CENTREX AND AIOD DIAGNOSTIC AND EXERCISE PROGRAMS
SOFTWARE SUBSYSTEM DESCRIPTION (SSD)
2-WIRE NO. 1 AND NO. 1A ESS

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1. GENERAL

INTRODUCTION

1.01 The centrex diagnostic and exercise programs provide for automatic and manual testing of the centrex attendant console, data loop, and related equipment. The AIOD diagnostic and exercise program provides for testing of the AIOD equipment.

1.02 When this section is reissued, the reason for reissue will be given in this paragraph.

1.03 Part 5 of this section provides a defined list of the abbreviations and acronyms as used herein.

PURPOSE OF THE DIAGNOSTIC AND EXERCISE PROGRAMS

1.04 Console and data loop testing is provided to determine if signals originating from the attendant telephone consoles are properly received at the ESS central office and if signals generated at the ESS central office are properly displayed to the attendant. Testing is provided by parity checks on a per-call basis and by automatic diagnostic programs injected at regular intervals. The automatic test is a round-trip test designed to test the entire console data interchange system. In the event of parity failures or round-trip failures, the ESS initiates a special series of diagnostic tests in sequences which help in localizing the troubles. If a trouble is suspected, diagnostic programs may be injected at any time by a request from the maintenance TTY at the ESS central office by which the centrex customer group is served.

SCOPE OF THE SECTION

1.05 This section provides an introduction to the centrex and AIOD diagnostic and exercise programs operating in a No. 1 or No. 1A ESS central office. Information unique to a specific system application is so noted.

1.06 This section is based on the 1E5 (No. 1 ESS) and 1AE5 (No. 1A ESS) versions of the generic program.

2. PIDENTS DESCRIBED IN THIS SECTION

2.01 Table A provides a PIDENT to program number cross-reference for the PIDENTs described in this section. Table A is not an exhaustive list of all PIDENTs containing diagnostic related software; only those which constitute the core of the centrex diagnostic and exercise software are listed.

2.02 A brief introduction to each PIDENT is given below. Detailed information is provided in subsequent parts of this document and in the program listings.

TABLE A

CENTREX AND AIOD DIAGNOSTIC AND EXERCISE PIDENTs

PIDENT	TITLE	NO 1 PR__	NO 1A PR__
CXMA	Centrex Maintenance Program	1A056	6A056
CXMC	Data Link Diagnostic Control	1A056	6A056
CXMS	Centrex Maintenance Supervisory Program	1A057	6A057
CXDX	Centrex Data Link And Console Demand Exercise Program	1A058	6A058
AIDG	AIOD Diagnostic Program	1A059	6A059

(a) The data link diagnostic control program, PIDENT CXMC, sets up tests for the centrex data loop and interprets the test results.

(b) The centrex maintenance program, PIDENT CXMA, carries out most of the necessary input-output work via PIDENT ECIO (executive control input-output program).

(c) The centrex maintenance supervisory program, PIDENT CXMS, provides a variety of functions necessary for the proper supervision and maintenance of the hardware and software associated with the centrex data link.

(d) The centrex data link and console demand exercise program, PIDENT CXDX, provides the diagnostic capabilities necessary to identify and locate faults in centrex attendant consoles, centrex console control cabinets, and centrex data links.

(e) The AIOD (automatic identified outward dialing) diagnostic program, PIDENT AIDG, provides the diagnostic functions for the AIOD interface circuit (AIODIC) and the automatic number identification circuit (ANI).

3. FUNCTIONAL DESCRIPTION

INTRODUCTION

3.01 In order to control the lamp states and to receive key signals from the remote centrex attendant consoles, a data loop and a console control system are employed. Figure 1 is a block diagram of a typical centrex customer group. The centrex data loop connects the attendant telephone consoles at the customer premises to the 2-wire No. 1 or 1A ESS central office. This loop is a peripheral unit which provides 2-way data communications between the central office and the attendant consoles. Lamp data is transmitted by means of this loop to the attendant consoles in order to control the states of lamps on the consoles. The console lamps indicate service requests or other supervisory signals to the attendant. Key signals from the attendant consoles are also transmitted to the central office by the data loop. These key signals are interpreted at the ESS central office as requests for specific actions at the central office. Only one console is shown although as many as four may be controlled by a single data loop and console control system.

3.02 In order to provide data for use by a management information system (MIS) or other peripheral equipment (CRT, printer, etc) at the customer premises, a remote data interface (RDI) system is installed on the customer premises to provide the necessary interface functions.

3.03 The central office end of a centrex data loop terminates in a centrex data link circuit mounted on a centrex data link frame. The data link is a peripheral unit which provides the interface between the data loop and the ESS central office control equipment.

3.04 The remote end of the data loop terminates in a console control circuit contained in the 51A-CPS centrex console control cabinet or in a remote data interface system at the customer location. The console control circuit provides the interface between the data loop and the attendant consoles. The remote data interface provides the interface between the data loop and a management information system or other peripheral equipment.

HARDWARE DESCRIPTION

3.05 In order to better understand the tests applied to the data loop by the diagnostic program, further description of the circuitry from a maintenance point of view is given below.

A. Centrex Data Link Circuit

3.06 The centrex data link circuit consists basically of a 26-bit shift register, a 700-Hz oscillator, a 2100-Hz oscillator, a 5-bit counter circuit, and a single controller. Each centrex data link frame may contain from one to eight such circuits, depending on the data link frames. The inputs to the shift register are bits 0 through 23 of the peripheral unit (PU) bus. The common bus circuitry (eg, cable receivers) is the only duplicated equipment on the frame.

3.07 Two (duplicated) enable central pulse distributor (CPD) points are assigned to each of the data links for loading from the PU buses. This provides four routes for shift register loading, allowing it to continue when any combination of bus and CPD is out of service.

3.08 A third (duplicated) CPD point is assigned to the data link, which, when operated, allows the contents of the shift register to be transmitted serially to the distant end circuitry.

3.09 Included in the centrex data link circuit are certain maintenance features as follows:

(a) A relay which, when operated, isolates the distant end circuitry by connecting the transmission pair to the reception pair (T1, R1 to T2, R2) through a lumped constant pad simulating the behavior of an exchange cable. This allows data sent from the shift register to loop around locally and return to its original position in the shift register.

(b) The circuitry to allow the shift register and counter circuit to advance 1 bit at a time as opposed to normal circuit speed of 1400 bits per second.

(c) Circuitry which monitors the continuity of the cables and power at both ends.

3.10 Finally, outputs are provided from the data link circuit to a master scanner. Thirty-one outputs are provided in total, two in the fast scan field used for normal input-output functions, 28 in the directed field, of which four are used exclusively for maintenance purposes, and one in the supervisory field which is used for maintenance purposes.

3.11 The function of the data link controller circuit is to accept the CPD enable signals, and use them to instruct the rest of the circuitry to accept signals from the PU bus or to begin transmission.

3.12 The 700-Hz and 2100-Hz oscillators function as the 0 and 1 signal sources for transmission respectively. One of these signals is applied to the line, depending on the value of the leading bit of the shift register at any given time. In the idle state, 700 Hz is continuously sent to the distant end over T1, R1 and 700 Hz is continuously received over T2, R2. To begin an actual data transmission, therefore, bit 25 must be set to a 1.

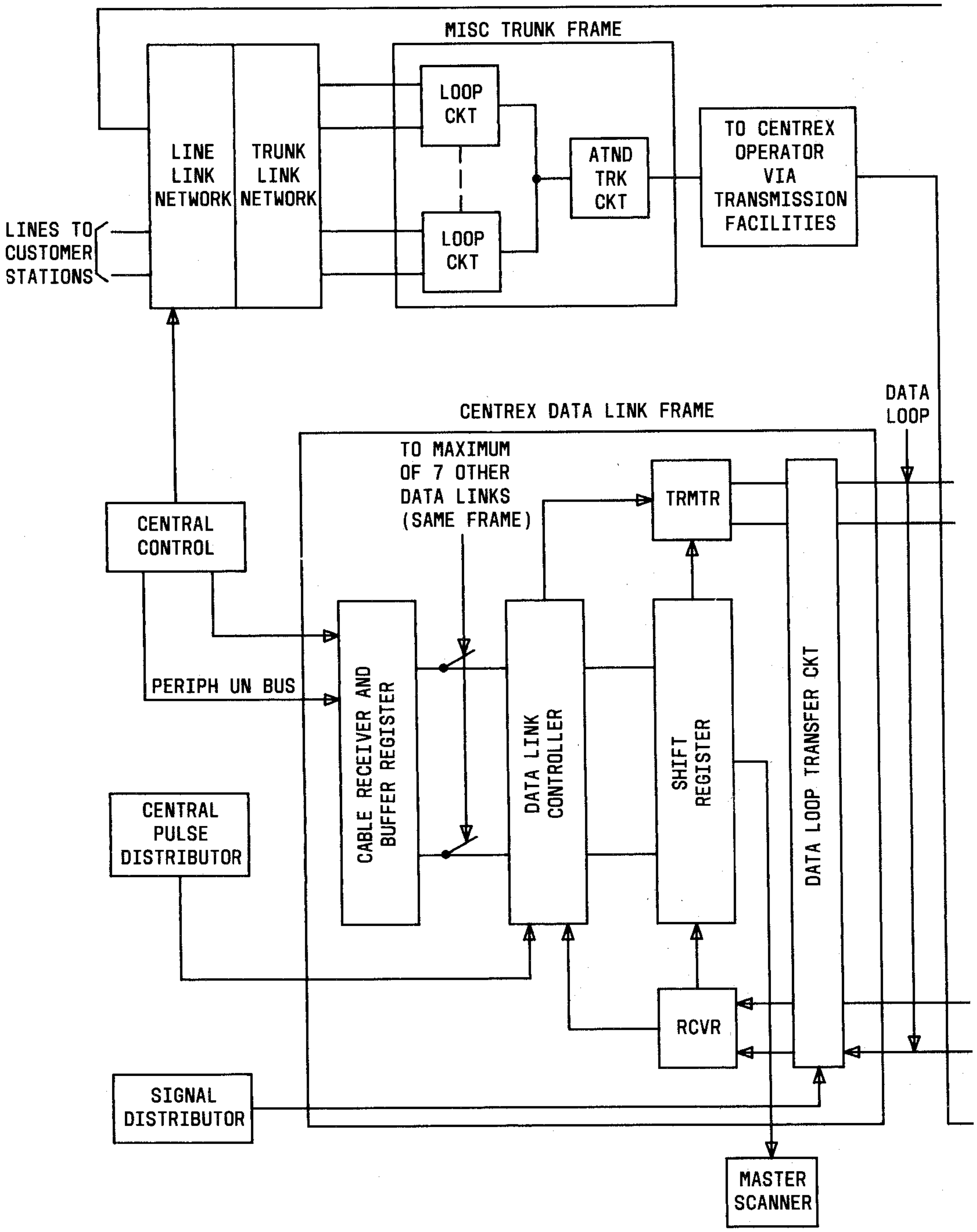
3.13 Once transmission has been initiated on the data loop by activation of the enable start flip-flop, it transmits independently of the ESS system. The function of the 5-bit binary counter is to generate a stop transmission signal to the circuit, when it has counted 26 bits.

