PDP-15 Systems
Instruction Manual

Volume 1

# LT19 Multi-Station Teletype Control

# LT19
# MULTI-STATION
# TELETYPE CONTROL
# INSTRUCTION MANUAL

DIGITAL EQUIPMENT CORPORATION • MAYNARD, MASSACHUSETTS

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# CHAPTER 1
# GENERAL DESCRIPTION

## 1.1 INTRODUCTION

This manual describes the LT19 Multi-Station Teletype Control used with both the PDP-9 and PDP-15 Programmed Data Processors manufactured by Digital Equipment Corporation, Maynard, Massachusetts. The LT19 Multi-Station Teletype Control increases the basic teletypewriter facility by permitting data transfers between the processor and any combination of up to five teletypewriters or level-operated data terminal devices that are EIA-compatible*.

The LT19 consists of three logic subgroups: I/O bus interface logic; optional Teletype® control logic; and optional EIA-level converter logic (refer to Table 1-1). Initially, this manual covered only the A, B, and C versions of these logic subgroups. Because the D, E, and F versions are used with the PDP-15, portions of this manual are updated to cover these models, where they differ.

Table 1-1
Differences Between Models

| Logic Subgroup | PDP-9 | PDP-15 | Differences |
|---|---|---|---|
| Interface Logic | LT19A | LT19D | LT19D includes wiring changes to permit separate transmit clocks for each channel. |
| Teletype Control Units | LT19B | LT19E | LT19E has an additional R401 Variable Clock module for the separate transmit clock. |
| EIA-level converters | LT19C | LT19F | Identical |

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*Logic levels specified in Electronic Industries Association (EIA) Standard RS-232C "Interconnection of Data Terminal Equipment with a Communication Channel".

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Unless otherwise indicated, references in text or illustrations to LT19A, B, or C type numbers are interchangeable with their corresponding LT19D, E, or E type numbers. Similarly, references to PDP-9 I/O operations are valid for the PDP-15, as well.

## 1.2 FUNCTIONAL DESCRIPTION

Figure 1-1 shows a typical LT19 configuration utilizing three Teletypes and two EIA devices. Under program control, the PDP-9 sends control signals, device select signals, and parallel data words to the LT19A through the I/O bus. The LT19A serves as an interface and control between the PDP-9 I/O bus and a specific LT19B or LT19C unit.
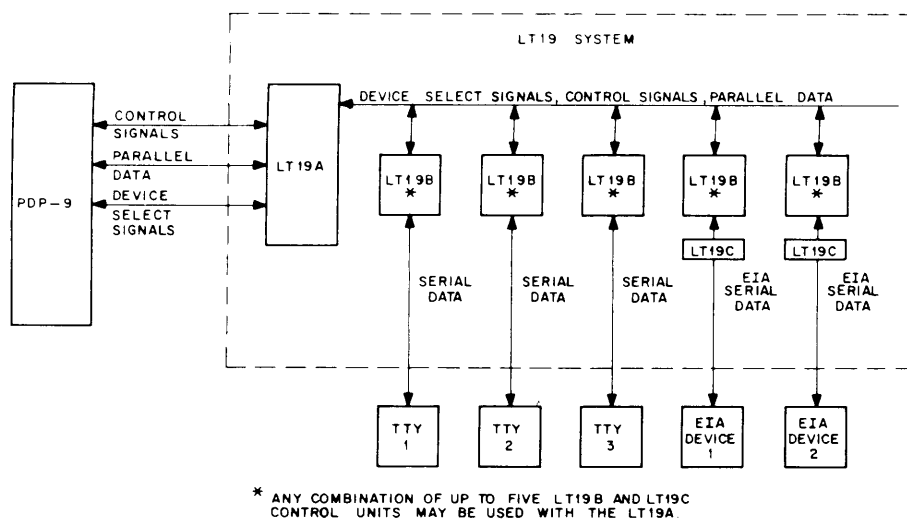


Figure 1-1   LT19 System, Typical Configuration

Each LT19B includes the logic that comprises one Teletype control unit for operation with ASR, KSR, RO, or SO Teletype devices. Under control of the LT19A, the LT19B converts parallel data words from the PDP-9 to serial information which can be applied to the Teletype device. In a similar manner, the LT19B receives serial information from a Teletype and converts it to parallel data which can be transmitted to the PDP-9.

The LT19C adds EIA-level converter logic, which permits data transfers between the PDP-9 computer and a device using EIA levels.

Since the PDP-9 can service a device in approximately 4 μs (one IOT instruction time), all of the slower operating devices (TTY and EIA) can operate simultaneously and indicate a servicing requirement to the PDP-9 via the Program Interrupt Enable (PIE) facility. To allow this type of operation, each device is assigned its own specific device code which enables the PDP-9 to address the device when servicing is required.

1-2

This manual contains operation and maintenance information for the LT19 Multi-Station Teletype Control. Maintenance and operation descriptions for the PDP-9 are contained in the documents listed in Table 1-2.

Table 1-2
Related Documentation

| Title | Document Number | Description |
|---|---|---|
| PDP-9 User Handbook<br>or<br>PDP-15 User's Handbook | F-95<br><br>DEC-15-H2DC-D | Contains IOT instruction format and program controlled transfer considerations. |
| PDP-9 Maintenance Manual, Volumes I and II<br>or<br>PDP-15 Maintenance Manual | F-97<br><br><br>DEC-15-H2BB-D | Provides maintenance techniques and IOT device selection information. |
| Digital Logic Handbook | C-105 | Specifications and descriptions of most FLIP CHIP modules, plus simplified explanations for selecting and using these modules in numerous applications. |
| KF09A Automatic Priority Interrupt Instruction Manual | DEC-09-15AA-D | Operation and maintenance information for the PDP-9 Automatic Priority Interrupt option. |
| Technical manual for Model 32 and 33 ASR, KSR, and RO/SO Teletype sets. | Teletype Bulletin 273B Volumes I and II | Volume I contains installation, disassembly, reassembly, lubrication and operation documentation. Volume II includes adjustment information on all component units of these Teletypes. |
| Parts list for Model 32, and 33 ASR, KSR, and RO Teletype sets | Teletype Bulletin 1184B | Provides complete parts documentation for these Teletypes. |
| LT19 Diagnostic PDP-9<br>            PDP-15 | MAINDEC-09-D8CC<br>MAINDEC-15-D8CA | Fault isolating maintenance program. |
| LT19 Diagnostic | MAINDEC-09-D8CC-D<br>MAINDEC-15-D8CA-D | Program description. |

Table 1-3
Specification Summary

| Characteristic | Specification |
|---|---|
| Character code | 5- or 8-bit* character code |
| Start code | 1 unit start code* |
| *Standard Unit | |

Table 1-3 (Cont)
Specification Summary

| Characteristic | Specification |
|---|---|
| Stop codes | 1-, 1.5-, or 2-units* stop code |
| Operation | Full duplex |
| Service | Up to five units per LT19A or LT19D |
| Speed | |
|    LT19B | 10,000 baud, maximum. All units operate at the same speed. |
|    LT19E | Variable to 30,000 baud. See Note. |
| Transmission distance | 2000 ft, maximum. 20 mA Current Loop only – 110 baud. Maximum length of LT19H is 250 feet. |
| Operating temperature range | 55-122 °F (15-50 °C) |
| Operating humidity range | 10-95% |
| Primary power requirements | 115V, 60 Hz, 250W (approx.) |
| *Standard Unit | |

NOTE

The overall speed for all LT19E channels is limited to
30,000 baud, for all N channels combined, where N = 1
to 16. This limitation is imposed so that the normal proc-
essor service routines may handle all N channels simul-
taneously.

