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LC11
DECwriter system manual

digital

DEC-11-HLCA-D

LC11
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CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

The LC11 DECwriter System is a high-speed teletypewriter system designed to interface with the PDP-11 family of processors to provide both input (keyboard) and output (printer) functions for the system. The system can receive characters from the keyboard or can print at speeds up to 30 characters per second in standard ASCII formats. The LC11 System consists of two distinct components: an LA30 DECwriter and a DEC PDP-11 interface unit, which is referred to as the LC11 Controller.

LA30 DECwriter — A dot matrix impact printer and keyboard for use as a full-scale hard copy I/O terminal teletypewriter.

Keyboard is either 96 or 128 characters. Print set is 64 ASCII characters, 80 characters per line, 10 characters per inch.

LC11 Controller — An interface between the DECwriter and the PDP-11 Unibus. Controls data transfers between the DECwriter and other devices in a PDP-11 System. Also monitors printer status, indicates when the keyboard buffer is full, and enables the interrupt logic.

Also referred to as "control unit", "interface", and "DECwriter control".

1.2 SCOPE

This manual provides the user with the information necessary to operate the LC11 DECwriter System and provides the theory of operation and logic diagrams necessary to understand and maintain the LC11 Controller.

This manual and the appropriate LA30 DECwriter manual must be used together for a complete understanding of the entire LC11 System. The prime subject of this manual is the LC11 Controller. In addition to providing complete coverage of the controller, this manual includes sections covering overall system operation and programming.

The prime subject of the LA30 DECwriter Manual (DEC-00-LA30-DA) is the teletypewriter itself. The manual presents a detailed discussion of the print mechanism and electronics including installation, operation, principles of operation, maintenance, troubleshooting, and engineering drawings.

Table 1-1 lists related PDP-11 System documents that are applicable to the LC11 DECwriter System.

Table 1-1
Applicable Documents

Title	Number	Coverage
Unibus Interface Manual, Second Edition	DEC-11-HIAB-D	Provides detailed theory, flow, and logic descriptions of the Unibus and external device logic. Includes detailed discussions of the following modules used in the LC11 Controller: M105 Address Selector M782 Interrupt Control
PDP-11/20 System* (7-volume series)	DEC-11-HR1B-D through DEC-11-HR7B-D	Provides detailed theory of operation, flow, logic diagrams, operation, installation, and maintenance for components of the PDP-11 System including processor, memory, console, and power supply.
PDP-11 Handbook	Second Edition, 1970	A general handbook that provides discussions of addressing modes, the overall PDP-11 System, and the basic instruction set from a programming point of view. Includes some installation and interface information.
Logic Handbook	DEC, 1971	Presents functions and specifications of the M-series logic modules, accessories, and connectors used in the controller. Includes other types of logic produced by DEC but not used with PDP-11 devices.
Paper-Tape Software Programming Handbook	DEC-11-GGPB-D	Provides a detailed discussion of the PDP-11 software system used to load, dump, edit, assemble, and debug PDP-11 programs; input/output programming; and the floating point and math package.

*Applicable PDP-11/15 manuals provide system coverage on PDP-11/15 Systems.

1.3 SPECIFICATIONS

Operating and physical specifications for the LC11 Controller are given in Table 1-2. Specifications for the LA30 DECwriter are given in Table 1-3.

Table 1-2
LC11 Controller Specifications

Registers:	Keyboard Status Register (KBS) Keyboard Buffer Register (KBB) Printer Status Register (PRS) Printer Buffer Register (PRB)
Register Addresses:	KBS 777560 (when used as console) KBB 777562 PRS 777564 PRB 777566
Data type:	7-bit parallel character in ASCII code
Interrupts:	Priority = BR4 (keyboard slightly higher level than printer because electrically closer to processor) Vectors = location 60 for keyboard (when used as location 64 for printer console) Types = DONE (keyboard has loaded buffer) READY (printer ready to receive data)
Bus Cycles:	DATI or DATOB
Status Indications:	DONE, READY, and ID (interrupt enable)
Size:	The LC11 Controller occupies ¼ of a DD11-A or one of two controller slots in a KA11 or KC11 Processor System Unit.
Power:	0.25A @+5V (derived from H720 Power Supply in mounting box where controller is installed)
Cable:	25 feet 17 twisted pairs (TTL compatible parallel) plus one spare pair

Table 1-3
LA30 DECwriter Specifications

Printing Speed:	30 characters/second, asynchronous 300 ms carriage return 30 line feeds/second
Print Characters:	64 upper case ASCII subset (lower case codes print in upper case)
Print Format:	5x7 dot matrix typeface 80 characters/line 10 characters/inch 6 lines/inch
Paper:	9 and 7/8 inch wide tractor driven continuous form original plus one carbon (can be adjusted for up to 6 copies)
Ribbon:	nylon, ½ inch by 120 feet
Keyboard:	96 characters (normal) 128 characters (optional) USASCII 1968 characters
Dimensions:	20½ inches wide 31 inches high 24 inches deep
Weight:	110 pounds
DC Power:	self-contained
Power Input:	300 watts, maximum voltage and frequency dependent on model: LA30 PA 115V/60Hz LA30 PB 230V/60Hz LA30 PC 115V/50Hz LA30 PD 230V/50Hz
Temperature:	50°F to 130°F
Humidity:	5% to 90% (non-condensing)

1.4 MAINTENANCE

The basic maintenance philosophy of the LC11 DECwriter System is to present the user with the information necessary to understand normal operation of the system. The user can use this information when analyzing trouble symptoms to determine necessary corrective action. It is beyond the scope of this manual to present detailed trouble-shooting information.