B. Centrex Data Transmitter and Receiver Circuit

3.14 The centrex data transmitter and receiver circuit is housed at the customer premises and consists basically of a 26-bit shift register, a 700-Hz oscillator, a 2100-Hz oscillator, a 5-bit counter, and control circuitry to allow the shift register contents to be sent to the lamp control circuit to load information into the shift register.

3.15 The two 26-bit shift registers at the No. 1 ESS or No. 1A ESS and at the customer premises comprise the information path of the data loop. Transmission of data from the ESS automatically causes the contents of the far end shift register to be circulated out and back to the ESS, and to

2-WIRE NO. 1 OR 1A ESS OFFICE ARRANGED WITH CENTREX SERVICE



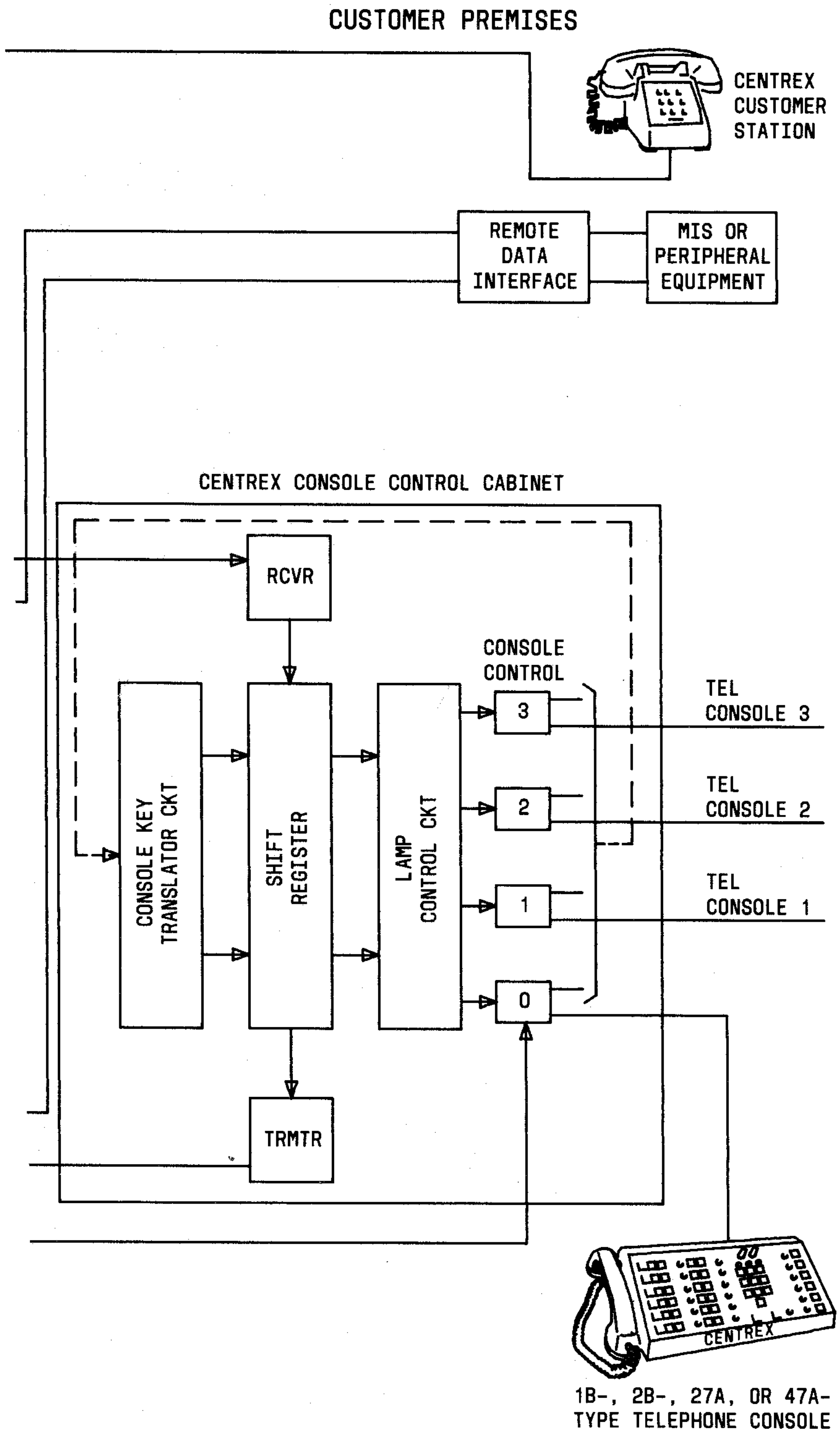


Fig. 1—Centrex-CO or PBX-CO Services Using Console Control Cabinet—Block Diagram

be replaced by the contents of the register at the central office. Although the far end circuit cannot initiate transmission, it may request the ESS to do so by signaling over a DC phantom path. Then the ESS may load and transmit a dummy word in order to circulate the far end information.

3.16 The oscillators and counter function the same way as those described for the centrex data link circuit.

3.17 The control function at the centrex data receiver and transmitter circuit is performed by interpretation of three control bits sent from the ESS. When bit 22 is 1, the control circuitry signals the lamp control circuit to gate the shift register contents into the circuit and operate on them. The other two control bits (bit 20 and 21) are then useful only to the lamp control circuit. This is the normal state of the data. However, when bits 20 and 21 are 1s and 22 is 0, the control circuitry interprets this as a maintenance order and effectively disables any communication, either input or output, from the lamp control circuit. This, in effect, means that the maintenance order resides in the distant end shift register until another transmission by the ESS pushes it out.

C. Lamp Control Circuit and Centrex Attendant Console

3.18 The function of the lamp control circuit is to read and decode the orders sent to it from the ESS, and to translate key signals from the centrex attendant console for propagation to the ESS. The decoding function is performed by closing certain crosspoints in a ferreed matrix which connect signal sources to lamps on the attendant console. The sources and lamps are chosen according to the information contained in the centrex data receiver and transmitter circuit when bit 22 = 1. At this time, all bits of the shift register are reset to zeros, in order that key signals from the attendant console (if any) be received for propagation to the ESS. These signals are decoded by a diode decoder which sets a binary number in the shift register according to the attendant key depressed.

3.19 Two lamps on each centrex attendant console are wired so that they can be verified. That is, when a specific lamp order is sent from the ESS, the lamp control circuit verifies the state (lighted or not lighted) of the position busy and night lamps and marks specific bits in the shift register. This information may then be transmitted back to the ESS to determine the state of the lamps.

DIAGNOSTIC REQUESTS

3.20 Improper console lamp operations and key signals may be caused by faults occurring in a centrex attendant telephone console (hereafter referred to as console), a centrex console control cabinet, the interconnecting data link circuitry, or the 2-wire No. 1 ESS or No. 1A ESS central office equipment.

3.21 When a fault becomes apparent at the attendant consoles, attempts may be made at the ESS central office to determine and to correct the faults. Data link diagnostic programs may be requested to determine if the fault is occurring in the data link circuitry. The data link diagnostic programs may be requested automatically due to repeated parity failures or they may be requested manually from the maintenance teletypewriter (TTY). TTY messages are printed out to indicate any difficulties in the data link circuitry discovered by diagnostic routines.

3.22 If the trouble cannot be located and corrected from the central office, it may be necessary for maintenance personnel to go to the centrex customer's location to aid in determining the trouble.

3.23 When a fault causing a trouble occurs at a centrex customer location, its cause may not be readily apparent to maintenance personnel on the customer's premises. By requesting that diagnostics be performed at the ESS central office, routine exercises may be directed to the desired console (and associated equipment) to aid in locating and identifying the fault. These routines may be performed only on consoles and console controls (or trunk busy memory units) which previously have been removed from service by the proper TTY input message.

3.24 Maintenance features for controlling data link and associated attendant telephone consoles are made available through the use of the maintenance teletypewriter (TTY). These features, which are provided by the centrex maintenance supervisory program, are as follows:

(a) To unconditionally restore or remove a data link from service

(b) To force the data link to use a specified bus and/or central pulse distributor choice

(c) To initiate the diagnosis of a specified data link or all data links

(d) To determine the status of all data links

(e) To remove from or restore to service a single attendant console

(f) To initiate the centrex console demand exercise routine to aid in console maintenance.

3.25 In addition to carrying out the hardware testing, the diagnostic programs make the data link busy at the No. 1 ESS while performing the tests, analyze the results of the tests, and, on the basis of the analysis, generate trouble numbers. These numbers may then be used in conjunction with the centrex data link dictionary (TLM-1A265) to enable the maintenance craft force to resolve the difficulty by replacing the faulty circuit pack or packs indicated.

3.26 Another function of the programs is to generate printouts of raw data results on a per-test basis. This enables the maintenance craft force to pinpoint the exact failure pattern due to a particular test.

CONSOLE OVERRIDE STATES

3.27 The in-service (I/S) override and out-of-service (O/S) override states are used for controlling maintenance activity on the data link. These states may only be reached as a result of an entry on the maintenance TTY. Furthermore, a data link in either of these two states will not assume any other state unless a proper entry is made on the TTY. The only exception is that during an emergency action phase 1 all data links in state 2 are restored to state 0 (normal I/S state). This protects against a possible large volume of erroneous inputs from a faulty data link causing repeated emergency actions. (Fig. 2)

A. In-Service Override State (010)

3.28 This state is derived as follows:

- The O/S bit is not set; therefore, the link is in service.
- The override bit is set; therefore, the link is forced into service. (That is, fault recognition is limited to a single retrial if an all-seems-well failure occurs.)
- The diagnostic bit is not set.

