INPUT-OUTPUT SPECIFICATIONS FOR

CONTROL DATA 160 AND 160-A COMPUTERS

INPUT/OUTPUT SPECIFICATIONS FOR

CONTROL DATA 160 AND 160-A COMPUTERS

025d
REV 5/63

RECORD OF CHANGE NOTICES

C. N. NO.	DATE ORIGINATED	DATE ENTERED	INITIALS	REMARKS

Minor Revision (May, 1963)
This edition, publication 025d, is a minor revision and does not obsolete publication 025c. Pages changed are marked by a dot in the top outside corner.

Address comments concerning this manual to:

Control Data Corporation
Technical Publications Department
501 Park Avenue
Minneapolis 15, Minnesota

CONTENTS

FIGURES

TABLES

CONTROL DATA 160 COMPUTER
INPUT/OUTPUT SPECIFICATIONS

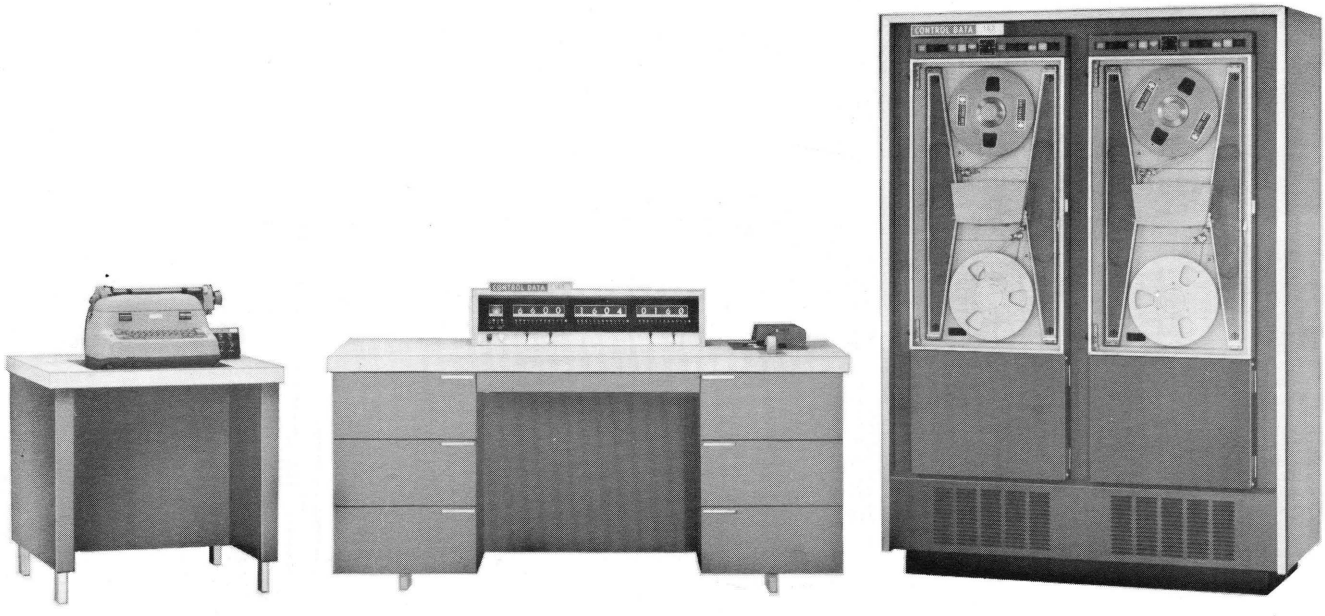


Figure 1. 160 Installation

The input/output specifications for the CONTROL DATA* 160 Computer apply to all devices which connect with the computer. This specification is written to allow a minimum data exchange time consistent with accepted engineering practices and moderate hardware requirements.

The 160 has an optional high speed input/output feature (I/O Active) for more efficient I/O operations if the speed of the external equipment approaches that of the computer.

All information is measured as binary "1" and "0" voltage levels, nominal ground level (-0.5v) constituting a "1" and -16v a "0".** Voltage is measured at the output terminals of the computer and the external equipments.

COMMUNICATION LINES

Communication between the computer and peripheral equipment is accomplished through two cables; one carries input signals, the other output signals. Each cable contains 12 data lines plus various control lines. Every external unit must be connected to the output cable because the external function code, which must be available to both input and output devices, is carried by the data lines of the output cable. The power capacities of the transistors in the output amplifier cards, and maximum cable length, limit to five the number of I/O devices attached to the 160. Any combination of input/output devices may be used.

Because the paper tape reader and the paper tape punch communicate directly with the computer and do not use the I/O cables, they are not included in the total number of units which may be attached to the cables.

Table 1 gives jack locations for I/O cables. Doors in the back of the computer permit access to jack locations, found on the bottom of chassis 10100 when the chassis is swung down. Tables 2 and 3 describe the lines in each of the cables; table 4 defines the signal available at each of the pins in the terminating plugs. Cables from external equipment are brought into the computer through the rectangular opening in the bottom.

---

* Registered trademark of Control Data Corporation.

