

SYSTEM CENTURY®
DIGITAL CENTRAL OFFICE

MAINTENANCE AND TEST FACILITIES
DESCRIPTION AND USE

CONTENTS					
Par.		Page	Par.		Page
1.	Introduction	2	22.	Selective Diagnostic Programs	23
2.	Related Information	2	23.	Alarm Sending and Checking	23
2.01	General	2	23.01	General	23
2.02	Related Sections	2	23.02	Alarm Sending	23
2.03	Related Drawings	2	23.03	Alarm Checking	24
3.	General	2	24.	Functional Operation of Maintenance and Test Facilities	24
4.	Basic Maintenance Panel and Wire Chiefs		24.01	General	24
	Test Set	3	24.02	Port Group Control II Detects Error	24
5.	Maintenance Processor	3	24.03	Timeslot Interchange Diagnostics	
6.	Data Links	5		Circuit Notifies Maintenance	
7.	Maintenance Communications Interface	6		Processor of Error	24
8.	Switchover Control	6	24.04	Maintenance Processor Does Diagnostics to Determine Faulty Circuit	24
9.	Maintenance Bus Interface	6	24.05	Teleprinter Prints Fault Information	24
10.	Test Access Selector Control	7			
11.	Test Access Selectors	7			
11.01	Test Access Selector II	7			
11.02	Test Access Selector III	9			
12.	Test Call Generator	9	Fig.		Page
12.01	General	9			
12.02	Test Call Generator I	10	1.	Association of Maintenance and Test Circuits to Other Circuits in System	4
12.03	Test Call Generator II	11	2.	Maintenance Bus Interfacing	7
12.04	Test Call Generator III	11	3.	Association of Test Access Selector and Control Circuits	8
12.05	Test Call Generator IV	14	4.	Test Access Selector II, Block Diagram	9
13.	Line Test Controller	14	5.	Test Call Generator Access, Block Diagram	10
14.	Automatic Line Insulation Test	14	6.	Test Call Generator I, Block Diagram	11
15.	Maintenance and Diagnostics Controller	16	7.	Test Call Generator II, Block Diagram	12
16.	Timeslot Interchange Diagnostics	16	8.	Test Call Generator III, Block Diagram	13
17.	Timeslot Interchange/Port Control		9.	Test Call Generator IV, Block Diagram	15
	System Diagnostics	16	10.	Line Test Controller, Orientation Diagram	16
18.	Service Group Diagnostics	17	11.	Timeslot Interchange Diagnostics Circuit, Block Diagram	17
19.	Fault Detection and Isolation	20			
19.01	Automatic Routine Testing	20			
19.02	Manual Testing	21			
19.03	Automatic Diagnostic Programs	21			
20.	Diagnostic Printouts	23			
21.	PWBA Replacement and System Repair				
	Verification	23			

ILLUSTRATIONS

Fig.		Page
1.	Association of Maintenance and Test Circuits to Other Circuits in System	4
2.	Maintenance Bus Interfacing	7
3.	Association of Test Access Selector and Control Circuits	8
4.	Test Access Selector II, Block Diagram	9
5.	Test Call Generator Access, Block Diagram	10
6.	Test Call Generator I, Block Diagram	11
7.	Test Call Generator II, Block Diagram	12
8.	Test Call Generator III, Block Diagram	13
9.	Test Call Generator IV, Block Diagram	15
10.	Line Test Controller, Orientation Diagram	16
11.	Timeslot Interchange Diagnostics Circuit, Block Diagram	17

ILLUSTRATIONS (Cont)

Fig. **Page**

- | | | |
|-----|---|----|
| 12. | Timeslot Interchange/Port Control System Diagnostics Circuit, Orientation Diagram | 18 |
| 13. | Service Group Diagnostics Circuit, Orientation Diagram | 19 |
| 14. | Fault Detection by Maintenance and Test Circuits | 25 |

1.01 INTRODUCTION

1.01 This section provides functional descriptions and use of the maintenance facilities in a SYSTEM CENTURY® Digital Central Office (DCO) equipped with a local line switch (LLS).

2. RELATED INFORMATION

2.01 General.

A Sales and Instructional Literature Index of latest available publications can be obtained from your Stromberg-Carlson sales representative or from Publications Services, Stromberg-Carlson Corporation, P.O. Box 1698, Sanford, Florida 32771.

2.02 Related Sections.

The following sections are recommended for use with this document:

- | | |
|-----------|--|
| 23-002-97 | System Operators Manual |
| 23-002-99 | Message Dictionary |
| 23-200-31 | Basic Maintenance Panel Operating Instructions |
| 23-209-10 | Wire Chiefs Test Set, Description, Installation, Test Procedures, Operation, and Maintenance |
| 23-223-51 | Equipment Removal and Replacement Procedures |

2.03 Related Drawings.

The circuit schematic diagrams and available circuit descriptions for the following circuits are recommended for use with this document. Each circuit is identified by a six-digit base number. Drawings are identified by prefixing the base number either with an S-

for circuit schematic or DS- for circuit description. The base numbers and circuit names are as follows:

<u>BASE NUMBER</u>	<u>NAME</u>
814052	Data Link
814051	Maintenance Bus Interface
814064	Test Access Selector II
814069	Timeslot Interchange Diagnostics
814071	Switchover Control
814074	Primary Service Group Diagnostics
814088	Test Access Selector III
814095	Service Group Diagnostics
814265	Timeslot Interchange/Port Control System Diagnostics
814292	Test Call Generator IV
814428	Basic Maintenance Panel Logic Card 1
814429	Basic Maintenance Panel Logic Card 2
814430	Basic Maintenance Panel Logic Card 3
814451	Wire Chiefs Test Panel
814452	Wire Chiefs Test Panel Transformer Card
814453	Wire Chiefs Test Panel Card 1
814454	Wire Chiefs Test Panel Card 2
814455	Wire Chiefs Test Panel Card 3
814456	Test Call Generator I
814457	Test Call Generator II
814458	Test Call Generator III
814460	Basic Maintenance Panel
817500	Test Access Selector Control
817501	Line Group Access
817503	Line Group Multiplexer
817505	Maintenance Communications Interface
817507	Line Test Controller
817512	Line Switch Controller
817514	Maintenance and Diagnostic Controller

3. GENERAL

3.01 The DCO maintenance facilities include the following:

- a. Memory-resident and disk-stored diagnostic programs
- b. Maintenance processor (maintenance and administration computer)
- c. Switchover control for redundant equipment

- d. Automatic test call generator
- e. Service group, timeslot interchange, and timeslot interchange/port control system diagnostic circuits
- f. Switched maintenance access network for ports
- g. Maintenance bus interface circuit
- h. Basic maintenance panel
- i. Wire chiefs test circuit
- j. Input/output devices (console and floppy disk)

3.02 Built-in, automatic, performance-checking and fault-detection facilities provide surveillance of vital system functions. The common control has a self-checking capability to monitor the operation on, and transfer of, data. Automatic switchover of redundant equipment also produces a printout. Normally, fault printouts provide fault identification down to an individual printed wiring board assembly (PWBA) level.

3.03 The maintenance and diagnostics elements of the DCO are shown in figure 1 as shaded blocks. All fault indications result in interrupts to the maintenance processor (MP), which takes appropriate action, dependent on the nature of the fault. Interrupts and fault data are sent to the MP by way of the maintenance bus interface (MBI) or a data link, each of which provides two-way communications with specific areas of the system.

4. BASIC MAINTENANCE PANEL AND WIRE CHIEFS TEST SET

4.01 The basic maintenance panel monitors system faults and status, and provides for testing and limited control of the system. Faults are detected by diagnostic circuits strategically located throughout the system and are reported to the maintenance processor and, consequently, to the basic maintenance panel to activate alarms and indicators on the panel.

4.02 A wire chiefs test set, which provides access to subscriber lines (both out toward the subscriber and in toward the system), is available. Calls can be

originated or terminated at the test set and various tests can be made using the front panel controls. Jacks are provided to connect external test equipment.

4.03 Refer to the sections titled, *Basic Maintenance Panel, Operating Instructions, and Wire Chiefs Test Set, Description, Installation, Test Procedures, Operation, and Maintenance*, referenced in paragraph 2.02, for descriptions of the two units.

5. MAINTENANCE PROCESSOR

5.01 The maintenance processor (MP), also identified as the maintenance and administration computer, provides the user interface to the system and controls the maintenance and diagnostic processing required to assure system integrity and service continuity. The principal functions of the MP include the following:

- a. System startup.
- b. Administrative interface.
- c. Recovery.
- d. Routine testing.
- e. First-level diagnostics.
- f. Second-level diagnostics.
- g. Executive control and input/output device control.

5.02 The system startup function includes bootstrapping, the initial loader program that, in turn, loads the executive control program and the startup program from the floppy disk. The manual startup program request causes the loading of the two call processors (CPs) with the call-processing software and all required tables and directories. These programs and data bases are first read from the floppy disk into the MP memory and then transferred into memories of the two CPs by way of the data links. After CP loading is completed, the processors are started and directed to initialize the port control store (PCS) and the timeslot interchange (TSI) stores [send, receive, and cross-office highway (XOH)]. After initialization, the CPs are brought into synchronized operation and normal processing begins.