General PDP-11 maintenance information is presented in the PDP-11 Conventions Manual, DEC-11-HR6B-D as well as in the KA11 Processor Manual, DEC-11-HR2B-D and the KC11 Processor Manual, DEC-11-HKCA-D. Detailed maintenance and trouble-shooting information for the DECwriter itself is included in the LA30 DECwriter Manual DEC-00-LA30-DA.

1.5 ENGINEERING DRAWINGS

A complete set of reduced engineering drawings and module circuit schematics is provided in a companion volume to this manual which is entitled, LC11 DECwriter System, Engineering Drawings. The general logic symbols used on these drawings are described in the DEC Logic Handbook, 1971. Specific symbols and conventions are also included in the PDP-11 Conventions Manual, DEC-11-HR6B-D.

1.6 TERMINOLOGY

The PDP-11 Conventions Manual, DEC-11-HR6B-D, contains a list of terminology and abbreviations used with the PDP-11 family of systems. A glossary of PDP-11 terms, as well as general computer and programming terms, is also included.

CHAPTER 2
GENERAL DESCRIPTION

2.1 INTRODUCTION

The LA30 DECwriter serves as an input (keyboard) and output (page-printer) device for PDP-11 Systems. The LC11 Controller is an interface that handles parallel data transfers between the DECwriter and the PDP-11 Unibus. The controller consists of three integrated circuit modules mounted on one-fourth of a system unit (slots 13 or 14 in the DD11-A Peripheral Mounting Panel). Thus, four DECwriter control interfaces can be mounted in the space of a single system unit.

2.2 DECWRITER

The LA30 DECwriter is a dot matrix impact printer and keyboard designed for use as a full-scale hard copy I/O terminal teletypewriter. The DECwriter operates at a speed of up to 30 characters per second and prints on a continuous form paper. There are four models available (refer to Table 2-1). The prime difference among models is the input power requirement.

Table 2-1
DECwriter Models

Model No.	Voltage	Frequency
LA30-PA	115 Vac	60 Hz
LA30-PB	230 Vac	60 Hz
LA30-PC	115 Vac	50 Hz
LA30-PD	230 Vac	50 Hz

The DECwriter keyboard is capable of producing either a 128- or 97-character ASCII subset. The letter keys are in a standard typewriter layout, and the additional printing and non-printing (control) keys are laid out similar to a Teletype keyboard. The keyboard inputs character codes into the interface but does not type directly on the paper unless an echo program is used.

The DECwriter printing head is capable of printing 64 different characters under control of the interface. The printing head is advanced by a stepping motor that is controlled by solid-state logic. Seven spring-loaded wires in the print head are activated by solenoids to impact a standard nylon ribbon in order to form the required character. No special thermal or electrostatic paper is needed and standard 80-column, fanfold paper is used. The DECwriter is normally set for single or two-sheet copy but up to six-part paper can be used by readjusting the impact loading.

Signals transferred between the DECwriter and the LC11 Controller consist of 7-bit character codes and three control signals. All information, regardless of direction of transfer, is transmitted in parallel. No start or stop codes are required. The 7-bit standard ASCII code is used for all printing and non-printing characters. Standard codes for these characters are given in Appendix A.

The DECwriter is a free-standing, pedestal-mounted unit. All operating controls and indicators, with the exception of the power circuit breakers, are mounted on the front of the DECwriter.

2.3 LC11 CONTROLLER

The LC11 Controller handles data one character at a time by means of a program interrupt for parallel transfer to or from the Unibus. When the processor addresses the bus, the LC11 Controller decodes the incoming address to determine if the DECwriter is the selected external device and, if selected, whether it is to perform an input or output operation. For the following discussion, refer to the simplified block diagram shown in Figure 2-1.

The address selector module decodes the incoming address and responds to one of four possible sequential addresses. The register that is selected and the type of bus data transfer operation being performed determine whether a keyboard or printer operation is to be used. If , for example, the DECwriter has been selected to accept information for printout, the controller waits for a READY flag, which indicates the printer is available and is requesting a character from the controller. At this point, the controller strobes a character from the bus into the printer buffer register for transfer to the printer. The READY flag drops during the storage and print operation. The printer READY flag is also used to activate the interrupt control module, provided the module is enabled (ID true). The purpose of this module is to cause a program interrupt by means of a specific vector address.

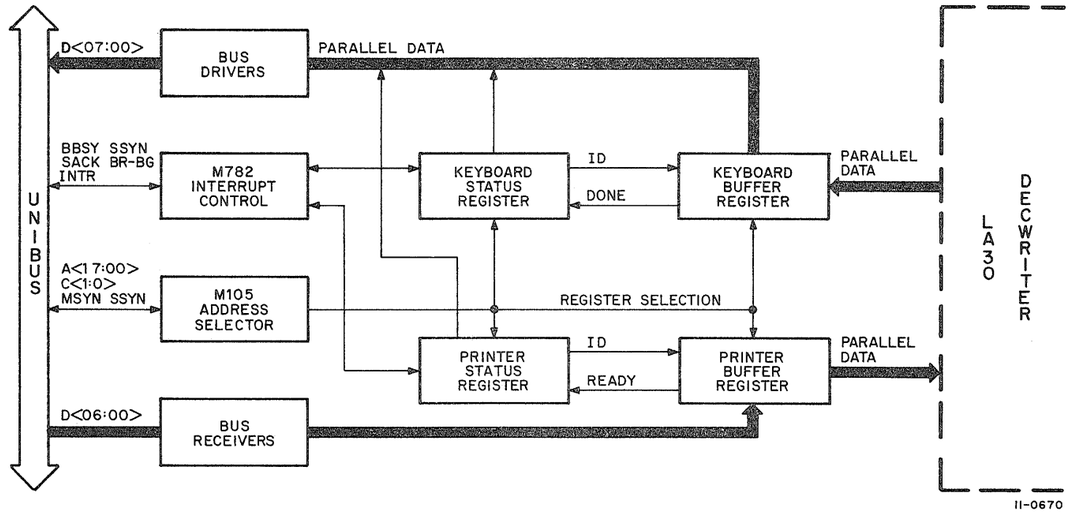


Figure 2-1 LC11 Controller—Simplified Block Diagram

When receiving data from the DECwriter, the operation is essentially the reverse. When the keyboard has assembled a character, it generates a KEY STROBE signal to activate the interface and the 7-bit character is parallel loaded into the keyboard buffer register. When the buffer is loaded, the interface sets a DONE flag, indicating to the program that a character is ready for transfer to the Unibus. The DONE flag activates the interrupt control module (if enabled), thereby causing a vectored interrupt.