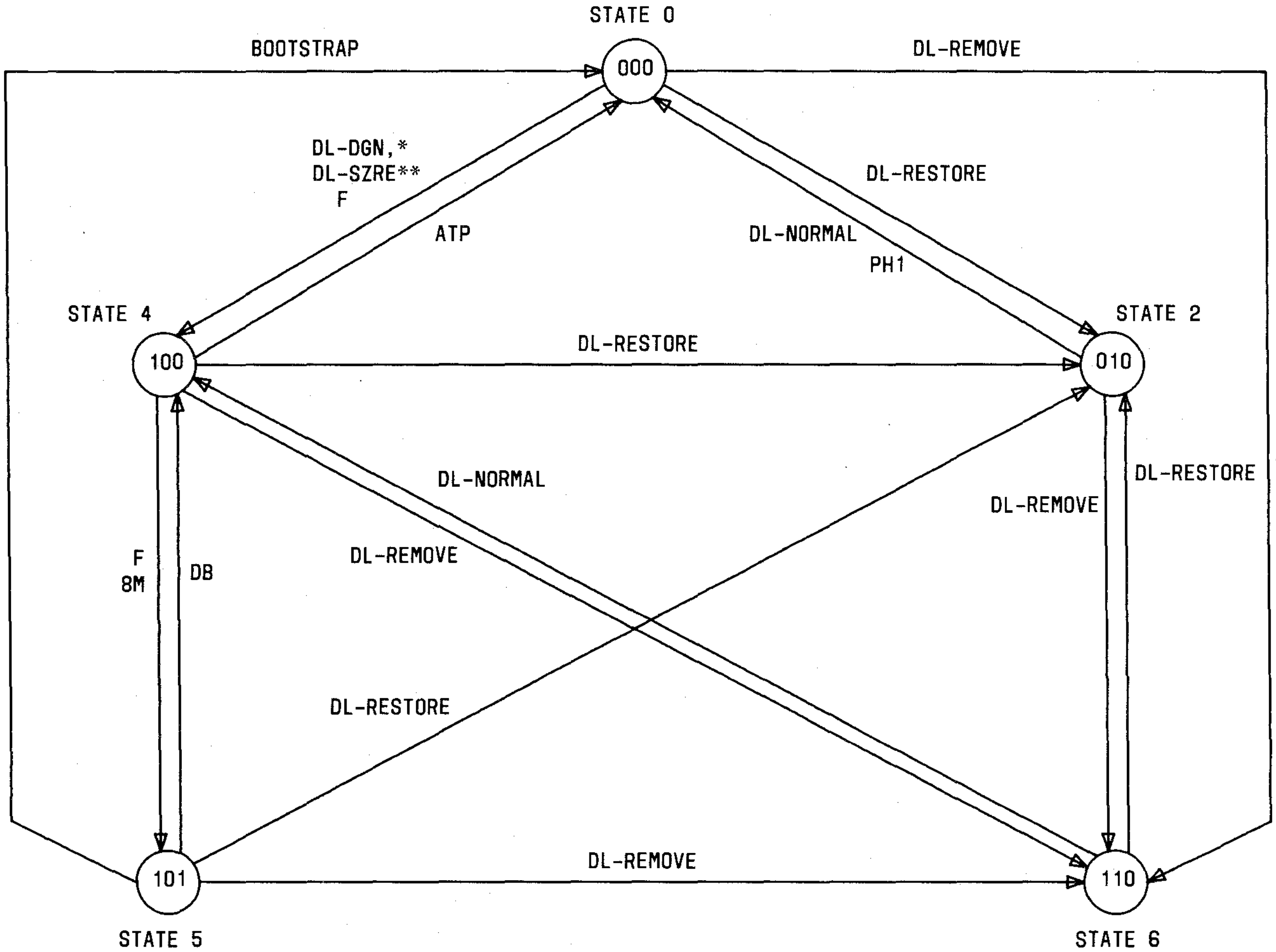
The link is therefore forced into service and diagnosis of the link is inhibited. The system will operate the link by using the bus and central pulse distributor determined by the variables in the input message. (If an F-level interrupt occurs, the system choices of a bus and a central pulse distributor will be used.)

Use of the In-Service Override State

3.29 Many situations may arise where the in-service override state is a valuable maintenance aid; the following two examples illustrate the usefulness of this state:

3.30 ***Usable Data Link Will Not Stay in Service:*** If certain types of failures occur, such as a failure within the all-seems-well circuitry, the fault recognition programs may determine that a usable data link is bad and take it out of service. It is also possible that the existence of some problem or failure (such as a noisy line) is degrading service somewhat, but the link is still useful. If such conditions should occur, the data link may be forced to continue service by placing it in the I/S override state using the DL-RESTORE message. Under this condition the link will never be removed from service by the fault recognition program. The bus and central pulse distributor choice for the link will never be changed unless a serious system problem occurs (an F-level interrupt, an emergency action phase 1, or a demand-enable update). When the necessary repairs are completed, the link may be restored to normal service by using the DL-NORMAL message.

3.31 ***Wiring Changes Are Required for a Data Link Frame:*** Occasionally it becomes necessary to work on the common equipment portion of the centrex data link frame. The peripheral bus connection circuitry on a data link frame is shared by all links on the frame. In such a situation it is desirable to force a data link (or several data links) to use a certain bus and central pulse distributor choice. For example: If a data link comes out of service and the trouble number indicates that a circuit pack must be replaced in



* IF THIS MESSAGE FAILS BECAUSE ALL CUSTOMERS ARE NOT ON NIGHT SERVICE, DL-SZRE MAY BE USED

** ONLY VALID FROM STATE 0

LEGEND:

PROGRAM ABBREVIATIONS:
- PH1 - EMERGENCY ACTION PHASE 1
- F - FAULT RECOGNITION DETECTED FAILURE (ASW, ALWAYS BUSY, ERROR COUNT)
- 8M - 8-MINUTE CHECK CAUSES STATE CHANGE (SETS DIAGNOSTIC FLAG)
- DB - DIAGNOSIS BEGINS
- ATP - ALL TESTS PASSED ON DIAGNOSIS
- TRAP - IF IN STAGE 5 FOR 8 MINUTES, LINK IS RESTORED WITHOUT DIAGNOSIS

DATA LINK STATES:
- STATE 0 - 000 - NORMAL IN-SERVICE STATE
- STATE 1 - 001 - INVALID
- STATE 2 - 010 - IN-SERVICE OVERRIDE STATE
- STATE 3 - 011 - INVALID
- STATE 4 - 100 - NORMAL OUT-OF-SERVICE STATE
- STATE 5 - 101 - OUT-OF-SERVICE DIAGNOSIS FLAGGED STATE
- STATE 6 - 110 - OUT-OF-SERVICE OVERRIDE STATE
- STATE 7 - 111 - INVALID

Fig. 2—Data Link State Diagram

the bus 0 common equipment portion of the data link frame circuitry, the DL-RESTORE message should be used to force all data links on the frame to use the bus 1 choice. The power may be removed on the bus 0 receiving cicuitry for that frame and the circuit pack may be replaced. When the procedure is completed, all data links should be restored to normal by typing the DL-NORMAL message.

3.32 It may become necessary to remove power on a central pulse distributor. If so, the procedure above may also be desirable since the probability that a data link will come out of service is raised because an O/S central pulse distributor removes two of the four possible routes to the data link controller.

B. Out-of-Service Override State (110)

3.33 This state is derived as follows.

- The O/S bit is set; therefore, the link is out of service.
- The override bit is set; therefore, the link is forced out of service.
- The diagnostic bit is not set; therefore, no diagnostic will be run.

The link is unconditionally removed from service and automatic diagnosis of the link is inhibited. No periodic attempts to restore the link to service will occur.

Use of the Out-of-Service Override State

3.34 Although many situations might arise where the O/S override state is a valuable maintenance aid, the following example illustrates the usefulness of this state.

3.35 ***Continual Diagnosis of a Link (CTX-7, Issue 8, and earlier generic programs):*** During installation or growth periods, data links are often placed in translation (in the unit-type, member-number translator) without having the customer console control cabinet connected to the central office data link. In such configuration, the data link will come out of service since no all-seems-well answer is received from the customer cabinet when an order is transmitted. (Periodically the system sends a pair of maintenance orders to each data link even though there is no normal key signal or lamp order traffic on the data link.) Every eight minutes the system will set a diagnostic flag for an O/S data link. The data link will always fail phase 3 of the diagnosis. The trouble number printed on the maintenance TTY will indicate that no customer console control cabinet is present. Furthermore, if the diagnostic flag is not answered by the diagnostic programs within eight minutes, the link is put back into service without diagnosis. These actions are taken so that a usable data link which has been taken out of service due to a momentary fault will not remain out of service for an extended length of time.

3.36 If the diagnostic activity is objectionable (such as during an installation period), the message DL-REMOVE should be typed on the maintenance TTY. This causes the link to be placed in the O/S override state and thus inhibits all automatic maintenance activity on the link. The only indication that the system ever gives that this link has been placed in the override state is a CTX14 message in the hourly printout messages. (A diagnostic will be performed at midnight on links forced out of service.)

3.37 A diagnosis may still be requested while the data link is in the O/S override state by entering the DL-DGN message on the TTY; however, even if the data link passes diagnosis, it will not be restored to service.

4. PIDENT FUNCTIONAL DESCRIPTIONS

CENTREX MAINTENANCE SUPERVISORY PROGRAM—PIDENT CXMS

4.01 The centrex maintenance supervisory program provides a variety of functions necessary for the proper supervision and maintenance of the hardware and software associated with the centrex data link. These features may be broken down into five main categories as described in the following paragraphs.

4.02 The first set of programs is used for emergency action (EA) and recovery purposes. A phase 4 (or higher) hardware initialization program exists to set to the proper state the data links and customer console equipment. Since the normal input-output (I/O) program for the centrex data link employs buried enable addresses and addresses of enable addresses, a routine is provided for D-level, F-level, and K-level interrupts to update and to correct this critical data. A similar activity is performed in a phase 1 recovery program; however, this program aborts certain flagged centrex maintenance jobs.

4.03 The console verification program constitutes the second major portion of the maintenance supervisory program. This program acts under the control of the audit programs to determine the state of the night and the position busy lamps and console headset on every equipped console.

This data is used by the centrex audit. In addition, an emergency power indicator for the customer end equipment is interrogated.

4.04 The maintenance personnel in a centrex office have a variety of features available to them from the maintenance teletypewriter (TTY) for controlling the data link. The features provided by the maintenance supervisory program include the ability either to initiate a diagnosis of a data link from the maintenance TTY or to place the link in override states (either in-service or out-of-service), and the ability to restore or to remove a link from service. In addition, this portion of the centrex maintenance supervisory program provides the TTY output interface for the data link diagnostic program.

4.05 The data link maintenance activity control programs regulate diagnostic activity on the link. One important feature of this system is the periodic diagnosis of out-of-service links. Since this equipment is unduplicated, an attempt is made to diagnose an out-of-service link every 8 minutes. (The link is restored to service if it passes.) Further, if the diagnostic flag is not answered for 8 minutes by maintenance control (MACR), the link is restored. The other major feature of the system is an upper limit placed on the number of performances of a diagnosis. In addition, an error count is maintained on those links displaying a high error rate. These error counts are printed hourly on the maintenance TTY. Lists of links in override states or on emergency power also are printed hourly. Finally, each day all available links are diagnosed automatically. Available links have their customers on night service.

4.06 A routine is also provided for error trapping on centrex data links. Error trapping is initiated on a link by the TTY message DL-ONTRAP-ab. or on all links by DL-TRAPALL-. It is stopped by typing DL-OFFTRAP-. (or if an EA PH1 occurs). When error trapping is in progress and an ASW error occurs on a link, a TTY message is printed giving the failing lamp order. If a key signal error occurs, a TTY message is printed giving the illegal key code and console. The trap status is given by a TTY message in response to the input message DL-TRPS-.

4.07 The ability to remove a single console from service and to restore it to service also is provided by the centrex maintenance supervisory program. This feature permits the centrex console demand exercises to perform console maintenance.

4.08 Two input messages are provided to allow the central office personnel to change the night service state of any console group (CTX-ONITE-aaa. and CTX-OFFNITE-aa.). If the primary console and its data link are in service, a lamp order is sent to set the night lamp to the appropriate state.

