CRT Video Attributes Controller VAC

FEATURES

- On chip video shift register (28.5 MHz max.)
- On chip attributes logic
  - Reverse video
  - Character blank
  - Character blink
  - Underline
  - Full/half intensity
- Four modes of operation
  - Wide graphics
  - Thin graphics
  - Character mode without underline
  - Character mode with underline
- On Chip logic for double height/double width characters
- Accepts scan line information in parallel or serial format
- Four cursor modes dynamically selectable via 2 input pins
  - Underline
  - Blinking underline
  - Reverse video
  - Blinking reverse video
- Programmable character blink rate
- Programmable cursor blink rate
- On chip data and attribute latches
- +5 volt operation
- TTL compatible
- MOS n-Channel silicon gate COPLAMOS® process
- Compatible with CRT 5037 VTAC®; CRT 9007 VPAC™

PIN CONFIGURATION

DØ	1	28	D1
MSØ	2	27	D2
MS1	3	26	D3
REVID	4	25	D4
CHABL	5	24	D5
BLINK	6	23	D6
INTIN	7	22	D7
+5V	8	21	$\overline{\text{VSYNC}}$
ATTEN	9	20	GND
INTOUT	10	19	SLØ/SLD
CURSOR	11	18	SL1/$\overline{\text{SLG}}$
RETBL	12	17	SL2/BLC
$\overline{\text{LD}}$/SH	13	16	SL3/BKC
VIDEO	14	15	VDC

PACKAGE 28-pin D.I.P.

GENERAL DESCRIPTION

The SMC CRT 9021 Video Attributes Controller (VAC) is an n-channel COPLAMOS MOS/LSI device containing Graphics logic, attributes logic, data and attributes latches, cursor control, and a high speed video shift register. The CRT 9021, 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 9021 serial video output may be connected directly to a CRT monitor's video input. The maximum video shift register frequency of 28.5 MHz allows for CRT displays of up to 132 characters per data row.

The CRT 9021 attributes include: reverse video, underline, character blank, character blink, and full/half intensity selection. In addition, when used in conjunction with the CRT 9007 VPAC,™ the CRT 9021 will provide double height or double width characters.

Four programmable cursor modes are provided on the CRT 9021. They are: underline, blinking underline, reverse video character block, and blinking reverse video character block. When used in the serial scan line input mode, the cursor mode may be selected via two input pins. When used in the parallel scan line input mode, the cursor mode is a mask program option and is fixed at the time of manufacture.

Two graphics modes are provided. In the wide graphics mode, the CRT 9021 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 by allowing 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 or vertical lines.