STARTUP OF LOADING
INFO INTO PROCESSOR FROM DISK

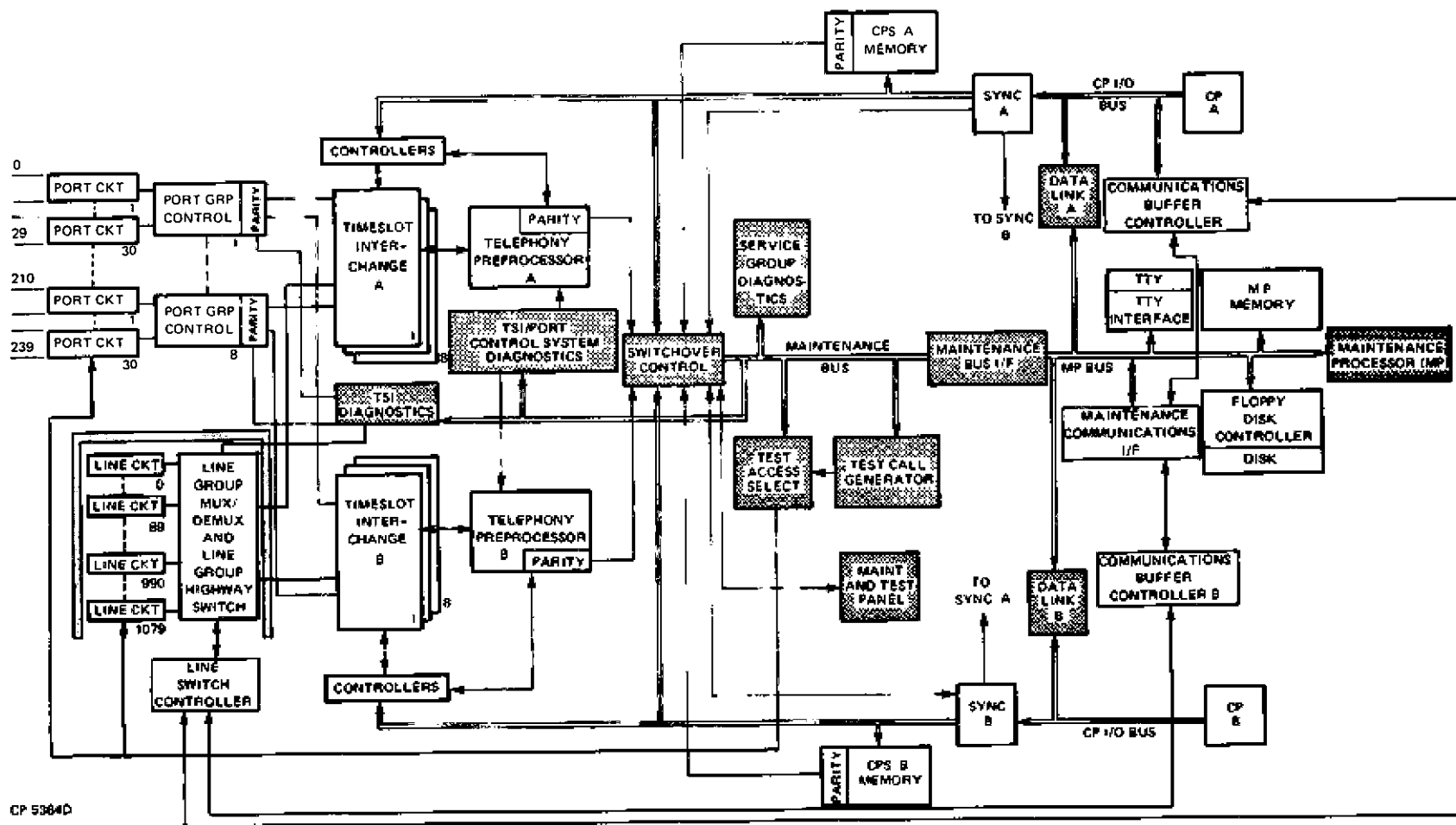


Figure 1. Association of Maintenance and Test Circuits to Other Circuits in System

5.03 The administrative interface function permits the user to effect changes in the system configuration and in service-related data bases. These changes usually deal with number changes, class-of-service changes, line and trunk additions, etc. The user communicates these changes to the MP with the teleprinter. These requests are interpreted and executed by task-specific administrative programs.

5.04 The recovery function returns the system to synchronized and redundant operation after one side has been switched out of operation. This involves restoring the memory of the recovering side so that identical programs and data are contained in both sides. It also involves copying the contents of the port control store (PCS), send store, receive store, and XOH store from the active side to the recovering side. The recovery function is done through software in the MP by way of a direct link access to the controller circuits. The execution of the recovery function is initiated automatically or by an operator command entered on the teleprinter.

5.05 The routine testing function tests and monitors the entire system continuously. This is done primarily by placing test calls through all ports by way of test access relays. The testing function also initiates self-tests in the MP and CPs. Routine testing operates continuously, as a background task in the MP, suspended only when faults are detected and diagnostic programs are to be run.

5.06 The diagnostic functions are called into operation after a fault is detected. Test circuits compare performance of on-line and backup subsystems, check the timing of the various processor buses, and monitor for power failure. Faults are signaled to the MP by the maintenance bus interface or by a data link as an interrupt. The MP immediately responds to an interrupt by scheduling and executing specific diagnostic programs. Two levels of diagnostic programs are used:

- a. The first-level diagnostics (FLD) function of the resident tasks program is automatically done in response to a system fault. FLD isolates faults to one side or the other in the A/B redundant portion of the system. FLD is usually involved whenever an A/B mismatch error occurs.

The mismatch error may be accompanied, preceded, or followed by other error signals that are side-specific. Certain error signals may determine the faulty side and others provide only a degree of probability. In the latter case, further diagnostic routines are used to verify side operation.

- b. The second-level diagnostic (SLD) program of the maintenance software is controlled by the second-level diagnostic controller. The SLD program can be manually executed at an input/output console in four modes: fault isolation, repair verification, restore verification, and selective diagnostics. SLD can test the following areas of the DCO: common control sectors, trunk and LLS frames, and the maintenance and administration system. Further details of SLD procedures and capabilities are described in the section titled *System Operators Manual*, referenced in paragraph 2.02.

5.07 The executive control and input/output device control functions make up the operating system under which the above functions are scheduled and executed as processing tasks. The scheduling algorithm of the executive program is designed specifically for the functional requirements of the MP. It provides the environment in which the administrative functions and routine testing functions normally operate concurrently. This multiprogram mode is terminated whenever a fault is detected, since diagnostics programs must be scheduled. All requests by specific process tasks for I/O service are passed through the I/O device control routines, which operate in concurrence with the executive program.

6. DATA LINKS

6.01 The data links (DL) provide the maintenance processor with access to the main memory and peripheral units of the call processors in the DCO. The DL electrically connects the I/O bus of the MP to the I/O bus of the CP as shown in figure 1. The links handle all communications between the MP and the CPs and provide the means for loading programs and data from the floppy disk and for cross-writing from one CP to the other, by way of the MP. In addition, certain fault conditions (primarily those originating in the port control area) are reported to the MP by way of the CP and the link.

6.02 Three modes of communication between the MP and CP are provided by the DL:

- a. Direct Memory Access (DMA) — allows the MP to read or write the contents of a word in the CP main memory and to access all other peripheral units connected to the CP I/O bus.
- b. Interrupt — allows the MP to generate an interrupt request and corresponding vector to the CP.
- c. CP Status — allows the MP to read the status of various control signals within the CP system and the switchover control circuits.

7. MAINTENANCE COMMUNICATIONS INTERFACE

7.01 The maintenance communications interface (MCI) provides an interface between the MP and the LLS by way of the communications buffer controllers (CBC). Each redundant CBC pair is connected to the MP through a dedicated MCI. Up to four MCIs can interface the MP through the MP bus.

7.02 The MCI has independent connections to the A and B CBCs to permit synchronous communication with both CBCs or exclusive communication with either CBC. Service requests from the CBC are converted to the proper format and passed on to the MP as interrupts.

7.03 Commands from the MP are analyzed by the MCI and then passed on to the LLS by way of the CBC. These commands are used to control bypass relays in the LLS frames and to control the line switch controllers (LSCs) with reset signals. Microprocessors in the CBCs are also reset by the MP.

8.

DON'T MESS WITH IF SYST IS DOING DIAG.
SWITCHOVER CONTROL

8.01 The switchover control circuit does the switchover between A and B redundant systems when a fault occurs in either, or by command from the MP, after a fault has been corrected. When no fault exists, the maintenance processor determines which system, A or B, is on-line; the selection is overridden by the switchover control if a fault is detected in the on-line system. If an automatic switchover occurs, it "locks out" any further automatic system switching, or any attempt by the MP to command a switchover, until a reset A or reset

B command is sent by the MP to release the automatic switchover lockout latch. When the lockout latch is in its reset state, a switchover can be done by either a newly generated switchover flag to the automatic circuitry or an MP-generated command to switch over.

8.02 A three-position switch is provided on the maintenance panel with safeguards to prevent its inadvertent or casual use. This manual switch provides the following options:

- a. System A selected.
- b. System B selected.
- c. Automatic.

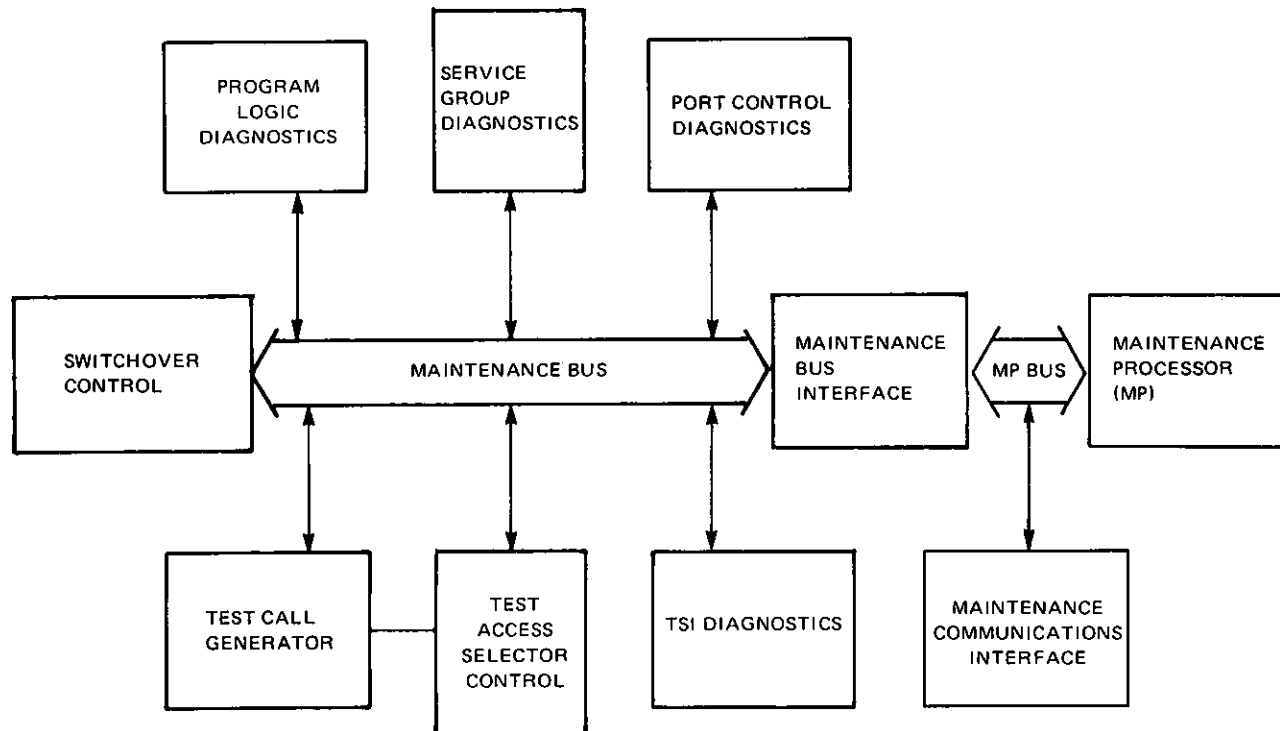
Setting the manual switch to either A or B position takes first priority and overrides any automatic switchover action and/or any subsequent command from the MP to switch over. The AUTO position of the manual switch allows the automatic switchover control circuitry to have first priority in determining which system is on-line.

9. MAINTENANCE BUS INTERFACE

9.01 The maintenance bus interface (MBI) is an interface between the MP bus and the maintenance bus, to which most of the maintenance circuitry is connected. The MBI and the maintenance bus provide for a larger number of devices and longer cable runs than could be accommodated directly on the MP bus. The MBI also provides the MP with flexibility in handling interrupts generated by devices connected to the maintenance bus and provides for an expanded addressing scheme for these devices without using an excessive number of addresses on the MP bus. Figure 2 shows the relationship of this circuit to associated maintenance-related circuits.

9.02 The primary functions of this circuit are:

- a. Provides drivers and receivers to accommodate the long cable runs and large number of devices associated with the maintenance bus.
- b. Provides necessary time buffering or latching functions.
- c. Translates the 16-bit MP bus structured data to a more economical 8-bit structure for the maintenance processor bus.



