H-646

TYPE
646
LINE PRINTER

DIGITAL EQUIPMENT CORPORATION • MAYNARD, MASSACHUSETTS

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COPY NO.

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PREFACE

This manual contains information on the theory of operation, installation, operation, and maintenance of the Line Printer Control Type 646. The line printer control is a program-controlled device which accepts data and controls from the PDP-6 general-purpose digital computing system via the I/O bus and sends printable characters and function signals to the 646 Line Printer at the printer acceptance rate. The control also informs the PDP-6 program of the line printer status. Chapter 1 of this manual presents information of a general nature. Chapter 2 explains the theory of operation for the control and its interface with the line printer. Chapters 3, 4, and 5 present information and procedures which enable personnel to install, operate, and maintain the control.

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CHAPTER 1

INTRODUCTION AND DESCRIPTION

PURPOSE OF EQUIPMENT

The Line Printer Control Type 646 is the program-controlled buffer interface between the Programmed Data Processor-6 (PDP-6) general-purpose digital computing system and the 646 Line Printer (series 5 ANelex line printer). Under program control, the line printer control accepts data from the I/O bus or transmits status indications to the PDP-6. Each data entry may include characters to be printed, control characters defining printout format, or illegal characters (codes not assigned to the line printer). Printable characters and format control signals are sent to the line printer at its acceptance rate and with printer-required signal characteristics. Illegal character codes are ignored. The PDP-6 program is free during each data transfer cycle to perform other routines. By means of the PDP-6 priority interrupt system, the line printer informs the program that its status should be interrogated. Status indications generated by the line printer consist of: done (ready for data entry), busy (line printer performing a program-directed function), printer error (line printer is off line or interface cable connection is not complete), and line overflow error (120-character capacity of line printer character buffer has been exceeded prior to the program sending a printout command through the line printer control).

DESCRIPTION

Functional Description

The Line Printer Control Type 646 receives signals from and sends signals to the PDP-6 system via the I/O bus. An interface cable conveys signals between the control and the line printer. The line printer control application diagram, Figure 1-1, shows the signal flow between the three.

All input/output devices in the PDP-6 system share the I/O bus. For this reason, a unique device selection code accompanies each program instruction to specify which device is to

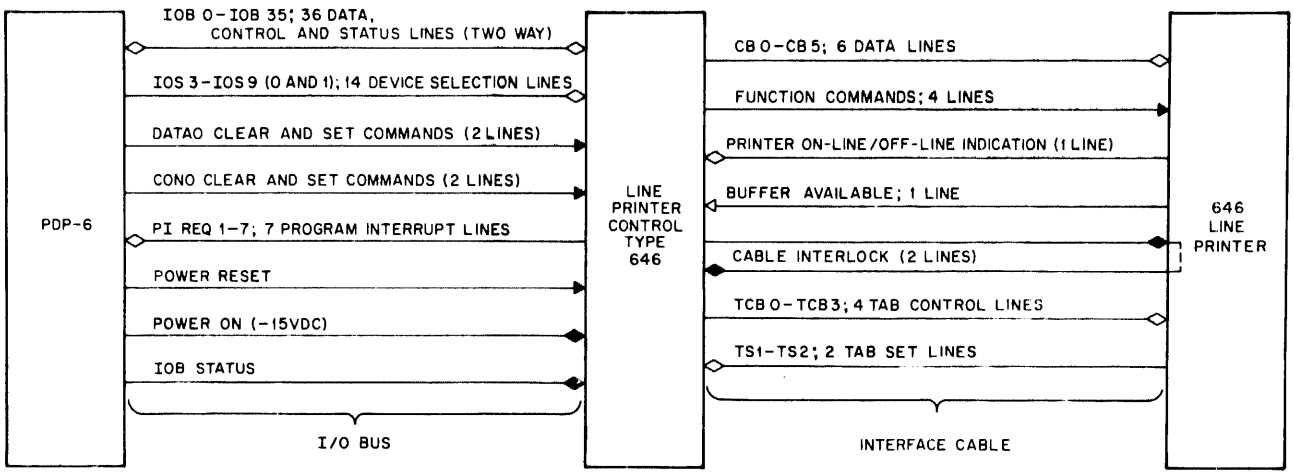


Figure 1-1 Line Printer Control, Application Diagram

respond. The device selection code is represented by seven pairs of complementary signals, with each pair containing one bit of the 7-bit code.

The input/output devices, or their respective controls, decode the 14 levels to determine if their code is present. The line printer code is 124_8. When the line printer control decodes a 001 010 1 from the IOS3-IOS9 lines, the program instruction, CONO (conditions out) or DATAO (data out), is accepted. Either instruction consists of a CLEAR pulse and a SET pulse. The CLEAR pulse readies the line printer control for the instruction; the SET pulse accomplishes the instruction.

A CONO instruction CLEAR pulse clears the line printer control. The following SET pulse enters the done and error priority interrupts in the control register; and if I/O bit 7 is 1, initiates clearing of the line printer control and the line printer character buffer. The control enters a busy status until the line printer sends a buffer available indication, which resets the busy flag and sets the done flag. The done interrupt is generated when the done flag is set. The error interrupt is generated if the line printer is off line, the interface cable is not connected, or if the program has overfilled the line printer character buffer. The IOB STATUS signal occurs with a conditioned CONI instruction (CONSO or CONSZ) to sample the line printer control status indications into the PDP-6 through the I/O bus.

A DATAO CLEAR pulse clears the character acceptance portion of the line printer control. The subsequent DATAO SET pulse samples five 7-bit ASCII-coded characters present on IOB0 through IOB35 lines into the line printer control. The done flag is reset and the busy flag is set. The five characters are processed in turn by the line printer control. Printable characters are sequentially sent to the line printer for entry in its character buffer. Control characters defining printout formatting are decoded within the line printer control to create signals which are sent to the line printer to accomplish the required function. The five-character entry may contain character codes not assigned to the line printer. The line printer control will detect these illegal codes and inhibit their passage to the line printer. Unless the five characters contained a STOP control character, completion of the data transfer cycle generates a done interrupt by setting the done flag. The program recognizes this as a request for another five-character loading. If a STOP control character is decoded, the busy flag is reset but the done flag is not set to generate the interrupt.

Once the line printer is on line and characters are loaded into its character buffer, the line printer cannot go off line until the characters are printed out or cleared out of the buffer. A program command can initiate the printout or clearing operation. Depression of the MANUAL PRINT control on the line printer also initiates the printout. If the program transfers more than 120 printable characters without a printout command or clearout command, the line printer locks in the busy state to prohibit further character transfers (these characters would be lost). A carriage return control character or a CONO program instruction must be sent to return the line printer control to operation.

Eleven control character inputs to the line printer control initiate operations within the control and the line printer. Two (horizontal tab and carriage return) control the horizontal format of the printout. Eight (form feed, line feed, vertical tab and DC0-DC4) control the vertical format of the printout. One (stop) halts line printer control operation. A summary of these characters and their respective functions follows.

Horizontal Tab - Performance of this control character is analogous to typewriter tabs. Upon decoding a horizontal tab control, the line printer loads space characters in the line printer character buffer until the tab setting is reached. The next printable character enters the

character buffer at this printing point. The tab setting is preselected by the line printer tab selection switch to be one of five increments (8, 10, 12, 16, or 20 columns).

Carriage Return - A decoded carriage return control character clears the line printer control column counter to enter the next character at column 1 in the line printer character buffer. This clearing returns the printout point to the extreme left-hand column. A carriage return can also initiate printout of characters stored in the buffer but cannot initiate a paper advance.

Form Feed - A form feed control character initiates a print and space command to the line printer. Characters previously entered in the buffer are printed out. The paper then advances to the top of the next page. Unless a carriage return occurs, the next character enters the character buffer at column N plus 1, where N equals the column count of the previous printout.

Line Feed - A line feed control character initiates a print and space command. After stored characters are printed out, the paper advances 20 lines. The next character entry in the buffer is at column N plus 1 (see Form Feed).

Vertical Tab - A vertical tab control character initiates the printout of stored characters and advances the paper 20 lines. The next character entry in the buffer is at column N plus 1 (see Form Feed).

DC0-DC4 - Five vertical tab control characters can initiate printout of stored characters. After the printout, the paper advances 30, 2, 3, 6, or 10 lines, respectively. The next character entry in the buffer is at column N plus 1 (see Form Feed).

Stop - Decoding of this control character halts line printer control and thus line printer operation.

There are 66 printing lines per page. A vertical format tape contained in the line printer ensures that the top two and the bottom two remain blank to leave 62 usable printing lines. Refer to the ANelex instruction manual for a description of the vertical format control.

Physical Description

The Line Printer Control Type 646 consists of 45 DEC system modules installed in three module panels of a standard computer cabinet. (See engineering drawing UML-D-646-0-11 in Appendix 1.) Usually, the control is not installed in a separate cabinet but in one housing additional input/output device controls or system logic for the PDP-6 general-purpose digital computing system. The actual location of the line printer control modules is indeterminate as the complexity of a purchased system determines space availability. The reader is advised to refer to engineering documentation accompanying the system for location and wiring information.

The standard computer cabinet has front and rear split doors. The front door permits access to the connector wiring for the module panels. The rear door and an internal door provide access to the cabinet power supply, the modules, and the eight I/O bus cables. The PDP-6 system I/O bus is serially connected to each input/output device or its control. Four of the eight I/O bus cables interface the line printer control with the I/O bus system. The other four leave the line printer control interface to connect some subsequent input/output device with the I/O bus. One Type 1032 Terminating Package (47 ohms) must be installed in connectors number 4 (Figure 3-1) if the line printer control is the last I/O device connected to the I/O bus cables.

Electrical Description

Standard DEC power supplies installed in the computer cabinet operate from line inputs of 115 vac to provide the module-required voltages of -15 vdc and +10 (A) vdc and +10 (B) vdc. Refer to the PDP-6 System Manual for descriptions of these power supplies and the loading imposed upon them by the line printer control modules.

Line Printer Description

The following reference data listing summarizes the principal characteristics of the 646 Line Printer (series 5 ANelex printer).

Physical Characteristics

Height:	52 to 57 in., adjustable
Length:	56 in.
Depth:	30 in.

Weight:	1350 lbs

Printing Characteristics

Width:	120 columns (characters) max. at 10/in.
Lines per inch:	6 max.
Lines per minute:	300 max.
Load character in buffer:	10 μsec
Paper advance:	18 msec/line
Printout of stored characters:	180 msec

Paper Media

Single copy:	20-lb wt
Multiple copy:	Paper 9 to 12 lb wt; high-speed carbon 5 to 7 lb wt
Width:	3 to 19 in.
Feed holes:	Diameter of 0.155 (+0.005; -0.000) in.; 0.500 (+0.010) in. center-to-center vertically; 0.250 (+0.010) in. center of holes to vertical edge of paper.

Ribbon Requirements

Multilith ribbon and roll assembly:	ANelex Part No. 66209

Power Requirements

Input:	115 volts, 60-cycle, 3KVA (obtained independently of the PDP-6 system)

Symbols and Terminology

Readers who are unfamiliar with the DEC conventions of symbols and terminology to represent logical functions are advised to refer to the symbols and terminology discussion in Appendix 1. Reference to the DEC System Modules Handbook (C-100) will amplify this discussion.

Pertinent Documents

Discussions in the subsequent sections of this manual assume that the reader has read and is familiar with the content of the following documents.

System Modules Handbook (C-100)
PDP-6 Maintenance Manual (F-67)
PDP-6 Handbook (F-65)
PDP-6 Installation Manual (F-68)
Series 5 ANelex Printer Instruction Manual

Abbreviations

The following lists those abbreviations used throughout this manual and their meaning.

ASCII	American Standard Code for Information Interchange
I/O	Input/Output
CONO	Conditions Out
DATAO	Data Out
PDP-6	Programmed Data Processor-6 system
LPT	Line Printer Control
IOB	Input/Output Bus

CHAPTER 2

THEORY OF OPERATION

OVERALL FUNCTIONAL DESCRIPTION

The Line Printer Control Type 646, once data is entered from the PDP-6 system, operates at the 646 Line Printer acceptance rate in transferring printable characters and commands to the printer character buffer or vertical format control section. A CONO instruction (Figure 2-1) enters the priority codes in the control register and with IOB7 1 clears the line printer control and line printer character buffer. The codes also appear in the status register along with status indications. The IOB STATUS interrogation signal (initiated by CONSO, CONSZ, or CONI) samples these indications through the I/O bus into the PDP-6. A DATAO instruction enters five 7-bit characters in the character input register and initiates processing of the first character. Each character is decoded in turn by the character decoding section. If illegal, the character is shifted out of the character input register and nothing is sent to the line printer. If legal, the character (printable or control) appears in the control buffer and a command is sent to the character transfer section to initiate the required action. This character is not shifted out of the character input register until the action is accomplished. The process continues until five characters have been shifted out of the register at which time a word request generates the done interrupt to request another five-character entry. If a stop character appears in an entry, the line printer control halts upon decoding it.

The error interrupt occurs to inform the PDP-6 that the line printer went off line, the interface cable became disconnected, or the program exceeded the 120-character capacity of the line printer buffer before sending a printout command.

The DATA STROBE command samples printable characters into the line printer character buffer. If a horizontal tab function is requested by the program, DATA STROBE samples space characters into the buffer until the tab stop is reached. Selection of the tab column increment is made through use of the line printer tab selection switch. DATA STROBE also enters space characters in the buffer when a carriage return does not occur to return the printout point to column 1. The space characters are entered until the last column of the previous printout is reached. The next character is then processed.

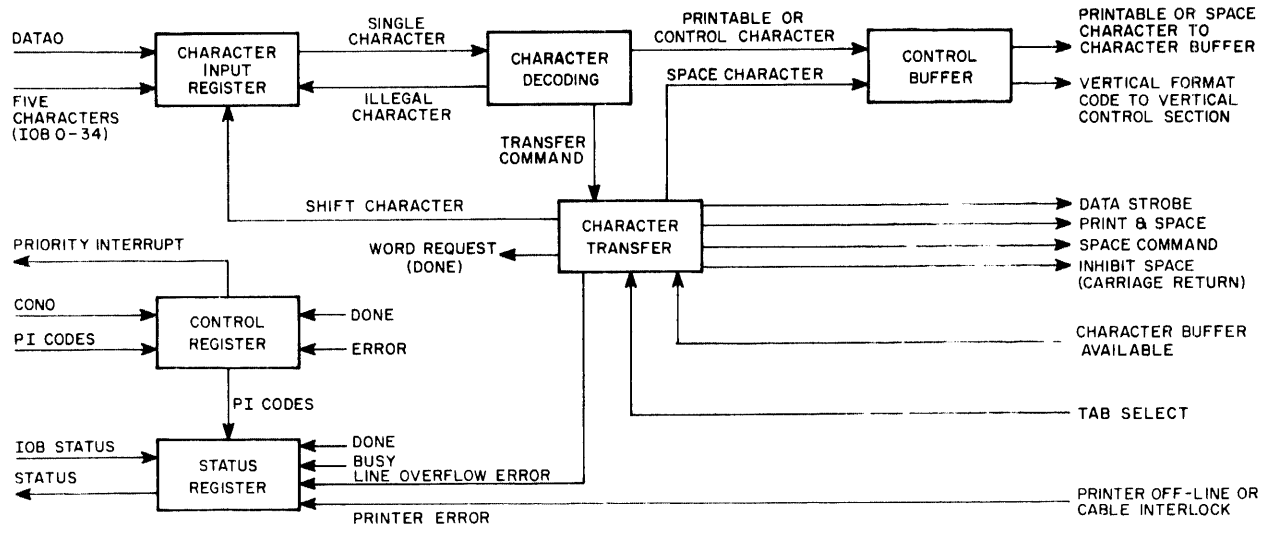


Figure 2-1 Line Printer Control, Block Diagram

The PRINT and SPACE command is used to print out stored characters and to advance the paper to the line specified by the decoded vertical format control character. If a carriage return function initiates PRINT and SPACE, the paper is inhibited from advancing.

The SPACE COMMAND advances the paper to the line specified by the decoded vertical format control character. This command occurs only when there are no characters in the line printer character buffer.

DETAILED DESCRIPTION

Logic circuits for the line printer control are grouped in five major functional sections. They are:

1. the interrupt and status logic,
2. the character input register,
3. the control character decoding circuit,
4. the character transfer circuit, and
5. the counters and tab selection circuit.

An engineering logic drawing for each functional logic section is contained in Appendix 1. Reference is made to these diagrams in the paragraphs following which describe the circuit

functions. These descriptions presume that the reader is familiar with the DEC logic signal and element symbology. Any reader not possessing this knowledge is advised to refer to the symbols and terminology portion of Appendix 1. Line printer control logic drawings refer to I/O bits; PDP-6 system drawings refer to the same as IOB bits.

Interrupt and Status Logic

The interrupt and status logic (diagram 646-0-6, Appendix 1) accepts a program instruction (CONO or DATAO) and accomplishes the required action only when the line printer device selection code (124_8) accompanies the instruction. Line printer selection is made when the IOS3-IOS9 lines provide seven ground level signals, representing 001 010 1, to a Type 4118 Diode Gate which decodes the levels to place LPT SEL at -3 volts. The LPT SEL negative level goes to four Type 4606 Pulse Amplifiers and to one Type 4113 Diode Gate allowing a program instruction input to affect the required circuits.

A CONO CLR instruction pulse (Figure 2-2) input at pin D of I/O bus 4 generates a 0.4-microsecond pulse for LPT IC CLR. This LPT IC CLR pulse clears the control register (flip-flops PIA0, PIA1, PIA2, PIB0, PIB1, and PIB2) and the DONE, BUSY, and CLEAR flip-flops. The IOB PWR RES (power reset) negative pulse also generates the LPT IC CLR pulse when the system power is turned on or when the I/O RESET key on the computer console is depressed.

Approximately 1 microsecond after the CONO CLR pulse, the CONO SET pulse (Figure 2-2) input to pin E of I/O bus 4 generates the 0.4-microsecond LPT IC SET pulse which enters I/O bits 15, 16, and 17 in the PIA (priority interrupt) protion of the control register and I/O bits 12, 13, and 14 in the PIB portion. The PIA and PIB 3-bit codes reflect the priority interrupt code for the line printer control. The PIA code is not released to the PDP-6 unless the LPT DONE FLAG applies a ground input to pin P of Type 4151 Binary-to-Octal Decoder. The PIB code is not sent to the PDP-6 unless a PRINTER ERROR or a LINE OVERFLOW condition occurs. The LP IC SET pulse sets the BUSY flip-flop if IO-10 is at ground (1) or the DONE flip-flop if IO-11 is at ground (1).

The IOB STATUS signal is negative during a CONSO, CONSZ, or CONI instruction input. Coupled with the LPT SEL level, IOB STATUS samples the information bits in the line printer status register (ten Type 4657 Bus Drivers) into the PDP-6 I/O bus system.

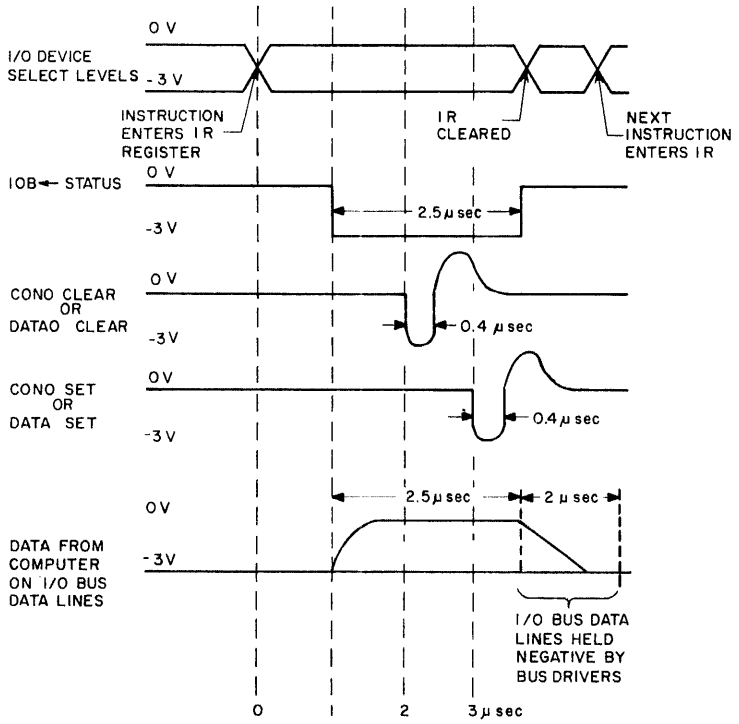


Figure 2-2 PDP-6 I/O Bus Timing Diagram

If I/O bit 7 is 1, the CONO SET pulse sets the CLEAR flip-flop producing a -3 ground transition for the LPT CLEAR signal. This transition is applied to a 4606 Pulse Amplifier to produce the LPT DATA CLR pulse (B-2) which clears the character input register and to a 4606 Pulse Amplifier in the character transfer circuit to initiate clearing of the line printer character buffer. The LPT CLEAR pulse also sets the busy flag. When the line printer indicates completion of character buffer clearing, the busy flag is reset and the done flag is set by the WORD REQUEST input from the character transfer circuit.

