TD-3 MICROWAVE RADIO

OVERALL SYSTEM

TESTS

ENVELOPE DELAY DISTORTION

CONTENTS PAGE

1. GENERAL

1.01 This section contains the procedures for making envelope delay distortion (EDD) measurements. Procedures are given for using the J68347A visual delay set, the Wandel and Goltermann VZM-83 distortion measuring set, and the KS-20548 Hewlett-Packard microwave link analyzer. If the EDD measurement is to be made with any other type of set, the manufacturer's instruction manual for that set should be used for test setup and operation information.

1.02 This section is reissued to include Charts 3, 4, and 5. This reissue does not affect the Equipment Test List.

1.03 Cross-modulation noise can be produced whenever the FM signal being carried on the radio channel is transmitted through any portion of the system having either residual envelope delay distortion or residual amplitude distortion. Envelope delay distortion is a measure of the departure from perfect phase linearity across the IF or RF frequency band. Amplitude distortion is a measure of the departure from perfect amplitude (or gain) flatness across the IF or RF frequency band. Both distortions must be held within tight limits if the system cross-modulation noise objectives are to be met.

1.04 Because of the complex nature of the FM signal, there is no simple method of determining the cross-modulation noise from a complicated EDD characteristic. However, it is possible to find from the measurement, by inspection, several simple predominant components of the EDD characteristic, such as slope, parabola, and ripple. Delay slope is generally the largest contributor to the system cross-modulation noise, and, therefore, it is essential that the slope component of the characteristic be minimized.

1.05 Normally, some delay slope will be present in all radio channels before mop-up equalization is applied. Some delay slope will be introduced by the circular and rectangular waveguide runs at a radio station. The amount of delay slope introduced over a 12-MHz channel is directly proportional to the lengths of the waveguide runs involved. This source of slope arises because the velocity of propagation of the signal through the waveguide decreases as the frequency approaches the cut-off frequency of the waveguide. A small residual delay slope in each hop also can be caused by some of the IF circuits in the radio receiver and transmitter, and by the channel separation network

of the immediately preceding radio repeater bay, if any, in the normal bay line up.

1.06 One of the principal causes of additional delay slope in those radio channels equipped with the J68386A and J68386B T/R bays is that the basic equalizer may not precisely match the distortion characteristics of the microwave networks and filters with which it is associated. Ideally, the basic equalizer used in each radio receiver should exactly equalize both the amplitude and delay distortion introduced by the microwave networks and filters used in the signal paths of the radio receiver and the associated radio transmitter at the far station. However, some slight misequalization may occur, due in part to the normal manufacturing tolerances that have to be placed on the networks, filters, and equalizer. Also, the equalization is very dependent upon the operating temperature and humidity conditions of the microwave networks and filters. To minimize equalization changes due to the latter effects, both the temperature control of the station and either the humidity control of the station or dry air in the indoor waveguide runs are used. In addition, invar rather than copper has been used in the construction of the 141B-type channel networks and 1322-type bandpass filters to minimize the effects of temperature variations.

1.07 ▶Radio channels equipped with the J68386G and J68386H T/R bays employ self-equalized microwave networks and filters, thereby avoiding some of the problems associated with the use of a basic equalizer at IF frequencies. Still, some delay slope will be contributed by the microwave networks and filters due to normal manufacturing tolerances. Those remarks previously made with respect to the effect of temperature and humidity also apply here but to a lesser extent because of the self-equalization. A somewhat wider passband, together with the use of microwave equalization, has permitted the use of copper, rather than invar, for the microwave networks and filters of the J68386G and J68386H bays. However, dry air is still required in the indoor waveguide runs to minimize the effects of humidity.◀

1.08 The residual delay slope distortion in a radio channel is brought within limits by distributing 918A, 918B, 919A or 920A mop-up delay slope equalizers along the radio route. Provision is made for mounting one mop-up equalizer (of any type) in each radio receiver.

1.09 Residual parabolic distortion may be present in some radio channels, equipped with the J68386A and J68386B bays. The cause of this distortion is believed to be a very slight difference between the delay distortion characteristics of some basic equalizers and some of the microwave networks and filters. This distortion can be reduced by distributing 918C parabolic mop-up equalizers along the radio route.

1.10 Ripple is produced by an echo in the IF or RF path. A small amount of ripple will always be present, but abnormalities such as foreign bodies in the waveguide, dents or punctures due to bullets, and IF coaxial trunking irregularities may often be identified by the outstanding sinusoidal ripple they produce. Assuming that waveguide runs and IF cabling have been properly installed and maintained, excessive delay ripple may be an indication of a trouble condition in one or more transmitter-receiver bays. In some cases, the trouble may be caused by a poor IF return loss on a unit in the bay. If this is suspected, IF return loss measurements should be made on each unit, including the IF equalizer and the IF filters, to locate the defective unit. If the antenna waveguide system is suspected, RF return-loss measurements on the waveguide system should be made to locate the irregularity.

1.11 Besides permitting mop-up equalization, EDD measurements are useful for the following:

(a) Locating defective RF networks or filters, IF equalizers, or other components, particularly on new installations.

(b) Possible correlation with, or interpretation of, the results obtained from noise load runs.

(c) Obtaining a measure of the system stability. The latter information, concerning system stability, can be obtained by accumulating a series of EDD measurements of a given radio channel, taken under normal (nonfading) operating conditions, and over a reasonably long period of time. Since some variation in the delay slope characteristics may occur with time, it is recommended that the delay slope equalization be checked periodically.

1.12 The test procedures given in the following charts may be applied to an overall MUR, to an individual IF switching section within an MUR, or to one or more hops within an IF switching section. To obtain the best overall noise and baseband response performance, it is recommended that each IF switching section within an MUR be mop-up equalized to meet the requirements given in Part 3.

1.13 An EDD test should be made on the FM terminal equipment which is to be used in the system tests. It is assumed that the FM terminal transmitter and receiver to be used in these measurements meet Bell System Practice requirements. If possible, portable terminals used on switching sections or at intermediate points should be measured back to back at a central location before being dispatched to the test points. Terminal equipment normally assigned to an MUR would necessarily have to be checked with complementary equipment located at the end stations. This complementary equipment should be in good operating condition and meet applicable Bell System Practice requirements.

1.14 ▶When performing tests which involve use of the TD-3A, 4A FMR, or 4A FMT, it will be necessary to utilize 190A adapters for test equipment setups.◀

2. TESTS

CHART 1

ENVELOPE DELAY DISTORTION MEASUREMENT USING THE J68347A VISUAL DELAY SET

APPARATUS:

Transmitting Station

1—J68347A Visual Delay Set

1—J68383A (3A) or J68418A (4A) FM Terminal Transmitter

1—J68337J 3A FM Terminal Test Panel (part of the J68337H L1, L3 FM Terminal Test Set) (See Note 2, Fig. 6.)

1—P2BJ Cord (8 feet long)

1—19A Pad, 14 or 17 dB (see Fig. 1A)

Receiving Station

1—J68347A Visual Delay Set with a Dumont 304 or KS-15586 Oscilloscope

1—J68383B (3A) or J68418B (4A) FM Terminal Receiver

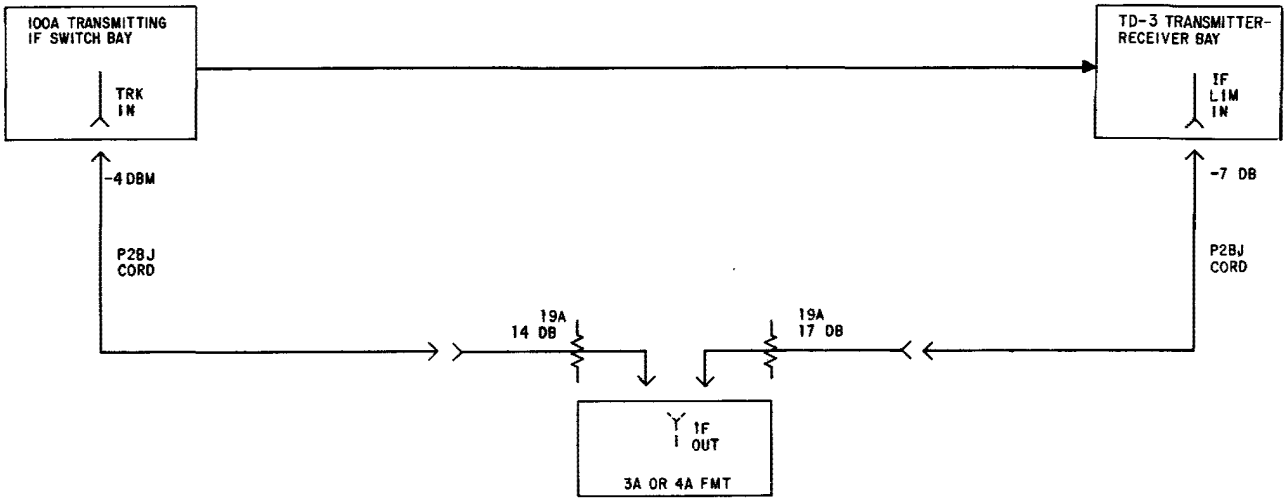
1—P2BJ Cord (8 feet long)

