OPERATION AND MAINTENANCE
MAINTENANCE SUPPORT
DR 6/11-135A AND 135EC
FADE MARGIN AND INTERFERENCE TESTS

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1. GENERAL

In analog, multihop radio systems, unwanted thermal noise and/or interference from a cochannel, an adjacent channel, or other signal sources that are close enough in frequency to cause interference can accumulate from hop to hop. In contrast, multihop regenerative digital radio systems, such as DR 6/11-135, operate without such hop-to-hop accumulation and can give acceptable performance even when the S/N (signal-to-noise) ratio on one or more hops in a terminal section approaches values as low as 30 dB. Thus, if each hop is engineered to keep the noise contributors on that hop to acceptable levels, satisfactory end-to-end performance over multiple hop systems is virtually guaranteed, even during periods of extreme radio path fading. This usually happens when the engineering guidelines normally used for locating and laying out radio hops are followed.

If each hop is properly engineered, the signal-to-noise ratios achieved for the various possible interference components are usually more than adequate to give acceptable fade margins. However, problems created by improper installation, defective antenna system components, or unanticipated interferences can result in radio hops with unacceptable fade margins. Such conditions may go undetected during the normal S/I (signal-to-interference) stress checks made on each radio hop at installation time. Also, equipment and/or environmental degradations that increase the impact of existing interferences or noise sources, which were originally under control, may occur after the system is in service. New interferences, which degrade the usable fade margin, may also be introduced after a system is put in service. This can occur by adding growth channels on the same system or from the deployment of other radio systems nearby. As a result of all these factors, test procedures and techniques for evaluating the fade margin capability of radio hops at initial turn-up are necessary to ensure proper system performance. Such procedures are also necessary as diagnostic tools for maintenance on in-service systems.

This practice satisfies the above objectives by providing the techniques necessary to determine the parameters necessary to calculate the FFM (flat fade margin) of a DR 6/11-135 regenerative radio hop (see ***Note***).

Note: Two types of radio fading are possible, those that simply attenuate the level of the received signal and those that introduce both attenuation and amplitude-versus-frequency distortions into the received signal spectrum. The first type, which is discussed in this practice, is commonly referred to as a "flat-fade." With this type of fading, all components of the signal spectrum are attenuated equally. Procedures for determining the capability of DR 6/11-135 systems to handle the second type of shape-producing fades, which are generally caused by multipath propagation disturbances, are elsewhere. (See "Over-the-Air Propagation Distortion Check" in the applicable station O&M manual under the "Station Test" tab.)

1. **TEST PROCEDURES FOR DETERMINING FADE MARGIN PARAMETERS**, gives the procedures for determining the noise and interference parameters that are necessary to calculate the FFM.
2. **FLAT FADE MARGIN CALCULATION PROCEDURES**, gives the equations and details for determining and evaluating the FFM of a hop using the parameters obtained via Part 2.
3. **MEASUREMENT APPROACH AND IDENTIFICATION OF NOISE SOURCES**, provides background and tutorial information to introduce first-time or inexperienced users with the basic techniques for evaluating and the parameters that can influence the FFM of a digital radio hop. The basic measurement approach and the origin and

characteristics of the various noise and interference sources that can limit the FFM of a radio hop are described. The symbols that are used throughout the test procedures of Parts 2 and 3 are also defined.

A primary prerequisite for successful completion of fade margin testing and evaluation is familiarity with the background information provided in the third part. Inexperienced users must be familiar with this information before attempting to perform the measurements or an evaluation.

Generally, experienced users need only follow the procedures in Parts 2 and 3 to perform an FFM evaluation of a digital radio hop. Most of the procedures in the second part are structured to be performed by users without such a familiarity.

1.1 UPDATE INFORMATION

This practice is being reissued to include consideration for the new 4400 series Down Converter. The entire practice has been updated at the same time to include corrections and improvements to most parts of the practice.

2. TEST PROCEDURES FOR DETERMINING FADE MARGIN PARAMETERS

This part of the Fade Margin and Interference Tests practice gives the procedures for determining the types and measuring the levels of the fade-limiting noise and interference that may be present in a DR 6/11-135 digital radio hop.

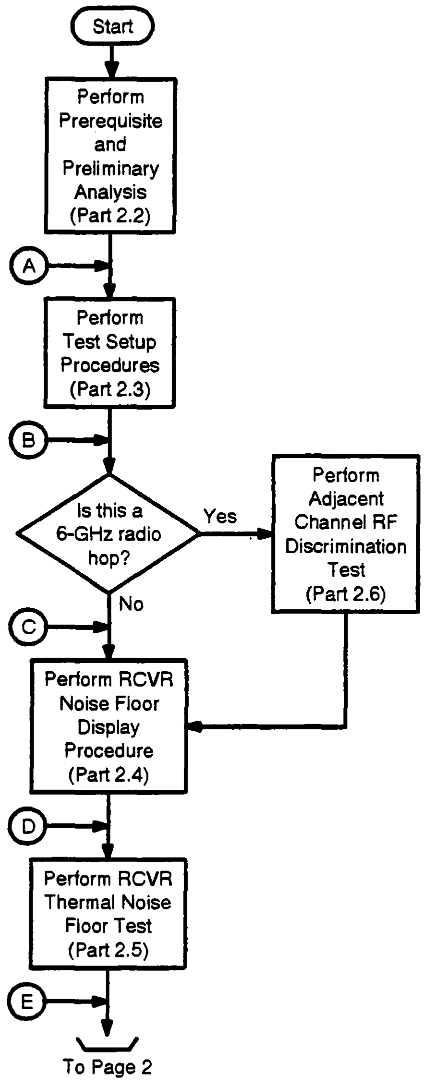
2.1 TEST SEQUENCE FLOWCHART

The overall process for performing the Fade Margin and Interference tests is given in the Test Sequence Flowchart (Flowchart 1). It is important that the sequence of steps and logical decisions shown in the flowchart be followed to achieve proper test results and equalization of the radio hop.

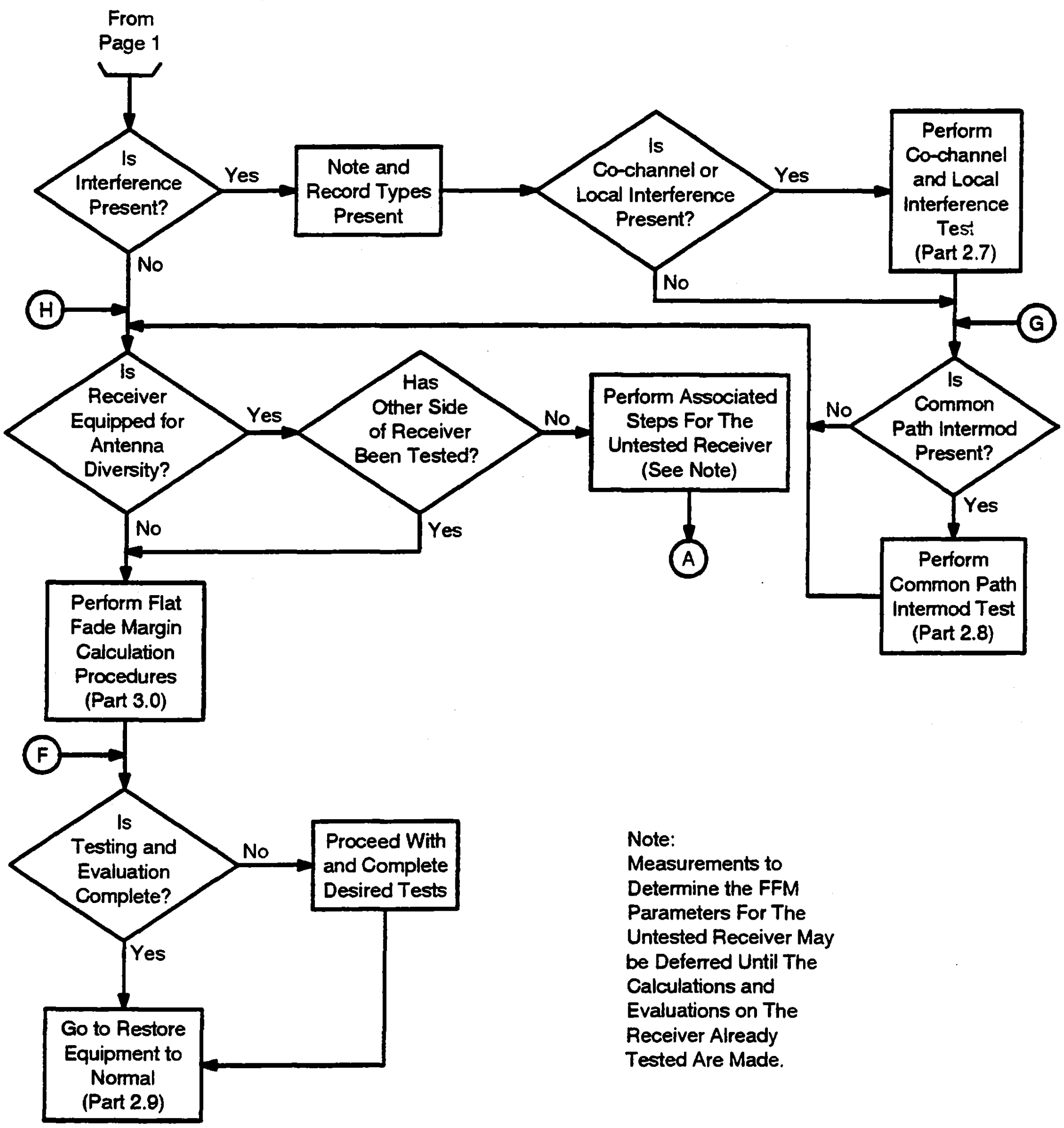
The procedural details and test requirements necessary to support the flowchart are given in more detailed procedures. The procedures are referenced by the flowchart.

It is important to note that the radio channel being tested ***MUST BE TAKEN OUT OF SERVICE TO PERFORM THIS PROCEDURE.*** Therefore, arrange to have the appropriate protection switching operation performed before proceeding. That is, if testing a regular working channel, transfer service to the protection channel, and if testing a protection channel, perform a lockout operation so that the protection channel will not be used for protection.

Note that maintenance personnel are required at each end of the radio hop being tested. Frequent communication between the personnel at each end of the hop is necessary to effectively perform these tests. If the radio channel being tested is carrying the service channel that provides voice communications between the two stations, perform the appropriate service channel switching operations to maintain communication.



Flowchart 1–Flowchart of Test Procedures Process (Sheet 1 of 2)



Flowchart 1–Flowchart of Test Procedures Process (Sheet 2 of 2)

2.2 PREREQUISITES AND PRELIMINARY ANALYSIS

This section details the preliminary analysis necessary to establish the channel lineup and occupancy for the radio hop.

Establish Configuration and Channel Makeup of Radio Hop to be Evaluated

The first step in preparing for the interference and fade margin tests is to identify the lineup of 6- and/or 11-GHz radio channels assigned to the same receiving antenna as the channel to be evaluated. This can normally be done by using the station records for the receive-end station of the hop to be tested. (See Table A or B for the corresponding Channel Number versus Frequency information on 6-GHz hops and Table C or D for the corresponding information on 11-GHz hops.) Use a diagram like that shown in Figure 1 to identify and locate, on a relative position basis, all the radio channels (of both polarities) assigned to the same antenna. Figure 2(a) gives a specific example for a 6-GHz radio lineup.

If a 6-GHz receiver lineup is being evaluated, first determine whether the channel to be tested has any adjacent channels present. If it does, note the ones that are present, and using the information given in Figure 3(a) or 5(b), determine and sketch how the IF spectrum will appear on the spectrum analyzer at the receiver down-converter output. Figure 2(b) gives an example of this step for the lineup example shown in Figure 2(a). If an 11-GHz lineup is being evaluated, begin testing after determining the lineup configuration.

Prerequisite for Performance Checks

If it is not known whether the hop and transmitter-receiver combination to be evaluated for fade margin meets the over-the-air S/I hop performance requirement under normal signal conditions, do that performance check before proceeding. Otherwise, the calculations to evaluate fade margins using the results of the procedures given here may be incorrect. Follow the procedures for the Over-The-Air S/I Test given in the applicable station operation and maintenance manual.

Return to the Test Sequence Flowchart at point A.

TABLE A 6-GHZ REGULAR FREQUENCY PLAN				
CHANNEL			RECEIVER DOWN CONV AND MWV GEN	
Number	Frequency (MHz)	Sideband On L. O.	Letter Code	Gen Mon Frequency (MHz)
11T	5945.20	Lower	B	6015.20
12T	5974.85	Lower	D	6044.85
13T	6004.50	Lower	F	6074.50
14T	6034.15	Lower	H	6104.15
15T	6063.80	Upper	K	5993.80
16T	6093.45	Upper	M	6023.45
17T	6123.10	Upper	P	6053.10
18T	6152.75	Upper	S	6082.75
21T	6197.24	Lower	AB	6267.24
22T	6226.89	Lower	AD	6296.89
23T	6256.54	Lower	AF	6326.54
24T	6286.19	Lower	AH	6356.19
25T	6315.84	Upper	AK	6245.84
26T	6345.49	Upper	AM	6275.49
27T	6375.14	Upper	AP	6305.14
28T	6404.79	Upper	AS	6334.79

TABLE B 6-GHZ STAGGERED FREQUENCY PLAN				
CHANNEL			RECEIVER DOWN CONV AND MWV GEN	
Number	Frequency (MHz)	Sideband On L. O.	Letter Code	Gen Mon Frequency (MHz)
11S	5960.025	Lower	C	6030.025
12S	5989.675	Lower	E	6059.675
13S	6019.325	Lower	G	6089.325
14S	6048.975	Upper	J	5978.975
15S	6078.625	Upper	L	6008.625
16S	6108.275	Upper	N	6038.275
17S	6137.925	Upper	R	6067.925
18S	6167.575	Upper	T	6097.575
20S	6182.415	Lower	AA	6252.415
21S	6212.065	Lower	AC	6282.065
22S	6241.715	Lower	AE	6311.715
23S	6271.365	Lower	AG	6341.365
24S	6301.015	Upper	AJ	6231.015
25S	6330.665	Upper	AL	6260.665
26S	6360.315	Upper	AN	6290.315
27S	6389.965	Upper	AR	6319.965

TABLE C 11-GHZ REGULAR FREQUENCY PLAN				
RADIO CHANNEL			TRANSMITTER UP CONV AND MWV GEN OR RECEIVER DOWN CONV AD MWV GEN	
Number	Center Frequency (KHz)	Sideband On L. O.	Letter Code	Gen Mon Jack Center Frequency (KHz)
1P	10,755,000	Upper	PB	10,685,000
10P	10,795,000	Upper	PC	10,725,000
11P	10,835,000	Upper	PD	10,765,000
6P	10,875,000	Upper	PE	10,805,000
7P	10,915,000	Upper	PF	10,845,000
2P	10,955,000	Upper	PG	10,885,000
3P	10,995,000	Upper	PH	10,925,000
12P	11,035,000	Upper	PJ	10,965,000
9P	11,075,000	Upper	PK	11,005,000
8P	11,115,000	Upper	PL	11,045,000
5P	11,155,000	Upper	PM	11,085,000
9J	11,245,000	Lower	JA	11,315,000
12J	11,285,000	Lower	JB	11,355,000
5J	11,325,000	Lower	JC	11,395,000
8J	11,365,000	Upper	JD	11,295,000
1J	11,405,000	Upper	JE	11,335,000
4J	11,445,000	Upper	JF	11,375,000
11J	11,485,000	Upper	JG	11,415,000
10J	11,525,000	Upper	JH	11,455,000
7J	11,565,000	Upper	JJ	11,495,000
6J	11,605,000	Upper	JK	11,535,000
3J	11,645,000	Upper	JL	11,575,000

TABLE D 11-GHZ ALTERNATE FREQUENCY PLAN				
RADIO CHANNEL			TRANSMITTER UP CONV AND MWV GEN OR RECEIVER DOWN CONV AND MWV GEN	
Number	Center Frequency (KHz)	Sideband On L. O.	Letter Code	Gen Mon Jack Center Frequency (KHz)
4E	10,735,000	Upper	EA	10,665,000
1E	10,775,000	Upper	EB	10,705,000
10E	10,815,000	Upper	EC	10,745,000
11E	10,855,000	Upper	ED	10,785,000
6E	10,895,000	Upper	EE	10,825,000
7E	10,935,000	Upper	EF	10,865,000
2E	10,975,000	Upper	EG	10,905,000
3E	11,015,000	Upper	EH	10,945,000
12E	11,055,000	Upper	EJ	10,985,000
9E	11,095,000	Upper	EK	11,025,000
8E	11,135,000	Upper	EL	11,065,000
12D	11,265,000	Lower	DB	11,335,000
5D	11,305,000	Lower	DC	11,375,000
8D	11,345,000	Lower	DD	11,415,000
1D	11,385,000	Upper	DE	11,315,000
4D	11,425,000	Upper	DF	11,355,000
11D	11,465,000	Upper	DG	11,395,000
10D	11,505,000	Upper	DH	11,435,000
7D	11,545,000	Upper	DJ	11,475,000
6D	11,585,000	Upper	DK	11,515,000
3D	11,625,000	Upper	DL	11,555,000
2D	11,665,000	Upper	DM	11,595,000

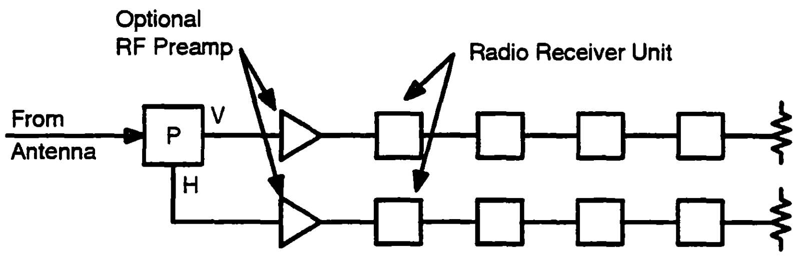
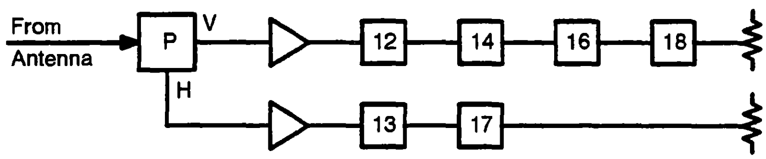
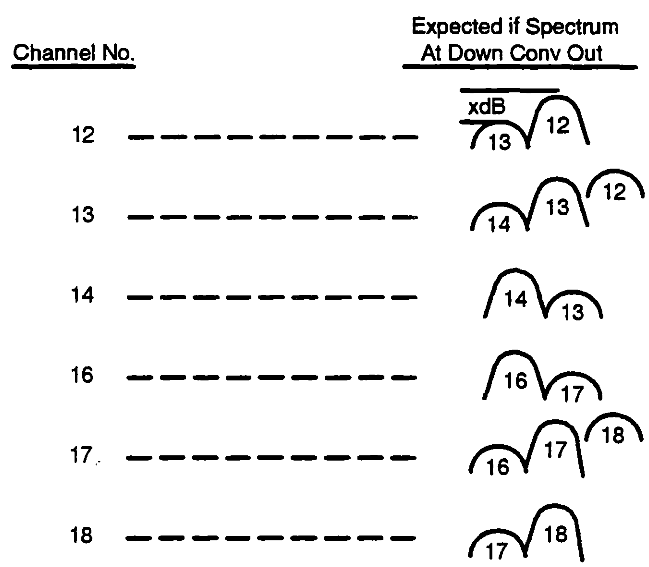


Figure 1-Suggested Sketch to Show Receiver Lineup of Channels at a Station

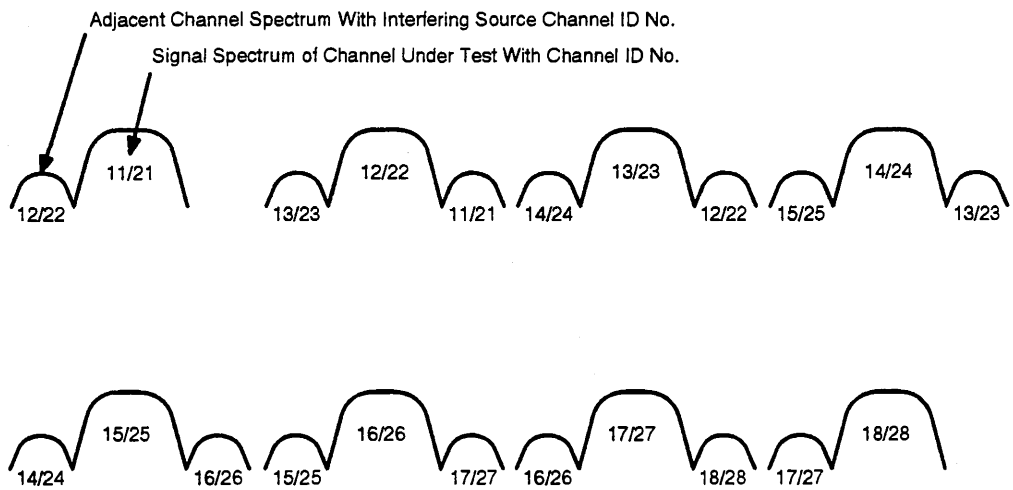


(a) Channel Lineup



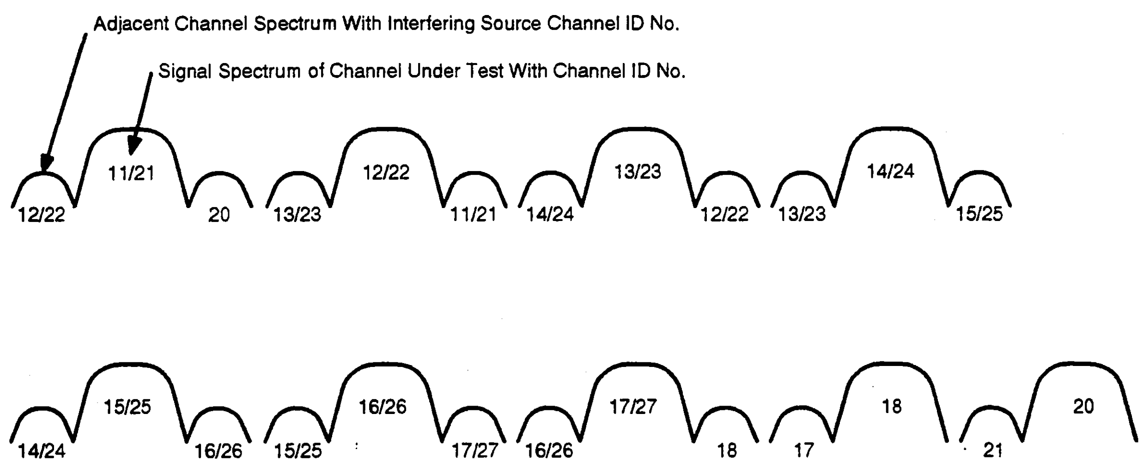
(b) Expected IF Spectrum Shapes

Figure 2-Example of Station Lineup and IF Spectrum Profile Sketches to Use for Evaluating DR 6 Adjacent Channel Interference



Note: Notice that Adjacent Channel Interference into Channels 11-14 and 21-24 Are Reversed in Frequency at IF Relative to Their Frequency Position at RF. This is Because Their Receiver Local Oscillator's Are Above the Center Frequency for Each of These Channels. (See Table A)

(a) Regular Frequency Plan



Note: Notice that Adjacent Channel Interference into Channels 11-13 and 20-23 Are Reversed in Frequency at IF Relative to Their Frequency Position at RF. This is Because Their Receiver Local Oscillator's Are Above the Center Frequency for Each of These Channels. (See Table B)

(b) Alternate Frequency Plan

Figure 3–Sketches Illustrating Received IF Spectrum for DR6 Each Channel with All Adjacent Channels Present

2.3 TEST SETUP PROCEDURE

This procedure establishes the test setup to permit an evaluation of the noise and interference components using the spectrum at the IF output of the radio receiver down-converter.

