

**2600 HZ FWA, FWB, AND FWC SINGLE FREQUENCY
SIGNALING UNITS SD-1C225-01 AND SD-1C583-01
DESCRIPTION**

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A. System and Unit Description

1.03 On the face of the FWA, FWB, and FWC SF units (Fig. 1 and 2) are 16 slide switches. 34B or 34C attenuators can be inserted into the transmit and receive circuits. There is a range from 0 to -16.5 dB in .1dB steps by adding combinations of these sliders. The values are determined by the individual trunk design. With the attenuators out of the circuit, the SF unit's transmit and receive circuit insertion loss or gain is within .2dB of 0 dBm level. A metallic path exists in the transmit direction in the FWA and FWB.

1.04 A complete 11-foot by 6-inch type F signaling bay consists of two 2600-Hz tone supply and transfer units, six regulated -48V dc to -24V dc power converters, fuse and alarm circuit and 132 FWA, FWB, or FWC SF units. The SF units must be located near enough to the -16 dB and +7 dB TLPs so that the transmission loss at 2600 Hz does not exceed 5 dB (sum of cabling losses at both ends). See Fig. 3. E and M lead signaling is used between the SF unit and the connecting equipment. A simplified application schematic of an FWA, FWB, or FWC SF unit with its connections to the line and equipment facilities is shown in Fig. 3.

1.05 The FWA, FWB, and FWC SF unit circuit components are mounted on a printed wiring board. The board is mounted on a die cast aluminum frame approximately 10-1/2 inches by 7 inches by 1-1/2 inches. All interconnecting wiring to and from the SF unit is via a 20-pin connector which is part of the printed wiring board. There are two pairs of pin jacks on the face of the FWA, FWB, and FWC SF units designated LINE TRMT and LINE RCV. These jacks provide bridging access to the transmit and receive circuits transmission ports. (Fig. 3.)

1. GENERAL

1.01 This section describes the FWA, FWB, and FWC single-frequency signaling units (SF units) which are component parts of the type F signaling system.

1.02 This section is being reissued to include the FWC SF unit.

1.06 The FWA, FWB, FWC and other component parts of the type-F signaling system have

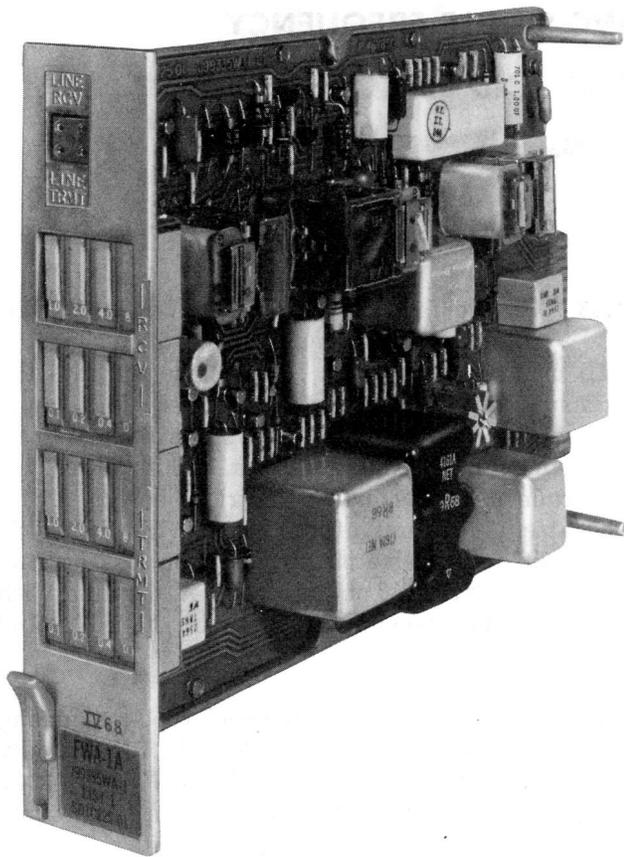


Fig. 1—FWA or FWB SF Unit

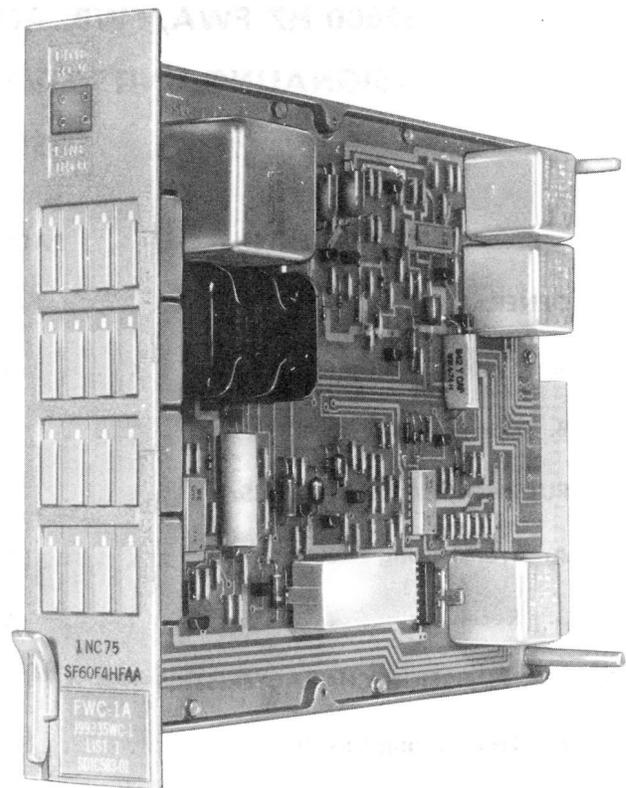


Fig. 2—FWC SF UNIT

been designated by placing the letter F ahead of the last two letters of the units equipment drawing number. Following are some of the type F units and their corresponding equipment drawing numbers.

DESIGNATION	UNIT DESCRIPTION	DRAWING NO.
FTA	Test Extender	J99335TA
FWA	4-W Message SF Unit	J99335WA
FWB	4-W AUTOVON SF Unit	J99335WB
FYA	Tone Supply & Transfer Ckt	J99335YA

1.07 The color coding on the FWA and FWB units is a green label with black lettering. The color coding for the FWC unit is a green label with white lettering.

B. Compatibility

▶FWA AND FWB UNITS▶

1.08 The FWA and FWB SF units are identical in appearance. The difference is a factory wiring option Y or Z. The FWA SF unit is equipped with Z option and the FWB equipped with Y option. Option Z reduces the operate time of the receiving circuit so that it will respond to shorter incoming tone pulses. The FWA SF unit is suitable for use on trunks that use senderized dial pulse (DP) or multifrequency (MF) pulsing. The FWA SF unit can be used at both the originating and terminating ends of the trunk. The FWB SF unit is intended for use on AUTOVON trunks (which use MF signaling), but it can also be used on other MF trunks or at the originating end of DP trunks. The FWB SF units receive circuit will not accept DP signals and therefore *cannot* be used at the terminating end of DP trunks. Table A provides a list of SF units that are compatible with the FWA and FWB SF units.

▶FWC UNITS

1.09 The FWC unit provides the following features and characteristics:

- The FWC is physically interchangeable with the FWA and FWB. The FWC uses integrated circuits in place of the discrete components used in the FWA and FWB.
- The FWC is not equipped with the voice path cut circuits used in the FWA and FWB. As a result, transients from change of supervisory state and dial pulsing can pass through the unit and on to the facility. The transients will block 2600 Hz tone for the duration of the transient on all facilities and for a much longer recovery time on compandored facilities. Therefore, the FWC is limited to non-compandored facilities and for MF pulsing only.
- The FWC is compatible with the FWA units for end-to-end signaling. The FWC is also functional at both originating and terminating ends of the trunk.

Table A provides a list of SF units that are compatible with the FWA, FWB, and FWC SF units.▶

2. PULSING CHARACTERISTICS

A. Transmitting

2.01 The FWA and FWB SF units accept ▶dial▶ pulses on the M lead from 7.5 to 12.5 pulses per second (pps) with the following percent break limitations. ▶These values do not apply to the FWC SF unit.▶

PPS	% BREAK RANGE
7.5	16-84
10.0	21-79
12.5	26-74

When the FWA and FWB SF units are used at the originating end of SXS and PBX DP trunks, an M lead pulse corrector must be used. The transmitting circuit does not provide for pulse correction. The values shown previously are input values, however the output of the transmitting circuit must fall within the limits of the receiving circuit provided in 2.02. Since there is no pulse correction in the transmitting circuit, the percent break limits are effectively the same as the receiving circuit.

