

# **SYSTEM CENTURY®** **DIGITAL TRUNK INTERFACE**

## **GENERAL DESCRIPTION**

| CONTENTS |                            |      | ILLUSTRATIONS |                                                                                                                                                                                                                                                   |      |
|----------|----------------------------|------|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| Par.     |                            | Page | Fig.          |                                                                                                                                                                                                                                                   | Page |
| 1.       | Introduction               | 1    | 1.            | Typical DTI Applications                                                                                                                                                                                                                          | 2    |
| 2.       | Related Information        | 1    | 2.            | DTI Cell Configuration                                                                                                                                                                                                                            | 4    |
| 2.01     | General                    | 1    | 3.            | T-1 Data Format                                                                                                                                                                                                                                   | 5    |
| 2.02     | Related Sections           | 1    | 4.            | PGH Data Format                                                                                                                                                                                                                                   | 6    |
| 2.03     | Related Drawings           | 2    | 5.            | DTI Data Waveforms                                                                                                                                                                                                                                | 7    |
| 3.       | Purpose and Use            | 2    | 6.            | DTI System, Simplified Block Diagram                                                                                                                                                                                                              | 8    |
| 4.       | Capabilities               | 2    |               |                                                                                                                                                                                                                                                   |      |
| 5.       | Engineering Considerations | 3    |               |                                                                                                                                                                                                                                                   |      |
| 6.       | Technical Specifications   | 3    | 1.            | INTRODUCTION                                                                                                                                                                                                                                      |      |
| 6.01     | Output to T-1 Span         | 3    | 1.01          | This section provides descriptive information for the Digital Trunk Interface (DTI). The DTI is the direct digital interface of a SYSTEM CENTURY Digital Central Office (DCO) with a T-1 carrier span, using D2/D3 formatting.                    |      |
| 6.02     | Input from T-1 Span        | 3    |               |                                                                                                                                                                                                                                                   |      |
| 6.03     | Dc Power Input             | 4    | 1.02          | This section is reissued to revise information provided in paragraph 2.02.                                                                                                                                                                        |      |
| 7.       | Equipment Description      | 4    |               |                                                                                                                                                                                                                                                   |      |
| 7.01     | General                    | 4    |               |                                                                                                                                                                                                                                                   |      |
| 7.02     | DTI Cell                   | 4    |               |                                                                                                                                                                                                                                                   |      |
| 7.03     | Cell Power Supply          | 4    |               |                                                                                                                                                                                                                                                   |      |
| 7.04     | DTI Interface              | 4    |               |                                                                                                                                                                                                                                                   |      |
| 7.05     | DTI Receiver               | 5    |               |                                                                                                                                                                                                                                                   |      |
| 7.06     | DTI Transmitter            | 5    | 2.            | RELATED INFORMATION                                                                                                                                                                                                                               |      |
| 7.07     | DTI Diagnostics            | 5    | 2.01          | General.                                                                                                                                                                                                                                          |      |
| 8.       | System Description         | 5    |               | 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. |      |
| 8.01     | Data Format                | 5    |               |                                                                                                                                                                                                                                                   |      |
| 8.02     | Data Path                  | 6    |               |                                                                                                                                                                                                                                                   |      |
| 8.03     | DTI Port Group             | 6    |               |                                                                                                                                                                                                                                                   |      |
| 8.04     | Supervision and Signaling  | 7    |               |                                                                                                                                                                                                                                                   |      |
| 8.05     | Fault Detection            | 7    |               |                                                                                                                                                                                                                                                   |      |
| 8.06     | Carrier Group Alarm        | 9    | 2.02          | Related Sections.                                                                                                                                                                                                                                 |      |
| 9.       | Diagnostic Tests           | 9    |               | The following sections are recommended for use with this document:                                                                                                                                                                                |      |
| 9.01     | Purpose and Use            | 9    |               |                                                                                                                                                                                                                                                   |      |
| 9.02     | Data Test                  | 9    |               |                                                                                                                                                                                                                                                   |      |
| 9.03     | Frame Sync Test            | 10   | 24-015-25     | DTI, Precutover Test Procedures                                                                                                                                                                                                                   |      |
| 9.04     | Loop-Back Test             | 10   |               |                                                                                                                                                                                                                                                   |      |
| 9.05     | Test Procedure Documents   | 10   | 24-015-50     | DTI, Maintenance                                                                                                                                                                                                                                  |      |

**2.03 Related Drawings.**

The schematic diagram and description of each circuit listed below is recommended for use with this document. Each circuit is identified by a six-digit base number. A schematic or circuit description is identified by prefixing a base number with S- or DS- respectively.

| <u>BASE NUMBER</u> | <u>NAME</u>               |
|--------------------|---------------------------|
| 814503             | DTI Interface             |
| 814504             | DTI Receiver              |
| 814505             | DTI Transmitter           |
| 814506             | DTI Diagnostics           |
| 814536             | DTI Interface CUA Complex |

