TRUNK, TEST, AND SERVICE CIRCUIT DIAGNOSTIC SOFTWARE SUBSYSTEM DESCRIPTION NO. 3 ELECTRONIC SWITCHING SYSTEM

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1. GENERAL

INTRODUCTION AND PURPOSE

1.01 This section describes the software required to perform diagnostic tests of the trunk, test, and service circuits for a No. 3 Electronic Switching System (ESS). Descriptions are included for the following:

- Diagnostic control program
- Diagnostic statement subroutines
- Coin control circuit tests
- Customer dial pulse receiver tests
- Dial pulse transmitter circuit tests
- Two way E&M trunk tests
- Junctor circuit tests
- Multifrequency receiver tests
- Multifrequency transmitter tests
- Milliwatt and transmission environment test circuit tests
- Regular ringing circuit tests
- Superimposed ringing circuit tests
- FCG, PC, RV, and test vertical circuit tests
- Continuity and polarity test circuit tests
- Outgoing reverse battery trunk tests
- Recorded announcement tests
- Tone present test circuit tests
- Trunk operational and transmission tests
- Tone circuit tests
- Three port conference circuit.

Information is included for requesting diagnostics and interpretation of the diagnostic results.

1.02 When this section is reissued, the reason(s) for reissue will be included in this paragraph.

REFERENCE INFORMATION

1.03 Table A is a list of abbreviations and acronyms which are applicable to this section.

TABLE A

ABBREVIATIONS AND ACRONYMS

TERM	DEFINITION
CDPR	Customer dial pulse receiver
FCG	False cross and ground
Hz	Cycles-per-Second
MF	Multifrequency
PUDAL	Peripheral unit diagnostic language
PWC	Power cross
TV	Test vertical

1.04 Other documents which may be helpful in utilizing this section include:

SECTION	TITLE
233-121-115	Trunk, Test, and Service Circuit Description

SECTION	TITLE
233-140-100	Office Maintenance
233-153-105	Programmed Maintenance Aids
233-153-125	Alarm and Status Reporting
233-153-135	Error Analysis and Fault Recovery
233-154-110	Program Listing Standards
233-154-115	3A Instruction Set
233-154-145	PUDAL Diagnostic Language

TRUNK, TEST, AND SERVICE CIRCUIT DIAGNOSTIC PROGRAMS

1.05 Programs which implement the major portion of the trunk, test, and service circuit diagnostics are:

(a) Diagnostic Control Program (DCON)— PR-3H226: is the monitor and control portion of the peripheral unit diagnostic tests which are in ***table-driven*** form. DCON determines the sequence of tasks to be executed, the data table required, and the Peripheral Unit Diagnostic Language (PUDAL) statement execution subroutine for that task.

(b) Diagnostic PUDAL Statement Execution Subroutines (DCNSUB)—PR-3H265: contain the subroutines required to interpret the PUDAL macro statements.

(c) Coin Control Circuit Tests (CCCT)— PR-3H280: contain the data tables (pointing to interpretive routines in DCNSUB) required to generate diagnostic tests for the coin control circuitry.

(d) Customer Dial Pulse Receiver Tests (CDPRT)—PR-3H281: contain the data tables required to generate diagnostic tests for the customer dial pulse receivers.

(e) Two-way E&M Trunk Tests (EMTWT) — PR-3H284: contain the data tables required to generate diagnostic tests for the two-way E&M trunks.

(f) Junctor Circuit Tests (JCTRT) — PR-3H286: contain the data tables required to generate diagnostic tests for the junctor circuits.

(g) Multifrequency Receiver Tests (MFRT) — PR-3H288: contain the data tables required to generate diagnostic tests for the multifrequency receivers.

(h) Multifrequency Transmitter Tests (MFTT)—PR-3H289: contain the data tables required to generate diagnostic tests for the multifrequency transmitters.

(i) Milliwatt and Transmission Environment Test Circuit Tests (MWLAT)—PR-3H290: contain the data tables required to generate diagnostic tests for the milliwatt and transmission environment test circuitry.

(j) Regular Ringing Circuit Tests (RRCT) — PR-3H293: contain the data tables required to generate diagnostic tests for the regular ringing circuitry.

(k) Superimposed Ringing Circuit Tests (SUPRT)—PR-3H285: contain the data tables required to generate diagnostic tests for the superimposed ringer circuitry.

(l) Dial Pulse Transmitter Tests (TDPTT) — PR-3H294: contain the data tables required to generate diagnostic tests for the dial pulse transmitters.

(m) FCG, PC, RV, and Test Vertical Circuit Tests (TVCT)—PR-3H298: contain the data tables required to generate the diagnostic tests for the test vertical circuits.

(n) Continuity and Polarity Test Circuit Tests (CNPLT)—PR-3H282: contain the data tables required to generate the diagnostic tests for the continuity and polarity test circuit tests.

(o) Outgoing Reverse Battery Trunk Tests (ORBT)—PR-3H291: contain the data tables required to generate the diagnostic tests for the outgoing reverse battery trunk.

(p) Recorded Announcement Tests (RACT) — PR-3H292: contain the data tables required to generate the diagnostic tests for the recorded announcement set.

(q) Tone Present Test Circuit Tests (TPDT)—PR-3H295: contain the data tables required to generate the diagnostic tests for the tone present test circuit.

(r) Trunk Operational and Transmission Tests (TTRT)—PR-3H297: contain 3A code to retrieve office data necessary to determine trunk type, location, etc, of the trunk(s) to be tested as well as the data tables required to generate associated diagnostic tests.

(s) Tone Circuit Tests (TONET)—PR-3H299: contain the data tables required to generate the diagnostic tests for the tone circuits which appear on the network.

(t) Three Port Conference Circuit Tests (TPCCT)—PR-3H300: contain the data tables required to generate the diagnostic tests for the three port conference circuit.

2. TRUNK, TEST, AND SERVICE CIRCUIT DIAGNOSTIC FORMAT AND USE

TABLE-DRIVEN STRUCTURE

2.01 The trunk, test, and service circuit diagnostic test programs are written in the Peripheral Unit Diagnostic Language (PUDAL). PUDAL utilizes a ***table-driven*** programming structure, consisting of three elements:

(a) Data tables

(b) Control program

(c) Interpretive routine.

Figure 1 shows the relationship of the three elements.

2.02 The control program (DCON) determines which data table is to be accessed to generate the required diagnostic test and then controls the sequence of execution. Each diagnostic test (ie, Coin Control Circuitry Test, etc) is a data table element comprised of numerous data blocks. These blocks contain 5-bit op-code which points to an interpretive routine (one of 32) and the related data for the associated operation. The interpretive routines contain the machine code necessary to execute each PUDAL statement. Upon completion of a task, the control program selects the next data table entry to be accessed and executed and continues this sequence until the test is completed.

2.03 Several advantages are realized by using the table-driven program approach. The major advantages are:

(a) A higher level programming language is made available for generating test code.

(b) Once the diagnostic tests are generated (data tables), they can be used for field or factory testing with changes required only to the control program and interpretive routines.

PAGING DIAGNOSTIC PROGRAMS INTO MEMORY

2.04 No. 3 ESS diagnostic programs are not resident in main store but are maintained on magnetic tape in order to conserve memory. When diagnostics are to be used, they are brought into main memory from the tape cartridge. A segment of main memory, known as the paging buffer, is reserved to accommodate programs which must be brought in from tape but are not required on a high usage basis.

2.05 When No. 3 ESS diagnostic tests are requested, DCON (diagnostic control program), DCNSUB (diagnostic PUDAL statement execution subroutines), and phase 0 of the test to be executed are loaded into the paging buffer (Fig. 2) for the duration of the test. The diagnostic tests, phases 1 through n, are brought in one phase at a time and stored (until executed) in that portion of the paging buffer reserved for the diagnostic tests (Fig. 2). The size of the diagnostic test phase is limited by being able to reside within the area reserved in the paging buffer. This requirement ensures that the cartridge tape drive will not be exposed to excessive wear when a test phase is run in the repeat mode.