The keyboard and printer status registers can be addressed and read by the program to determine the status of the READY flag, DONE flag, and the two interrupt enable (ID) bits.

Although the information transferred between the DECwriter and LC11 Controller is a 7-bit ASCII character, the controller can add an eighth bit to the keyboard character prior to loading the character onto the bus. This additional bit is controlled by jumpers on the LC11.

CHAPTER 3
OPERATION

3.1 INTRODUCTION

This chapter provides the information necessary for normal operation of the LC11 DECwriter System and is divided into three major parts: controls and indicators, keyboard, and paper installation. Additional operating procedures, such as ribbon replacement, calibration, and mechanical adjustments, are covered in the LA30 DECwriter Manual, DEC-00-LA30-DA.

3.2 CONTROLS AND INDICATORS

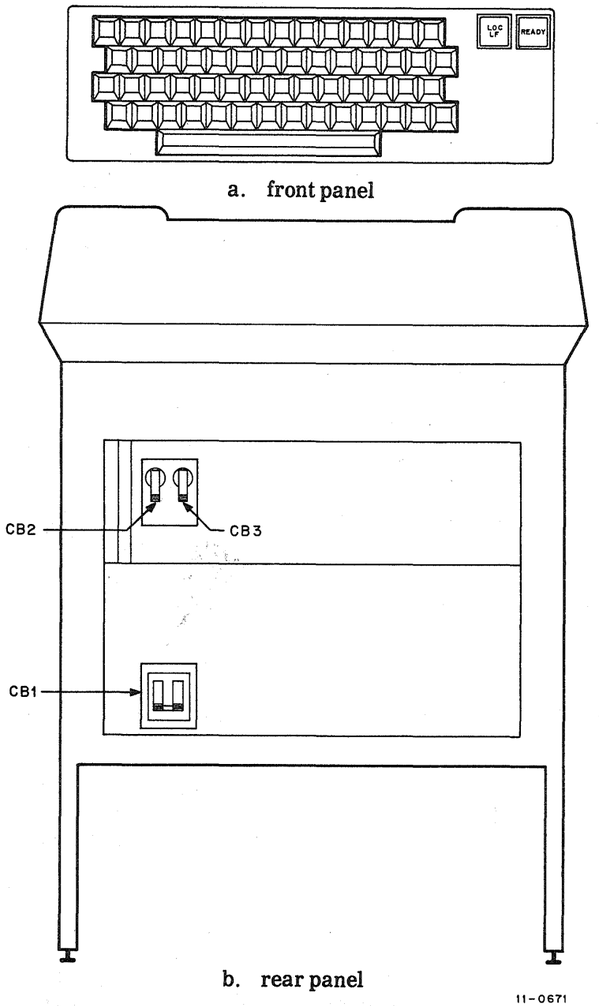
The controls and indicators used to operate the LC11 DECwriter System (with the exception of the keyboard) are shown in Figure 3-1 and listed in Table 3-1. The table lists each control, its location, type, and function.

3.3 KEYBOARD

The following discussion covers only certain operational notes regarding the keyboard. It is beyond the scope of this manual to provide a detailed description of the keyboard. A complete description is given in the LA30 DECwriter Manual, DEC-00-LA30-DA.

The keyboard doestnot type directly into the printer; it simply sends the appropriate ASCII code to the LC11 Controller for transmission to the bus. Therefore, in order to have the keyboard type directly on the paper, it is necessary to use an echo keyboard program. An example of this program is given in Paragraph 4.6. Basically, the controller receives the code from the keyboard and then transmits the same code to the DECwriter printer for printing. A pin on the back plane of the LA30 can set the printer to a maintenance mode that connects the keyboard directly to the printer.

The keyboard can be set to produce either 97 or 128 characters even though the printer is capable of printing only 64 different characters. The additional keyboard characters, however, can be handled by the LC11 Controller for transfer to another device, such as a 96-character line printer. Because many of the additional keyboard characters are actually control commands, an output printing device may have fewer characters than the associated keyboard.



a. front panel

b. rear panel

Figure 3-1 DECwriter Controls and Indicators

Table 3-1
Controls and Indicators

Control or Indicator	Location	Type	Function
READY indicator	front panel	single light (white)	When lit, indicates that power has been applied to the system and the DECwriter is ready for use in either an input (keyboard) or output (printer) mode. If keyboard is being used, indicates an interrupt has been initiated provided ID bit has been set in the controller. When printer is being used, light goes out during print operation to indicate printer cannot receive additional data and keyboard cannot be used until print cycle is complete. Light comes on when printing is completed.
LOC LF switch	front panel	pushbutton switch with indicator	When depressed, advances paper one line. Keyboard and printer operation disabled during line feed. This is an off-line operation and has no effect on the controller.
CB3	rear panel	circuit breaker 2-position toggle switch	When set to on (up) position, applies power to printer head electronics.
CB2	rear panel	circuit breaker 2-position toggle switch	When set to on (up) position, applies power to printer stepping motor electronics.
CB1	rear panel	circuit breaker double-pole, single throw	When set to on (up) position, applies primary power to the DECwriter.