CP 5317B

Figure 2. Maintenance Bus Interfacing

- d. Provides for an expanded addressing scheme within the maintenance devices without using an excessive number of addresses on the maintenance processor bus.
- e. Acts as a concentration point for interrupt signals and provides flexibility in interrupt handling.

10. TEST ACCESS SELECTOR CONTROL

10.01 The test access selector (TAS) control circuits provide interfacing between the maintenance bus and the TAS circuits. See figure 3. The address words, data words, and control signals received from the maintenance bus are decoded and used to select (energize) the appropriate TAS relays for application of the appropriate test functions to the T, R, E, and M buses in the system. The test functions that can be applied are:

- a. Test call generator (trunks only)
- b. Primary manual test
- c. Secondary manual test
- d. Remote automatic line test

10.02 Inputs and outputs to the maintenance bus are by way of balanced differential line drivers and receivers; the outputs to TAS relay cards are single-ended bus drivers. Up to 11 TAS control PWBA's are required for a fully-equipped system. At least two PWBA's are needed to set up a path through the TAS network; one to set up a path through a TAS II or III PWBA on the left side of figure 3 and one to do the same for a TAS II PWBA on the right side of figure 3.

11. TEST ACCESS SELECTORS

11.01 Test Access Selector II.

- a. TAS II circuits provide metallic access to all DCO tip and ring (TR) and E&M trunks for any of the test functions described in paragraph 10.01. In addition, metallic access is provided to LLS tip and ring lines for any test function except the test call generator.
- b. The call processor selects a trunk or line and transfers the tip and ring or E&M leads to the test access bus by way of the test access relay in the trunk or line circuit. The TAS II circuits then connect this test access bus (TRA, TRB, TRC, EMA, or EMB) to the required test units so



8

that the appropriate test function can be done. See figure 4. Any test access bus can be switched to the test functions. Control for the relays on the TAS II PWBA's comes from the TAS control PWBA's. A ground on a relay control input lead activates a relay driver through an optical coupler. The optical coupler electrically isolates the TAS control and TAS II circuits.

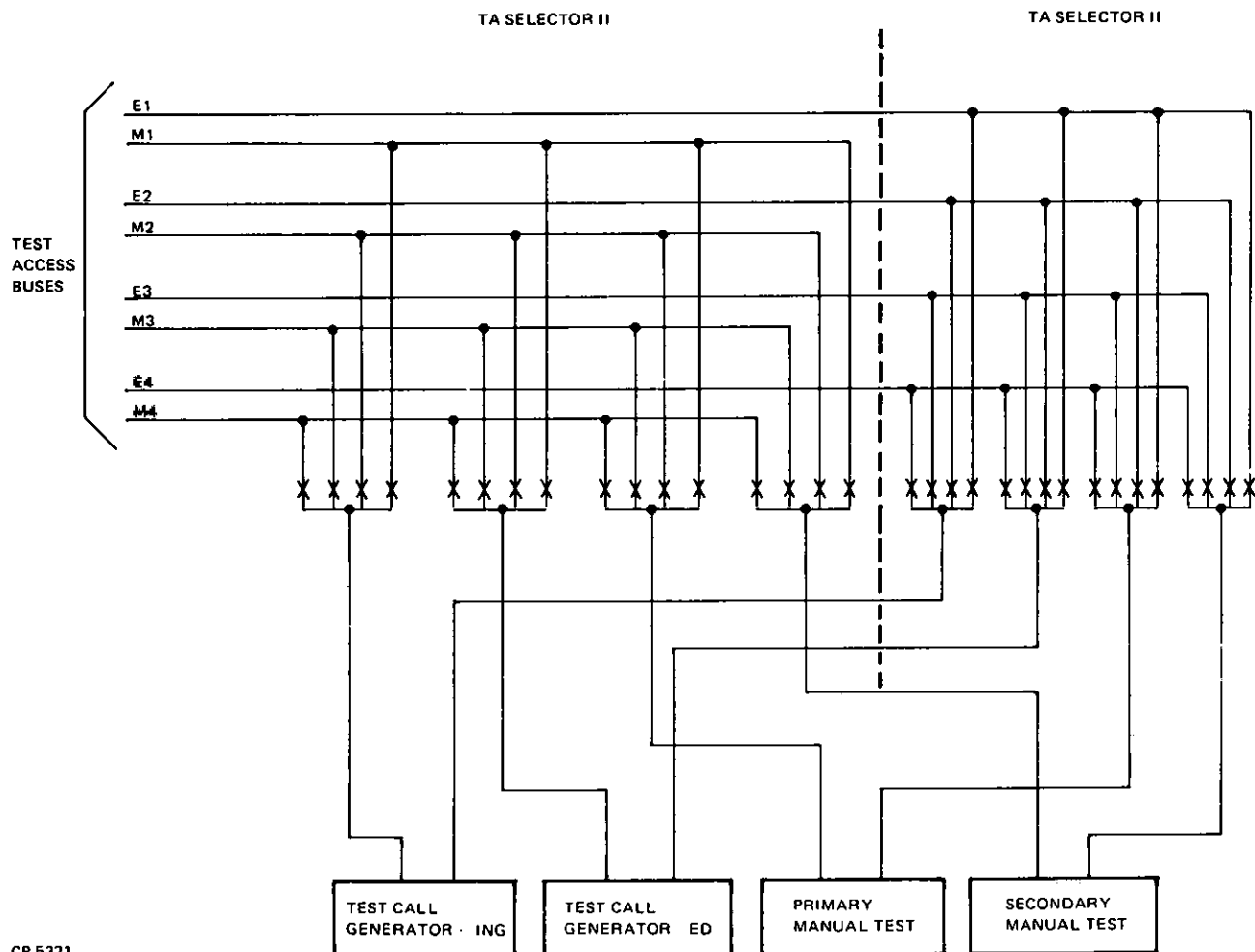
11.02 Test Access Selector III.

The TAS III circuit is similar to TAS II and provides metallic access to LLS E&M lines for testing, as shown in figure 3. One TAS III PWBA is required for each seven LLS frames.

12. TEST CALL GENERATOR

12.01 General.

- a. The automatic test call generator (TCG) simulates the functions of calling and called trunks in causing a call path to be set up through the system. (Each trunk circuit is equipped with a test access relay that, in conjunction with a common group of steering relays, allows any desired trunks to be connected to the TCG). It then checks transmission in each direction, by generating and detecting test tones, after which the path is released and the next call is established. This process repeats, continually, in a pattern that



CP 5321

Figure 4. Test Access Selector II, Block Diagram

eventually tests every trunk at least once a day; it also tests each major area of the system as frequently as possible. Test calls constitute the primary means of testing the nonredundant portions of the system; they are also a powerful diagnostic tool.

b. The TCG communicates with the maintenance processor through the maintenance bus interface to receive commands and transfer data to the MP. The MP determines the sequence for stepping through the trunks and establishes the tests that are made. Tests usually consist of placing a call from the calling trunk and monitoring the responses at the called trunk, but some parameters can also be monitored at the calling trunk.

c. Figure 5 shows the functional location of the four parts of the test call generator in the system. It also shows a one-way path from a trunk circuit that permits the TCG to terminate both the calling and called outside trunks and monitor for off-hook conditions on both. When an off-hook is detected, tests are aborted and the

trunks are returned to normal. The MP arranges the return of the trunks by releasing the test access relays, in the trunk circuits involved, that were originally used to break the connection. This is shown in figure 6 as well as the two-way path for the inside ports to the DCO system. Access to the TCG is by way of the TAS from the test access relays for all trunks under test.

12.02 Test Call Generator I.

The TCG I circuit functions with the TCG II, TCG III, and TCG IV circuits to execute test calls through the trunks and switching system. The TCG I receives commands from the maintenance processor by way of the maintenance bus and the MBI and stores these in data registers. Status information stored in another register is sent back to the maintenance processor also by way of the maintenance bus and MBI. The commands stored in the data registers are used to initialize timers and enable various monitoring circuits in the TCG I circuit and to activate other circuits on the TCG II, TCG III, and TCG IV PWBA's. Figure 6 is a block diagram of TCG I.

