# CHAPTER K

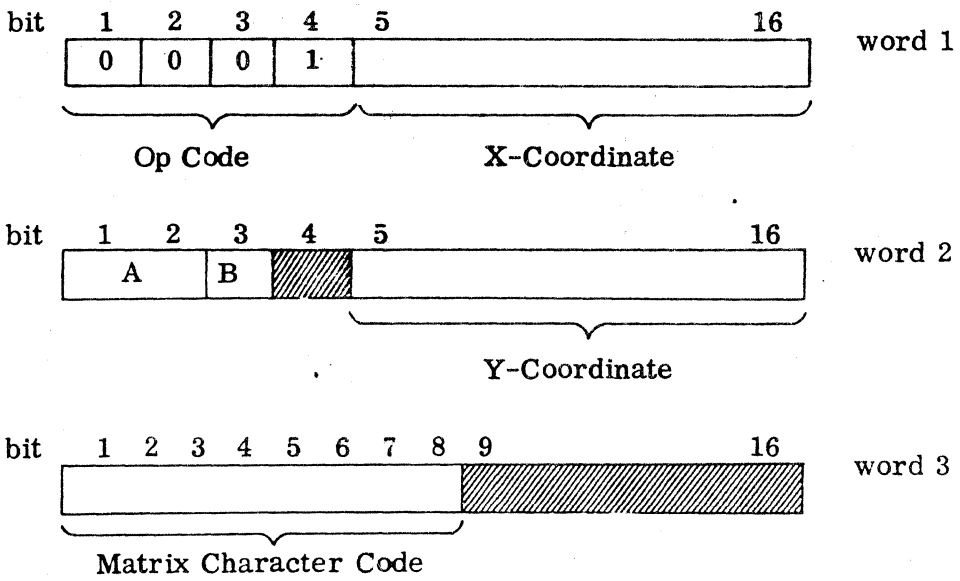
## 4060 GRAPHICS INSTRUCTIONS

### PRINT HEAD WORD FORMATS

The following is a detailed description of the 4060 print head formats. Table K-1 summarizes these formats. Chapter M, "CRT Programming Specifications", discusses the details of line and character plotting.

### Plot Specified Point

This instruction will plot the character specified by the character code in word 3 (see Table K-2 for character Matrix Codes) at the point (location) specified in words 1 and 2 with the size and orientation specified in word 2.



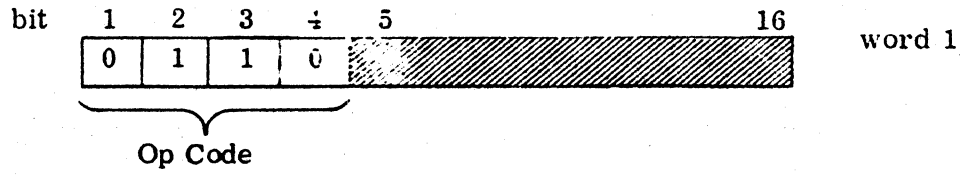

A = 00 Normal size character
= 01 Small size character
= 10 Medium size character
= 11 Large size character

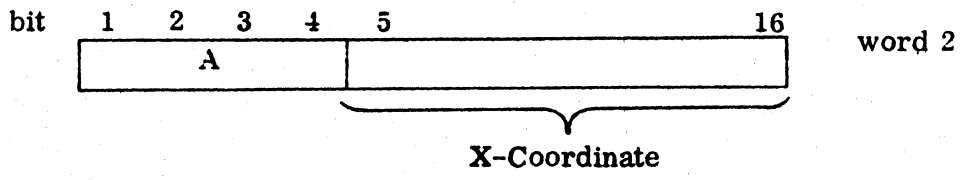
B = 0 Vertical Character (Normal)
= 1 Horizontal Character (Rotated)

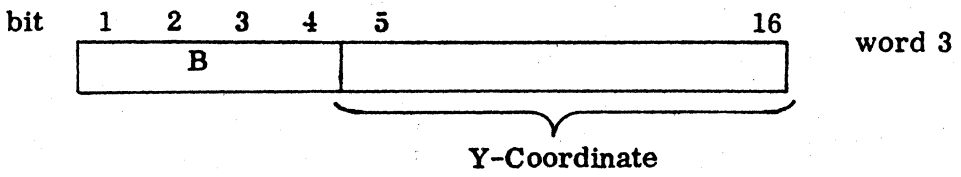
Bit position 4 of word 2 and bit positions 9 thru 16 of word 3 are not used.