A. EA, Recovery, and Initialization Routines

4.09 During EA phase 4 or above, the data link hardware and customer equipment must be reinitialized. The first step in this process is to locate a bus and central pulse distributor (CPD) configuration by which each data link shift register can be loaded. Then a sequence of orders is transmitted over links which turn off every light on the attendant consoles, except for the release lamps which are turned on and the night and position busy lamps which are reiterated. The states of these lamps are read first by means of special maintenance orders. The initial states of the position busy lamps are left for the centrex audit, so that the console registers and console group head cells are initialized correctly. Similarly, the state of the night lamps is used to set correctly the night service state of each customer group.

4.10 The centrex lamp and key signaling program processes all lamp orders and key signals on in-service data links by using a block of call store data containing the various required enables and addresses of enables. This reduces the real time needed for this job. If this program produces a K-, F-, or D-level maintenance interrupt, it is necessary to update the enables and addresses which could create an interrupt. To perform this function, the recovery programs use subroutines provided by the centrex maintenance supervisory programs.

4.11 The possibility exists that flagged centrex maintenance programs in some fashion will seriously damage the system. If an EA phase 1 occurs, the J-level maintenance I/O program is turned off. In addition, the L-level and J-level data link restoration programs are aborted by reinitialization of their control registers. They begin again automatically. The console restoration program also is aborted. It prints a termination message but must be started again by a new TTY request. Finally, the same actions taken for F- or D-level interrupts also are performed.

B. Console Verification Routines

4.12 It is desirable to periodically confirm the state of the position busy lamp on each console and the night service state of each customer. The console verification program performs this process at the beginning of each run of the audit programs. This is accomplished by sending a pair of maintenance orders over each data link. This causes the links to report the night and position busy lamps state on each console as well as whether the customer's equipment is on emergency power.

4.13 Since this process is carried out periodically on all in-service links, to help perform this activity the normal centrex I/O programs have been adapted. The required orders are dispatched from special purpose lamp blocks by the centrex lamp control program in the same way normal lamp orders are sent. The answers received from the customer end are scanned and reported through the centrex hopper by the centrex I/O program, just as key signals are reported. The states of the night and position busy lamps are left in the maintenance word of the appropriate console registers. At this time, a scan is made of the headset scan point of each equipped console, and the state of this point is also left in the register. Finally, the emergency power bit for the link is updated from the verification answer.

4.14 If it is impossible to transmit the orders (ie, they stay on queue), a single retrial is attempted. If this fails or if no answer returns on any links, a "no verification" indicator is set in the affected console registers.

C. Data Link Service Routines and TTY Interface

4.15 All TTY output from link diagnoses, except raw data prints, passes through the maintenance supervisory program. This allows the program to control the diagnostic activity on the link. In addition, aborts of a diagnosis and normal conclusions pass through the program.

4.16 Any major action relating to the data link state is handled through a uniform scheme of the table controlled programs. Such major actions include automatic or TTY initiated requests to remove a link from service and requests to force a link into service. This description explains only the general approach to possible situations and their solutions. The reader should refer to the input and output message manuals for detailed user information.

4.17 When a given task is to be performed, the general approach first is to perform an assignment check on the existence of the link. Next, the state of the data link is derived. The state of the link is defined as the concatenation of the out-of-service bit, the override bit, and the diagnostic bit for that link. The data link state is used as an index to a table of program orders which initiates the appropriate action, usually the transfer to a subroutine (Fig. 3).

4.18 The explanation of the data link state concept requires a discussion of the bits involved. To understand the out-of-service bit, it is necessary to consider the process of removing a link from service. When the fault recognition section of the centrex I/O program determines that a link is failing, a hopper report is made which is given to a memory clean-up routine in the data link diagnostic control programs. This routine marks the trouble bit in the data link subsystem status table at the beginning of the clean-up process. At the last stage of the process, the out-of-service bit is set. Similar actions are performed if the link is removed manually from service.

4.19 The override bit is used to indicate that a link is forced either into or out of service. If a link is forced into service, no fault recognition is used on that link; thus, the link will not come out of service. If an EA phase 1 occurs, all links in this state are put back to normal by the phase 1 recovery program. If a link is forced out of service, no periodic attempts are made to restore it.

4.20 The diagnostic bit is in the subsystem status table for the data link unit type. When this bit is set, MACR initiates a diagnosis of the link as soon as higher priority work is completed.

4.21 The significance of each possible data link state easily is seen. State 0 is the normal in-service state. Unequipped data links by definition are in state 0. Since a diagnosis cannot be performed on an in-service link, state 1 is an invalid state. State 2 is the forced-into-service state (no fault recognition is performed). State 3 is an illegal

BITS 23-3 - ZERO
BIT 2 - DIAGNOSTIC
BIT 1 - OVERRIDE
BIT 0 - OUT-OF-SERVICE

STATE		CONDITION
0	000	NORMAL IN-SERVICE
1	001	INVALID - NO DIAGNOSTICS ON AN IN-SERVICE LINK
2	010	FORCED INTO SERVICE
3	011	INVALID - NO DIAGNOSTICS ON FORCED IN-SERVICE LINK
4	100	NORMAL OUT-OF-SERVICE
5	101	NORMAL OUT-OF-SERVICE WITH DIAGNOSTICS
6	110	FORCED OUT-OF-SERVICE
7	111	INVALID - NO DIAGNOSTICS ON FORCED OUT-OF-SERVICE LINK

Fig. 3—Data Link Status Word

state, because a diagnosis cannot be flagged on a link forced into service. State 4 is the normal out-of-service state. State 5 is the normal out-of-service state with the diagnosis flag set. State 6 is the forced out-of-service state (no periodic attempts to restore the link will occur). State 7 is invalid, since a diagnosis cannot be flagged on a link forced out of service. (This does not prevent a link in state 6 from being diagnosed from the maintenance TTY because the routine request table, not the subsystem status table in MACR, is used to start the diagnosis.)

4.22 When invalid states are encountered while performing some maintenance activity on the link, the most reasonable state for the link is selected by a failure subroutine. The link is placed in that state, and the execute table is entered again to take the appropriate action dictated by the new state.

D. Data Link Maintenance Activity Control

4.23 Diagnostic activity counters and periodic program entries provide the two major mechanisms for controlling maintenance activity on the centrex data link. The centrex maintenance supervisory program maintains a count of the number of flagged successful diagnoses (ie, program generated requests as opposed to those initiated from the maintenance TTY). These counters are decremented every 8 minutes for each link. (Odd and even numbered links are done alternately every 4 minutes.) If either count becomes excessive, the link involved is not restored to service, even though it passes diagnosis. If too many aborts occur, no further automatic attempts are made to complete the diagnosis. (Normally, if a diagnosis is aborted, the diagnostic flag is set again.) These features prevent MACR from being occupied too long by the data link diagnostic program.

4.24 Since the centrex data link is unduplicated, this maintenance system attempts periodic restoration of any out-of-service links. Every 8 minutes, an out-of-service diagnostic bit of a link is set. If the link passes, it is put back in service. If MACR is unable to honor the diagnostic request in the next 8-minute period, the link is brought back into service.

4.25 Error counts are maintained for each link. For each invalid key signal or twice retransmitted lamp order, the centrex I/O program increments an error counter. If this count becomes too large, the link is removed from service. Further, every 4 minutes these error counters are read and zeroed by the centrex maintenance supervisory program. If they exceed one, a high error counter is incremented. This error counter is printed every hour for each data link with a nonzero high error counter.

4.26 Each hour an entry is made to the centrex maintenance supervisory program. In addition to the error count print, lists of links in override states and a list of data links on emergency power are printed. If the customer equipment of any link is on emergency power as part of the periodic emergency power test, the appropriate bit is set in memory to record this fact.

4.27 Each night an attempt is made to diagnose each data link. Only those links having all their customers on night service are diagnosed. The routine request table in MACR is employed for this purpose.

E. Console Maintenance Features

4.28 The ability to remove from service and to restore to service individual consoles is provided in the centrex maintenance supervisory program. This console state exists independent of the data link state. However, if a link is being restored to service and a given console on that link was out of service, that particular console would not be restored to service. Similarly, if an attempt is made to restore an out-of-service console on an out-of-service link, the console is not actually put in service, although its out-of-service bit is reset.

4.29 When a console is out of service, all key signals from it are routed to the centrex console demand exercise program. Since all calls are removed from a console which is being taken out of service and no new calls are routed to it, the only lamp order traffic comes from the console demand exercise program. Under the control of the maintenance personnel, this program sends lamp orders and read key signals to test individual consoles. When a console is restored to service, all such activity on that console is aborted.

DATA LINK DIAGNOSTIC CONTROL—PIDENT CXMC

4.30 This program handles some of the L-level work associated with the diagnosis of the centrex data link. It prepares the link for diagnosis by tearing down all calls associated with it. CXMC then turns on a J-level I/O program which enters PIDENT CXMA to send the peripheral orders and scan for the test results. When the I/O work is done, CXMC then analyzes the raw data and computes a trouble number which it passes to CXMS to print out on the TTY.

A. Prepare to Begin Diagnostics

4.31 When the fault recognition programs determine that there is trouble on a data link due to an "all-seems-well" failure on two consecutive lamp order transmissions, control is transferred to the centrex diagnostic programs. CXMC is entered via CXMAIN or CXMBIO from CXMS, CXKY (centrex console lamp and key) or SACX (centrex registers audit—audit No. 38). CXMAIN stores the address of ECMP.RETURN in the J register. CXMBIO performs the tasks necessary to ready the system to run diagnostic tests.

4.32 The first step is to verify the state of the data link. That is done by CXMS.CXMVIO. If the link is found to be in service or unequipped, bit 19 in the audit request table is set. This flags SARG (call register audit) to run audit 43 which will check the validity of the loop register data.

4.33 If the data link is type 3 or 4, then an attempt is made to remove the carrier from the data link to signal to the far end that the link is now out-of-service. If the carrier is successfully removed, control is transferred to ECMP.RETURN. Failure to obtain a POB, to execute the remove carrier order, will not result in abort actions as the carrier will be automatically removed when diagnostics start.

4.34 Further actions are necessary if the program failed to obtain a POB. The lamp order queue is cleaned of all lamp orders waiting to be transmitted on the data link in trouble. This is done in two steps: (1) the "queue clean" flag is reset (ECMP flag No. 135); (2) the data link trouble bits are set. Queue returns are prevented by writing a no-return code into the lamp order block of each active console register and loop register. This prevents clients that have orders to be transmitted on the lamp order queue from getting queue returns.

4.35 The console registers that are associated with the data link are marked maintenance busy, and are removed from the idle linked list of console registers if they appear on it. (Up to eight console registers may be associated with each data link.) Since a customer may have attendant consoles on other No. 1/No. 1A ESS data links than the faulty one, the program checks to see if the consoles involved are the last idle consoles in a group. If so, the emergency night service bit in the console group block is marked. This indicates that all attendant consoles for the particular customer are busy, and all attendant bound calls are to be rerouted to the centrex night service number. If the consoles are not the last idle consoles in a group, the headset-out count is incremented by 1, and the emergency night service bit is not marked. The headset-out count is equivalent to a count of busy consoles.

4.36 In addition, the busy-idle bits of the console registers are all idled. These bits correspond to the state of all loop registers associated with the console. If the console registers are attached to active calls, the RI (register identifier) and PT (program tag) of all loop registers associated with the console register are marked to the audit codes of 0 and 7, respectively. Up to six calls may be associated at any given time with each of four consoles; therefore, a maximum of 24 calls may be lost. Finally, control is transferred to the calling client.