A DATAO CLR pulse input (Figure 2-2) at pin B of I/O bus 4 generates the LPT DATA CLR pulse which clears the character input register. Approximately 1 microsecond after DATAO CLR, a DATAO SET pulse generates the LPT DATA SET pulse which sets the busy flag, resets the done flag and samples five 7-bit characters into the character input register through IOB0-IOB34 lines. Thereafter, a WORD REQUEST input at the end of each five-character transfer cycle sets the done flag to generate the done priority interrupt and resets the busy flag. This WORD REQUEST initiation of the done interrupt continues until an EOT control character is entered in the character input register by the PDP-6 program. Decoding of this control character places STOP at a negative level allowing a COLUMN COUNT pulse to reset the busy flag without setting the done flag to generate the done priority interrupt to request additional character inputs.

Character Input Register

The character input register (diagram 646-0-9, Appendix 1) consists of seven Type 4221 Shift Register modules. Five 7-bit ASCII-coded characters can be simultaneously transferred from the PDP-6 system to the register modules through I/O bit lines 0-34. Bit 1 of the first character is stored in the first stage (W input) of module CI-0 (A-3); bit 2 is stored in the first stage (W input) of module CI-1 (A-5); bit 3 is stored in module CI-2; bit 4 is stored in module CI-3; etc. In like fashion, the other four characters are stored in the second, third, fourth, and fifth stages of the seven modules. The sixth, or left-most, stage of each register module does not receive data and, further, is clamped in the 0 state by the constant INHIBIT level resulting from the -15 vdc input at pins E and R of module CI-0 (B-1).

Three signals control operation of the character input register. They are: LPT (line printer) DATA SET, LPT DATA CLR, and SHIFT CHARACTER. The LPT signals are generated in the interrupt and status logic circuit as a result of I/O instructions from the PDP-6 processor. The SHIFT CHARACTER input is developed in the character transfer circuit. A CONO instruction with I/O bit 7 a 1 generates a 0.4-microsecond pulse for LPT DATA CLR, which applied to pin Z of each register module, clears the character input register. A DATAO instruction generates a 0.4-microsecond pulse for the LPT DATA SET input to pin Y of each register module. Any module stage having a ground level (logical 1) at its respective I/O bit input is switched by the LPT DATA SET pulse to the 1 state. All module stages not having an I/O bit input at ground remain in the 0 state. The characters entered in the character input register can be printable characters, control characters (defining machine functions requested of the line printer by the PDP-6), or illegal characters (codes not assigned to the line printer).

The I and O side outputs of the first stage in each register module (pins N and P, respectively) go to the control character decoding circuit. This circuit decodes the bit-content of the character to determine if it is legal or illegal; and if legal, what action is requested. A legal character is one in which bits 1 and 2 complement each other. Conversely, an illegal character has bits 1 and 2 at the same logical level.

After LPT DATA SET enters the five 7-bit characters in the character input register, a 0.4-microsecond pulse is generated in the character transfer circuit for the SHIFT CHARACTER input to pin X of each register module. This pulse shifts the five characters to the right.

Character 1 is dumped out of the register and replaced in the first stage of each module by character 2. If character 1 was legal, the required action (transfer of character code or machine function command to line printer) was accomplished prior to the SHIFT CHARACTER pulse. If the character was illegal, data is not transferred to the line printer and the character is simply shifted out of the character input register.

Thereafter, while the line printer indicates that its character buffer is available for data entries and a printable character or legal control character is in the character 1 position of the character input register, the SHIFT CHARACTER pulse occurs until the five 7-bit characters have been shifted out of the register. During the interim between SHIFT REGISTER pulses, the bit-content of each character is examined to determine its legality and the action required. With the shift of the fifth character out of the register, the done priority interrupt occurs to request an additional five-character entry. A decoded EOT (stop) control character inhibits generation of the done priority interrupt and thus halts operation of the line printer control.

Character Counter and Decoder

The character counter (diagram 606-0-9, Appendix 1) consists of a Type 4215 Complementing Flip-Flop module (C-7, 8), a Type 4606 Pulse Amplifier, and a Type 4606 Pulse Amplifier. The decoder includes two Type 4112 Negative-Diode NORs and a Type 4102 Inverter module. The counter circuit counts SHIFT CHARACTER pulses to produce outputs which the decoder employs to indicate when the five 7-bit characters have been shifted out of the character input register. The counter also, through its CHARACTER COUNT pulse output, initiates the four SHIFT CHARACTER pulses after the first one is initiated by the LPT DATA SET pulse input to the character transfer circuit.

The LPT DATA CLR 0.4-microsecond pulse which clears the character input register, also by triggering the 4606 Pulse Amplifier, clears the character counter. The pulse amplifier delivers a 1.0-microsecond pulse to the flip-flop module, which places the three stages in the 0 state. Thereafter, each SHIFT CHARACTER 0.4-microsecond pulse input to pin U of Pulse Amplifier 4606 produces a 0.4-microsecond pulse output. The counter has a modulus 5 configuration. The first pulse switches flip-flop 5-2 to the 1 state. The second pulse complements 5-2 and switches 5-1 to 1. The third pulse again complements 5-2. Flip-flop 5-1 remains in the 1

state. The fourth pulse complements 5-2 and 5-1 and switches 5-1 to 1. The fifth pulse complements 5-0. The following table summarizes the response of the counter to the pulse inputs.

TABLE 2-1 COUNTER RESPONSES

Flip-flop	5-0	5-1	5-2
LPT DATA CLR	0	0	0
SHIFT CHARACTER - 1	0	0	1
SHIFT CHARACTER - 2	0	1	0
SHIFT CHARACTER - 3	0	1	1
SHIFT CHARACTER - 4	1	0	0
SHIFT CHARACTER - 5	0	0	0

The 0 side outputs of the three flip-flops go to the pin X-Y negative diode NOR and the inverter module. When the character counter represents an all zero condition due to the LPT DATA CLR pulse or the counting of five SHIFT CHARACTER pulses, the WORD TRANSFER COMP (complete) output is at - 3 volts. This level initiates a word request that sets the done flag and clears the busy flag in the interrupt and status logic circuit. While the counter is decoding SHIFT CHARACTER pulses, one of the three inputs to the decoder is 1 (see above). This condition places WORD TRANSFER COMP at ground and $\overline{\text{WORD TRANSFER COMP}}$ at - 3 volts. The latter level enables generation of the SHIFT CHARACTER pulses by the character transfer circuit.

Either a horizontal tab operation (011) input at pin M or a form advance input to pin N of the other negative diode gate also produces the enabling - 3 volt level for $\overline{\text{WORD TRANSFER COMP}}$ and the ground inhibiting level for WORD TRANSFER COMP.

Horizontal Tab Selection

The horizontal tab selection circuit (diagram 646-0-5, Appendix 1) functions in association with the line printer tab selection switch to set up preselected tab column increments when the program specifies a horizontal tab control character. The two-pole, five-position switch

is located within the right-hand door of the line printer on the test panel. The circuit includes a Type 4215 Complementing Flip-Flop module, a Type 4606 Pulse Amplifier, a Type 4114 Diode Gate, and a Type 6102 Inverter module.

A CLEAR COLUMN COUNTER pulse input to the pulse amplifier clears the flip-flops. Thereafter, the flip-flops are cleared by a COUNT COLUMN pulse while the TS-1 and TS-2 inputs to the 4114 Diode Gate are simultaneously at ground levels. The TS-1 and TS-2 inputs come from the tab selection switch in the line printer and become grounded as a result of the switch position and the counting of columns by the 4215 Flip-Flops. The flip-flops are stepped by each transition to ground of the 0 side output of column counter stage CC6 (A-5). These transitions occur when CC6 switches from the 1 state to the 0 state at alternate column counts.

The five tab increments are controlled as follows:

Tab 8 — TS-1 is grounded when TC-1 is switched to the 1 state by the fourth CC6 pulse input, which is equivalent to eight columns. TS-2 is grounded through an internal switch connection.

Tab 10 — TS-1, as for tab 8, grounds at the fourth CC6 pulse input. TS-2 is grounded by switching TC-3 to the 1 state at the fifth CC6 pulse input.

Tab 12 — TS-1 is grounded at the fourth CC6 pulse input. TS-2 is grounded by the switching of TC-2 to the 1 state at the sixth CC6 pulse input.

Tab 16 — TS-1 is grounded at the switching of TC-0 to the 1 state at the eighth CC6 pulse input. TS-2, as before, grounds through an internal switch connection.

Tab 20 — TS-1 grounds at the eighth CC6 pulse input. TS-2 grounds at the tenth CC6 pulse input.

Character Transfer

The character transfer circuit (diagram 646-0-8, Appendix 1) synchronizes operations within the line printer control and generates command signals which initiate functions requested of the line printer by the PDP-6 control character entered in the character input register. The requested functions include: clear the character buffer, enter the control buffer output data in the character buffer or in the vertical format control section of the line printer, and print out characters stored in the character buffer and advance the paper to the line specified by the control character input in the vertical format control section.

Additionally, the character transfer circuit controls the loading of space characters in the line printer character buffer when a horizontal tab control character is in the character input register or when a previous printout of stored characters did not fill the 120-character line and the next printout is to appear below and to the right of the last printed line. When the control character decoding circuit decodes a horizontal tab control character, space characters are entered in the line printer character buffer until the next preselected tab stop is reached. This operation is analogous to typewriter tabbing in that if a tab stop is passed, a printable character appears at the next tab stop after a tab control loads the intervening line increment with spaces. If a vertical format control character, rather than a carriage return control character, initiates the printout of characters stored in the character buffer, space characters equal to the number of columns printed out are entered in the character buffer before the next character is processed. For example: assume that a line feed control character has initiated the printout of 60 columns and advanced the paper one line. Before the next character is processed by the line printer control, 60 space characters are entered in the character buffer. The next character, if printable, enters the sixty-first column point of the buffer.

Printer Commands

One of the PAS (print and space), ESC (enable space command) and EDS (enable data strobe) signals (Diagram 646-0-8, Appendix 1) is negative to enable generation of its respective printer command signal during the processing of each legal character in the character input register. The type of character (printable or control) and the printout format (previous line and present line) determine which signal is negative.

The DATA STROBE negative pulse samples the CB0-CB5 output of the control buffer (diagram 646-0-7, Appendix 1) into the line printer character buffer. The EDS signal is negative to allow generation of the DATA STROBE negative pulse if:

1. the character is printable, or
2. the character is a horizontal tab control (011), in which case the CB0-CB5 output contains a space character, or
3. a carriage return control (015) was not sent to the line printer control to return the printout point to the extreme left-hand column.

The PRINT and SPACE negative pulse initiates the printout of characters stored in the line printer character buffer and, if the character in process is not a carriage return control (015), samples the CB0-CB5 output representing a vertical format code into the line printer vertical control section. After the printout is completed, the paper advances to the line specified by the vertical format code. If the character was a carriage return control (015), the paper does not advance. The PAS signal is negative to allow generation of the PRINT and SPACE negative pulse if:

1. the character is a carriage return control (015), or
2. the character is a vertical format control (form feed, line feed, vertical tab, or DC0-DC4) and at least one character has been entered in the line printer character buffer; in other words, a form (paper) advance and not column 1.

The SPACE COMMAND negative pulse samples the CB0-CB5 control buffer output into the line printer vertical format control section. The paper advances to the line specified by the control character vertical format code. The ESC signal is negative to allow generation of SPACE COMMAND when the character is a control character specifying vertical paper motion (form advance) and characters have not been entered in the line printer character buffer.

Clear Control

A CONO instruction with I/O bit 7 a 1 produces a - 3 volt-to-ground transition for LPT CLEAR in the interrupt and status logic. This positive transition applied to Type 4604 Pulse Amplifier (C-2) generates a negative CPB (clear printer buffer) pulse to initiate clearing of the line printer character buffer. The LPT CLEAR transition also develops the CLEAR negative pulse

which, in turn, develops the positive CLEAR SPACE COUNTER and CLEAR COLUMN COUNTER pulses. Both counters (diagram 646-0-5, Appendix 1) are cleared of previous space and column counts. After the line printer character buffer is cleared, the BUFFER AVAILABLE positive pulse through two Type 4606 Pulse Amplifiers generates a negative pulse for WORD REQUEST (WORD TRANSFER COMPLETE is negative at this time) which goes to the interrupt and status logic to reset the busy flag and set the done flag. The latter initiates the done priority interrupt to request a five-character input from the program. The BUFFER AVAILABLE pulse occurs after every line printer function.

Character Transfer Cycle

A DATAO instruction enters five 7-bit characters in the character input register by generating a LPT DATA SET negative pulse. This same pulse also comes to a Type 4301 One-Shot (A-2, diagram 646-0-8, Appendix 1) to initiate the character transfer cycle. During the 2.5-microsecond delay interval, the first character is checked by the control character decoding circuit to determine if it is legal or illegal, and if legal whether it is a printable or control character. To perform the operations involved in a character transfer cycle for an illegal character, a printable character, and a control character, the following paragraphs describe the use of the character transfer circuit (diagram 646-0-8, Appendix 1).

The CHARTSYN (character transfer synchronizing) pulse output of Type 4606 Pulse Amplifier (A-14) is the primary control signal in all character transfer cycles. The initial CHARTSYN pulse occurs approximately 3 microseconds after the LPT DATA SET pulse. Thereafter, while WORD TRANSFER COMPLETE is negative, either BUFFER AVAILABLE or CHARACTER STROBE generates the CHARTSYN pulse. Each CHARTSYN pulse performs three functions.

1. It initiates generation of a printer command signal if character decoding enables one of the three gates.

2. It initiates generation of a CLEAR COLUMN COUNTER pulse if the character is decoded as a carriage return control (015 at negative).

3. It, after the 2.5-microsecond delay of Type 4301 One-Shot (B-4), generates a COLUMN COUNT pulse.

Detection of an illegal character by the control character decoding circuit places ILLEGAL CHARACTER (B-7) at the 0-volt level. Because this illegal character does not represent a function required of the line printer, the CHARTSYN pulse cannot generate any of the printer command signals. It does generate a COLUMN COUNT pulse which is gated through Type 4217 Inverter Gate (output pin T) to generate the SHIFT CHARACTER pulse. The inverter gate is enabled since the character is neither a horizontal tab control character (011) nor a vertical format control character thereby placing the $\overline{011}$ and $\overline{\text{FORM ADV}}$ signals at 0-volt levels to produce the required negative level at pin S of the gate. The SHIFT CHARACTER pulse goes to the character input register and the character counter (diagram 646-0-9, Appendix 1) to shift the illegal character out of the register and advance the character counter one count through generation of a CHARACTER COUNT pulse. This CHARACTER COUNT pulse also comes to the Type 4303 Integrating One-Shot (diagram 646-0-8, Appendix 1) which develops the CHARACTER STROBE signal (B-8). If the character shifted into position 1 of the character input register is also decoded as being illegal, the ILLEGAL CHARACTER level remains at 0 volts allowing the CHARACTER COUNT pulse to tirgger the one-shot. The CHARACTER STROBE level increases from - 3 volts to 0 volts and remains 0 volts for 6 microseconds. At the end of this interval, CHARACTER STROBE decreases back to - 3 volts. This negative transition triggers Type 4606 Pulse Amplifier (A-2) to initiate generation of a CHARTSYN pulse if $\overline{\text{WORD TRANSFER COMPLETE}}$ is negative. The CHARTSYN pulse produces the COLUMN COUNT pulse to again generate SHIFT CHARACTER. The operation continues until either a legal character is decoded or the word (five characters) transfer is completed.

A printable character transfer cycle follows. The LPT DATA SET pulse of a BUFFER AVAILABLE pulse initiates generation of a CHARTSYN pulse which in turn produces the DATA STROBE pulse (EDS - enable data strobe is negative) and a COLUMN COUNT pulse. The DATA STROBE pulse samples the control buffer CB0-CB5 output into the line printer character buffer. The COLUMN COUNT pulse through inverter gate (output pin T) generates SHIFT CHARACTER. The pulse also steps the column counter one count. The SHIFT CHARACTER pulse shifts the character out of the character input register and generates a CHARACTER COUNT pulse to step the character count (diagram 646-0-9, Appendix 1). The cycles continue in the same manner until a printable character is not decoded or the word transfer is completed.

The operations involved in character transfer cycles for control characters depend on the type of control character being processed.

A horizontal tab control character (011) results in the following circuit operations for a character transfer cycle. Decoding of the horizontal control character places CB0 of the control buffer at 0 volts and CB1 through CB5 at - 3 volts; these six bits represent a space character. A BUFFER AVAILABLE pulse or the LPT DATA SET pulse generates the CHARTSYN pulse. Because of the EDS negative level, this pulse initiates generation of the DATA STROBE which samples the CB0-CB5 content into the line printer character buffer. The COLUMN COUNT pulse resulting from the CHARTSYN pulse is inhibited from passage through the inverter gates to initiate a SHIFT CHARACTER pulse. The BUFFER AVAILABLE pulse indicating receipt of the CB0-CB5 data initiates generation of a CHARTSYN pulse if the horizontal tab character was not the last character of the five-character entry in the character input register ($\overline{\text{WORD TRANSFER COMPLETE}}$ negative). The entry of space characters in the line printer character buffer continues until the TS-1 and TS-2 inputs to Type 4114 Diode Gate (D-1) are simultaneously at 0 volts. The resulting negative level for TAB STOP enables the Type 4217 Inverter Gate (output pin L) to pass the COLUMN COUNT pulse to initiate a SHIFT CHARACTER pulse that shifts the horizontal tab control character out of the character input register. Thus, when the TAB STOP column point is reached, space characters have been entered between the last printable character and the column point for the next printable character entry. The column counter records the number of columns used since each COLUMN COUNT pulse steps the counter.

A vertical format control character which occurs at column 1 (characters not entered in character buffer) has a character transfer cycle similar to that of a printable character. The CHARTSYN pulse, produced by either LPT DATA SET or BUFFER AVAILABLE, initiates generation of the SPACE COMMAND pulse. The resulting COLUMN COUNT pulse through output pin T inverter gate initiates generation of a SHIFT CHARACTER pulse which shifts the vertical format control character out of the character register. The column counter does not advance as the EDS signal remains negative and inhibits the COLUMN COUNT pulse from stepping the counter (diagram 646-0-5, Appendix 1).

A vertical format control character transfer cycle after characters (printable or space) have been entered in the line printer character buffer (column count more than one) follows. The

CHARTSYN pulse initiates generation of PRINT and SPACE. The vertical format code is sampled into the vertical control section of the line printer to advance the paper to the specified line. The CHARTSYN pulse also produces the COLUMN COUNT pulse. This pulse cannot generate SHIFT CHARACTER as all three inverter gates are inhibited. The output pin T gate is inhibited since a form advance occurred and the column count exceeded one. The output pin L gate is inhibited since a horizontal tab control character is not being processed. The output pin H gate is inhibited since LOAD SPACE and EQUAL COUNT are not both at 0 volts. The FORM ADV · $\overline{1\ \text{COUNT}}$ level is negative to allow COLUMN COUNT to set the LOAD SPACE flip-flop (B-7). After the characters stored in the line printer character buffer are printed out and the paper advances to the specified line, BUFFER AVAILABLE initiates generation of a CHARTSYN pulse. The CHARTSYN pulse initiates generation of DATA STROBE which samples the CB0-CB5 content representing a space character into the character buffer. The CHARTSYN pulse also produces a COLUMN COUNT pulse which steps the space counter rather than the column counter (diagram 646-0-5, Appendix 1). The EQUAL COUNT circuit compares the count in the column counter to the count in the space counter representing space characters entered in the character buffer. The CHARTSYN pulse continues to generate the DATA STROBE pulse and the COLUMN COUNT pulse until the count of the space counter equals the count in the column counter. The CHARTSYN pulse at this equal count condition produces a COLUMN COUNT pulse, which, since both LOAD SPACE and EQUAL COUNT are 0 volts, passes through the output pin H gate to generate SHIFT CHARACTER. The vertical format character is shifted out of the character input register and a CHARACTER COUNT pulse steps the character counter. This CHARACTER COUNT pulse also generates a CLEAR SPACE COUNTER pulse which resets the LOAD SPACE flip-flop and returns the space counter to a zero-count status.

A decoded carriage return control character results in the following transfer cycle. The CHARTSYN pulse generates the PRINT and SPACE command signal and, since 015 (carriage return) is negative, the CLEAR COLUMN COUNTER pulse. The characters stored in the line printer character buffer are printed out but the INHIBIT SPACE signal prevents advance of the paper (diagram 646-0-7, Appendix 1). The clearing of the column counter in effect returns the printing point for subsequent characters to the extreme left-hand column of the page.

Control Character Decoding

The control character decoding circuit (diagram 646-0-7, Appendix 1) determines if a character in the character input register is legal or illegal; and if it is legal, what action is required. The circuit consists of two Type 4151 Binary-to-Octal Decoders which decode the seven bits of each character. Additional decoding is performed by diode gates, Type 4112 and Type 4113.

If the first two bits of the character complement each other or the character is decoded as a horizontal tab control (011) or a load space operation is to be performed as a result of a PRINT and SPACE command, the ENABLE DATA STROBE levels are at the voltage potentials to enable a CHARTSYN pulse to generate the DATA STROBE command.

Enable PRINT and SPACE is negative to allow generation of the PRINT and SPACE command signal if: a load space operation is not required; a carriage return control character (015) is decoded; or a paper advance occurred after characters were entered in the line printer character buffer (FORM ADV · $\overline{1\ \text{COUNT}}$).

FORM ADVANCE levels are at the enabling potentials when the character is decoded as being a vertical format control (see listing on diagram). FORM ADVANCE coupled with a column 1 count (diagram 646-0-5, Appendix 1) produces a negative enabling level for ENABLE SPACE COMMAND. FORM ADVANCE and $\overline{\text{FORM ADVANCE}}$ combines with the count in the column counter to provide enabling levels for the $\overline{\text{FORM ADV}}$ + 1 COUNT and FORM ADV + $\overline{1\ \text{COUNT}}$ signals used with the vertical format control characters.

