

**EPSON**<sup>®</sup>



## **S1D13806 Embedded Memory Display Controller**

# **Hardware Functional Specification**

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# 1 Introduction

## 1.1 Scope

This User Guide provides technical information for the S1D13806 Embedded Memory Display Controller. Included in this document are timing diagrams, AC and DC characteristics, register descriptions, and power management descriptions. This document is intended for two audiences: Video Subsystem Designers and Software Developers.

This guide is updated as appropriate. Please check the Epson Electronics America Website at [www.eea.epson.com](http://www.eea.epson.com) or the Epson Research and Development Website at [www.erd.epson.com](http://www.erd.epson.com) for the latest revision of this document before beginning any development.

We appreciate your comments on our documentation. Please contact us via email at [documentation@erd.epson.com](mailto:documentation@erd.epson.com).

## 1.2 Overview Description

The S1D13806 is a highly integrated color LCD/CRT/TV graphics controller with embedded memory supporting a wide range of CPUs and display devices. The S1D13806 architecture is designed to meet the low cost, low power requirements of the embedded markets, such as Mobile Communications, Hand-Held PC's, and Office Automation.

The S1D13806 supports multiple CPUs, all LCD panel types, CRT, TV, and additionally provides a number of differentiating features. EPSON Independent Simultaneous Display technology allows the user to configure two different images on two different displays, while the SwivelView™, Hardware Cursor, Ink Layer, and BitBLT features offer substantial performance benefits. Products requiring digital camera input can take advantage of the directly supported WINNOV Videum® Cam digital interface. While focusing on devices targeted by the Microsoft Windows CE Operating System, the S1D13806's impartiality to CPU type or operating system makes it an ideal display solution for a wide variety of applications.

## 2 Features

Table 2-1 : S1D13806 Features

<b>S1D13806 Features</b>	
<p><b>Embedded Memory</b></p> <p>1280K byte embedded synchronous DRAM.</p> <p>Up to 50MHz data rate (100M Bytes/second).</p> <p>Display buffer address space is directly and contiguously available through the 21-bit address bus.</p>	<p><b>Display Modes</b></p> <p>4/8/16 bit-per-pixel (bpp) color depths.</p> <p>Up to 64K colors on TFT,CRT and TV.</p> <p>Up to 64K colors in 16 bpp mode on color passive LCD panels using dithering (4096 colors in 4/8 bpp).</p> <p>Up to 64 shades of gray on monochrome passive panels using Frame Rate Modulation (FRM) and Dithering.</p> <p>4/8 bit-per-pixel color depths are mapped using three 256x4 Look-Up Tables (LUT).</p> <p>Separate LUTs for LCD and CRT/TV.</p> <p>16 bit-per-pixel modes are mapped directly bypassing the LUT.</p>
<p><b>CPU Interfaces</b></p> <p>Epson E0C33.</p> <p>Hitachi SH-4.</p> <p>Hitachi SH-3.</p> <p>MIPS/ISA.</p> <p>Motorola MC68000.</p> <p>Motorola MC68030.</p> <p>Motorola PowerPC MPC82x.</p> <p>MPU bus interface with programmable READY.</p> <p>NEC MIPS VR41xx.</p> <p>PC Card (PCMCIA).</p> <p>Philips MIPS PR31500/PR31700.</p> <p>StrongARM (PC Card).</p> <p>Toshiba MIPS TX39xx.</p> <p>One-stage write buffer for minimum wait-state CPU writes.</p> <p>Registers are memory-mapped – M/R# pin selects between display buffer and register address space.</p>	<p><b>Display Features</b></p> <p>SwivelView™: 90°, 180°, 270° hardware rotation of display image.</p> <p>EPSON Independent Simultaneous Display (EISD): displays independent images on different displays (CRT or TV and passive or TFT panel).</p> <p>Virtual Display Support: displays images larger than the physical display size through the use of panning and scrolling.</p> <p>2D BitBLT Engine.</p> <p>Hardware Cursor/Ink Layer: separate 64x64x2 hardware cursor or 2-bit ink layer for both LCD and CRT/TV.</p> <p>Double Buffering/Multi-pages: for smooth animation and instantaneous screen update.</p>
<p><b>Display Support</b></p> <p>4/8-bit monochrome or 4/8/16-bit color LCD interface for single-panel, single-drive displays.</p> <p>8-bit monochrome or 8/16-bit color LCD interface for dual-panel, dual-drive displays.</p> <p>Direct support for 9-bit, 12-bit, 18-bit, 2x9-bit, 2x12-bit TFT/D-TFD.</p> <p>Direct support for CRT.</p> <p>Direct support for S-Video/Composite TV output (NTSC or PAL format).</p>	<p><b>Miscellaneous</b></p> <p>Power save mode is initiated by software.</p> <p>Built-in MediaPlug Interface for Winnov Camera.</p> <p>Highly Flexible Clocking.</p> <p>Eight configuration pins (CONF[7:0]) are used to configure the chip at power-on.</p> <p>13 General Purpose Input/Output pins.</p> <p>Operating voltage from 3.0 volts to 3.6 volts.</p> <p>144-pin QFP20 package.</p> <p>220-pin PFBGA package</p>



### 3 Typical System Implementation Diagrams

For pin mapping of each system implementation, see Table 4-10, “CPU Interface Pin Mapping,” on page e34.

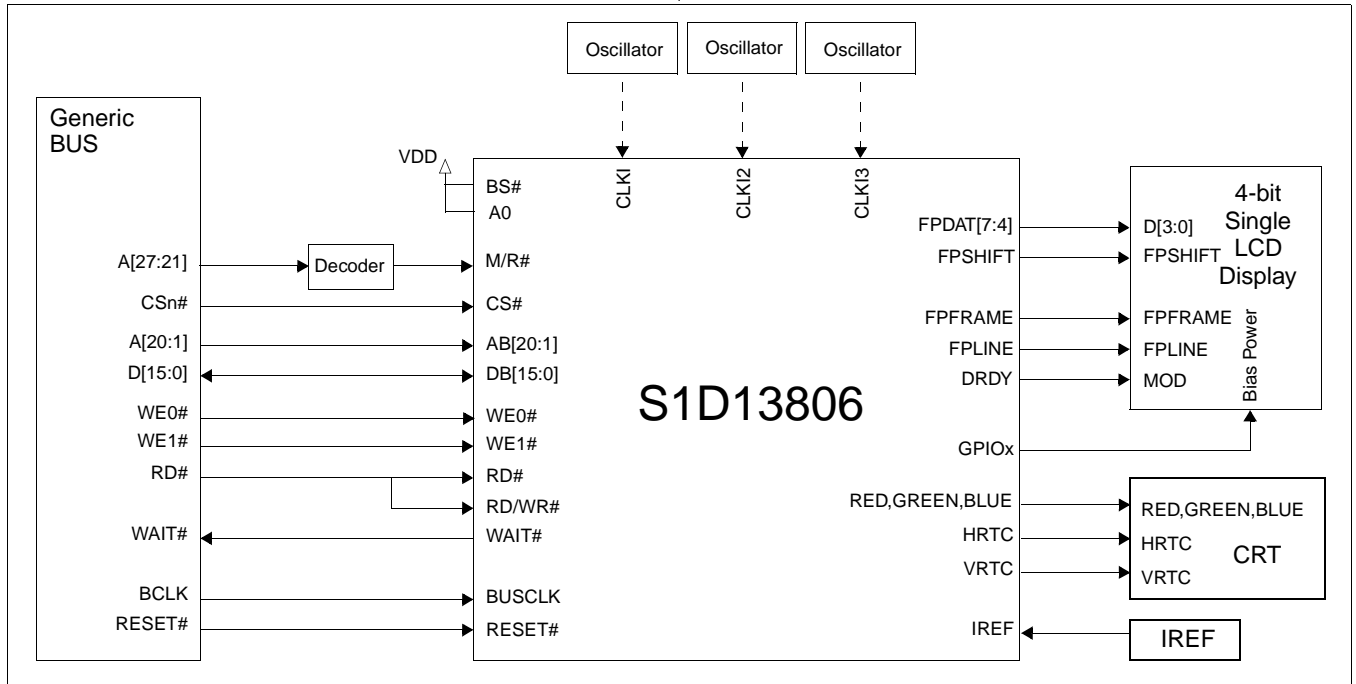


Figure 3-1: Typical System Diagram (Generic Bus)

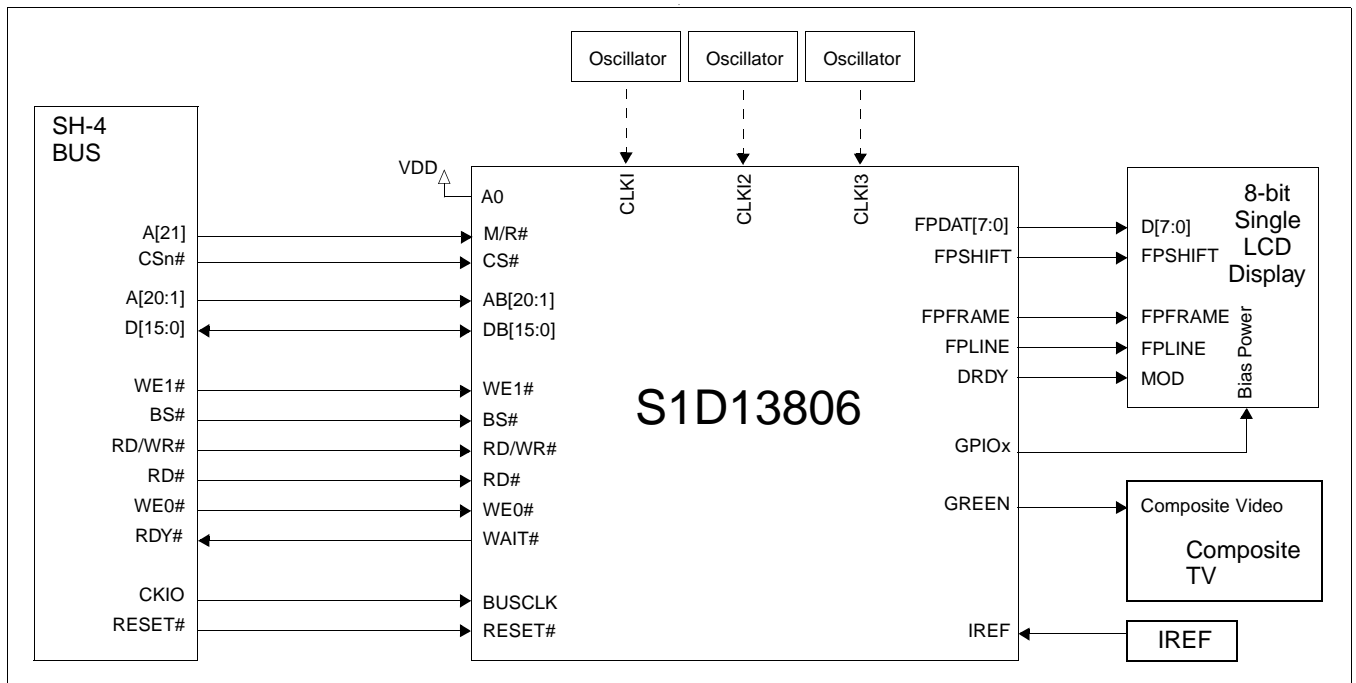


Figure 3-2: Typical System Diagram (Hitachi SH-4 Bus)

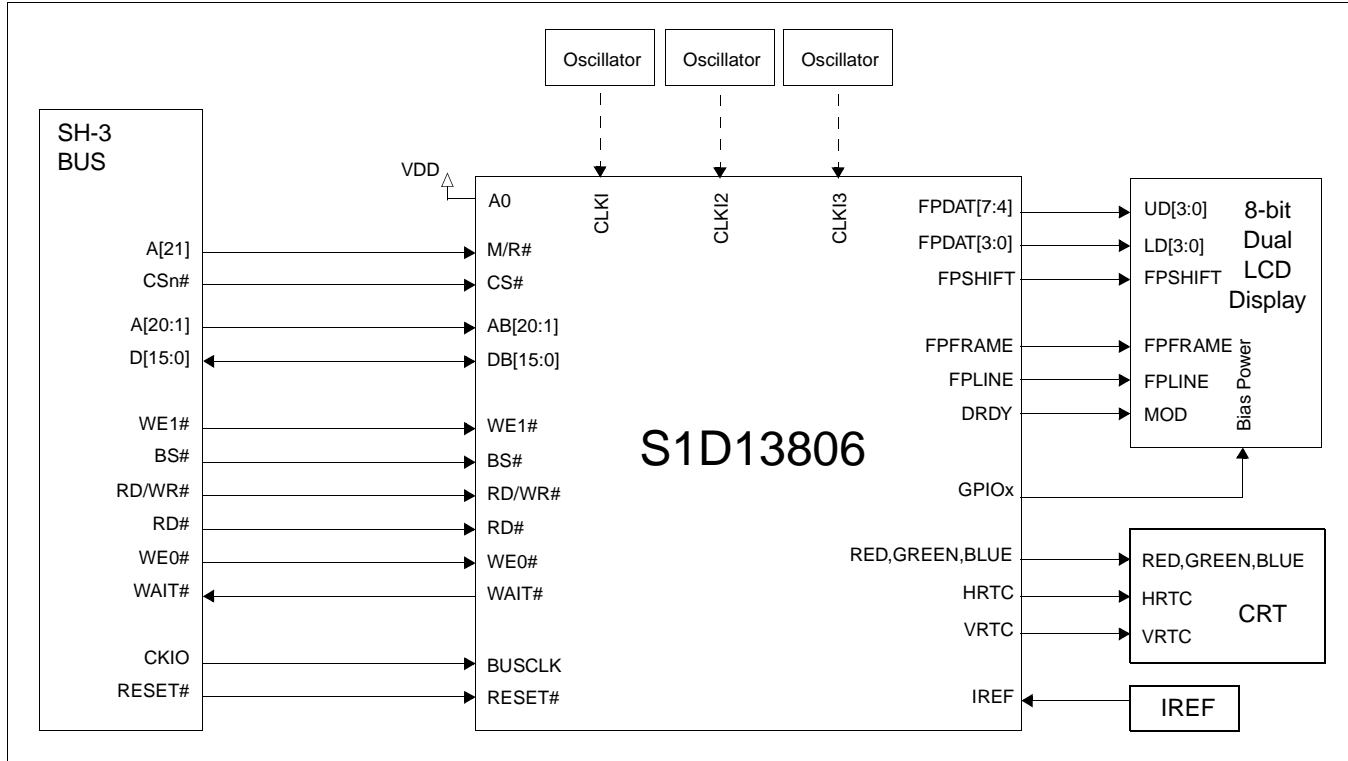


Figure 3-3: Typical System Diagram (Hitachi SH-3 Bus)

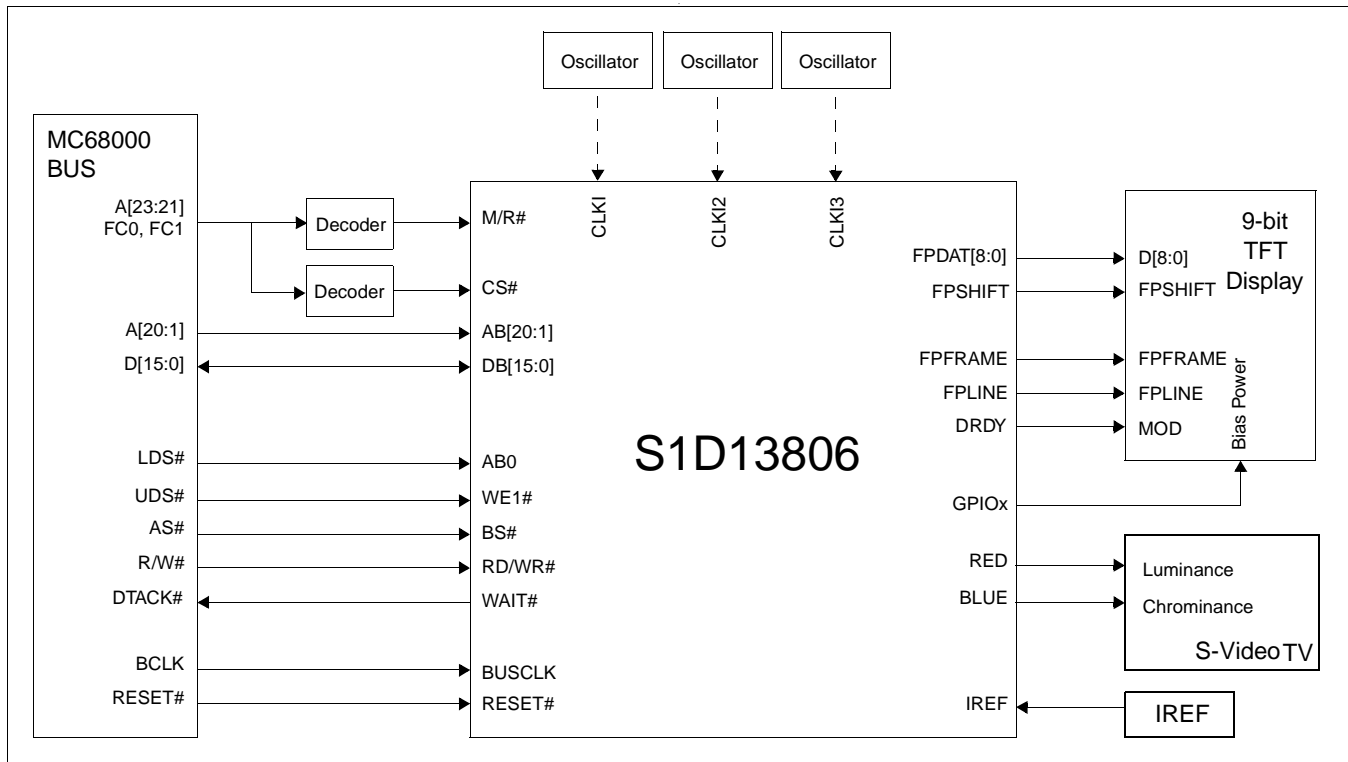


Figure 3-4: Typical System Diagram (MC68K Bus 1, Motorola 16-Bit 68000)

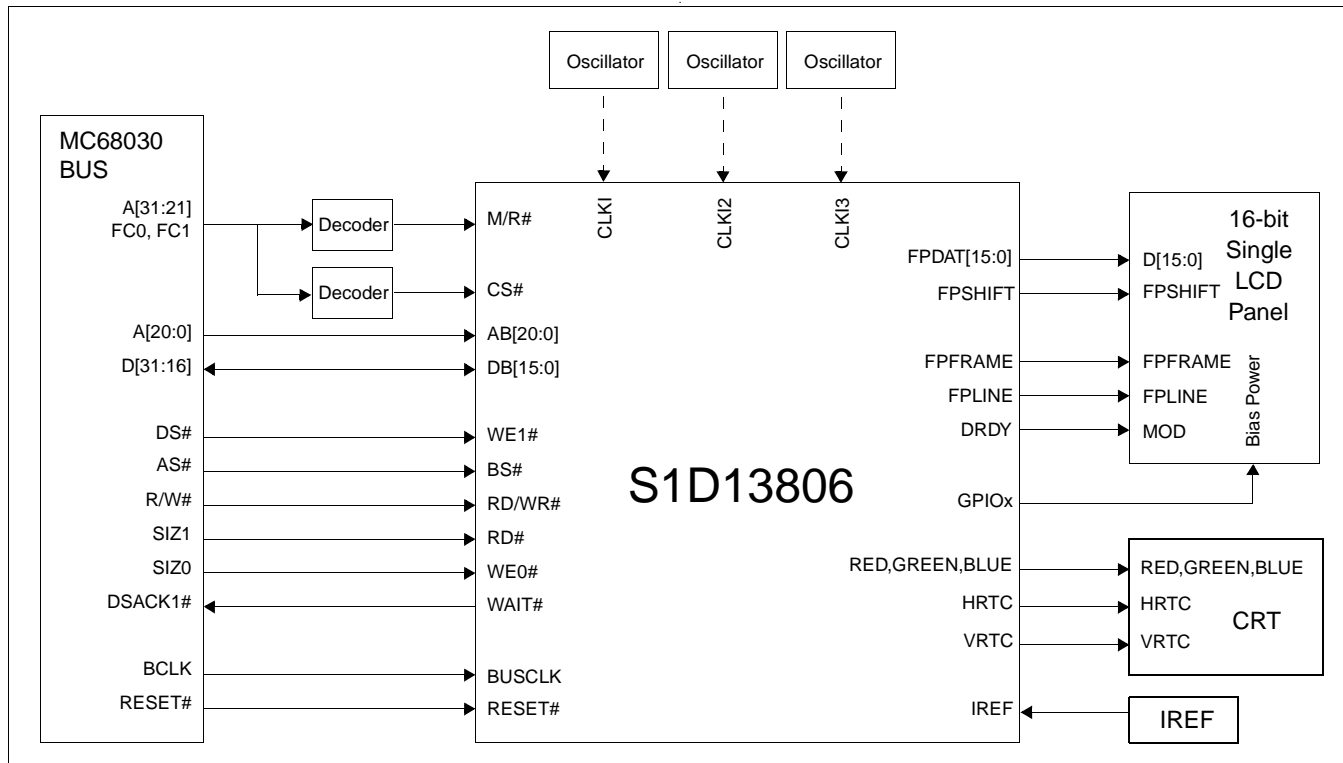


Figure 3-5: Typical System Diagram (MC68K Bus 2, Motorola 32-Bit 68030)

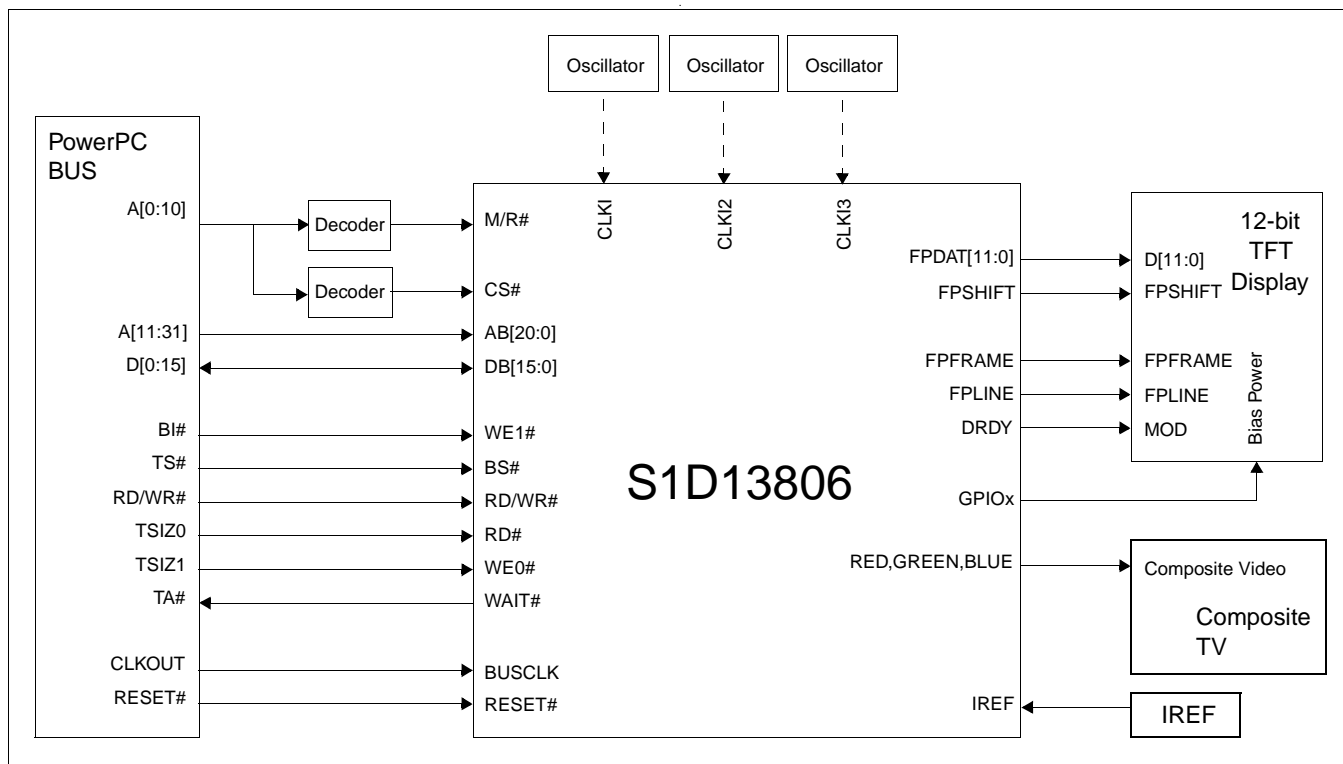


Figure 3-6: Typical System Diagram (Motorola Power PC Bus)

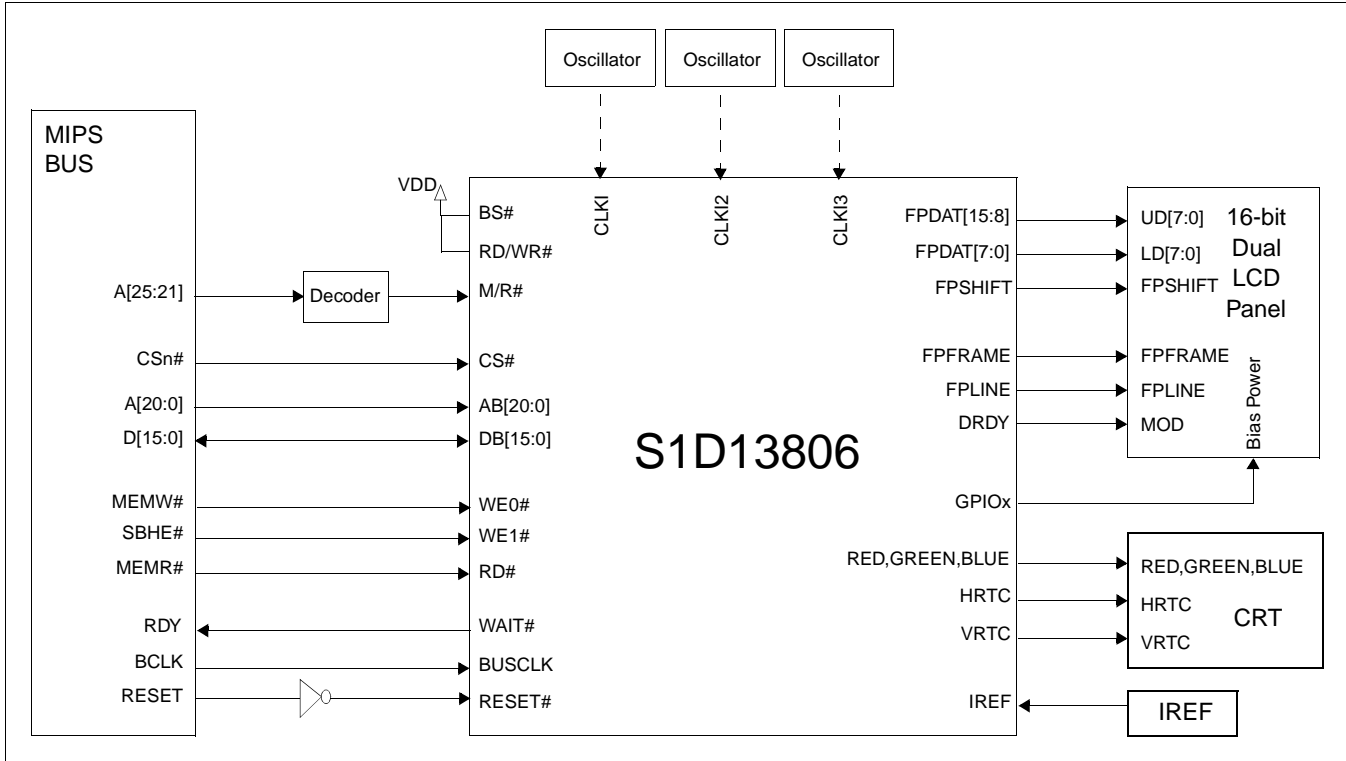


Figure 3-7: Typical System Diagram (NEC MIPS VR41xx Bus)

