NO. 10A REMOTE SWITCHING SYSTEM INTERFACE DESCRIPTION AND MAINTENANCE CONSIDERATIONS
2-WIRE NO. 1 AND NO. 1A ELECTRONIC SWITCHING SYSTEMS

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1. GENERAL

1.01 This section covers the No. 10A Remote Switching System (RSS) interface to a No. 1 or No. 1A Electronic Switching System (ESS). The RSS provides a distributed switching capability for the host. The RSS consists of a remote switching entity that is controlled by a host ESS via data link (DL), and is used to economically provide ESS features to a relatively small number of lines (Fig. 1).

1.02 The reasons for reissuing this section are listed below. Since this reissue is a general revision, no revision arrows have been used to denote significant changes. Equipment Test Lists are not affected.

(1) Generally restructured for clarity

(2) Adds DL protocol information

(3) Adds DL diagnostic information

(4) Adds DL failure report information

(5) Adds DL state control output message information.

1.03 The No. 10A RSS (SD-4H001) is a remote terminal (RT) which performs call processing and maintenance tasks under direct commands from the host ESS. Transmission facilities, connecting the RSS switching network to line equipment terminals on the ESS line link network frames are required for voice transmission. Two voice channels are assigned to be DLs (Fig. 1). A peripheral unit controller for data links (PUC/DL) is required at the host ESS. The PUC/DL (SD-1A478) controls the duplicated DLs used for the RSS. A general description of the RSS is provided in Section 255-200-100.

1.04 The maintenance strategy of the RSS is incorporated into the existing maintenance strategy of the host. The teletypewriter (TTY) messages unique to RSS will appear on the host ESS maintenance TTY. Alarms associated with the RSS RT will trigger host central office alarms. The Switching Control Center (SCC) interface for the host also provides capability to monitor, analyze, and diagnose problems either unique to the RSS RT or common to the host and the RSS.

1.05 The DL information sent from the host ESS office to the RT will include commands to set up or tear down network paths, ring phones, collect coins, or operate relays. The host ESS may also make inquiries into the RSS status over the DL. The host ESS always decides which DL is to be active. The DL information from the RSS to the host ESS will be indications of its status such as the confirmation of a request action, the states of lines or circuits, and diagnostic results.

2. DATA LINK SYSTEM

2.01 The RSS DL communicates digital control data between the host ESS and the RSS. The DL requires a PUC/DL frame in the host ESS office, transmission facilities, and a data link interface (DLI) in the RT (Fig. 2). The entire DL is duplicated for reliability, and each DL can be used by either RSS microprocessor. Two voice channels from the multiplexed channels provided by the T1 or N carrier facility are dedicated for DL use.

PERIPHERAL UNIT CONTROLLER FOR DATA LINKS

2.02 The peripheral unit controller (PUC) is a selfchecking microprocessor controller. Figure 3 is a simplified block diagram of the PUC/DL. The PUC consists of two controllers. Each controller consists of a central processing unit (CPU), a memory, an ESS-PUC interface, and a PUC-peripheral interface which connects the serial DLs to the individual RSS DL ports.

2.03 The PUC/DL is a particular application of the PUC. The PUC/DL application firmware description is in the PUC description (BSP 231-037-020). The PUC is customized to the DL function with the use of a unique set of programs for its BELLMAC*-8 microprocessor. However, the basic interface to the No. 1/1A processor for all PUC applications is the same. Thus, much of the host ESS maintenance software is essentially the same for all uses of the PUC.

2.04 A PUC/DL frame can accommodate up to 16 separate DL channels. Each RSS application

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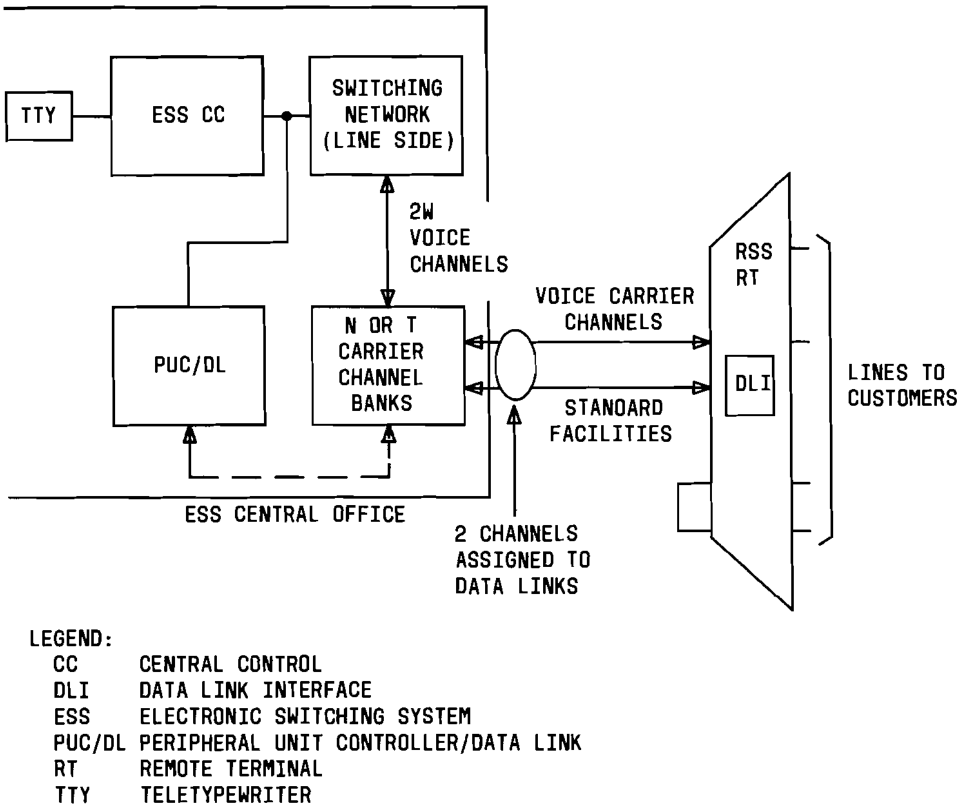


Fig. 1—Remote Switching System Block Diagram

uses two DL channels—one active and one standby. Therefore, a single PUC/DL frame has the capability of connecting up to eight RSS units. However, traffic limitations prevent more than six RSS units from being served per frame.

2.05 The RSS PUC/DL is a semiautonomous peripheral unit (PU) of the host ESS. It serves as the interface between the DL control function for the RSS RT and the host ESS central control (CC). In this application the PUC/DL performs the following functions:

(1) Receives data from the host, buffers, and formats the data into the appropriate DL message protocol and then transmits it serially on the DL to the RSS

(2) Responds to DL reconfiguration requests from the host CC

(3) Receives serial data from the RSS, buffers it, and signals the host CC so that the information received can be read by the host system

(4) Detects its own PUC faults and reports to the host CC

(5) Performs diagnostic tests when requested by the host CC or on a timed basis

(6) Performs audits of its own memory when requested by the host CC

(7) Reinitializes itself when requested by the host CC.

2.06 The PUC/DL is a single frame of equipment that attaches to the PU communication bus of the host ESS. It sorts, buffers, and transmits the outgoing DL messages. The PUC/DL similarly receives incoming DL messages from the various DLs. It verifies the message integrity and communicates the result of the message to the host CC.

2.07 A peripheral unit controller for data link (PUC/DL) faults will be reported to maintenance personnel via the host ESS maintenance TTY. The host will control all PUC/DL diagnostics. The host software includes the software for DL maintenance.

2.08 Each DL connects to a line interface unit (LIU) in the PUC/DL. The LIU performs a full duplex parallel to serial conversion and supports the synchronous data link control (SDLC) protocol which is used to assemble data into blocks and provide error control.

TRANSMISSION FACILITIES

2.09 Digital or analog carrier facilities connect the RT with the host ESS for voice channels as well as DL channels.

2.10 The digital facilities are T1 carrier (Fig. 4). Two D4 channel banks are required for T1 carrier. Each D4 bank has two groups of 24 channel units. One of these channels is a data service unit-data port (DSU-DP). The DSU-DP provides conversion from the 2400 bit/second signals used by the DLs to the time divided 8-bit bursts at an 8 kHz rate needed for T1 carrier transmission. The burst speed is 1.544 M bit/sec but the average T1 channel data rate is 64 kb/sec. The DSU-DP occupies channel slot twelve. Each data byte is repeated 20 times for error correction.

2.11 At the host ESS, the D4 equipment is external to the PUC/DL. At the remote end, the D4 functions are integrated into the RT hardware.

2.12 The analog facilities are N carrier (Fig. 5) or some other acceptable analog carrier. When carrier (N2, N3, N4) is used for the transmission to the host, a 201C data set is used for the DL modem. The modem converts the digital DL data to an N carrier analog signal and operates at 2400 bits per second. The modem is external to the PUC/DL at the host and external to the RT frame at the remote site.

2.13 The modem supplies an Electronic Industries Association (EIA) 232 interface, a remote loop on the digital side of the modem, and a local loop on the analog side of the modem.

REMOTE TERMINAL - DATA LINK INTERFACE

2.14 The DLI at the RSS RT performs some of the same functions as the PUC/DL at the host ESS. The DLI provides the circuitry to transmit and receive control information from either RT controller to the host ESS via the dedicated voice channels assigned to the DLs. There is one DLI for each DL (DLI0 and DLI1) and each DLI has access to either controller.