An ILLEGAL CHARACTER enabling level occurs when the character cannot be decoded as a printable or as a control character.

If a control character is not decoded, the CB0-CB5 content reflects a printable character. Decoding of a control character alters the CB0-CB5 code to reflect the action required of the line printer vertical format control section in advancing the paper the specified number of lines.

SPECIAL CIRCUITS

With one exception, all modules used in the Line Printer Control Type 646 are fully discussed in the System Modules Catalog (C-100). The exception is the Type 4657 Diode Gates which

form the status register and drive the I/O bus lines (see diagram 646-0-6, Appendix 1). A detailed description ot this circuit is presented in the PDP-6 Arithmetic Processor Circuits Manual, F-67 (166 cir.).

CHAPTER 3

INSTALLATION AND INTERFACE

INSTALLATION

The Line Printer Control Type 646 is housed in a standard DEC cabinet separate from the line printer (refer to the PDP-6 Installation Manual, F-68). Its exact location will depend upon the configuration of the purchased system. In a new PDP-6 system, the control is mounted in the cabinet prior to shipment, and installation procedures after delivery consist of the following:

1. Remove tape securing line printer control modules in the module panels.

2. Check module types and installed positions with engineering documentation accompanying the PDP-6 system. If discrepancies are noted, change module types and/or positions to conform to the engineering documentation.

3. Compare the installation of the eight I/O bus cables to the engineering documentation; change if necessary.

4. Place all module panel power distribution control switches in the NORMAL position.

5. Install interface cable between the Line Printer Control Type 646 and the 646 Line Printer.

6. Refer to the PDP-6 Maintenance Manual for instructions pertaining to the application of primary power to the computer cabinet.

7. Connect 646 Line Printer to primary power source and check its operation per test procedures described in the Series 5 ANelex Printer Instruction Manual.

8. Perform diagnostic program routine described in PDP-6 Maintenance Manual to verify operation of line printer control and line printer.

If the Line Printer Control Type 646 and 646 Line Printer are to be added to an existing PDP-6 system, install the units according to the instructions in the accompanying engineering documentation. After installation is complete, perform steps 7 and 8 of the above installation procedure to verify operation of the line printer control and line printer.

INTERFACE

The interface signals between the line printer control and the I/O bus cables (Figure 3-1) are listed under Signal Interface (I/O Bus). The interface signals between the line printer control and the line printer (Figure 3-2) are listed under Signal Interface (Line Printer).

Signal Interface (I/O Bus)

Signal Levels

Logical 1: 0 volts nominal
Logical 0: -3 volts nominal

PI1-PI7 (priority interrupt) - seven lines, seven-level priority interrupt code input (done or error) to PDP-6 program.

IOS3-IOS9 (I/O select) - 14 lines (1 and 0), 7-bit device selection code. Line printer is selected when line printer control decodes 001 010 1 (124_8).

CONO CLEAR - one line, negative pulse clears control register of printer control.

CONO SET - one line, negative pulse enters done and error interrupt codes in line printer control register and clears line printer control and line printer character buffer if IOB7 bit is 1.

DATAO CLEAR - one line, negative pulse initiates clearing of the line printer control character input register.

DATAO SET - one line, negative pulse enters five 7-bit characters (IOB0 through IOB34) in line printer control character input register and initiates processing of first character.

PIN	I.O. CABLE #1	I.O. CABLE #2	I.O. CABLE #3	I.O. CABLE #4
A	GND	GND	GND	GND
B	IOB Ø (1) ⟷	IOB 18 (1) ⟷	POWER RESET →	DATAO CLEAR →
C	IOB 1 (1) ⟷	IOB 19 (1) ⟷	POWER ON -15V	DATAO SET →
D	IOB 2 (1) ⟷	IOB 2Ø(1) ⟷		CONO CLEAR →
E	IOB 3 (1) ⟷	IOB 21 (1) ⟷		CONO SET →
F	IOB 4 (1) ⟷	IOB 22 (1) ⟷	IOS 3 (Ø) ⟷	IOB ← DATAI →
H	IOB 5 (1) ⟷	IOB 23 (1) ⟷	IOS 3 (1) ⟷	IOB ← STATUS →
J	GND	GND	GND	GND
K	IOB 6 (1) ⟷	IOB 24 (1) ⟷	IOS 4 (Ø) ⟷	
L	IOB 7 (1) ⟷	IOB 25 (1) ⟷	IOS 4 (1) ⟷	
M	IOB 8 (1) ⟷	IOB 26 (1) ⟷	IOS 5 (Ø) ⟷	
N	IOB 9 (1) ⟷	IOB 27 (1) ⟷	IOS 5 (1) ⟷	
P	IOB 1Ø(1) ⟷	IOB 28 (1) ⟷	IOS 6 (Ø) ⟷	
R	IOB 11 (1) ⟷	IOB 29 (1) ⟷	IOS 6 (1) ⟷	PI REQ 1 ⟷
S	GND	GND	GND	GND
T	IOB 12 (1) ⟷	IOB 3Ø(1) ⟷	IOS 7 (Ø) ⟷	PI REQ 2 ⟷
U	IOB 13 (1) ⟷	IOB 31 (1) ⟷	IOS 7 (1) ⟷	PI REQ 3 ⟷
V	IOB 14 (1) ⟷	IOB 32 (1) ⟷	IOS 8 (Ø) ⟷	PI REQ 4 ⟷
W	IOB 15 (1) ⟷	IOB 33 (1) ⟷	IOS 8 (1) ⟷	PI REQ 5 ⟷
X	IOB 16 (1) ⟷	IOB 34 (1) ⟷	IOS 9 (Ø) ⟷	PI REQ 6 ⟷
Y	IOB 17 (1) ⟷	IOB 35 (1) ⟷	IOS 9 (1) ⟷	PI REQ 7 ⟷
Z	GND	GND	GND	GND
	(SOURCE 3L6)	(SOURCE 3L7)	(SOURCE 2L13)	(SOURCE 2N25)

ARRANGEMENT OF
I/O BUS CONNECTORS

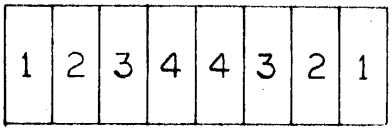


Figure 3-1 Signal Interface (I/O Bus)

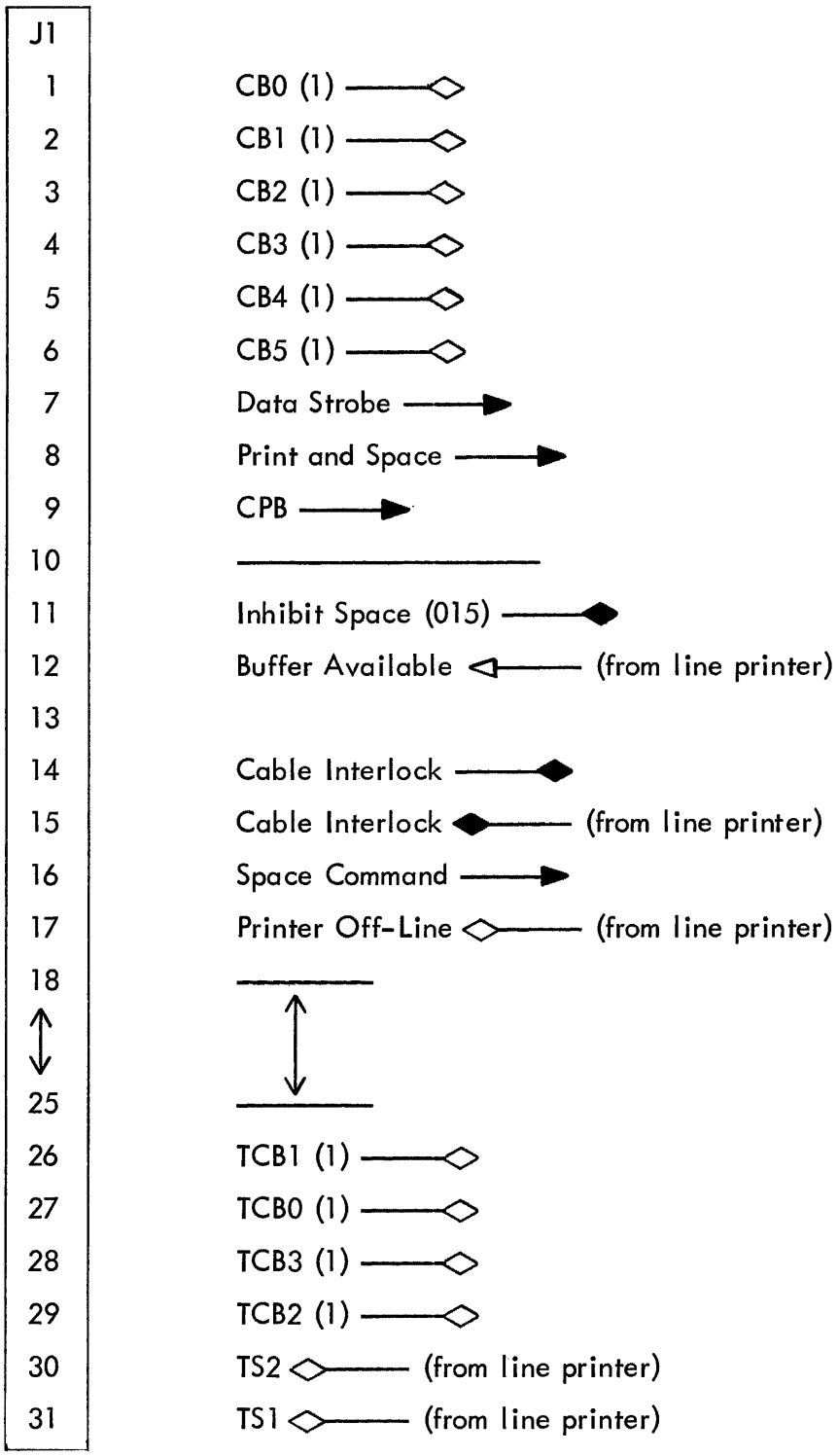


Figure 3-2 Signal Interface (Line Printer)

IOB0-IOB35 - 36 lines (two-way), logical levels (1 or 0) represent interrupt code for entry in control register by CONO, characters for entry in character input register by DATAO, or line printer control status signals for entry in PDP-6.

IOB STATUS - one line, -3 volt level coupled with line printer control selection samples contents of status register into PDP-6.

IOB POWER RESET - one line, negative pulse clears line printer control register.

Signal Interface (Line Printer)

Signal Levels

Logical 1: 0 volts nominal
Logical 0: -3 volts nominal

Output Signals (to line printer)

CB0-CB5 - six lines, printable character or control character code sent in two octal bits; printable character sampled into line printer character buffer by DATA STROBE pulse. Control character code entered in line printer vertical format control section by PRINT and SPACE or SPACE COMMAND signal unless INHIBIT SPACE signal occurs.

DATA STROBE - one line, negative pulse samples CB0-CB5 printable character into line printer character buffer.

PRINT and SPACE - one line, negative pulse initiates printout of characters stored in the line printer character buffer. Also samples CB0-CB5 control character code into line printer vertical control section. Paper advances to specified line after printout is completed unless INHIBIT SPACE signal occurs.

SPACE COMMAND - one line, negative pulse samples CB0-CB5 control character code into line printer vertical control section. Paper is advanced to line specified by code entry.

CPB (clear printer buffer) - one line, negative pulse initiates clearing of the line printer character buffer.

TC0-TC3 (tab count) - four lines, levels (1 or 0) indicate binary count of tabbed columns.

CABLE INTERLOCK - two lines, indicate by voltage level when line printer interface cable is connected.

INHIBIT SPACE - one line, negative level inhibits line printer from advancing paper when PRINT and SPACE signal occurs; stored characters in the line printer character buffer are printed out. A carriage return control character initiates the INHIBIT SPACE signal.

Input Signals (from line printer)

BUFFER AVAILABLE - one line, positive pulse indicates that line printer character buffer is ready to accept a CB0-CB5 printable character input.

TS1, TS2 (tab select) - two lines, both simultaneously at 0 volts only when preselected tab increment of 8, 10, 12, 16, or 20 columns is reached. Tab increment is selected by line printer tab selection switch.

PRINTER OFF-LINE - one line, 0-volt level indicates line printer is in off-line status; -3 volt level indicates on-line status.

CHAPTER 4

OPERATION

With two exceptions, the PDP-6 system through CONO and DATAO program instructions completely controls operation of the Line Printer Control Type 646. The first exception is the manual positioning of the 646 Line Printer tab selection switch to preselect the tab increment (8, 10, 12, 16, or 20 columns) for use with the horizontal tab control character input from the program. The tab selection switch is located within the right-hand access door of the 646 Line Printer on the test switch panel. The second exception is the MANUAL PRINT control located on the line printer console. Depression of this control initiates an immediate printout of characters stored in the line printer character buffer. Refer to the separate manual for the 646 Line Printer (series 5 ANelex line printer) listed under pertinent documents, page 1-7, for line printer operation.

Programming for the Line Printer Control Type 646 is discussed in detail in the PDP-6 Handbook (F-65) under the input/output chapter. A summary of programming for this device follows.

CONO (conditions out) - enters done and error priority interrupt codes in control register. Also clears line printer control and line printer character buffer if I/O bit 7 is 1.

DATAO (data out) - enters five 7-bit characters in character input register and initiates processing of first character.

Priority Interrupt Codes - I/O bits 12, 13, and 14 enter error priority interrupt code; I/O bits 15, 16, and 17 enter done priority interrupt code.

Device Selection Code - IOS3 through IOS9 lines must reflect 001 010 1 (124_8) to select the line printer.

CONO instruction information comes to the line printer control through the right half (I/O bits 0-17) of the 36 data lines. The status register is read out through the left half (I/O bits 18-36) of the data lines.

The five 7-bit character entries come to the line printer control through I/O bit lines 0-34.

If the line printer character buffer capacity of 120 printable characters and spaces is exceeded before the program sends a printout command, the line printer control locks in the busy state. Enter a carriage return control character by a DATAO instruction or send a CONO instruction to clear the line printer control and the line printer.

When a carriage return function is to be exercised, program the carriage return control character prior to the vertical format (paper advance) control character rather than after it. This relationship results in faster operation.

CHAPTER 5

MAINTENANCE

Maintenance of the Line Printer Control Type 646 consists of procedures repeated periodically as preventive maintenance and tasks performed in the event of equipment malfunction as corrective maintenance. The procedures presented here assume that the reader understands the function of the controls and indicators described in Table 4-1 and is familiar with PDP-6 input/output programming described in the PDP-6 Handbook and in Chapter 4 of this manual. Refer to the series 5 ANelex Line Printer Manual for maintenance of the line printer. Maintenance activities require use of the equipment listed in Table 5-1, or equivalent, as well as the use of standard hand tools, cleansers, and test cables and probes.

TABLE 5-1 MAINTENANCE EQUIPMENT

Equipment	Manufacturer	Model
Multimeter	Triplett or Simpson	630-NA or 260
Oscilloscope	Tektronix	540 Series
Parallel Drum Diagnostic Program Tape	DEC	DEC-1-137-M
System Module Extender*	DEC	1954
System Module Puller*	DEC	1960

*One supplied with the equipment

If it is necessary to remove modules during preventive or corrective maintenance, the Type 1960 System Module Puller should be used. Turn off all power before extracting or inserting modules. Carefully hook the small flange of the module puller over the center of the module rim, and gently pull the module from the mounting panel. Use a straight, even pull to avoid damage to plug connections or twisting of the printed-wiring board. Since the puller does not fasten to the module, grasp the rim of the module to prevent it from falling. Access to controls on the module for use in adjustment or access to points used in signal tracing can be gained by removing the module, connecting a Type 1954 System Module Extender into the mounting panel, and then inserting the module into the extender.

PREVENTIVE MAINTENANCE

Preventive maintenance consists of tasks performed prior to the initial operation of the Line Printer Control Type 646 and periodically during its operating life to ensure that it is in satisfactory operating condition. Faithful performance of these tasks forestalls possible future failure by correcting minor damage and discovering progressive deterioration at an early stage. A log book used to record data found during the performance of each preventive maintenance task will indicate the rate of circuit operation deterioration and provide information to determine when components should be replaced to prevent failure of the equipment. These tasks consist of mechanical checks, which include cleaning and visual inspections; checks of specific elements such as the power supplies, clock and delay module timing; and marginal checks which aggravate border-line conditions or intermittent failure so that they can be detected and corrected. All preventive maintenance tasks should be performed as a function of conditions at the installation site and the downtime limitations of equipment use. Perform the mechanical checks at least once each month or as often as required to allow efficient functioning of the air filters. All other tasks should be performed on a regular schedule, at an interval determined by the reliability requirements of the system. For a typical application, a schedule of every four months or 700 equipment operating hours, whichever occurs first, is suggested.

Mechanical Checks

Assure good mechanical operation of the equipment by performing the following steps and the indicated corrective action for any substandard conditions found:

1. Clean the exterior and the interior of the equipment cabinet housing the Line Printer Control Type 646 by using a vacuum cleaner or clean cloths moistened in nonflammable solvent.

2. Clean the air filter at the bottom of the cabinet. Remove the filter by removing the fan and housing, which are held in place by two knurled and slotted captive screws. Wash the filters in soapy water, dry in an oven or by spraying with compressed gas, and spray with Filter-Kote (Research Products Corporation, Madison, Wisconsin) before replacing them in the cabinets.

3. Lubricate door hinges and casters with a light machine oil. Wipe off excess oil.

4. Visually inspect the equipment for completeness and general condition. Repaint any scratched or corroded areas with DEC blue enamel, No. 5150-S65.

5. Inspect all wiring and cables for cuts, breaks, fraying, deterioration, kinks, strain, and mechanical security. Tape, solder, or replace any defective wiring.

6. Inspect all mounting panels of logic to assure that each module is securely seated in its connector.

7. Verify that eight I/O bus cables are firmly seated in their respective connectors.

8. Inspect power supply capacitors for leaks, bulges, or discolorations. Replace any capacitors giving these signs of malfunction.

Power Supply Checks

Check the output voltage and ripple content of the Type 728 Power Supplies and assure that they are within tolerance. Use the multimeter to make the output voltage measurements without disconnecting the load. Use the oscilloscope to measure the peak-to-peak ripple content on dc outputs of the supplies. These supplies are not adjustable; so if the output voltage or ripple content is not within the tolerance specified, the supply is considered defective and troubleshooting procedures should be undertaken.

Check the +10-volt output between the black (-) and the red (+) terminals to assure that it is between 9.5 and 11.0 volts with less than 800 millivolts ripple. Check the -15 volt output between the black (+) and blue (-) terminals to assure that it is between 14.5 and 16.0 volts with less than 400 millivolts ripple. Note that the black terminals are common with the power supply chassis.

CORRECTIVE MAINTENANCE

The Line Printer Control Type 646 is constructed of highly reliable transistorized modules and standard circuits. Use of these circuits and faithful performance of the preventive maintenance tasks ensure relatively little equipment downtime due to failure. Should a malfunction occur, the condition should be analyzed and corrected as indicated in the following procedures. No special tools or test equipment are required for corrective maintenance other than a broad bandwidth oscilloscope and a standard multimeter. The best corrective maintenance tool is a thorough understanding of the physical and electrical characteristics of the system. Persons responsible for maintenance should become thoroughly familiar with the theory of operation as described in Chapter 2, specific circuit modules as described in the DEC System Modules Catalog, the engineering drawings presented in Appendix 1, and the location of mechanical and electrical components as described in Chapter 1.

Diagnosis and remedial action for a fault condition are performed in the following phases:

1. Preliminary investigation to gather all information and to determine the physical and electrical security of the drum system.

2. System troubleshooting to locate the fault to within a module through the use of diagnostic programming, signal tracing, or aggravation techniques.

3. Circuit troubleshooting to locate defective parts within a module.

4. Repairs to replace or correct the cause of a malfunction.

5. Validation test to assure that the fault has been corrected.

6. Log entry to record pertinent data.

Preliminary Investigation

It is virtually impossible to outline any specific procedures for locating faults within a complexed digital system such as the line printer control. Before commencing troubleshooting procedures, explore every possible source of information. Ascertain all possible information concerning any unusual function of the system prior to the fault and all possible program information such

as routine in progress, condition of indicators, etc. Search the maintenance log to determine if this type of fault has occurred before or if there is any cyclic history of this kind of fault, and determine how this condition was previously corrected. When the entire line printer control fails, perform a visual inspection to determine the physical and electrical security of all power sources, cables, connectors, etc. Assure that the power supplies are working properly and that there are no power short circuits by performing the power supply checks as described under Preventive Maintenance.

System Troubleshooting

Do not attempt to troubleshoot the line printer control without first gathering all information possible concerning the fault, as outlined under Preliminary Investigation.

Commence troubleshooting by performing that operation in which the malfunction was initially observed, using the same program. Thoroughly check the program for proper control settings, and note all indicator light operations before and at the time of the error. Careful checks should be made to assure that the system is actually at fault before continuing with corrective maintenance procedures. Loose or faulty cable connections can often give indications very similar to those caused by internal malfunctions. Faulty ground connections between pieces of equipment are a common source of trouble.

If the fault has been determined to lie within the Line Printer Control Type 646, but cannot be localized to a specific logic function, perform the diagnostic program procedure. When the location of the fault has been narrowed to a logic element, continue troubleshooting to locate the defective module or component by means of signal tracing. If the fault is intermittent, a form of aggravation tests should be employed to locate the source of the fault.