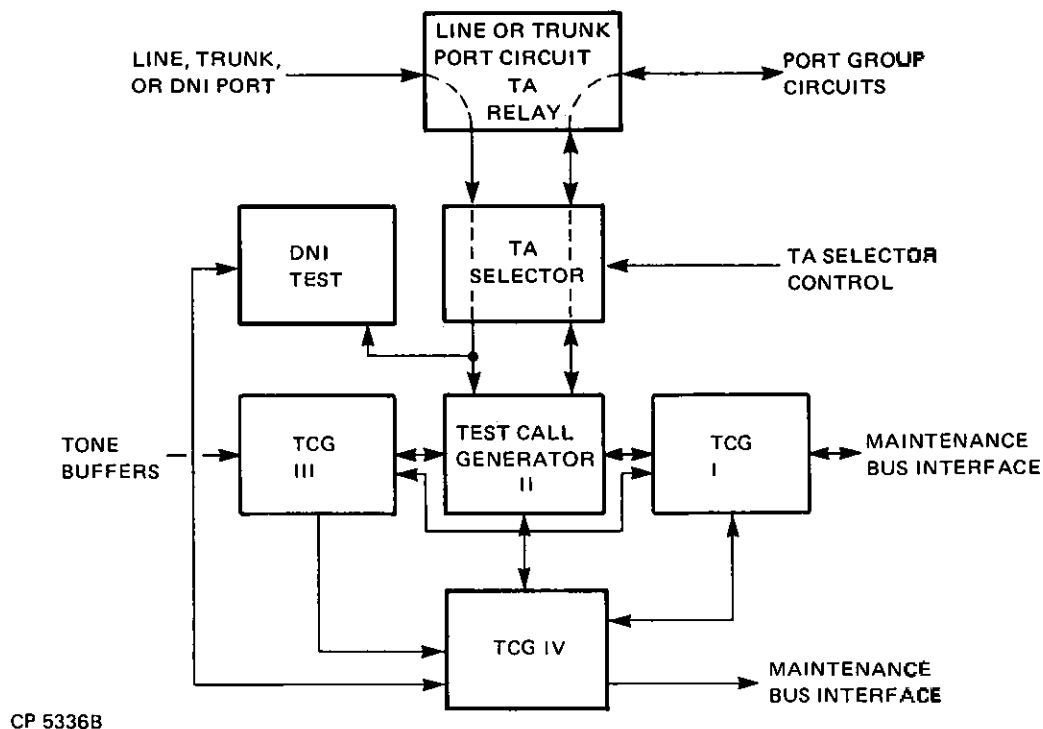


Figure 5. Test Call Generator Access, Block Diagram

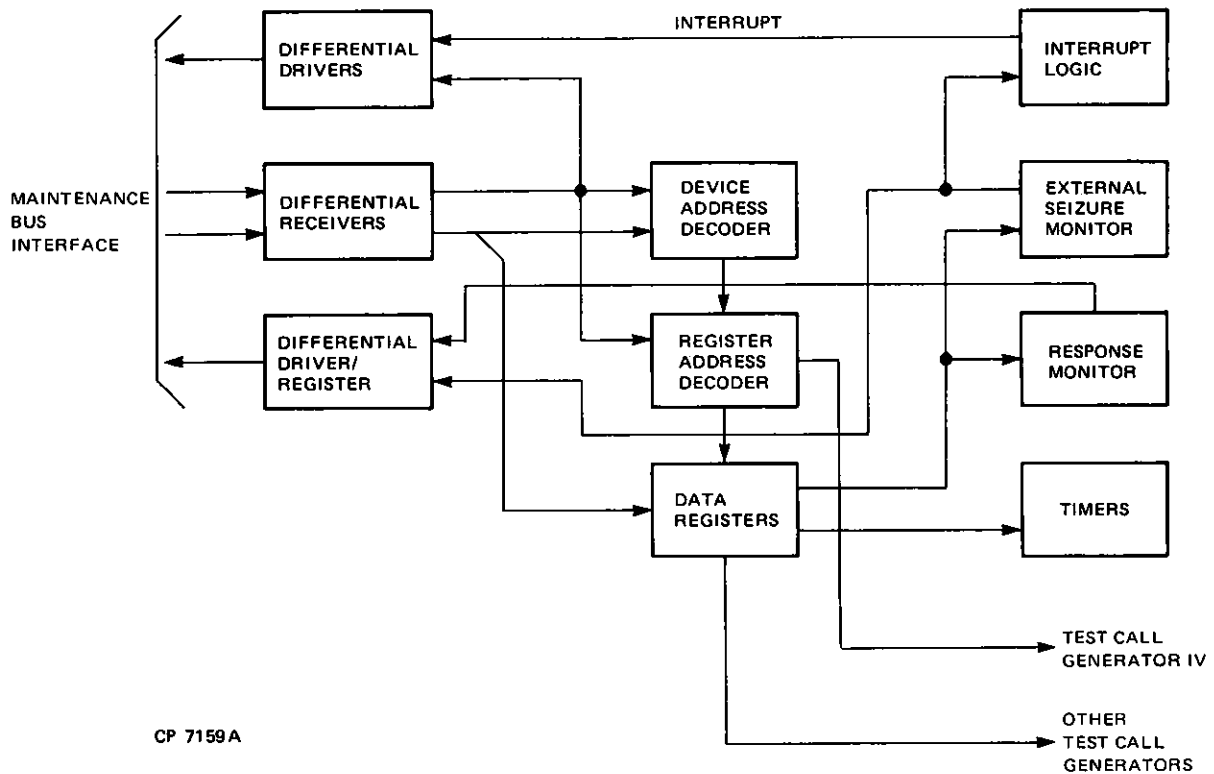


Figure 6. Test Call Generator I, Block Diagram

12.03 Test Call Generator II.

a. The TCG II circuit provides the interface between trunks under test and the rest of the TCG; it matches any trunk type to be tested. It provides signaling and supervision for the calling and called trunks and permits signals to be injected on the trunks under test and removed from the trunks for monitoring purposes. Tones to be detected are sent to TCG II, but other data to be analyzed is collected and sent to TCG I and TCG IV.

b. Figure 7 shows the block diagram for TCG II. The outside calling and called ports are used only to terminate the trunks whose circuits are being tested and to detect seizure attempts on them. Off-hook detect signals are sent to TCG I so that the MP can be advised to abort tests when there is a detection. Relay drivers use logic input signals to operate both 5-volt and 48-volt relays. A contact on each relay is used by the relay operation verification circuit to generate a logic signal at the time of closure and to compare that with the input command. The verification circuit generates a logic signal that is forwarded to TCG I to indicate whether the relays agree with the pro-

grammed command. Inside calling and called ports contain the circuitry necessary for interfacing with any trunk circuit.

12.04 Test Call Generator III.

a. The TCG III circuit receives inputs from the tone buffers for generation of toll multi-frequency (MF) signals. Figure 8, the block diagram for TCG III, shows the tone buffer inputs to an MF sender circuit and then to an amplifier where a 2.84-kHz signal can also be programmed as an input. The amplifier output goes to TCG II. The 2.84-kHz signal and the toll MF signal are not programmed simultaneously, but share the same output amplifier to TCG II when they are programmed. The 2.84-kHz signal is a square wave that is generated in TCG I by dividing the 2.048-MHz clock by 720. TCG III acts like a low-pass filter to this signal; its output is detected by the high-pass filter on TCG II, which is followed by a narrow-band tone detector.

b. The outpulsing detector determines if a trunk is outpulsing. Both dial-pulse (DP) and multifrequency (MF) outpulsing are monitored,

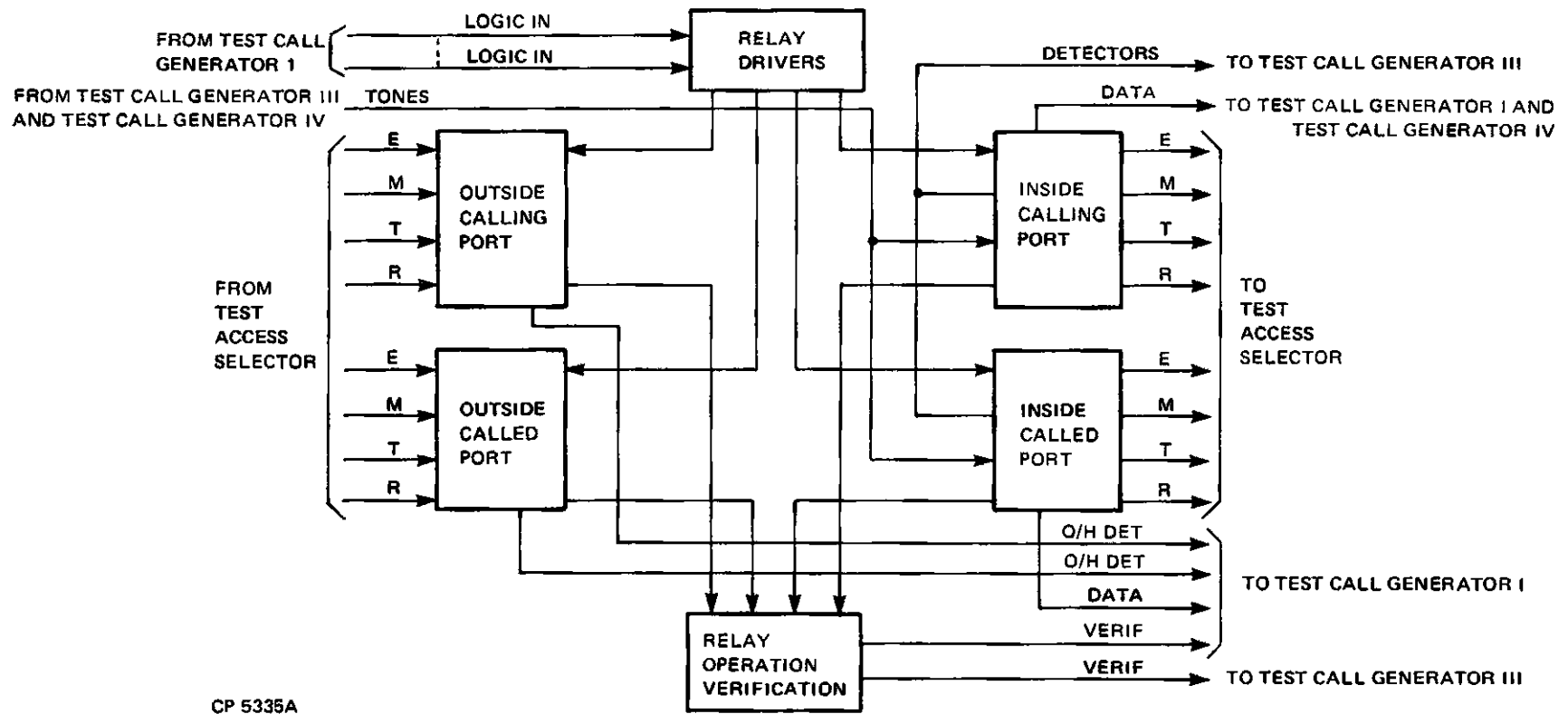


Figure 7. Test Call Generator II, Block Diagram

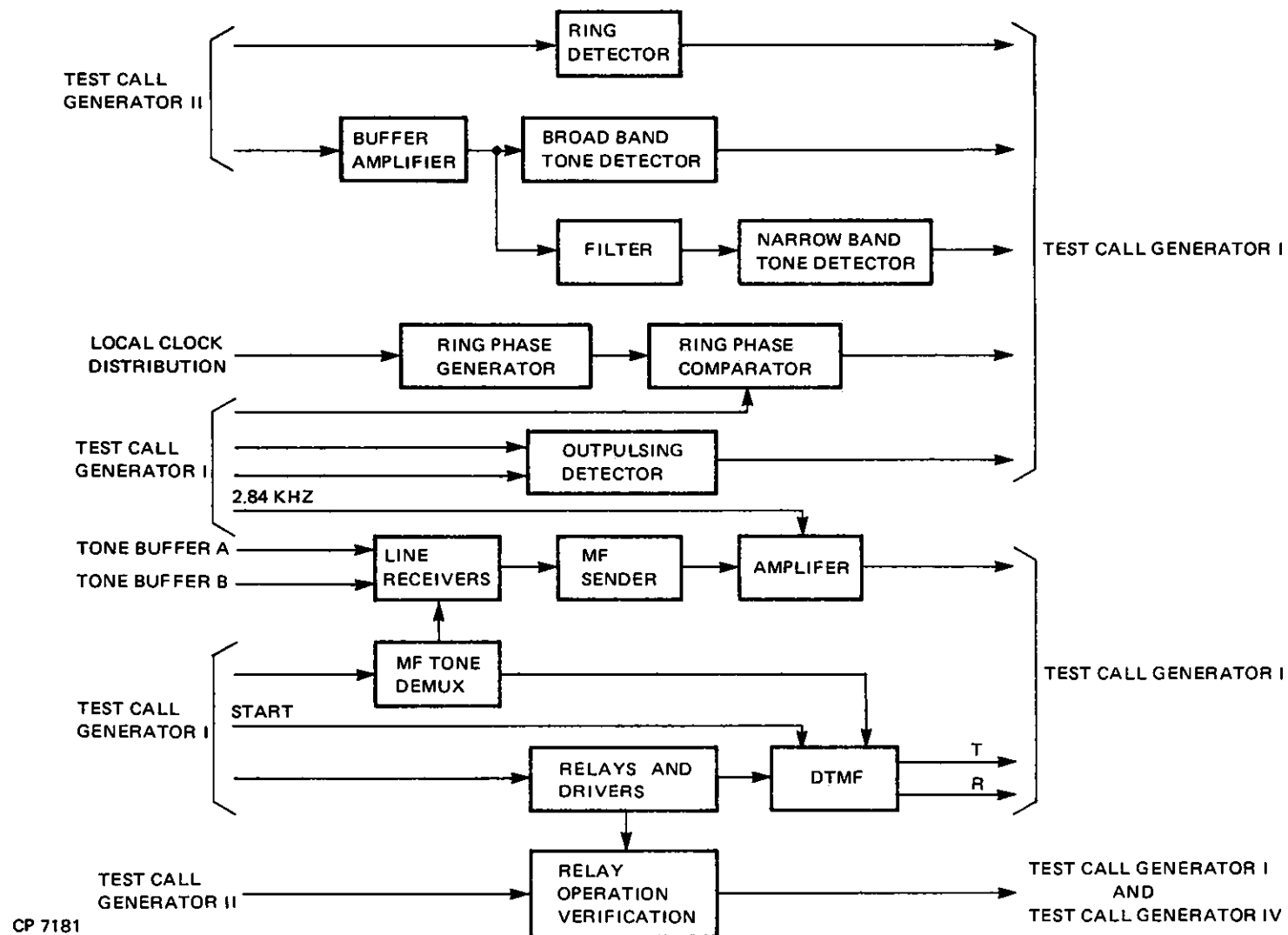


Figure 8. Test Call Generator III, Block Diagram

and a signal is sent to TCG I when a valid digit is detected.

c. A dual-tone MF (DTMF) circuit generates tones as programmed from TCG I, and a relay operation verification circuit for DTMF checks that the DTMF relays are in the positions programmed. The verification output is sent to TCG I and TCG IV.

d. In addition to the narrowband detector mentioned above, there is a broadband detector that monitors for dial tone, ringback tone, DTMF, etc., and a ring detector that monitors for a ring signal from TCG II, as programmed. When there is a detection, it supplies a logic signal to TCG I, verifying the detection.

