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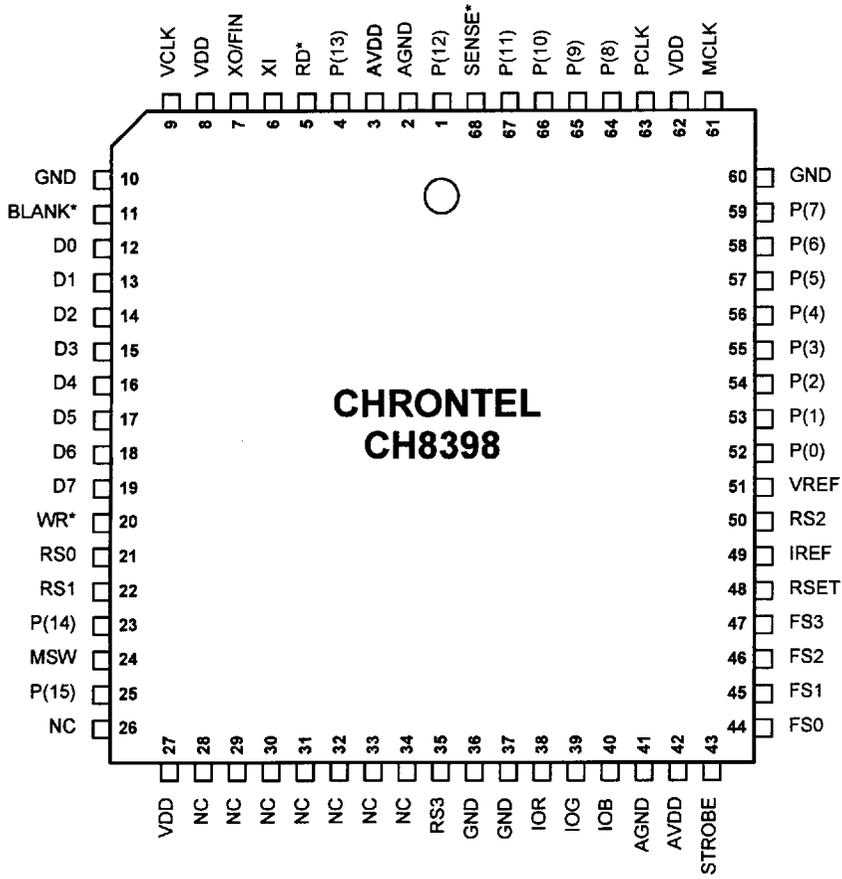


Figure 2: CH8398

Table 1 • Pin Description

Pin #	Symbol	Type	Name / Description
1, 4, 23, 25, 52 – 59, 64 – 67	P12, P13, P14, P15, P0 – P7, P8 – P11	I	Pixel. TTL compatible. Pixel data is latched on the rising edge of PCLK. Pseudo-color mode: pixel data is used as an address map to color palette RAM. Bypass color mode: pixel data represents actual color and directly drives DACs.
2, 41	AGND	P	Analog Ground. AGND pins must be connected to system ground.
3, 42	AVDD	P	Analog Power. AVDD pins must be connected to +5V.
5	RD*	I	Read (Active Low). TTL compatible. RS[3:0] data is latched and transferred from selected register to data bus on falling edge of RD*.
6	XI	I	Crystal Oscillator. 14.318 MHz crystal or connect to GND if XO / FIN is connected to an external reference clock.
7	XO / FIN	I / O	Crystal Oscillator / External Frequency. 14.318 MHz crystal or external reference clock input.
8, 27, 62	VDD	P	Digital Power. VDD pins must be connected to +5V.
9	VCLK	O	Video Clock. TTL compatible. 28.322 MHz upon power up.
10, 36, 37, 60	GND	P	Digital Ground. GND pins must be connected to system ground.
11	BLANK*	I	Blank (Active Low). TTL compatible. BLANK* is latched on the rising edge of PCLK. When asserted, the analog outputs are turned off and the pixel inputs are ignored.
12 – 19	D0 – D 7	I / O	Data Bus. TTL compatible. Bi-directional data bus.
20	WR*	I	Write (Active Low). TTL compatible. RS[3:0] data is latched on falling edge of WR*. D[7:0] data is latched on rising edge of WR*.
21, 22, 35, 50	RS0, RS1, RS3, RS2	I	Register Select. TTL compatible. RS[3:0] data is latched on falling edge of RD* or WR*. RS[3:0] inputs determine which internal register to access. RS3 pin is internally pulled up to VDD.
24	MSW	I	Mode Switch. TTL compatible with internal pull-down resistor. MSW is latched on the rising edge of PCLK. MSW input enables on-the-fly mode switching between primary and secondary modes.
26, 28 – 34	NC	—	No Connect. Unconnected pins.
38, 39, 40	IOR, IOG, IOB	O	Color Signals Output. Red, green, and blue DAC outputs, high impedance current sources capable of driving singly or doubly terminated 75 Ω load directly.
43	STROBE	I	Strobe. TTL compatible with internal pull-up resistor. FS[3:0] inputs are latched on the falling edge of STROBE. The STROBE control pin should be held at VDD or left open for direct pass-through of FS[3:0]. For further details, please refer to Figure 22 on page 4-69.
44 – 47	FS0 – FS3	I	External Video Clock Select. TTL compatible with internal pull-down resistor. FS[3:0] inputs are bit-wise "OR"ed with internal register CSR [3:0].
48	RSET	A	Reference Resistor. This pin should be connected through an external 147 Ω ± 1% resistor to GND. DAC output current levels are controlled by this resistor. See Note 2 below.
49	IREF	A	Current Reference. External current reference input.
51	VREF	A	Voltage Reference. If using an external voltage source, supply this input with a 1.23V reference.
63	PCLK	I	Pixel Clock. TTL compatible. Pixel data is latched on the rising edge of PCLK.
61	MCLK	O	Memory Clock. TTL compatible. 40 MHz upon power up.
68	SENSE*	O	Sense (Active Low). TTL compatible. Monitor detect signal. SENSE* is logical 0 if one or more of the IOR, IOG, and IOB outputs has exceeded the internal voltage reference level of 340 mV.

Note 1:

- I Input signal
- O Output signal
- I / O Bi-directional signal
- P Power pins
- A Analog signal

Note 2:

$$I_{FS} = \frac{V_{REF}}{R_{SET}} \times 2.1$$

where

- IFS is full-scale output current
- VREF is the voltage reference with value 1.23V
- RSET is the resistor connected between the RSET pin and ground, typical value is 147 W ± 1%

Display Modes

Chrontel CH8398 offers two basic color modes: pseudo and bypass.

Pseudo-color mode: Pixel address (8-bit), after being logically "AND"ed with the pixel Read Mask Register (RMR), is used to address all red, green, and blue palette RAM.

Bypass color mode: Pixel data is used to drive inputs of the DACs directly, bypassing the palette RAM and the RMR.

CH8398 provides 14 different display modes, each consisting of a primary and secondary mode. The pixel-by-pixel mode switching between primary and secondary modes is accomplished on-the-fly, and can be achieved through either hardware or software control.

Table 2 • Summary of Display Modes

Mode	CR[7:4]	MSW = 0, PRIMARY MODE		Primary Mode Description	Colors
0*	0000	8B1P1C	8 bpp, 1 pixel address, 1 PCLK cycle	8-bit pseudo	256
1*	0001	15B1P1C	15 bpp, 1 pixel data, 1 PCLK cycle	15-bit 5-5-5 bypass	32K
2*†	0010	8B2P1C	8 bpp, 2 pixel addresses, 1 PCLK cycle	8-bit pseudo	256
3*	0011	16B1P1C	16 bpp, 1 pixel data, 1 PCLK cycle	16-bit 5-6-5 bypass	64K
4*	0100	8B1P2C (4 + 4)	8 bpp, 1 pixel address, 2 PCLK cycles	8-bit pseudo (4 + 4 pixel data transfer)	256
5*	0101	24B1P2C	24 bpp, 1 pixel data, 2 PCLK cycles	24-bit 8-8-8 bypass	16.7M
6*	0110	16B1P2C	16 bpp, 1 pixel data, 2 PCLK cycles	16-bit 5-6-5 bypass	64K
7*	0111	24B1P3C	24 bpp, 1 pixel data, 3 PCLK cycles	24-bit 8-8-8 bypass	16.7M
8*	1000	8B1P2C (4 + 4)	8 bpp, 1 pixel address, 2 PCLK cycles	8-bit pseudo (4 + 4 pixel data transfer)	256
9*	1001	8B1P2C (8 + 0)	8 bpp, 1 pixel address, 2 PCLK cycles	8-bit pseudo (8 + 0 pixel data transfer)	256
A†	1010	8B2P1C	8 bpp, 2 pixel addresses, 1 PCLK cycle	MIX-COLOR®, 8-bit pseudo	256
B†	1011	24B2P3C	24 bpp, 2 pixel data, 3 PCLK cycles	24-bit 8-8-8 bypass	16.7M
C	1100	15B1P2C	15 bpp, 1 pixel data, 2 PCLK cycles	15-bit 5-5-5 bypass	32K
D†	1101	8B2P1C	8 bpp, 2 pixel addresses, 1 PCLK cycle	MIX-COLOR®, 8-bit pseudo	256
Mode	CR[7:4]	MSW = 1, SECONDARY MODE		Secondary Mode Description	Colors
0*	0000	16B1P1C	16 bpp, 1 pixel data, 1 PCLK cycle	16-bit 5-6-5 bypass	64K
1*	0001	8B1P1C	8 bpp, 1 pixel address, 1 PCLK cycle	8-bit pseudo	256
2*†	0010	8B2P1C	8 bpp, 2 pixel addresses, 1 PCLK cycle	8-bit pseudo	256
3*	0011	8B1P1C	8 bpp, 1 pixel address, 1 PCLK cycle	8-bit pseudo	256
4*	0100	24B1P2C	24 bpp, 1 pixel data, 2 PCLK cycles	24-bit 8-8-8 bypass	16.7M
5*	0101	16B1P2C	16 bpp, 1 pixel data, 2 PCLK cycles	16-bit 5-6-5 bypass	64K
6*	0110	24B1P2C	24 bpp, 1 pixel data, 2 PCLK cycles	24-bit 8-8-8 bypass	16.7M
7*	0111	24B1P3C	24 bpp, 1 pixel data, 3 PCLK cycles	24-bit 8-8-8 bypass	16.7M
8*	1000	16B1P2C	16 bpp, 1 pixel data, 2 PCLK cycles	16-bit 5-6-5 bypass	64K
9*	1001	24B1P2C	24 bpp, 1 pixel data, 2 PCLK cycles	24-bit 8-8-8 bypass	16.7M
A†	1010	15B1P1C	15 bpp, 1 pixel data, 1 PCLK cycle	MIX-COLOR®, 15-bit 5-5-5 bypass	32K
B†	1011	24B2P3C	24 bpp, 2 pixel data, 3 PCLK cycles	24-bit 8-8-8 bypass	16.7M
C	1100	8B1P2C (4 + 4)	8 bpp, 1 pixel address, 2 PCLK cycles	8-bit pseudo (4 + 4 pixel data transfer)	256
D†	1101	16B1P1C	16 bpp, 1 pixel data, 1 PCLK cycle	MIX-COLOR®, 16-bit 5-6-5 bypass	64K

Note: bpp = bits per pixel

† = on-chip clock doubler enabled

* = ATT20C498 compatible mode

Display Modes (continued)

Mode 1

Primary Mode:

15B1P1C: 15 bpp (5-5-5), 1 pixel data, 1 PCLK cycle, 32K colors

Pixel data is latched on the rising edge of PCLK. Pixel data is organized as 5 bits of color information each for the red, green, and blue color palette. For further information, please refer to **Figure 5** on page 4-45.