** See page 29 for tolerances on these voltage levels.

TABLE 1. CABLE DESIGNATIONS
160 INPUT/OUTPUT EQUIPMENT

Use	Cable Number
Input Cable	J09 J10
Output Cable	J11 J12

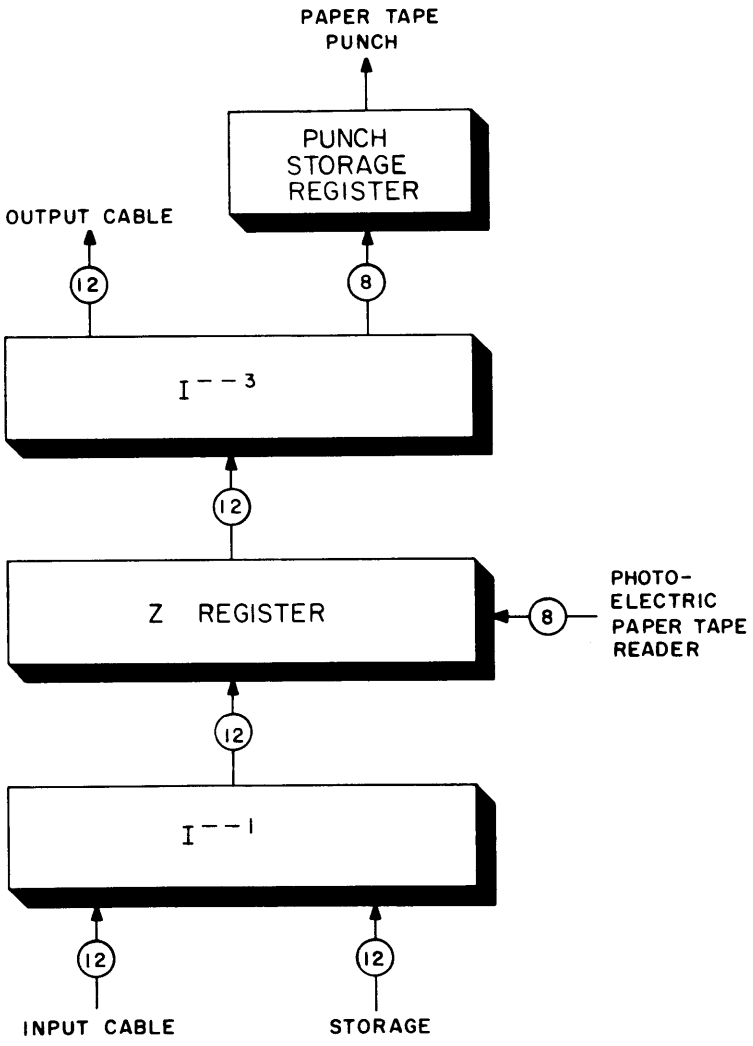


Figure 2. 160 Input/Output System

TABLE 2. COMMUNICATION LINES

Output Cable

Computer to External Equipment	
External Master Clear (Pin U)	Static "1" signal appears on the line whenever Load/Clear switch at 160 console is in Clear (down) position. Signal is available to clear external equipments attached to the computer.
Function Ready (Pin T)	Static "1" signal is produced on the line when an external function code is present on output data lines for examination and translation by external equipment. Signal is removed by output resume signal from external equipment.
Information Ready (Pin R)	Static "1" signal accompanies each word of output information. Signal is turned off by output resume signal from external equipment.
Output Active (Pin V)	Static "1" is produced when the computer is engaged in a block output operation. Signal drops when the last word of the block has been sent.
External Equipment to Computer	
Output Resume (Pin S)	Static "1" indicates external equipment has accepted a word of information or an external function code. Signal turns off information ready or function ready signal at computer. Output resume drops when function ready or information ready drops.
Output Data and External Function Lines (Pins A, B, C, D, E, F, H, J, K, L, M, and N)	The 12 lines which carry output data and external function information perform as follows: 1) when accompanied by information ready signal, lines hold output word from computer. External equipment samples these lines to read the output word. 2) when accompanied by function ready signal, lines hold EF code which selects operational mode within external equipment.

TABLE 3. COMMUNICATION LINES

Input Cable

Computer to External Equipment	
Input Request (Pin S)	Static "1" signal is produced when computer is ready to receive an input word. Signal drops on receipt of input ready signal.
Input Active (Pin T)	Static "1" signal is produced when the computer is engaged in a block input operation. Signal drops when the last word of the block has been accepted.
External Equipment to Computer	
Input Ready (Pin R)	Static "1" signal produced when information, in a state which computer may sample, is present in input register of external equipment. Signal is dropped when computer drops input request signal.
Disconnect (Pin V)	Static "1" signal is produced when input device has transmitted final word of input data and the computer transmits an additional Input Request. Upon receipt of signal, computer drops Input Request and resumes main program with no further delay. Signal is dropped when computer drops input request signal. (Generally, input instruction establishes a storage field of greater capacity than the anticipated input data block.)
Input Data and Status Lines (Pins A, B, C, D, E, F, H, J, K, L, M, and N)	The 12 lines which carry input data and status information perform as follows: 1) Following a normal input mode selection, lines hold content of external equipment input register which computer samples. Data is removed from lines when input request is dropped from computer. 2) Following request for status from computer, lines contain external equipment response. (Input instruction is programmed to ascertain status response.)

TABLE 4. PIN ASSIGNMENTS, INPUT/OUTPUT CABLES

Input Cable	Pin	Output Cable
Bit 0 input status and information	A	Bit 0 output function and information
1	B	1
2	C	2
3	D	3
4	E	4
5	F	5
6	H	6
7	J	7
8	K	8
9	L	9
10	M	10
11	N	11
	P	
Input Ready	R	Information Ready
Input Request	S	Output Resume
Input Active	T	Function Ready
	U	Master Clear
Disconnect	V	Output Active
	W	
	X	
	Y	
	Z	
	a	
Ground	b	Ground

NORMAL INPUT/OUTPUT

Sequence of Events In Normal Input (Refer to figure 3)

1. The computer executes a 75 instruction and sends out an external function code (EF), together with a function ready signal to select external equipment. The time required for initiating the EF code is 12.8 usec. Total time to generate the EF is approximately 15 usec.
2. The external equipment receives the EF code at its own rate, and sends back an output resume turning off the function ready signal. (Termination of the function ready signal in the computer must turn off the output resume in the external equipment within 4 usec.)
3. The computer takes 12.8 usec to set up the input instruction (72XX), after which an input request signal is issued.
4. The external equipment accepts the input request signal, places a word on the data lines, and generates an input ready signal. The external equipment delivers the word to the computer at its own rate. The input ready signal turns off the input request in the computer. (Termination of the input request signal must turn off the input ready signal from the external device within 4 usec.)

   Concurrent with the reception of the input ready signal, the computer initiates a store sequence which takes 12.8 usec. At the end of the store sequence, the computer issues another input request if more information is desired.

   Steps 3 and 4 repeat until the last word is received in the computer. Termination of data input may originate in the computer by failure to issue an input request, or in the external equipment by an input disconnect. Average minimum time between inputs is 15 usec.

Sequence of Events in Normal Output (Refer to figure 4)

1. Same as normal input.
2. Same as normal input.
3. In 19.2 usec the computer sets up the output instruction and delivers the first word to the data lines, along with an information ready signal to indicate that data is available to the external equipment.
4. The external equipment recognizes the information ready signal after a 2 usec delay, stores the data at its own rate, and returns an output resume signal to the computer.