## Fast Plot

This instruction sets the fast plot mode in word 1. The high order 4 bits of the character code is in word 2 and the low order 4 bits is in word 3. The plotting location is also given in words 2 and 3. Subsequent characters and locations must be structured according to words 2 and 3. The code '17 in bit positions 1 thru 4 of word 2 will terminate the fast plot mode. At least one character must be specified when entering the fast plot mode.



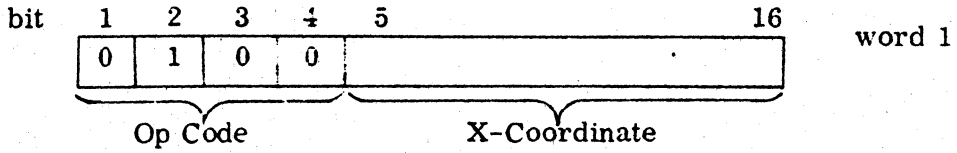



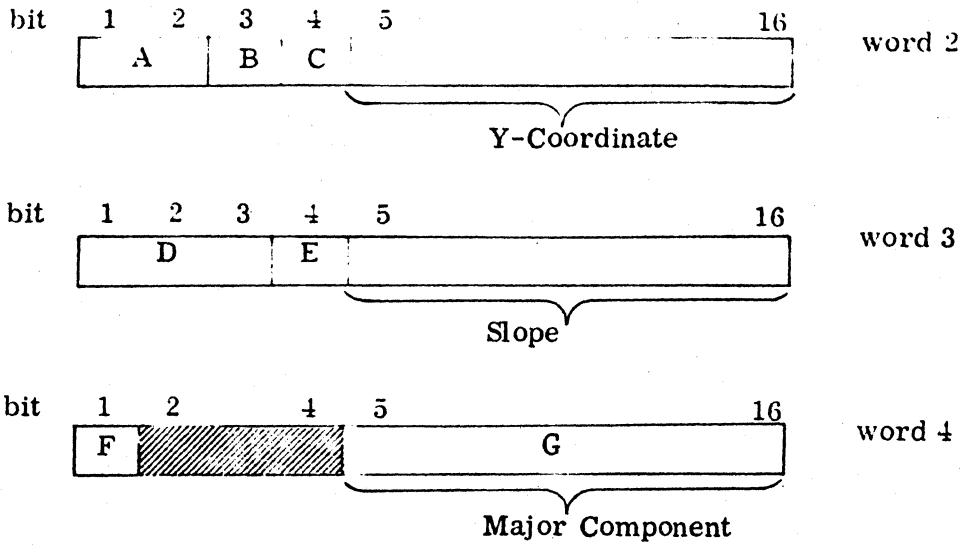

A = High Order 4 Bits of Matrix Character Code
B = Low Order 4 Bits of Matrix Character Code

Bit Positions 5 thru 16 of word 1 are not used.

## Draw Vector

This instruction will draw a line starting at the location specified in words 1 and 2. The horizontal component is specified by $\Delta X$ and the vertical as $\Delta Y$. If $\Delta X > \Delta y$, the slope required by word 3 must be $(\Delta Y \cdot 4095) / \Delta X$. If $\Delta Y > \Delta X$, then the slope must be $(\Delta X \cdot 4095)/\Delta Y$.






