PARITY ERROR AND FRAME LOSS MONITORING

INTRODUCTION

No digital system can operate error-free. Even though no performance alarm may exist, errors will still be occurring at a very low bit-error rate. In the digital receiver, the DS139 signal is divided into four synchronous data rails. Errors on each of the four rails are monitored and combined so that an error rate can be calculated for the DS139 signal rate. The types of errors that can be monitored are frame loss, hop parity, and section parity.

This procedure describes how to perform real-time error monitoring. This monitoring will be useful in the following situations:

- When the channel is not equipped with a CHANNEL MONITOR unit.
- When a BER of 10^{-10} or better is to be measured. (The channel monitor normally displays a BER between 10^{-4} and 10^{-9}.)
- When errors can be correlated with fading problems and other intermittent problems.
- When circuits that are related to the performance monitor need checking.

TEST PROCEDURE

Access to the channel is made at the LOW SPEED FRAMER. Connection to the FR LOSS (frame loss) jack will monitor frame-loss errors. A normal operating system should not have any frame-loss errors; if they are occurring, there is an equipment failure or severe fading activity.

Connection to the HOP PTY (hop parity) jack will monitor parity errors for the hop coming in to the receiver. These errors will be corrected before the signal is transmitted to the next station.

Connection to the SECT PTY (section parity) jack will monitor parity errors accumulated over all preceding hops up through the receiver being monitored. Section parity is also referred to as "uncorrected parity."

To verify that errors are occurring, the jacks can be monitored with an oscilloscope. Monitoring can also be performed with a counter or a strip chart recorder. If remote monitoring is desired, the signals can be sent out over the telemetry system.

The signals to be monitored at the low speed framer jacks are at TTL (transistor-transistor logic) levels. If no errors are present, the levels will be ≥2.4 volts (TTL high). An error will cause the level to change to 0 volts ±0.4 volt (TTL low).

During a frame loss, parity errors are inhibited. The HOP PTY and SECT PTY outputs are held at a TTL high.

Parity error measured at these jacks should be multiplied by a factor of 1.67 to get a reasonably accurate BER. For example, if 85 parity errors are measured in a one second period, this represents an error rate of about 10^{-6}.

PHASE-PLANE TESTING

INTRODUCTION

The 16-QAM signal used in the DR 6/11-40-140 radio system is demodulated to baseband by means of two product detectors in quadrature, followed by filtering and decision circuits (Fig. 1).

Eye Pattern

If a demodulated 4-level signal is monitored immediately ahead of the decision circuit and displayed on an oscilloscope as a function of time, an eye pattern will be formed.