2.15 For the receive function, the DLI buffers the incoming bit stream. As each byte is received, an interrupt is generated to both controllers. The active controller will read the buffer and thus allow the next byte to be received by the DLI. The process is repeated until the entire message is received. Interrupts are also generated by the DLI for several other conditions that are determined by the DLI. These conditions include error check failures on the incoming bit stream, overflow of the DLI buffers, carrier failure, and other similar conditions.

2.16 The DLI transmit function is similar to the receive function in reverse. Data is transmitted serially in blocks of between 2 and 16 bytes, plus 6 bytes of SDLC overhead per block.

2.17 The same DLI is used for either T1 or N carrier, since both interfaces are provided on the circuit pack.

2.18 Figure 6 is a functional block diagram of the DLI. The buffers at the right of the diagram steer the information so that data may be transmitted to or received from either microprocesor. They also allow address input from either processor. The buffers are enabled by the gating logic shown above the buffers. The read, write, and enable signals to the gating logic come from the microprocessors. Eight bits of data and three bits of address flow between the buffers and the SDLC integrated circuit.

2.19 The T1 interface has encode and decode functions which translate between each data bit on the SDLC circuit and a fixed T1 stream. The encode and decode operations also have error correction ability. Processor controlled loop-backs are also provided in this interface. For T1 carrier, the DLI interfaces directly into the T1 common channel interface logic. For N carrier, an EIA 232 interface is provided in the DLI.

2.20 The DLI provides the necessary hardware to implement the SDLC protocol (format and

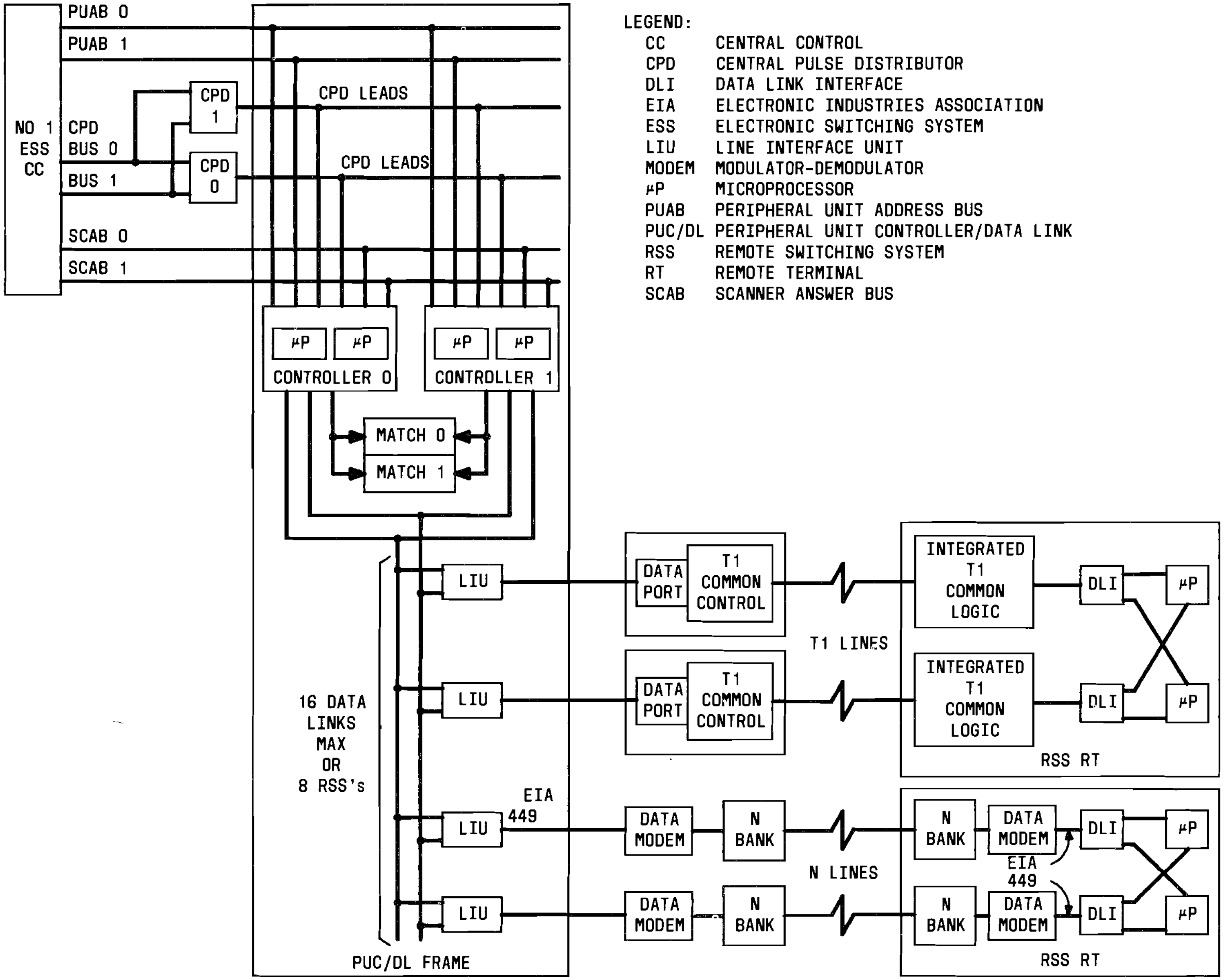
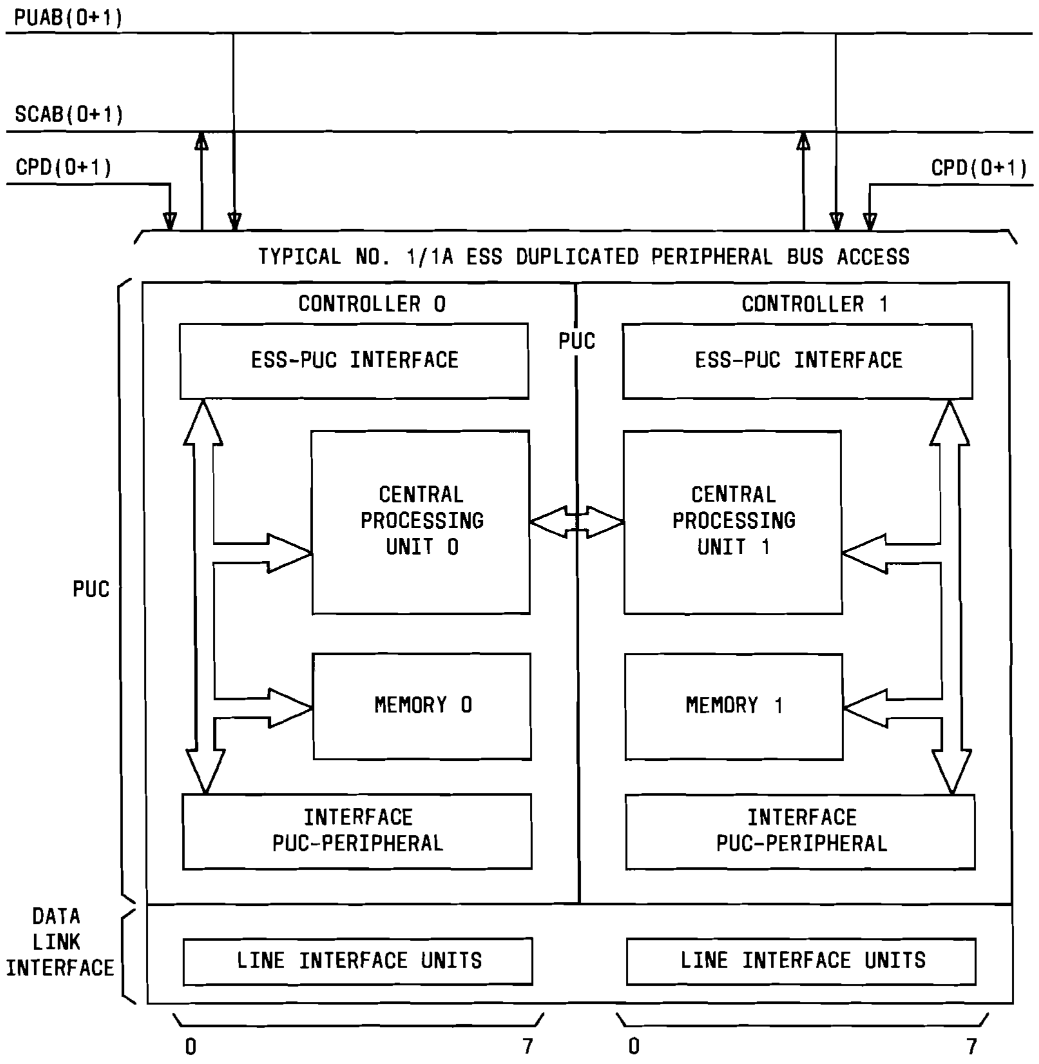


Fig. 2—Data Links



LEGEND:
- CPD CENTRAL PULSE DISTRIBUTOR
- ESS ELECTRONIC SWITCHING SYSTEM
- PUAB PERIPHERAL UNIT ADDRESS BUS
- PUC PERIPHERAL UNIT CONTROLLER
- SCAB SCANNER ANSWER BUS