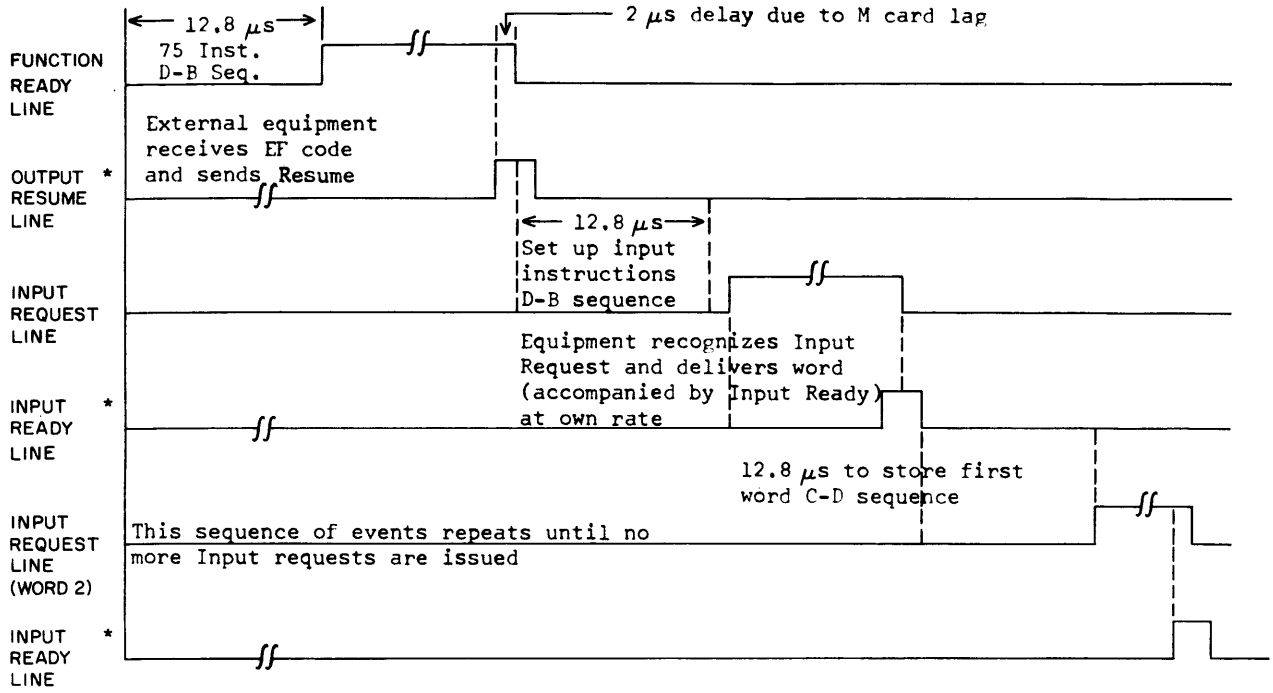


Figure 3. Normal Input 160

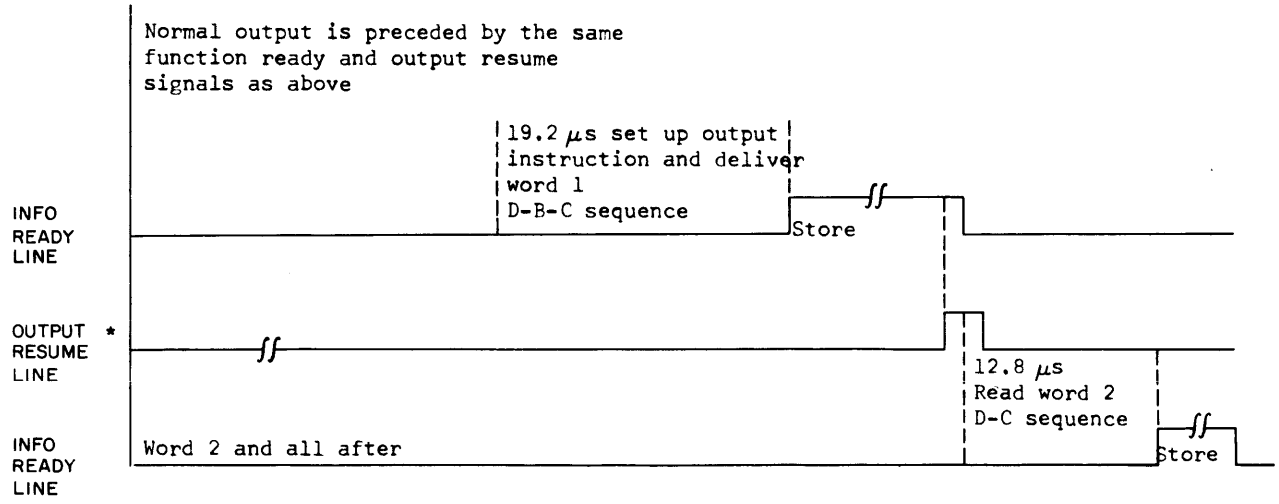


Figure 4. Normal Output 160

* Signals generated by external equipment

5. The computer accepts the output resume signal and turns off the information ready signal. At the same time, the computer reads another word (in 12.8 usec), generates an information ready signal, and repeats step 4. This process continues until all words are transferred into the external equipment. Transfer of output data is terminated by failure of the computer to issue an information ready signal. Average minimum time between outputs is 15 usec. (Termination of the information ready signal must turn off the output resume in the external equipment within 4 usec.)

INPUT/OUTPUT ACTIVE

Input Active (Refer to figure 5)

The optimum case is shown for the sequence of events during input active; delivery time of the word by the external equipment equals the storage time of the computer (12.8 usec). Storage of a word and delivery of another occur almost simultaneously, or within 2 usec in the ideal case. Delivery of the word occurs when the input request drops, rather than when it rises, as in normal input. When the time for delivering a word from the external equipment exceeds 12.8 usec, idle computer time increases (figure 5 shaded area).

Output Active (Refer to figure 6)

The external equipment issues an output resume as soon as the computer issues an information ready signal rather than after a word is accepted as in normal output. The computer then delivers word 2 while the external equipment is accepting word 1. The optimum case is shown, in which time of acceptance by the external equipment equals the time of delivery by the computer; the shaded area indicates idle computer time. When delivery or acceptance time of the external equipment falls below 60 kc or 16.6 usec/word, Input/Output Active has no advantage over normal Input/Output.

SELECT CODES

The computer selects external equipment for input or output operation by select codes. The I/O operation is initiated by a 75 instruction which selects a 12-bit code and places it on the output lines with a function ready signal. The upper 6 master bits (unit designator) select the external equipment; the lower 6 bits (function designator) designate the function. Master bits for select codes must be unique for each 160 I/O equipment. The master bits given below are in octal notation, and represent standard devices currently available. It is recommended that the 160 Engineering Department of Control Data Corporation be consulted before assigning master bits for select codes

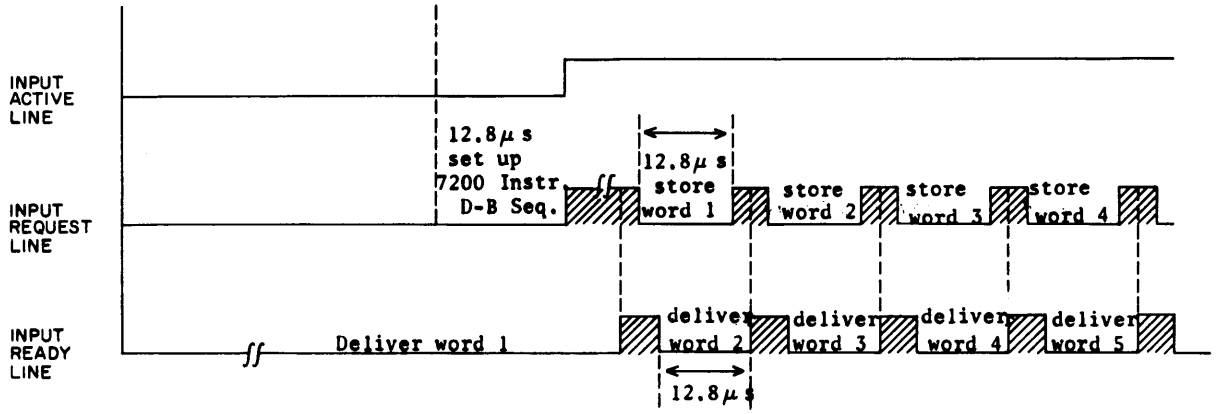


Figure 5. Input Active 160

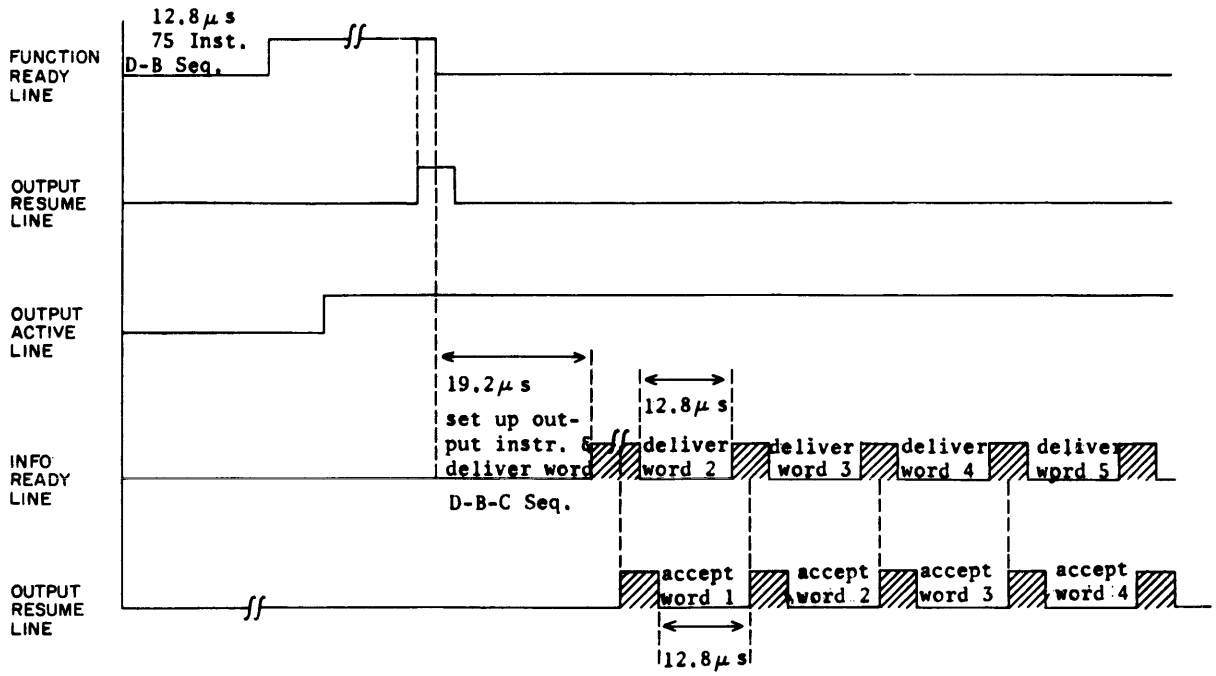


Figure 6. Output Active 160

on new equipment. This will minimize the chance of select code duplication through future expansion of an existing system.