A = 00 Normal Line Width
= 01 Small Line Width
= 10 Medium Line Width
= 11 Large Line Width

B = 0 for $\Delta X > \Delta Y$
= 1 for $\Delta Y > \Delta X$

C = 0 for $+\Delta X$
= 1 for $-\Delta X$

D = 000 Solid Line
= 001 Short Dashed Line
= 011 Normal Dashed Line
= 101 Medium Dashed Line
= 111 Large Dashed Line

E = 0 for $+\Delta Y$
= 1 for $-\Delta Y$

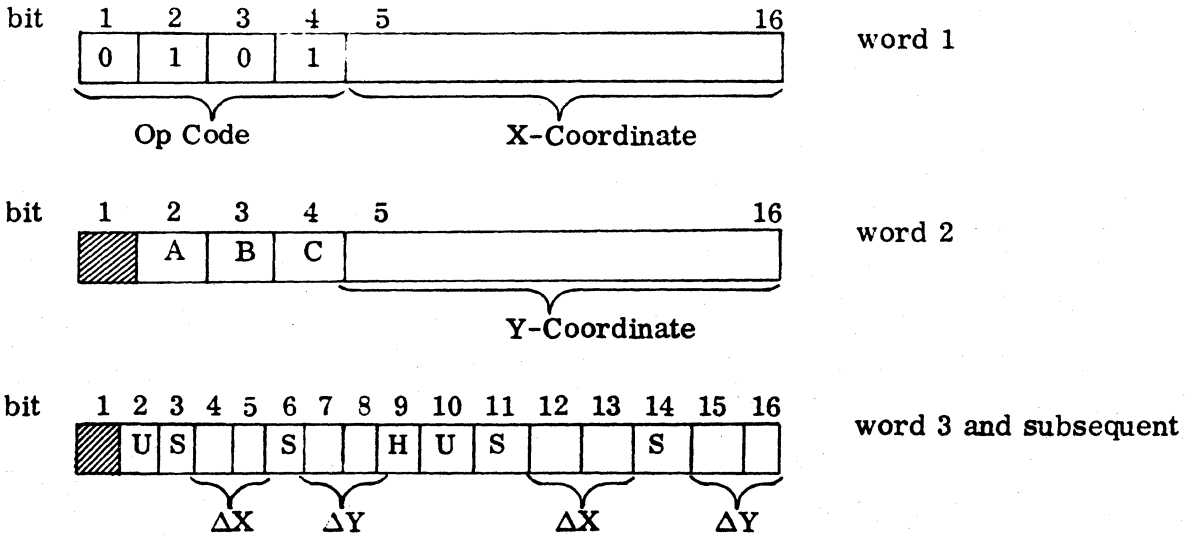
F = 0 Standard Line Density (bold typeface)
= 1 Light Line Density (light typeface)

G = $\Delta X$ for $\Delta X > \Delta Y$
= $\Delta Y$ for $\Delta Y > \Delta X$

Bit positions 2 thru 4 of word 4 are not used.

Stroke Write (Optional)

This instruction will draw a stroke character starting at the location specified in words 1 and 2. The height adjust bit is used to increase the height of certain characters which otherwise would be out of alignment. The size bit determines the overall size of the character. A short settle time may be selected if the stroke character is located within 80 plotting positions from the previous stroke character. Any number of strokes may be used as required. The stroke designator must be marked to indicate the last stroke word.




| | | | |
|---|---|---|---|
| A | = | 0 | Normal Settle Time |
| | = | 1 | Fast Settle Time |
| B | = | 0 | Normal Size |
| | = | 1 | Large Size |
| C | = | 0 | Normal Height |
| | = | 1 | Increased Height |
| U | = | 0 | Blank (Stroke not recorded) |
| | = | 1 | Unblank (Record stroke) |
| S | = | 0 | $+\Delta X$ or $+\Delta Y$ |
| | = | 1 | $-\Delta X$ or $+\Delta Y$ |
| H | = | 0 | Continue |
| | = | 1 | Terminate Stroke Mode |