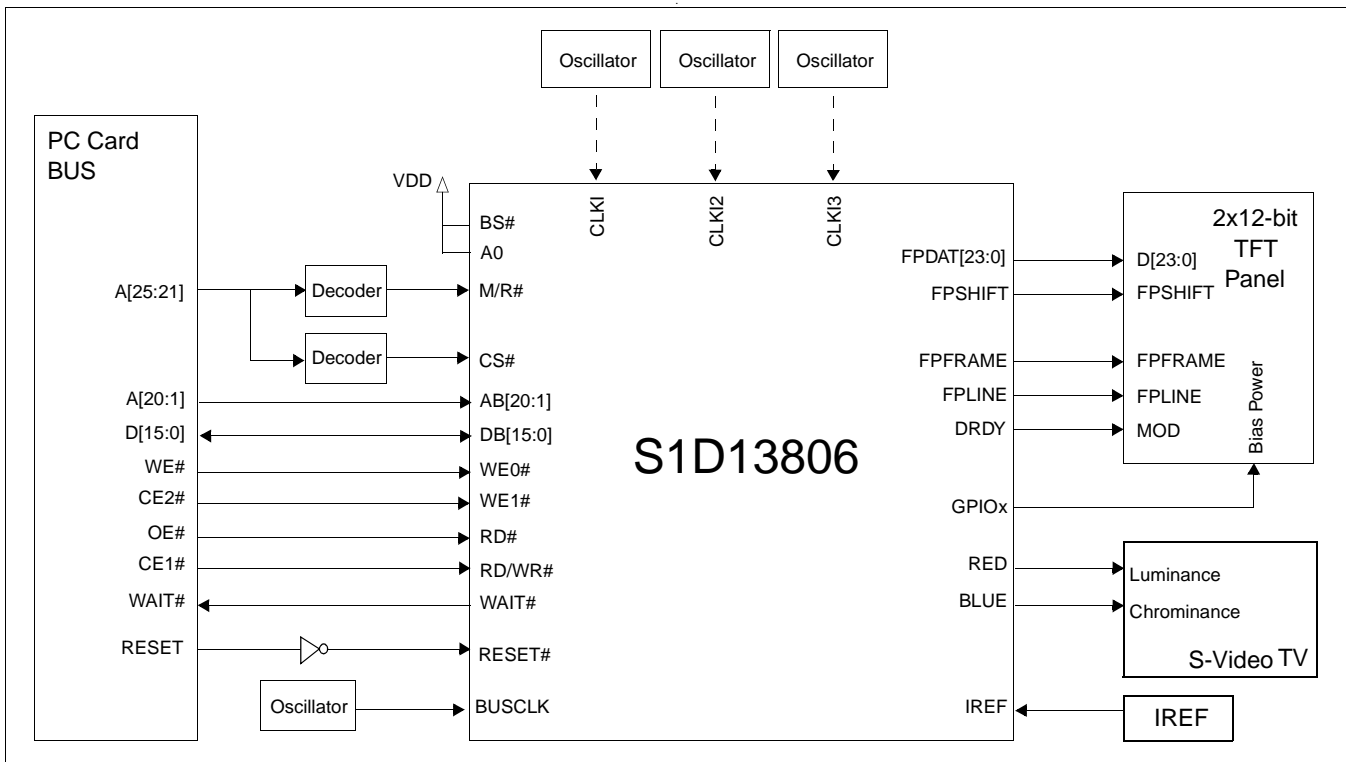


Figure 3-8: Typical System Diagram (PC Card Bus)

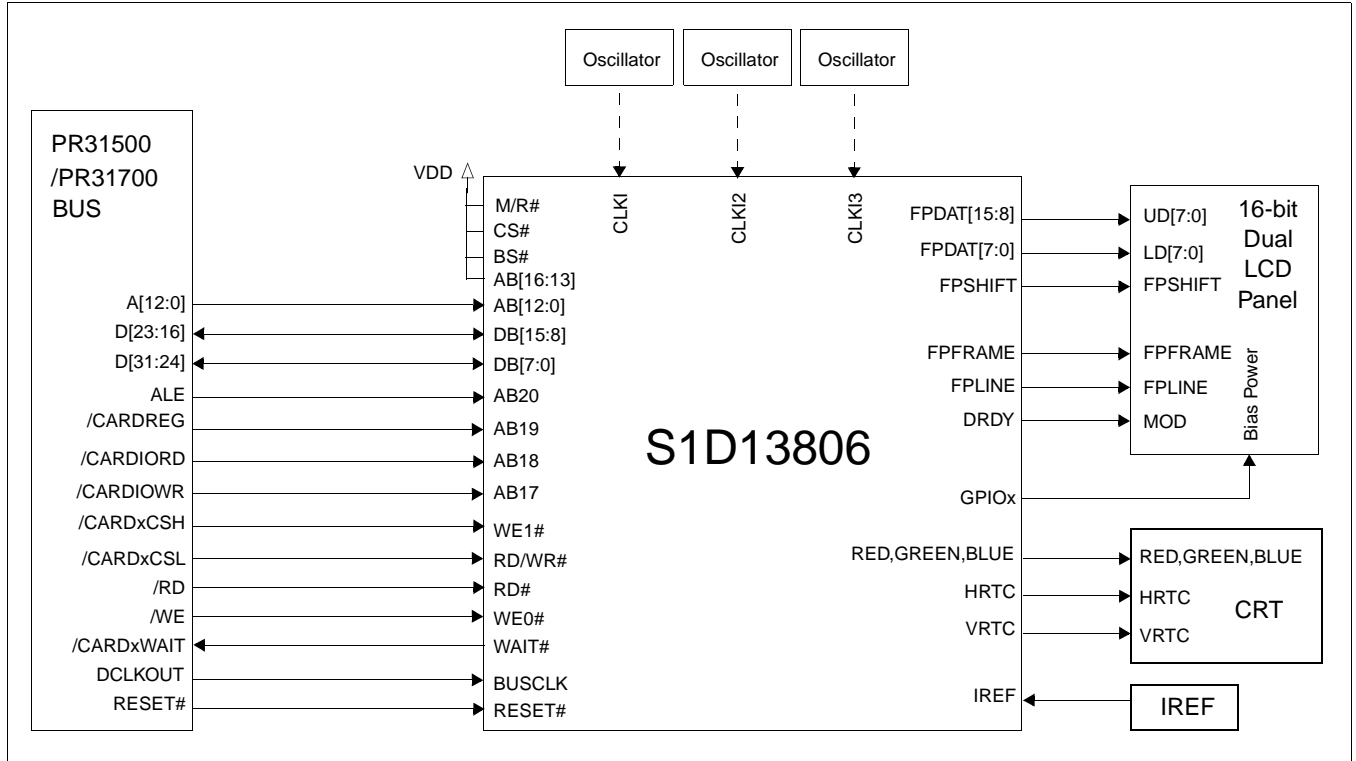


Figure 3-9: Typical System Diagram (Philips MIPS PR31500/PR31700 Bus)

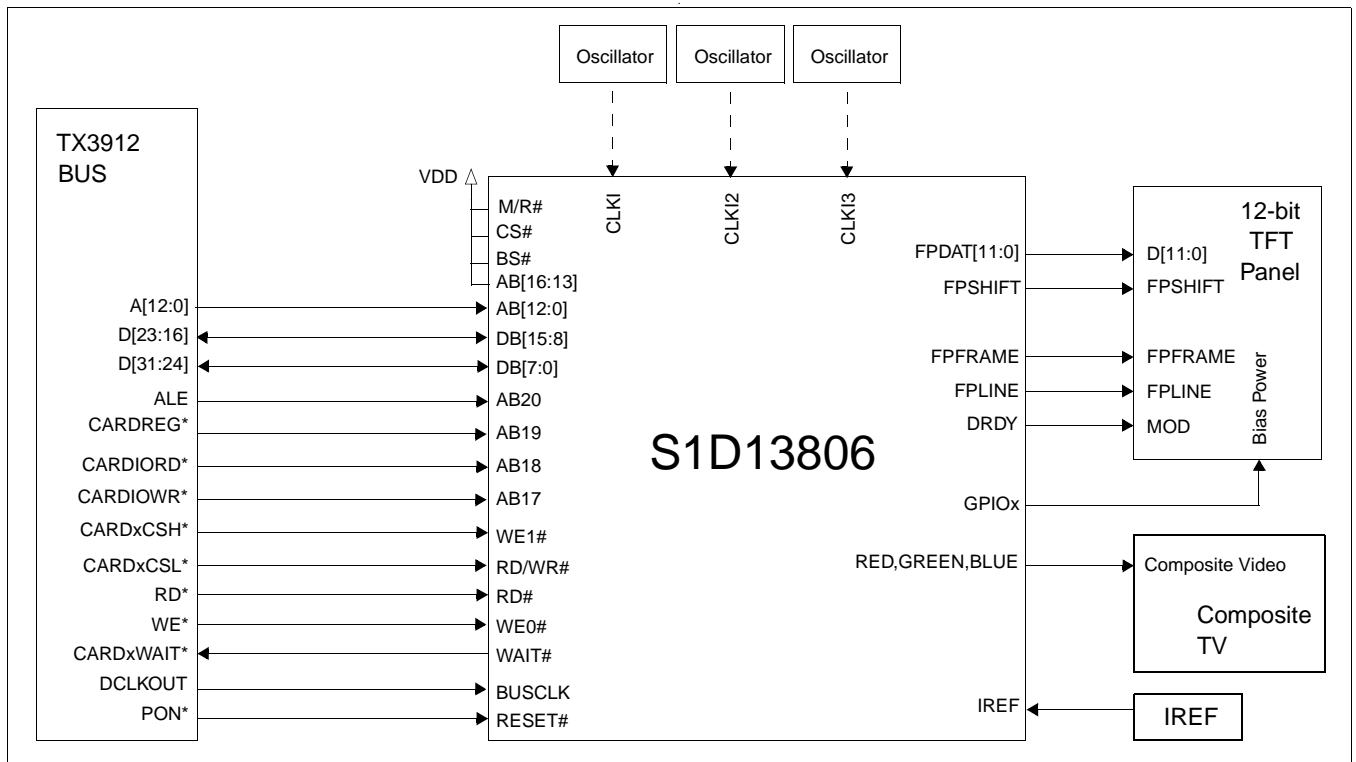


Figure 3-10: Typical System Diagram (Toshiba MIPS TX39xx Bus)

# 4 Pins

## 4.1 Pinout Diagram

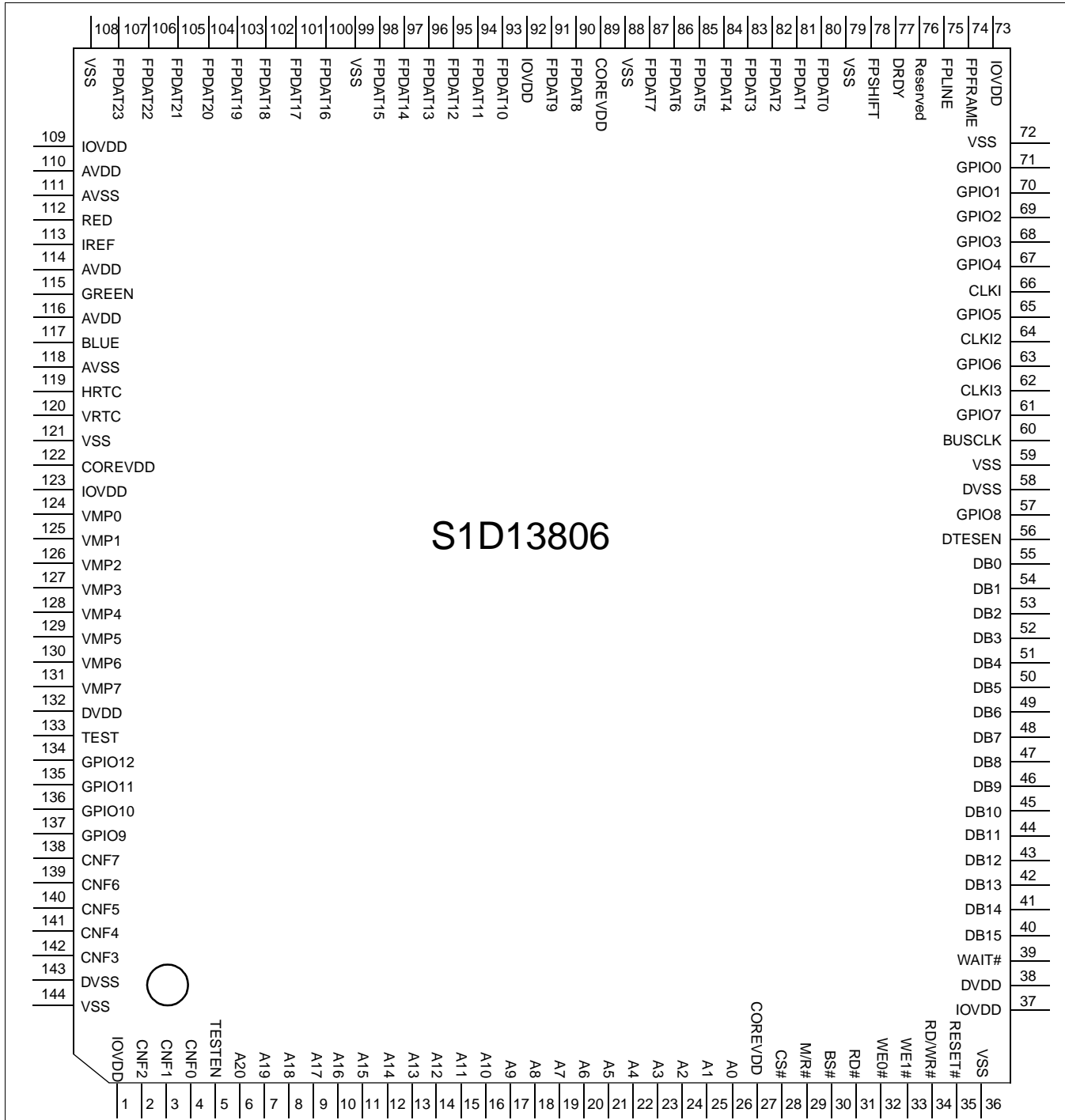


Figure 4-1: Pinout Diagram 144-Pin QFP20 Surface Mount Packages

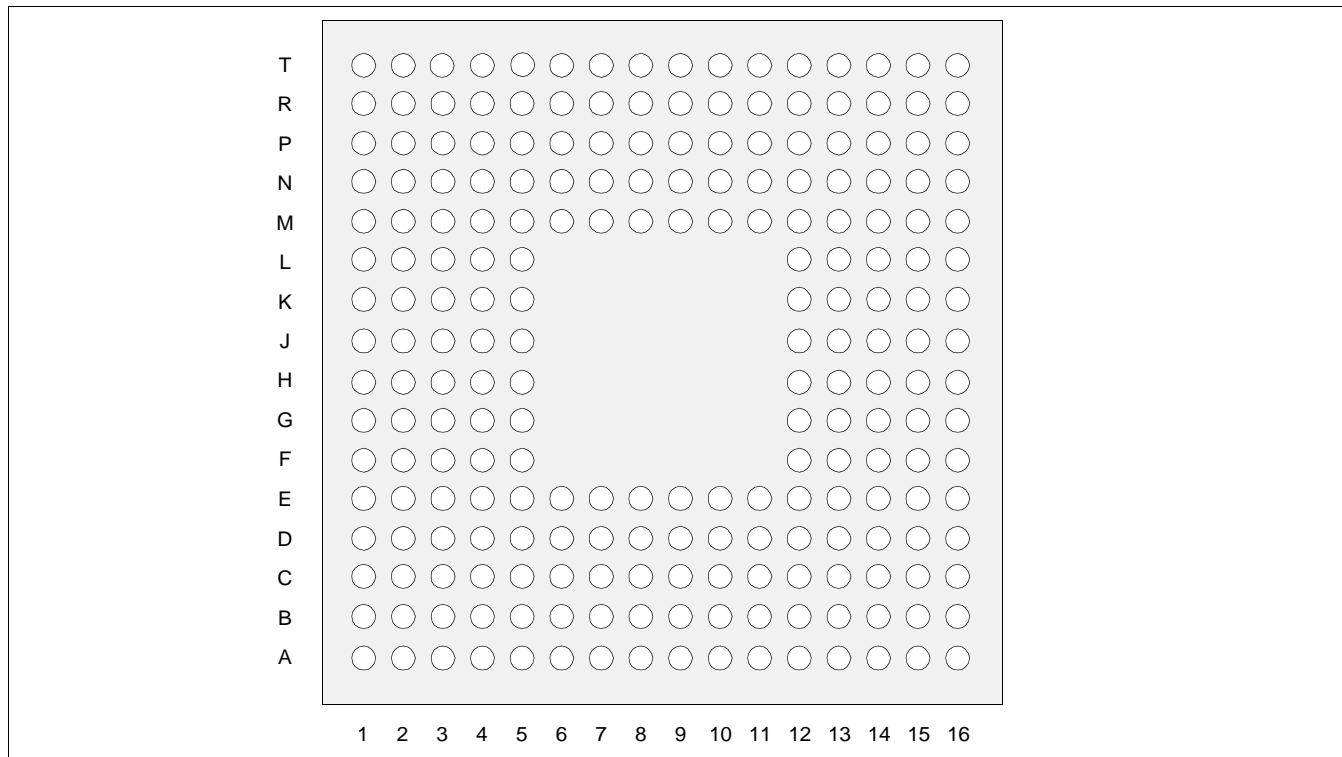


Figure 4-2: Pinout Diagram 220-Pin PFBGA Surface Mount Package

Table 4-1: PFBGA 220-pin Mapping

<b>T</b>	AB	NC	DVDD	NC	DB12	NC	DB6	DB2	DTESTEN	BUSCLK	GPIO6	CLKI	NC	GPIO0	NC	NC
<b>R</b>	NC	NC	NC	NC	DB13	DB10	DB7	DB4	NC	DVSS	GPIO7	GPIO5	GPIO4	NC	NC	NC
<b>P</b>	RESET#	RD/WR#	NC	WAIT#	DB14	DB11	DB8	DB5	DB0	NC	NC	GPIO3	GPIO1	NC	NC	FPFRAME
<b>N</b>	WE1#	NC	NC	NC	IOVDD	NC	NC	DB3	GPIO8	CLKI3	NC	VSS	NC	FPLINE	NC	NC
<b>M</b>	BS#	M/R#	WE0#	VSS	NC	DB15	DB9	DB1	VSS	CLKI2	GPIO2	NC	IOVDD	DRDY	FPSHIFT	VSS
<b>L</b>	COREVDD	AB1	NC	RD#	NC							Reserved	NC	FPDAT0	FPDAT1	NC
<b>K</b>	AB2	AB4	NC	AB0	CS#							FPDAT2	FPDAT5	FPDAT3	FPDAT4	NC
<b>J</b>	AB6	NC	AB7	AB5	AB3							FPDAT8	VSS	FPDAT6	PFDAT7	COREVDD
<b>H</b>	AB9	AB11	AB12	AB10	AB8							FPDAT12	FPDAT10	FPDAT9	NC	IOVDD
<b>G</b>	NC	AB14	AB15	AB13	AB17							FPDAT16	FPDAT15	NC	FPDAT11	FPDAT13
<b>F</b>	AB16	NC	AB18	NC	CNF0							FPDAT21	NC	NC	FPDAT14	VSS
<b>E</b>	AB19	AB20	TESTEN	IOVDD	NC	CNF4	GPIO10	VMP7	VMP2	NC	RED	NC	VSS	FPDAT20	FPDAT17	FPDAT18
<b>D</b>	NC	NC	CNF1	NC	VSS	NC	GPIO12	VMP5	VMP0	NC	AVDD	IOVDD	NC	FPDAT22	FPDAT19	NC
<b>C</b>	CNF2	NC	NC	CNF3	CNF5	NC	NC	VMP3	COREVDD	HRTC	BLUE	AVDD	NC	NC	NC	FPDAT23
<b>B</b>	NC	NC	NC	CNF6	GPIO9	TEST	VMP6	NC	IOVDD	VRTC	AVSS	GREEN	AVSS	NC	NC	NC
<b>A</b>	NC	NC	DVSS	NC	CNF7	GPIO11	DVDD	VMP4	VMP1	VSS	NC	NC	IREF	AVDD	NC	NC
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>	<b>12</b>	<b>13</b>	<b>14</b>	<b>15</b>	<b>16</b>

**Note**

NC is no connection.

Reserved must be left unconnected and floating.

## 4.2 Pin Description

### Key:

Hi-Z	=	High impedance
I	=	Input
O	=	Output
IO	=	Bi-Directional (Input/Output)
A	=	Analog
P	=	Power pin
C	=	CMOS level input
CD	=	CMOS level input with pull down resistor (typical value of 50K $\Omega$ at 3.3V)
CS	=	CMOS level Schmitt input
COx	=	CMOS output driver, x denotes driver type (1=2/-2mA, 2=6/-6mA @ 3.3V)
TSx	=	Tri-state CMOS output driver, x denotes driver type (1=2/-2mA, 2=6/-6mA @ 3.3V)
TSxU	=	Tri-state CMOS output driver with pull up resistor (typical value of 100K $\Omega$ at 3.3V), x denotes driver type (1=2/-2mA, 2=6/-6mA @ 3.3V)
TSxD	=	Tri-state CMOS output driver with pull down resistor (typical value of 100K $\Omega$ at 3.3V), x denotes driver type (1=2/-2mA, 2=6/-6mA @ 3.3V)

### 4.2.1 Host Interface

Table 4-2 : Host Interface Pin Descriptions

Pin Name	Type	QFP Pin #	PFBGA Pin #	Cell	RESET# State	Description
AB0	I	26	K4	CS	Hi-Z	<ul style="list-style-type: none"> <li>For Generic Bus, this pin must be connected to V<sub>SS</sub> or IO V<sub>DD</sub>.</li> <li>For SH-4/SH-3 Bus, this pin must be connected to V<sub>SS</sub> or IO V<sub>DD</sub>.</li> <li>For MC68K Bus 1, this pin inputs the lower data strobe (LDS#).</li> <li>For MC68K Bus 2, this pin inputs system address bit 0 (A0).</li> <li>For MIPS/ISA Bus, this pin inputs system address bit 0 (SA0).</li> <li>For PC Card (PCMCIA) Bus, this pin must be connected to V<sub>SS</sub> or IO V<sub>DD</sub>.</li> <li>For Philips PR31500/31700 Bus, this pin inputs system address bit 0 (A0).</li> <li>For Toshiba TX3912 Bus, this pin inputs system address bit 0 (A0).</li> <li>For PowerPC Bus, this pin inputs system address bit 31 (A31).</li> </ul> <p>See Table 4-10, "CPU Interface Pin Mapping," on page 34 for summary. See the respective AC Timing diagram for detailed functionality.</p>
AB[12:1]	I	14-25	H3, H2, H4, H1, H5, J3, J1, J4, K2, J5, K1, L2	C	Hi-Z	<ul style="list-style-type: none"> <li>For PowerPC Bus, these pins input the system address bits 19 through 30 (A[19:30]).</li> <li>For all other busses, these pins input the system address bits 12 through 1 (A[12:1]).</li> </ul> <p>See Table 4-10, "CPU Interface Pin Mapping," on page 34 for summary. See the respective AC Timing diagram for detailed functionality.</p>



Table 4-2 : Host Interface Pin Descriptions (Continued)

Pin Name	Type	QFP Pin #	PFBGA Pin #	Cell	RESET# State	Description
AB[16:13]	I	10-13	F1, G3, G2, G4	C	Hi-Z	<ul style="list-style-type: none"> <li>• For Philips PR31500/31700 Bus, these pins are connected to <math>V_{DD}</math>.</li> <li>• For Toshiba TX3912 Bus, these pins are connected to <math>V_{DD}</math>.</li> <li>• For PowerPC Bus, these pins input the system address bits 15 through 18 (A[15:18]).</li> <li>• For all other busses, these pins input the system address bits 16 through 13 (A[16:13]).</li> </ul> <p>See Table 4-10, "CPU Interface Pin Mapping," on page 34 for summary. See the respective AC Timing diagram for detailed functionality.</p>
AB17	I	9	G5	C	Hi-Z	<ul style="list-style-type: none"> <li>• For Philips PR31500/31700 Bus, this pin inputs the IO write command (/CARDIOWR).</li> <li>• For Toshiba TX3912 Bus, this pin inputs the IO write command (CARDIOWR*).</li> <li>• For PowerPC Bus, this pin inputs the system address bit 14 (A14).</li> <li>• For all other busses, this pin inputs the system address bit 17 (A17).</li> </ul> <p>See Table 4-10, "CPU Interface Pin Mapping," on page 34 for summary. See the respective AC Timing diagram for detailed functionality.</p>
AB18	I	8	F3	C	Hi-Z	<ul style="list-style-type: none"> <li>• For Philips PR31500/31700 Bus, this pin inputs the IO read command (/CARDIORD).</li> <li>• For Toshiba TX3912 Bus, this pin inputs the IO read command (CARDIORD*).</li> <li>• For PowerPC Bus, this pin inputs the system address bit 13 (A13).</li> <li>• For all other busses, this pin inputs the system address bit 18 (A18).</li> </ul> <p>See Table 4-10, "CPU Interface Pin Mapping," on page 34 for summary. See the respective AC Timing diagram for detailed functionality.</p>
AB19	I	7	E1	C	Hi-Z	<ul style="list-style-type: none"> <li>• For Philips PR31500/31700 Bus, this pin inputs the card control register access (/CARDREG).</li> <li>• For Toshiba TX3912 Bus, this pin inputs the card control register access (CARDREG*).</li> <li>• For PowerPC Bus, this pin inputs the system address bit 12 (A12).</li> <li>• For all other busses, this pin inputs the system address bit 19 (A19).</li> </ul> <p>See Table 4-10, "CPU Interface Pin Mapping," on page 34 for summary. See the respective AC Timing diagram for detailed functionality.</p>
AB20	I	6	E2	C	Hi-Z	<ul style="list-style-type: none"> <li>• For the MIPS/ISA Bus, this pin inputs system address bit 20. Note that for the ISA Bus, the unlatched LA20 must first be latched before input to AB20.</li> <li>• For Philips PR31500/31700 Bus, this pin inputs the address latch enable (ALE).</li> <li>• For Toshiba TX3912 Bus, this pin inputs the address latch enable (ALE).</li> <li>• For PowerPC Bus, this pin inputs the system address bit 11 (A11).</li> <li>• For all other busses, this pin inputs the system address bit 20 (A20).</li> </ul> <p>See Table 4-10, "CPU Interface Pin Mapping," on page 34 for summary. See the respective AC Timing diagram for detailed functionality.</p>

Table 4-2 : Host Interface Pin Descriptions (Continued)

Pin Name	Type	QFP Pin #	PFBGA Pin #	Cell	RESET# State	Description
DB[15:0]	IO	40-55	M6, P5, R5, T5, P6, R6, M7, P7, R7, T7, P8, R8, N8, T8, M8, P9	C/TS2	Hi-Z	<p>These pins are the system data bus.</p> <ul style="list-style-type: none"> <li>• For SH-3/SH-4 Bus, these pins are connected to D[15:0].</li> <li>• For MC68K Bus 1, these pins are connected to D[15:0].</li> <li>• For MC68K Bus 2, these pins are connected to D[31:16] for 32-bit devices (e.g. MC68030) or D[15:0] for 16-bit devices (e.g. MC68340).</li> <li>• For Generic Bus, these pins are connected to D[15:0].</li> <li>• For MIPS/ISA Bus, these pins are connected to SD[15:0].</li> <li>• For Philips PR31500/31700 Bus, pins DB[15:8] are connected to D[23:16] and pins DB[7:0] are connected to D[31:24].</li> <li>• For Toshiba TX3912 Bus, pins DB[15:8] are connected to D[23:16] and pins DB[7:0] are connected to D[31:24].</li> <li>• For PowerPC Bus, these pins are connected to D[0:15].</li> <li>• For PC Card (PCMCIA) Bus, these pins are connected to D[15:0].</li> </ul> <p>See Table 4-10, "CPU Interface Pin Mapping," on page 34 for summary. See the respective AC Timing diagram for detailed functionality.</p>
WE1#	IO	33	N1	CS/TS2	Hi-Z	<p>This is a multi-purpose pin:</p> <ul style="list-style-type: none"> <li>• For SH-3/SH-4 Bus, this pin inputs the write enable signal for the upper data byte (WE1#).</li> <li>• For MC68K Bus 1, this pin inputs the upper data strobe (UDS#).</li> <li>• For MC68K Bus 2, this pin inputs the data strobe (DS#).</li> <li>• For Generic Bus, this pin inputs the write enable signal for the upper data byte (WE1#).</li> <li>• For MIPS/ISA Bus, this pin inputs the system byte high enable signal (SBHE#).</li> <li>• For Philips PR31500/31700 Bus, this pin inputs the odd byte access enable signal (/CARDxCSH).</li> <li>• For Toshiba TX3912 Bus, this pin inputs the odd byte access enable signal (CARDxCSH*).</li> <li>• For PowerPC Bus, this pin outputs the burst inhibit signal (BI#).</li> <li>• For PC Card (PCMCIA) Bus, this pin inputs the card enable 2 signal (CE2#).</li> </ul> <p>See Table 4-10, "CPU Interface Pin Mapping," on page 34 for summary. See the respective AC Timing diagram for detailed functionality.</p>
M/R#	I	29	M2	C	Hi-Z	<ul style="list-style-type: none"> <li>• For Philips PR31500/31700 Bus, this pin is connected to <math>V_{DD}</math>.</li> <li>• For Toshiba TX3912 Bus, this pin is connected to <math>V_{DD}</math>.</li> <li>• For all other busses, this input pin is used to select between the display buffer and register address spaces of the S1D13806. M/R# is set high to access the display buffer and low to access the registers. See <i>Register Mapping</i>.</li> </ul> <p>See Table 4-10, "CPU Interface Pin Mapping," on page 34.</p>
CS#	I	28	K5	C	Hi-Z	<ul style="list-style-type: none"> <li>• For Philips PR31500/31700 Bus, this pin is connected to <math>V_{DD}</math>.</li> <li>• For Toshiba TX3912 Bus, this pin is connected to <math>V_{DD}</math>.</li> <li>• For all other busses, this is the Chip Select input.</li> </ul> <p>See Table 4-10, "CPU Interface Pin Mapping," on page 34. See the respective AC Timing diagram for detailed functionality.</p>