REQUESTING TRUNK, TEST, AND SERVICE CIRCUIT DIAGNOSTIC TESTS

2.06 Trunk, junctor, test, and service circuit diagnostic tests can be manually requested via the teletypewriter (TTY). The input messages, formats, variations, and replies are shown in Fig. 3a, 3b, 3c, and 3d. It should be remembered that the periphery control units should be "known good" ie, fully functional, prior to requesting trunk, junctor, test, or service circuit diagnostics since

these circuits are diagnosed via various periphery orders.

2.07 Diagnostics will also be run with the inputting of the restore message (RST:xxx!) via the TTY. The restore unconditional message (RST:xxx:UCL!) will not cause diagnostics to be performed since it returns the unit to service immediately.

3. TRUNK, TEST, AND SERVICE CIRCUIT DIAGNOSTIC TEST DESCRIPTIONS

GENERAL

3.01 The trunk, test, and service circuit diagnostics consist primarily of periphery unit orders generated by use of PUDAL statements (See Section 233-154-145 for PUDAL statement definitions.) An example is using the OPERATE order to change states of distribute points, followed by the SCAN order to ensure correct operation. When addressing these units, the logical unit assignments for all diagnostic tests are:

0—Online scanner (first subchannel)

1—Online peripheral pulse distributor

2—Online network controller

3—Online scanner (second subchannel)

4—Offline scanner (first subchannel)

5—Offline peripheral pulse distributor

6—Offline network controller

7—Offline scanner (second subchannel)

16—Master scanner

COIN CONTROL CIRCUIT TESTS

3.02 The coin control circuit is tested using the loop environment test circuit. Available distributor states of the loop environment test circuit are (where 0=released and 1=operated):

STATE	RELAY				
	E	D	C	B	A
Idle	0	0	0	0	0
Minimum leakage resistance not detected	0	0	0	0	1
Ringing on tip	0	0	0	1	0
Maximum leakage resistance detected	0	0	0	1	1
Trip test	0	0	1	0	1
Ringing on ring	0	0	1	1	0
Non trip test	0	0	1	1	1
Coin collect voltage test	0	1	0	0	0
Coin relay non operate	0	1	0	0	1
Coin return voltage test	0	1	0	1	0
Coin relay operate	0	1	0	1	1
Safety trip operate	0	1	1	0	0
Safety trip non operate	0	1	1	0	1
Restore verify GS test	0	1	1	1	0
Restore verify LS test	0	1	1	1	1
Power cross plus test tip	1	0	0	1	0
Power cross plus test ring	1	0	1	1	0
Power cross minus test tip	1	1	0	1	0
Power cross minus test ring	1	1	1	1	0

3.03 The available distributor states of the coin control circuit to be tested are (0=released and 1=operated):

STATE	RELAY			
	D	C	B	A
Idle	0	0	0	0
Transient state	0	0	0	1
P130 voltage drain	0	0	1	0
N130 voltage drain	0	0	1	1
Overtime coin deposit drain	1	0	0	0
Initial coin deposit drain	1	0	0	1
P130 volts and drain	1	0	1	0
N130 volts and drain	1	0	1	1
Overtime coin deposit test	1	1	0	0
Initial coin deposit test	1	1	0	1

3.04 The SEIZE statement is used to reserve all required circuits for exclusive use during diagnostics. The loop environment test circuit is then connected to the coin control circuit via the network (Fig. 4). The CONNECT statement is used to execute closure of the proper network path.

3.05 The OPERATE statement is used to set desired relay states in both the coin control circuit and the loop environment test circuit for each diagnostic test. Each expected result is verified by explaining various scan points by executing the SCAN statement. When all tests are completed, the DISCONNECT order is used to tear down the network path and the RELEASE order is used to release those circuits previously reserved for exclusive use of this diagnostic.

CUSTOMER DIAL PULSE RECEIVER TESTS

3.06 The customer dial pulse receiver test consists of four phases. Phase 0 is the normal definition phase. Phases 1, 2, and 3 contain the actual diagnostic test data tables.

3.07 ***CDPR Phase 1:*** The CDPR is connected to the tone present detector as shown in Fig. 4. Available distributor states of each unit are:

CUSTOMER DIAL PULSE RECEIVER DISTRIBUTOR		
STATE	RELAY	
	B	A
Toll Diversion	0	0
2-Party coin test	0	1
Dial tone	1	0
Receive digits	1	1

TONE PRESENT DETECTOR DISTRIBUTOR STATES			
STATE	RELAY		
	C	B	A
Idle	0	0	0
AC continuity	0	0	1
Three port	0	1	1
Junctor	1	0	0
Tone detect	1	0	1

3.08 The OPERATE order is used to set desired states of the two circuits. The SCAN order is used to determine that expected responses occurred. Upon completion of the phase, the circuits are released and disconnected.

3.09 ***CDPR Phase 2:*** The CDPR to be diagnosed is connected to the dial pulse receiver test circuit (Fig. 4) after each is seized for use during diagnostics. The available distributor states of the customer dial pulse test circuit are:

STATE	RELAY					
	F	E	D	C	B	A
Idle	0	0	0	0	0	0
CDPRT1	0	0	0	0	0	1
CDPRT3	0	0	0	0	1	0
CDPRT2	0	0	0	0	1	1
Tip party non operate	0	0	0	1	0	0
Reverse battery	0	0	0	1	0	1
Tip party operate	0	0	0	1	1	0
T2 21PPS 52% break	0	0	0	0	1	1
T1 13PPS 50% break	0	0	1	0	0	1
T3 21PPS 71% break	0	1	0	0	1	0
ST T2 21PPS 52% break	1	0	0	0	1	1
ST T1 13PPS 50% break	1	0	1	0	0	1
ST T3 21PPS 71% break	1	1	0	0	1	0

3.10 OPERATE orders are executed to set the states of the CDPR and the customer dial pulse receiver test circuit to test for pulse reception. SCAN orders are used to verify test results. As with other tests, a DELAY order is used prior to SCAN in order to allow for relay operate time. The circuits are disconnected and released upon test completion.

3.11 ***CDPR Phase 3:*** CDPRs equipped with a TOUCH-TONE® receiver are tested by phase 3. The TOUCH-TONE receiver test circuit is used to generate test signals which must be recognized by the TOUCH-TONE receiver. Distributor states of the TOUCH-TONE test circuit are:

STATE	RELAY		
	R	P	N
Power off	0	0	0
Load channel 1	1	0	0
Load amplitude	1	0	1
Load channel 2	1	1	0
Idle	1	1	1

Distributor states for amplitude select for the TOUCH-TONE receiver test circuit are:

STATE	RELAY			
	D	C	B	A
1 tone at 0 dBm	0	0	0	0
2 tones at 0 dBm	0	0	0	1
1 noisy tone at 0 dBm	0	0	1	0
2 noisy tones at 0 dBm	0	0	1	1
1 tone at −10 dBm	1	0	0	0
2 tones at −10 dBm	1	0	0	1
1 noisy tone at −10 dBm	1	0	1	0
2 noisy tones at −10 dBm	1	0	1	1
1 tone at −21 dBm	1	1	0	0
2 tones at −21 dBm	1	1	0	1
1 noisy tone at −21 dBm	1	1	1	0
2 noisy tones at −21 dBm	1	1	1	1

3.12 Thirty-two discrete tone frequencies can be selected via operation of 11 distributor relay combinations in the TOUCH-TONE test circuit.

3.13 The required circuits are seized for exclusive use during the diagnostic test. The TOUCH-TONE receiver and test circuits are initialized prior to connecting the CDPR to the TOUCH-TONE test circuit via the network as shown in Fig. 4.