Diagnostic Program

The most efficient means of troubleshooting the line printer control makes use of the diagnostic program described in Maindec 646. This routine provides a complete test of operations of the line printer control.

Signal Tracing

If the fault has been located within a functional logic element, program the PDP-6 to repeat some instruction in which all functions of that logic element are utilized. If this test is to be performed without the use of the computer, control flip-flops or register flip-flops can be cleared or set manually by momentarily supplying a ground potential to the appropriate flip-flop output terminals. Counting operations of registers can be checked by supplying count pulses to the register from the output of a variable clock. Under these conditions, use the oscilloscope to trace signal flow through the suspected logic element. Oscilloscope sweep may be synchronized with any line printer control signal by connecting the trigger input to the appropriate module terminal on the wiring side (front) of the equipment. Trace output signals from the connector back to the origin, and trace input signals from the connector to its final destination. The signal-tracing method can be used to determine with absolute certainty the quality of pulse amplitude, duration, rise time, and the correct timing sequence of this signal. If an intermittent malfunction occurs, signal tracing must be combined with an appropriate form of aggravation test.

Intermittent Failures

Intermittent failures caused by poor wiring connections can often be revealed by vibrating the modules while running a repetitive routine, such as the diagnostic program. Often, wiping the handle of a screwdriver across the back of a suspect row of modules is a useful technique. By repeatedly starting the program and vibrating fewer and fewer modules, the malfunction can be localized to within one or two modules. After isolating the malfunction in this manner, check the seating of the modules in the connector, the module connector for wear and misalignment, and the module wiring for cold solder joints or wiring kinks.

Circuit Troubleshooting

The procedure followed for troubleshooting and correcting the cause of faults within modules and power supplies depends upon thedowntime limitations of line printer control use. Where downtime must be kept at a minimum, it is suggested that a provisioning parts program be adopted to maintain one spare module or power supply which can be inserted into the cabinet when system troubleshooting procedures have traced the fault to a particular component. A list of

Often the response time of the multimeter is too slow to detect the rapid transients produced by the intermittent connections. Current interruptions of very short durations, caused by an intermittent connection, can be detected by connecting a 1.5-volt flashlight battery in series with a 1500-ohm resistor across the suspected connection. Observe the voltage across the 1500-ohm resistor with an oscilloscope while probing the connection.

Dynamic Bench Tests

Dynamic bench testing of modules can be performed through the use of special equipment. A Type 922 Test Power Cable and either a Type 722 or Type 765 Power Supply can be used to energize a system module. These supplies provide both the +10 vdc and -15 vdc operating power for the module as well as ground and -3 volt sources which may be used to simulate signal inputs. The signal input potentials can be connected to any terminal normally wired to receive logic level signals by means of eyelets provided on the power cable. Type 911 Patch Cords may be used to make these connections between eyelets on the plug. In this manner logic operations and voltage measurements can be made throughout the circuit. When using the Type 765 Bench Power Supply, marginal checks of an individual module can also be obtained.

Repair

In all soldering and unsoldering operations in the repair and replacement of parts, avoid placing excessive solder or flux on adjacent parts or service lines. When soldering semiconductor devices (transistors, crystal diodes, and metallic rectifiers) which may be damaged by heat, the following special precautions should be taken:

1. Use a heat sink, such as a pair of pliers, to grip the lead between the device and the joint being soldered.

2. Use a 6-volt soldering iron with an isolation transformer. Use the smallest soldering iron adequate for the work.

3. Perform the soldering operation in the shortest possible time to prevent damage to the component and delamination of the module etched wiring.

When any part of the equipment is removed for repair and replacement, make sure that all leads or wires which are unsoldered, or otherwise disconnected, are legibly tagged or marked for identification with their respective terminals. Replace defective comments only with parts of equal or greater quality or narrower tolerance.

Validation Test

Following the replacement of any electrical component in the equipment, a test should be performed to assure the correction of the fault condition and to make any adjustment of the timing or signal levels affected by the replacement. This test should be taken from the preventive maintenance procedure most applicable to the portion of the system in which the fault was found. For example, if a filter capacitor was replaced in one of the power supplies, the ripple check for that power supply should be repeated as specified under Power Supply Checks. If repairs or replacements are made in an area which is not checked on preventive maintenance, an appropriate operational test should be devised. Normally, the diagnostic program serves this purpose if the error was found in a logic element pertaining to data transfer functions. If the fault occurred in the control elements of the machine, such as a flip-flop replacement, the register or control function performed by the flip-flop should be completely checked by manually setting and clearing or by programmed exercise of that function.

When time permits, it is suggested that the entire preventive maintenance tasks be performed as a validation test. The reasons for this are:

1. If one fault occurred and was corrected, other components may be marginal.

2. While the equipment is down and available, preventive maintenance can be performed and need not be scheduled again for four months (or the normal period).

Log Entry

Corrective maintenance activities are not completed until they are recorded in the maintenance log. Record all data indicating the symptoms given by the fault, the method of fault detection, the component at fault, the results of the validation tests, and any other information which would be helpful in maintaining the equipment in the future.

APPENDIX 1

ENGINEERING DRAWINGS

Reduced engineering drawings are produced in this appendix as an aid to understanding and maintaining the system. A complete set of formal engineering drawings is supplied separately with each system. Should any discrepancy exist between the drawings in this manual and those supplied with the equipment, assume the formal drawings to be correct.

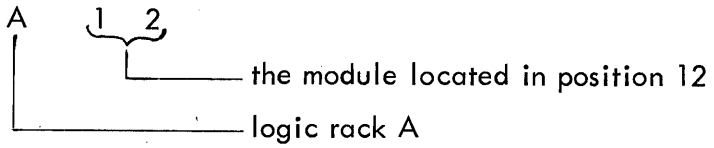
Refer to the Table of Contents for a complete list of engineering drawings for this system and the page on which the drawings appear.

For all modules illustrated, circuit type is always shown as a four-digit number. This number is the same type number used to identify the circuit in the DEC System Modules Catalog (C-100).

Example: 4112 --- Six 2-Input Negative Diode Gates (500-kc series)

On all circuit modules, the circuit location code is lettered directly below the circuit type number. Circuit location code is shown as a single letter followed by one or two digits.

Example:



As indicated on certain block schematics, the normal four-digit module identification number is followed by the letter R. This letter indicates that these modules contain internal jumpers which connect output terminals to clamped load resistors located on the module. Such modules are shipped from Digital with all jumpers connected. Before these modules can be installed in a particular Digital component, the module user must consult the block schematic for that component to determine which jumpers are to be removed and which jumpers are to remain connected. A number following a module identification number indicates which circuits of the module have clamped loads and which have unclamped loads. Decode this number (octal to binary) with 0 indicating an unclamped load and 1 indicating a clamped load. Each engineering logic drawing is divided into 32 zones (four horizontal and eight vertical) by marginal map coordinates. Figure references in the text are usually followed by a letter and a digit specifying the zone in which the referenced circuit is located.

SYMBOLS AND TERMINOLOGY

Engineering drawing numbers for this equipment contain five pieces of information, separated by hyphens. Reading from left to right, these bits of information are a two-letter code specifying the type of drawing, a one-letter code specifying the size of the drawing, the type number of the equipment, the manufacturing series of the equipment, and a two-digit number specifying the number of a drawing within a particular series. The drawing type codes are:

1. BS, block schematic or logic diagram
2. CD, cable diagram
3. CS, circuit schematic
4. FD, flow diagram
5. ID, interconnection drawing
6. PW, power wiring
7. RS, replacement schematic
8. SD, system diagram
9. TD, timing diagram
10. TFD, timing and flow diagram
11. UML, utilization module list
12. WD, wiring diagram

Logic Signals

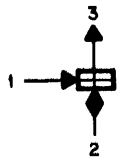
All logic signals are either standard Digital logic levels or standard Digital pulses. A standard Digital logic level is either a ground (0 to -0.3 volts) or -3 volts (-2.5 to -3.5 volts). Logic signals are generally given mnemonic names which indicate the condition represented by assertion of the signal. An open diamond (——◇) indicates that the signal is a level and that ground represents assertion; a solid diamond (——◆) indicates that the signal is a level and that -3 volts represents assertion.

All logic levels applied to the conditioning-level inputs of capacitor-diode gates must be present either 1 or 3 microseconds (depending on the module used) before an input triggering pulse is applied to the gate.

The standard Digital negative pulse is indicated by a solid triangle (——▶) and goes from ground to -2.5 or -3 volts (-2.3 to -3.5 volt tolerances). The standard Digital positive pulse, indicated by an open triangle (——▷), goes either from -3 volts to ground or from ground to +2.5 volts (+2.3 to +3.0 volts). The width of the standard pulses used in this equipment is either 1.0, 0.4, or 0.07 microseconds, depending on the module and application.

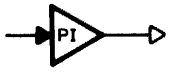
Occasionally, the transition of a level is used at an input where a standard pulse is otherwise expected and a composite symbol (——◇▷) is drawn to indicate this fact. The triangle is drawn open or solid depending, respectively, on whether the positive (-3 volt to ground) or the negative (ground to -3 volt) transition triggers circuit action. The shading of the diamond is the same as that of the triangle to indicate triggering on the leading edge of a level, or is opposite that of the triangle to indicate triggering on the trailing edge.

Any other signal is nonstandard and is indicated by an arrowhead (——→) pointing in the direction of signal flow. Figure A1-1 shows the standard symbols used in all Digital logic drawings.

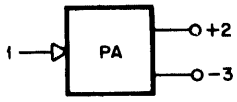


CAPACITOR-DIODE GATE, POSITIVE OR NEGATIVE INDICATED BY POLARITY OF THE INPUTS.

1. PULSE INPUT
2. CONDITIONING LEVEL INPUT
3. PULSE OUTPUT



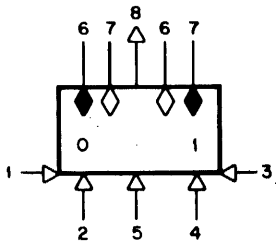
PULSE INVERTER



PULSE AMPLIFIER

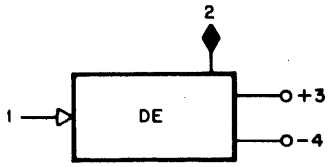
1. PULSE INPUT, POLARITY INDICATED BY INPUT SIGNAL

2,3. TRANSFORMER-COUPLED PULSE OUTPUT



FLIP-FLOP (MOST FLIP-FLOPS HAVE ONLY SOME OF THE FOLLOWING):

1. DIRECT-CLEAR INPUT
2. GATED-CLEAR INPUT
3. DIRECT-SET INPUT
4. GATED-SET INPUT
5. COMPLEMENT INPUT
6. OUTPUT LEVEL, -3 V IF 0, 0 V IF 1
7. OUTPUT LEVEL, 0 V IF 0, -3 V IF 1
8. CARRY PULSE OUTPUT



DELAY (ONE-SHOT MULTIVIBRATOR)

1. INPUT PULSE
2. OUTPUT LEVEL, -3V DURING DELAY

3,4. TRANSFORMER-COUPLED PULSE OUTPUT

Figure A1-1 Digital Logic Symbols

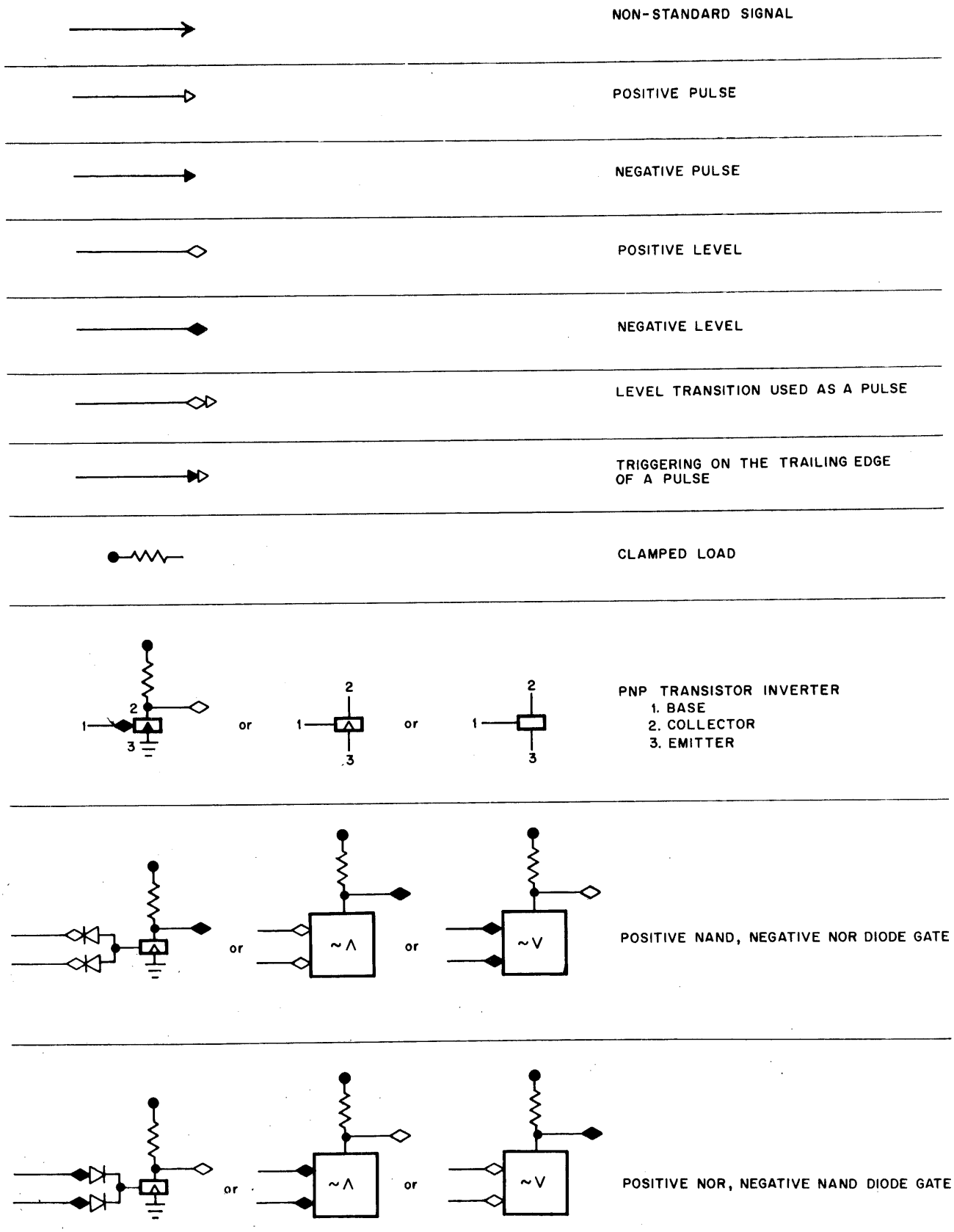
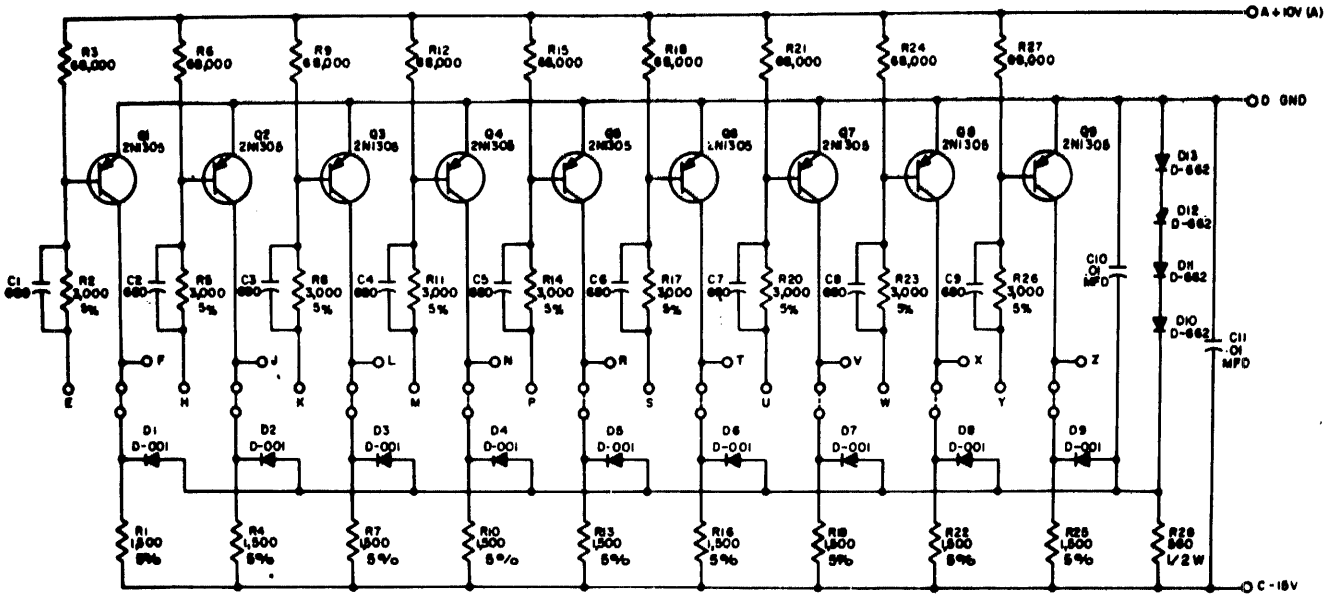


Figure A1-1 Digital Logic Symbols (continued)