Table 4-2 : Host Interface Pin Descriptions (Continued)

Pin Name	Type	QFP Pin #	PFBGA Pin #	Cell	RESET# State	Description
BUSCLK	I	60	T10	C	Hi-Z	<p>This pin inputs the system bus clock. It is possible to apply a 2x clock and divide it by 2 internally - see CONF5 in <i>Summary of Configuration Options</i>.</p> <ul style="list-style-type: none"> <li>• For SH-3/SH-4 Bus, this pin is connected to CKIO.</li> <li>• For MC68K Bus 1, this pin is connected to CLK.</li> <li>• For MC68K Bus 2, this pin is connected to CLK.</li> <li>• For Generic Bus, this pin is connected to BCLK.</li> <li>• For MIPS/ISA Bus, this pin is connected to CLK.</li> <li>• For Philips PR31500/31700 Bus, this pin is connected to DCLKOUT.</li> <li>• For Toshiba TX3912 Bus, this pin is connected to DCLKOUT.</li> <li>• For PowerPC Bus, this pin is connected to CLKOUT.</li> <li>• For PC Card (PCMCIA) Bus, this pin is connected to an external input clock source.</li> </ul> <p>See Table 4-10, "CPU Interface Pin Mapping," on page 34 for summary. See the respective AC Timing diagram for detailed functionality.</p>
BS#	I	30	M1	CS	Hi-Z	<p>This is a multi-purpose pin:</p> <ul style="list-style-type: none"> <li>• For SH-3/SH-4 Bus, this pin inputs the bus start signal (BS#).</li> <li>• For MC68K Bus 1, this pin inputs the address strobe (AS#).</li> <li>• For MC68K Bus 2, this pin inputs the address strobe (AS#).</li> <li>• For Generic Bus, this pin is connected to <math>V_{DD}</math>.</li> <li>• For MIPS/ISA Bus, this pin is connected to <math>V_{DD}</math>.</li> <li>• For Philips PR31500/31700 Bus, this pin is connected to <math>V_{DD}</math>.</li> <li>• For Toshiba TX3912 Bus, this pin is connected to <math>V_{DD}</math>.</li> <li>• For PowerPC Bus, this pin inputs the Transfer Start signal (TS#).</li> <li>• For PC Card (PCMCIA) Bus, this pin is connected to <math>V_{DD}</math>.</li> </ul> <p>See Table 4-10, "CPU Interface Pin Mapping," on page 34 for summary. See the respective AC Timing diagram for detailed functionality.</p>
RD/WR#	I	34	P2	CS	Hi-Z	<p>This is a multi-purpose pin:</p> <ul style="list-style-type: none"> <li>• For SH-3/SH-4 Bus, this pin inputs the read write signal (RD/WR#). The S1D13806 needs this signal for early decode of the bus cycle.</li> <li>• For MC68K Bus 1, this pin inputs the read write signal (R/W#).</li> <li>• For MC68K Bus 2, this pin inputs the read write signal (R/W#).</li> <li>• For Generic Bus, this pin inputs the read command for the upper data byte (RD1#).</li> <li>• For MIPS/ISA Bus, this pin is connected to <math>V_{DD}</math>.</li> <li>• For Philips PR31500/31700 Bus, this pin inputs the even byte access enable signal (/CARDxCSL).</li> <li>• For Toshiba TX3912 Bus, this pin inputs the even byte access enable signal (CARDxCSL*).</li> <li>• For PowerPC Bus, this pin inputs the read write signal (RD/WR#).</li> <li>• For PC Card (PCMCIA) Bus, this pin inputs the card enable 1 signal (CE1#).</li> </ul> <p>See Table 4-10, "CPU Interface Pin Mapping," on page 34 for summary. See the respective AC Timing diagram for detailed functionality.</p>

Table 4-2 : Host Interface Pin Descriptions (Continued)

Pin Name	Type	QFP Pin #	PFBGA Pin #	Cell	RESET# State	Description
RD#	I	31	L4	CS	Hi-Z	<p>This is a multi-purpose pin:</p> <ul style="list-style-type: none"> <li>• For SH-3/SH-4 Bus, this pin inputs the read signal (RD#).</li> <li>• For MC68K Bus 1, this pin is connected to <math>V_{DD}</math>.</li> <li>• For MC68K Bus 2, this pin inputs the bus size bit 1 (SIZ1).</li> <li>• For Generic Bus, this pin inputs the read command for the lower data byte (RD0#).</li> <li>• For MIPS/ISA Bus, this pin inputs the memory read signal (MEMR#).</li> <li>• For Philips PR31500/31700 Bus, this pin inputs the memory read command (/RD).</li> <li>• For Toshiba TX3912 Bus, this pin inputs the memory read command (RD*).</li> <li>• For PowerPC Bus, this pin inputs the transfer size 0 signal (TSIZ0).</li> <li>• For PC Card (PCMCIA) Bus, this pin inputs the output enable signal (OE#).</li> </ul> <p>See Table 4-10, "CPU Interface Pin Mapping," on page 34 for summary. See the respective AC Timing diagram for detailed functionality.</p>
WE0#	I	32	M3	CS	Hi-Z	<p>This is a multi-purpose pin:</p> <ul style="list-style-type: none"> <li>• For SH-3/SH-4 Bus, this pin inputs the write enable signal for the lower data byte (WE0#).</li> <li>• For MC68K Bus 1, this pin must be connected to <math>V_{DD}</math>.</li> <li>• For MC68K Bus 2, this pin inputs the bus size bit 0 (SIZ0).</li> <li>• For Generic Bus, this pin inputs the write enable signal for the lower data byte (WE0#).</li> <li>• For MIPS/ISA Bus, this pin inputs the memory write signal (MEMW#).</li> <li>• For Philips PR31500/31700 Bus, this pin inputs the memory write command (/WE).</li> <li>• For Toshiba TX391 Bus, this pin inputs the memory write command (WE*).</li> <li>• For PowerPC Bus, this pin inputs the Transfer Size 1 signal (TSIZ1).</li> <li>• For PC Card (PCMCIA) Bus, this pin inputs the write enable signal (WE#).</li> </ul> <p>See Table 4-10, "CPU Interface Pin Mapping," on page 34 for summary. See the respective AC Timing diagram for detailed functionality.</p>
RESET#	I	35	P1	CS	0	<p>Active low input that clears all internal registers and forces all outputs to their inactive states. Note that active high RESET signals must be inverted before input to this pin.</p> <ul style="list-style-type: none"> <li>• For Toshiba TX3912 Bus, this pin is called NOP*.</li> </ul>

Table 4-2 : Host Interface Pin Descriptions (Continued)

Pin Name	Type	QFP Pin #	PFBGA Pin #	Cell	RESET# State	Description
WAIT#	IO	39	P4	C/TS2	Hi-Z	<p>The active polarity of the WAIT# output is configurable; the state of CONF[3:0] on the rising edge of RESET# defines the active polarity of WAIT# for some busses - see "Summary of Configuration Options".</p> <ul style="list-style-type: none"> <li>• For SH-3 Bus, this pin outputs the wait request signal (WAIT#).</li> <li>• For SH-4 Bus, this pin outputs the ready signal (RDY#).</li> <li>• For MC68K Bus 1, this pin outputs the data transfer acknowledge signal (DTACK#).</li> <li>• For MC68K Bus 2, this pin outputs the data transfer and size acknowledge bit 1 (DSACK1#).</li> <li>• For Generic Bus, this pin outputs the wait signal (WAIT#).</li> <li>• For MIPS/ISA Bus, this pin outputs the IO channel ready signal (IOCHRDY).</li> <li>• For Philips PR31500/31700 Bus, this pin outputs the wait state signal (/CARDxWAIT).</li> <li>• For Toshiba TX3912 Bus, this pin outputs the wait state signal (CARDxWAIT*).</li> <li>• For PowerPC Bus, this pin outputs the transfer acknowledge signal (TA#).</li> <li>• For PC Card (PCMCIA) Bus, this pin outputs the wait signal (WAIT#).</li> </ul> <p>See Table 4-10, "CPU Interface Pin Mapping," on page 34 for summary. See the respective AC Timing diagram for detailed functionality.</p>

**Note**

When WAIT# is always driven, WAIT# is in its inactive state at RESET#. CONF[3:0] determines whether WAIT# is active high or low.

## 4.2.2 LCD Interface

Table 4-3 : LCD Interface Pin Descriptions

Pin Name	Type	QFP Pin #	PFBGA Pin #	Cell	RESET# State	Description
FPDAT[23:0]	O	107-100, 91-90, 98-93, 87-80	C16, D14, F12, E14, D15, E16, E15, G12, G13, F15, G16, H12, G15, H13, H14, J12, J15, J14, K13, K15, K14, K12, L15, L14	CO2	0	Panel data bus. Not all pins are used for some panels - see Table 4-10, "CPU Interface Pin Mapping," on page 34 for details. Unused pins are driven low.
FPFRAME	O	74	P16	CO2	0	Frame pulse
FPLINE	O	75	N14	CO2	0	Line pulse
FPSHIFT	O	78	M15	CO2	0	Shift clock
DRDY	O	77	M14	CO2	0	<p>This is a multi-purpose pin:</p> <ul style="list-style-type: none"> <li>• For TFT/D-TFD panels this is the display enable output (DRDY).</li> <li>• For passive LCD with Format 1 interface this is the 2nd Shift Clock (FPSHIFT2).</li> <li>• For all other LCD panels this is the LCD backplane bias signal (MOD).</li> </ul> <p>See Table 4-11, "LCD Interface Pin Mapping," on page 35 and REG[030h] for details.</p>

## 4.2.3 MediaPlug Interface

Table 4-4 : MediaPlug Pin Description

Pin Name	Type	QFP Pin #	PFBGA Pin #	Cell	RESET# State	Description
VMP[7]	O	131	E8	CO2	0	MediaPlug VMPLCTL pin.
VMP[6]	I	130	B7	CD	Hi-Z	MediaPlug VMPRCTL pin. Internal pull-down resistors (typical value of 50K $\Omega$ at 3.3V respectively) pull the reset states to 0. External pull-up resistors can be used to pull the reset states to 1.
VMP[5:2]	IO	129-126	D8, A8, C8, E9	C/TS2U	0 or Hi-Z	MediaPlug VMPD[0:3] pins. See Section 17.3, "MediaPlug Interface Pin Mapping" on page 188. Internal pull-up resistors (typical value of 100K $\Omega$ at 3.3V respectively) pull the reset states to 1. External pull-down resistors can be used to pull the reset states to 0.
VMP[1]	O	125	A9	CO2	0	MediaPlug VMPCLK pin.
VMP[0]	O	124	D9	CO2	0	MediaPlug VMPCLKN pin.

**Note**

The RESET# states of VMP[5:2] are 0 if VMP is enabled, otherwise Hi-Z.

**Note**

When the MediaPlug interface is enabled, GPIO12 is configured as the MediaPlug output pin VMPEPWR.

## 4.2.4 CRT Interface

Table 4-5 : CRT Interface Pin Descriptions

Pin Name	Type	QFP Pin #	PFBGA Pin #	Cell	RESET# State	Description
HRTC	O	119	C10	CO2	0	Horizontal retrace signal for CRT
VRTC	O	120	B10	CO2	0	Vertical retrace signal for CRT
RED	O	112	E11	A	—	Analog output for CRT color Red / S-Video Luminance
GREEN	O	115	B12	A	—	Analog output for CRT color Green / Composite Video Out
BLUE	O	117	C11	A	—	Analog output for CRT color Blue / S-Video Chrominance
IREF	I	113	A13	A	—	Current reference for DAC. If the DAC is not needed, this pin must be left unconnected and floating.

## 4.2.5 General Purpose IO

Table 4-6 : General Purpose IO Pin Descriptions

Pin Name	Type	QFP Pin #	PFBGA Pin #	Cell	RESET# State	Description
GPIO12	IO	134	D7	C/TS2	1 or Hi-Z	Bi-directional GPIO pin. When the MediaPlug interface is enabled, GPIO12 is configured as the MediaPlug output pin VMPEPWR.
GPIO[11:0]	IO	135-137, 57, 61, 63, 65, 67-71	A6, E7, B5, N9, R11, T11, R12, R13, P12, M11, P13, T14	C/TS2	Hi-Z	Bi-directional GPIO pin.

**Note**

The RESET# state of GPIO12 is 1 if MediaPlug is enabled, otherwise Hi-Z.

## 4.2.6 Configuration

Table 4-7 : Configuration Pin Descriptions

Pin Name	Type	QFP Pin #	PFBGA Pin #	Cell	RESET# State	Description
CONF[7:0]	I	138-142, 2-4	A5, B4, C5, E6, C4, C1, D3, F5	C	Hi-Z	Input Configuration pin. State of pins are latched at RESET# to configure S1D13806 -- Table 4.3, "Summary of Configuration Options," on page 33 for details.

## 4.2.7 Miscellaneous

Table 4-8 : Miscellaneous Interface Pin Descriptions

Pin Name	Type	QFP Pin #	PFBGA Pin #	Cell	RESET# State	Description
CLKI	I	66	T12	C	Hi-Z	Input clock for the internal pixel clock (PCLK), memory clock (MCLK), and MediaPlug clock.
CLKI2	I	64	M10	C	Hi-Z	Input clock for the internal pixel clock (PCLK) and MediaPlug clock.
CLKI3	I	62	N10	C	Hi-Z	Input clock for memory clock (MCLK) (Possible to use for PCLK and MediaPlug clock.)
TESTEN	I	5	E3	CD	Hi-Z	Test Enable. This pin should be connected to V <sub>SS</sub> for normal operation.
DTESEN	I	56	T9	C	Hi-Z	Test Enable for embedded SDRAM. This pin should be connected to V <sub>SS</sub> for normal operation.
TEST	—	133	B6	—	—	Test Pin. <b>This pin must be left unconnected and floating.</b>
IOVDD	P	1, 37, 73, 92, 109, 123	E4, N5, M13, H16, D12, B9	P	—	V <sub>DD</sub> for IO (IO V <sub>DD</sub> )
COREVDD	P	27, 89, 122	L1, J16, C9	P	—	V <sub>DD</sub> for core (Core V <sub>DD</sub> )
AVDD	P	110, 114, 116	A14, C12, D11	P	—	V <sub>DD</sub> for DAC (DAC V <sub>DD</sub> ). When the DAC is not used this pin must be connected to DVDD.
DVDD	P	38, 132	A7, T3	P	—	V <sub>DD</sub> for embedded SDRAM (SDRAM V <sub>DD</sub> )
VSS	P	36, 59, 72, 79, 88, 99, 108, 121, 144	M4, M9, N12, M16, J13, F16, E13, A10, D5	P	—	V <sub>SS</sub>
AVSS	P	111, 118	B13, B11	P	—	V <sub>SS</sub> for DAC (DAC V <sub>SS</sub> )
DVSS	P	58, 143	A3, R10	P	—	V <sub>SS</sub> for embedded SDRAM (SDRAM V <sub>SS</sub> )
Reserved	—	76	L12	--	—	<b>This pin must be left unconnected and floating.</b>



### 4.3 Summary of Configuration Options

Table 4-9 : Summary of Power-On/Reset Options

Pin Name	state of this pin at rising edge of RESET# is used to configure:					(1/0)
	1					
CONF6, CONF[3:0]	Select host bus interface as follows:					
	<b>CONF6</b>	<b>CONF3</b>	<b>CONF2</b>	<b>CONF1</b>	<b>CONF0</b>	<b>Host Bus</b>
	0	0	0	0	0	Generic; Little Endian; Active Low WAIT# with tristate <sup>note</sup>
	1	0	0	0	0	Generic; Little Endian; Active Low WAIT# always driven
	0	0	0	0	1	Generic; Little Endian; Active High WAIT# with tristate <sup>note</sup>
	1	0	0	0	1	Reserved
	0	0	0	1	0	Generic; Big Endian; Active Low WAIT# with tristate <sup>note</sup>
	1	0	0	1	0	Generic; Big Endian; Active Low WAIT# always driven
	0	0	0	1	1	Generic; Big Endian; Active High WAIT# with tristate <sup>note</sup>
	1	0	0	1	1	Reserved
	0	0	1	0	0	MIPS/ISA; Little Endian; Active Low WAIT# with tristate <sup>note</sup>
	1	0	1	0	0	MIPS/ISA; Little Endian; Active Low WAIT# always driven
	0	0	1	0	1	MIPS/ISA; Little Endian; Active High WAIT# with tristate <sup>note</sup>
	1	0	1	0	1	Reserved
	0	0	1	1	0	MC68000; Big Endian; Active High WAIT# with tristate <sup>note</sup>
	1	0	1	1	0	Reserved
	0	0	1	1	1	MC68030; Big Endian; Active High WAIT# with tristate <sup>note</sup>
	1	0	1	1	1	Reserved
	0	1	0	0	0	PR31500/31700/TX3912; Little Endian; Active Low WAIT# with tristate <sup>note</sup>
	1	1	0	0	0	PR31500/31700/TX3912; Little Endian; Active Low WAIT# always driven
	0	1	0	0	1	PC Card; Little Endian; Active Low WAIT# with tristate <sup>note</sup>
	1	1	0	0	1	PC Card; Little Endian; Active Low WAIT# always driven
	0	1	0	1	0	Reserved
	1	1	0	1	0	Reserved
0	1	0	1	1	MPC821; Big Endian; Active High WAIT# with tristate <sup>note</sup>	
1	1	0	1	1	Reserved	
0	1	1	0	0	SH3; Little Endian; Active Low WAIT# with tristate <sup>note</sup>	
1	1	1	0	0	SH3; Little Endian; Active Low WAIT# always driven	
0	1	1	0	1	SH4; Little Endian; Active High WAIT# with tristate <sup>note</sup>	
1	1	1	0	1	Reserved	
0	1	1	1	0	SH3; Big Endian; Active Low WAIT# with tristate <sup>note</sup>	
1	1	1	1	0	SH3; Big Endian; Active Low WAIT# always driven	
0	1	1	1	1	SH4; Big Endian; Active High WAIT# with tristate <sup>note</sup>	
1	1	1	1	1	Reserved	
CONF4	Reserved. Must be tied to ground.					
CONF5	BUSCLK input divided by 2				BUSCLK input not divided	
CONF7	Configures GPIO12 as MediaPlug output pin VMPEPWR and enables MediaPlug functionality.				Configure GPIO12 for normal use and disables MediaPlug functionality.	

**Note**

WAIT# is tristated (high impedance) when the chip is not accessed by the host

## 4.4 Multiple Function Pin Mapping

Table 4-10 : CPU Interface Pin Mapping

S1D13806 Pin Names	Generic	Hitachi SH-4/SH-3	MIPS/ISA	Motorola MC68K Bus 1	Motorola MC68K Bus 2	Motorola PowerPC	PC Card	Philips PR31500 /PR31700	Toshiba TX3912
AB20	A20	A20	LatchA20	A20	A20	A11	A20	ALE	ALE
AB19	A19	A19	SA19	A19	A19	A12	A19	/CARDREG	CARDREG*
AB18	A18	A18	SA18	A18	A18	A13	A18	/CARDIORD	CARDIORD*
AB17	A17	A17	SA17	A17	A17	A14	A17	/CARDIOWR	CARDIOWR*
AB[16:13]	A[16:13]	A[16:13]	SA[16:13]	A[16:13]	A[16:13]	A[15:18]	A[16:13]	Connected to V <sub>DD</sub>	
AB[12:1]	A[12:1]	A[12:1]	SA[12:1]	A[12:1]	A[12:1]	A[19:30]	A[12:1]	A[12:1]	A[12:1]
AB0	Connected to V <sub>DD</sub> <sup>1</sup>	Connected to V <sub>DD</sub> <sup>1</sup>	SA0	LDS#	A0	A31	Connected to V <sub>DD</sub> <sup>1</sup>	A0	A0
DB[15:8]	D[15:0]	D[15:8]	SD[15:0]	D[15:8]	D[31:24]	D[0:7]	D[15:0]	D[23:16]	D[23:16]
DB[7:0]	D[7:0]	D[7:0]	SD[7:0]	D[7:0]	D[23:16]	D[8:15]	D[7:0]	D[31:24]	D[31:24]
WE1#	WE1#	WE1#	SBHE#	UDS#	DS#	Bl#	CE2#	/CARDxCSH	CARDxCSH*
M/R#	External Decode							Connected to V <sub>DD</sub>	
CS#	External Decode							Connected to V <sub>DD</sub>	
BUSCLK	BCLK	CKIO	CLK	CLK	CLK	CLKOUT	External Oscillator <sup>2</sup>	DCLKOUT	DCLKOUT
BS#	Connected to V <sub>DD</sub>	BS#	Connected to V <sub>DD</sub>	AS#	AS#	TS#	Connected to V <sub>DD</sub>	Connected to V <sub>DD</sub>	
RD/WR#	RD1#	RD/WR#	Connected to V <sub>DD</sub>	R/W#	R/W#	RD/WR#	CE1#	/CARDxCSL	CARDxCSL*
RD#	RD0#	RD#	MEMR#	Connected to V <sub>DD</sub>	SIZ1	TSIZ0	OE#	/RD	RD*
WE0#	WE0#	WE0#	MEMW#	Connected to V <sub>DD</sub>	SIZ0	TSIZ1	WE#	/WE	WE*
WAIT#	WAIT#	WAIT#	IOCHRDY	DTACK#	DSACK1#	TA#	WAIT#	/CARDxWAIT	CARDxWAIT*
RESET#	RESET#	RESET#	inverted RESET	RESET#	RESET#	RESET#	inverted RESET	RESET#	PON*

### Note

All GPIO pins default to input on reset and unless programmed otherwise, must be connected to either V<sub>SS</sub> or IO V<sub>DD</sub> if not used.

### Note

<sup>1</sup> AB0 is not used internally for these busses and must be connected to either V<sub>SS</sub> or IO V<sub>DD</sub>.

<sup>2</sup> For further information on interfacing the S1D13806 to the PC Card bus, see *Interfacing to the PC Card Bus*, document number X28B-G-005-xx.

## 4.5 LCD Interface Pin Mapping

Table 4-11 : LCD Interface Pin Mapping

S1D13806 Pin Names	Monochrome Passive Panel			Color Passive Panel						Color Active (TFT) Panel				
	Single		Dual	Single	Single Format 1	Single Format 2	Single	Dual						
	4-bit	8-bit	8-bit	4-bit	8-bit	8-bit	16-Bit	8-bit	16-bit	9-bit	12-bit	18-bit	2x9-bit	2x12-bit
FPFRAME	FPFRAME													
FPLINE	FPLINE													
FPSHIFT	FPSHIFT													
DRDY	MOD			FPSHIFT2	MOD					DRDY				
FPDAT0	driven 0	D0	LD0	driven 0	D0 (B5) <sup>1</sup>	D0 (G3) <sup>1</sup>	D0 (R6) <sup>1</sup>	LD0 (241-R2) <sup>1</sup>	LD0 (241-G3) <sup>1</sup>	R2	R3	R5	R02	R03
FPDAT1	driven 0	D1	LD1	driven 0	D1 (R5) <sup>1</sup>	D1 (R3) <sup>1</sup>	D1 (G5) <sup>1</sup>	LD1 (241-B1) <sup>1</sup>	LD1 (241-R3) <sup>1</sup>	R1	R2	R4	R01	R02
FPDAT2	driven 0	D2	LD2	driven 0	D2 (G4) <sup>1</sup>	D2 (B2) <sup>1</sup>	D2 (B4) <sup>1</sup>	LD2 (241-G1) <sup>1</sup>	LD2 (241-B2) <sup>1</sup>	R0	R1	R3	R00	R01
FPDAT3	driven 0	D3	LD3	driven 0	D3 (B3) <sup>1</sup>	D3 (G2) <sup>1</sup>	D3 (R4) <sup>1</sup>	LD3 (241-R1) <sup>1</sup>	LD3 (241-G2) <sup>1</sup>	G2	G3	G5	G02	G03
FPDAT4	D0	D4	UD0	D0 (R2) <sup>1</sup>	D4 (R3) <sup>1</sup>	D4 (R2) <sup>1</sup>	D8 (B5) <sup>1</sup>	UD0 (1-R2) <sup>1</sup>	UD0 (1-G3) <sup>1</sup>	G1	G2	G4	G01	G02
FPDAT5	D1	D5	UD1	D1 (B1) <sup>1</sup>	D5 (G2) <sup>1</sup>	D5 (B1) <sup>1</sup>	D9 (R5) <sup>1</sup>	UD1 (1-B1) <sup>1</sup>	UD1 (1-R3) <sup>1</sup>	G0	G1	G3	G00	G01
FPDAT6	D2	D6	UD2	D2 (G1) <sup>1</sup>	D6 (B1) <sup>1</sup>	D6 (G1) <sup>1</sup>	D10 (G4) <sup>1</sup>	UD2 (1-G1) <sup>1</sup>	UD2 (1-B2) <sup>1</sup>	B2	B3	B5	B02	B03
FPDAT7	D3	D7	UD3	D3 (R1) <sup>1</sup>	D7 (R1) <sup>1</sup>	D7 (R1) <sup>1</sup>	D11 (B3) <sup>1</sup>	UD3 (1-R1) <sup>1</sup>	UD3 (1-G2) <sup>1</sup>	B1	B2	B4	B01	B02
FPDAT8	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	D4 (G3) <sup>1</sup>	driven 0	LD4 (241-R2) <sup>1</sup>	B0	B1	B3	B00	B01
FPDAT9	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	D5 (B2) <sup>1</sup>	driven 0	LD5 (241-B1) <sup>1</sup>	driven 0	R0	R2	driven 0	R00
FPDAT10	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	D6 (R2) <sup>1</sup>	driven 0	LD6 (241-G1) <sup>1</sup>	driven 0	driven 0	R1	R12	R13
FPDAT11	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	D7 (G1) <sup>1</sup>	driven 0	LD7 (241-R1) <sup>1</sup>	driven 0	G0	G2	driven 0	G00
FPDAT12	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	D12 (R3) <sup>1</sup>	driven 0	UD4 (1-R2) <sup>1</sup>	driven 0	driven 0	G1	G12	G13
FPDAT13	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	D13 (G2) <sup>1</sup>	driven 0	UD5 (1-B1) <sup>1</sup>	driven 0	driven 0	G0	G11	G12
FPDAT14	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	D14 (B1) <sup>1</sup>	driven 0	UD6 (1-G1) <sup>1</sup>	driven 0	B0	B2	driven 0	B00
FPDAT15	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	D15 (R1) <sup>1</sup>	driven 0	UD7 (1-R1) <sup>1</sup>	driven 0	driven 0	B1	B12	B13
FPDAT16	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	B0	B11	B12
FPDAT17	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	R0	R11	R12
FPDAT18	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	R10	R11
FPDAT19	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	R10
FPDAT20	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	G10	G11
FPDAT21	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	G10
FPDAT22	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	B10	B11
FPDAT23	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	driven 0	B10

### Note

<sup>1</sup>These pin mappings use signal names commonly used for each panel type, however signal names may differ between panel manufacturers. The values shown in brackets represent the color components as mapped to the corresponding FPDATxx signals at the first valid edge of FPSHIFT. For further FPDATxx to LCD interface mapping, see Section 6.5, “Display Interface” on page 64.

## 4.6 CRT/TV Interface

The following figure shows external circuitry for the CRT/TV interface.