Audit Maintenance Status Bits

4.37 When a main program flag is set, ECMP transfers control to CXMC.CXQUCL to audit the maintenance status bits. CXQUCL is entered indirectly by CXMBIO setting main program flag 135 while stopping further lamp orders from being generated. An invalid status exists when a data link is marked in trouble (TBL) and out-of-service (OS) with the diagnostic (DIAG) not marked, or the TBL or DIAG bits are set by themselves.

4.38 A loop index and counter are used to loop through and check the status for all frames. If the DIAG bit is set with OS and TBL not set, then the DIAG bit is reset and the check continues. If the TBL bit is set with OS and DIAG not set, then OS and DIAG are set and control is transferred to subroutine CXMSTRBL. This subroutine turns on the primary centrex trouble lamp and returns to CXMC. Next, CXMS.CXMSOS is called to print a TTY message indicating that the data link has been taken out-of-service. Finally, control is transferred to CNLP.CNADLD to remove all lamp blocks associated with the data link from the linked list and then transfer to ECMP.RETURN.

4.39 When all groups of sixteen links have been checked, the "queue clean" flag is reset and control is transferred to ECMP.RETURN.

B. Start Diagnostics for Centrex Data Links

4.40 The global address used to begin testing of a particular data link is noted by the symbol CXDIAG. This global is entered via MACR (maintenance control program) when diagnostic and trouble bits are set in the subsystem status table (M4CNTX).

4.41 CXMC.CXDIAG first checks to see if any of the four available routes to the shift register in the central office is available. This is done by reading the out-of-service bit (bit 2) of the PU bus status words for bus 0 and bus 1. If the bit is zero, the corresponding bus is available; if one, it is not. Similarly, bit 2 of the CPD status words for CPD 0 and CPD 1 are checked.

4.42 When the program finds no available routes, control is transferred to CXMS.CXMSNB. This results in a TTY message indicating that a diagnostic cannot be performed on the specified data link because it cannot be reached over either bus via either CPD.

4.43 If at least one peripheral route is marked available, then a check is made to see if power exists on the data link frame and on the data link. The test for frame power consists of a scan of the fuse alarm scan point. Power exists if the ferrod is saturated. If the ferrod is not saturated (ie, no power exists on the frame), control is transferred to CXMS.CXMSNP which causes an appropriate TTY message to be printed. The scan for data link power consists of determining if all the scan points associated with the data link are unsaturated (ie, the ferrod readouts are one indicating no power on the link). The right half of the link is checked first. The left half is checked only if power does not exist on the right half. If there is no power on either half of the data link, then control is transferred to CXMS.CXMSLP which causes an appropriate TTY message to be printed.

4.44 If the route availability and power tests pass, the last step taken by CXDIAG is to operate a relay in the data link circuit. This will cause the two tip and ring pairs to be opened to the far end and connected together through a lumped-constant pad which simulates two miles of exchange cable. This action is necessary to avoid interaction with customer's equipment during the first three phases of testing. The relay is operated by calling MACR.MACS11 to seize and load a POB with the SD action to loop the data link information back into the central office shift register. If no POB is available, the diagnostic is aborted and will be rerequested. Otherwise, control is transferred to MACR.MACP05 which assigns a portion of the MACR scratch pad area for the centrex diagnostic programs.

C. Test Phases

Phase 0

4.45 Phase 0 constitutes an access test of the central office shift register. Each available route to the shift register is checked for its ability to load the register. For each route checked the current bus choice and CPD choice is loaded into the CPD enable word. And, a different test word is loaded into call store (CXDATA +4) for each route. The criterion used for the test is that the enable used for loading, along with the test word sent over the bus, causes a change in the contents of the register. If there is no change, the particular route being tested will be marked in trouble.

4.46 The program store address of the next segment of level L work is placed in MACR control location MA2PMSCRATCH92. Until all the access tests are done, the address stored is for CXMC.PH0_RESULT_PROCESSING. This subroutine checks to see if the test passed for the route currently being checked and records the routes that fail.

4.47 When all available routes have been tested, the program determines which have failed, if any, and generates a trouble number indicating the condition. The all tests pass flag is reset (NOATP) indicating that at least one test failed. Control is then transferred to CXMS.CXMSTR to print an appropriate TTY message.

4.48 If no routes can gain access to the shift register, the diagnostic is aborted and control is transferred to CXMS which prints an appropriate TTY message. If at least one route is available, however, the program continues with phase 1 testing.

Phase 1

4.49 Phase 1 constitutes a bus loading test designed to determine if the shift register can be loaded with accuracy from both buses (or one bus, if only routes involving one bus are available). The test consists of loading the shift register with a single 1 in a field of 0s and then a 0 in a field of 1s. In addition, words containing all zeros and all ones are interspersed throughout to give the test more completeness.

4.50 The test is carried out in two separate segments because of the magnitude of the results (64 words). The test data is stored in a program store table, and consists of the floating 1s pattern. The first word of the table contains the size of the table and the call store start address of where the test data is to be stored. The CXMC program then loads this data into call store, initializes the counter, updates the CPD enable word and other control words, and initiates I/O.

4.51 Data Normalization: The data consists of two scan rows of results loaded into two consecutive call store locations. The first word contains the 10 least significant bits of the shift register and the second contains the 14 most significant bits. The expected results are listed in a program store table (M4GS). The actual results are exclusive OR'ed with the expected results. The results of the logical operation are stored in an error word for later use in generating a trouble number. Every 1 in an error word represents a failure.

4.52 After the test has been run using a route involving bus 0, it is repeated in its entirety for bus 1 if a route exists to the shift register for this bus. It should also be noted that the test will be run on bus 1 alone if no bus 0 routes are available. At the termination of the tests, the error words are checked for each bus. If neither error word contains 1s, the phase is considered to be passed and the program starts phase 2. If one error word contains 1s and the other contains 0s, a trouble number is generated describing the bus that failed and its failure pattern, and transfer is made to CXMS for printing of the trouble number. However, the failure is considered nonfatal and return is made to CXMC and diagnosis continued using the (assumed) error-free bus. If both records contain 1s, the program generates a trouble number, releases the loop relay, and then transfers to CXMS which prints the trouble number and releases the diagnostic programs from MACR.

Phase 2

4.53 The phase 2 test is designed to determine the ability of the shift register to shift a word one bit at a time accurately. It also tests the ability of the shift register to start and stop transmission by letting it run at speed (1400 BPS) transmitting through the pad circuit back into itself.

Single Shift Test

4.54 The one bit shift is accomplished by sending the enable-start order followed immediately by a load order. The enable-start enable is derived from the enable-load enable by zeroing bits 8 and 9, and marking bit 7. When 26 shifts have taken place, the I/O work is completed and control is returned to CXMC.

4.55 Each result of the shifting operation is checked against a program store table of expected results as done in phase 1. Mismatches are recorded in an error word. In addition to the shift register scan points, a scan point which monitors the logic circuit which determines when the counter has reached 26 is checked at each step of the way, along with scan points providing access to the nonbus accessible (nonloadable) shift register bits (bits 24 and 25). These three scan points are exclusively used for maintenance.

4.56 If the single shift test failed (ie, there are 1s in the error word), a trouble number is generated describing the failure, and the central office loop around relay is released. Control is then transferred to CXMS which prints the trouble number and releases the diagnostic programs and scratch memory from MACR.

High Speed Start-Stop Shift Test

4.57 Once the single shift test has been successfully passed, the ability to shift the contents at speed is tested by loading a test word, starting transmission (setting the enable-start flip-flop via the CPD), and scanning the shift register 10 ms later and 25 ms later.

4.58 The last scan is then compared with the loaded test word and if a mismatch occurred, the diagnostic is terminated since the dynamic activity of the link should be stopped at the 25-ms time period. If these scans match, the 10-ms scan is checked against the test word. These results should result in a mismatch, since at 10 ms after sending the transmit enabled, the circuit should be in the process of shifting. If they do ***not*** result in a mismatch, the diagnostic terminates via CXMS.

4.59 If all phase 2 tests passed, CXMC releases the central office loop around relay. Raw data will be printed if it was requested. Control is then transferred to MACR.MACP05 to segment. The next segment address is CXMC.CXMP3B which begins phase 3 testing.

Phase 3

4.60 Phases 3, 4, and 5 constitute tests involving the far end of the data loop, whereas phases 0, 1, and 2 involved only the central office circuitry. Therefore, the trouble numbers generated in these phases are ***meaningless*** in terms of pack replacement at either end and are generated in order to give further insight into what may be causing the problem (see TLM-1A265).

4.61 The phase 3 test consists of transmitting a series of orders to the distant end, getting them back again, and verifying the integrity of the result by comparison to a program store table of expected results. In addition, use is made of another maintenance scan point on the data link. This point monitors the 700-ms idle signal. Absence of the signal implies that continuity has been lost, or power has been removed from the far end. In case the scan point is not saturated, diagnosis is aborted as in phase 1.

4.62 CXMC first scans the rows of the data link, loads the central office shift register, and then transmits the loaded word by setting the enable-start flip-flop via the CPD. All test words sent in this phase have bits 20 and 21 set to 1, so that once they have been received in the distant end shift register, they do not cause actions by the console control circuit to occur and may be transmitted back to the central office circuitry.

4.63 Once the results have been obtained, CXMC analyzes them by comparison to a program store table. When a mismatch occurs, a counter is incremented. A mismatch in this phase causes termination of the diagnostic programs, as in phases 1 and 2 with the resulting trouble number printed. Included in the trouble number for this phase, however, is a counter of failing words. When the all-tests-pass condition is observed, the program proceeds to phase 4.

Phase 4

4.64 This phase tests the all-seems-well (ASW) circuitry at both the central office and customer premises. The test is performed by transmitting two good parity words and two bad parity words to the far end. After each transmission the ASW scan point is scanned, and the result is loaded into CXDATA. A change in the reading indicates that the far end received a good transmission, and no change indicates a bad transmission.

4.65 After the scanning, transmission, and loading functions have been performed for all four words, CXMC formulates a result word from the scan data. This word is compared with the program store word containing the expected results. A mismatch results in a trouble number being generated and termination of the diagnostic. Included in the trouble number is a count of the number of ASW failures. If no failure occurs, the program continues with phase 5 testing.

Phase 5

4.66 This final phase of testing determines if the ferreed crosspoints associated with the night and position busy lamps on the console can be operated and released. This feature is provided on only those ferreed crosspoints in the console control circuit. This function is performed by loading and transmitting the following series of orders:

(a) Order to light both night and position busy lamps

(b) Order to interrogate night and position busy lamps

(c) Order to transmit results of interrogation back to the central office

(d) Order to extinguish both night and position busy lamps

(e) A repetition of orders (b) and (c).

4.67 Failure of any console in this phase of testing constitutes a nonfatal error. A printout of the trouble number showing which consoles failed to light or extinguish will be given but the data link will be restored to service by CXMS.