Fig. 3—Peripheral Unit Controller for Data Links - Block Diagram

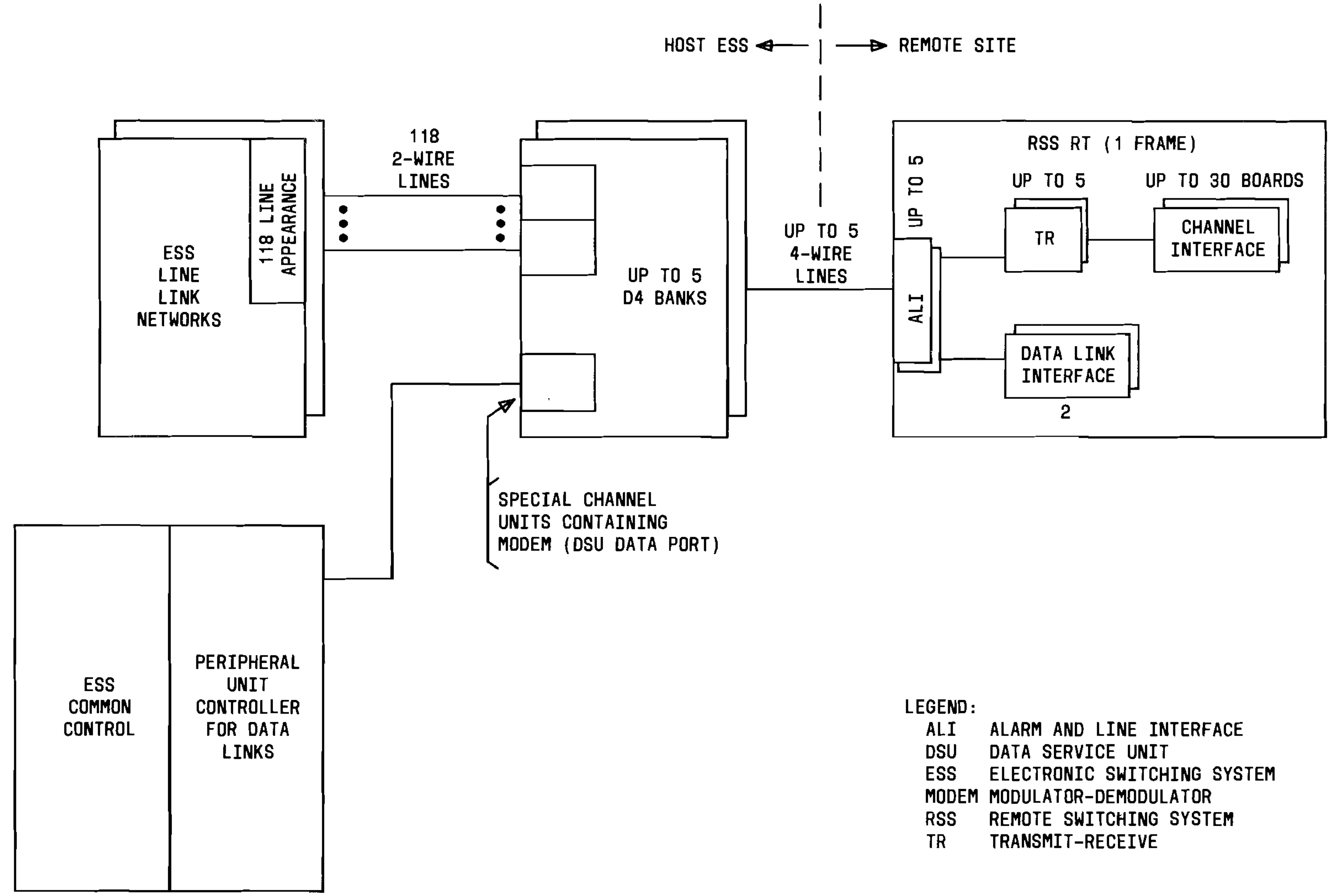
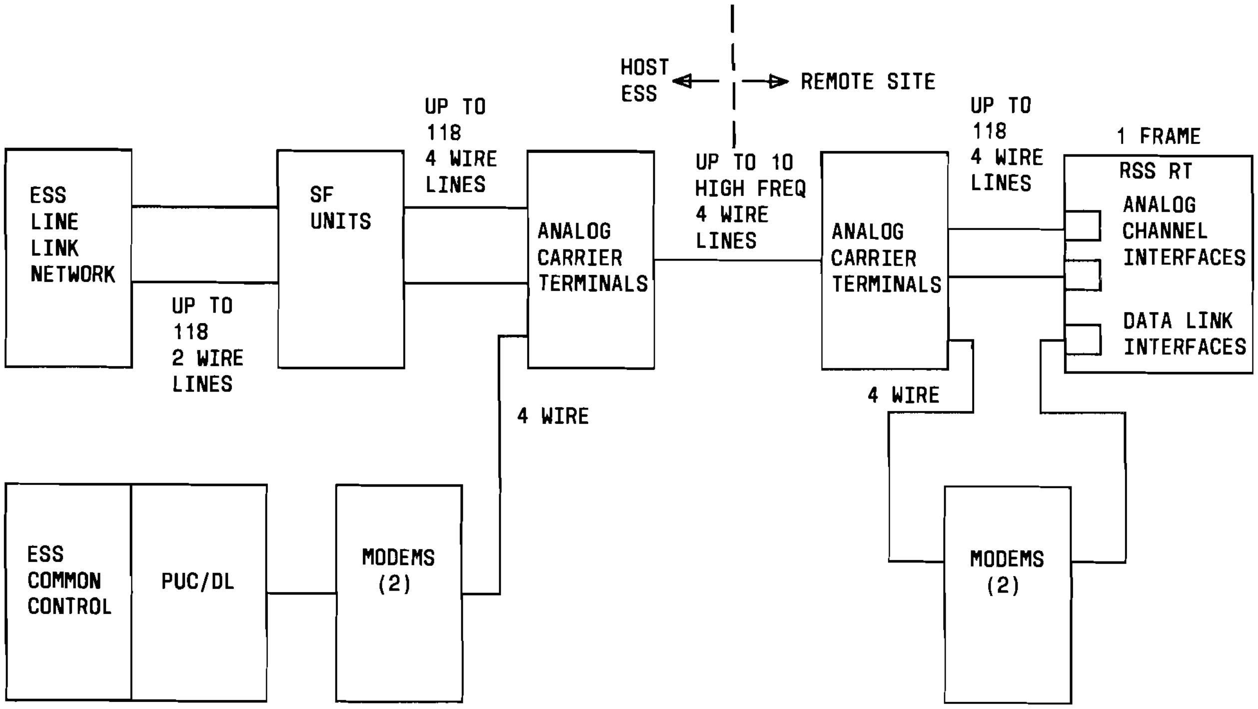


Fig. 4—Digital Channel Transmission Plan



LEGEND:
ESS ELECTRONIC SWITCHING SYSTEM
MODEM MODULATOR-DEMODULATOR
PUC/DL PERIPHERAL UNIT CONTROLLER/DATA LINK
RSS REMOTE SWITCHING SYSTEM
RT REMOTE TERMINAL
SF SINGLE FREQUENCY

Fig. 5—Analog Channel Transmission Plan

timing). This protocol provides the ability to detect transmission errors. The serial data received from the host ESS at the RT is changed to parallel data by the SDLC circuit. The same circuit is used to change parallel data from the RT to serial data to be transmitted to the host ESS.