3.4 LOADING PAPER

The proper procedure for loading paper into the LA30 DECwriter is detailed below and shown in Figure 3-2.

Step	Procedure
1	Set main power circuit breaker CB1 to the off (down) position.
2	Open DECwriter cover by pressing up on both sides of front panel.

CAUTION
Release both ball studs from their spring retainers at approximately the same time to avoid skewing and/or damage to the top cover.

Step	Procedure
3	Raise cam lever located on left-hand side of print bar assembly until it disengages. Slide the bar assembly back.
4	Feed paper from its box on the floor under the DECwriter up through the opening in the bottom of the base plate casting. Pull fresh supply into the machine; discard any unused portions of the previous supply.
5	Make certain paper is feeding straight and then engage paper with the sprocket feed wheels.
6	Advance paper by rolling knobs. Make certain paper rolls smoothly.
7	Feed end of paper over lid and close lid, making certain that both ball studs latch to the base assembly.
8	Place circuit breaker CB1 to the on (up) position.

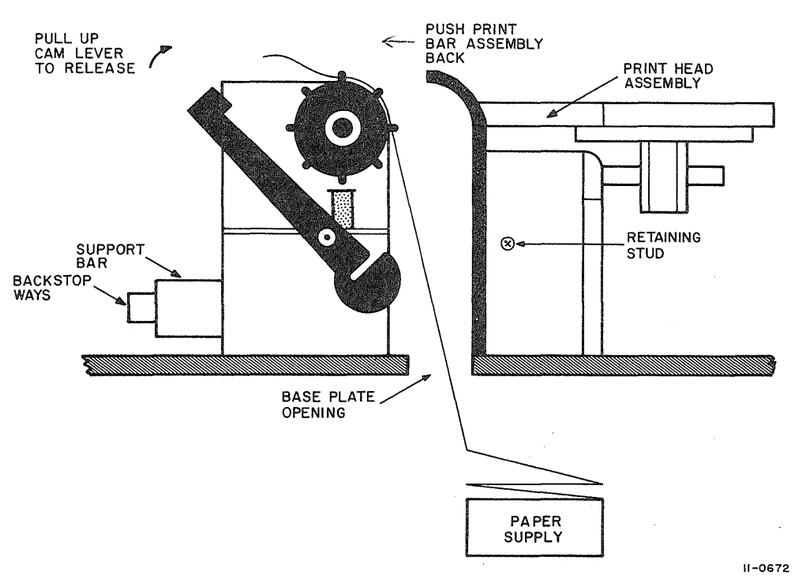


Figure 3-2 Loading Paper into LA30 DECwriter

CHAPTER 4
PROGRAMMING INFORMATION

4.1 SCOPE

This chapter presents general programming information for software control of the LC11 DECwriter Controller. Although a few typical program examples are included, it is beyond the scope of this manual to provide detailed programs. For more detailed information on programming, refer to the Paper-Tape Software Programming Handbook, DEC-11-GGPB-D.

This chapter is divided into four major portions:

a. device registers
b. interrupts
c. timing considerations
d. programming examples

4.2 DEVICE REGISTERS

All software control of the LC11 DECwriter Controller is performed through four device registers. These registers have been assigned memory addresses, and can be read or loaded using any PDP-11 instruction that refers to their address.

The four device registers and associated addresses are listed in Table 4-1. Note that these addresses can be changed by altering the jumpers on the M105 Address Selector Module. However, any DEC programs or other software referring to these addresses must also be modified accordingly if the jumpers are changed.

Figures 4-1 through 4-4 show the bit assignments within the four device registers. The "unused" and "load only" bits are always read as zeros. Loading "unused" or "read only" bits has no effect on the bit position. The mnemonic INIT refers to the initialization signal issued by the processor. Initialization is caused by one of the following: issuing a programmed RESET instruction; depressing the START switch on the processor console; or occurrence of a power-up or power-down condition of the processor power supply.

Table 4-1
Standard Device Register Assignments

Register	Mnemonic	Address
Keyboard Status Register	KBS	777560
Keyboard Buffer Register	KBB	777562
Printer Status Register	PRS	777564
Printer Buffer Reigster	PRB	777566

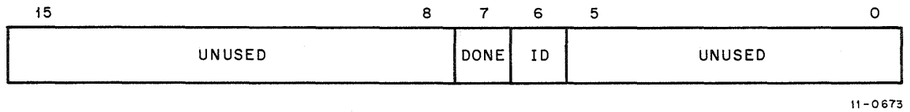


Figure 4-1 Keyboard Status Register — Bit Assignments

Bit	Designation	Meaning and Operation
15-08	Unused	Not Applicable
07	DONE	Indicates that a character is available in keyboard buffer register. Cleared by INIT or by referencing keyboard buffer. Causes interrupt when ID (bit 06) equals 1. Read only.
06	ID	Interrupt enable on DONE. When this bit is set, enables DONE (bit 07) to cause an interrupt. Cleared by INIT.
05-00	Unused	Not Applicable

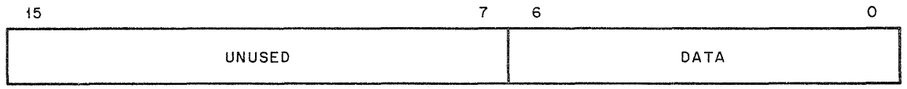


Figure 4-2 Keyboard Data Buffer Register—Bit Assignments

Bit	Designation	Meaning and Operation
15-07	Unused	Note that bit 07 is not offered as parity option with the LA30.
06-00	Data Buffer	7-bit ASCII character buffer. Holds character read in from the LA30 keyboard. Read only. Cannot be loaded from the bus.