Following is the **15B1P1C (5-5-5)** pixel data transfer format:

P[15]	P[14]	P[13]	P[12]	P[11]	P[10]	P[9]	P[8]	P[7]	P[6]	P[5]	P[4]	P[3]	P[2]	P[1]	P[0]
X	R7	R6	R5	R4	R3	G7	G6	G5	G4	G3	B7	B6	B5	B4	B3

Note: Lowest three bits of the DAC inputs are padded with zeros

bpp = bits per pixel
R[7:3] = red pixel data

X = unused bit
G[7:3] = green pixel data

P[i] = pixel input pin
B[7:3] = blue pixel data

Secondary Mode:

8B1P1C: 8 bpp, 1 pixel address, 1 PCLK cycle, 256 colors

Pixel address for the red, green, and blue color palette is latched on the rising edge of PCLK. Palette RAM contains 256 colors of 256K possible colors (6 bits each for the IOR, IOG, and IOB outputs). Pseudo color pixel address (P[7:0]) is then bit-wise "AND"ed with the pixel RMR.

Following is the **8B1P1C** pixel address transfer format:

P[15]	P[14]	P[13]	P[12]	P[11]	P[10]	P[9]	P[8]	P[7]	P[6]	P[5]	P[4]	P[3]	P[2]	P[1]	P[0]
X	X	X	X	X	X	X	X	P7	P6	P5	P4	P3	P2	P1	P0

Note: bpp = bits per pixel
P[i] = pixel input pin

X = unused bit
P[7:0] = pseudo color pixel address

Display Modes (continued)

Mode 2

Primary /

Secondary Modes: **8B2P1C:** 8 bpp, 2 pixel addresses, 1 PCLK cycle, 256 colors

Pixel addresses for the red, green, and blue color palette are latched on the rising edge of PCLK. Palette RAM contains 256 colors of 256K possible colors (6 bits each for the IOR, IOG, and IOB outputs). Pseudo color pixel addresses (P[7:0]) are then bit-wise “AND”ed with the RMR.

Following is the **8B2P1C** pixel address transfer format:

P[15]	P[14]	P[13]	P[12]	P[11]	P[10]	P[9]	P[8]	P[7]	P[6]	P[5]	P[4]	P[3]	P[2]	P[1]	P[0]
P7	P6	P5	P4	P3	P2	P1	P0	P7	P6	P5	P4	P3	P2	P1	P0

Note: Internal clock doubler enabled to produce twice the pixel resolution per PCLK period

bpp = bits per pixel

P[i] = pixel input pin

P[7:0] = pseudo color pixel address

Mode 3

Primary Mode:

16B1P1C: 16 bpp (5-6-5), 1 pixel data, 1 PCLK cycle, 64K colors

Pixel data is latched on the rising edge of PCLK. Pixel data is organized as 5 bits of color information for red and blue, and 6 bits of color information for the green color palette. For further information, please refer to **Figure 6** on page 4-45.

Following is the **16B1P1C (5-6-5)** pixel data transfer format:

P[15]	P[14]	P[13]	P[12]	P[11]	P[10]	P[9]	P[8]	P[7]	P[6]	P[5]	P[4]	P[3]	P[2]	P[1]	P[0]
R7	R6	R5	R4	R3	G7	G6	G5	G4	G3	G2	B7	B6	B5	B4	B3

Note: Lowest two or three bits of the DAC inputs are padded with zeros

bpp = bits per pixel

P[i] = pixel input pin

B[7:3] = blue pixel data

R[7:3] = red pixel data

G[7:2] = green pixel data

Secondary Mode:

8B1P1C: 8 bpp, 1 pixel address, 1 PCLK cycle, 256 colors

Pixel address for the red, green, and blue color palette is latched on the rising edge of PCLK. Palette RAM contains 256 colors of 256K possible colors (6 bits each for the IOR, IOG, and IOB outputs). Pseudo color pixel address (P[7:0]) is then bit-wise “AND”ed with the pixel RMR.

Following is the **8B1P1C** pixel address transfer format:

P[15]	P[14]	P[13]	P[12]	P[11]	P[10]	P[9]	P[8]	P[7]	P[6]	P[5]	P[4]	P[3]	P[2]	P[1]	P[0]
X	X	X	X	X	X	X	X	P7	P6	P5	P4	P3	P2	P1	P0

Note: bpp = bits per pixel

 X = unused bit

 P[i] = pixel input pin

 P[7:0] = pseudo color pixel address

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Display Modes (continued)

Mode 4

Primary Mode:

8B1P2C: 8 bpp (4 + 4), 1 pixel address, 2 PCLK cycles, 256 colors

Pixel address for the red, green, and blue color palette is latched on every two consecutive rising edges of PCLK. Palette RAM contains 256 colors of 256K possible colors (6 bits each for the IOR, IOG, and IOB outputs). Pseudo color pixel address (P[7:0]) is then bit-wise "AND"ed with the RMR.

Following is the **8B1P2C (4 + 4)** pixel address transfer:

	P[15]	P[14]	P[13]	P[12]	P[11]	P[10]	P[9]	P[8]	P[7]	P[6]	P[5]	P[4]	P[3]	P[2]	P[1]	P[0]
1st	X	X	X	X	X	X	X	X	X	X	X	X	P3	P2	P1	P0
2nd	X	X	X	X	X	X	X	X	X	X	X	X	P7	P6	P5	P4

Note: bpp = bits per pixel

X = unused bit

P[i] = pixel input pin

Secondary Mode:

24B1P2C: 24 bpp (8-8-8), 1 pixel data, 2 PCLK cycles, 16.7M colors

Pixel data is latched on every two consecutive rising edges of PCLK. Pixel data is organized as 8 bits of color information each for the red, green, and blue color palette.

Following is the **24B1P2C (8-8-8)** pixel data transfer format:

	P[15]	P[14]	P[13]	P[12]	P[11]	P[10]	P[9]	P[8]	P[7]	P[6]	P[5]	P[4]	P[3]	P[2]	P[1]	P[0]
1st	G7	G6	G5	G4	G3	G2	G1	G0	B7	B6	B5	B4	B3	B2	B1	B0
2nd	X	X	X	X	X	X	X	X	R7	R6	R5	R4	R3	R2	R1	R0

Note: bpp = bits per pixel

X = unused bit

P[i] = pixel input pin

R[7:0] = red pixel data

G[7:0] = green pixel data

B[7:0] = blue pixel data

1st = first pixel data latched in

2nd = second pixel data latched in

Display Modes (continued)

Mode C

Primary Mode: **15B1P2C:** 15 bpp (5-5-5), 1 pixel data, 2 PCLK cycles, 32K colors

Pixel data is latched on every two consecutive rising edges of PCLK. Pixel data is organized as 5 bits of color information each for the red, green, and blue color palette. For further information, please refer to **Figure 5** on page 4-45.

Following is the **15B1P2C (5-5-5)** pixel data transfer format:

	P[15]	P[14]	P[13]	P[12]	P[11]	P[10]	P[9]	P[8]	P[7]	P[6]	P[5]	P[4]	P[3]	P[2]	P[1]	P[0]
1st	X	X	X	X	X	X	X	X	G5	G4	G3	B7	B6	B5	B4	B3
2nd	X	X	X	X	X	X	X	X	X	R7	R6	R5	R4	R3	G7	G6

Note: Lowest three bits of DAC inputs are padded with zeros

 bpp = bits per pixel

 X = unused bit

 P[i] = pixel input pin

 R[7:3] = red pixel data

 G[7:3] = green pixel data

 B[7:3] = blue pixel data

 1st = first pixel data latched in

 2nd = second pixel data latched in

Secondary Mode:

8B1P2C: 8 bpp (4 + 4), 1 pixel address, 2 PCLK cycles, 256 colors

Pixel address for the red, green, and blue color palette is latched on every two consecutive rising edges of PCLK. Palette RAM contains 256 colors of 256K possible colors (6 bits each for the IOR, IOG, and IOB outputs). Pseudo color pixel address (P[7:0]) is then bit-wise "AND"ed with the RMR.

Following is the **8B1P2C (4 + 4)** pixel address transfer format:

	P[15]	P[14]	P[13]	P[12]	P[11]	P[10]	P[9]	P[8]	P[7]	P[6]	P[5]	P[4]	P[3]	P[2]	P[1]	P[0]
1st	X	X	X	X	X	X	X	X	X	X	X	X	P3	P2	P1	P0
2nd	X	X	X	X	X	X	X	X	X	X	X	X	P7	P6	P5	P4

Note: bpp = bits per pixel

 X = unused bit

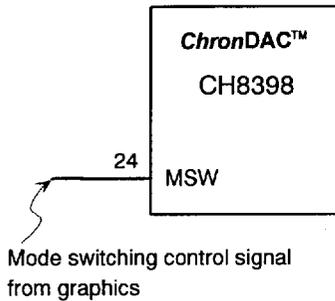
 P[i] = pixel input pin

Hardware and Software Mode Switching

Hardware mode switching: The external mode control pin (MSW) is used to switch between primary and secondary modes and requires bit 2 (MSDIS) = 0 (default value) in the Control Register (CR).

Primary mode: MSW = 0

Secondary mode: MSW = 1



Hardware mode switching

The external MSW signal (pin 24) handles the hardware mode switching for CH8398.

The mode switching control signal from the graphics controller drives the MSW input on CH8398.

Figure 3: Hardware Mode Switching

Software (embedded) mode switching: The mode control signal is used to switch between primary and secondary modes and is *embedded* in the pixel data.

Embedded switching can be applied to modes 1, 8, A, and C.

