STANDARD MICROSYSTEMS CORPORATION

CRT 9041A
CRT 9041B
CRT 9041C

CRT Video Attributes Controller VAC

FEATURES

- ☐ On chip 12 bit shift register
  - 3 speed versions:
    - CRT 9041A -33MHz
    - CRT 9041B -30MHz
    - CRT 9041C -28.5MHz
- ☐ On chip attributes logic
  - Reverse video
  - Character blank
  - Character blink to blank
  - Character blink between any two of four video intensity levels
  - Two independent underline attributes
  - Four video intensity levels
  - Two general purpose attributes
- ☐ Wide graphics mode
- ☐ Thin graphics mode
- ☐ Reverse screen input
- ☐ On chip logic for double height/double width data rows
- ☐ Accepts scan line information in parallel or serial format
- ☐ Supports multiple cursors
- ☐ Four cursor modes dynamically selectable via 2 input pins
  - Underline
  - Blinking underline
  - Reverse video block
  - Blinking reverse video block
- ☐ Mask programmable cursor blink rate and duty cycle

PIN CONFIGURATION

CURS	1	40	Vcc
RETBL	2	39	GP2O
LD/SH	3	38	GP1O
VDC	4	37	HINTO
VIDEO	5	36	BOLDO
DST	6	35	ATTEN
D11	7	34	CHABL
D10	8	33	UL2/GP2I
D9	9	32	XCURS/GP1I
D8	10	31	HINTI
D7	11	30	BOLDI
D6	12	29	BLINK
D5	13	28	RS
D4	14	27	REVID
D3	15	26	MS1
D2	16	25	MSØ
D1	17	24	$\overline{\text{VSYNC}}$
D0	18	23	SL0/SLD
SL3/BKC	19	22	SL1/$\overline{\text{SLG}}$
GND	20	21	SL2/BLC

- ☐ Mask programmable character blink rate and duty cycle
- ☐ On chip data and attribute latches
- ☐ Externally multiplexible for higher video rates
- ☐ Dot stretch on a character basis
- ☐ + 5 volt operation
- ☐ TTL compatible
- ☐ MOS n-channel silicon gate COPLAMOS® process
- ☐ Compatible with the CRT 5037 and CRT 9007

SECTION V

GENERAL DESCRIPTION

The SMC CRT 9041 Video Attributes Controller (VAC) is an n-channel COPLAMOS® MOS/LSI device containing graphics logic, attributes logic, data and attribute latches, cursor control, and a high speed video shift register. The CRT 9041, a character generator ROM, and a CRT controller such as the CRT 9007 provide all of the major circuitry for the display portion of a CRT video terminal.

The CRT 9041 serial video output may be connected directly to a CRT monitor's video input. The CRT 9041 is available in three speed versions: 28.5 MHZ (9041C), 30 MHZ (9041B) and 33 MHZ (9041A).

The CRT 9041 attributes include: reverse video, 2 underlines, character blank, and character blink. Character blink may be to background, or between any 2 of 4 possible video intensity levels. Two output pins define 4 video levels: half, three quarters, full, and bold. When used in conjunction with the CRT 9007 VPAC™, the CRT 9041 will provide double height or double width data row display.

Two cursor input pins allow simultaneous display of two cursors. Each of these cursors can be displayed in one of 4 display formats: underline, blinking underline, reverse video character block, and blinking reverse video character block. When used in the serial scan line input mode, each cursor may be displayed in any of the 4 cursor display modes as selected via the two input pins. When used in the parallel scan line input mode, each cursor display mode is mask programmable and fixed at the time of manufacture.

The cursor format or the parallel scan line information can be changed on a character by character basis to allow different cursor formats on separate areas of the screen or for superscripted or subscripted characters.

Two graphics modes are provided. In the wide graphics mode, the CRT 9041 produces a graphic entity the size of the character block. The graphic entity contains eight parts, each of which is associated with one bit of the input byte thereby providing 256 unique graphic symbols. The thin graphics mode enables the user to create thin line drawings and forms. In both graphics modes, continuous horizontal and vertical lines may be drawn. Additional flexibility is provided through the mask programming of the placement and dimensions of the blocks or lines within a character block. In the thin graphics mode, mask programming allows serrated horizontal lines.

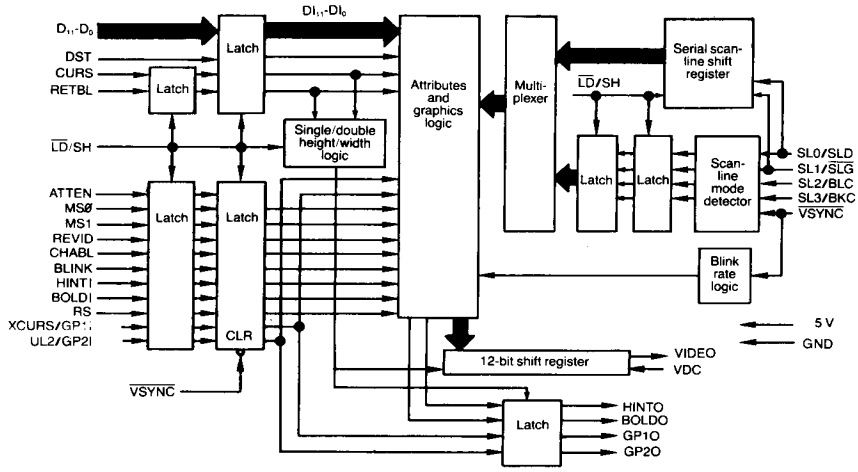


FIGURE 1: CRT 9041 BLOCK DIAGRAM

DESCRIPTION OF PIN FUNCTIONS

PIN NO.	NAME	SYMBOL	FUNCTION
1	Cursor	CURS	When this input is high and RETBL is low, the programmed cursor format will be displayed. When this input is high, and RETBL is high, the CRT 9041 enters the double width mode. See section entitled "Cursor Formats" for details.
2	Retrace Blank	RETBL	When this input is high, the parallel inputs to the video shift register are unconditionally cleared to all zeros and loaded on the next $\overline{LD}$/SH pulse. This forces the Video output to a low voltage level, independent of all attributes for blanking the CRT during horizontal and vertical retrace time.
3	$\overline{Load}$/Shift	$\overline{LD}$/SH	The 12 bit video shift register parallel-in load or serial-out shift operation is established by the state of this input. When high, this input enables the shift register for serial shifting with each video dot clock pulse (VDC input). When low, the video shift register is parallel loaded on the next video dot clock pulse and all data and attributes are moved to the next position in the internal pipeline. In addition, input data and attributes are latched on the positive transition of $\overline{LD}$/SH. If the period of this signal is greater than 12 dots, video information will be supplied in the form of backfill dots as specified in the mask programmed options.
4	Video Dot Clock	VDC	This input clock controls the rate at which video data is shifted out on the VIDEO output.
5	Video	VIDEO	The Video output provides the serial dot stream to the CRT. Video data is shifted out on the rising edge of the video dot clock VDC. The timing of the $\overline{LD}$/SH input will determine the number of backfill dots.
6	Dot Stretch	DST	This input determines if all dots in the video stream will be stretched by one dot. In normal video, all 1's are stretched and in reverse video all 0's are stretched. This input enters the CRT 9041 along with D11-D0 with one $\overline{LD}$/SH delay. Updating can occur each $\overline{LD}$/SH to allow selected dot stretching on a character by character basis. A high voltage will cause the dot stretch and a low voltage will inhibit the dot stretch mechanism. See section entitled "Dot Stretch" for details.
7-18	Data	D11-D0	In the character mode, the data on these inputs are passed through the attributes logic into the 12 bit high speed video shift register. The binary information on D11 will be the first bit output after the $\overline{LD}$/SH input goes low. In the thin or wide graphics mode only the D11 through D4 inputs will individually control the on/off condition of the particular portion of the character block or line drawing. Tables 5 and 6 illustrate the wide and thin graphics modes respectively and their relationships to D11-D4.