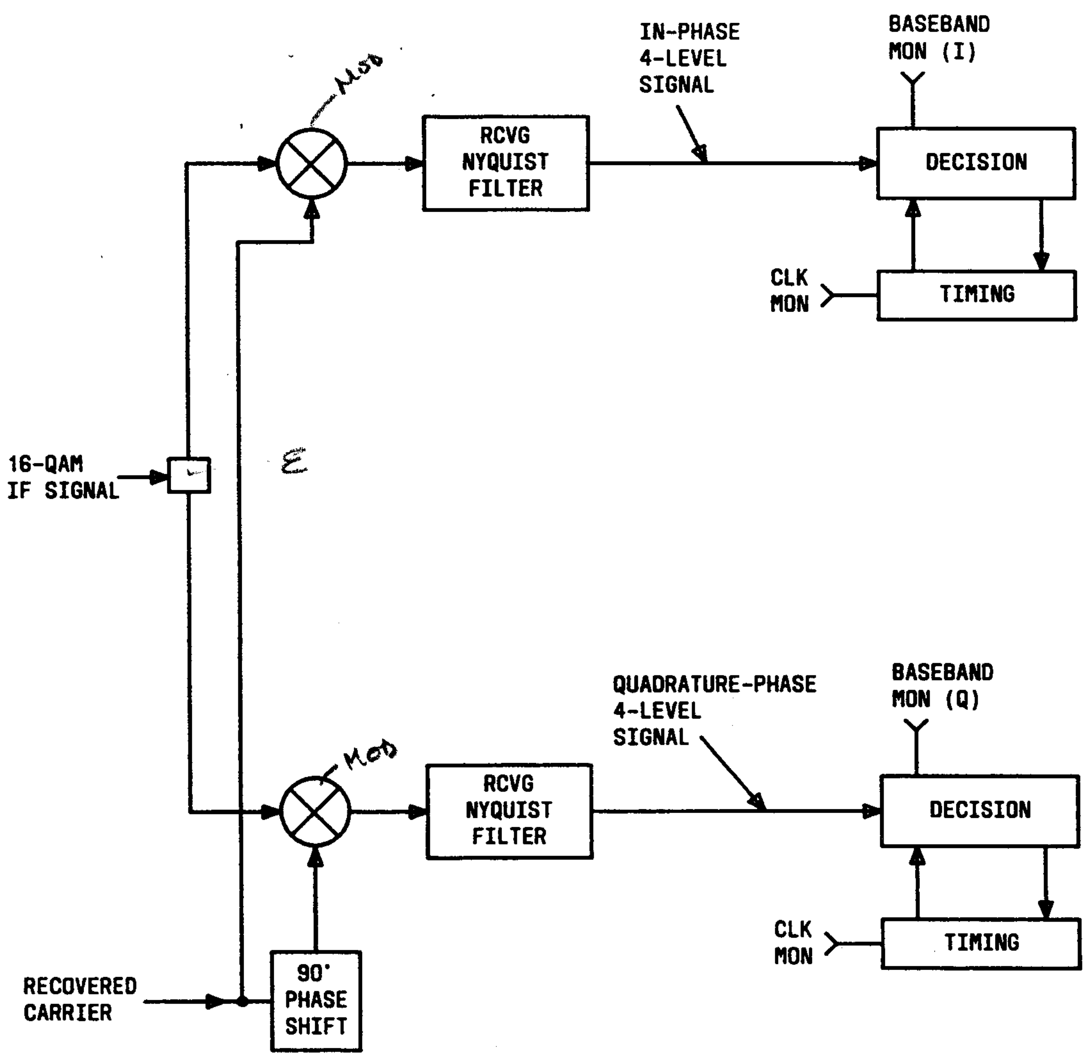


Fig. 1—16-QAM Demodulation

The eye pattern is made by superimposing the waveforms of all possible pulse sequences (Fig. 2). The eye pattern provides a convenient method of checking the quality of a digital transmission line and determining the margin for error. Figure 2 shows the three eyes (or decision areas) formed by the signal. The greater the eye opening, the better the decision circuitry can determine the data bits. The decision crosshairs within each eye represent the intersection of the decision level with the ideal decision time.

Degradations reduce the eye opening. Amplitude degradations shrink the eye vertically. This can be caused by echos, intersymbol interference, and decision threshold uncertainties. Horizontal shrinkage of the eye pattern indicates timing degradations such as jitter and decision time misalignment. Noise is another degradation that will be displayed in the eye pattern. A poor quality eye pattern usually indicates the need for circuit adjustment and possible unit replacement.

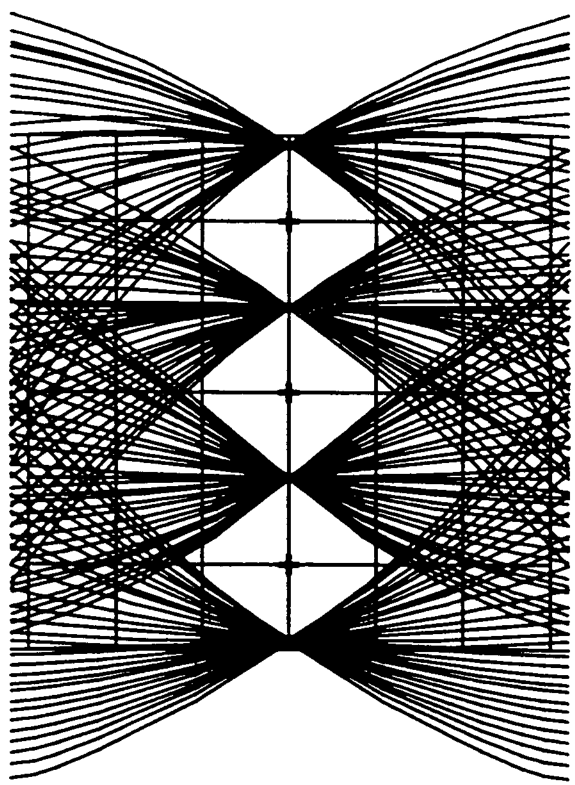


Fig. 2—Typical I or Q Phase 4-Level Signal

Phase Plane

Let the output of a 4-level signal be represented as +3, +1, -1, and -3 volts. The output of the two quadrature 4-level signals that make up a 16-QAM signal can be shown as (X,Y) coordinates on the 16-QAM phase plane shown in Fig. 3.