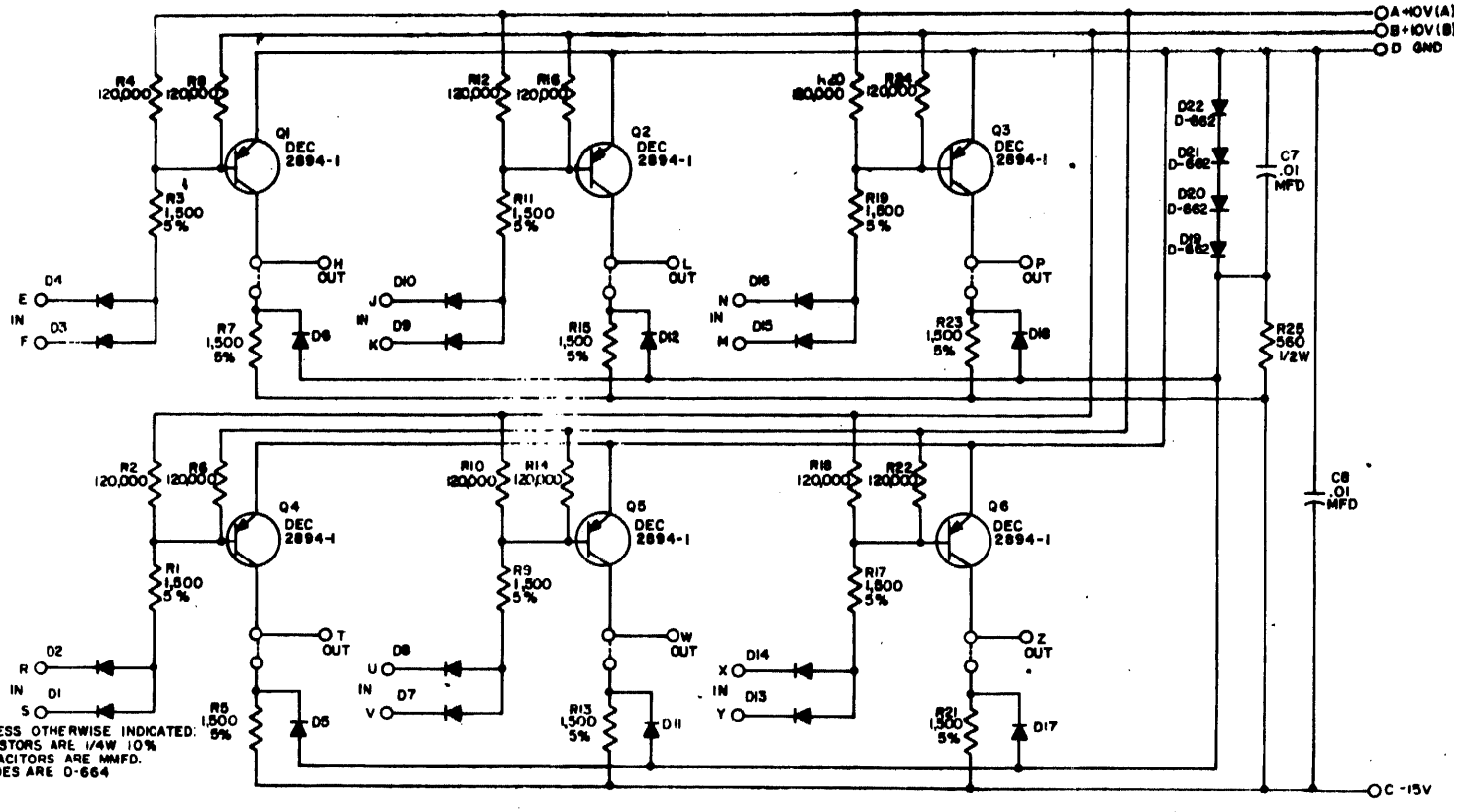


UNLESS OTHERWISE INDICATED
RESISTORS ARE 1/4W 10%
CAPACITORS ARE MMFD

TRANSISTOR & DIODE CONVERSION CHART			
DEC	EIA	DEC	EIA

Inverter

RS-4102

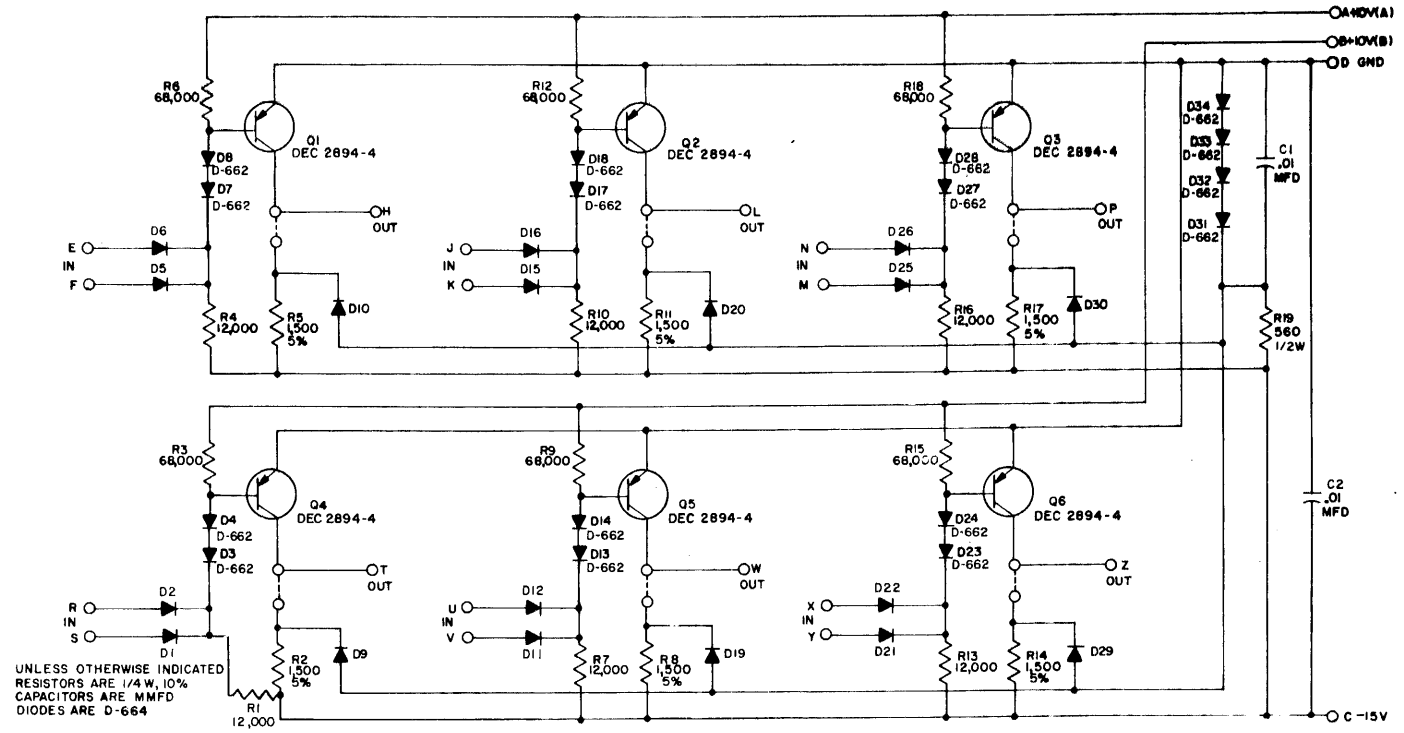


UNLESS OTHERWISE INDICATED:
RESISTORS ARE 1/4W 10%
CAPACITORS ARE MMFD.
DIODES ARE D-664

TRANSISTOR & DIODE CONVERSION CHART			
DEC	EIA	DEC	EIA

Diode

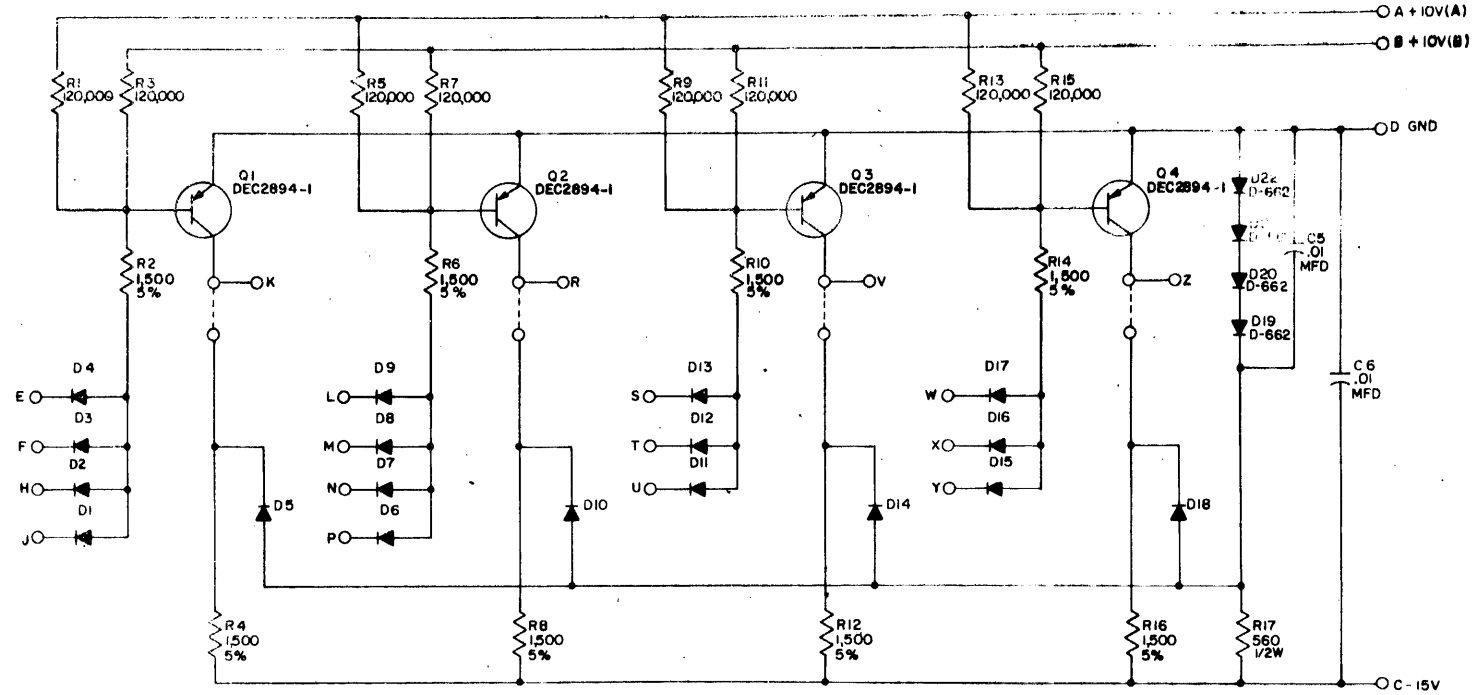
RS-4112



TRANSISTOR & DIODE CONVERSION CHART			
DEC	EIA	DEC	EIA
DEC 2894-4	DEC 2894		
D-662	IN645		
D-664	IN3606		

Diode

RS-4113

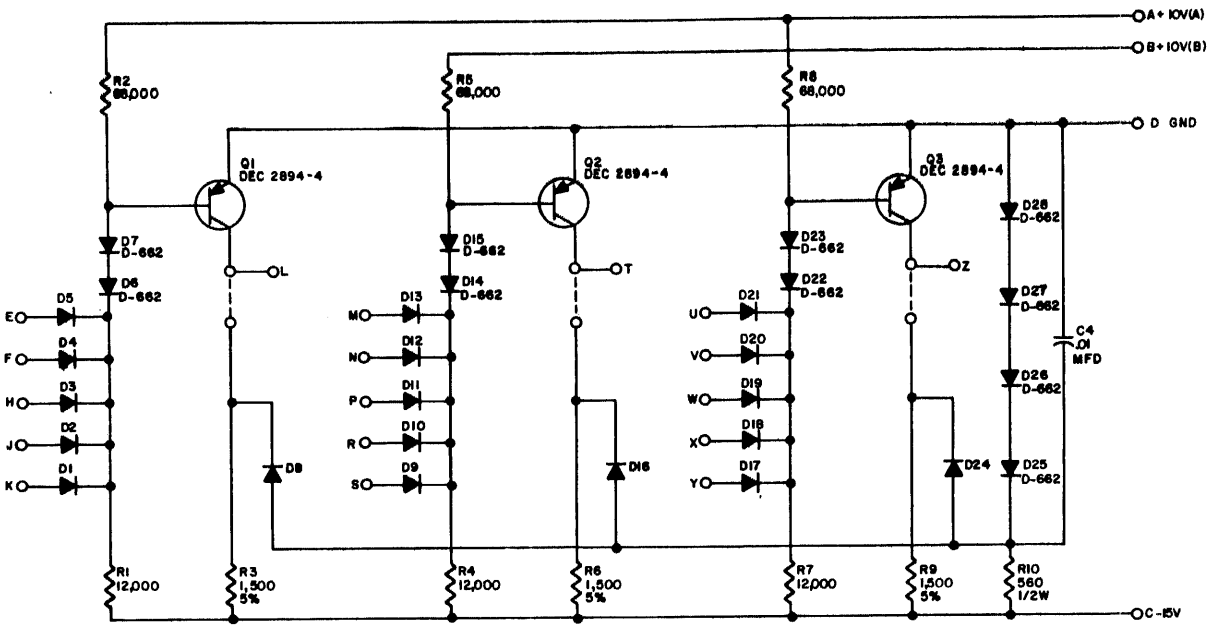


UNLESS OTHERWISE INDICATED:
RESISTORS ARE 1/4W; 10%
CAPACITORS ARE MMFD.
DIODES ARE D-664

TRANSISTOR & DIODE CONVERSION CHART			
DEC	EIA	DEC	EIA
[illegible]	[illegible]		
[illegible]	[illegible]		
[illegible]	[illegible]		