B. Receiving

2.02 The receiving circuit of the FWA SF unit has pulse correcting features. It will accept 2600-Hz tone pulses in the range of 7.5 to 12.5 pps and with the following percent break limitations. ▶These values do not apply to the FWC SF unit.▶

PPS	% BREAK RANGE
7.5	25
10.0	35-84
12.5	47-80

The response of the receiving circuit to incoming tone pulses in actual in-service conditions are often worse than these figures indicate due to transient noise effects introduced by line and equipment facilities. Providing the noise remains below 65 dBrnc at the +7 TLP, it shall not interfere with the receiving circuit performance.

Note: Received pulses less than 50 milliseconds (duration of pulse) will produce an output on the E lead of 51 ± 3.5 milliseconds. Pulses greater than 60 milliseconds will produce an output within 2 milliseconds of its input. Pulses between 50 and 60 milliseconds on the input will be between 51 ± 3.5 and 60 ± 2 milliseconds.

The approximate amount of pulse correction realized between the input to the signal receiver and the output on the E lead is shown in Fig. 4. The FWB and FWC SF units are not used at the terminating end of DP applications. Therefore Fig. 4 **does not** apply to FWB and FWC SF units.

2.03 Input signals to the receive circuit of the FWA, FWB, and FWC SF units are split into two separate paths. One path is via a band-pass filter, signal amplifier, rectifier and on to a dc comparator. The other path is via a guard amplifier, a rectifier and on to the dc comparator. The dc comparator is preset to operate only when the ratio between the signal and guard amplifier circuits is correct. The signal to guard ratio (8 dB) can only be correct if the 2600-Hz tone is relatively pure, ie, unaccompanied by speech or noise components. The nominal band width of the 2600-Hz filter in the receive circuit is 75 Hz (70 Hz for FWC unit). However, to insure a reliable SF unit performance, the 2600-Hz tone at the line receive port should be 2600 ± 15 Hz and no lower than -24 dBm. Tone within the limits activates the comparator which results in the operation of the H and R (F and R for FWC units) relays. The H relay releases after a time interval. The F relay on the FWC remains activated until approximately 200 ms after 2600 Hz tone is removed. The H relay reoperates and remains operated until the interdigital timing period and the R relay follows the signals from the dc comparator.

3. TRANSMISSION CHARACTERISTICS

3.01 The stability of the transmit and receive circuits are dependent upon certain environmental conditions, such as impedance, temperature, aging and operating voltage. The discussion that follows assumes that the temperature is approximately 70°F, the input and output transmission ports are terminated with 600 ohms and the dc power converter is within $\pm 5\%$ of -24V. The FWA, FWB, and FWC SF units will,

however, remain stable unless severe changes to these environmental conditions exist.

A. Transmitting Circuit

FWA AND FWB SF UNITS

3.02 The envelope delay distortion present in the transmit and receive circuits of the FWA and FWB SF UNITS can be seen in Fig. 5.

3.03 On certain E signaling system applications, repeating coils are required between the 4-wire side of the SF unit and the carrier terminals MOD IN port. Improvements have been made in the performance of the FWA SF units which has eliminated the need of the coils.

3.04 The transmit circuit consists of a straight through connection with transformer T5 bridged across it. Contacts of the CT relay are also in the path and control the closure of the T and R leads in the idle and talking conditions. During dialing the CT relay operates and terminates the line and drop facilities with 600 ohms. There is only a negligible amount of loss in the transmit path (excluding the P-pads) of the FWA and FWB SF units. The approximate loss values in the voice frequency range is shown in Fig. 6. Since the loss is negligible, no amplification is required in the transmit circuit.

FWC SF UNITS

3.05 The envelope delay distortion present in the transmit and receive circuits of the FWC unit can be seen in Fig. 5. On the transmit curve from 1000 Hz and up, there is practically no distortion. Between 400 and 1000 Hz, the distortion does not exceed 20 microseconds. On the receive curve the distortion remains below 10 microseconds on frequencies above 1000 Hz.

3.06 The transmit circuit input and output leads of the FWC unit are coupled together by transformers T2 and T3. There is an operational amplifier between the two transformers, which provides sufficient gain to make up all the losses in the circuit. The operational amplifier controls the closure of the T and R leads cut. There is an impedance at the LINE TRMT and EQPT TRMT terminals of 600 ohms. These 600 ohm impedances enable the FWC unit to meet return loss requirements.

The transmit circuits also contain logic gates and timer circuits, which are controlled by the M lead input status. The logic gates and timer circuits control the gain of the operational amplifiers in the voice frequency and 2600 Hz tone injection paths. The approximate loss values in the voice frequency range is shown in Fig. 6.◀

B. Receiving Circuit

▶FWA AND FWB SF UNITS◀

3.07 The transmission path through the receive circuit is via input transformer T1, an input buffer amplifier, a 2 dB pad, an output amplifier and output transformer T2. A band-elimination filter is also bridged across the receiving circuit transmission path. The output level of the transmission path in the receiving circuit is within 0.4 dB of the input signal level between 300 and 3000 Hz. The variation between input and output levels in the voice frequency range with the band elimination filter in and out of the circuit is demonstrated in Fig. 7 and 8.

Note: The sharp drop-off between 2200 and 2800 Hz in Fig. 6 is due to the band-elimination filter. Insertion of the filter prevents spillover of the SF tone into succeeding signaling links or to customer stations.

3.08 Voice frequencies entering the receive circuit are dropped 2 dB before passing to the input buffer amplifier. The 2 dB drop guards the input buffer amplifier against peak voice currents. The input buffer amplifier is of the emitter-follower type of transistor configuration. It serves as an impedance buffer. The voice frequencies from the input buffer amplifier pass through the band-elimination filter and a resistor where they are dropped another 7 dB before entering an output amplifier. The output amplifier is of the hybrid feedback variety. It provides the receive circuit with 9 dB of gain with an output impedance of 600 ohms.

3.09 The harmonic distortion performance of the voice path is illustrated in Fig. 9. Most of the distortion is in the second harmonic frequency range. It can be concluded that signals entering the receive circuit below approximately +14 dBm will have a total harmonic distortion of less than 55 dB. Internal noise of the receive circuit, which includes battery noise, is below 20 dBrc0.

3.10 The FWA and FWB SF units provide high return loss and longitudinal balance characteristics. On signals between 250 and 4000 Hz being applied at the input, return loss measurements when compared to 600 ohms exceed 30 dB and there is a minimum of 65 dB of longitudinal balance. On the output, there is a minimum of 60 dB of longitudinal balance between frequencies of 200 to 3000-Hz.

3.11 The band-elimination filter is switched in the receive circuit under control of the H and R relays. With H and/or R relays operated the band-elimination filter is connected to the output amplifier stage. When both H and R relays are released, an idle path termination is provided. When no signal tone is being received, the H and R relays are released and the band-elimination filter is out of the circuit. When 2600 Hz tone is received, the H relay operates first cutting the band-elimination filter into the circuit. After a short period of time, the R relay operates and establishes a redundant path through the SF tone filter. The redundant path will remain until the H relay releases. When tone is removed, the R relay releases and the band-elimination filter is removed from the transmission path. The band-elimination filter blocks the tone toward the drop. On multilink connections, the SF tone signals are effectively confined to one link. There is an improvement of between 3:1 and 4:1 against talk-off over similar SF units in other in-band signaling systems.

▶FWC SF UNIT

3.12 The voice frequency path of the FWC unit is comprised of an input operational amplifier (op amp) and an output op amp, which drives a unity turns ratio transformer. The two op amp are connected by either a direct resistive path or through a band elimination filter (BEF) and buffer/phase inversion amplifier. In Fig. 5 the sharp drop-off between 2200- and 2800-Hz is due to the band elimination filter. The output level of the receiving circuits is within 0.4 dB of the input level between 300 and 3000 Hz. Figures 6 and 7 illustrate the variations between input and output levels of the voice frequency range with the BEF in and out of the circuit.

3.13 The receiver circuit contains a balanced 600 ohm load between the input operational amplifier and the LINE RECEIVE terminals. The balanced 600 ohm load is made up of two voltage

divider circuits. These voltage dividers protect the inputs of the operational amplifier against short circuits to the -48V dc battery and from common mode input signals. There is also a band elimination filter, a buffer/phase inversion amplifier, and an output amplifier. The output amplifier has sufficient gain to result in an overall gain of unity. The output amplifier is driven by either the input amplifier or the filter buffer amplifier. These two signal sources are cut in by the operation of the F relay. The output operational amplifier is transformer coupled to the EQPT RCV terminals and will provide +17 dBm power into a 600 ohm load.