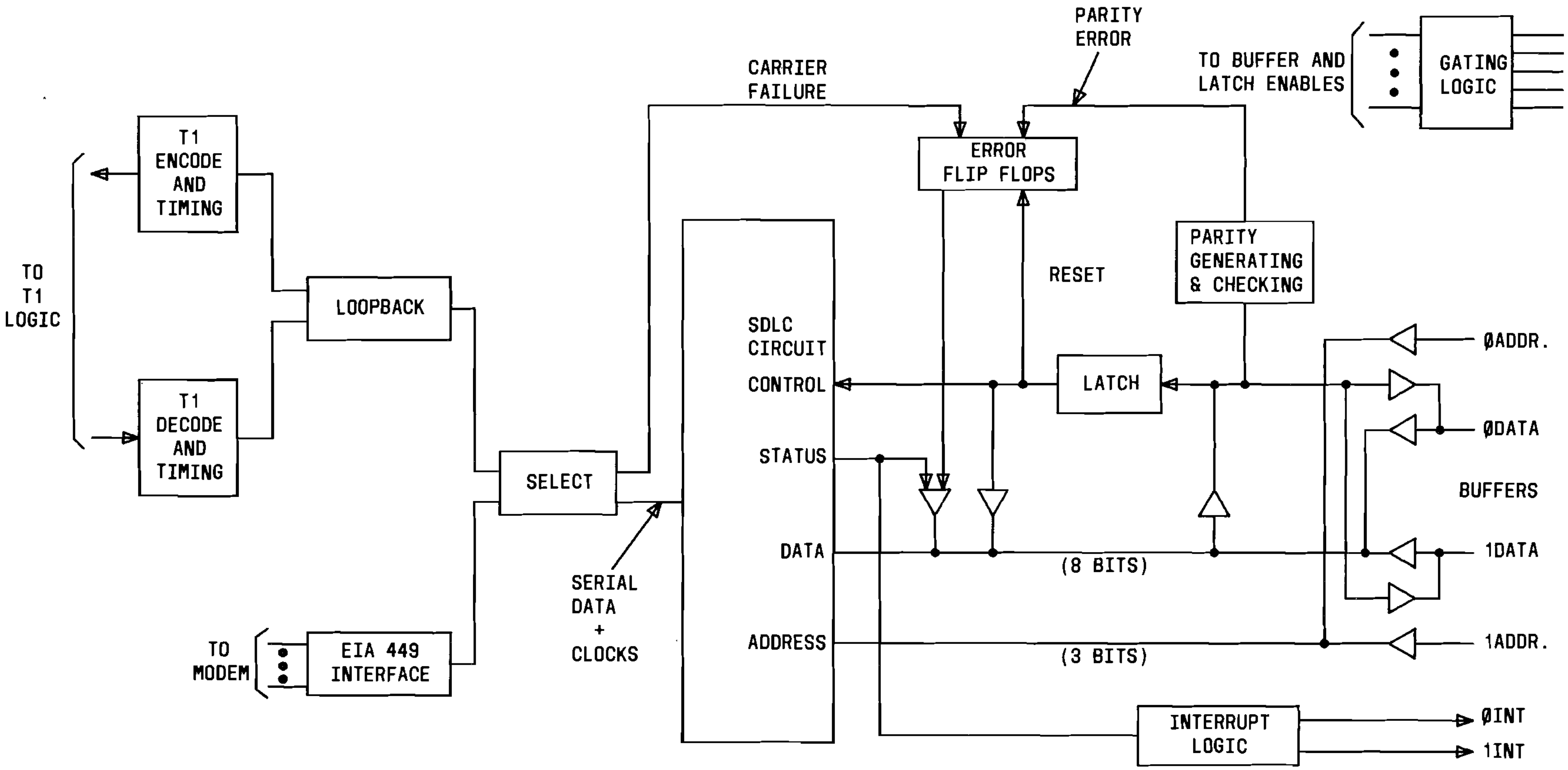
2.21 The SDLC circuit shifts data in and out serially from the communications channel. The serial data from this shift register is parallel loaded into a latch which transfers data to and from the RT data bus.

2.22 Some of the SDLC control signals come from a control latch. This latch is used for various reset and transmit/receive enable signals. The latch is controlled by the gating logic.

2.23 The DLI provides maintenance arrangements that allow control and data paths to be checked. For example, loop arounds can automatically be set up to check the DLI.

2.24 Troubles in the DLI will be detected and indicated to the RSS microprocessors via interrupts. Problems causing DLI interrupts are:

(1) Receive buffer overflow



LEGEND:
ADDR ADDRESS
EIA ELECTRONIC INDUSTRIES ASSOCIATION
INT INTERRUPT
SDLC SYNCHRONOUS DATA LINK CONTROL

Fig. 6—Data Link Interface Functional Block Diagram

(2) Cyclic redundancy code check failure

(3) Transmitter underflow

(4) Data parity error

(5) Carrier failure.

2.25 The interrupts will force the DLI to stop responding to the data received from the DL. This will be detected at the host end of the DL when the PUC/DL receives no response from the remote end. Several retries are attempted and if they fail,the host recovery programs will automatically order the RSS to diagnose the DLI. A TTY report of the recovery reconfiguration and the results of the automatic diagnostics will be printed.

2.26 Most DLI diagnostics will be automatically run. However, the host office maintenance personnel can make a TTY request for a DLI diagnostic. The diagnostics can all be run from the host ESS or from the SCC serving the host office. Only TTY access to the host is required.

2.27 Any repairs made at the remote site must be verified prior to leaving the location. Diagnostic tests are possible if a portable TTY is carried to the RSS when the repairs are made. This should be done only by personnel qualified to make stored program control system (SPCS) inputs. Access to the host ESS from the RT will require contacting the SCC and arranging for a remote TTY connection at the SCC. These tests can also be made by telephoning the SCC and requesting remote activation of the tests. However, this is not recommended since it involves a two-person operation.

2.28 Circuit board diagnostics can be manually requested at the RT using the RSS maintenance panel. Normally, the suspect boards are loaded into the maintenance panel repair buffer before the maintenance personnel reaches the RT. The repair buffer is loaded with up to four boards via TTY input messages.

2.29 There are no defined manually initiated periodic maintenance routines for the DLs.

DATA LINK OPERATION

2.30 The DL, which allows the RT to be controlled by the host ESS, uses the same transmission facilities which connect the two entities for voice transmission. These facilities may be either digital (T1) or analog (N) carrier (paragraph 2.09).

2.31 Information will be sent on the DL in blocks of between 2 and 16 bytes of data, plus 6 bytes of SDLC overhead per block.

2.32 The amount of DL traffic is dependent on the number of calls per hour. The DL link has been engineered to run at 2400 bits per second in a synchronous mode.

2.33 Data is serially transmitted and received under the control of various transmit and receive options previously loaded in control registers. Full speed data flow may occur in the transmit and receive directions at the same time. The incoming and outgoing blocks have no need for synchronization.

2.34 Most DL input messages will be for call processing and will consist of instructions loaded into a remote order buffer (ROB) by the host ESS. At the RT, input items from the DL are collected and buffered by the operating system until a complete message is received. Then the appropriate execution routine is scheduled and the entire message is passed on to be decoded and executed.

2.35 The main vehicle for transmitting messages from the host to the RT is the ROB. The ROB functions much the same as the peripheral order buffer (POB) except that the ROB exclusively handles the orders for the remote site. The ROB is first hunted, loaded, and activated by the host. The ROB execution routines then send blocks of orders to the appropriate RSS. The execution routines also time and handle acknowledgments.

2.36 The DL is duplicated for reliability. One DL is normally active with the other in a standby state. There are other possible DL states for maintenance purposes (paragraph 5.33).

3. DATA LINK PROTOCOL

3.01 A DL protocol is a set of rules for DL error control. Data is formatted into blocks called frames which are subject to error detection and correction (Fig. 7). The protocol used for the RSS DL is an SDLC derivative International Telegraph and Telephone Consultive Committee (CCITT) standard

X.25. The outgoing X.25 data frame (Fig. 7) is built from data in the destination buffer (paragraph 4.04) and transmitted over the DL. Data received from the RT is extracted from the X.25 frame and loaded into the receiver buffer (paragraph 4.05).

3.02 The destination buffer in the PUC/DL is a list of outgoing data messages consisting of a sync, header, and data, all 16-bit words. The sync word allows the message routing program in the RT to identify the start of a message. The header word allows the program to determine the client program the message is to be routed to. The number of words used for the data message is variable. The message may contain several RSS orders. The only restriction on message content is that it contain data for a single client program. It may take several frames to contain the message, or several messages may be contained within a single frame depending on the message size. Data is transmitted in full-size frames as long as

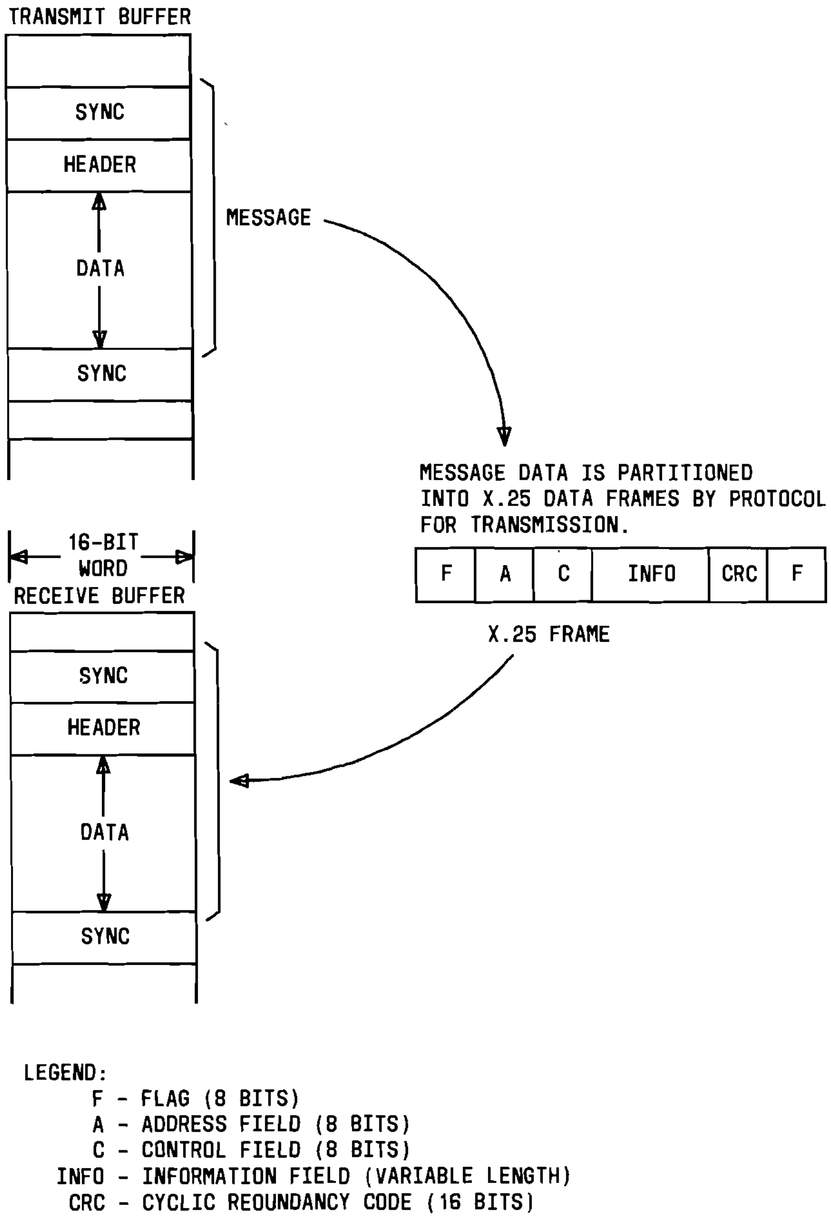


Fig. 7—X.25 Data Frame

there is sufficient data in the destination buffer to form them. Smaller, variable sized frames are transmitted whenever the destination buffer is emptied.