3.14 Two DOLOOPs are used to vary the frequency and amplitude to check the TOUCH-TONE receiver with:

- 2 out-of-band tones
- 2 in-band tones
- a single in/out of band tone
- 2 tones plus noise

The results are verified by use of the SCAN order. Upon completion of the test the circuits are disconnected and released from exclusive use. Appropriate TTY messages are outputted as is the case with all diagnostic tests.

TWO-WAY E&M TRUNK TESTS

3.15 EMTWT consists of two phases which provide for diagnostic testing of the two-way E&M trunk circuits. Two test circuits (the continuity polarity test circuit and the tone present detector) are used during this test. The continuity polarity test circuit is connected to the two-way E&M trunk as in Fig. 4 after the required circuits are seized. Distributor states for the two-way E&M trunk and the continuity polarity test circuit are:

TWO-WAY E&M TRUNK DISTRIBUTOR STATES			
STATE	RELAY		
	C	B	A
Idle and continuity check incoming	0	0	0
Talk free	0	0	1
Continuity check outgoing	0	1	0
Talk charge	0	1	1
Dial pulse outgoing	1	1	0

CONTINUITY POLARITY TEST CIRCUIT DISTRIBUTOR STATES			
STATE	RELAY		
	C	B	A
Idle	0	0	0
Polarity detect	0	0	1
Reverse polarity detect	0	1	1
Resistance battery	1	0	0
Low resistance battery	1	0	1
Reverse resistance battery	1	1	0
Low resistance reverse battery	1	1	1

Distributor states for the present detector are shown in 3.07.

3.16 The two-way E&M trunk and the continuity polarity test circuit are first idled. The scan points are then checked to determine if the scan points are in the expected unsaturated state. Continuity checks are next made on the two-way E&M trunk and then the polarity of battery and ground are checked from the trunk in the dial-pulse-out state. Upon completion, disconnect and release orders are issued for circuits used during this test.

3.17 The tone present detector is then connected to the two-way E&M trunk as depicted by Fig. 4. The tone present detector checks for AC continuity through the repeat coil of the trunk in the talk-free state. The tone present detector provides a 1000 Hz tone in the AC continuity state. When the test is completed the associated circuits are disconnected and released.

JUNCTOR CIRCUIT TESTS

3.18 The intent of this program is to diagnose the junctor circuit. The test is comprised of six phases. Phase 0, as in other diagnostics, is used to define test parameters, etc. Phases 1 through 5 contain the coding required to execute the tests. The continuity polarity test circuit and the restore verify circuit are used for DC testing of the junctor circuit. The tone present detector and the milliwatt circuits are used for AC testing of the junctor.

3.19 Junctor distributor states are:

STATE	RELAY		
	C	B	A
Open	0	0	0
Line to trunk	0	0	1
Trunk to line	0	1	0
Line to line	0	1	1
Bypass	1	0	0
Audible ring	1	0	1
Overflow tone	1	1	0

3.20 Milliwatt circuit distributor states are:

STATE	P	T 1	A 1	J	T 0	A 0
Idle	0	0	0	0	0	0
Milliwatt 0	0	0	0	0	0	1
Cont 0 Idle 1	0	0	0	0	1	0
Balance term	0	0	0	0	1	1
Junctor	0	0	0	1	0	1

Distributor states for the tone present detector and the continuity polarity test circuit are shown in 3.07 and 3.15, respectively.

3.21 Phases 1 through 3 are used to perform DC continuity tests on the junctor circuit. The required circuits are first seized for testing and then the test circuit is connected as shown in Fig. 5. In phase 1, tests are made to test for various continuity conditions through the junctor. Operate orders are executed to control the state of the test and junctor circuits, and scan orders are used to examine for expected results. Phase 2

executes orders to perform DC continuity tests across the circuit side of the junctor circuit.

3.22 In phase 3 the continuity polarity test circuit is connected across the wire side of the junctor (Fig. 6). DC continuity tests are then made across the wire side of the junctor circuit. The operate and scan orders are again used to execute and verify the various test conditions. As in previous tests, the delay order is executed prior to the scan order to provide relay operate time.

3.23 Phases 4 and 5 execute AC testing of the junctor circuit. After seizing the required circuits, the tone present detector and the milliwatt test circuit are connected across the junctor circuit as shown in Fig. 7. Operate orders are again used to generate the test conditions and scan orders are used for verifying test results.

MULTIFREQUENCY RECEIVER TESTS

3.24 The Multifrequency Receiver Test program (MFRT) is provided to perform diagnostic tests on an MF receiver. The continuity and polarity test circuit is used to check the supervisory scan point of the MF receiver. An in-service MF transmitter and the milliwatt and transmission environment test circuit are used to check the frequency response of the MF receiver at marginal levels.

3.25 The MF receiver scan point results are (1=OFFHOOK 0=ONHOOK):

RESULTS	STATE								
	SCAN POINT	7	6	5	4	3	2	1	0
No tones detected		0	0	0	0	0	0	1	0
Detect 700 Hz		0	0	0	0	0	1	1	0
Detect 700 & 900 Hz		0	0	0	0	1	1	0	0
Detect 700 & 1100 Hz		0	0	0	1	0	1	0	0
Detect 900 & 1100 Hz		0	0	0	1	1	0	0	0
Detect 700, 900 & 1100 Hz		0	0	0	1	1	1	0	0
Detect 1100 & 1300 Hz		0	0	1	1	0	0	0	0
Detect 700 & 1500 Hz		0	1	0	0	0	1	0	0
Detect 1300 & 1500 Hz		0	1	1	0	0	0	0	0
Detect 1100, 1300 & 1500 Hz		0	1	1	1	0	0	0	0
Detect 1700 Hz		1	0	0	0	0	0	1	0
Detect 1500 & 1700 Hz		1	1	0	0	0	0	0	0
Detect 1100, 1500 & 1700 Hz		1	1	0	1	0	0	0	0

3.26 Multifrequency transmitter distributor states are:

STATE	CK	T	S17	S15	S13	S11	S9	S7
Idle	0	0	0	0	0	0	0	0
Send 700 Hz	0	1	1	0	0	0	0	1
Send 900 Hz OSC0	0	1	1	0	0	0	1	0
Send 1100 Hz OSC0	0	1	1	0	0	1	0	0
Send 1300 Hz OSC0	0	1	1	0	1	0	0	0
Send 1500 Hz OSC0	0	1	1	1	0	0	0	0
Send 900 Hz OSC1	1	1	0	0	0	0	1	1
Send 1100 Hz OSC1	1	1	0	0	0	1	0	1
Send 1300 Hz OSC1	1	1	0	0	1	0	0	1
Send 1500 Hz OSC1	1	1	0	1	0	0	0	1
Send 1700 Hz	1	1	1	0	0	0	0	1
Send 700 & 900 Hz	1	0	0	0	0		1	1
Send 700 & 1100 Hz	1	0	0	0	0	1	0	1
Send 900 & 1100 Hz	1	0	0	0	0	1	1	0
Send 1100 & 1300 Hz	1	0	0	0	1	1	0	0
Send 700 & 1500 Hz	1	0	0	1	0	0	0	1
Send 1300 & 1500 Hz	1	0	0	1	1	0	0	0
Send 1500 & 1700 Hz	1	0	1	1	0	0	0	0
2 out of 6 check	1	0	0	1	0	1	0	1

3.27 Milliwatt and transmission environment distributor states are:

STATE	P	T 1	A 1	J	T 0	A 0
Idle	0	0	0	0	0	0
MW0 Idle 1	0	0	0	0	0	1
Cont0 Idle1	0	0	0	0	1	0
BT0 Idle1	0	0	0	0	1	1
Junctor loss test	0	0	0	1	0	1
MW0 MW1	0	0	1	0	0	1
Cont0 MW1	0	0	1	0	1	0
BT0 MW1	0	0	1	0	1	1
Idle0 Cont1	0	1	0	0	0	0
MW0 Cont1	0	1	0	0	0	1
Cont0 Cont1	0	1	0	0	1	0
BT0 Cont1	0	1	0	0	1	1
Idle0 BT1	0	1	1	0	0	0
MW0 BT1	0	1	1	0	0	1
Cont0 BT1	0	1	1	0	1	0
BT0 BT1	0	1	1	0	1	1
Loop around	1	0	0	0	0	0
Flat loss pad	1	0	0	0	0	1
Modulation products test	1	0	0	0	1	1
Twist test pad	1	0	0	1	1	0
MF detect pad	1	1	0	0	1	0
MF non detect pad	1	1	0	1	1	0
Double keying test	1	1	1	0	1	1

3.28 Phase 1 of the multifrequency receiver diagnostic is used to test the supervisory circuit of the receiver. The required circuits are seized and the continuity polarity test circuit connected to the MF receiver as depicted in Fig. 4. OPERATE orders set the desired test states while the SCAN order examines scan points to determine the test results. After test completion, the previously seized circuits are released.