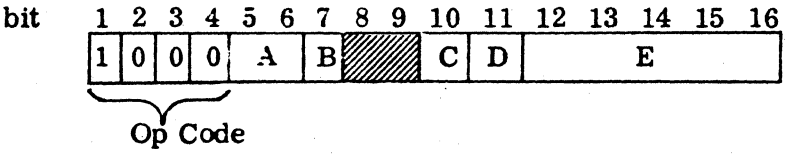
| | | |
|---|---|---|
| ΔX | = 00 | |
| | = 01 | X-Component of Stroke |
| | = 10 | |
| ΔY | = 00 | |
| | = 01 | Y-Component of Stroke |
| | = 10 | |

Bit position 1 of words 2 and 3 are not used

Control Functions

This single word instruction provides for the selection of combinations of print head control commands. Generally, a control function may be given alone or in combination with other control functions. The exceptions are:

1. VOID FRAME must be accompanied with a FRAME ADVANCE.
2. GENERATE LEADER and DELAY must be given alone.

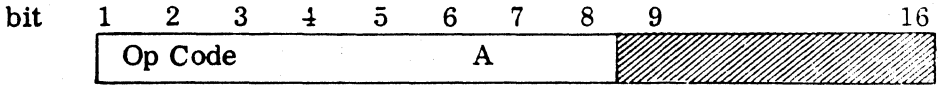



| | | | |
|---|---|---|---|
| A | = 00 | No Change in FORM FLASH Mode |
| | = 10 | Single FORM FLASH |
| B | = 0 | No Action |
| | = 1 | 64 millisecond DELAY |
| C | = 0 | No Action |
| | = 1 | VOID FRAME Strobe |
| D | = 0 | No Action |
| | = 1 | GENERATE LEADER |

| | | | |
|---|---|---|---|
| E = | 10000 | 2 pole (4 perf) | FRAME ADVANCE |
| = | 10001 | 3 pole (6 perf) | FRAME ADVANCE |
| = | 10010 | 4 pole (8 perf) | FRAME ADVANCE |
| = | 10100 | 5 pole (10 perf) | FRAME ADVANCE |
| = | 11000 | 6 pole (12 perf) | FRAME ADVANCE |

Bit positions 8 and 9 are not used

Special Functions




Op Code

| | | | |
|---|---|---|---|
| '13 | A = | 0100 | CLEAR BLOCK MODE |
| | = | 1000 | Start FILM PROCESSOR |
| | = | 0010 | NOTCH FILM |
| '14 | A = | 0000 | Set BLOCK MODE |
| '15 | A = | 0000 | 6 perf. film advance - no hard copy |
| | = | 1101 | 4 perf. film advance - strip chart |
| | = | 0110 | 6 perf. film advance - 8 1/2 x 11 H.C. |
| | = | 0100 | 6 perf. film advance - 11 x 14 H. C. |

Op Code '15 represents the EXPOSE HARDCOPY command
It must be followed by the DELAY command.

| | | | |
|---|---|---|---|
| '16 | A = | 0000 | TEST MODE |

Op Code '16 will reset a previous TEST MODE command

Bit positions 9 thru 16 are not used

Table K-1 Summary of Print Head Commands

| Operation | Function |
|---|---|
| PLOT SPECIFIED POINT | Plots any matrix character at the raster coordinates (point) specified, in any of four sizes and with either of two orientations. |
| FAST PLOT | Plots any matrix character at the point specified. The characteristics of this command are:<br>1. Uses the two smallest character sizes only.<br>2. Any character must be plotted within 80 raster units of the previous plotted character. The first character plotted with this command should be a blank.<br>3. Character size and orientation for this mode is established by first plotting a blank with the Plot Specified Point Command. |
| DRAW VECTOR | Draws a line from any point on the raster, with a given slope either solid or dashed in any of four line widths and in either of two line densities. The slope is found by multiplying the smallest vector component by 4095 and dividing by the largest component. Light density is not recommended for the smallest line width. A zero length vector will result in a plotted blank. |
| STROKE WRITE (Optional)' | Draws a stroke generated character at the point specified. A full discussion of stroke write is given in Stromberg-Carlson document #9500209. "S-C 4060 Stored Program Recording System - Description and Specifications." |
| FORM FLASH* | Causes a form slide to be projected and recorded on film either singly or concurrent with each frame advance. |