3.03 The X.25 data frame consists of a flag, address, control data, information, and a cyclic redundancy code (CRC). The flag is used to indicate the beginning and end of a frame. The address identifies the receiving station. The control field is used to give the data frame an identification number. The information field contains the data to be transmitted. The CRC check word is used to detect transmission error.

3.04 A 16-bit CRC check word is sent with each data frame. The check word is calculated using the address, control, and data fields of the data frame. Upon reception of the data frame, the check word is recalculated and compared with the transmitted check word. If the two words are not the same, a CRC error is indicated.

3.05 If an error is indicated concerning the data frame, retransmission of the data frame is attempted. If the error continues to occur despite multiple retries, a protocol impasse error report is sent to the ESS. Retransmission attempts continue until the DL is deactivated.

4. PERIPHERAL UNIT CONTROLLER OPERATION

4.01 The PUC/DL is connected to the host CC via the peripheral unit address bus (PUAB) and the scanner answer bus (SCAB). Data transmitted to the PUC/DL will be sent over the PUAB and data received from the DLs will be transferred to the CC over the SCAB. All data words transferred between the PUC/DL and CC are in parallel form.

4.02 The transferring of information between the PUC/DL and the ESS is accomplished by the PUC/DL application firmware which is covered in detail in the PUC description (Section 231-037-020).

DATA TRANSMISSION

4.03 The PUC/DL interface to the PUAB is a 256-word, 24-bit/word first in - first out (FIFO) buffer. All data and commands transferred to the PUC/DL will be passed via the FIFO buffer which will be unloaded by the PUC controller on a periodic interrupt.

4.04 All incoming data from the ESS is read from the input FIFO buffer and sorted in three categories—data, parameters, and maintenance orders. The data is destined to be sent on a DL. Data is not addressed to a specific link number; it is marked with a destination number specifying a buffer in the PUC/DL read-write memory. One destination buffer exists for each RT. The association of a destination buffer and a single DL is specified in a parameter. The data is loaded in the appropriate destination buffer. The DL protocol program unloads the destination buffer and transmits data over the DL to the RT.

DATA RECEPTION

4.05 Data link messages received from the RT in the PUC/DL are loaded into the receive buffers in the scan memory. There are four scan memories having 64 words each provided for received data. These scan memories are read by the ESS over the SCAB.

4.06 Each DL will have a receive buffer in a dedicated area of the scan memory and data will be read using the standard scan commands. The operation of the CC and PUC/DL controllers are completely autonomous without any coordination between their internal task schedules.

MAINTENANCE

4.07 A description of PUC maintenance capabilities is in Section 231-037-020. Task oriented practice (TOP) 231-050-030 contains procedures for clearing trouble using PUC diagnostics.

5. DATA LINK MAINTENANCE

5.01 The condition of the DL is checked by the PUC. Trouble is detected by carrier loss, protocol response failure from the remote end, or excessive error rates. When trouble is detected, the PUC reports this to the host ESS which then attempts recovery of the DL. Recovery involves establishing a working configuration with the RSS, if possible, diagnosing the faulty link, and reporting the fault to maintenance personnel by a host TTY message. If both DLs to the RSS are inoperative, the recovery program will restore (with manual stimulus) communication whenever one of the links becomes usable.

5.02 Recovery from DL faults will most often be handled automatically by the recovery programs. However, some faults may require manual intervention. If so, almost all permissible DL states can be forced by TTY messages from the host ESS.

5.03 Some DL faults may require the replacement of faulty circuit boards before recovery can be achieved. The PUC/DL diagnostics and sectionalization capabilities are used to locate the faulty circuit boards.

5.04 The DL diagnostics will test various sections of the DL by looping signals at different interfaces. The applied signals are designed to stress the system. The return signal which has been looped is compared to the transmitted signal with mismatches indicating a failure. Following completion of the diagnostic, the results and failed circuits are indicated to the maintenance personnel via a TTY message.

5.05 Data link input messages are typed at the local maintenance TTY in the host ESS, the remote maintenance channel at the SCC, or the portable TTY at the RSS RT. The messages are inputted to obtain the DL status, switch DL states, initialize DLs, or request DL diagnostics. A pair of DLs pertaining to a single RSS is specified by the application (RSS) and the application member number. The application member number indicates which RSS the pair of DLs pertain to. A single DL is specified by the PUC member number and the DL member number. The PUC member number indicates the PUC to which the DLs are connected. The DL member number indicates the particular DL on the specified PUC.

DATA LINK DIAGNOSTICS

5.06 If there is a problem transferring data between the ESS and RSS, the fault will be located in either the PUC/DL, the RT, or the DL channel facilities. Depending on the type of problem, the PUC/DL or the RT will run DL diagnostics to find the fault. The microprocessors in the PUC/DL and the RT will run the diagnostics requested and controlled by the host ESS CC. Routine DL diagnostics run automatically. The DL diagnostics run concurrently with call processing to detect and locate faults.

5.07 When a fault is detected in an RSS link, a diagnostic is automatically requested and traffic is switched to the standby link. If the diagnostic fails, the link is removed from service. Normally, the diagnostic should be requested again to validate the previous results. If the diagnostic passes, it should be requested once more to verify if an intermittent fault exists.

5.08 Each diagnostic can be requested manually via TTY input message or automatically via ESS maintenance software. The actual programs which perform the various diagnostic checks reside in the PUC and RT firmware.

5.09 The ESS master control center (MCC) diagnostic-in-progress lamp provides a visual indication that a diagnostic is being executed. This lamp is not unique to the PUC/DL feature. It also serves to indicate other unrelated diagnostics. Key 20 on the MCC buffer bus 17 aborts an in-progress DL diagnostic and prevents a request for a DL diagnostic from being honored.

5.10 A full diagnostic may be requested at any time. If the link is active, an automatic request is made to the state control software to switch links. If state control successfully switches the links, the diagnostic test will be executed. If not, an abort message will be printed.

5.11 The diagnostic may abort if the PUC experiences an input/output fault. A TTY output message reports PSTAT if this is the case.

5.12 The partial diagnostic request is very useful for tracking intermittent problems. In this case, the link should be made unavailable using the PDL-LNK-FRU state control input message. Then, the diagnostic should be requested to loop on the phase in question. The RAW mode of TTY output is very useful in this instance since only changes in state (PASS/FAIL) or changes in failing result are printed.

5.13 The circuits for the PUC/DL at the host are diagnosed like the circuit packs of the No. 1/1A ESS. These diagnostics test a local circuit which is physically contained on one or more boards.

5.14 The diagnostics for the DLI at the RT test the entire board for a faulty circuit. Each diagnostic is designed to test a single board type. The diagnostic will test many logical components which are contained on one board. The microprocessors will run routine diagnostics requested from the host ESS.

5.15 If the RT DL diagnostic finds a fault, failure information is printed on the TTY containing the suspected faulty board location numbers with the most probable board first. The maintenance personnel can use this board number to find the physical location of the board. Once the faulty board has been replaced, a repair verification is done to insure the fault is fixed and no new faults were introduced with the new circuit board.

A. Diagnostic Restrictions

5.16 Several restrictions apply to RSS DL diagnostics. To diagnose any link, the link must be off-line. If a diagnostic is requested on an active link, an automatic request is made to DL state control software to switch links. If state control is unable to switch links, an output message will indicate that the diagnostic was aborted. The diagnostic will also abort if a link under diagnosis is needed for service. If a loop on a phase is requested, the link must be manually placed in the unavailable state. Another restriction is that the diagnostic program will not run if maintenance is removed from the PUC controlling the DL.

B. Diagnostic Structure

5.17 The RSS DL diagnostic is segmented into seven phases. A request for the full RSS DL diagnostic normally results in all seven phases being executed except when the DL is using N carrier. The data sets used for N carrier does not provide the remote loop-back capability required for execution of phase 6. In this case, phase 6 reports all tests pass (ATP) without actually running the phase.

5.18 Phase 1 resets the LIU and checks the status of the input/output ports to verify that they were reset to the proper state. It also exercises all enables to insure their connections to the FG40.