Mode A

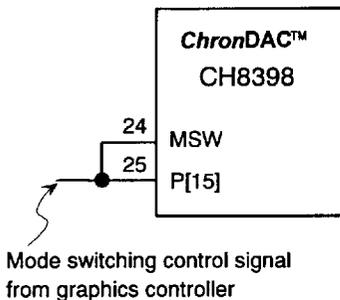
Primary mode: P[7] and P[15] = 0

Secondary mode: P[15] = 1

Modes 1, 8, and C

Primary mode: P[15] = 0

Secondary mode: P[15] = 1



Software mode switching

CH8398 handles software or embedded mode switching by connecting MSW and P[15] pins.

The mode switching control signal from the graphics controller drives MSW and P[15] inputs on CH8398.

Note: Design flexibility utilizing either hardware or software (embedded) mode switching may be achieved by connecting pins through a 0 Ω resistor

Figure 4: Software Mode Switching

Note: Hardware mode switching method applies to all display modes
Software mode switching method is limited to certain display modes

Bypass Mode Diagrams

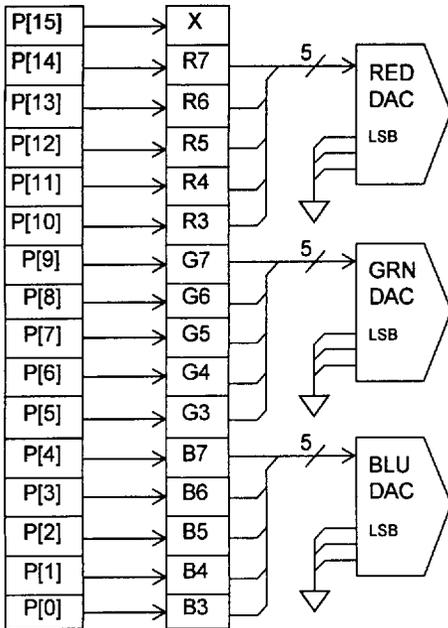


Figure 5: 15-bit bypass mode
(used in Modes 1, A, C)

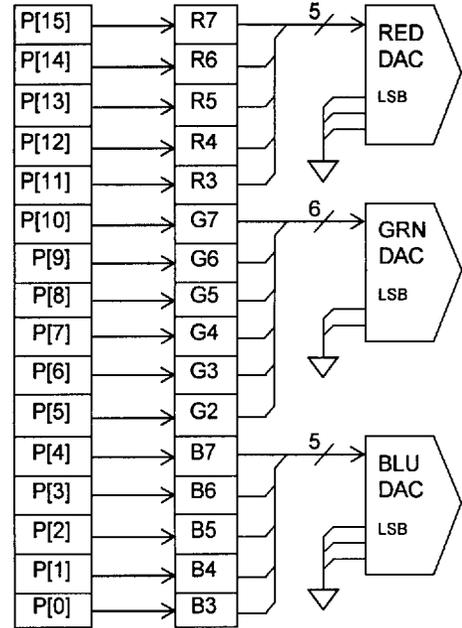


Figure 6: 16-bit bypass mode
(used in Modes 0, 3, 5, 6, 8, D)

Note: Lowest two or three bits of DAC inputs are padded with zeros
 P[i] = pixel input pin R[7:3] = red pixel data
 G[7:2] = green pixel data B[7:3] = blue pixel data

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Table 3 • Pixel Data Organization

Mode	MSW = 0			MSW = 1			Organization of Pixel Inputs					
	Prime	P[15:8]	P[7:0]	Second	P[15:8]		P[7:0]					
0*	8B1P1C	X X X X X X X X	P7 P6 P5 P4 P3 P2 P1 P0	16B1P1C	R7 R6 R5 R4 R3 G7 G6 G5	G4 G3 G2 B7 B6 B5 B4 B3						
1*	15B1P1C	X R7 R6 R5 R4 R3 G7 G6	G5 G4 G3 B7 B6 B5 B4 B3	8B1P1C	X X X X X X X X	P7 P6 P5 P4 P3 P2 P1 P0						
2*†	8B2P1C	P7 P6 P5 P4 P3 P2 P1 P0	P7 P6 P5 P4 P3 P2 P1 P0	8B2P1C	P7 P6 P5 P4 P3 P2 P1 P0	P7 P6 P5 P4 P3 P2 P1 P0						
3*	16B1P1C	R7 R6 R5 R4 R3 G7 G6 G5	G4 G3 G2 B7 B6 B5 B4 B3	8B1P1C	X X X X X X X X	P7 P6 P5 P4 P3 P2 P1 P0						
4*	8B1P2C (4 + 4)	X X X X X X X X	X X X P3 P2 P1 P0	24B1P2C	G7 G6 G5 G4 G3 G2 G1 G0	B7 B6 B5 B4 B3 B2 B1 B0						
5*	24B1P2C	G7 G6 G5 G4 G3 G2 G1 G0	B7 B6 B5 B4 B3 B2 B1 B0	16B1P2C	X X X X X X X X	R7 R6 R5 R4 R3 R2 R1 R0						
6*	16B1P2C	X X X X X X X X	R7 R6 R5 R4 R3 R2 R1 R0	24B1P2C	G7 G6 G5 G4 G3 G2 G1 G0	B7 B6 B5 B4 B3 B2 B1 B0						
7*	24B1P3C	X X X X X X X X	B7 B6 B5 B4 B3 B2 B1 B0	24B1P3C	X X X X X X X X	R7 R6 R5 R4 R3 R2 R1 R0						
8*	8B1P2C (4 + 4)	X X X X X X X X	X X X P3 P2 P1 P0	16B1P2C	X X X X X X X X	G7 G6 G5 G4 G3 G2 G1 G0						
9*	8B1P2C (8 + 0)	X X X X X X X X	P7 P6 P5 P4 P3 P2 P1 P0	24B1P2C	G7 G6 G5 G4 G3 G2 G1 G0	R7 R6 R5 R4 R3 R2 R1 R0						
A†	8B2P1C	P7 P6 P5 P4 P3 P2 P1 P0	P7 P6 P5 P4 P3 P2 P1 P0	15B1P1C	X R7 R6 R5 R4 R3 G7 G6	G5 G4 G3 B7 B6 B5 B4 B3						
B†	24B2P3C	G7 G6 G5 G4 G3 G2 G1 G0	B7 B6 B5 B4 B3 B2 B1 B0	24B2P3C	G7 G6 G5 G4 G3 G2 G1 G0	B7 B6 B5 B4 B3 B2 B1 B0						
C	15B1P2C	X X X X X X X X	G5 G4 G3 B7 B6 B5 B4 B3	8B1P2C (4 + 4)	X X X X X X X X	R7 R6 R5 R4 R3 R2 R1 R0						
D†	8B2P1C	P7 P6 P5 P4 P3 P2 P1 P0	P7 P6 P5 P4 P3 P2 P1 P0	16B1P1C	R7 R6 R5 R4 R3 G7 G6 G5	G4 G3 G2 B7 B6 B5 B4 B3						

Note: * = ATT20C498 compatible mode
 † = on-chip clock doubler enabled
 Bi, Gi, Ri = pixel input for bypass mode, where i indicates pixel bit number
 Pi = pixel input for pseudo-color mode, where i indicates pixel bit number
 X = unused bits

MIX-COLOR®

CH8398 offers an enhanced feature called MIX-COLOR® mode, which allows the simultaneous display of image regions with different spatial resolution and color depth in a single bitmapped frame. MIX-COLOR® is capable of displaying 64K colors within a high resolution (1280 x 1024 @ 75 Hz) graphics window. This feature is particularly useful in Windows® applications where a colorful picture is placed within a page of text.

Window Frame

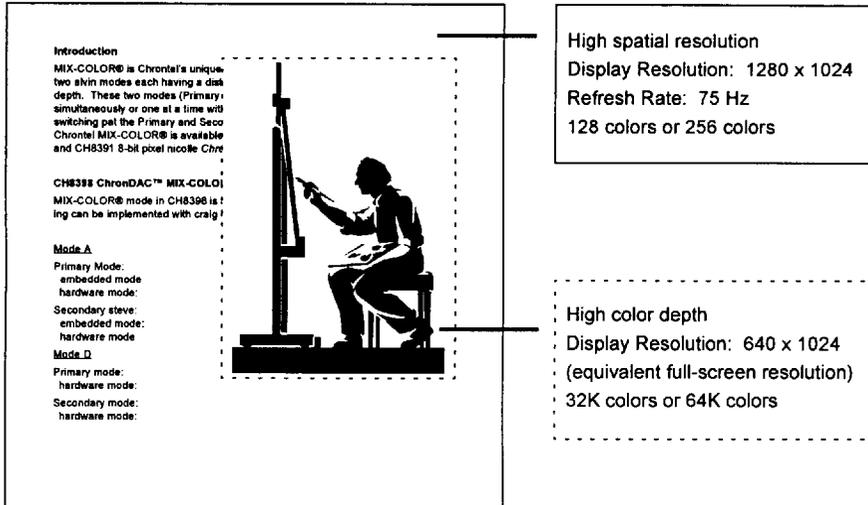


Figure 7: MIX-COLOR® Mode

MIX-COLOR® mode is available in modes A and D:

Mode A

Primary mode:	Pseudo-color mode	
	embedded mode:	128 colors
	hardware mode:	256 colors
Secondary mode:	Bypass color mode	
	embedded mode:	32K colors
	hardware mode:	32K colors

Mode D

Primary mode:	Pseudo-color mode	
	hardware mode:	256 colors
Secondary mode:	Bypass color mode	
	hardware mode:	64K colors

Comparison of MIX-COLOR® and PixMix™ Modes

CH8398 supports both MIX-COLOR® and PixMix™ modes for displaying high resolution graphics in addition to high color depth within the same frame of data.