Assign the highest speed channels to the first channels in
the system to keep the skip chain short. In a multiple
LT19D System, all high-speed channels must be first to
prevent a low-speed channel from locking out a high-
speed unit.

## 1.3 LT19H DATA COMMUNICATIONS CABLE OPTION

The LT19H is a data communications cable option used for interprocessor buffer applications. It is used
between an LT19 and PT08, between two LT19s, or between the LT19 and other devices with equivalent
interface and timing characteristics. The cable is available in five lengths:

| Option | Length (ft.) |
|---|---|
| LT19HA | 50 |
| LT19HB | 100 |
| LT19HC | 150 |
| LT19HD | 200 |
| LT19HE | 250 |

## 1.4 PROGRAMMING

Communication between the PDP-9 or PDP-15 and the LT19 units is accomplished by IOT instructions. The keyboard and teleprinter circuits of a Teletype are considered independent devices. Therefore each circuit is assigned a different device code to control its operation. The first Teletype has a device code of 400X assigned to its teleprinter circuit and a device code of 410X assigned to its keyboard (or paper-tape reader) circuit.

The LT19 employs the IOT instruction format discussed in the PDP-9 and PDP-15 User Handbook. The format example in Figure 1-2 shows the bit assignments.
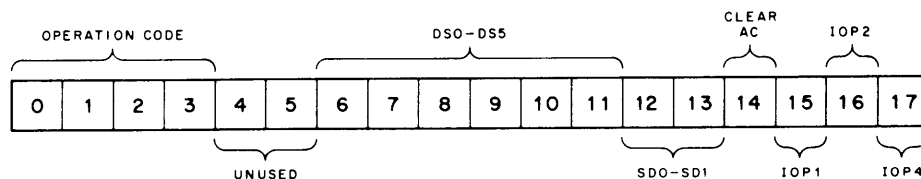


Figure 1-2   IOT Instruction Format

The main components of the IOT instruction are as follows; four operation code bits, six device selection bits (DS0 through DS5), two subdevice selection bits (SD0 and SD1), and three IOP bits (IOP1, 2, and 4). In all IOT instructions the operation code is $70_8$. The device selection bits identify the device selected and the type of operation to be performed. The subdevice selection bits identify the selected circuit within the LT19 and the IOP pulses initiate the required function within the selected circuit. A 1 in bit 14 clears the processor accumulator prior to an input data transfer. Bits 4 and 5 are not used.

### 1.4.1   LT19B - (1 through 5) Device Selection Codes

The IOT format for the first five LT19B units is shown in Table 1-4. The specific device select coding for each control unit is underlined. Channel assignments for systems with more than one LT19 unit are described in Paragraph 2.5 of Chapter 2, Installation.

Table 1-4
Device Select Codes

| Unit | Transmitter Code (Teleprinter) | Receiver Code (Keyboard) |
|---|---|---|
| LT19B-1 | 70400X | 70410Y |
| LT19B-2 | 70402X | 70412Y |

Table 1-4 (Cont)
Device Select Codes

| Unit | Transmitter Code (Teleprinter) | Receiver Code (Keyboard) |
|------|--------------------------------|--------------------------|
| LT19B-3 | 70404X | 70414Y |
| LT19B-4 | 70406X | 70416Y |
| LT19B-5 | 7042ZX | 7043ZY |

The letter X in the transmitter codes represents either IOP1, IOP2 or IOP4. The letter Y in the receiver codes represents either IOP1 or IOP2. The subdevice code for LT19B-5 (the fifth unit in each LT19 system) is represented by the letter Z in Table 1-4 because subdevice codes have not been assigned to this unit. The subdevice code assigned to this line is dependent upon the number of Teletypes (or EIA devices) that are connected to the processor via the LT19 interface(s). These subdevice codes therefore, are hand wired after the user's requirements have been determined.

Device selection and the functions performed within the LT19B units are accomplished by W103 Device Selector modules which decode the device selection signals, subdevice signals and IOP pulses. The appropriate diodes are removed from the inputs of the W103 modules to obtain the proper selection codes.

1.4.2   LT19 IOT Instruction Set

Table 1-5 shows the complete set of IOT instructions for the LT19 teleprinter and keyboard circuits and identifies the function(s) of each instruction. Identical functions are performed by the LT19-1 through LT19B-5 IOT instructions. Programming examples are provided in the PDP-15 User's Handbook, Volume 2, Chapter 4.

Table 1-5
LT19 IOT Instructions

| Teleprinter Instructions | |
|--------------------------|--------------------------|
| IOT | Function |
| 704001 | Skip if transmitter flag is set |
| 704002 | Clears transmitter flag |
| 704004 | Loads transmitter module and sends character to teleprinter |

Table 1-5 (Cont)
LT19 IOT Instructions

| Keyboard Instructions | |
|---|---|
| IOT | Function |
| 704101 | Skip if receiver flag is set |
| 704102 | Reads contents of receiver module and clears receiver flag. |

### 1.4.3 Program Interrupts

The LT19A or LT19D supplies API and program interrupt (PI) facilities for each of the Teletype controls. All transmit flags are ORed together to cause interrupts on either PI or API. When API is implemented in the processor, a transmit interrupt causes a trap to location $74_8$ on priority level 3. A receive interrupt causes a trap to location $75_8$ on priority level 3.

### 1.5 ENGINEERING DRAWING REFERENCES

Engineering drawings provided in Volume 2 of this manual are referenced by the letter-number combination appearing at the end of the complete drawing designation. For example, drawing D-BS-LT19-A-1 is referred to as drawing A-1. Similarly, drawing D-BS-LT19B-1 (sheet 1 of 5) is referred to as drawing B-1-1 while drawing D-BS-LT19B-1 (sheet 4 of 5) is referenced as drawing B-1-4. In the LT19B and LT19C units, sheet numbers correspond to channel numbers.

### 1.6 SIGNAL MNEMONICS

Uncommon signal mnemonics are explained parenthetically the first time they are mentioned in the discussion, e.g., TSO (Teletype Serial Output).

# CHAPTER 2
# INSTALLATION

## 2.1 INSTALLATION

The LT19 system is contained within two module mounting panels of a standard PDP-9, 19-in. optional cabinet. Complete installation consists of inserting the LT19A interfacing modules and additional LT19B/LT19C control modules into prewired locations on the mounting panels. The LT19 operates via program control, therefore, location on the I/O bus is not critical.

The exact number of LT19B and LT19C subsystems contained within the LT19 depends upon each user's requirements. One LT19B subsystem is required for each Teletype and an LT19B with an LT19C is required for each EIA-level operated device. Any combination of up to five of these subsystems may be incorporated into an LT19 system. Because device codes assigned to the LT19 will handle up to 16 devices, additional LT19 systems can be connected to the PDP-9.