5.19 Phase 2 places the LIU in an on-board, loop-back mode at the output of the universal serial receiver-transmitter, verifies that data transmitted is equal to data received, and that no CRC errors occurred. The data consists of a zero walked through a field of ones followed by a one walked through a field of zeros.

5.20 Phase 3 is identical to phase 2 except that the loop-back is at the DSU-DP instead of at the LIU.

5.21 Phase 4 is run by the RSS RT and consists of ten tests. These tests verify reset, read/write of control registers, and error checking circuitry. Included in the tests is an on-board, local loop-back.

5.22 Phase 5 performs a local loop-back through the DSU-DP or the remote modem, depending on the facility, from the RT. Testing is done to verify that data received is the same as data transmitted.

5.23 A remote loop-back on an N carrier data set cannot be performed under program control. Because of this, phase 6 is shipped and always reports ATP when a full diagnostic is requested for N carrier DLs.

5.24 Phase 6 for T1 carier DLs causes data to loop back at the DLI in the RT.

5.25 Phase 7 is the final go/no-go test of the diagnostic. It requests that the link be made active and sends a message over the link to the RT. When the RT receives this message, it responds over the link being diagnosed. After the diagnostic program sends the message, it periodically checks the DL for the response. This phase will result in an STF if the correct response is not received within approximately 5 seconds.

5.26 Phases 4 and 5, executed by the RT, report some tests pass (STP) when both links servicing an RSS are out of service (OOS). This is because an active link is not available for the RT to report the status of these phases. When this occurs, phase 7 provides the only test of the remote portion of the link. If phase 7 passes diagnostic tests, the link is good.

C. Routine Diagnostics

5.27 Two maintenance control (MAC) routine exercise programs attempt to place OOS DLs back into service on a routine basis if manual action is not taken. One program is executed every hour and the other every midnight. These programs schedule diagnostics on OOS DLs that are not in the forced-unavailable state. If the diagnostics pass, the links are then restored to service.

5.28 In addition to the routine exercises on the OOS DLs, a diagnostic is also scheduled on the standby mate of an in-service duplex-application link at midnight. If the diagnostic passes, the standby link is switched into service. This is to assure that if no reconfiguration occurs on the pair of links during the day, they are automatically switched at midnight so that neither link is favored to remain in service.

FAILURE REPORTS

5.29 A total DL outage failure report is printed when both links of a duplex pair fail. When a total outage occurs, the ESS recovery program waits 30 seconds and sends orders to the PUC to place a link into service. The ESS then waits 6 seconds or until the PUC returns a response message. If the response indicates that the link was successfully placed into service, the recovery sequence is completed. If the response indicates that the link was not placed into service, or if there was no response, the recovery program waits for 30 seconds again. If possible, the program attempts to recover the mate of the link; otherwise, it will retry the same link. If six of these cycles pass without a successful recovery, the program stops retrying and schedules a diagnostic at high priority.

5.30 The DL maintenance state is not allowed to oscillate between in-service and OOS for a long period of time. This oscillation may be caused by the presence of a DL fault which disrupts traffic but cannot be detected by the diagnostic. When the DL failure is detected, the link is removed from service and a diagnostic is scheduled. The diagnostic runs and passes since it cannot find any fault. The DL is then placed back into service.

5.31 The process used to detect DL state oscillation is called trouble analysis. The three trouble analysis thresholds for acceptable DL outage rates are as follows:

(1) Four transitions per hour between the active state and an OOS state

(2) Eight transitions per hour between the active degraded state and an OOS state

(3) Ten transitions per hour between either of the above states and an OOS state.

Counts are kept of these transitions. If any of them exceed the appropriate threshold, the DL is placed into the OOS trouble analysis state instead of the state into which it would otherwise be placed.

DATA LINK STATES

5.32 Each RSS DL can be in one of several possible states (Table A). One DL per RSS is normally in the active state while the other is in a standby state. This occurs when both DLs have a low error rate. The active DL is on line while the standby DL is off line.

5.33 All RSS data is transmitted over the active DL. Only diagnostic messages to evaluate its own performance are transmitted on the standby DL. A failure in the active DL will be detected by built-in error checks and reported to the host CC. The host CC will then request a switch to the standby DL. The host ESS controls all the DL state switching by sending switch requests to the PUC.

5.34 Data link states can be changed automatically by the ESS or manually by typing a message at the host ESS or the RSS RT via the portable TTY. Manually changing the DL states may override the automatic control and should be used with care. The changing of DL states is dependent on the current state of the on-line DL, current state of the off-line DL, and the reconfiguration stimulus.

5.35 When a fault occurs on the active DL, the links are switched and a diagnostic is scheduled. The diagnostic returns failure data to be used to locate the fault. Once the fault is repaired the DL must be restored to service via a TTY message. The DL is diagnosed and is put back in service if the diagnostic passes.

5.36 If the PUC encounters a high error rate on a DL but cannot find a hard fault, the DL is put in a degraded state. The OOS DL will be made active after a routine diagnostic if the error rate improves.

5.37 A DL state control output message is printed to indicate the current status of DLs. State control can be activated manually or automatically. The first line of the message contains five fields as shown in the example below.

```
 \M/  \PUCDL DLOO/  \PUCOO/  \TTYSWT/  \EXC/
  |         |          |         |        |
  |     DATA LINK     PUC    STIMULUS     |
  |      MEMBER     MEMBER                |
PRIORITY                             DISPOSITION
OF ACTION
```

5.38 The priority of action field consists of up to two characters indicating the priority of the action to be taken. This field can be used to determine why the output occurred and if further action is required. The priority of action codes and their meanings are shown in the output message manual. The DL and PUC member fields contain the member numbers of the designated link. The stimulus field contains a mnemonic for the requested action. The disposition field contains a code indicating whether or not the action was successful. The second and following lines give the application, application member number, DL member number, and the resulting state of each link involved in the reconfiguration.

LOOP-BACKS FOR T1 CARRIER APPLICATIONS

5.39 Sections of the DL can be checked for correct data transmission by sending data out on the DL from either the host ESS or the RSS RT and looping back the data at several points (Fig. 8). The data received is compared with the data transmitted to find errors.

5.40 The following loop-backs are provided for a DL using T1 carrier and under the control of the host ESS. They are activated by automatic diagnostic routines.

- ***LIU Maintenance*** —The peripheral unit controller-line interface unit (PUC-LIU) loops data back to the host ESS after passing through the PUC and LIU.
- ***DSU-DP Local***—The data service unit-data port (DSU-DP) loops data back to the ESS after passing through about 20 percent of the logic in the D4 data port. This is activated by a signal wire from the PUC-LIU.
- ***DSU-DP Remote***—This loops the data back to the ESS after passing over the T1 span, through the integrated T1 common logic at the RT, and through a major portion of the T1 encode/decode logic on the DLI circuit pack. This loop-back is activated by a signal wire from the PUC-LIU to the DSU-DP.

5.41 The following loop-backs are under direct control of the RT processor, and data from the RT is looped back to itself. They are activated by automatic diagnostic routines.

- ***DLI Maintenance***—This loops data after passing through the processor interface and the SDLC logic on the DLI circuit pack.
- ***DLI Local***—This loops data back after passing through about 75 percent of the DLI logic.
- ***DLI Remote***—This loops data after passing over the T1 main span, through the host D4 bank common equipment and about 80 percent of the DSU-DP logic.

5.42 The following loop-back is activated manually and is not used by the usual diagnostic routines. All 24 channels of a particular T1 group are looped-back. This loop-back is used only after all other diagnostic methods have failed.

- ***D4 Bank***—Inserting a tip plug in the faceplate of the LIU common equipment plug-in of the D4 common equipment loops all 24 channels back to the ESS.

LOOP-BACKS FOR N CARRIER APPLICATIONS

5.43 The following N carrier loop-back is under direct control of the PUC, and loops data from the PUC back to the PUC for maintenance purposes. This loop-back is part of the automatic diagnostics for the DL (Fig. 9).

- ***LIU Maintenance***—This loops data after passing through all of the PUC and the LIU.