MIX-COLOR®

- MIX-COLOR® has flexibility for both on-the-fly hardware and software (embedded) switching modes.
- MIX-COLOR® maintains the maximum possible resolution for the given clock rate by utilizing all pixel data available.
- 2 pixel addresses per pixel clock.
- MIX-COLOR® efficiently correlates pixel data stored in memory with pixel data displayed.
- MIX-COLOR® simultaneously displays bypass and pseudo-color modes with the following specs:
 - Bypass mode: 16-bit or 64K colors
 - Pseudo-color mode: 256 colors
 - Standard resolution (max):
1280 x 1024 @ 75 Hz

PixMix™

- PixMix™ implementation is only available in the embedded switching mode.
- PixMix™ pixel resolution does not fully utilize the pixel bus bandwidth or the frame buffer memory pixel data.
- 1 pixel address per pixel clock.
- PixMix™ inefficiently maps between pixel data stored in memory with pixel data displayed.
- PixMix™ simultaneously displays bypass and pseudo-color modes with the following specs:
 - Bypass mode: 15-bit or 32K colors
 - Pseudo-color mode: 256 colors
 - Standard resolution (max):
800 x 600 @ 72 Hz

Note: 1280 x 1024 can be achieved using Chronitel's MIX-COLOR®

Window Frame

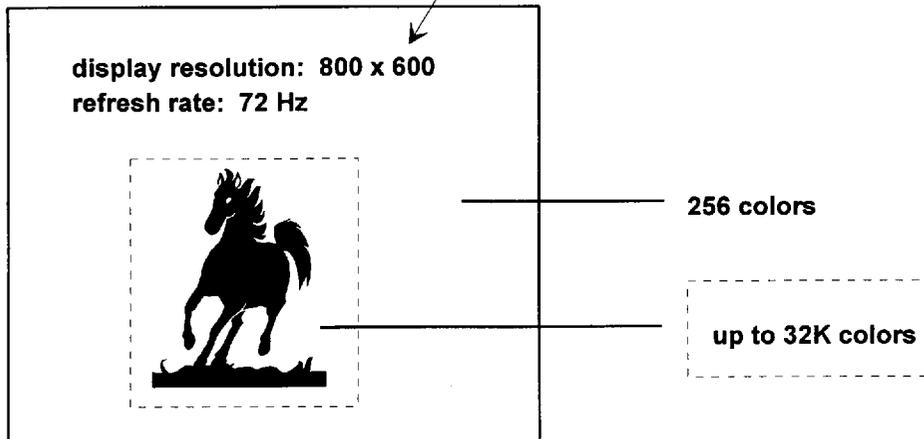


Figure 8: PixMix™ Mode

Examples of Embedded Mode Switching for MIX-COLOR® and PixMix™

Example # 1: Embedded mode switching for MIX-COLOR®

Mode A

Primary mode: Pseudo-color mode
P[7] and P[15] set to 0

Secondary mode: Bypass color mode
P[15] set to 1

	P[15]	P[14]	P[13]	P[12]	P[11]	P[10]	P[9]	P[8]	P[7]	P[6]	P[5]	P[4]	P[3]	P[2]	P[1]	P[0]
Pseudo	0	P6	P5	P4	P3	P2	P1	P0	0	P6	P5	P4	P3	P2	P1	P0
5-5-5	1	R7	R6	R5	R4	R3	G7	G6	G5	G4	G3	B7	B6	B5	B4	B3

Note: Embedded case requires palette RAM table to be reconfigured for 128 colors instead of 256 colors

P[i] = pixel input pin

R[7:3] = red pixel data

G[7:3] = green pixel data

B[7:3] = blue pixel data

CH8398 is capable of implementing PixMix™ mode, using P[15] as a mode switch control signal.

Example # 2: Embedded mode switching for PixMix™

Mode 1

Primary mode: Bypass color mode
P[15] set to 0

Secondary mode: Pseudo-color mode
P[15] set to 1

	P[15]	P[14]	P[13]	P[12]	P[11]	P[10]	P[9]	P[8]	P[7]	P[6]	P[5]	P[4]	P[3]	P[2]	P[1]	P[0]
5-5-5	0	R7	R6	R5	R4	R3	G7	G6	G5	G4	G3	B7	B6	B5	B4	B3
Pseudo	1	X	X	X	X	X	X	X	P7	P6	P5	P4	P3	P2	P1	P0

Note: P[i] = pixel input pin

R[7:3] = red pixel data

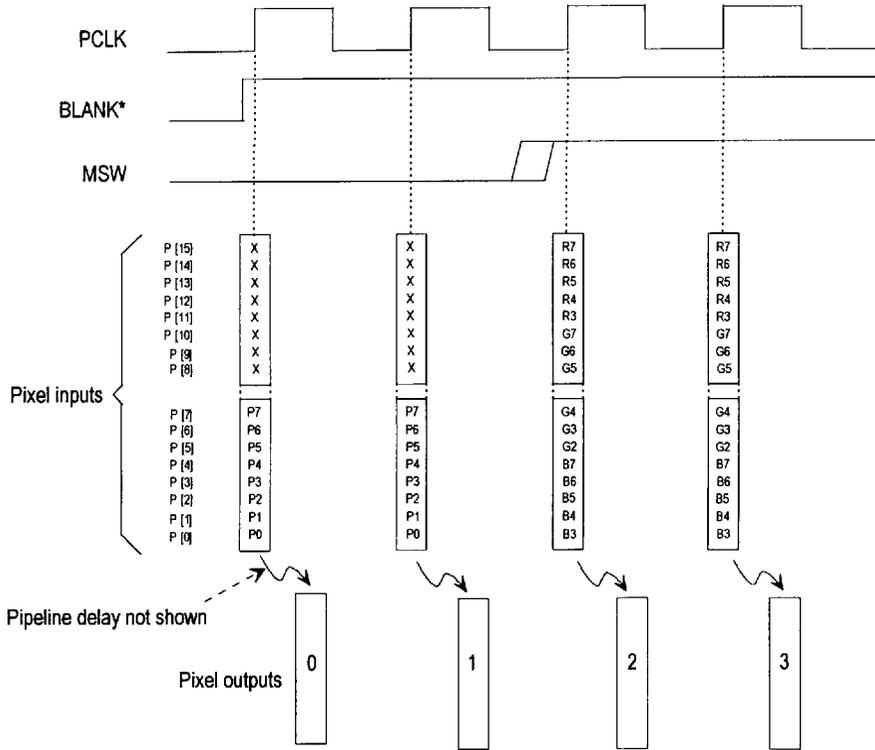
P[7:0] = pseudo pixel address

G[7:3] = green pixel data

X = unused bit

B[7:3] = blue pixel data

PCLK Timing Diagrams



Primary mode: 8-bit pseudo (8B1P1C)

Secondary mode: 16-bit bypass (16B1P1C)

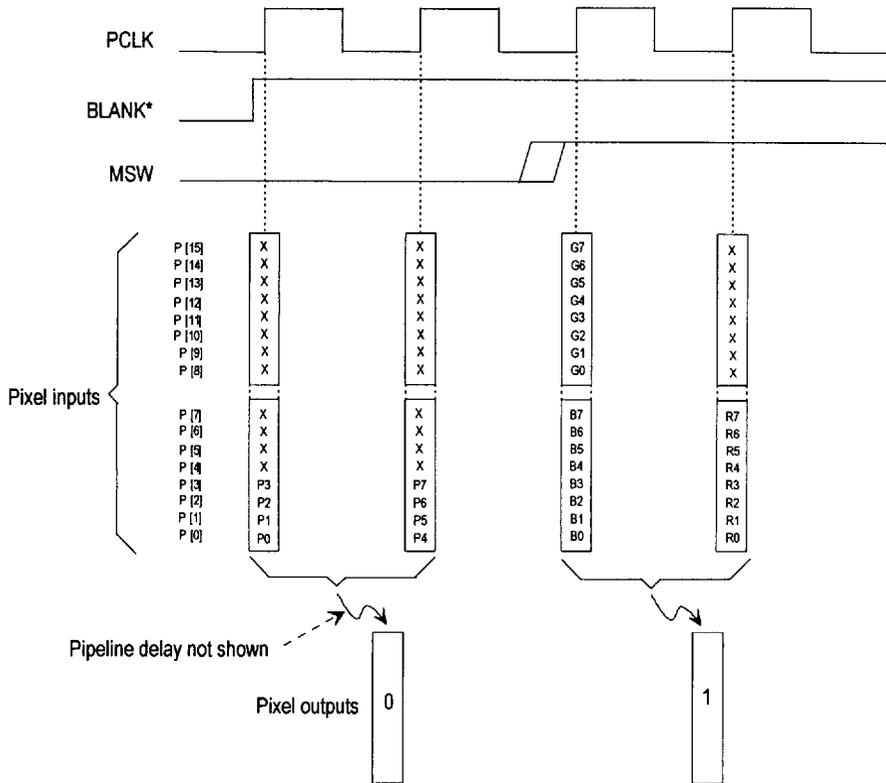
Figure 9: PCLK Timing Mode 0 Using Hardware Mode Switching¹

Mode	CR[7]	CR[6]	CR[5]	CR[4]	Primary Mode	Secondary Mode
0	0	0	0	0	8-bit pseudo	16-bit 5-6-5 bypass

Note: CR[7:4] corresponds to display mode control bits located in the control register

¹ Figures 9 through 12 represent the most commonly used options
For information on other available options, please call Chronitel

PCLK Timing Diagrams (continued)



Primary mode: 8-bit pseudo (8P1P2C)
 Secondary mode: 24-bit bypass (24B1P2C)

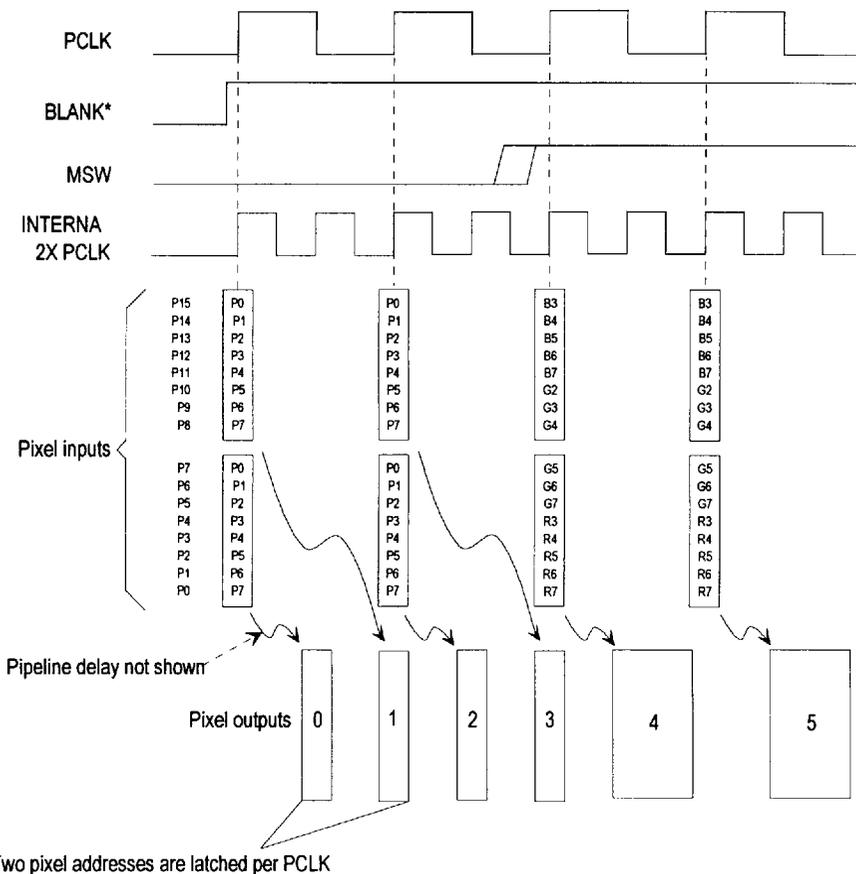
Figure 10: PCLK Timing for Mode 4 Using Hardware Mode Switching¹