1—19A Pad, 6 or 16 dB (see Fig. 1B)

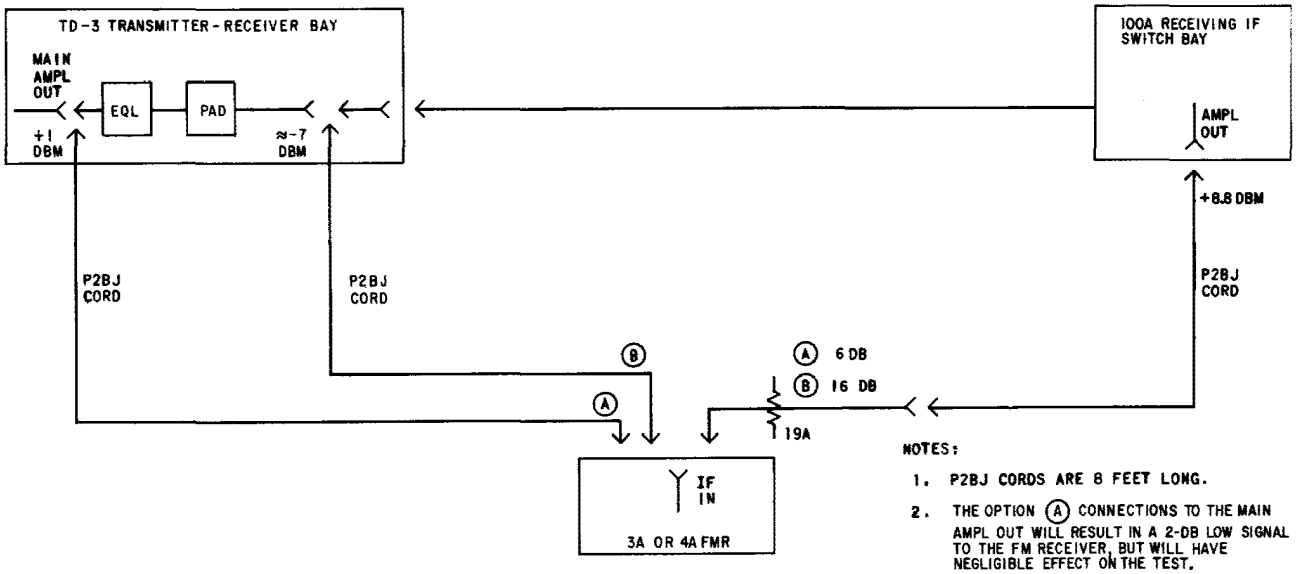
1—Oscilloscope Camera (optional)

CHART 1 (Cont)

STEP	PROCEDURE
	Caution: These tests are performed on an out-of-service basis. Check that the channel is not being used.
1	At the ***transmitting*** and ***receiving*** stations, connect and calibrate the test equipment as shown in Fig. 1 and 6.



A. FM TRANSMITTER CONNECTIONS TRANSMITTING STATION



B. FM RECEIVER CONNECTIONS RECEIVING STATION

NOTES:

1. P2BJ CORDS ARE 8 FEET LONG.
2. THE OPTION (A) CONNECTIONS TO THE MAIN AMPL OUT WILL RESULT IN A 2-DB LOW SIGNAL TO THE FM RECEIVER, BUT WILL HAVE NEGLIGIBLE EFFECT ON THE TEST.

OPTIONS:

(A) USE IF THE 3A FM RECEIVER IS EQUIPPED WITH A J68383H LIMITER-AMPLIFIER.

(B) USE WITH THE 4A FM RECEIVER OR IF THE 3A FM RECEIVER IS EQUIPPED WITH A J68383L LIMITER-AMPLIFIER.

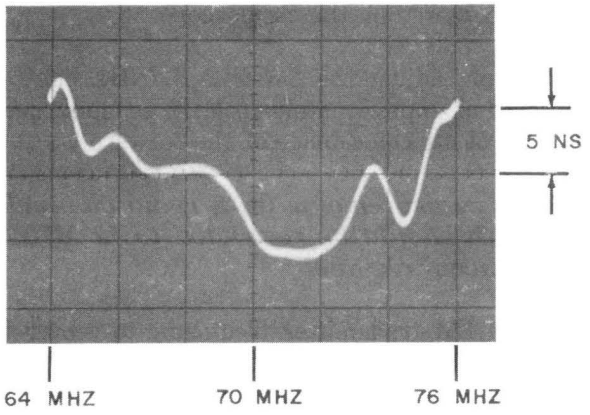
Fig. 1—FM Terminal Connections

CHART 1 (Cont)

STEP	PROCEDURE
	Caution: Turn the SWEEP RANGE and FM INDEX controls on the delay exciter fully counterclockwise before connecting to the FM transmitter.
2	At the ***receiving*** station, set S1 on the delay detector to the TERM REC position.
3	At the ***transmitting*** station, adjust the FM INDEX control on the delay exciter for a meter indication of 100 at the ***receiving*** station.
4	At the ***receiving*** station, set S2 to the MEAS position and adjust the FREQ control for minimum vertical oscillation on the oscilloscope.
5	Set S5 to the MEAS AND ALL CAL position and adjust the VERT CENT control until the trace is approximately centered on the oscilloscope.
6	At the ***transmitting*** station, adjust the SWEEP RANGE control for a 12-MHz (i.e., $\pm$6 MHz) sweep range centered at approximately 70 MHz as monitored at the ***receiving*** station. Adjust the PHASING control for coincidence of the forward trace and retrace. ***Caution: When making measurements on a radio channel adjacent to a working channel, the sweep width should be restricted to 12 MHz (i.e., $\pm$6 MHz) to avoid interference into the adjacent channel.*** ***Note:*** DO NOT adjust the FM transmitter frequency to center the 12-MHz range exactly at 70 MHz as indicated by the calibrated frequency meter dials. The absolute accuracy of the frequency meters is not as great as the frequency setting of the FM transmitter. Therefore, the frequency meters can be used to set the 12-MHz sweep range (i.e., 63.5 to 75.5, 64 to 76, 64.5 to 76.5), but should not be used to dictate a change of the FM transmitter frequency to center the range exactly at 64 to 76 MHz. For interpretation of the test results, the sweep range should be considered to be exactly 64 to 76 MHz.
7	Remove the frequency meters from the circuit.
8	At the ***receiving*** station, set S4 to the 25 MUS or 50 MUS position.
9	Adjust the oscilloscope vertical gain control for an appropriate calibration such as 10 or 20 ns per inch.
10	Adjust the oscilloscope horizontal gain control for a convenient calibration such as 3 or 4 MHz per inch.
11	Restore S4 to the MEAS position.
12	The display on the oscilloscope at this point represents the delay distortion of the radio channel plus the FM terminal and associated equipment.

CHART 1 (Cont)

STEP	PROCEDURE
13	Insert mop-up equalizers as prescribed in Part 3 of this section to meet the applicable requirements. If a camera is available, the oscilloscope display should be photographed before and after inserting the mop-up equalization to obtain a permanent record of the measurements. A typical delay distortion measurement of a 24-hop system taken with a 47A set is shown in Fig. 2. ***Note:*** It is usually desirable to display low frequencies on the left side of the oscilloscope for direct viewing, or on the right side for photographs with mirror image-type cameras. The low-frequency end of the oscilloscope display can be reversed by simply reversing the balanced plug which is patched into J1 and J2.
14	See Part 4 for the delay ripple requirement.