A simplified block diagram of the setup is shown in Figure 5. The objective of this setup procedure is to establish a usable spectrum display at the receiver down-converter IF output and an external IF attenuator (ATTEN) at the input to the transmitter to produce calibrated drops (fades) in the transmitter RF output signal.

Note that the IF PDSTR, if equipped, must be by-passed and the transmitter must be in the manual gain mode for the direction of these tests.

For Frequency Diversity systems, both the Regular and Diversity radio channels should be checked. For systems with Antenna Diversity, both the Regular and Diversity radio receivers should be checked.

Note: A FADE MARGIN worksheet is provided (Figure 4) to perform the following measurements and calculations. Additional copies of this worksheet should be made to do additional test.

The following equipment is required to perform this procedure.

At transmitting end:

- 1 - RF power meter
- 1 - 0-50 dB IF attenuator (calibrated in 1 dB steps)
- * - Miscellaneous adapters and cables

At the receiving end:

- 1 - IF spectrum analyzer
- 1 - IF power meter
- 1 - RF power meter
- * - Miscellaneous IF pads, adapters, and cables.

Note: Before using the spectrum analyzer in these tests, its thermal noise floor must be determined and recorded for use later, to ensure that it does not mask the thermal noise floor on the receivers being tested. This may be done by terminating the input to the analyzer and adjusting the controls for the conditions specified in the procedure for measuring receiver thermal noise floor; i.e. at least a 50 MHz span, 100 kHz resolution bandwidth, and minimum input attenuation. With no signal into the analyzer, the displayed trace represents the analyzer thermal noise floor level in dBm. In general, any low level signal being observed should be 6 to 10 dB above the thermal noise floor of the analyzer. If it is not, then the observed level will be higher than the actual level due to power addition of the two noise sources.

Example: At a 6 dB level, the thermal noise floor error is about 1 dB. At a 10 db level, the thermal noise floor error is about 0.4 dB.

FADE MARGIN WORKSHEET		
STATION: CHANNEL NO:		DATE: TIME:
LINE NO.	ITEM	MEASURED OR CALCULATED VALUE
1	REF P_{in}	dBm
2	RF OUT	dBm
3	TST P_{in}	dBm
4	ATTEN CAL (REF P_{in} - TST P_{in})	dB
5	AGC V (a)	V
6	AGC V (b)	V
7	RCVR CONV RF IN	dBm
8	REF ATTEN (-50 - RCVR CONV RF IN)	dB
9	REF FADE (ATTEN CAL - REF ATTEN)	dB
10	AGC V (1)	V
11	NFCAL (1)	dB
12	NFCAL (2)	dB
13	NFCAL (0) (NFCAL (1) - NFCAL (2))	dB
14	TN	dB
15	S/TN (REF FADE + NFCAL (0) + TN)	dB
16	NAS	dB
17	S/ACI (NAS + ATTEN CAL - 1)	dB
18	SWB (Signal Bandwidth)	MHz
19	RBW (Resolution Bandwidth of analyzer)	MHz
20	S/I (actual) S/I (observed) + 10 log (SBW/RBW) Note: Signal interference ratio for tone interferers	dB
21	IFW (Interference Bandwidth)	MHz
22	SBW (Signal Bandwidth for a 25 MHz, QAM signal)	MHz
23	S/I (actual) S/I (observed) + 10 log (SBW/IFW) Note: signal interference with a distributed, noise-like Spectrum.	dB
24	S/CCI (REF FADE + NFCAL (0) + " bandwidth corrected" S/I ratio)	dB
25	S/NELI (REF FADE + NFCAL (0) + " bandwidth corrected" S/I ratio)	dB
26	S/IMN (REF FADE + NFCAL (0))	dB

Figure 4– FADE MARGIN Worksheet

PROCEDURE

1. Obtain a release on the channel to be tested.
   a. If a Frequency Diversity system is being tested, perform one of the following:
      - if testing a regular channel, protect service by performing a manual line switch in ***both*** directions.
      - if testing the protection channel protect service by performing a protection lockout for ***both*** directions.
      - If a Hot Standby system is being tested, go to Step 2.
2. At the transmit station, perform the necessary switching operations to put the desired transmitter on the air (i.e., regular or standby), and perform a manual LOCKOUT switch operation at the transmitter to prevent any switching during testing.

Check Transmitter QAM IF Input, RF Input, and Operating Frequency

3. Set the transmitter for manual gain operation (ALC OFF).
4. Measure and record the IF Input to the Transmitter up-converter. Call this recorded value REF P_{in}.
5. Measure and record the RF Output power at the RF MON jack. Call this recorded value RF OUT.
6. On the UP CONV unit, adjust the IF LEV ADJ control to meet the actual value measured on the radio DATA CARD for the RF MON jack.

Bypass Predistorter

7. Note whether the transmitter is equipped with a predistorter unit. ***If equipped***, bypass the predistorter for these tests; go to Step 9.

   If ***not equipped*** with a predistorter, go to Step 8.
8. Insert a calibrated adjustable 0-50 dB IF attenuator between the IF IN on the up-converter and the coaxial cable normally connected to that input. Then go to Step 10.
9. To ***bypass*** the predistorter unit, ensure that the transmitter is still in the ALC OFF mode and connect the output of a calibrated adjustable 0-50 dB IF attenuator to the IF IN connector on the up-converter. Connect the cable normally connected to the IF IN connector of the predistorter unit to the input of the attenuator. (Figure 5a or 6a)

Calibrate Transmitter IF Test Attenuator (ATTEN)

10. Set the external IF attenuator to 0 dB.
11. Measure and record the IF power at the cable now connected to the input to the up-converter. Call this recorded value TST P_{in}.
12. Determine the attenuator calibration factor (ATTEN CAL) necessary to compensate for the cable and connector lossed associated with inserting the test attenuator.

$$\text{ATTEN CAL} = \text{REF } P_{in} - \text{TST } P_{in}$$

This value must be added to the attenuator setting to establish total transmitter fade values in later steps.

Establish REF FADE Signal at Receiver

13. At the receive end of the hop, for receivers equipped with antenna diversity, terminate the IF input to the IF COMBINER associated with the receiver not being tested. (Figure 6b)

14. Operate the MAN/AUTO switch on the IF COMBINER to the MAN position.

15. Operate the MAN/AUTO switch on the IF AGC AMPL to MAN position. Measure and record the AGC V on the ALARM AND METER unit. Call this recorded value AGC V(a).

16. If the receiver being tested is equipped with a 4400 series RCVR DOWN CONV, verify that the AGC AUTO/MAN pushbutton is in the MAN position. Measure and record the AGC V on the RCVR DOWN CONV unit. Call this recorded value AGC V(b).

    If ***not equipped*** with a 4400 series RCVR DOWN CONV, go to Step 17.

17. Remove the semi-rigid coax cable between the OUT jack of the Isotransducer and the RF IN jack of the RCVR DOWN CONV.

    Note: Remove the REG or DIV cable for receivers that are equipped with antenna diversity.

18. With an RF power meter connected to the OUTPUT jack of the Isotransducer, measure and record the received RF power level. Call this recorded value RCVR CONV RF IN.

19. Based on the preceding measurement, calculate the REF ATTEN value as follows:

    REF ATTEN = -50 - RCVR CONV RF IN

    Set the transmitter IF attenuator for this amount of loss.

    Note: If adjacent channel interference is suspected or known to be present, the power meter cannot be relied upon to give an accurate reading of received RF power level at the -50 dBm point. If it is certain that adjacent channel interference is not present, the power meter may be used to set this signal level. An alternative in either case would be to use an RF spectrum analyzer. This would permit direct measurement of the spectrum level, with or without adjacent channel interference.

20. Calculate the REF FADE value as follows:

    REF FADE = ATTEN CAL + REF ATTEN

21. Reconnect the semi-rigid coax cable that was removed in Step 17.

22. If the receiver being tested is equipped with a 4400 series RCVR DOWN CONV, rotate the MAN GAIN control to the maximum position (turning it CW), or until the voltage measure at the AGC V test jack is more positive than -0.1 V.

Note: This Step and Step 16 will insure that the 4400 series RCVR DOWN CONV is out of its internal AGC range.

If ***not equipped*** with a 4400 series RCVR DOWN CONV, go to Step 23.

23. With the REF FADE signal present at the transmitter, connect a spectrum analyzer to the IF OUT jack of the IF AGC AMPL of the receiver being tested. Condition the spectrum analyzer to view a spectrum at least 50 MHz wide and centered at 70 MHz.

24. With a vertical sensitivity of 10 dB per division, a resolution bandwidth of 100 kHz, and the analyzer input attenuation set to a minimum, adjust the analyzer vertical position controls to position the center of the displayed spectrum on a convenient reference line near the top of the screen.

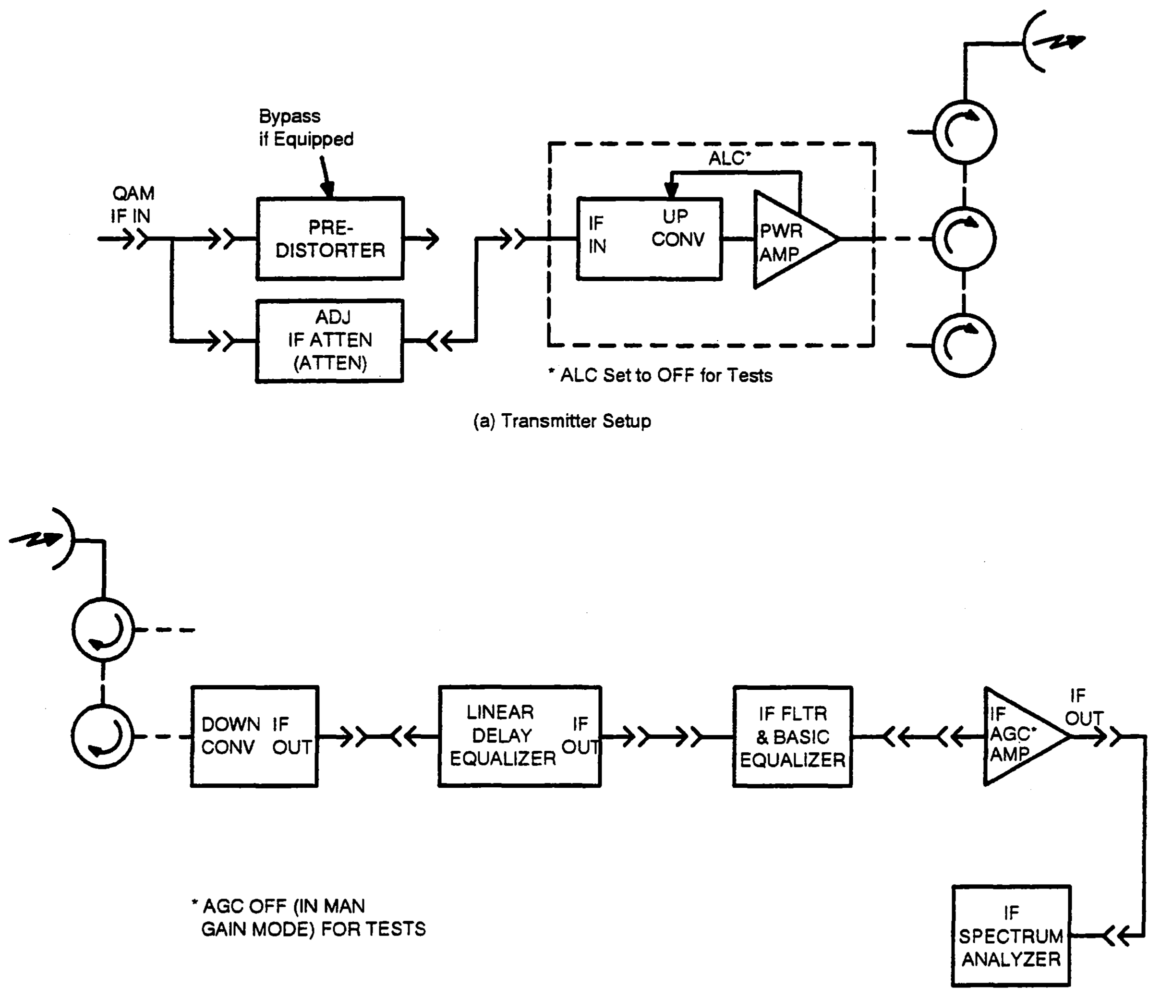
    Note: If the spectrum analyzer lacks the desired adjustment range, the IF AGC AMPL MAN GAIN control may be used for this purpose.

25. The test set-up for evaluating noise and interference levels and their characteristics is now complete. At this point, proceed with the applicable condition below:

    a. If a complete fade margin evaluation needs to be done, return to the Test Sequence Flowchart at point B.

    b. If this set-up is being used in conjunction with another procedure, return to that procedure for further instructions.

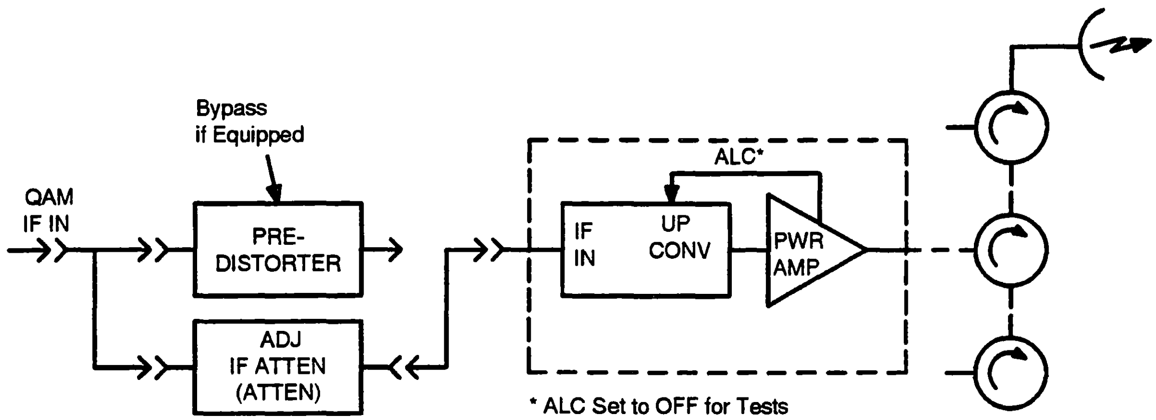
END OF PROCEDURE



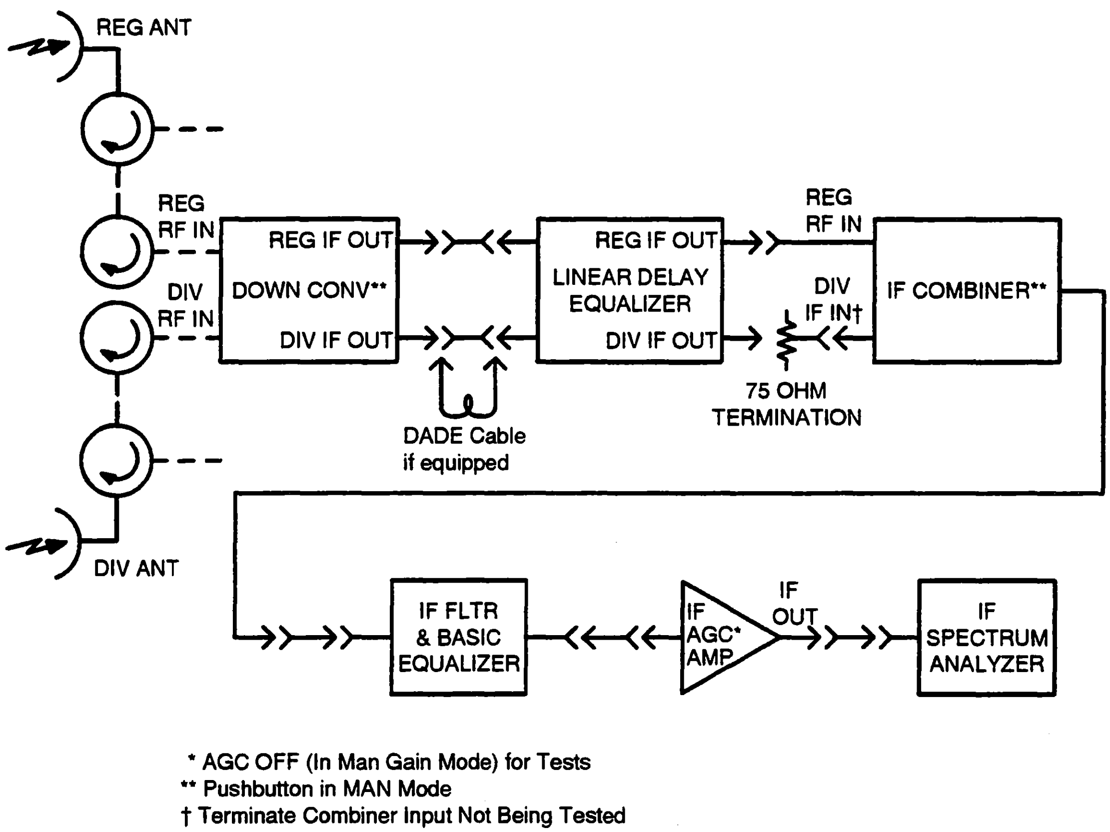
(a) Transmitter Setup

(b) Receiver Setup

Figure 5-Simplified Block Diagram of Test Setup for Fade Margin and Interference Tests



(a) Transmitter Setup



(b) Receiver Setup

Figure 6–Simplified Block Diagram of Test Setup for Fade Margin and Interference Tests (Antenna Diversity)

2.4 RECEIVER NOISE FLOOR DISPLAY PROCEDURE

This procedure is used to establish a calibrated display of the receiver noise floor that may be used to determine the S/I and S/N ratios of the significant in-channel noise contributors. This is done by turning off the REF FADE signal at the transmitter after a vertical reference position is established on the spectrum analyzer for the REF FADE signal.

Prerequisite: Complete Part 2.3 before proceeding with this procedure.

PROCEDURE

1. With the REF FADE signal present at the transmitter, the displayed spectrum should be located on a reference line near the top on the screen.
2. Note and record for later use, the RCVR AGC V on the ALARM AND METER unit. Call this recorded value AGC V(1).

   Note: This check of AGC voltage and the following recheck is necessary to account for residual AGC action even though the IF AGC AMPL is in the MAN GAIN or AGC OFF mode. Any change in this voltage when the REF FADE signal is removed totally is indicative of the effect and must be accounted for by readjusting the manual gain for the same value observed with the REF signal present. If this is not done the observed S/N ratio will be incorrect.

3. Observe the spectrum analyzer display and note the vertical position of either the top of one of the adjacent channel signals (if present) or the flat noise floor on one side of the REF FADE signal (if no adjacent channel signals are present). See Figure 6 and note below.

   Note: The amplitude of any adjacent channel signals observed will probably be lower than they appear in Figures 7 and 8, relative to the REF FADE signal. This is the result of attenuation at the band edges due to the roll-off in the IF filter preceding the IF AGC AMPL.

4. Record the vertical location for the applicable case in dB relative to the top graticule line on the spectrum analyzer and label as NFCAL(1) (record as positive number). Refer to Figure 7.

   Note: This check of the Noise Floor or Adjacent Channel Signal Location is necessary to account for any residual AGC gain in the down converter or combiner (for receivers equipped with antenna diversity) from the REF FADE reference signal point when that signal is removed to locate the Noise Floor. Any change in the vertical location of these observed spectrum points when the REF FADE signal is totally removed and after the AGC voltage has been corrected, is indicative of such residual action and must be accounted for in the S/N calculations using the NFCAL(0) factor.

5. At the transmitter, remove the IF IN input from the transmitter.
6. Condition the power amplifier to eliminate any residual transmitter RF signals from being transmitted to the receiver.

Depending on the type of transmitter available, perform one of the following:

a. For a transmitter equipped with a ***TWT AMPLIFIER***, switch the TWT to STBY.

b. For a transmitter equipped with a ***SOLID-STATE AMPL***, remove the semirigid coaxial cable connected between the RF OUT of the amplifier and the input to the iso/adapter on the transmitter filter. Terminate both SMA connectors to which this cable was connected.

7. If a receiver with antenna diversity is used, check combiner faceplate to insure that the green (REG or DIV) ACTIVE LED for the side under test is illuminated and remains on for the duration of the noise floor measurements. If not, combiner may be defective and should be replaced.

8. Recheck the RCVR AGC voltage and compare with AGC V(1) recorded previously. If reading is different, reset MAN GAIN control to obtain the original reading.

9. Relocate the top of the same channel or noise floor part of the display used to record NFCAL previously.

10. Record NFCAL(2) for this same point in frequency as NFCAL(1) and in dB relative to top graticule (record as a positive number).