3.29 Phase 2 of MFRT executes the operational test for the MF receiver. After seizing the required circuits, the test circuit is connected as shown in Fig. 8 (CKT#1=MF TRANS, CKT#2=MW XMIS0, CKT#3=MW XMIS1, CKT#4=MF RECVR). The operational test consists of sending various tones and combination of tones from the MF transmitter through the flat loss pads of the MW transmission environment test circuit to the MF receiver. The OPERATE order is used to select the tone(s) sent, some of which are illegal. The SCAN order is used to verify that the MF receiver recognizes the tone(s) as expected. Upon completion of the test, the test circuits are disconnected and released from exclusive use by the test program.

MULTIFREQUENCY TRANSMITTER TESTS

3.30 The Multifrequency Test program (MFTT) is provided to perform diagnostic tests on an MF transmitter. The continuity and polarity test circuit is used to check the MF transmitter's supervisory and continuity scan points. The milliwatt and transmission environment test circuit and the tone present detector are used to check the power level of each MF tone from both oscillators of the MF transmitter. An in-service MF receiver and the milliwatt and transmission environment test circuit are used to verify the frequencies of the tones produced by the MF transmitter.

3.31 Distributor states of the MF transmitter are shown in 3.26. The MF receiver scan point results are shown in 3.28 while 3.27 contains the distributor states of the milliwatt and transmission environment test circuit. Distributor states of the continuity polarity test circuit are shown in 3.15 and the tone present detector distributor states are shown in 3.07.

3.32 Phase 1 of test program MFTT executes tests of the MF transmitter scan points. The circuits are seized and the CONNECT order

used to connect the continuity polarity test circuit to the MF transmitter being tested as shown in Fig. 4. OPERATE orders are used to set desired distributor states of each circuit followed by SCAN orders to verify test results. Upon completion of the test the circuits are disconnected and released.

3.33 The power level of oscillator 0 of the MF transmitter is checked in phase 2. The required circuits are first seized for use during testing and the test circuit connected as shown in Fig. 8 (CKT#1=MF TRANS, CKT#2=MW XMIS0, CKT#3=MW XMIS1, CKT#4=TONE PRES). The 700, 900, 1100, 1300, and 1500 Hz tones are checked to be within -6.5 to 6.0 dBm level. The MF receiver scan point (SC00) should saturate when each tone is transmitted through the 23.4 dB loss pad of the MW and transmission environment test circuit and should not saturate when the 23.9 dB loss pad is used. The OPERATE order is used to set the desired test states while the SCAN order is used to verify that expected results exist. When the test is completed, the circuit is disconnected and released.

3.34 Phase 3 of the multifrequency transmitter test is similar to phase 2 except oscillator 1 power levels are checked. Oscillator 1 generates the 900, 1100, 1300, 1500, and 1700 Hz tones.

3.35 Tone frequencies of the MF transmitter are checked in phase 4 of MFTT. The required circuits are seized and the test circuit connected as in Fig. 8 (CKT#1=MF TRANS, CKT#2=MW XMIS0, CKT#3=MW XMIS1, and CKT#4=MF RECVR). A tone from oscillator 0 and a tone from oscillator 1 are sent to the MF receivers (through the MW XMIS circuit with 21 dB loss inserted) in the following combinations:

OSC 0	OSC 1
(a) 700 Hz	900 Hz
(b) 900 Hz	1100 Hz
(c) 1100 Hz	1300 Hz
(d) 1300 Hz	1500 Hz
(e) 1500 Hz	1700 Hz

Each transmission should be detected by the MF receiver if the tone frequencies are within tolerance. A 2-out-of-6 error is also generated to check that the error can be detected. The operate and scan orders are used in previous tests and when the test is completed the circuits are disconnected and released.

MILLIWATT AND TRANSMISSION ENVIRONMENT TEST CIRCUIT TESTS

3.36 The Milliwatt and Environment Test circuit test program (MWLAT) is provided to perform diagnostic tests on the milliwatt and environment test circuit. This program consists of three phases; phase 0 is the definition (etc) portion and 1 and 2 are the two test phases. Distributor states of the milliwatt and environment test circuit are shown in 3.27.

3.37 Four other circuits are used in testing the MW and transmission environment test circuit. The distributor states and scanner results states are shown previously as listed:

- Tone present detector—in 3.07.
- Continuity and polarity test circuit—in 3.15
- MF transmitter—in 3.26
- MF receiver—in 3.25

3.38 Phase 1 of MWLAT contains the tone and continuity tests of the MW and transmission test circuit. The required circuits are seized and then connected as shown in Fig. 8 (CKT#1=TONE PRES, CKT#2=MW XMIS0, CKT#3=MW XMIS1, and CKT#4=CONT POL).

3.39 OPERATE orders set various distributor states to check tone return from PORT 0 and 1500 ohm bridge and balanced termination on PORT 1. The circuit is then disconnected, released, and reseized and reconnected with PORT 0 connected to the CONT POL test circuit and PORT 1 connected to the TONE PRES detector. The initial tests of phase 1 are rerun with the functions of PORT 0 and PORT 1 interchanged. Upon completion, disconnect and release orders are issued.

3.40 Phase 2 checks the MF detect and nondetect pad as well as miscellaneous operational tests. The required circuits are seized and the test circuit connected as in Fig. 8 (CKT#1=MF TRANS, CKT#2=MW XMIS0, CKT#3=MW XMIS1, and CKT#4=TONE PRES). Checks are made at 700 Hz and 1700 Hz to determine that the MF detect pad of the MW and transmission environment test circuit provides less than 24 dB loss and that the nondetect pad provides more than 24 dB loss. This test is accomplished by sending a -6 dBm tone from the MF transmitter through the MW and transmission environment test circuit and is detected by the tone present detector. A check is also made to verify that the MW and transmission environment test circuit can produce an 1100 Hz tone when in the modulation products test state. Test conditions and scanner results are determined as usual by use of the OPERATE and SCAN order. At this point the circuit is disconnected and released.

3.41 New seize and connect orders are executed in preparation for the miscellaneous milliwatt operational tests. The circuit is connected as in Fig. 8 (CKT#1=MF TRANS, CKT#2=MW XMIS0, CKT#3=MW XMIS1 and CKT#4=MF RECVR). Tests are executed to ensure proper operation of:

- Twist pad loss
- Modulation products test state
- Double keying test state
- Flat loss pad

When the test execution is complete, the circuit is disconnected and released for normal service.

REGULAR RINGING CIRCUIT TESTS

3.42 The Regular Ringing Circuit Test program (RRCT) is provided to perform diagnostic tests on the regular ringing circuit. All tests on the regular ringing circuit are done using the loop environment test circuit connected as shown in Fig. 4. Distributor states of the loop environment test circuit are shown in 3.02. Regular ringing circuit distributor states are:

STATE	RELAY		
	C	B	A
Pre Trip Test 0	0	0	0
PreTrip Test 1	0	1	0
Silent interval ring the ring	1	0	0
Ringing interval ring the ring	1	0	1
Silent interval ring the tip	1	1	0
Ringing interval ring the tip	1	1	1

3.43 After the circuits are seized and connected, phase 1 of RRCT executes the diagnostic tests. The OPERATE and SCAN orders are used to set test conditions and verify results for testing the following functions of the regular ringing circuit:

- Detection of maximum line leakage
- Line leakage detector sensitivity
- Regular ringing circuit continuity detector
- Ability to apply regular ringing to line
- Ringing intervals
- Ringing ability on special line conditions

When all tests are complete, the circuit is disconnected and released.