03	1609, 1610 Control Units
06	1612 Printer
07	166 Printer
11, 12, 13	162/163 Magnetic Tape Systems, 6-Bit Transfer
14	1608 Magnetic Tape System
21, 22, 23	162/163, 12-Bit Transfer
24	1608
30	170 Card Punch Control Unit
33	168 Auxiliary Arithmetic Unit
41	Console Reader and Punch
42, 43	161 Typewriter
44	165 Plotter
45	167/177/1614 Card Readers
50, 60	1607 MTS/Satellite 1615 MT Controller
53	Exchange Unit
70	Disk Files

CONTROL DATA 160-A COMPUTER
INPUT/OUTPUT SPECIFICATIONS

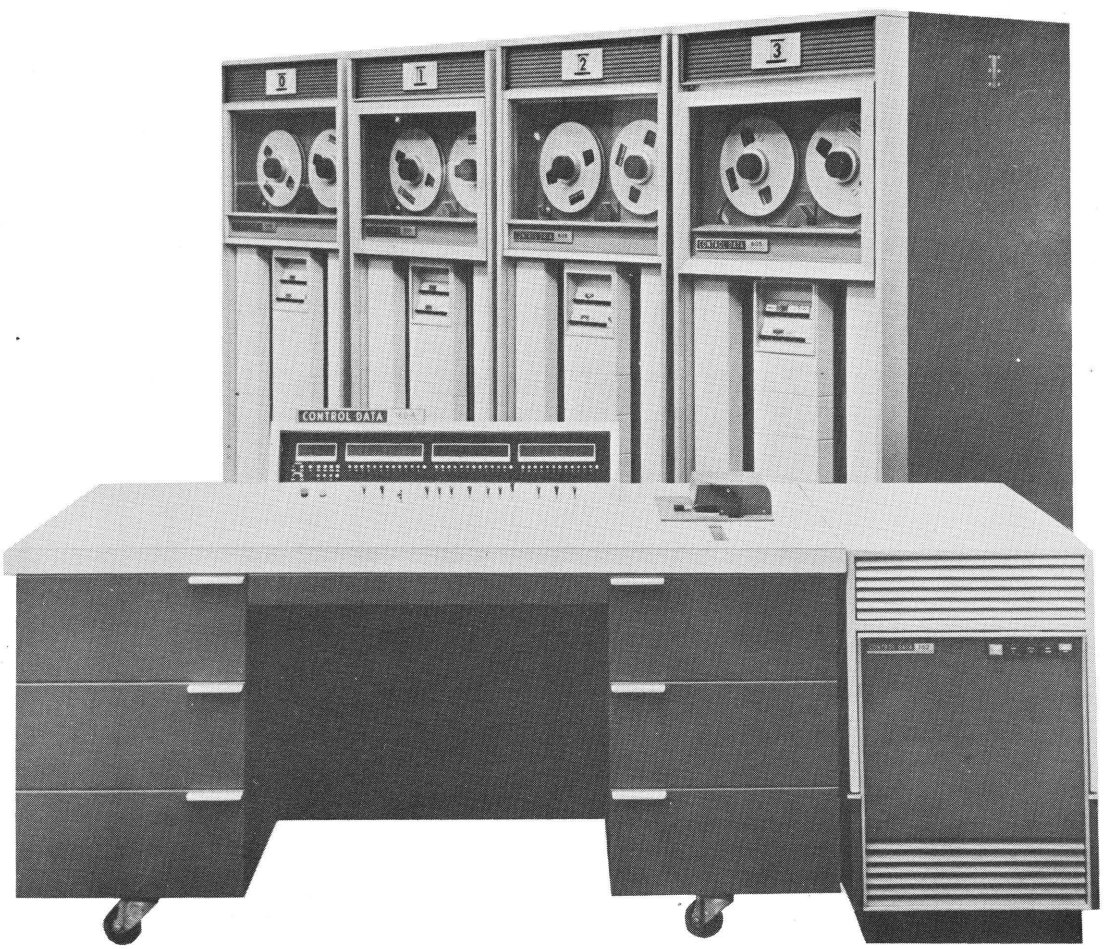


Figure 7. 160-A Installation

The input/output (I/O) specifications for the CONTROL DATA 160-A Computer apply to all devices which connect with the computer. This specification is written to allow a minimum data exchange time consistent with accepted engineering practices and moderate hardware requirements.

The 160-A has an optional interrupt and a buffered I/O. The latter permits the computer to continue high-speed computation while communicating with external equipment. The minimum system may be expanded to include the following external equipment:

- Additional magnetic tape stations (40 maximum)*
- I/O typewriters
- Punched card readers, punches, and low speed line printers
- High speed printers - 1000 lines/minute
- Plotting and digital display equipment
- Analog to digital and digital to analog equipment
- Two or more Control Data computers operating in a satellite system
- Two 160-A computers operating independently, but sharing the same magnetic core memory

All information is measured as binary "1" and "0" voltage levels, nominal ground level (-0.5v) constituting a "1", and -16v a "0".** Voltage is measured at the output terminals of the computer and the external equipments.

INTERRUPT

Certain internal and external conditions arise which make it desirable for the main program to be notified of their presence. An interrupt is the program signal which transfers computer control to some fixed location in memory without losing the information needed to return to the main program.

---

* If 40 magnetic tape stations are used, no other I/O equipment may be connected.