PIN NO.	NAME	SYMBOL	FUNCTION
19	Scan line 3/ Block Cursor	SL3/BKC	Information on this input is delayed 2 $\overline{LD}$/SH cycles before entering the Attribute and Graphics Logic. As a result, this input can be changed on a character basis to allow the cursor format to enter the CRT 9041 as an attribute or to allow the parallel scan line information to change on a character basis. This input has two separate functions depending on the way scan line information is presented to the CRT 9041. In the Parallel Scan Line Mode, this input is the most significant bit of the binary scan line row address. In the Serial Scan Line Mode, this input controls the cursor's physical dimensions. If high, the cursor will appear as a reverse video block (the entire character cell will be displayed in reverse video). If low, the cursor will appear as an underline on the scan line(s) programmed. (See Table 4.)
20	Ground	GND	Ground
21	Scan line 2/ Blink Cursor	SL2/BLC	Information on this input is delayed 2 $\overline{LD}$/SH cycles before entering the Attributes and Graphics Logic. As a result, this input can be changed on a character basis to allow the cursor format to enter the CRT 9041 as an attribute or to allow the parallel scan line information to change on a character basis. This input has two separate functions depending on the way scan line information is presented to the CRT 9041. (See Table 4.)
22	Scan Line 1/ $\overline{\text{Scan Line Gate}}$	SL1/$\overline{SLG}$	This input has two separate functions depending on the way scan line information is presented to the CRT 9041. In the Parallel Scan Line Mode this input is the next to the least significant bit of the binary scan line row address. In this mode the information presented is delayed 2 $\overline{LD}$/SH cycles before entering the Attributes and Graphics Logic to allow the scan line information to be changed on a character basis. In the Serial Scan Line Mode this input will be low for 5 or 6 $\overline{LD}$/SH pulses to allow the scan line information to be serially shifted into the serial scan line shift register. If this signal is low for 7 or more $\overline{LD}$/SH pulses, the CRT 9041 will assume the parallel input scan line row address mode.
23	Scan line 0/ Scan Line data	SL0/SLD	This input has two separate functions depending on the way scan line information is presented to the CRT 9041. Refer to Table 4. In the Parallel Scan Line Mode this input is the least significant bit of the binary scan line row address. The information presented in this mode is delayed 2 $\overline{LD}$/SH cycles before entering the Attributes and Graphics Logic to allow the scan line information to be changed on a character basis. In the Serial Scan Mode this input will present the scan line information in serial form (least significant bit first) to the CRT 9041 and permits the proper scan line information to enter the serial scan line shift register during the $\overline{LD}$/SH pulses framed by $\overline{SLG}$.
24	$\overline{\text{Vertical}}$ $\overline{\text{Sync}}$	$\overline{VSYNC}$	This input is typically connected to the vertical sync output of the CRT controller and is used as the clock input for the on-chip mask programmable blink rate dividers. The cursor blink rate can be a multiple or submultiple of the character blink which is selectable as a mask program option (see Table 10.) In addition, the internal attributes are reset when this input is low. The $\overline{VSYNC}$ input is also used to determine the scan line mode (parallel or serial) used. See the section "Scan Line Input Modes".
25 26	Mode Select 0 Mode Select 1	MS0 MS1	These 2 inputs define the four modes of operation of the CRT 9041 as follows: MS1 / MS0 / MODE 0 / 0 / Wide graphics mode 1 / 0 / Thin graphics mode 0 / 1 / Character mode without underline one 1 / 1 / Character mode with underline one See section entitled Display Modes for details.
27	Reverse Video	REVID	When this input and Retrace Blank (RETBL) are both low, data from the Attributes and Graphics Logic is presented directly to the video shift register. When this input is high and RETBL is low, the Attribute and Graphics Logic will invert the data before presenting it to the video shift register.
28	Reverse Screen	RS	This input defines the base background level of the screen. A low on this input will cause normal (non-reverse) video to appear white with a black background. A high on this input will cause normal (non-reverse) video to appear black with a white background.

PIN NO.	NAME	SYMBOL	FUNCTION
29	Blink	BLINK	When this input is high and both the RETBL and CHABL inputs are low, the character will blink at the programmed character blink rate. This input allows a character to blink between 2 of 4 levels of video or to the background level according to one of the 3 mask programmable blink tables (Tables 1, 2 and 3). The duty cycle for the character blink is mask programmable at either 75/25 (off/on) or 50/50.
30	Bold in	BOLDI	The BOLDI input along with the BOLDO output provides a user with a Bold (high intensity) attribute on a character by character basis. Data input on BOLDI will appear at BOLDO with the same delay as that from any other attribute input to the serial video output (VIDEO). By using an external mixing circuit, it is possible to raise the voltage level of the video output to produce the bold attribute.
31	Half intensity in	HINTI	The HINTI input along with the HINTO output provides a user with a half intensity attribute on a character by character basis. Data input on HINTI will appear at HINTO with the same delay as that from any other attribute input to the serial video output (VIDEO). By using an external mixing circuit, it is possible to lower the voltage level of the video output to produce the half intensity attribute.
32	Extra Cursor/ General Purpose Attribute 1 In	XCURS/ GP1I	This input has a dual function. It can produce a second cursor with either a dynamically selectable format or a masked programmed format. If no scan line(s) are programmed for the XCURS format (or if the programmed scan lines are beyond the range of the actual scan lines), this input will simply be pipelined through the CRT 9041 to produce a user controlled general purpose attribute. Data appearing on this input is pipelined to the GP1O with the same delay as that from any other attribute input and can affect the video as desired. Whether XCURS is used or not, data appearing on this input will be pipelined to the GP1O output.
33	Underline 2 General Purpose Attribute 2 In	UL2/ GP2I	This input has a dual function. It can produce a second underline (UL2) at the masked programmed scan line(s). If no scan line(s) are programmed for underline 2, this input will simply be pipelined through the CRT 9041 to produce a user controlled general purpose attribute. Data appearing on this input is pipelined to the GP2O with the same delay as that from any other attribute input and can affect the video as desired. Whether UL2 is used or not, data appearing on this input will be pipelined to the GP2O output. Note that underline 1 is selected via the MS0 and MS1 inputs.
34	Character Blank	CHABL	When this input is high, the parallel inputs to the video shift register are all set low (or high depending on the state of REVID and RS) thus providing a constant video level for the entire length of the character block. Only the cursor is visible in a character blank field.
35	Attribute Enable	ATTEN	When this input is high, the internal attribute latch is updated at the positive going edge of the $\overline{LD}$/SH input with data appearing on the REVID, CHABL, MS1, MS0, BLINK, BOLDI, HINTI, UL2/GP2I, DST RS, and XCURS/GP1I inputs. By selectively bringing this input high, the user will update the attribute only at specific character times; all subsequent characters will carry with them the attributes last updated thus allowing "field" or "embedded" attributes. When using a wide video memory where attribute bits are attached to every character, the internal attribute latch may be updated at each character by tying this input high (thus allowing "invisible" attributes). All attributes are reset by the $\overline{VSYNC}$ input.
36	Bold out Out	BOLDO	This output is used in conjunction with the BOLDI input to provide a three character pipeline delay when creating a high intensity effect on the video bit stream. In addition, this output is activated independent of the BOLDI signal during certain character and cursor blink operations according to Tables 1, 2 and 3.
37	Half Intensity Out	HINTO	This output is used in conjunction with the HINTI input to provide a three character pipeline delay when creating a half intensity effect on the video bit stream. In addition, this output is activated independent of the HINTI signal during certain character and cursor blink operations according to Tables 1, 2 and 3.
38	General Purpose Attribute 1 out	GP1O	This output is used in conjunction with the XCURS/GP1I input and provides a three character pipeline delay to allow for general purpose attributes to be implemented.
39	General Purpose Attribute 2 out	GP2O	This output is used in conjunction with the UL2/GP2I input and provides a three character pipeline delay to allow for general purpose attributes to be implemented.
40	Supply Voltage	Vcc	+ 5 volt power supply.