SUPERIMPOSED RINGING CIRCUIT TESTS

3.44 The Superimposed Ringing Circuit Test program (SUPRT) is provided to perform diagnostic testing on the superimposed ringing circuit. All tests are performed using the loop

environment test circuit connected as shown in Fig. 4. Loop environment distributor states are shown in 3.02. Distributor states for the superimposed ringing circuit are:

STATE	RELAY			
	D	C	B	A
Pre Trip test ring	0	0	0	0
Pre Trip test tip	0	0	1	0
Silent interval ring minus	1	0	0	0
Silent interval ring plus	1	1	0	0
Silent interval tip minus	1	0	1	0
Silent interval tip plus	1	1	1	0
Ringing interval ring minus	1	0	0	1
Ringing interval ring plus	1	1	0	1
Ringing interval tip minus	1	0	1	1
Ringing interval tip plus	1	1	1	1

3.45 Phase 1 of diagnostic program SUPRT executes the tests on the superimposed ringing circuit after the required circuits are seized and connected. Functions checked are:

- Detection of maximum line leakage
- Line leakage detector sensitivity
- Superimposed ringing circuit continuity detector
- Ringing interval
- Operation of safety trip under various conditions

When all tests are complete, the test circuit is disconnected and released for service.

TRUNK DIAL PULSE TRANSMITTER TESTS

3.46 The purpose of the Trunk Dial Pulse Transmitter Test program (TDPTT) is to perform continuity tests on the trunk dial pulse transmitter using the continuity polarity test circuit. Distributor states for the continuity polarity test circuit are shown in 3.15. Trunk dial pulse transmitter distributor states are:

STATE	RELAY		
	P	BD	A
Onhook long loop supervision	0	0	0
Onhook short loop supervision	0	0	1
Long onhook digit pulse	0	1	0
Short onhook digit pulse	0	1	1
Offhook long loop supervision	1	0	0
Offhook short loop supervision	1	0	1
Long offhook digit pulse	1	1	0
Short offhook digit pulse	1	1	1

3.47 The OPERATE order is used to set various distributor states of the trunk dial pulse transmitter and the continuity polarity test circuit after seizing and connecting the circuits as shown in Fig. 4. The SCAN order examines scan points to determine if correct test results were obtained. When all tests have executed, the circuits are disconnected and released.

FCG, PC, RV AND TEST VERTICAL CIRCUIT TESTS

3.48 The Test Vertical Circuit Diagnostic Test program (TVCT) is provided to perform diagnostic tests on the test vertical circuit. All tests are performed using the loop environment test circuit connected as shown in Fig. 9. Distributor

states for the loop environment test circuit are shown in 3.02. Test vertical test circuit distributor states are:

STATE	RELAY		
	C	B	A
Idle	0	0	0
Power cross	0	0	1
Restore verify LS	0	1	0
Power cross test	0	1	1
False cross and ground	1	0	1
Restore verify GS	1	1	0
Power cross test	1	1	0

3.49 Test vertical test circuit scan states are:

STATE	FCG	PWC
All idle	0 0	0
Power cross	0 0	0
FCG tip	0 1	0
FCG ring	1 0	0
FCG tip ring	1 1	0
PWC FCG tip	0 1	1
PWC FCG ring	1 0	1
PWC FCG tip ring	1 1	1

3.50 The required circuits are seized and connected. OPERATE orders are executed to set the desired distributor states of the circuits. The SCAN order is used to examine scan points to determine test results. Checks made on the test vertical circuit are:

- Operation of the FCG scan points
- Restore verify ground start resistor
- Restore verify loop start resistor
- Negative voltage power cross detection
- Positive voltage power cross detection
- Circuit component verification
- 130-volt rectifiers

When all tests have executed, the test circuits are disconnected and released.

CONTINUITY AND POLARITY TEST CIRCUIT TESTS

3.51 The purpose of the Continuity and Polarity Test circuit diagnostic test program (CNPLT) is to verify proper operation of the continuity and polarity test circuit. The tests are performed using the milliwatt and transmission environment test circuit connected as shown in Fig. 4. Distributor states for the circuits used in these tests are as shown in previous paragraphs.

(a) Continuity and polarity test circuit—in 3.15

(b) Milliwatt and transmission environment test circuit—in 3.27

(c) Junctor circuit—in 3.19.

3.52 Phase 0 of CNPLT is used to specify the required data definitions. Test execution is performed during phase 1 where the required circuits are seized and connected. The PUDAL statements OPERATE and SCAN are used to set up and verify results of the following tests:

- Stuck operated relay or scan points
- Continuity of the circuit under test
- Capability of the continuity polarity test circuit to detect impedances, voltages, and polarity of voltages placed across the tip and ring.

When the tests have executed, the circuits are restored, disconnected, and released for normal use.

OUTGOING REVERSE BATTERY TRUNK TESTS (ORBT)

3.53 Diagnostic test program ORBT is provided

to perform diagnostic tests on the outgoing reverse battery trunk. The continuity polarity test circuit is used in performing these tests and is connected to the outgoing reverse battery trunk as depicted in Fig. 4. Distributor states for the outgoing reverse battery trunk are:

STATE	RELAY		
	C	B	A
Idle	0	0	0
Continuity and hold	0	0	1
Bypass	0	1	0
Talk free	0	1	1

Distribute states for the continuity polarity test circuit are shown in 3.15.

3.54 Phase 0 of ORBT specifies data definitions as in other test programs. Phase 1 executes the outgoing reverse battery trunk tests. Required circuits are first seized and then connected. The OPERATE and SCAN orders are executed to check for proper polarity on the trunk of battery and ground from the distant office. Then a check is made to verify continuity to the trunk through the network. When the tests are completed, the circuits are restored, disconnected, and released for normal use.

RECORDED ANNOUNCEMENT TESTS (RACT)

3.55 Test program RACT is designed to diagnose the recorded announcement circuit for the presence of various announcements. The recorded announcement circuit provides the 7A Announcement Machine with appearance on the switching network. All tests are performed using the tone present detector connected to the recorded announcement circuit as depicted in Fig. 4. Distributor states of the tone present detector circuit and the junctor circuit are shown in 3.07 and 3.19, respectively.

3.56 Phase 0 of RACT is used for data definitions while the tests are executed by phase 1. The required circuits are first seized and connected. The OPERATE and SCAN orders are used to verify the presence of the recorded announcement message. Upon completion of the test, the circuits are disconnected and released for normal operation.

TONE PRESENT TEST CIRCUIT TESTS

3.57 The tone present detector test circuit test program (TPDT) is provided to perform diagnostic tests on the tone present detector test circuit. The continuity and polarity test circuit, the milliwatt and transmission environment test circuit, and an in-service MF transmitter are used to perform the required tests. Distributor states for each circuit are shown in the following designated paragraphs:

(a) Tone present detector test circuit—in 3.07

(b) Continuity and polarity test circuit—in 3.15

(c) Milliwatt and transmission environment test circuit—in 3.27

(d) MF transmitter—in 3.26.

TDPT consists of two phases, phase 0 containing data definitions and phase 1 containing the test data tables.

3.58 Orders are first issued to seize the required circuits and connect the continuity polarity test circuit to the tone present detector as illustrated in Fig. 4. OPERATE and SCAN orders set up test conditions and then verify the DC continuity of the tone present detector. This test circuit is then released and disconnected prior to connecting the next test circuit.