** See page 29 for tolerances on these voltage levels.

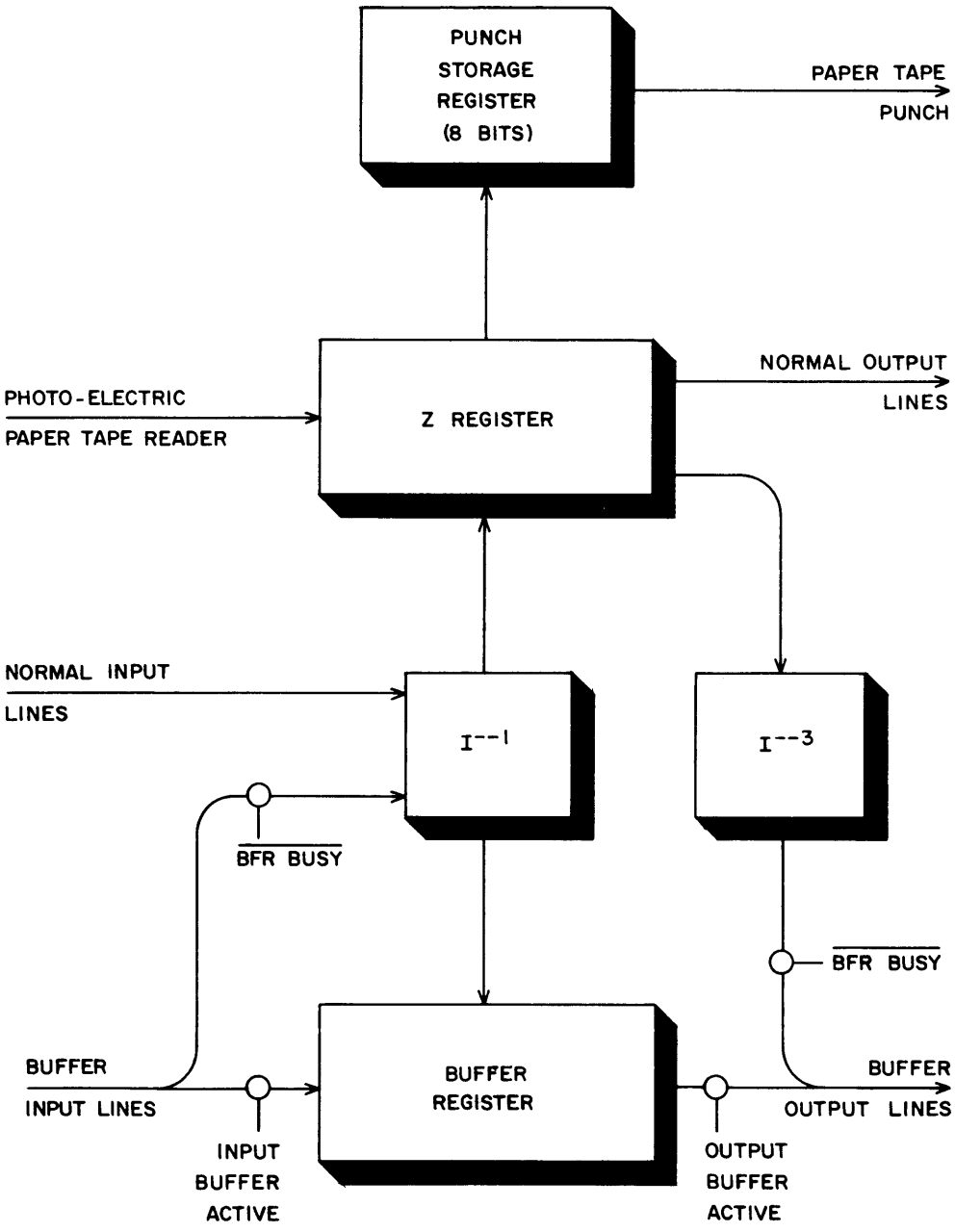


Figure 8. 160-A Input/Output System

The 160-A has four interrupt lines: two internal, 10 and 20, and two external, 30 and 40. When an external equipment generates an interrupt the computer may enter the interrupt routine if the interrupt lockout is not on. The computer program may send a status request to all equipments which might have generated the interrupt to determine which interrupted. This status request is a signal to the external equipment to turn off the interrupt, or the signal in the external device may be turned off by a function response.

SELECT CODES

The computer selects the external equipment for I/O operation by the use of select codes. The I/O operation is initiated by a 75 instruction which selects a 12-bit code and places it on the output lines with a function ready signal. The upper 6 master bits (unit designator) select the external equipment, and the lower 6 bits (function designator) designate the function.

Master bits for select codes must be unique for each 160-A I/O equipment. Master bits given below are in octal notation, and represent devices currently available. It is recommended that the 160-A Engineering Department of Control Data Corporation be consulted before assigning master bits for select codes on new equipment. This will minimize the chance of select code duplication through future expansion of an existing system.

03	1609, 1610 Control Units
06	1612 Printer
07	166 Printer
11, 12, 13	162/163 Magnetic Tape Systems, 6-Bit Transfer
14	1608 Magnetic Tape System
21, 22, 23	162/163, 12-Bit Transfer
24	1608
30	170 Card Punch Control Unit
33	168 Auxiliary Arithmetic Unit
41	Console Reader and Punch
42, 43	161 Typewriter
44	165 Plotter
45	167/177/1614 Card Readers
47	169 Auxiliary Memory Unit
50, 60	1607 MTS/Satellite 1615 MT Controller
53	Exchange Unit
70	Disk Files

TABLE 5. COMMUNICATION LINES
Output Cable

Computer to External Equipment	
External Master Clear (Pin U)	Static "1" signal appears on the line whenever Load/Clear switch at 160-A console is set to Clear. Signal is available to clear external equipments attached to the computer.
Function Ready (Pin T)	Static "1" signal is produced on the line when external function code is present on output data lines for examination and translation by external equipment. Signal is removed by output resume signal from external equipment.
Information Ready (Pin R)	Static "1" signal accompanies each word of output information. Signal is turned off by output resume signal from external equipment.
External Equipment to Computer	
Output Resume (Pin S)	Static "1" indicates external equipment has accepted word of information or external function code. Signal turns off information ready or function ready signal at computer. Output resume drops when function ready or information ready drops.
Interrupt 30, 40 (Pins Y, Z)	Static "1" signal notifies computer that interrupt is generated. Computer enters interrupt routine and sends status request code which signifies that the interrupt should be turned off.
Output Data and External Function Lines (Pins A, B, C, D, E, F, H, J, K, L, M, and N)	The 12 lines which carry output data and external function information perform as follows: 1) when accompanied by information ready signal, lines hold output word from computer. External equipment samples these lines to read the output word. 2) when accompanied by function ready signal, lines hold EF code which selects operational mode within external equipment.

TABLE 6. COMMUNICATION LINES

Input Cable

Computer to External Equipment	
Input Request (Pin S)	Static "1" signal is produced when computer is ready to receive an input word. Signal drops on receipt of input ready signal.
External Equipment to Computer	
Input Ready (Pin R)	Static "1" signal produced when information, in a state which computer may sample, is present in input register of external equipment. Signal is dropped when computer drops input request signal.
Disconnect (Pin V)	Static "1" signal is produced when input device has transmitted final word of input data and the computer transmits an additional Input Request. Upon receipt of signal, computer drops Input Request and resumes main program with no further delay. Signal is dropped when computer drops input request signal. (Generally, input instruction establishes a storage field of greater capacity than the anticipated input data block.)
Input Data and Status Lines (Pins A, B, C, D, E, F, H, J, K, L, M, and N)	The 12 lines which carry input data and status information perform as follows: 1) Following a normal input mode selection, lines hold content of external equipment input register which computer samples. Data is removed from lines when input request is dropped from computer. 2) Following request for status from computer, lines contain external equipment response. (Input instruction is programmed to ascertain status response.)

TABLE 7. CABLE DESIGNATIONS
160-A INPUT/OUTPUT EQUIPMENT

Use	Cable Number
Input Cable	1J17 1J18
Output Cable	1J19 1J20
Buffer Input Cable	1J21 1J22
Buffer Output Cable	1J23 1J24

COMMUNICATION LINES

Of the four communication cables between the computer and all external equipment, two carry normal I/O signals and two carry buffer I/O signals. Each cable contains 12 data lines plus various control lines, and each has two connectors. Cables from external equipment enter the computer through the rectangular opening in the bottom. Doors in the back of the computer permit access to jack locations found on the bottom panel of chassis 10100. (Jack numbers for I/O lines are given in table 7.)

Every external unit must be connected to the output cable because the external function code (carried on data lines of output cable) must be available to both input and output devices.

The total number of devices attached to one line is limited by maximum cable length and power capacities of the transistors on the amplifier cards. Five equipments may be attached to the normal channel and five to the buffer channel. Because the paper tape reader and the paper tape punch communicate directly with the computer, and do not use the I/O cables, they are not considered when determining the number of units which may be attached to the cables.

Equipments attached to the buffer lines may be addressed directly if no buffer operation is in progress. Consequently any one of up to ten external equipments may be addressed by normal I/O if the buffer is not busy.