Raw Data

4.68 Raw data may be requested as an option from the input message DL-DGN-abb. The CXMC program recognizes this request during all phases of diagnosis except phase 0 and phase 5, in which the trouble number itself constitutes the raw data. This is also true for the high-speed test in phase 2. If raw data is requested and failures are observed, the output message contains the standard heading (see OM-1A001 - DR06) followed by PH "X" STF and the raw data, where X represents the phase number in which tests failed. If all tests passed, a PH "X" ATP is printed for each phase on which the condition is observed. Only nonzero data results are included in the print.

4.69 CXMC uses the dictionary output generation program (DOCT) as a service routine to print the raw data results and the heading message. This program is treated as a closed subroutine by CXMC, return being made on the contents of the J register.

CENTREX MAINTENANCE PROGRAM—PIDENT CXMA

4.70 This PIDENT functions as the interface between CXMC and ECIO (executive control input-output program). It is entered through the global entry point CXMA.CXMAIO via ECIO. CXMAIO is a transfer vector table which allows entry into the proper point in the J-level program. The entry point is determined by the "in progress" bits (0 through 5) of the control word MA2PMSCRATCH 78.

4.71 CXDATA is a 60 word block in call store used for maintenance data. It is used by the centrex diagnostic and maintenance programs to store test vectors, scan results, and other necessary control information.

4.72 The CXMA subroutines load the CPD enable word to send test vectors out to the peripherals, enable a scanner, and then read and store the test results. The following items are needed as input:

(1) CNT—number of scan result words to be stored

(2) AEA—address of the scanner enable

(3) SCNR—scanner row

(4) ENABL—CPD enable word

(5) CNTRL—control word for the I/O programs.

CENTREX DATA LINK AND CONSOLE DEMAND EXERCISE PROGRAM—PIDENT CXDX

4.73 The CXDX program is provided in No. 1 ESS and No. 1A ESS offices equipped with centrex service. A customer provided with centrex has on the premises one or more centrex console controls along with one or more attendant consoles. A fault occurring in any of this equipment requires maintenance personnel to go to the customer premises. To assist in locating the fault, the CXDX program can be requested to step through lamp orders in a specific sequence. The program also recognizes key signals sent from an out-of-service console. CXDX contains two demand exercise routines: a high-speed demand exercise routine and a slow-speed demand exercise routine. The high-speed exercise routine does not recognize key signals.

A. Initiating the Program

4.74 The CXDX program can be initiated from the TTY or the attendant console on the customer's premises. Before the program begins, the console control to be tested must be taken out of service by a TTY request.

4.75 The program can always be initiated from the TTY by use of the CTX-EXC message. (Refer to the TTY Input Message Manual for more detail.) Any specific exercise must be initiated from the TTY, and all exercises can be stopped from the TTY.

4.76 Only a complete exercise (lamp and trunk busy, and/or key exercise) can be initiated from the attendant console. This is done by depressing the loop O key one, two, or three times depending on the desired exercise. The exercise can be executed either once or repeatedly.

4.77 CXDX.CXTTY is the subroutine that handles TTY input messages and console requests. It verifies the validity of the request and checks that there is not already a demand exercise in progress. The requested exercises are indicated by marking a corresponding bit in word four of the GBT buffer (M4GT). Control is returned to the TTY program TTIA.

B. Slow Speed Exercises

4.78 The slow speed exercises consists of three exercise routines: a lamp exercise, trunk busy exercise, and a key exercise. Each exercise can be executed individually or in combination. The program can also repeat a specific lamp or key order.

4.79 ***Routine CXDX.CXLAMP:*** A lamp exercise may be requested for a particular console. This routine operates all of the lamps (other than the trunk busy lamps) on the selected console in all of its various states. The states to which they may normally be operated are steady, wink 60 ipm, and wink 120 ipm. The lamp exercise may be performed separately, or it may be included in the complete exercise routine.

4.80 During the lamp exercise routine, data which attempts to light and extinguish lamps in logical groupings is transmitted. Several lamps may be included in a single request. Lamp failures (either a failure to light or to be extinguished) can be readily recognized by maintenance personnel at the console location.

4.81 ***Routine CXDX.CXTBSY:*** A trunk busy lamp exercise routine may be requested for a particular console. This exercise routine does not exercise all of the trunk busy lamps on a console. Only those trunk busy lamps will be exercised which are controlled by the console control unit (or optional trunk busy memory) to which the exercise is addressed. Table B lists the console control units which may be assigned to a customer group and the trunk busy lamps which may be controlled by each of the console control units. Personnel in the central office must be aware of which console control position to direct an exercise to in order to exercise the desired trunk busy lamps.

4.82 When a customer group is equipped with several console control cabinets, the trunk busy lamps are normally controlled by the first console control cabinet installed for the customer's use.

4.83 ***Routine CXDX.CXKEY:*** A key exercise routine may be requested for a particular console. This routine tests key signals which originate at consoles to verify that they are properly received and interpreted at the central office. This routine may be requested from either the central office or the console. A key exercise may be performed separately or may be included in a complete exercise routine. A key exercise is performed at double speed (that is, the lamp responses to the key signals are 2 seconds in duration).

4.84 When a key request is initiated, maintenance personnel at the console location must depress each key on the console in a special sequence. The key signal data received at the central office is analyzed and a reply is returned which gives an indication at the console of the success (audible for two seconds) or failure [LOOP 0, SRC (60 ipm) for two seconds] of the central office to receive a valid signal. An indication is also given if the same key is depressed twice [LOOP 0, SRC (wink) for two seconds].

4.85 ***Routine CXDX.SPEC:*** A request to exercise a specific lamp may be initiated only at the central office maintenance TTY using the CTX-EXC input message.

4.86 A request may be made for an exercise to be performed only once or to be repeated until stopped. A specific lamp exercise may be stopped at either the central office maintenance TTY or the console on the customer's premises.

4.87 Two or more lamps may be included in a specific request; however, all of the lamps to be included must be part of the same lamp group. When it appears desirable to exercise specific lamps which are in different lamp groups, it is necessary either to request a complete lamp exercise routine or to type in separate, but not simultaneous, requests directed to the different lamp groups.

4.88 Data must be encoded and entered into the g-field of the CTX-EXC input message to select a specific lamp and to determine the state to which it is to be operated. The g-field also includes the address (lamp group select code) of the lamp group containing the lamp or lamps to which the exercise is being directed.

4.89 ***Routine CXDX.SENDLP:*** This routine gets the complete lamp order and loads it into the buffer. It calls CNLP.CNLMPO (centrex lamp control program) to actually send the lamp order to the attendant console.

TABLE B

TRUNK BUSY LAMP CONTROL

	1B- AND 27A-TYPE CONSOLES		2B- AND 47A-TYPE CONSOLES	
	CONSOLE CONTROL POSITION	TRUNK BUSY LAMPS	CONSOLE CONTROL POSITION	TRUNK BUSY LAMPS
Multiple 1B- and 27A-Type Console or Single or Multiple 2B- and 47A-Type Console	0 1 2-31	0-11 12-17 None	0 1 (OTBM) 2 3 4-31	0-11 12-35 36-47 48-59 None
Single 1B- and 27A-Type Console	0, 1, 2, or 3	0-11		

Capabilities and Restrictions

4.90 The CXDX program is capable of checking all attendant console lamps and keys. It also checks the circuitry and data link associated with the attendant console. Faults are indicated by the failure to light a lamp or receive the proper acknowledgment signal from central control.

4.91 The CXDX program executes only on an out-of-service console control. The data link must be in-service. If a console control should be restored to service while an exercise is in progress, the exercise is aborted, and a TTY message is printed to indicate that the exercise has been stopped.

4.92 A specific lamp or key exercise can be initiated only from the TTY. All exercises except a specific key request can be stopped from the attendant console; a specific key request can be stopped only by the TTY. An exercise cannot be started or stopped from the attendant console if a fault is located in the loop 0 key circuitry, since this is the signal to start or stop an exercise via the console. A maximum of four console controls can be tested simultaneously, due to the limit of four general buffer tables (GBTs) in an office.

C. High Speed Exercises

4.93 The high speed exercise routine (also called camp-on) can repetitively transmit orders as fast as one every 100 ms. This permits maintenance personnel to use an oscilloscope to troubleshoot the more difficult and/or intermittent problems. TTY messages are used to initiate the high-speed exercise. Note that the data link under camp-on must remain in-service throughout the exercise. Camp-on will do nothing if the data link goes out of service.

TTY Messages

4.94 Three TTY messages are used to control the operation of the centrex data link camp-on routine. They are the following:

(a) CX-LOAD-aa bbbbbbbb

(b) CX-CAMP-c d e f gg

(c) CX-START-.

4.95 Three messages are used to easily insert the request into the system, to quickly make changes, to allow complete flexibility, and to easily and quickly start the routine once the system has the requests.

4.96 ***TTY Message—CX-Load:*** The CX-LOAD message is used to load the orders to be transmitted to the console. Up to twelve orders may be specified. The order number is defined by aa(00-11). The sequence of transmitting orders is consecutive, always starting at order zero. However, the orders can be initially loaded (or changed at a later time) in any sequence, and only the required orders to be transmitted need be inserted. In addition, the orders can be changed whether or not the camp-on routine is active. The eight octal digit number bbbbbbbb defines the order. Maintenance orders and all zeros (bbbbbbbb = 0) can also be transmitted.

4.97 ***TTY Message—CX-CAMP:*** The CX-CAMP message initializes the camp-on control routine. This message always terminates the execution of any active request when a new request is made; c d e f gg should equal 0 when this message is being used only for termination. The frame number is defined by c(0-3); d(0-7) specifies the data link number on the frame.

4.98 The letter e is defined later. The rate or frequency transmitting the orders is defined by f(1-7). The numbers 1 through 7 represent the number of 100-ms increments; thus, a value of 6 for f means that an order is transmitted every 600 ms. The value of gg is set equal to one less than the number of orders to be transmitted. As an example, to send 5 orders, gg would equal 04, and the orders loaded in the first 5 locations (aa = 00-04 in the CX-LOAD message) would be transmitted.

4.99 The value of e can represent either of two functions. To use e as the console number, its value must be set equal to 0, 1, 2, or 3. When this is the case the console number normally defined in the body of the order (bbbbbbbb) is updated to equal the console number defined by e. Therefore, much time can be saved when it is desired to switch from one console to another. As an example, if 10 orders were being sent to console 0 and these same 10 orders were to be switched to console 2, it would not be necessary to update bbbbbbbb 10 times using the CX-LOAD message. Instead, the

CX-CAMP message would be used with e = 2. The console number defined in bbbbbbbb is updated to equal the console number defined by e only to the extent of the value of gg + 1 (the number of orders being transmitted); that is, if 5 orders were to be transmitted, bbbbbbbb would be changed in locations aa = 0-4. This feature provides complete flexibility to the maintenance man. When e contains the value of 4, 5, or 6, no change of the console number in bbbbbbbb takes place. The second function of e is to send automatically all combinations of lamp orders* to a given console. When this function is desired, e is set equal to 7. The console used is defined in bbbbbbbb in word number 11 (aa = 11). In this case, gg is ignored (ie, don't care).

*Approximately 115 lamp orders, one at a time, are automatically transmitted to the console. A lamp order is sent whether or not the console is equipped with the lamp.