NOTE
Any reference to KBB (as word or byte) or to KBB+1, clears DONE in the keyboard status register.

Figure 4-3 Printer Status Register—Bit Assignments

Bit	Designation	Meaning and Operation
15-08	Unused	Not Applicable
07	READY	This bit is set whenever the printer is ready for the next character to be loaded. Indicates that the previous function is either complete or has been started and continued to a point where the printer can accept the next command. This bit is set only by the LC11 Controller. This bit is set when power is applied to the LA30 and cleared by the leading edge of the PRINT STROBE signal, which indicates that the printer has received a command.

Bit	Designation	Meaning and Operation
		Note that the printer sets READY approximately 2 us after it receives a carriage return (CR) command. This permits non-printing characters, such as line feed, to be received during carriage return time. If a printing character is received during carriage return time, READY is cleared and is then set after CR and printing are complete. When set READY causes an interrupt provided ID (bit 06) is set. Read only bit.
06	ID	Interrupt enable bit. When this bit is set, it enables READY (bit 07) to cause an interrupt. Cleared by INIT.
05-00	Unused	Not Applicable

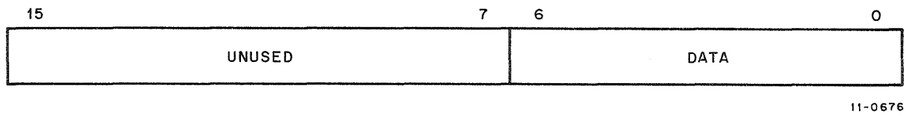


Figure 4-4 Printer Data Buffer Register—Bit Assignments

Bit	Designation	Meaning and Operation
15-07	Unused	Note that bit 07 is not offered as a parity option with the LA30.
06-00		7-bit ASCII character buffer. Transfers data from the Unibus to the LA30 printer. Holds the data strobed in from the bus until the READY bit is set, which indicates that the printer is ready to receive the data. **NOTE** **Any instruction (word or byte) that modifies the printer data buffer clears the READY bit and initiates the print cycle.** Load only.

4.3 INTERRUPTS

The LC11 Controller uses BR interrupts to gain control of the bus in order to perform data transfers. When the processor grants the requestand other Unibus conditions are met, the LC11 gains conrtrol of the bus(becomes bus master) and performs a DATI or DATO to transfer data directlyto or from the Unibus.

When the keyboard DONE flag is set, it activates the interrupt control so that it can notify the processor that a character has been assembled. When the printer READY flag is set, it activates the interrupt control so that it can notify the processor that another character can be loaded into the printer buffer.

The keyboard initiates an interrupt whenever DONE = 1 and ID = 1 both become true. The vector address is 60. The printer initiates an interrupt whenever READY = 1 and ID = 1 both become true. The vector address in this case is 64. The standard priority interrupt level is set at the BR4 level for both the keyboard and the reader. The keyboard has a slightly higher priority because it is electrically closer to the processor on the BG4 level.

Although the vector addresses and priority level are standard, they can be changed by the user, if desired. However, all DEC programs reference the standard addresses and priority and, therefore, must also be changed if the standard assignments are changed.

4.4 TIMING CONSIDERATIONS

The LC11 Controller provides parallel operation on the bus and operates in a demand response mode; therefore, there are no special timing requirements that must be considered.

The basic operating times of the keyboard and printer are as follows:

Keyboard	Maximum key-in rate = 30 cps time between buffer loads = 33.3 ms
Printer	Printing rate = 30 cps carriage return time = 300 ms line feed time = 33.3 ms time between buffer loads = 33.3 ms

4.5 PROGRAMMING NOTE

If any difficulty is experienced when reading the keyboard buffer register (KBB), inspect the jumpers at W1 and W2 on the M791 Module. There must be a jumper at either W1 or W2 but not both or processor errors occur when attempting to read the buffer. The use of these jumpers is described more fully in Paragraph 5.4.

4.6 PROGRAMMING EXAMPLES

The following examples represent typical programs for reading a character from the keyboard and for echoing the keyboard.

a. Reading a Character (from Keyboard)

```
LOOP:   TSTB TKS        ;LOOK FOR DONE
        BPL LOOP        ;WAIT IF DONE=Ø
READ:   MOV TKB,RØ      ;READ CHARACTER
```

b. Echoing Keyboard

```
ECHO:   TSTB TKS        ;CHARACTER AVAILABLE?
        BPL ECHO        ;WAIT IF DONE=Ø
WAIT:   TSTB TPS        ;IS PRINTER READY?
        BPL WAIT        ;WAIT IF READY=Ø
        MOV TKB,TPB     ;PRINT CHARACTER
        BR ECHO         ;REPEAT FOR NEXT CHARACTER
```

CHAPTER 5
THEORY OF OPERATION

5.1 INTRODUCTION

This chapter provides a detailed description of the LC11 DECwriter Controller. The controller may be divided into four major functional areas: selection logic, interrupt logic, keyboard logic, and printer logic. Each of these areas is covered separately in subsequent paragraphs. The purpose of each of these functional areas is as follows:

Selection Logic	Determines if the DECwriter has been selected for use, which register is to be used, and what type of transfer (DATI or DATOB) is to be performed. Consists of the M105 Address Selector Module.
Interrupt Logic	Permits the controller to gain bus control and perform a program interrupt. Priority level of bus request (BR) line may be changed by user. Consists of the M782 Interrupt Control Module and the ID (interrupt enable) bits in the keyboard and printer status registers (M791 Module).
Keyboard Logic	Consists of a data buffer that receives one character from the keyboard for parallel transmission to the bus and a status register that indicates to the program when the character has been loaded. Also provides the interrupt enable bit so that the character can be transferred by means of an interrupt. Part of M791 Module.
Printer Logic	Consists of a data buffer and a status register. The buffer holds data strobed in from the bus until the printer is ready for use, at which time it transfers the data to the printer. The status register indicates when the printer is ready and also provides an interrupt enable bit so that the data can be transferred by means of an interrupt. Part of the M791 Module.