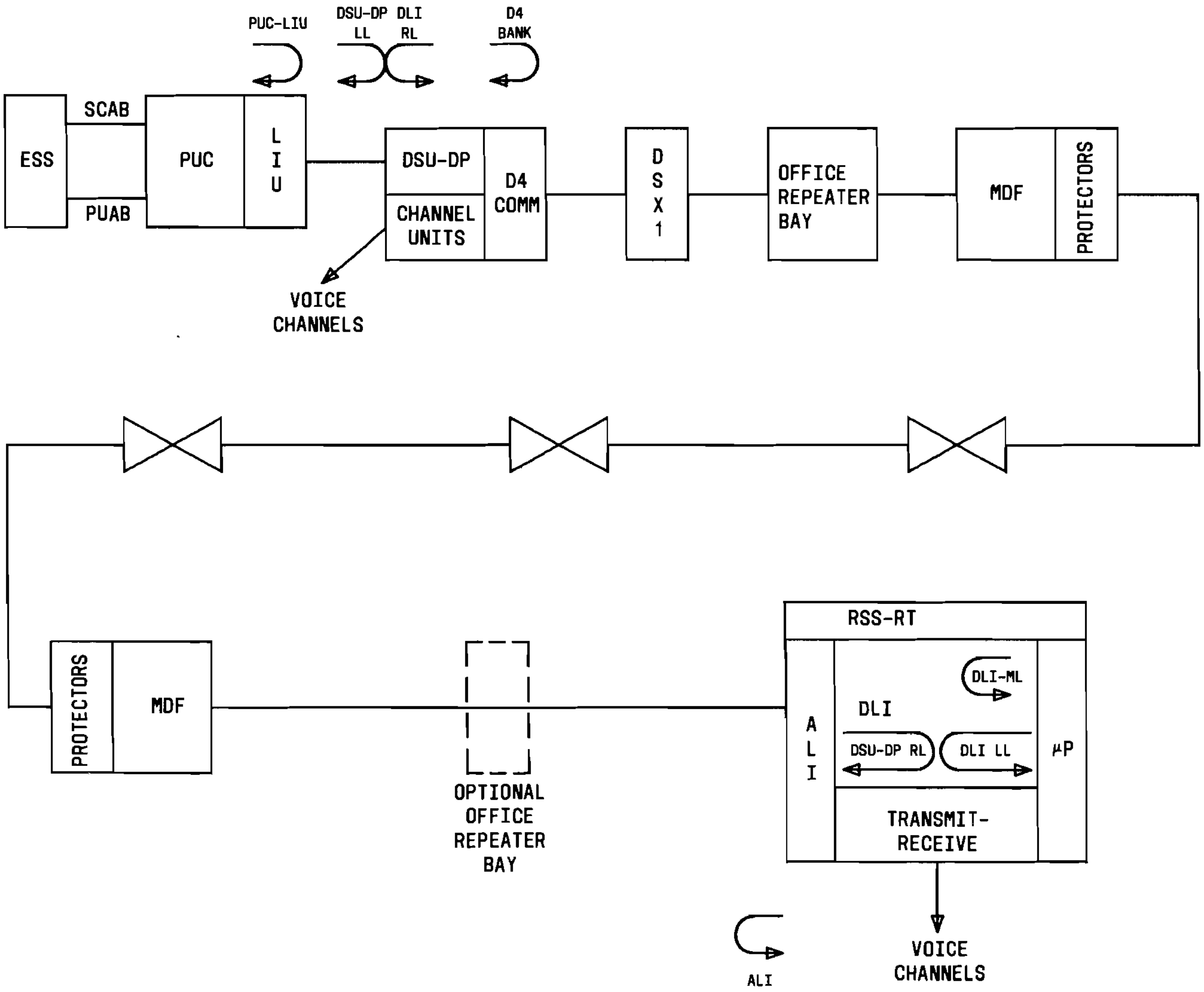
5.44 The following loop-back is under direct control of the RT processor and loops data from the RSS back to the RSS.

- ***DLI Maintenance***—This loops data after passing through the DLI processor interface and SDLC logic.

TABLE A

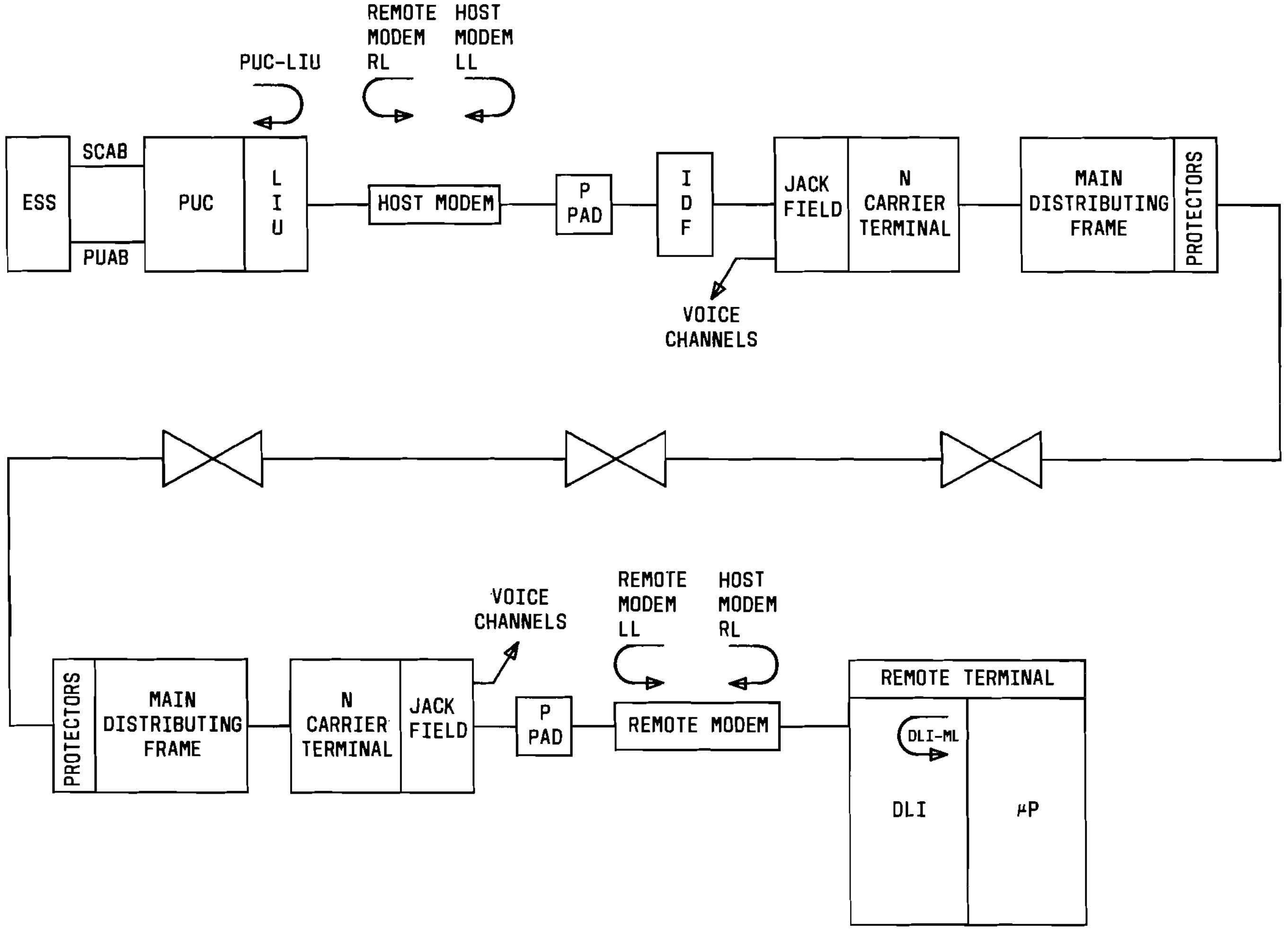
REMOTE SWITCHING SYSTEM DATA LINK STATES

STATE NAME	DESCRIPTION OF STATE
ACTIVE	The DL is transferring RSS data at a low error rate.
ACTIVE DEGRADED	The DL is transferring data but accepts a high error rate without reporting error rate faults.
ACTIVE FORCE	***CAUTION—Do not use this state unless absolutely necessary.*** This state is brought about manually via TTY input message and must be used with caution. This state forces the DL on line and causes the PUC/DL to ignore all errors. No automatic maintenance is done and the DL state cannot be changed automatically by the PUC.
STANDBY	The DL was OK when last used and is on standby to go on line if needed.
OUT OF SERVICE (OOS) DEGRADED	This state occurs when a high error rate is encountered. The DL is switched off line and a diagnostic is scheduled.
OOS MANUAL	This state is requested by TTY message. The DL is off line but may be switched on line automatically if needed. This state is used to run manually requested diagnostics.
OSS REMOVED	The PUC will switch the DL to this state automatically if a fault or high error rate occurs. A diagnostic is scheduled but the DL may be brought back on line automatically if needed.
OOS FAULT	This state occurs if a diagnostic finds a hard fault. The fault must be corrected before the DL is brought back on line.
OOS TROUBLE ANALYSIS	This state occurs automatically when the DLs have been switching between states repeatedly. This indicates that there is a fault which the normal diagnostics cannot locate. The DL may be switched on line automatically if needed.
UNAVAILABLE	The unavailable state is requested manually to take the DL out of service. This state is used when changing circuit packs associated with the DL because the DL cannot go on line automatically.
INVALID	***CAUTION—Do not use this state unless absolutely necessary.*** This state manually forces the DL out of service. Maintenance personnel forces this state to make changes of equipment associated with this DL.
RECOVERY ACTIVE	State control is attempting to recover the link.
RECOVERY OOS	State control is waiting before attempting to recover the link.