**3. PURPOSE AND USE**

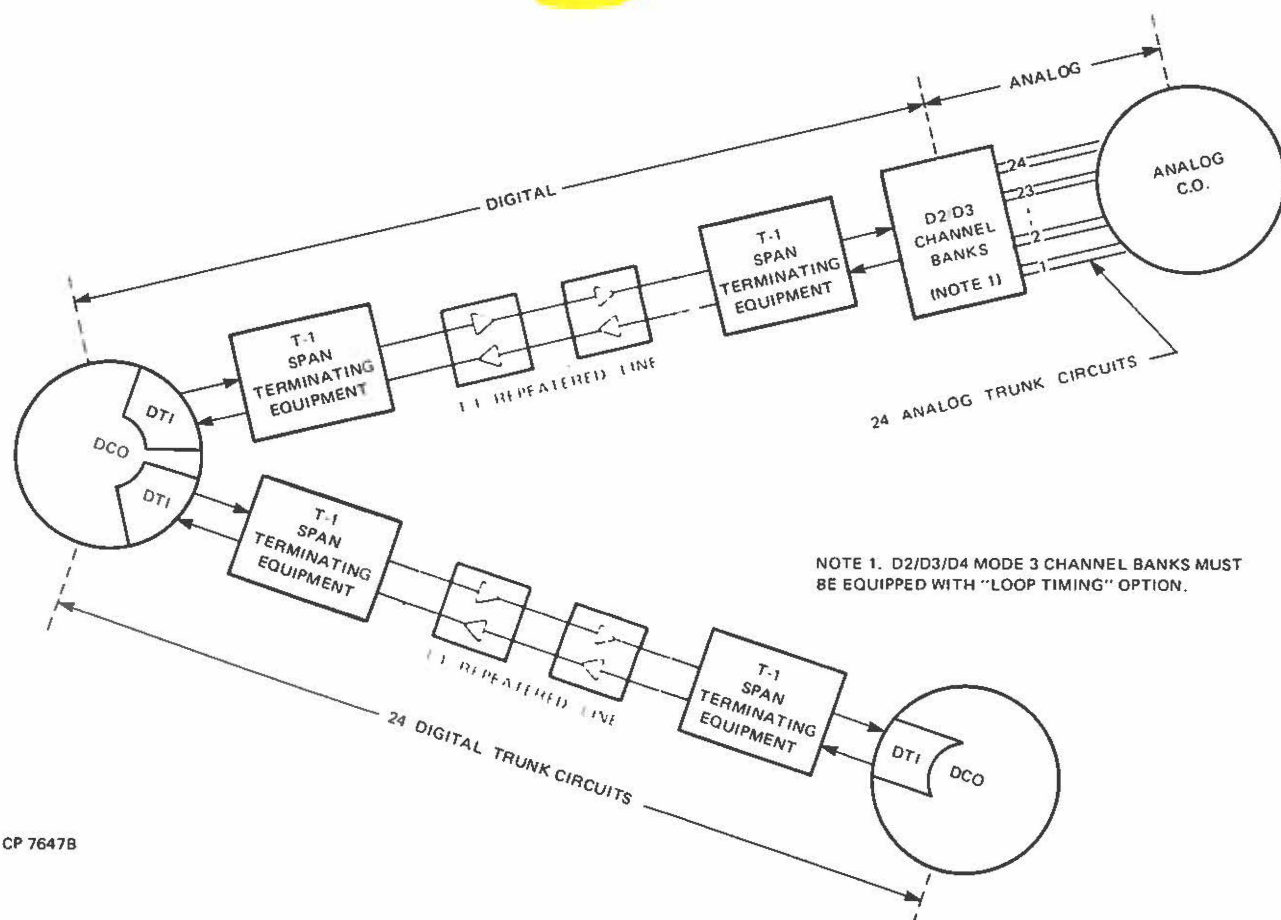
**3.01** The Digital Trunk Interface provides the means for the internal digital network of the DCO to directly interface with a T-1 carrier span on a digital basis. Direct connection to the T-1 span line eliminates

the need for PCM carrier channel bank equipment and corresponding analog trunk circuits, thus providing an efficient and economical system for interfacing T-1 lines to the DCO.

**3.02** The DTI can be used to interface the DCO to trunks from a distant analog central office that is equipped with D2/D3 channel bank equipment, or from a distant digital central office that has direct D2/D3 compatible T-1 interface capabilities. Typical DTI applications to both an analog central office and to another DCO are shown in figure 1.

**4. CAPABILITIES**

**4.01** One Digital Trunk Interface is capable of transmitting and receiving pulse-code modulated (PCM) voice and signaling information through 24 local or toll-type trunks. Each DTI terminates one 24-channel T-1 span at a single DCO port group.



CP 7647B

Figure 1. Typical DTI Applications

**4.02** The DTI contains digital attenuation pads that provide automatic level attenuation for each incoming channel. Attenuation pad values are selected by the DCO call processor and are in compliance with the AT&T fixed loss plan for the mixed analog/digital network. The trunk type and office test level determines the level of attenuation required for each trunk group.