The phase plane can be observed by using a sampling scope to view the 4-level demodulated analog signals at the I and Q baseband monitor jacks. By sampling the 4-level signals at the center of the eye, the quality of the eye openings can be evaluated. Using this method, the transitions between signaling states are ignored and only the signal level at the decision time is displayed.

If both decision circuit inputs are sampled at the same time and displayed in an X vs. Y format on a sampling scope, the 2-dimensional array of the 16 possible signaling states will be displayed (Fig. 3).

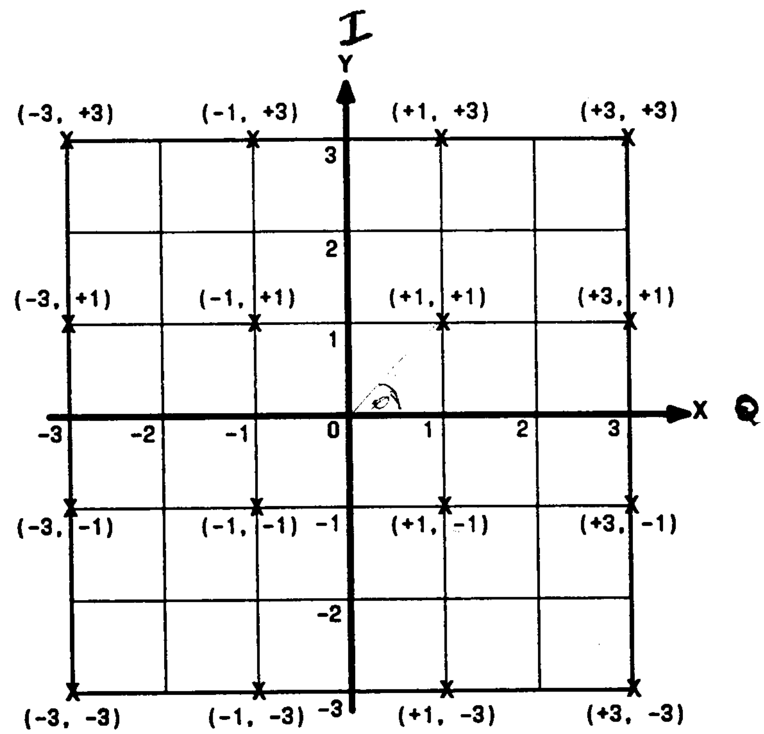


Fig. 3—16-QAM Phase Plane

This phase plane is a unique means of displaying digital signals that are both phase- and amplitude-modulated. Amplitude is measured radially from the center of the display. Phase separation is measured as the angle between the radials. The axes of the figure represent the in-phase (I) and quadrature (Q) components of the 16-QAM signal which form the plane. The 16 different states are identified with an "X". With time, the digital signal will move between the different states on the phase plane. If the signal is not degraded and is sampled at the ideal timing points, the signal will be found only at the points marked "X".

By analyzing the phase plane, specific problems can be identified that cannot be detected in the eye pattern. This saves both trouble-shooting and replacement time. Faults specifically identified by this technique include the following:

- Nonlinear distortion (compression & expansion)
- AM-to-PM conversion
- Nonquadrature modulator/demodulator
- Carrier phase offset and/or jitter
- AGC instability
- Transversal equalizer effects.

The following problems can NOT be identified by analysis of the phase plane:

- Linear distortion (amplitude shape and delay distortion)
- Timing recovery offset and jitter
- Poor noise figure.

Since this is not a perfect system, each signaling state is represented by a cluster of dots instead of a single point. The ideal display will consist of 16 tightly grouped clusters in a perfectly square pattern (Fig. 4). Departures from this ideal are the basis for fault diagnosis.