5.2 SELECTION LOGIC

The M105 Address Selector Module decodes the address information from the bus and provides four select line and two gating signals that determine which register has been selected and whether it is to perform an input or output function. The M105 Module jumpers are arranged so that the module responds only to standard device register addresses 777560, 777562, 777564, and 777566 (jumpers in bit positions 3 and 7). Although these addresses have been selected by DEC as the standard assignments for the LC11 DECwriter Controller, the user may change the jumpers to any address desired. However, any MainDEC program (or other software) that references the LC11 standard address assignments must be modified if other than the standard assignments are used.

The first five digits of the address (77756) indicate that the LC11 has been selected as the device to be used. The final digit, consisting of address lines A02, A01, and A00, determines which register has been selected and whether a word or byte operation is to be performed. Actually, the operation is always a byte operation even if a word operation is selected because bits 8 through 15 in all four registers are unused. The two mode control lines, C00 and C01, determine whether the selected register is to perform an input or output operation.

Address lines A02 and A01 are decoded by the M105 to produce one of four select line signals, which select the register to be used (refer to Table 5-1). The two mode control lines produce IN and OUT gating signals (Table 5-1) that determine whether the bus cycle is a DATI or DATO. Note that an IN gating signal is not supplied for select line 6 (printer buffer register) because the printer buffer cannot be read from the bus; it is a load only register. Note also, that an OUT gating signal is not provided for select line 2 because the keyboard buffer is a read only buffer and cannot be loaded from the bus.

It is beyond the scope of this manual to cover operation of the M105 Address Selector Module; detailed descriptions of this module are covered in the 1971 DEC Logic Handbook and in the Unibus Interface Manual, Second Edition, DEC-11-HIAB-D.

5.3 INTERRUPT CONTROL

The M782 Interrupt Control Module (drawing D-CS-M782-0-1) permits the LC11 Controller to gain control of the bus (become bus master) and perform an interrupt operation. The M782 Module jumpers are arranged so that the module has normal vector addresses of 60 and 64 (jumpers in bit positions 3, 6, and 7). Although these are the recommended vector addresses, the user can change the jumpers to correspond to any address desired, but MainDEC programs reference the standard vector address assignments of 60 and 64. Note that changing the jumpers affects only the first part of the vector addresses. The last digit is controlled internally by the M782 Module and is always either 0 or 4.

Table 5-1
Gating and Select Line Signals

Select Line	Gating Signal	Function Selected	Reg.	Bus Cycle
0	IN	Keyboard status to bus	KBS	DATI
2	IN	Keyboard buffer to bus	KBB	DATI
4	IN	Printer status to bus	PRS	DATI
0	OUT	Bus to keyboard status	KBS	DATO or DATOB
4	OUT	Bus to printer status	PRS	DATO or DATOB
6	OUT	Bus to printer buffer	PRB	DATO or DATOB

The M782 Module contains two completely independent request and grant acknowledge circuits (channels A and B) for establishing bus control. Channel A is used with the keyboard logic; channel B is used with the printer logic. The module has a priority level of BR4, with the A channel (keyboard) slightly higher in priority because it is electrically closer to the processor. Note that the priority level can be changed by means of the priority plug. However, any programs referring to the BR4 level must also be changed. All DEC software references the standard priority level.

Before the M782 Module can generate an interrupt request, two input signals must be high: INT ENB and INTERRUPT. Because both of these signals are needed for each channel, there are actually four signals developed by the logic: INT ENB A and INT A for channel A, and INT ENB B and INT B for channel B. Generation of these signals is discussed below. It is beyond the scope of this manual, however, to cover operation of the M782 Module itself. Detailed descriptions of the M782 Interrupt Control Module are covered in the 1971 DEC Logic Handbook and in the Unibus Interface Manual, Second Edition, DEC-11-HIAB-D.

When the keyboard done (DONE) flag is set, it activates the interrupt control A channel so that it can notify the processor that a character has been loaded into the controller and is ready for transfer to the bus. Thus, the keyboard initiates an interrupt whenever DONE = 1 and ID = 1 both become true.

The logic for the keyboard interrupt signals is shown on drawing D-CS-M791-0-1. When the ID (interrupt enable) bit is loaded by the program, a 1 is loaded onto bus data line D06, which is the D input to the INT ENB A flip-flop. The C input to the flip-flop is high when both SELECT 0 and OUT LOW are high, indicating that the keyboard status register has been selected for loading.

These two inputs set the flip-flop which produces the INT ENB A H pulse that is the enabling signal for the A channel in the M782 Module. When the DECwriter produces a KEY STROBE signal, indicating a character is ready for transfer (DONE), it sets the INT A flip-flop which produces the INT A H pulse that causes the A channel of the M782 to initiate an interrupt.

The logic circuits for the printer interrupt signals is also shown on drawing D-CS-M791-0-1. When the ID (interrupt enable) bit in the printer status register is set, a 1 is loaded onto bus data line D06, which is the D input to the INT ENB B flip-flop. The C input to this flip-flop is high when both SELECT 4 and OUT LOW are high, indicating that the printer status register has been selected for loading. These two inputs set the flip-flop which produces the INT ENB B H pulse that is the enabling signal for the B channel in the M782 module. When the DECwriter is ready to receive data, it issues a P DEMAND H signal (READY). This signal becomes the INT B H pulse that causes the B channel of the M782 to initiate an interrupt.