3.14 The band elimination filter is switched in the receive circuit under control of the F relay. When the F relay operates, the band elimination filter and buffer amplifier are connected to the output operational amplifier stage. The F relay operates in approximately 10 ms when 2600 Hz tone is detected. With the F relay operated, the direct signal path from the input amplifier stage is grounded, blocking any signal transmission to the output. On multilink connections, SF tone signals are effectively confined to one link. With no tone present, the F relay de-energizes providing an idle path termination.◆

4. SIGNALING UNIT OPERATION

4.01 The following references may be helpful in discussing the FWA, FWB, or ◆FWC◆ SF unit operation.

- (1) Table B—Lists conditions of E and M leads under operating conditions. The affect of a condition on the M lead at one end of the trunk can be seen on the E lead at the other end of the trunk.
- (2) Tables C ◆and D◆ —Lists conditions of transmitting and receiving circuits related to changes in 2600-Hz tone.
- (3) Fig. 10—Simplified schematic of the transmitting and receiving circuits of FWA or FWB SF units.
- (4) ◆Fig. 11—Simplified schematic of the transmitting and receiving circuits of the FWC SF units.◆

In the idle condition both ends of the trunk are ON-HOOK, and 2600-Hz tone is transmitted toward the line facility in both directions. The operation described for MF also applies to DP applications. The removal of tone as an equipment ready (wink) signal may or may not apply to DP applications depending upon connecting equipment.

A. MF Operation—Transmitting

◆FWA AND FWB SF UNITS◆

4.02 When MF signals are to be transmitted, a dc signal (battery) is put on the M lead to the FWA or FWB SF Unit. This signal is received at the SF units M timing circuit. The normally operated M and CT relays release. When the M relay releases, it removes the 2600-Hz tone from the line facility in the transmit direction. The CT relay releases after a time delay and cuts the transmission path through to the line facility. MF signals can now be passed through the transmit path of the SF unit.

◆FWC SF UNIT

4.03 When MF signals are to be transmitted, a dc signal (battery) is put on the M lead to the FWC SF unit. This dc signal controls the logic circuits which consist of an off-hook timer, an on-hook timer and a tone gate. When the battery (off-hook) is applied to the M lead, the gain of the tone gate operational amplifier is reduced, cutting off the 2600 Hz tone. This dc signal on the M lead also causes the gain of the voice frequency path operational amplifier to increase after a delay of 130 ms. MF signals can now be passed through the transmit path of the SF unit. When the dc signal (battery) is removed (on-hook), the gain of the tone gate operational amplifier increases and the voice frequency operational amplifier gain decreases causing the voice frequency path to be effectively open and put the 2600 Hz back on line.◆

B. MF Operation—Receiving

◆FWA, FWB, AND FWC SF UNITS◆

4.04 When the 2600-Hz tone is removed from the line facility for a period of at least 33 ms (50 ms for FWC) by the transmitter at the distant end, the normally operated (released for FWC) R relay in the near-end receiver releases

◆(operates for FWC).◆ Release of the R relay provides a dc signal ground on the E lead which indicates a seizure to the trunk circuit. The trunk circuit responds to the E lead ground by returning a battery signal on the M lead for a brief interval. Battery on the M lead causes 2600-Hz tone to be removed toward the originating end as a signal that the terminating trunk equipment is attached. This signal is only for a brief interval and then 2600-Hz tone is again transmitted toward the originating end. The receiving circuit is now ready to receive MF signals. The MF signals pass through the voice path and on to the attached trunk equipment.

C. DP Operation—Transmitting

◆FWA AND FWB SF UNITS◆

4.05 The FWA and FWB transmit circuit can be divided into four basic parts: (1) the M lead timing circuit, (2) the tone gate circuit, (3) the CT relay cut control circuit and (4) the transmission circuit. The M lead timing circuit is triggered by the change from a ground or open to a battery signal on the M lead. The battery on the M lead causes the normally operated M and CT relays to release. The M relay released, removes the low level 2600-Hz tone towards the line in the transmit direction. When the battery and ground or open pulses on the M lead are initiated, the CT relay reoperates and terminates the line and drop with 600 ohms during pulsing. The CT relay controls a precut circuit which guards the SF unit against noise from entering the transmission path. When there is a delay in pulsing of at least 125 milliseconds (interdigital timing or end of dialing) the CT relay releases. The battery and ground pulses on the M lead are presented to the M timing circuit for control of the M relay. Contacts of the M relay open and close a gate circuit that supplies 2600 Hz of high level tone pulses to the line. At the end of dialing, the M and CT relays release and the voice transmission path is cut through. Transmit pads (P-pads) may be inserted into the transmit voice path if additional loss is required.

D. DP Operation—Receiving

◆FWA SF Units Only◆

4.06 The FWA SF receiving circuit can functionally be divided into three circuits: (1) the signal and guard detector circuit, (2) the signal timing

circuit, and (3) the voice transmission circuit. In the idle condition 2600-Hz tone is present at the FWA SF unit receive circuit. The presence of the tone results in the operation of the H and R relays. After a time delay, the H relay releases. When the originating end removed the tone (seizure), the R relay releases. The receive circuit is now ready to receive tone pulses. The 2600-Hz tone pulses that are transmitted over the line facility are received at the SF receiving circuit. The tone pulses are first presented to signal and guard detector circuits. The tone pulses pass through a band pass filter, are amplified, and then rectified before passing on to a dc comparator. The comparator recognizes a positive or turn-on signal from the signal amplifier and rectifier circuit and switches the now dc pulses to the signal timing circuit. Also when 2600 Hz tone is present, the R relay is operated and the H relay is released. During this condition, the circuit path between the guard channel and comparator is open (broadbanding function). The broadbanding condition is invoked for long duration signals such as start dial or free call condition. The broadbanding eliminates the possibility of false release of the receiver by noise or speech interference. Signals or speech other than 2600-Hz are blocked by the band pass filter and routed through a guard amplifier and rectifier circuit. This would send a negative or turnoff signal to the comparator which would close its gate and block the dc signals from entering the signal timing circuit. Signals passed into the signal timing circuit are presented to operate and release timers for pulse timing. The signals ultimately drive the R relay. The R relay which is a normally operated relay, releases on the absence of the 2600-Hz tone. Contacts of the R relay provide for E lead control. When the R relay is operated the E lead is open, and when the R relay releases, it grounds the E lead. Separate from the operate and release timers is the H relay control circuit. Its function is to insert a band eliminating filter into the transmission path of the receive circuit during pulsing. The H relay is a slow releasing relay and remains operated during pulsing. A narrowband condition exists during the off-hook state and also during pulsing, as the H relay is slow to release. This narrow banding reduces false operation by speech simulated signals when in the talking mode. The H relay releases again during the interdigital timing period or end of dialing. At the end of dialing the H and R relays are both released and the band-elimination filter circuit is open. The voice frequencies go through two amplifier stages. The

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first stage provides no gain, but provides for impedance matching. The output amplifying stage matches impedance and provides sufficient gain for zero insertion loss of voice frequencies. Receive pads may be inserted into the receive transmission path if circuit design requires loss.

E. Supervision

◆FWA AND FWB SF Units◆

4.07 When the called end answers the call, battery is put on the M lead towards its associated SF unit. The battery signal releases the M relay which in turn operates the CT relay. The CT relay releases after a time interval. The releasing M relay causes the idle 2600-Hz tone to be removed from the SF units transmitting circuit, and the CT relay releasing cuts through the transmission path. Loss of the 2600-Hz tone releases the normally operated R relay. The R relay released, grounds the E lead and signals the trunk equipment of an answered call. (See Table B.)

◆FWC SF UNITS

4.08 When the called end answers the call (off-hook), battery is put on the M lead towards its associated SF unit. The battery signal on the M lead causes the gain of the tone gate operational amplifier to be reduced and the gain of the operational amplifier in the voice frequency

path to increase. Reduction of the gain of the tone gate operational amplifier causes the 2600 Hz tone to be removed from the SF units transmitting circuits. Loss of the 2600 Hz tone releases the normally operated R relay. When the R relay releases, ground is applied to the E lead, which signals the trunk equipment of an answered call. (See Table B.)◆

5. MAINTENANCE

5.01 There are no field adjustments provided on the FWA, FWB, and ◆FWC◆ SF units (excluding the P-pads). SF units not meeting circuit requirements should be sent to Western Electric Company for repair. Defective units should be replaced with spare units.

5.02 The F-Type Test Extender SD-1C241-01 is provided to gain access to the transmission and signaling ports. Use of the test extender will necessitate the removal of the SF units from the bay. The test extender provides jack and key access to all transmission and signaling ports of the SF units.

5.03 Descriptive or test practices on other related components within the type F signaling system can be found under individual component headings in the Bell System Practices Index 179-000-000.