11. Calculate the noise floor calibration factor NFCAL(0) as follows:

    NFCAL(0) = NFCAL(1) - NFCAL(2)

12. Note the spectrum display with the transmit signal and noise contributions removed. The in-channel spectrum displayed represents the composite noise floor generated within, and picked up by, the receiver. This composite noise floor may now be evaluated to determine the types and relative values of the in-channel noise and interference present.
    Perform one of the following:

    - If this subroutine is being used to perform a complete FFM test, return to the Test Sequence Flowchart at reentry Point D.
    - If this procedure is being used with some other procedure, return to that procedure for further instructions.

END OF PROCEDURE

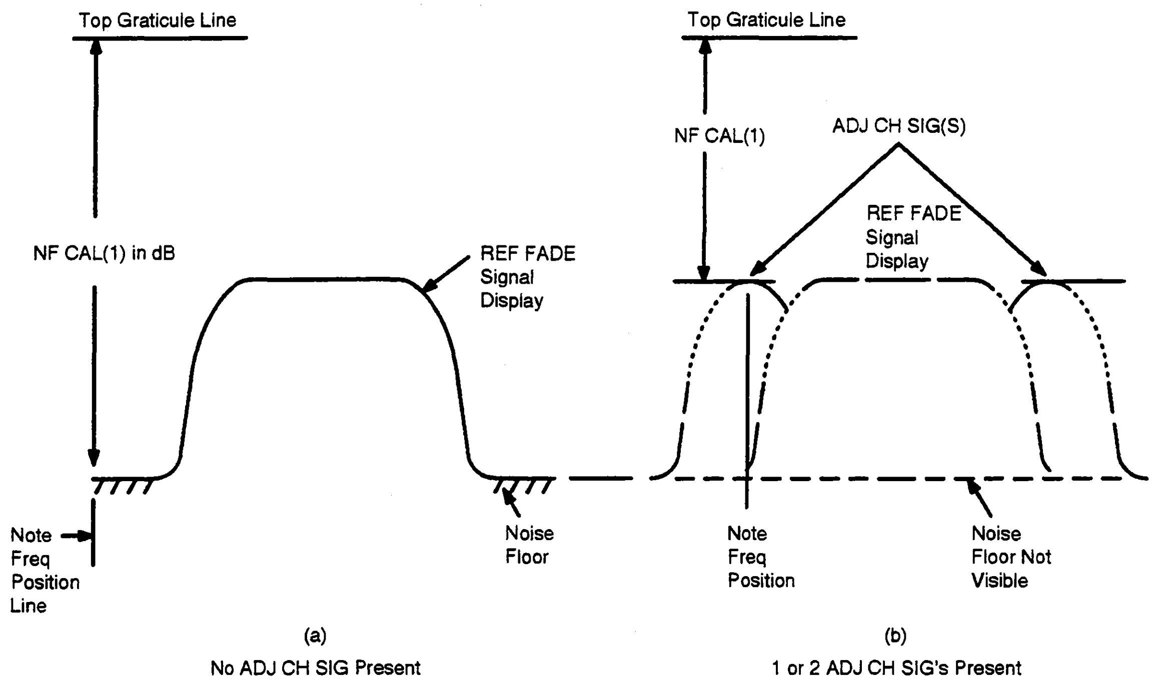


Figure 7– Examples of Displays to Determine NFCAL (with REF FADE signal still present)

2.5 RECEIVER THERMAL NOISE FLOOR S/N TEST

This procedure is used to determine the ratio of the normal signal level to the level of the thermal noise floor component S/TN (signal-to-thermal noise) that is generated within the receiver. This ratio is determined by adding the number of dB that the TN floor is below the REF FADE signal reference line on the spectrum analyzer to the REF FADE value established in TEST SETUP PROCEDURES.

Prerequisite: Complete Parts 2.2, 2.3, and 2.4 before continuing with this procedure.

PROCEDURE

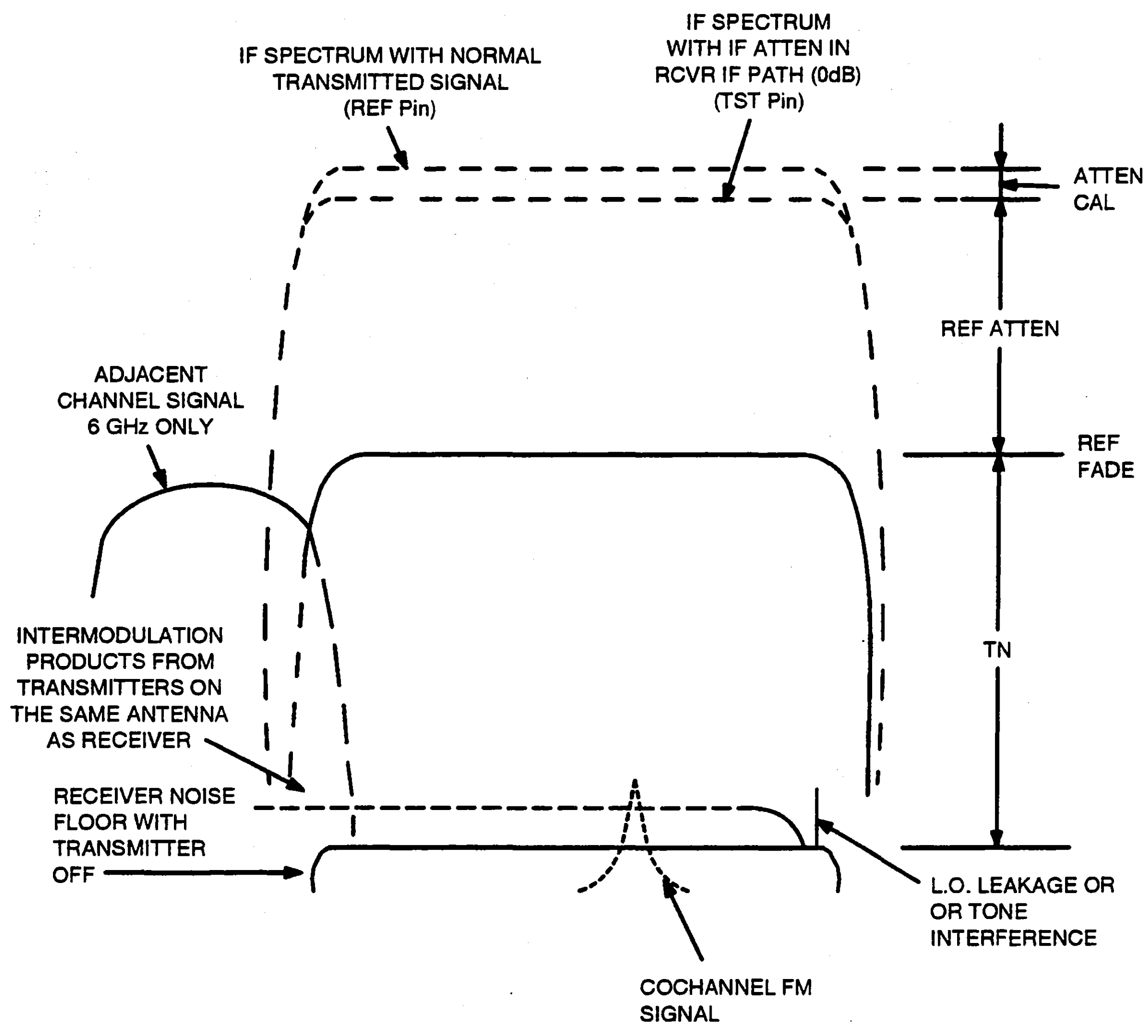
Examine Noise Floor for Presence of In-Channel Interference Components

1. With the transmit signal removed, examine the receiver noise floor spectrum at the IF output of the IF AGC AMPL. Note whether any significant in-channel interference from external sources appears in the channel (examples in Figure 8).

2. Depending on the result of this observation, proceed with one of the following:

   a. ***No Interference Evident:*** If the spectrum of the in-channel noise floor is flat and is a total of 65 dB or more below the normal signal (ie x + REF FADE ≥ 65dB), assume that no significant interference exists. When this is the case, the in-channel noise is controlled by the TN (thermal noise) component generated within the receiver. Perform Determine the S/TN ratio. (Step 3)

   b. ***Interference Present:*** If in-channel interference ***is evident***, identify and note for future reference the type(s) present (cochannel, tone interference, or common path intermodulation) using Figure 8 as a guide. Each interference present will eventually be evaluated using the Test Sequence Flowchart and the related interference test procedures. However, before evaluating the interference components, the receiver TN floor component must be evaluated. Therefore, note the type(s) of interference present and then go to "Determine the S/TN ratio."



ATTEN CAL = REF Pin - TST Pin
REF FADE = ATTENCAL + REF ATTEN
S/TN = REF FADE + TN

Figure 8–Example of IF Output Spectrum Displays During Process to Determine Receiver Noise Floor and In-Channel Noise Components

Determine the S/TN ratio

3. Note the spectrum display with the transmit signal removed. Using the examples of Figure 8 as a guide, identify and locate a horizontal section of the analyzer display trace that represents the thermal noise floor component. Record this signal as TN.

   Note: Normally, the TN component of the noise floor is as shown in these examples. It is obvious even with cochannel, local, or intermodulation interference components present. However, noise-like interference, such as cochannel interference from another DR-135 radio transmitter operating on the same frequency, may sometimes be present in enough magnitude to obscure the true receiver TN noise floor. Such a condition may be suspected if the S/N ratio of the apparent thermal noise floor is several dB lower than the minimum S/TN requirements stated in Table E. When this is the case, and the receiver is known to be operating properly, it generally means that an out-of-limit interference condition exists. The source of this out-of-limit noise or interference must be isolated and eliminated before a meaningful measurement can be completed to determine the parameters necessary for calculating the flat fade margin of a radio hop. Unless the source of such an interference is obvious, locating the contaminating source generally involves a trial-and-error approach. Once a suspected source is identified, it must be verified by turning it on and off.

4. Once the vertical position of the TN noise floor component is located on the display, note the number of dB that TN is below the horizontal REF FADE signal reference line.

5. Calculate S/TN using the following equation (note):

   S/TN = REF FADE + NFCAL(0) + TN

   REF FADE and NFCAL(0) were recorded in previous test procedures. If uncertain, reference the Test Sequence Flowchart for proper location.

6. Compare the resulting S/TN ratio with the MIN S/TN given in Table E and Table F.

TABLE E
6 GHZ MINIMUM S/TN REQUIREMENTS

	4300 Series Down Conv			4400 Series Down Conv		
	PREAMP CODE			PREAMP CODE		
RSL	NONE	329A	331A	NONE	329A	331A
-10	71	67.5	86	85.5	86	86.5
-15	66	62.5	81	80.5	81	81.5
-20	61	57.5	76	75.5	76	76.5
-25	56	52.5	71	70.5	71	71.5
-30	51	47.5	66	65.5	66	66.5
-35	46	42.5	61	60.5	61	61.5

TABLE F 11 GHZ MINIMUM S/TN REQUIREMENTS				
	4300 Series Down Conv		4400 Series Down Conv	
	PREAMP CODE		PREAMP CODE	
RSL	NONE	805B	NONE	805B
-10	74.5	82.5	81.5	84.5
-15	69.5	77.5	76.5	79.5
-20	64.5	72.5	71.5	74.5
-25	59.5	67.5	66.5	69.5
-30	54.5	62.5	61.5	64.5
-35	49.5	57.5	56.5	59.5

Note: The MIN S/TN RATIO requirement given in these tables are only applicable for the specified ***received signal level***. For other RSLs, the MIN S/TN RATIO requirement must be increased or decreased by the same amount that the RSL is above or below the value specified. If there is any doubt about the RSL, measure it using the procedure given in TASR 4 (Down-Converter RF Input Power Check), which is found in the applicable station O&M manual. This procedure permits a determination of the RSL to within a ± 1 dB tolerance.

If the requirement is met, that is, if the calculated S/TN ratio ***equals*** or ***exceeds*** the MIN S/TN RATIO requirement in the table, the S/TN evaluation test is complete. Do one of the following:

- If this S/TN result is to be used to calculate the flat fade margin, record the resulting ratio and return to the Test Sequence Flowchart at reentry Point E.
- If this subroutine is being used with another procedure, return to that procedure for further instructions.

If the requirement is NOT met, that is, if the calculated S/TN RATIO is less than the min S/TN ratio in Table E, either the RSL (received signal level) is lower than that shown in the table or the noise figure of a receiver unit is out-of-limit. Go to Resolving Low Receiver S/TN Noise Floor Problems, to isolate and resolve this problem.

Resolving Low Receiver S/TN Noise Floor Problems.

7. Check the RSL per the procedure given in the RADIO RECEIVER PROCEDURES tab Part 3.3, RF INPUT CHECK AND RSL CALCULATION.

   If the ***RSL is in-limits***, but not equal to the ***level*** given in the S/TN requirements table, go to Step 8.

   If the ***RSL is out-of-limits***, follow the procedures given in TASR 4 to isolate and resolve the problem. Once the RSL is restored to normal, reestablish and recalibrate the REF FADE and noise floor displays. (see Parts 2.3 and 2.6)

8. Recheck the calculated S/TN against the MIN S/TN RATIO requirements in Table E or Table F. make any adjustment required for the intermediate RSL levels.

   If the S/TN result **meets** the corrected MIN S/TN RATIO requirement, go to Step 11.

   If the S/TN still does not meet the corrected requirement, the noise figure of the receiver unit is probably out-of-limits. Go to Step 9 to resolve this problem.

9. To resolve a receiver noise figure problem, a replacement/recheck procedure must be used. Normally the problem will be a defective RF preamp, if equipped, or down-converter. If it is not known which unit to suspect, replace the down-converter first and go to Step 10. this may avoid unnecessary replacement of the preamp, which, when used, is common to all channels equipped in a radio bay. See the procedures for replacing these units in the applicable station O&M manual.

10. After replacing any receiver unit, reestablish and recalibrate REF FADE and the noise floor displays before re-evaluating the S/TN ratio.

    To recalibrate, reference Parts 2.3 and 2.6 and then re-evaluate S/TN by performing Determine the S/TN Ratio in this section.

    If the MIN S/TN REQUIREMENT is now met, go to Step 11.

    If the MIN S/TN REQUIREMENT is still not met and the RF Preamp has not been replaced, replace it, and repeat this step. If both the down-converter and the RF preamp have already been replaced, go to Step 12.

11. After replacing a defective receiver unit and/or achieving a satisfactory S/TN result, do one of the following:

    a. If the S/TN result is to be used to calculate the flat fade margin, record the resulting S/TN ratio and return to the Test Sequence Flowchart at reentry point E. (see ***Note***).

    b. If this subroutine is being used with another procedure, return to that procedure for further instructions.

    Note: If any units were replaced, the results of any S/I tests for adjacent channel, cochannel, or intermodulation interference that were obtained with the original receiver units should be rechecked with the new receiver units in place. Perform applicable procedures to ensure that the S/I ratios measured for these components are still valid.

12. If an unusual problem exists within the receiver, the test setup, or the test sets, check the test setup and test equipment. If the problem is in the receiver, it could be because of a defective spare, a receiver DC power problem, or defective receiver RF networks. If available, try additional spares. If this is not successful, check DC voltages supplied to the units using the information available on applicable schematic drawings and the information on the receiver units found in this Maintenance Support Manual. Also, try replacing radio receiver power units. If the problem doesn't appear to be in the receiver's active components, try replacing or evaluating the RF networks in the receiver ahead of the down-converter. Consult engineering or the AT&T-NS Customer Support group for additional help.

After the problem is resolved and a satisfactory S/TN ratio is obtained, proceed with the conditions given in Step 11.

END OF PROCEDURE

2.6 ADJACENT CHANNEL RF DISCRIMINATION TEST

This procedure is used to determine the amount of adjacent channel RF discrimination (S/ACI ratio) provided by the XPD (cross-polarization discrimination) of the antenna system.

Note: As mentioned in Part 3, the RF discrimination is only part of the total discrimination to the adjacent channel signal. Additional discrimination is provided by the post-detection baseband receiver filters in the digital receiving equipment. The amount of adjacent channel discrimination provided by this filter is 28 or 33 dB, depending on whether the system is equipped with the error correction option or not. This additional discrimination, along with the amount of any correlated adjacent channel joint-fading, must be added to the discrimination provided by the XPD of the antenna system before assessing the final result of this type of interference on the flat fade margin. These corrections are accounted for in **Flat Fade Margin Calculation Procedures.**

Prerequisite: Complete Part 2.2 and 2.3 before proceeding with this procedure.

PROCEDURE

1. At the receiving station, connect the spectrum analyzer to the IF OUT jack (REG or DIV if equipped with Antenna Diversity) of the RCVR DOWN CONV. Control settings should remain the same as when the analyzer was connected to the output of the IF AGC AMPL.
2. At the Transmitter end, determine the following:
   a. For a transmitter ***equipped with a TWT-AMPLIFIER***, switch the TWT to TRANS.
   b. For a transmitter ***equipped with a Solid-State Amplifier***, reconnect the semirigid coaxial cable that was connected between the RF OUT of the amplifier and the input to the iso/adapter on the transmitter filter.
   c. Replace the faded IF IN input from the transmitter up-converter.
3. Observe the spectrum display with the REF FADE signal present at the transmitter.
4. Note the vertical position of the peak or top of the displayed in-channel REF FADE signal spectrum. If necessary, make adjustments to locate the peak of the displayed in-channel signal spectrum on a convenient horizontal reference line near the top of the display.
5. With the reference line for the in-channel signal established, note the level of the peak of an adjacent channel interference spectrum relative to the center of the in-channel signal spectrum.

   Note: If adjacent channel interferers are present on both sides of the channel under test, perform the procedure described separately for both interferers. For identification purposes, refer to an adjacent channel by its horizontal location relative to the in-channel signal (that is, left or right). The adjacent channel signals observed at this point are unaffected by any IF filtering, so they should appear more closely like those shown in Figure 9.

6. While observing the difference in level between the spectrum peaks of the adjacent channel interferer and the main signal, have the technicians at the transmit end of the hop adjust the external IF test attenuator (ATTEN) up or down to bring the peak of the displayed adjacent channel signal spectrum to the same level as the peak of the in-channel signal spectrum. (See Figure 9 for before and after illustration of this process.)

7. Note and record the new setting of the test attenuator that produced the equal level condition. Call this setting NAS.

8. Using the attenuator setting ATTEN CAL factor calculated in Part 2.3, and this new attenuator setting, NAS, calculate the pre-RF-filter adjacent channel discrimination (S/ACI ratio) using the following equation:

   S/ACI = (NAS + ATTEN CAL - 1) dB

   Where:

   The [NAS + ATTEN CAL] term represents the total drop in the in-channel transmitter signal necessary to bring its displayed spectrum to a level equal to that of the displayed adjacent channel signal on the spectrum analyzer.

   The 1-dB factor is a correction factor to account for the loss of the receiver channel dropping filter is 1 dB higher at the displayed peak of the adjacent channel signal than it is to the in-channel signal. The S/ACI at the input to the channel dropping filter is actually 1dB poorer than observed.

9. Record and label the above S/ACI ratio appropriately for the relative location (left or right) of the adjacent channel being evaluated.

   Note: To avoid later confusion, use a sketch like that shown in Figure 2(b). Record the calculated S/ACI ratio on the sketch as shown in the example for channel 12 (eg. X dB). This is necessary if a calculation of flat fade margin is eventually to be done using the procedures in this practice. The use of an orderly recording process will help to avoid errors and make it possible to recheck the results if necessary.

10. If a second adjacent channel interferer is present, repeat the above test for that interferer; otherwise, continue to the next step.

11. Evaluate the S/ACI results with one of the following:

    a. If the signals being carried by the adjacent and main channels are both DR6-135, 64-QAM signals that are known to be ***equal*** in power at the input to the receive antenna, the S/ACI values determined by this procedure represents the amount of XPD provided by the antenna system. Here, the observed S/ACI result(s) should be evaluated directly against the ***Objective*** given below.

    b. If an adjacent channel, 64-QAM signal is known to be Y dB greater or less than the in-channel signal, the true XPD is respectively Y dB greater or less than the observed result(s). Make the appropriate adjustment in the above S/ACI ratio to account for signal level differences, and then evaluate the result with the ***Objective*** given below.

Note: If the received signal levels are not known, do a measurement of the RSL for the channels involved before a final evaluation of whether the XPD objective is being met or not. Refer to RADIO RECEIVER PROCEDURES.

c. If an adjacent channel signal is other than a similar DR6-135, 64-QAM signal, other measurements and/or adjustments must be made to determine the true XPD. Consult engineering if it is desired to calculate the amount of discrimination being provided.

Objective: DR 6-135 performance objectives for proper operation in the presence of adjacent channels carrying the same type of signal are based on an XPD objective of 29 dB. If the S/ACI value for an adjacent channel does not meet this objective, corrective action may be warranted. Maintenance information for the antenna system in use should be consulted.

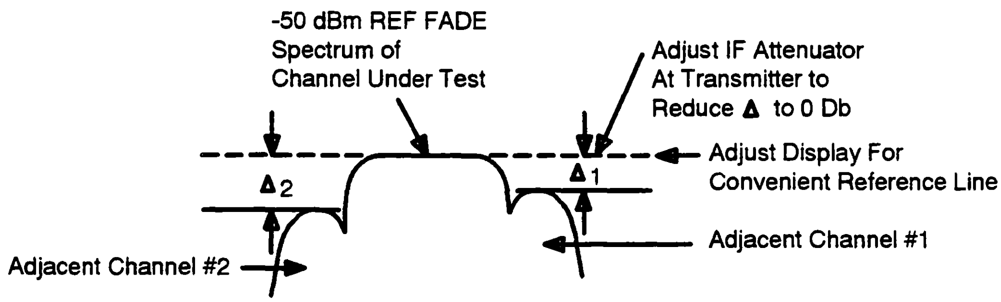
Once satisfactory results are obtained, go to the next step.