## 2.2 POWER REQUIREMENTS

The LT19 receives dc operating power from one DEC Type 728 Power Supply. This supply is mounted on the back door of the optional bay in which the LT19 is installed. When the PDP-9 is turned on, primary ac power from a Type 841A Power Control, mounted in the optional bay, energizes the 728 Power Supply. In a similar manner, ac power is removed from the 728 when the PDP-9 is turned off. The LT19 does not require any special power controls or fan assemblies other than those utilized in the PDP-9 multibay system. The maximum load for the +10V supply is 7.2A and 2.8A for the -15V supply. The following chart indicates typical current drain for each supply for various LT19E configurations:

| Number of LT19Es | +10V Supply (amperes) | -15V Supply (amperes) |
|------------------|-----------------------|-----------------------|
| 1 | 1.47 | 1.58 |
| 2 | 2.88 | 1.86 |
| 3 | 4.30 | 2.14 |
| 4 | 5.72 | 2.42 |
| 5 | 7.14 | 2.70 |
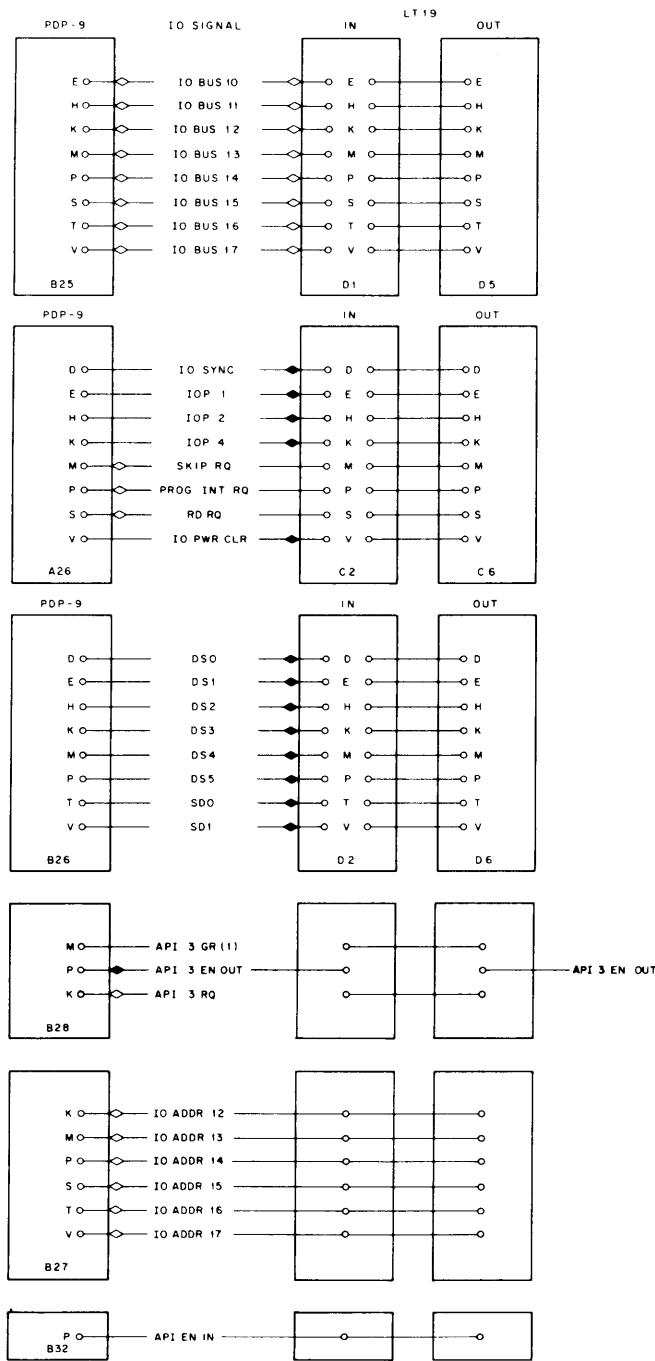
Figure 2-1  Interface Connections

## 2.3 INTERFACE

All connections between the LT19 and the PDP-9/15 Processor are made through the I/O bus, using standard I/O bus cables. Each teletypewriter (TTY) or EIA-level device is connected to the LT19 by a single control cable supplied with the device. The TTY cable is terminated with DEC W078A cable connector modules that plug into assigned locations in the logic mounting panels. EIA-level devices are connected with a data set cable, DEC part no. 70-05717.

Each LT19 receives all I/O bus signals and sends them to the next device on the I/O bus. Figure 2-1 shows only those interface connections between the processor that are pertinent to LT19 operation. The interface between the LT19 and its devices is shown in Figure 2-2. For additional interface information, refer to the PDP-9 User Handbook or the PDP-15 Interface Manual.



TSO - TELETYPE SERIAL OUTPUT
PSM - PRINT SELECTOR MAGNET
RRE - READER RUN ENABLE

Figure 2-2  LT19-Device Interface Connections

## 2.4 LT19E BAUD RATE SELECTION

Each R401 Clock module provides a selectable clock frequency that is twice the baud rate for the associated channel. The doubled output frequency is required by the W706/W707, which divides the clock frequency by two.

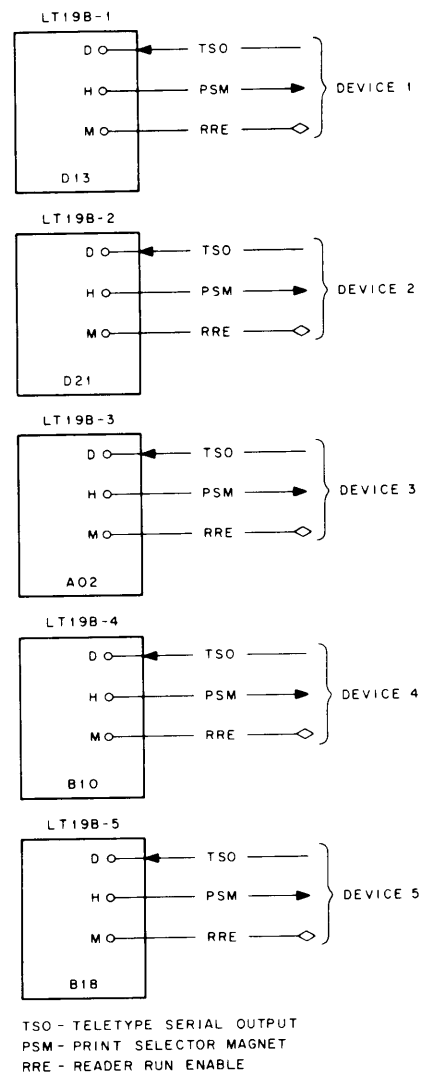To select a specific baud rate, locate the appropriate range in Table 2-1. Connect a jumper from pin R on the R401 to the indicated pin (L, M, N, or P). Then connect the indicated resistor (Rx) between pins R and T. Fine tune the R401 Clock output by adjusting the internal potentiometer (R11) on the R401.