Note that the same bus data line (D06) is used as an input for both the INT ENB A and B flip-flops. Therefore, any time a 1 is loaded into bit position 06, the D lines of both flip-flops are true. However, the flip-flop that becomes set is dependent on the C line input which consists of the SELECT line and GATING signals used to reference either the keyboard or printer status register.

5.4 KEYBOARD LOGIC

During keyboard operation of the DECwriter, the keyboard buffer register in the controller receives each character as it is produced. The character is stored in the buffer until placed on the Unibus for transfer to memory or some other bus device. The keyboard buffer and associated logic is shown on drawing D-CS-M791-0-1.

Whenever a key on the DECwriter keyboard is depressed, the DECwriter logic produces a 7-bit ASCII code that represents the symbol shown on the key. This 7-bit code is applied in parallel to the data input lines of the seven flip-flops comprising the keyboard buffer register. After the data has had time to settle, the DECwriter issues a KEY STROBE signal, which is inverted and used as a clock input for the seven flip-flops. Thus, when the KEY STROBE is issued by the DECwriter, it strobes the information on the data lines into the buffer. At this point, the status of each flip-flop (set or cleared) corresponds to the information that was placed on the corresponding data line by the DECwriter.

The output of each flip-flop is tied to one input of an associated 2-input AND gate. The other input for all seven gates is connected to an AND gate that is true only when both SELECT 2 and IN are true, which indicates the buffer has been selected for reading. When these conditions are true, the buffer output is coupled to bus data lines D00 through D07.

As explained in Paragraph 5.3, the KEY STROBE signal also sets a flip-flop that produces the INT A H signal that initiates an interrupt request so that the contents of the buffer can be transferred to the bus. This INT A H signal is also applied to one leg of a 2-input AND gate to provide the DONE indication (bit 07) in the keyboard status register. The other input to the AND gate is qualified when the keyboard status register is addressed for reading (SELECT 0 H and IN H are both true).

An eighth data bit can also be gated onto the bus (line D07) if desired. However, this bit does not come directly from the DECwriter keyboard but is provided by a jumper on the controller module. If a 1 is desired in this bit position, then a jumper is added at W1; if a 0 is desired, a jumper is added at W2.

CAUTION

A jumper must always be connected to either W1 or W2, but not both. If both W1 or W2 are jumpered, or if neither W1 or W2 are jumpered, a processor error occurs.

Note that there is no bit 00 for the keyboard. The keyboard data bits are numbered 1 through 7 (KB1 through KB7 on the drawing) and correspond to bus data lines D00 through D06 respectively. Thus, for example, keyboard bit 3 is read on bus data line D02.

5.5 PRINTER LOGIC

During printer operation of the DECwriter, a character from memory or some other bus storage device is transferred to the DECwriter for printing. When a print operation is desired, the LC11 Controller must wait for a READY flag to be set, indicating that the DECwriter is ready to receive a character for printing. This flag is set by the printer logic and cannot be controlled by the LC11 Controller. When the READY flag is received, it causes an interrupt to be generated, and the controller loads a character from the bus into the printer buffer register (PRB). This character and a print command signal are strobed into the DECwriter. The DECwriter immediately drops the READY flag to indicate that it is busy and cannot accept another print command at this time, and then prints out the character. After the character is printed, the READY flag is again set, and the process repeated for the next character from the bus. The printer buffer register and associated logic is shown on drawing D-CS-M791-0-1.

Whenever the DECwriter is ready for printing (keyboard not in use), it sets the READY flag, which is applied to the LC11 Controller as the P DEMAND H signal. This signal passes through a gate and inverter and is applied to the M782 Interrupt Control Module as INT B H. Thus, an interrupt is generated by READY provided bit 06 (ID) in the printer status register is set. Bit 06 causes the INT ENB B H signal to be generated. Interrupts are described in Paragraph 5.3.

The P DEMAND H signal is also applied to one leg of a 2-input AND gate connected to bus data line D07. The other leg of the gate is qualified whenever the printer status register (PRS) is selected for reading (SELECT 4 H and IN H both true). Therefore, the P DEMAND H signal sets the READY bit (bit 07) in the printer status register.

When the interrupt request is granted, the controller loads a character into the DECwriter, issues a print command, and clears the READY bit in the status register. This sequence is described in the following paragraphs.

During the interrupt, the program addresses the printer buffer register and places a 7-bit ASCII code, representing one character, on Unibus data lines D00 through D06. The levels on the bus lines are inverted and applied to printer input lines P01 through P07 respectively. Note that there is no printer P00 line. Therefore, bus line D00 feeds printer line P01, bus line D01 feeds P02, etc.

As soon as the program addresses the printer buffer register, the SELECT 6 H and OUT LOW H signals become true and qualify a gate to produce STROBE L. The STROBE L signal is the print command sent to the DECwriter (referred to as PRINT STROBE in the printer logic). When the printer receives the print command, it starts printing the data from the buffer and drops the READY flag, causing P DEMAND H to go low. If the program addresses the printer status register while P DEMAND H is still low, the READY bit is clear because P DEMAND H being low inhibits the gate for bit 07.

Thus, when the printer buffer register is addressed, a print command is issued, data is gated from the bus into the DECwriter, and the READY flag drops.

5.6 INTERFACE SIGNALS

All signals to or from the DECwriter are true in the high state (+3V). The operational state of the DECwriter is determined by two signals (KEY STROBE and P DEMAND H), which are applied from the DECwriter to the LC11 Controller logic. The KEY STROBE signal indicates that the DECwriter keyboard is in use, the P DEMAND H indicates that the printer is able to accept a character for printing. Either one, but not both, of these signals may be true at any given time.