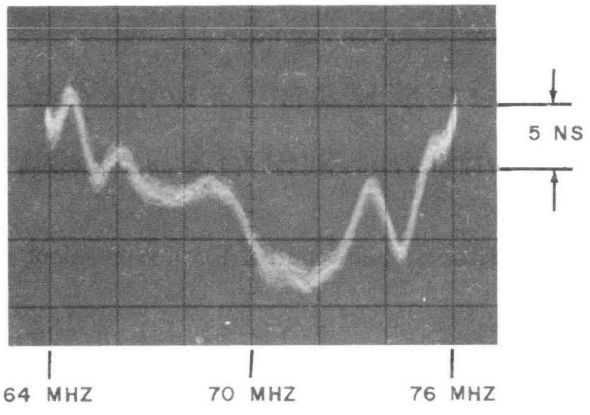


Fig. 2—Typical Oscilloscope Display—Envelope Delay Distortion of a 24-Hop System

CHART 2

ENVELOPE DELAY DISTORTION MEASUREMENTS USING THE VZM-83 DISTORTION MEASURING SET

APPARATUS:

Transmitting Station

1—VZM-83 Wandel and Goltermann Distortion Measuring Set with patch cords

1—J68383A (3A) or J68418A (4A) FM Terminal Transmitter

1—J68392A Transmitter-Receiver Test Set

1—P2BJ Cord (8 feet long)

1—19A Pad, 14 or 17 dB (see Fig. 1A)

Receiving Station

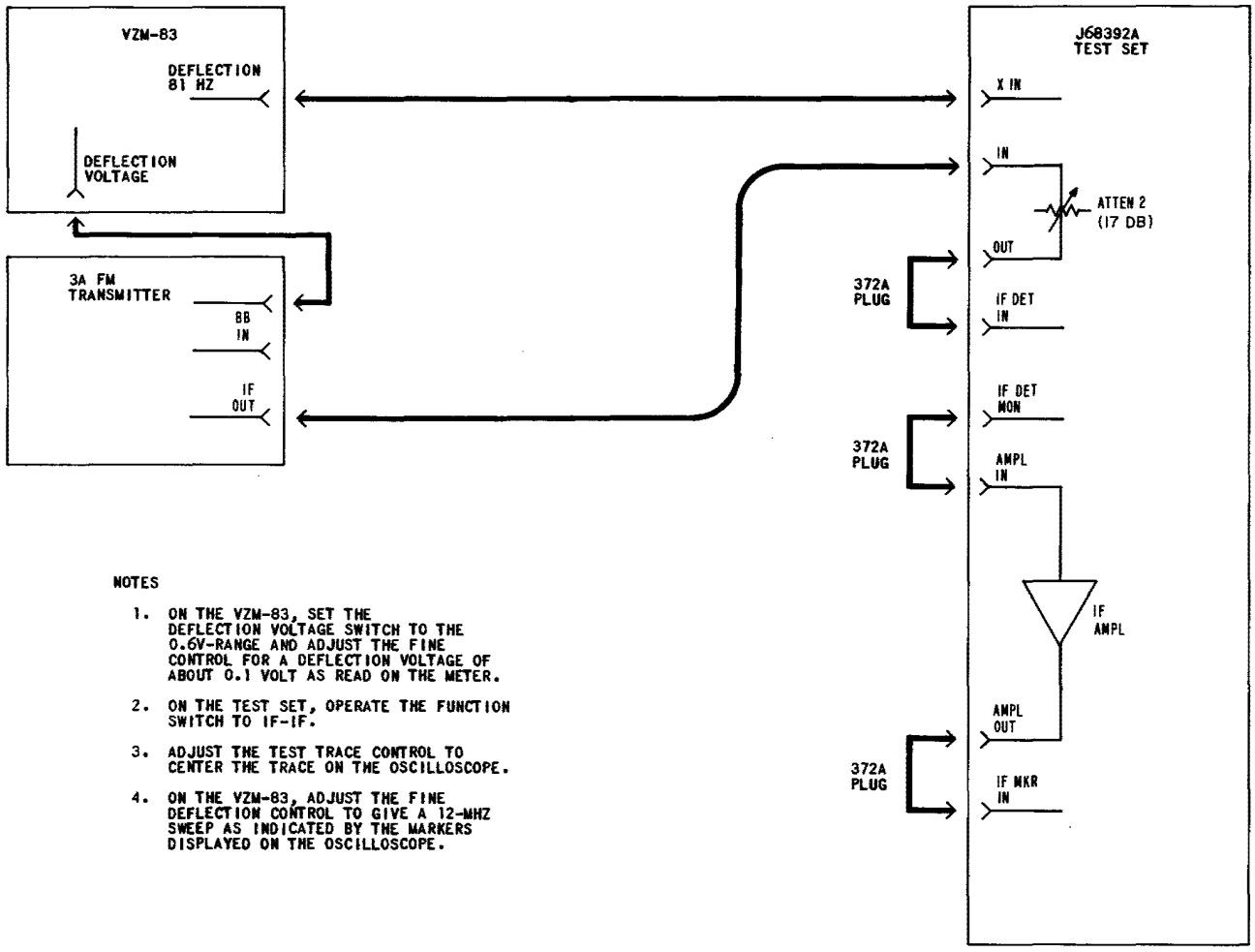
1—VZM-83 Wandel and Goltermann Distortion Measuring Set with patch cords

1—Oscilloscope

1—Oscilloscope Camera (optional)

Note: The KS-19976, L1 or Hewlett-Packard Model E24-140A Oscilloscope supplied with the J68392A Transmitter-Receiver Test Set may be used. A 304-type Dumont Oscilloscope is also suitable.

STEP	PROCEDURE
	Caution: These tests are performed on an out-of-service basis. Check that the channel is not being used.
1	At the ***transmitting*** station, set up the deflection voltage on the VZM-83 according to instructions in Fig. 3. DO NOT adjust the DEFLECTION voltage controls for the remainder of the test. Set the MEASURE FREQUENCY switch to 304 kHz.
	Caution: When making measurements on a radio channel adjacent to a working channel, the sweep width should be restricted to 12 MHz (i.e., $\pm$6 MHz) to avoid interference into the adjacent channel.
2	Connect the equipment at the transmitting and receiving stations as shown in Fig. 1 and 4, using option (X) if 100A switching equipment is included, and option (Y) if 100A equipment is not present.



NOTES

1. ON THE VZM-83, SET THE DEFLECTION VOLTAGE SWITCH TO THE 0.6V-RANGE AND ADJUST THE FINE CONTROL FOR A DEFLECTION VOLTAGE OF ABOUT 0.1 VOLT AS READ ON THE METER.
2. ON THE TEST SET, OPERATE THE FUNCTION SWITCH TO IF-IF.
3. ADJUST THE TEST TRACE CONTROL TO CENTER THE TRACE ON THE OSCILLOSCOPE.
4. ON THE VZM-83, ADJUST THE FINE DEFLECTION CONTROL TO GIVE A 12-MHZ SWEEP AS INDICATED BY THE MARKERS DISPLAYED ON THE OSCILLOSCOPE.

Fig. 3—Test Setup for Setting the FM Transmitter Deviation

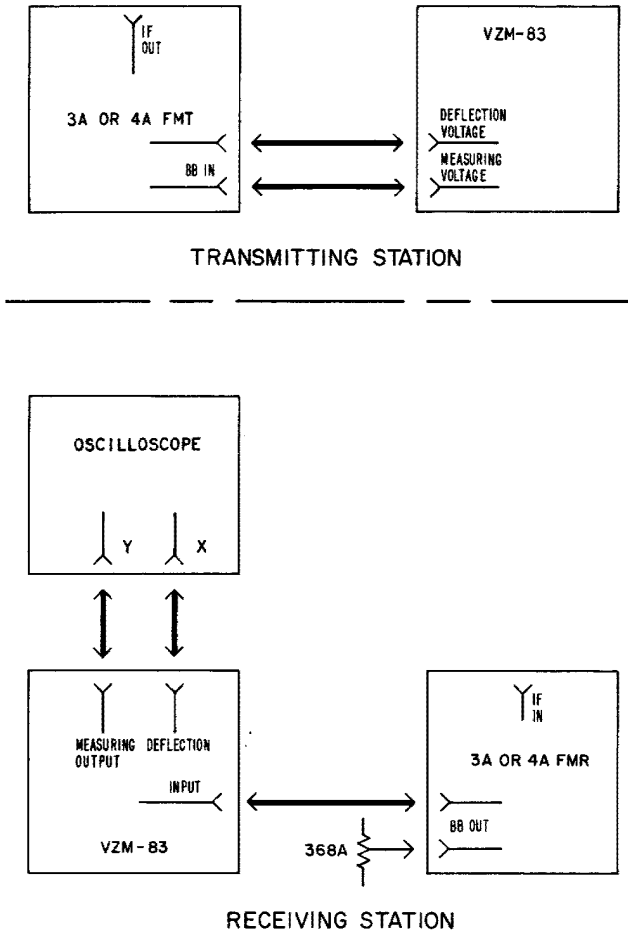


Fig. 4— Test Setup for Measuring Envelope Delay Distortion Using VZM-83 Distortion Measuring Set

CHART 2 (Cont)

STEP	PROCEDURE
3	At the ***receiving*** station, operate the INPUT VOLTAGE switch on the VZM-83 to the most sensitive position (0.003 to 0.06). Set the MEASURE FREQUENCY switch to 304 kHz.
4	Advise the operator at the transmitting station to adjust the fine MEASURING VOLTAGE control to give an indication within the 3-60 band on the test set meter at the receiving station.
5	Adjust the oscilloscope X-AXIS gain control for the desired sensitivity, and adjust the fine DEFLECTION VOLTAGE PHASE control on the VZM-83 for coincidence of the forward trace and retrace. Use the DEFELCTION VOLTAGE 0-180° control on the test set to reverse the oscilloscope presentation if desired (e.g., to obtain a frequency scale which increases from left to right).