**4.03** Alarm and test functions are integrated into the DCO system. Local and remote alarm capabilities, with alarm sending to the distant office, are in accordance with AT&T digroup terminal unit compatibility specifications. The functional equivalent of a carrier group alarm provides for automatic simultaneous system restoral coordinated with the remote office.

**4.04** The DTI has fault detecting circuits that monitor normal system operation. Fault conditions are communicated to the DCO maintenance processor. When established maintenance limits are reached, the maintenance processor automatically transmits an appropriate maintenance message to the DCO input/output (I/O) console. When established out-of-service limits are reached, outgoing calls are denied access to the ports of the DTI.

**4.05** Diagnostic tests can be done on each DTI system. The individual diagnostic tests are run manually through the keyboard control on the I/O console. Access to each DTI trunk from the I/O console also permits end-to-end analog transmission testing.

## **5. ENGINEERING CONSIDERATIONS**

**5.01** The local T-1 span terminating equipment should be located in the same building as the DCO equipment. Separate twisted-pair shielded cables must be used to provide the transmit and receive data paths between the DTI and the T-1 office repeater. Use STROMBERG-CARLSON SC 207520-XXX, National Wire & Cable Corporation D-210-4X, or equivalent low-capacitance type cabling. The maximum allowable length for this cabling is 150 feet (46 meters). Departures from these specifications will require Stromberg-Carlson Engineering to resolve special line equalization problems prior to installation.

**5.02** The DTI can interface with STROMBERG-CARLSON® S-C 1106 T-1 Span Line Equipment or span terminating and T-1 line equipment of other manufacturers that meet the AT&T DS1 span line compatibility requirements.

**5.03** PCM channel bank equipment at the distant central office can be either STROMBERG-CARLSON S-C 975 PCM Carrier Trunk Terminal Equipment or D2/D3 terminal equipment of other manufacturers that meet the AT&T compatibility specifications for D2/D3 channel banks. To prevent excessive frame slips, the channel banks must be loop-timed to the DTI.

**5.04** When the distant office interfaces the T-1 line on a direct digital connection, a synchronous network clock (SNC) is installed in the DCO common control frame. The SNC controls the DCO master clock to ensure that all timing signals occur at the same rate within the digital connection.

## **6. TECHNICAL SPECIFICATIONS**

### **6.01 Output to T-1 Span.**

Line rate: 1.544 Mb/s,  $\pm 1$  b/s

Line code: Bipolar

Line impedance: 100 ohms nominal

Pulse characteristics (at input to line equalizer or pad):

- a. Base-to-peak height: 6V,  $\pm 0.6$ V
- b. Unbalance in height of negative and positive pulse:  $\pm 0.3$ V
- c. Half-amplitude width: 324 ns,  $\pm 30$  ns
- d. Unbalance in width of negative and positive pulse:  $\pm 15$  ns
- e. Maximum rise or fall time: 80 ns
- f. Average minimum pulse density: one pulse in eight consecutive pulse positions
- g. Maximum consecutive zeros: 15
- h. Overshoot at trailing edge of pulse: 20% to 40% of pulse height with decay to 10% or less of base line-to-peak value within 400 ns

### **6.02 Input from T-1 Span.**

Line rate: 1.544 Mb/s,  $\pm 200$  b/s\*

Line code: Bipolar

Amplitude:  $\pm 1.5$ V to 3V

Input impedance: 100 ohms

\*Requirement is shown for synchronous operation between digital switches. For loop-timed D-channel banks, the line rate variance is  $\pm 50$  b/s maximum.



**6.03 Dc Power Input.**

Voltage: -44 to -56 volts dc

Power dissipation: 36 watts maximum

**7. EQUIPMENT DESCRIPTION****7.01 General.**

The DTI equipment is located in a DCO Line/Trunk Frame (LTF). Each DTI terminal, providing facilities to interface 24 trunk circuits to a single T-1 span, is mounted in a separate cell location within the LTF. Each terminal consists of a cell power supply and four printed wiring board assemblies (PWBA's). A separate DTI terminal must be provided for each D2/D3 channel bank at the distant office (or for each 24-channel digital T-1 interface at a distant digital office).

**7.02 DTI Cell.**

The DTI cell assembly provides mounting facilities for one DTI terminal. It can be located in any cell position of a line/trunk frame. The individual PWBA's required for one DTI terminal are plugged into connectors positioned on the backplane of the cell assembly. The DTI cell configuration, showing the connector position for each PWBA, is shown in figure 2.