◆TABLE A◆

COMPATIBILITY OF FWA, FWB AND FWC SF UNITS

TYPE OF ADDRESS SIGNALS		LOCATION OF FWA, FWB OR FWC SF UNIT	OTHER SF UNIT														
			FWA	FWB	FWC	E1AK E1BK	E1AKD E1BKD	E2BK E3BK	E2BKA E3BKA E4B	E1CK E1CKB	E2C	E3C	E4C	E1DK E1DKC	E2D E4D E5D	E3D	E1J
FWA	DP	Originating	✓	No	No	✓	✓	✓	✓	No	No	No	No	No	C2	No	No
		Terminating	✓	✓	No	No	C3	C1	✓	No	✓	No	✓	No	No	No	No
	MF	Originating	✓	✓	✓	✓	✓	✓	✓	No	No	No	No	No	C2	✓	✓
		Terminating	✓	✓	✓	✓	✓	✓	✓	✓	No	✓	✓	No	No	No	✓
FWB	DP	Originating	✓	No	No	✓	✓	✓	✓	No	No	No	No	No	C2	No	No
		Terminating	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
	MF	Originating	✓	✓	✓	✓	✓	✓	✓	No	No	No	No	No	C2	✓	✓
		Terminating	✓	✓	✓	✓	✓	✓	✓	✓	No	✓	✓	No	No	No	✓
FWC	DP	Originating	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
		Terminating	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
	MF	Originating	✓	✓	✓	✓	✓	✓	✓	No	No	No	No	No	C2	✓	✓
		Terminating	✓	✓	✓	✓	✓	✓	✓	✓	No	✓	✓	No	No	No	✓

Note 1: E & M units generally require M lead pulse correctors per SD-99766-01 for non-senderized dial pulsing. For particulars see Compatibility Drawing SD-99421-01 (179-100-306).

Note 2: The FWB unit can be used interchangeably with the E1J unit on Autovon Trunks.

Note 3: The E1J units are to be used only on a stock-pile basis. *Do not* order E1J units to use with FWA units.

Legend:

✓—Compatible No—Not Compatible

C1—Compatible except when originating unit is in a Crossbar Tandem or No. 5 Crossbar and other end is a Step by Step.

C2—Compatible when terminating unit is associated with long disconnect time trunk.

C3—Transmission path cut circuit, SD-99778-01 shall be used when these units are at the originating end of dial pulse circuits.

TABLE B

SF SIGNALS USED IN E AND M LEAD SIGNALING

ORIGINATING END				TERMINATING END			
SIGNAL OR STATE	M LEAD	E LEAD	SF TONE	SF TONE	E LEAD	M LEAD	SIGNAL OR STATE
Idle	Ground	Open	On	On	Open	Ground	Idle
Connect (Note 1)	Batt	Open	Off	On	Ground	Ground	Connect
Stop Dialing	Batt	Ground	Off	Off	Ground	Batt	Stop Dialing (Note 1)
Start Dialing	Batt	Open	Off	On	Ground	Ground	Start Dialing (Note 1)
Dial Pulsing (Note 1 & 2)	Ground Batt	Open	On Off	On	Open Ground	Ground	Dial Pulsing
Off-Hook	Batt	Ground	Off	Off	Ground	Batt	Off-Hook (Note 1) (Answer)
Ring Forward (Note 1)	Ground Batt	Ground	On Off	Off	Open Ground	Batt	Ring Forward
Ringback	Batt	Open Ground	Off	On Off	Ground	Ground Batt	Ringback (Note 1)
Flashing	Batt	Open Ground	Off	On Off	Ground	Ground Batt	Flashing
On-Hook (Note 3)	Batt	Open	Off	On	Ground	Ground	On-Hook (Note 1 & 3)
Disconnect (Note 1)	Ground	Open	On	On	Open	Ground	Disconnect

Note 1: Terminal originating signal.

Note 2: Dial Pulsing does not apply to FWB and FWC units.

Note 3: When Type II interface is used, the on-hook M lead state is open rather than ground.

TABLE C
TYPES FWA AND FWB SF SIGNALING UNITS
CONDITION OF TRANSMITTING AND RECEIVING SPEECH PATHS RELATED TO CIRCUIT AND SIGNAL TONE CONDITIONS
(REFERENCES ARE TO SF UNIT AT NEAR END)

CIRCUIT CONDITION	SIGNAL TONE CONDITION		CONDITION OF TRANSMITTING SPEECH PATH			RECEIVING SPEECH PATH BANDSTOP FILTER
	OUTGOING	INCOMING	BEFORE	CHANGE	AFTER	
1. Idle	On	On	Cut	—	Cut	In circuit
2. Near End Seized	On-Off Transition	On	Cut	Stays cut additional 125±50 MS	Not Cut	In circuit
3. Far End Returns "Delay" Signal	Off	On-Off Transition	Not Cut	—	Not Cut	Switched out after 50±5 MS
4. Far End Returns "Start" Signal	Off	Off-On Transition	Not Cut	—	Not Cut	Switched in after 13±8 MS
5. Near End Dial Pulsing	Off-On Transition, Then On-Off, Off-On, Etc., Ending with On-Off Transition	On	Not Cut	Precut 8±7 MS, remains cut as long as outgoing on-off transitions are less than 125±50 MS apart. Remains cut 125±50 MS after last outgoing on-off transition	Not Cut	In circuit
6a. Far End Answers—Free Call	Off	On	Not Cut	—	Not Cut	In circuit
6b. Far End Answers—Pay Call	Off	On-Off Transition	Not Cut	—	Not Cut	Switched out after 50±5 MS
7. Talking—Pay Call	Off	Off	Not Cut	—	Not Cut	Out of circuit
8. Near End Hangs Up First	Off-On Transition	Off	Not Cut	Precut 8±7 MS, then cut 625±150 MS	Not Cut	Out of circuit
9. Far End Hangs Up Later	On	Off-On Transition	Not Cut	Cut within 9±4 MS	Cut	Switched in after 13±8 MS
10. Far End Seized	On	On-Off Transition	Cut	Stays cut additional 625±150 MS	Not Cut	Switched out after 50±5 MS
11. Near End Returns "Delay" Signal	On-Off Transition	Off	Not Cut	Cut 125±50 MS	Not Cut	Out of circuit
12. Near End Returns "Start" Signal	Off-On Transition	Off	Not Cut	Precut 8±7 MS, then cut 625±150 MS	Not Cut	Out of circuit
13. Far End Dial Pulsing	On	Off-On Transition, Then On-Off, Off-On, Etc., Ending with On-Off Transition	Not Cut	Cut within 9±4 MS, remains cut as long as incoming on-off transitions are less than 625±150 MS apart. Remains cut 625±150 MS after last incoming on-off transition	Not Cut	Switched in after 13±8 MS. Remains in circuit until 50±5 MS after last incoming on-off transition.
14a. Near End Answers—Free Call	On	Off	Not Cut	—	Not Cut	Out of circuit
14b. Near End Answers—Pay Call	On-Off Transition	Off	Not Cut	Cut 125±50 MS	Not Cut	Out of circuit
15. Talking—Pay Call	Off	Off	Not Cut	—	Not Cut	Out of circuit
16. Far End Hangs Up First	Off	Off-On Transition	Not Cut	—	Not Cut	Switched in after 13±8 MS
17. Near End Hangs Up Later	Off-On Transition	On	Not Cut	Precut 8±7 MS, then cut	Cut	In circuit
18. Idle	On	On	Cut	—	Cut	In circuit

TABLE D
TYPE FWC SF SIGNALING UNIT
CONDITION OF TRANSMITTING AND RECEIVING SPEECH PATHS RELATED TO CIRCUIT AND
SIGNAL TONE CONDITIONS (REFERENCES ARE TO SF UNIT AT NEAR END)