*May be included in same command

Table K-1. Summary of Print Head Commands (cont)

| Operation | Function |
|---|---|
| VOID FRAME* | Exposes the film frame to a light source which causes a circular spot near the top of the frame. This command must be accompanied by a frame advance. |
| GENERATE LEADER | Advances leader through camera adequate for last exposed frame to reach hard copy station. Recording is delayed until the leader is generated. |
| FRAME ADVANCE* | Causes the film to be advanced through the camera. The distance advanced may be 2, 3, 4, 5, or 6 poles. For 35mm perforated film, this is 4, 6, 8, 10, or 12 perforations. |
| DELAY | Delays input to the print head for a period of 64 milliseconds. |
| BLOCK MODE | Conditions how much film the film processor will do once started. If a film notcher is installed, the processor will develop film continuously until a notch is encountered in the edge of the film. If a notcher is not installed, the processor will develop 242 perfs of film. In either case the processor will stop on input loop empty if that occurs first. |
| RESET BLOCK MODE | Clears a previously set Block Mode. Film Processor when started will run to input loop empty. |
| START PROCESSOR | Starts the film processor. How much film will be processed is determined by whether the machine is in Block Mode or not. |
| NOTCH FILM | Activates an electromechanical film notcher required for Block Mode synchronization. The notch may also be used for hard copy sync. The notch will be placed on the upper edge of the film. |
| EXPOSE HARDCOPY | Exposes the upper edge of the film to a coded dot pattern required by the hardcopy processing station. The pattern is interpreted to produce strip chart, 11 x 14 or 8 1/2 x 11 paper feed, or, if no pattern is exposed, no hard copy. This command must be followed by the delay command to allow for the code light strobe time. |
| TEST MODE | Bypasses the print head interlocks to enable S-C 4060 operation in a non-monitored condition. |

*May be included in same command

Table K-2 Character Conversion Codes

| Matrix Symbol | Octal Value | Hexadecimal Value | Matrix Symbol | Octal Value | Hexadecimal Value |
|---|---|---|---|---|---|
| A | 125 | 55 | Z | 211 | 89 |
| B | 105 | 45 | a | 126 | 56 |
| C | 065 | 35 | b | 106 | 46 |
| D | 145 | 65 | c | 066 | 36 |
| E | 165 | 75 | d | 146 | 66 |
| F | 205 | 85 | e | 166 | 76 |
| G | 047 | 27 | f | 206 | 86 |
| H | 147 | 67 | g | 050 | 28 |
| I | 265 | B5 | h | 150 | 68 |
| J | 245 | A5 | i | 266 | B6 |
| K | 171 | 79 | j | 246 | A6 |
| L | 067 | 37 | k | 072 | 7A |
| M | 107 | 47 | l | 170 | 38 |
| N | 127 | 57 | m | 110 | 48 |
| O | 305 | C5 | n | 130 | 58 |
| P | 227 | 97 | o | 306 | C6 |
| Q | 247 | A7 | p | 230 | 98 |
| R | 267 | B7 | q | 250 | A8 |
| S | 327 | D7 | r | 270 | B8 |
| T | 307 | C7 | s | 330 | D8 |
| U | 071 | 39 | t | 310 | C8 |
| V | 111 | 49 | u | 072 | 3A |
| W | 131 | 59 | v | 112 | 4A |
| X | 151 | 69 | w | 132 | 5A |
| Y | 225 | 95 | x | 152 | 6A |