12.05 Test Call Generator IV.

a. The TCG IV circuit tests the pulse code modulation function of the DCO. Testing is done by generating a test tone, applying it to a port, and monitoring the output at another port. The output is checked for amplitude and frequency distortion. Figure 9 is a block diagram of TCG IV.

b. The 2.048-MHz clock is divided by 48 and used to clock a 10-stage shift register, which further divides the signal by 20. The resulting 2133-Hz output passes through a resistive summing network, which produces a simulated 20-sample-per-second sine wave. This is filtered, amplified, and attenuated to provide the proper input level to the calling port by way of TCG II.

c. The signal received at the called port is applied (by way of TCG II) to a switchover circuit in TCG IV. The switchover circuit can select either the received signal or the sine wave output of TCG IV (for calibration). The switchover output is buffered and filtered and then converted to a dc level corresponding to the true RMS value of the signal by RMS detectors.

d. An analog-to-digital (A/D) converter converts the analog bandpass filter signal to a digital representation of the received analog signal. The signal (noise) that gets through the band reject

filter is converted to a 1-bit digital signal by another A/D converter and then compared to a reference level to determine if the noise and distortion are within acceptable limits.

e. The results of the various tests are sent to the MBI by way of selectors and drivers.

13. LINE TEST CONTROLLER

13.01 The line test controller (LTC) consists of two PWBA's in the LLS frame. The circuit is used for LLS line routing (in place of the test call generator) and party identification. The LTC operates under control of the line switch controller and reports all test results to that circuit.

13.02 The line switch controller causes a test access path to be set up between the selected line and the LTC (fig. 10). The LTC then checks dial tone, dialing, and dial-tone removal. The voice path, noise level, supervisory paths, and most of the control functions are tested during line routing.

13.03 The LTC communicates with the MP through the line switch controller, communications bus controller, maintenance communications interface, and MP bus to receive commands and transfer data to the MP. The MP determines the sequence for stepping through the lines and establishes the tests that are made.

14. AUTOMATIC LINE INSULATION TEST

14.01 The optional automatic line insulation test (ALIT) circuitry is mounted on two PWBA's in the LSC Y cell. The ALIT control PWBA contains a microprocessor and most of the associated digital test circuits. The ALIT PWBA contains the actual measuring device (an 8-bit analog-to-digital converter).

14.02 The ALIT circuit interfaces to the LSC by way of the LTC; the ALIT control circuit controls the interface between the ALIT and the LTC. ALIT control receives messages from the LSC, by way of the LTC, does the required tests, and returns the results to the LSC, by way of the LTC. During ALIT, the line circuit is split into an inward and an outward section. While the LTC checks the line circuit inward, the ALIT circuitry checks the outside plant.

14.03 The purpose of ALIT is to find outside plant problems before they affect a subscriber's ability to make and receive calls. Tests made on the out-

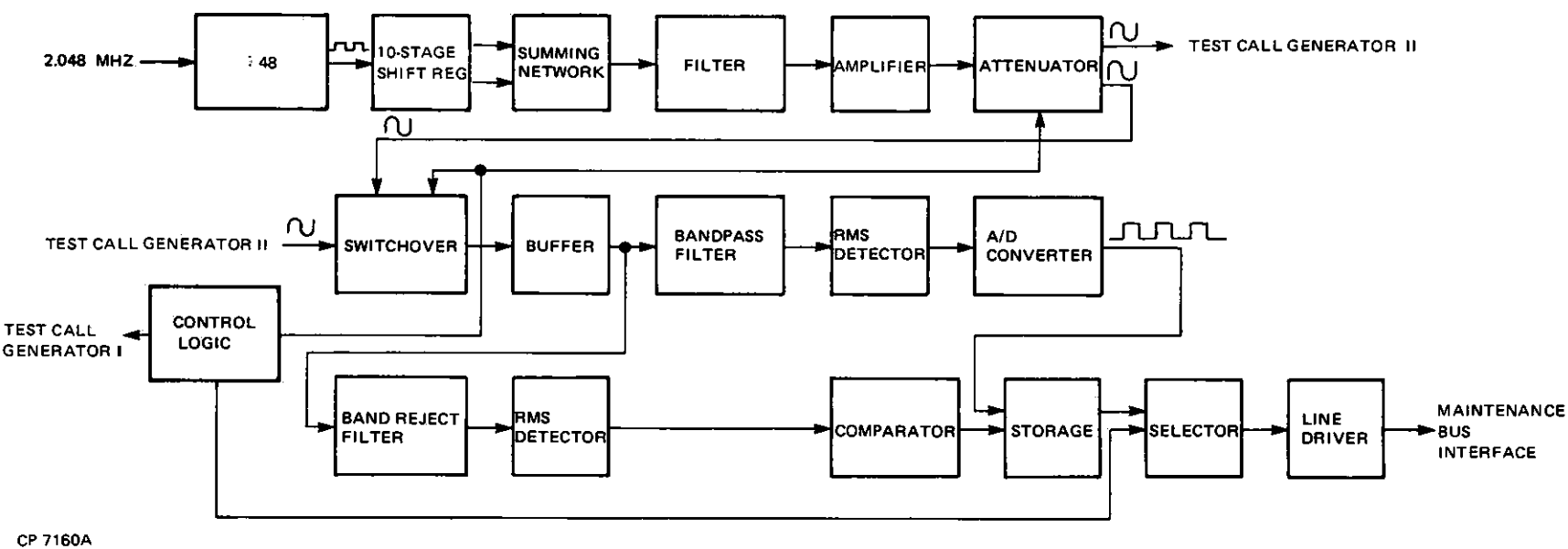


Figure 9. Test Call Generator IV, Block Diagram

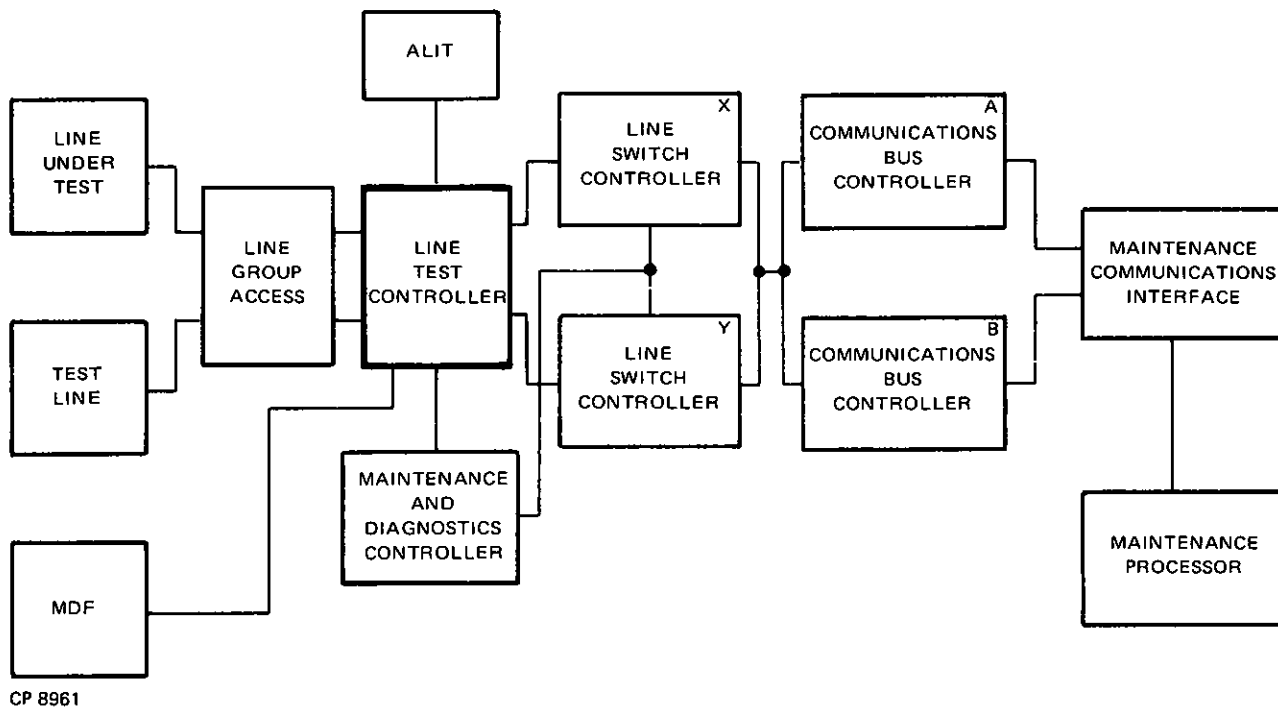


Figure 10. Line Test Controller, Orientation Diagram

side plant include insulation (leakage), capacitance, foreign voltage (ac and dc), and noise. The noise measurement determines the differential voltage across tip and ring.

15. MAINTENANCE AND DIAGNOSTICS CONTROLLER

The maintenance and diagnostics controller (MDC) is a gathering point for alarms and status changes in the LLS frame. If a fault is detected in a redundant circuit, the MDC causes the faulty circuit to be taken off-line. The MDC sends alarm indications to the LSC, which passes them on to the MP. The MDC is mounted in and powered by the LSC X cell. If an X-side power failure occurs, however, the MDC receives power from the Y side.

16. TIMESLOT INTERCHANGE DIAGNOSTICS

16.01 A timeslot interchange diagnostics (TSID) circuit provides the interface between the mismatch detectors in 32 port group control (PGC) circuits and the maintenance bus. The maintenance bus is, in turn, interfaced by way of the MBI to the maintenance processor.

16.02 Two TSID PWBA's are provided for each common control. Each TSID consists of a common portion plus an individual section for each of the 32

associated PGCs. See figure 11. The common portion includes bus drivers and receivers for interfacing with the MBI, address decoding, and data multiplexing.

17. TIMESLOT INTERCHANGE/PORT CONTROL SYSTEM DIAGNOSTICS

17.01 The timeslot interchange/port control system diagnostics (TSI/PCSD) circuit does two general maintenance and diagnostics functions in each TSI/PCS cell. It serves as a control and status link between the TSI/PCS cell and the maintenance processor (MP) by way of the maintenance bus; it also detects data mismatches between redundant sides A and B at several strategic points in the PCS. Error conditions, which may or may not be mismatches, are placed in two first-in/first-out memories. This allows the MP to access the error stores in the order of occurrence, asynchronous to the TSI/PCSD loading of the stores.

