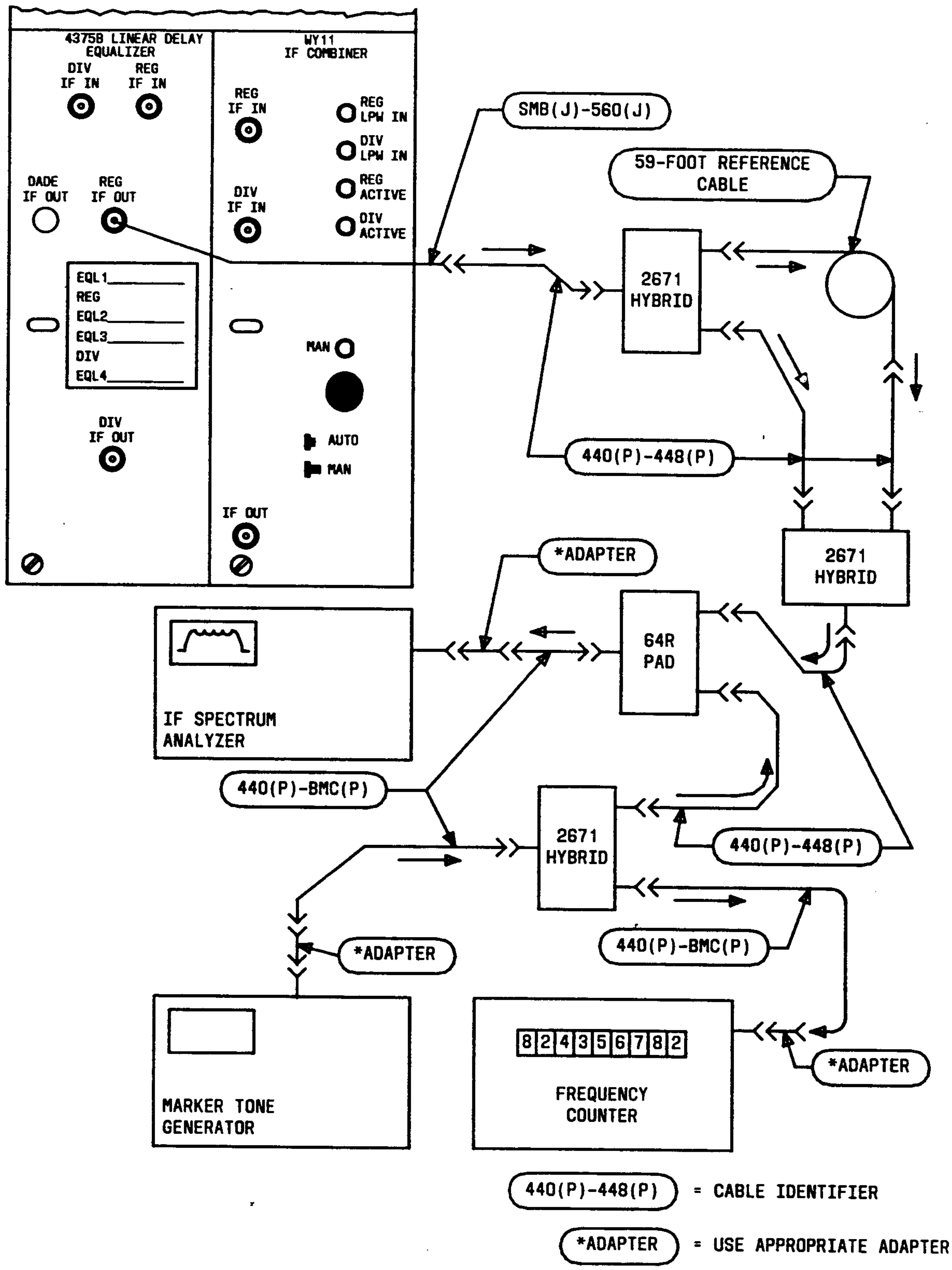

Fig. 3—Reference Cable Calibration Test Configuration