3.59 After seizing the required circuits for exclusive use by this test, the MF transmitter is connected to the tone present detector through the milliwatt and transmission environment test circuit. This test connection is depicted in Fig. 8 (CKT#1 being MF TRANS, CKT#2—MW PORT 0, CKT#3—MW PORT 1, and CKT#4—TONE PRES). OPERATE and SCAN orders are approximately issued to initiate the following tests and verify the results of each.

- The frequency response of the tone present detector is checked using the MF transmitter and the detect-nondetect pads of the milliwatt and transmission environment test circuit.

- The voice-detect state of the tone present detector is checked using the twist test pad of the milliwatt and transmission environment test circuit and the MF transmitter.

- The AC continuity check state of the tone present detector is tested using the balanced termination from PORT 1 of the milliwatt and transmission environment test circuit.

When the tests have executed, the circuits are idled, released, and disconnected.

TRUNK OPERATIONAL AND TRANSMISSION TESTS (TTRT)

3.60 Test program TTRT is provided to execute an operational and transmission test on the various trunk types which may be located within the office. The tone present detector is used during various stages of the test. Distributor states for the tone present detector are shown in 3.07.

3.61 The trunk operational and transmission tests program consists of three phases. Phase 0 provides storage and circuit definitions. Phase 1 retrieves office translation data to determine trunk type, start codes, and other information regarding the trunk to be tested. Phase 2 seizes the required circuits and connects the trunk being tested to the tone present detector (or transmitter). PUDAL statements as well as 3A code are used to execute the following test where applicable:

- Start signal detection

- Test line digit outpulsing

- Automatic number identification (ANI) for CAMA trunk

- Interrupted audible tone test

- Test offhook pulse counting

When the final test has executed, the associated circuits are idled, released, and disconnected.

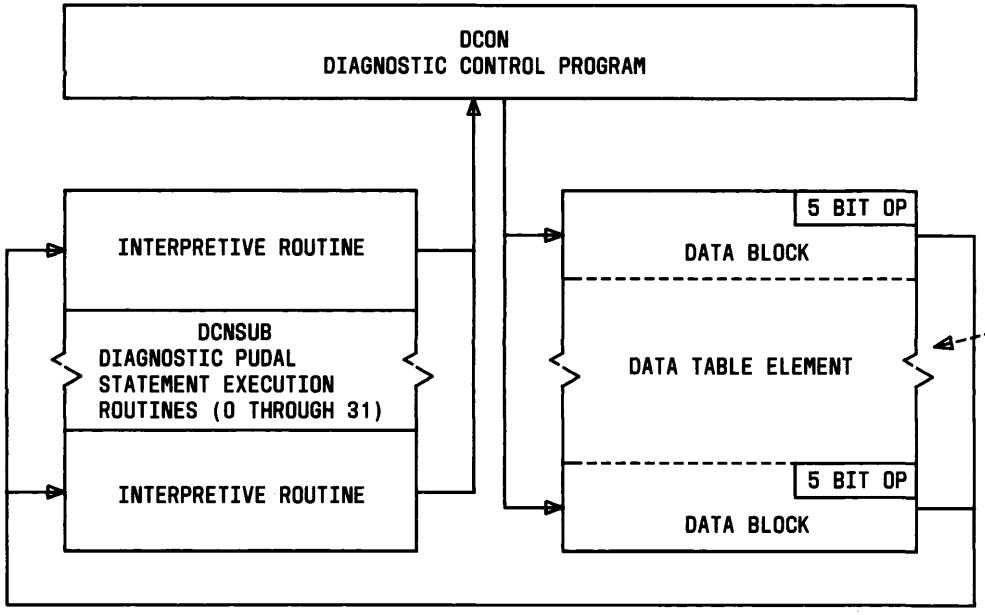
TONE CIRCUIT TESTS (TONET)

3.62 Test program TONET is provided to check for the presence of various tones which appear on the switching network. The tone present detector is used to implement these tests and is connected to the tone source as depicted in Fig. 4. TONET is a two phase program with Phase 0 performing the normal tasks. Phase 1 executes the tests by first seizing and connecting the required circuits. OPERATE and SCAN orders set conditions and verify tone presence. Upon completion, the associated circuits are idled, released, and disconnected.

THREE PORT CONFERENCE CIRCUIT TESTS

3.63 Test program TPCCT is designed to diagnose the three port conference circuit. The tone presence detector and the milliwatt and transmission environment test circuit are used to test the three port conference circuit. The circuits are connected as shown in Fig. 10 for execution of this test. Junctor distribute states are shown in Part 3.19, tone presence circuit distribute states are shown in Part 3.07, and distribute states of the milliwatt and transmission environment test circuit are shown in Part 3.27.

3.64 The required circuits are seized and connected (as shown in Fig. 10). A DC continuity test is then made from each port of the three port conference circuit to the associated test circuit. Transmission loss is first checked between ports 0 and 1 of the conference circuit with port 2 terminated. Next, the transmission loss is checked between ports 1 and 2 with port 0 terminated. The circuits are then disconnected and released for service.



* SOME DATA TABLES CONTAIN 3A CODE AS WELL AS THE PUDAL 3 EXECUTION STATEMENTS

DATA TABLES *

CCCT - COIN CONTROL CIRCUIT TEST
CDPRT - CUSTOMER DIAL PULSE RECEIVER TEST
CNPLT - CONTINUITY & POLARITY TEST CIRCUIT
EMTWT - TWO WAY E & M TRUNK TEST
JCTRT - JUNCTOR CIRCUIT TEST
MFRT - MULTIFREQUENCY RECEIVER TEST
MFTT - MULTIFREQUENCY TRANSMITTER TEST
MWLAT - MILLIWATT & TRANSMISSION ENVIRONMENT TEST CIRCUIT TEST
ORBT - OUTGOING REVERSE BATTERY TRUNK TEST
RACT - RECORDED ANNOUNCEMENT TEST
RRCT - REGULAR RINGING CIRCUIT TEST
SUPRT - SUPERIMPOSED RINGING CIRCUIT TEST
TDPTT - DIAL PULSE TRANSMITTER CIRCUIT TEST
TONET - TONE CIRCUIT TEST
TPDT - TONE PRESENT TEST CIRCUIT TEST
TTRT - TRUNK OPERATIONAL AND TRANSMISSION TEST
TVCT - FCG, PC, RV & TEST VERTICAL CIRCUIT TEST
TPCCT - THREE PORT CONFERENCE CIRCUIT TEST

Fig. 1—Interrelationship of Trunk, Junctor, Test, and Service Circuit Diagnostic Programs

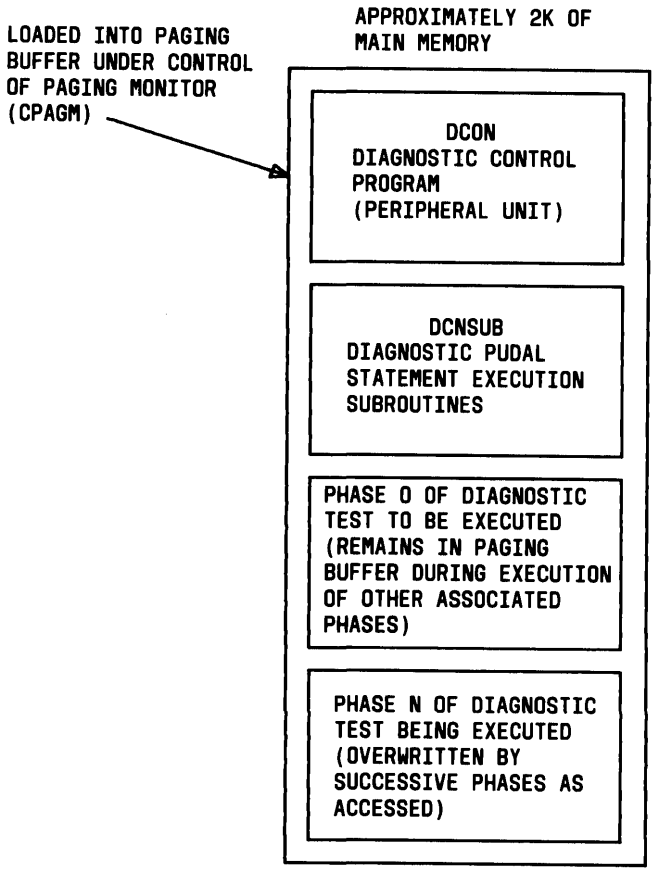


Fig. 2—Paging Buffer

1. INPUT MESSAGE FORMAT

DGN:JC (a,b) !