12. Have the IF test attenuator at the transmitter restored to the original REF FADE value from Part 2.3.
13. If the receiver that is being tested is equipped with a 4400( ) series RCVR DOWN CONV, switch the AGC AUTO/MAN back to the AUTO position.
14. The measurements to determine the S/ACI ratios are now complete. Proceed with one of the following:

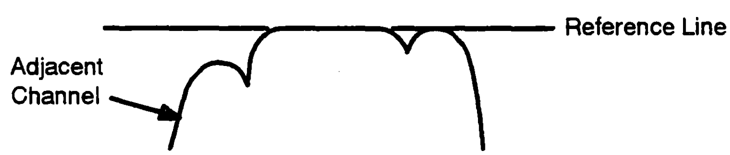
If a.

b. If this subroutine is being used with another procedure, return to that procedure for further instructions.

END OF PROCEDURE



(a) Typical IF Spectrum With Two Adjacent Channel Interferers And Ref Fade Signal Present, Prior to Setting Signal Level to Level of Adjacent Channel #1



(b) Spectrum After Setting Signal Level to Adjacent Channel #1 Level

Figure 9– Example of Spectrum Display Before and After Transmitter Level Adjustment to Determine S/ACI Ratio for an Adjacent Channel Interferer

2.7 COCHANNEL AND LOCAL INTERFERENCE TEST

This procedure is used to determine the signal-to-interference ratios of any significant cochannel or ***near-end*** local interferers that may be present in a channel.

Prerequisite: Complete Part 2.3, 2.4, 2.5, and 2.6 before proceeding with this procedure.

Preliminary Observations

Depending on the source, ***cochannel*** interference will take on several different appearances. Three examples of such interference are shown superposed on the receiver noise floor in Figure 8. The signal from an FM analog microwave radio system carrying voice signals is characterized by a sharp carrier spike with sloping, noise-like, near-in sidebands. The spectrum of the same signal carrying FM TV, on the other hand, has a spectrum that is more spread in appearance. Cochannel interference from SSB AM microwave signals or another system carrying multistate QAM or PSK payloads will be more noise-like and will have interference spectrums resembling the 64-QAM signal spectrum. Interference from local near-end leakage may also come from such noise-like sources but is more often tonal in nature, since it normally comes from high level, CW sources in nearby equipment.

When using a spectrum analyzer to evaluate the S/I ratio of tone or tone-like signals, such as low-index analog FM, which have a strong dominant carrier, the observed S/I ratio must be corrected to account for the resolution bandwidth of the spectrum analyzer used to generate the spectrum display. This correction factor is necessary because only a portion of the total power of the S (signal), which is distributed over many MHZ, falls within the resolution bandwidth, while the total power of a tone or tone-like I (interferer) will effectively be contained within the analyzer bandwidth when it sweeps through the frequency location of the interference. Thus, the observed signal spectrum to interference ratio is less than the total signal to interference ratio seen by the digital receiver.

To determine the total signal to interference ratio for tone or tone-like interferers, the S/I ratio observed on the spectrum analyzer screen must be increased to account for the bandwidth used with the following equation:

S/I (actual) = S/I (observed) + 10 log (SBW/RBW) dB

Where:

SBW = Signal Bandwidth in MHz
RBW = Resolution Bandwidth of analyzer in MHz

For example, if a 100-kHz resolution bandwidth is used, the bandwidth correction factor for the 64-QAM DR 6/11-135 signal, which has a 25-MHz bandwidth, is:

10 log (25/0.1) = 24 dB.

Consequently, a tone that appears to be 15 dB below the reference signal line on an analyzer set up to use a resolution bandwidth of 100 kHz is in reality 15 + 24 = 39 dB below the reference signal. From the viewpoint of level relative to a flat noise floor, a tone that appears to be 24 dB above the noise floor has a power equal to the total noise power contained in the noise-floor over the bandwidth normally occupied by the signal (25 MHz). Stated another way, an in-channel tone that is less than 14 dB above the floor or 10 dB below the total power in the noise floor (24-14) will have less than a 0.5 dB effect on that component of the flat fade margin allocated to interference.

For interferers with a distributed, noise-like spectrum, the S/I ratio determined by noting the difference in level between the reference signal and the interference spectrum locations is the correct ratio if the bandwidth occupied by the interference is the same as that occupied by the in-channel signal. If the bandwidth of the interferer is less than the signal, the observed S/I ratio must be corrected using the following equation:

S/I (actual) = S/I (observed) + 10 log SBW/IFW dB

Where:

IFW = Interference Bandwidth in MHz
SBW = Signal Bandwidth in MHz (25 MHz for 64 QAM signal).

PROCEDURE

Determine the S/I Ratio for Interferers Present.

1. Note the spectrum display of the noise floor with the transmit signal removed. Note any cochannel interferences (CCI) or near-end local interferences (NELI) that may be present.
2. Using Figure 8 as a guide, note and record the number of dB each interference is below the reference line previously established for the REF FADE signal spectrum. Identify each S/CCI or S/NELI ratio with an appropriate label, and note whether the interference is noise-like or tone-like in character. For tone-like and/or noise-like interferers, apply the appropriate bandwidth correction factor per the information in the ***Preliminary Observations*** section.

   Determine the S/CCI and/or S/NELI ratio with a normal signal present.

   S/CCI = REF FADE + NFCAL(0) + " bandwidth corrected" S/I ratio
   S/NELI = REF FADE + NFCAL(0) + " bandwidth corrected" S/I ratio

Evaluate S/I Components for Acceptability

3. Note whether the ratios of any interferers are less than 71 dB, and proceed with one of the following conditions:
4. If all S/I ratios ***are acceptable*** (71 dB or greater) and the results are to be used to calculate the flat fade margin, return to the Test Sequence Flowchart at reentry point F.
5. If all S/I ratios ***are acceptable*** (71 dB or greater), and this subroutine is being used with another procedure, return to that procedure for further instructions.
6. If one or more S/I ratios ***are not acceptable***, that is, less than 71 dB, and it is not known whether the interference is because of cochannel or local near-end pickup, make an additional investigation to determine which type of interference it is. If the interference is because of a cochannel interferer, a joint-fading factor may be applicable to relax the 71-dB requirement. This determination may be done by terminating the input to the receiver at the coaxial input to the down-converter. If the interference disappears it can generally be assumed that the interference is coming in via the antenna and is probably because of a cochannel interferer.

Note: Although unlikely, local or near-end leakage can still be the source of an interference in this case. RF leakage can occur in the waveguide components ahead of the down-converter because of damaged networks, loose waveguide flanges, or, if equipped, a defective common RF preamplifier. Further isolation for these types of interference will, generally, require tests in the common waveguide paths and will involve service interruptions.

For cochannel interferences, try to locate the source of the interference, and determine if a joint-fading factor is applicable. If ***joint fading*** is the case and the amount is adequate to keep the S/I under faded conditions to 40 dB or better, the out-of-limits S/I ratio for this interferer need not be pursued further. Note and record the amount of joint-fading that may be counted for each interference.

If no ***joint fading*** can be counted on or the interference is because of local near-end pickup, corrective action will be necessary to reduce and/or eliminate the interference. Otherwise, unsatisfactory performance during fading may result. The action to be taken will depend on the type and location of the interference. Once the source is located, engineering help may be necessary to determine the best course of action. Consultation with the AT&T NS Customer Support group may also prove helpful.

If it is desired to make a judgement on an out-of-limits interference because of the result on flat fade margin, go to Step 3. Once acceptable S/I ratios are obtained, proceed as indicated in that step.

END OF PROCEDURE

2.8 COMMON PATH INTERMODULATION TEST

This procedure is used to determine the signal-to-interference ratio (S/IMN) of any significant common path intermodulation that falls into a receiving channel.

Prerequisite: Complete Part 2.3, 2.4, and 2.6 before proceeding with this procedure.

Preliminary Observations

As mentioned in the tutorial section (Part 4), intermodulation between multiple transmitter signals can occur whenever an element in the common waveguide path to the antenna becomes nonlinear. Since these products are low level, they normally go unnoticed in the channels associated with the transmitters. However, in situations where a common transmit-receive antenna is used, intermodulation from such a source can create products at frequencies that, once generated, propagate into the receiver channels sharing the same antenna via the common waveguide paths. The level of such intermodulation products is usually low enough to go unnoticed in the contaminated receiver channels under normal received signal conditions. If high enough, however, it can seriously effect the fade capability of a contaminated channel, since such product levels do not fade with the signal.

Figure 10 shows some of the possible product generation points in the two normal shared antenna configurations. As shown in this figure, there are many points in the common antenna waveguide paths where a nonlinear element can cause problems of this type. Nonlinearities can be introduced by defective circulators, corroded waveguide joints, antenna parts, or some of the other networks used in such antenna-waveguide systems. Problems can occur whenever two or more transmitters share an antenna in either of these configurations. Whether fade limitations result in these cases depends on the frequency location of the transmitters relative to the receivers. The details of how to determine the frequency location of the possible products are discussed and illustrated in the Near-End Local Interference section of this practice. Reference to that information is recommended whenever problems of this type are being diagnosed.

An example of the in-channel interference spectrum created by this type of common path intermodulation is shown in Figure 8. The spectrum of this interference has a distributed noise-like spectrum similar to the payload signal and, depending on the frequencies of the transmitters responsible for the products, may or may not be offset in frequency from the channel with which it is interfering. Usually, the in-channel bandwidth of the interfering spectrum is the same as the signal bandwidth. The S/I ratio observed on the spectrum analyzer display represents the actual ratio and may normally be used as such, with no corrections for differences in signal and interference bandwidths (see ***Note***). Only the correction factor, which accounts for the use of a REF FADE signal, need be applied to the observed S/I ratio to determine the actual S/IMN ratio.

Note: If the bandwidth of the resultant IMN is significantly different from that of the signal, which is 25 MHz, the bandwidth correction factor given in Part 2.7, for noise like CCI or NELI types of interference, may be used to determine the actual S/IMN ratio.

Note that ***any*** observable interference of this type usually means an out-of-limits common path intermodulation condition. Therefore, when this procedure is initiated by the observations made in Part 2.5, a diagnostic process to isolate and eliminate such intermodulation interference will normally be necessary. The techniques for this process are a major part of this subroutine. Whether acceptable or not, however, the S/IMN ratio determined by the these procedures may be used in the flat fade margin calculations to determine the impact of such noise on the fading capabilities of a radio hop.

Determine the S/IMN Ratio

PROCEDURE

1. Note the spectrum display of the noise floor without a signal present at the transmitter.

2. Using the example of Figure 8 as a guide, identify the IMN component of the noise floor spectrum. Note and record the number of dB that the IMN noise floor is below the reference line previously established with the REF FADE signal present.

   Determine the S/IMN ratio with a normal signal present.

   S/IMN = REF FADE + NFCAL(0)

   The resulting ratio is the S/IMN ratio that should be used to evaluate the acceptability of this type of interference and/or to evaluate the impact of this interference on the flat fade margin.

   Evaluate Acceptability of S/IMN Ratio

3. Note whether the S/IMN ratio determined in Step 2 is less than 71 dB. Proceed with one of the following:

4. ***Acceptable S/IMN:*** If the S/IMN ratio is 71 dB or more, the result is acceptable. Record the value and then do one of the following:

   - If the S/IMN value is to be used as an input for calculating the flat fade margin, return to reentry point H on the Test Sequence Flowchart.
   - If this procedure is being used with another procedure, return to that procedure for further instructions.

5. ***Out-of-Limits S/IMN:*** If the S/IMN ratio is less than 71 dB, corrective action is warranted. The source(s) of nonlinearity responsible for the excessive common path intermodulation interference should be isolated and eliminated. Go to Step 4 for the recommended diagnostic procedure.

   Diagnosing Poor S/IMN Ratio

   Whenever intermodulation interference of this type is suspected, usually, it can be verified by turning off transmitters one at a time while observing the interference spectrum. This process will also identify the specific transmitters responsible for the offending interference.

   The most direct way to isolate the source of a common path intermodulation problem is to insert a low value test attenuator (3 dB recommended) into the waveguide run at different points and observe the impact on the product levels. Because this process will require many service interruptions, if possible, reroute service before beginning.

   The details for using this diagnostic approach follow. The procedures are keyed to the labels shown in Figure 10 and result in level changes that occur when the test attenuator is inserted at these various locations. Use the change in product level versus attenuator location information given in Table G as a guide during the isolation process.

6. Cut in the low loss waveguide attenuator (3 dB assumed) at one of the points marked in Figure 10 (such as X_1), and note the change in the product level on the spectrum analyzer display. The product level at the receiver will drop by 0, 3, 6, 9, or 12 dB, depending on the location of the nonlinear element relative to the location of the test attenuator; that is, the elements or waveguide network sections defined by labels A through H in Figure 10.

   Note that the CHANGE-IN-PRODUCT-RESULTS in Table G are based on the use of a 3-dB pad. If a different pad is used, multiply the results in Table E by the ratio of the loss in dB of the pad used to 3 dB.

7. Use Table G and the resultant change in the IMN product level observed on the analyzer to determine the most likely location of the nonlinearity.

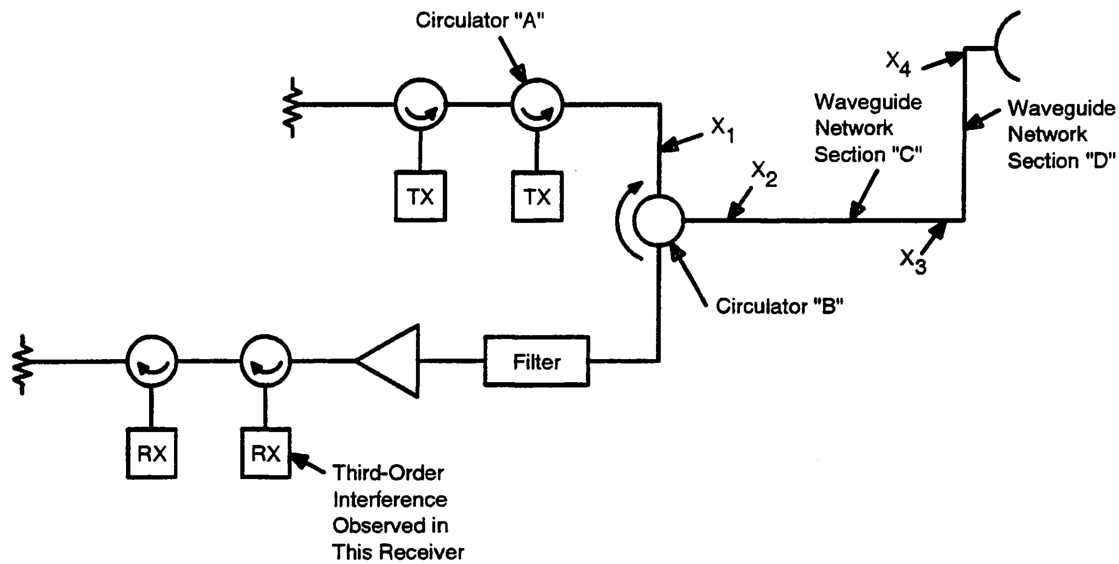
8. If the result is inconclusive, move the attenuator to another "X" point and observe the resultant change in IMN product again. Continue this process in an orderly fashion, using Table G as a guide, until the nonlinearity has been found and eliminated by replacement or repair.

9. Once a satisfactory S/IMN ratio has been achieved, record the value and proceed with one of the following:

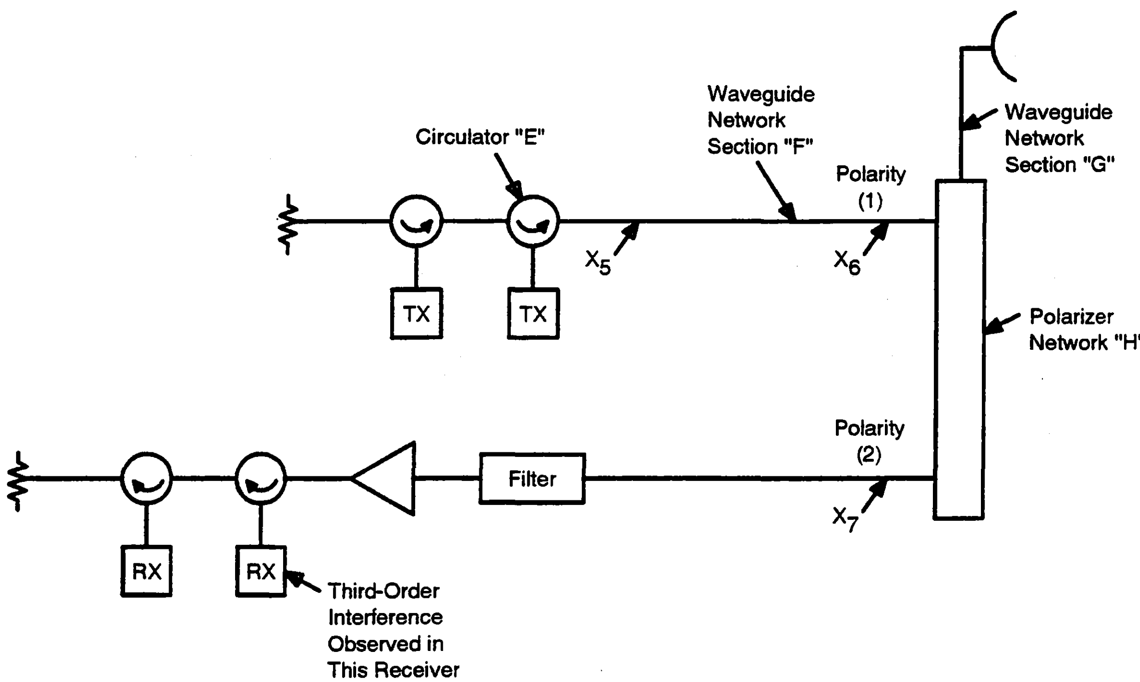
   a. If the S/IMN value is to be used as an input for calculating the flat fade margin, return to the Test Sequence Flowchart at reentry point H.

   b. If this procedure is being used with another procedure, return to that procedure for further instructions.

END OF PROCEDURE



(a) Shared Antenna System With Transmitters And Receivers on Same Polarization



(b) Shared Antenna System With Transmitters And Receivers on Different Polarization

Figure 10–Common Path Intermodulation Product Generation Points in Shared Antenna Systems

TABLE G CHANGE IN PRODUCT LEVEL AT RECEIVER VS. NONLINEARITY AND 3 DB PAD LOCATION (dB) (NOTE 1)							
Location of Waveguide Element or Network section With Non-Linearity (Note 2)	**3 dB Pad Location (Note 2)**						
	x_1	x_2	x_3	x_4	x_5	x_6	x_7
A	3	0	0	0	-	-	-
B	9	0	0	0	-	-	-
C	9	12	0	0	-	-	-
D	9	12	12	0	-	-	-
E	-	-	-	-	3	3	3
F	-	-	-	-	9	3	3

Notes:

1. **If other than a 3 dB pad is used (say "Y" dB) Multiply change in product level in table by a radio Y/3 for correct values to use for that case.**
2. **See Figure 10A and 10B.**

2.9 RESTORING EQUIPMENT TO NORMAL

PROCEDURE

1. When all measurements and evaluations requiring the FFM test set-up are complete, leave the protection switching system in the mode established to perform this procedure, and go to the next step.
2. Remove all the test equipment, and restore the radio bay connections and all transmitter/receiver unit operating modes to normal.
3. Go to the Repair Verification Procedure given in the applicable station O&M manual and follow the instructions in that procedure to return the system to service.

END OF PROCEDURE

3. FLAT FADE MARGIN CALCULATION PROCEDURES

These procedures are used to calculate and evaluate the FFM (flat fade margin) of a DR 6/11-135 digital radio hop using the noise and interference parameters measured in Part 2. The general approach and equations used are outlined in introductory sections that precede the detailed step procedures. The calculation and evaluation process is guided by a Test Sequence Flowchart that specifies the correct detailed calculation procedure for the interference and noise condition that are normally encountered.

3.1 PREREQUISITES

The first prerequisite for calculating and evaluating the FFM is that Part 2 must be completed and all significant fade limiting S/N and S/I ratios must be in hand. Also, the user should be familiar with the information, terminology, and identifying symbols given for the noise and interference sources in Part 2. Familiarity with the information in the ***General Equations for Calculating Flat Fade Margin***, which follows, is also necessary.

3.2 GENERAL EQUATIONS FOR CALCULATING FLAT FADE MARGIN

The FFM is defined as the flat fade from the ***normal*** received signal level (in dB) that can occur before the S/CPN (signal-to-composite noise) ratio degrades to the 10^{-3} and 10^{-6} BER (bit-error-rate) performance points. For DR 6/11-135 systems, the worse case S/CPN reference ratios corresponding to these BER performance points are 24 and 29 dB respectively.

Note: The 24/29 dB, 10^{-3} and 10^{-6} BER performance point S/CPN reference ratios represent the upper limit for DR 6/11-135 radio hops. Many hops will operate at lower S/CPN ratios before degrading to these threshold BER points. Thus, the FFM of a specific hop may be better than the results shown by the equations given below. These equations are based on the worst case 24 and 29 dB ratios. If an S/N test set is available, the actual S/CPN reference ratio for these BER points may be determined with over-the-air measurements. The resulting S/CPN reference limits may then be substituted for the worst case 24/29 dB reference values used in the equations given here. The calculated FFM determined with the actual S/CPN reference limits will be more accurate for the specific hop under test.

Once the S/N and S/I ratios are known for the significant noise or interference contributors, the normal signal S/CPN ratio and, therefore, the amount of signal fade to the indicated performance threshold points may be calculated for each case. Two general cases exist.

General Case 1. No Interference Present:

Without interference, the fade margin is limited only by a single contributor, the thermal noise (S/TN ratio) of the radio receiver. The FFM to the 10^{-3} and 10^{-6} BER performance threshold points is determined by subtracting the 24 dB and 29 dB reference ratios from the S/TN value measured for the hop. This gives the number of dB the signal can fade before reaching the reference S/CPN ratios. In equation form, the FFM for the two BER conditions are:

[EQ-1] ***10^{-3} BER FFM calculation***

FFM = S/TN -24 dB

[EQ-2] ***10^{-6} BER calculation***

FFM = S/TN - 29 dB

General Case 2. Interference Present:

For cases where interference is present, the composite noise-to-signal ratio (CPN/S) in dB may be determined by summing (on a power addition basis) the significant noise-to signal ratios (N/S or I/S) also in dB.

Note: These ratios are the inverse of the signal-to-noise ratios needed to calculate the FFM. This is equivalent to power summing the negative dB values of all the contributing S/N or S/I ratios.