CHART 2 (Cont)

STEP	PROCEDURE
	Note: A convenient method to test for correct frequency "sense" is to insert a delay sloper in the IF path and determine that the oscilloscope presentation tilts in the correct direction. (A negative sloper should cause the 76-MHz frequency to move down with respect to the 64-MHz frequency. A positive sloper should cause the 76-MHz frequency to move up with respect to the 64-MHz frequency.)
6	Set the TYPE OF MEASUREMENT switch to the desired DELAY TIME calibration range. Adjust the VERTICAL gain controls of the oscilloscope to obtain the desired vertical sensitivity. Restore the switch to the DELAY TIME, 0 position.
	Note: A sensitivity of 5 ns/cm usually provides the required resolution.
7	The display on the oscilloscope at this point represents the delay distortion of the radio channel plus the FM terminals and associated equipment.
8	Insert mop-up equalization as prescribed in Part 3 of this section to meet the applicable requirements. If a camera is available, the oscilloscope display should be photographed before and after inserting the mop-up equalization to obtain a permanent record of the measurements. A typical delay distortion measurement of a 24-hop system taken with a VZM-83 set is shown in Fig. 2.
9	See Part 4 for the delay ripple requirement.

▶CHART 3

ENVELOPE DELAY DISTORTION MEASUREMENTS USING THE HEWLETT-PACKARD KS-20548 MICROWAVE LINK ANALYZER

APPARATUS:

Transmitting Station

1—KS-20548, L1 Transmitter

1—P2BJ Cord (8 feet long)

1—372A Patch Plug

Receiving Station

1—KS-20548, L2 Receiver

1—P2BJ Cord (8 feet long)

1—Oscilloscope camera (optional)

CHART 3 (Cont)

STEP	PROCEDURE
	Caution: These tests are performed on an out-of-service basis. Check that the channel is not being used.
1	Become familiar with the preliminary SYSTEM OPERATING INSTRUCTIONS given in the manufacturer's instruction manual before using the test set.
2	On the KS-20548,L1 transmitter, connect the 372A patch plug between the IF OUTPUT terminal and the nearest ATTENUATOR terminal (Fig. 7).
3	Set the controls on the KS-20548,L1 transmitter as follows:

CONTROL	POSITION
VOLTAGE SELECTOR SWITCH (rear panel)	115 or 230V As required
LINE	ON
IF FREQUENCY	
COARSE	70 MHz*
FINE	0 (or as previously calibrated)
IF SWEEP WIDTH	
COARSE	10 MHz*
FINE	2 MHz*
ATTENUATION	Do in Step 6
BB	
FREQUENCY	277.778 kHz
DEVIATION	100
BB POWER	†
VERNIER	†
SWEEP	†
OUTPUT LEVEL	†
SET LEVEL	IF
OUTPUT POWER (meter)	Should indicate 10 dBm**
SLAVE (rear panel)	OFF

* Setting depends upon the desired measurement frequency and bandwidth.

† No adjustment necessary.

** If different from 10 dBm, adjust the IF adjusting screw, located to the right of the SET LEVEL control, for 10 dBm.

CHART 3 (Cont)

STEP	PROCEDURE
	Caution: When making measurements of a radio channel adjacent to a working channel, the sweep width should be restricted to 12 MHz (i.e., ±6 MHz) to avoid interference into the adjacent channel.
4	Adjust the ATTENUATION CONTROL on the KS-20548, L1 transmitter to provide the proper IF drive power for the system under test. (No attenuation in the ATTENUATOR provides +10 dBm).
5	Using a P2BJ 75-ohm cable, connect the ATTENUATOR output terminal on the KS-20548, L1 transmitter to the IF input of the system under test (Fig. 7).
6	Using another P2BJ 75-ohm cable, connect the IF output of the system under test to the IF INPUT of the KS-20548, L2 receiver (Fig. 7).
7	Set the controls on the KS-20548, L2 receiver as follows:

CONTROL	POSITION
VOLTAGE SELECTOR SWITCH (rear panel)	115 or 230V As required
LINE	ON
CAL	OFF
BB INPUT	INT DEMOD
IF LEVEL	Do in Step 8
SWEEP	IF REC
Y2 DISPLAY	REF
CALIBRATION	OFF
Y1 DISPLAY	IF
RETURN LOSS CAL BB POWER	 † Do in Step 10
MARKER OFFSET	±7 MHz
MARKER COMB.	ON
GROUP DELAY DETECTOR SET LEVEL PHASE LOCK	 Do in Step 13 Do in Step 12

CONTROL	POSITION
BB FREQUENCY	277.778 kHz
DELAY CALIBRATION	OFF
BANDWIDTH	5 kHz
UNBLANK (rear panel)	Unblanked (up)
BB BANDWIDTH (inside plug-in housing)	1.5 kHz

† No adjustment necessary.

CHART 3 (Cont)

STEP	PROCEDURE
8	Set the IF LEVEL attenuator to produce an on-scale indication on the RETURN LOSS/IF/BB LEVEL meter.
9	Turn the Y1 DISPLAY switch to the BB position.
10	Adjust the RETURN LOSS/BB POWER attenuator until the RETURN LOSS/IF/BB LEVEL meter indicates zero. With the meter at zero, the system's baseband power output can be read directly from the RETURN LOSS/BB POWER attenuator.
11	Turn the Y1 DISPLAY control to the DELAY position.
12	Adjust the GROUP DELAY DETECTOR/PHASE LOCK control so that the PHASE LOCK/LEVEL meter stops oscillating. ***(Note:*** The BB FREQUENCY must be the same as the BB FREQUENCY on the KS-20548,L1 transmitter.)
13	Center the reference trace with the Y2 position control. Center the delay trace with the Y1 position control.
14	Adjust the X GAIN control for a convenient spectrum width. (Frequency markers appear at 2-MHz intervals about the 70-MHz center frequency marker.)
15	Adjust the SET LEVEL control so that the PHASE LOCK/LEVEL meter is in the green zone. ***(Note:*** There may be some interaction between the PHASE LOCK and the SET LEVEL controls necessitating readjustment of the PHASE LOCK control.)
16	Set the DELAY CALIBRATION switch to an appropriate calibration setting (typical setting for multihop measurements, 10 ns), and adjust the Y1 GAIN control to produce a 2-cm difference between the alternating traces (this will give a 5 ns/cm calibration).
17	Turn the DELAY CALIBRATION switch to the OFF position.
18	Adjust the INTENSITY control to produce a faint retrace (the trace must be unblanked). Adjust the X PHASE SHIFT control so that the Y1 envelope delay distortion trace and retrace are as closely superimposed as possible. Most likely the frequency markers on the Y2 reference trace will no longer be properly phased; however, the parameter being measured (i.e., the envelope delay distortion) will be properly phased.*

CHART 3 (Cont)

STEP	PROCEDURE
	* Since the sweep and reference markers are derived from the IF section of the system and the envelope delay signal from the baseband section, and since in most systems there is a phase shift between the IF and baseband signals, it is usually impossible to have proper trace phasing for both IF-derived frequency markers and the envelope delay distortion display simultaneously.
19	Make the desired envelope delay distortion measurements from the Y1 display on the KS-20548,L2 receiver.
20	Insert mop-up equalization as prescribed in Part 3 of this section to meet the applicable requirements. If a camera is available, the oscilloscope display should be photographed before and after inserting the equalization to obtain a permanent record of the measurements.
21	See Part 4 for the delay ripple requirement.

CHART 4

ENVELOPE DELAY DISTORTION MEASUREMENTS USING THE J68347A VISUAL DELAY SET (TRANSMIT) AND THE HEWLETT-PACKARD KS-20548 MICROWAVE LINK ANALYZER (RECEIVE)

APPARATUS:

Transmitting Station

1—J68347A Visual Delay Set

1—J68383A (3A) or J68418A (4A) FM Terminal Transmitter

1—J68337J 3A FM Terminal Test Panel (part of the J68337H, L1, L3 FM Terminal Test Set) (See Note 2 on Fig. 8)

1—19A Pad, 14 or 17 dB (See Fig. 1A)

Receiving Station

1—KS-20548, L2 Receiver

1—P2BJ Cord (8 feet long)

1—Oscilloscope Camera (optional)

CHART 4 (Cont)

STEP	PROCEDURE
	Caution: These tests are performed on an out-of-service basis. Check that the channel is not being used.
1	At the ***transmitting*** station, connect the test equipment as shown in Fig. 1 and 8 for the J68347A visual delay set.
	Caution: Turn the SWEEP RANGE and FM INDEX controls on the delay exciter fully counterclockwise before making the connection to the FM transmitter.
2	Become familiar with the preliminary SYSTEM OPERATING INSTRUCTIONS given in the manufacturer's instruction manual before using the test set.
3	At the ***receiving*** station, connect the test equipment as shown in Fig. 8 for the KS-20548, L2 receiver.
4	Using a P2BJ 75-ohm cable, connect the IF output of the system under test to the IF INPUT of the KS-20548, L2 receiver (Fig. 8).
5	Set the controls on the KS-20548, L2 receiver as follows:

CONTROL	POSITION
VOLTAGE SELECTOR SWITCH (rear panel)	115 or 230V As required
LINE	ON
CAL	OFF
BB INPUT	INT DEMOD
IF LEVEL	Do in Step 6
SWEEP	IF REC
Y2 DISPLAY	REF
CALIBRATION	OFF
Y1 DISPLAY	IF
RETURN LOSS CAL BB POWER	 † Do in Step 8

CONTROL	POSITION
MARKER OFFSET	±7 MHz
MARKER COMB.	ON
GROUP DELAY DETECTOR	
SET LEVEL	Do in Step 12
PHASE LOCK	Do in Step 11
BB FREQUENCY	277.778 kHz
DELAY CALIBRATION	OFF
BANDWIDTH	5 kHz
UNBLANK (rear panel)	Unblanked (up)
BB BANDWIDTH (inside plug-in housing)	1.5 kHz

† No adjustment necessary.