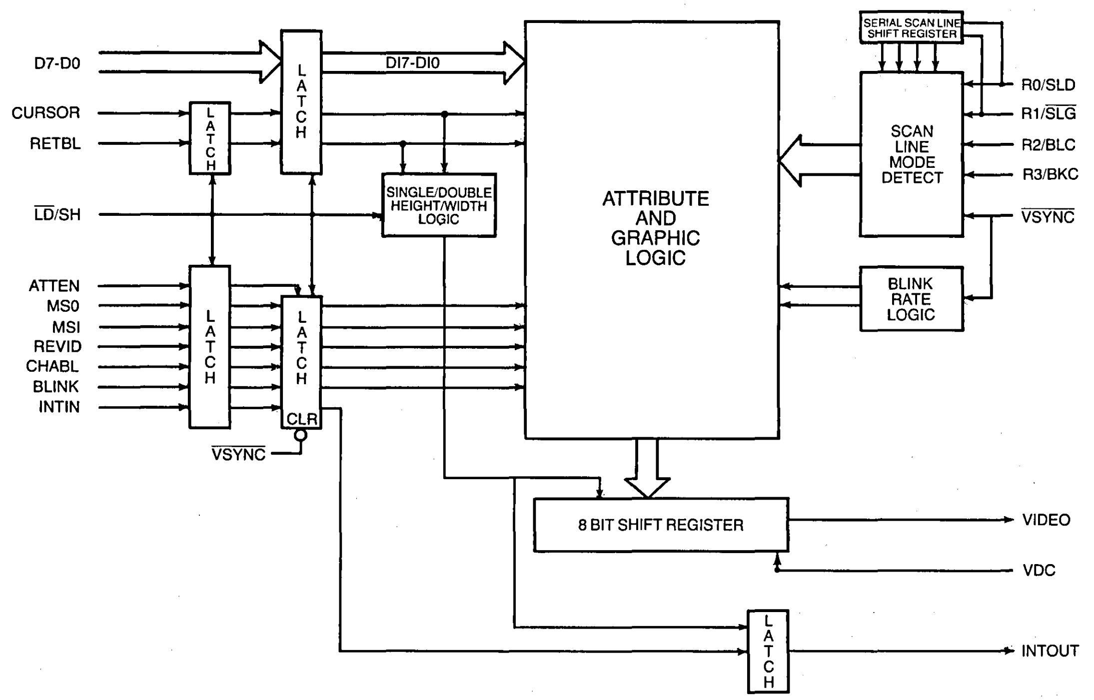


FIGURE 1: CRT 9021 BLOCK DIAGRAM

DESCRIPTION OF PIN FUNCTIONS

PIN NO.	NAME	SYMBOL	FUNCTION
1, 28, 27, 26, 25, 24, 23, 22	Data	D7-D0	In the character mode, the data on these inputs is passed through the Attributes logic into the 8 bit high speed video shift register. The binary information on D7 will be the first bit output after the LD/SH input goes low. In the thin or wide graphics mode these 8 inputs will individually control the on/off condition of the particular portion of the character block or line drawing. Figures 2 and 3 illustrate the wide and thin graphics modes respectively and their relationships to D7-D0
2 3	Mode Select 0 Mode Select 1	MS0 MS1	These 2 inputs define the four modes of operation of the CRT 9021 as follows: MS1, MS0 = 00; Wide graphics mode = 10; Thin graphics mode = 01; Character mode without underline = 11; Character mode with underline See section entitled Display Modes for details.
4	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.
5	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) thus providing a constant video level for the entire length of the character block.
6	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. Blinking is accomplished by causing the video to go to the background level during the "off" portion of the Character Blink cycle. This video level may be either the white or black level depending on state of REVID. The duty cycle for the character blink is 75/25 (on/off). This input is ignored if it coincides with the CURSOR input and the cursor is formatted to blink.
7	Intensity In	INTIN	The INTIN input along with the INTOUT output provides a user controlled general purpose attribute. Data input to INTIN will appear at INTOUT 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 or lower the voltage level of the video output to produce such attributes as "half intensity" or "intensity".

DESCRIPTION OF PIN FUNCTIONS CONT'D

PIN NO.	NAME	SYMBOL	FUNCTION
8	Supply Voltage	+5V	+5 volt power supply
9	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 and INTIN 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 tieing this input high (thus allowing for "invisible" attributes).
10	Intensity Out	INTOUT	This output is used in conjunction with the INTIN input to provide a three character pipeline delay to allow for general purpose attributes (such as intensity) to be implemented. See INTIN (pin 7).
11	Cursor	CURSOR	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 9021 enters the double width mode. See section entitled cursor formats for details.
12	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.
13	$\overline{Load}$/Shift	$\overline{LD}$/SH	The 8 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.
14	Video	VIDEO	The Video output provides the serial dot stream to the CRT. Video 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. See figure 5.
15	Video Dot Clock	VDC	This input clock controls the rate at which video is shifted out on the VIDEO output.
16	Scan line 3/Block Cursor	SL3/BKC	This input has two separate functions depending on the way scan line information is presented to the CRT 9021. *Parallel scan line mode*—This input is the most significant bit of the binary scan line row address. *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.
17	Scan line 2/Blink Cursor	SL2/BLC	This input has two separate functions depending on the way scan line information is presented to the CRT 9021. *Parallel scan line mode*—This input is the second most significant bit of the binary scan line row address. *Serial scan line mode*—This input if high, will cause the cursor to alternate between normal and reverse video at the programmed cursor blink rate. The duty cycle for the cursor blink is 50/50 (on/off). If this input is low, the cursor will be non-blinking.
18	Scan Line 1/Scan Line Gate	SL1/$\overline{SLG}$	This input has two separate functions depending on the way scan line information is presented to the CRT 9021. *Parallel scan line mode*—This input is the next to the least significant bit of the binary scan line row address. *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 9021 will assume the parallel input scan line row address mode.
19	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 9021. Refer to figure 6. *Parallel scan line mode*—This input is the least significant bit of the binary scan line row address. *Serial scan line mode*—This input will present the scan line information in serial form (least significant bit first) to the CRT 9021 and permits the proper scan line information to enter the serial scan line shift register during the $\overline{LD}$/SH pulses framed by $\overline{SLG}$ (pin 18).
20	Ground	GND	Ground
21	Vertical 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 two on-chip mask programmable blink rate dividers. The cursor blink rate (50/50 duty cycle) will always be twice the character blank rate (75/25 duty cycle). 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".

ATTRIBUTES FUNCTION

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

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.

Underline —MS1, MSØ = 1, 1 forces the video to go to the inverse of the background level for the scan line(s) programmed for underline.

Blink —The BLINK input will cause characters to blink by forcing the video to the background level 25% of the time and allowing the normal video for 75% of the time. When the cursor is programmed to blink (not controlled by the BLINK input), the video alternates from normal to reverse video at 50% duty cycle. The cursor blink rate always overrides the character blink rate when they both appear at the same character position.

Intensity (Half Intensity) —The INTIN input and the INTOUT output allow an intensity (or half intensity) attribute to be carried through the pipeline of the CRT 9021. An external mixer can be used to combine VIDEO and INTOUT to create the desired video level. See figure 8.

Table 1 illustrates the effect of the REVID, CHABL, UNDLN attributes as a function of the cursor format and the CURSOR and RETBL inputs.