4.100 ***TTY Message—CX-START:*** The CX-START message starts the camp-on routine. It is not necessary to reinitialize the information previously stored by the CX-LOAD and CX-CAMP message as long as the information remains the same. The CX-START message gives TTY response NG if c d e f gg = 0, the data link is not in the office, the data link is out-of-service, or f = 0.

Methods of Terminating the Routine

4.101 The CX-CAMP message terminates an active camp-on routine in progress. There are three other ways the routine can be terminated. The routine is terminated by setting to 1 keys 20 and 23 of buffer bus 17. These same keys are used in the network and SD diagnostic program for similar control, permitting termination of the routine without using the TTY. An EA phase also causes termination since the program uses real time. Provision is incorporated (the CX-START-. TTY message), which permits the routine to be easily restarted after the system properly recovers. To insure that the camp-on program is not left running inadvertently, a 30-minute counter automatically terminates the routine after such time.

4.102 This routine uses real time; therefore, in a cutover office, caution should be observed when running the exercise. Whenever possible, the slower transmission rates should be used, and the routine should be run during light or moderate traffic, light traffic if the higher transmission rates are used. In addition, prudence must be exercised when using the camp-on program to minimize the customer's inability to use equipment. As examples, maintenance orders and lamp orders to nonexistent lamps could be transmitted. These orders should not noticeably affect the operator's console. If lamp orders which control functioning lamps are to be transmitted, an arrangement should be made between the maintenance personnel and console operator to determine which lamps can be affected with minimum interference.

AIOD DIAGNOSTIC PROGRAM—PIDENT AIDG

4.103 The AIOD services are not considered essential to normal call processing and no system emergency action or interrupt will occur for any type of AIOD malfunction. Fault detection is accomplished primarily by the AIOD call processing program. However, provision is made for the quarantining of an ANI if error analysis shows it to be faulty, and for diagnosis of a receiver suspected of malfunction.

4.104 The primary function of the AIOD diagnostic program is to test a given receiver (0 or 1). Based on the test results, the receiver will either be removed from service or returned to service. When a receiver fails the diagnosis, a dictionary trouble number cross-referenced with a matching number in the trouble locating manual (TLM) points to the faulty circuit.

4.105 The receiver diagnosis is divided into five sections called phases. The five phases of test data are executed in numerically increasing order. Phase 1 tests the shift register (SR) with the test transmitter (TT) disconnected. Phase 2 tests the maintenance control (MC) hardware prior to its use in phase 3. Phase 3 connects the TT to the receiver and checks that data can be transmitted and received by the hardware. Both TTs are used in phase 3. Phase 4 tests the shift register error (SRE) and ANI parity error (APE) circuitry (although phases 1 and 3 also perform some SRE and APE tests). Phase 5 is a special test pattern designed to detect the most difficult SR hardware problems.

4.106 In addition, AIDG performs continuity checks on the number identification circuit (ANI), and tests to ensure that the data circuit can connect and disconnect, and is free from shorted contacts to the specified receiver. To completely test the ANIs and the data circuit the diagnosis must be done twice, once with each receiver. The ANI diagnosis generally runs only upon TTY request. However, if the normal diagnoses finds that an ANI has been left falsely connected to the receiver under test, it will call in the ANI diagnosis.

4.107 The AIDG diagnostic program provides the following features:

(a) System request

(1) Provides diagnosis via system request entered through the fault recognition program (AIFR).

(b) TTY request

(1) Provides the option of selecting normal or raw data diagnosis.

(2) Provides the ability to remove a receiver from service.

(3) Provides the ability to idle (return to service) a receiver.

(4) Releasesthe maintenance relays.

(5) Prints the status of both receivers.

(6) Provides the ability to test all or any specified ANI.

(7) Provides a routine diagnosis of both receivers once a day.

(8) Provides an AIOD camp-on (repetitive exercise) routine.

A. AIDG TTY Input Messages

4.108 The following TTY input message is used to request receiver diagnosis or to request that AIDG perform some subsidiary function:

AD - DGN - a b.

Where:

a = type of request

= N = normal diagnosis

= R = raw diagnosis

= S = print status of both receivers

= M = release maintenance relays CA, CB, DA, and DB

= I = idle receiver

= B = remove receiver from service only if the other receiver is in service

= O = remove receiver from service unconditionally

b = receiver member number.

4.109 The following TTY message is used to request the diagnosis of a single ANI or all ANIs. When all ANIs are tested, the X2LMN table is used in determining the number of ANIs assigned to the office. The message is:

AD-INCKT- a bbb c.

Where:

a = A = test all ANIs. Set bbb = 0

or = O = test one ANI as specified by bbb

bbb = ANI member number

c = receiver member number.

4.110 The camp-on TTY message format and data requirements are as follows:

AD-CAMP- a b c d eeeeeeee fffffff gggggggg hhhhhhhh.

Where:

a = 0 if TT0 is to be connected to receiver

= 1 if TT1 is to be connected to receiver

= 2 if no TT is to be connected to receiver.

b = CPD (0 or 1) to be used when performing CPD bipolar point addressing.

c = A if the SR is to be initialized each cycle (approximately every 100 ms), 0 if SR is to be loaded only once.

d = receiver member number.

eeeeeeee = bits 0 through 21 in octal representing the first word of data to be loaded into the SR. The most significant 1 represents the end of data and does not go into the SR. Example: eeeeeeee = 00000023 states that 4 bits are to be loaded into the SR in the following sequence (loading starts with bit 0) 1100. The first two bits loaded would be 1s, the next two bits would be 0s; bit 4 represents the end of loading since the rest of the word equals 0. eeeeeeee cannot equal 00000000, but can equal 00000001 if no data is to be loaded.

fffffff = bits 0 through 20 represent the second word of data to be loaded into the SR. See eeeeeeee for detail.

gggggggg = 00000000 if no type of reset is desired every 100 ms.

= 00000100 if CPD41R type of reset is to be executed every 100 ms (reset CM counter only).

= 00000200 if CPDSTP type of reset is to be executed every 100 ms (reset entire receiver).

hhhhhhhh = if bit 11 is set to one the data in the SR will be transmitted every 100 ms. Bits 0 through 5 (must be a number less than 42) represent the number of bits in the SR to be transmitted every 100 ms.

4.111 It may appear that the input data required in the previous message can be reduced, and it can. However, the layout conforms with the PS layout which is used in executing the receiver orders for diagnosis. That is, the same routine used to execute the diagnostic PS table is used to execute the call store table loaded by the TTY message. It is felt that this message will not be used often enough to warrant the extra cost of providing a simpler message.

4.112 The camp-on message is generally used when the maintenance personnel must find the trouble in the receiver by using an oscilloscope and observing various signals. Generally, this routine is time consuming and requires repeated TTY requests, since any one request will run automatically for only about 15 minutes and then be automatically terminated. Because of the complexity of the AD-CAMP message, another TTY message is provided which will restart the camp-on program. This TTY message is:

AD-COPY-.

4.113 To obtain manual termination of the camp-on program, keys 20 and 23 of buffer bus No. 17 should be momentarily set to 1. (The identical procedure is used to terminate the centrex high speed camp-on program.)

B. AIDG TTY Output Messages

4.114 Besides the TTY output messages described in the succeeding paragraphs, the dictionary output control program (DOCT) will print the standard DR01 and DR02 messages which indicate the diagnostic results of the tests. The standard DR04 abort message will be printed whenever a maintenance interrupt occurs during the running of program AIDG.

4.115 Whenever a receiver under diagnosis fails its tests and is to be placed out of service (O/S), the status of the other receiver is checked. If the other receiver is also O/S, the following TTY message will be printed:

AD01 BOTH AIOD O/S.

4.116 Each failure detected during the ANI and data circuit diagnosis will produce an output message in the following format:

AD02 ANI FAIL aaaaaaaaaa bb c.

Where:

bb = ANI member number

c = receiver member number

aaaaaaaaaa = 1000000000 = A, B, CA, or CB relay operated (none should be)

= 0100000000 = TRR-TRT not 11, no data circuit energized

= 0010000000 = Bid scan point = 0, no data circuit energized

= 0001000000 = Cannot energize ANI data circuit

= 0000100000 = AOP or BOP not = 0, data circuit energized

= 0000010000 = Bid scan point = 1, data circuit energized

= 0000001000 = TRR-TRT not 00, data circuit energized

= 0000000100 = CMD = 0, data circuit energized. TI, CM, CMD should be high (1)

= 0000000010 = Cannot release ANI data circuit

= 0000000001 = Bid scan point = 0, data circuit released.

C. Receiver Diagnostic

4.117 Some of the initial tests made before starting diagnosis are as follows:

(a) Check member number for validity.

(b) Check to see if AIODIC is in office.

(c) Check to see if the other receiver is in service. This check is performed only on TTY requests. Diagnosis is not permitted on a specified receiver if the other receiver is O/S. This is done to prevent both receivers from accidentally being removed from service since AIDG must remove it prior to diagnosis.

(d) Check power and fuse scan points.

Phase 1

4.118 Phase 1 first checks that no ANI is falsely connected to the receiver under test. Once this condition has been verified, the main function of phase 1 is to check that the SR can be loaded via the maintenance CPD points (includes the use of both CPDs). In performing this task, partial tests are made of the SR, APE, SRE, TRR, TRT, and CM.

4.119 At the beginning of phase 1, the TR scan points are read to ensure that they are in the "one" state (unsaturated). Upon obtaining a reading of one from the TR scan points, the SR is next checked. Over 90 percent of the SR errors should be detected in this phase.

4.120 The SR (see Fig. 4) will be filled with the following patterns:

(a) 1 - - - - - - 11

D7 D6-D1 D0 PMB*

(b) 01010 - - - - 01010 0

D7 D6-D1 D0 PMB*

(c) 1010, - - - - 10101 1

* PMB = premessage bit.

4.121 After each loading of the SR, the SR cells, APE, SPM, SRE, TRR, TRT, and CM are read. To completely test SRE and APE, 31 SR patterns are required; (a), (b), and (c) are three of these 31 patterns. The remaining patterns are executed in phase 4 (except for 1 in phase 3). Since no transmission takes place at this time, CM, SPM, and TRs are checked for their reset state (no ANI connected but receiver is reset). Phase 1 requires 14 words of call store to store the test result.

Phase 2

4.122 Phase 2 checks the MC hardware (FS 6) prior to its connection to the receiver. This is done essentially by executing CPD orders and scanning ferrod BC at the appropriate times. Phase 2 requires one word of call store to store the test result.

Phase 3

4.123 Except for the first test in phase 3, all tests are repeated using both TTs. Prior to performing tests (b) through (i) below, the following preliminary tests are made. Relay DA/DB is operated and ferrod BC is read for the 0 state (at this time no TT is connected). The BC ferrod is monitoring lead CMD via a DA/DB contact. If this test fails, phase 3 is immediately terminated.

4.124 The CA/CB relay is operated (TT1/TT0 connected) and test (a) below is made. This test checks to see that the connection of the TT resets the receiver.