Table K-2 Character Conversion Codes (cont)

| Matrix Symbol | Octal Value | Hexadecimal Value | Matrix Symbol | Octal Value | Hexadecimal Value |
|---|---|---|---|---|---|
| y | 226 | 96 | - | 263 | B3 |
| z | 212 | 8A | \ | 064 | 34 |
| 0 | 232 | 9A | → | 104 | 44 |
| 1 | 252 | AA | & | 124 | 54 |
| 2 | 272 | BA | " | 144 | 64 |
| 3 | 312 | CA | ( | 164 | 74 |
| 4 | 113 | 4B | ) | 204 | 84 |
| 5 | 133 | 5B | * | 224 | 94 |
| 6 | 153 | 6B | / | 244 | A4 |
| 7 | 173 | 7B | ¬ | 264 | B4 |
| 8 | 213 | 8B | — | 304 | C4 |
| 9 | 233 | 9B | γ | 045 | 25 |
| δ | 122 | 52 | } | 325 | D5 |
| Π | 142 | 62 | BLANK | 052 | 2A |
| ? | 162 | 72 | ~ | 326 | D6 |
| # | 202 | 82 | · | 167 | 77 |
| ± | 222 | 92 | • | 207 | 87 |
| { | 103 | 43 | • | 170 | 78 |
| ← | 123 | 53 | • | 210 | 88 |
| @ | 143 | 63 | Π | 051 | 29 |
| ! | 163 | 73 | ; | 231 | 99 |
| % | 203 | 83 | , | 251 | A9 |
| , | 223 | 93 | . | 271 | B9 |
| — | 243 | A3 | : | 311 | C9 |

Table K-2 Character Conversion Codes (cont)

| Matrix Symbol | Octal Value | Hexadecimal Value | |
|---|---|---|---|
| $\beta$ | 331 | D9 | |
| ° | 332 | DA | |
| $\Delta$ | 073 | 3B | |
| + | 253 | AB | |
| - | 273 | BB | |
| o | 313 | CB | |
| $\alpha$ | 114 | 4C | |
| \| | 134 | 5C | |
| > | 154 | 6C | |
| < | 174 | 7C | |
| □ | 214 | 8C | |
| [ | 234 | 9C | |
| ] | 254 | AC | |
| $\int$ | 274 | BC | |
| $\wedge$ | 115 | 4D | |
| $\partial$ | 135 | 5D | |
| $ | 155 | 6D | |
| ¢ | 175 | 7D | |
| = | 215 | 8D | |
| $\Sigma$ | 235 | 9D | |
| ' | 255 | AD | |

# CHAPTER L

# PRINT HEAD OPERATIONS

## Functional Characteristics

The S-C 4060 print head logic utilizes Direct Multiplex Control (DMC) channel 2 of the PCU. Print head commands, as described in Section VI, consist of a series of one or more 16-bit words and are delivered to the print head in block form. Block transfers to the print head are made from the address stored in location '22 at the address stored in location '23. At the completion of a transfer, location '22 holds the final address from which data was transferred, plus 1. Addresses stored in locations '22 and '23 define the DMC transfer limits and must not exceed '17777.

The time required to transfer a 16-bit word to the print head is a function of DMC transfer time. The time required to execute a function on the print head is a function of print head response and may vary from 2 microseconds to 112 milliseconds depending upon the graphic function or control function to be performed.

## Basic Print Head Instructions

The following instructions are used to control the print head operations:

SKS '060 — Skip if Print Head Ready

This instruction causes a skip of one instruction of the print head is ready to receive the next word. This instruction may be given at any time.

OCP '060 — Enable Print Head DMC Channel

This instruction starts the transfer of data to the print head through DMC channel 2.

OCP '0260 — Clear Print Head

This instruction will perform the following:

1. Stops the generation of leader (if in progress)
2. Clears form flash and frame advance failures.
3. Resets DMC Flip-Flop.

This instruction performs the same function as depressing the MASTER CLEAR button on the PCU console except that it will not clear block mode or automatic form flash.