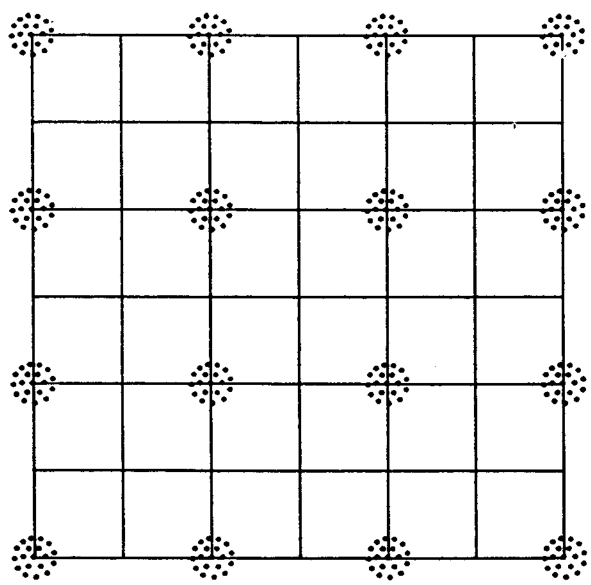


Fig. 4—Representative Phase-Plane Dot Clusters

TEST EQUIPMENT

1 Sampling oscilloscope, or

1 Oscilloscope mainframe (Tektronix Model 7704A or equivalent)

1 Sampling sweep unit (Tektronix Model 7T11 or equivalent)

2 Sampling units (Tektronix Model 7S11 or equivalent with Type S4 or S6 sampling heads)

3 Coaxial cables each equipped with an SMB(F) connector and a SMA(M) connector.

The oscilloscope connections are shown in Fig. 5. The preliminary control settings are given in Table A.

Note 1: This test can be performed on a channel that is in service.

Note 2: Depending on the sampling heads used, terminations may have to be added to the data leads.

Note 3: The two data leads should be matched in length within 3 inches. The clock or timing lead length is not critical.