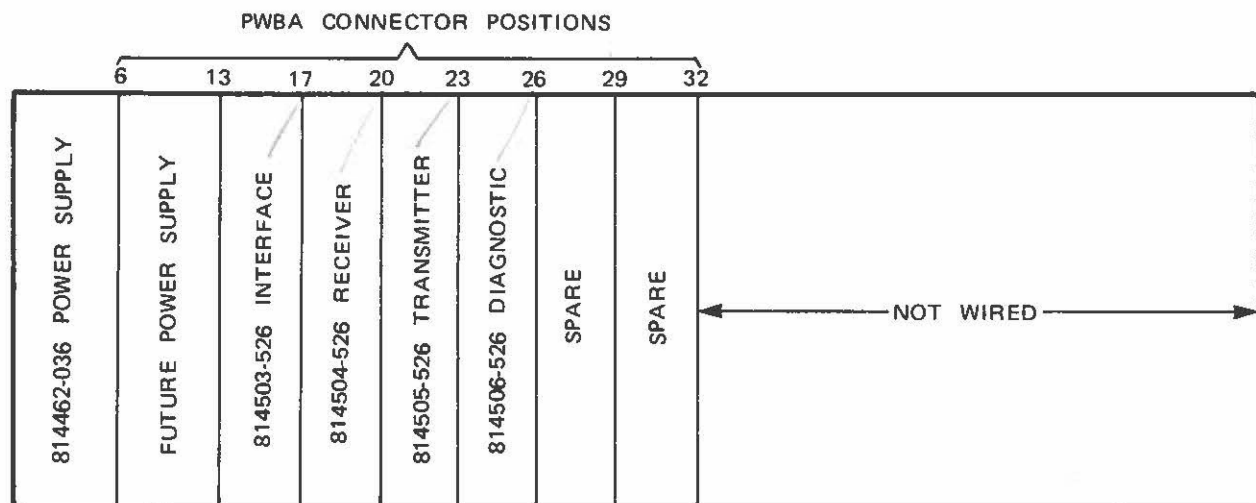
**7.03 Cell Power Supply.**

The cell power supply operates from the -48-volt office battery to supply all power requirements

to the DTI cell. The power supply provides a +5-volt input to each PWBA contained in the cell. In addition, it supplies a -5-volt and a +8-volt input to the interface PWBA. The power supply mounts in position six of the DTI cell, as shown in figure 2.

**7.04 DTI Interface.**

The DTI interface PWBA mounts in cell position 17 to provide for transformer isolation of the T-1 span and to function as a buffer between the DTI and the port group highway (PGH). It contains circuitry to convert the incoming bipolar data to NRZ data and to regenerate the incoming T-1 clock signal. Additional circuits are used to convert the outgoing digital bit stream from NRZ to bipolar form and to generate the outgoing 1.544-MHz clock signal. Two red light-emitting diodes (LEDs) are located at the front of the printed wiring board. The upper LED lights when the outgoing T-1 bit count is not synchronous with the DCO port group highway bit count. The lower LED lights when the DTI is in the loop-back mode. Relays are located on the interface PWBA to loop the line-side output back to the line-side input. Another function of the interface PWBA is to monitor the incoming bit stream from the T-1 span to detect bit errors. The bit-error rate is measured, and when the error rate parameters are exceeded, an alarm indication is transmitted to the diagnostics PWBA.



CP 7648

Figure 2. DTI Cell Configuration

**7.05 DTI Receiver.**

The DTI receiver PWBA has circuitry to transpose the incoming data received from the T-1 span to a rate and digital format that is compatible with the DCO port group highway. The receiver also performs the frame synchronization function. A red LED is lighted when the frame synchronizer is in the search mode to provide a visual indication that the receiver has lost synchronization with the incoming data frame. In addition, circuits are provided to correct any phase error that may occur between the incoming T-1 frame and the PGH data frame. Digital pads, under control of the DCO call processor, are used to supply the required level attenuation for each channel. The receiver PWBA mounts in position 20 of the DTI cell.

**7.06 DTI Transmitter.**

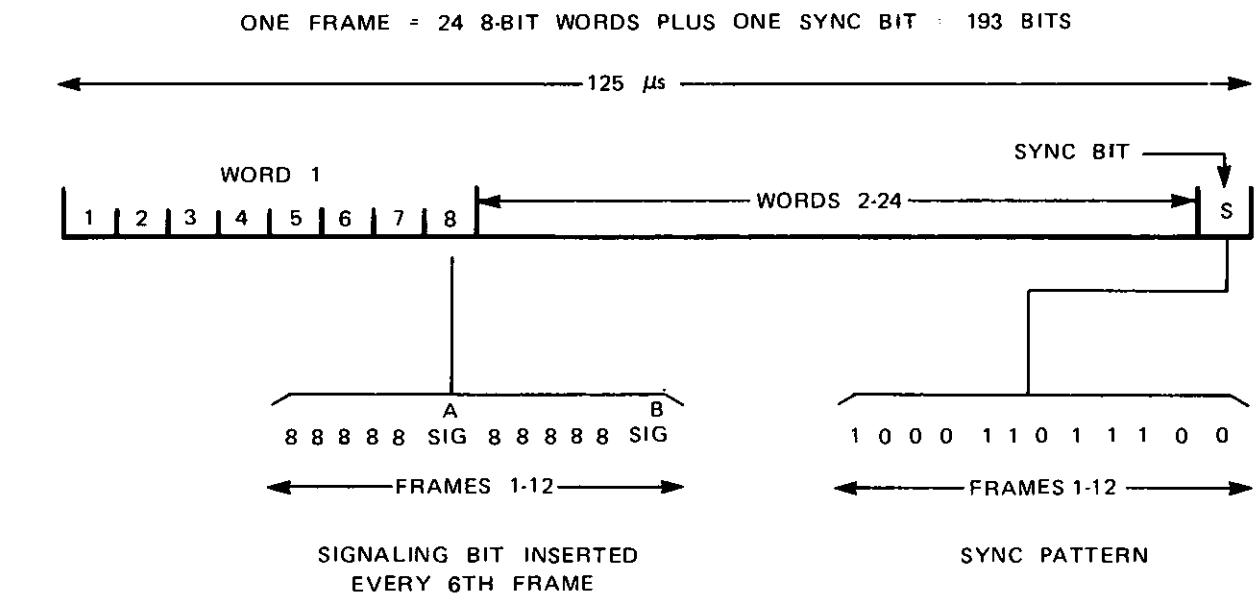
The digital signals from the port group highway (PGH) are converted to the T-1 data rate and format by the DTI transmitter PWBA. The transmitter mounts in cell position 23. It has circuitry to generate the outgoing T-1 frame synchronization pattern and a zero suppressor circuit to prevent the transmission of all "zeros" to the span line. An additional function of the transmitter is to store the attenuation pad values for use by the digital pads in the receive section.