Diode

RS-4114

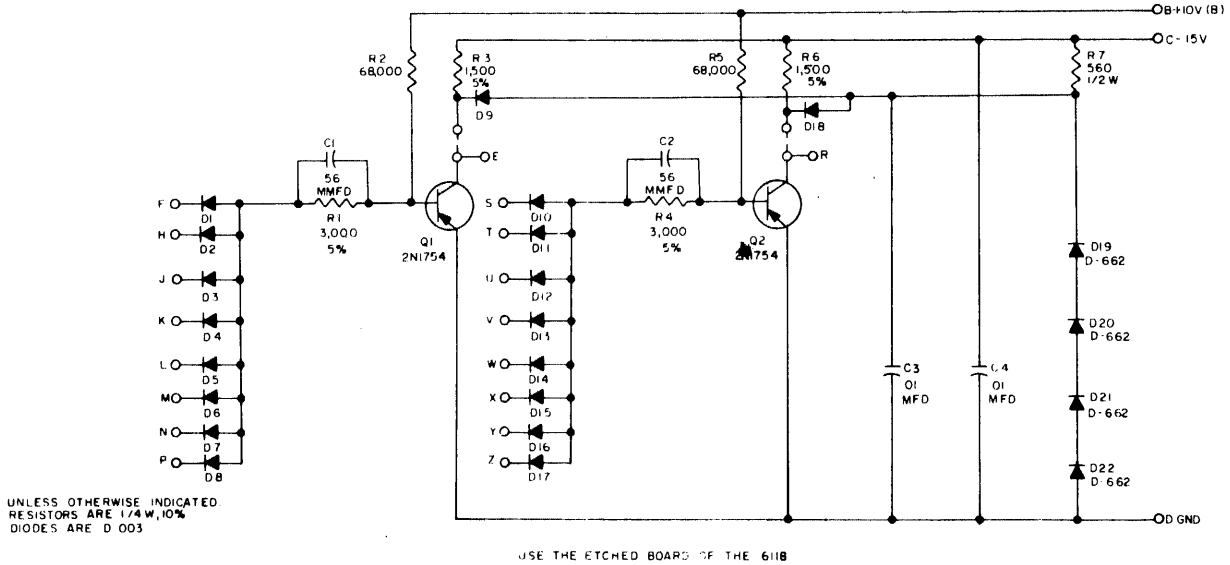


UNLESS OTHERWISE INDICATED:
RESISTORS ARE 1/4W; 10%
DIODES ARE D-664

Diode

RS-4117

TRANSISTOR & DIODE CONVERSION CHART			
DEC	EIA	DEC	EIA
DEC 2894-4	DEC 2894		
D-664	IN3606		
D-662	IN645		



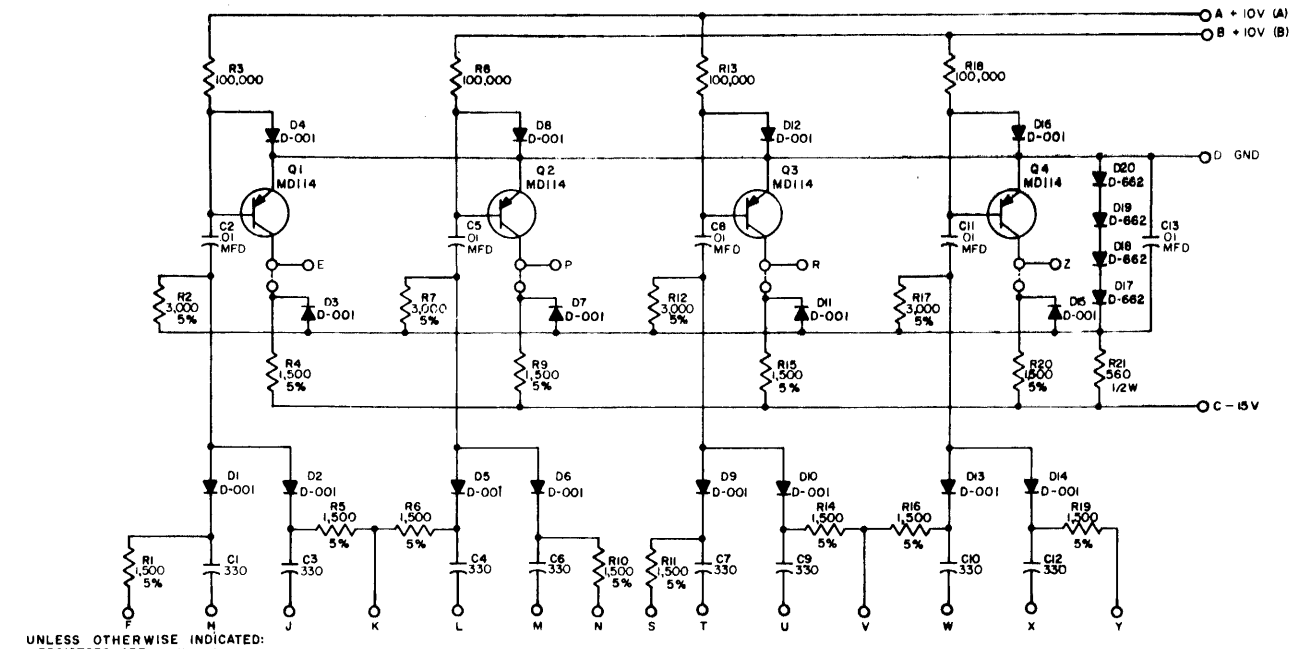
UNLESS OTHERWISE INDICATED
RESISTORS ARE 1/4W, 10%
DIODES ARE D 003

USE THE ETCHED BOARD OF THE 6118

TRANSISTOR & DIODE CONVERSION CHART			
DEC	EIA	DEC	EIA
D-003	IN994		
D-662	IN645		
2N1754	2N1754		

Negative Diode NOR

RS-4118

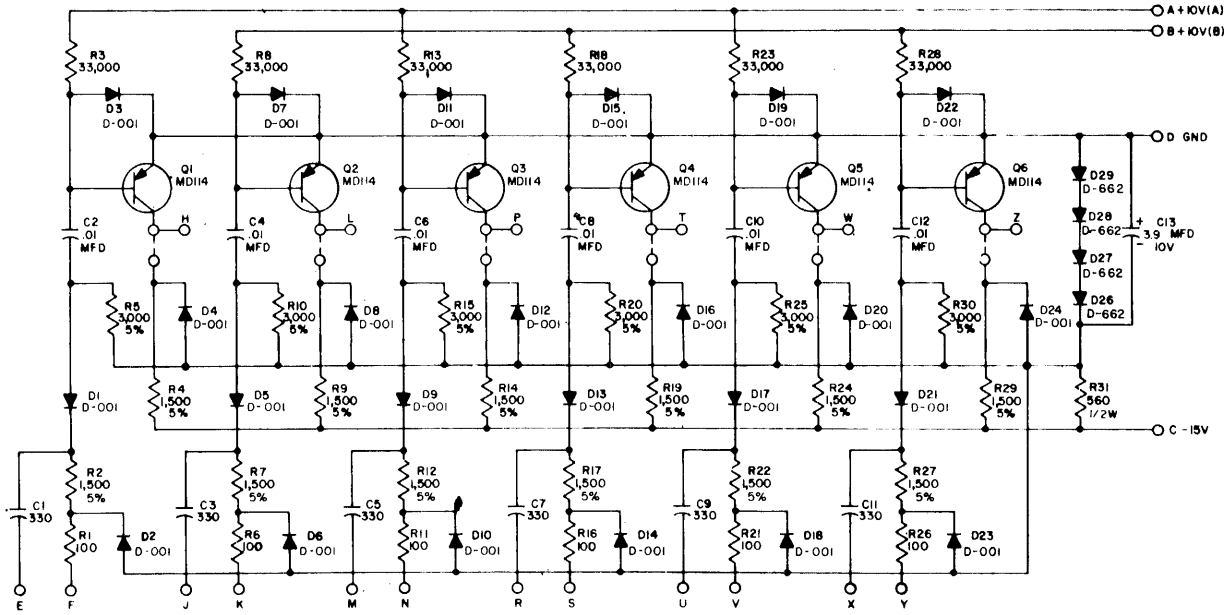


UNLESS OTHERWISE INDICATED:
RESISTORS ARE 1/4W; 10%
CAPACITORS ARE MMFD

TRANSISTOR & DIODE CONVERSION CHART			
DEC	ETA	DEC	ETA
MD114	2N1499A		
D-001	IN278		
D-662	IN646		

Capacitor-Diode-Inverter

RS-4125

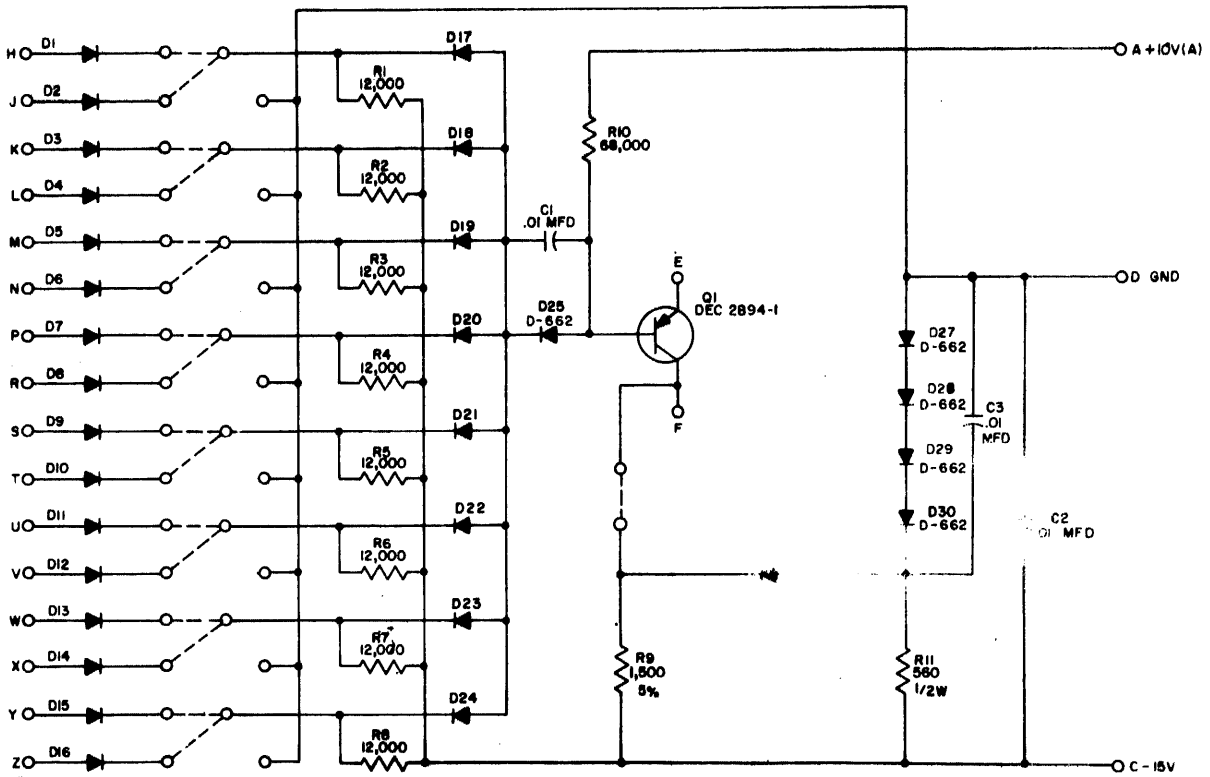


UNLESS OTHERWISE INDICATED
RESISTORS ARE 1/4W, 10%
CAPACITORS ARE MMFD

TRANSISTOR & DIODE CONVERSION CHART			
DEC	ETA	DEC	ETA
MD114	2N1499A		
D-001	IN278		
D-662	IN646		

Capacitor-Diode-Inverter

RS-4127

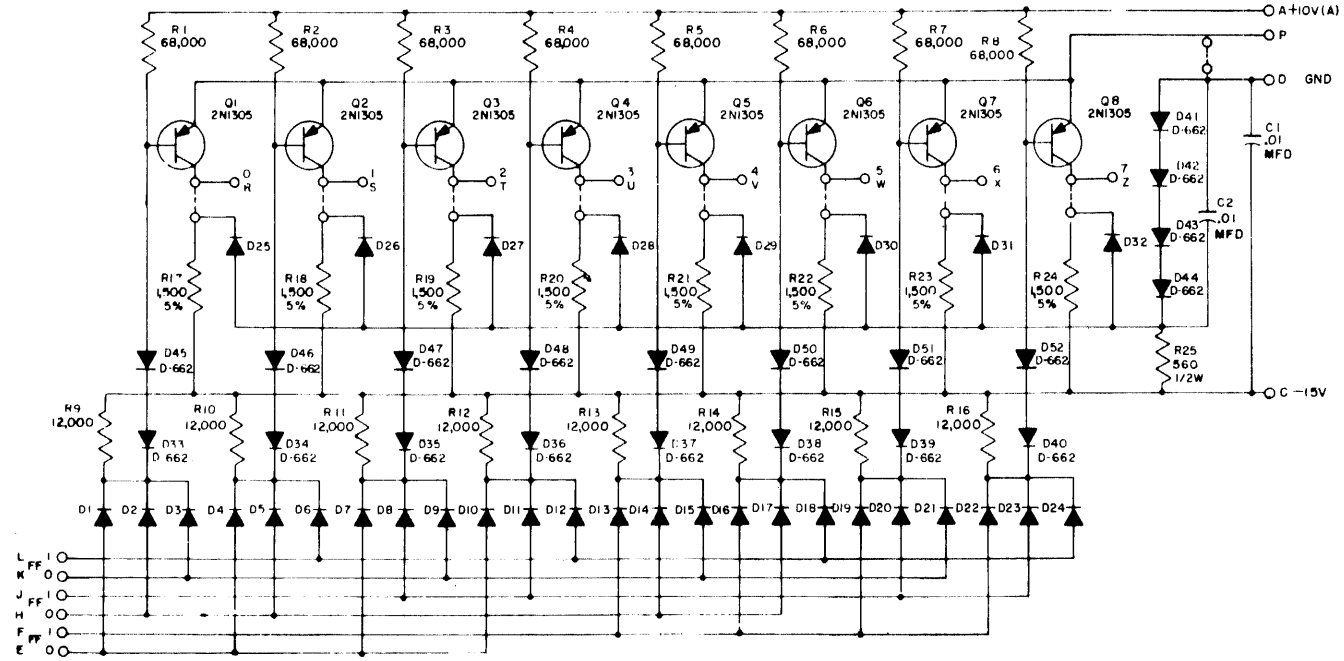


UNLESS OTHERWISE INDICATED:
RESISTORS ARE 1/4W; 10%
DIODES ARE D-664

TRANSISTOR & DIODE CONVERSION CHART			
DEC	EIA	DEC	EIA
DEC 2894-1	DEC 2894-1		
D-662	IN645		
D-664	IN3604		

Diode Unit

RS-4141

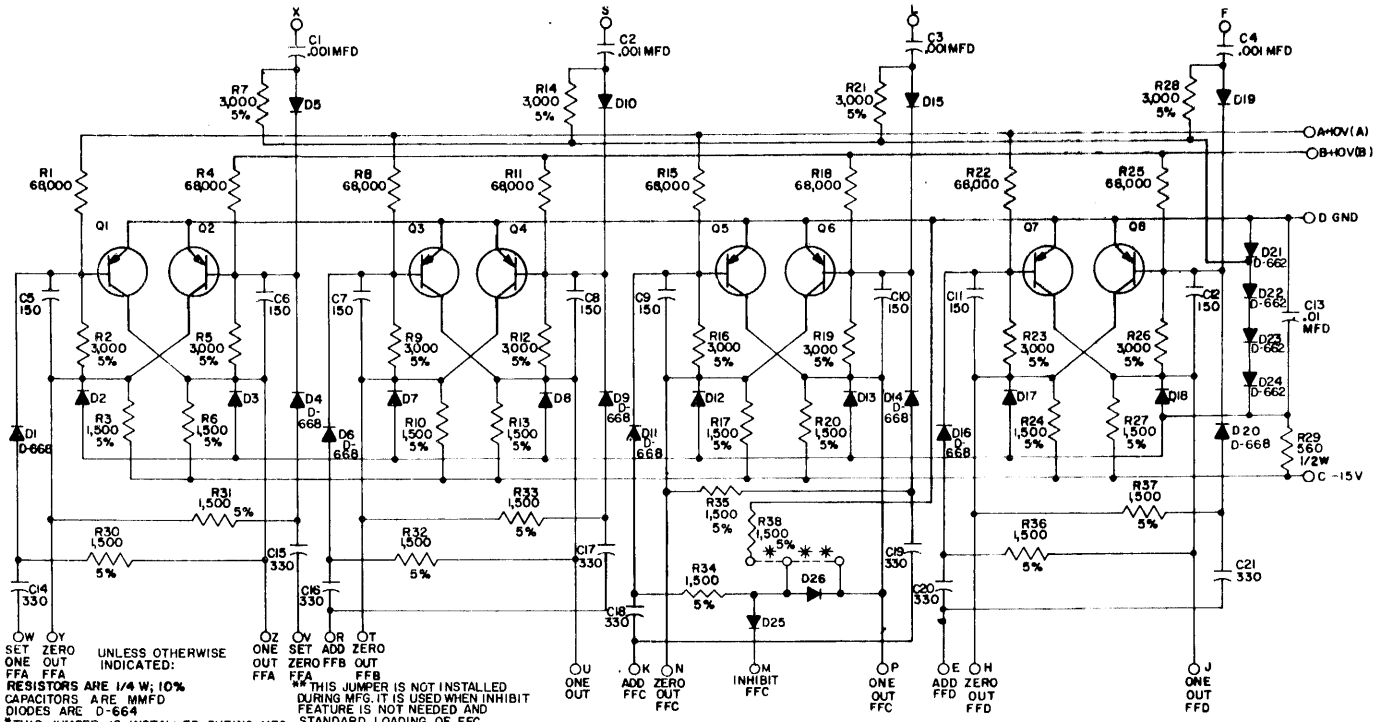


UNLESS OTHERWISE INDICATED
RESISTORS ARE 1/4W, 10%
DIODES ARE D-001

TRANSISTOR & DIODE CONVERSION CHART			
DEC	EIA	DEC	EIA
2N1305	2N1305		
D-001	IN276		
D-662	IN645		

Binary-to-Octal Decoder

RS-4151

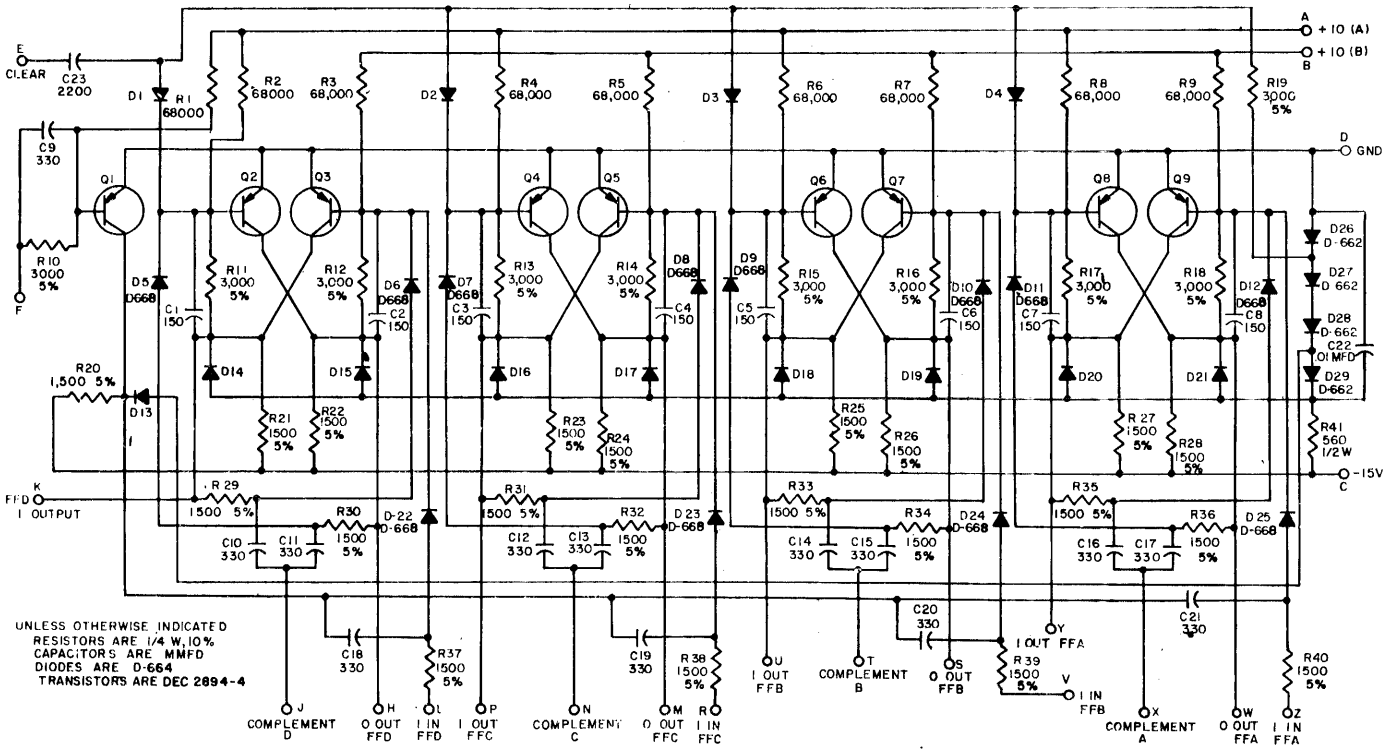


TRANSISTOR & DIODE CONVERSION CHART			
DEC	EIA	DEC	EIA
DEC 2894-4	DEC 2894		
D-668	D-668*		
D-662	IN645		
D-664	IN3606		

NOTES
* (TWO) IN3606 IN SERIES

4-Bit Counter

RS-4215

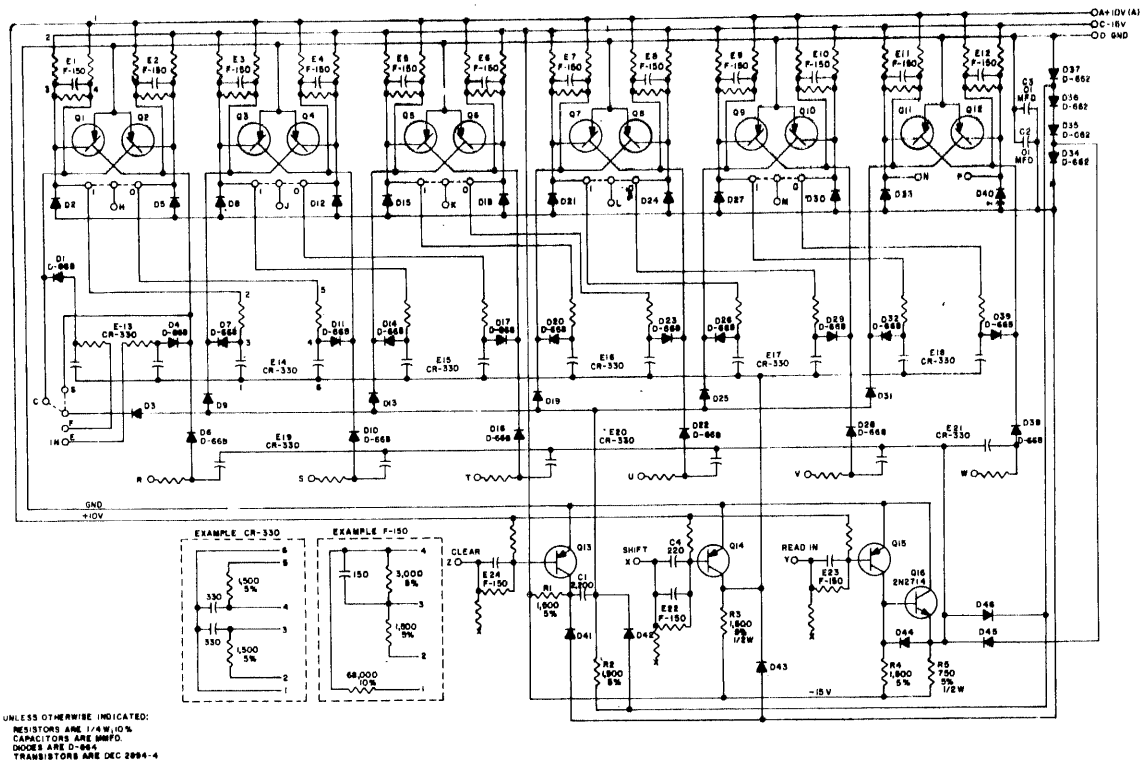


TRANSISTOR & DIODE CONVERSION CHART			
DEC	EIA	DEC	EIA
DEC 2894-4	DEC 2894		
D-668	D-668*		
D-662	IN645		
D-664	IN3606		

NOTES
* (TWO) IN3606 IN SERIES

4-Bit Counter

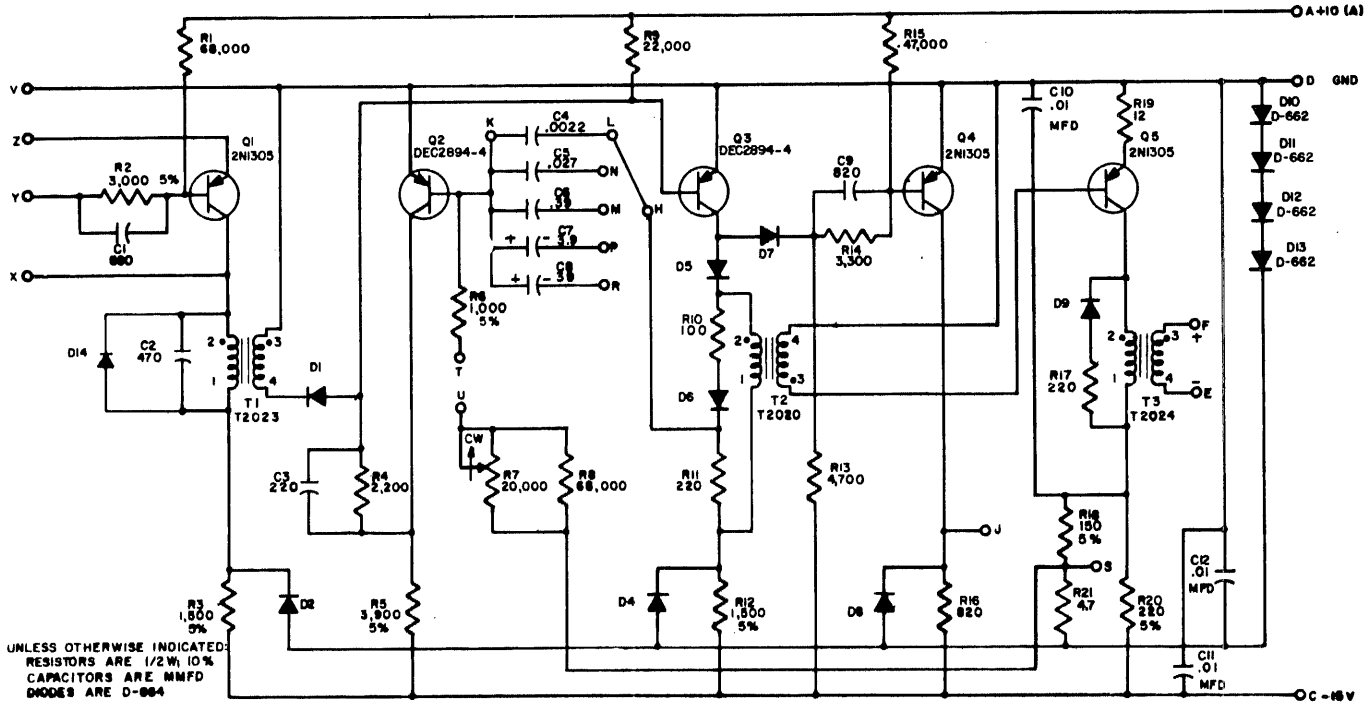
RS-4217



TRANSISTOR & DIODE CONVERSION CHART				NOTES
DEC	EIA	DEC	EIA	* (TWO) INSIDE IN SERIES
DEC 2894-4	DEC 2894			
2N1305	2N1305			
D-664	1N645			
D-662	1N645			
D-664	1N645*			

6-Bit Shift Register

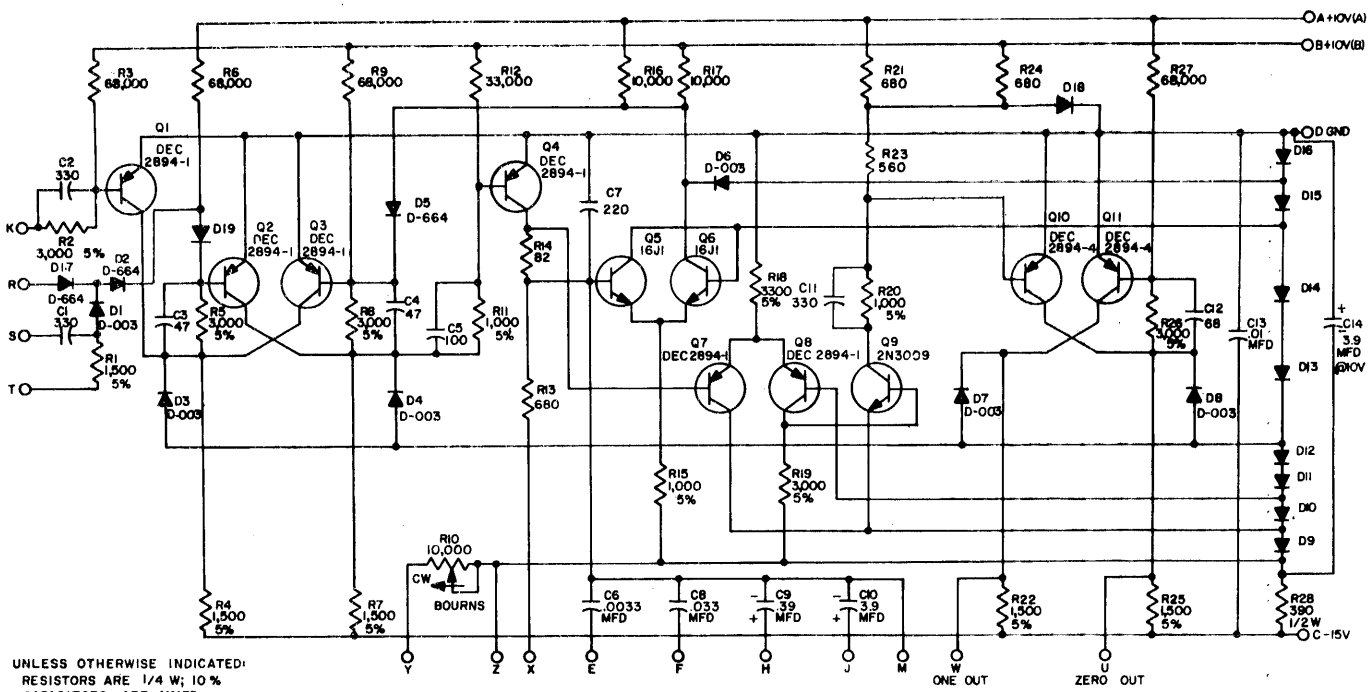
RS-4221



TRANSISTOR & DIODE CONVERSION CHART			
DEC	EIA	DEC	EIA
DEC 2894-4	DEC 2894		
2N1305	2N1305		
D-664	1N645		
D-662	1N645		

Delay

RS-4301

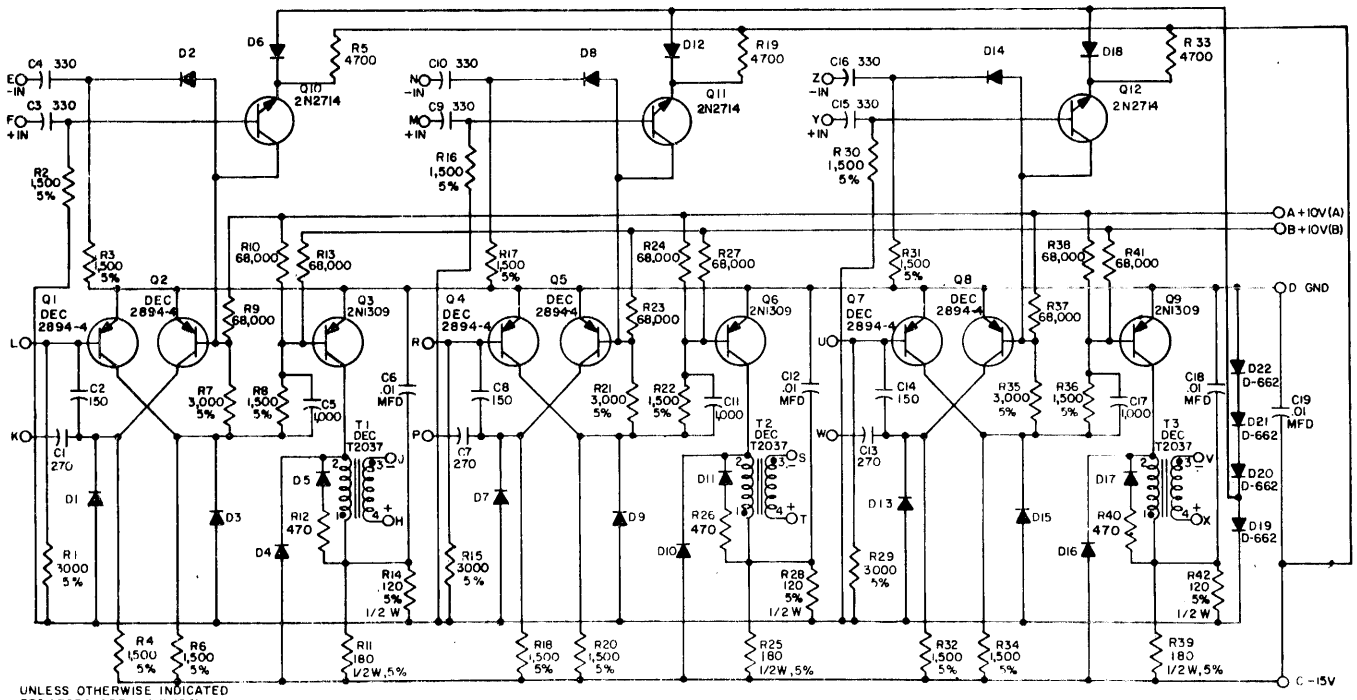


UNLESS OTHERWISE INDICATED:
RESISTORS ARE 1/4 W; 10 %
CAPACITORS ARE MMFD
DIODES ARE D-662

TRANSISTOR & DIODE CONVERSION CHART			
DEC	EIA	DEC	EIA
DEC 2894-1	DEC 2894	D-662	IN645
2N3009	2N3009	DEC 2894-4	DEC 2894
16J1	16J1		
D-003	IN994		
D-664	IN3605		