Eight input lines originate in the controller logic and terminate in the DECwriter. Seven of these are PRINTER DATA lines (P01 through P07) and the eighth is the STROBE line. When the STROBE line goes true, data on the seven PRINTER DATA lines is parallel transferred into the printer, causing P DEMAND H to go low until the printer logic has shifted the printable character into its associated memory.

Eight output lines originate in the DECwriter and terminate in the controller logic. Seven of these are KEYBOARD DATA lines (KB1 through KB7) and the eighth is the KEY STROBE line. When the KEY STROBE line goes true, data on the seven KEYBOARD DATA lines is parallel transferred into a controller flip-flop register. This register stores the character until it is loaded onto the Unibus for transfer to some other bus device such as memory.

All interface signals are shown in Figure 5-1 and listed in Table 5-2 along with their related function. The signal names used on the table are the functional names; the name in parenthesis indicates the nomenclature used on the print set. Table 5-3 lists these same interface signals, but includes wiring information. A complete list of ASCII codes (as used in the LA30 DECwriter) is given in Appendix A.

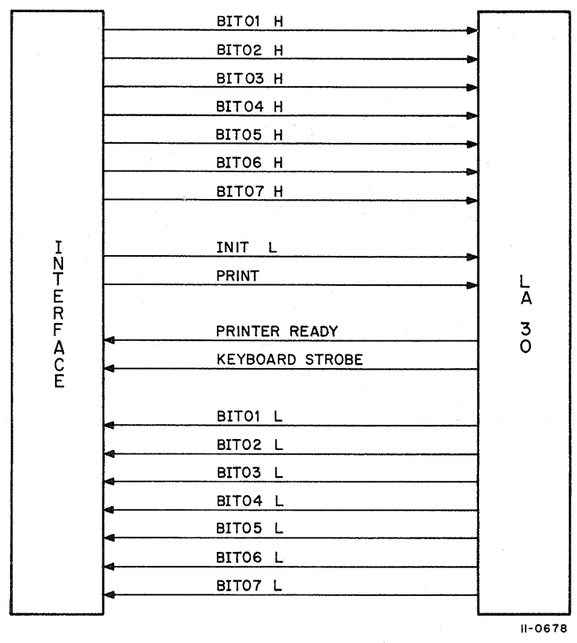


Figure 5-1 Interface Signals

Table 5-2
Controller-DECwriter Interface Signals

Signal	Source	Function
READY (P DEMAND H)	DECwriter	Indicates to the user's system that the DECwriter printer is available for use; synchronizes data transmission between the DECwriter and LC11 Controller. The P DEMAND H signal requests a character from the controller and this signal remains true until the PRINT STROBE signal is received. The READY indication (P DEMAND H) is disabled while the character is being stored in memory and during the print operation. When printing is complete, READY again becomes true unless KEY STROBE is true.
PRINT STROBE (STROBE)	Controller	STROBE indicates that the printer can accept the information on the PRINTER DATA lines. Each time the STROBE signal occurs, the DECwriter printer samples the data lines and READY goes false while the data character is being stored.
PRINTER DATA (P01 – P07)	Controller	PRINTER DATA is coded information transmitted from the controller to the printer on seven data lines. Each character of the ASCII character set is transmitted as a 7-bit PRINTER DATA signal.
KEY STROBE	DECwriter	KEY STROBE indicates when the keyboard has generated a character for transfer to the controller. Each time the KEY STROBE signal occurs, the controller initiates an interrupt, samples the KEYBOARD DATA lines, and stores the character in a buffer for transfer to the bus.
KEYBOARD DATA (KB1 – KB7)	DECwriter	KEYBOARD DATA is coded information transmitted in parallel from the DECwriter keyboard to the controller on seven data lines. Each character of the ASCII character set is transmitted as a 7-bit KEYBOARD DATA signal. The controller may add an eighth bit to this data prior to loading on the bus.

Table 5-3
Controller Input/Output Signals

Signal Name	Direction	LC11 Pin	LA30 Pin	Signal Function
KEYBOARD DATA	From LA30	Z	M1	Indicates character is ready in keyboard buffer
KEYBOARD DATA	From LA30			These seven data bits represent the ASCII code for the character being transmitted from the keyboard.
Bit 01		N	S1	
Bit 02		L	D2	
Bit 03		V	H2	
Bit 04		R	M2	
Bit 05		F	P2	
Bit 06		J	S2	
Bit 07		T	T2	
PRINTER READY (P DEMAND H)	From LA30	X	B1	Indicates printer is ready to accept a character from the interface.
PRINT STROBE (STROBE)	To LA30	VV	E2	Print command that causes printer to accept data and print it out.
PRINTER DATA	To LA30			These seven data bits represent a character from the controller that is being transferred to the DECwriter for printing.
Bit 01		JJ	D1	
Bit 02		LL	E1	
Bit 03		BB	H1	
Bit 04		FF	J1	
Bit 05		TT	K2	
Bit 06		RR	L1	
Bit 07		DD	P1	
INIT L	To LA30		V2	Initializes printer.

APPENDIX A
CHARACTER CODES

BITS b_4	b_3	b_2	b_1	ROW / COLUMN	0 (000)	1 (001)	2 (010)	3 (011)	4 (100)	5 (101)	6 (110)	7 (111)
0	0	0	0	0	NUL	DLE	SP	0	@	P	`	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	¦
1	1	0	1	13	CR	GS	–	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	___	o	DEL

128-CHARACTER SET (KEYBOARD)

96-CHARACTER SET (KEYBOARD)

64-CHARACTER SET (PRINTER)

11-0677

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