CHART 4 (Cont)

STEP	PROCEDURE
6	Set the IF LEVEL attenuator to produce an on-scale indication on the RETURN LOSS/IF/BB LEVEL meter.
7	Turn the Y1 DISPLAY switch to the BB position.
8	Adjust the RETURN LOSS/BB POWER step attenuator to 20 and the variable control to 1.0.
9	At the ***transmitting*** station, adjust the FM INDEX control for an on-scale indication on the RETURN LOSS/IF/BB LEVEL meter at the receiving station. Adjust the RETURN LOSS/BB POWER variable control for an indication of zero on the meter.
10	Turn the Y1 DISPLAY control to the DELAY position.
11	Adjust the GROUP DELAY DETECTOR/PHASE LOCK control so that the PHASE LOCK/LEVEL meter stops oscillating. ***(Note:*** The BB FREQUENCY must be set to 277.778.)
12	Adjust the SET LEVEL control so that the PHASE LOCK/LEVEL meter is in the green zone. ***(Note:*** There may be some interaction between the PHASE LOCK and the SET LEVEL controls necessitating readjustment of the PHASE LOCK control.)
13	At the ***transmitting*** station, adjust the SWEEP RANGE control for a 12-MHz (i.e., ±6 MHz) sweep range centered at approximately 70 MHz as monitored at the receiving station. ***Caution: When making measurements on a radio channel adjacent to a working channel, the sweep width should be restricted to 12 MHz (i.e., ±6 MHz) to avoid interference into the adjacent channel.***

CHART 4 (Cont)

STEP	PROCEDURE
	Note: DO NOT adjust the FM transmitter frequency to center the 12-MHz range exactly at 70 MHz as indicated by the KS-20548, L2 receiver. The frequency setting of the FM transmitter is more accurate than the absolute frequency marking of the delay receiver. For interpretation of the test results, the sweep range should be considered to be exactly 64 to 76 MHz.
14	At the receiving end, center the reference trace with the Y2 position control. Center the delay trace with the Y1 position control.
15	Adjust the X GAIN control for a convenient spectrum width. (Frequency markers appear at 2-MHz intervals about the 70-MHz center frequency marker.)
16	Adjust the INTENSITY CONTROL to produce a faint retrace (the trace must be unblanked). Adjust the X PHASE SHIFT control so that the Y1 envelope delay distortion trace and retrace are as closely superimposed as possible. Most likely the frequency markers on the Y2 reference trace will no longer be properly phased; however, the parameter being measured (i.e., the envelope delay distortion) will be properly phased.* *Since the sweep and reference markers are derived from the IF section of the system and the envelope delay signal from the baseband section, and since in most systems there is a phase shift between the IF and baseband signals, it is usually impossible to have proper trace phasing for both the IF-derived frequency markers and the envelope delay distortion display simultaneously.
17	Set the DELAY CALIBRATION switch to an appropriate calibration setting (typical setting for multihop measurements, 10 ns), and adjust the Y1 GAIN control to produce a 2 cm difference between the alternating traces (this will give a 5 ns/cm calibration).
18	Turn the DELAY CALIBRATION switch to the OFF position.
19	Make the desired envelope delay distortion measurements from the Y1 display on the KS-20548, L2 receiver.
20	Insert mop-up equalization as prescribed in Part 3 of this section to meet the applicable requirements. If a camera is available, the oscilloscope display should be photographed before and after inserting the equalization to obtain a permanent record of the measurements.
21	See Part 4 for the delay ripple requirement.

CHART 5

ENVELOPE DELAY DISTORTION MEASUREMENTS USING THE HEWLETT-PACKARD KS-20548 MICROWAVE LINK ANALYZER (TRANSMIT) AND THE J68347A VISUAL DELAY SET (RECEIVE)

APPARATUS:

Transmitting Station

1—KS-20548, L1 Transmitter

1—P2BJ Cord (8 feet long)

1—372A Patch Plug

Receiving Station

1—J68347A Visual Delay Set with a Dumont 304 or KS-15586 Oscilloscope

1—J68383B (3A) or J68418B (4A) FM Terminal Receiver

1—19A Pad, 6 or 16 dB (See Fig. 1B)

1—Oscilloscope Camera (optional)

CHART 5 (Cont)

STEP	PROCEDURE *
	Caution: These tests are performed on an out-of-service basis. Check that the channel is not being used.
1	Become familiar with the preliminary SYSTEM OPERATING INSTRUCTIONS given in the manufacturer's instruction manual before using the test set.
2	At the ***transmitting*** station, connect the test equipment as shown in Fig. 9 for the KS-20548, L1 transmitter.
3	At the ***receiving*** station, connect and calibrate the test equipment as shown in Fig. 1 and 9 for the J68347A visual delay set.
4	On the KS-20548, L1 transmitter connect the 372A patch plug between the IF OUTPUT terminal and the nearest ATTENUATOR terminal.
5	Set the controls on the KS-20548, L1 transmitter as follows:

CONTROL	POSITION
VOLTAGE SELECTOR SWITCH (rear panel)	115 or 230V As Required
LINE	ON
IF FREQUENCY	
COARSE	70 MHz*
FINE	0 (or as previously calibrated)

CONTROL	POSITION
IF SWEEP WIDTH	
COARSE	10 MHz*
FINE	2 MHz*
ATTENUATION	Do in Step 4
BB	
FREQUENCY	277.778 kHz
DEVIATION	158 approx
BB POWER	†
VERNIER	†
SWEEP	†
OUTPUT LEVEL	†
SET LEVEL	IF
OUTPUT POWER (meter)	Should read 10 dBm**
SLAVE (rear panel)	OFF

* Setting depends upon the desired measurement frequency and bandwidth.

† No adjustment necessary.

** If different from 10 dBm, adjust the IF adjustive screw, located to the right of the SET LEVEL control, for 10 dBm.

CHART 5 (Cont)

STEP	PROCEDURE
6	Adjust the ATTENUATION control on the KS-20548, L1 transmitter to provide the proper IF drive power for the system under test. (No attenuation in the ATTENUATOR provides +10 dBm.)
7	Using a P2BJ 75-ohm cable, connect the ATTENUATOR output terminal on the KS-20548, L1 transmitter to the IF input of the system under test.
8	At the ***receiving*** station, set S1 on the delay detector to the TERM REC position.
9	At the ***transmitting*** station, adjust the BB DEVIATION control for a meter indication of 100 at the receiving station. (If the meter indicates above 100 with the BB DEVIATION control at minimum, adjust the CAL 4 control on the delay detector for an indication of 100.)
10	Set S2 to the MEAS position and adjust the FREQ control for minimum vertical oscillation on the oscilloscope.
11	Set S5 to the MEAS AND ALL CAL position and adjust the VERT CENT control until the trace is approximately centered on the oscilloscope.

CHART 5 (Cont)

STEP	PROCEDURE
12	At the ***transmitting*** station, adjust the IF SWEEP WIDTH-FINE control for a 12-MHz (i.e., ±6 MHz) sweep range and adjust the IF FREQUENCY-FINE control to center the sweep at 70 MHz as monitored at the receiving station. Adjust the PHASING control for coincidence of the forward trace and retrace. ***Caution: When making measurements on a radio channel adjacent to a working channel, the sweep width should be restricted to 12 MHz (i.e., ±6 MHz) to avoid interference into the adjacent channel.***
13	At the ***receiving*** station, remove the frequency meters from the circuit.
14	Set S4 to the 25 MUS or 50 MUS position.
15	Adjust the oscilloscope vertical gain controls for an appropriate calibration such as 10 or 20 ns per inch.
16	Adjust the oscilloscope horizontal gain control for a convenient calibration.
17	Restore S4 to the MEAS position.
18	The display on the oscilloscope at this point represents the delay distortion of the radio channel plus the FM terminal and associated equipment.
19	Insert mop-up equalization as prescribed in Part 3 of this section to meet the applicable requirements. If a camera is available, the oscilloscope display should be photographed before and after inserting the equalization to obtain a permanent record of the measurements.
20	See Part 4 for the delay ripple requirement.