LEGEND:
ALI ALARM AND LINE INTERFACE
DLI DATA LINK INTERFACE
DSU-DP DATA SERVICE UNIT-DATA PORT
DSX1 DIGITAL SIGNAL CROSS CONNECT
ESS ELECTRONIC SWITCHING SYSTEM
LIU LINE INTERFACE UNIT
LL LOCAL LOOP
ML MAINTENANCE LOOP
MDF MAIN DISTRIBUTING FRAME
PUAB PERIPHERAL UNIT ADDRESS BUS
PUC PERIPHERAL UNIT CONTROLLER
RL REMOTE LOOP
SCAB SCANNER ANSWER BUS
µP MICROPROCESSOR

Fig. 8—T1 Carrier Data Link Loop-Backs



LEGEND:

DLI	DATA LINK INTERFACE
ESS	ELECTRONIC SWITCHING SYSTEM
LIU	LINE INTERFACE UNIT
LL	LOCAL LOOP
ML	MAINTENANCE LOOP
PUAB	PERIPHERAL UNIT ADDRESS BUS
PUC	PERIPHERAL UNIT CONTROLLER
RL	REMOTE LOOP
SCAB	SCANNER ANSWER BUS
µP	MICROPROCESSOR

Fig. 9—RSS N Carrier Data Link Loop-Backs

6. RSS CHANNELS

6.01 Instead of terminating as trunk facilities, it is necessary to wire transmission facility channels to the line side of the ESS network. RSS channels represent high usage lines similar to the private branch exchange (PBX) trunks in that they will carry 25 to 30 hundred-call-seconds (CCS) of traffic and terminate on the line side of the host network. They are similar to PBX trunks in that an individual channel appearance at the main frame does not represent a unique RSS line appearance.

6.02 Each 1024-line remote terminal can provide a maximum of 120 individual channels to the host ESS. Two channels must be used for DLs. A maximum size system (2 frames) of 2048 lines will provide 240 channels. The actual number of RSS voice channels is determined by the traffic characteristics of the system. A minimum of two carrier systems per RSS are required for DL reliability.

6.03 The individual voice channels at the host will be connected directly (in the case of the T carrier) from the output of the channel bank hardware to the line side of the host ESS network via the main distributing frame. For N carrier, it will be necessary to include a single frequency (SF) signaling unit to provide a signaling interface and to convert 4-wire to 2-wire and vice versa before connecting to the main frame (Fig. 5).

6.04 The two voice channels assigned to the DL function are not connected to the line side of the network. These two channels will be connected to the PUC/DL. The duplicated DLs must be separated into different circuit groups so that the failure of a single piece of common equipment will not result in the loss of both DLs.

T1 CARRIER

6.05 For T1 carrier, the D4 channel banks are used for interfacing (Fig. 4). The host ESS office uses the D4 channel bank frame. This frame will contain a maximum of 192 voice channels or eight T1 systems.

6.06 A single D4 channel bank frame can be shared by different RSS RTs, but the duplicated DL for an individual RT must be in separate T1 and D4 systems with no common circuitry. The DLs for a particular RT must be equipped in separate equipment mounting racks since it is possible to have two T1 systems in the same rack or unit with some common circuitry feeding them. It is permissible to have one of these D4 banks containing a DL for one RT and the DL for another separate RT. It is imperative that powering for the equipment used by the DLs be separated so that a power failure will not force a duplex DL failure.

6.07 The RSS DL channels can be either T1 or N carrier. For the T1 carrier interface, a D4 channel unit has been designed to plug directly into a D4 channel bank in place of a normal voice frequency channel pack. The LIU in the PUC/DL connects directly to this port. It is possible for one DL for a single RSS to use N carrier and the other to use T1 carrier.

6.08 For T carrier, the RT and its T carrier channel interface circuitry performs most of the functions of a conventional D4 channel bank. The channel interface accepts the high speed 1.544 megabit data stream directly from a T1 line and converts this signal into 24 voice channels. These functions are implemented with standard D4 circuitry contained on RSS circuit packs. Thus, the receiving functions of demultiplexing, digital-to-analog conversion, 4-wire to 2-wire conversion, and alarm monitoring are all performed in this interface.

6.09 The same functions are performed in the transmit direction except that a per-channel loop supervisory state is inserted in the bit stream.

6.10 For T carrier, the equivalent D4 bank is contained in three different circuit packs. These packs are the T1 channel interface (CI), the T1 transmit-receive (TR), and the T1 alarm and line interface (ALI).

6.11 The T1 CI circuit pack is the first stage of interfacing from the RSS voice frequency electronic network in the RT to the T1 digital carrier. This circuit pack provides one stage of network switching, transmission path conditioning, and conversion from voice frequency to multiplexed pulse amplitude modulated transmission. Each CI circuit pack provides for four audio channels. Six packs are used to form the analog interface portion of a T1 digital group of 24 channels.

6.12 The T1 transmit-receive circuit pack provides the analog-to-digital (A/D) conversion and vice versa. It also provides T1 framing and T1 system signaling infomation that is to be performed.

6.13 The T1 alarm and line interface circuit pack is the direct interface between the 1.544 megabit digital T1 line and the A/D encoders in the transmit-receive circuit. It also incorporates the functions normally found in the office repeaters, the D4 channel unit plug-ins, the office interface units, and the alarm control unit (ACU). This circuit pack also provides the capability to provide a loop-back in either direction to verify proper operation as determined by the host ESS central office.

6.14 Six T1 CI circuit packs, one T1 TR and one T1 ALI, provide a full T1 digital group of 24 voice channels.

6.15 If an office repeater bay is required for back powering a T1 line, then it must be provided separately from the RSS frame. Similarly, if T1 out state is used, it has to be provided independent of the RSS frame.

N CARRIER

6.16 Three types of N carrier equipment are compatible with RSS: N2, N3, and N4. At the host ESS, the output of the existing channel bank must have its normal crossconnect removed from its normal trunk interface and reconnected (via SF signaling unit) to the line side of the network via the main distributing frame.

6.17 The DLs for N carrier, like T carrier, use two of the voice channels and must be assigned to separate N carrier systems for reliability. With N carrier, there is no restriction on which voice channel is assigned to the DL function. It is recommended that a channel in the middle of a group be used to avoid potential phase distortion problems with end channels.

6.18 For DLs using N carrier, a data modem is required at the host as well as the RT (Fig. 2). The data modem converts the digital data received from the PUC/DL to a voice frequency representation of the data and vice versa. The EIA 232 standard interface is used between the data modem and the PUC/DL.

6.19 Correspondingly, at the RT there will also be an N carrier channel bank and a data modem. The interface between the modem and the DLI at the RT is also an EIA 232 standard.

6.20 For the N carrier interface, the existing carrier channel banks perform the multiplexing-demultiplexing functions. All of the other necessary operations are provided in the CI portion of the RSS.

6.21 If N carrier is used, the circuitry for the CI for T carrier is removed from the RSS frame. The standard N (N2, N3, and N4) carrier frame is used and its 4-wire output is interfaced to an N carrier channel interface that will be placed in the RSS frame where the T1 CI circuit packs were for the T1 carrier case.

6.22 The N carrier CI performs the function that the T1 CI circuit packs did for T carrier. Thus, the N carrier CI contains the circuitry for four N carrier voice channels, the 4-wire to 2-wire conversions, and the first stage of PNPN switching. The TR and ALI boards are removed for this group.

CHANNEL MAINTENANCE

6.23 Remote Switching System channels can be accessed via the trunk test panel in the host ESS or the remote trunk test facilities at the SCC. The RSS transmission plan requires that the RSS-host ESS channels be routinely tested to ensure the proper operation. Centralized automatic reporting on trunks (CAROT) should be the main vehicle to accomplish this. If a host ESS office is not equipped with CAROT, a regularly scheduled manual routine to test these RSS channels is required.

6.24 The software for trunk maintenance routines was designed to test circuit appearances on the trunk side of the network. Since RSS voice channels appear on the line side of the network, rearrangement of existing equipment is needed to utilize the trunk maintenance programs. The new configuration is called a back-to-back trunk connection (BTBTC).

6.25 A BTBTC is achieved by wiring together two SD-1A166 trunks mounted on a single plate and assigning them adjacent trunk network numbers (TNN) on the reference trunk link network (TLN). Six BTBTCs are required for a host office. The trunks that are involved in the BTBTC should be located next to each other.

7. ABBREVIATIONS

7.01 The following abbreviations are used in this section.

TERM	DEFINITION
ACU	Alarm Control Unit
A/D	Analog-to-Digital
ALI	Alarm and Line Interface
AMA	Automatic Message Accounting
ATP	All Tests Pass
BTBTC	Back-To-Back Trunk Connection
CAROT	Centralized Automatic Reporting on Trunks
CC	Central Control
CCS	Hundred Call Seconds
CI	Channel Interface
CPU	Central Processing Unit
CRC	Cyclic Redundancy Code
DL	Data Link
DLI	Data Link Interface
DSU-DP	Data Service Unit-Data Port
EIA	Electronic Industries Association
ESS	Electronic Switching System
FIFO	First In - First Out
LIU	Line Interface Unit
LLN	Line Link Network
MCC	Mater Control Center
OOS	Out Of Service
ORB	Office Repeater Bay
PBX	Private Branch Exchange
POB	Peripheral Order Buffer
PU	Peripheral Unit
PUAB	Peripheral Unit Address Bus
PUC	Peripheral Unit Controller
PUC/DL	Peripheral Unit Controller/Data Link
PUC-LIU	Peripheral Unit Controller-Line Interface Unit
ROB	Remote Order Buffer
RSS	Remote Switching System
RT	Remote Terminal
SCAB	Scanner Answer Bus
SCC	Switching Control Center
SDLC	Synchronous Data Link Control
SF	Single Frequency
SPCS	Stored Program Control System
STP	Some Tests Pass
TLN	Trunk Link Network
TNN	Trunk Network Number
TOP	Task Oriented Practices
TR	Transmit - Receive
TTY	Teletypewriter.