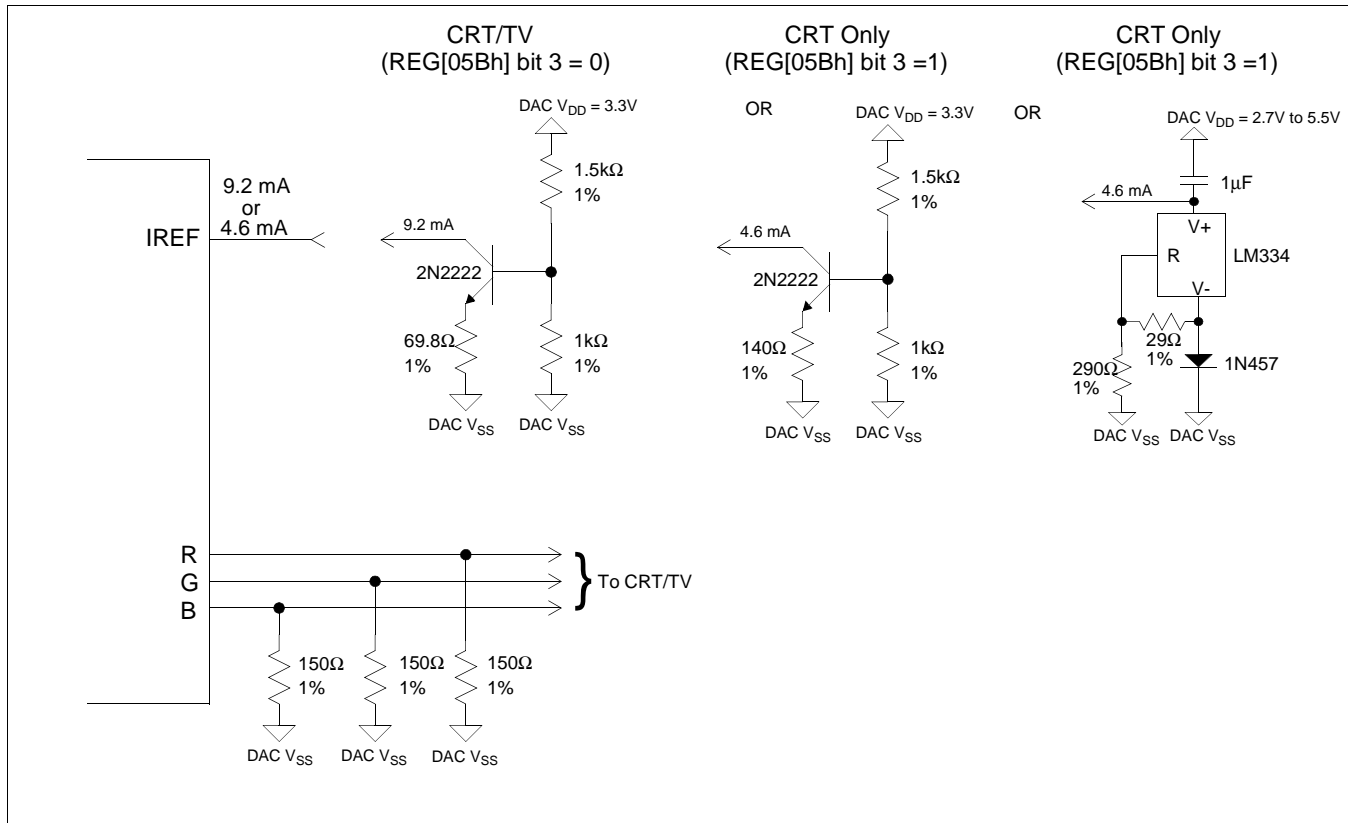


Figure 4-3: External Circuitry for CRT Interface

### Note

Example implementation only, individual characteristics of components may affect actual IREF current.

## 5 D.C. Characteristics

Table 5-1 : Absolute Maximum Ratings

Symbol	Parameter	Rating	Units
IO $V_{DD}$	Supply Voltage	$V_{SS} - 0.3$ to 4.0	V
Core $V_{DD}$	Supply Voltage	$V_{SS} - 0.3$ to 4.0	V
DAC $V_{DD}$	Supply Voltage	$V_{SS} - 0.3$ to 4.0	V
SDRAM $V_{DD}$	Supply Voltage	$V_{SS} - 0.3$ to 4.0	V
$V_{IN}$	Input Voltage	$V_{SS} - 0.3$ to $V_{DD} + 0.5$	V
$V_{OUT}$	Output Voltage	$V_{SS} - 0.3$ to $V_{DD} + 0.5$	V
$T_{STG}$	Storage Temperature	-65 to 150	° C
$T_{SOL}$	Solder Temperature/Time	260 for 10 sec. max at lead	° C

Table 5-2 : Recommended Operating Conditions

Symbol	Parameter	Condition	Min	Typ	Max	Units
IO $V_{DD}$	Supply Voltage	$V_{SS} = 0$ V	3.0	3.3	3.6	V
Core $V_{DD}$	Supply Voltage	$V_{SS} = 0$ V	3.0	3.3	3.6	V
DAC $V_{DD}$	Supply Voltage	$V_{SS} = 0$ V	3.0	3.3	3.6	V
SDRAM $V_{DD}$	Supply Voltage	$V_{SS} = 0$ V	3.0	3.3	3.6	V
$V_{IN}$	Input Voltage		$V_{SS}$		$V_{DD}$	V
$T_{OPR}$	Operating Temperature		-40	25	85	° C

Table 5-3 : Electrical Characteristics for VDD = 3.3V typical

Symbol	Parameter	Condition	Min	Typ	Max	Units	
I <sub>DDs</sub>	Quiescent Current	Quiescent Conditions			170	uA	
I <sub>Iz</sub>	Input Leakage Current	—	-1		1	μA	
I <sub>Oz</sub>	Output Leakage Current	—	-1		1	μA	
V <sub>OH</sub>	High Level Output Voltage	VDD = min I <sub>OH</sub> = -2mA (Type1), -6mA (Type2)	V <sub>DD</sub> - 0.3			V	
V <sub>OL</sub>	Low Level Output Voltage	VDD = min I <sub>OL</sub> = 2mA (Type1), 6mA (Type2)			0.3	V	
V <sub>IH</sub>	High Level Input Voltage	LVTTL level, V <sub>DD</sub> = max	2.0			V	
V <sub>IL</sub>	Low Level Input Voltage	LVTTL level, V <sub>DD</sub> = min			0.8	V	
V <sub>T+</sub>	High Level Input Voltage	LVTTL Schmitt	1.1		2.4	V	
V <sub>T-</sub>	Low Level Input Voltage	LVTTL Schmitt	0.6		1.8	V	
V <sub>H1</sub>	Hysteresis Voltage	LVTTL Schmitt	0.1			V	
R <sub>PD</sub>	Pull-Down Resistance	V <sub>I</sub> = V <sub>DD</sub>	Type 1	20	50	120	kΩ
			Type 2	40	100	240	kΩ
R <sub>PU</sub>	Pull-Up Resistance	V <sub>I</sub> = 0V	Type 1	20	50	120	kΩ
			Type 2	40	100	240	kΩ
C <sub>I</sub>	Input Pin Capacitance				10	pF	
C <sub>O</sub>	Output Pin Capacitance				10	pF	
C <sub>IO</sub>	Bi-Directional Pin Capacitance				10	pF	

## 6 A.C. Characteristics

Conditions:  $V_{DD} = 3.3V \pm 10\%$  (IO and Core)  
 $T_A = -40^\circ C$  to  $85^\circ C$   
 $T_{rise}$  and  $T_{fall}$  for all inputs must be  $\leq 5$  ns (10% ~ 90%)  
 $C_L = 50pF$  (CPU Interface), unless noted  
 $C_L = 100pF$  (LCD Panel Interface)  
 $C_L = 10pF$  (Display Memory Interface)  
 $C_L = 10pF$  (CRT Interface)

### 6.1 Clock Timing

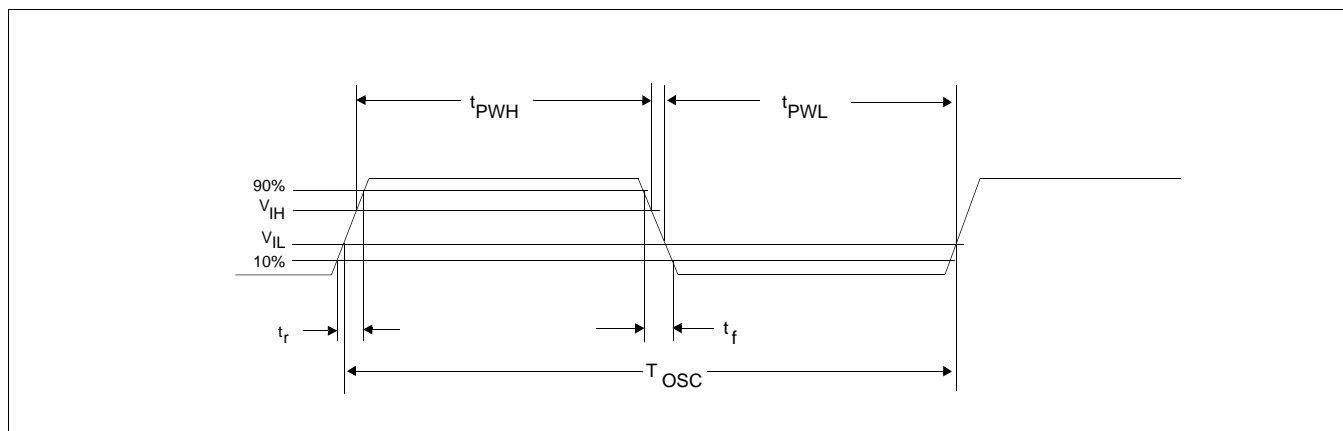


Figure 6-1: Clock Input Requirement

Table 6-1 : Clock Input Requirements for BUSCLK, CLKI, CLKI2, and CLKI3 When Not Divided

Symbol	Parameter	Min	Max	Units
$f_{OSC}$	Input Clock Frequency		Note	MHz
$T_{OSC}$	Input Clock Period	$1/f_{OSC}$		ns
$t_{PWH}$	Input Clock Pulse Width High	6		ns
$t_{PWL}$	Input Clock Pulse Width Low	6		ns
$t_f$	Input Clock Fall Time (10% - 90%)		5	ns
$t_r$	Input Clock Rise Time (10% - 90%)		5	ns

**Note**

For maximum internal clock frequency values see Table 6-4: “Internal Clock Requirements,” on page 41.

Table 6-2 : Clock Input Requirements for MCLK Source when Source Divided

Symbol	Parameter	Min	Max	Units
$f_{OSC}$	Input Clock Frequency		80	MHz
$T_{OSC}$	Input Clock Period	$1/f_{OSC}$		ns
$t_{PWH}$	Input Clock Pulse Width High	5.6		ns
$t_{PWL}$	Input Clock Pulse Width Low	5.6		ns
$t_f$	Input Clock Fall Time (10% - 90%)		5	ns
$t_r$	Input Clock Rise Time (10% - 90%)		5	ns

**Note**

For MCLK source selection see Section 7.3, “Clock Selection” on page 94.

**Note**

For maximum internal clock frequency values see Table 6-4: “Internal Clock Requirements,” on page 41.

Table 6-3 : Clock Input Requirements for LCD PCLK, CRT/TV PCLK, or MediaPlug Source when Source Divided

Symbol	Parameter	Min	Max	Units
$f_{OSC}$	Input Clock Frequency		100	MHz
$T_{OSC}$	Input Clock Period	$1/f_{OSC}$		ns
$t_{PWH}$	Input Clock Pulse Width High	4.5		ns
$t_{PWL}$	Input Clock Pulse Width Low	4.5		ns
$t_f$	Input Clock Fall Time (10% - 90%)		5	ns
$t_r$	Input Clock Rise Time (10% - 90%)		5	ns

**Note**

For PCLK source selection see Section 7.3, “Clock Selection” on page 94.

**Note**

For maximum internal clock frequency values see Table 6-4: “Internal Clock Requirements,” on page 41.



## 6.2 Internal Clocks

This section provides the minimum and maximum required frequencies of the internal clocks used by the S1D13806. For detailed information on the internal clocks, refer to Section 7, “Clocks” on page 92.

Table 6-4: Internal Clock Requirements

Symbol	Parameter	Min	Max	Units
$f_{MCLK}$	Memory Clock Frequency	5	50	MHz
$f_{LCD\ PCLK}$	LCD Pixel Clock Frequency		Note 1	MHz
$f_{CRT/TV\ PCLK}$	CRT/TV Pixel Clock Frequency		Note 2	MHz
$f_{MediaPlug\ Clock}$	MediaPlug Clock Frequency		20	MHz
$f_{BCLK}$	Internal Bus Clock Frequency		Note 3	MHz

### Note

1. The maximum LCD pixel clock for TFT panels is 65MHz.  
The maximum LCD pixel clock for passive panels is 40MHz.
2. The maximum CRT pixel clock is 65MHz.  
The TV pixel clock for NTSC output is fixed at 14.318MHz.  
The TV pixel clock for PAL output is fixed at 17.734MHz.
3. For maximum BCLK frequencies refer to the specific CPU Interface Timing in Section 6.3, “CPU Interface Timing” on page 42.

## 6.3 CPU Interface Timing

### 6.3.1 Generic Interface Timing

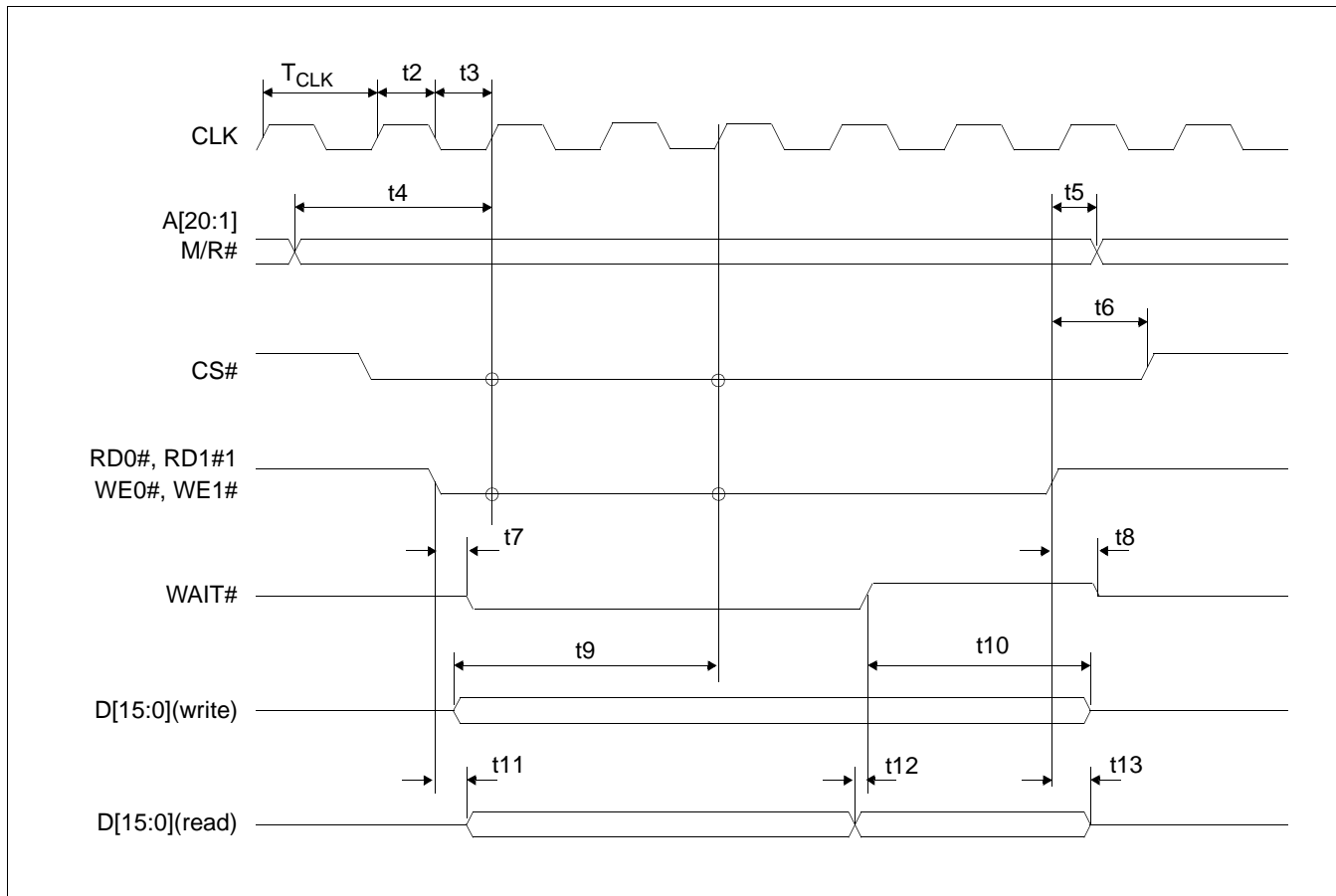


Figure 6-2: Generic Interface Timing

**Note**

BUSCLK cannot be divided by 2 for this interface. CONF5 must be set to 0 (BUSCLK not divided).

**Note**

WAIT# is always driven when CONF6 = 1.

Table 6-5 : Generic Interface Timing

Symbol	Parameter	Min	Max	Units
$f_{CLK}$	Clock Frequency		50	MHz
$T_{CLK}$	Clock period	$1/f_{CLK}$		ns
t2	Clock pulse width high	6		ns
t3	Clock pulse width low	6		ns
t4	A[20:1], M/R# setup to first CLK where CS# = 0 and either RD0#, RD1# = 0 or WE0#, WE1# = 0	4		ns
t5	A[20:1], M/R# hold from rising edge of either RD0#, RD1# or WE0#, WE1#	0		ns
t6	CS# hold from rising edge of either RD0#, RD1# or WE0#, WE1#	0		ns
t7	Falling edge of either RD0#, RD1# or WE0#, WE1# to WAIT# driven low	5	15	ns
t8	Rising edge of either RD0#, RD1# or WE0#, WE1# to WAIT# tri-state	4	13	ns
t9	D[15:0] setup to third CLK where CS# = 0 and WE0#, WE1# = 0 (write cycle)	0		ns
t10	D[15:0] hold (write cycle)	0		ns
t11	Falling edge RD0#, RD1# to D[15:0] driven (read cycle)	3		ns
t12	D[15:0] setup to rising edge WAIT# (read cycle)	0		ns
t13	Rising edge of RD0#, RD1# to D[15:0] tri-state (read cycle)	3	10	ns

### 6.3.2 Hitachi SH-4 Interface Timing

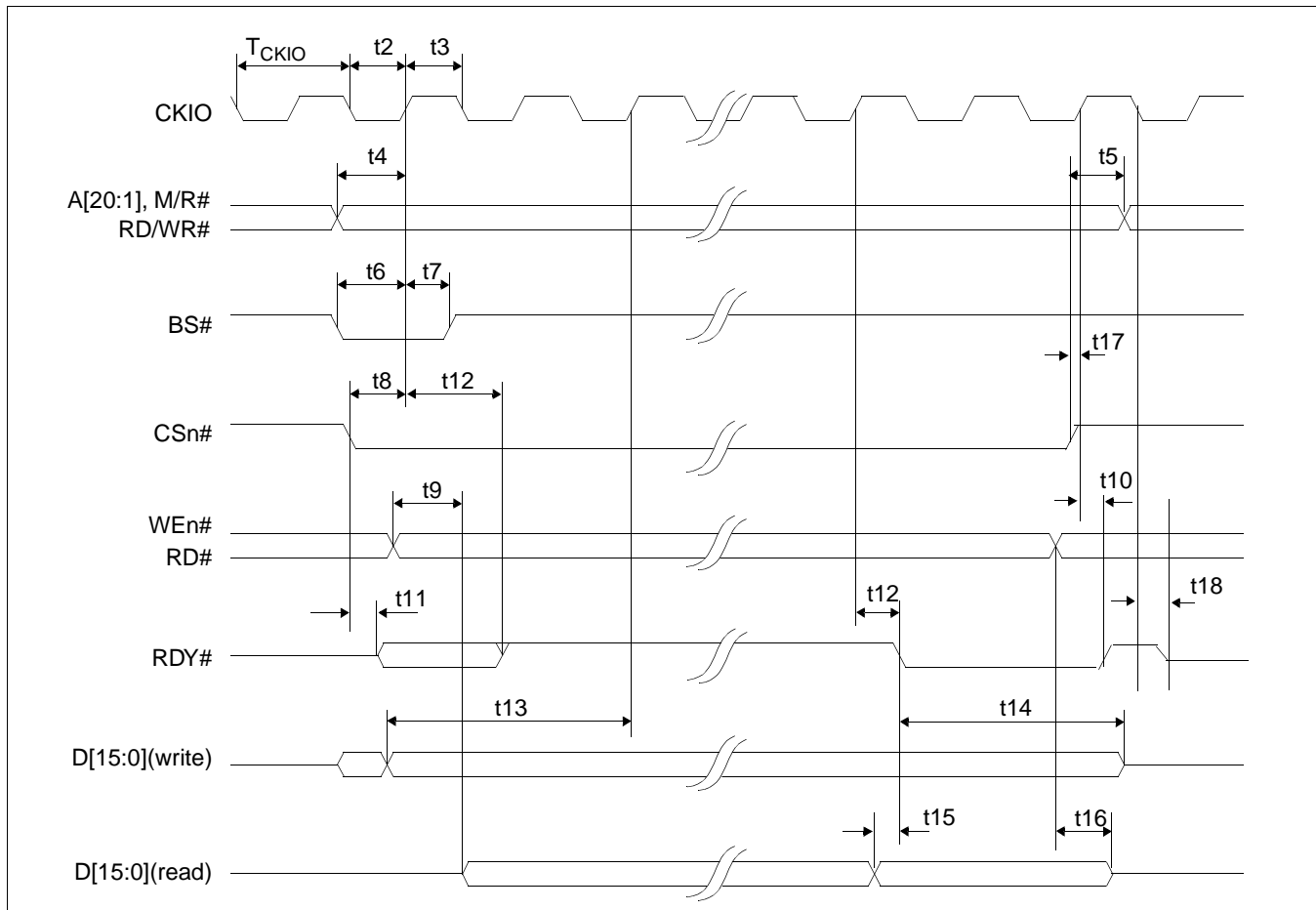


Figure 6-3: Hitachi SH-4 Interface Timing

**Note**

BUSCLK cannot be divided by 2 for this interface. CONF5 must be set to 0 (BUSCLK not divided).

**Note**

The SH-4 Wait State Control Register for the area in which the S1D13806 resides must be set to a non-zero value. The SH-4 read-to-write cycle transition must be set to a non-zero value (with reference to BUSCLK).

**Note**

RDY# is always driven when CONF6 = 1.

Table 6-6 : Hitachi SH-4 Interface Timing

Symbol	Parameter	Min <sup>1</sup>	Max <sup>1</sup>	Units
f <sub>CKIO</sub>	Clock Frequency		66	MHz
T <sub>CKIO</sub>	Clock period	1/f <sub>CKIO</sub>		ns
t <sub>2</sub>	Clock pulse width high	6		ns
t <sub>3</sub>	Clock pulse width low	6		ns
t <sub>4</sub>	A[20:1], M/R#, RD/WR# setup to CKIO	4		ns
t <sub>5</sub>	A[20:1], M/R#, RD/WR# hold from CS#	0		ns
t <sub>6</sub>	BS# setup	4		ns
t <sub>7</sub>	BS# hold	3		ns
t <sub>8</sub>	CSn# setup	3		ns
t <sub>9</sub>	Falling edge RD# to DB[15:0] driven	3		ns
t <sub>10</sub>	CKIO to RDY# high	4	22	ns
t <sub>11</sub>	Falling edge CSn# to RDY# driven	3	12	ns
t <sub>12</sub>	CKIO to RDY# delay	4	13	ns
t <sub>13</sub>	DB[15:0] setup to 2 <sup>nd</sup> CKIO after BS# (write cycle)	0		ns
t <sub>14</sub>	DB[15:0] hold (write cycle)	0		ns
t <sub>15</sub>	DB[15:0] valid to RDY# falling edge (read cycle)	0		ns
t <sub>16</sub>	Rising edge RD# to DB[15:0] tri-state (read cycle)	6	29	ns
t <sub>17</sub>	CSn# high setup to CKIO	3		ns
t <sub>18</sub>	Falling edge CKIO to RDY# tri-state	3	15	ns

**Note**

1. Two software WAIT states are required.

### 6.3.3 Hitachi SH-3 Interface Timing

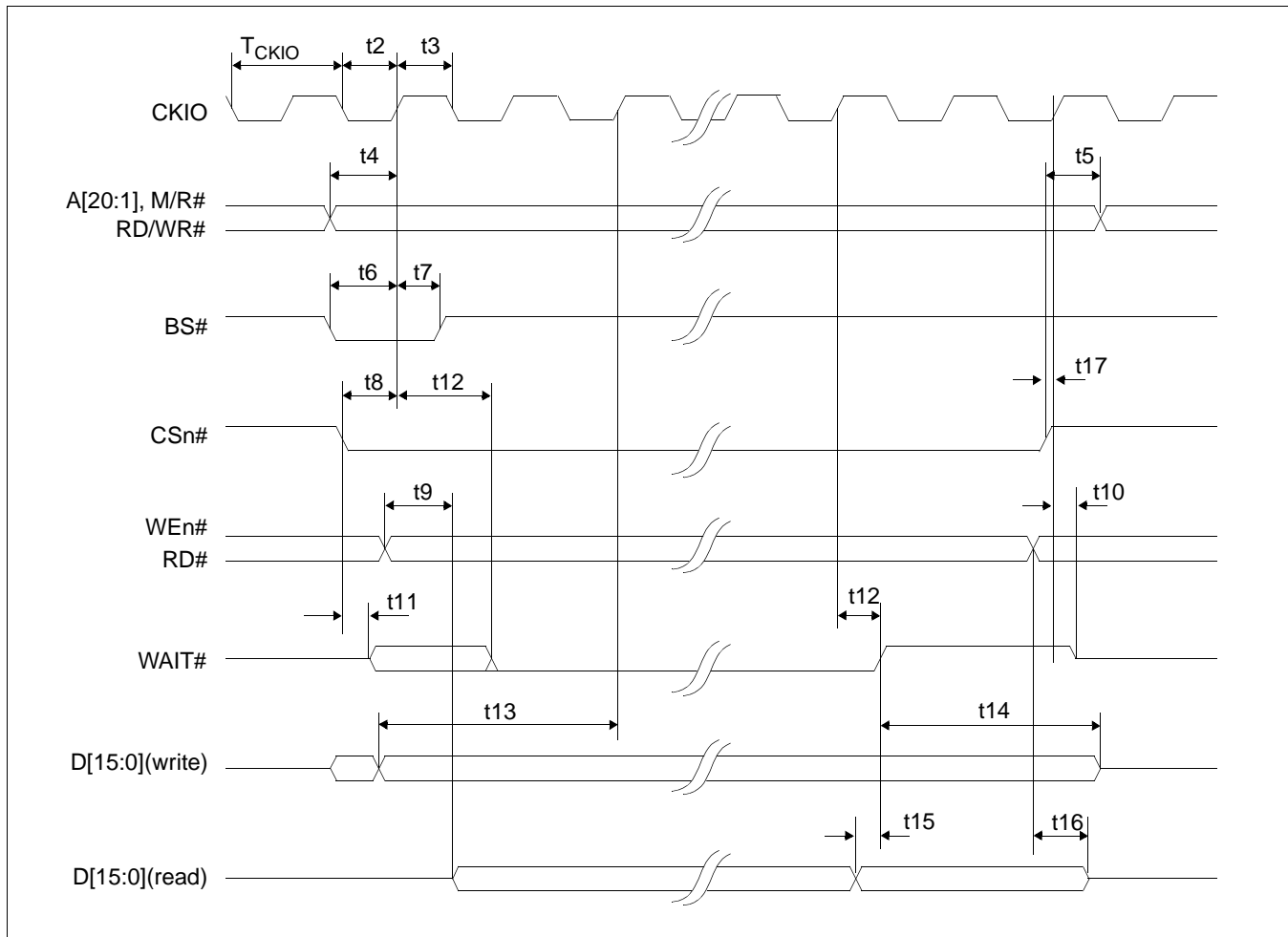


Figure 6-4: Hitachi SH-3 Interface Timing

**Note**

BUSCLK cannot be divided by 2 for this interface. CONF5 must be set to 0 (BUSCLK not divided).

**Note**

The SH-3 Wait State Control Register for the area in which the S1D13806 resides must be set to a non-zero value.

**Note**

WAIT# is always driven when CONF6 =1.