### NOTE

The Rx values listed in Table 2-1 are design center values, with 10 percent capacitor and resistor tolerances. Other values of Rx may be used if necessary. Use the lowest value of Rx that allows adjustment to the required frequency.

Some examples of common baud rates are:

| | |
|---|---|
| 110 baud: | Jumper pin R to L, Rx = 1.2K |
| 2000 baud: | Jumper pin R to M, Rx = 750 |
| 2400 baud: | Jumper pin R to M, Rx = 470 |
| 11,000 baud: | Jumper pin R to N, Rx = 3.3K |
| 30,000 baud: | Jumper pin R to P, Rx is open circuit. |

Table 2-1
Baud Rate Selection

| Baud Rate Range | Connect Rx Between R and T | Jumper Pin R to – |
|---|---|---|
| 59 – 106 | 3.3K | L |
| 106 – 122 | 1.2K | L |
| 116 – 146 | 1.0K | L |
| 133 – 142 | 750 | L |
| 137 – 146 | 680 | L |
| 146 – 155 | 560 | L |
| 155 – 161 | 470 | L |

Table 2-1 (Cont)
Baud Rate Selection

| Baud Rate Range | Connect Rx Between R and T | Jumper Pin R to – |
|---|---|---|
| 159 – 860 | open | M |
| 860 – 1297 | 3.3K | M |
| 1560 – 1795 | 1.2K | M |
| 1710 – 1910 | 1.0K | M |
| 1910 – 2084 | 750 | M |
| 2010 – 2150 | 680 | M |
| 2150 – 2265 | 560 | M |
| 2270 – 2400 | 470 | M |
| 1590 – 8600 | open | N |
| 8600 – 12,970 | 3.3K | N |
| 15,600 – 17,950 | 1.2K | N |
| 17,100 – 19,100 | 1.0K | N |
| 19,100 – 20,840 | 750 | N |
| 20,100 – 21,500 | 680 | N |
| 21,500 – 22,600 | 560 | N |
| 22,700 – 24,000 | 470 | N |
| 18,600 – 98,000* | open | P |
| *Maximum baud rate is 30,000 | | |

## 2.5 CHANNEL ASSIGNMENTS

Table 2-2 lists the channel assignments for one LT19 that includes from one to five channels.

NOTE

When the system includes an LT15, it becomes
logical unit number 1.

Table 2-2
Channel Assignments for One LT19

| Unit No. | Transmitter Code | Receiver Code | Logical Unit No. |
|---|---|---|---|
| 1 | xx400x | xx410x | 1 |
| 2 | xx402x | xx412x | 2 |
| 3 | xx404x | xx414x | 3 |
| 4 | xx406x | xx416x | 4 |
| 5 | xx420x | xx430x | 5 |

Table 2-3 lists the channel assignments for a system with two LT19s, containing up to 10 channels.

## Table 2-3
### Channel Assignments for Two LT19s

| Unit No. | Transmitter Code | Receiver Code | Logical Unit No. |
|---|---|---|---|
| LT19 #1 | | | |
| 1 | xx400x | xx410x | 1 |
| 2 | xx402x | xx414x | 2 |
| 3 | xx404x | xx414x | 3 |
| 4 | xx406x | xx416x | 4 |
| 5 | xx440x | xx450x | 11 |
| LT19 #2 | | | |
| 1 | xx420x | xx430x | 5 |
| 2 | xx422x | xx432x | 6 |
| 3 | xx424x | xx434x | 7 |
| 4 | xx426x | xx436x | 10 |
| 5 | xx442x | xx452x | 12 |

Table 2-4 lists the channel assignments for a system with three LT19s, containing up to 15 channels.

## Table 2-4
### Channel Assignments for Three LT19s

| Unit No. | Transmitter Code | Receiver Code | Logical Unit No. |
|---|---|---|---|
| LT19 #1 | | | |
| 1 | xx400x | xx410x | 1 |
| 2 | xx402x | xx412x | 2 |
| 3 | xx404x | xx414x | 3 |
| 4 | xx406x | xx416x | 4 |
| 5 | xx460x | xx470x | 15 |
| LT19 #2 | | | |
| 1 | xx420x | xx430x | 5 |
| 2 | xx422x | xx432x | 6 |
| 3 | xx424x | xx434x | 7 |
| 4 | xx426x | xx436x | 10 |
| 5 | xx462x | xx472x | 16 |
| LT19 #3 | | | |
| 1 | xx440x | xx450x | 11 |
| 2 | xx442x | xx452x | 12 |
| 3 | xx444x | xx454x | 13 |
| 4 | xx446x | xx456x | 14 |
| 5 | xx464x | xx474x | 17 |

For a system containing four LT19s, the channel assignments for the first three LT19 units would be the same as listed in Table 2-4. Table 2-5 lists the channel assignment for the single channel serviced by the fourth LT19.

Table 2-5
Channel Assignment for Fourth LT19

| Unit No. | Transmitter Code | Receiver Code | Logical Unit No. |
|----------|------------------|---------------|------------------|
| 1 | Not Used | Not Used | - |
| 2 | Not Used | Not Used | - |
| 3 | Not Used | Not Used | - |
| 4 | Not Used | Not Used | - |
| 5 | xx466x | xx476x | 20 |

## 2.6  INSTALLATION CHECKOUT

### 2.6.1  LT19D Tests

Test each LT19 unit using program tape MAINDEC-09-D8CC-PH or -15-D8CA-PH and test procedure MAINDEC-09-D8CC-D or -15-D8CA-D under normal +10V and -15V margins.

### 2.6.2  LT19F Tests

The LT19F EIA-level converters are intended to drive a Dataset cable or an LT19H option. To simulate the cable and perform test procedures, add the following temporary jumpers to slot A25, A26, A27, A28 or A29:

> Jumper pin S to H
> Jumper pin T to V
> Jumper pin E to P (output-to-input jumper)

Then run the appropriate sections of diagnostic -09-D8CC or -15-D8CA. Remove temporary jumpers on completion of test procedure.

### 2.6.3  LT19H Test

The LT19H test procedure consists of two parts. Part 1 is to run the LT19F tests described in Paragraph 2.6.2, with the LT19H option installed. Perform part 2 as follows:

| Step | Procedure |
|------|-----------|
| 1 | Insert one end of the LT19H cable into the appropriate output slot for the channel under test. |

| Step | Procedure |
|------|-----------|
| 2 | Insert the opposite end into the unused slot A32. |
| 3 | Remove the jumper between pins E and P and install between pins A32E and P. |
| 4 | Repeat test described in Paragraph 2.6.2. |