S/CPN = (-S/TN) " + " $(-S/I_{(1)})$ " + " $(-S/I_{(2)})$ " + " ...." + " $(-S/I_{(n)})$ in dB

Where:

a. S/TN is the signal-to-thermal noise component in dB

b. The S/I(i) through S/I(n) terms are all the significant signal to interference components (adjacent or in channel) involved

c. The " + " symbol represents a power addition of terms in dB

Given the S/TN and S/I values, the exact equation for forming this sum and calculating the resultant S/CPN ratio is :

[EQ-3]

$$S/CPN = -10\log\left[10^{\frac{-\left(\frac{S}{TN}\right)}{10}} + 10^{\frac{-\left(\frac{S}{I(1)}\right)}{10}} + ...10^{\frac{-\left(\frac{S}{I(n)}\right)}{10}}\right]$$

Where the terms inside the [ ] are the inverse log of the negative S/N or S/I terms divided by 10, or in other words, the numerical noise-to-signal power ratios.

Once the S/CPN ratio is known, the FFM to the 10^{-3} and 10^{-6} BER points is a matter of subtracting the reference ratios corresponding to these BER's, that is, 24 and 29 respectively. Thus the equations for calculating the 10^{-3} and 10^{-6} are:

[EQ-4] ***10^{-3} BER FFM calculation***

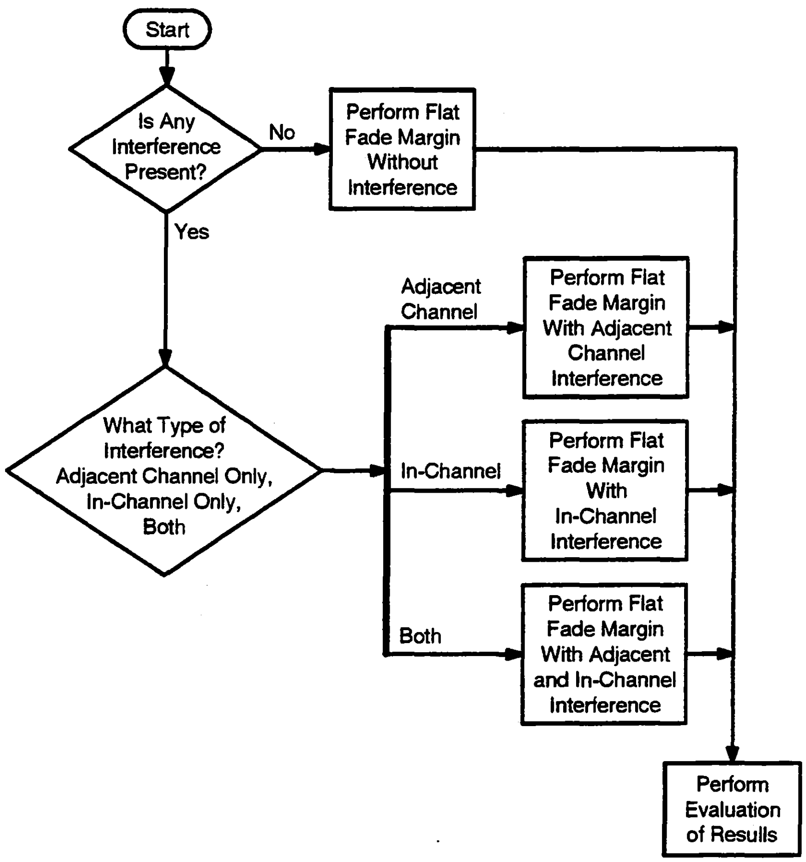
FFM = S/CPN (from EQ-3) - 24 dB

[EQ-5] ***10^{-6} BER calculation***

FFM = S/CPN (from EQ-3) - 29 dB

3.3 FLAT FADE MARGIN TEST SEQUENCE FLOWCHART

The process for calculating the Flat Fade Margin (FFM) to the 10^{-3} and 10^{-6} BER points is controlled by the FFM Test Sequence Flowchart (Flowchart 3). This flowchart guides the user to the proper detailed procedures for each of the various types of noise and interference conditions that are likely to be encountered. The procedures are located in the next section.



Flowchart 2– Flat Fade Margin (FFM) Test Sequence Flowchart

3.4 DETAILED PROCEDURES FOR CALCULATING AND EVALUATING FLAT FADE MARGIN

The following procedures for calculating the FFM for specific cases of noise and interference conditions use the general equations for calculating flat fade margin. Each of the following sections give the guidelines for selecting the equations and the particular S/N or S/I inputs to use for calculating the FFM for the specific noise and interference case.

3.4.1 Flat Fade Margin Without Interference

Without any interference present, the flat fade margin is limited only by the signal to receiver thermal noise floor ratio, that is, the S/TN ratio determined in TEST PROCEDURES FOR DETERMINING FADE MARGIN PARAMETERS.

1. Substitute the applicable value of S/TN into EQ-1 and EQ-2 to calculate the FFM for the 10^{-3} and 10^{-6} BER threshold points.
2. Following the calculation, return to the FFM Test Sequence Flowchart.

3.4.2 Flat Fade Margin With Adjacent Channel Interference

For this condition, the flat fade margin is limited by composite noise because of adjacent channel interference and the receiver TN noise floor. The equations, EQ-4 and EQ-5, must be used to calculate the 10^{-3} and 10^{-6} BER FFM's. However, the S/CPN ratio of EQ-3 must first be calculated.

To calculate S/CPN, the S/TN value for the thermal noise floor term and an S/I( ) value for each adjacent channel interference term are necessary. The applicable S/TN value from the results of the tests procedures may be used directly for equation EQ-3. Each adjacent channel S/I( ) term must first be calculated by applying for a correction factor to the applicable S/ACI ratios determined in Part 2. The correction factor for S/ACI depends on whether the system is equipped with Error Correction or not.

[EQ-6] For systems ***without*** the Error-Correction option

S/I( ) = S/ACI (of Part 2) + 33 + 11 dB

[EQ-7] For systems ***with*** the Error-Correction option

S/I( ) = S/ACI (of Part 2) + 28 + 11 dB

Where the last two terms in each equation are the correction factors necessary to account for the adjacent channel discrimination provided by the digital receiver post-detection baseband filters and the normal joint-fading factor, respectively. (See ***Note*** for explanation.)

a. Correct the S/ACI values of Part 2 using the applicable equation (EQ-6 or EQ-7) to determine the S/I( ) term for each adjacent channel interference present.
b. Calculate the S/CPN ratio using the applicable S/TN and Adjacent Channel S/I ratio determined in EQ-3.
c. Using the S/CPN ratio calculated in (b), calculate the $10^{-3}/10^{-6}$ BER FFM's using EQ-4 and EQ-5.
d. Following the FFM calculation, return to the FFM Test Sequence Flowchart.

Note: As mentioned in the tutorial in Part 4, the S/ACI ratios measured and recorded using the test procedures represent the amount of adjacent channel discrimination provided by the XPD of the antenna system only. The actual discrimination against adjacent channel interference is much higher as a result of two other factors. Therefore, correction factors that account for these two factors must be applied to the S/ACI ratios determined in Part 2 to derive the correct S/I( ) adjacent channel interference terms to use in the S/CPN calculation of EQ-3.

The ***first correction factor*** necessary accounts for the post-detection discrimination provided by the baseband filters, which follow the demodulators in the digital receiver. The post-detection discrimination provided by these filters has been determined experimentally and depends on whether the digital system being tested is equipped with the Error-Correction option or not. For systems with and without the error-correction option, the amount of additional adjacent channel discrimination is 28 and 33 dB respectively.

The ***second correction factor*** accounts for the fact that adjacent channels normally experience some joint-fading, along with the channel into which they are interfering. Since the S/ACI values obtained in Part 1 are based on a test procedure in which the transmitter output for the channel under test is faded without reducing the signals from the adjacent transmitters, this ratio does not account for any joint-fading. Therefore, the S/ACI ratio must be corrected to account for the reality of joint-fading. The amount of additional discrimination that may be counted on as a result of joint-fading is a variable that depends on many complex parameters associated with each radio hop. However, many experimental propagation studies have been done to determine the statistical nature of fading and show that for fades in the 35- to 40-dB range adjacent channels will experience at least 11 dB of joint fading. Therefore, this value has been used for the joint-fading correction factor in EQ-6 and EQ-7.

3.4.3 Flat Fade Margin With In-Channel Interference

For this condition, the flat fade margin is limited by composite noise because of in-channel interference and the receiver TN noise floor. Equations EQ-4 and EQ-5 must be used to calculate the 10^{-3} and 10^{-6} BER cases FFMs. The S/CPN ratio of EQ-3 must be calculated first in this case.

To calculate the S/CPN ratio, the S/TN value for the thermal noise floor term and an S/I( ) value for each significant in-channel interference term (cochannel, local or common path intermodulation) are necessary. The applicable S/TN value from the results of Part 2 may be used directly in equation EQ-3 for this purpose. For interference resulting from local interference or common path intermodulation, the S/NELI or S/IMN ratio(s) determined in the test procedures may also be used directly for the related S/I( ) terms. For a cochannel interference (S/CCI) term, however, a joint-fading improvement factor may be applicable (see ***Note***).

a. If applicable, add the appropriate joint-fade factor to each S/CCI ratio from Part 2 to determine the S/I( ) term for that interferer. If no joint-fading factor is appropriate, use the S/CCI ratios directly for the related S/I( ) term in equation EQ-3.

b. Calculate the S/CPN ratio using the applicable S/TN and S/CCI, S/NELI, and S/IMN ratios from Part 2 and (a) above in EQ-3.

c. Using the S/CPN ratio calculated in (b), calculate the $10^{-3}/10^{-6}$ BER FFM's using EQ-4 and EQ-5.

d. Following the FFM calculation, return to the FFM Test Sequence Flowchart.

Note: For cochannel interference, if it can be determined that the desired and interfering signals come over the same path, a degree of joint fading may be applicable with adjacent channel interference. This can only be determined by carefully deciding which paths are involved and will usually require observation during fading to verify. In marginal cases, however, the effort necessary to determine a joint fading factor may be warranted.

3.4.4 Flat Fade Margin With Both Adjacent and In-Channel Interference

For this condition, the FFM is limited by the composite noise caused by adjacent channel and in-channel interference, plus the receiver noise floor therefore, the general combining equations, EQ-4 and EQ-5, must be used to calculate the 10^{-3} and 10^{-6} BER FFM's. The S/CPN ratio of EQ-3 must first be calculated in this case.

This case is a combination of FFM with adjacent channel and in-channel interference previously discussed. To calculate the S/CPN ratio, the value of S/TN from Part 2 may be used directly in equation EQ-3. The S/I( ) terms for any adjacent channel and in-channel interferences must be modified, if necessary, as shown in Part 3.4.2 and 3.4.3 by working with each of these interferences separately.

a. Generate and correct the Adjacent and In-channel S/I ratios to be used (Part 3.4.2 and 3.4.3).

b. Calculate the S/CPN ratio using the applicable S/TN, Adjacent Channel, and In-channel S/I ratios (adjusted per (a) as necessary) in EQ-3.

c. Using the S/CPN ratio calculated in (b), calculate the $10^{-3}/10^{-6}$ BER FFM's using EQ-4 and EQ-5.

d. Following the FFM calculation, return to the FFM Test Sequence Flowchart.

3.4.5 Evaluation of Calculated Flat Fade Margin Result

1. After calculating the FFM for a specific case, the acceptability or unacceptability of the result must be judged based on the outage objectives established for flat fading on that hop. To make this evaluation, note that, from an overall performance point of view, the "CFM" (composite fade margin) is of primary concern. The CFM allows for dispersive as well as flat fading. The amount of fade margin that must be allotted to dispersive fading depends on the propagation characteristics of the particular radio hop being evaluated. As a result, the allocation for flat fading over a particular hop depends somewhat on the allowance necessary for dispersive fading.

   Generally, a system designed for a CFM of 35 dB or better will give satisfactory performance. Thus, a hop that is engineered and equipped for the normal 36-dB dispersive fade margin will require an FFM of about 42 dB to achieve the 35-dB CFM objective. For hops that are not subject to dispersive fading, an FFM of 35 dB may be acceptable.

   If all individual contributors meet the allocations given for them in Part 2, the calculated FFM should be satisfactory. If the specific allocations for fading are not known or are not clear, consult engineering to determine the acceptability of an FFM result. Engineering should be consulted whenever a critical evaluation of an FFM result is desired.

2. When satisfactory FFM results are achieved, return to the main Test Sequence Flowchart at reentry point F.

   If the results are unsatisfactory because one or more of the contributors are out of limits, the source of the out-of-limits interference or noise contributor must be isolated and eliminated or reduced to acceptable levels. The information in Part 4 can be useful for this purpose. If the techniques available in this practice do not help resolve the problem, consult engineering and/or the AT&T NS Customer Support group for additional help.

3.4.6 10-3 and 10-6 BER Flat Fade Margin Tables

Tables H through Q reflect the worst-case calculated flat fade margins for the 10-3 and 10-6 BER conditions, for RT and non-RT systems. They are included here for reference purposes only, and should be used only as a guide for evaluating the results obtained from the general equations. Values given in the tables are based on the following assumptions:

- Only adjacent channel type interferences are present.
- A cross-pole discrimination of 29 dB.
- A cross-detection filter correction factor of 28 dB with error correction, and 33 dB without error correction.
- A joint fading correction factor of 11 dB.
- Meeting the MIN S/TN requirement for a given RSL.

TABLE H 6 GHz 10-3 BER FFM For 4300 Series Down Conv Without Error Correction												
	NO PREAMP				329A PREAMP				331A PREAMP			
	MIN	# ADJ CHAN			MIN	# ADJ CHAN			MIN	# ADJ CHAN		
RSL	S/TN	0	1	2	S/TN	0	1	2	S/TN	0	1	2
-10	76.0	52.0	47.8	45.0	82.5	58.5	48.5	45.5	86.5	62.5	48.8	45.9
-15	71.0	47.0	44.9	43.8	77.5	53.5	47.7	45.3	81.5	57.5	48.4	45.7
-20	66.0	42.0	41.2	40.5	72.5	48.5	45.5	44.1	76.5	52.5	47.4	45.1
-25	61.0	37.0	36.7	36.5	67.5	43.5	42.4	41.6	71.5	47.5	45.2	43.7
-30	56.0	32.5	31.9	31.8	62.5	38.5	38.1	37.8	66.5	42.5	41.6	40.9
-35	51.0	27.0	27.0	26.9	57.5	33.5	33.4	33.3	61.5	37.5	41.2	36.9

TABLE I 6 GHz 10-3 BER FFM For 4300 Series Down Conv With Error Correction												
	NO PREAMP				329A PREAMP				331A PREAMP			
	MIN	# ADJ CHAN			MIN	# ADJ CHAN			MIN	# ADJ CHAN		
RSL	S/TN	0	1	2	S/TN	0	1	2	S/TN	0	1	2
-10	76.0	52.0	43.4	40.7	82.5	58.5	43.8	40.9	86.0	62	43.9	41.0
-15	71.0	47.0	42.2	40.0	77.5	53.5	43.5	40.8	81.0	57	43.7	40.9
-20	66.0	42.0	39.9	38.5	72.5	48.5	42.7	40.3	76.0	52	43.4	40.7
-25	61.0	37.0	36.2	35.5	67.5	43.5	40.7	39.1	71.0	47	42.2	40.0
-30	56.0	32.0	31.7	31.5	62.5	38.5	37.4	36.6	66.0	42	39.9	38.5
-35	51.0	27.0	26.9	26.8	57.5	33.5	33.1	32.8	61.0	37	36.2	35.5

TABLE J
6 GHz 10-3 BER FFM For 4400 Series Down Conv
Without Error Correction

	NO PREAMP				329A PREAMP				331A PREAMP			
	MIN	# ADJ CHAN			MIN	# ADJ CHAN			MIN	# ADJ CHAN		
RSL	S/TN	0	1	2	S/TN	0	1	2	S/TN	0	1	2
-10	85.5	61.5	48.8	45.9	86.0	62	48.8	45.9	86.5	62.5	48.8	45.9
-15	80.5	56.5	48.3	45.6	81.0	57	48.4	45.7	81.5	57.5	48.4	45.7
-20	75.5	51.5	47.1	44.9	76.0	52	47.2	45.0	76.5	52.5	47.4	45.1
-25	70.5	46.5	44.6	43.2	71.0	47	44.9	43.5	71.5	47.5	45.2	43.7
-30	65.5	41.5	40.8	40.2	66.0	42	41.2	40.5	66.5	42.5	41.6	40.9
-35	60.5	36.5	36.3	36.0	61.0	37	36.7	36.5	61.5	37.5	41.2	36.9

TABLE K
6 GHz 10-3 BER FFM For 4400 Series Down Conv
With Error Correction

	NO PREAMP				329A PREAMP				331A PREAMP			
	MIN	# ADJ CHAN			MIN	# ADJ CHAN			MIN	# ADJ CHAN		
RSL	S/TN	0	1	2	S/TN	0	1	2	S/TN	0	1	2
-10	85.5	61.5	43.9	41.0	86.0	62	43.9	41.0	86.5	62.5	43.9	41.0
-15	80.5	56.5	43.8	40.9	81.0	57	43.8	40.9	81.5	57.5	43.8	40.9
-20	75.5	51.5	43.3	40.6	76.0	52	43.4	40.7	76.5	52.5	43.4	40.7
-25	70.5	46.5	42.1	39.9	71.0	47	42.2	40.0	71.5	47.5	42.4	40.1
-30	65.5	41.5	39.6	38.2	66.0	42	39.9	38.5	66.5	42.5	40.2	38.7
-35	60.5	36.5	35.8	35.2	61.0	37	36.2	35.5	61.5	37.5	36.6	35.9

TABLE L 6 GHz 10-6 BER FFM For 4300 Series Down Conv Without Error Correction												
	NO PREAMP				329A PREAMP				331A PREAMP			
	MIN	# ADJ CHAN			MIN	# ADJ CHAN			MIN	# ADJ CHAN		
RSL	S/TN	0	1	2	S/TN	0	1	2	S/TN	0	1	2
-10	76.0	47.0	42.8	40.0	82.5	53.5	43.5	40.5	86.5	57.5	43.8	40.9
-15	71.0	42.0	39.9	38.2	77.5	48.5	42.7	40.3	81.5	52.5	43.4	40.7
-20	66.0	37.0	36.2	35.5	72.5	43.5	40.5	39.1	76.5	47.5	42.4	40.1
-25	60.0	32.0	37.7	31.5	67.5	38.5	37.4	36.6	71.5	42.5	40.2	38.7
-30	56.0	27.5	26.9	26.8	62.5	33.5	33.1	32.8	66.5	37.5	36.6	35.9
-35	51.0	22.0	22.0	21.9	57.5	28.5	28.4	28.3	61.5	32.5	36.2	31.9

TABLE M 6 GHz 10-6 BER FFM For 4300 Series Down Conv With Error Correction												
	NO PREAMP				329A PREAMP				331A PREAMP			
	MIN	# ADJ CHAN			MIN	# ADJ CHAN			MIN	# ADJ CHAN		
RSL	S/TN	0	1	2	S/TN	0	1	2	S/TN	0	1	2
-10	76.0	47.0	38.4	35.7	82.5	53.5	38.8	35.9	86.0	57	38.9	36.0
-15	71.0	42.0	37.2	35.0	77.5	48.5	38.5	35.8	81.0	52	38.7	35.9
-20	66.0	37.0	34.9	33.5	72.5	43.5	37.7	35.3	76.0	47	38.4	35.7
-25	61.0	32.0	31.2	30.5	67.5	38.5	35.7	34.1	71.0	42	37.2	35.0
-30	56.0	27.0	26.7	26.5	62.5	33.5	32.4	31.6	66.0	37	34.9	33.5
-35	51.0	22.0	21.9	21.8	57.5	28.5	28.1	27.8	61.0	32	31.2	30.5

TABLE N 6 GHz 10-6 BER FFM For 4400 Series Down Conv Without Error Correction												
	NO PREAMP				329A PREAMP				331A PREAMP			
	MIN	# ADJ CHAN			MIN	# ADJ CHAN			MIN	# ADJ CHAN		
RSL	S/TN	0	1	2	S/TN	0	1	2	S/TN	0	1	2
-10	85.5	56.5	43.8	40.9	86.0	57	43.8	40.9	86.5	57.5	43.8	40.9
-15	80.5	51.5	43.3	40.6	81.0	52	43.4	40.7	81.5	52.5	43.4	40.7
-20	75.5	46.5	42.1	39.9	76.0	47	42.2	40.0	76.5	47.5	42.4	40.1
-25	70.5	41.5	39.6	38.2	71.0	42	39.9	38.5	71.5	42.5	40.2	38.7
-30	65.5	36.5	35.8	35.2	66.0	37	36.2	35.5	66.5	37.5	36.6	35.9
-35	60.5	31.5	31.3	31.0	61.0	32	31.7	31.5	61.5	32.5	36.2	31.9

TABLE O 6 GHz 10-6 BER FFM For 4400 Series Down Conv With Error Correction												
	NO PREAMP				329A PREAMP				331A PREAMP			
	MIN	# ADJ CHAN			MIN	# ADJ CHAN			MIN	# ADJ CHAN		
RSL	S/TN	0	1	2	S/TN	0	1	2	S/TN	0	1	2
-10	85.5	56.5	38.9	36.0	86.0	57	38.9	36.0	86.5	57.5	38.9	36.0
-15	80.5	51.5	38.8	35.9	81.0	52	38.8	35.9	81.5	52.5	38.8	35.9
-20	75.5	46.5	38.3	35.6	76.0	47	38.4	35.7	76.5	47.5	38.4	35.7
-25	70.5	41.5	37.1	34.9	71.0	42	37.2	35.0	71.5	42.5	37.4	35.1
-30	65.5	36.5	34.6	33.2	66.0	37	34.9	33.5	66.5	37.5	35.2	33.7
-35	60.5	31.5	30.8	30.2	61.0	31	31.2	30.5	61.5	32.5	31.6	30.9

TABLE P 11 GHz 10-3 BER FFM With or Without Error Correction				
	4300 Series Down Conv		4400 Series Down Conv	
RSL	NO PREAMP	805B PREAMP	NO PREAMP	805B PREAMP
-10	50.5		57.5	
-15	45.5		52.5	
-20	40.5	48.5	47.5	50.5
-25	35.5	33.5	42.5	45.5
-30	30.5	28.5	37.5	40.5
-35	25.5	23.5	32.5	35.5

TABLE Q 11 GHz 10-6 BER FFM With or Without Error Correction				
	4300 Series Down Conv		4400 Series Down Conv	
RSL	NO PREAMP	805B PREAMP	NO PREAMP	805B PREAMP
-10	45.5		52.5	
-15	40.5		47.5	
-20	35.5	43.5	42.5	45.5
-25	30.5	28.5	37.5	40.5
-30	25.5	23.5	32.5	35.5
-35	20.5	18.5	27.5	30.5

4. MEASUREMENT APPROACH AND IDENTIFICATION OF NOISE SOURCES

The background information that is necessary to familiarize a new or inexperienced user with procedures used to evaluate the FFM of a DR 6/11-135 digital radio hop is given in this part of the Fade Margin and Interference Tests practice. Familiarity with the information given is necessary to perform the measurement, calculation, and evaluation procedures given in Part 2 and 3. Following a general description of the measurement approach, the noise and interference parameters that can limit the FFM are categorized and described. The symbols that are used in the Part 2 and Part 3 procedures are introduced and defined. The mechanisms and some of the factors that influence the acceptability of these various noise and interference sources are discussed. Finally, an interference example is described, which helps to illustrate some of the mechanisms and the impact that interference can have on digital radio systems.