Table 6-7 : Hitachi SH-3 Interface Timing

Symbol	Parameter	Min <sup>1</sup>	Max <sup>1</sup>	Units
f <sub>CKIO</sub>	Clock Frequency		66	MHz
T <sub>CKIO</sub>	Clock period	1/f <sub>CKIO</sub>		ns
t2	Clock pulse width high	6		ns
t3	Clock pulse width low	6		ns
t4	A[20:1], M/R#, RD/WR# setup to CKIO	4		ns
t5	A[20:1], M/R#, RD/WR# hold from CS#	0		ns
t6	BS# setup	4		ns
t7	BS# hold	3		ns
t8	CSn# setup	3		ns
t9	Falling edge RD# to DB[15:0] driven	3		ns
t10	Rising edge CSn# to WAIT# tri-state	4	17	ns
t11	Falling edge CSn# to WAIT# driven	3	16	ns
t12	CKIO to WAIT# delay	4	21	ns
t13	DB[15:0] setup to 2 <sup>nd</sup> CKIO after BS# (write cycle)	0		ns
t14	DB[15:0] hold (write cycle)	0		ns
t15	DB[15:0] valid to WAIT# rising edge (read cycle)	0		ns
t16	Rising edge RD# to DB[15:0] tri-state (read cycle)	6	29	ns
t17	CSn# high setup to CKIO	3		ns

**Note**

1. Two software WAIT states are required when f<sub>CKIO</sub> is greater than 33MHz.

### 6.3.4 MIPS/ISA Interface Timing (e.g. NEC VR41xx)

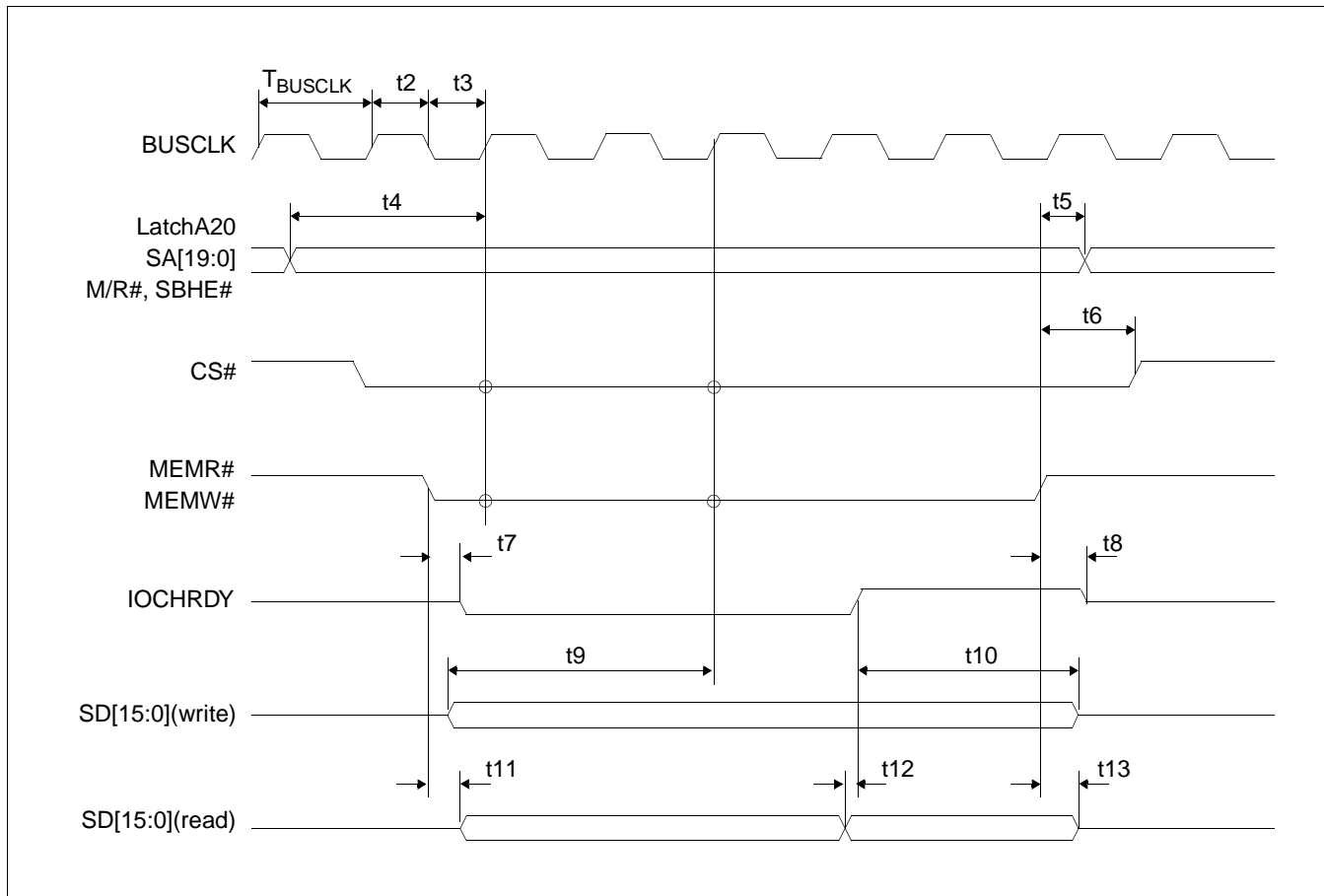


Figure 6-5: MIPS/ISA Interface Timing

**Note**

BUSCLK cannot be divided by 2 for this interface. CONF5 must be set to 0 (BUSCLK not divided).

**Note**

IOCHRDY is always driven when CONF6 =1.



Table 6-8 : MIPS/ISA Interface Timing

Symbol	Parameter	Min	Max	Units
$f_{\text{BUSCLK}}$	Clock Frequency		50	MHz
$T_{\text{BUSCLK}}$	Clock period	$1/f_{\text{BUSCLK}}$		ns
t2	Clock pulse width high	6		ns
t3	Clock pulse width low	6		ns
t4	LatchA20, SA[19:0], M/R#, SBHE# setup to first BUSCLK where CS# = 0 and either MEMR# = 0 or MEMW# = 0	4		ns
t5	LatchA20, SA[19:0], M/R#, SBHE# hold from rising edge of either MEMR# or MEMW#	0		ns
t6	CS# hold from rising edge of either MEMR# or MEMW#	0		ns
t7	Falling edge of either MEMR# or MEMW# to IOCHRDY# driven low	3	15	ns
t8	Rising edge of either MEMR# or MEMW# to IOCHRDY# tri-state	2	11	ns
t9	SD[15:0] setup to third BUSCLK where CS# = 0 MEMW# = 0 (write cycle)	0		ns
t10	SD[15:0] hold (write cycle)	0		ns
t11	Falling edge MEMR# toSD[15:0] driven (read cycle)	4		ns
t12	SD[15:0] setup to rising edge IOCHRDY# (read cycle)	0		ns
t13	Rising edge of MEMR# toSD[15:0] tri-state (read cycle)	6	29	ns

### 6.3.5 Motorola MC68K Bus 1 Interface Timing (e.g. MC68000)

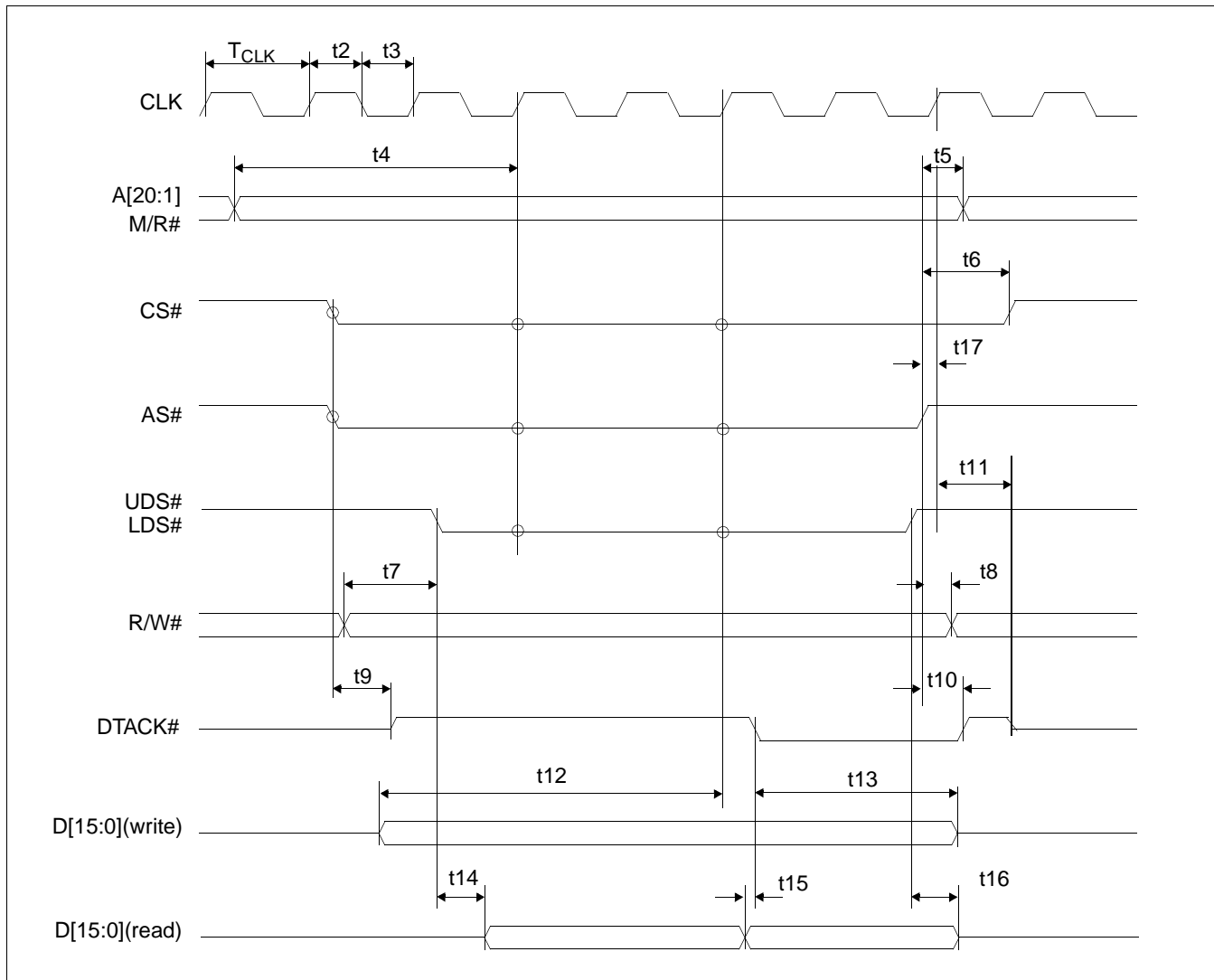


Figure 6-6: Motorola MC68K Bus 1 Interface Timing

**Note**

BUSCLK cannot be divided by 2 for this interface. CONF5 must be set to 0 (BUSCLK not divided).

**Note**

DTACK# is always driven when CONF6 =1.

Table 6-9 : Motorola MC68K Bus 1 Interface Timing

Symbol	Parameter	Min	Max	Units
$f_{CLK}$	Clock Frequency		50	MHz
$T_{CLK}$	Clock period	$1/f_{CLK}$		ns
t2	Clock pulse width high	6		ns
t3	Clock pulse width low	6		ns
t4	A[20:1], M/R# setup to first CLK where CS# = 0 AS# = 0, and either UDS#=0 or LDS# = 0	5		ns
t5	A[20:1], M/R# hold from AS#	0		ns
t6	CS# hold from AS#	0		ns
t7	R/W# setup to before to either UDS#=0 or LDS# = 0	10		ns
t8	R/W# hold from AS#	0		ns
t9	AS# = 0 and CS# = 0 to DTACK# driven high	1		ns
t10	AS# high to DTACK# high	4	19	ns
t11	First BCLK where AS# = 1 to DTACK# high impedance		16	ns
t12	D[15:0] valid to third CLK where CS# = 0 AS# = 0, and either UDS#=0 or LDS# = 0 (write cycle)	0		ns
t13	D[15:0] hold from falling edge of DTACK# (write cycle)	0		ns
t14	Falling edge of UDS#=0 or LDS# = 0 to DB driven (read cycle)	3		ns
t15	D[15:0] valid to DTACK# falling edge (read cycle)	0		ns
t16	UDS# and LDS# high to D[15:0] invalid/high impedance (read cycle)	6	30	ns
t17	AS# high setup to CLK	4		ns

### 6.3.6 Motorola MC68K Bus 2 Interface Timing (e.g. MC68030)

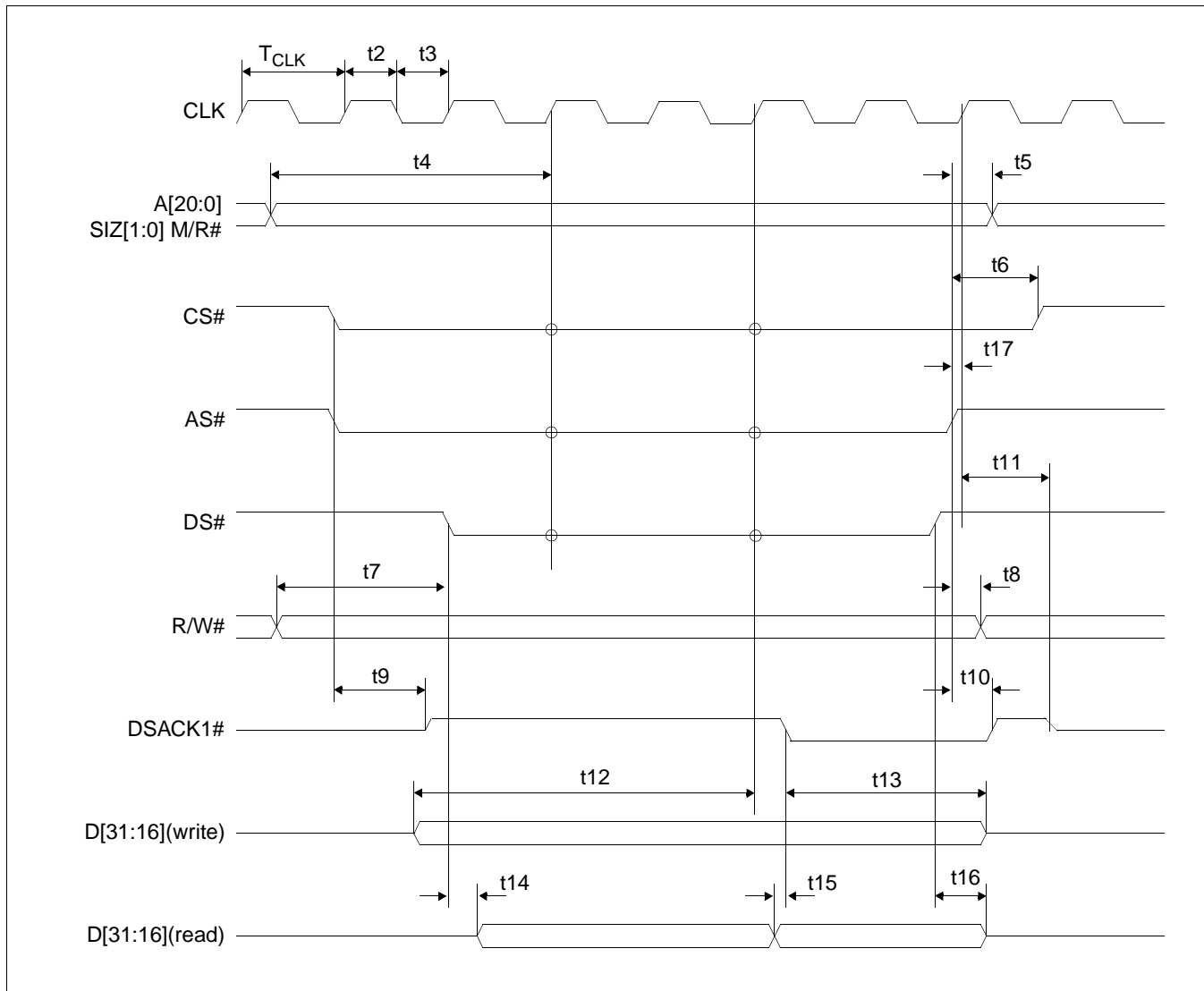


Figure 6-7: Motorola MC68K Bus 2 Interface Timing

**Note**

BUSCLK cannot be divided by 2 for this interface. CONF5 must be set to 0 (BUSCLK not divided).

**Note**

DSACK1# is always driven when CONF6 = 1.

Table 6-10 : Motorola MC68K Bus 2 Interface Timing

Symbol	Parameter	Min	Max	Units
$f_{CLK}$	Clock Frequency		50	MHz
$T_{CLK}$	Clock period	$1/f_{CLK}$		ns
t2	Clock pulse width high	6		ns
t3	Clock pulse width low	6		ns
t4	A[20:0], SIZ[1:0], M/R# setup to first CLK where CS# = 0 AS# = 0, and DS#= 0	5		ns
t5	A[20:0], SIZ[1:0], M/R# hold from AS#	0		ns
t6	CS# hold from AS#	0		ns
t7	R/W# setup to DS#	10		ns
t8	R/W# hold from AS#	0		ns
t9	AS# = 0 and CS# = 0 to DSACK1# driven high	1		ns
t10	AS# high to DSACK1# high	4	19	ns
t11	First BCLK where AS# = 1 to DSACK1# high impedance	3	16	ns
t12	D[31:16] valid to third CLK where CS# = 0 AS# = 0, and DS#= 0 (write cycle)	0		ns
t13	D[31:16] hold from falling edge of DSACK1# (write cycle)	0		ns
t14	Falling edge of DS#= 0 to DB driven (read cycle)	3		ns
t15	D[31:16] valid to DSACK1# falling edge (read cycle)	0		ns
t16	DS# high to D[31:16] invalid/high impedance (read cycle)	6	30	ns
t17	AS# high setup to CLK	4		ns

### 6.3.7 Motorola PowerPC Interface Timing (e.g. MPC8xx, MC68040, Coldfire)

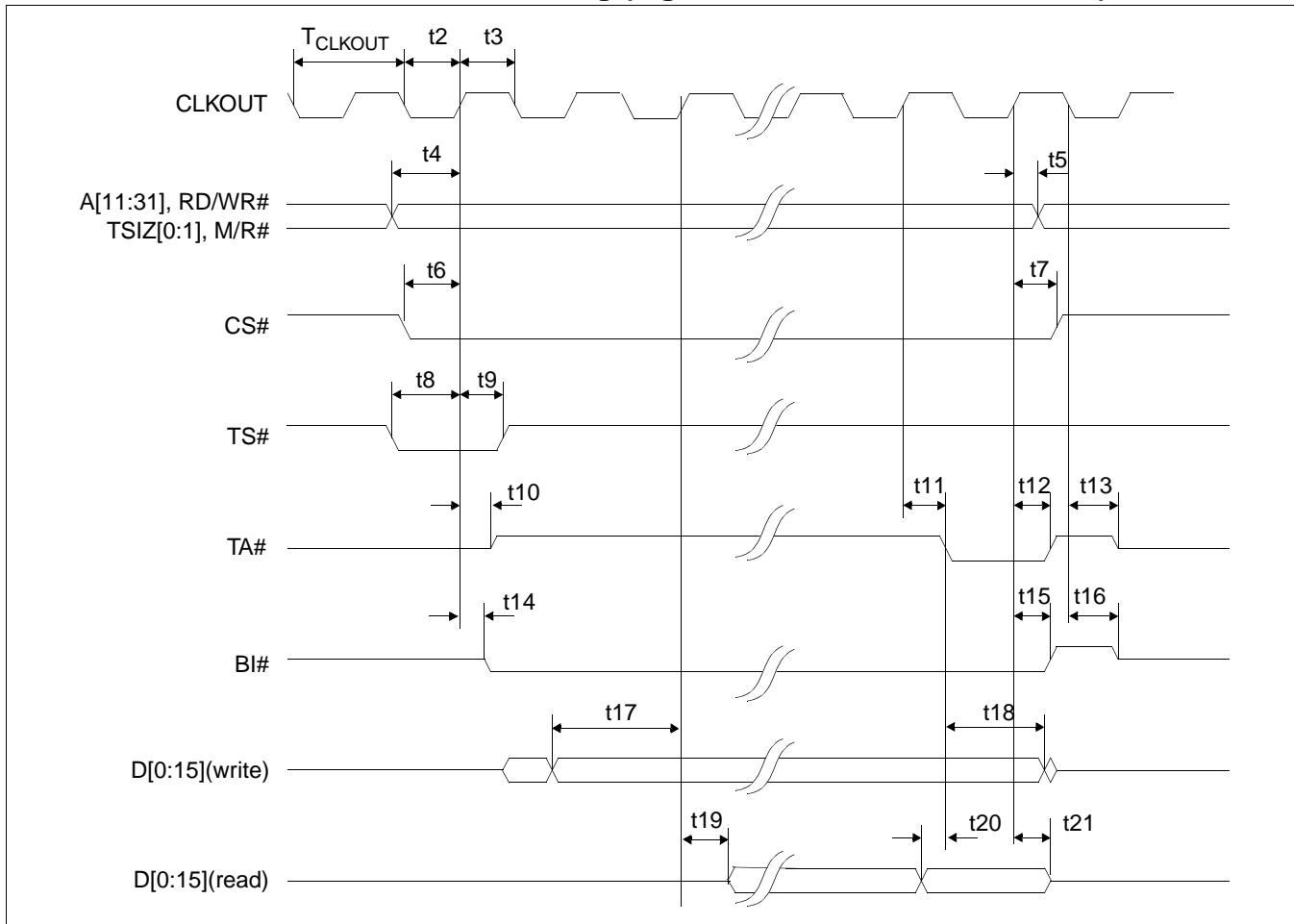


Figure 6-8: Motorola PowerPC Interface Timing

**Note**

BUSCLK cannot be divided by 2 for this interface. CONF5 must be set to 0 (BUSCLK not divided).

**Note**

TA# is always driven when CONF6 = 1.

Table 6-11 : Motorola PowerPC Interface Timing

Symbol	Parameter	Min	Max	Units
f <sub>CLKOUT</sub>	Clock Frequency		45	MHz
T <sub>CLKOUT</sub>	Clock period	1/f <sub>CLKOUT</sub>		ns
t2	Clock pulse width low	6		ns
t3	Clock pulse width high	6		ns
t4	AB[11:31], RD/WR#, TSIZ[0:1], M/R# setup	0		ns
t5	AB[11:31], RD/WR#, TSIZ[0:1], M/R# hold	0		ns
t6	CS# setup	1		ns
t7	CS# hold	1		ns
t8	TS# setup	1		ns
t9	TS# hold	1		ns
t10	CLKOUT to TA# driven	5		ns
t11	CLKOUT to TA# low	4	14	ns
t12	CLKOUT to TA# high	5	15	ns
t13	negative edge CLKOUT to TA# tri-state	3	12	ns
t14	CLKOUT to BI# driven	5	15	ns
t15	CLKOUT to BI# high	4	14	ns
t16	negative edge CLKOUT to BI# tri-state	3	9	ns
t17	DB[15:0] setup to 2nd CLKOUT after TS# = 0 (write cycle)	0		ns
t18	DB[15:0] hold (write cycle)	0		ns
t19	CLKOUT to DB driven (read cycle)	0		ns
t20	DB[15:0] valid to TA# falling edge (read cycle)	0		ns
t21	CLKOUT to DB[15:0] tri-state (read cycle)	3	11	ns

**Note**

Output pin loading on DB[15:0], TA#, BI# is 10pF.

### 6.3.8 PC Card Timing (e.g. StrongARM)

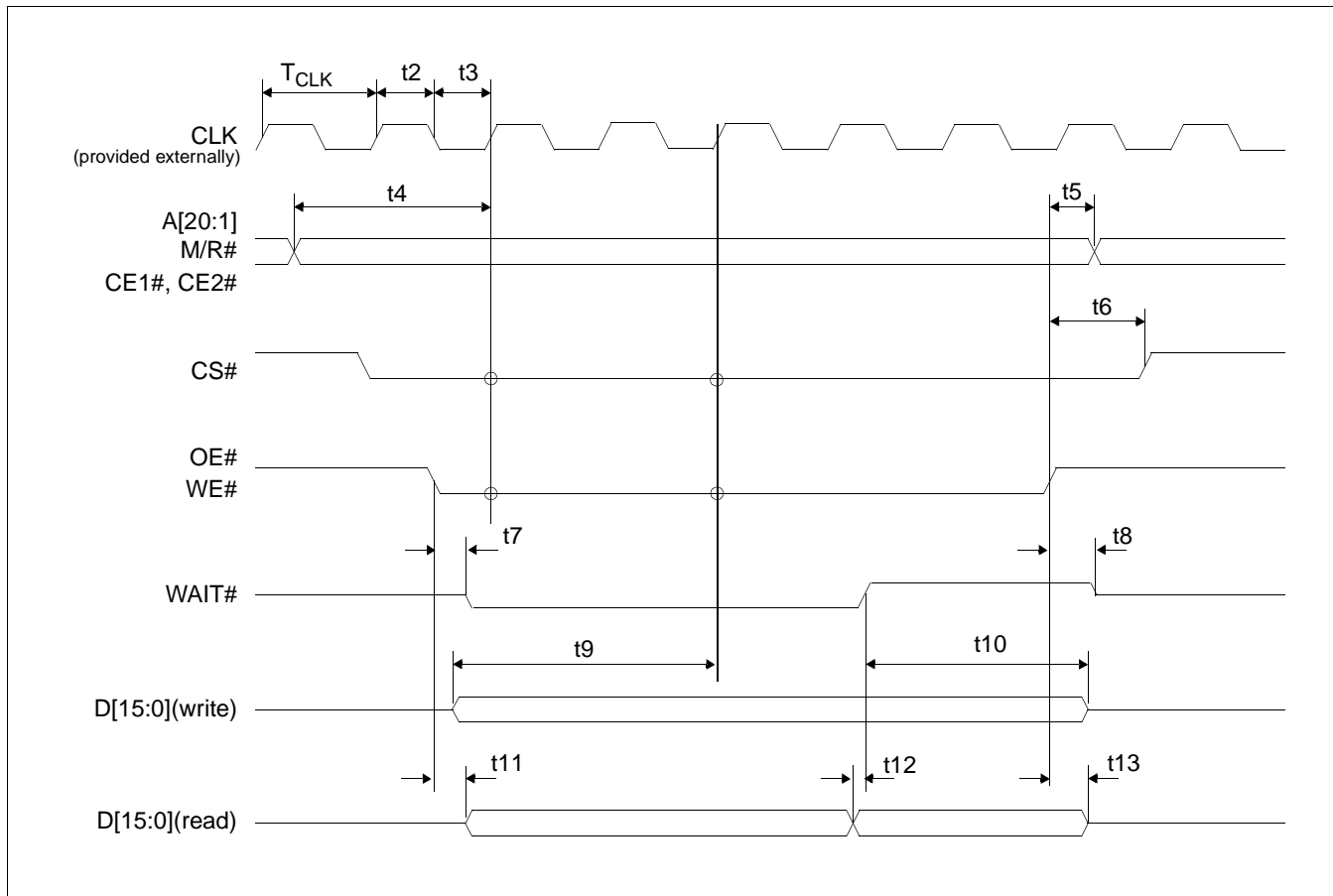


Figure 6-9: PC Card Timing

**Note**

BUSCLK cannot be divided by 2 for this interface. CONF5 must be set to 0 (BUSCLK not divided).



Table 6-12: PC Card Timing

Symbol	Parameter	Min	Max	Units
$f_{\text{CLK}}$	Clock frequency		50	MHz
$T_{\text{CLK}}$	Clock period	$1/f_{\text{CLK}}$		ns
t2	Clock pulse width high	6		ns
t3	Clock pulse width low	6		ns
t4	A[20:1], M/R# setup to first CLK where CE1# = 0 or CE2# = 0 and either OE# = 0 or WE# = 0	4		ns
t5	A[20:1], M/R# hold from rising edge of either OE# or WE#	0		ns
t6	CS# hold from rising edge of either OE# or WE#	0		ns
t7	Falling edge of either OE# or WE# to WAIT# driven low	5	15	ns
t8	Rising edge of either OE# or WE# to WAIT# tri-state	3	13	ns
t9	D[15:0] setup to third CLK where CE1# = 0, CE2# = 0 and WE# = 0 (write cycle)	0		ns
t10	D[15:0] hold (write cycle)	0		ns
t11	Falling edge OE# to D[15:0] driven (read cycle)	9		ns
t12	D[15:0] setup to rising edge WAIT# (read cycle)	0		ns
t13	Rising edge of OE# to D[15:0] tri-state (read cycle)	3	10	ns

### 6.3.9 Philips Interface Timing (e.g. PR31500/PR31700)

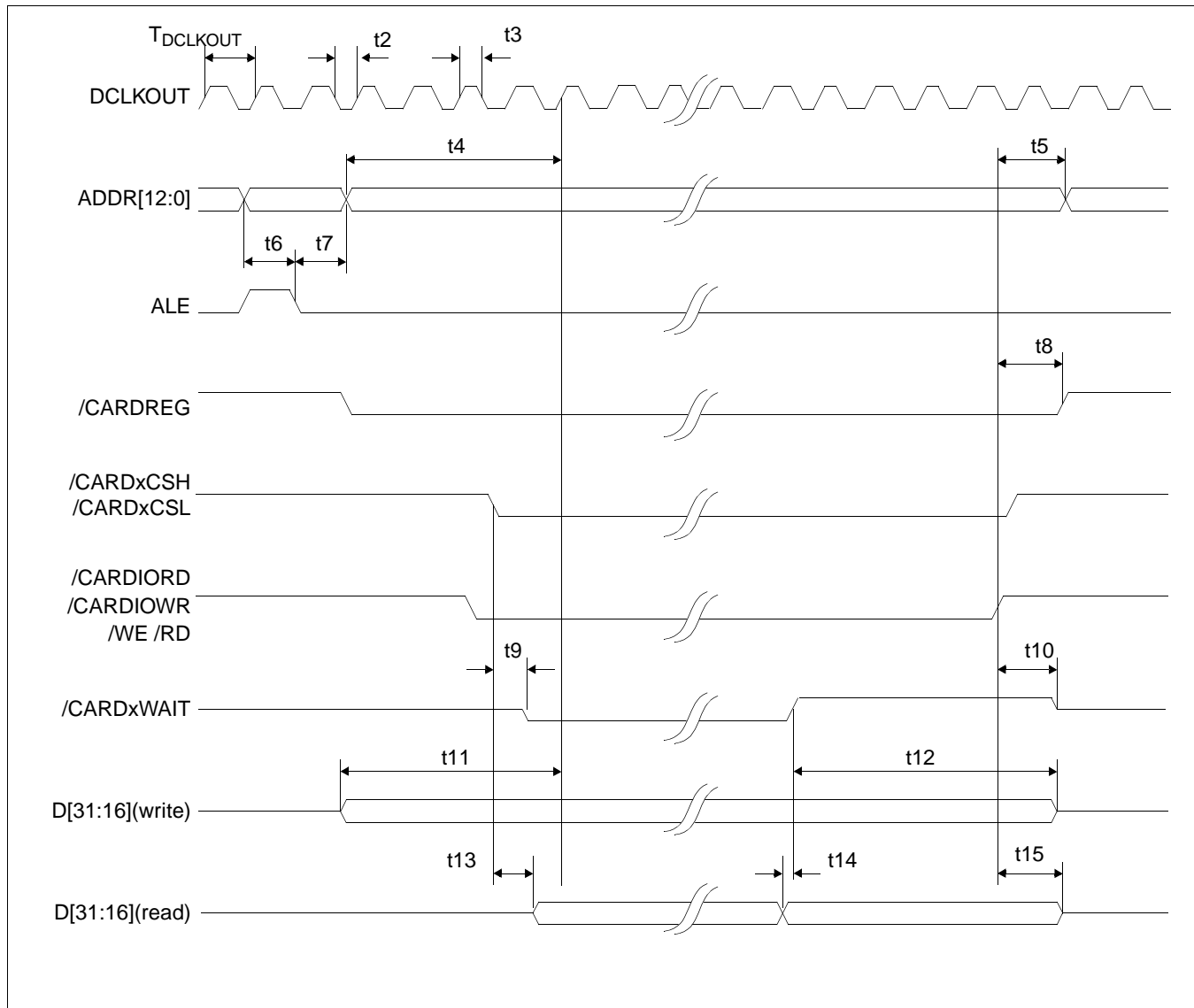


Figure 6-10: Philips Interface Timing

**Note**

/CARDxWAIT is always driven when CONF6 = 1.

