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ELECTRONIC SWITCHING SYSTEMS

NO. 1 or 2
ARRANGED WITH 2-WIRE FEATURES

"TOUCH-TONE" STATION TEST CIRCUIT

CHANGES

D. Description of Changes

D.1 Corrected a drawing error on CAD 2 which had been incorporated into the manufactured units.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5317-ZAK-GH

ELECTRONIC SWITCHING SYSTEMS

NO. 1 OR 2
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"TOUCH-TONE" STATION TEST CIRCUIT

CHANGES

B. Changes in Apparatus

Superseded	Superseded By
A163 Circuit Pack, Option N - App Fig. 1	A1009 Circuit Pack, Option M - App Fig. 1

D. Description of Changes

D.1 Increased the sensitivity of this circuit by replacing the A163 circuit pack with the A1009 circuit pack.

D.2 Modified the transmission test requirements table in order to clarify and coordinate test requirements between manufacturing, installation, and operating organizations.

D.3 Changed Circuit Note 104, FS 1, and App Fig. 1 to show options M and N.

F. Changes in CD Section III

F.1 Change 3.06 to read:

3.06 To respond to TOUCH-TONE® signals whose amplitude is less than 0.95 volt RMS but greater than 0.078 volt RMS for option N and 0.060 volt RMS for option M per tone at the input of the TOUCH-TONE calling detector. The ratio of the two signaling frequencies shall not be greater than 1.6 to 1.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5323-ZAK-GH

CIRCUIT DESCRIPTION

CD-1A199-01
ISSUE 2AC
APPENDIX 1B
DWG ISSUE 13B

ELECTRONIC SWITCHING SYSTEMS

NO. 1 OR 2
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"TOUCH-TONE®" STATION TEST CIRCUIT

CHANGES

D. Description of Changes

D.1 A feature has been added on an option basis to arrange this circuit, in conjunction with SD-1A157-01, so that it can test the operation of TOUCH-TONE® automatic card dialers.

D.2 Options P and Q have been added to show leads 697A, 697B, 1336A, 1336B, SP and SP1 in FS 1, and CADs 1 and 2.

BELL TELEPHONE LABORATORIES, INCORPORATED

DEPT 5323-ZAK-GH

ELECTRONIC SWITCHING SYSTEMS

NO. 1 OR NO. 2
ARRANGED WITH 2-WIRE FEATURES

"TOUCH-TONE®" STATION TEST CIRCUIT

TABLE OF CONTENTS PAGE

SECTION I - GENERAL DESCRIPTION

1. PURPOSE OF CIRCUIT

1.01 This circuit is used in conjunction with the station ringer test circuit to check voice frequency TOUCH-TONE® signals from a customer telephone set for correct frequency and amplitude. Its function is to receive voice frequency TOUCH-TONE signals, recognize what frequencies are present, and convert the signaling frequencies into dc signals suitable for operating associated scan points. Because this circuit makes marginal tests on the received signals, its bandwidth for each signaling frequency is narrower and more accurately maintained than the corresponding bandwidth of the TOUCH-TONE calling detector circuit, SD-1A173-01. In addition, it is less sensitive to input amplitude. Thus an oscillator in a customer telephone set which is drifting in terms of either frequency or amplitude will be detected by this circuit before it drifts far enough to be unable to operate a TOUCH-TONE calling detector circuit.

1.02 In addition to testing TOUCH-TONE signals, this circuit offers a high degree of protection against false operation by voice frequency components contained in speech, or noise picked up by the telephone transmitter.

1.03 In connection with an associated station ringer test circuit, the TOUCH-TONE station test circuit can test many of its own components on each call.

1.04 A high impedance bridging amplifier permits monitoring a TOUCH-TONE test without affecting signaling conditions.

2. GENERAL DESCRIPTION OF OPERATION

2.01 TOUCH-TONE signaling uses two groups of frequencies in the speech band. Each group is made up of four frequencies, and the code is known as the 4-by-4 code. A valid signal consists of exactly one frequency from the low group and exactly one from the high group. There are sixteen valid combinations.

2.02 The TOUCH-TONE station test circuit is normally bridged across tip and ring in a station ringer test circuit. It has a high input impedance from dc on up to prevent interference with other tests. A filter in the TOUCH-TONE station test circuit prevents dial tone supplied to the calling customer from interfering with detector operation. Dial tone is always present during TOUCH-TONE testing to provide a rigorous test.

2.03 The TOUCH-TONE station test circuit first separates the high and low group frequencies present in a valid signal combination. The signal from each group is amplified and limited separately. It appears at the output of each limiter as a square wave of constant amplitude, with a period corresponding to that of the input signal. Each of the two square waves is applied to four tuned detector circuits. One of the four detector circuits in each band will respond to the fundamental component of the square wave. The ac signal will be rectified and converted to a dc signal suitable for operating scan points. Each

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of the eight detectors has its own scan point in an associated scanner.

