ELECTRONIC SWITCHING SYSTEMS
COMMON
MF RECEIVER
CIRCUIT

CHANGES

B. Changes in Apparatus

B.1 Added

100J Varistor (RV1)
Option P
App Fig. 1

D. Description of Changes

D.1 Option P was added to limit transient signals.

D.2 Option Q has been rated Manufacture Discontinued.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 55556-EHS

WE DEPT 55117-GJS-TEP

ELECTRONIC SWITCHING SYSTEMS
COMMON
MF RECEIVER
CIRCUIT

CHANGES

D. Description of Changes

D.1 The terminal numbering of the power-off key has been corrected to agree with the manufactured product.

D.2 CLEI information has been added.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 55327-JCM

WECO DEPT 57217-GJS-TEP

ELECTRONIC SWITCHING SYSTEMS

COMMON

MF RECEIVER CIRCUIT

TABLE OF CONTENTS

SECTION I - GENERAL DESCRIPTION

1. PURPOSE OF CIRCUIT

1.01 This circuit receives voiceband multifrequency (MF) signals from operator key sets or senders in distant offices, recognizes what frequencies are present, and converts the signaling frequencies into dc signals suitable for operating associated scan points.

1.02 In addition to receiving MF signaling information, this circuit offers a high degree of protection against false operation by voice frequency components contained in speech or noise picked up by the operator transmitter or coupled into the transmission facility as crosstalk.

1.03 This circuit transmits a wink signal, a tip-ring battery reversal, which when terminated, informs the distant office to start pulsing. It also supervises loop trunks while sending the wink signal, and while receiving digits. In addition, it tests many of its components while the wink signal is being sent. The tip-ring path can be opened and closed by this circuit to keep the trunk link network from having to make or break current. A very high return loss in the voice-frequency band is presented to the transmission facility.

1.04 When this circuit is equipped with the signaling irregularities (SIGI) feature, an A1278 circuit pack is provided which provides an operational amplifier in the tip and ring circuitry in order to supply a high input impedance toward the trunk switching network. With option R (SIGI), this circuit does not provide a wink signal during its normal call sequencing or any supervision toward trunk circuits, since it is bridged onto existing talking connections by the no-test verticals and must not produce any noticeable disturbances.

2. GENERAL DESCRIPTION OF OPERATION

2.01 MF signaling uses one group of six frequencies in the speech band; a valid signal consists of exactly two of these frequencies. The signaling code is known as the two-out-of-six code. There are 15 valid combinations which can be used as digits (to identify called customer directory numbers) or other signals.

2.02 In the reception of MF signals, the receiver is first connected to the trunk via the trunk link network. A wink signal is returned to the distant office, and that office proceeds to transmit information in the two-out-of-six code. This procedure is for loop trunks. E&M trunks require a slightly different procedure.

2.03 In the actual receipt of MF signals, the two signaling frequencies are put through a variolosser (followed by an amplifier and driver) which adjusts the signal level to the proper value for

detection. The amplitude of one frequency relative to that of the other is unchanged. The driver applies the signal to six tuned circuits in parallel, two of which are excited. Detectors follow the tuned circuits to rectify the ac signal and amplify the resulting dc so that scan points in an associated scanner are activated.

2.04 To prevent momentary noise and speech signals from simulating digits, a signal must be present for a certain minimum period of time before it is recognized. A timer is started when an ac signal larger than a certain minimum value is received. If this signal does not persist for the whole interval, the timer is reset. If the ac signal persists until the timer times out and if two (or more) frequency detector outputs are active long enough to cause a second timer to time out, a seventh scan point is activated to indicate that a signal is present. Only when this signal present indication has been observed are the detector outputs scanned to obtain the digit. The detector outputs are not scanned again until the signal present scan point becomes inactive and changes to active again.

2.05 Certain types of noise can momentarily block a valid signal after it has been recognized. To prevent double registration of the same digit when the noise ceases to mask the incoming tones, a third timer holds the signal present scan point active for an interval after the incoming tones vanish. Thus, the signal present scan point bridges the noise interruption and does not initiate a new scan of the channel detectors.

2.06 Additional techniques, notably guard action, are used in the design of the MF receiver circuit to prevent noise from interfering with or simulating valid signals.

2.07 When this circuit is equipped with the SIGI feature, the preceding description of operation applies except that:

(a) No wink signal is generated since this circuit is bridged onto existing talking connections.

(b) A signal present indication by the seventh scan point would be generated with one or more MF frequencies present if the circuit is equipped with option Q.