ATTRIBUTES FUNCTIONS

Reverse Video – The REVID input causes inverted data to be loaded into the video shift register.

Character Blank – The CHABL input forces the video to go to the current background level as defined by Reverse Video and Reverse screen. This attribute blanks all video with the exception of both cursor displays.

Underline – MS1, MS0 = 1,1 or UL2 = 1: either condition forces the video to the inverse of the background level (all 1's or all 0's) for all scan line(s) programmed for underline. The two underlines are independent.

Half Intensity – The HINTI input and the HINTO output allow a half intensity attribute to be carried through the pipeline of the CRT 9041. An external mixer can be used to combine VIDEO and HINTO to create a decreased white level in the video.

Retrace Blank – The RETBL input causes the VIDEO to go to the zero (black) level regardless of the state of all other inputs.

Bold – The BOLDI input and the BOLDO output allow a bold (high intensity) attribute to be carried through the pipeline of the CRT 9041. An external mixer can be used to combine VIDEO and BOLDO to create an increased white level in the video.

Blink – The BLINK input will cause characters to blink in a number of mask programmable ways. Referring to Tables 1, 2 or 3, video can be made to blink between 2 or 4 possible video levels with either a 50/50 on/off or a 75/25 on/off duty cycle. The tables also illustrate that the blink levels can be programmed to be a function of the reverse video input attribute. A blinking cursor overrides the character blink for the scan lines programmed for cursor. The CRT 9041 can implement character blinking in several different mask programmable visual formats as shown in the Tables. The blink function illustrated in Table 2 implements CRT 9021 compatibility blinking.

The CRT 9041 may be mask programmed for one of three combinations of blinking operation. These are illustrated respectively in Tables 1, 2, and 3. Since 4 levels of video are possible, Tables 1 and 3 define the video blinking between 2 video levels and Table 2 defines the video blinking to the background level making this table compatible with the CRT 9021.

The Non-blink Option Table 1A shows the state of the video DATA (DATA = non inverted video, $\overline{DATA}$ = inverted video) and the value of the output attributes (BOLDO, HINTO) that can be applied to the video DATA as a function of the four input attributes. The BLINK = 0 inputs in Table 1A result in a non-character blink display as compared to the video DATA shown in the Blink Combinations Option Table 1B.

(1) Reverse video = (REVID) and ($\overline{RS}$) or ($\overline{REVID}$) and (RS)

TABLE 1A: NON-BLINK COMBINATIONS OPTION TABLE

INPUTS					OUTPUTS	
BLINK	REVERSE VIDEO (1)	BOLDI	HINTI	VIDEO	BOLDO	HINTO
0	0	0	0	DATA	0	0
0	0	0	1	DATA	0	1
0	0	1	0	DATA	1	0
0	0	1	1	DATA	1	1
0	1	0	0	$\overline{DATA}$	0	1
0	1	0	1	$\overline{DATA}$	0	1
0	1	1	0	$\overline{DATA}$	0	0
0	1	1	1	$\overline{DATA}$	1	1

TABLE 1B: BLINK COMBINATIONS OPTION TABLE

INPUTS				CHARACTER BLINK WITHOUT CURSOR (2)		OUTPUTS			
BLINK	REVERSE VIDEO (1)	BOLDI	HINTI			BOLDO		HINTO	
				A*	B*	A*	B*	A*	B*
1	0	0	0	DATA	DATA	0	0	0	1
1	0	0	1	DATA	DATA	0	0	1	0
1	0	1	0	DATA	DATA	1	0	0	0
1	0	1	1	DATA	DATA	1	0	1	0
1	1	0	0	$\overline{DATA}$	$\overline{DATA}$	0	0	0	1
1	1	0	1	$\overline{DATA}$	$\overline{DATA}$	0	0	0	1
1	1	1	0	$\overline{DATA}$	$\overline{DATA}$	0	1	0	0
1	1	1	1	$\overline{DATA}$	$\overline{DATA}$	0	1	0	1

The Blink Combinations Option Table 1B shows the state of the video DATA (DATA = non inverted video; $\overline{DATA}$ = inverted video) during a character blink cycle (TIME A = OFF, TIME B = ON). The values of the output attributes (BOLDO, HINTO) that can be applied to the video DATA are determined by the state of the four input attributes. The BLINK = 1 inputs in Table 1B result in a blinking character display as compared to the non-blinking video DATA shown in the Non-blink Combinations Option Table 1A. Since 4 levels of video are possible, Table 1B defines video blinking between 2 video levels. This is shown in the explanation Table 1C below. It should be noted that the designation NORMAL, ½ INTENSITY, ¾ INTENSITY and BOLD have been used arbitrarily. The actual video levels caused by the BOLDO and HINTO are defined by the external video mixing circuit.

TABLE 1 C

BOLDO	HINTO	INTENSITY LEVEL	BLINK BETWEEN THESE 2 LEVELS (OFF-ON) NON REVERSE VIDEO	REVERSE VIDEO
0	0	NORMAL (N)	N - ½	N - ½
0	1	½ INTENSITY (½)	½ - N	N - ½
1	0	BOLD (B)	B - N	N - B
1	1	¾ INTENSITY (¾)	¾ - N	N - ¾

*The duty cycle for the blink with respect to the video, HINT, BOLD is mask programmable with the following choices:

A = 75% OR 50% B = 25% OR 50% (A + B must equal 100%)

(2) The combinations in Table 1 allow the user to define the cursor and the character blink interaction. A non-blinking cursor adds one more inversion to either a non-blinking character or a blinking character. A blinking cursor overrides a character blink for the scan lines programmed for cursor. A blinking cursor will introduce and then remove one more inversion to either a non-blinking character or a blinking character.

TABLE 2A: ALTERNATE NON-BLINK COMBINATIONS FOR CRT 9021 COMPATIBILITY

INPUTS					OUTPUTS	
BLINK	REVERSE VIDEO	BOLDI	HINTI	VIDEO	BOLDO	HINTO
0	0	0	0	DATA	0	0
0	0	0	1	DATA	0	1
0	0	1	0	DATA	1	0
0	0	1	1	DATA	1	1
0	1	0	0	$\overline{DATA}$	0	0
0	1	0	1	$\overline{DATA}$	0	1
0	1	1	0	$\overline{DATA}$	1	0
0	1	1	1	$\overline{DATA}$	1	1

The Alternate Non-blink Combinations for CRT 9021 Compatibility Table 2A show the state of the video DATA (DATA = non inverted video; $\overline{DATA}$ = inverted video) and the value of the output attributes (BOLDO, HINTO) that can be applied to the video DATA as a function of the four input attributes. The BLINK = 0 inputs in Table 2A result in a non-character blink display as compared to video DATA shown in Alternate Blink Combinations for CRT 9021 Compatibility Table 2B.