4.1 MEASUREMENT APPROACH

The flat fade margin of a radio hop is normally defined as the number of dBs that the received signal of the hop may drop below its normal value at the receiver input before the BER of the digital signal being carried exceeds 10^{-3}. For AT&T-NS Digital Radio Systems, the flat fade margin to a BER of 10^{-6} is also of interest since it is a typical protection switching threshold and, therefore, will have an impact on overall system availability.

The fading that occurs in the air path between the transmitter and receiver is a complex, selective process that is difficult to simulate or introduce on an experimental basis. Therefore, determination of the actual, in-service flat fade margin of a radio hop by direct measurement is impractical. The characteristics of fading have been determined by numerous statistical studies; however, the in-service fade margin may be determined accurately by calculation if the levels of the significant noise and interference components that limit flat fading are known. Since it is possible and practical to determine these components in the field, a procedure using this technique is given. The basic approach involves the following general steps:

a. With normal signal and propagation conditions, use experimental procedures at the receiver for the hop under test to determine the level of the noise or interference components that will contribute significantly to the noise floor, which limits the flat fade capability.

b. Add the individual noise components to determine the composite fade-limiting noise floor.

c. Once the composite fade-limiting noise floor is known, calculate the expected, in-service, flat fade margin by noting the number of dBs the signal may drop to reach the S/N ratio, which will result in the specified BER.

Note: For DR 6/11-135, 64-QAM systems, the maximum S/N ratios required to guarantee meeting the 10^{-6} and 10^{-3} BER thresholds have been determined experimentally to be 29 and 24 dB respectively. Typically, a hop will perform better than these limiting S/N ratios show (e.g., will meet the specified BER thresholds with lower S/N ratios). If desired, the actual S/N ratio for these BER thresholds may be determined experimentally for the hop being tested using the procedures given in the station O&M manual.

The process of evaluating the flat fade margin becomes one of determining the level of the various noise or interference sources that make up the limiting noise floor at the receiver. Since the noise sources of interest are typically many dB below the normal signal level, it is difficult to measure the absolute level of each noise source. Therefore, the level of each noise or interference source is determined on a relative or S/N or S/I basis. This is done by using a calibrated spectrum analyzer at the IF output of the receiver down-converter. The S/N ratio of a particular noise contributor is determined, via the analyzer display, by noting its level relative to the signal under normal conditions. Figure 11 shows a sketch of the typical IF signal spectrum shape that exists at the down-converter output for DR 6 and DR 11 radio hops.

The S/N or S/I ratios under normal signal conditions are typically large. Therefore, to improve the accuracy of these relative noise measurements, the transmitted signal level is reduced by a convenient amount for the spectrum analyzer used. The S/N or S/I ratios are then determined relative to the location of the reduced level signal spectrum on the analyzer. This approach helps eliminate dynamic range limitations of the spectrum analyzer and also brings the down-converter out of its AGC (automatic gain control) up-fade protection range. A -50 dBm level into the down-converter is normally adequate and convenient for this purpose. The desired drop in transmitted RF signal level is achieved by reducing (fading) the IF input to the transmitter up-converter with the transmitter ALC (automatic level control) circuit disabled. In this mode, the transmitter output drops dB for dB with the drop in the IF input signal. A calibrated adjustable IF attenuator is used to improve the accuracy of the relative value measurements. Using an adjustable attenuator also provides flexibility in evaluating the various fade limiting contributors. For example, the S/I ratios for adjacent channel signals may be accurately determined by adjusting this attenuator, which brings the observed signal spectrum equal to the interference spectrum being measured on the spectrum analyzer, and then noting the attenuator change required to produce equality. In-channel S/N ratios are generally determined by turning off the transmitter and noting how far the noise components are below the original location of the signal spectrum before it was turned off. The procedures are always designed to account for the noise contribution of the transmitter, which is more significant when the transmitter output is reduced in this manner. Note that maintenance personnel are required at both ends of the radio hop being tested to perform these tests.

The detailed procedures for determining the various S/N and S/I ratios to support the above process are given in TEST PROCEDURES FOR DETERMINING FADE MARGIN PARAMETERS. The procedures for calculating and evaluating the flat fade margin using the S/I and S/N results are provided in FLAT FADE MARGIN CALCULATION PROCEDURES.

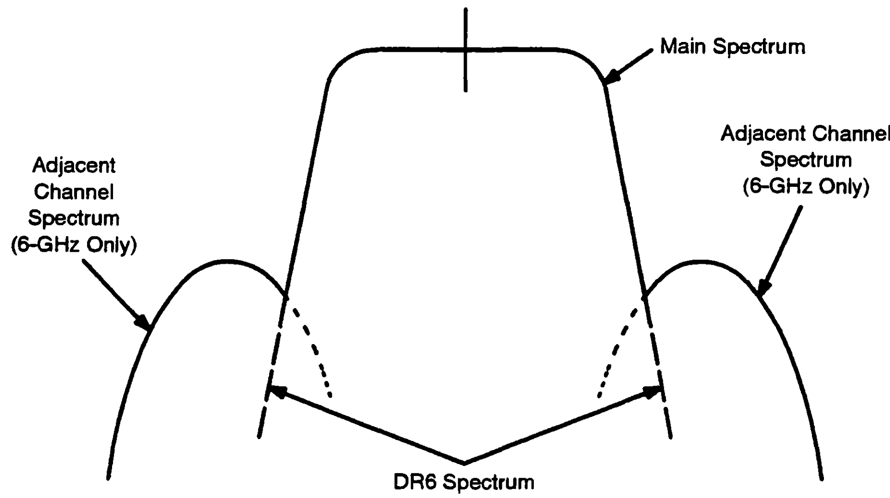


Figure 11 – Typical IF Spectrum Display at Down Converter Output

4.2 NOISE AND INTERFERENCE SOURCES THAT LIMIT FLAT FADE MARGIN

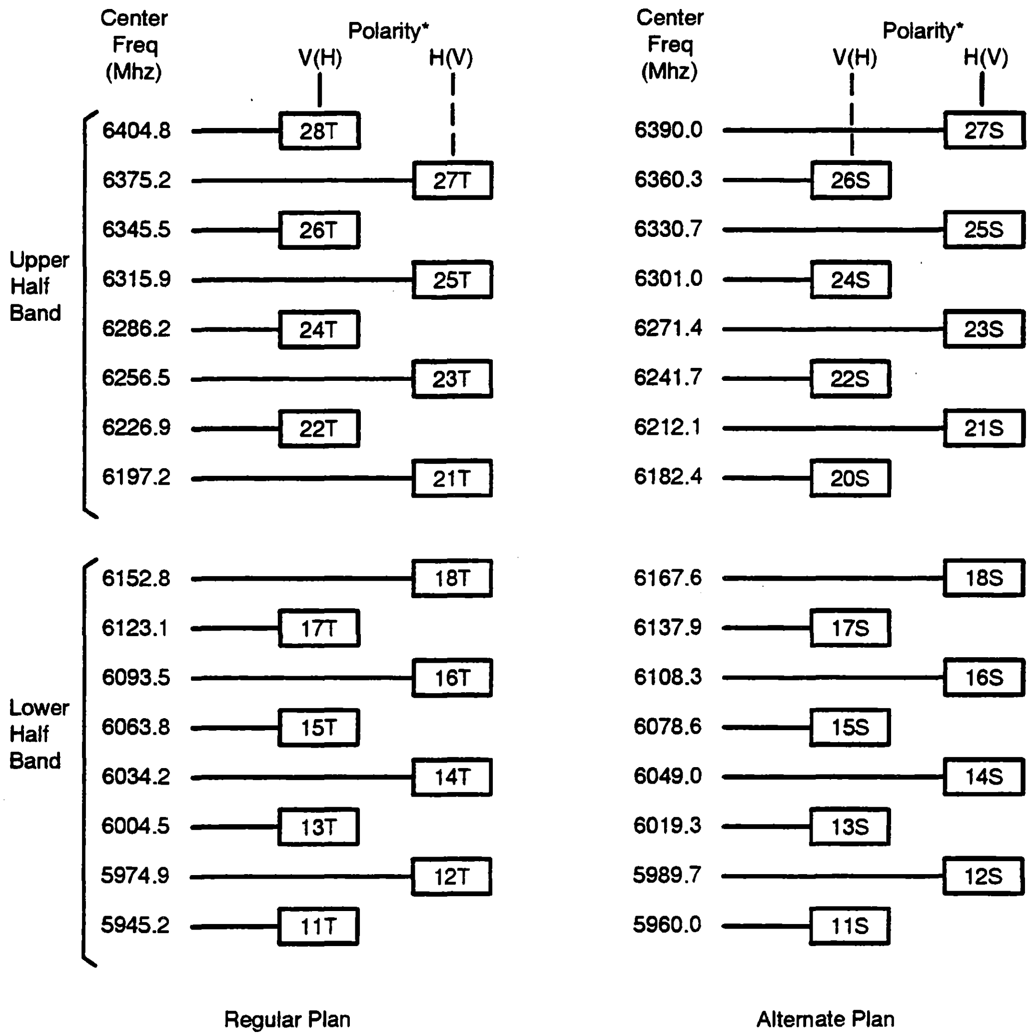
The noise and/or interference that can limit the flat fade margin of DR 6/11-135 radio hops comes from both internal and external sources (see ***Note***). ***Internal noise*** is the noise that is generated by the radio equipment. This noise is always present and establishes the minimum or lower noise floor limit for flat fading. ***External interference*** can come from many sources but, in general, may be grouped into two major categories, ***adjacent channel interference*** and ***in-channel interference***.

Note: Other types of degradations besides noise and interference can also limit the fade margin by reducing the signal-to-noise ratio or eye-opening under normal received signal conditions. When these degradations exist, the allowance for fade-induced noise is reduced. Such degradations as excessive amplitude and/or envelope delay distortion in the radio hop IF-to-IF transmission characteristics or excessive nonlinearity in radio transmitter/receiver units, for example, can have an adverse effect on the flat fade margin. Therefore, all potential in-channel performance degradations must be within limits before a proper evaluation of the flat fade margin of a radio hop can be made using the procedures in this practice. Validation of hop performance, under normal conditions, is best determined by using the Over the Air S/I Stress Check procedure given in the "Station Procedures" tab of the applicable station O&M manual. If performance under normal conditions is uncertain, perform these tests before proceeding with the fade margin tests.

Adjacent channel interference is a specific type of interference that can occur when one or both of the radio channel(s) assigned to operate on the channel frequencies immediately adjacent to the desired channel are present. When an adjacent channel is present, a portion of its signal spectrum inevitably leaks into the desired channel at the channel edges and may degrade the fade margin of the operating channel. The amount of degradation depends on the spectrum width and level of the leaked signal and is dependent on the channel spacing, the type of signal, and the operating power of the adjacent channel signal. Figures 12 and 13 show the frequency and channelization plans used for the DR 6 and DR 11 systems, and Figure 14 shows the spectrum of the 64-QAM signal carried by the radio on both DR 6-135 and DR 11-135 systems. These system parameters plus the discrimination characteristics of the radio channel filters are such that adjacent channel interference is only of concern on DR 6 systems. Thus, the specific procedures given for determining the effect of adjacent channel interference on the flat fade margin is limited to 6-GHz systems.

In-channel interference is any noise and/or interference that leaks into the passband of the channel. Such interference can come from many sources. However, in-channel interference occurs via two major mechanisms: direct over-the-air pickup at the receive antenna or equipment-to-equipment leakage at the transmit or receive end of the radio hop. When it occurs as a result of over-the-air pickup, in-channel interference is normally referred to as CCI (***cochannel interference***), since the source is usually another transmitter operating on the same or overlapping frequency. ***In-channel interference*** resulting from equipment leakage at the transmit or receive ends of a radio hop is usually referred to as LI (***local interference***) and, depending on whether it occurs at the transmit or receive equipment site, it is further qualified as FELI (far end LI) or NELI (near end LI), respectively. From the viewpoint of impact on fade margin, only the LI that occurs at the receive end of a hop (NELI) is significant. This is because local interference, when present, is usually fixed in level. Therefore, when it occurs at a receiver, the S/I ratio degrades dB for dB with signal fades.

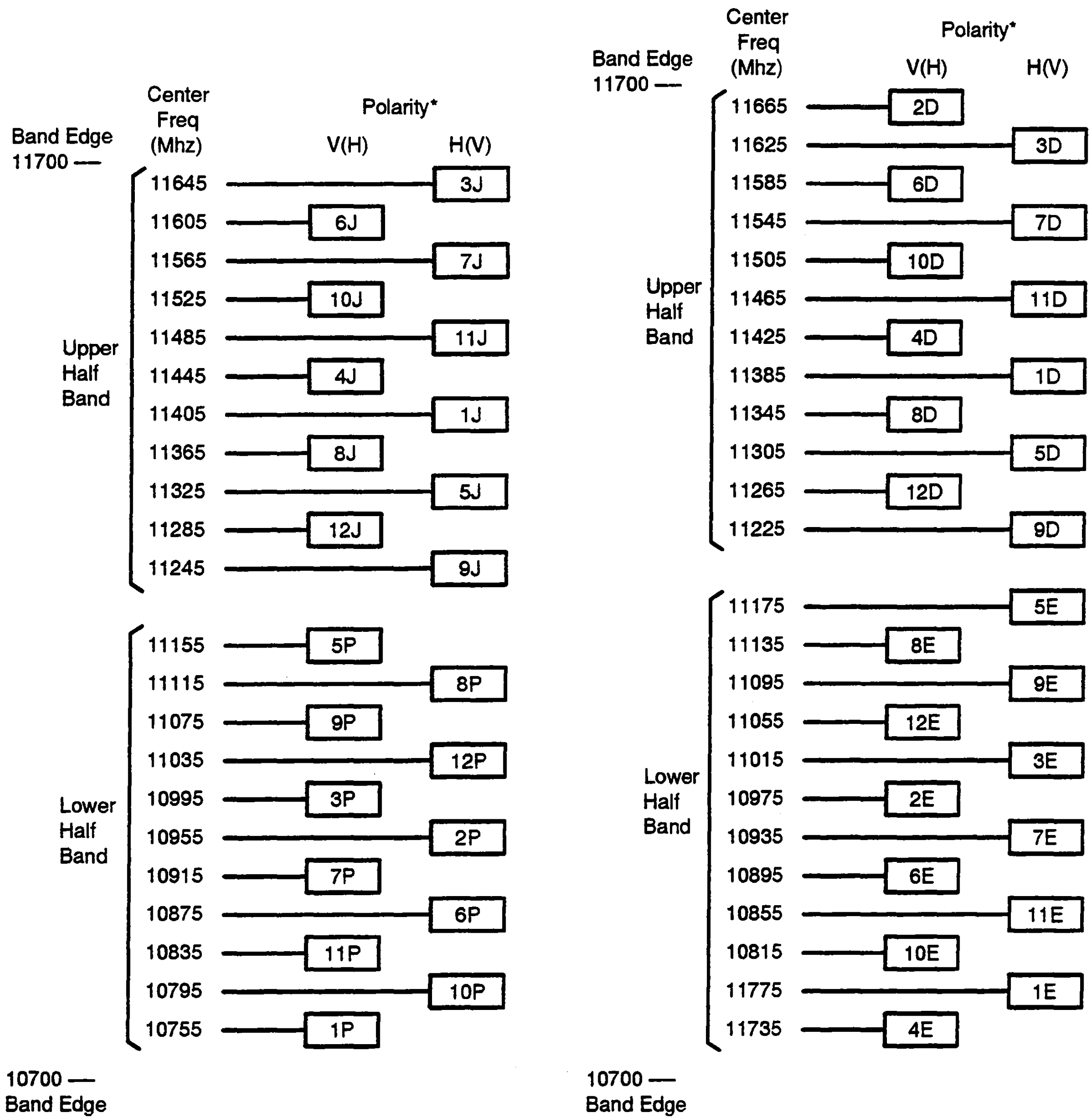
Note: In-channel interference from local equipment-to-equipment pickup at the transmit (far end) of a radio hop is usually not significant from the viewpoint of fade margin, since it fades as the signal fades and maintains a constant S/I ratio. Far-end interference can result in poor performance, however, if it is high enough to degrade the composite S/N ratio under normal operating conditions. In such a situation, this poor performance would usually cause an alarm. The troubleshooting procedures for the alarm given in the applicable station O&M manual would lead to a resolution.



* Immediate Adjacent Channels Must Be On Different Polarities

Channel Identification Numbers Shown In Boxes

Figure 12–Domestic 6-GHz Frequency Plans



* Immediately Adjacent Channels Must Be On Different Polarities.
Channel Identification Numbers Shown In Boxes

Figure 13 – Domestic 11-GHz Frequency Plans

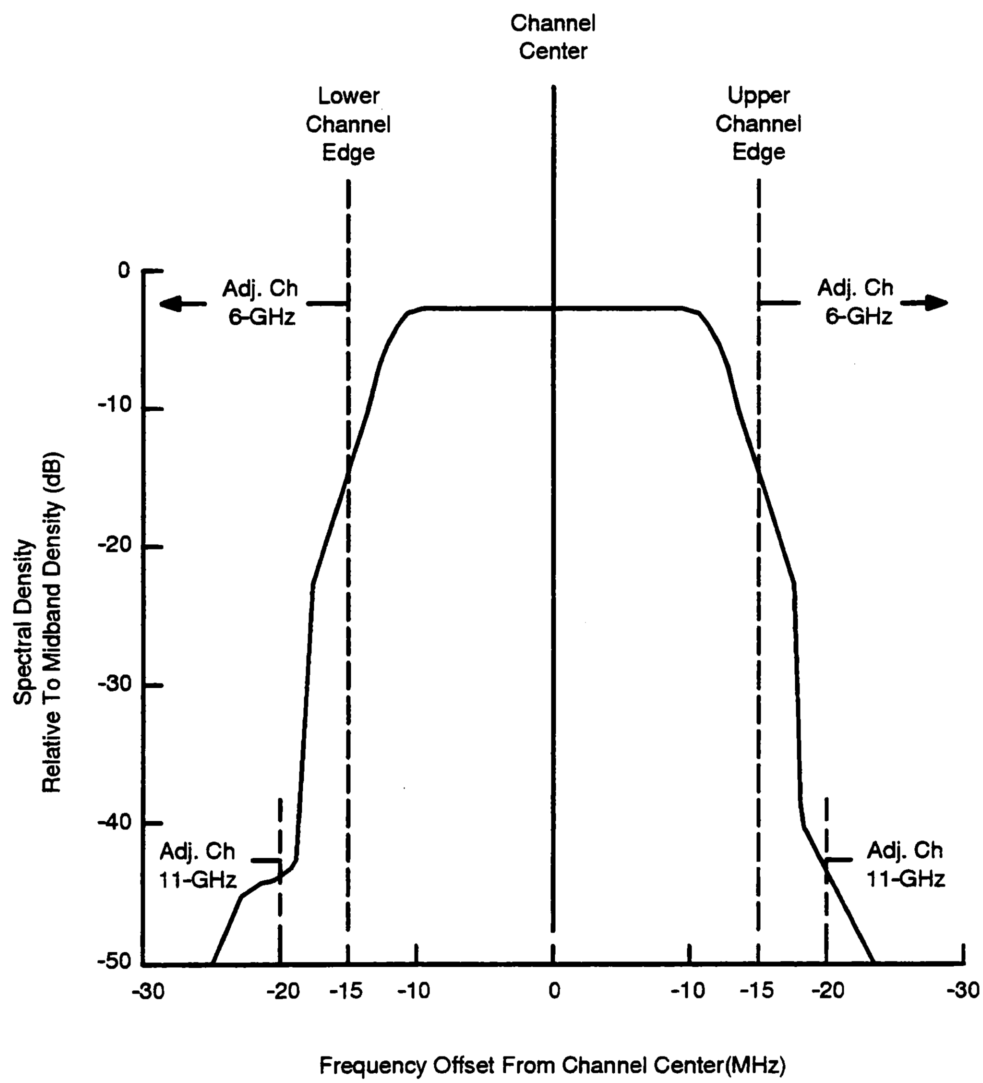


Figure 14–DR 6-30-135 and DR 11-40-35 Transmitted Spectrum

Since there are so many potential types and sources of NELI, the procedures and guidelines to evaluate and locate such local interference can only be general in nature. One specific mechanism of near-end pickup is common enough to warrant separate attention, however. This category of LI, which is referred to as IMN (common path intermodulation noise), can occur when transmitters and receivers share a common antenna system. Since this is a fairly common and frequent practice in DR 6/11-135 radio systems, specific procedures are given for evaluating in-channel LI because of IMN. The procedures for evaluating and isolating all other types of in-channel interference because of NELI are covered in a general procedure.

The internal noise and external interference categories discussed above are summarized in the following outline. The headings and symbols given for each of the noise or interference sources are those that are used throughout this practice whenever the related noise source or category is referred to.