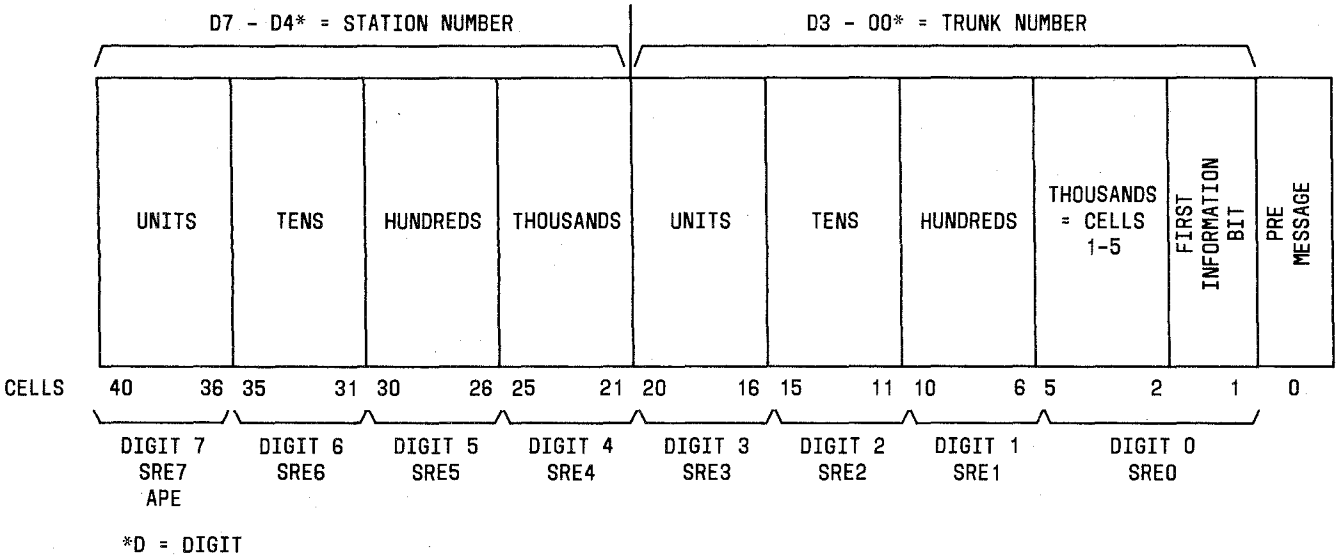


Fig. 4—AIODIC Shift Register Layout

4.125 After the test above is made, the delay circuit associated with lead CMD is tested. This is accomplished by reading BC for the 0 state (BC monitoring lead CMD) 3.5 ms after lead CM is made high. BC is read again, 100 ms later, but now for the 1 state. The CPDSTP function is executed next (CM made low) and, 1/2 ms later, BC is read for the 0 state.

4.126 In addition to the TTS, the following tests are made using the data shown:

(a) Read PMB, FIB, TRR, APE, and SPM upon application of TT.

(b) Load SR with 1 - - - - 1. Read all 48 scan points.

(c) Transmit (b) above and reread 48 scan points.

(d) Reset hardware and read 48 scan points.

(e) Load 0 - - - - - 010. Shift contents by 5 and read 16 scan points (status row).

(f) Reset CM counter only and load:

D7 D0 PMB
11010 - - - - - 11010 1

Shift 42 and read 48 scan points.

(g) Load 0 - - - - 01. Shift 40 and read 48 scan points.

(h) Reset CM counter and shift 1. Read six scan points (CM, FIB, TRR, PMB, SPM, and APE).

(i) Release TT and read same six scan points as in (h).

4.127 The above series of tests checks to see:

(a) That the application of each TT resets the receiver.

(b) That the SR can be loaded with the TT connected to it, the TRR reads 0 and SPM indicates reset state (produced when TT was connected to receiver).

(c) That the SR can be shifted, the data receiver can receive many ones in succession, and SPM can be set.

(d) That the SR (SR reset to all 0s) and SPM can be reset.

(e) That a leading 0 cannot start transmission.

(f) If another pattern is needed to completely test APE and SRE. It also checks the ability of the TT, data receiver, etc, to function properly under changing states.

(g) That the CM counter can be incremented by the maintenance hardware so that a shift of less than a full 41 bits can be accomplished.

(h) That the CM counter can be reset without any affect on the SR.

(i) That the TT (equivalent to ANI) can be removed without producing a receiver reset pulse.

Phase 3 requires 26 words of call store for the test results.

Phase 4

4.128 Phase 4 is a continuation test of SRE and APE. To finish the test of SRE and APE, 27 different SR patterns are required. Each digit (5 bits), except as noted, will be set with the patterns shown in Table C. Phase 4 requires 21 call store words for storage of test results.

Phase 5

4.129 Phase 5 consists of an SR pattern which, because this particular pattern may not be needed, is placed in a separate phase. Changes can be made to it, if desirable, without affecting the dictionary numbers produced in the earlier phases. The pattern is as follows:

00000011111 01100010111 00010111 00110101001.

D. ANI and Data Circuit Diagnostic

4.130 The ANI diagnostic relies on the fact that the ANI is in the idle state. To perform the ANI tests the DA/DB maintenance relay is energized. The DA/DB relay places ground on the T-R leads while the ANI (when in the idle state) places -48 volts on the T-R leads, thus providing saturating current for the TRR and TRT ferrods. Most tests that fail are retried ten times at 100-ms intervals (minimum). This is based on the assumption that, if the ANI becomes active during the test, it will idle before the ten tries are completed since the average ANI holding time is 500 ms. If the ANI still fails after ten tries, the AD02 ANI fail message is printed to indicate which test failed.

4.131 The program is deliberately designed to release the data circuit relay of each ANI under test, even if the diagnosis of the ANI fails. Therefore, a means of releasing all data circuit relays to a specified receiver is built into the program when requesting the testing of all ANIs. The testing of the data circuit (relays that connect the ANI to the receiver), bid ferrods, and the circuitry between the ANI and the AIOD is accomplished via a TTY request. The request can specify the testing of one ANI (one ANI input, one bid ferrod, and one data circuit relay) or all ANIs (all ANIs, all bid ferrods, and all data circuit relays associated with a receiver). This test should be performed (mainly the all-ANI request) during

TABLE C

PHASE 4 TEST PATTERNS

1.	00001; digit 0 = 00011	Less than 2/5 orders
2.	00010; digit 1 = 00110	
3.	00100; digit 4 = 01100	
4.	01000; digit 6 = 10010	
5.	10000; digit 7 = 10100	
6.	00111; digit 2 = 00101	More than 2/5 orders
7.	01011; digit 3 = 01001	
8.	10011; digit 5 = 10001	
9.	01101	
10.	01110	
11.	10110	
12.	11001	
13.	11100	
14.	11110	
15.	11101	
16.	11011	
17.	10111	
18.	01111	
19.	00011; digit 0 = 00001	Valid 2/5 orders
20.	00101; digit 2 = 00111	
21.	00110; digit 1 = 00010	
22.	01001; digit 3 = 01011	
23.	01100; digit 4 = 00100	
24.	10001; digit 5 = 10011	
25.	10010; digit 6 = 01000	
26.	10100; digit 7 = 10000	
27.	11000	

periods of low PBX traffic. In most cases, this would be the late evening to early morning hours.

Initial ANI Checks

4.132 Before the ANI diagnosis is run the following initial checks are performed:

(a) Check to see that the TTY request is valid, that is, that the request was A (test all ANIs) or 0 (test one ANI).

(b) Check to see if the AIOD feature is in the office.

(c) Check to see if the other receiver is in service. The ANI diagnosis is not performed if the other receiver is O/S, since the test requires the removal of the specified receiver. If the diagnosis was run indiscriminately, both receivers would be O/S.

(d) Check to see if the power and fuse scan points read 0 (power on).

(e) If the request was to test one ANI, check to see that the ANI is in the office.

Simplified Program Flow

4.133 After the initial tests are performed, relay DA/DB is energized. Then the A/BOP scan point is read for the 1 state. Next the two TR scan points are read for the (1, 1) state since no data circuit is yet operated. The bid ferrod is now read for the 1 state to see if the ANI is idle. With the previous tests passing, the data circuit assigned to the ANI is operated. The bid scan point should now be saturated, along with the two TR scan points. The data circuit is released, and the bid scan point is read for the 1 state (ANI reconnected).

Early Termination Provision

4.134 When all ANIs are being tested it may be desirable to terminate the test before it is actually completed. Provision has been made to do this in a clean way, that is, by restoring the ANI to its normal state. To terminate, keys 20 and 23 of buffer bus number 17 should be momentarily set to 1.

E. Camp-On (Repetitive) Exercise

4.135 The diagnostic program will provide a camp-on routine (repetitive exercise). The routine is initiated via the TTY. The TTY message will specify the receiver number, the TT, the CPD, and the contents that are to be loaded into the SR. The data may be repetitively transmitted around the SR every 100 ms, or it may be reloaded in the SR and transmitted each time. Upon a TTY request, the specified receiver will be removed from service (the other receiver must be in service or the TTY will give a request-denied message), the maintenance relays will be operated, and the SR will be loaded and its contents transmitted. The camp-on feature provides the tool for finding the most difficult of faults.

5. ABBREVIATIONS AND ACRONYMS

AIFR	Automatic Identified Outward Dialing Fault Recognition Program
AIOD	Automatic Identified Outward Dialing
AIODIC	AIOD Interface Circuit
ANI	Automatic Number Identification
APE	ANI Parity Error
ASW	All Seems Well
ATP	All Tests Pass
BC	Bid Check
BPS	Bits Per Second
CC	Central Control
CM	Complete Message
CMD	Complete Message Delayed
CNR	Console Register
CNRA	Console Register Address
CO	Central Office
CPD	Central Pulse Distributor

CPDN	CPD Number
CS	Call Store
CU	Customer Premises
DC	Direct Current
DIAG	Diagnostics
DL	Data Link
DOCT	Dictionary Output Control Program
EA	Emergency Action
ESS	Electronic Switching System
GBT	General Buffer Table
I/O	Input Output
IPM	Interruptions Per Minute
I/S	In-Service
MAC, MACR	Maintenance Control Program
MC	Maintenance Control
MSN	Master Scanner Number
O/S	Out-of-Service
POB	Peripheral Order Buffer
PROCON	Remote Data Interface
PS	Program Store
PT	Program Tag
PU	Peripheral Unit
RDI	Remote Data Interface
RI	Register Identifier
SD	Signal Distributor
SPM	Signal Present With Memory
SR	Shift Register
SRE	Shift Register Error
STF	Some Tests Failed
TBL	Trouble
TLM	Trouble Locating Manual
TR	Transmission Signal
TRBL	Trouble
TT	Test Transmitter
TTY	Teletypewriter
UTYP	Data Link Unit Type

6. REFERENCES

A. Centrex and AIOD Diagnostic and Exercise PIDENTs (See Table A)

B. Section 231-160-301—Centrex Data Link and Console Demand Exercise Program

C. Section 231-160-302—Centrex Data Link and Attendant Telephone Console Maintenance Procedures Using Maintenance Teletypewriter

D. Section 231-037-000—Centrex Data Loop and Console Control Description/Theory

E. Section 966-102-100—Centrex and PBX—CO Service