**7.07 DTI Diagnostics.**

The DTI diagnostics PWBA supplies the DTI with alarm and testing capabilities. Information received from fault indications is used to initiate alarm functions. The diagnostics PWBA has a data pattern generator used to test the data path for each DTI port. Circuits are also provided to initiate loop-back and frame synchronization tests. The diagnostics PWBA is mounted in cell position 26.

**8. SYSTEM DESCRIPTION****8.01 Data Format.****a. T-1 Data Format.**

The pulse code modulated (PCM) voice and signaling information for the 24 associated trunks is transmitted over the T-1 span lines in D2/D3 compatible format, as shown in figure 3. One frame has 24 8-bit words plus one synchronization bit, for a total of 193 bits. Frames occur at an 8-kHz (125  $\mu$ s) rate. In every sixth frame the least significant bit (bit 8) in each word is replaced with a signaling bit. The signaling bit is time-shared by alternate A and B signaling bits, each of which occur at a 12-frame rate. Frame identification is provided by the synchronization bit, which forms a unique pattern of ones and



BIT RATE = 1.544 Mb/s

CP 7649

Figure 3. T-1 Data Format

zeros that recycles every 12 frames. Twelve frames make up one superframe.

**b. PGH Data Format.**

The data transmitted over the port group highway is in the PGH format shown in figure 4. Eight 32-bit frames from one port group combine to form a 256-bit superframe. Each frame contains the same bit from each 8-bit port word plus two supervisory bits. Frame one contains all bit ones, frame two contains all bit twos, etc. Thirty-two superframes make up a major frame. Frame synchronization is provided by a pulse that occurs at the major frame rate of 4 ms.

**c. Data Waveforms.**

The multiplexed bit streams that are processed by the DTI occur in three basic forms, as shown in figure 5. The T-1 data bit stream is in bipolar return to zero (RZ) form. Alternate pulses are of opposite polarity, and each bit returns to the zero level. This bipolar signal is full-wave rectified to produce unipolar RZ, in which each bit returns to zero but all bits retain the same polarity. Further processing produces unipolar nonreturn to zero (NRZ) data, which is used by the DCO. The NRZ signal remains constant until the actual change of state of a particular bit is detected.

**8.02 Data Path.**

The DTI operates as a full-duplex system to receive and transmit PCM voice and signaling information over T-1 span lines. As shown in figure 6, data from the T-1 span terminating equipment is routed by way of the MDF to the DTI input transformer. The incoming D2/D3 formatted data is in bipolar form at a 1.544-Mb/s rate. The receive portion of the DTI rectifies the bipolar data, regenerates the T-1 clock signal, and synchronizes the incoming data frame. The received data is routed through digital pads, which provide level attenuation for each channel as a function of call routing. The data is then converted to a format compatible with the 2.048-Mb/s port group highway (PGH) and routed to the DCO timeslot interchange (TSI). The transmit portion of the DTI accepts data from the port group highway, transposes the data to the T-1 format, and generates the T-1 frame synchronization pattern. The outgoing 1.544-MHz timing information is derived from the 2.048-MHz system clock. The multiplexed data is then routed in bipolar form to the T-1 span terminating equipment.