TABLE 8. PIN ASSIGNMENTS, INPUT/OUTPUT CABLES

Normal Input and Buffer Input Cable	Pin	Normal Output and Buffer Output Cable
Bit 0 input status and information	A	Bit 0 output function and information
1	B	1
2	C	2
3	D	3
4	E	4
5	F	5
6	H	6
7	J	7
8	K	8
9	L	9
10	M	10
11	N	11
	P	
Input Ready	R	Information Ready
Input Request	S	Output Resume
	T	Function Ready
	U	Master Clear
Disconnect	V	
	W	
	X	
	Y	Interrupt 30
	Z	Interrupt 40
	a	
Ground	b	Ground

NORMAL INPUT/OUTPUT

Sequence of Events in Normal Input (Refer to figure 9)

1. The computer executes a 75 instruction and sends out an external function code (EF), together with a function ready signal to select external equipment. The time required for initiating the EF code is 12.8 usec.
2. The external equipment receives the EF code at its own rate, and sends back an output resume, turning off the function ready signal. (Termination of the function ready signal in the computer must turn off the output resume in the external equipment within 4 usec.)
3. The computer takes 12.8 usec to set up the input instruction (72XX), after which an input request signal is issued.
4. The external equipment accepts the input request signal, places a word on the data lines, and returns an input ready signal which turns off the input request in the computer. The external equipment delivers the word to the computer at its own rate. (Termination of the input request signal must turn off the input ready signal in the external device within 4 usec.)

   When the computer receives an input ready signal, it initiates a store sequence and issues another input request if more information is desired. Steps 3 and 4 repeat until the last word is received in the computer. Termination of data input may originate in the computer through failure to issue an input request or in the external equipment through an input disconnect.

Sequence of Events in Normal Output (Refer to figure 10)

1. Same as normal input.
2. Same as normal input.
3. In 19.2 usec, the computer sets up the output instruction and delivers the first word to the data lines along with an information ready signal to indicate that data is available to the external equipment.
4. The external equipment recognizes the information ready signal after a 2 usec delay, stores the data at its own rate, and returns an output resume signal to the computer.
5. The computer accepts the output resume signal and turns off the information ready signal. (Termination of the information ready signal must turn off the output resume in the external equipment within 4 usec.) At the same time, the computer reads another word in 12.8 usec, generates an information ready signal, and repeats step 4 until all words are transferred into the external equipment. Transfer of output data is terminated by failure of the computer to issue an information ready signal.

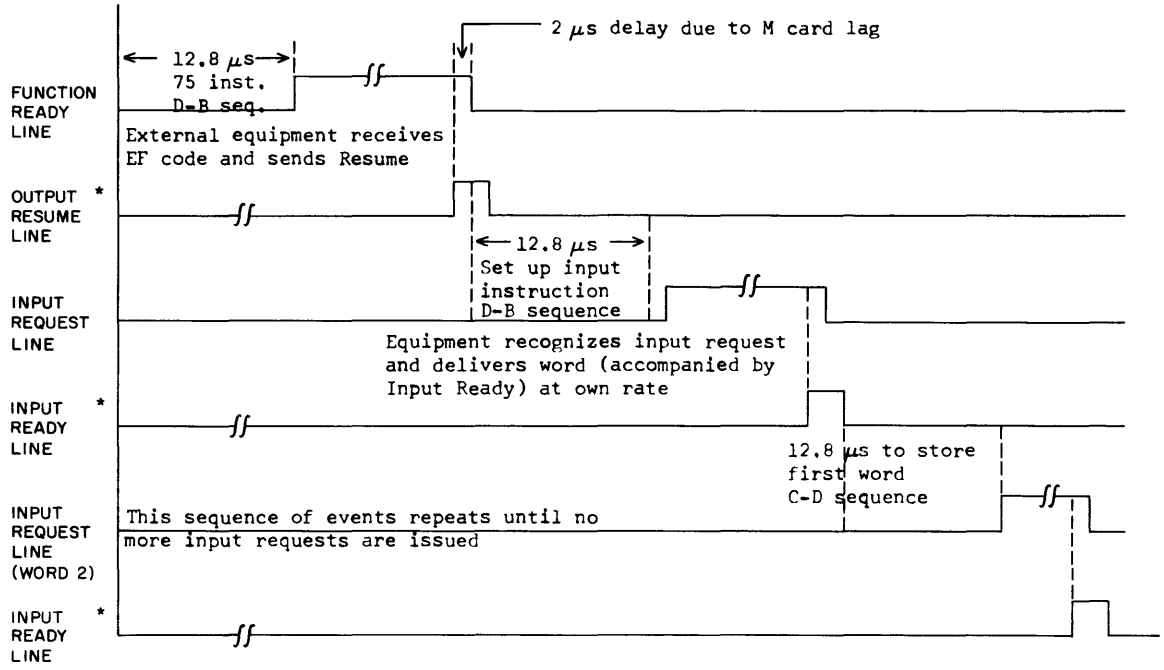


Figure 9. Normal Input 160-A

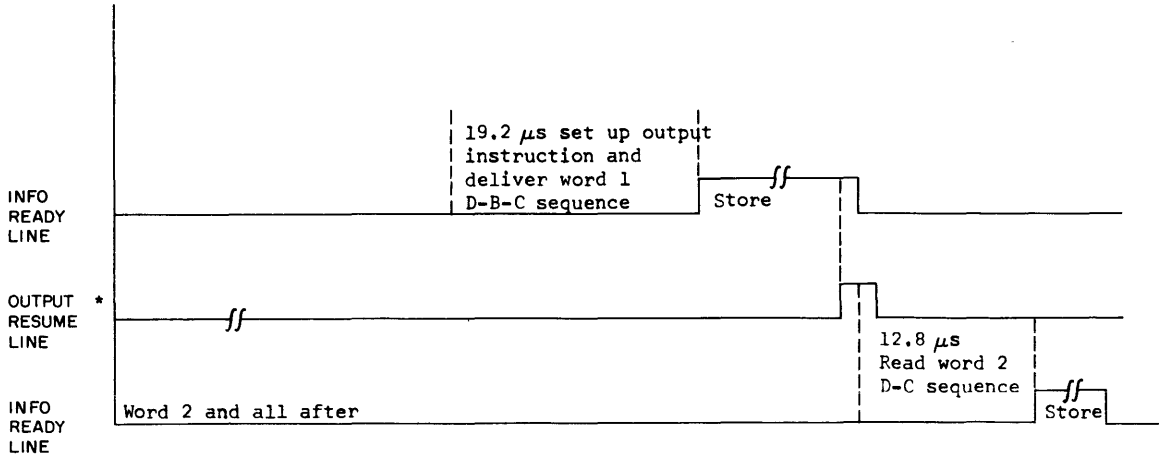


Figure 10. Normal Output 160-A

* Signals generated by external equipment

BUFFERED INPUT/OUTPUT

Sequence of Events in Buffered Input (Refer to figure 11a)

1. Same as normal input.
2. Same as normal input.
3. The computer reads the 7200 instruction in 6.4 usec. It then generates an input request, releasing the 160-A for computation.
4. The external equipment accepts the input request signal, places a word on the data lines, and generates an input ready signal.
5. The computer accepts the input ready signal and stores the word.* Recognition of the input ready signal terminates the input request which turns off the input ready signal in the external equipment.
6. The computer issues another input request and steps 4 and 5 repeat until all words are buffered into the computer.

Sequence of Events in Buffered Output (Refer to figure 11b)

1. Same as normal input.
2. Same as normal input.
3. The computer reads the 7300 instruction in 6.4 usec and initiates a buffer cycle to place the first word on the data lines and issue an information ready signal. The computer is then free for computation.
4. The external equipment accepts the information ready signal and data at its own rate and returns an output resume signal.
5. Recognition of the output resume signal initiates another buffer cycle and terminates the information ready signal.**
6. Termination of the information ready signal in the computer turns off the output resume signal in external equipment.
7. Steps 3-5 are repeated for each word until all words are buffered out of the computer.

---

* It may take the computer up to 25.6 usec to recognize the input ready and store the word, depending on which cycle the computer is in when the input ready signal occurs.