Table 6-13 : Philips Interface Timing

Symbol	Parameter	Min	Max	Units
$f_{DCLKOUT}$	Clock frequency		75	MHz
$T_{DCLKOUT}$	Clock period	$1/f_{DCLKOUT}$		ns
t2	Clock pulse width low	6		ns
t3	Clock pulse width high	6		ns
t4	ADDR[12:0] setup to first CLK of cycle	10		ns
t5	ADDR[12:0] hold from command invalid	0		ns
t6	ADDR[12:0] setup to falling edge ALE	10		ns
t7	ADDR[12:0] hold from falling edge ALE	5		ns
t8	/CARDREG hold from command invalid	0		ns
t9	Falling edge of chip select to /CARDxWAIT driven	0	15	ns
t10	Command invalid to /CARDxWAIT tri-state	5	25	ns
t11	D[31:16] valid to first CLK of cycle (write cycle)	10		ns
t12	D[31:16] hold from rising edge of /CARDxWAIT	0		
t13	Chip select to D[31:16] driven (read cycle)	1		ns
t14	D[31:16] setup to rising edge /CARDxWAIT (read cycle)	0		ns
t15	Command invalid to D[31:16] tri-state (read cycle)	5	25	ns

**Note**

If BUSCLK exceeds 37.5MHz, it must be divided by 2 using CONF5 (see Table 4-9, “Summary of Power-On/Reset Options,” on page 33).

### 6.3.10 Toshiba Interface Timing (e.g. TX39xx)

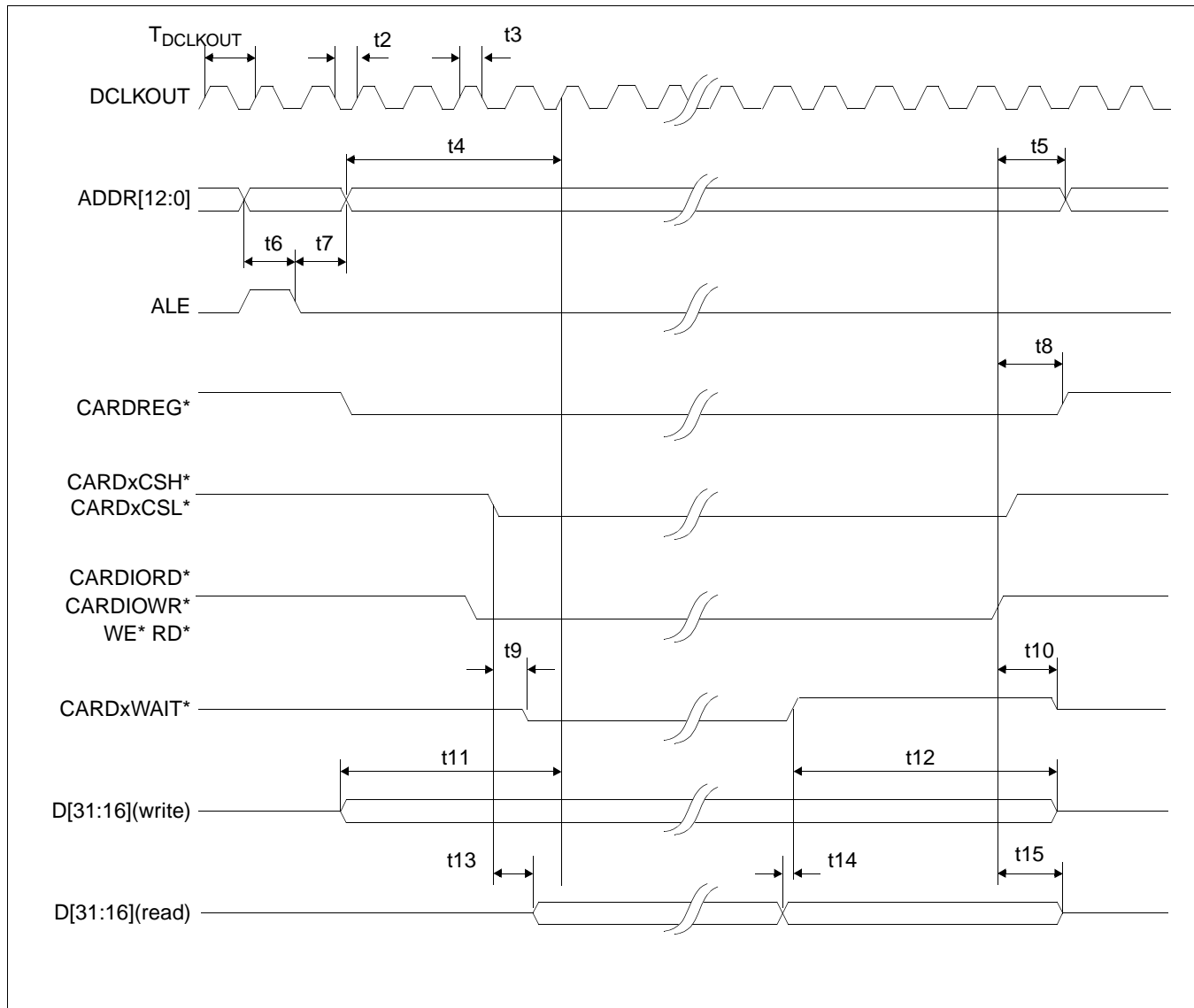


Figure 6-11: Toshiba Interface Timing

**Note**

CARDxWAIT\* is always driven when CONF6 =1.

Table 6-14 : Toshiba Interface Timing

Symbol	Parameter	Min	Max	Units
$f_{\text{DCLKOUT}}$	Clock frequency		75	MHz
$T_{\text{DCLKOUT}}$	Clock period	$1/f_{\text{DCLKOUT}}$		ns
t2	Clock pulse width low	6		ns
t3	Clock pulse width high	6		ns
t4	ADDR[12:0] setup to first CLK of cycle	10		ns
t5	ADDR[12:0] hold from command invalid	0		ns
t6	ADDR[12:0] setup to falling edge ALE	10		ns
t7	ADDR[12:0] hold from falling edge ALE	5		ns
t8	CARDREG* hold from command invalid	0		ns
t9	Falling edge of chip select to CARDxWAIT* driven	0	15	ns
t10	Command invalid to CARDxWAIT* tri-state	5	25	ns
t11	D[31:16] valid to first CLK of cycle (write cycle)	10		ns
t12	D[31:16] hold from rising edge of CARDxWAIT*	0		
t13	Chip select to D[31:16] driven (read cycle)	1		ns
t14	D[31:16] setup to rising edge CARDxWAIT* (read cycle)	0		ns
t15	Command invalid to D[31:16] tri-state (read cycle)	5	25	ns

**Note**

If BUSCLK exceeds 37.5MHz, it must be divided by 2 using CONF5 (see Table 4-9, “Summary of Power-On/Reset Options,” on page 33).

## 6.4 Power Sequencing

### 6.4.1 LCD Power Sequencing

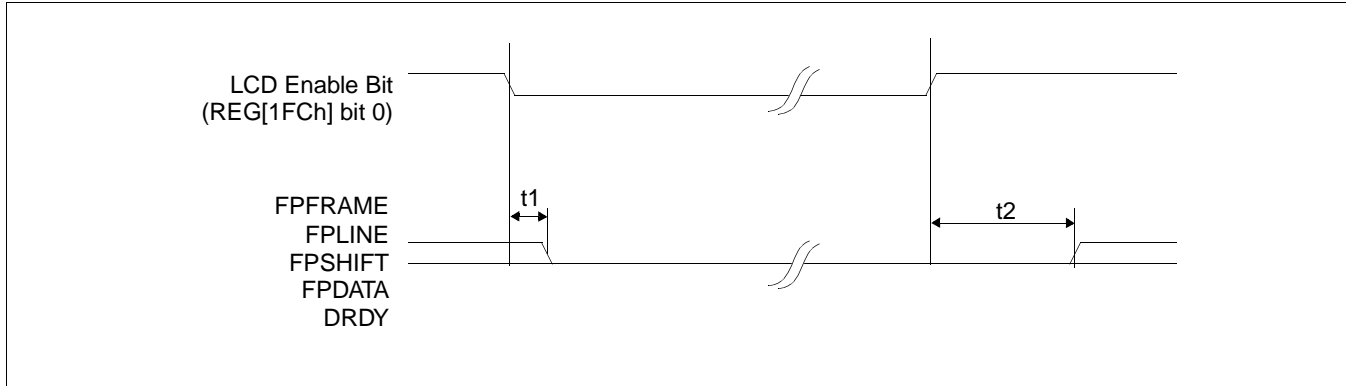


Figure 6-12: LCD Panel Power-off/Power-on Timing

Table 6-15 : LCD Panel Power-off/Power-on

Symbol	Parameter	Min	Max	Units
t1	LCD Enable Bit low to FPF, FPL, FPS, FPD, DRDY inactive		1	$T_{FPLINE}$
t2	LCD Enable Bit high to FPF, FPL, FPS, FPD, DRDY active	1	2	$T_{FPLINE}$

**Note**

Where  $T_{FPLINE}$  is the period of FPLINE.

**Note**

The above timing assumes REG[1F0h] bit 4 is set to 1.

## 6.4.2 Power Save Status

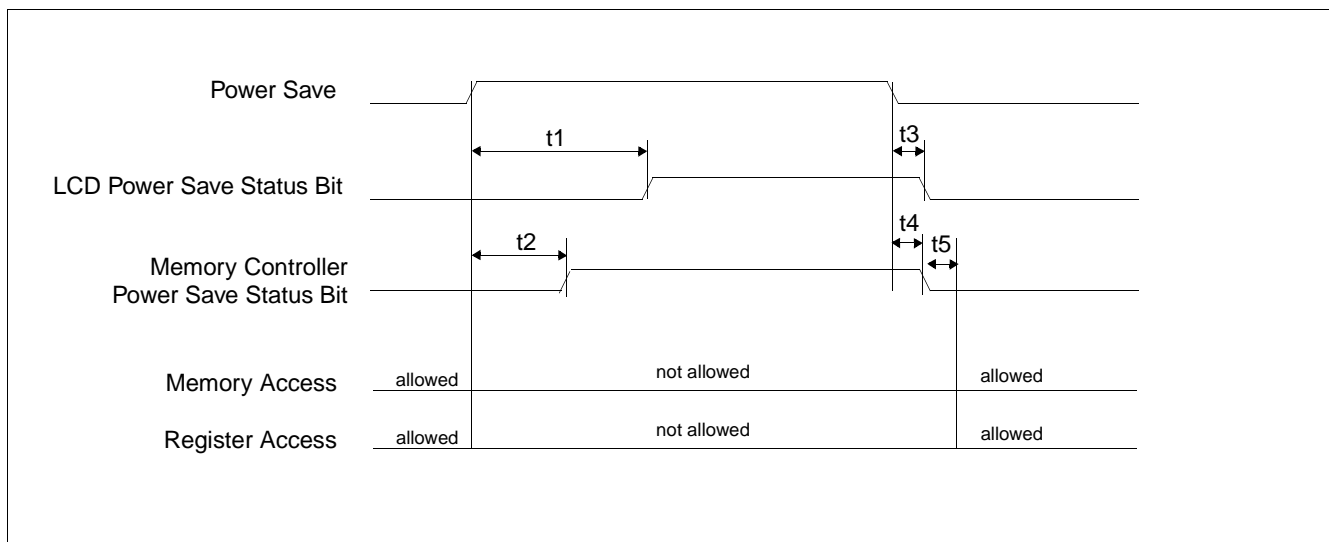


Figure 6-13: Power Save Status Bits and Local Bus Memory Access Relative to Power Save Mode

**Note**

Memory access should not be performed after Power Save Mode has been initiated.

**Note**

Power Save is initiated through the Power Save Mode Enable bit (REG[1F0h] bit 0).

Table 6-16 : Power Save Status and Local Bus Memory Access Relative to Power Save Mode

Symbol	Parameter	Min	Max	Units
t1	Power Save initiated to rising edge of LCD Power Save Status	1	2	T <sub>FPLINE</sub>
t2	Power Save initiated to rising edge of Memory Controller Power Save Status		note 1	MCLK
t3	Power Save deactivated to falling edge of LCD Power Save Status		1	T <sub>FPFRAME</sub>
t4	Power Save deactivated to falling edge of Memory Controller Power Save Status		12	MCLK
t5	Falling edge of Memory Controller Power Save Status to the earliest time where memory access is allowed		8	MCLK

- t<sub>2max</sub> = The maximum value for t2 is based on the SDRAM Refresh Rate (REG[021h] bits 2:0) as follows.

Table 6-17 : SDRAM Refresh Period Selection

REG[021h] bits 2:0	SDRAM Refresh Period (MCLKs)
000	76
001	140
010	268
011	524

## 6.5 Display Interface

### 6.5.1 Single Monochrome 4-Bit Panel Timing

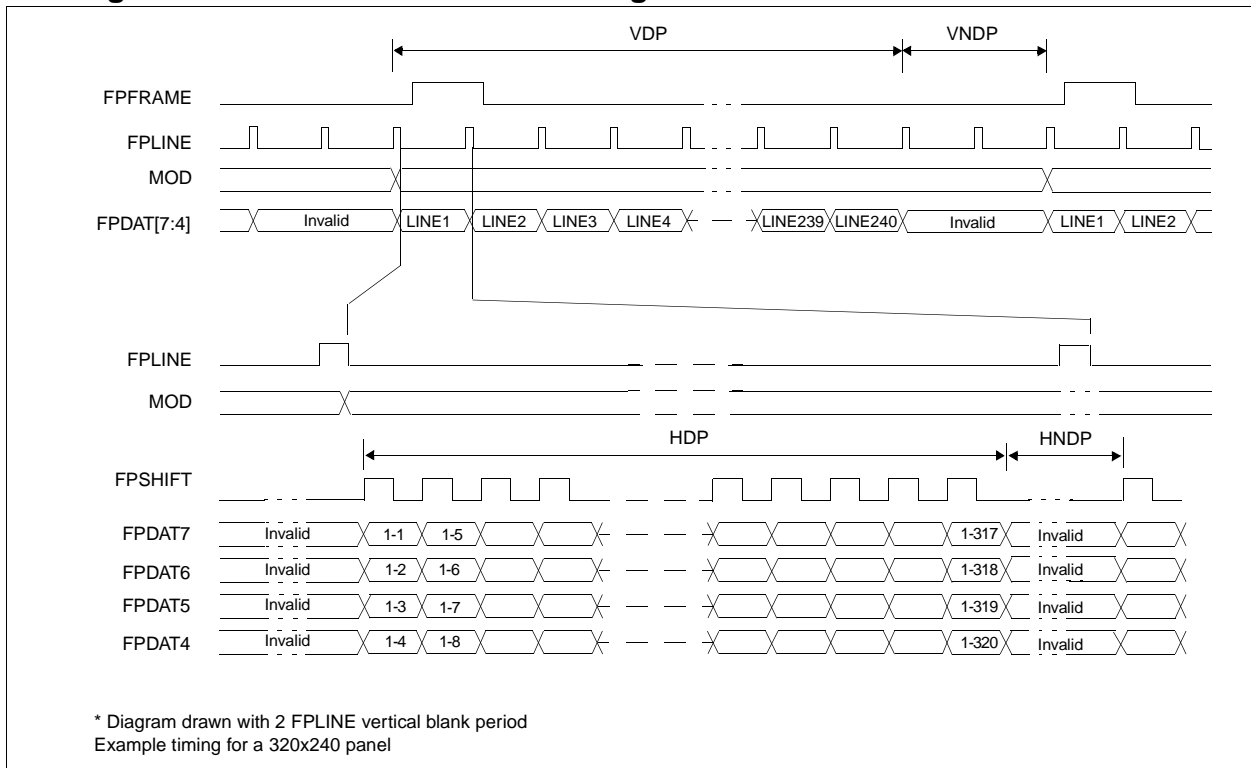


Figure 6-14: Single Monochrome 4-Bit Panel Timing

VDP =	Vertical Display Period	= (REG[039h] bits [1:0], REG[038h] bits [7:0]) + 1
VNDP =	Vertical Non-Display Period	= (REG[03Ah] bits [5:0]) + 1
HDP =	Horizontal Display Period	= ((REG[032h] bits [6:0]) + 1) × 8Ts
HNDP =	Horizontal Non-Display Period	= ((REG[034h] bits [4:0]) + 1) × 8Ts



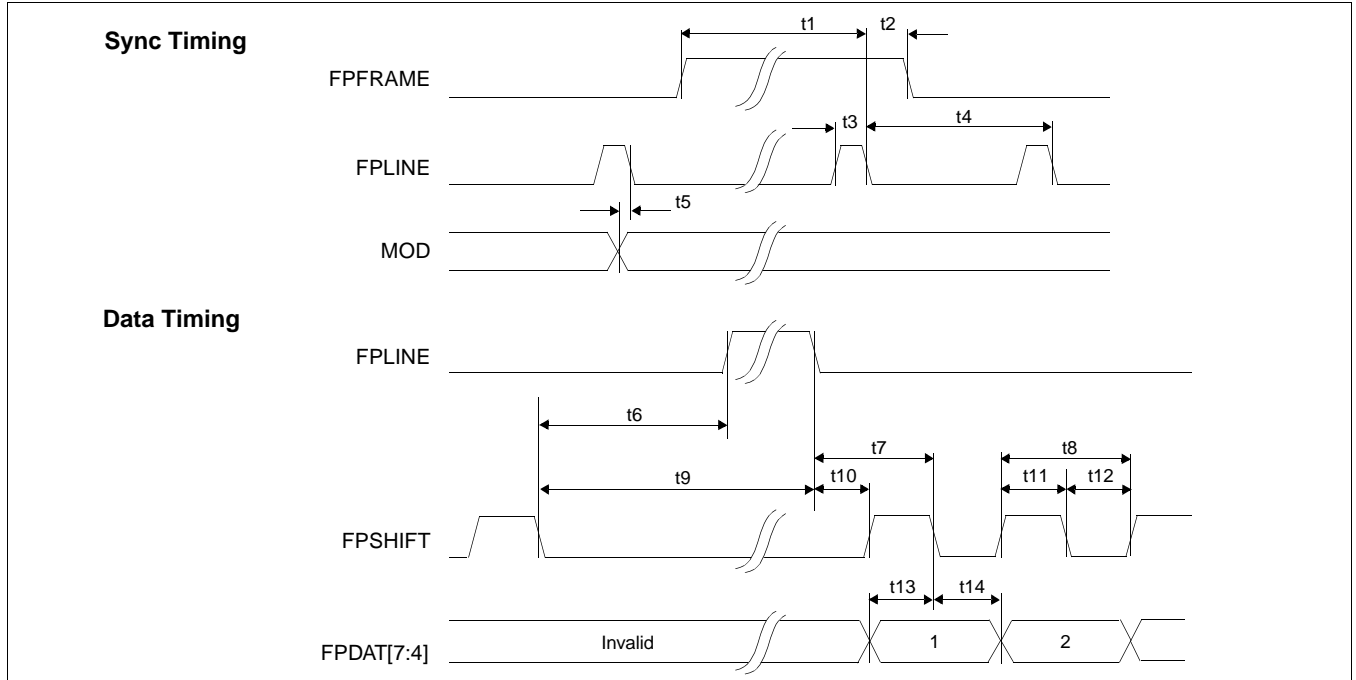


Figure 6-15: Single Monochrome 4-Bit Panel A.C. Timing

Table 6-18 : Single Monochrome 4-Bit Panel A.C. Timing

Symbol	Parameter	Min	Typ	Max	Units
t1	FPFRAME setup to FPLINE falling edge	note 2			Ts (note 1)
t2	FPFRAME hold from FPLINE falling edge	12			Ts
t3	FPLINE pulse width	11			Ts
t4	FPLINE period	note 3			Ts
t5	MOD transition to FPLINE falling edge	3		note 4	Ts
t6	FPSHIFT falling edge to FPLINE rising edge	note 5			Ts
t7	FPLINE falling edge to FPSHIFT falling edge	t10 + 2			Ts
t8	FPSHIFT period	4			Ts
t9	FPSHIFT falling edge to FPLINE falling edge	note 6			Ts
t10	FPLINE falling edge to FPSHIFT rising edge	note 7			Ts
t11	FPSHIFT pulse width high	2			Ts
t12	FPSHIFT pulse width low	2			Ts
t13	FPDAT[7:4] setup to FPSHIFT falling edge	2			Ts
t14	FPDAT[7:4] hold to FPSHIFT falling edge	2			Ts

- Ts = LCD pixel clock period. LCD pixel clock frequency is LCD pixel clock source divided by 1, 2, 3 or 4 (see REG[014h]).
- $t1_{min} = t4_{min} - 12$
- $t4_{min} = [((REG[032h] \text{ bits } [6:0]) + 1) \times 8 + ((REG[034h] \text{ bits } [4:0]) + 1) \times 8]$
- $t5_{max} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 + 3]$
- $t6_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 26]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 25]$  for 16 bpp color depth
- $t9_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 15]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 14]$  for 16 bpp color depth
- $t10_{min} = 17$  for 4 bpp or 8 bpp color depth  
 $= 16$  for 16 bpp color depth

## 6.5.2 Single Monochrome 8-Bit Panel Timing

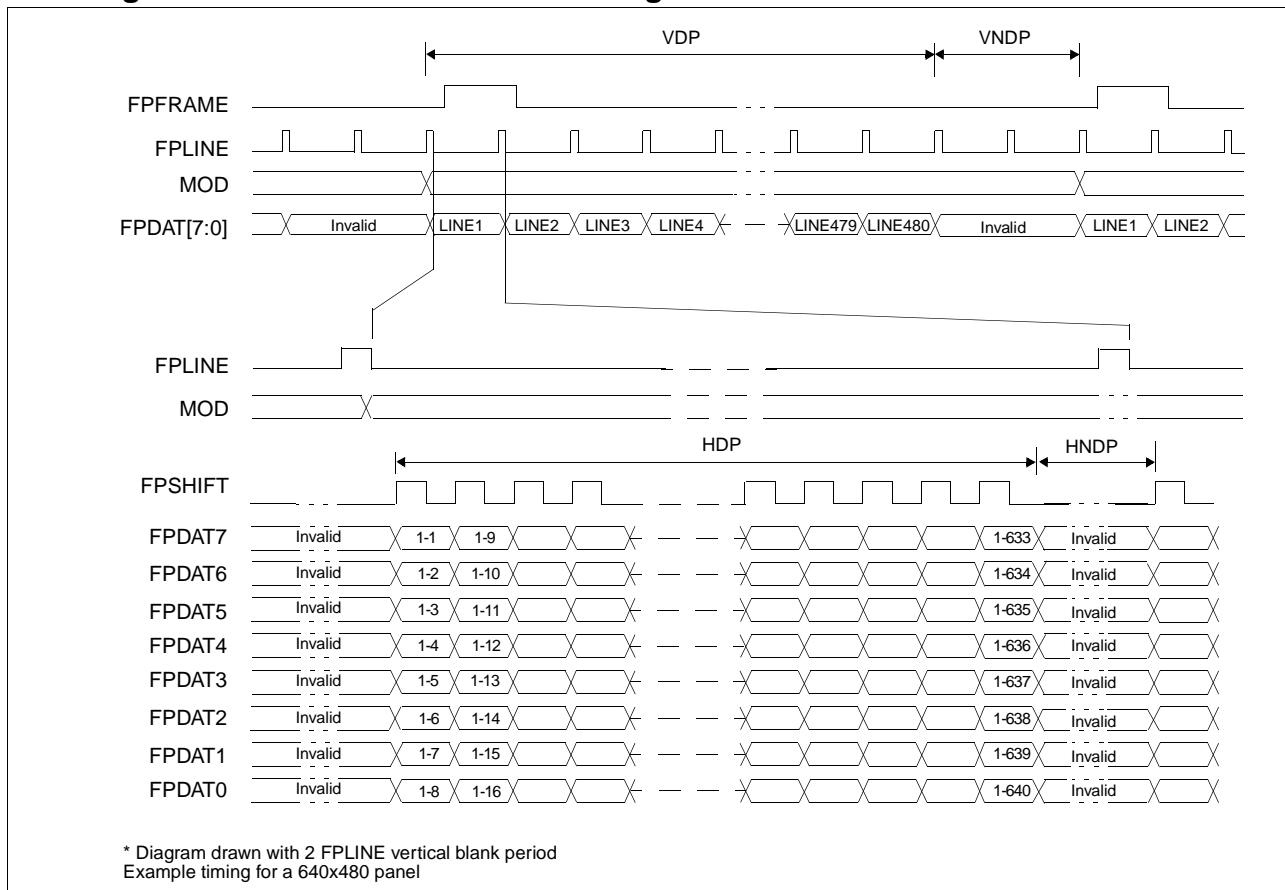


Figure 6-16: Single Monochrome 8-Bit Panel Timing

VDP	= Vertical Display Period	= (REG[039h] bits [1:0], REG[038h] bits [7:0]) + 1
VNDP	= Vertical Non-Display Period	= (REG[03Ah] bits [5:0]) + 1
HDP	= Horizontal Display Period	= ((REG[032h] bits [6:0]) + 1) × 8Ts
HNDP	= Horizontal Non-Display Period	= ((REG[034h] bits [4:0]) + 1) × 8Ts