TABLE: 2B BLINK COMBINATIONS OPTION TABLE

INPUTS				CHARACTER BLINK WITHOUT CURSOR (1)	OUTPUTS			
BLINK	REVERSE VIDEO	BOLDI	HINTI		BOLDO		HINTO	
					A*	B*	A*	B*
1	0	0	0	DATA 0	0	0	0	0
1	0	0	1	DATA 0	0	0	1	1
1	0	1	0	DATA 0	1	1	0	0
1	0	1	1	DATA 0	1	1	1	1
1	1	0	0	$\overline{DATA}$ 1	0	0	0	0
1	1	0	1	$\overline{DATA}$ 1	0	0	1	1
1	1	1	0	$\overline{DATA}$ 1	1	1	0	0
1	1	1	1	$\overline{DATA}$ 1	1	1	1	1

The Alternate Blink Combinations for CRT 9021 Compatability Table 2B show the state of the video DATA (DATA = non inverted video; $\overline{DATA}$ = inverted video) during a character blink cycle (TIME A = OFF, TIME B = ON). The values of the output attributes (BOLDO, HINTO) that can be applied to the video DATA are determined by the state of the four input attributes. The BLINK = 1 inputs in Table 2B result in a blinking character display as compared to the non-blinking video DATA shown in the Alternate Non-Blink Combinations for CRT Compatibility Table 2A. In this table, the BOLDO and HINTO attributes are controlled by the BOLDI and HINTI attributes making them truly general purpose.

*The duty cycle for the blink with respect to the video, HINT, BOLD is mask programmable with the following choices:

A = 75% OR 50% B = 25% OR 50% (A + B must equal 100%)

(1) The combinations in Table 2 allow the user to define the cursor and the character blink interaction. A non-blinking cursor adds one more inversion to either a non-blinking character or a blinking character. In both cases the character blinks to the background video level. A blinking cursor overrides a character blink for the scan lines programmed for cursor. A blinking cursor will introduce and then remove one more inversion to either a non-blinking cursor or a blinking character.

TABLE 3A: NON-BLINK COMBINATIONS FOR THE STANDARD CRT 9041 (CRT 9041-004)

INPUTS					OUTPUTS	
BLINK	REVERSE VIDEO	BOLDI	HINTI	VIDEO	BOLDO	HINTO
0	0	0	0	DATA	0	0
0	0	0	1	DATA	0	1
0	0	1	0	DATA	1	0
0	0	1	1	DATA	1	1
0	1	0	0	$\overline{DATA}$	0	0
0	1	0	1	$\overline{DATA}$	0	1
0	1	1	0	$\overline{DATA}$	1	0
0	1	1	1	$\overline{DATA}$	1	1

The Non-blink Combinations for the Standard CRT 9041 of Table 3A shows the state of the video data (DATA = non inverted video; $\overline{DATA}$ = inverted video) and the value of the output attributes (BOLDO, HINTO) that can be applied to the video DATA as a function of the four input attributes. The BLINK = 0 inputs in Table 3A result in a non-character blink display as compared to video DATA shown in the Blink Combinations for the Standard CRT 9041 of Table 3B.

TABLE 3B: BLINK COMBINATIONS FOR THE STANDARD CRT 9041 (CRT 9041-004)

INPUTS				NON-CURSOR(2)		OUTPUTS			
BLINK	REVERSE	BOLDI	HINTI			BOLDO		HINTO	
				A*	B*	A*	B*	A*	B*
1	0	0	0	DATA	DATA	0	0	0	1
1	0	0	1	DATA	DATA	0	1	1	1
1	0	1	0	DATA	DATA	1	0	0	0
1	0	1	1	DATA	DATA	1	0	1	0
1	1	0	0	$\overline{DATA}$	$\overline{DATA}$	0	0	0	1
1	1	0	1	$\overline{DATA}$	$\overline{DATA}$	0	1	1	1
1	1	1	0	$\overline{DATA}$	$\overline{DATA}$	1	0	0	0
1	1	1	1	$\overline{DATA}$	$\overline{DATA}$	1	0	1	0

The Blink Combinations for the Standard CRT 9041 of Table 3B shows the state of the video DATA (DATA = non inverted video; $\overline{DATA}$ = inverted video) during a character blink cycle (TIME A = OFF, TIME B = ON). The values of the output attributes (BOLDO, HINTO) that can be applied to the video DATA are determined by the state of the four input attributes. The BLINK = 1 inputs in Table 3B result in the blinking character display as compared to the non-blinking video DATA shown in the Non-Blink Combinations for the Standard CRT 9041 Table 3A. Since 4 levels of video are possible, Table 3B defines video blinking between 2 video levels. This is shown by the explanation Table 3C below. It should be noted that the designation NORMAL, ½ INTENSITY, ¾ INTENSITY and BOLD have been used arbitrarily. The actual video level caused by the BOLDO and HINTO are defined by the external video mixing circuit.

TABLE 3C

BOLDO	HINTO	INTENSITY LEVEL	BLINK BETWEEN THESE 2 LEVELS (OFF-ON)	
			NON REVERSE VIDEO	REVERSE VIDEO
0	0	NORMAL (N)	N - ½	N - ½
0	1	½ INTENSITY (½)	½ - ¾	½ - ¾
1	0	BOLD (B)	B - N	B - N
1	1	¾ INTENSITY (¾)	¾ - N	¾ - N

*The duty cycle for the blink with respect to the video, HINT, BOLD is mask programmable with the following choices:

A = 75% OR 50% B = 25% OR 50% (A + B must equal 100%)

(2)The scan lines programmed for a non-blinking cursor force a non-blinking or blinking character to a normal video level and introduce one more level of inversion. A blinking cursor adds one more level of inversion to the video during the blink time to a non-blinking or blinking character.

CURSOR FORMATS

Four cursor formats are possible with the CRT 9041. If the parallel scan line input mode is used, one of four cursor formats may be selected as a mask programmed option for each cursor independently. If the serial scan line input is used, the cursor format is dynamically selectable on a character by character basis via input pins 21 and 19 (SL2/BLC, SL3/BKC). See Table 4. The four cursor formats are as follows:

Underline – The cursor will appear as an underline. The position and width of the cursor underline is mask programmed. An underline cursor will add one more level of inversion to the video on the programmed scan line(s) for underline cursor.

Blinking Underline – The cursor will appear as an underline and introduce and then remove one more level of inversion to the video on the programmed scan line(s) for cursor underline. The cursor blink rate and duty cycle is mask programmable as outlined in Tables 1, 2 or 3.

Reverse Video Block – The cursor will appear as a reverse video block. The block cursor will add one more level of inversion to the video for all scan lines in the character cell.

Blinking Reverse Video – The cursor will appear as a blinking reverse video block. The cursor will introduce and then remove one more level of inversion to the video for all scan lines in the character cell. The cursor blink rate and duty cycle is mask programmable as outlined in Tables 1, 2 or 3.

In the parallel scan line mode it is possible to change the scan line count on a character by character basis. If the scan inputs are stable a time TS2 (figure 2) prior to the next rising edge of the LD/SH input the scan line count will enter the delay latch of the CRT 9041. In the serial scan line mode, it is possible to change the cursor format on a character by character basis with the timing identical to that described in the parallel scan line mode (TS2). This timing is shown in the AC timing diagram, Figure 2.