3. MOP-UP EQUALIZATION OF DELAY SLOPE AND PARABOLIC DISTORTION

3.01 Examine the delay characteristic and note the presence or absence of slope or parabolic shape.

Note: ▶Without any mop-up equalization, channels 1, 2, 7, and 8 will, in general, have a net positive delay slope whereas the remaining channels will have a net negative delay slope. In the TD-3 radio system these characteristics are perfectly normal, the deciding factor being whether or not the BO frequency is above or below the channel center frequency. Those channels having the BO frequency above should have a positive delay slope whereas those with the BO below should have a negative delay slope.◀

3.02 Insert 918-, 919-, or 920-type equalizers at the receiving station to meet the following requirements.

Delay Slope: ±1.5 nanoseconds over the 64- to 76-MHz range.

Parabolic Distortion: ±1.75 nanoseconds at the 64- and 76-MHz points.

The characteristics of the 918-, 919-, and 920-type equalizers are as follows:

CODE	CHARACTERISTIC	MAGNITUDE		ABSOLUTE DELAY AT 70 MHZ NS	MINIMUM RETURN LOSS 62 TO 78 MHZ		MAXIMUM INSERTION LOSS
		NS	OVER THE RANGE MHZ		INPUT dB	OUTPUT dB	dB
918A	Negative Slope	6	64 to 76	23.5	33	33	0.45
918B	Negative Slope	3	64 to 76	23.5	33	33	0.45
918C	Negative Parabolic	3.4	*	25	33	33	0.7
919A	Positive Slope	3	64 to 76	23.5	33	33	0.7
919B	Flat Delay	—	—	23.5	33	33	0.6
920A	Positive Slope	6	64 to 76	23.5	33	33	0.85
* At the 64- and 76-MHz points							

Note: At this point, do not put 918A or 918B equalizers in tandem with 919A or 920A equalizers, as their characteristics are opposite.

3.03 If the mop-up equalization is being determined for the first time on a newly installed radio channel, the mop-up equalizers that were found necessary to meet the requirements of 3.02 now should be distributed as uniformly as possible along the radio line. The equalizers are installed in the radio receiver portion of the transmitter-receiver bay. Only one mop-up equalizer may be installed in a receiver. The equalizer is connected between the IF OUT jack of the IF main amplifier and the input jack of the 19E or 63E pad. The connecting cables, mounting bracket, and miscellaneous hardware for mounting the equalizer in the bay are furnished in an equalizer mounting kit. ◗(ED-50970-30 G1 for the J68386A and J68386B T/R bays and ED-50970-31 G1 for the J68386G and J68386H T/R bays.)◖

Note 1: The delay slope and parabolic mop-up equalizers have approximately equal absolute delay at 70 MHz. They have been designed to have as close to the same absolute delay as possible to permit the mop-up equalization to be performed independently of the system Differential Absolute Delay Equalization (DADE). If at a station one channel has to be equipped with a delay equalizer, then each channel ***in the same direction of transmission*** at that staton should be equipped with a suitable equalizer. If at that station there are any channels that do not require a delay slope or parabolic equalizer to meet system requirements, a 919B flat delay equalizer should be installed in the receivers for these channels. This plan permits the mop-up equalization to be installed without introducing electrical length differences between channels. By following this plan initially, before DADE equalizing the channels, the amount of DADE cable required at the main stations, to build the channels out to the electrical length of the longest channel, will be held to a minimum. Furthermore, future changes can be made in the mop-up equalization, by substituting one code of equalizer for another in any channel at any station equipped with equalizers, without significantly affecting the DADE equalization.

Note 2: ***If possible,*** arrange the equalizers such that a 919B flat delay equalizer can be installed in each channel at the receiving main stations of each switching section. This arrangement permits a two-step positive or negative slope adjustment to be made at the main station if future EDD tests indicate the need to change the mop-up equalization.

Note 3: If the number of equalizers to be installed is greater than the number of bays to be equipped, sacrifice 918C parabolic equalizers in favor of the 918, 919, and 920 delay slope equalizers. Delay slope is a much greater source of cross-modulation noise than parabolic shape and should be eliminated first.

3.04 If the test is being performed on a previously mopped-up channel and a change in the mop-up equalization is indicated, the change in equalization should be made by either changing the equalizer in the receiving main station, or in one or more receivers along the line, or both if necessary.

3.05 After installation of the equalizers, recheck the EDD and change, if necessary, the equalization at the receiving main station to meet the requirements of 3.02.

> ***Note:*** If a change in the delay slope mop-up is found necessary, it is permissible to install an equalizer at the receiving main station having a slope opposite in sign to the other equalizers on the channel. However, if subsequent tests of EDD on that channel indicate that the mop-up equalizer should continue to be of the opposite slope, then an appropriate adjustment should be made of the repeater station equalization to correct the condition.

4. DELAY RIPPLE REQUIREMENT

4.01 Figure 5 has been prepared to be used as a guide in determining the seriousness of any ripple observed in the measurement. Any ripple which exceeds the limit shown on Fig. 5 may be an indication of trouble and should be investigated. This curve applies to the J68347A visual delay set, KS-20548 microwave link analyzer, and Wandel and Goltermann VZM-83 set with a measuring frequency of 304 kHz.