SECTION II - DETAILED DESCRIPTION

1. SIGNALING CODE

1.01 The relation between digits and other signals and the MF signaling frequencies of the two-out-of-six code is shown in Table A.

TABLE A

MULTIFREQUENCY TWO-OUT-OF-SIX CODE

CPS	700	900	1100	1300	1500
900	1				
1100	2 CC	3			
1300	4	5	6		
1500	7	8	9	0	
1700	R	Spare	KP CR	Spar	ST

CC = Coin Collect
CR = Coin Return
R = Rering or Ringback
KP = Key Pulse
ST = Start

2. STATES OF CIRCUIT

2.01 This circuit has two magnetic latching relays, A and B. When these relays are operated and released by the signal distributor circuit, they can put this circuit into four different states. Each state can be defined by the particular magnetic latching relays operated and identified by the sum of the weighting numbers for each operated relay. Weighting numbers are assigned as follows:

A = 1
B = 2

2.02 Only one relay at a time can be operated or released by the signal distributor circuit. Thus, at any one time, any state digit can change by only 1 or 2.

2.03 Information Note 302 on the SD displays the circuit states pictorially. Crossing a vertical line in the diagram is equivalent to the operation or release of one relay by the signal distributor circuit.

2.04 In general, the circuit is placed in a given state by the signal distributor circuit under control of the program. The scanner circuit, again under program control, reports circuit conditions to the system control so that the proper decision can be made to select the next circuit state.

3. PURPOSE OF CIRCUIT COMPONENTS

3.01 An MF receiver circuit consists of 10 printed wire boards (11 printed wire boards when option R is provided), input transmission circuitry switched by two magnetic latching relays A and B, and a voltage divider to derive the required voltages for proper operation of the circuits on the printed wire boards. The voltage divider is made up of R1, R2, R3, R4, R5, R7, and R9. Because all operating potentials are proportional to the battery voltage, all potential changes are as well.

Thus, overall battery variations have little effect on receiver performance. Capacitors C1, C2, C3, C4, C9, and C10 smooth the output voltages from the divider. When provided, a power-off key removes battery from the circuit to permit printed wire board removal and testing. R8 limits current flowing in the power-off indicator lamp. The remainder of the circuit components are discussed in the order in which the signal passes through them.

3.02 The input transmission components are L, T, C5, C6, C7, and C8. Inductor L feeds battery to the trunk via scan point 1, the trunk supervisory scan point. Transformer T has very low capacity between its primary and secondary windings and provides a high degree of protection from longitudinal lightning surges to the following circuitry. Capacitors C5, C6, C7, and C8 charge quickly to provide protection against metallic surges. C5 and C6 also block dc out of the primary winding of T. When the entire combination is terminated by the variolosser on circuit pack A260, it presents a very high return loss to the incoming trunk.

3.03 Resistor R6 can be bridged from tip to ring to test the trunk supervisory scan point without connecting tip and ring to the trunk switching circuit.

3.04 The variolosser, part of circuit pack A260, provides a transmission path with controlled loss from the input transmission circuit components to the AGC amplifier. DC control current from the AGC amplifier changes the shunt impedance and the gain of the variolosser transmission path; this feedback ensures an almost constant steady-state ac signal at the variolosser output.

3.05 The time it takes for the feedback loop to operate and adjust the variolosser output level is called the attack time of the AGC system. For this receiver, the attack time is about 5 ms. If a high-level signal is received, it passes through the variolosser and produces an excessive input signal to the AGC amplifier until the feedback path reduces the variolosser gain.

3.06 When battery is reversed by the B relay to transmit the start-pulsing signal to the distant office, a transient is produced which has components in the voice frequendy range. Because of the high level of these frequency components and the short attack time of the AGC system, the variolosser might be put in a high-loss condition which would persist long enough to prevent detection of a low-level KP signal from the distant office. Thus, the inhibit amplifier, part of circuit pack A262, prevents the feedback path from functioning for about 20 ms after the B relay operates. By this time, the battery-reversal transients have died and can no longer affect the operation of the receiver.

3.07 The AGC amplifier, part of circuit pack A261, amplifies the signal supplied by the variolosser and supplies the amplified signal to the signal driver, guard driver, signal present timer, and rectifier in the variolosser which generates dc current to control the variolosser gain.