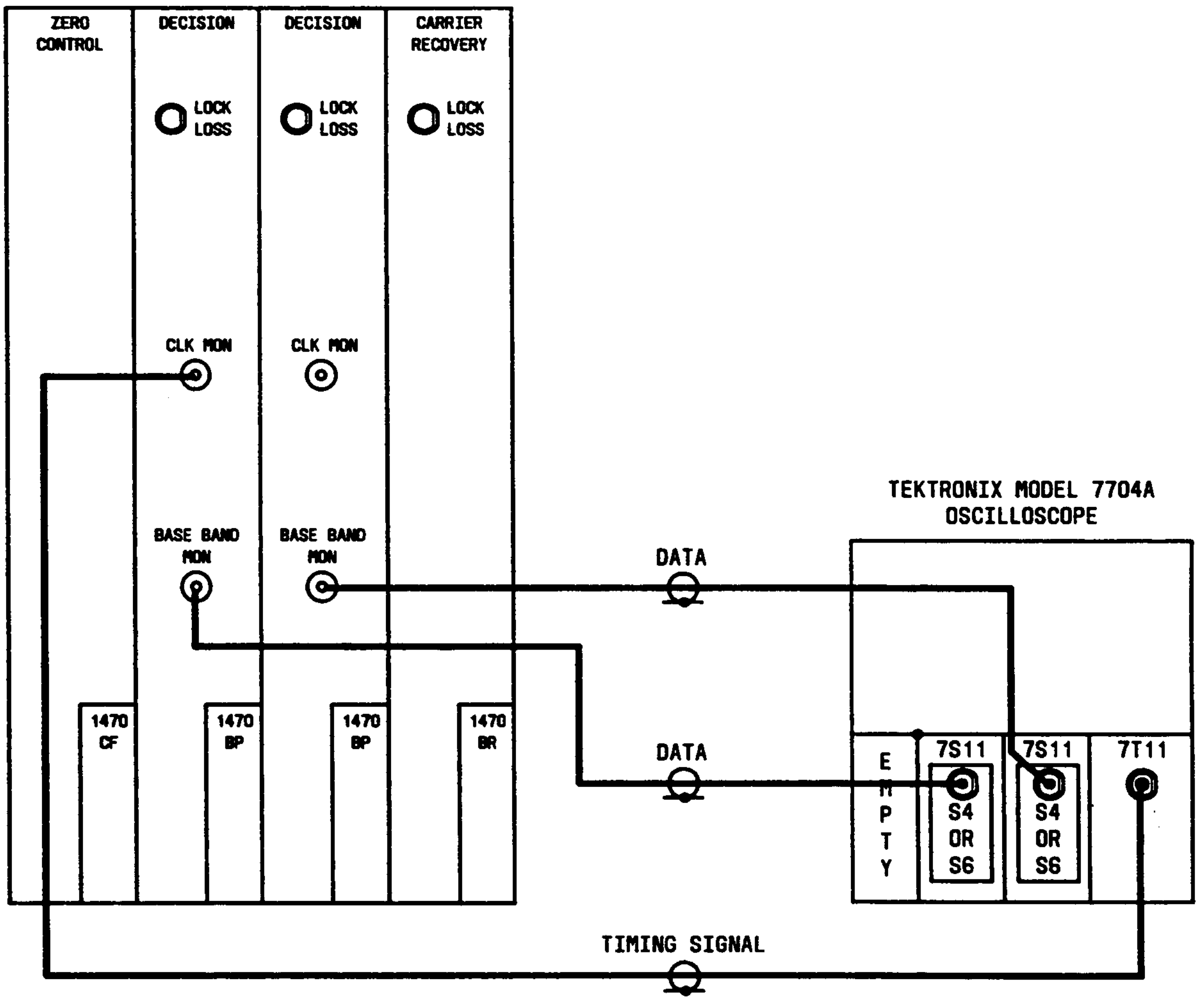


Fig. 5—Oscilloscope Connections

TABLE A
PRELIMINARY OSCILLOSCOPE SETTINGS

UNIT	CONTROL	SETTING
7704A DISPLAY UNIT	HORIZONTAL MODE (SWITCH)	A (DOTS) B (EYE)
7S11 SAMPLING UNITS (2) (S4 OR S6)	VARIABLE (CAL IN) DELAY DOT RESPONSE	100 and OUT Trim for best response Trim for best response
7T11 SAMPLING SWEEP UNIT	TRIG LEVEL TRIG AMP EXT TIME/DIV SWEEP RANGE SWITCH SAMPLING	For stable display X10 50 TIME POS RNG 5 ns TIM DIV 0.5 us REP (EYE) MAN (DOTS)

Until experience is gained, it may prove easier to use the "EYE" settings to establish sampling stability (Table A). Once this is accomplished, shift to the "DOTS" option. Adjust the "TRIM" controls of DELAY and DOT RESPONSE to get the sharpest groupings.

Note 1: The left sampling unit is adjusted for vertical sharpness. The right sampling unit is adjusted for horizontal sharpness.

Note 2: Adjustments to the sampling units can compensate slightly for defects in the Nyquist filter shape, but this does not make this procedure less useful.

Use the VARIABLE gain and DC OFFSET controls to place the cluster centers as nearly as possible on the scope graticule intersections (Fig. 4). This way, departures from the ideal can easily be measured. Experience will refine the operator's ability to judge defects, and will lead to less dependence on the graticule.

DISPLAYS

The following displays represent faults and defects that can be identified.

Caution: The channel must be taken out-of-service before breaking the IF signal path into the digital receiver.

Repeatedly breaking and making the IF signal path into the digital receiver will cause the pattern to switch between vertical and horizontal inequality. This is a result of the ambiguity that is inherent in recovering the carrier from a QAM signal.

Figure 6 is a display of unequal gaps. This pattern is caused by a defective ENCODER unit in the digital transmitter (terminal or regenerator).