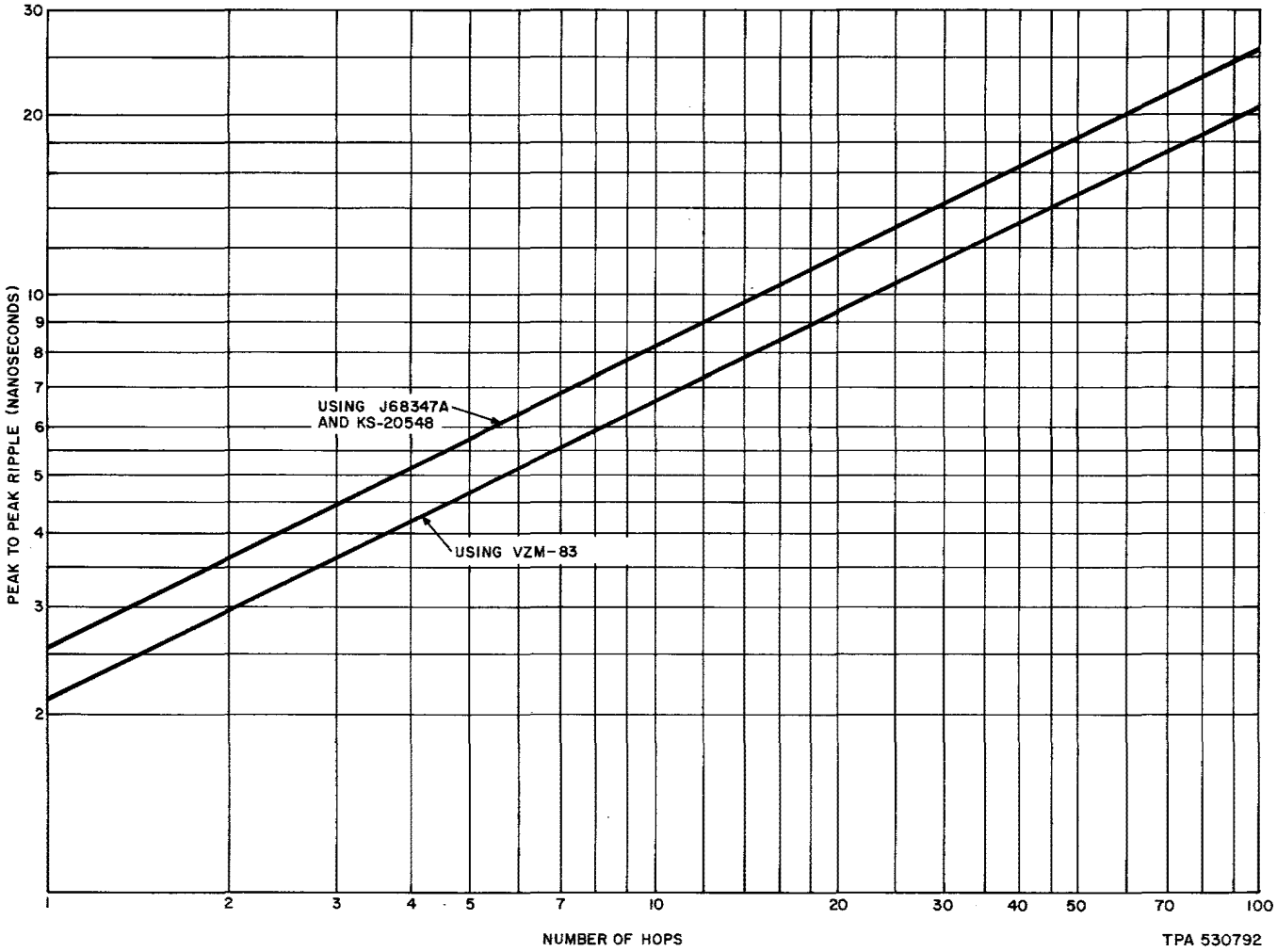
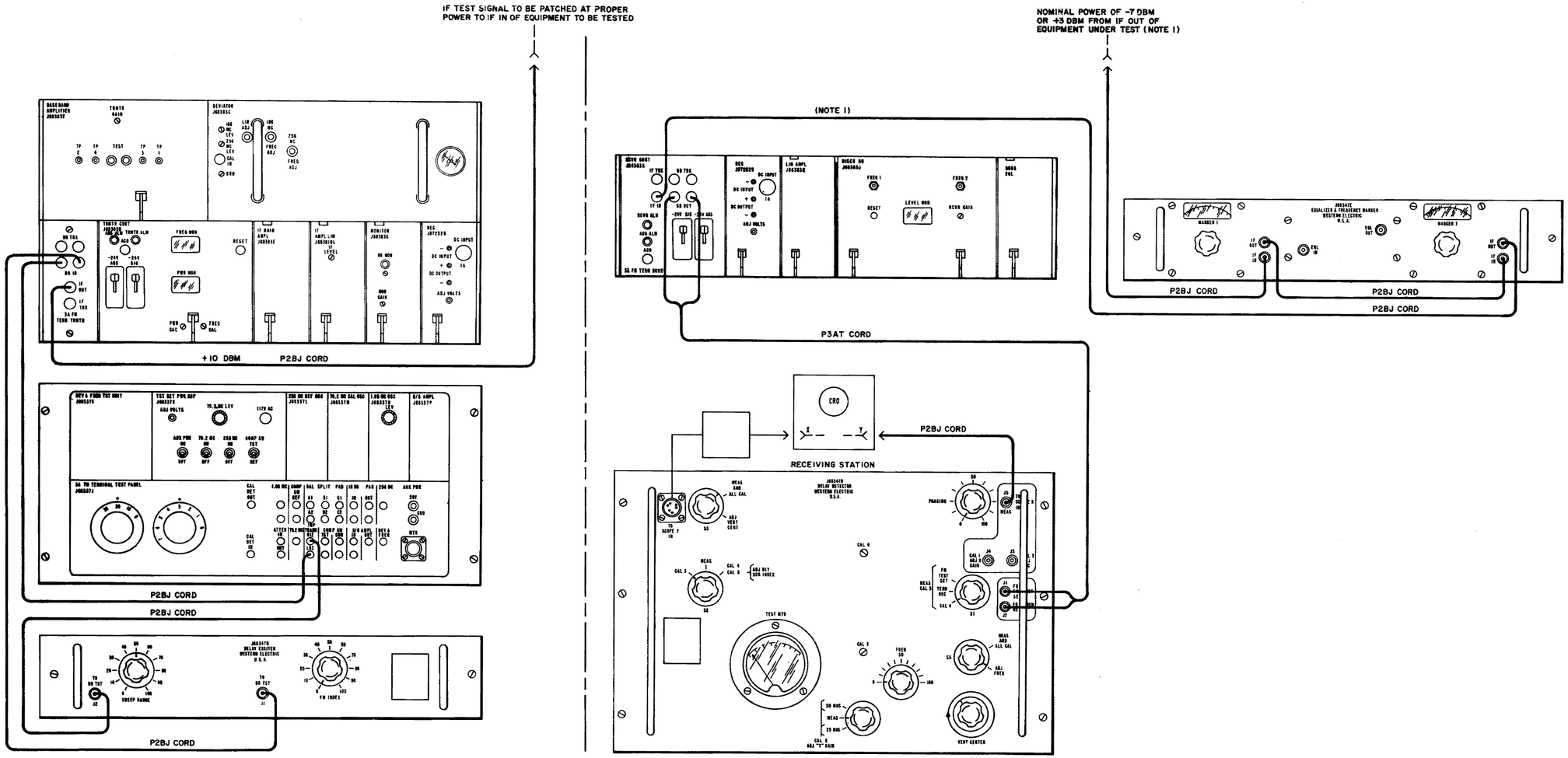


Fig. 5—Delay Ripple Requirements



◆ Fig. 6—Test Setup for Measuring Envelope Delay Distortion Using the J68347A Visual Delay Set ◆

CALIBRATION INSTRUCTIONS

1. With no input to the oscilloscope, adjust the oscilloscope DC balance and adjust the oscilloscope Y position for vertical center.

2. Set the controls of the delay detector as follows:

CONTROL	POSITION
S1	CAL 4
S2	CAL 3
S3	MEAS AND ALL CAL
S4	MEAS
S5	ADJ FREQ

3. Adjust the CAL 3 gain control for a meter indication of 100.

4. Set S2 to the CAL 4/CAL 5 position, and adjust the CAL 4 gain control for a meter indication of 100.

Notes:

1. Nominal input power to the receiver is −7 dBm if the receiver is equipped with a J68383L limiter-amplifier, or +3 dBm if the receiver is equipped with a J68383H limiter-amplifier.

2. If modification in accordance with option K of SD-59557-01, Issue 4B has been made to the J68337D delay exciter, the J68337J test panel can be omitted. Make a direct connection between J2 on the delay exciter and one side of the BB IN jack on the FM transmitter.