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 both the high and low groups have active detector outputs. If the signal persists for the timer interval, a ninth scan point is activated. Only when this signal-present indication has been observed will the detector outputs be scanned to obtain the digit.

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 in such an instance, the timer does not release until after the signal has been gone for another timed interval.

2.06 Additional techniques are used in the design of the TOUCH-TONE station test circuit to prevent noise from interfering with or simulating valid signals.

2.07 In connection with the associated station ringer test circuit, all detector circuit packs, the timer circuit pack and the associated scan points can be checked on each test call.

2.08 Under certain conditions an operator at the central office or test desk must monitor a TOUCH-TONE test. A high impedance bridging amplifier makes this possible. Amplifier switching, along with all other switching required by the use of this circuit, is carried out by the associated station ringer test circuit, SD-1A157-01.

SECTION II - DETAILED DESCRIPTION

1. SIGNALING CODE

1.01 The TOUCH-TONE signaling code is shown in Table A. The frequencies in each group are spaced geometrically (each is approximately 11 percent higher than the next lower) and the two groups are arranged in such a way that almost no harmonic relationship exists between low and high group frequencies. Since speech signals are rich in harmonics, this discrimination against harmonics tends to prevent digit simulation.

TABLE A

RELATION OF "TOUCH-TONE" SIGNALS AND FREQUENCIES

Low Band	High Band	1209 Hz	1336	1477	1633
697 Hz		1	2	3	Spare
770		4	5	6	Spare
852		7	8	9	Spare
941		Spare	0	Spare	Spare

2. PURPOSE OF CIRCUIT COMPONENTS

2.01 A TOUCH-TONE station test circuit is made up of seven printed wire boards, three filters, and a bridging amplifier. The purpose of each device will be described in the order in which a signal passes through the circuit.

2.02 The input filter, part of the 638B filter assembly, is a high-pass filter which blocks dial tone and longitudinally induced power frequencies out of the TOUCH-TONE station test circuit and passes as much as possible of the remainder of the voice frequency band. In addition to reactive components, the input filter contains a 19,600-ohm resistor in series with the T and R leads to the station ringer test circuit. This high impedance prevents interference with other tests and keeps this circuit's operation similar to that of TOUCH-TONE calling detector.

2.03 The input amplifier, CPS A163, amplifies the portion of the voice frequency band passed by the input filter and applies it to the two band-elimination filters from independent outputs.

2.04 The two signaling frequencies are then separated by the two band-elimination filters in the 638B filter assembly. The filter which serves the low group frequency detectors rejects only the high group frequencies and passes the remainder of the voice frequency band. Similarly, the filter serving the high group detectors rejects only the low group frequencies. As will be seen, the reason for using this type of frequency separation is to provide protection against simulation of digits by speech or noise.

2.05 After separation by the band-elimination filter, each signaling frequency passes through a limiter. Both high and low group limiters are on CPS A164. The output of each limiter is a square wave of fixed amplitude, whose transitions occur at the 0 voltage crossings of the incoming ac signal. Thus, with a pure signaling frequency at a limiter input, the limiter output will contain the fundamental plus the odd harmonics of the signaling frequency at a carefully controlled amplitude.

2.06 The low group limiter output goes to detectors on CPS A165 and A166, and the high group limiter output goes to detectors on A167 and A168. Each detector contains a series-tuned circuit used for recognition of one signaling frequency. Each tuned circuit is followed by a transistor circuit which operates when the tuned circuit is exposed to a frequency at or near its resonant frequency. The operated detectors apply a suitable dc output signal to the associated scanner ferrods.

2.07 Because each limiter has a standardized output amplitude, the tuned circuit frequency response will be a curve of fixed amplitude with its peak near the resonant frequency. The operating threshold levels of the detectors are set about 2 dB below the peak of the tuned circuit response curves. The intersections of the detector threshold level with the tuned circuit response curve mark the bounds of detector operating bandwidth.

2.08 The detectors connect to CPS A175 which is used to verify the operation of one detector in each group. To provide added protection against digit simulation, CPS A175 does not deliver a signal-present indication as soon as this check is satisfied, but instead requires the detector outputs to persist uninterrupted for an interval of approximately 11 ms. If the validity check fails after the 11-ms timing is begun, the signal timer is recycled and must start over again. If a valid signal persists for the required period, the signal timer delivers a signal to the signal-present ferrod in the master scanner as an indication of a valid input signal.

2.09 The signal timer remains operated as long as a valid signal is present at the input. At the conclusion of the input signal, the channel detectors release and the validity check is no longer satisfied. However, the signal-present output is not released immediately. It is held until the validity check has been off for a period of about 22 ms. This provides protection against short break-ups in valid signals as a result of noise at the receiver input, and prevents double registration of the same signal.