INA '1160 Access Print Head Status Word

This instruction transfers the PHSW to the A-register, and resets the processor and frame advance interrupt flip-flops.

Print Head Status Word (PHSW)

A 16-bit print head status word is available to the programmer (INA '1160). Table L-1 shows an analysis of the PHSW.

The PHSW may be accessed at any time but the examination if it is recommended at the beginning of a run and prior to and succeeding certain instructions. The conditions sensed by the PHSW are as follows:

A. Print Head Ready. This condition results from:

1. Power supply on and operative
2. Mirror in position
3. Normal mode (not test mode)
4. Film available
5. Deflection enabled
6. Ready button depressed

B. Tube Orientation. This condition indicates the orientation of the CHARACTRON tube (see appendix A CRT Programming Specifications.)

C. Film Low. This condition warns that the length of unexposed film available is critically short.

D. Film Processor Ready. This condition results from:

1. Film drive on
2. Chemical pumps on
3. Manual switch off
4. Chemicals at operating temperature

This condition is indicated at "not ready" if the film processing option is not included.

E. Film Processor in Position. This condition indicates the availability of the film processor. Film processor 'not in position' will be indicated if the film processing option is not included.

F. Hardcopy Ready. This condition results from:

1. Paper available
2. Hardcopy processor power on
3. Film threaded through the hardcopy exposure station

This condition will be indicated as 'not ready' if the hardcopy option is not included.

G. Paper Low. This condition warns that the quantity of unexposed paper available is critically low 'Paper Low' will be indicated if the hardcopy option is not included.

H. Input Loop Empty. This condition indicates a minimum length of exposed film between the camera and the film processor. This condition will be indicated if the film processing option is not included.

J. Output Loop Empty. This condition indicates a minimum length of processed film between the film processor and the hardcopy exposure station. This condition will be indicated if the hardcopy option is not included.

K. Film Processor Advance Interrupt. A 4 perforation film advance through the film processor will cause an interrupt signal to be sent to the PCU. This condition may be examined whether or not the PCU has been enabled for the interrupt. The condition is reset when the PHSW is accessed (INA '1160).

To enable the PCU for this and a camera advance interrupt, the following instruction sequence may be used:

```
LDA = '20000
OTA '0020
ENB
```

If the PCU is not enabled for this interrupt, a test for this condition may be made within approximately one-half second after the last film processor advance is executed.

L. Camera Advance Interrupt. A single film pull through the camera will cause an interrupt signal to be sent to the PCU. This condition is reset and enabled simultaneously with the Film Processor Advance Interrupt. If the PCU is not enabled for this interrupt a test for this condition may be made with 16 milliseconds after the frame advance is executed.

M. Test Mode. This condition indicates the operational mode of the S-C 4060.

Table L-1. Print Head Status Word

| Bit | Value | Condition | Bit | Value | Condition |
|---|---|---|---|---|---|
| 1 | 0 | Print head ready | 9 | 1 | Form flash failure |
| | 1 | Print head not ready | | 0 | Form flash normal |
| 2 | 1 | CRT in normal position | 10 | 1 | Input loop empty |
| | 0 | CRT in rotated position | | 0 | Input loop not empty |
| 3 | 0 | Film low | 11 | 1 | Output loop empty |
| | 1 | Film not low | | 0 | Output loop not empty |
| 4 | 0 | Film processor ready | 12 | 1 | Film processor advance interrupt |
| | 1 | Film processor not ready | | 0 | No film processor advance interrupt |
| 5 | 1 | Film processor in position | 13 | 1 | Camera advance interrupt |
| | 0 | Film processor not in position | | 0 | No camera advance interrupt |
| 6 | 0 | Hardcopy ready | 14 | - | Not used-always = 0 |
| | 1 | Hardcopy not ready | | | |
| 7 | 1 | Paper low | 15 | - | Not used-always = 0 |
| | 0 | Paper not low | | | |
| 8 | - | Not used-always = 0 | 16 | 1 | S-C 4060 in test mode |
| | | | | 0 | Not in test mode |

# CHAPTER M

# CRT PROGRAMMING SPECIFICATIONS

## Standard Raster

The 4060 standard raster consists of a rectangular array of 12,582,906 addressable points. The number of addressable points in the vertical direction is 3072 and in the horizontal direction, 4096. It is first quadrant with the origin at (0, 512) and bounded by the corner points (0, 3583), (4095, 3583), and (4095, 512).