Integrating One-Shot

RS-4303

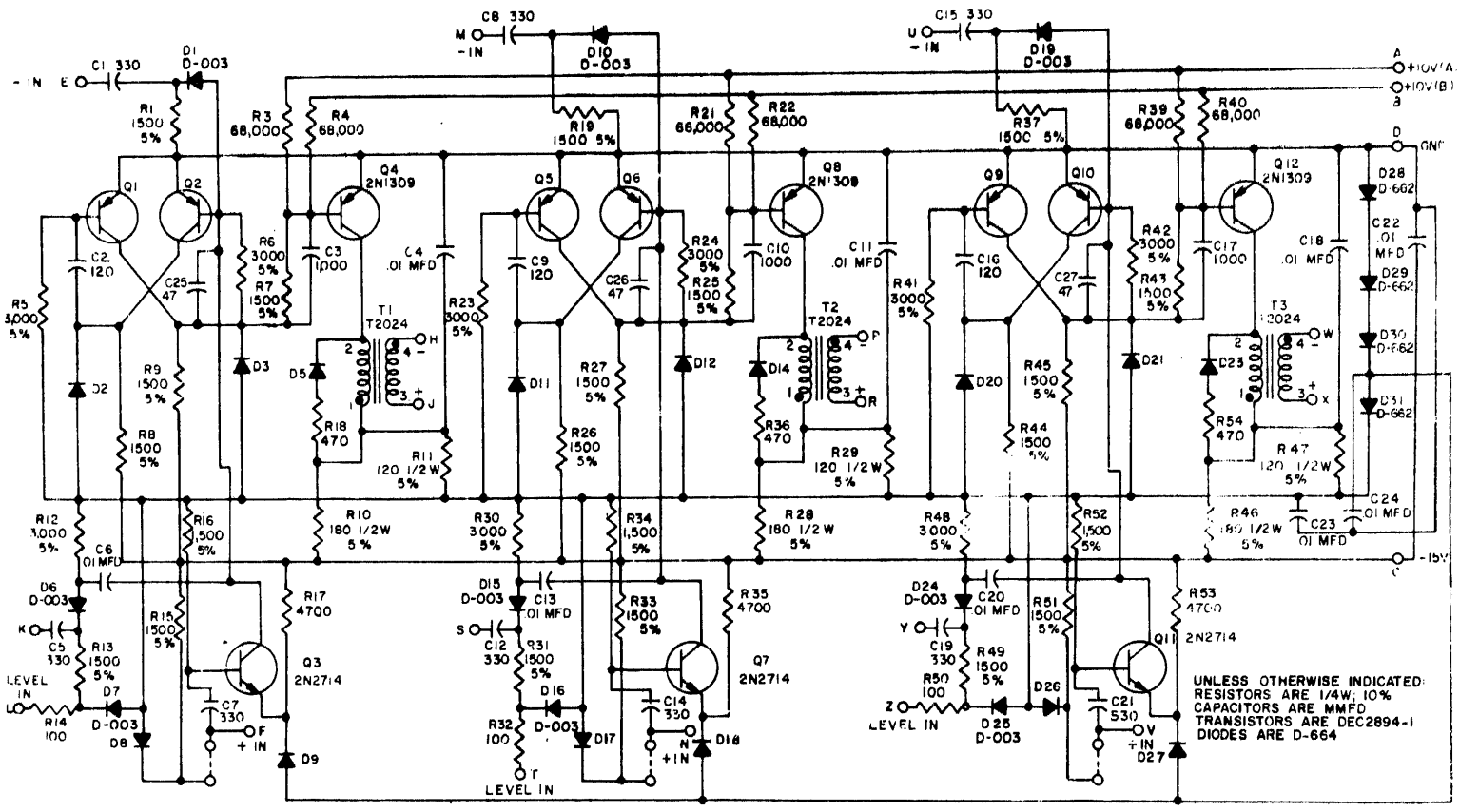


UNLESS OTHERWISE INDICATED
RESISTORS ARE 1/4W, 10%
CAPACITORS ARE MMFD
DIODES ARE D-664

TRANSISTOR & DIODE CONVERSION CHART			
DEC	EIA	DEC	EIA
2N2714	2N2714		
DEC 2894 4	DEC 2894		
2N1309	2N1309		
D-664	IN3606		
D-662	IN645		

Pulse Amplifier

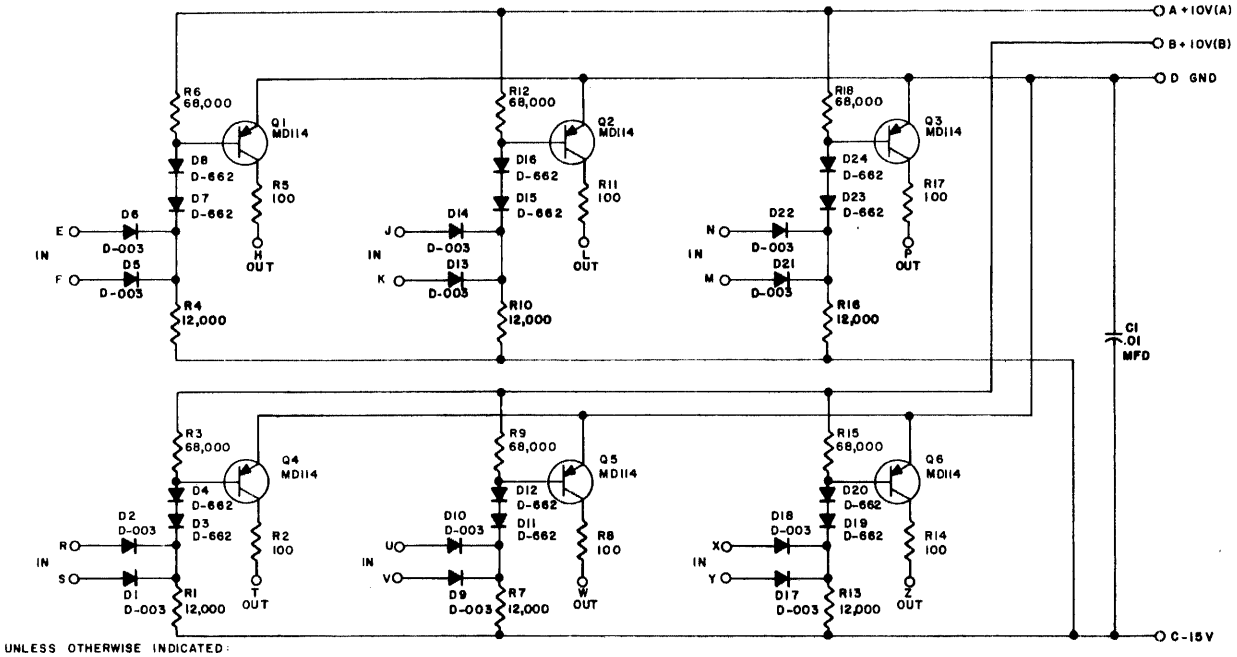
RS-4604



TRANSISTOR & DIODE CONVERSION CHART			
DEC	EIA	DEC	EIA
DEC 2894-1	DEC 2894	D-003	IN994
2N2714	2N2714		
2N1309	2N1309		
D-664	IN3604		
D-662	IN646		

Pulse Amplifier

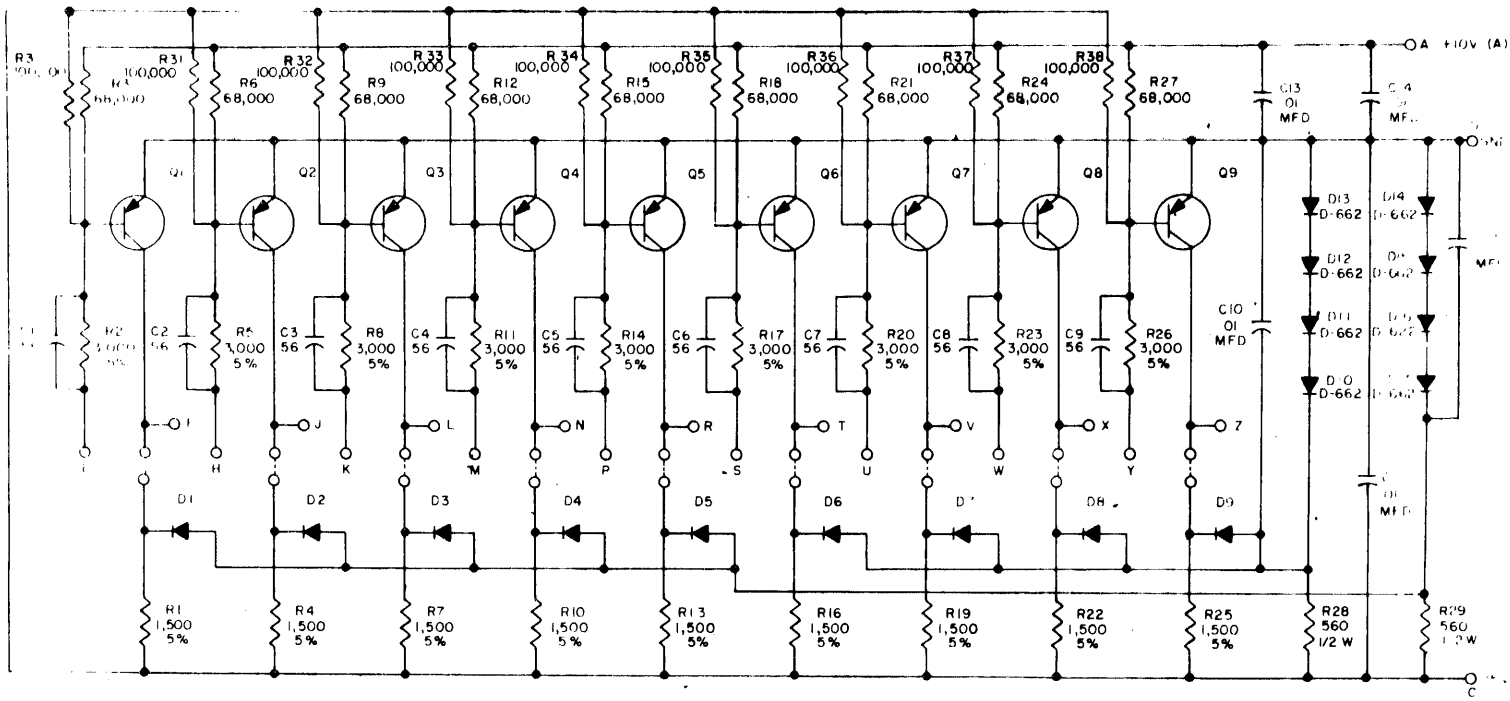
RS-4606



TRANSISTOR & DIODE CONVERSION CHART			
DEC	EIA	DEC	EIA
MD114	2N1490A		
D-003	IN994		
D-662	IN648		

I/O Bus Driver

RS-4657

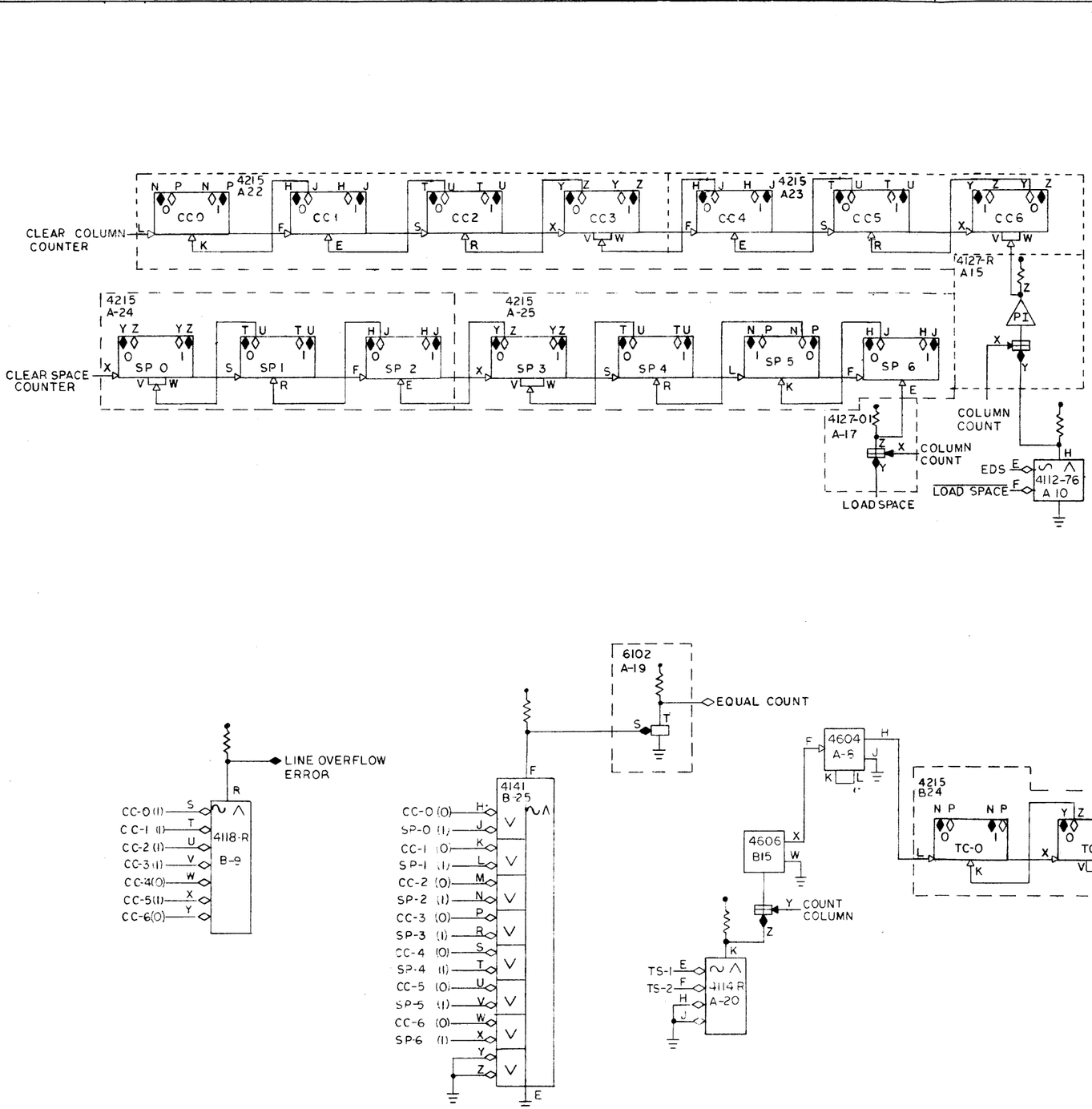


UNLESS OTHERWISE INDICATED
RESISTORS ARE 1/4 W, 10%
CAPACITORS ARE MMFD
TRANSISTORS ARE DEC 2894-1
DIODES ARE D-664

TRANSISTOR & DIODE CONVERSION CHART			
DEC	EIA	DEC	EIA
DEC 2894-1	2N[illegible]		
D-664	1N[illegible]		
D-662	1N[illegible]		