3.08 The MF guard driver, part of circuit pack A260, supplies a frequency-dependent dc bias to the MF channel detectors to prevent digit simulation. The MF guard filters, on circuit packs A262 and A263, short signaling frequencies out of the MF guard driver input. All other voice frequencies are amplified and rectified in the guard driver and used to produce the dc guard bias.

3.09 The signal driver, part of circuit pack A261, provides the power gain required to drive the MF channel filters on circuit packs A264 and A265. These filters are a parallel combination of series resonant circuits. Because of the low impedance such a configuration offers at signaling frequencies, the signal driver must be able to supply high ac current.

3.10 After the MF channel filters have separated the signaling frequencies, these freguencies are applied to the MF channel detectors on the A152 circuit packs. For a valid signal, two signal frequencies and no nonsignaling frequencies are present. Thus, the presence of suitable ac signals and the absence of guard bias at the MF channel detector inputs permit the appropriate channel detectors to respond and produce a rectified, filtered dc current suitable for operating scan points.

3.11 The MF signal present timer on circuit pack A266 is really three separate timers and an AND gate. The first timer is driven by the ac signal from the MF signal driver. If this input is active continuously for 20 ms, the timer times out and activates one input of the AND gate. The second timer is driven by dc outputs from the MF channel detectors. When two (or more) of the channel detector outputs are active continuously for 10 ms, the other input of the AND gate is activated and the SP timer drives its associated scan point. The third timer holds the scan point active for a fixed interval after either of the inputs from the signal driver or the channel filters become inactive.

3.12 The channel detectors saturate their associated scan points to produce 0 outputs when whey are actively indicating the presence of a signaling frequency. The SP timer unsaturates its scan point to produce a 1 output when it indicates a signal is present.

3.13 When this circuit is equipped with the SIGI feature, option R, the A1278 circuit pack provides a unity gain operational amplifier in the tip and ring circuitry in order to provide a high impedance appearance toward the trunk switching network. Since this circuit is bridged onto existing talking connections by the no-test verticals, the normal generation of wink signals and supervision toward the trunks are not provided within this circuit.

3.14 If this circuit is arranged with option Q, the signal present indication is generated when one or more MF frequencies are present. This option permits the reporting of single frequencies as mutilated digits to the I/O program.

3.15 Additional interface and logic is provided in the A1278 circuit pack which autonomously detects the generation of KP digits and causes the saturation of five out of six of the MF channel detector scan points. This indicates the presence of a KP signal to the I/O program.

3.16 Except for the descriptions in 3.13 through 3.15, the MF receiver circuitry functions as described in 3.01 through 3.12 when the circuit is equipped with the SIGI feature.

4. PROTECTION AGAINST DIGIT SIMULATION BY GUARD ACTION AND SP TIMING

4.01 The MF receiver uses guard action to reduce digit simulation or the response of the receiver to signals which are not genuine MF pulses. The guard driver applies a dc bias to the channel detectors that varies in magnitude according to the frequency and amplitude of the received signal. With guard action, genuine MF pulses excite the guard driver only weakly and strongly excite the proper channel detectors. Thus, the receiver is able to respond. In contrast, most speech signals contain many frequency components which excite the guard driver more strongly than the channel detectors. Guard bias is generated to inhibit the response of the channel detectors and the receiver tends not to respond to signaling frequencies in the presence of other signals.

4.02 The AGC amplifier applies a signal to the guard driver. The MF guard filter effectively shorts the signaling frequencies out of the guard driver; any voice frequency signal not shorted out is amplified and rectified to produce a dc bias voltage. Since the MF signaling frequencies are shorted out, the dc bias only appears as a result of the presence of nonsignaling frequencies. This bias raises the threshold of the channel detectors and inhibits their ability to recognize signal frequencies. Consequently, if a signal is to be recognized, frequencies in the two-out-of-six code must be present and other signals must be either absent or at a much lower level.

4.03 Because some digit simulating signals may contain momentary bursts of nothing but signal frequencies, guard action as described may be insufficient. However, in speech, pure digit-simulating frequencies are very brief. By making at least two channel detector outputs remain active for 10 ms before digit recognition is possible, most speech-generated potential simulations come and go without being recognized.

4.04 Another longer timing is provided for ac signal levels approximately equal to or greater than the minimum expected MF signals. Lower levels cannot activate the timer at all. This timer requires that an ac signal be present for 20 ms before a digit can be recognized. Guard action and two separate timing operations prevent digit simulations by voice frequency energy.