DGN:JC (a,b), PH p,TST t;action-option !

2. EXPLANATION OF MESSAGE

Used to request DiaGNostics to be run on a JunCtor circuit. The diagnostic may be executed to the first failure or it may be executed in the step or repeat or unconditional modes.

The circuit must be removed from service before the unit can be diagnosed.

3. EXPLANATION OF VARIABLE FIELD

a

Is the CONCENTRATOR GROUP NUMBER of the junctor circuit.

b

Is the JUNCTOR SWITCH NUMBER of the junctor circuit.

p

Is the phase requested for step or repeat mode.

t

Is the test requested for step or repeat mode. This is an optional parameter for step or repeat mode.

action-option

RPT

Execute the requested diagnostic phase repetitively. To stop the diagnostic, depress the execute key. To restart, depress the execute key again.

STEP

Execute the requested diagnostic phase by executing the phase whenever the execute key is depressed.

UCL

Unconditionally execute the entire diagnostic.

(CONTINUED)

(CONTINUED) DGN:JC

4. SYSTEM RESPONSES

?I

The junctor circuit identification field is in error or the message is constructed incorrectly.

NG

The junctor circuit is currently not in the correct state to be diagnosed.

IP

The diagnostic request has been accepted and is in progress.

RL

A diagnostic is in progress or another msf is in progress. Repeat the request later.

5. REFERENCES

PR-3H266-01 DCON – DISGNOSTIC CONTROL PROGRAM

Fig. 3A—Input Message Format

1. INPUT MESSAGE FORMAT

DGN:SVC (a,b) !

DGN:SVC (a,b), PH p,TST t;action-option!

2. EXPLANATION OF MESSAGE

Used to request DiaGNostics to be run on a SerViCe circuit. The diagnostic may be executed to the first failure or it may be executed in the step or repeat or unconditional modes.

The circuit must be removed from service and in the locked-out state before the unit can be diagnosed.

3. EXPLANATION OF VARIABLE FIELD

a

Is the GROUP NUMBER of the service circuit.

b

Is the MEMBER NUMBER of the service circuit.

p

Is the phase requested for step or repeat mode.

t

Is the test requested for step or repeat mode. This is an optional parameter for step or repeat mode.

action-option

RPT

Execute the requested diagnostic phase repetitively. To stop the diagnostic, depress the execute key. To restart, depress the execute key again.

STEP

Execute the requested diagnostic phase by executing the phase whenever the execute key is depressed.

UCL

Unconditionally execute the entire diagnostic.

(CONTINUED)

4. SYSTEM RESPONSES

?I

The service circuit identification field is in error or the message is constructed incorrectly.

NG

The service circuit is currently not in the correct state to be diagnosed.

IP

The diagnostic request has been accepted and is in progress.

RL

A diagnostic is in progress or another msf is in progress. Repeat the request later.

5. REFERENCES

PR-3H266-01 DCON – DIAGNOSTIC CONTROL PROGRAM

Fig. 3B—Input Message Format

1. INPUT MESSAGE FORMAT

DGN:TRK (a,b) !

DGN:TRK (a,b), PH p,TST t;action-option!
DGN:TRK (a,b), OTO p,TST t;action-option!

2. EXPLANATION OF MESSAGE

Used to request DiaGNostics to be run on a TRunK. The diagnostic may be executed to the first failure or it may be executed in the step or repeat or unconditional modes.

The trunk must be removed from service and in the disabled state before the unit may be diagnosed.

3. EXPLANATION OF VARIABLE FIELD

a

Is the GROUP NUMBER of the trunk.

b

Is the MEMBER NUMBER of the trunk.

OTO

Office to office transmission test requested.

p

Is the phase requested for step or repeat mode.

t

Is the test requested for step or repeat mode. This is an optional parameter for step or repeat mode.

action-option

RPT

Execute the requested diagnostic phase repetitively. To stop the diagnostic, depress the execute key. To restart, depress the execute key again.

STEP

Execute the requested diagnostic phase by executing

(CONTINUED)

the phase whenever the execute key is depressed.

UCL

Unconditionally execute the entire diagnostic.

4. SYSTEM RESPONSES

?I

The trunk identification field is in error or the message is constructed incorrectly.

NG

The trunk is currently not in the correct state to be diagnosed

IP

The diagnostic request has been accepted and is in progress

RL

A diagnostic is in progress or another msf is in progress. Repeat the request later.

5. REFERENCES

PR-3H266-01 DCON — DIAGNOSTIC CONTROL PROGRAM

Fig. 3C—Input Message Format

DGN:TV

1. INPUT MESSAGE FORMAT

DGN:TV TC(a)!

DGN:TV TC(a) ,PH p,TST t;action-option!

2. EXPLANATION OF MESSAGE

Used to request DiaGNostics to be run on a Test Vertical Test Circuit. The diagnostic may be executed to the first failure or it may be executed in the step or repeat or unconditional modes.

The circuit must be removed from service before the unit can be diagnosed.

3. EXPLANATION OF VARIABLE FIELD

a

Is the CIRCUIT NUMBER of the test vertical test circuit.

p

Is the phase requested for step or repeat mode.

t

Is the test requested for step or repeat mode. This is an optional parameter for step or repeat mode.

action-option

RPT

Execute the requested diagnostic phase repetitively. To stop the diagnostic, depress the execute key. To restart, depress the execute key again.

STEP

Execute the requested diagnostic phase by executing the phase whenever the execute key is depressed.

UCL

Unconditionally execute the entire diagnostic.

(CONTINUED)

(CONTINUED) DGN:TV

4. SYSTEM RESPONSES

?I

The test vertical test circuit identification field is in error or the message is constructed incorrectly.

NG

The test vertical test circuit is currently not in the correct state to be diagnosed

IP

The diagnostic request has been accepted and is in progress

RL

A diagnostic is in progress or another msf is in progress. Repeat the request later.