** It may take the computer up to 25.6 usec to recognize the output resume and put the next word on the output lines, depending on which cycle the computer is in when the output resume occurs.

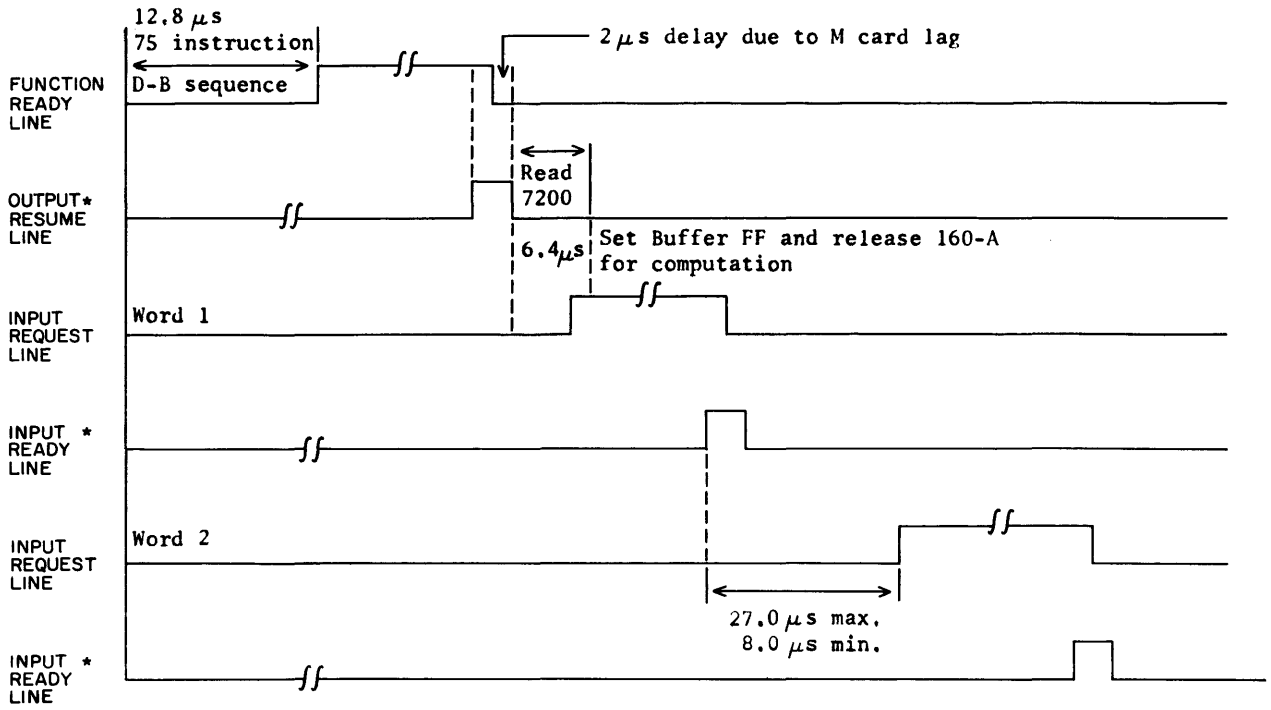


Figure 11a. Buffered Input, 160-A

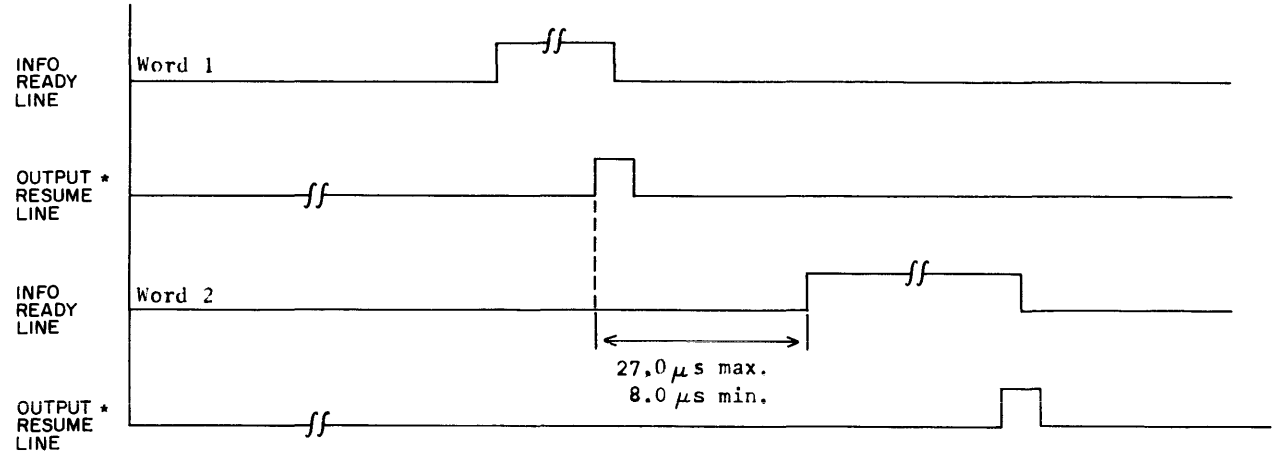
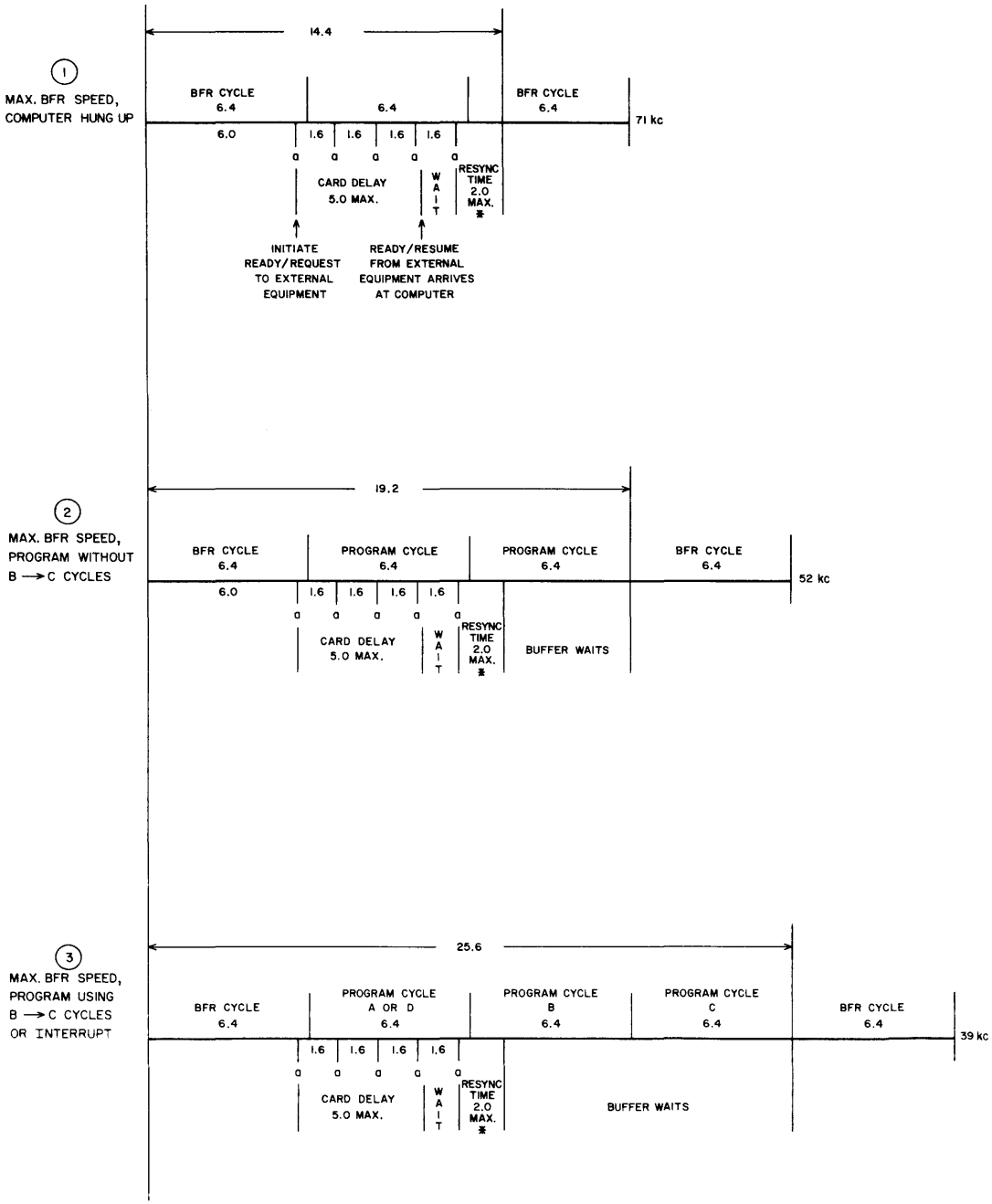