TABLE 1: CRT 9021 ATTRIBUTE COMBINATIONS

CURSOR FORMAT	CRT 9021 INPUTS					VIDEO SHIFT REGISTER LOADED WITH:	
	RETBL	CURSOR	REVID	CHABL	UNDLN		
X	1	X	X	X	X	**all zero's**	
	0	0	0	0	0	data	
	0	0	0	0	1	One's for selected scan line(s); Data for all other scan lines.	
	0	0	0	1	X	All zero's	
	0	0	1	0	0	$\overline{\text{data}}$	
	0	0	1	0	1	Zero's for selected scan line(s); $\overline{\text{data}}$ for all other scan lines.	
	0	0	1	1	X	One's for all scan lines.	
UNDERLINE[2]	0	1	0	0	X[1]	One's for selected scan line(s) for cursor; data for all other scan lines.	
	0	1	0	1	X[1]	One's for selected scan line(s) for cursor; zero's for all other scan lines.	
	0	1	1	0	X[1]	Zero's for selected scan line(s) for cursor; $\overline{\text{Data}}$ for all other scan lines.	
	0	1	1	1	X[1]	Zero's for selected scan line(s) for cursor; one's for all other scan lines.	
BLINKING[3] UNDERLINE[2]	0	1	0	0	X[1]	One's for selected scan line(s) blinking; Data for all other scan lines.	
	0	1	0	1	X[1]	One's for selected scan line(s) blinking; zero's for all other scan lines.	
	0	1	1	0	X[1]	Zero's for selected scan line(s) blinking; $\overline{\text{Data}}$ for all other scan lines.	
	0	1	1	1	X[1]	Zero's for selected scan line(s) blinking; one's for all other scan lines.	
REVID BLOCK	0	1	0	0	0	$\overline{\text{Data}}$ for all scan lines.	
	0	1	0	0	1	Zero's for selected scan line(s) for underline; data for all other scan lines.	
	0	1	0	1	X	One's for all scan lines.	
	0	1	1	0	0	Data for all scan lines	
	0	1	1	0	1	One's for selected scan line(s) for underline; data for all other scan lines.	
	0	1	1	1	X	Zero's for all scan lines.	
BLINKING[3] REVID BLOCK	0	1	0	0	0	On $\overline{\text{Data}}$ for all scan lines.	Off Data for all scan lines.
	0	1	0	0	1	Zero's for selected scan line(s) for underline; $\overline{\text{Data}}$ for all other scan lines.	One's for selected scan line(s) for underline; Data for all other scan lines.
	0	1	0	1	X	One's for all scan lines.	Zero's for all scan lines.
	0	1	1	0	0	Data for all scan lines.	$\overline{\text{Data}}$ for all scan lines.
	0	1	1	0	1	One's for selected scan line(s); Data for all other scan lines.	Zero's for selected scan line(s); $\overline{\text{Data}}$ for all other scan lines.
	0	1	1	1	X	Zero's for all scan lines.	One's for all scan lines.

1 - if the programmed scan line(s) for cursor and underline coincide, the cursor takes precedence; otherwise both are displayed.
2 - at programmed scan line(s) for underline
3 - at cursor blink rate
Note—cursor blink rate overrides character blink rate.

DISPLAY MODES

Inputs MS1 and MS0 select one of four display modes. All attributes except underline operate independent of the display mode used. Figures 8a and 8b illustrate a typical CRT 9021 configuration which operates in all display modes for both the parallel and serial scan line modes respectively.

MS1, MS0 = 00 —Wide Graphics Mode.
In this display mode, inputs D7-D0 define a graphics entity as illustrated in figure 2. Note that individual bits in D7-D0 will illuminate particular portions of the character block. Table 2 shows all programming ranges possible when defining the wide graphic boundaries. No underline is possible in this display mode.

MS1, MS0 = 10 —Thin Graphics Mode.
In this display mode, inputs D7-D0 define a graphic entity as illustrated in figure 3. Note that individual bits in D7-D0 will illuminate particular horizontal or vertical line segments within the character block. Table 3 shows all programming ranges possible when defining the thin graphics boundaries. No underline is possible in this display mode.

MS1, MS0 = 01 —Character Mode Without Underline.
In this display mode, inputs D7-D0 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 pixal on the CRT) or an external character generator as shown in figures 8a and 8b.

MS1, MS0 = 11 —Character Mode With Underline.
Same operation as MS1, MS0 = 01 with the underline attribute appearing on the scan line(s) mask programmed.