CIRCUIT CONDITION	SIGNAL TONE CONDITION		CONDITION OF TRANSMITTING SPEECH PATH			RECEIVING SPEECH PATH BANDSTOP FILTER
	OUTGOING	INCOMING	BEFORE	CHANGE	AFTER	
1. Idle	On	On	Cut	—	Cut	In circuit
2. Near End Seized	On-Off Transition	On	Cut	Stays cut for additional 130 ± 50ms	Not Cut	In circuit
3. Far End Returns "Delay" Signal	Off	On-Off Transition	Not Cut	—	Not Cut	Switched out after 200 ± 50 MS
4. Far End Returns "Start" Signal	Off	Off-On Transition	Not Cut	—	Not Cut	Switched in after 13 ± 8 MS
5a. Far End Answers— Free Call	Off	On	Not Cut	—	Not Cut	In circuit
5b. Far End Answers— Pay Call	Off	On-Off Transition	Not Cut	—	Not Cut	Switched out after 200 ± 50 MS
6. Talking—Pay Call	Off	Off	Not Cut	—	Not Cut	Out of circuit
7. Near End Hangs Up First	Off-On Transition	Off	Not Cut	Cut for 400 ± 50 MS	Not Cut	Out of circuit
8. Far End Hangs Up Later	On	Off-On Transition	Not Cut	Cut within 50 ± 5 MS	Cut	Switched in after 13 ± 8 MS
9. Far End Seized	On	On-Off Transition	Cut	Stays cut additional 50 ± 5 MS	Not Cut	Switched out after 200 ± 50 MS
10. Near End Returns "Delay" Signal	On-Off Transition	Off	Not Cut	Cut for 130 ± 50 MS	Not Cut	Out of circuit
11. Near End Returns "Start" Signal	Off-On Transition	Off	Not Cut	Cut for 400 ± 50 MS	Not Cut	Out of circuit
12a. Near End Answers —Free Call	On	Off	Not Cut	—	Not Cut	Out of circuit
12b. Near End Answers —Pay Call	On-Off Transition	Off	Not Cut	Cut for 130 ± 50 MS	Not Cut	Out of circuit
13. Talking—Pay Call	Off	Off	Not Cut	—	Not Cut	Out of circuit
14. Far End Hangs Up First	Off	Off-On Transition	Not Cut	—	Not Cut	Switched in after 13 ± 8 MS
15. Near End Hangs Up Later	Off-On Transition	On	Not Cut	Cut	Cut	In circuit
16. Idle	On	On	Cut	—	Cut	In circuit

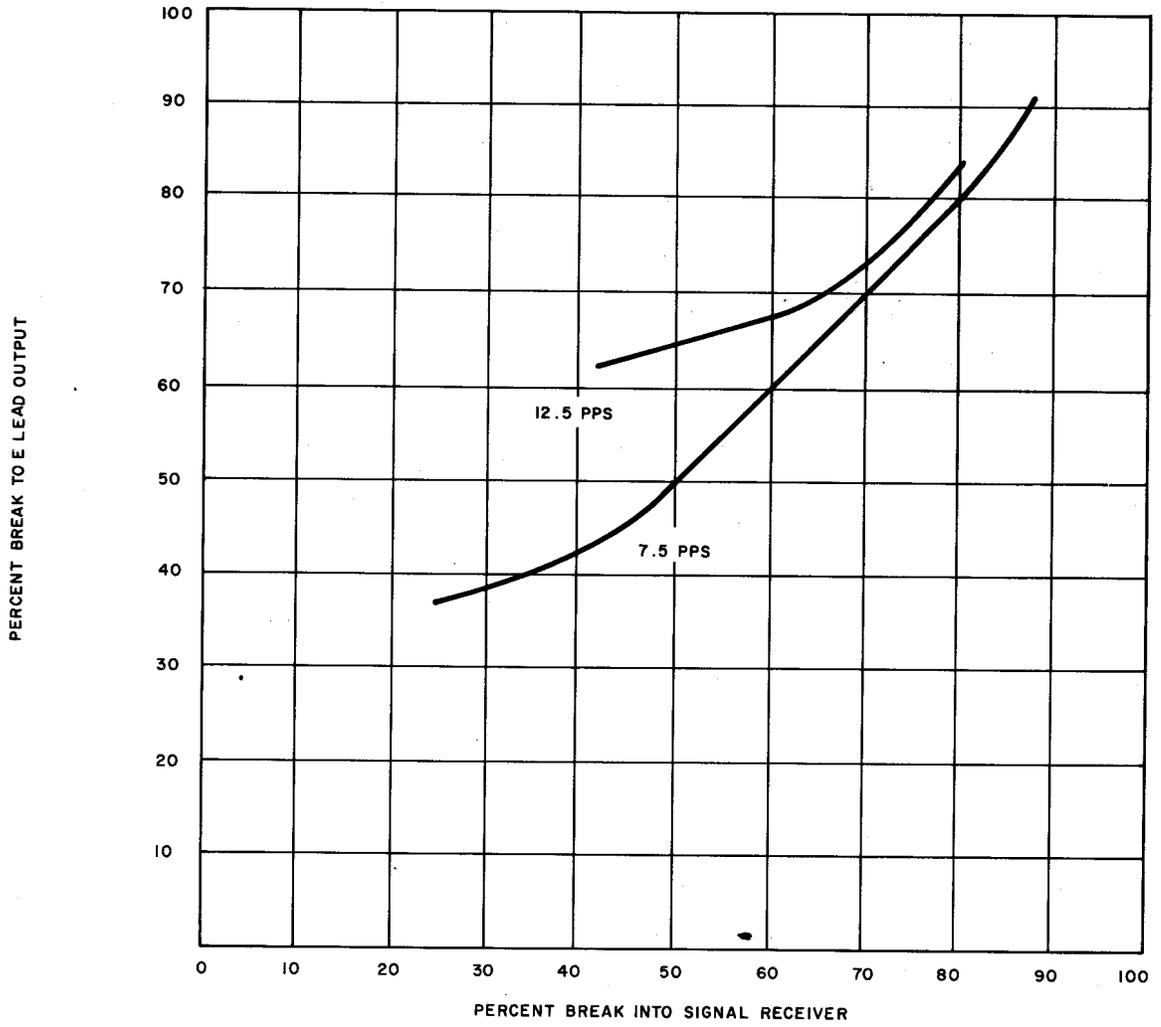


Fig. 4—Receiver Pulse Correction (FWA SF UNITS ONLY)