Figure 11b. Buffered Output, 160-A

* Signals generated by external equipment



a - Sampling of incoming signals occurs at 1.6 usec intervals during all machine cycles.

* This resync period may start earlier with a shorter card delay (at previous sample time "a").

(3) This case for interrupt assumes that the computer has been modified according to Equipment Change Notice 36 for 160-A.

Figure 12. Maximum Permissible Transfer Rates Using Buffer Channel

160 AND 160-A COMMUNICATION CIRCUITS

In communicating with external devices the computer signals undergo a level change to minimize effects of cable impedance. The computer signals are referred to as logic levels, the cable signals as line levels. The binary representation for the two levels are:

Logic	"1"	-3.0v	(± 0.25v)
	"0"	-0.5v	(± 0.25v)
Line	"1"	-0.5v	(± 0.25v) *
	"0"	-16v	(± 2.5v)

Both line and logic levels are encountered in the input and output amplifier cards. All external equipment control signals are resynchronized upon entering the computer.

INPUT CIRCUITS

In the schematic diagram of the input amplifier circuit (figure 13), resistor R01 and the -20v supply hold the input to the circuit (point a) to line "0" when no input signal is supplied, or when no data or control line is tied to the circuit. If a line "1" is supplied to the input pin, the base of Q01 (point b) rises due to the voltage divider action of R02, R06, and R08. Subsequently Q01 stops conducting, and the output to the computer circuits represents a logic "1". Conversely, if a line "0" is applied to the circuit, Q01 conducts and the output to the computer circuits approaches -0.5v (logic "0"). Stated simply, the input amplifier inverts the signal electrically, but not logically.

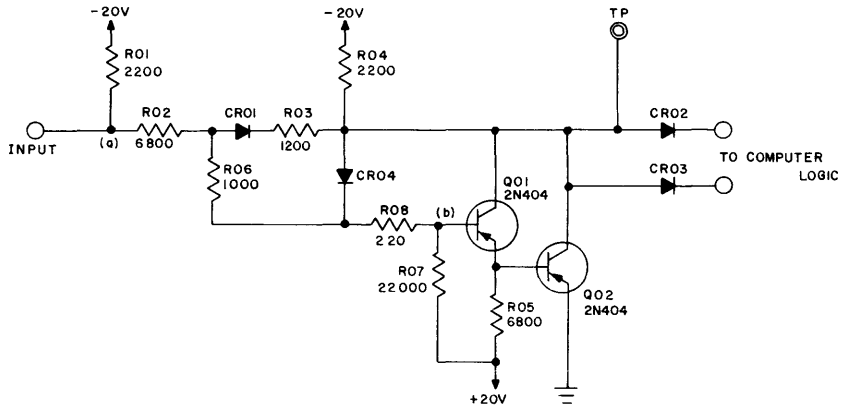


Figure 13. Input Amplifier Circuit

* Tolerances given are for Control Data equipment. When other equipment is connected to Control Data computers, the following variation may be tolerated on the "1" line level:

+0.5v, -2.5v

Maximum steady-state current drawn by an input amplifier circuit does not exceed 10 ma. If the wire to the input pin is disconnected, the effect is as though a line "0" were present continually. The current waveform has a slope which does not exceed 5 ma per usec.

OUTPUT CIRCUITS

In the output amplifier circuit (figure 14), resistor R01 and the -20v supply hold the input to the circuit (point a) at a logic "1" when no signal is applied, or when no data or control line is tied to the circuit. The collector of transistor Q01 is connected to its base through a 150uuf capacitor (C01) which integrates this output of Q01. When a logic "1" is applied to either input pin, Q01 turns on, placing a low impedance between ground and the output line. Capacitor C01 tends to oppose the initial conduction of Q01 by feeding back a signal less positive than that initially placed on the base. When C01 is fully charged, Q01 reaches full conduction and the output rises to -0.5v (line "1"). If a logic "0" is applied to this circuit, the voltage divider action of the circuit turns off Q01, and the output stabilizes at -16v (line "0"). Stated simply, the output amplifier inverts the signal electrically, but <u>not</u> logically.

The output amplifier need supply no more than 10 ma to any input amplifier in another equipment. Transition time of the signal waveform from the output amplifier circuit is 2 usec minimum, 4 usec maximum. Total line capacity may vary between 0 and 0.002 uf.

Voltage level rise and fall rates are 8v/usec; d-c resistance of cable ground return must not exceed 0.5 ohm. All data lines are stable before information is sampled.

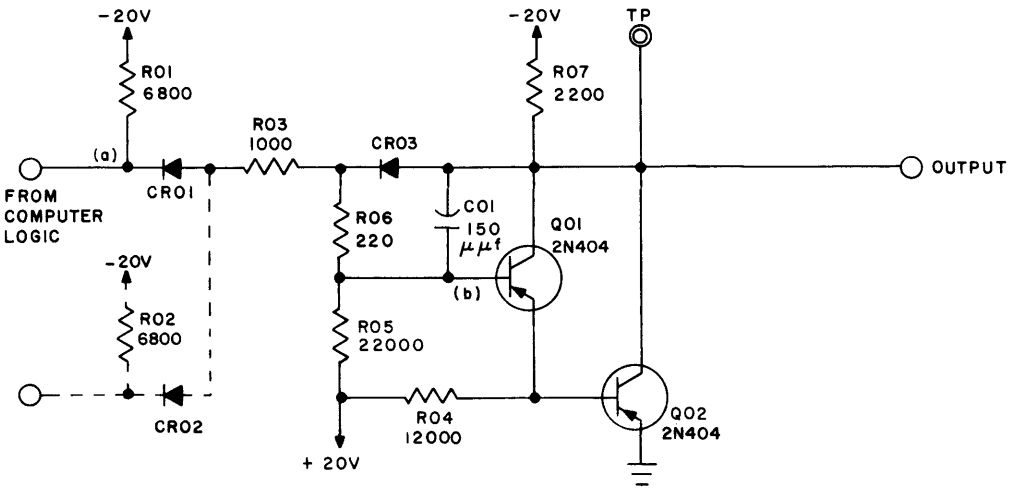


Figure 14. Output Amplifier Circuit

CABLE CONNECTORS

All data and signal connections between the 160 or 160-A computer and peripheral equipment are made using 24-pin Amphenol twist-lock connectors. The Amphenol part numbers are given for the male (P) connectors used on all cable ends and the female (S) connectors used for panel mounting.

67-06P-18-24P	(cable)
67-02E-18-24S	(panel)

CONTROL DATA
CORPORATION

501 PARK AVENUE, MINNEAPOLIS 15, MINNESOTA • FEDERAL 9-0411