2.10 The bridging amplifier which permits the central office or test-desk personnel to monitor TOUCH-TONE tests is described in detail in SD-99316-01.

3. PROTECTION AGAINST DIGIT SIMULATION BY LIMITER GUARD ACTION

3.01 Consider what happens when the TOUCH-TONE station test circuit is exposed to speech. Assume the speech contains two frequencies capable of simulating a TOUCH-TONE digit. It will also contain other frequency components. Since the band-elimination filters reject a relatively small portion of the voice band, each limiter will be exposed to a signaling frequency component plus other components in the voice band. The nature of limiters is such that if there is an interfering frequency at the input whose amplitude is comparable to a signaling frequency component, the amplitude of the signaling component at the limiter output is decreased below its normal value. Since the detector threshold level is set high on the tuned circuit response curve, the amplitude-reducing effect produced by interfering frequencies either reduces detector bandwidth or, if the interfering frequencies are strong enough, prevents detector response to a signaling component. In this manner the combination of band-elimination filters, limiters, tuned circuit, and high threshold detectors provide an effective means of protecting against digit simulation. This principle is known as limiter guard action.

3.02 Limiter operation and high detector threshold as described also prevent more than one detector in each group from responding at one time when a valid signal is received in the presence of somewhat smaller noise signals at TOUCH-TONE frequencies.

4. METHOD OF OPERATION

4.01 The TOUCH-TONE station test circuit is used in two different ways. First, it can be used by an installer at the customer premises to make an automatic test of the TOUCH-TONE oscillators in the subset at the time of installation; second, it can be used by an operator at a test desk, aided by either a customer or another operator at the subset, to make similar tests.

4.02 The TOUCH-TONE station test circuit is always used in conjunction with a station ringer test circuit, SD-1A157-01. The latter contains all switching, and CD-1A157-01 should be consulted for details on sequences of operation. It should be noted thatthe TOUCH-TONE station test circuit does not connect directly to the trunk switching circuit; rather it goes via swtiching in the station ringer test circuit. This usage corresponds to that of the TOUCH-TONE detector circuit, SD-1A173-01, and the customer dial pulse receiver circuit, SD-1A172-01.

4.03 The TOUCH-TONE station test circuit and the TOUCH-TONE calling detector circuit differ from one another only in details of circuitry; the former has narrower frequency limits and less amplitude sensitivity so that it can detect changes in subset oscillators before frequency or amplitude drift prevent operation of the latter. The TOUCH-TONE station test circuit also has a bridging amplifier to permit monitoring TOUCH-TONE tests. The bridging amplifier is connected via switching in the station ringer test circuit to an appearance on the trunk switching circuit different from the one which connects to the subset under test.

4.04 To check results, an installer may key a special directing code followed by the four digits of the directory number. The ESS system control compares the directors number with the equipment number and, if agreement is obtained, sets up a connection to a station ringer test circuit equipped with a TOUCH-TONE station test circuit. Otherwise, busy tone is returned. If all

station ringer test circuits are busy, overflow tone is returned.

4.05 Upon connection to the station ringer and TOUCH-TONE circuit, the installer hears dial tone. The TOUCH-TONE oscillators in the subscriber set may now be tested by depressing the pushbuttons in the prescribed order. Proper operation or failure is signaled by zip tones from the station ringer test circuit.

4.06 To test a TOUCH-TONE subscriber set, the operator at a test desk dials the customer number into the system over the appropriate trunk circuit and requests help from the customer. The customer is told what must be done and the test operator then signals the ESS to start the test.

4.07 The customer line is then connected to the station ringer test circuit at the same input used by an installer. The trunk from the test desk is connected to a special input on the station ringer test circuit at the same time. The customer pushes the subset buttons and the maintenance personnel listens in via a bridging amplifier. The customer cannot be talked to at this time. The station ringer test circuit and its associated TOUCH-TONE station test circuit provide the system control with information about the subscriber set oscillators, and the system control causes the station ringer test circuit to send back signals appropriate to the results. The test operator then terminates the test signal which has been transmitting via the trunk circuit, the paths to the station ringer test circuit are taken down and the circuit made idle, and the customer is reconnected to the trunk to the maintenance personnel. At this point the test can be terminated or, after further instructions or comment, repeated.

4.08 During all TOUCH-TONE tests, dial tone is returned from the station ringer test circuit. Dial tone is not tripped after the first digit as in the case of a TOUCH-TONE receiver; rather, it is left on to make certain that all digits can be received in the presence of this interference.