### 2.6.4 LT19H System Verification

Verify the LT19H system in the field as follows:

| Step | Procedure |
|------|-----------|
| 1 | Perform the checkout procedure described in Paragraph 2.6.2. |
| 2 | Check the opposite terminal on the data communications link. This may be another LT19 or a PT08-F. Use MAINDEC-08-D8PA if it is the latter. |
| 3 | Verify that the baud rates are identical. Then connect the LT19H cable into both terminals of the data communications link. |
| 4 | Load the most recent version of the LT19 diagnostic program into the PDP-9/15. |
| 5 | Instead of adding the output-to-input jumper, use a "turnaround" program in each processor. |

a. A sample PDP-8 turnaround program is as follows:

| LOC | Content | Comment |
|-----|---------|---------|
| 20 | 6401 | Skip on R flag |
| 21 | 5020 | JMP.-1 |
| 22 | 6406 | Read IOT |
| 23 | 3040 | DCA 40 |
| 24 | 1040 | TAD 40 |
| 25 | 7000 | NOP |
| 26 | 6416 | XMIT |
| 27 | 5020 | JMP 20 |

b. A sample PDP-9/15 turnaround program is as follows:

| LOC | Content | Comment |
|-----|---------|---------|
| 200 | 704101 | Skip on R flag |
| 201 | 600200 | JMP.-1 |
| 202 | 704112 | Read |
| 203 | 740000 | NOP |
| 204 | 704006 | XMIT |
| 205 | 600200 | JMP 200 |

| Step | Procedure |
| --- | --- |

NOTE

Both sample turnaround programs assume channel 1. Revise IOT codes as required for each specific channel.

6    Check the channel as described in Paragraph 2.6.2.

# CHAPTER 3
# PRINCIPLES OF OPERATION

The LT19 system performs two types of programmed-controlled operations during which data is transferred between a processor and a Teletype or EIA device (for example, dataphone interface). A transmit operation is performed to transfer data from a processor to a teleprinter (or EIA device) and a receive operation is performed to transfer data from a Teletype keyboard (paper tape reader or EIA device) to a processor.

## 3.1 BLOCK DIAGRAM DESCRIPTION

Figure 3-1, a detailed block diagram of the LT19 system, shows the LT19A and LT19B-1 control unit (one of the LT19B units). the other four LT19B units (LT19B-2 through LT19B-5) are connected to the LT19A in a similar fashion and operate in a similar manner. The LT19B-1 receives data from the Teletype keyboard via the TSO (Teletype Serial Output) line and sends data to the teleprinter via the PSM (Print Selector Magnet) line. A signal sent to the Teletype over the RRE (Reader Run Enable) line advances the paper tape reader if the Teletype is equipped with a relay controlled paper tape reader. To communicate with an EIA-level operated device instead of a Teletype, EIA-level converters which change DEC standard logic levels to EIA levels are added to the control unit. The control unit is then designated LT19C.

The transmit and receive IOT decoders are used to decode the signals on the device select, subdevice, and IOP lines and to generate the required control signals. The control signals are sent to the transmitter and receiver modules and the IOT control register. The control register consists of three flip-flops which are set to perform LT19 control functions. The flip-flops within the register are cleared by either the CLR IOT 1 CONTROL or CLR IOT 2 CONTROL signal. These signals are initiated by an IOP1 or IOP2 pulse, respectively. They are also generated during initial processor turn-on by the IO PWR CLR signal or whenever the IO SYNC signal is generated. Output signals from the IOT control register generate a SKIP RQ, RD RQ, or initiate a receive operation.

LT19 system operation can be controlled via the Program Interrupt Enable (PIE) facility or the Automatic Priority Interrupt (API) facility. In the description of the transmit or receive operations, both types of operation are discussed.
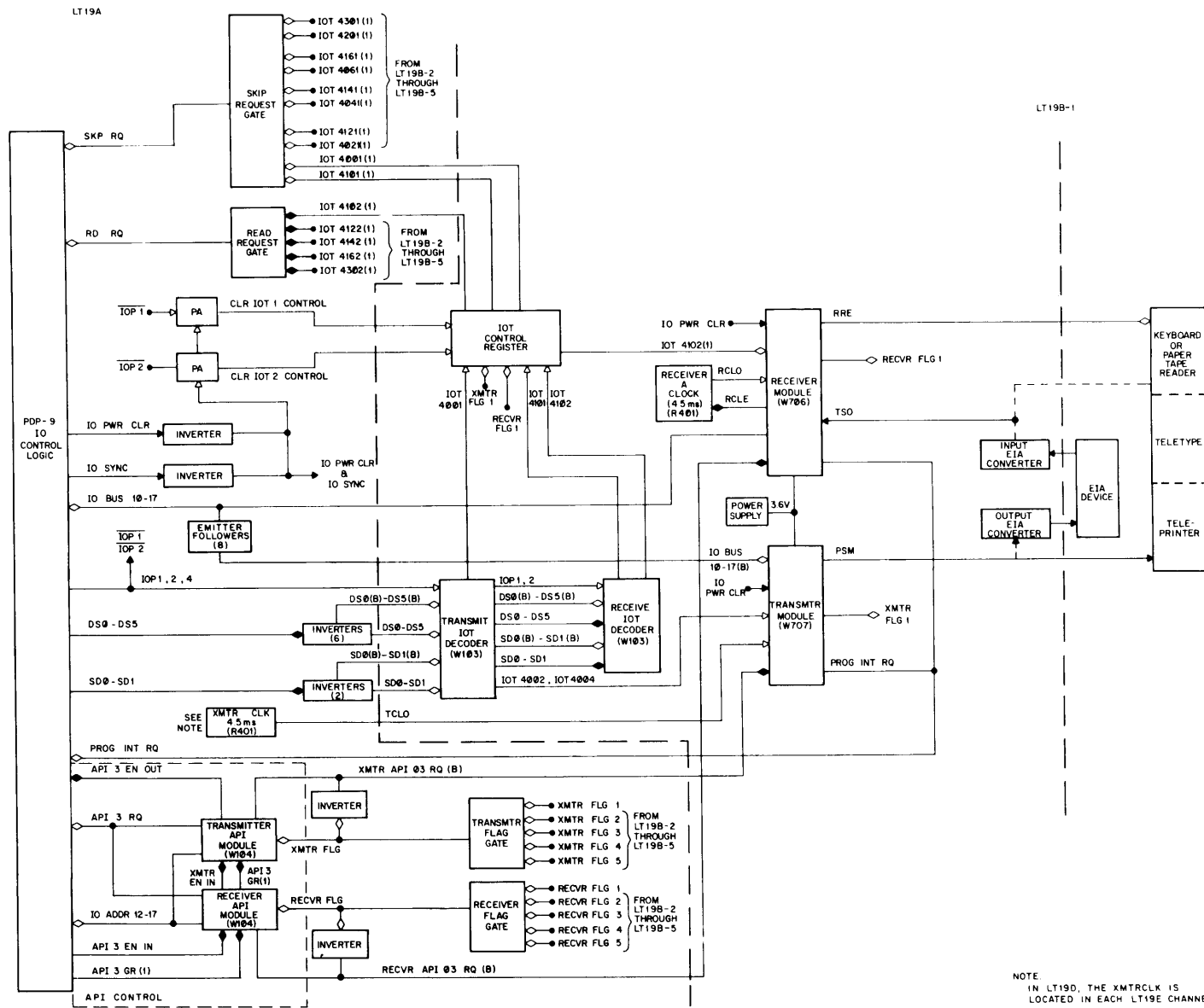
Figure 3-1  LT19 Detailed Block Diagram

### 3.1.1 Transmit Operation

The transmit operation is performed to print a single character on the teleprinter. An IOT 704004 instruction is used to initiate a character print on the teleprinter connected to LT19B-1. Prior to executing the instruction, the 8-bit code of the character is placed in bits 10 through 17 of the accumulator (AC) (bits 13 through 17 for 5-bit character codes). During the execution of the instruction, the contents of the AC are present on the I/O bus. The signals on the IO BUS 10 through 17 lines are applied to emitter followers and the resultant signals are sent to the transmitter module (W707).