Mode	CR[7]	CR[6]	CR[5]	CR[4]	Primary Mode	Secondary Mode
4	1	0	0	0	8-bit pseudo (4+4)	24-bit 8-8-8 bypass

Note: CR[7:4] corresponds to display mode control bits located in the control register

¹ Figures 9 through 12 represent the most commonly used options
 For information on other available options, please call Chronitel

PCLK Timing Diagrams (continued)



Primary Mode: 8-bit pseudo (8B2P1C)
 Secondary Mode: 16-bit bypass (16B1P1C)

Figure 12: PCLK Timing for Mode D, MIX-COLOR®, Using Hardware Mode Switching¹

Mode	CR[7]	CR[6]	CR[5]	CR[4]	Primary Mode	Secondary Mode
D	1	1	0	1	MIX-COLOR® 8-bit pseudo	MIX-COLOR® 16-bit 5-6-5 bypass

Note: CR[7:4] corresponds to display mode control bits located in the control register

¹ Figures 9 through 12 represent the most commonly used options
 For information on other available options, please call Chrontel

Table 4 • Register Maps and Definitions

	RS3	RS2	RS1	RS0	Description	Default upon Power Up
PWA	1	0	0	0	Palette RAM Write Address Register	N/A
PDR	1	0	0	1	Palette RAM Data Register	N/A
RMR	1	0	1	0	Pixel Read Mask Register (IDR, alternate access to control register)	IDR = C0H CR = 00H
PRA	1	0	1	1	Palette RAM Read Address Register	N/A
CWA	0	1	0	0	Clock RAM Write Address Register (alternate access to clock select register)	N/A
CDR	0	1	0	1	Clock RAM Data Register	N/A
CR¹	0	1	1	0	Control Register	00H
CRA	0	1	1	1	Clock RAM Read Address Register	N/A
CSR¹	1	0	0	0	Clock Select Register	00H
IDR	—	—	—	—	Identification Register	C0H
TEST¹	0	0	0	1	Test Register (internal use only)	—
AUX²	—	—	—	—	Auxiliary Register	00H

- Note:** 1 These registers can also be accessed by using the alternate accessing method
 2 This register can **only** be accessed by using the alternate accessing method

PWA: Palette RAM Write Address Register

PWA specifies the address to the palette RAM for write access.

PDR: Palette RAM Data Register

PDR contains the data read from the palette RAM or the data to be written to the RAM. The read address is specified by PRA, the write address is specified by PWA.

RMR: Read Mask Register

RMR is used in pseudo and MIX-COLOR® modes. Each bit of RMR is bit-wise logically “AND”ed with the 8-bit palette RAM address. The resulting address is used to point to the palette RAM. Under the alternate register access method, this register is used to access the ID Register, Control Register, Auxiliary Register, and Test Register. For further information, please refer to “**Alternate Access Method**” on page 4-61.

Note: This register is **NOT** initialized upon power up

When pseudo mode is activated, the pixel address uses the RMR. The RMR content is bit-wise “AND”ed with the pixel address, and the result is used to address the color palette RAM. On the 15-bit or 16-bit bypass mode, the lowest 2 or 3 bits of the DACs are padded with zeros. For further information, please refer to **Figures 5 and 6** on page 4-45. In MIX-COLOR® mode, the masking operation is enabled for pseudo-color mode. To disable the masking operation, write FFH into the RMR.

PRA: Palette RAM Read Address Register

PRA specifies the address to the palette RAM for read access.

CWA: PLL Clock RAM Write Address Register

CWA specifies the address to the PLL RAM for write access. Using the alternate register access, CWA accesses the Clock Select Register. For further information, please refer to “**Alternate Access Method**” on page 4-61.

CDR: PLL Clock RAM Data Register

CDR contains data read from the PLL RAM or data to be written to the RAM. CRA specifies the read address and CWA specifies the write address.

CR: Control Register

CR determines the display modes, power down modes, and MPU interface to the color palette RAM.

CR[7]	CR[6]	CR[5]	CR[4]	CR[3]	CR[2]	CR[1]	CR[0]
DM3	DM2	DM1	DM0	PD1	MSDIS	V / P	PD0

CR[0]:PD0 = Power Down control bit 0

These power down modes are well-suited for both LCD and CRT applications, and support "Green PC" applications. CH8398 supports both LCD graphics-only controllers and LCD graphics controllers with simultaneous CRT and LCD display. Power consumption of the graphics subsystem can be greatly reduced using these power down modes.

CR[1]:V / P = Select VCLK / PCLK ratio

If:

the MNK values of VCLK are chosen so $VCLK / PCLK = 1$,

then:

set CR[1] = 0

This is used only for optimization of the internal doubler.

Please note that whether CR[1] is set to "0" or "1," a change may not be readily apparent to the user.

For example: PCLK = 28.322 MHz, and the VGA controller requires
VCLK = 2 x PCLK

Step 1. Program the proper M, N, and K values in the PLL RAM to generate 56.444 MHz (i.e., M = 21, N = 174, K = 1)

Step 2. Set CR[1] = 1

This example requires the following data format:

MSB								LSB							
D7	D6	D5	D4	D3	D2	D1	D0	D7	D6	D5	D4	D3	D2	D1	D0
0	1	0	1	0	1	0	1	1	0	1	0	1	1	1	0

CR[2]: MSDIS = MSW input pin disable

0 = MSW pin control display mode switching (default)

1 = MSW pin in interpreted as 0 regardless of its state

CR[3]: PD1 = Power Down control bit 1

CR: Control Register (continued)

Table 5 • Power Down Control Bits.

CR[3]	CR[0]	
PD1	PD0	Description
0	0	MPLL, VPLL, and LUTDAC are ON. Normal operation mode.
0	1	MPLL and VPLL are ON, LUTDAC is OFF. Used for flat panel controller where LUTDAC is not required. Both PLL and palette RAMs can still be accessed from the MPU bus.
1	0	MPLL is ON, VPLL and LUTDAC are OFF. MPLL is on, memory image is retained. Used in CRT and flat panel applications. Both PLL and palette RAMs can still be accessed from the MPU bus.
1	1	MPLL, VPLL, and LUTDAC are OFF. Graphics subsystem is completely powered down. Only palette RAM can still be accessed from the MPU bus.

CR[7:4]: Display mode control bits

These bits correspond to DM[3:0] in the control register are used to select the display modes.

Table 6 • Display Mode Control Bits

	CR[7]	CR[6]	CR[5]	CR[4]	Description	
Mode	DM3	DM2	DM1	DM0	MSW = 0, PRIMARY MODE	MSW = 1, SECONDARY MODE
0*	0	0	0	0	8-bit pseudo	16-bit 5-6-5 bypass
1*	0	0	0	1	15-bit 5-5-5 bypass	8-bit pseudo
2*†	0	0	1	0	8-bit pseudo	8-bit pseudo
3*	0	0	1	1	16-bit 5-6-5 bypass	8-bit pseudo
4*	0	1	0	0	8-bit pseudo (4 + 4)	24-bit 8-8-8 bypass
5*	0	1	0	1	24-bit 8-8-8 bypass	16-bit 5-6-5 bypass
6*	0	1	1	0	16-bit 5-6-5 bypass	24-bit 8-8-8 bypass
7*	0	1	1	1	24-bit 8-8-8 bypass	24-bit 8-8-8 bypass
8*	1	0	0	0	8-bit pseudo (4 + 4)	16-bit 5-6-5 bypass
9*	1	0	0	1	8-bit pseudo (8 + 0)	24-bit 8-8-8 bypass
A†	1	0	1	0	MIX-COLOR®, 8-bit pseudo	MIX-COLOR®, 15-bit 5-5-5 bypass
B†	1	0	1	1	24-bit 8-8-8 bypass	24-bit 8-8-8 bypass
C	1	1	0	0	15-bit 5-5-5 bypass	8-bit pseudo (4 + 4)
D†	1	1	0	1	MIX-COLOR®, 8-bit pseudo	MIX-COLOR®, 16-bit 5-6-5 bypass

CRA: PLL Clock RAM Read Address Register

CRA specifies the address to the PLL RAM for read access.

CSR: Clock Select Register

CSR internally selects MPLL and VPLL frequencies. See **Table 11** on page 4-64 for further details on PLL RAM data organization.

CSR[3:0]: VS[3:0] = VPLL Select

These bits are logically bit-wise “OR”ed with the external FS[3:0].
Selects 1 of 16 entries.

CSR[6:4]: MS[2:0] = MPLL Select

Select 1 of 8 entries.

CSR[7]: PH* = PLL Frequency Hold

CSR[7] = 0 PLL frequency holds at the current value. No change to MCLK or VCLK outputs, regardless of the value written to CSR[6:0] of this register, or the state of external FS[3:0].

CSR[7] = 1 PLL frequency releases the current value. MCLK frequency depends on the value of MS[2:0] (CSR[6:4]). VCLK frequency depends on the logically bit-wise “OR”ed value of external FS[3:0] with the internal VS[3:0] (CSR[3:0]).

CSR[7]	CSR[6]	CSR[5]	CSR[4]	CSR[3]	CSR[2]	CSR[1]	CSR[0]
PH*	MS2	MS1	MS0	VS3	VS2	VS1	VS0

IDR: Identification Register

IDR is a read only register with a predefined value of C0H.

IDR[7]	IDR[6]	IDR[5]	IDR[4]	IDR[3]	IDR[2]	IDR[1]	IDR[0]
1	1	0	0	0	0	0	0

TEST: Test Register

TEST is for internal use only.

AUX: Auxiliary Register

AUX sets both the video and memory clock output voltage levels to a target 50% duty cycle. See **Tables 7** and **8** below for available voltage levels.

AUX[1:0]: ML[1:0] = Select bits for memory clock voltage level output

AUX[3:2]: VL[1:0] = Select bits for video clock voltage level output

AUX[7:4]: Reserved bits

AUX[7]	AUX[6]	AUX[5]	AUX[4]	AUX[3]	AUX[2]	AUX[1]	AUX[0]
X	X	X	X	VL1	VL0	ML1	ML0

Table 7 • Video Clock

AUX[3]	AUX[2]	Targeted 50% Duty Cycle
VL1	VL0	Level (Volts)
0	0	1.8
0	1	1.5
1	0	2.1
1	1	2.4

Table 8 • Memory Clock

AUX[1]	AUX[0]	Targeted 50% Duty Cycle
ML1	ML0	Level (Volts)
0	0	1.8
0	1	1.5
1	0	2.1
1	1	2.4

MPU Access

All MPU access is through D[7:0] bus, with RD* and WR* control signals, and RS[3:0] to select which register is to be accessed. Some registers have an alternate access method for graphics controllers that do not provide an RS3 output signal.