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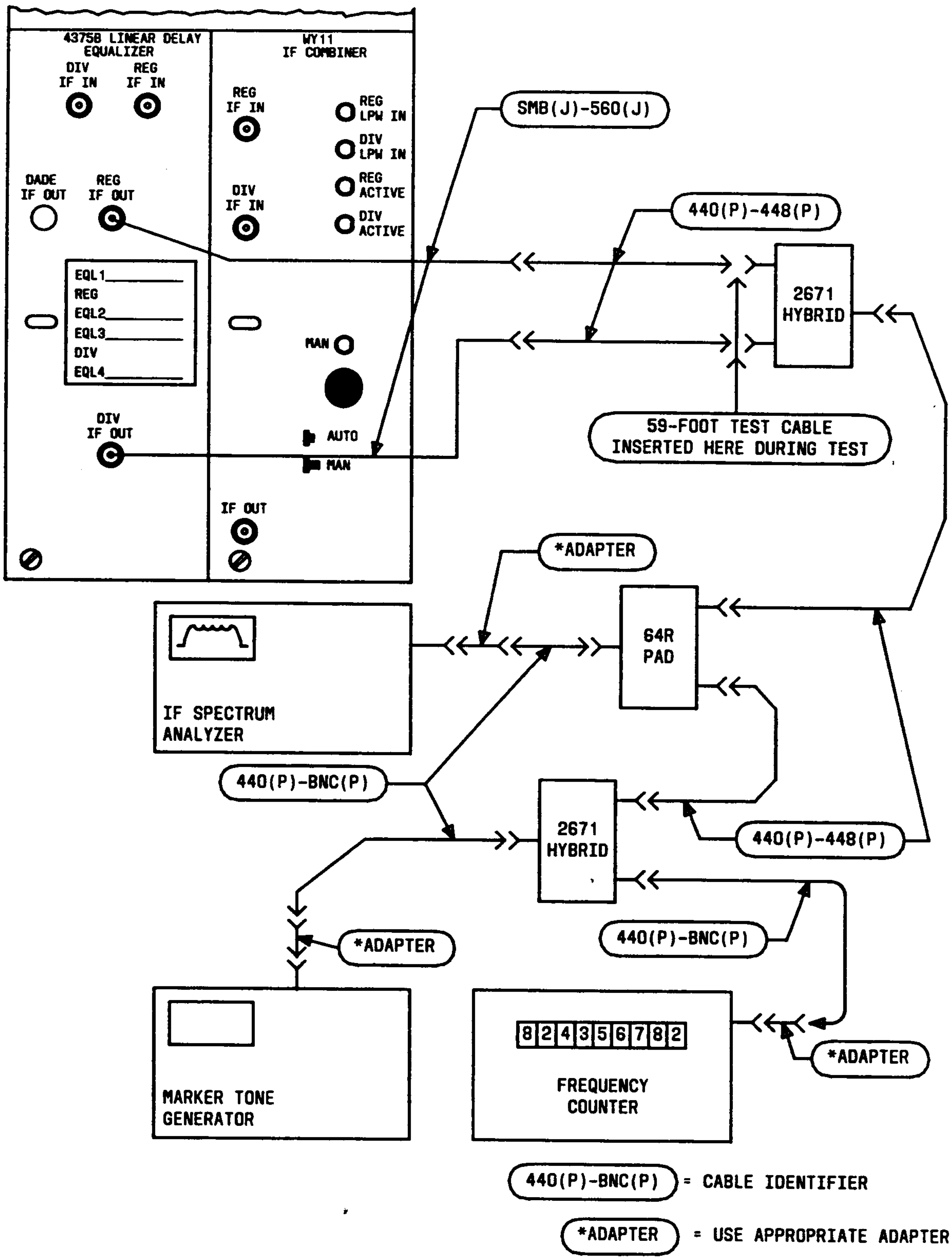