The device code for the IOT 704004 instruction is decoded by the transmit IOT decoder (W103 module) and the IOP4 pulse produces the IOT 4004 pulse. The IOT 4004 pulse strobes the signals on the IOB 10 (B) through 17 (B) lines into the transmitter module shift register and the module shifts the character to the teleprinter in a serial fashion via the PSM line. The rate of transfer is determined by the TCLO clock pulse from the LT19A.

After the transfer is complete, a stop signal is placed on the PSM line, the transmitter flag is set generating the XMTR FLG 1 signal. The XMTR FLG 1 signal is sent to the transmitter flag gate generating the XMTR FLG signal. The XMTR FLG signal conditions the transmitter API module, generating the API 3 RQ that is sent to the processor (if a receiver flag is also raised, the receiver has a higher priority and the XMTR EN IN signal disables the transmitter API module).

The processor detects the request and sends the API 3 GR (1) signal to the transmitter API module in the LT19 order of priority. The API 3 GR (1) signal enables the transmitter API module sending a preset address to the processor via the IO ADDR 12 through 17 lines and the program executes the preset location. In this case, the program executes location $74_8$. The processor performs a series of IOT instructions which checks for a raised transmitter flag because the API has identified a transmitter interrupt. When the IOT 704001 instruction is executed, the IOT 4001 signal is ANDed with the XMTR FLG 1 signal generating the IOT 4001 (1) signal. The skip request gate is enabled and the SKP RQ is generated indicating that the next character can be sent.

If API is not used in a particular system, the PIE facility of the processor must be turned on to generate a program interrupt. In this case, the XMTR FLG signal is inverted generating the XMTR API 03 RQ (B) signal that is sent to the transmitter module. The PROG INT RQ is generated and sent to the processor. After detecting the PROG INT RQ, the PDP-9 enters a routine to check all its I/O devices for a raised flag. When the processor executes an IOT 704001 instruction, the skip request gate is enabled and the SKP RQ is generated and sent to the processor.

The SKP RQ causes program control to be transferred to a service routine and the next character is sent and an IOT 704004 is performed. If the processor does not have additional data for the transmitter module, it can clear the transmitter flag and remove the XMTR FLG 1 signal by performing an IOT 704002 instruction.

The XMTR FLG 1 signal removes the XMTR FLG signal when the IOT 704002 instruction is performed if the XMTR FLG 2 through XMTR FLG 5 signals from the other LT19B (or LT19C) units are not present. If one or more of these signals is present, the API 3 RQ is generated and/or PROG INT RQ remains in the true condition. The processor must enter the appropriate checking routine to locate the raised flag and perform the necessary service routine.

## 3.1.2 Receive Operation

The receiver operation is performed when the shift register in the receiver module is loaded via the TSO line. It can be initiated in one of the following ways: a Teletype key is pressed, a paper tape reader is enabled sending out a character, or an EIA device is enabled.

When a receive operation is initiated, a start bit appears on the TSO line, it is followed by the serial word bits and triggers the W706 receiver module.

The presence of data on the TSO line causes the RCLE signal to enable the receiver 1 clock. The RCLO signals are generated and sent to the receiver module loading the serial data into the shift register of the module. After the last data bit is loaded, the receiver flag is set and the RECVR FLG 1 signal is generated. The RECVR FLG 1 signal is used to generate the API 3 RQ, if API is used, and the PROG INT RQ. These signals perform functions that are similar to the functions explained in the transmit operation with the following differences: the receiver API module causes a program execute of location $75_8$ when it receives the API 3 GR(1) signal from the PDP-9; the PDP-9 enters a subroutine which checks for the raised receiver flag; if the PIE facility is in use instead of API, the PDP-9 must check all of its I/O devices for a raised flag.

When the IOT 704101 instruction is performed, a SKP RQ is generated by ANDing the RECVR FLG 1 and IOT 4101 signals which generate the IOT 4101 (1) signal. The PDP-9 detects the SKP RQ and transfers program control to a service routine.

To fetch the data from the receiver module, the PDP-9 performs an IOT 704102 instruction and the receiver IOT decoder generates the IOT 4102 pulse. The IOT 4102 pulse is sent to the IOT control register generating the IOT 4102 (1) signal. The IOT 4102 (1) signal enables the read request gate generating the RD RQ that enables the PDP-9 AC to accept data, transfers the data to the PDP-9 in parallel form via the IO BUS 10 through 17 lines, and removes the RECVR FLG 1 signal by clearing the receiver module flag. The API 3 RQ and/or PROG INT RQ are also removed if all RECVR FLG and XMTR FLG signals from the other LT19B (LT19C) unit are cleared.

## 3.2 DETAILED TRANSMIT OPERATION

Figure 3-2 shows the timing sequence of a transmit operation within the LT19B-1. Engineering drawings A-1, A-2 and B-1 are used as a reference during the following discussion.
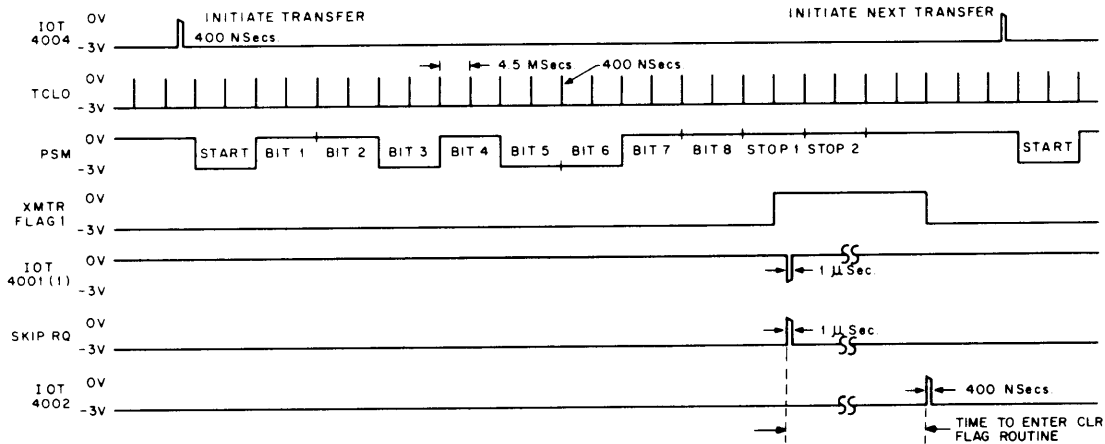


Figure 3-2  Transmit Operation Timing Diagram

During initial processor turn-on, the IO PWR CLR pulse generates the CLR IOT 1 CONTROL and CLR IOT 2 CONTROL pulses (drawing A-1) clearing the IOT control register flip-flops (B-1). The IO PWR CLR pulse also clears the transmitter module (W707 - CD15) and the transmitter API module (W104 - CD32).