5. CIRCUIT STATES

5.01 The circuit states are summarized in Table B. Additional information is in the reference paragraphs.

STATE 0, IDLE

5.02 All relays are released, and all ferrods are inactive.

STATE 1, WINK

5.03 Tip and ring are connected through the trunk switching circuit to the incoming trunk circuit. Battery polarity reversed from that normally seen at the trunk circuit is applied by the MF receiver circuit. Digits cannot be received from the distant office in this state. The channel detectors and the SP timer are all forced into their active states to test their operation and that of the associated scan points. There is approximately a 20-ms delay between the time the channel scan points and the signal-present scan point become active and approximately a 22-ms delay between the time the channel scan points and the signal-present scan point become inactive.

STATE 3, DIGITS

5.04 In state 3, the battery is reversed from the polarity of state 1. The reversal from state 1 to state 3 is usually interpreted as the start-pulsing signal by the distant office. The circuitry receives MF pulses as described in 3. The reverse battery transient is prevented from affecting the AGC feedback by the inhibit amplifier.

TABLE B
CIRCUIT STATES

State		Operated Relays	Components Associated With Tip-Ring Circuit		Connected Ferrods	Tip-Ring Connected Trunk Switching Circuit	Para-graph
No.	Name		Function	Designations			
0	IDLE	None	None		None	No	5.02
1	WINK	A	Supervisory Termination	L,T,C5,C6,C7, C8, CPS A260	1, see Note 1	Yes	5.03
3	DIGITS	A,B	Supervisory Termination Digit Detection	L,T,C5,C6,C7,C8 A260,A261,A262, A263,A264,A265, A152,A266	0,1,2,3, 4,5,6,7	Yes	5.04
2	TEST	B	Supervisory Termination Test Bridge	L,T,C5,C6,C7, C8, CPS A260, R6	Note 2	No	5.05

Note 1: Scan points 0 and 2 through 7 are forced into their active states to test detectors and timer.

Note 2: Scan points are forced into their active states to test supervision, detector, and timer.

STATE 2, TEST

5.05 State 2 permits testing the channel detectors and the SP timer without connecting the MF receiver circuit to the trunk switching circuit. All scan points, including the one normally used for trunk supervision, are forced into their active states. There is approximately a 20-ms delay between the time the channel scan points and the signal-present scan point become active. When this state is terminated, there is approximately a 22-ms delay between the time the channel scan points and the signal-present scan point become inactive.

5.06 When option R is provided, scan point 1 is connected across the tip and ring leads to the trunk switching circuit. This state cannot be used in the normal connect or disconnect sequence for fraud detection because undesirable disturbances would be generated toward the trunk switching circuit. Hence, this state may only be used for testing.

OPERATING SEQUENCES

5.07 The normal operating sequence for incoming calls is 0-1-3-2-0. With option R, the normal sequence of operation is 0-1-3-1-0. The test seguence is 0-2-0. The states of this circuit must be carefully coordinated with the states of the particular incoming trunk circuit involved. For loop trunks, the trunk circuit must be put into its bypass state after the MF receiver circuit is connected to the trunk link network in its WINK state. The trunk circuit must be taken to the state following bypass before the MF receiver circuit is taken from the DIGITS state toward IDLE. For E&M trunk circuits, the WINK state is not required since the trunk circuit M lead is operated by the signal distributor circuit. Thus, the MF receiver circuit can be taken all the way to state 3 before an E&M trunk is bypassed.

SECTION III - REFERENCE DATA

1. WORKING LIMITS

Trunk Supervision

Maximum external loop resistance	9,2000 ohms
Mininum insulation resistance	30,000 ohms
Battery limits	-42.75 to -52.5 volts
	+20.75 to +26.25 volts (option R)

1.01 The outputs of CP A152 and A266 shall be connected to scanner D-type ferrod sensors with 100 ohms maximum external circuit resistance.

2. FUNCTIONAL DESIGNATIONS

2.01 Circuit States

Designation	Meaning
WINK	Battery polarity reversed from that normally seen at the trunk circuit is applied by this circuit.
DIGITS	In this state, this circuit is ready to receive digits.
TEST	This circuit checks the channel detectors and SP timer.

2.02 Relays

Designation	Meaning
A,B	These relays are alphabetically designated for program reference. For circuit functions associated with the operation of these relays, see Information Note 302 and 2.01.