A. Internal Noise

  1. Self-Generated Random or Thermal Noise (TN)

B. External Interference

  1. Adjacent Channel Interference (ACI)
  2. In-Channel Interference (ICI)
     a. Cochannel Interference (CCI)
     b. Local Interference (LI)
        1. Common Path Intermodulation Noise (IMN)
        2. General Near-End Local Interference (NELI)

Additional details relative to each of the noise and interference categories listed in the above outline are given under the headings that follow. Before presenting these details note that interference from a single source may sometimes manifest itself via the mechanisms associated with more than one of the above categories. To illustrate this point, a specific example of such an interference, is also included in the descriptions that follow. Although this specific example is restricted to DR 6 systems, it illustrates the types of interference that can create performance problems in digital systems. This interference, which can create poor performance with or without fading present, can manifest itself with characteristics of both the cochannel and the common path intermodulation LI categories listed above. The external interference example is under the heading ***Interference Example—DR 6 Interference from Weather Radar***.

4.2.1 Internal Noise

Self-Generated Random or Thermal Noise

For both DR 6 and DR 11 systems, the self-generated random or thermal noise existing at the receive end of a radio hop is determined by the sum of the noise contributions from all of the radio transmitter and receiver circuits. Under normal received signal conditions, the resulting noise floor, which is always present, is determined by contributions from both the transmitter and receiver. From the viewpoint of the flat fade capability of a radio hop, however, the significant component of the receiver noise floor (TN) is because of to the noise generated within the receiver. This receiver-generated noise floor may be described in terms of an equivalent noise figure at the receiver input. When this is done, it can be seen that the internal S/N ratio (S/TN), which limits the flat fade margin, is determined by the ratio of the received signal to that portion of the receiver input noise that is attributable to the receiver input noise figure alone. Thus, the limiting component of the flat fade margin depends only on the transmitter power, the loss of the radio hop path (section loss), and the noise figure at the receiver input.

Since the receiver input noise figure is dominated by the input circuits (channel separating network loss, down-converter and, if equipped, the common waveguide RF preamplifier), the noise existing at the output of the receiver down-converter includes all the significant noise. The measurement of the receiver S/TN ratio may thus be done at the down-converter IF output. Using the ***Measurement Approach*** described earlier, the desired S/TN ratio is determined, via the spectrum analyzer, by observing the difference in dB between the spectrum location with the reference signal present and the location of the TN component of the in-channel noise floor when the transmitter is turned off. This component of the self-generated noise has a flat spectrum shape, and its level is independent of received signal level. As a result, the S/TN ratio will drop dB for dB with the received signal level. Therefore, if a 40-dB flat fade margin to a BER of 10^{-6} is desired for the TN component of noise alone, the measured S/TN ratio under normal signal conditions must be at least 69 dB; that is, the sum of the 40-dB fade objective plus the 29 dB S/N ratio required to guarantee meeting the 10^{-6} BER.

An out-of-limits receiver thermal noise floor usually means a receiver noise figure problem. Figure 15(a) shows a sketch of how the receiver noise floor spectrum would appear at the IF output of the down-converter with no interference present. Even with interference present, the receiver noise figure related noise component, TN, is normally obvious as shown in Figure 15(b). However, cochannel or intermodulation interference from other radio transmitter(s) carrying signals with noise-like spectrums can produce in-channel interference that looks like the receiver noise figure noise. If high enough, such interference can mask the true receiver noise figure component and lead erroneously to the conclusion of an out-of-limits noise figure condition. The sequential test procedure, given in Part 2, for doing a complete flat fade margin evaluation is designed to be sensitive to this possibility. Techniques given to help recognize such a condition would normally lead to the proper conclusion and resolution when such problems occur.

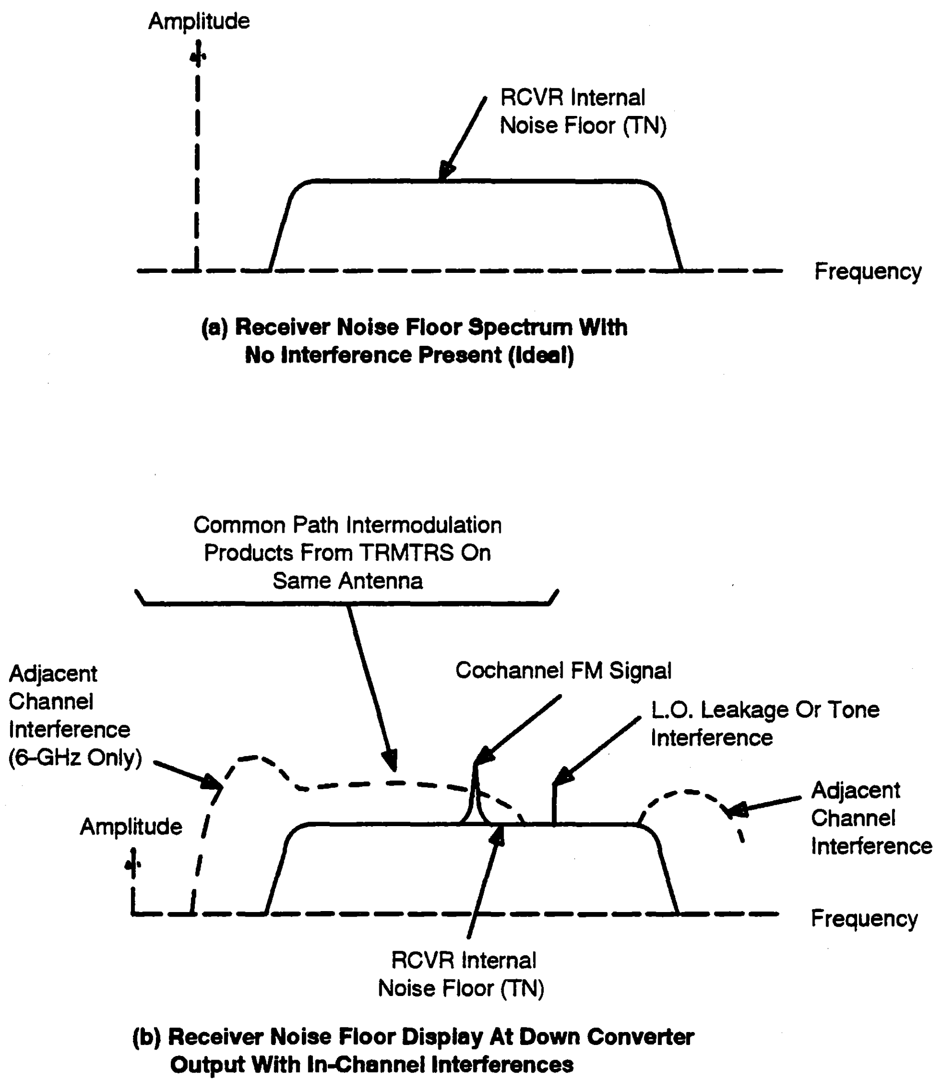


Figure 15–Examples of Receiver Noise Floor Spectrum Displays at Down-Converter IF Output

4.2.2 External Noise

Adjacent Channel Interference—DR 6-135 Radio Hops Only (See Note)

Note: From the viewpoint of effect on fading, adjacent channel interference is only of concern for DR 6-135 radio hops. The spectrum width of the DR 6/11-135, 64-QAM signal, coupled with the DR 11 RF and IF discrimination characteristics and the wider channel spacing used for DR 11 channels (40 MHz for DR 11 versus 29.65 MHz for DR 6), makes this potential fade-limiting component of interference negligible on DR 11 radio hops. Therefore, measurement and analysis relative to adjacent channel leakage levels are not necessary for DR 11-135 radio hops.

In the DR 6-30 frequency plan, channels are spaced 29.65 MHz apart with adjacent channels on opposite polarities. This frequency and channelization plan is shown in Figure 12. The transmitted signal spectrum for both DR 6 and DR 11 radio hops is shown in Figure 14. As this figure shows, the radiated signal has spectral components that will fall into an adjacent channel when DR 6 radio is used. The level of these components, which can appear as interference in the baseband of the channel under consideration, is controlled by three factors:

1. The effective attenuation introduced by antenna XPD (cross-polarization discrimination)
2. The effective attenuation achieved via the discrimination of the digital receiver post-detection baseband filters
3. The degree of joint fading between the interfering and desired channel.

For 64-QAM, DR 6-30-135 systems, the allocation for interference from an adjacent DR 6-135 channel is based on a 29-dB XPD objective, a 28/33 dB receiver discrimination factor for systems equipped for operation with and without error correction respectively, and 11 dB for a joint-fading factor. Therefore, the degradation allocation for adjacent channel interference is based on total RF-to-baseband discrimination factors of 68 dB (29+28+11) and 73 dB (29+33+11) for systems operating with and without the error correction option. Systems meeting these objectives will normally have acceptable fading performance relative to adjacent channel interference.

Of the three adjacent channel discrimination factors, only the XPD can be easily determined by direct measurement. This is the most likely factor to degrade, however, and the ability to measure it is essential to system deployment and maintenance. The other two factors are generally stable and seldom fail to be realized. When a baseband filter fails to give the normal adjacent channel discrimination, it will normally produce other performance degradations that will invoke the necessary troubleshooting procedures to restore it to normal. If a hop has unusual fading characteristics that significantly alter the joint-fading factor, continued poor performance during fading periods will lead to a realization of this fact also. Engineering can then take steps to isolate and eliminate this condition.

The measurement of XPD is done indirectly by determining the level of an adjacent channel signal spectrum relative to the normal in-channel signal (S/ACI ratio). The ratio at the input to the receiving channel dropping filter of the channel under test is determined from an IF spectrum display. If the levels of the adjacent channel and the normal in-channel signals are the same at the input to the receive antenna, the S/ACI ratio at the receiver input filter is a direct measure of the XPD. The S/ACI ratio is also determined using the ***Measurement Approach*** outlined in this part. Figure 11 shows a typical spectrum display with adjacent channel interferers present. As outlined in Part 2, the S/ACI ratio at the RF input to a receiver may be found by determining the attenuation necessary in the transmitter output signal to bring the adjacent channel spectrum level equal to the in-channel signal spectrum at the down-converter IF output. The S/ACI ratio determined by this process need only be corrected to account for two factors:

a. Differences in levels between the normal in-channel and adjacent channel signals at the receiver antenna input

b. Difference in the attenuation to the normal in-channel and adjacent channel signals caused by the receiving channel dropping filter.

If the S/ACI ratio is out of limits after applying the appropriate corrections, an out-of-limits XPD ratio is normally the cause. Since XPD can only be controlled by proper antenna design and/or adjustment, such an out-of-limits condition will usually require the performance of antenna maintenance procedures, which are covered elsewhere.

Cochannel Interference

Cochannel interference results when the receiving antenna for the channel under consideration also receives a signal from another unrelated radio transmitter that is radiating spectral components in the same frequency band (see ***Note***). Normally, interference from this source is kept under control by proper route engineering. However, such control depends on the accuracy of the radio interference information, which is used to locate and lay out each hop of a route. Reflections of cochannel interferers off surrounding buildings or other reflective surfaces are often overlooked or difficult to predict when the route is being engineered. Therefore, cochannel interference problems can be encountered during the initial turn-up process. Cochannel interference can also become a problem after initial installation, because of changes in the surrounding area that can alter the propagation paths of potential interferers. Further additions of new radio systems in the nearby area can also bring on interference after the system is successfully put in service. Therefore, the ability to recognize and then isolate such interference is important, both at initial turn-up and after the system is in service.

Note: Cochannel interference usually comes from another transmitter operating either directly on the same frequency or on a frequency that is offset by some fraction of the normal channel spacing as a result of using an alternate or staggered frequency plan. Such interference can also result from poor control or filtering of the image sidebands emanating from these other transmitters. Multichannel systems are especially vulnerable to this problem since the existence of such sidebands can overlap other active channels. Finally, cochannel interference can result via direct leakage from other transmitters in the same station operating on the same frequency or frequencies that are in the image band of the contaminated channel. If this coupling occurs at the receive end of a hop, it can severely limit the fade margin, since it is not subject to fading with the desired signal. This type of interference is discussed further under Interference From Local Sources.

The impact of cochannel interference on the fade margin depends on the type of interfering signal and on whether the interferer experiences joint fading when the desired signal fades. Figure 16 shows three potential cases by which cochannel interference can occur. Interference via Path A would normally undergo joint fading that is highly correlated with fading of the desired signal, since it arrives over the same air path. If the path for the desired signal is significantly different from that of the interferer path, however, joint fading cannot be assumed. Interference Paths B and C in Figure 16 show cases where the desired and interference paths are separated. For these cases, the interference level must be 71 dB or more below the normal received signal level to maintain an adequate fade margin. Since it is usually difficult to determine which type of condition exists experimentally, the 71-dB objective should be met unless the source of interference is so located to make the determination of a reasonable joint fading factor possible.

The presence of cochannel interference and the level of this interference relative to the normal signal level (S/CCI ratio) is also determined using the ***Measurement Approach*** outlined in this part. Figure 15(b) shows a typical spectrum display at the output of the down-converter with a cochannel interferer present and the transmitter turned off. When present, the S/CCI ratio for each interferer may be determined by observing the ratio level relative to the background or receiver noise floor for which an S/TN ratio that has previously been determined. The techniques for determining the S/CCI ratio for a specific interferer using the spectrum analyzer display depends on whether the interferer is a noise or tone-like interferer. For tone-like interferences, the resolution bandwidth of the spectrum analyzer must be taken into consideration when determining the actual S/CCI ratio from the display. The details for determining the S/CCI ratios and the techniques for isolating the intrinsic receiver background noise from noise-like interferers are given in Part 2.

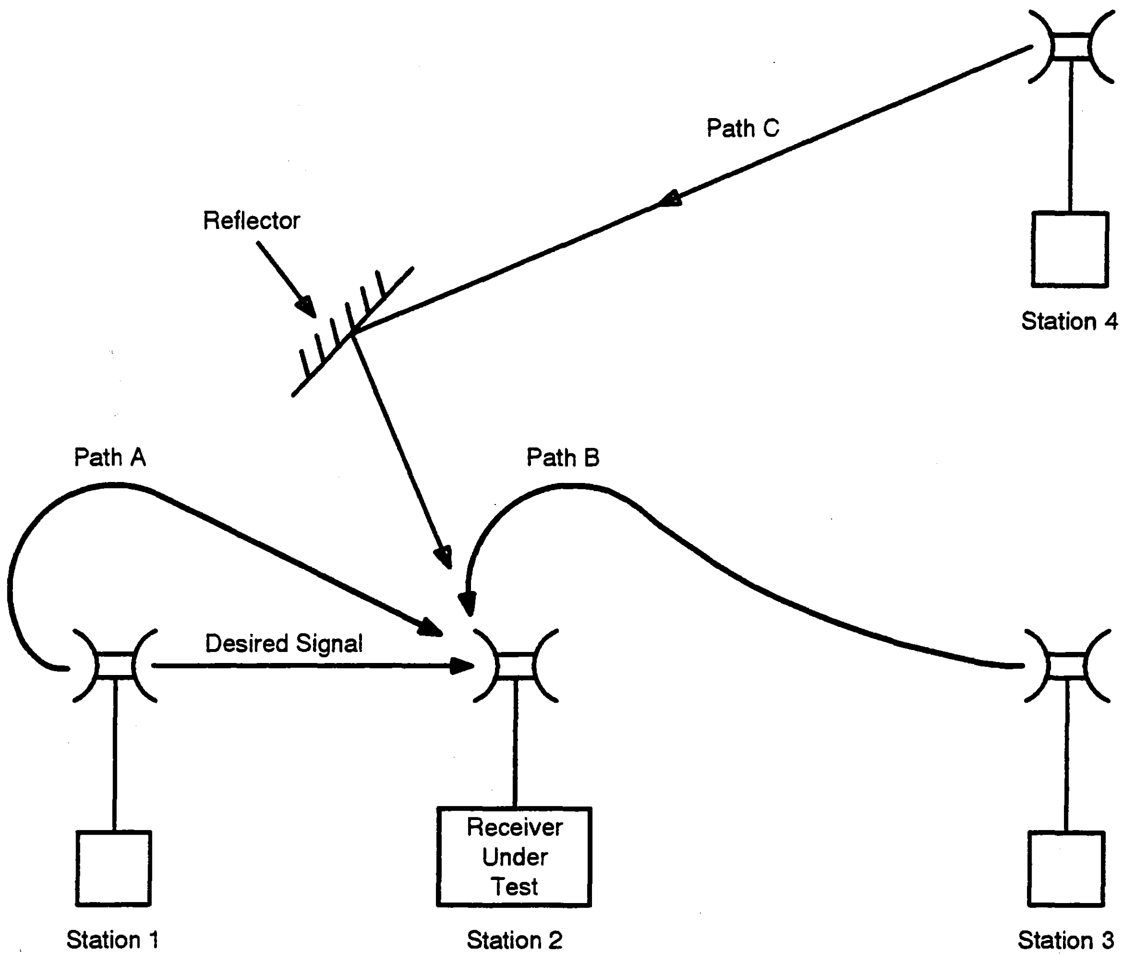


Figure 16–Potential Cochannel Interference Paths

Local Interference

General Near-End Local Interference

In-channel interference from sources located at the receive station (NELI) can severely reduce the flat fade margin of a radio hop. This interference occurs when the receivers pick up miscellaneous in-band signals from other co-located equipment. The source of such interference is usually other radio transmitting or receiving equipment units that are operating nearby. This equipment will often contain high level RF or IF sources operating directly at frequencies that overlap the signal band of the channel under test. In other cases, the interfering equipment may contain sources operating at frequencies in the image band for the receiver under test or at frequencies that can be translated into the pass band of the receiver as a result of intermodulation or some other translation process. The source may even be transmitters or receivers that are part of the same radio system. When such problems occur, they are usually the result of a defect in either the interfering or interfered-with equipment that results in a direct coupling leakage path or indirect coupling via intermodulation in a non-linear common path element. Local interference resulting from this latter source is discussed separately under ***Common Path Intermodulation Noise***.

For receive interference arising from equipment-to-equipment leakage problems, the level of the in-band leakage signals must be 71 dB or more below the normal received signal level to maintain an adequate fade margin. This is necessary since such interference is usually fixed in level relative to the incoming received signal; and thus, the S/I ratio will degrade dB for dB of signal fade. The presence of in-channel interference because of near-end coupling or leakage and the level of this interference relative to the normal signal level (S/NELI ratio) is also determined using the ***Measurement Approach***. Figure 15(b) shows a typical spectrum display at the output of the down-converter with such interferers present and the transmitter turned off. When present, the S/NELI ratio for each interferer may be determined by observing the ratio level relative to the background or receiver noise floor for which an S/TN ratio has previously been determined. The techniques for determining the S/NELI ratio for a specific interferer using the spectrum analyzer display depends on whether the interferer is a noise or tone-like interferer. For tone-like interferences, the resolution bandwidth of the spectrum analyzer must be taken into consideration when determining the actual S/NELI ratio from the display. The details for determining the S/NELI ratios and the techniques for isolating the intrinsic receiver background noise from noise-like interferers are given in Part 2.

Common Path Intermodulation Noise

Occasionally, in a waveguide run carrying both transmit and receive signals as shown in Figure 17, a nonlinear element such as a defective circulator or a corroded waveguide joint will create modulation products of the higher level transmit signals. When multiple transmit channels are involved, intermodulation between the transmitter signals can produce product frequencies that fall into the frequency slots of receivers on the same antenna system. The products, which can cause this problem, are usually dominated by third-order (2A-B) and (A+B-C) products.

The (2A-B) term refers to the frequency location of a particular third-order intermodulation product that results from two sources, one located at frequency A and the other at frequency B. For this product, the frequency location of the resulting intermodulation product may be calculated by substituting the frequencies of any two A and B sources into the (2A-B) expression and performing the shown subtraction. If the frequencies used for the A and B terms are the center frequencies of two channels, the resultant 2A-B frequency is the center of the resultant intermodulation product spectrum. The spectral width or frequency span of the product centered at the 2A-B frequency is equal to three times the spectrum width of the source channels (assuming all the contributing channels have the same signal spectrum width).

The frequency location and spectral width of third-order intermodulation products generated by the (A+B-C) term refers to the frequency location of a particular third-order intermodulation product that can result from three sources located at frequencies A, B, and C. The frequency location of the center of the intermodulation product spectrum generated by this product may be similarly found by substituting the center frequencies of any three A, B, and C sources into the (A+B-C) expression and performing the shown addition and subtraction. Like the 2A-B product, the frequency span of the resulting (A+B-C) product is three times the width of the spectrum width of the individual contributing channels.

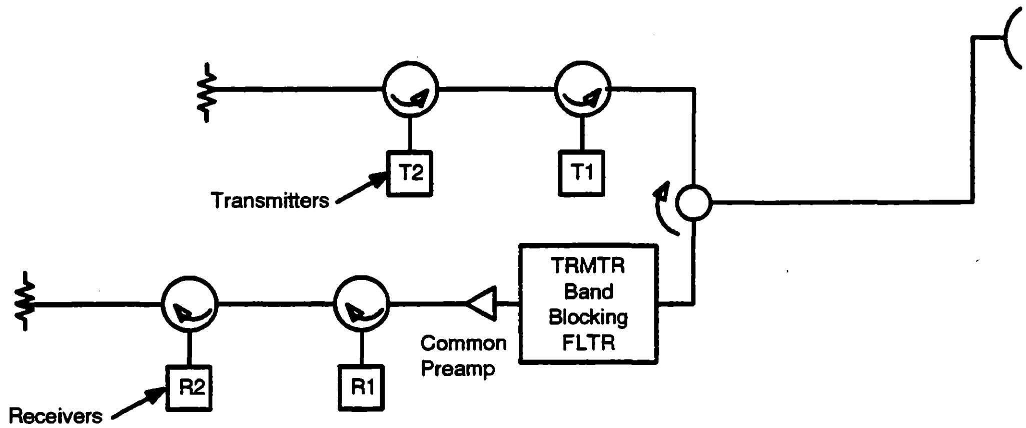
By performing these calculations for all the possible (A,B) and (A,B,C) combinations of transmitters present, all the potential product locations can be determined. If both the product location and the sources responsible for each product are recorded, examination of the results will show where the possible receiver interferences may be expected. This information can also be used to help track down the potential sources when such problems are encountered.