**8.03 DTI Port Group.**

The DTI interfaces one 24-channel T-1 span line to a single port group. Ports 0 through 23 of the

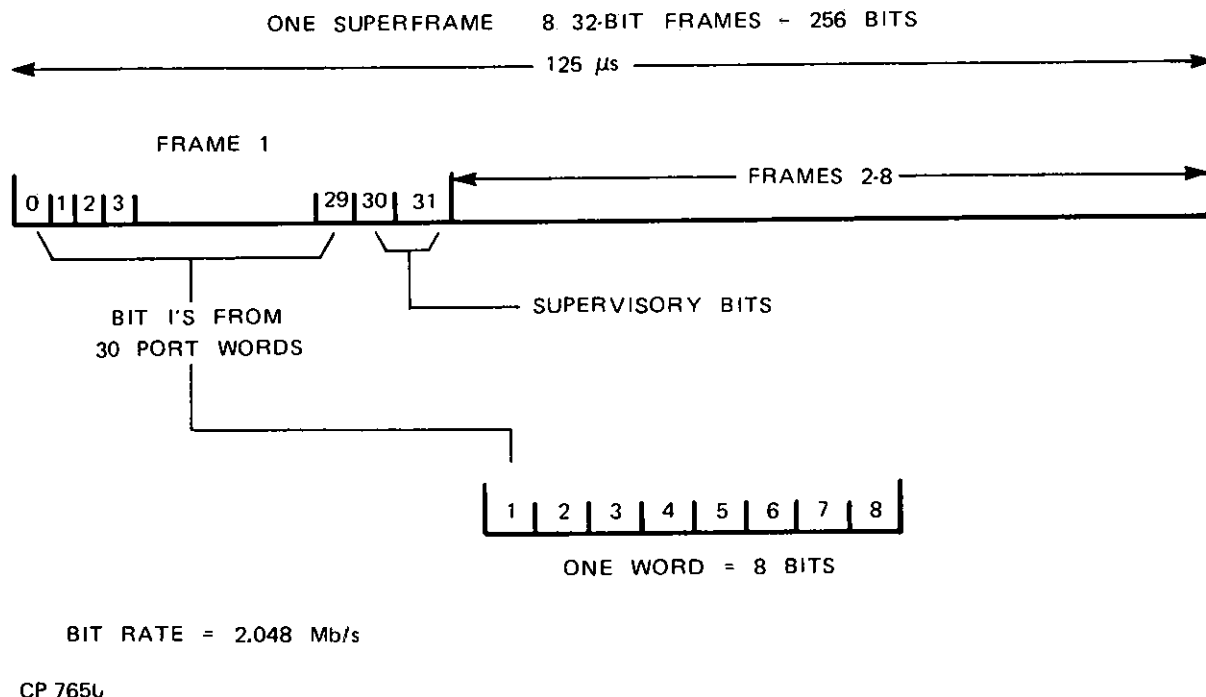
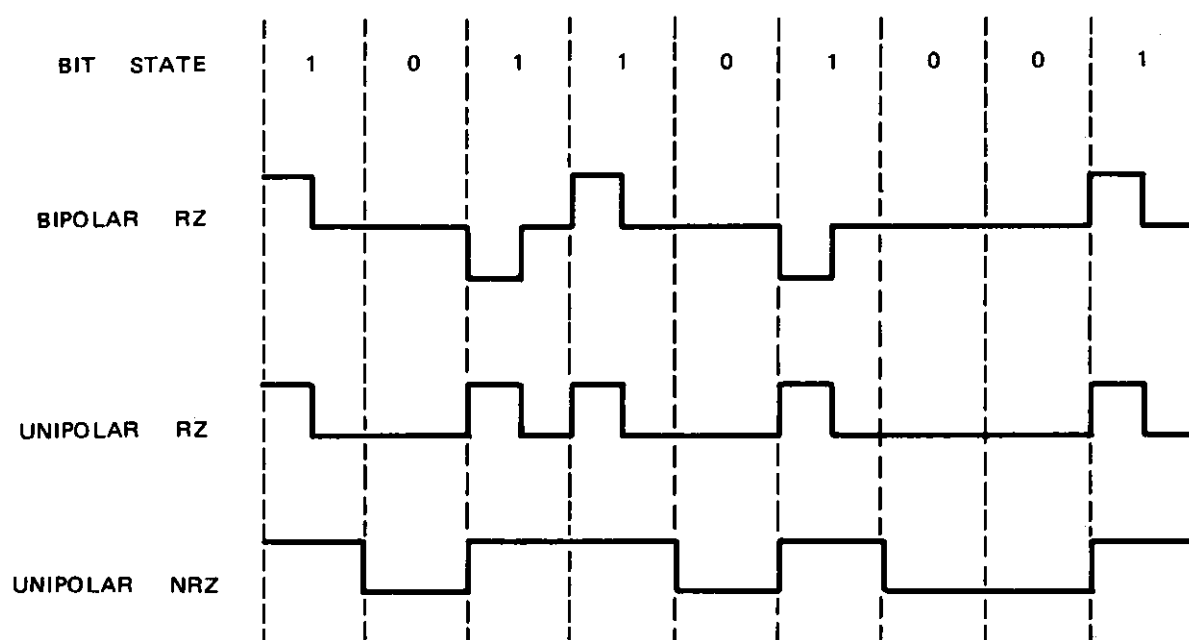


Figure 4. PGH Data Format



CP 7651

*Figure 5. DTI Data Waveforms*

associated port group correspond to channels 1 through 24 of the distant D3 channel bank or digroup terminal unit. Trunk-to-channel assignments are under program control and can be updated from the DCO I/O console. Ports 30 and 31 are used for supervisory, alarm, and test purposes. Ports 24 through 29 of the DTI port group are not used.