Fig. 4—Test Setup for Radio Receiver DADE Procedure

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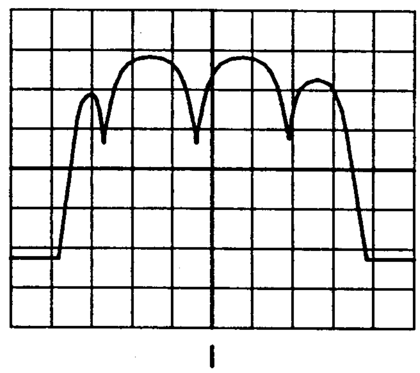

Fig. 5—Typical IF Spectrum at Output of Combining Hybrid Before DADEing

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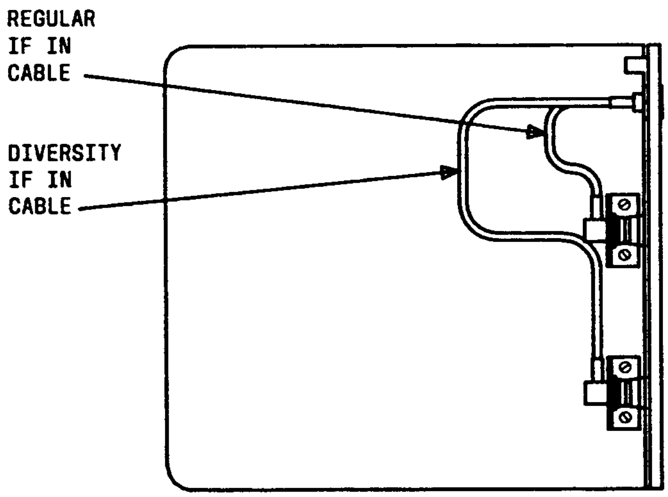
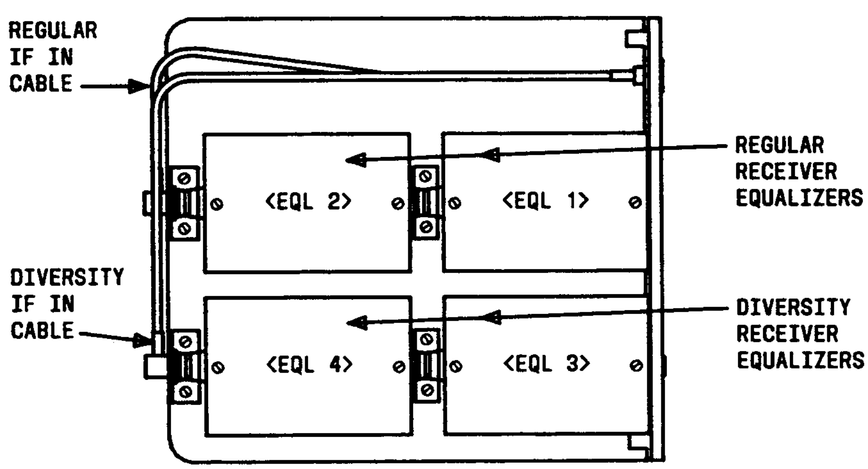


A. NO EQUALIZER EQUIPPED



B. FOUR EQUALIZERS EQUIPPED
BEFORE MOUNTING MINI-COAX COIL

Fig. 6—Mounting and Connecting Details (Sheet 1 of 2)