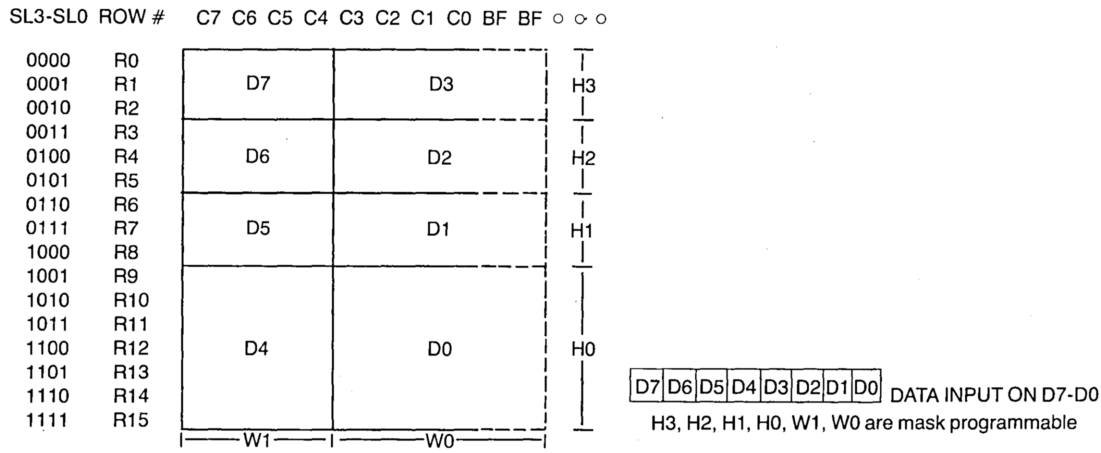
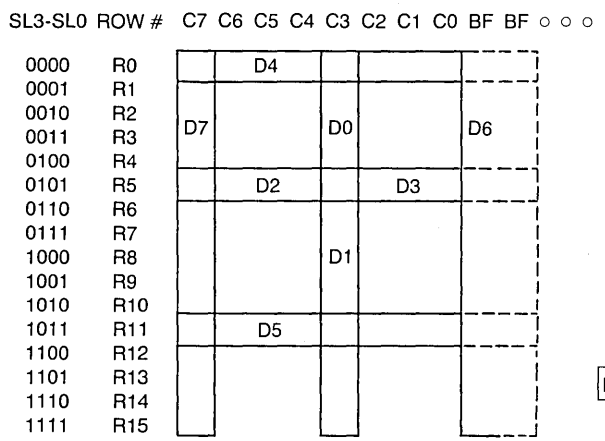


FIGURE 2: WIDE GRAPHICS MODE FOR STANDARD CRT 9021



	VERTICAL HEIGHT*	HORIZONTAL POSITION
D0	R0-R5	PROGRAMMABLE
D1	R6-R15	PROGRAMMABLE
D6	R0-R15	PROGRAMMABLE
D7	R0-R15	PROGRAMMABLE

	HORIZONTAL LENGTH*	VERTICAL POSITION
D2	C7-C3	PROGRAMMABLE
D3	C3-BF	PROGRAMMABLE
D4	C7-BF	PROGRAMMABLE
D5	C7-BF	PROGRAMMABLE

D7	D6	D5	D4	D3	D2	D1	D0

DATA INPUT ON D7-D0

* These values are fixed

FIGURE 3: THIN GRAPHICS MODE FOR STANDARD CRT 9021

BACKFILL

Backfill is a mechanism that allows a character width of greater than 8 dots and provides dot information (usually blanks) for all dot positions beyond 8. The character width is defined by the period of the $\overline{LD}$/SH input. For the character modes, backfill is added to the tail 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 C7.

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

For the wide graphics mode, the backfill dots will always be the same as the dot displayed in position C0 (method B) with no programmable option.

CURSOR FORMATS

Four cursor formats are possible with the CRT 9021. If the parallel scan line input mode is used, one of four cursor formats may be selected as a mask programmed option. If the serial scan line input mode is used, the cursor format is selected via input pins 16 and 17 (SL3/BKC, SL2/BLC). See Table 5. The four cursor modes are as follows:

Underline — The cursor will appear as an underline. The position and width of the cursor underline is mask programmed.

Blinking Underline — The cursor will appear as an underline. The underline will alternate between normal and reverse video at the mask programmed cursor blink rate.

Reverse Video Block — The cursor will appear as a reverse video block (The entire character cell will be displayed in reverse video).

Blinking Reverse Video Block — The cursor will appear as a reverse video block and the entire block (character plus background) will alternate between normal and reverse video at the masked programmed cursor blink rate.

Scan Line Input Mode	Pin 17	Pin 16	Cursor Function
Serial	0	0	Underline
	0	1	Reverse Video Block
	1	0	Blinking Underline
	1	1	Blinking Reverse Video Block
Parallel	X	X	Mask programmable Only

TABLE 5: CURSOR FORMATS

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. With respect to the CRT 9021, no distinction between double width and double height display is necessary. Figure 4 illustrated 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 9021 with no additional hardware.