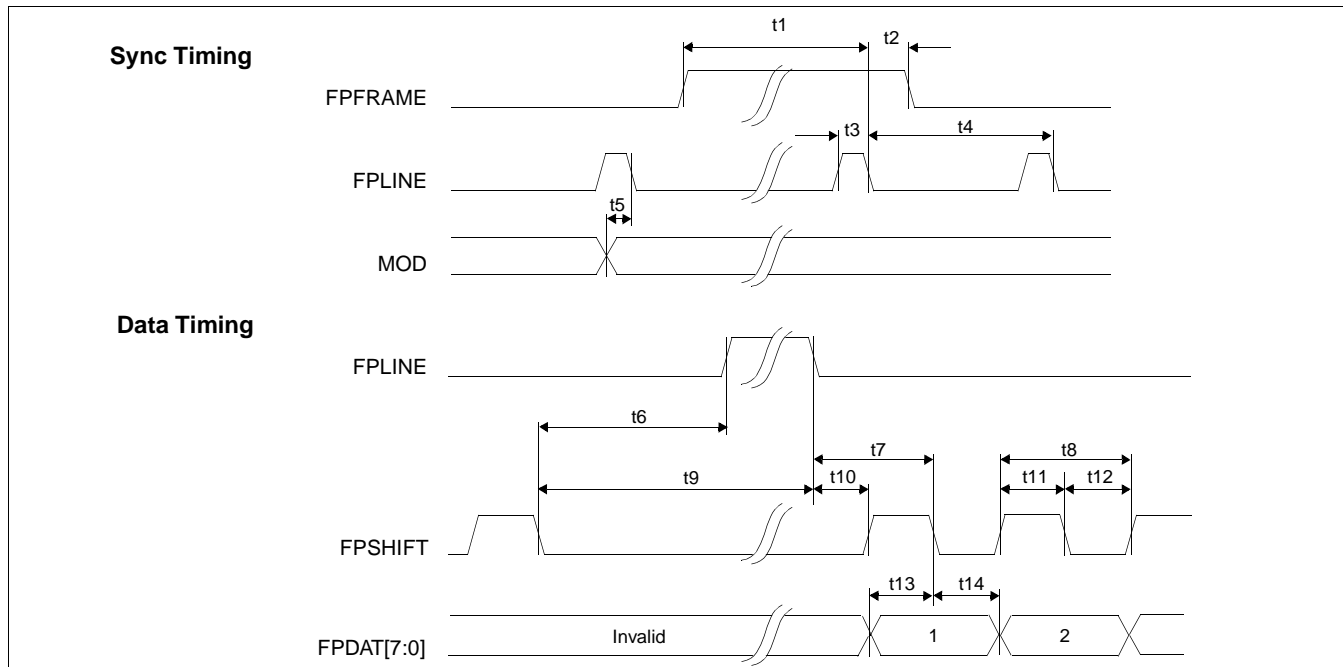


Figure 6-17: Single Monochrome 8-Bit Panel A.C. Timing

Table 6-19 : Single Monochrome 8-Bit Panel A.C. Timing

Symbol	Parameter	Min	Typ	Max	Units
t1	FPFRAME setup to FPLINE falling edge	note 2			Ts (note 1)
t2	FPFRAME hold from FPLINE falling edge	12			Ts
t3	FPLINE pulse width	11			Ts
t4	FPLINE period	note 3			Ts
t5	MOD transition to FPLINE falling edge	3		note 4	Ts
t6	FPSHIFT falling edge to FPLINE rising edge	note 5			Ts
t7	FPLINE falling edge to FPSHIFT falling edge	t10 + 4			Ts
t8	FPSHIFT period	8			Ts
t9	FPSHIFT falling edge to FPLINE falling edge	note 6			Ts
t10	FPLINE falling edge to FPSHIFT rising edge	note 7			Ts
t11	FPSHIFT pulse width high	4			Ts
t12	FPSHIFT pulse width low	4			Ts
t13	FPDAT[7:0] setup to FPSHIFT falling edge	4			Ts
t14	FPDAT[7:0] hold to FPSHIFT falling edge	4			Ts

1. Ts = LCD pixel clock period. LCD pixel clock frequency is LCD pixel clock source divided by 1, 2, 3 or 4 (see REG[014h]).
2.  $t1_{min} = t4_{min} - 12$
3.  $t4_{min} = [((REG[032h] \text{ bits } [6:0]) + 1) \times 8 + ((REG[034h] \text{ bits } [4:0]) + 1) \times 8]$
4.  $t5_{max} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 + 3]$
5.  $t6_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 24]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 23]$  for 16 bpp color depth
6.  $t9_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 13]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 12]$  for 16 bpp color depth
7.  $t10_{min} = 17$  for 4 bpp or 8 bpp color depth  
 $= 16$  for 16 bpp color depth

### 6.5.3 Single Color 4-Bit Panel Timing

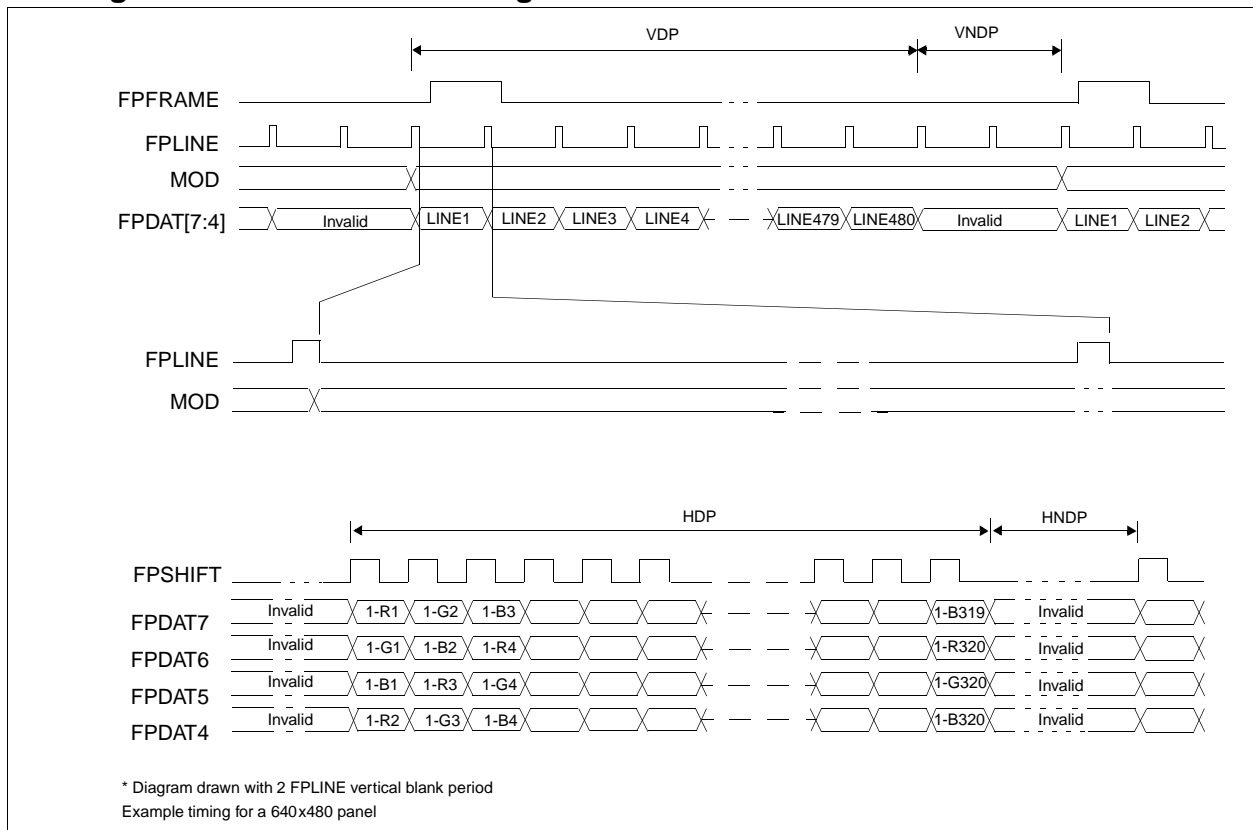


Figure 6-18: Single Color 4-Bit Panel Timing

VDP	= Vertical Display Period	= (REG[039h] bits [1:0], REG[038h] bits [7:0]) + 1
VNDP	= Vertical Non-Display Period	= (REG[03Ah] bits [5:0]) + 1
HDP	= Horizontal Display Period	= ((REG[032h] bits [6:0]) + 1) × 8Ts
HNDP	= Horizontal Non-Display Period	= ((REG[034h] bits [4:0]) + 1) × 8Ts

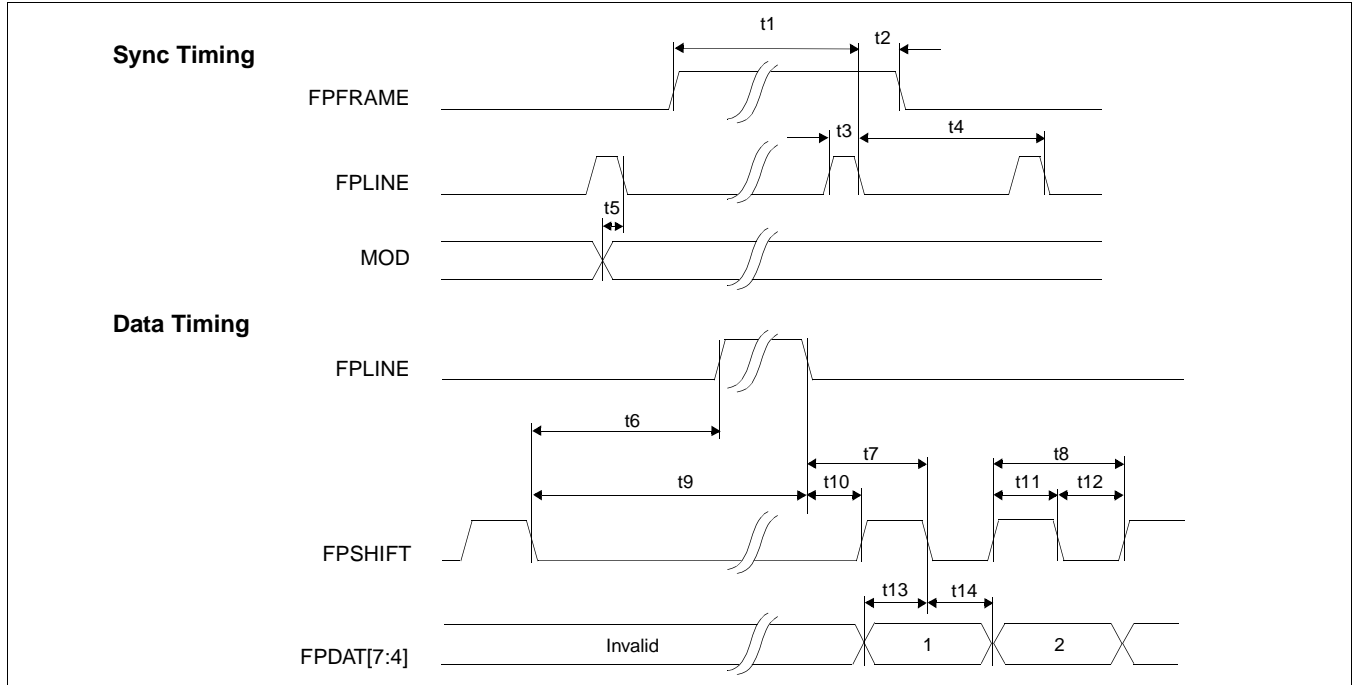


Figure 6-19: Single Color 4-Bit Panel A.C. Timing

Table 6-20 : Single Color 4-Bit Panel A.C. Timing

Symbol	Parameter	Min	Typ	Max	Units
t1	FPFRAME setup to FPLINE falling edge	note 2			Ts (note 1)
t2	FPFRAME hold from FPLINE falling edge	12			Ts
t3	FPLINE pulse width	11			Ts
t4	FPLINE period	note 3			Ts
t5	MOD transition to FPLINE falling edge	3		note 4	Ts
t6	FPSHIFT falling edge to FPLINE rising edge	note 5			Ts
t7	FPLINE falling edge to FPSHIFT falling edge	t10 + 0.5			Ts
t8	FPSHIFT period	1			Ts
t9	FPSHIFT falling edge to FPLINE falling edge	note 6			Ts
t10	FPLINE falling edge to FPSHIFT rising edge	note 7			Ts
t11	FPSHIFT pulse width high	0.5			Ts
t12	FPSHIFT pulse width low	0.5			Ts
t13	FPDAT[7:4] setup to FPSHIFT falling edge	0.5			Ts
t14	FPDAT[7:4] hold from FPSHIFT falling edge	0.5			Ts

- Ts = LCD pixel clock period. LCD pixel clock frequency is LCD pixel clock source divided by 1, 2, 3 or 4 (see REG[014h]).
- $t1_{min} = t4_{min} - 12$
- $t4_{min} = [((REG[032h] \text{ bits } [6:0]) + 1) \times 8 + ((REG[034h] \text{ bits } [4:0]) + 1) \times 8]$
- $t5_{max} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 + 3]$
- $t6_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 28.5]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 27.5]$  for 16 bpp color depth
- $t9_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 17.5]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 16.5]$  for 16 bpp color depth
- $t10_{min} = 18$  for 4 bpp or 8 bpp color depth  
 $= 17$  for 16 bpp color depth

## 6.5.4 Single Color 8-Bit Panel Timing (Format 1)

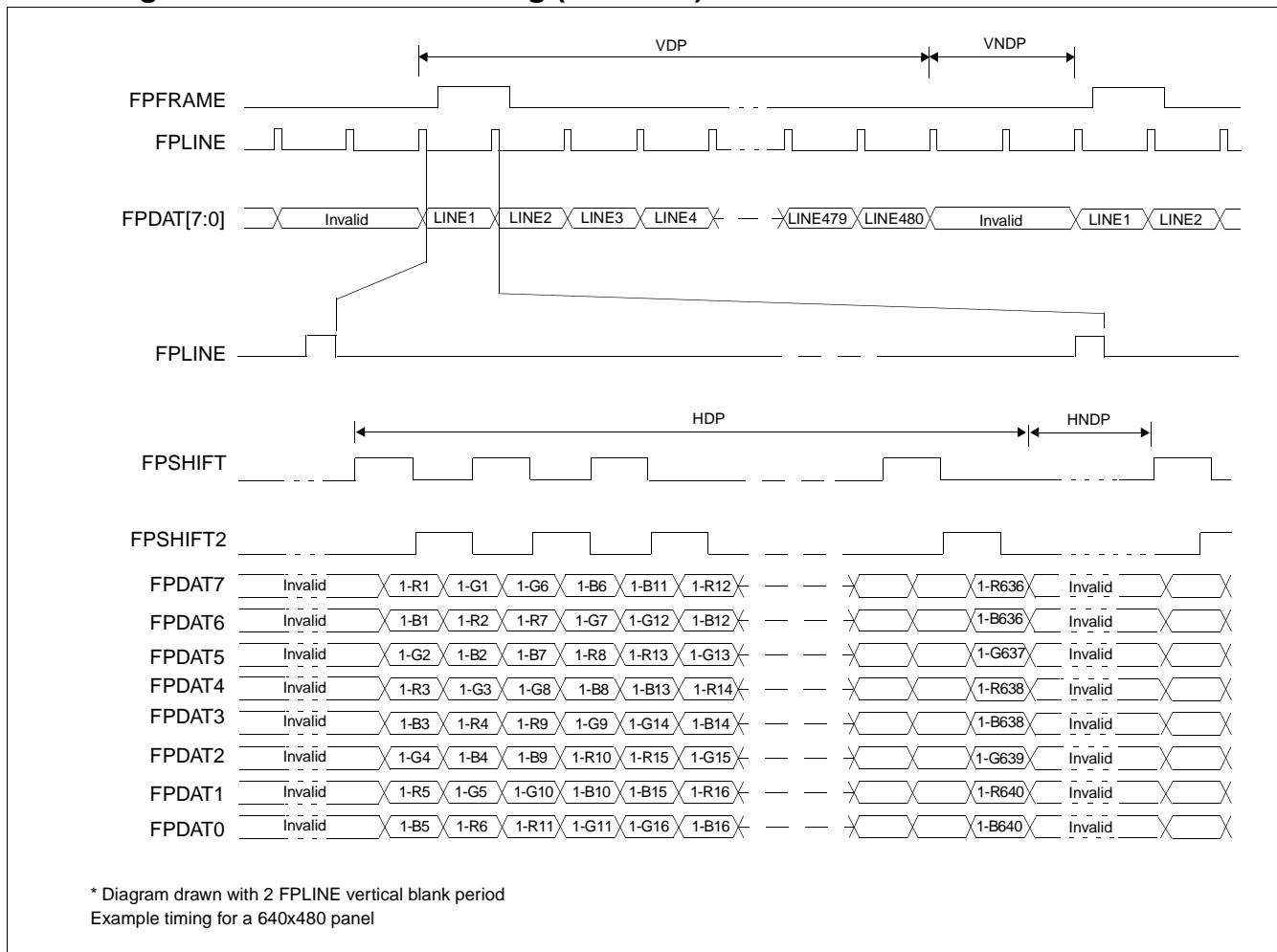


Figure 6-20: Single Color 8-Bit Panel Timing (Format 1)

VDP	= Vertical Display Period	= (REG[039h] bits [1:0], REG[038h] bits [7:0]) + 1
VNDP	= Vertical Non-Display Period	= (REG[03Ah] bits [5:0]) + 1
HDP	= Horizontal Display Period	= ((REG[032h] bits [6:0]) + 1) × 8Ts
HNDP	= Horizontal Non-Display Period	= ((REG[034h] bits [4:0]) + 1) × 8Ts

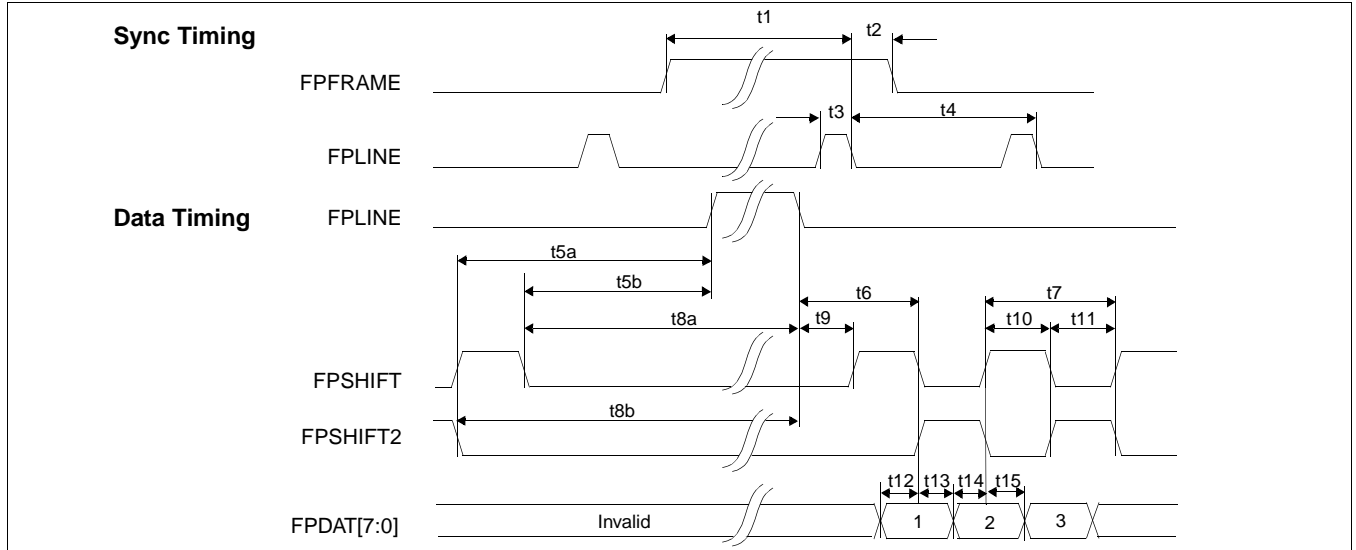


Figure 6-21: Single Color 8-Bit Panel A.C. Timing (Format 1)

Table 6-21 : Single Color 8-Bit Panel A.C. Timing (Format 1)

Symbol	Parameter	Min	Typ	Max	Units
t1	FPFRAME setup to FPLINE falling edge	note 2			Ts (note 1)
t2	FPFRAME hold from FPLINE falling edge	12			Ts
t3	FPLINE pulse width	11			Ts
t4	FPLINE period	note 3			Ts
t5a	FPSHIFT2 falling edge to FPLINE rising edge	note 4			Ts
t5b	FPSHIFT falling edge to FPLINE rising edge	note 5			Ts
t6	FPLINE falling edge to FPSHIFT falling, FPSHIFT2 rising edge	t9 + 2			Ts
t7	FPSHIFT, FPSHIFT2 period	4			Ts
t8a	FPSHIFT falling edge to FPLINE falling edge	note 6			Ts
t8b	FPSHIFT2 falling edge to FPLINE falling edge	note 7			Ts
t9	FPLINE falling edge to FPSHIFT rising edge	note 8			Ts
t10	FPSHIFT pulse width high, FPSHIFT2 pulse width low	2			Ts
t11	FPSHIFT pulse width low, FPSHIFT2 pulse width high	2			Ts
t12	FPDAT[7:0] setup to FPSHIFT falling edge	1			Ts
t13	FPDAT[7:0] hold from FPSHIFT falling edge	1			Ts
t14	FPDAT[7:0] setup to FPSHIFT2 falling edge	1			Ts
t15	FPDAT[7:0] hold from FPSHIFT2 falling edge	1			Ts

- Ts = LCD pixel clock period. LCD pixel clock frequency is source divided by 1, 2, 3 or 4(see REG[014h]).
- $t1_{min} = t4_{min} - 12Ts$
- $t4_{min} = [((REG[032h] \text{ bits } [6:0]) + 1) \times 8 + ((REG[034h] \text{ bits } [4:0]) + 1) \times 8]$
- $t5a_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 26]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 25]$  for 16 bpp color depth
- $t5b_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 28]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 27]$  for 16 bpp color depth
- $t8a_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 17]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 16]$  for 16 bpp color depth
- $t8b_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 15]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 14]$  for 16 bpp color depth
- $t9_{min} = 17$  for 4 bpp or 8 bpp color depth  
 $= 16$  for 16 bpp color depth

## 6.5.5 Single Color 8-Bit Panel Timing (Format 2)

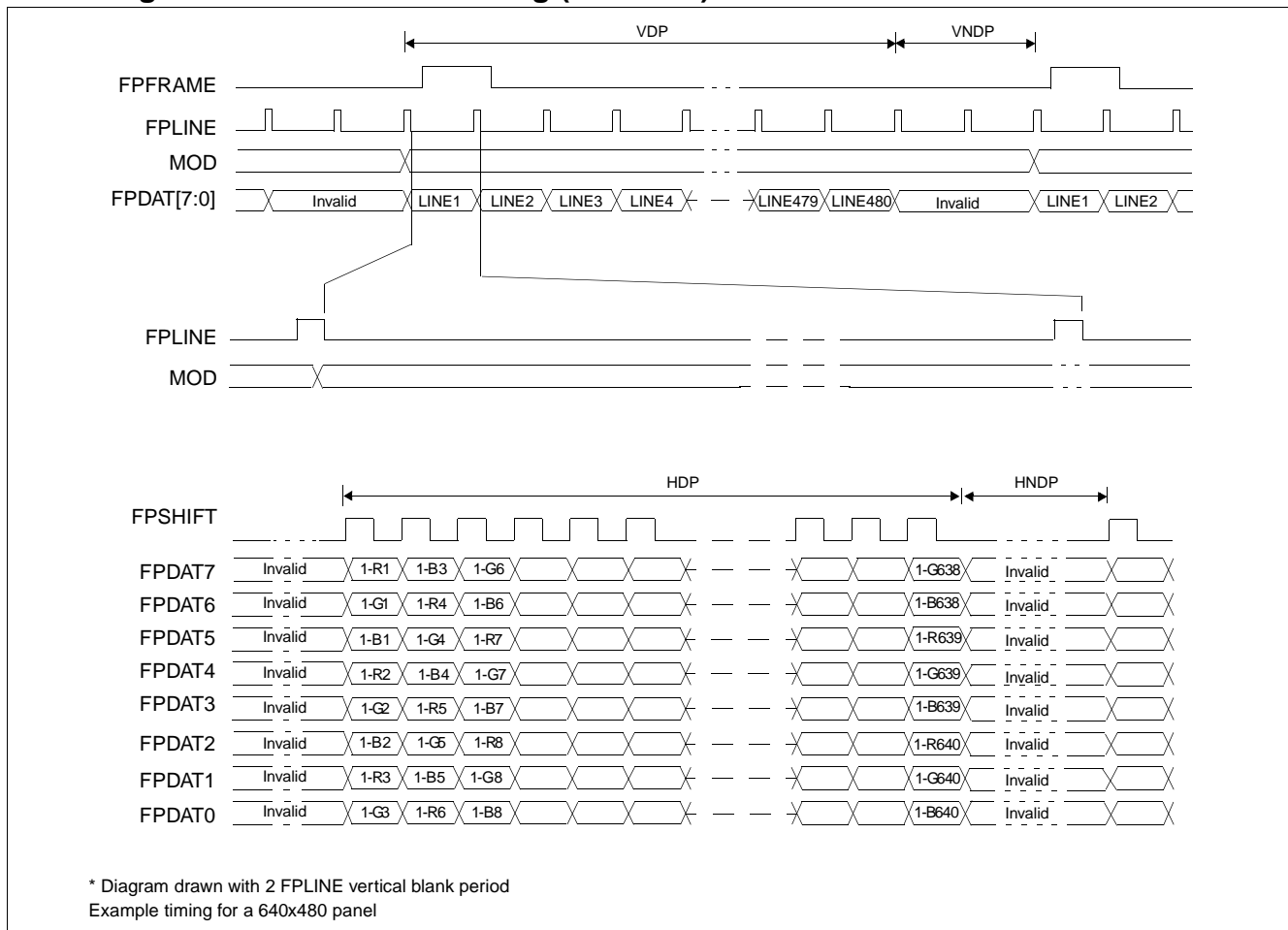


Figure 6-22: Single Color 8-Bit Panel Timing (Format 2)

VDP	= Vertical Display Period	= (REG[039h] bits [1:0], REG[038h] bits [7:0]) + 1
VNDP	= Vertical Non-Display Period	= (REG[03Ah] bits [5:0]) + 1
HDP	= Horizontal Display Period	= ((REG[032h] bits [6:0]) + 1) × 8Ts
HNDP	= Horizontal Non-Display Period	= ((REG[034h] bits [4:0]) + 1) × 8Ts



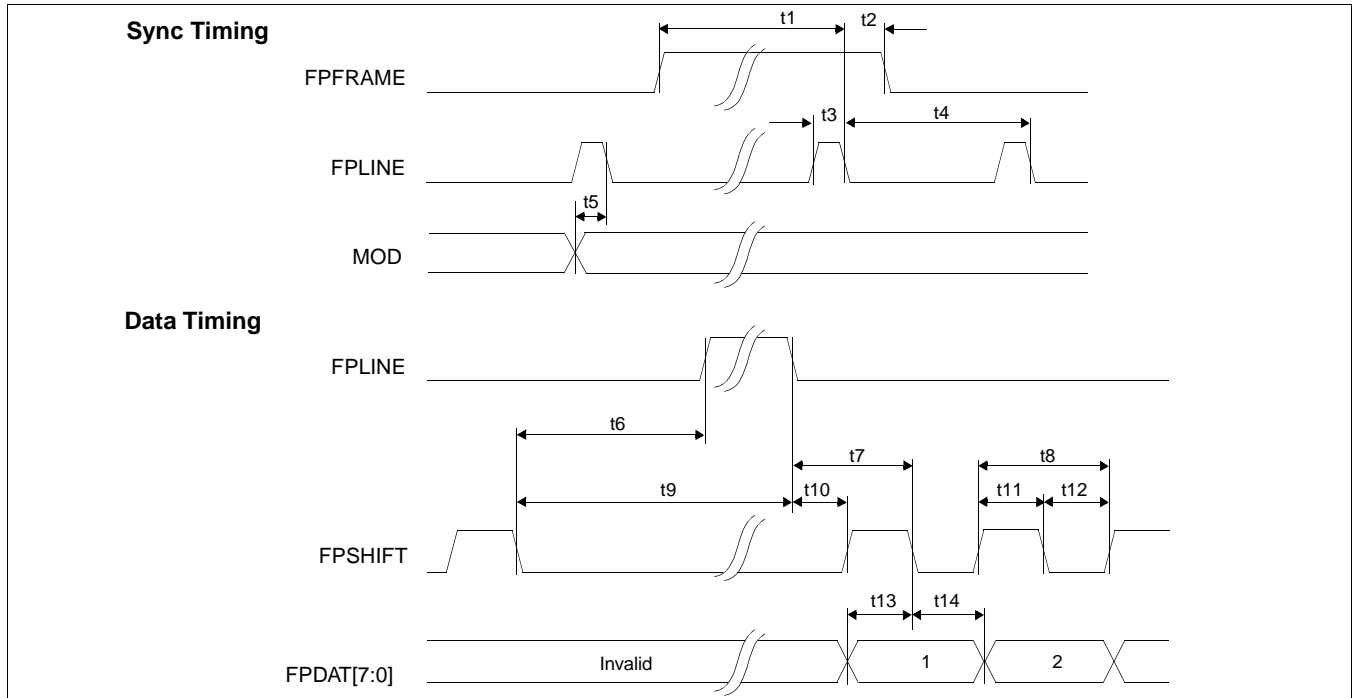


Figure 6-23: Single Color 8-Bit Panel A.C. Timing (Format 2)

Table 6-22 : Single Color 8-Bit Panel A.C. Timing (Format 2)