17.02 Two TSI/PCSD PWBA's are provided for each common control, one in each TSI/PCS cell (side A and side B). Each TSI/PCSD PWBA has its own unique address on the maintenance bus; however, when both sides are running, the PWBA's operate as one functional unit with certain mismatch detection tasks being shared between them and other error status and command functions being duplicated for each side. Figure 12 shows the interconnection of the TSI /PCSD circuits with the as-

sociated circuits in the TSI/PCS cell and with the maintenance bus.

18. SERVICE GROUP DIAGNOSTICS

18.01 The service group diagnostics (SGD) circuit is the alarm-reporting center for various service circuits. It reports alarms to the maintenance processor by means of interrupts from the maintenance bus interface. The following circuits and equipment are monitored:

- a. Master clock
- b. Master clock distribution
- c. Local clock distribution
- d. Precise tone generator
- e. Ring monitor and serializer
- f. Ringing generator
- g. Power supply monitors
- h. Miscellaneous customer-supplied equipment, such as air blowers and burglar alarms.

18.02 Two types of service group diagnostics PWBA are used: one is the primary SGD and the other is simply the SGD. The primary SGD, which serves the master and local clock circuits, precise tone generators, and ringing generators is always required. One regular SGD PWBA is required for each common control. This circuit serves the ANI/clock distribution, ring monitor and serializer, and customer-provided equipment for common control.

18.03 Each SGD (fig. 13) has several status registers that receive alarms and send flags to the maintenance bus interface. The maintenance bus interface interrupts the maintenance processor and alerts it to the alarm existing in the monitored circuit or equipment. The maintenance processor reads the SGD flag-interrupt register to determine which SGD is reporting the alarm, then reads the SGD status register to determine the type of alarm, and finally accesses the alarm-status register to receive specific alarm information. By reading the SGD registers in a particular sequence, the maintenance processor pinpoints the exact location of the alarm. Remedial action (switchover to redundant equipment) is initiated through control registers. At the same time, the TTY printout shows the nature and location of the fault(s).

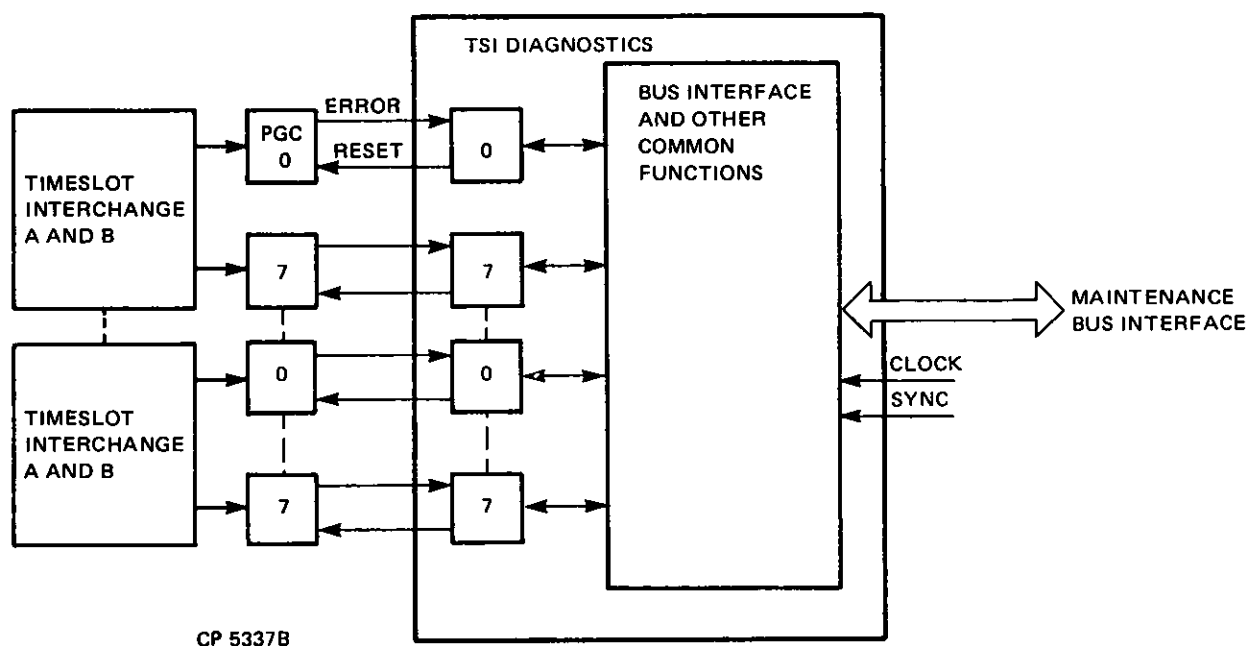
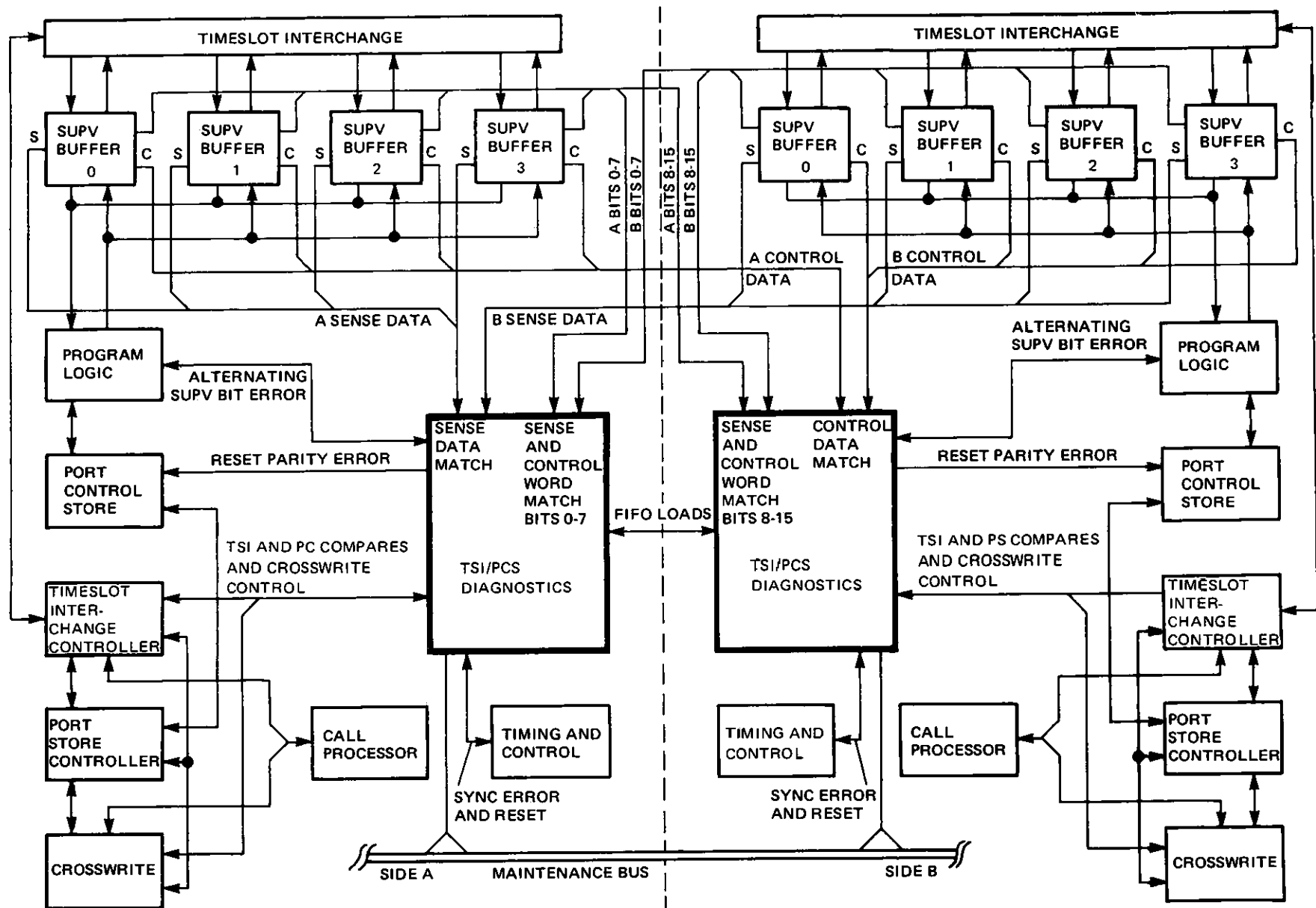


Figure 11. Timeslot Interchange Diagnostics Circuit, Block Diagram



CP 7145

Figure 12. Timeslot Interchange/Port Control System Diagnostics Circuit, Orientation Diagram