SCAN LINE INPUT MODES

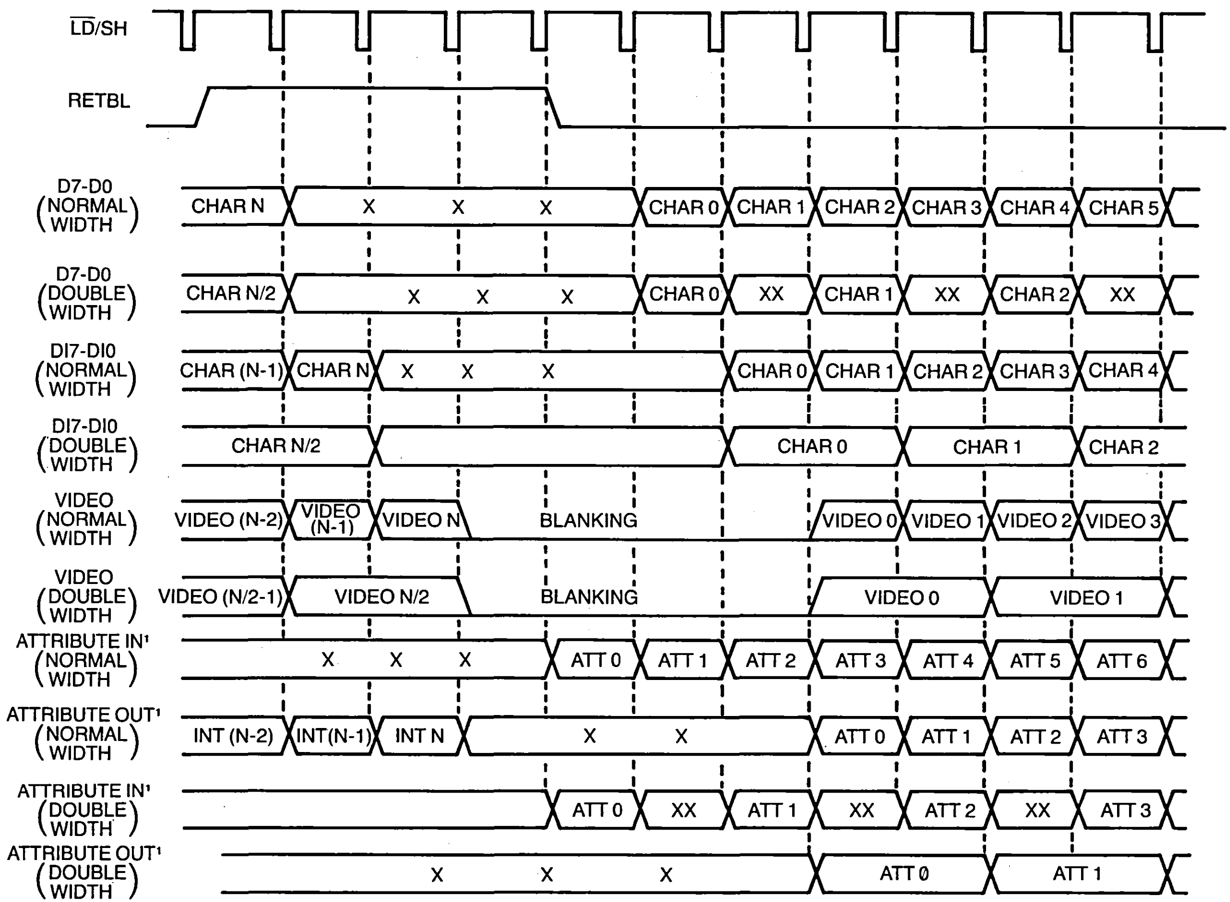
Scan line information can be introduced into the CRT 9021 in parallel format or serial format. Table 6 illustrates the pin definition as a function of the scan line input mode. The CRT 9021 will automatically recognize the proper scan line mode by observing the activity on pin 18. In parallel mode, this input will be stable 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 18 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 field. The parallel scan line input mode will be selected for the next field if the following two conditions occur during $\overline{VSYNC}$ low time. First, at least one positive transition must occur on pin 18 and second, pin 18 must be low for seven or more $\overline{LD}$/SH periods. Refer to figure 7 for timing details.

Scan Line Input Mode	CRT 9021 Pin Number			
	19	18	17	16
Serial	SLD	$\overline{SLG}$	BLC	BKC
Parallel	SL0	SL1	SL2	SL3

TABLE 6: PIN DEFINITION FOR PARALLEL AND SERIAL SCAN LINE MODES

PROGRAM OPTIONS

The CRT 9021 has a variety of mask programmed options. Tables 2 and 3 illustrate the range of these options for the wide and thin graphics modes respectively. Table 4 illustrates the range of the miscellaneous mask programmed options. In addition, Tables 2, 3 and 4 show the mask programmed options for the standard CRT 9021.



1-Attributes include MS0, MSI, BLINK, CHABL, INTENSITY, REVID

FIGURE 4: CRT 9021 FUNCTIONAL I/O TIMING

MAXIMUM GUARANTEED RATINGS*

Operating Temperature 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 .... .15V
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.

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

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

PARAMETER	MIN	TYP	MAX	UNIT	COMMENTS
DC CHARACTERISTICS					
INPUT VOLTAGE LEVELS					
Low Level V_{IL}			0.8	V	
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_{OL} = 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}		20		pf	For $\overline{LD}$/SH
C_{IN3}		25		pf	For VDC
POWER SUPPLY CURRENT					
I_{CC}		50		mA	

AC CHARACTERISTICS

PARAMETER	MIN	TYP	MAX	UNIT	COMMENTS
VDC					
$1/t_{CY1}$ VDC frequency	1.0		28.5	MHZ	
t_{CKL} VDC low	10			ns	
t_{CKH} VDC high	10			ns	Measured from 10% to 90% points
t_{CKR} VDC rise time			7.5	ns	Measured from 90% to 10% points
t_{CKF} VDC fall time			7.5	ns	
$\overline{LD}$/SH					
t_{CY2}	315			ns	
t_{S1}	7			ns	
t_{H1}	0			ns	
INPUT SETUP AND HOLD					
t_{S2}	35			ns	
t_{H2}	0			ns	
MISCELLANEOUS TIMING					
t_{PD}			35	ns	C_L = 15 pf
t_{DW}	t_{CY2}				