#### 8.04 Supervision And Signaling

a. The DTI is transparent to the contents of the signaling bits. That is, the DTI accepts the signaling bits from each channel and inserts them into the designated timeslots without format transposition. The A and B signaling bits from the T-1 span require only rate conversion before being loaded into the corresponding PGH supervisory bit positions. During a carrier group alarm condition, the supervisory bits for all 24 incoming channels are forced to the on-hook condition to release each DCO trunk circuit and to place the associated DTI ports out of service to outgoing calls.

b. In addition to signaling information, the PGH supervisory bits are used to provide port test, pad select, and sync loss information for each channel.

The port 30 supervisory bits are used to sense DTI alarm conditions and to control DTI test functions. Port 31 uses supervisory bits to check the continuity of the supervisory path between the DTI and the call processor.

#### 8.05 Fault Detection.

##### a. General.

Maintenance software and the DTI fault detection circuits provide a comprehensive system to detect failures. The DTI monitors the incoming data to detect misframes, frame-slips, and bit errors. The maintenance processor maintains a count of all errors detected. When established error limits are reached, the maintenance processor activates the appropriate audio and visual alarm indications on the DCO basic maintenance panel and transmits a message to the I/O console. If the out-of-service limit for a particular error is reached, outgoing calls are denied access to the 24 ports associated with the DTI.

##### b. Misframes.

A misframe (loss of frame synchronization) causes the call processor to freeze the current call states present on the 24 ports associated with the DTI port

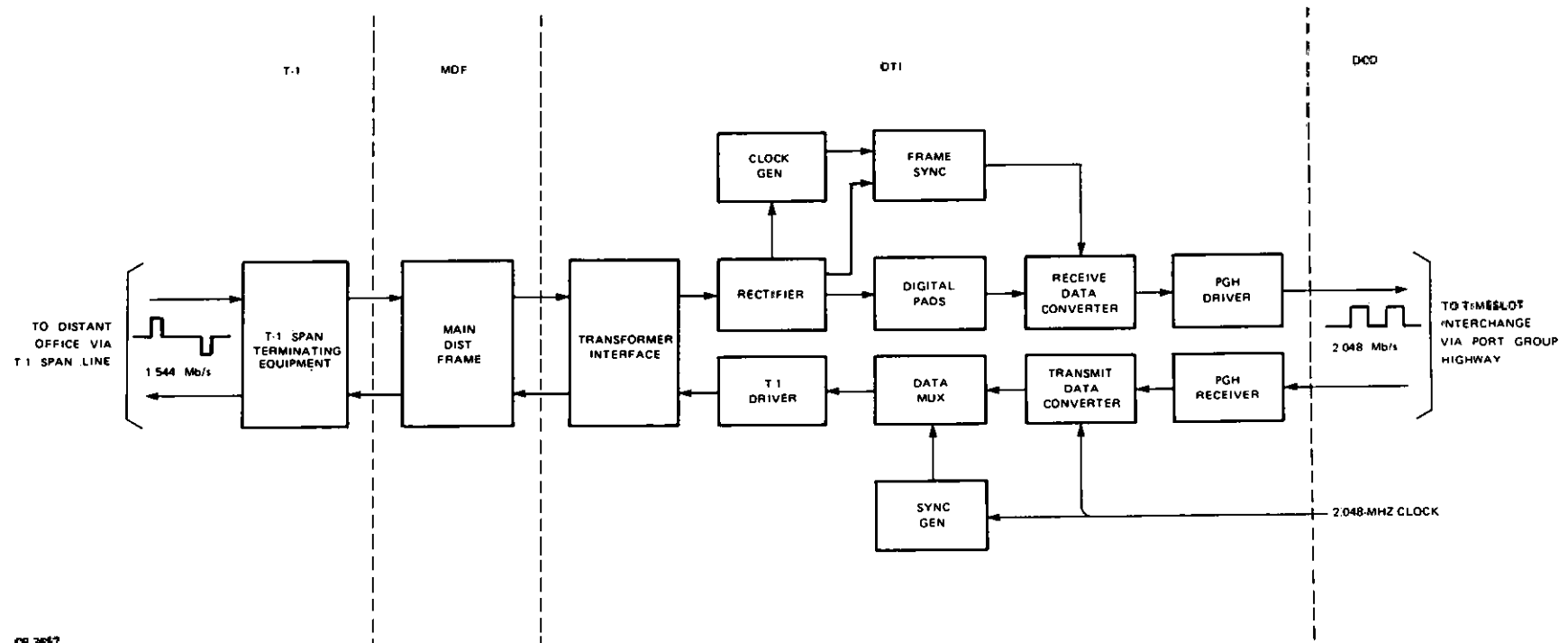


Figure 6. DTI System, Simplified Block Diagram



group. This action prevents false events (such as on-hook conditions) from occurring during the sync loss period. Each misframe is presented as a statistic on the DTI status report. A total of 17 misframes within a 24-hour period results in the transmission of a maintenance message to the I/O console. A total of 511 misframes within a 24-hour period results in the transmission of an out-of-service message and causes the DTI ports to be placed out-of-service to outgoing calls.