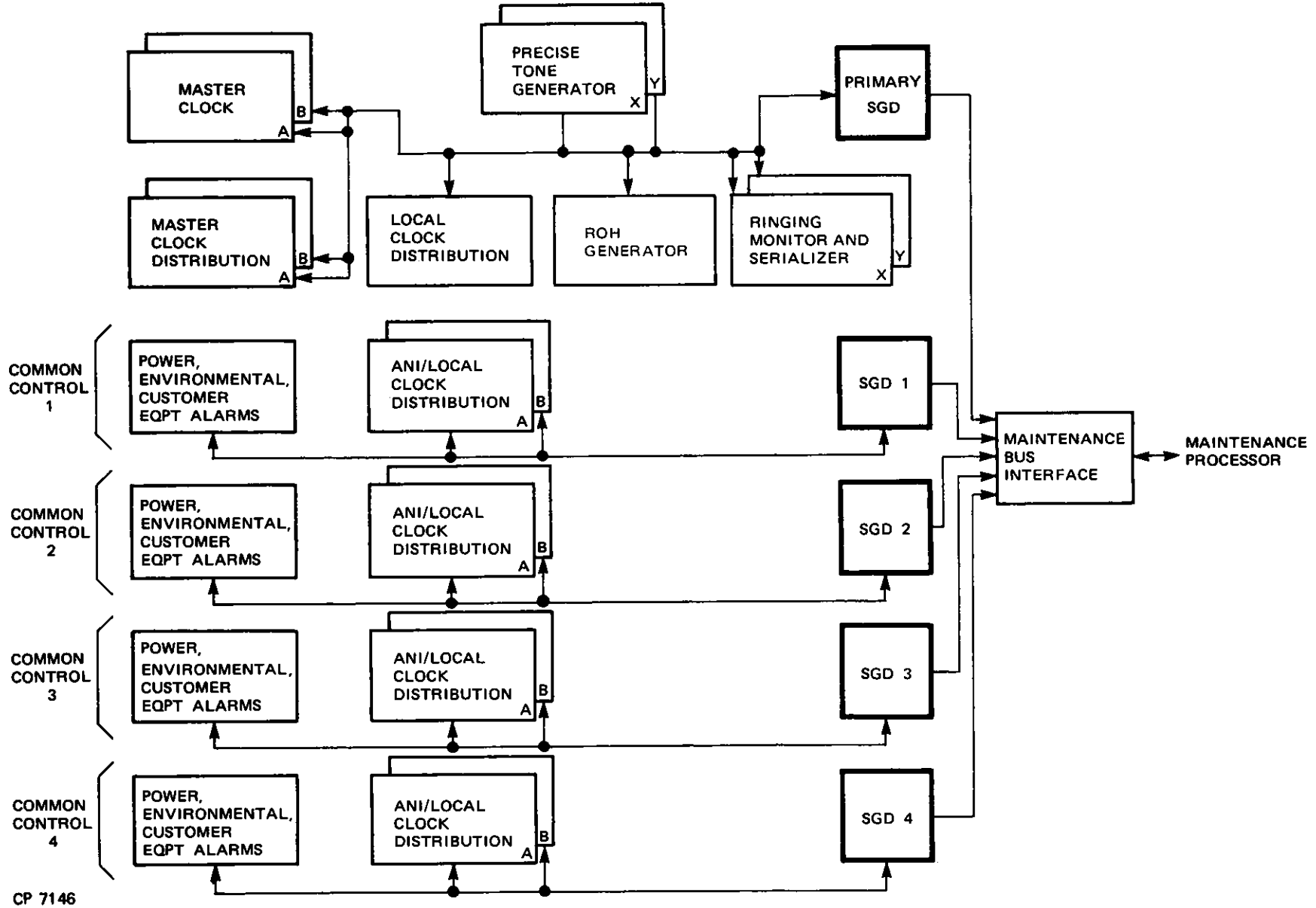


Figure 13. Service Group Diagnostics Circuit, Orientation Diagram

19. FAULT DETECTION AND ISOLATION**19.01 Automatic Routine Testing.****a. General.**

1. Along with other strategically located hardware detectors, a memory resident program in the maintenance processor (MP) continually exercises and tests the DCO system using the circuits previously described in paragraphs 5 through 18. Among the parameters monitored are parity checks in the call processors and port store memories, bus mismatches between various portions of the redundant systems, and synchronization losses between the two call processors on all bus transactions.

2. Detection of any fault generates an interrupt to the MP which then takes appropriate action according to the nature of the fault.

b. Test Calls Using Test Call Generator.

1. The test call generator, under control of the MP, provides the capability for automatically generating test calls by simulating the actions of trunks. Proper system responses and communication paths are checked at various stages of each call.

2. The selection of ports to be used in each test call is made by an algorithm that is designed to maximize the areas of the system tested by a given number of calls. Since it is possible for a port to be busy, or otherwise not available when selected for a test call, a substitute port is selected. The busy port simply loses its turn until chosen on the next pass. Certain ports, however, can be given a high test priority, so that if they are found busy when selected, they are entered on a "deferred test" list. The MP, then, makes periodic attempts to test the ports on this list.

3. After the ports to be used on a given test call have been selected and found to be idle by the CP, the MP causes the CP

to place the ports in the "maintenance busy" state. The MP also interrogates the CP to obtain additional data on the selected ports, such as port type and class of service. Certain of these parameters are used to select the proper entry in a "type of call" table in order to control setup of the test call in a manner that is appropriate for the port types involved. Port type data is also sent to the test call generator (TCG).

4. Metallic paths are next established from the TCG to the selected ports by way of test access relays in individual port circuits and the test access network. The call is then set up in incremental fashion, with the MP issuing a command for each action to be performed (go off-hook, dial a digit, etc.) and for each system response to be detected (tone, ringing, etc.). When the TCG has completed the required action and/or detected the appropriate response, it interrupts the MP which then proceeds to the next step. The MP times each step of the test call and, if a response is not received within the allotted time, the call is assumed to have failed and diagnostic routines are initiated.

c. Test Calls Using Line Test Controller.

1. The line test controller, under control of the line switch controller and maintenance processor, automatically generates test calls by simulating the actions of subscriber lines. Proper system responses and communications paths are checked at various stages of each call.

2. An origination test is scheduled every 10 seconds by the maintenance processor. The line switch controller causes a test access path to be set up between the selected line and the LTC and then commands the LTC to do the origination test. The LTC establishes an off-hook condition for the line, resulting in a transmission path being set up and dial tone being returned to the off-hook line. The LTC detects dial tone, dials the digit 1, and detects dial tone removal when the digit is received by the sys-

tem. The LTC puts the line on-hook and disconnect is reported by the call processor.

3. Line routining provides a thorough test of the LLS line circuits once a day. In addition, the voice path, supervisory paths, and most of the control functions are tested. If ALIT is provided, a test of the subscriber line is done at the same time as the line is being tested. Line routining is usually done during low traffic periods at night.

a) Before testing is started, the LTC does a self check. The line switch controller then selects a line for testing and checks that it is equipped and idle. If busy, the line is put on a test-later list; if idle, a metallic path is set up between the line and the line router in the LTC.

b) After some initial checks, the LTC goes off-hook and dials a 3-digit code to establish a voice path from the line under test, through the system, and back to a dedicated LLS line that has a direct-wired access to the LTC. The LTC makes a noise test on the path, tests voice transmission by generating and detecting a tone in each direction, and releases the voice path.

c) Line circuit relay functions (ringing, tip and ring reversal, etc.) are now checked by generating supervisory control bits in the LTC and monitoring the results. The test access path is released and the next line to be tested is selected.

d. Automatic Line Insulation Testing.

If ALIT is done concurrently with port routining, the ALIT unit provides a set of line measurement values to the LSC by way of the line test controller. The LSC compares the measurements with a set of established threshold values and if any measured value exceeds the threshold, the tests are repeated. If the second test shows the same discrepancy, the maintenance processor is notified.

e. Sanity Test.

A part of the routine testing function involves the execution of a set of instructions stored in the CP memory. These instructions are designed to provide a quick check of the CP computer's own functional capability (sanity). The program is designed to produce a specific result, within a prescribed period of time, that is compared to a hardware-stored "correct" result. If there is disagreement or no response as a result of the comparison, appropriate error processing is initiated.

f. A and B Switchover.

The redundant A and B systems are periodically switched to ensure that the switchover circuitry is functioning properly. The time interval between switchovers is scheduled by the system real-time clock.

g. Fault Detectors.

The routine testing function periodically tests the various fault detector circuits throughout the DCO system. (Refer to paragraphs 5.05 through 18.) Generally, this is done by introducing simulated fault conditions and checking that the circuits respond properly.

19.02 Manual Testing.

Certain test routines that are a part of the routine testing function described in paragraph 19.01, as well as other routines, can be manually implemented by the technician by using the system console and/or the basic maintenance panel. Refer to the sections titled *Basic Maintenance Panel, Operating Instructions; System Operators Manual; and Wire Chiefs Test Set Description, Installation, Test Procedures, Operation and Maintenance*, referenced in paragraph 2.02.

19.03 Automatic Diagnostic Programs.

a. General.

1. The automatic diagnostic programs, together with the fault detection circuits described in paragraph 19.01, take full advantage of the fact that the system is redundant and runs synchronously. Three methods of fault detection used by the system are: comparison of the signals between synchronous sides of the system, detection

of error flags in individual circuits, and generation of test calls.

2. Detection of a non-side-specific fault causes first-level diagnostic routines to be called. These routines determine which side of the redundant system (A or B) is faulty and, if necessary, effect switchover.
3. If automatic switchover occurs, second-level diagnostic routines are called to isolate the fault to a specific PWBA.
4. In addition, the DCO system technician is provided with the capability of selectively executing various diagnostic routines. These selective diagnostics are provided for testing various areas of the system, such as common control, line and trunk, etc. The common control area consists of the A/B redundant equipment, such as the timeslot interchanges, call processor, etc. Diagnostics in this area are selectable on a basis of subsystem, PWBA, or test on a PWBA function. The line and trunk area consists of the non-redundant circuitry such as port circuits, multiplexers/demultiplexers, TMF senders, etc.

b. First-Level Diagnostics.

1. The primary function of first-level diagnostics is the isolation of faults to one side or the other of the A-B redundant portions of the DCO system. As secondary functions, the first-level diagnostics calculate preliminary disability factors for either side and furnish error data and test results to second-level diagnostics for use in isolation to the PWBA level.
2. The first-level diagnostics perform a detailed error analysis from error data provided by the error handler routines. This results in the generation of two basic vectors, an error type and an error location. The error type vector gives information as to the type of PWBA or subsection of the system in which a fault is indicated, and/or the type of error detector that initially reported the

fault. The error location vector localizes the fault, when possible, to one out of several similar PWBA's or functional subsections of the system.

3. From a system standpoint, first-level diagnostics can be viewed as consisting of a sequence of three functionally distinct types of test activity, referred to as phases 0, 1, and 2. Phase 0 is actually performed in hardware and consists of side-specific error detectors, plus any tests that are put into effect by hardware (such as the call processor sanity test) that can lead to a hardware switchover decision. Thus, first-level diagnostic software is primarily concerned with phases 1 and 2.
4. Phase 1 runs with call processing suspended and, therefore, executes rapidly to minimize the impact on traffic handling. The types of tests run during phase 1 will vary depending on the nature of the error indication. They do, however, include a write/read check of test data patterns in registers and memories accessible from the call processor bus and control function tests. If phase 1 tests are unable to resolve the fault, call processing is resumed and phase 2 testing is started.
5. Phase 2 consists primarily of patterns of test calls directed to the suspected areas of the system. It is assumed at this point that, since phase 0 and phase 1 tests did not uncover the fault, more than likely it is not a catastrophic one. If the fault has not been located at the conclusion of phase 2, a recovery is performed and a switchover decision is made. In most cases, the on-line side will be favored and no switchover will occur.
6. If the fault is detected at any point during phase 1 or phase 2, testing is discontinued and a switchover decision is made. At this point, the second-level diagnostic program is called to isolate the faulty PWBA.

c. **Second-Level Diagnostics.**

1. Upon detection of a system failure and subsequent removal of the faulty side from service, fault isolation is scheduled. The objective of fault isolation is to determine the location of a faulty circuit element within a minimum group of replaceable PWBA's and to provide a printout on the DCO system console that lists these PWBA's in a most-probable-to-least-probable order.

2. A second-level diagnostic controller monitors and controls the execution of the second-level diagnostic programs by maintaining a diagnostic control table. The various PWBA's in the DCO system have dedicated sets of diagnostic programs which verify the functionality of their associated circuits. The initiation of second-level diagnostics to perform fault isolation involves making a decision as to which PWBA(s) is to be tested. Specifically, fault isolation results in the identification of appropriate second-level diagnostic tasks that exercise those PWBA's suspected of being faulty.

20. DIAGNOSTIC PRINTOUTS

All fault interrupts received by the maintenance processor automatically produce printouts at the DCO system console. Diagnostic messages are also printed indicating the results of the first-level and/or second-level diagnostics described previously.

21. PWBA REPLACEMENT AND SYSTEM REPAIR VERIFICATION

21.01 Using the PWBA list produced by second-level diagnostics, PWBA's should be replaced one at a time using the technique described in the section titled *Equipment Removal and Replacement Procedures*, referenced in paragraph 2.02. After replacement of a PWBA, it is necessary to determine whether or not the replacement corrected the fault.

21.02 The success of the PWBA replacement action is verified by using the repair and restore verification procedures provided in the section titled *System Operators Manual*, referenced in paragraph 2.02.