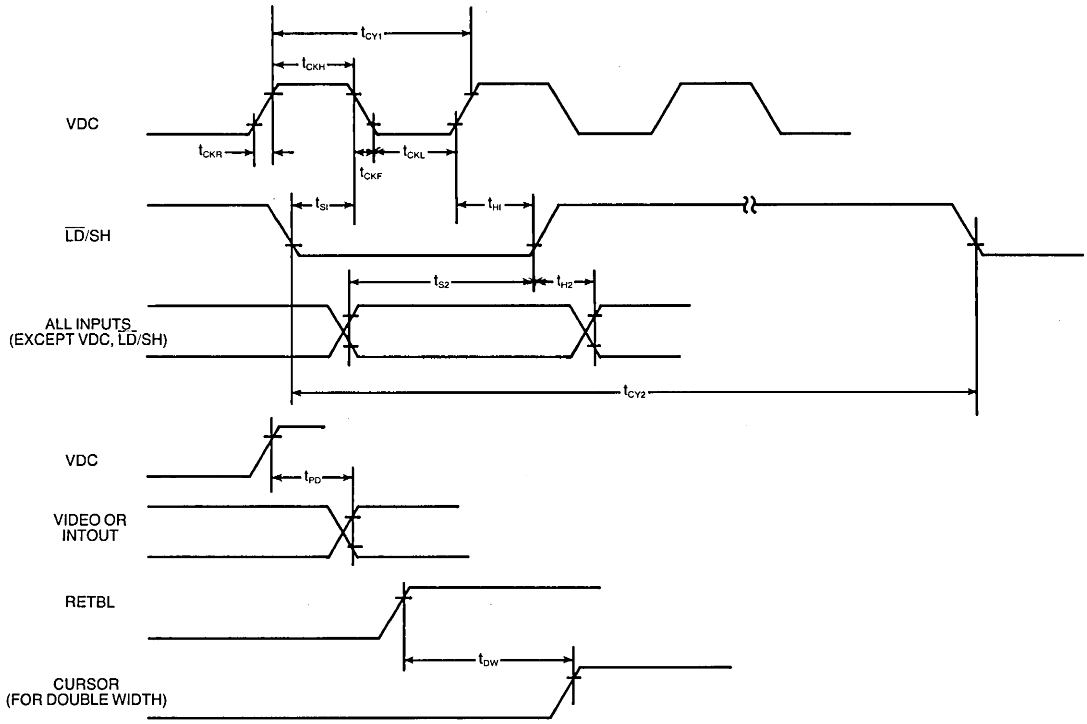


FIGURE 5: CRT 9021 INPUT/OUTPUT TIMING

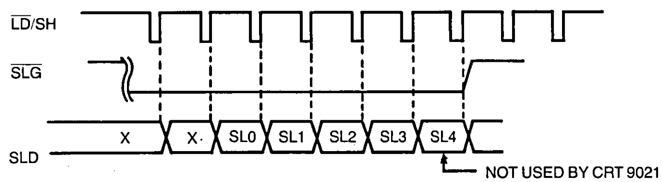


FIGURE 6: SERIAL SCAN LINE MODE TIMING

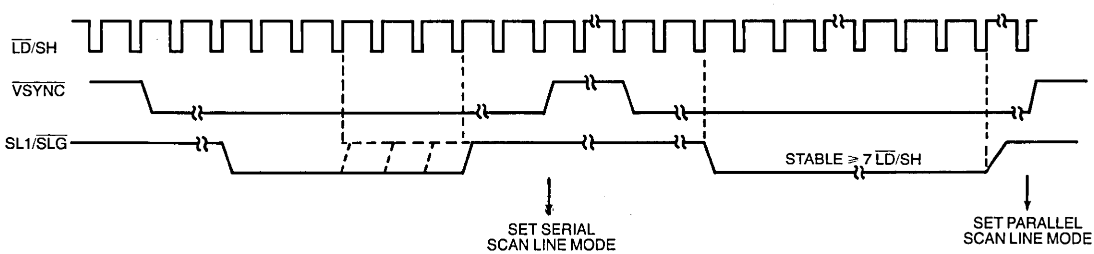


FIGURE 7: SERIAL/PARALLEL SCAN LINE MODE SELECTION TIMING

SECTION V

TABLE 2
WIDE GRAPHICS MASK PROGRAMMING OPTIONS

OPTION	CHOICES	STANDARD CRT 9021
Height of graphic block*		
D7 and D3	any scan line(s)	R0, R1, R2
D6 and D2	any scan line(s)	R3, R4, R5
D5 and D1	any scan line(s)	R6, R7, R8
D4 and D0	any scan line(s)	R9, R10, R11, R12, R13, R14, R15
Width of D7, D6, D5, D4**	any number of dots 0 to 8	C7, C6, C5, C4
Width of D3, D2, D1, D0**	any number of dots 0 to 8	C3, C2, C1, C0, 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.