The PDP-9 gates the character to be transferred into its AC register and onto the IO BUS 10 through 17 lines. The signals are buffered by inverters and applied to the parallel data inputs of the transmitter module. To initiate the transfer, the PDP-9 executes an IOT 704004 instruction that is decoded by the transmitter IOT decoder (W103 - CD16) generating the IOT 4004 pulse. The IOT 4004 pulse is applied to the transmitter module gating the data into the shift register of the transmitter module. At this time, the transmitter module is enabled to transfer the character in a serial fashion to the teleprinter via the PSM line. Shifting commences with the first TCLO pulse following the IOT 4004 pulse. The TCLO pulse is a 400 ns pulse generated by the XMTR clock (R401 - D09) every 4.5 ms. The frequency of the TCLO pulse is twice the baud rate which allows for sampling each bit during the middle of the bit time.

The first bit on the PSM line is a START bit which synchronizes operation between the Teletype and the LT19. Bit 1, which corresponds to the original information on the IO BUS 17 (B) line, is sent to the teleprinter via the PSM line and bits 2 through 8 are shifted out in a similar manner. Jumper connections on the W707 transmitter module allow selection of either an 8-bit or 5-bit code and either a 1.0, 1.5 or 2.0 unit stop code.

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As data is shifted out of the register, binary 0s are shifted into the other end of the register. When the register contains all 0s (after bit 8 is sampled), transfer of the character is complete and the transmitter module generates a STOP bit(s) that is sent to the teleprinter via the PSM line.

One-half unit after the STOP bit is placed on the PSM line, the XMTR FLG 1 signal is generated and either the API or PIE facility is enabled. The operation of the PIE facility is described first.

The XMTR FLG 1 signal is sent to a NOR gate (drawing A-1) generating the XMTR FLG signal that is inverted generating the XMTR API 03 RQ (B) signal. The XMTR API 03 RQ (B) signal is applied to the CV terminal of the W707 module and causes the PROG INT RQ line to go to 0V. After receiving the PROG INT RQ, the PDP-9 enters a subroutine to check all its I/O devices for the raised flag. When an IOT 704001 instruction is performed, the transmitter IOT decoder generates the IOT 4001 pulse that is applied to the DCD gate at the set side of the IOT 4001 flip-flop (drawing B-1). Since the XMTR FLG 1 signal has conditioned the DCD gate, the IOT 4001 flip-flop is set. The IOT 4001 (1) output signal from the flip-flop is applied to a NOR gate generating a SKP RQ (drawing A-1) and causing the PDP-9 to jump to a service routine. The IOT 4001 flip-flop is cleared by the CLR IOT 1 CONTROL pulse that is generated by the $\overline{IOP1}$ signal.

For API, the XMTR FLG signal enables the transmitter API module (drawing A-2) sending an API 3 RQ signal to the PDP-9 (assuming no receiver flag is set). The PDP-9 services the interrupt request by sending the API 3 GR (1) signal to the transmitter API module in the LT19 order of priority. A $74_8$ address is sent to the PDP-9 via the IO ADDR 12 through 15 lines. The program executes this location and enters a routine which checks the LT19 transmitter flags. An IOT 704001 instruction causes a SKP RQ to be generated and program control is transferred to a service routine.

At this time, the PDP-9 can send the next character by executing an IOT 704004 instruction. If it does not have additional data for this teleprinter, it clears the XMTR FLG 1 signal by performing an IOT 704002 instruction.

The transmit operation of the other four LT19B (or LT19C) units takes place in a manner that is similar to the LT19B-1. The main difference between the units is in the transmitter IOT decoders which are coded for their specific codes.


## 3.3   DETAILED RECEIVE OPERATION

Figure 3-3 shows the timing sequence of the serial input from a paper tape reader. The tape is placed into the reader and the START lever is pressed. The paper tape is advanced one line, the content of the line is read and shifted to the receiver module (W706 - CD18) in a serial fashion via the TSO line (the TSO line also carries the data from the keyboard or EIA device).

The first bit on the TSO line is a START pulse that causes the RCLE pulse to go to -3V enabling the CLK module (R401 - D19). The CLK module generates the 400 ns RCLO pulses at a 4.5 ms rate to synchronize the incoming signals on the TSO line and load the character bits into the shift register of the receiver module. After all character bits have been loaded, the receiver module flag is set and the RECVR FLG 1 signal is generated.
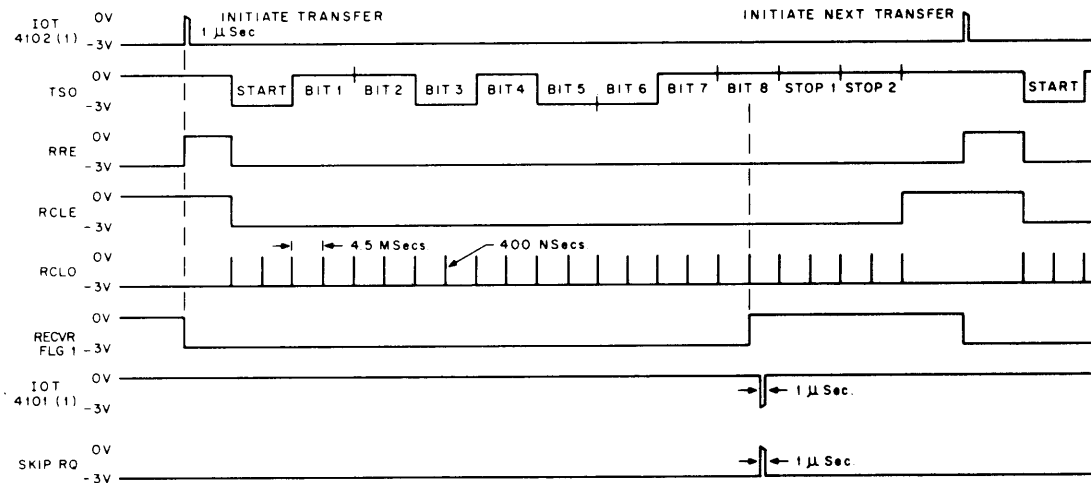


Figure 3-3   Read Operation Timing Diagram

The function performed by the RECVR FLG 1 signal is dependent upon which interrupt facility is in use. If the PIE facility is used, a RECVR FLG 1 signal is applied to a NOR gate (drawing A-1) generating the RECVR FLG signal. The RECVR FLG signal is inverted generating the RECVR API 03 RQ (B) signal (drawing A-2) which enables the receiver module to generate a PROG INT RQ. After detecting the PROG INT RQ, the PDP-9 enters a subroutine to check all I/O devices. When an IOT 704101 instruction is performed, the receiver IOT decoder (W103 - CD17) generates the IOT 4101 pulse that enables the DCD gate at the set side of the IOT 4101 flip-flop. Since the RECVR FLG 1 signal has conditioned the DCD gate, the IOT 4101 flip-flop is set and the IOT 4101 (1) signal is generated. The IOT 4101 (1) signal from the flip-flop is applied to a NOR gate (drawing A-1) generating a SKP RQ that causes the program to enter a service routine. Flip-flop IOT 4101 is cleared when the IOP1 signal goes true generating the CLR IOT 1 CONTROL pulse.