Note that two or more transmitters on the same antenna system are required to generate interference via this process. Both DR 6 and DR 11 systems are subject to this type of interference. Figures 18 and 19 show the frequency span and location of products for two types of shared antenna situations at stations operating with DR 6 radio. The related figures 18 and 20, also give specific examples that illustrate the common path intermodulation problem for each type of station. In these figures, the channel numbers are used to identify the source channels responsible for a particular product. The location of the 2A-B and A+ B-C products for DR 11 systems may be similarly generated.

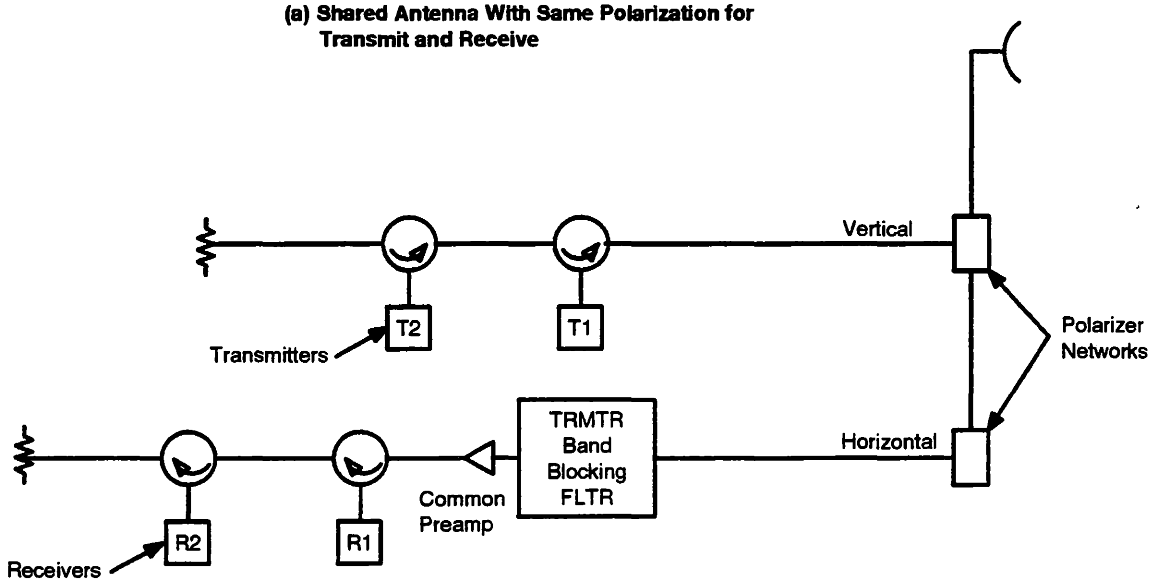
Since the interference levels of the leaked transmitter signals are constant, the level of any intermodulation products generated by this process is also fixed at the receiver input. Therefore, interference from this source must be kept at least 71 dB below the normal received signal level to allow for an adequate fade margin for this component.

Other types of common path intermodulation can also occur. If a common waveguide RF preamplifier is used, for example, the presence of high level signals that are either close to, or in, the operating frequency band of the amplifier can cause the amplifier to overload and become nonlinear. This condition can cause excessive distortion to a single channel signal and/or excessive intermodulation products in multiple channel cases even though the received signal levels for the desired payload signals are normal. Such a condition can occur in stations where a DR 6/11-135 system is sharing a receive antenna with other higher power analog or digital systems. A specific example of an overload problem is the weather radar interference problem that is discussed later in this Part. The overload condition and, thus, the resulting performance problems are cyclic.

Interference levels resulting from common path intermodulation are determined much like those for cochannel or local in-channel interference. Using the ***Measurement Approach***, the in-channel receiver noise floor at the output of the down-converter is displayed on the spectrum analyzer with the transmitter for the channel under test turned off. The remaining noise floor is then examined and evaluated for the presense of interference from this source. Figure 15(b) includes an example of interference generated as a result of excessive intermodulation from transmitters sharing the same antenna. The signal-to-interference objective for this type of noise-like interference (S/IMN) is nearly the same as that for the residual receiver background noise figure noise (S/TN). Therefore, any interference of this type that is observable in the receive noise floor probably represents an out-of-limit condition. Usually, it is necessary to turn off the sources suspected to be contributing to such interference to confirm that this type of noise is present.

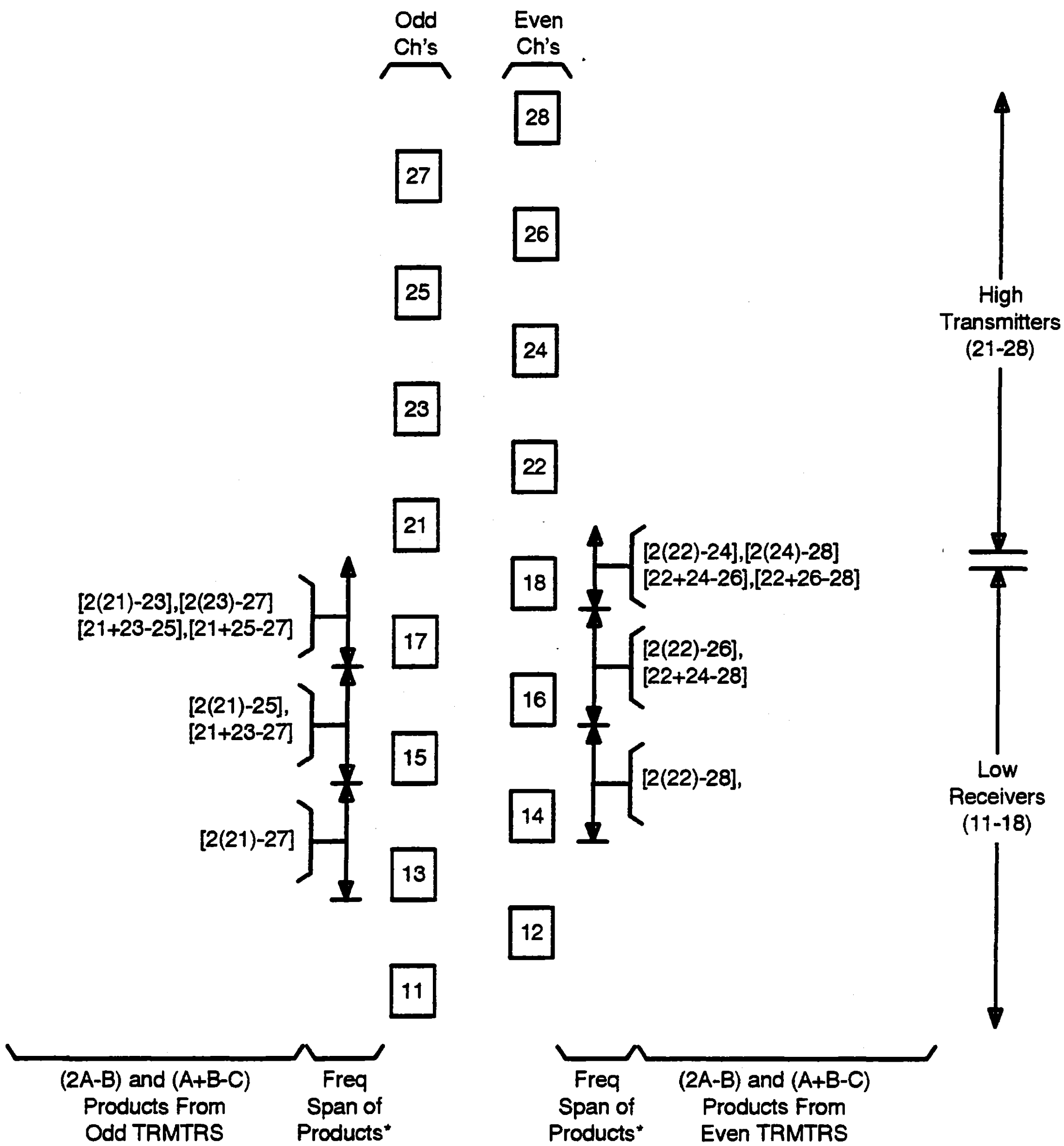


(a) Shared Antenna With Same Polarization for Transmit and Receive



(b) Shared Antenna With Different Polarzation for Transmit and Receive

Figure 17-Shared Transmit/Receive Antenna Configurations



* Location of Products Calculated Using Channel Frequencies Associated With Channel Number Identifications Indicated in [ ] Brackets

(See Fig. 16 For Example)

Figure 18–Potential Common Path Intermodulation Products for 6 GHz High Transmit, Low Receive Shared Antenna Case

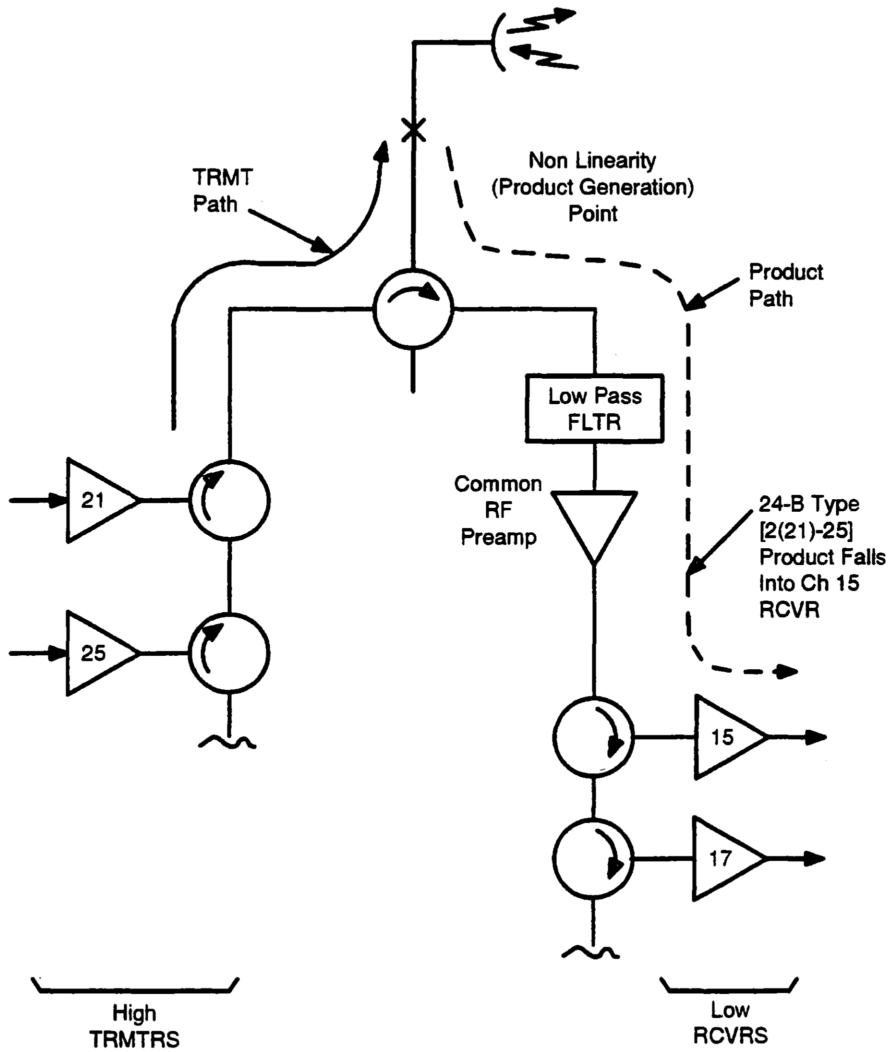
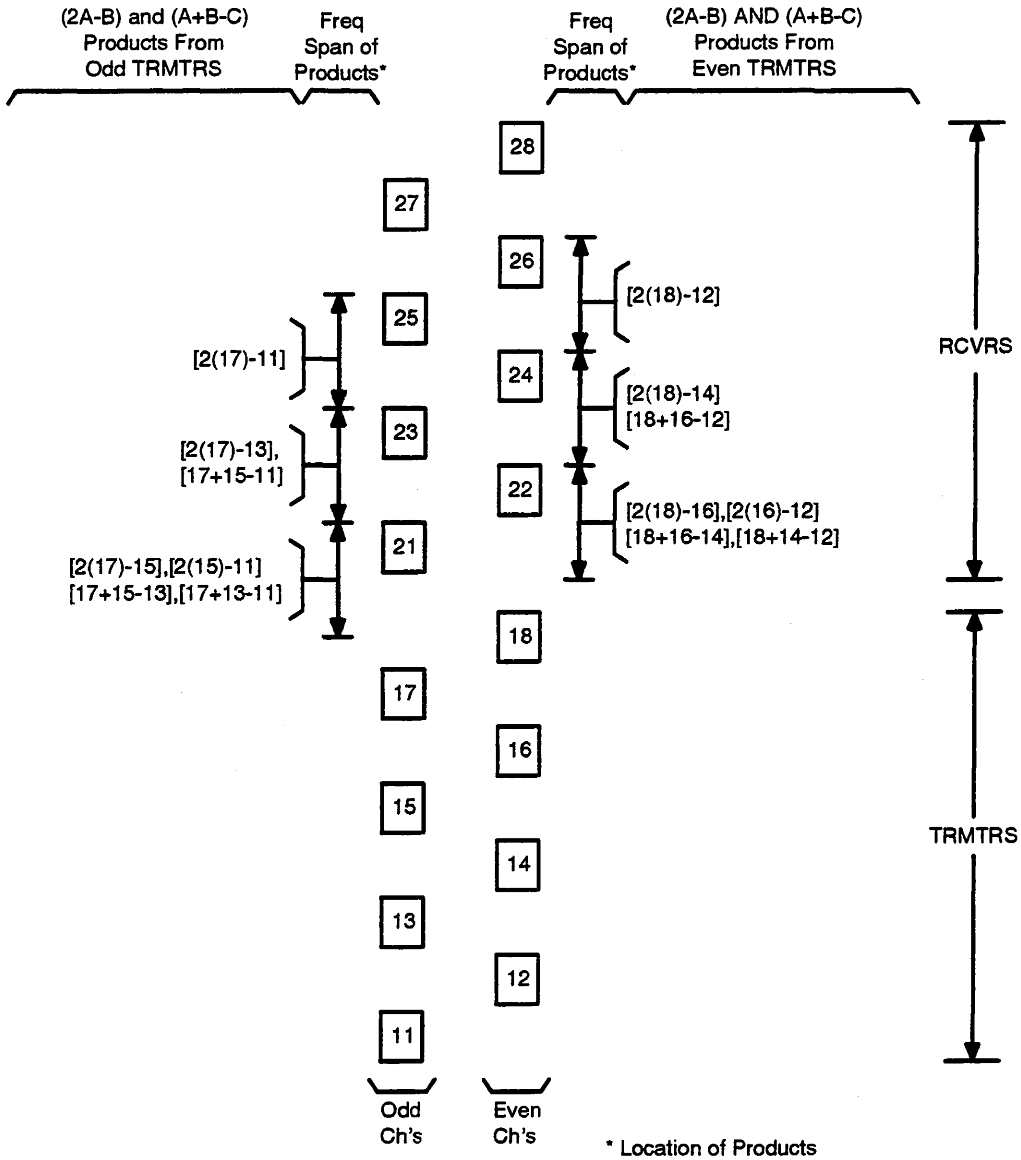


Figure 19-Example of Common Path Intermodulation Problem in High Transmit, Low Receive Station



* Location of Products Calculated Using Channel Frequencies Associated With Channel Number Identifications Indicated in [ ] Brackets.

(See Fig. 18 For Example)

Figure 20–Potential Common Path Intermodulation Products for 6 GHz Low Transmit, High Receive Shared Antenna Case

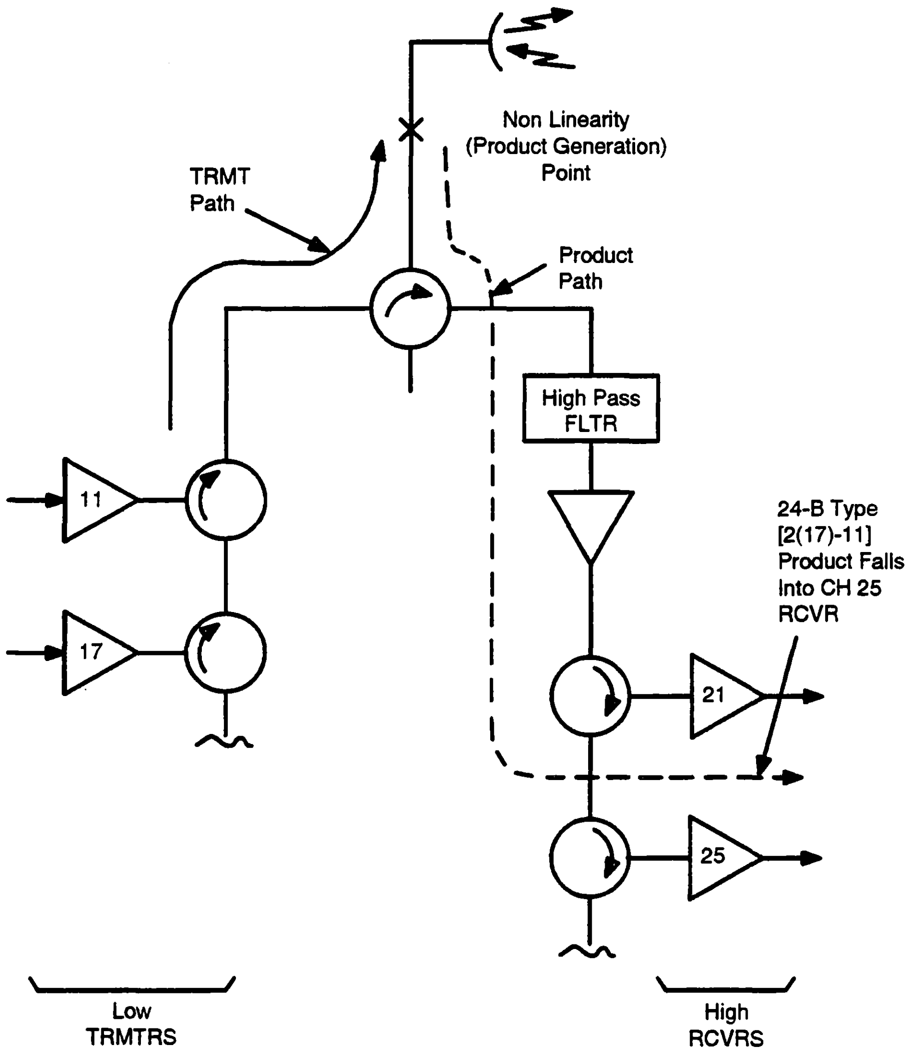


Figure 21 - Example of Common Path Intermodulation Problem in Low Transmit, High Receiver Station

4.2.3 Interference Example—DR 6 Interference from Weather Radar

Weather surveillance radar transmitters operate at or about 5,625 MHz, which is just below the 6-GHz common carrier band (5,925 to 6,425 MHz). These weather radar systems are operated by the United States National Weather Service and by some United States television stations, and their use is widespread throughout the country. Since the radar operating frequency is within the transmission band of the antenna and waveguide systems used for receiving 6-GHz common carrier band signals, the radar signals are carried nearly undiminished to the common input port of the DR 6 radio equipment whenever they appear at the antenna. Interference from this source was first observed on early DR 6-30-90 digital radio systems. These systems, like the DR 6-30-135 systems, were also designed to operate in the 6-GHz common carrier band and use similar channel dropping/combining techniques and filters.

When signals from a weather surveillance radar are intercepted by a DR 6 radio receiver, the interference generated can create poor performance with and/or without fading present. Initial observations indicated that this interference could manifest itself to generate components that show up as belonging to either or both of the cochannel interference and/or common path intermodulation noise categories described above. Later studies showed that the interference category depended on the power level of the intercepted radar signal, relative to the power handling capabilities of the DR 6 receiver configuration used and on the characteristics of the radar transmitter. These two modes are described further below:

1. ***Receiver Overload Problems :*** When the DR 6 broadband RF preamplifier is used in the common waveguide run to the radio receiver line-up, a radar signal of high enough level could overload or saturate this amplifier to the point where it is unusable for transmission of the desired signals. This problem shows up as repeated loss-of-frame events at regular intervals corresponding to the turning rate of the radar antenna. This problem normally occurs when a receive antenna is in a location subject to direct line-of-sight exposure to the signal from the radar transmitter. Eliminate this overload problem by using a radar blocking high-pass filter (AT&T-NS Code 1384M) in front of the RF preamplifier.

2. ***Problems Dependent on Radar Transmitter Characteristics:*** The second weather radar related problem, which may remain even after the above overload problem is eliminated, is dependent on the characteristics of the radar transmitter used. Since no rigid requirements are placed on out-of-band emissions from weather radar transmitters, such emissions are not necessarily controlled. As a result, some radar transmitters are found to have high levels of out-of-band energy that falls within the 6-GHz common carrier band, thus producing direct in-channel cochannel type noise for DR 6 digital channels.

This in-channel interference problem manifests itself as periodic error bursts that also occur at the turning rate of the radar antenna. The severity of such interference depends on the level of the received radar signal relative to the DR 6 signal. If the interference is high enough, as it might be if the exposure is on a direct line-of-site basis, the error events may occur even at normal DR 6 received signal levels. For lower level interference cases, such as might occur when the received radar signal is being received via a reflection or back-scatter, the error activity may only occur under conditions where the DR 6 signal is faded. For this in-channel interference, the only practical solution is to eliminate or reduce the out-of-band emissions by modifying the radar transmitter itself. Since this latter problem can occur as a result of intercepting either the direct line-of-sight or a reflected or back-scattered radar signal, it is sometimes difficult to locate the actual offending radar source and will often require some investigative trial and error work to achieve success. Once the offending radar transmitter is located, negotiation with the operator and the radar manufacturer will usually lead to a solution of the problem.

Since the DR 6-30-135 system also uses a broadband RF preamplifier, these same problems will be encountered if weather surveillance radar signals appear at DR 6-135 receivers. In general, the use of the same radar blocking filter (1384M) is recommended whenever this potential exists. This will eliminate the possibility of the overload problem. If a potential interfering radar is also suspected to be of the type that emits excessive out-of-band energy, corrective action to eliminate this possible interferer should be taken before turning up a DR 6 system for service. If a system is deployed without knowledge of this interference or if a weather surveillance radar is installed after the system is in service, the solution can usually be deduced from the response of the system to the radar as outlined above.

In any case, whenever interference of this type is encountered, it is suggested that your AT&T-NS Customer Service Representative be contacted to arrange for engineering help.