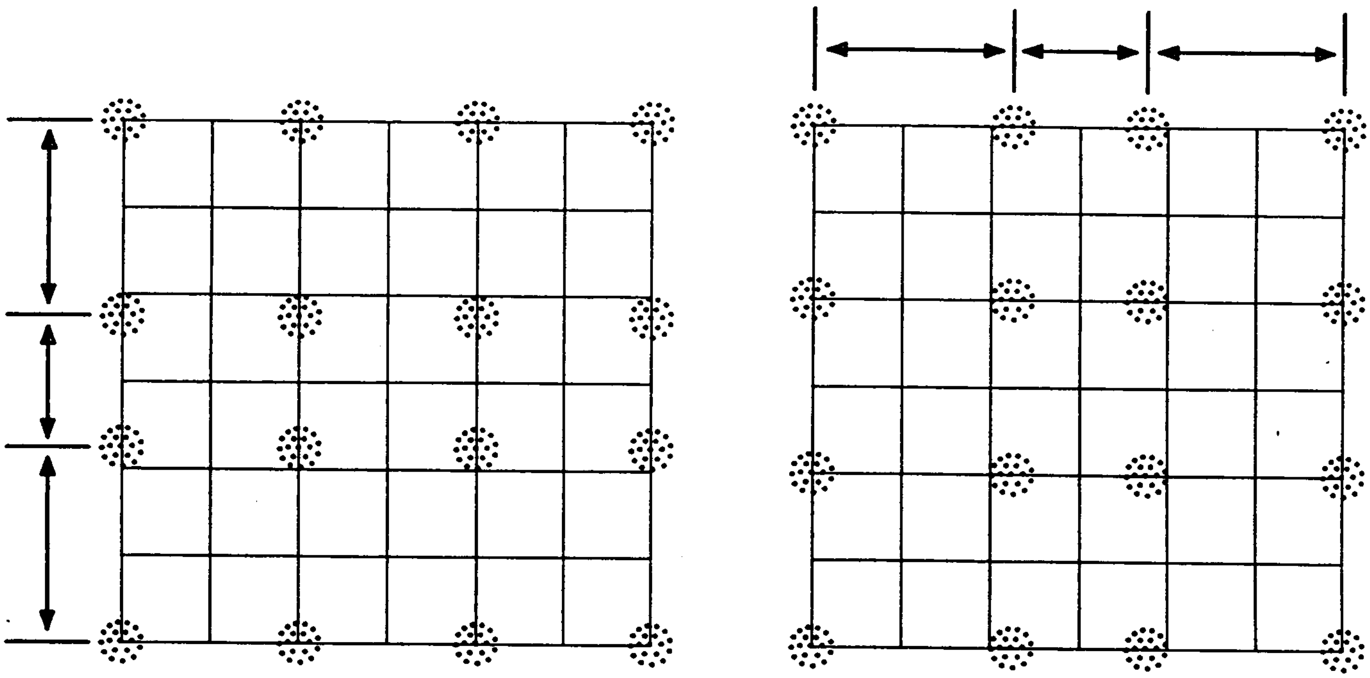


Fig. 6—Unequal Gaps

Figure 7 is a display of a 3-ring bullseye and may be continuous or intermittent. This indicates a loss of carrier lock which may be caused by a CARRIER RECOVERY unit failure, or intermittent generator frequency jumping.

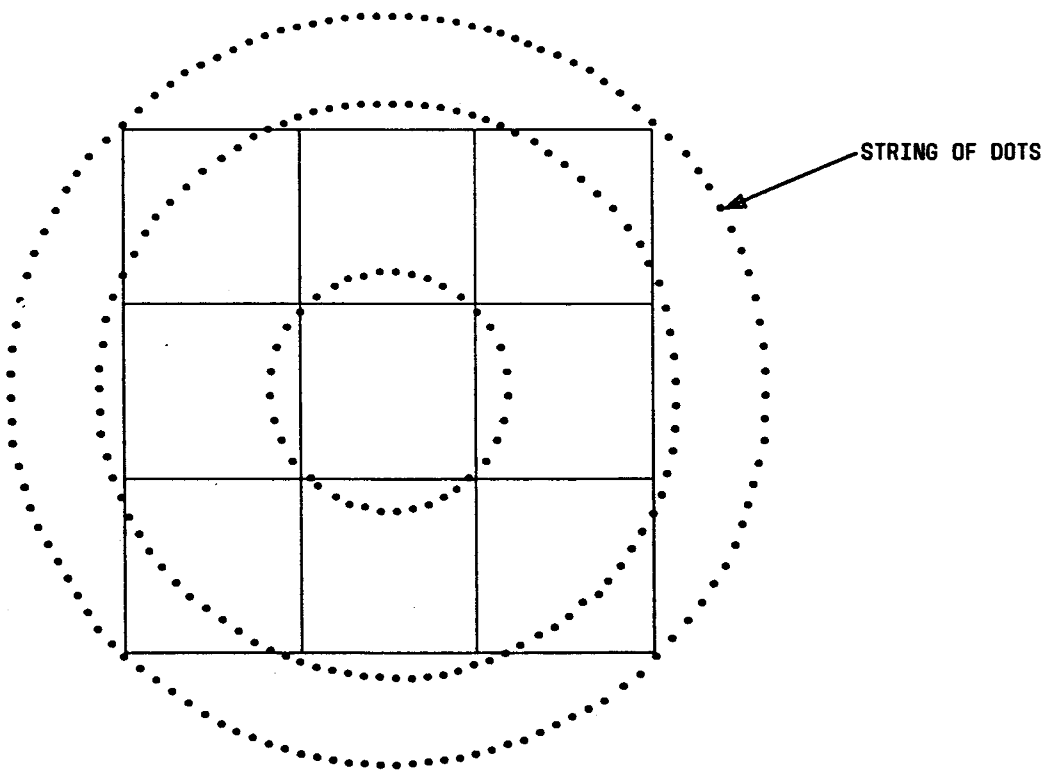


Fig. 7—3-Ring Bullseye

Figure 8 is a display of rotation. This is caused by recovered carrier phase offset due to frequency misadjustment or a faulty CARRIER RECOVERY unit.