4.09 The signal-present output from the TOUCH-TONE test timer, CPS A175, is scanned at a 10-ms rate. When a TOUCH-TONE signal satisfying the frequency and amplitude requirements is received, the signal is handled as described in Section II. One scan point in the low group and one in the high group are saturated and, after an 11-ms timing interval, the signal-present scan point changes from saturated to unsaturated. Within 10 ms its active state is detected, and the system control immediately directs a scan to the eight scan points corresponding to the frequency outputs. The digit thus detected is stored in memory and no further scans are made of the frequency outputs until the signal-present scan point changes from its unsaturated state to saturated and then back to unsaturated again.

4.10 While the station ringer test circuit is carrying out tests on the ringer, the associated TOUCH-TONE station test circuit is tested via the X, Y, and Z leads between the two circuits. The C relay in the station ringer test circuit, when operated, applies a simulated signal to all frequency detectors in the TOUCH-TONE station test circuit. All outputs to the scanner corresponding to TOUCH-TONE frequencies should change from inactive to active (from unsaturated to saturated or from 1s to 0s). After the 11-ms timing interval, the signal-present scan point will also change from inactive to active. In this case, however, the inactive state is a saturated scan point (=0) and the active condition is an unsaturated scan point (=1).

SECTION III - REFERENCE DATA

1. WORKING LIMITS

1.01 The outputs from circuit packs A165, A166, A167, A168, and A175 shall be connected to scanner D-type ferrod sensors with a maximum of 100-ohm external loop resistance.

2. FUNCTIONAL DESIGNATIONS

2.01 None.

3. FUNCTIONS

3.01 The functions of the TOUCH-TONE station test circuit are as follows.

3.02 To receive TOUCH-TONE signals from a customer TOUCH-TONE telephone set and to convert the received signals into dc outputs suitable for detection by ESS scanners.

3.03 To offer a sufficiently high input-impedance to permit bridging across the tip and ring conductors of a station ringer test circuit without adversely affecting other test operations.

3.04 To respond to valid TOUCH-TONE signals whose duration is greater than 40 ms, whose cycle time is no less than 80 ms, and whose interpulse interval is at least 40 ms.

3.05 To respond to signaling frequencies within ±1.3 percent of their nominal value, and to reject frequencies which deviate from nominal signaling frequency values by more than ±1.7 percent.

3.06 To respond to TOUCH-TONE signals whose amplitude is less than 1.5 volts RMS but greater than 0.107 volt RMS per tone at the input of the TOUCH-TONE calling detector. The ratio of the amplitude of the two signaling frequencies shall not be greater than 1.6 to 1.

3.07 To deliver dc output signals whose duration is at least 10.5 ms for each of the signaling frequencies regardless of input-signal duration, for a valid signal.

3.08 To deliver a signal-present output signal which starts about 11 ms after both digit outputs are present and remains operated until about 22 ms after the input signal is terminated.

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

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

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

(a) Limiter guard action.

(b) Fast-acting detectors.

(c) A signal validity check requiring the operation of one and only one detector in each of the two signaling groups.

(d) A fast recycling timer which forces a valid-looking signal to persist uninterrupted for a required time-interval before the signal-present output is delivered.

(e) Close control of channel bandwidth.

(f) Negative feedback in limiters to provide control of limiter sensitivity and equalization.

(g) Signal timer holding to prevent recycling when noise causes short break-ups in the input signals.

3.12 To provide for the reception of input signals whose amplitudes may vary over a wide range, and whose two frequencies may differ considerably from each other in relative amplitude, by means of band-elimination filters (which separate the two frequencies into their respective groups) and high gain limiters.

3.13 To be able to receive signals in the presence of dial tone.

3.14 To tolerate and be unresponsive to high-amplitude voltage transients resulting from dial pulses, line surges, etc.

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

3.16 To operate solely from standard +24-volt central office battery supplies.

4. CONNECTING CIRCUITS

4.01 When this circuit is listed on a key-sheet the information thereon is to be followed.

(a) Miscellaneous Trunk Frame Scanner Circuit - SD-1A117-01 and/or Master Scanner Circuit - SD-1A118-01 as required.

(b) Station Ringer Test Circuit - SD-1A157-01.

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

(d) The KS-19328,L1 amplifier circuit is shown on SD-99316-01, which includes amplifier circuit SD-99724-01.

5. MANUFACTURING TESTING REQUIREMENTS

5.01 See Section 231-135-501.

6. TAKING EQUIPMENT OUT OF SERVICE

6.01 This circuit is taken out of service by following directions in CD-1A132-01. When taking this circuit out of service, the associated station ringer test circuit must also be taken out of service, and conversely.

6.02 Before working on the circuit or removing circuit packs, the associated power-removal switch on the miscellaneous circuit must be operated to disconnect battery.

SECTION IV - REASONS FOR REISSUE

D. Description of Changes

D.1 For the use of No. 2 ESS offices only, Circuit Note 107 and Information Note 305 were added to describe the differences between No. 1 and No. 2 ESS scan point assignments. These are also shown on FS 1.

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