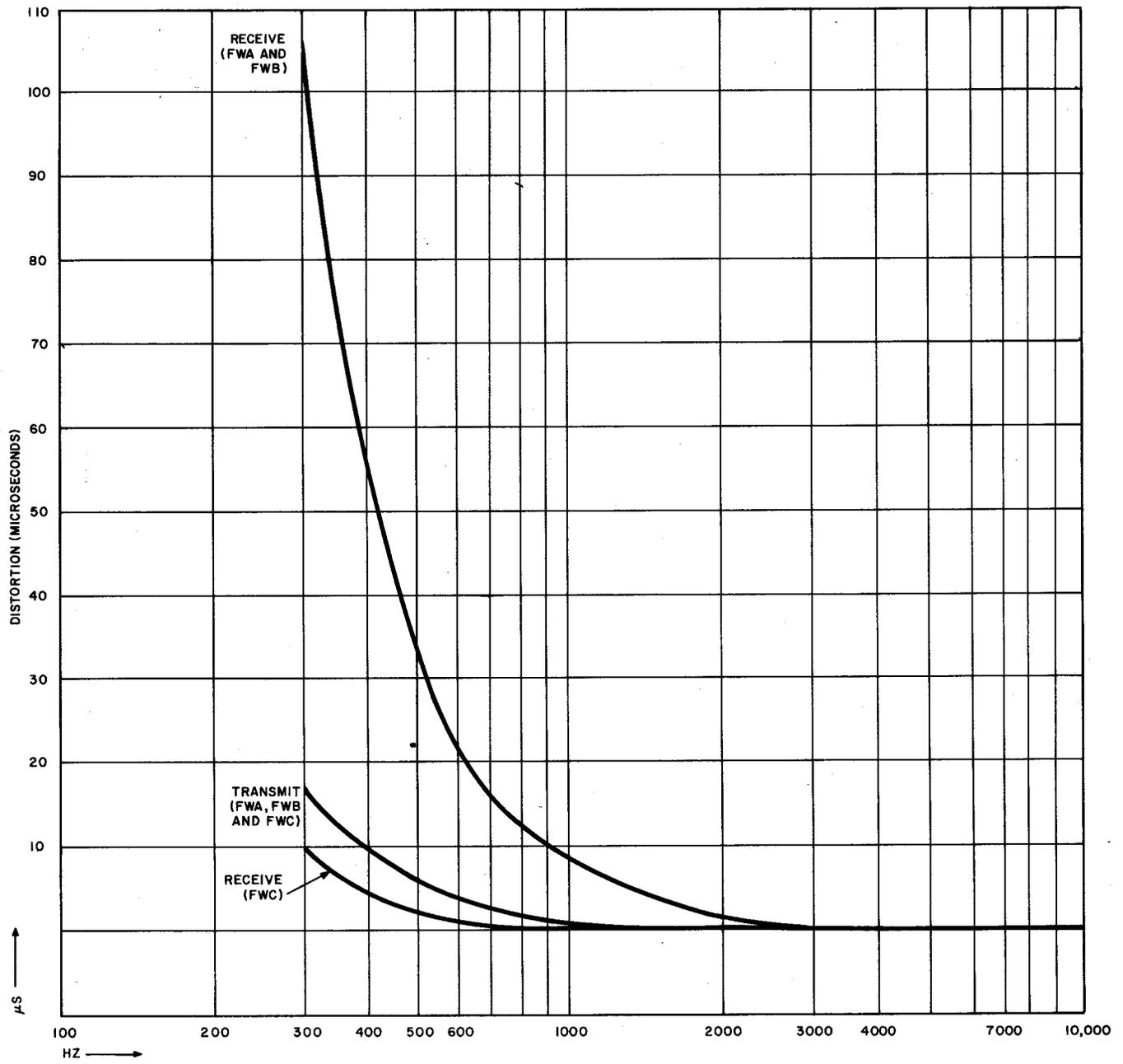


Fig. 5—Delay Envelope Distortion

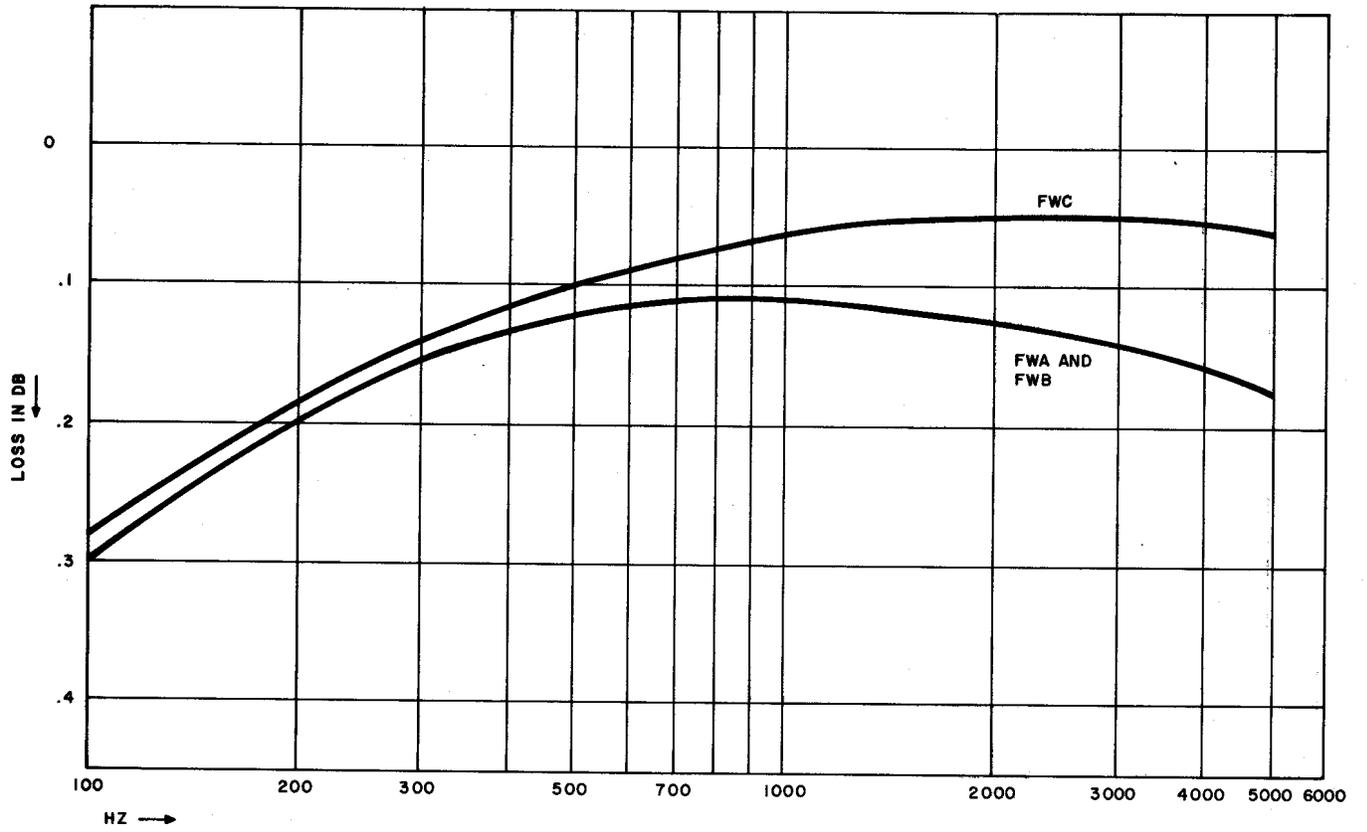


Fig. 6—Transmit Circuit Insertion Loss

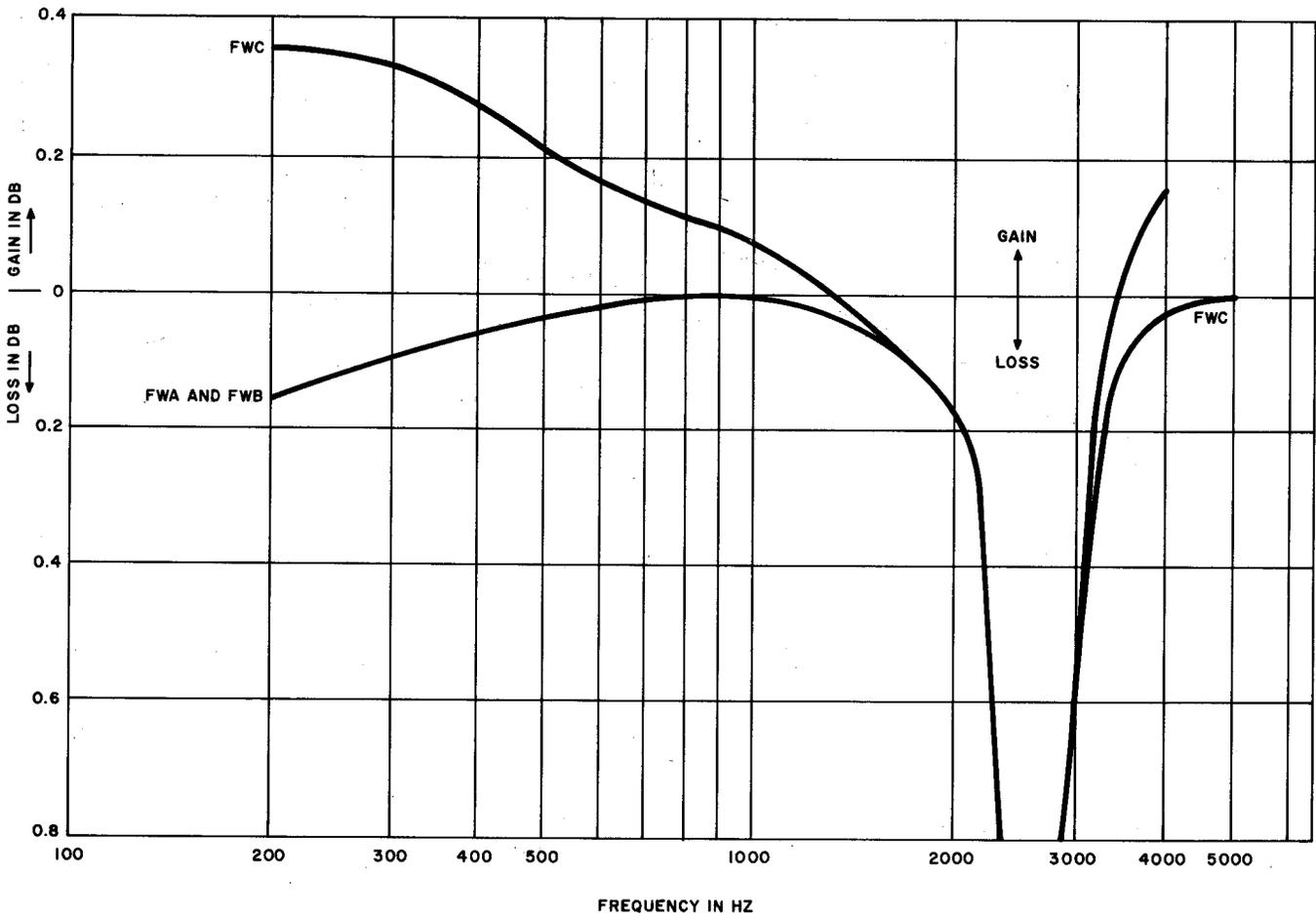


Fig. 7—Receive Circuit Insertion With Band Elimination Filter