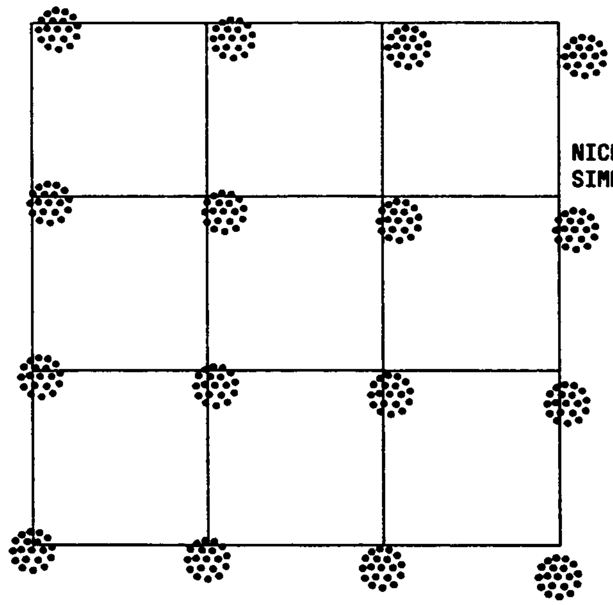


Fig. 8—Rotation

Figure 9 shows the effect of compression that results from an excessive power level in an amplifier. This could occur in a receiving circuit as the result of a strong received signal, or improper RF preamplifier gain or padding. Misadjustment of the transmitter ALC could also cause compression.

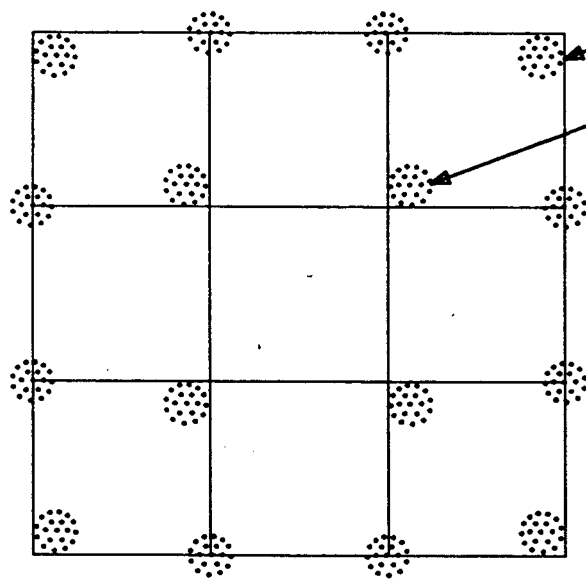
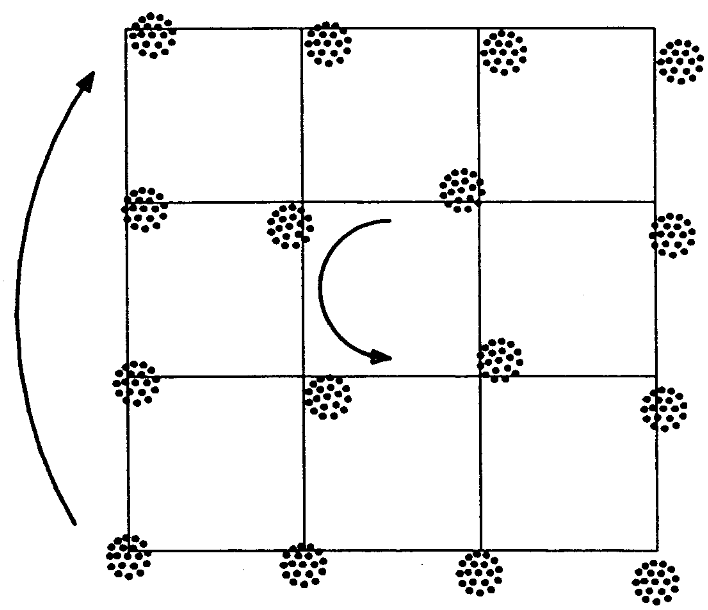


Fig. 9—Compression

Figure 10 shows the effect of AM-to-PM conversion. This results from a high level IF input to the POWER AMPLIFIER or a defective power amplifier.



NOTE:
1. Opposite rotation of inner vs outer groups.
   Outer four corners rotate one direction
   Inner four corners rotate opposite direction

Fig. 10—AM-to-PM Conversion

Figure 11 shows an out-of-square display resulting from a defective modulator in a transmitting terminal or regenerator, or a defective demodulator in a receiving terminal or regenerator.

Caution: The channel must be taken out of service before breaking the IF signal into the digital receiver.

The defective unit can be determined by repeatedly breaking and making the carrier lock.

A defective demodulator will cause the display to remain stationary.

A defective modulator will cause the display to alternately change from one orientation to the other. (Refer to the description of Fig. 6.)