TABLE 4: CURSOR FORMATS

Scan Line Input Mode	(PIN21) SL2/BLC	(PIN19) SL3/BKG	Cursor Function
Serial	1	0	Underline
	1	1	Reverse Video Block
	0	0	Blinking Underline
	0	1	Blinking Reverse Video Block
Parallel	X	X	Mask programmable only

DISPLAY MODES

Inputs MS1 and MS0 select one of four display modes. All attributes except underline operate independent of the display mode used. Figures 6a and 6b illustrate a typical CRT 9041 configuration which operates in all display modes for the parallel and serial scan line modes respectively.

MS1,MS0 = 00–Wide Graphics Mode.
In this display mode, inputs D11-D4 define a graphic entity as illustrated in Table 5. Note that individual bits in D11-D4 will illuminate particular portions of the character block. Table 5 shows all programming ranges possible when defining the wide graphics boundaries. Only underline 2 is possible in this display mode.

MS1,MS0 = 10–Thin Graphics Mode.
In this display mode inputs D11-D4 define a graphic entity as illustrated in Table 6. Note that individual bits in D11-D4 will illuminate particular horizontal or vertical line segments within the character block. Table 6 shows all programming ranges possible when defining the thin graphics boundaries. Only underline 2 is possible in this display mode.

MS1,MS0 = 01–Character Mode without Underline 1.
In this display mode, inputs D11-D4 go directly from the input latch to the video shift register via the Attributes and Graphics Logic. This mode requires either a bit mapped system RAM (1 bit in RAM equals 1 pixel on the CRT) or a character generator as shown in Figures 6a and 6b. Underline 2 is available in this display mode.

MS1,MS0 = 11–Character Mode with Underline 1.
Same operation as MS1, MS0 = 01 with the underline attribute byte appearing on the scan line(s) mask programmed. Underline 2 is available in this display mode.

TABLE 5: WIDE GRAPHICS MODE

SL3-SL0	ROW#	C11	C10	C9	C8	C7	C6	C5	C4	C3	C2	C1	C0	BF	BF ...
0000	R0	D11					D7								H3
0001	R1														
0010	R2														
0011	R3	D10					D6								H2
0100	R4														
0101	R5	D9					D5								H1
0110	R6														
0111	R7	D8					D4								H0
1000	R8														
1001	R9														
1010	R10														
1011	R11														
1100	R12														
1101	R13														
1110	R14														
1111	R15	W1					W0								

H0, H1, H2, H3, W0, W1, are mask programmable.
The values shown are for the CRT 9041-004.

TABLE 6: THIN GRAPHICS MODE

SL3-SL0	ROW#	C11	C10	C9	C8	C7	C6	C5	C4	C3	C2	C1	C0	BF	BF ...
0000	R0		D8												
0001	R1														
0010	R2	D11				D4				D10					
0011	R3														
0100	R4														
0101	R5		D6				D7								
0110	R6														
0111	R7					D5									
1000	R8														
1001	R9		D9												
1010	R10														
1011	R11														
1100	R12														
1101	R13														
1110	R14														
1111	R15														

	VERTICAL HEIGHT	HORIZONTAL POSITION
D4	R0-R5	PROGRAMMABLE
D5	R6-R15	PROGRAMMABLE
D10	R0-R15*	PROGRAMMABLE
D11	R0-R15*	PROGRAMMABLE

	HORIZONTAL LENGTH	VERTICAL POSITION
D6	C11-C7	PROGRAMMABLE
D7	C7-BF	PROGRAMMABLE
D8	C11-BF*	PROGRAMMABLE
D9	C11-BF*	PROGRAMMABLE

The height of D4 and D5, the length of D6 AND D7, and the position of D4-D11 are mask programmable. The values shown are for the CRT 9041-004.
*These values are fixed

DOUBLE WIDTH MODE

In order to display double width characters, video must be shifted out at half frequency and the video shift register must receive new information (parallel load) every other $\overline{LD}$/SH input pulse. In order to divide the video dot clock (VDC) and the $\overline{LD}$/SH pulse internally at the proper time, the cursor input should be pulsed during RETBL prior to the scan line to be displayed as double width. The CURSOR input must remain low for a minimum of 1 $\overline{LD}$/SH period from the leading edge of RETBL. The CURSOR input can stay high for the entire RETBL time but should not extend into active video. If it does, a cursor will be displayed. It is assumed that the CRT controller knows when a particular scan line should be double width and it should activate the CURSOR in the manner just described. Double height/double width characters can also be displayed if the scan line count is incremented by the CRT controller every other scan line. Figure 5 illustrates timing for both single and double width modes. The CRT 9007, which supports double height double width characters, will produce the cursor signal as required by the CRT 9041 with no additional hardware. It should be noted that the XCURSOR input will not affect the double width logic on the CRT 9041 in any way.

SCAN LINE INPUT MODES

Scan line information can be introduced into the CRT 9041 in parallel format or serial. Table 7 illustrates the pin definition as a function of the scan line input mode. The CRT 9041 will automatically recognize the scan line mode by observing the activity on pin 22. In parallel mode, this input will be active low for at least 1 scan line and in serial mode this input will remain low for about 5 or 6 $\overline{LD}$/SH periods. If pin 22 goes active low for less than seven but more than two continuous $\overline{LD}$/SH periods during the last scan line that has an active low on the $\overline{VSYNC}$ input, the serial mode will be locked in for the next frame. The parallel scan line input mode will be selected for the next frame if the following two conditions occur during the VSYNC low time. First, at least one positive transition must occur on pin 22 and second, pin 22 must be low for seven or more $\overline{LD}$/SH periods. Refer to Figure 4 for timing details. Whenever the CRT 9041 detects a change of scan line modes (from parallel to serial or visa versa), the internal blink counter will be initialized to a known count value. This allows the user to achieve phase synchronization of the blink rates from two or more CRT 9041's. This is useful if one multiplexes alternate dots from two CRT 9041's to double the allowable video dot rate.

TABLE 7: PIN DEFINITION FOR PARALLEL

Scan Line Input Mode	CRT 9041 Pins			
	23	22	21	19
Serial	SLD	SLG	BLC	BKC
Parallel	SL0	SL1	SL2	SL3

DOT STRETCH

Dot stretch is a mechanism whereby a single illuminated dot will never stand alone in the video stream. This eliminates the intensity variation otherwise found between single and multiple dots by raising the intensity level of single dots up to the level of consecutively displayed dots. To accomplish this, each illuminated dot (represented by a logic "1") will be extended into the next dot position. The following example illustrates the dot stretch mechanism.

Input bit pattern (D11-D0)	100101100100
Output bit pattern	110111110110

For reverse video, logic "0"'s are stretched (logic "1" represents the background of the reverse video character). The following example illustrates the mechanism in reverse video.

Input bit pattern (D11-D0)	010011001000
Reverse video pattern	101100110111
Output bit pattern	100100010011

In all cases, the next load of the shift register will always load the D11 bit to the output regardless of the value of the video output prior to the load. This dot stretch mechanism can be enabled on a character by character basis (or scan line by scan line) and is controlled by the DST input which is updated each $\overline{LD}$/SH period. The dot stretch signal enters the CRT 9041 with the D11-D0 inputs. In all cases, backfill (BF) is not affected by the dot stretch input.

BACKFILL

Backfill is a mechanism that allows a character width of greater than 12 dots and provides dot information (usually blanks) for all dots beyond 12. The character width is defined by the period of the $\overline{LD}$/SH input. For the character modes, backfill is added to the end of the character by two methods which are mask programmable.

Method A– The backfill (BF) dots will be the same as the dot displayed in position C11.

Method B– The backfill (BF) dots will be the same as the dots displayed in position C0.