Access to the Palette RAM

6-bit Access to the Palette RAM

CH8398 supports access to the Palette RAM only in a 6-bit format, as indicated in **Figures 13 and 14** below.

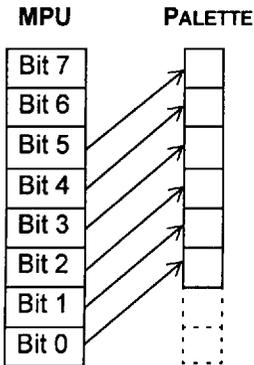


Figure 13: 6-bit Write Mode

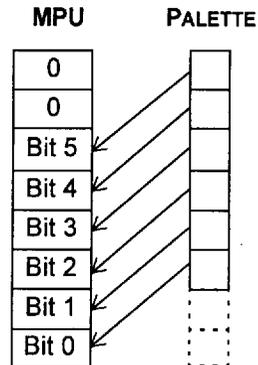


Figure 14: 6-bit Read Mode

To write the palette RAM:

- Step 1. Load the initial RAM write address to PWA.
- Step 2. Write PDR with the red, green, and blue values. The first write is accessed to write the data to be stored in the red temporary register, the second is the green, and the third is the blue. Internally there is a modulo 3 counter. After the third (blue) write to the PDR, the red, green, and blue data is written to the palette RAM and the address is incremented. The entire palette RAM can be written by sequential writes to PDR. The address rolls over to 00H after reaching FFH. The modulo 3 counter resets after each write to PRA or PWA.

To read the palette RAM:

- Step 1. Load the initial RAM read address to PRA. This action triggers a fetch from the palette RAM, transferring the red, green, and blue data to the temporary register. The address is automatically incremented after the fetch.
- Step 2. Read the PDR for the red, green, and blue values. The first read is accessed to read the data stored in the red temporary register, the second to green, and the third to blue. Internally there is a modulo 3 counter. After the third (blue) access, the device triggers another fetch followed by an address increment. The entire palette RAM can be read by sequential reads of the PDR. The address rolls over to 00H after reaching FFH. The modulo 3 counter resets after each write to PRA or PWA.

Table 9 • Palette RAM Data Organization

Address	Byte 0	Byte 1	Byte 2
00H	Red	Green	Blue
01H	Red	Green	Blue
...
...
...
FEH	Red	Green	Blue
FFH	Red	Green	Blue

Access to the PLL Clock RAM

Access to PLL Clock RAM is similar to the palette RAM, except the modulus counter is modulo 2. Each PLL is two bytes wide: the first access is the LSB, the second is the MSB value. VPLL has 16 locations, occupying the first 32 bytes, while MPLL occupies the next 16 bytes with 8 locations.

To write the PLL Clock RAM:

- Step 1. Load the initial RAM write address to the CWA.
- Step 2. Write CDR with the PLL values. The first write is the LSB, the second is the MSB. After the MSB write, the PLL data is written to the PLL RAM and the address is incremented. The entire PLL RAM can be written by sequential writes to CDR. The internal modulo 2 counter resets after each write to the CRA or CWA.

To read the PLL Clock RAM:

- Step 1. Load the initial RAM read address to the CRA. This triggers a fetch from the PLL Clock RAM, and the data transfers to the temporary register. The address automatically increments after the fetch.
- Step 2. Read the CDR for the PLL values. The first read is the access to the LSB, the second is the MSB. After the MSB access, the device triggers another fetch followed by an address increment. The entire PLL RAM can be read by sequential reads of the CDR. The internal modulo 2 counter resets after each write to CRA or CWA.

Table 10 • PLL Clock RAM Data Organization

Address Location	Frequency Outputs (MHz)	CSR[6:4] MS[2:0]	CSR[3:0] ¹ VS[3:0]
00H	25.175	N/A	0H
01H	28.322	N/A	1H
...	VPLL
0FH	VPLL	N/A	FH
10H	MPLL	0H	N/A
...	MPLL
17H	MPLL	7H	N/A

Note: ¹ CSR[3:0] is logically bit-wise "OR"ed with external FS[3:0] inputs respectively

Locations 0 – 1 of the VPLL RAM have been hard-wired to provide the following frequencies:

- Location 0 VCLK = 25.175 MHz
- Location 1 VCLK = 28.322 MHz

Alternate Access Method

CH8398 offers an alternate method to access several registers. This method is designed for graphics controllers that do not use an RS3 signal.

The alternate access method applies to the following registers:

- CSR
- CR
- IDR
- AUX

Note: The AUX register can only be accessed through the alternate access method. CR can be accessed without using the alternate access method even though the RS3 signal from the graphics controller is not used.

Access to the Clock Select Register

There are two methods of accessing the CSR. The first method requires RS[3:0] to be driven to [0000]. The alternate method does not require the RS3 signal. With RS3 internally pulled high, alternate access to CSR is achieved by:

- Step 1. Set RS[2:0] to [100].
- Step 2. Read CWA four consecutive times without accessing any other register between reads.
- Step 3. The fifth access (read or write) is directed to the CSR. Only one access is allowed for each sequence. During the alternate access sequence, RS[2:0] must be set to [100]. To terminate the access sequence, access a register other than the CWA.

To exit sequence: Access a register other than the CWA (i.e., set RS[2:0] to a value other than [100]).

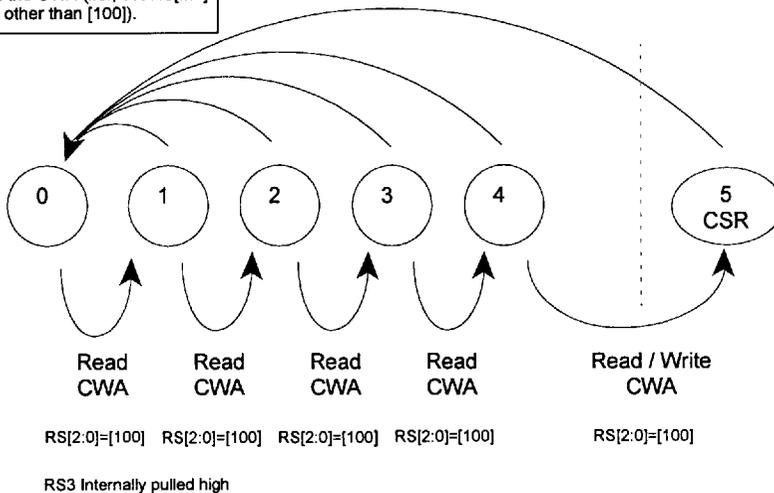


Figure 15: State for Alternate Access to Clock Select Register

Alternate Access Method (continued)

Access to the Control Register

There are two ways of accessing the CR. The first method requires RS[2:0] to be driven to [110]. The alternate method does not require the RS3 signal. With RS3 internally pulled high, alternate access to CR is achieved by:

- Step 1. Set RS[2:0] to [010].
- Step 2. Read RMR four consecutive times, without accessing any other register between reads. Please note the fourth read access returns the value of the IDR.
- Step 3. The fifth access (read or write) is directed to the CR. Only one access is allowed for each sequence. During the alternate access sequence, RS[2:0] must be set to [010]. The sequence will terminate and return to its initial state at any point when the content of RS[2:0] \neq [010].

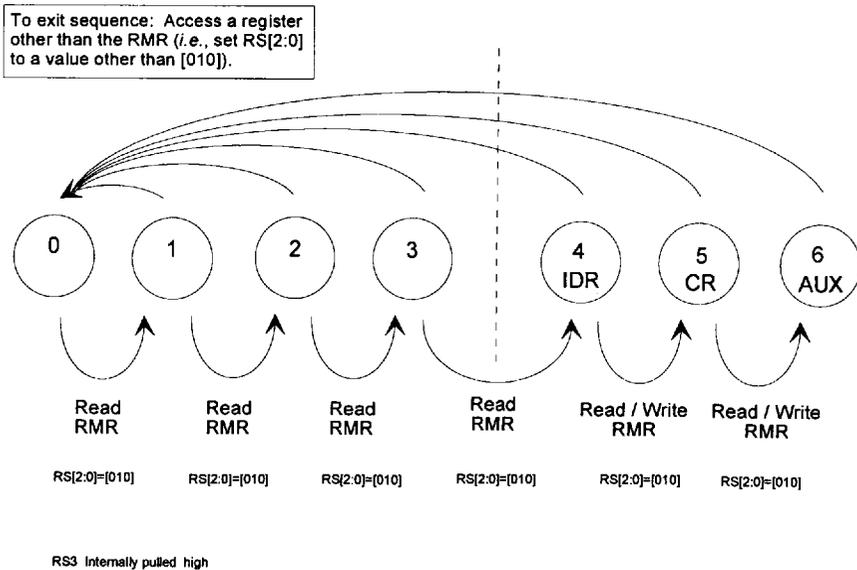


Figure 16: State for Alternate Access to ID, Control, Auxiliary, and Test Registers

Access to the Identification Register

Access to the IDR is achieved by:

- Step 1. Set RS[2:0] to [010].
- Step 2. Read the RMR three consecutive times, without accessing any other register between reads.
- Step 3. The fourth read returns the content of the IDR. Only one access is allowed for each sequence. During the alternate access sequence, RS[2:0] must be set to [010]. The sequence will terminate and return to its initial state at any point when the content of RS[2:0] \neq [010].

Alternate Access Method (continued)

Access to the Auxiliary Register

Access to AUX is achieved by:

- Step 1. Set RS[2:0] to [010].
- Step 2. Read RMR four consecutive times, without accessing any other register between reads. Please note the fourth read access returns the value of the IDR, and the fifth access (read or write) is directed to the CR.
- Step 3. The sixth access (read or write) is directed to AUX. Only one access is allowed for each sequence. During the alternate access sequence, RS[2:0] must be set to [010]. The sequence will terminate and return to its initial state at any point when the content of RS[2:0] ≠ [010]. Writing 00H to the next access will also terminate the sequence.

PLL Clock Generator

CH8398 incorporates Chronitel’s proprietary PLL technology, which is capable of generating any frequency from 8 MHz – 135 MHz, by writing the appropriate values to the PLL RAM. To synthesize various frequencies used in different graphics modes, a stable reference frequency is required. The source of this reference frequency can come from either:

- an on-chip crystal oscillator (a crystal with a nominal frequency of 14.318 MHz is required between pins 6 and 7), *or*
- an external frequency source being applied to pin 7 of CH8398 with pin 6 grounded.