5. REFERENCES

PR-3H266-01 DCON – DIAGNOSTIC CONTROL PROGRAM

Fig. 3D—Input Message Format

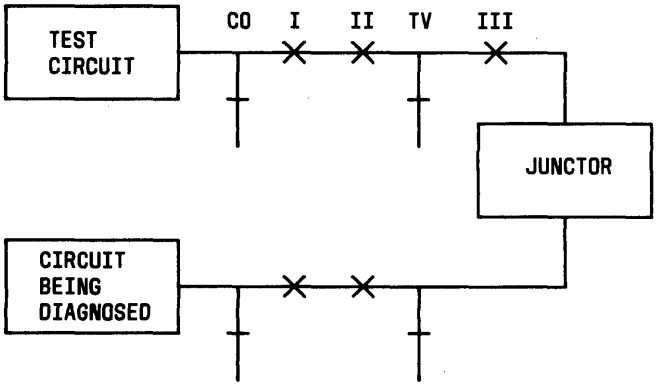


Fig. 4—Basic Test Connection

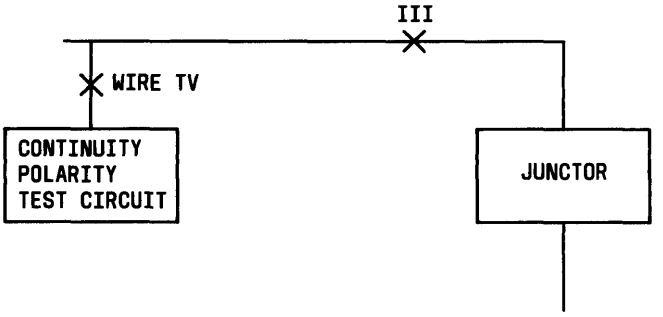


Fig. 6—Wire Junctor Test Connection

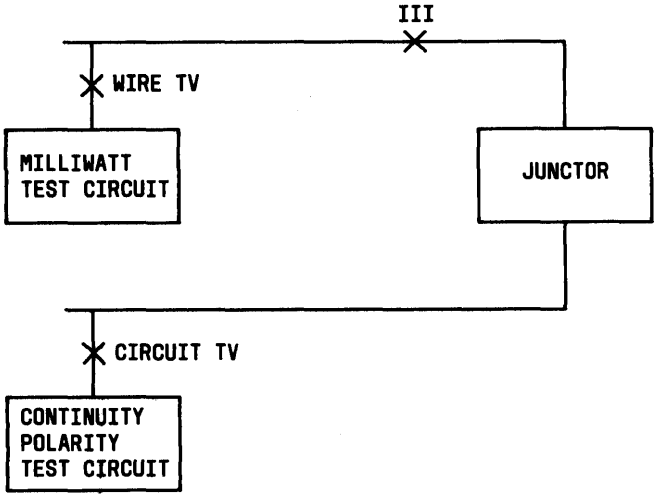


Fig. 5—Junctor Continuity Test Connection

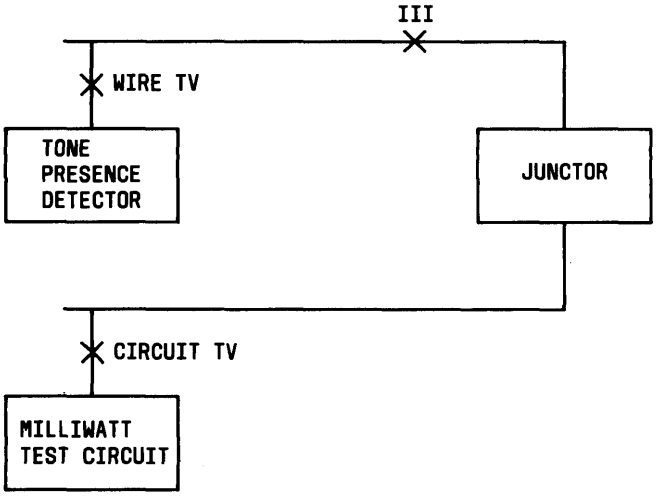


Fig. 7—Junctor AC Test Connection

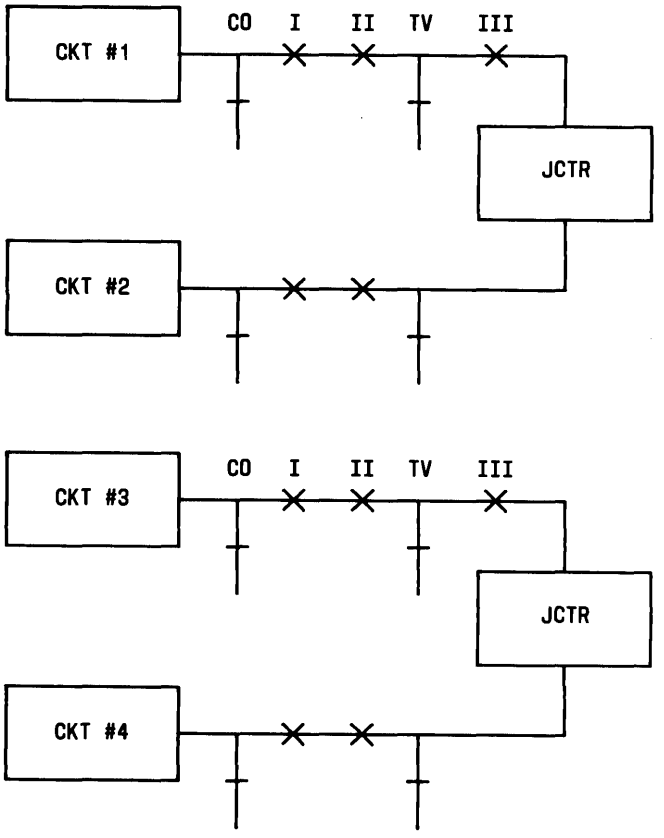


Fig. 8—Multiple Circuit Test Connection

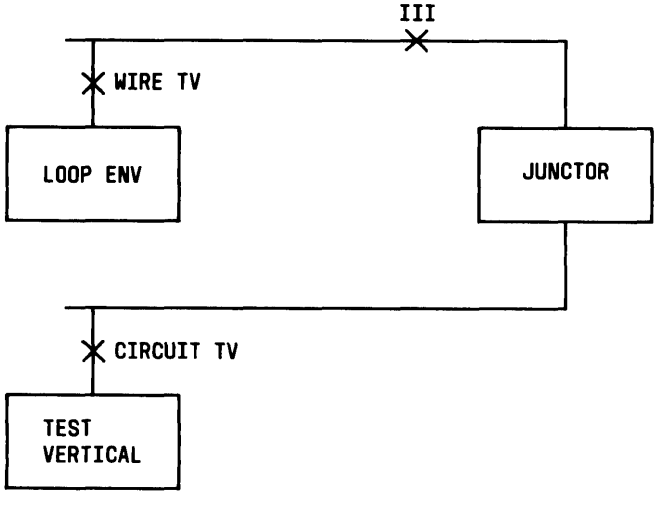


Fig. 9—Test Vertical Test Connection

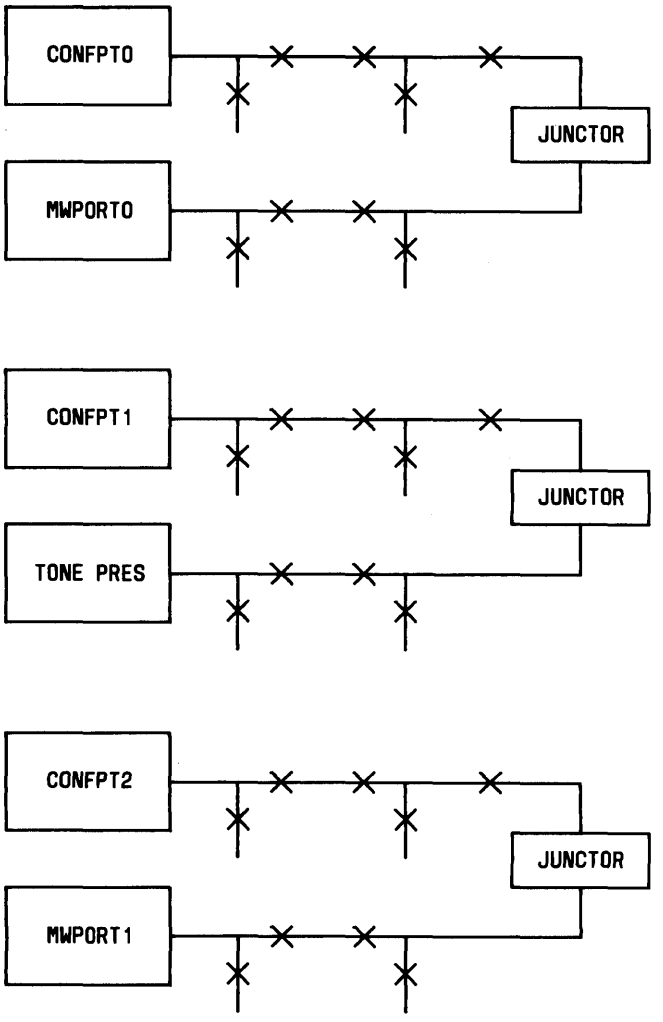


Fig. 10—Three Port Conference Test Connection