MAXIMUM GUARANTEED RATINGS*

Operating Temperature in Range ..... 0° C to +70°C
Storage Temperature Range ..... −55°C to +150°C
Lead Temperature (soldering, 10 sec.) ..... +325°C
Positive Voltage on any Pin, with respect to ground ..... +8V
Negative Voltage on any Pin, with respect to ground ..... −0.3V

*Stresses above those listed may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or at any other condition above those indicated in the operational sections of this specification is not implied.

NOTE: When powering this device from laboratory or system power supplies, it is important that the Absolute Maximum Ratings not be exceeded or device failure can result. Some power supplies exhibit voltage spikes or "glitches" on their outputs when the AC power is switched on and off. In addition, voltage transients on the AC power line may appear on the DC output. If this possibility exists it is suggested that a clamp circuit be used.

ELECTRICAL CHARACTERISTICS (T_A = 0°C to 70°C, V_{cc} = +5V ±5%, unless otherwise noted)

DC CHARACTERISTICS

PRELIMINARY
Notice: This is not a final specification
Some parametric limits are subject to change.

PARAMETER	MIN	TYP	MAX	UNIT	COMMENTS
INPUT VOLTAGE LEVELS					
Low Level V_{IL}			0.8	V	All inputs except VDC, $\overline{LD}$/SH
Low Level V_{IL}			0.65	V	For VDC, $\overline{LD}$/SH input
High Level V_{IH1}	2.0			V	All inputs except VDC, $\overline{LD}$/SH
High Level V_{IH2}	4.3			V	For VDC, $\overline{LD}$/SH input
OUTPUT VOLTAGE LEVELS					
Low Level V_{OL}			0.4	V	I_{OH} = 0.4 mA
High Level V_{OH}	2.4			V	I_{OH} = 100μA
INPUT LEAKAGE CURRENT					
Leakage I_{L1}			10	μA	$0 \leq V_{IN} < V_{cc}$; excluding VDC, $\overline{LD}$/SH
Leakage I_{L2}			50	μA	$0 \leq V_{IN} \leq V_{cc}$; for VDC, $\overline{LD}$/SH
INPUT CAPACITANCE					
C_{IN1}		10		pf	Excluding VDC, $\overline{LD}$/SH
C_{IN2}		35		pf	$\overline{LD}$/SH
C_{IN3}		35		pf	VDC
POWER SUPPLY CURRENT					
I_{CC}		95		mA	

AC CHARACTERISTICS

PARAMETER	MIN	TYP	MAX	UNIT	COMMENTS
VDC	1.0		33.0	MHZ	CRT9041A
$1/t_{CY1}$ VDC frequency	1.0		30.0	MHZ	CRT9041B
	1.0		28.5	MHZ	CRT9041C
t_{CKL} VDC low	10			ns	
t_{CKH} VDC high	10			ns	
t_{CKR} VDC rise time			10	ns	Measured from 10% to 90% points
t_{CKF} VDC fall time			10	ns	Measured from 90% to 10% points
$\overline{LD}$/SH					
t_{CY2}	250			ns	CRT9041A (1)
	270			ns	CRT9041B (1)
	300			ns	CRT9041C (1)
t_{S1}	7			ns	
t_{H1}	0			ns	
INPUT SETUP AND HOLD					
t_{S2}	60			ns	CRT9041A } For inputs $\overline{SLG}$, SLD,
	80			ns	CRT9041B } $\overline{VSYNC}$
	110			ns	CRT9041C }
	35			ns	For all other inputs except VDC, $\overline{LD}$/SH, $\overline{SLG}$, SLD, $\overline{VSYNC}$
t_{H2}	10			ns	For inputs $\overline{SLG}$, SLD, $\overline{VSYNC}$
	0			ns	For all inputs except VDC, $\overline{LD}$/SH, $\overline{SLG}$, SLD, $\overline{VSYNC}$
MISCELLANEOUS TIMING					
t_{PD}			30	ns	CRT9041A
			33	ns	CRT9041B
			35	ns	CRT9041C
t_{DW}	t_{CY2}				

(1) When mask programmed for CRT 9021 compatibility TCY2 will be slower.