**c. Frame Slips.**

A frame-slip is caused by a frame realignment in the DTI receiver that occurs as a result of a timing error between the DTI and the distant terminal. A maintenance message is generated when 4 frame-slips occur within a 24-hour period. When 255 frame-slips occur within a 24-hour period, an out-of-service message is generated and the DTI ports are automatically removed from service to outgoing calls.

**d. Bit Errors.**

A bit error, or a bipolar violation, is defined as the successive occurrence of two pulses of the same polarity. The DTI monitors the incoming bit stream to detect the presence of bit errors and then measures the bit-error rate (BER). The BER measurement is obtained by counting the number of errors that occur in a total of four million bits received. A bit-error rate of one bit-error per one million bits received ( $1 \times 10^{-6}$ ) is reported on the hourly DTI status report. When the BER reaches one bit-error per one thousand bits ( $1 \times 10^{-3}$ ) for a period of four seconds, an out-of-service message is transmitted to the I/O console and the DTI ports are placed out of service to outgoing calls.

**8.06 Carrier Group Alarm.**

A carrier group alarm (CGA) informs a distant terminal of the loss of received framing at the local end. A CGA is transmitted between offices by the presence of a "zero" in the second-bit position of each word. During a CGA condition, the 24 channels are disconnected and placed out of service at both offices. The channels are automatically restored to service when the alarm is cleared. The DTI generates a carrier group alarm when a framing loss persists for a period of 2.5 seconds. The alarm clears after framing is reestablished and maintained for a period of ten seconds.

**9. DIAGNOSTIC TESTS**

**9.01 Purpose and Use.**

Diagnostic testing capabilities are included in the DTI hardware and software functions. The diagnostic tests provide an effective instrument to evaluate the overall performance of the DTI system, as well as a means to verify the satisfactory performance of each channel associated with the DTI port group. The test programs are resident within a floppy disk system that is controlled by the DCO maintenance processor. The tests operate under second-level diagnostics control and are initiated manually from the I/O console. A diagnostic printout is transmitted to the I/O console when testing is completed.

**9.02 Data Test.**

a. A data test is provided to verify that each channel can accurately transmit and receive a data pattern that exercises the logic for both "one" and "zero" data states. The call processor first establishes a path for the transmission of data from a selected DTI channel to a second channel. A test pattern, generated within the DTI diagnostic PWBA, is then inserted into the selected channel. The pattern is returned on the second channel and compared with the pattern that was generated. Each DTI channel is tested in turn, beginning with port 0 as a transmit channel and port 1 as a receive channel. Then port 1 is used as the transmit channel, with port 2 as the receive channel. The process continues until the final pair of ports tested consists of port 23 (transmit) and port 0 (receive).

b. Only ports that are in the idle state (on-hook condition) are tested. Busy ports encountered during the operation of the data test are tested when they return to the idle condition. When a fault is detected, the maintenance processor uses another properly functioning DTI to isolate the defective channel, since the fault may be caused by either one, or both, of the channel pairs under test. First the transmit port, then the receive port, is switched with the second DTI, and the data test is repeated until the defective channel is isolated. If another DTI is not available, then both ports are listed as faulty. Ports that fail the data test are listed individually on the diagnostic printout.

### 9.03 Frame Sync Test.

A frame sync test is provided to verify that the DTI is able to detect a loss of frame synchronization and is then able to regain synchronization. A synchronization error is produced by setting the port-30 return-to-search control bit. If a loss of frame synchronization is not detected, the diagnostic printout indicates a failure. After four milliseconds, the return-to-search control bit is reset by hardware and the DTI operation is monitored to ensure that frame synchronization has been regained. The test-status sense bits are also examined to ensure that all test functions have been reset at the conclusion of testing.

### 9.04 Loop-Back Test.

The loop-back test routes the DTI line-side output back to the line-side input and tests the A and B

signaling bits for each channel with both "zero" and "one" bit values. While in the loop-back mode, the DTI transmits a pattern of all logical "ones" to the remote terminal. This pattern signals the remote terminal to suspend transmission over the span line. Ports that fail the loop-back test are listed individually at the conclusion of testing.

### 9.05 Test Procedure Documents.

Instructions for running the diagnostic tests and interpreting test results are included in the section titled *DTI, Maintenance*. End-to-end analog transmission test procedures are provided in the section titled *DTI, Pre-cutover Test Procedures*. Both of the above SCP sections are referenced in paragraph 2.02.

**Cut along Line**

**Title** \_\_\_\_\_

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☐ Maintenance

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☐ Deletion on page(s) \_\_\_\_\_

**Comments:** \_\_\_\_\_

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1. **Identify the main topic or question.** The main topic is the relationship between the number of hours worked and the number of hours of sleep. The question is whether there is a significant correlation between these two variables.

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