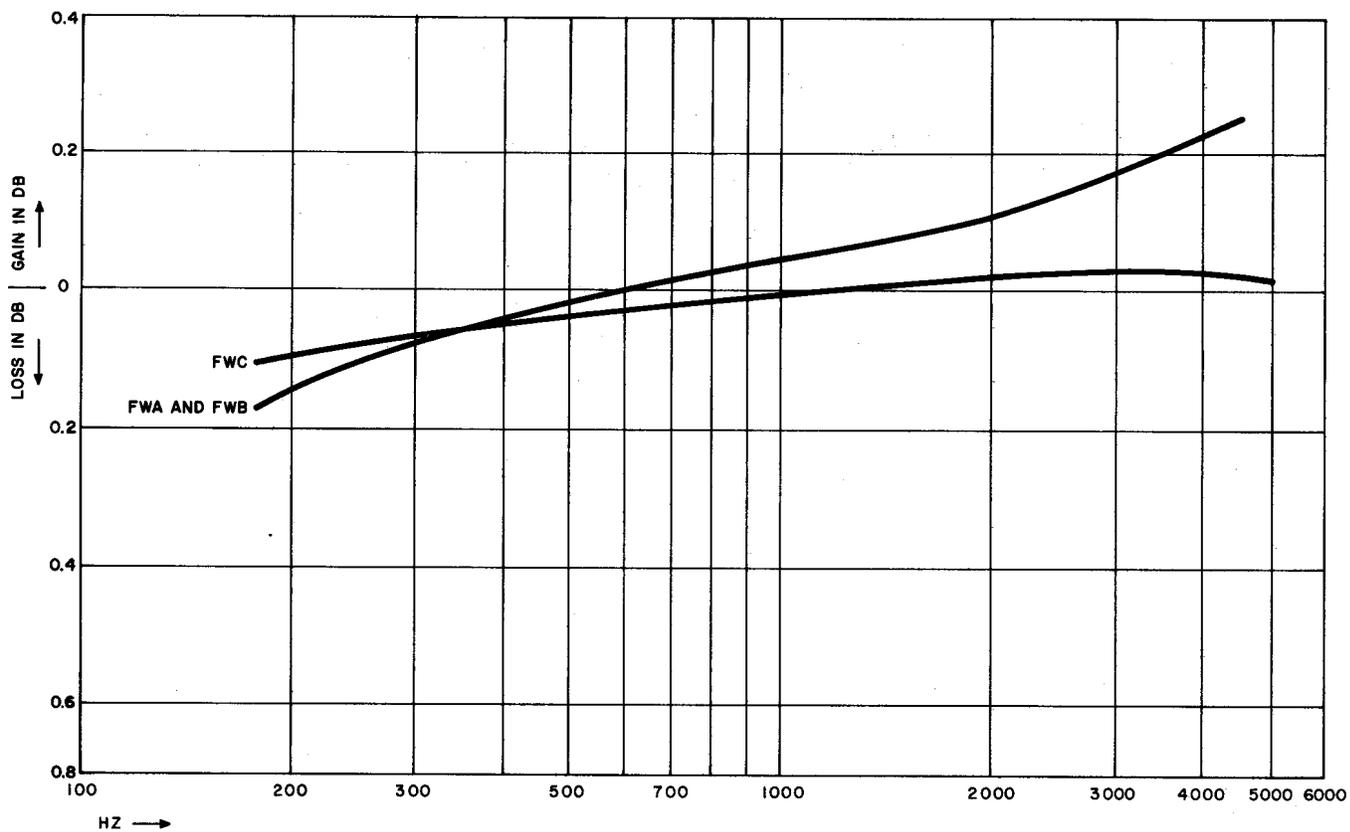


Fig. 8—Receive Circuit Insertion With Band Elimination Filter Out

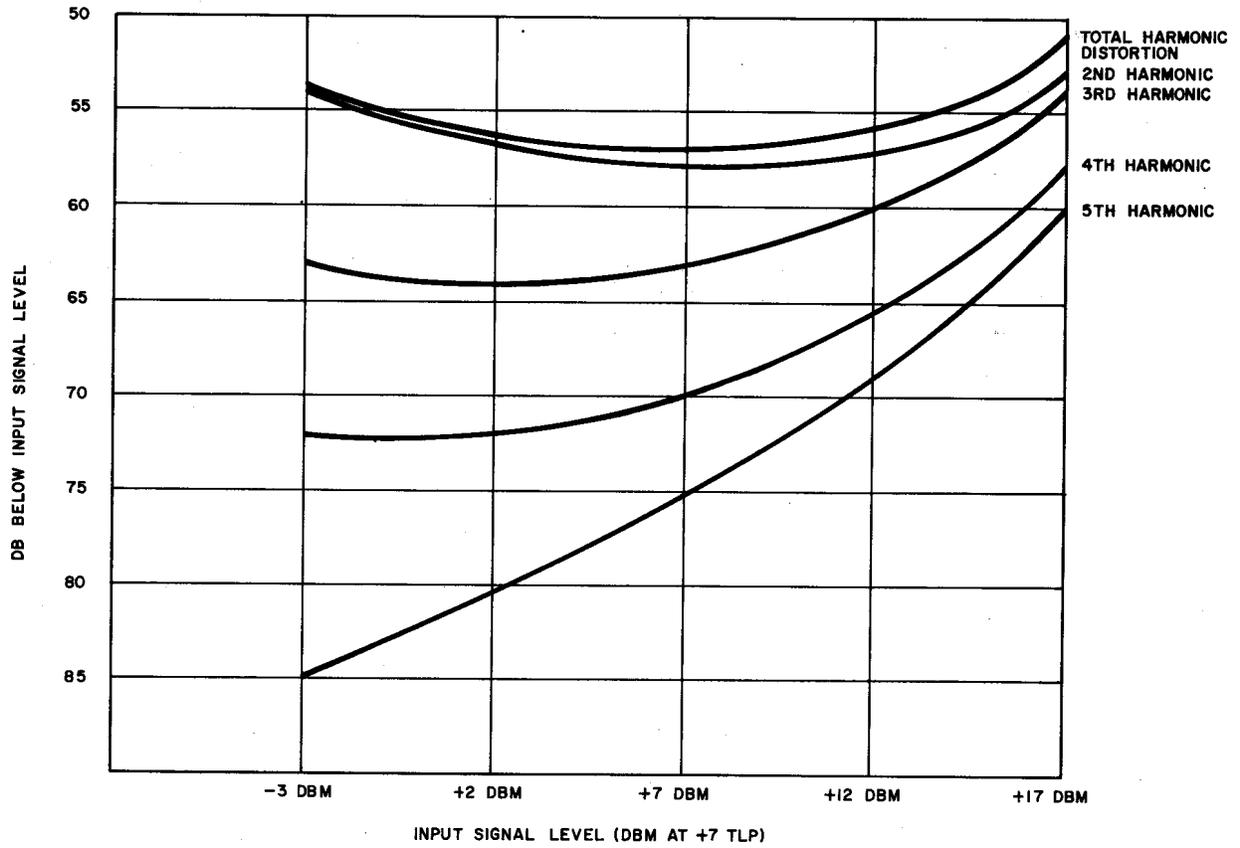


Fig. 9—Receive Harmonic Distortion Affect (FWA and FWB SF Units Only)