TABLE 3
THIN GRAPHICS MASK PROGRAMMING OPTIONS

OPTION	CHOICES	STANDARD CRT 9021
Backfill	C1 or C0	C0
Horizontal portion for		
D2 and D3	any scan line(s) R0-R15	R5
D4	any scan line(s) R0-R15	R0
D5	any scan line(s) R0-R15	R11
Blanked dots for serrated horizontal lines		
D2	any dot(s) C7-C0, BF	none
D3	any dot(s) C7-C0, BF	none
D4	any dot(s) C7-C0, BF	none
D5	any dot(s) C7-C0, BF	none
Vertical position for		
D0 and D1	any dot(s) C7-C0, BF	C3
D6[1]	any dot(s) C6-C0, BF	BF
D7[1]	any dot(s) C7-C0	C7
Vertical length for		
D0	any scan line(s)	R0 to R5
D1	all scan lines not used by D0	R6 to R15
D6	no choice; always R0-R15	R0 to R15
D7	no choice; always R0-R15	R0 to R15

1 - D7 must always come before D6 with no overlap; otherwise D6 is lost.

TABLE 4
MISCELLANEOUS MASK PROGRAMMING OPTIONS

OPTION	CHOICES	STANDARD CRT 9021
Backfill in character mode	C7 to C0	C7
Character blink rate (division of $\overline{\text{VSYNC}}$ frequency)	8 to 60 even numbers (7.5 Hz to 1 Hz)[1]	32 (1.875 Hz)[1]
Cursor blink rate[2]	Twice the character blink rate	16 (3.75 Hz)[1]
character underline position	any scan line(s) R0-R15	R11
cursor underline[3]	any scan line(s) R0-R15	not applicable
cursor format[4]	underline Blinking underline Reverse video block Blinking reverse video block	Blinking reverse video block

1 - Assumes $\overline{\text{VSYNC}}$ input frequency of 60 Hz.
2 - Valid only if the cursor is formatted to blink.
3 - Valid only if the cursor is formatted for underline.
4 - Valid for the parallel scan line mode only.