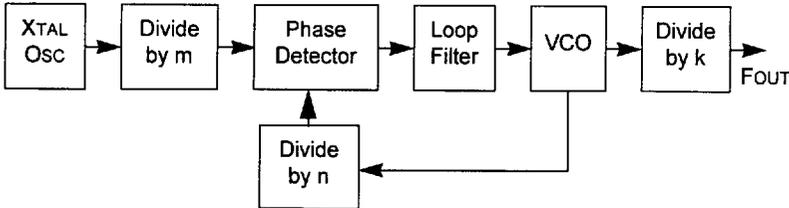


Figure 17: PLL Block Diagram

The formula for calculating the output frequency is achieved by:

$$F_{OUT} = F_{REF} \times \frac{n}{m \times k}$$

where:

- F_{REF} = 14.318 MHz (for normal operation)
- m = M + 2
- n = N + 8
- k = 2^K

MSB								LSB							
D7	D6	D5	D4	D3	D2	D1	D0	D7	D6	D5	D4	D3	D2	D1	D0
K1	K0	M5	M4	M3	M2	M1	M0	N7	N6	N5	N4	N3	N2	N1	N0

Note: Certain values of N are restricted, including: 0-7, 10-15, 19-23, 28-31, 37-39, 46, 47, 55.
Table 11 on page 4-64 shows some samples of M, N, and K values to be programmed. For frequencies not listed below, please contact Chronitel.
 D[7:0] = data bus input from graphics controller
 M[5:0] = reference frequency input divider
 K[1:0] = output frequency scale
 N[7:0] = VCO frequency divider

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Table 11 • Sample Frequency Coefficients (reference frequency = 14.318 MHz)

FOUT	M	N	K
14.318	8	72	3
25.06	3	27	2
25.20	23	168	2
25.95	6	50	2
27.44	7	61	2
28.28	8	71	2
28.33	21	174	2
28.64	2	24	2
30.07	3	34	2
31.50	8	80	2
32.57	8	83	2
33.75	5	58	2
35.89	3	17	1
37.59	6	34	1
38.48	6	35	1
40.09	8	48	1
43.98	5	35	1
44.74	6	42	1
47.25	3	25	1
50.11	3	27	1
51.90	6	50	1
54.89	7	61	1

FOUT	M	N	K
56.56	8	71	1
57.27	2	24	1
60.14	3	34	1
63.00	8	80	1
65.15	8	83	1
67.50	5	58	1
71.59	3	17	0
75.17	6	34	0
76.96	6	35	0
80.18	8	48	0
87.95	5	35	0
89.49	6	42	0
94.50	3	25	0
100.23	4	34	0
105.00	7	58	0
108.18	7	60	0
109.77	7	61	0
118.12	2	25	0
120.27	3	34	0
130.91	5	56	0
135.00	5	58	0

Note: Use M values of 10 or less for best circuit performance

Electrical Specifications

Table 12 • Absolute Maximum Ratings

Symbol	Description	Min	Typ	Max	Units
	VDD relative to GND	-0.5		7.0	V
	Input voltage of all digital pins ¹	GND - 0.5		VDD + 0.5	V
	Analog output short circuit duration			Indefinite	Sec
TSTOR	Storage temperature	-65		150	°C
TJ	Junction temperature			150	°C
TVPS	Vapor phase soldering (one minute)			220	°C

Note: Stresses greater than those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions above those indicated under the normal operating conditions is not recommended. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

- The device is fabricated using high-performance CMOS technology. It should be handled as an ESD-sensitive device. Voltage on any signal pin that exceeds the power supply voltage by more than +0.5V can induce destructive latchup.

Table 13 • Recommended Operating Conditions

Symbol	Description	Min	Typ	Max	Units
VDD	Supply voltage	4.75	5.00	5.25	V
TA	Ambient operating temperature	0	25	70	°C
RL	Output load to DAC outputs		37.5		Ω
IREF	Reference current RS-343A output PS/2™ compatible	-3.0 -3.0	-8.39 -8.88	-10.0 -10.0	mA mA

Table 14 • DC Characteristics (Operating Conditions: TA = 0°C – 70°C, VDD = 5V ± 5%)

Symbol	Description	Test Condition @TA = 25°C	Min	Typ	Max	Unit
	Resolution (each DAC)		8	8	8	Bits
	Accuracy (each DAC)					
LI	Integral linearity error				±1	LSB
LD	Differential linearity error				±1	LSB
	Gray scale error				±5	%
	Monotonicity	Guaranteed				
	Coding	Binary				

Table 15 • Digital Inputs / Outputs

Symbol	Description	Test Condition @ TA = 25°C	Min	Typ	Max	Units
VOH	Output high voltage	IOH = -400µA	2.4			V
VOL	Output low voltage	IOL = 3.2 mA			0.4	V
VIH	Input high voltage		2.0		VDD + 0.5	V
VIL	Input low voltage		GND - 0.5		0.8	V
ILK	Input leakage current (except for FS[3:0])		-10		10	µA
IPLD	Input pull down current FS[3:0]	VIN = 0.5V			20	µA
CDIN	Input capacitance (except for XI, XO / FIN)	f = 1 MHz, VIN = 2.4V			7	pF
CDIN	Input capacitance (XI, XO / FIN)	f = 1 MHz, VIN = 2.4V		20		pF
IOZ	Tri-state current				50	µA
CDOUT	Output capacitance				7	pF

Table 16 • Clock Output Buffer

Symbol	Description	Test Condition @ TA = 25°C	Min	Typ	Max	Units
IOH	Output high current	VOUT = 2.4V	-8			mA
IOL	Output low current	VOUT = 0.5V	8			mA

Table 17 • Analog Outputs (Operating Conditions: TA = 0°C – 70°C, VDD = 5V ± 5%)

Symbol	Description	Test Condition @ TA = 25°C	Min	Typ	Max	Units
IGRAY	Gray scale current range				20	mA
IWB	White level relative to black RS-343A PS/2™	VREF = 1.23V RSET = 147 Ω RSET = 139 Ω	16.74	17.62	18.50	mA
			18.00	18.65	20.00	mA
	Black level relative to blank			0		mA
IBLNK	Blank level			0		mA
				2	5	%
VOC	Output compliance		-1.0		+1.5	V
ZAOUT	Output impedance			10		kΩ
CAOUT	Output capacitance	f = 1 MHz, IOUT = 0 mA			30	pF
IVREF	Voltage reference input current			10		µA
PSRR	Power supply rejection ratio				0.5	% / % VDD

Table 18 • AC Characteristics

Symbol	Description	110	135	Units
F_MAX	Single-edge data clock rate	110	135	MHz
F_MAX	Dual-edge data clock rate	110	135	MHz
t1_MIN	RS[3:0] setup time	10	10	ns
t2_MIN	RS[3:0] hold time	10	10	ns
t3_MIN	RD* active to data asserted	5	5	ns
t4_MAX	RD* active to data valid	30	30	ns
t5_MAX	RD* inactive to data tristated	15	15	ns
t6_MIN	Read data hold time	5	5	ns
t7_MIN	Write data setup time	10	10	ns
t8_MIN	Write data hold time	10	10	ns
t9_MIN	RD*, WR* low pulse width	50	50	ns
t10_MIN	RD*, WR* high pulse width	7	7	PCLK cycles
t11_MIN	Pixel input setup time	2	2	ns
t12_MIN	Pixel input hold time	2	2	ns
t11_MIN	BLANK* setup time	2	2	ns
t12_MIN	BLANK* hold time	2	2	ns
t11_MIN	MSW setup time	2	2	ns
t12_MIN	MSW hold time	2	2	ns
t13_MIN	Clock cycle time	9.09	7.4	ns
t14_MIN	Clock pulse width high	3.5	3	ns
t15_MIN	Clock pulse width low	3.5	3	ns
t16_MAX	Analog output delay	30	30	ns
t17_TYP	Analog output rise / fall time	2	2	ns
t18_MAX	Analog output settling time	9	7.4	ns
TSU_MIN	Setup time, data to strobe	5	5	ns
THOLD_MIN	Hold time, strobe to data	5	5	ns
TSTROBE_MIN	Strobe pulse width	20	20	ns
TYP	Glitch impulse energy ¹	75	75	pV – sec
TYP	DAC-to-DAC crosstalk	-23	-23	dB
MAX	Analog output skew	2	1.5	ns
MIN	Pipeline delay	6	6	PCLK cycles
MAX		9	9	PCLK cycles
IDD_TYP	VDD supply current ¹	180	200	mA
IPD1_TYP	Power down mode ¹			
IPD2_TYP	Mode 1: MPLL & VPLL ON, LUTDAC OFF	55	55	mA
IPD3_TYP	Mode 2: MPLL ON, VPLL & LUTDAC OFF	35	35	mA
	Mode 3: MPLL, VPLL, & LUTDAC OFF	2	2	mA

Note: 1 MCLK = 40 MHz and VCLK = 28.32 MHz

Test Conditions: Unless otherwise specified, the testing conditions are the same as in Table 13, "Recommended Operating Conditions," on page 4-65. TTL input values are 0 – 3V, with input rise / fall times < 3 ns, measured between the VIL and VIH. Timing reference points at 50% for non-TTL inputs and outputs. TTL reference points at 1.5V for inputs and outputs. Analog output load < 10 pF, D[7:0] output load < 45 pF

Timing Diagrams

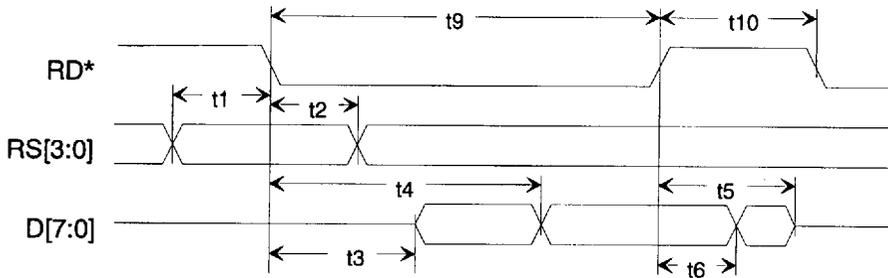


Figure 18: MPU Read Timing

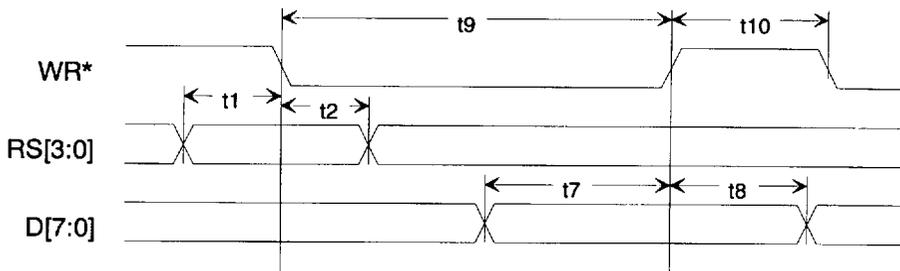


Figure 19: MPU Write Timing

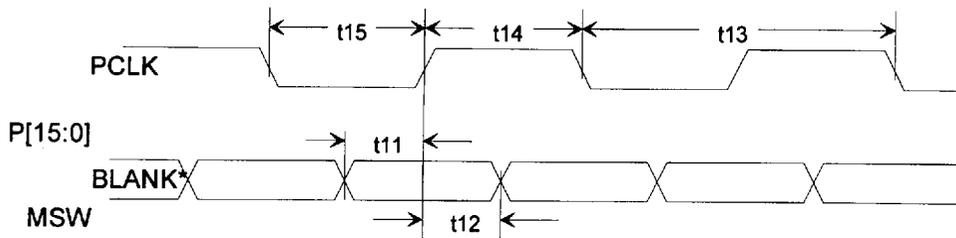


Figure 20: Pixel Data, BLANK* Control Signal, and Mode Switch Timing

Timing Diagrams (continued)