2.03 Circuit Packs

Designation	Meaning
MF	Multifrequency
MF VLSR	MF Variolosser
MF Sig Dr	MF Signal Driver
MF GD Dr	MF Guard Driver
CHAN Filter	Channel Filter
MF SP Timer	MF Signal Present Timer
MF Chan Det	MF Channel Detector

2.04 Associated Scanner ferrod Sensors

Designation	Meaning
0,1,2,3,4,5,6,7	Ferrod sensors associated with this circuit are numerically designated for program reference.

3. FUNCTIONS

3.01 To receive multifrequency signals from operator key sets or automatic sending equipment and to convert the received signals into outputs suitable for detection by ESS scanners.

3.02 To offer a return loss high enough to meet the transmission requirements of the No. 1 ESS.

3.03 To respond properly to MF pulses of 30-ms duration with 30-ms intervals between pulses.

3.04 To respond to MF pulses with received level within the limits of -22 dbm and -2 dbm per tone. The receiver shall be able to respond properly in the presence of 6.0-db twist between any two MF tones.

3.05 To deliver dc output signals of at least 11 ms for each of the signaling frequencies regardless of input signal duration when a valid signal is received.

3.06 To deliver a signal-present output signal which starts about 20 ms after a valid input signal is received and remains operated until about 22 ms after the input signal is terminated.

3.07 To provide ample power from the frequency and signal-present outputs to operate D-type scanner high-sensitivity ferrod sensors.

3.08 To tolerate a variation in the received signaling frequencies of ± 1.5 percent plus 10 Hz about the nominal MF signaling frequencies.

3.09 To be able to differentiate between valid MF signals and speech or noise without resorting to special out-of-band signals.

3.10 To provide protection against false operation on speech or noise by the following means:

(a) Guard action.

(b) Fast-acting detectors.

(c) A signal validity check requiring the operation of two (or more) detectors for a timed interval before the signal present output is delivered.

(d) A fast recycling timer which forces an input signal above a threshold level to persist uninterrupted for a required timed interval before the signal-present output is delivered.

(e) Signal-present holding to prevent recycling when noise causes short breakups in the input signals.

3.11 To prevent the reverse battery start-pulsing transient from affecting the AGC feedback loop, the feedback loop is inhibited for a timed interval after operation of the B relay.

3.12 To operate satisfactorily over an ambient temperature range of 32° F to 140° F.

3.13 To operate solely from the standard -48 volt central office battery supply when the circuit is equipped with option S. Option R requires -48 and +24 volts.

3.14 Under program control, to assume the states and carry out the operations described in Section II.

4. CONNECTING CIRCUITS

4.01 When this circuit is listed on a keysheet, the connecting information thereon is to be followed.

(a) Miscellaneous Trunk Frame Signal Distributor Circuit - SD-1A128-01, or Signal Distributor Circuit - SD-1A216-01, or Supplementary Signal Distributor Circuit - SD-1A247-01.

(b) Trunk Switching Circuit - SD-1A107-01.

(c) Miscellaneous Circuit for All Frames - SD-1A129-01.

(d) Miscellaneous Trunk Frame Scanner Circuit - SD-1A117-01, Master Scanner Circuit - SD-1A118-01, Master Scanner Circuit - SD-1A209-01 (as required).

(e) Service Link Circuit - SD-1A281-01.

5. MANUFATURING TESTING REQUIREMENTS

Intermediate Requirements

5.01 None

End Requirements

5.02 Manufacturing testing requirements are specified in X-77660.

5.03 Manufacturing testing requirements for equipment using magnetic latching relays are specified in X-77483.

6. ALARM INFORMATION

6.01 This circuit is fused individually with one fuse to the -48 volt supply, and one fuse to the +24 volt supply when option R is provided, on the bay fuse panel. If a fuse blows, it causes the FA relay in the frame miscellaneous circuit to operate an alarm.

7. TAKING EQUIPMENT OUT OF SERVICE

7.01 This circuit is taken out of service by following directions in CD-1A132-01. Before working on the circuit or removing the circuit packs, the power-removal switch must be operated to disconnect the battery.

SECTION IV - REASONS FOR REISSUE

B. Changes In Apparatus

B.1 Removed

L Inductor, 1633B - App Fig. 1

Replaced By

L Inductor, 1633G - App Fig. 1

B.2 Added

A1278 Circuit Pack, Option R - App Fig. 1

D. Description of Changes

D.1 Made the following changes to provide the SIGI feature in this circuit as part of option R.

(a) Added A1278 circuit pack.

(b) Added additional wiring to contacts 3 and 5 of the B relay.

(c) Added fusing and wiring necessary to supply +24 volts to the added circuit pack.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5333-GJS-GH