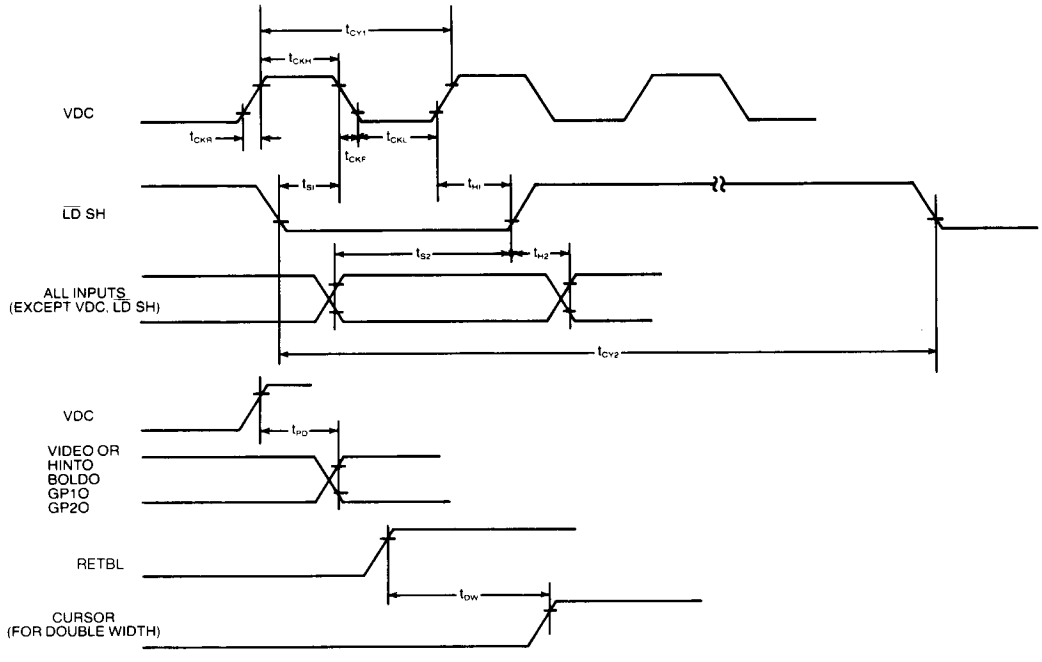


FIGURE 2: CRT 9041 INPUT/OUTPUT TIMING

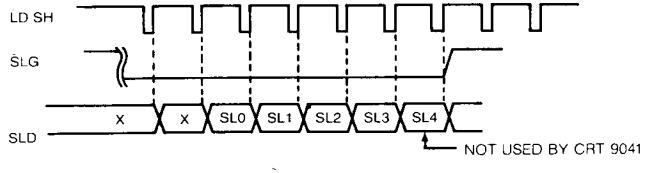


FIGURE 3: SERIAL SCAN LINE MODE TIMING

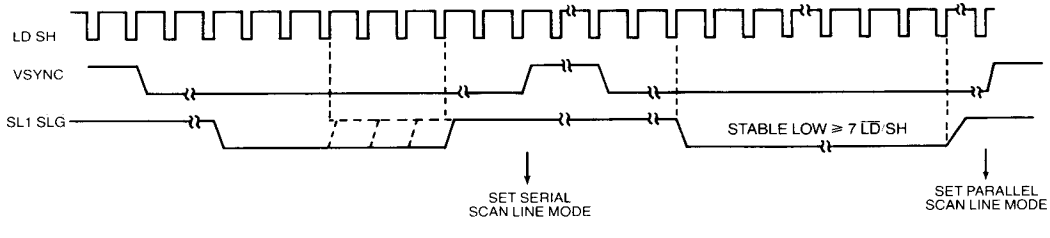


FIGURE 4: SERIAL/PARALLEL SCAN LINE MODE SELECTION TIMING

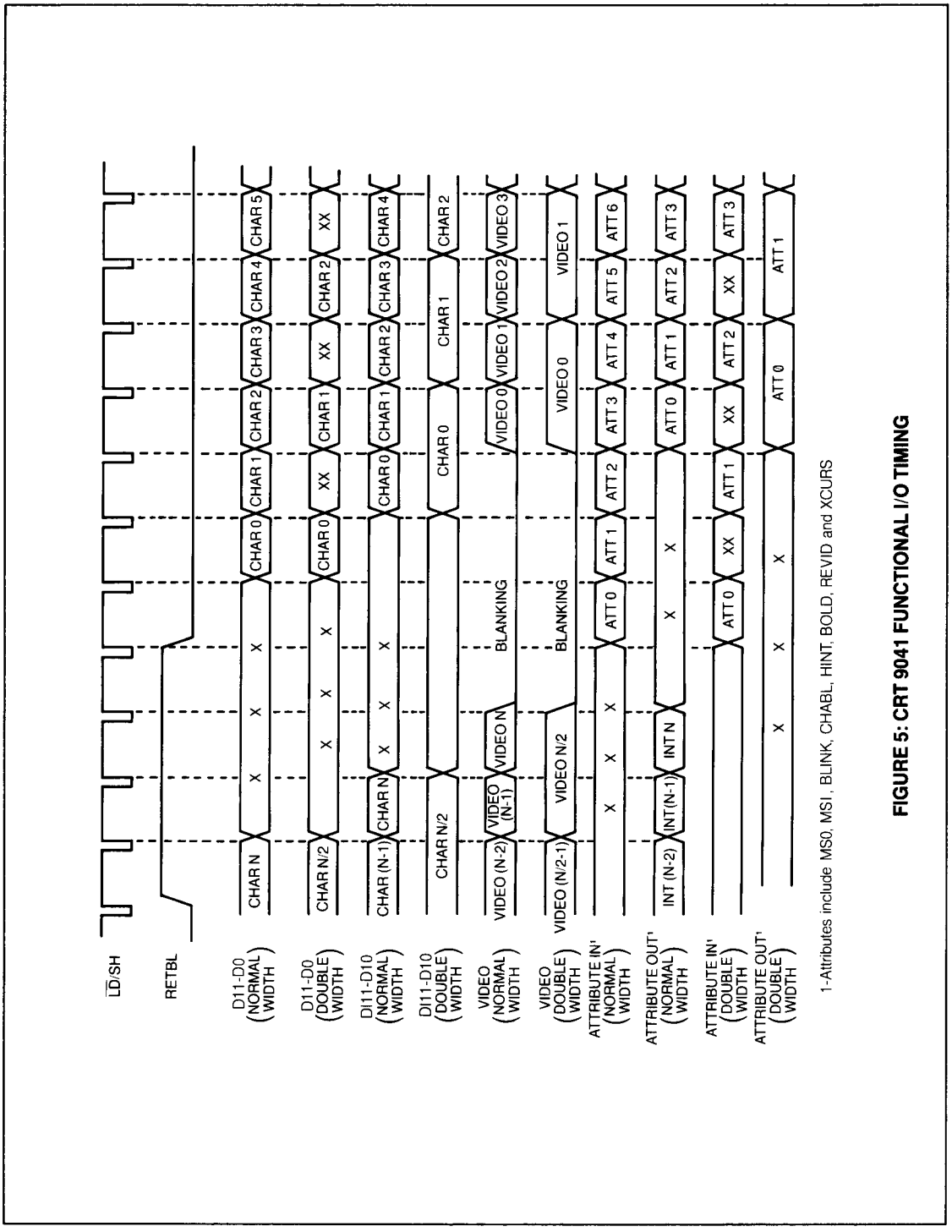


FIGURE 5: CRT 9041 FUNCTIONAL I/O TIMING

PROGRAM OPTIONS

The CRT 9041 has a variety of mask programmed options. Tables 8 and 9 illustrate the range of these options for the wide and thin graphics modes respectively. Table 10 illustrates the range of the miscellaneous other mask programmed options. In addition, Tables 8, 9 and 10 show the mask programmed options for the CRT 9041-004.

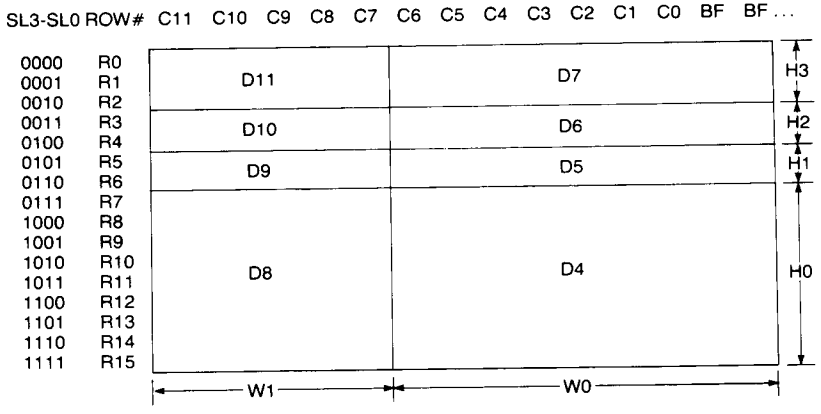
TABLE 8: WIDE GRAPHICS MASK PROGRAMMING OPTIONS

OPTION	CHOICES	CRT 9041-004
Height of Graphic block*		
D11 AND D7	any scan line(s)	R0,R1,R2
D10 AND D6	any scan line(s)	R3,R4
D9 AND D5	any scan line(s)	R5,R6
D8 AND D4	any scan line(s)	R7 thru R15
Width of graphic block**	any consecutive dots	C11 thru C7
D11,D10,D9,D8	C11 thru C0	
D7,D6,D5,D4	all remaining dots not specified above	C6 thru C0 plus BF

*Any graphic block pair can be removed by programming for zero scan lines.

**Total number of dots for both must be equal to the total dots per character with no overlap. D11,D10,D9 and D8 must always be to the left of D7-D4.

WIDE GRAPHICS



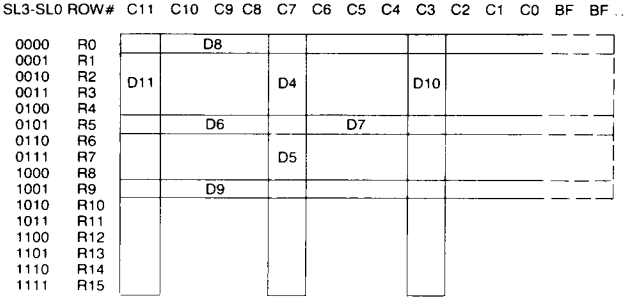
H0, H1, H2, H3, W0, W1, are mask programmable.
The values shown are for the CRT 9041-004.