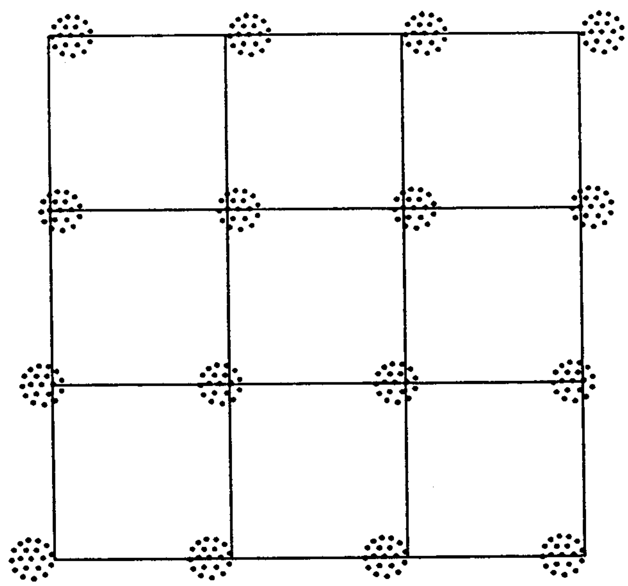


Fig. 11—Out of Square

Figure 12 shows the effect of cochannel interference. A constant-amplitude interference signal (CW or FM) will expand the dot clusters into circles.

If an AM interference signal is present (QAM or noise), the dot clusters will expand but will not show open centers.

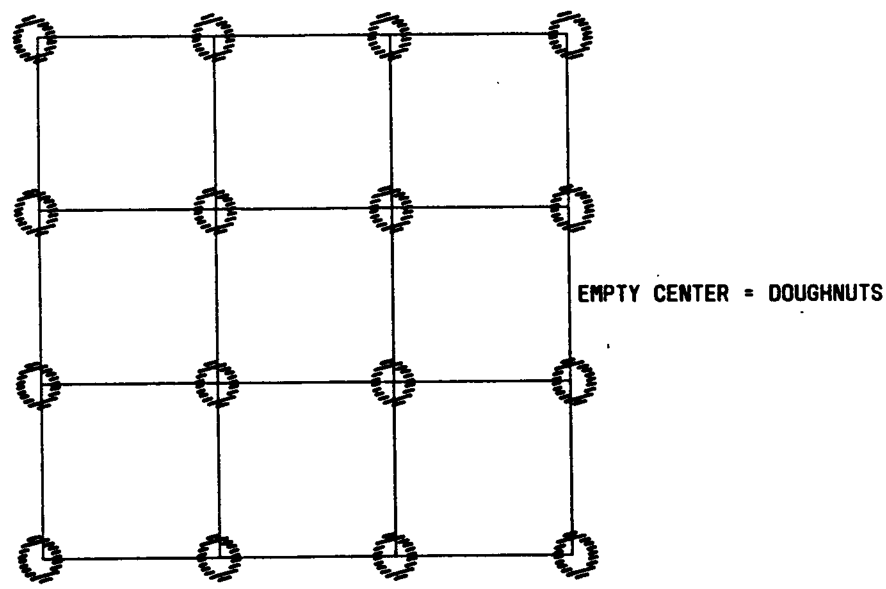
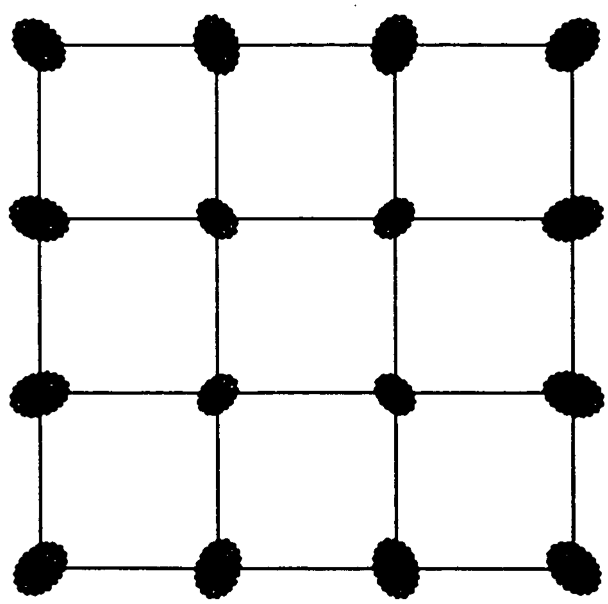


Fig. 12—Cochannel Interference

Figure 13 is a display of amplitude oscillation that may be caused by an unstable IF AGC AMPL unit.



NOTE:
1. All dot clusters point toward the center. Outer dot clusters spread more than the inner dot clusters.

Fig. 13—Amplitude Oscillation