22. SELECTIVE DIAGNOSTIC PROGRAMS

Various diagnostic routines can be executed by the technician using the DCO system console. These procedures are used to further isolate a fault after automatic, diagnostics routines (described in paragraph 20.03) have been completed.

23. ALARM SENDING AND CHECKING

23.01 General.

Alarm indications are sent to an operators position, a managers alarm box, or a 7- or 10-digit number. On receipt of the alarm indication, an alarm checking number must be dialed to obtain specific information on the alarm.

23.02 Alarm Sending.

The following options are available:

a. **Alarm Sending via Operator Trunk.**

Fault indications are forwarded via the regular operator trunk group. When a fault occurs, an operator trunk is seized and a request for service generated. On answer, the operator receives a distinctive tone indicating that the alarm checking number should be dialed. The operator trunk is released after answer.

b. **Alarm Sending via Dedicated Trunk.**

Similar to alarm sending via operator trunk except that a trunk is dedicated to alarm sending. This trunk may be one-way outgoing only or two-way with the incoming route being used for busy verification.

c. **Alarm Sending to Managers Alarm Box.**

A spare dial leg(s) is used to send battery or ground to a managers alarm box to operate a relay, light a lamp, or do some similar function.

d. **Alarm Sending to a 7- or 10-Digit Number.**

1. The DCO switching system is programmed to send a recorded announcement to a 7- or 10-digit number when an alarm occurs. A list of up to 10 alarm reporting numbers can be programmed.

2. When an alarm occurs, the first alarm reporting number is automatically dialed and a recorded announcement is sent

to the line. A timer is started and, if the alarm checking number is not dialed within a predetermined programable interval, the next number on the list is dialed. The system continues through the list (recycling if necessary) until the alarm checking number is dialed. (If one of the numbers programed is the operator, cycling stops and the operator is called repeatedly until the alarm checking number is dialed.)

3. The recorded announcement is normally made by the telephone company and tells the called party the name of the office, advises that an alarm condition exists, and gives the alarm checking number to be dialed for further information.

23.03 Alarm Checking.

When the alarm checking number is dialed, the caller hears an audible signal indicating the actual alarm classification. Tables 1 and 2 describe the various faults that cause an alarm to be sent for Stromberg-Carlson and REA alarm classifications, respectively.

24. FUNCTIONAL OPERATION OF MAINTENANCE AND TEST FACILITIES

24.01 General.

This paragraph describes, without detailed reference to circuit operation, how a fault is handled by the maintenance and test facilities of the SYSTEM CENTURY DCO. In this example, assume that a mismatch occurs between redundant sides A and B when call data is sent from redundant TSIs to the associated port group control II circuit. A block diagram (fig. 14) is used to show the sequence of connections made. Circuits indicated by broken lines are not part of the maintenance and test facilities.

24.02 Port Group Control II Detects Error.

Every 488 nanoseconds, port group control II (PGC II) receives a call-data or control-data bit from TSIs A and B (connection 1). The bits are stored and compared; when they differ, a mismatch signal is sent to the associated timeslot interchange diagnostics (TSID) circuit (connection 2).

24.03 Timeslot Interchange Diagnostics Circuit Notifies Maintenance Processor of Error.

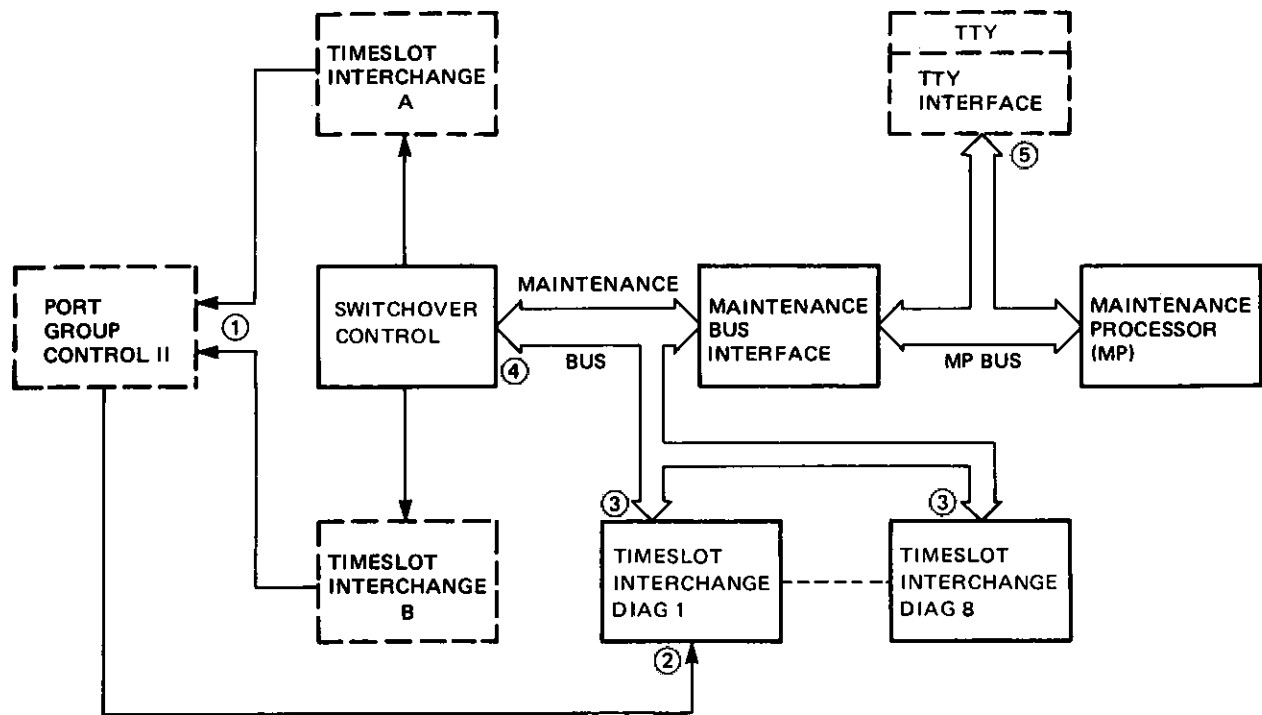
In the TSID circuit, error data is summarized and stored in a 16-word memory. If 16 errors are stored in a specified time period, a flag latch is set in the TSID circuit. Assume that 16 errors have been stored. The maintenance processor (MP) polls the eight TSID PWBA's that share a single flag line (connection 3) if an interrupt occurs. When the MP detects the error flag on TSID 1 in this example, it then addresses the TSID 1 memory to determine the PGC II, TSI, and timeslot involved.

24.04 Maintenance Processor Does Diagnostics to Determine Faulty Circuit.

The first-level diagnostics of the MP immediately determine whether the on-line or off-line system is faulty and initiates switchover, if required (connection 4). After the faulty side has been determined (in this case, side A, which was on-line), and switchover has occurred, second-level diagnostics automatically attempts to diagnose the fault in the off-line equipment down to the PWBA level. In this case, second-level diagnostics determines that TSI 3 serving common control 1 in side A is faulty.

24.05 Teleprinter Prints Fault Information.

As soon as the first indication of the fault is detected, the teleprinter begins printing error messages (connection 5). These error messages are explained in the section titled *Message Dictionary*, referenced in paragraph 2.02.



CP 7147

Figure 14. Fault Detection by Maintenance and Test Circuits

Table 1. Stromberg-Carlson Alarm Checking Fault Classification

ALARM CODE	POSSIBLE FAULT	PRIORITY
No tone	System inoperative.	Emergency
	All calls blocked.	Emergency
	Calls blocked in one common control sector.	Emergency
	Both programable ringing generators inoperative.	Emergency
	DSU: remote unit inoperative, total span outage, or inability to interpret message.	Emergency
Steady high tone	Calls blocked in one port group.	Group Emergency
	Degraded service throughout system.	Group Emergency
	Primary programable ringing generator failure.	Group Emergency
	DSU: span outage (degraded service), span transfer failure, charger failure and inoperative standby ac source.	Group Emergency
	DTI: thresholds exceeded (frame loss, slips, bipolar violations), DTI cell out of service, or span failure.	Group Emergency

Table 1. Stromberg-Carlson Alarm Checking Fault Classification (Cont)

<i>ALARM CODE</i>	<i>POSSIBLE FAULT</i>	<i>PRIORITY</i>
Steady low tone	Administrative and diagnostic functions operative but degraded.	Nonemergency
	Redundancy lost; degraded service on active side.	Nonemergency
	Degraded service in one common control sector.	Nonemergency
	Port fault detected by test call generator.	Nonemergency
	Cumulative line/trunk permanent.	Nonemergency
Steady low tone	High or low battery voltage.	Nonemergency
	DSU: ringing generator failure, loss of frame sync, cumulative permanent alarm, party detect failure, paystation power supply failure, illegal entry of remote facility, environment of remote facility outside normal limits, loss of cable pressure.	Nonemergency
120-ipm busy tone	Carrier or radio failure	Nonemergency
Ringback tone	Redundancy lost: on-line functioning.	Alert
	Environment outside normal limits; system operational.	Alert
	Battery charger failure.	Alert
100-Hz tone	Commercial ac power failure; standby ac generator inoperative.	Alert
Tick tone	Nonservice-affecting fault (X or Y ringing system, test call generator, etc.).	Alert
	Sensor-reported fault (cable pressure, forced entry into building, etc.).	Alert

Table 1. Stromberg-Carlson Alarm Checking Fault Classification (Cont)

<i>ALARM CODE</i>	<i>POSSIBLE FAULT</i>	<i>PRIORITY</i>
2-ring code (ringback tone)	No faults.	

Table 2. REA Alarm Checking Fault Classification

<i>ALARM CODE</i>	<i>POSSIBLE FAULT</i>	<i>PRIORITY</i>
No tone	System inoperative.	Catastrophic
	All calls blocked.	Catastrophic
	Calls blocked in one common control sector.	Catastrophic
	Administrative and diagnostic functions inoperative.	Catastrophic
	Both programmable ringing generators inoperative.	Catastrophic
	DSU: remote unit inoperative, total span outage, or inability to interpret message.	Catastrophic
60-ipm busy tone	Calls blocked in one port group.	Major
	Degraded service throughout system.	Major
	Redundancy lost; degraded service on active side.	Major
	Redundancy lost; active side functioning properly.	Major
	Charger failure.	Major
	Primary programmable ringing generator failure.	Major
	DSU: span outage (degraded service), span transfer failure, charger failure or commercial ac power failure and inoperative standby ac source.	Major
	DTI: thresholds exceeded (frame loss, slips, bipolar violations), DTI cell out of service, or span failure.	Major
1-ring code (ringback tone)	Nonservice-affecting fault (X or Y ringing system, test call generator, etc.).	Minor

Table 2. REA Alarm Checking Fault Classification (Cont)

<i>ALARM CODE</i>	<i>POSSIBLE FAULT</i>	<i>PRIORITY</i>
2-ring code (ringback tone)	Environment outside normal limits; system operational.	Minor
	DSU: ringing generator failure, loss of frame sync, cumulative permanent alarm, party detect failure, paystation power supply failure, illegal entry of remote facility, environment of remote facility outside normal limits, loss of cable pressure.	Minor
	No faults.	

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