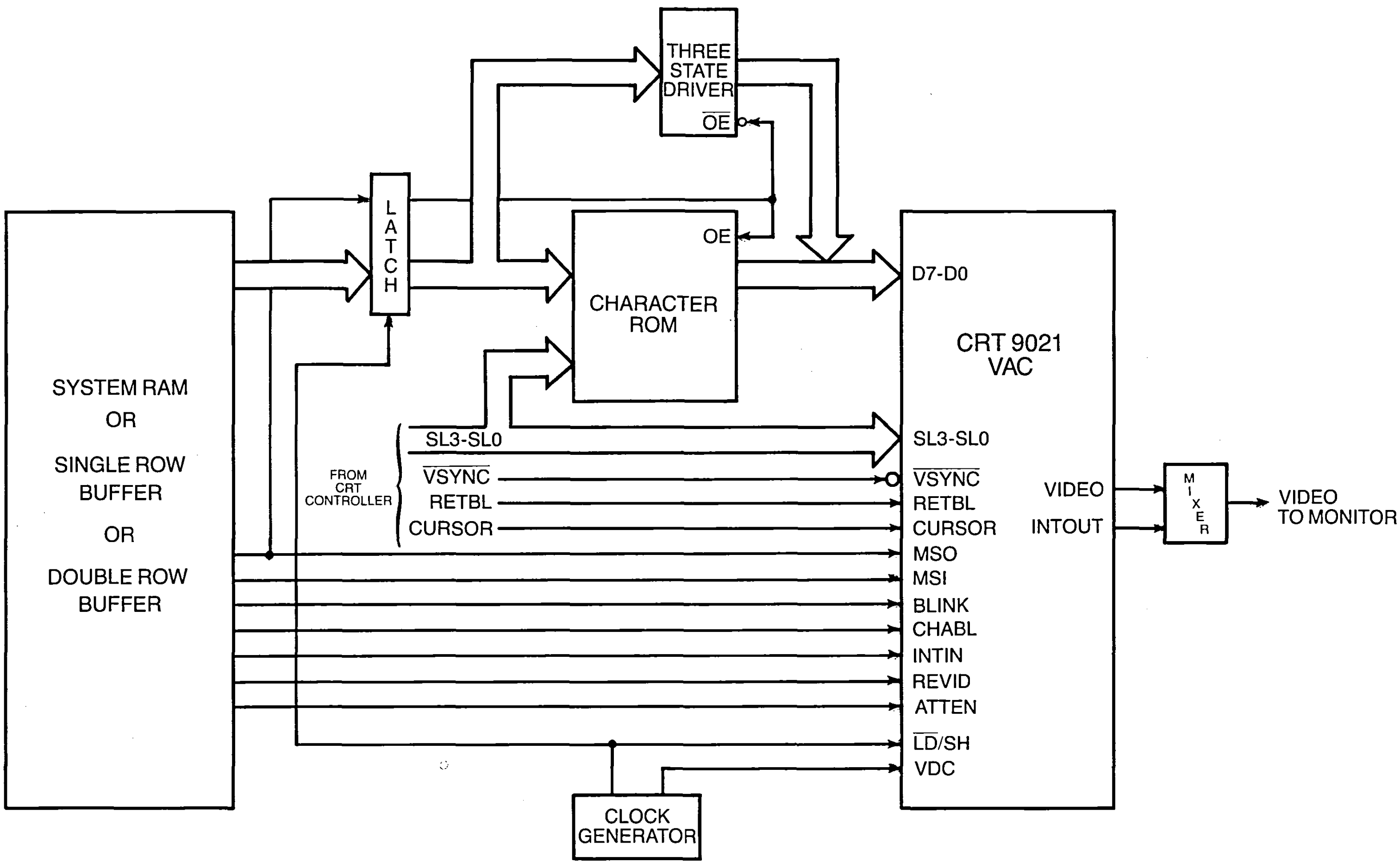


FIGURE 8a: CRT 9021 SYSTEM CONFIGURATION IN PARALLEL SCAN LINE MODE

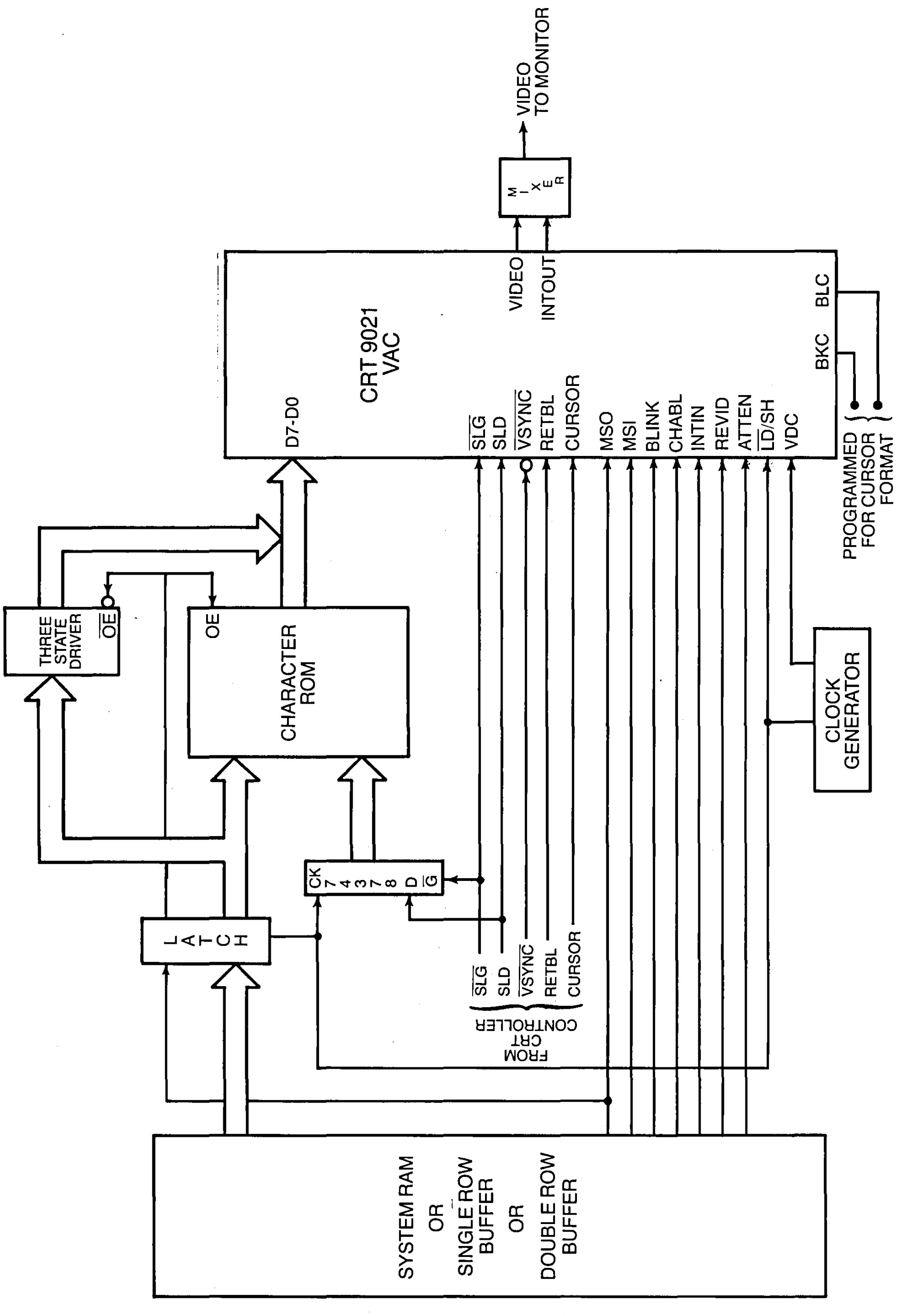


FIGURE 8b: CRT 9021 SYSTEM CONFIGURATION IN SERIAL SCAN LINE MODE