TABLE 9: THIN GRAPHICS MASK PROGRAMMING OPTIONS

OPTION	CHOICES	STANDARD CRT 9041-004
Backfill	any dot(s) within the programmed D7 range to the right of the programmed column(s) for D11.	C0
Horizontal position for		
D6 and D7	any scan line(s) R0-R15	R5
D8	any scan line(s) R0-R15	R0
D9	any scan line(s) R0-R15	R9
Horizontal length for		
D6 (1)	any consecutive dots	C11 thru C7
D7 (1)	all dots not covered by D6 with one dot overlapping.	C7 thru BF
Blanked dots for serrated horizontal lines		
D6	any dot(s), BF programmed	none
D7	any dot(s), BF programmed	none
D8, D9	any dot(s), BF programmed	none
Vertical position for:		
D4 and D5	any dot(s) C11-C0,BF	C7
D10 (2)	any dot(s) C10-C0,BF	C3
D11 (2)	any dot(s) C11-C0	C11
Vertical length for:		
D4	any scan line(s)	R0 thru R5
D5	any scan lines not in D4	R6 thru R15
D10	no choice; always R0 thru R15	R0 thru R15
D11	no choice; always R0 thru R15	R0 thru R15

(1) D6 and D7 must always overlap by 1 dot. This overlap may be blanked by specifying the proper column(s) in the serration program line. D7 must always be to the right of D6.
(2) D11 must always come before D10 with no overlap: otherwise D10 is lost.

THIN GRAPHICS



	VERTICAL HEIGHT	HORIZONTAL POSITION
D4	R0-R5	PROGRAMMABLE
D5	R6-R15	PROGRAMMABLE
D10	R0-R15	PROGRAMMABLE
D11	R0-R15*	PROGRAMMABLE

	HORIZONTAL LENGTH	VERTICAL POSITION
D6	C11-C7	PROGRAMMABLE
D7	C7-BF	PROGRAMMABLE
D8	C11-BF*	PROGRAMMABLE
D9	C11-BF*	PROGRAMMABLE

The height of D4 and D5, the length of D6 AND D7, and the position of D4-D11 are mask programmable. The values shown are for the CRT 9041-004.
*These values are fixed

TABLE 10: MISCELLANEOUS MASK PROGRAMMING OPTIONS

OPTION	CHOICES	"STANDARD" CRT 9041-004
Backfill in character mode	C11 or C0	C11
Character blink rate (division of VSYNC frequency)	7.5 Hz to 0.5 Hz (1) (1)	1.25Hz (1)
Cursor blink rate (2)	same as, half, or twice the character blink rate	2.50 Hz (1)
Character blink duty cycle	50/50 or 75/25	50/50
Cursor blink duty cycle	50/50 or 75/25	50/50
Character underline 1 position	any scan line(s) R0 thru R15	R8
Character underline 2 position	any scan line(s) R0 thru R15	R10
Cursor underline position	any scan line(s) R0 thru R15	R9
Extra cursor underline position	any scan line(s) R0 thru R15	R11
Cursor format (3)	underline blinking underline reverse video block blinking reverse video block	blinking reverse video block
Extra cursor format (3)	underline blinking underline reverse video block blinking reverse video block	blinking underline
Blink table	Table 1 Table 2 Table 3	Table 3
CURSOR or XCURSOR effect on BOLDO and HINTO	no effect or force to zero at cursor position	force to zero at cursor position.

(1) Assumes VSYNC input frequency of 60 HZ.
(2) Valid only if the cursor is formatted to blink.
(3) Valid for the parallel scan line mode only.

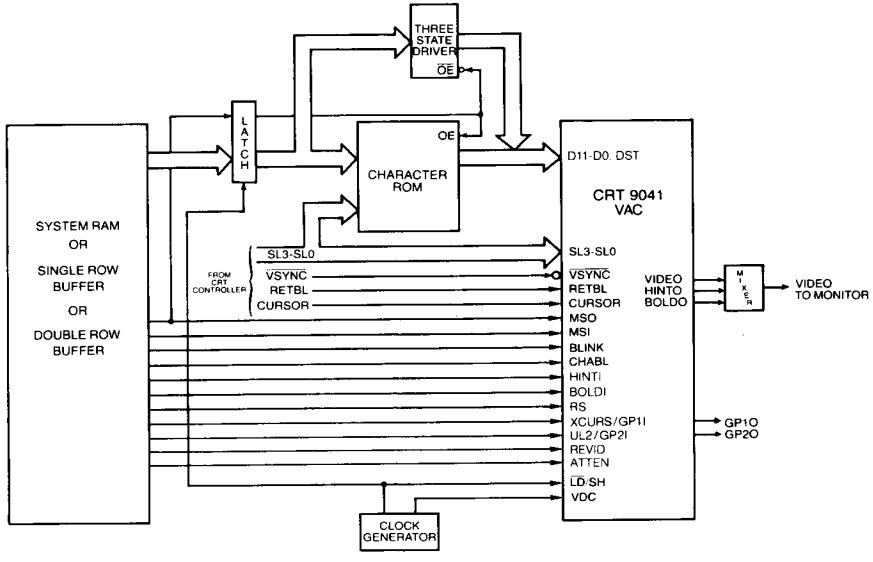


FIGURE 6a: CRT 9041 SYSTEM CONFIGURATION IN PARALLEL SCAN LINE MODE

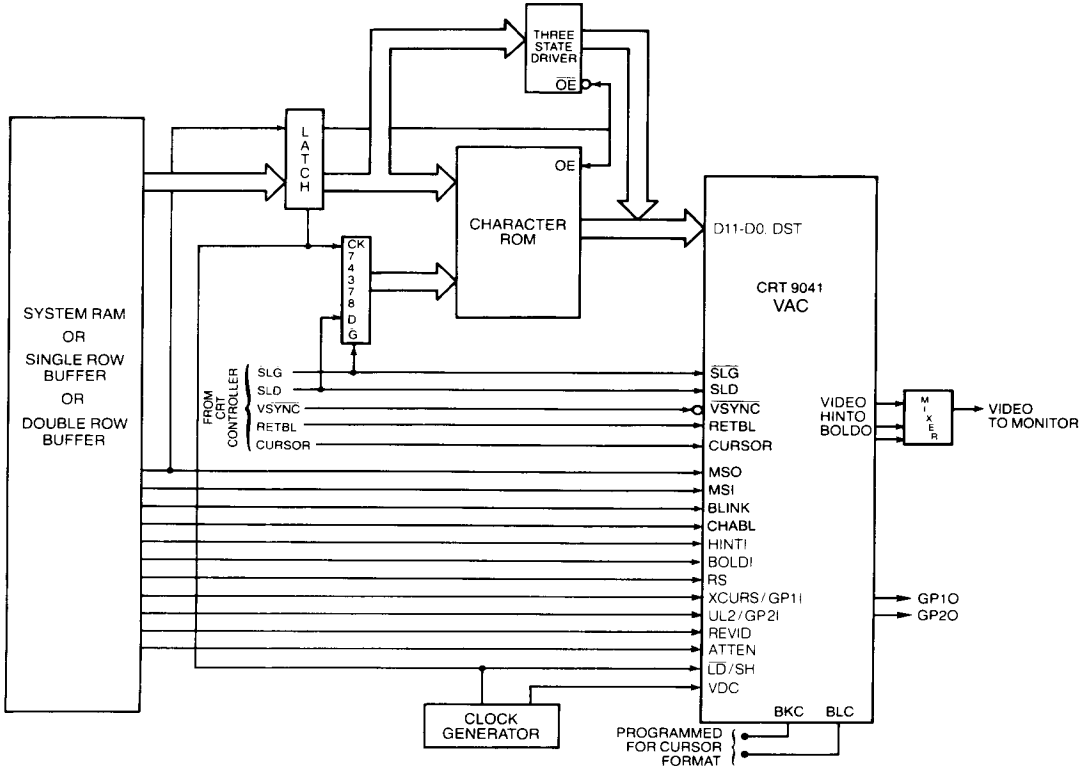


FIGURE 6b: CRT 9041 SYSTEM CONFIGURATION IN SERIAL SCAN LINE MODE