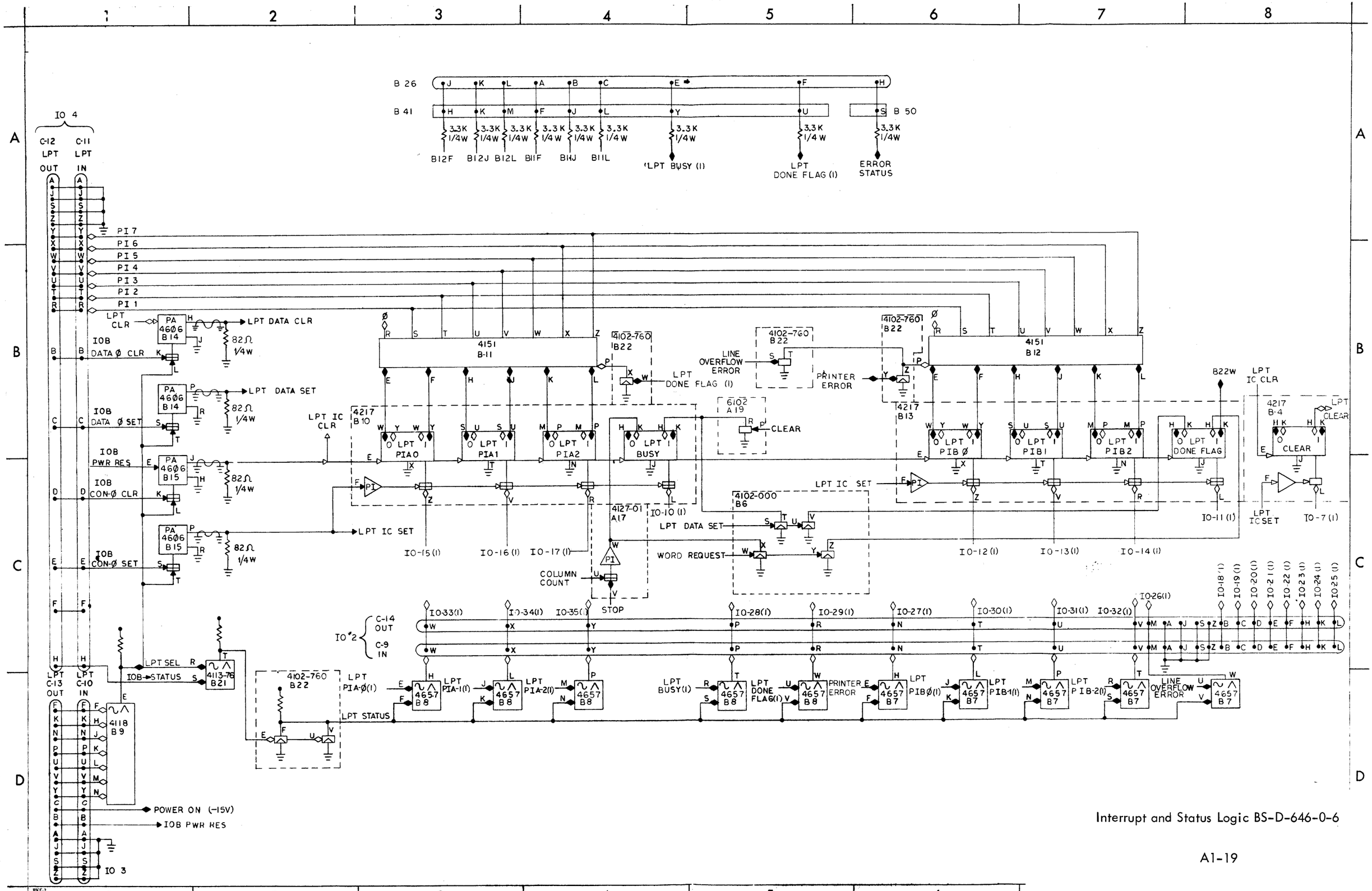
Inverter

RS-6102

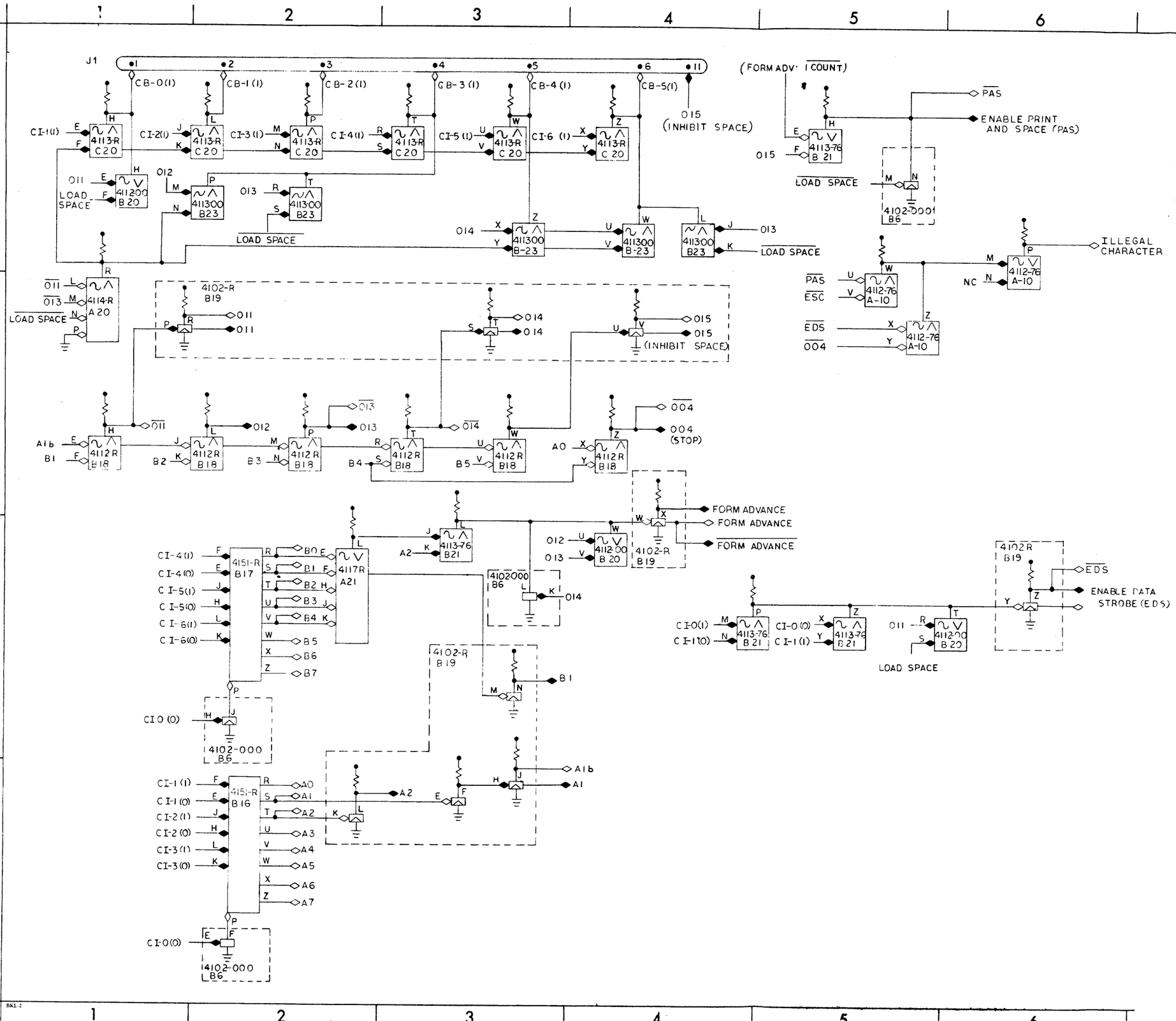


Counters and Tab Selection BS-D-646-0-5

A1-17



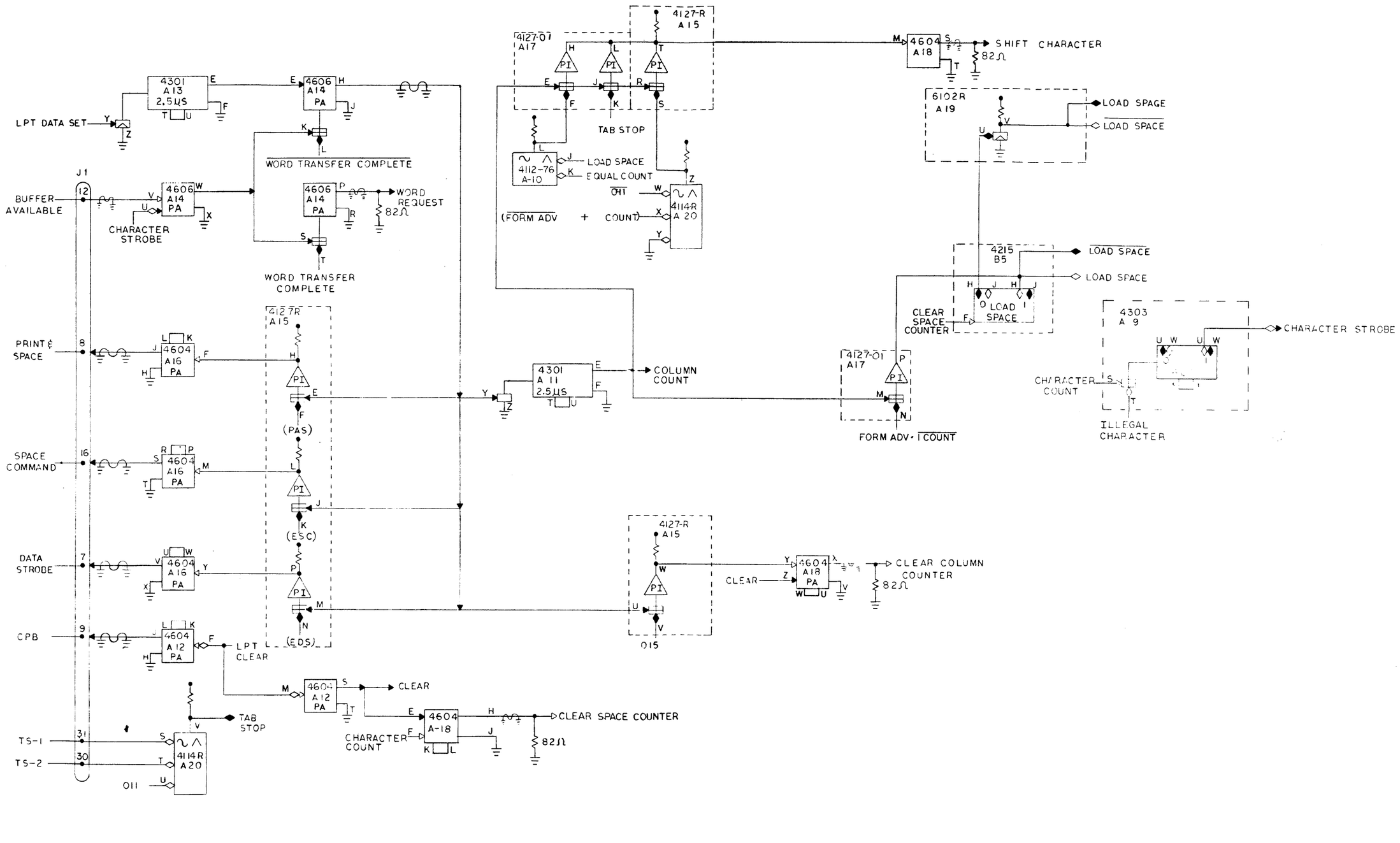
Interrupt and Status Logic BS-D-646-0-6



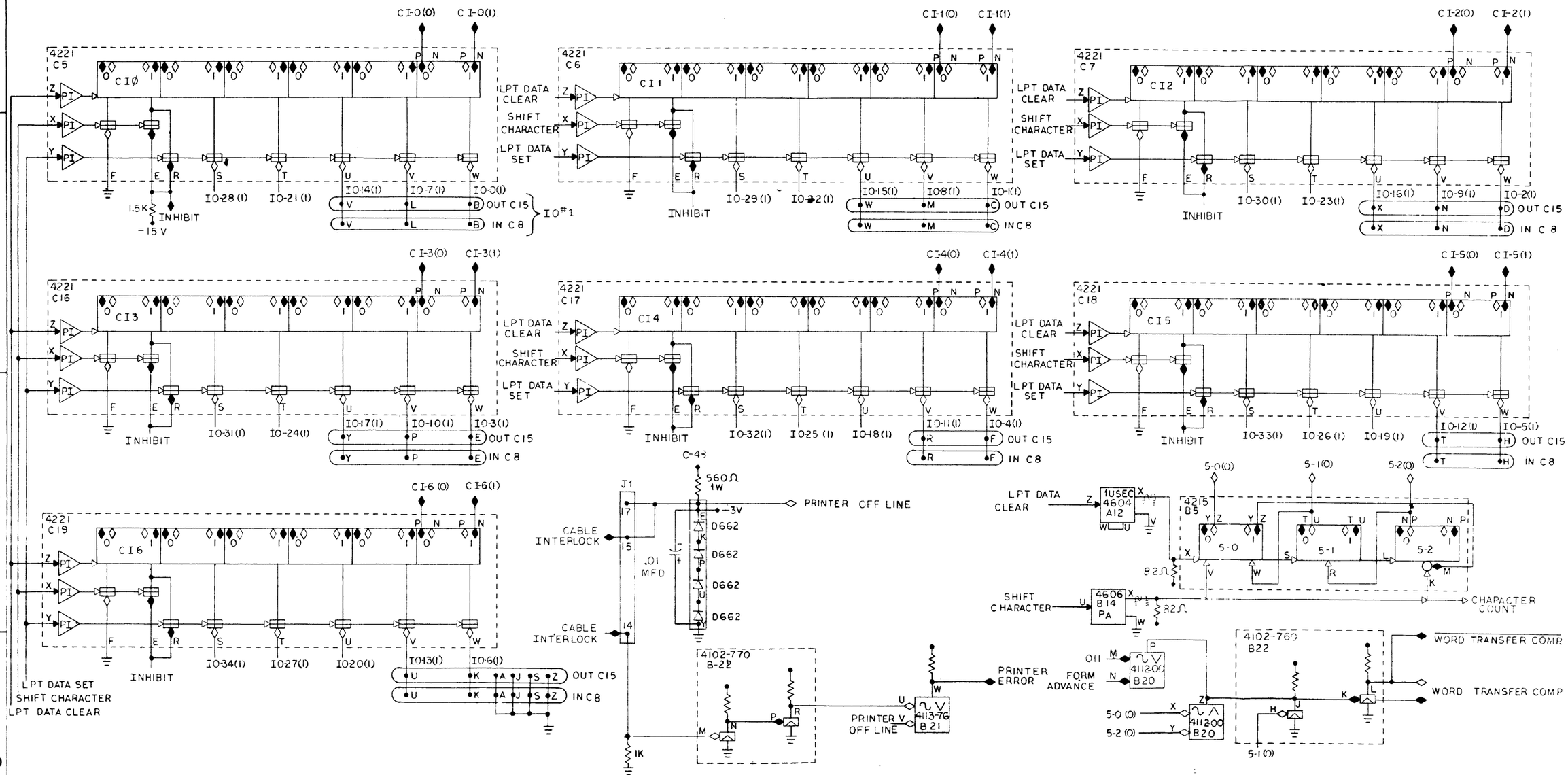
CONTROL CHARACTERS

HT-011	
LF-012	(VF 6) (TR-8)
VT-013	(VF 5) (TR-7)
FF-014	(VF 7) (TR-1)
CR-015	
DC_0-020	(VF 0) (TR-2)
DC_1-021	(VF 1) (TR-3)
DC_2-022	(VF 2) (TR-4)
DC_3-023	(VF 3) (TR-5)
DC_4-024	(VF 4) (TR-6)
EOT-004	

Control Character Decoding BS-D-646-0-7



Character Transfer BS-D-646-0-8



Character Input Register BS-D-646-0-9

JACK [x] PLUG [ ] FEMALE [x] MALE [ ]			LOCATION, LENGTH, ROUTE LOCATED RIGHT SIDE OF PANEL C, LENGTH AS NEEDED				
COLOR	PIN	PIN	NAME	COLOR	PIN	PIN	NAME
WHT	C-20H	1	CB0	WHT	A-19F	26	TCB-1(1)
	C-20L	2	CB1		A-19J	27	TCB-0(1)
	C-20P	3	CB2		A-19L	28	TCB-3(1)
	C-20T	4	CB3		A-19N	29	TCB-2(1)
	C-20W	5	CB4		A-20T	30	TS-2
	C-20Z	6	CB5		A-20S	31	TS-1
GRY TWP	A-15V	7	DATA STROBE			32	
	A-15J	8	PRINT & SPACE			33	
	A-12J	9	CPB			34	
BLK	GND	10	CBF			35	
WHT	B-18W	11	INHIBIT SPACE			36	
GRY TWP	A-14V	12	BUFF.AV(PULSE)			37	
		13	BUFF AV(LEVEL)			38	
WHT	B-22M	14	CABLE INTERLOCK			39	
WHT	C-43E	15	CABLE INTERLOCK			40	
GRY/TWP	A-18S	16	SPACE COMM.			41	
WHT	C-43E	17	PRINTER ERROR (LEVEL)			42	
		18				43	
		19				44	
		20				45	
		21				46	
		22				47	
		23			-15 volt	48	-15V TURN ON
		24			SIGNAL GND	49	SIGNAL GND
		25			CHASSIS GND	50	CHASSIS GND

JACK ☐ PLUG ☒ FEMALE ☒ MALE ☐	LOCATION, LENGTH, ROUTE B-26			
COLOR	PIN	PIN	NAME	REMARKS
W/BLK (X)	B41F	A	LPT PIAØ	
W/BRN (Z)	B41J	B	LPT PIA1	
W/RED (R)	B41L	C	LPT PIA2	
W/ORN (O)		D		
W/YEL (Y)	B41Y	E	LPT BUSY	
W/GRN (N)	B41U	F	LPT DONE FLAG	
W/BLU (B)	B39S	H	ERROR STATUS	
W/VIO (V)	B41H	J	LPT PIBØ	
W/GRY (G)	B41K	K	LPT PIB1	
WHT (W)	B41M	L	LPT PIB2	
W/BLK (X)		M		
W/BRN (Z)		N		
W/RED (R)		P		
W/ORN (O)		R		
W/YEL (Y)		S		
W/GRN (N)		T		
W/BLU (B)		U		
W/VIO (V)		V		
W/GRY (G)		W		
WHT (W)		X		
		Y		
		Z		

Indicator Cable for Interrupt and Status Logic

CL-A-646-0-13

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
								4604	4303	4112-76	4301	4604	4301	4604	4127-R	4604	4127-01	4604	6102-R	4114-R	4117-R	4215	4125-R	4215	4125
A								TC CLEAR D-5-C4	CHARACTER STROBE	CC6 D-5-A5 SHIFT CHAR D-8-A5 ILLEGAL CHARACTER D-8-A2 ESC D-5-A7 ILLEGAL CHARACTER D-8-A2	COLUMN COUNT	CPB D-8-C2 CLEAR D-8-D3 CLEAR S 0-2 D-9-C6	CONTROL STROBE D-8-A2	CONTROL STROBE D-8-A2 WORD REQUEST D-8-A2 BUFFER AVAILABLE D-8-A2	PRINT & SPACE D-8-B2 SPACE COMMAND D-8-C2 DATA STROBE D-8-C2 SHIFT CHARACTER D-8-A4 CLEAR COLUMN COUNTER D-8-C4 CC6 D-5-B5	PRINT & SPACE D-8-B2 SPACE COMMAND D-8-C2 DATA STROBE D-8-C2 LPT BUSY D-6-C4 SP-6 D-5-B2	SHIFT CHARACTER D-8-A4 SHIFT CHARACTER D-8-A4 FORM FEED D-8-B5 TAB(1) D-8-B5	CLEAR SPACE COUNTER D-8-A5 SHIFT CHARACTER D-8-A6 CLEAR COLUMN COUNTER D-8-C5	TCB-1(1) D-5-B6 TCB-0(1) D-5-B6 TCB-3(1) D-5-B6 TCB-2(1) D-5-C6 LPT BUSY D-6-C5 EQUAL COUNT D-5-B4 LOAD SPACE D-8-A6 012 + COUNT D-5-A7 FORM ADV T COUNT D-5-B8	TC CLEAR D-5-D4 CB-0 (1) D-7-A1 TAB STOP D-8-D2 SHIFT CHARACTER D-8-B4	ENABLE SPACE COMMAND D-7-C3 CC-1-4 D-5-A6 FORM ADV COUNT D-5-A8	CC 1 D-5-A3 CC 0 D-5-A2 CC 2 D-5-A1 CC 3 D-5-A2	CC 4 D-5-A4 CC 5 D-5-A4 CC 6 D-5-A5	SP 2 D-5-A4 SP 1 D-5-A4 SP 0 D-5-A5	SP 6 D-5-B2 SP 5 D-5-B3 SP 4 D-5-B4 SP 3 D-5-B4
B				4217 CLEAR D-6-B8 D-9-C7 D-9-C7 D-9-C6	4215 LOAD SPACE D-8-B6 5-2 D-9-C7 5-1 D-9-C7 5-0 D-9-C6	4102-000 A 0-7 D-7-D2 B 0-7 D-7-C2 FORM ADV D-7-C3 FORM ADV D-7-C3 ENABLE PRINT & SPACE D-7-A5 014 + COUNT D-5-A8 LPT BUSY D-6-C5 LPT DONE FLAG D-6-C5 LPT BUSY D-6-C5 LPT DONE FLAG D-6-C5	4657 10-27 (1) D-6-D6 10-30 (1) D-6-D6 10-31 (1) D-6-D7 10 32(1) D-6-D7 10 26(1) D-6-D8	4657 10-33 (1) D-6-D3 10-34 (1) D-6-D3 10-35 (1) D-6-D4 10-28 (1) D-6-D5 10-29 (1) D-6-D5	4118-R LPT SEL D-6-D1 LINE OVERFLOW ERROR D-5-C1	4217 LPT BUSY D-6-B4 LPT PIA$_2$ D-6-B4 LPT PIA$_1$ D-6-B3 LPT PIA$_0$ D-6-B3	4151 PI 1-7 D-6-B3	4151 PI 1-7 D-6-B7	4217 LPT DONE FLAG D-6-B8 LPT PIB$_2$ D-6-B7 LPT PIB$_1$ D-6-B7 LPT PIB$_0$ D-6-B6	4606 LPT DATA CLEAR D-6-B1 LPT DATA SET D-6-B1 CHARACTER COUNT D-9-C6	4606 LPT IC CLEAR D-6-C1 LPT IC SET D-6-C1	4151-R A 0-7 D-7-D2	4151-R B0 0-7 D-7-C2	4112-R 011 D-7-B1 012 D-7-B1 013 D-7-B2 014 D-7-B3 015 INHIBIT SPACE D-7-B3 004 STOP D-7-B3	4102-R A1 D-7-D3 A1 D-7-D3 A2 D-7-D2 B1 D-7-C3 011 D-7-B2 014 D-7-B3 015 D-7-B4 FORM ADV D-7-C4 ENABLE DATA STROBE D-7-C6	4112-00 CB-0 (1) D-7-A1 ESC D-5-A7 WORD TRANS. COMP. D-9-D6 ENABLE DATA STROBE D-7-C6 ENABLE SPACE CONTROL D-7-C3 WORD TRANS. COMP. D-9-D7	4113-76 ENABLE PRINT & SPACE D-7-A5 ENABLE SPACE COMMAND D-7-C3 ENABLE DATA STROBE D-7-C4 LPT STATUS D-6-D2 ERROR PRINT D-9-D5 ENABLE DATA STROBE D-7-C5	4102-760 LPT STATUS D-6-D2 WORD TRANS. COMP. D-9-D7 WORD TRANS. COMP. D-9-D7 ERROR STATUS D-9-D4 ERROR STATUS D-9-D4 LINE OVERFLOW ERROR D-6-B5 LPT STATUS D-6-D2 LPT DONE FLAG D-6-B4 ERROR STATUS D-6-B4	4113-74 CB5-0 D-7-A4 CB-3(1) D-7-A2 CB-5(1) D-7-A4 CB-4(1) D-7-A3	4215 TC-0 TC-1 TC-2 TC-3	4141-R EQUAL COUNT
				4221	4221	4221	IN	IN	IN	IN	OUT	OUT	OUT	OUT	4221	4221	4221	4221	4113-R						
C					CI 0 D-9-A3	CI 1 D-9-A5	CI 2 D-9-A8									CI 3 D-9-B3	CI 4 D-9-B5	CI 5 D-9-B8	CI 6 D-9-C3	CB-0 (1) D-7-A1 CB-1 (1) D-7-A2 CB-2 (1) D-7-A3 CB-3 (1) D-7-A3 CB-4 (1) D-7-A3 CB-5 (1) D-7-A4						

APPENDIX 2

ASCII LINE PRINTER CODE

@	100	Y	131	2	162
A	101	Z	132	3	163
B	102	[	133	4	164
C	103	\	134	5	165
D	104	]	135	6	166
E	105	↑	136	7	167
F	106	←	137	8	170
G	107	space	140	9	171
H	110	!	141	:	172
I	111	"	142	;	173
J	112	#	143	<	174
K	113	$	144	=	175
L	114	%	145	>	176
M	115	&	146	?	177
N	116	(apos) '	147	End of Transmission (EOT)	004
O	117	(	150		
P	120	)	151	Horizontal Tab	011
Q	121	*	152	Line Feed	012
R	122	+	153	Vert Tab	013
S	123	(comma) ,	154	Form Feed	014
T	124	-	155	Carriage Return	015
U	125	.	156	DCØ (SKIP 1 line)	020
V	126	/	157	DC1 (SKIP 2 lines)	021
W	127	Ø	160	DC2 (SKIP 3 lines)	022
X	130	1	161	DC3 (SKIP 6 lines)	023
				DC4 (SKIP 11 lines)	024

All others are ignored