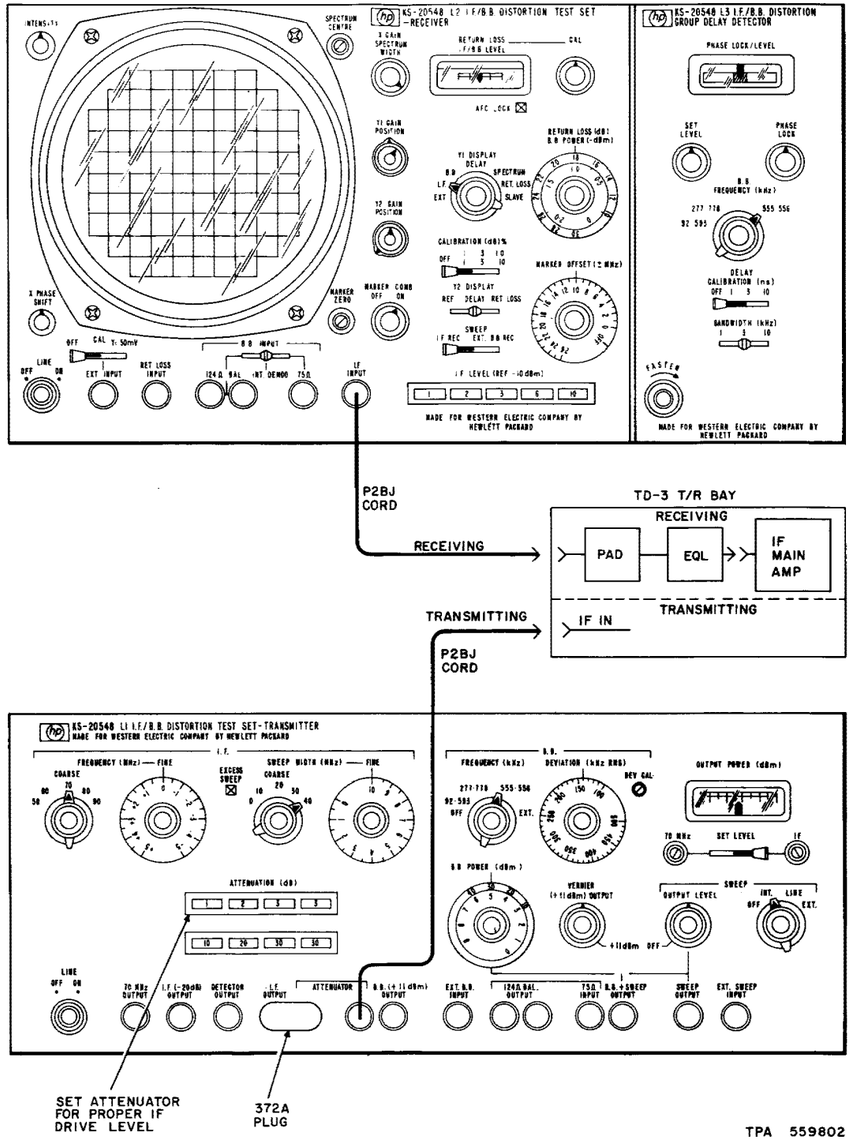
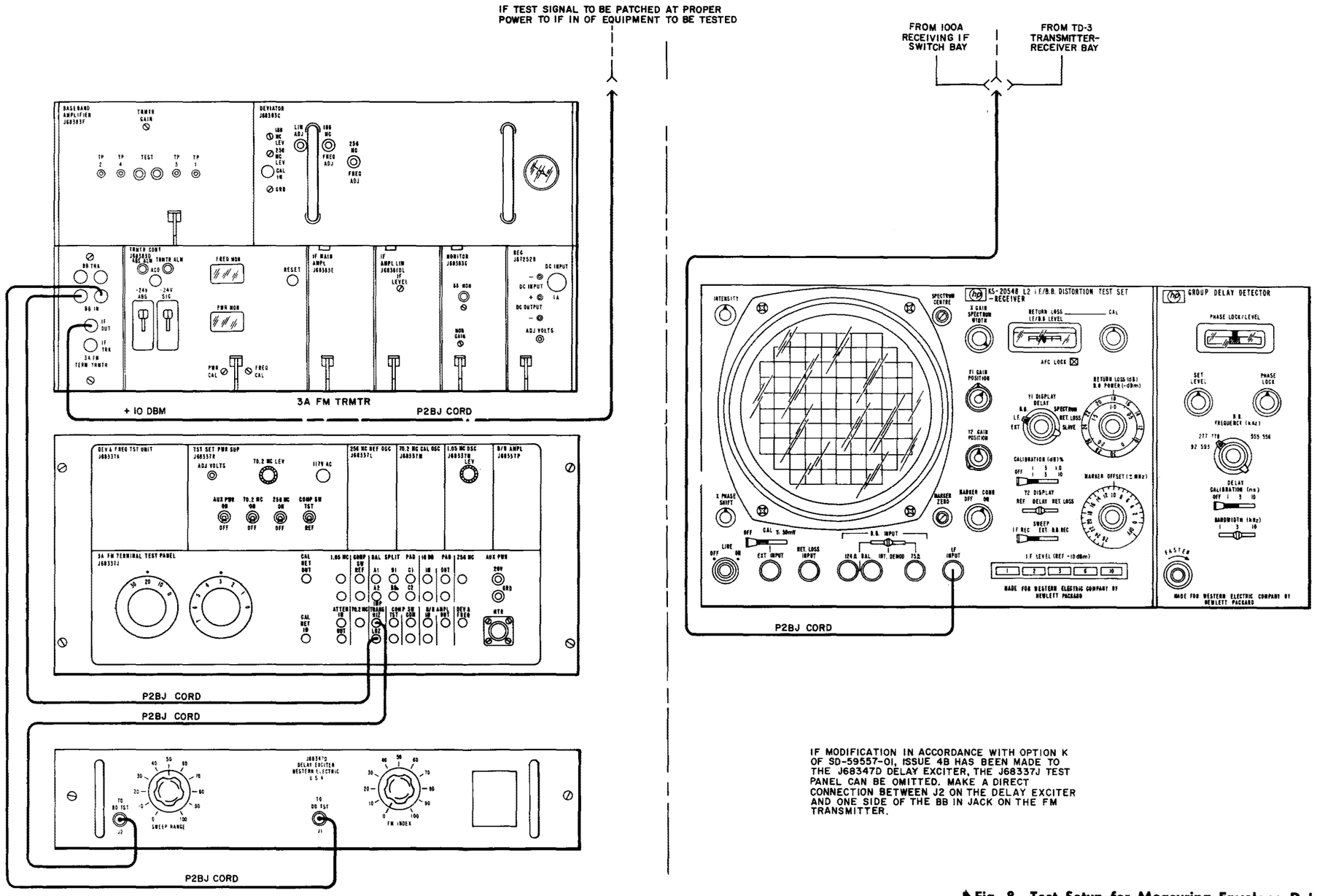
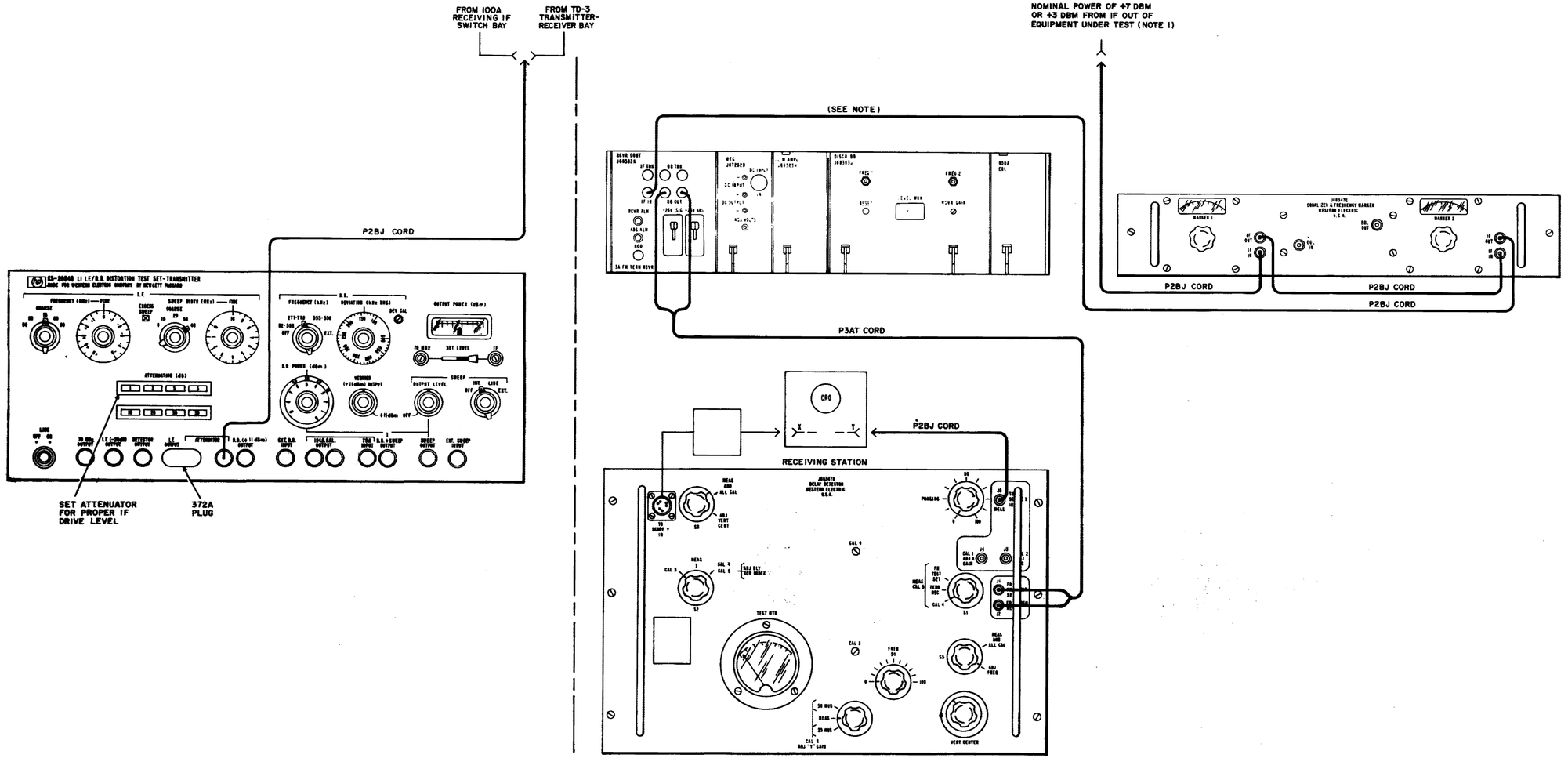


Fig. 7—Test Setup for IF—IF Envelope Delay Distortion



IF MODIFICATION IN ACCORDANCE WITH OPTION K OF SD-59557-01, ISSUE 4B HAS BEEN MADE TO THE J68347D DELAY EXCITER, THE J68337J TEST PANEL CAN BE OMITTED. MAKE A DIRECT CONNECTION BETWEEN J2 ON THE DELAY EXCITER AND ONE SIDE OF THE BB IN JACK ON THE FM TRANSMITTER.

Fig. 8—Test Setup for Measuring Envelope Delay Distortion Using the J68347A Visual Delay Set (transmit) and the Hewlett-Packard KS-20548 (receive)



CALIBRATION INSTRUCTIONS

1. With no input to the oscilloscope, adjust the oscilloscope DC balance and adjust the oscilloscope Y position for vertical center.

2. Set the controls of the delay detector as follows:

CONTROL	POSITION
S1	CAL 4
S2	CAL 3
S3	MEAS AND ALL CAL
S4	MEAS
S5	ADJ FREQ

3. Adjust the CAL 3 gain control for a meter indication of 100.

4. Set S2 to the CAL 4/CAL 5 position, and adjust the CAL 4 gain control for a meter indication of 100.

Note:

1. Nominal input power to the receiver is −7 dBm if the receiver is equipped with a J68383L limiter-amplifier, or +3 dBm if the receiver is equipped with a J68383H limiter-amplifier.

◆ Fig. 9—Test Setup for Measuring Envelope Delay Distortion Using the Hewlett-Packard KS-20548 (transmit) and the J68347A Visual Delay Set (receive) ◆