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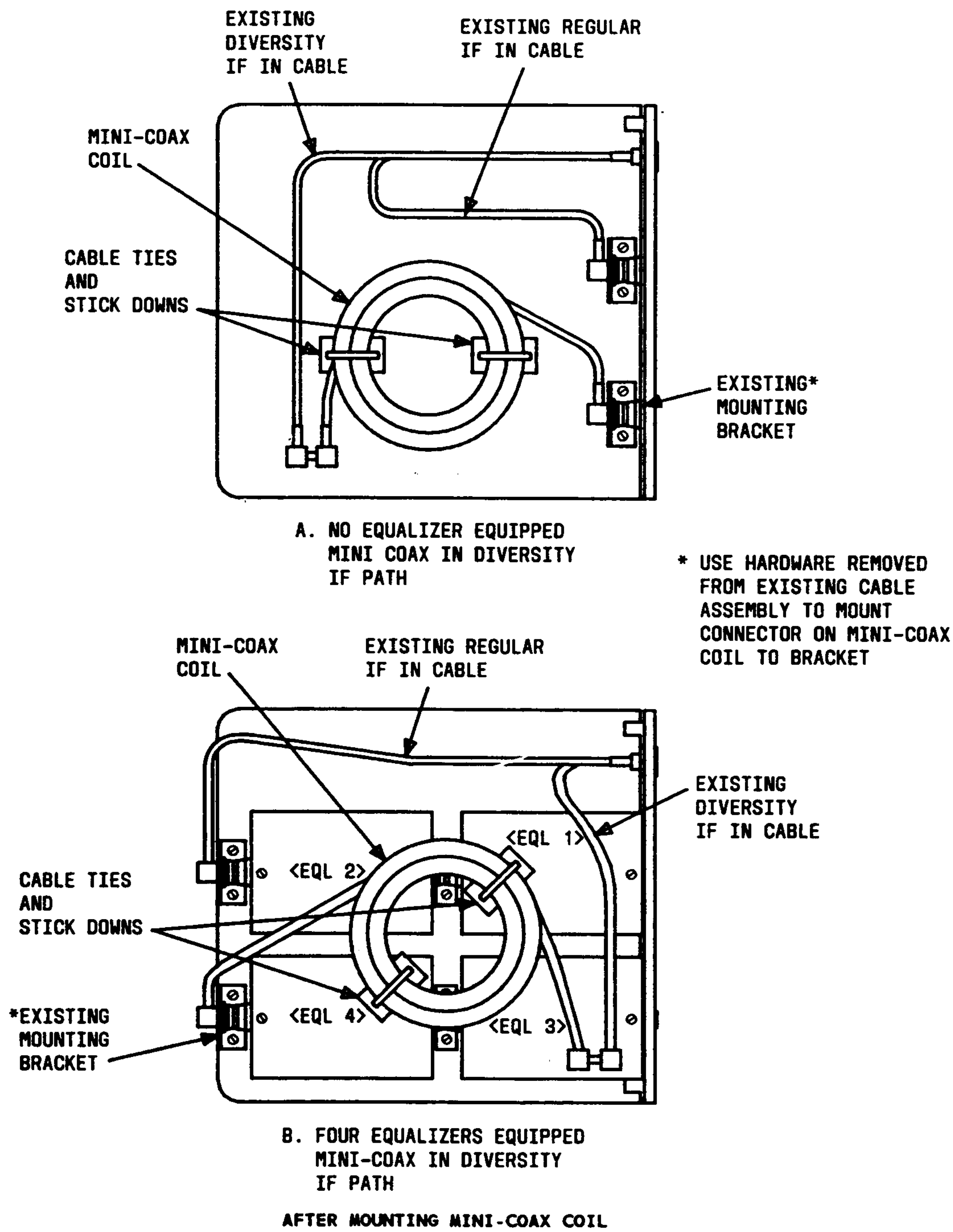

Fig. 6—Mounting and Connecting Details (Sheet 2 of 2)

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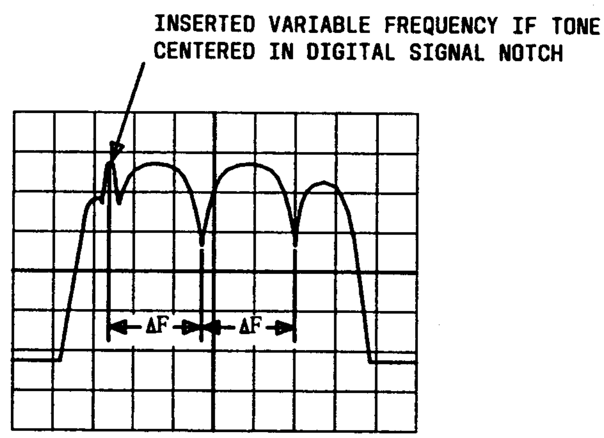

Fig. 7—Multinull IF Spectrum With Injected Tone

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