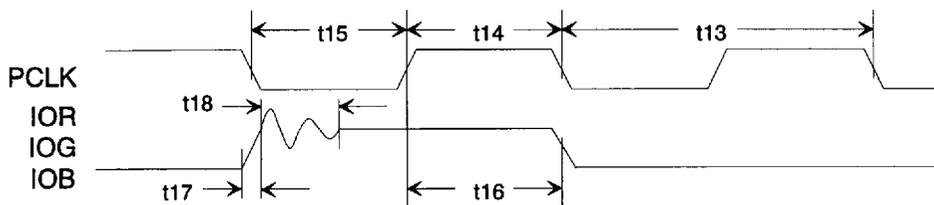


Figure 21: DAC Output Timing

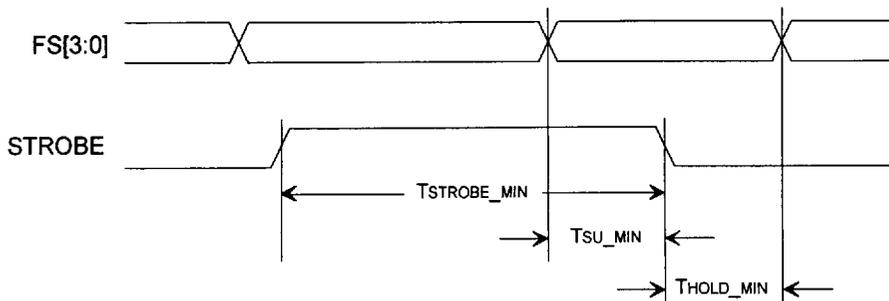


Figure 22: Strobe Timing

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PC Board Layout Considerations

CH8398 is a high performance mixed signal IC containing precision analog and digital circuits. In order to achieve high performance, it is important to optimize the PC board layout (PCB) for the CH8398. Care should be taken in laying out the power and ground planes to ensure good decoupling. In general, analog outputs should be short and wide to minimize inductive ringing, and analog signal traces crossover to digital signals should be minimized. When operating the device at high frequencies (> 50 MHz), the pixel data bus (P[15:0]) and the clock signals should have dedicated drivers. These signal traces should be kept short and placed beside each other the signal delays through the interconnects are matched, to minimize clock and data skew of the pixel bus.

Ground Planes

For four-layer PCBs with a uniform ground plane, CH8398 and its associated analog components (e.g., decoupling circuitry, current reference, and voltage reference) can be connected to the ground plane directly. The connections to the ground plane should be made with wide traces to minimize inductance. Connecting the analog and digital ground pins directly to the ground plane is highly recommended.

Supply Decoupling

For the digital power supply, bypass capacitors (0.1 μF) are recommended. Make leads as short as possible and place the capacitor as close as possible to the device. Connect the ground side of the capacitors directly to the ground plane.

For AVDD pin 42, a pi-filter configuration is recommended, with a 10 μF tantalum capacitor, in parallel with a 0.1 μF ceramic capacitor to GND, followed by a ferrite bead in series, then a 0.1 μF ceramic capacitor close to the AVDD pin.

For AVDD pin 3, a 5.1V zener diode with a 0.1 μF ceramic capacitor for supply conditioning that would result in optimal performance.

In general, short leads and direct connection to the power supply and ground planes are highly desirable. For details, please refer to **Figure 23** on page 4-71.

Digital Signal Interconnect

Place digital signals of the pixel bus, P[15:0] and PCLK, alongside each other to minimize data and clock skew. At high frequencies, these signals should have short traces, dedicated drivers, and series termination damping resistors to minimize signal reflections.

Analog Signal Interconnect

In general, analog signal traces should be as short as possible. Therefore, CH8398 should be located as close as possible to the VGA controllers and output connectors to minimize the amount of noise and transmission line reflection due to impedance mismatch between the PCB and the cable. Video outputs should overlay the analog ground plane to maximize supply rejection. To cut down the amount of transmission line reflection, connect a 75 Ω resistor with short leads between each video output and ground. Make the connection as close to the device as possible.

Some designs, such as VESA local bus, may have restrictions on component placement. For further discussion of this issue, please refer to "**Component Placement**" on page 4-74.

Clock Signals

In applications where either the video or memory clock frequencies are pushed toward the performance limit of the system, AC coupling circuitries should be used. This will allow for minor duty cycle adjustments for these high frequency signals. For additional information, please refer to **Application Notes, AN-03**.

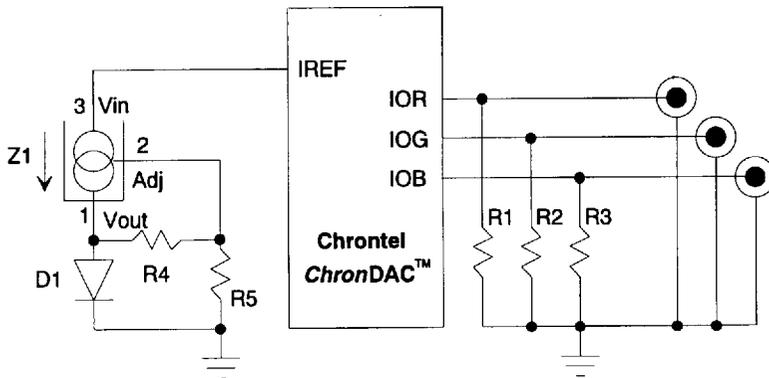


Figure 23: Typical Connection Using External Current Reference

Table 19 • List of Parts for Figure 23

Symbol	Description
D1	1N914 small signal diode
R1, R2, R3	75 Ω, metal film resistor
R4	18 Ω, 1/4W resistor
R5	180 Ω, 1/4W resistor
Z1	LM334Z or equivalent current reference

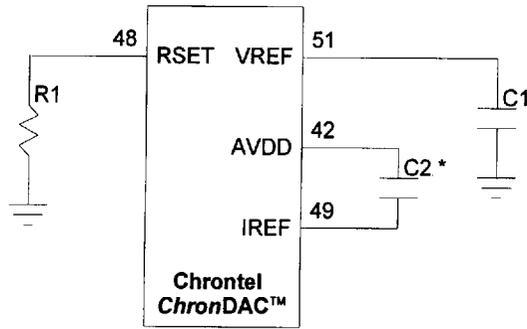


Figure 24: Typical Connection Using Internal Voltage Reference

Table 20 • List of Parts for Figure 24

Symbol	Description
C1	0.1 μ F ceramic capacitor
C2* (optional)	0.1 μ F ceramic capacitor
R1	147 Ω , 1/4W resistor

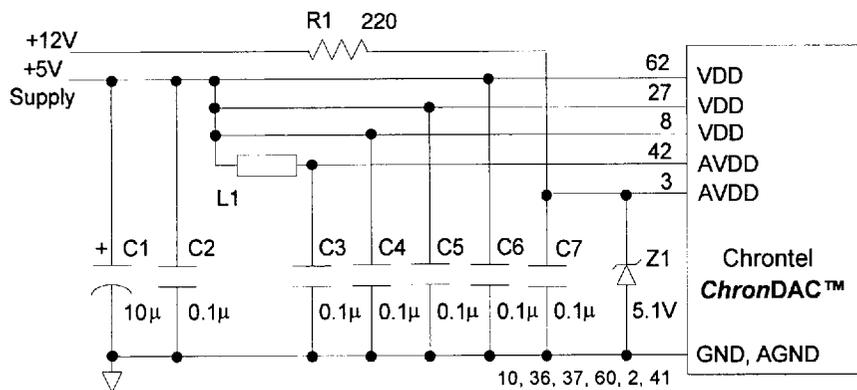


Figure 25: Recommended Supply Decoupling

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Table 21 • List of Parts for Figure 25

Symbol	Description
C1	10 μ F tantalum capacitor
C2, C3, C4, C5, C6, C7	0.1 μ F ceramic capacitors
L1	Ferrite bead
R1	220 Ω , 1/4W resistor
Z1	1N4733A 5.1V zener or equivalent current reference

Component Placement

Figure 26 below is an example of typical placement of VGA components on a local bus VGA adapter. CH8398 should be placed as close as possible to the VGA controller, since there are high speed signals between these two devices. For most local bus implementation, the VGA controller will be placed in close proximity to the local bus connector. Due to the low impedance nature of the CH8398 RGB outputs, they can be located farther from the VGA monitor connector. Micro-strips or strip lines with characteristic impedance of 75 Ω should be used to route these outputs to the video connector.

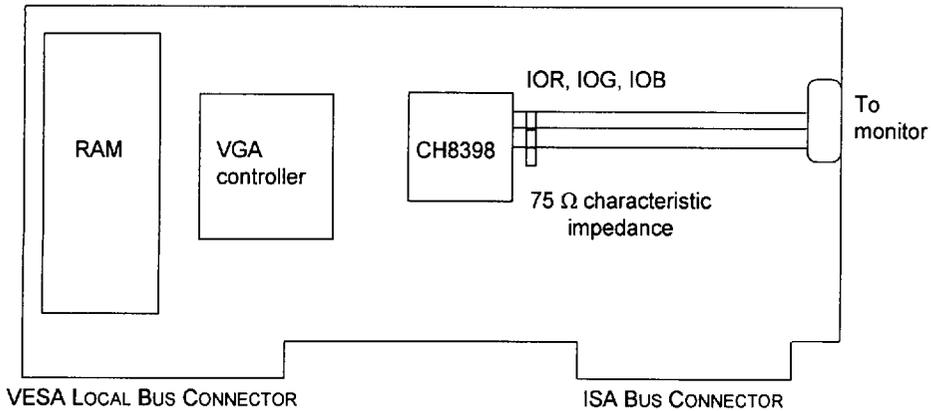


Figure 26: Recommended Placement of VGA Components for Local Bus VGA Adapter

ORDERING INFORMATION			
Part number	Package type	Number of pins	Voltage supply
CH8398	PLCC	68	5V

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