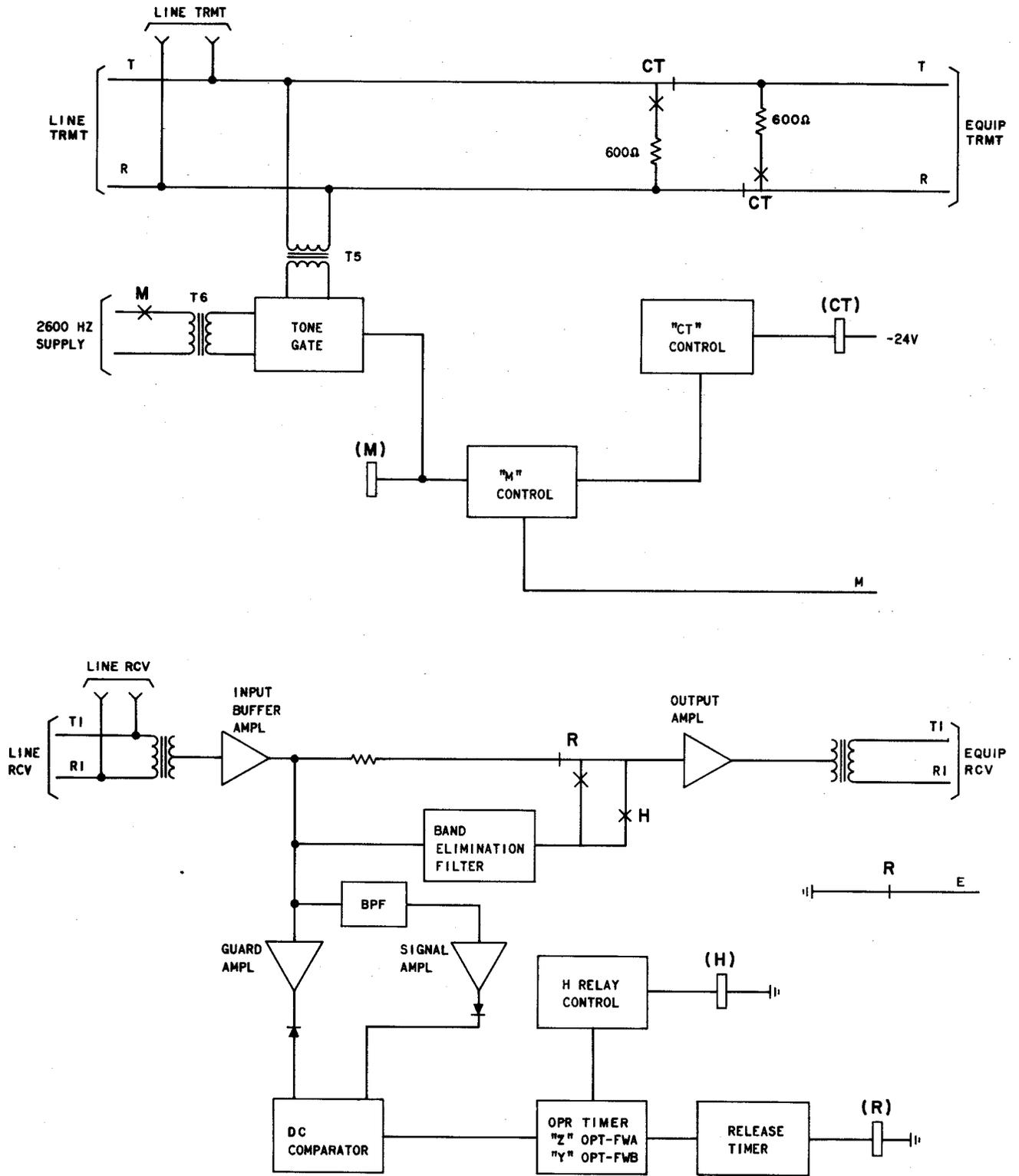


Fig. 10 → FWA and FWB Units ←

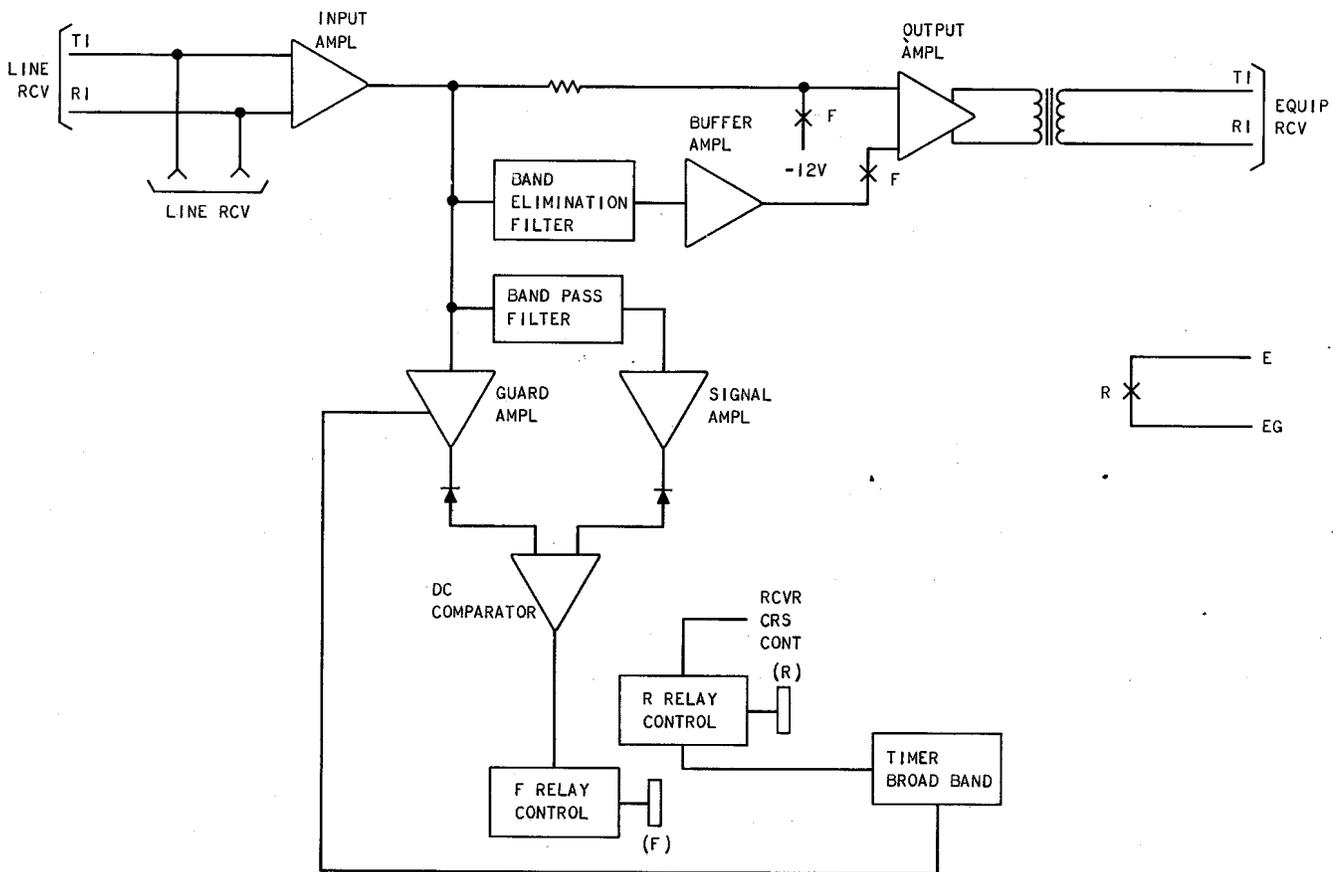
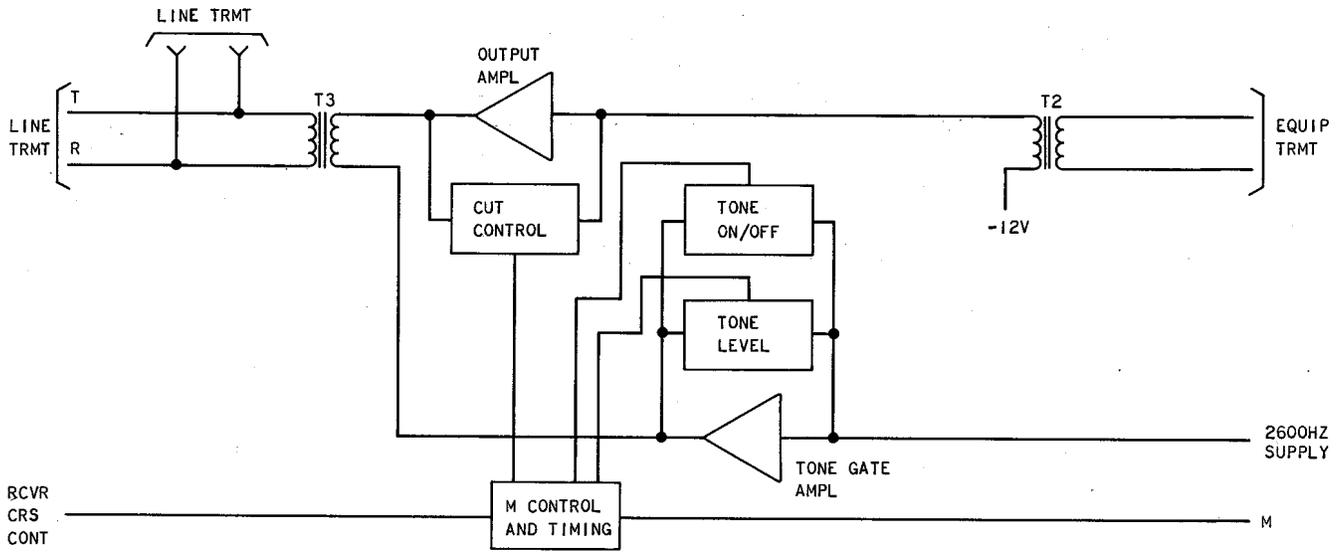


Fig. 11—FWC SF Units