Points addressed in the vertical direction which lie below 512 or above 3583 will be masked off by the camera aperture and will not be recorded on film.

The 4060 CRT may be physically rotated. In this case, the origin will lie at (512, 0) and the raster will be bounded by the corner points (512, 4095), (3583, 4095), and (3583, 0). See Figure M-1.

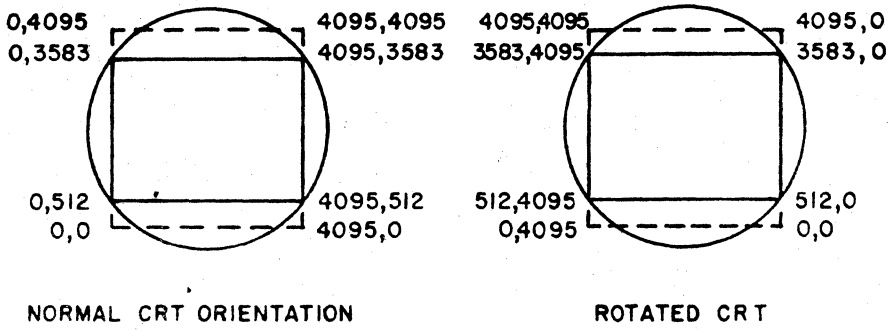



Figure M-1. CRT Orientation

## Character Specifications

The standard character matrix contains 116 characters as shown in Table K-2. The physical sizes of the characters in raster units varies with the individual character and the selected size. For example, the maximum width of a normal size character is normally set to allow 31 raster units to be used for normal character spacing (10 characters per inch with 100mm lens on hardcopy).

Any character may be plotted vertically (normal) or horizontally (rotated) under programmed control.

Recommended character and line spacing is shown in Table M-1. A decrease in the raster values specified may result in buttered or overlapped characters.

Table M-1. Character And Line Spacing

| Size | Spacing* Char. | Spacing* Line | Char/Line 11 x 14 | Char/Line 8 1/2 x 11 | Lines/Page | Size Ratio To Normal |
|---|---|---|---|---|---|---|
| Small | 24 | 38 | 171 | 92 | 81 | .75 |
| Normal | 31 | 52 | 132 | 72 | 60 | 1.00 |
| Medium | 40 | 64 | 103 | 56 | 49 | 1.25 |
| Large | 48 | 77 | 86 | 46 | 40 | 1.50 |

* In raster units

## Line Specifications

Lines (or vectors) may be drawn with a single beam sweep between any two points on the raster. They may be either solid or dashed.

Dashed lines will be drawn such that the solid portions and the spaces have the same length. Table M-2 specifies the dash (and space) lengths.

Four line widths (weights) are available as shown in Table M-3. The selected line width will be maintained for both solid and dashed lines.

All lines may be drawn in either of two densities; light or heavy. Heavy lines are considered normal density and should be used for all general line drawing. Light lines (or fast lines) are drawn at the rate of 250 nanoseconds per raster unit. This relatively short exposure time causes these lines to be recorded on film in a low density.

Table M-2. Standard Dashes In Raster Units

| Dash Size | Fast Line | Normal Line |
|---|---|---|
| Short | 32 | 8 |
| Normal | 64 | 16 |
| Medium | 128 | 32 |
| Long | 256 | 64 |

Table M-3 Standard Line Widths In Raster Units

| Size | Nominal Width |
|---|---|
| Small | 2* |
| Normal | 4 |
| Medium | 8 |
| Large | 16 |

*Not recommended for fast lines