With API, the RECVR FLG signal enables the receiver API module (W104 - CD31) if the API 3 EN IN line is at -3V (drawing A-2) and sends the API 3 RQ signal to the PDP-9. The PDP-9 returns the API 3 GR (1) signal to the receiver API module in the LT19 order of priority. The API 3 GR (1) signal enables the receiver API module sending a $75_8$ address to the PDP-9 via the IO ADDR 12 through 17 lines. The program executes location $75_8$ and enters a routine that checks the receiver flags. When the IOT 704101 instruction is performed, the SKP RQ is generated causing the program to enter a service routine.

After detecting a service requirement, the PDP-9 executes an IOT 704102 instruction and the receiver IOT decoder generates the IOT 4102 pulse setting the IOT 4102 flip-flop. The IOT 4102 (1) signal performs the following functions: it is sent to the read request gate (drawing A-1) generating the RD RQ that goes to the PDP-9 and enables its AC to receive the data from the receiver module; it is applied to the DT terminal of the receiver module gating the data in the shift register onto the IO BUS 10 through 17 lines (if an 8-bit character is read); it is applied to the CD terminal of the receiver module clearing the RECVR FLG 1 signal; and it causes the receiver module to generate the RRE pulse that advances the paper tape to the next line. The IOT 4102 flip-flop is cleared by the $\overline{IOP2}$ signal generating the CLR IOT 2 CONTROL pulse. The next receive operation is performed in an identical manner.

The receive operation of the other four LT19B (or LT19C) units is similar except that the receiver IOT decoders are coded for the specific codes.

# CHAPTER 4
# MAINTENANCE

## 4.1  GENERAL MAINTENANCE

The general maintenance practices described in the PDP-9 Maintenance Manual also apply to the LT19 System.  No special data formats, status bits, programming considerations, operator control or indicators are required for the LT19.

With the assumption that the processor is operating properly, faults within the LT19 system will be detected by the LT19 diagnostic program.  This program determines which Teletype, EIA device, or control unit is at fault by error halts.  Because of the simplicity of the system, most faults can be localized to a few modules.  Defective modules are replaced by spares to restore proper operation while the defective module is repaired.  Table 4-1 lists recommended spare modules.

Table 4-1
Recommended Spare Modules

| Unit | Modules |
|------|---------|
| LT19A/D | S123 Input Bus Gate<br>S603 Pulse Amplifier<br>S107 Inverter<br>W107 Bus Driver<br>W104 I/O Bus Multiplexer |
| LT19B/E | R401 Variable Clock<br>S203 Triple Flip-Flop<br>W005 Clamped Load<br>W078 Teletype Connector<br>W103 Device Selector |
| LT19C/F | W511 Negative Input Converter<br>W602 Bipolar Output Converter<br>(plus modules listed for LT19B/E) |

## 4.2  LT19E CLOCK ADJUSTMENTS

The following steps are recommended to set up clocks for each channel:

| Step | Procedure |
|------|-----------|
| 1 | Setup and adjust the free-running transmit clock first. Baud rate selection data is presented in Paragraph 2.4. |
| 2 | Remove the W706 Receiver module to allow the receive clock to run free. Set the oscilloscope to ALTERNATE Sweep, INT. Trigger. Do not trigger on CH1; this will allow the pulses from the receive clock to be matched to the transmit clock. |

NOTE

For 110-baud channels, each data bit is 9.09 ms duration, which requires an R401 Clock to be set for 4.545 ms. Each character has 11 bits of 9.09 ms, so that character duration is 100 ms. Because it is difficult to measure a clock interval of 4.545 ms, set up to measure an entire character of 100 ms. The oscilloscope calibration can be checked by displaying six complete cycles of 60 Hz in exactly 10 cm. With the oscilloscope calibrated to 100 ms, fine-tune the R401 to provide 23 clock pulses in 10 cm (22 clock pulses plus the first pulse of the next character).

## 4.3 ENGINEERING DRAWINGS

A complete set of LT19 Multi-Station Teletype Control engineering drawings is provided in Volume 2 of this manual. The drawings are under DEC revision control and are updated as required by ECOs (Engineering Change Orders). The Drawing Index List, Table 4-2, lists the drawings included in Volume 2 in the sequence that they appear.

Table 4-2
LT19 Multi-Station Teletype Control Drawing Index List

| Size | Type | Number | Title |
|------|------|--------|-------|
| | | | LT19D |
| C | UA | LT19-D-0 | Teletype Control, Unit Assembly |
| A | PL | LT19-D-0 | Teletype Control, Parts List |
| D | BS | LT19-D-1 | I/O Bus Interface Logic |
| D | BS | LT19-D-2 | I/O Bus Interface |
| D | MU | LT19-D-3 | Module Utilization |
| | | | LT19E |
| D | BS | LT19-E-1 | Teletype Control Unit Channel 1 |
| D | BS | LT19-E-2 | Teletype Control Unit Channel 2 |

| Size | Type | Number | Title |
|------|------|--------|-------|
| LT19E (Cont) | | | |
| D | BS | LT19-E-3 | Teletype Control Unit Channel 3 |
| D | BS | LT19-E-4 | Teletype Control Unit Channel 4 |
| D | BS | LT19-E-5 | Teletype Control Unit Channel 5 |
| LT19F | | | |
| D | BS | LT19-F-1 | Teletype Control Unit Channel 1 |
| D | BS | LT19-F-2 | Teletype Control Unit Channel 2 |
| D | BS | LT19-F-3 | Teletype Control Unit Channel 3 |
| D | BS | LT19-F-4 | Teletype Control Unit Channel 4 |
| D | BS | LT19-F-5 | Teletype Control Unit Channel 5 |
| LT19H | | | |
| C | IA | 7005891-0-0 | Data Communications Cable |
| Module Circuit Schematics | | | |
| B | CS | R401-0-1 | R401 Variable Clock |
| B | CS | S107-0-1 | S107 Inverter |
| B | CS | S123-0-1 | S123 Diode Gate |
| B | CS | S203-0-1 | S203 Triple Flip-Flop |
| B | CS | S603-0-1 | S603 Pulse Amplifier |
| B | CS | W005-0-1 | W005 Clamped Loads |
| B | CS | W078-0-1 | W078 Teletype Connector |
| C | CS | W103-0-1 | W103 Device Selector |
| D | CS | W104-0-1 | W104 I/O Bus Multiplexer Control |
| B | CS | W107-0-1 | W107 I/O Bus Receiver Circuit |
| B | CS | W511-0-1 | W511 Negative Level Converter |
| C | CS | W602-0-1 | W602 Bi-polar Level Amplifier |
| B | CS | W705-0-1 | W705 +3.6V Integrated Circuit Power Supply |
| C | CS | W706-0-1 | W706 Teletype Receiver |
| C | CS | W707-0-1 | W707 Teletype Transmitter |

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