Symbol	Parameter	Min	Typ	Max	Units
t1	FPFRAME setup to FPLINE falling edge	note 2			Ts (note 1)
t2	FPFRAME hold from FPLINE falling edge	12			Ts
t3	FPLINE pulse width	11			Ts
t4	FPLINE period	note 3			Ts
t5	MOD transition to FPLINE falling edge	3		note 4	Ts
t6	FPSHIFT falling edge to FPLINE rising edge	note 5			Ts
t7	FPLINE falling edge to FPSHIFT falling edge	t10 + 2			Ts
t8	FPSHIFT period	2			Ts
t9	FPSHIFT falling edge to FPLINE falling edge	note 6			Ts
t10	FPLINE falling edge to FPSHIFT rising edge	note 7			Ts
t11	FPSHIFT pulse width high	1			Ts
t12	FPSHIFT pulse width low	1			Ts
t13	FPDAT[7:0] setup to FPSHIFT falling edge	1			Ts
t14	FPDAT[7:0] hold to FPSHIFT falling edge	1			Ts

1. Ts = LCD pixel clock period. LCD pixel clock frequency is source divided by 1, 2, 3 or 4(see REG[014h]).
2.  $t1_{min} = t3_{min} - 12$
3.  $t3_{min} = [((REG[032h] \text{ bits } [6:0]) + 1) \times 8 + ((REG[034h] \text{ bits } [4:0]) + 1) \times 8]$
4.  $t5_{max} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 + 3]$
5.  $t6_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 27]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 26]$  for or 16 bpp color depth
6.  $t9_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 16]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 15]$  for 16 bpp color depth
7.  $t10_{min} = 17$  for 4 bpp or 8 bpp color depth  
 $= 16$  for 16 bpp color depth

## 6.5.6 Single Color 16-Bit Panel Timing

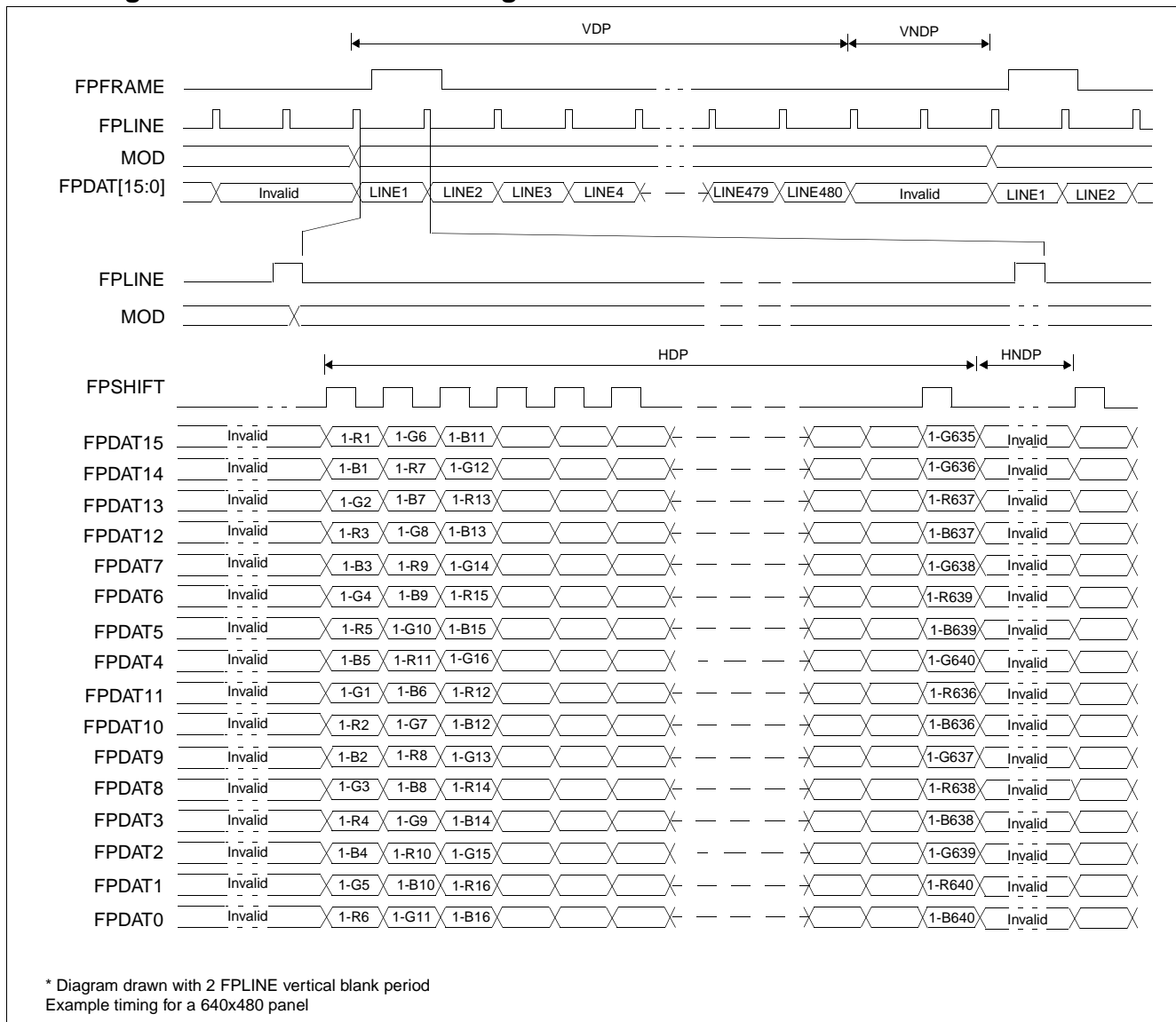


Figure 6-24: Single Color 16-Bit Panel Timing

VDP	= Vertical Display Period	= (REG[039h] bits [1:0], REG[038h] bits [7:0]) + 1
VNDP	= Vertical Non-Display Period	= (REG[03Ah] bits [5:0]) + 1
HDP	= Horizontal Display Period	= ((REG[032h] bits [6:0]) + 1) × 8Ts
HNDP	= Horizontal Non-Display Period	= ((REG[034h] bits [4:0]) + 1) × 8Ts

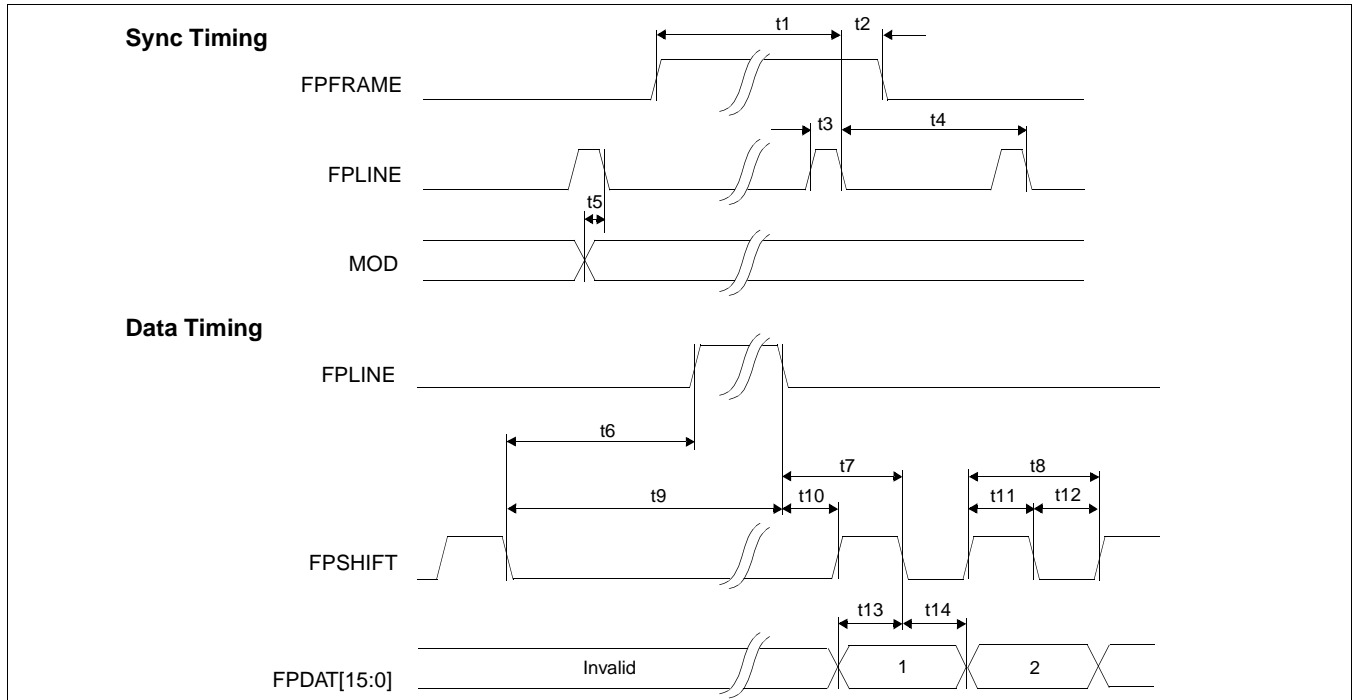


Figure 6-25: Single Color 16-Bit Panel A.C. Timing

Table 6-23 : Single Color 16-Bit Panel A.C. Timing

Symbol	Parameter	Min	Typ	Max	Units
t1	FPFRAME setup to FPLINE falling edge	note 2			Ts (note 1)
t2	FPFRAME hold from FPLINE falling edge	12			Ts
t3	FPLINE pulse width	11			Ts
t4	FPLINE period	note 3			Ts
t5	MOD transition to FPLINE falling edge	3		note 4	Ts
t6	FPSHIFT falling edge to FPLINE rising edge	note 5			Ts
t7	FPLINE falling edge to FPSHIFT falling edge	t10 + 3			Ts
t8	FPSHIFT period	5			Ts
t9	FPSHIFT falling edge to FPLINE falling edge	note 6			Ts
t10	FPLINE falling edge to FPSHIFT rising edge	note 7			Ts
t11	FPSHIFT pulse width high	2			Ts
t12	FPSHIFT pulse width low	2			Ts
t13	FPDAT[15:0] setup to FPSHIFT falling edge	2			Ts
t14	FPDAT[15:0] hold to FPSHIFT falling edge	2			Ts

1. Ts = LCD pixel clock period. LCD pixel clock frequency is source divided by 1, 2, 3 or 4(see REG[014h]).
2.  $t1_{min} = t3_{min} - 12$
3.  $t3_{min} = [((REG[032h] \text{ bits } [6:0]) + 1) \times 8 + ((REG[034h] \text{ bits } [4:0]) + 1) \times 8]$
4.  $t5_{max} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 + 3]$
5.  $t6_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 26]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 25]$  for 16 bpp color depth
6.  $t9_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 15]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 14]$  for 16 bpp color depth
7.  $t10_{min} = 17$  for 4 bpp or 8 bpp color depth  
 $= 16$  for 16 bpp color depth

## 6.5.7 Dual Monochrome 8-Bit Panel Timing

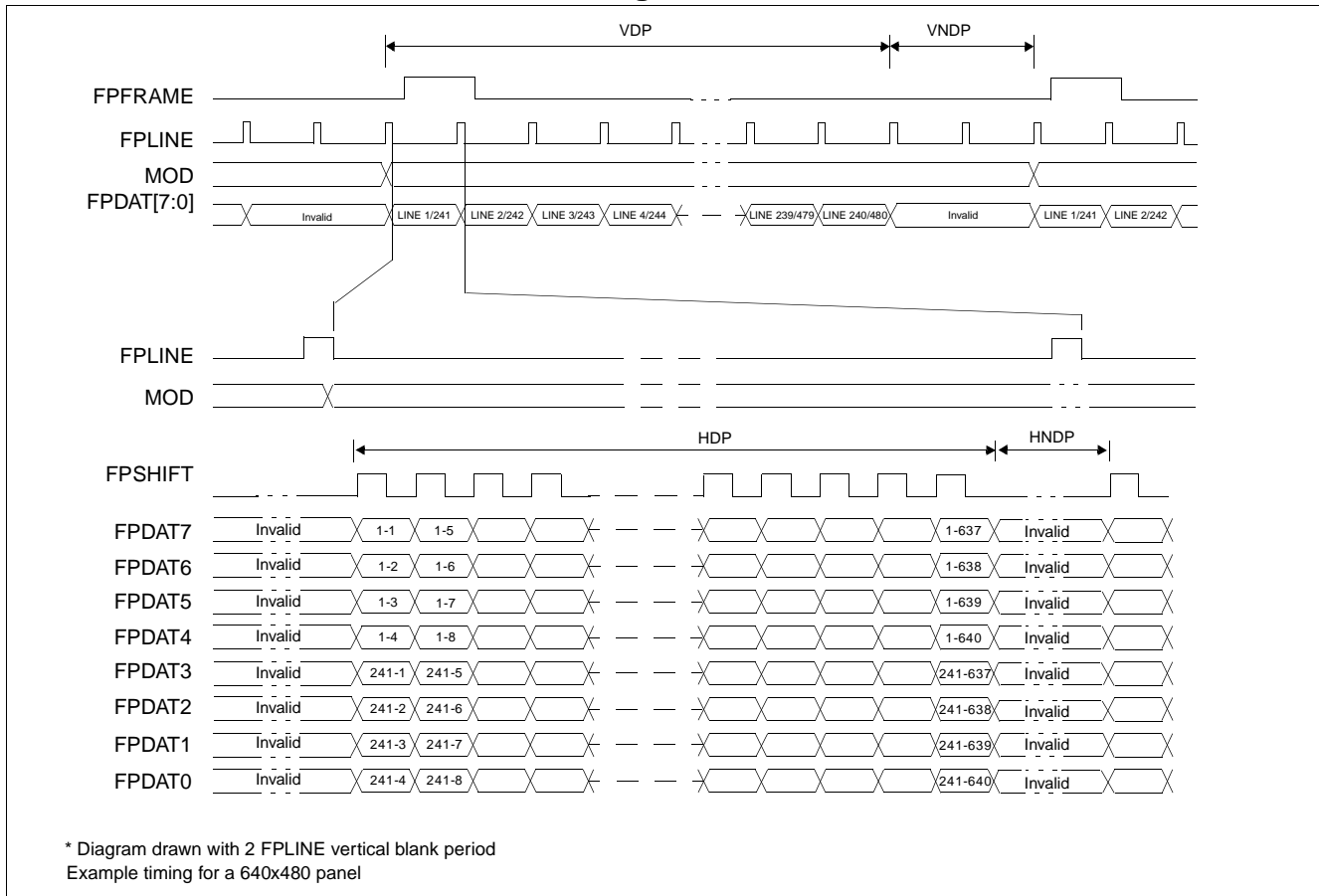


Figure 6-26: Dual Monochrome 8-Bit Panel Timing

VDP	= Vertical Display Period	= (REG[039h] bits [1:0], REG[038h] bits [7:1])
VNDP	= Vertical Non-Display Period	= (REG[03Ah] bits [5:0]) + 1
HDP	= Horizontal Display Period	= ((REG[032h] bits [6:0]) + 1) × 8Ts
HNDP	= Horizontal Non-Display Period	= ((REG[034h] bits [4:0]) + 1) × 8Ts

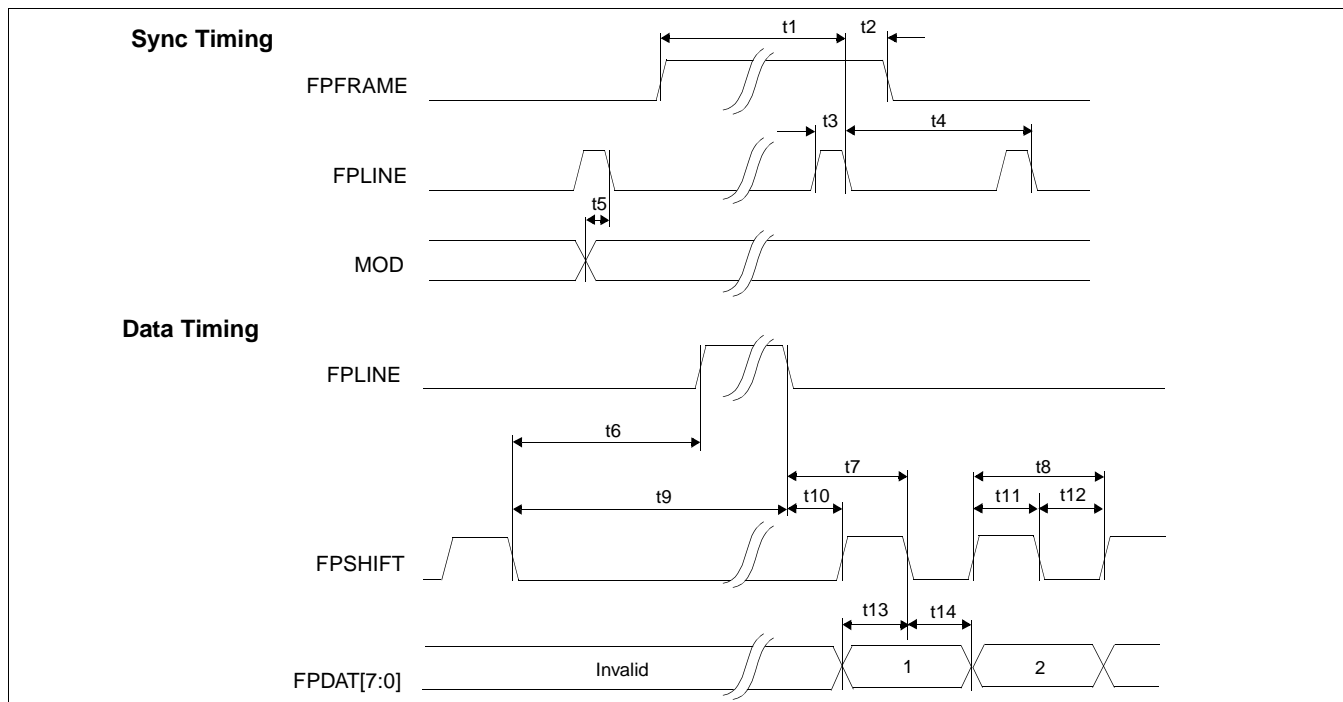


Figure 6-27: Dual Monochrome 8-Bit Panel A.C. Timing

Table 6-24 : Dual Monochrome 8-Bit Panel A.C. Timing

Symbol	Parameter	Min	Typ	Max	Units
t1	FPFRAME setup to FPLINE falling edge	note 2			Ts (note 1)
t2	FPFRAME hold from FPLINE falling edge	12			Ts
t3	FPLINE pulse width	11			Ts
t4	FPLINE period	note 3			Ts
t5	MOD transition to FPLINE falling edge	3		note 4	Ts
t6	FPSHIFT falling edge to FPLINE rising edge	note 5			Ts
t7	FPLINE falling edge to FPSHIFT falling edge	t10 + 2			Ts
t8	FPSHIFT period	4			Ts
t9	FPSHIFT falling edge to FPLINE falling edge	note 6			Ts
t10	FPLINE falling edge to FPSHIFT rising edge	note 7			Ts
t12	FPSHIFT pulse width low	2			Ts
t11	FPSHIFT pulse width high	2			Ts
t13	FPDAT[7:0] setup to FPSHIFT falling edge	2			Ts
t14	FPDAT[7:0] hold to FPSHIFT falling edge	2			Ts

1. Ts = LCD pixel clock period. LCD pixel clock frequency is source divided by 1, 2, 3 or 4(see REG[014h]).
2.  $t1_{min} = t3_{min} - 12$
3.  $t3_{min} = [((REG[032h] \text{ bits } [6:0]) + 1) \times 8 + ((REG[034h] \text{ bits } [4:0]) + 1) \times 8]$
4.  $t5_{max} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 + 3]$
5.  $t6_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 18]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 17]$  for 16 bpp color depth
6.  $t9_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 7]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 6]$  for 16 bpp color depth
7.  $t10_{min} = 9$  for 4 bpp or 8 bpp color depth  
 $= 8$  for 16 bpp color depth

### 6.5.8 Dual Color 8-Bit Panel Timing

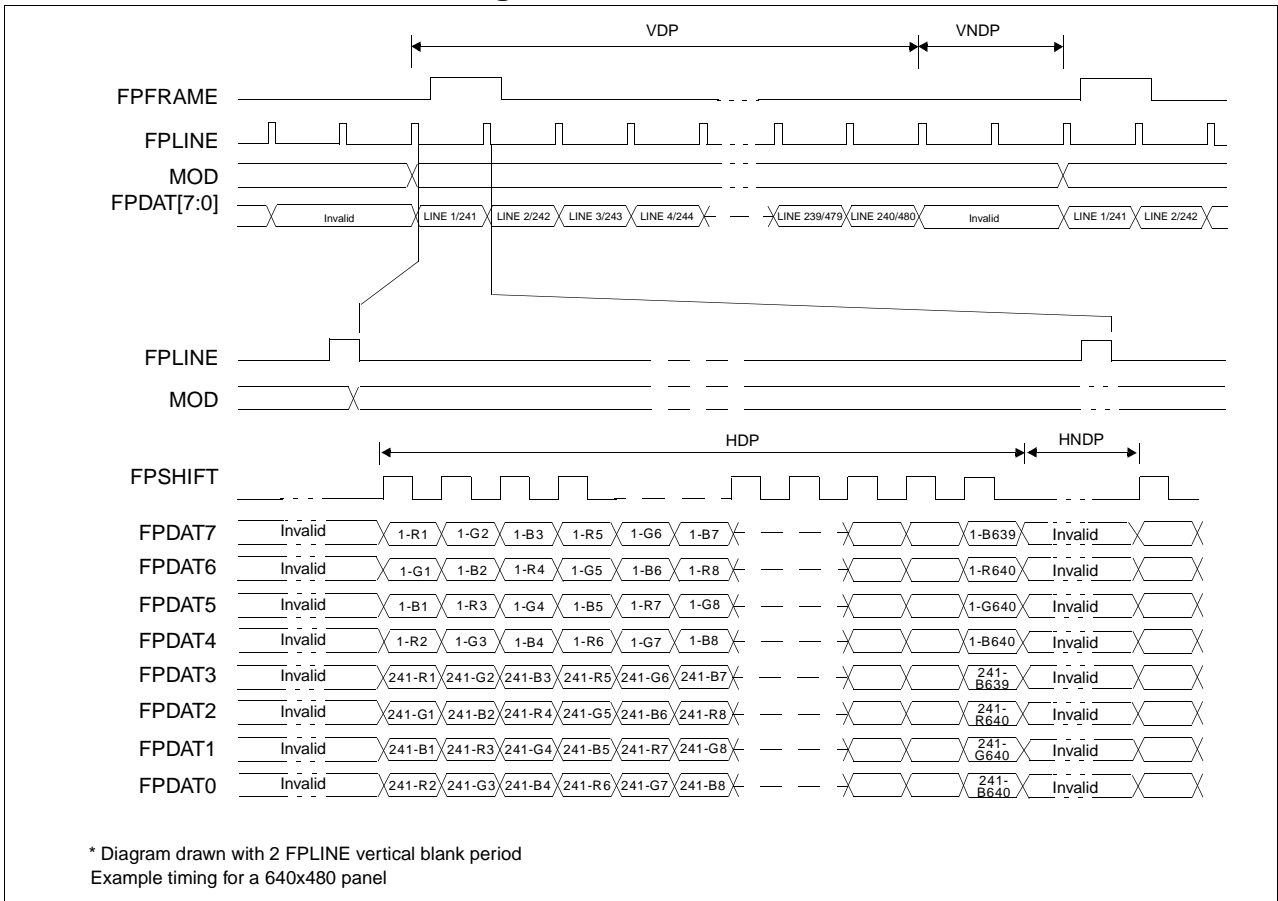


Figure 6-28: Dual Color 8-Bit Panel Timing

- VDP = Vertical Display Period =  $((\text{REG}[039\text{h}] \text{ bits } [1:0], \text{REG}[038\text{h}] \text{ bits } [7:0]) + 1) \div 2$
- VNDP = Vertical Non-Display Period =  $(\text{REG}[03\text{A}\text{h}] \text{ bits } [5:0]) + 1$
- HDP = Horizontal Display Period =  $((\text{REG}[032\text{h}] \text{ bits } [6:0]) + 1) \times 8\text{T}\text{s}$
- HNDP = Horizontal Non-Display Period =  $((\text{REG}[034\text{h}] \text{ bits } [4:0]) + 1) \times 8\text{T}\text{s}$

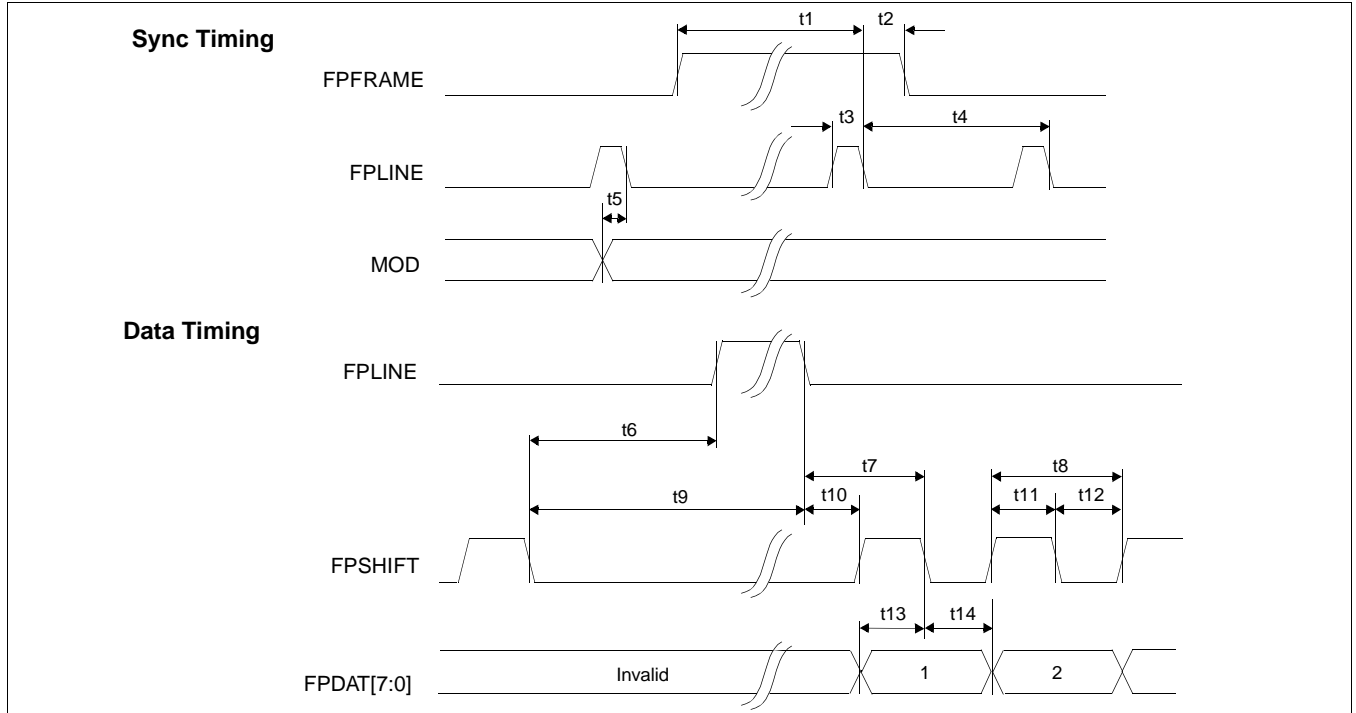


Figure 6-29: Dual Color 8-Bit Panel A.C. Timing

Table 6-25 : Dual Color 8-Bit Panel A.C. Timing

Symbol	Parameter	Min	Typ	Max	Units
t1	FPFRAME setup to FPLINE falling edge	note 2			Ts (note 1)
t2	FPFRAME hold from FPLINE falling edge	12			Ts
t3	FPLINE pulse width	11			Ts
t4	FPLINE period	note 3			Ts
t5	MOD transition to FPLINE falling edge	3		note 4	Ts
t6	FPSHIFT falling edge to FPLINE rising edge	note 5			Ts
t7	FPLINE falling edge to FPSHIFT falling edge	t10 + 0.5			Ts
t8	FPSHIFT period	1			Ts
t9	FPSHIFT falling edge to FPLINE falling edge	note 6			Ts
t10	FPLINE falling edge to FPSHIFT rising edge	note 7			Ts
t11	FPSHIFT pulse width high	0.5			Ts
t12	FPSHIFT pulse width low	0.5			Ts
t13	FPDAT[7:0] setup to FPSHIFT falling edge	0.5			Ts
t14	FPDAT[7:0] hold to FPSHIFT falling edge	0.5			Ts

1. Ts = LCD pixel clock period. LCD pixel clock frequency is source divided by 1, 2, 3 or 4(see REG[014h]).
2.  $t1_{min} = t3_{min} - 12$
3.  $t3_{min} = [((REG[032h] \text{ bits } [6:0]) + 1) \times 8 + ((REG[034h] \text{ bits } [4:0]) + 1) \times 8]$
4.  $t5_{max} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 + 3]$
5.  $t6_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 18.5]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 17.5]$  for 16 bpp color depth
6.  $t9_{min} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 8.5]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 6.5]$  for 16 bpp color depth
7.  $t10_{min} = 10$  for 4 bpp or 8 bpp color depth  
 $= 9$  for 16 bpp color depth

## 6.5.9 Dual Color 16-Bit Panel Timing

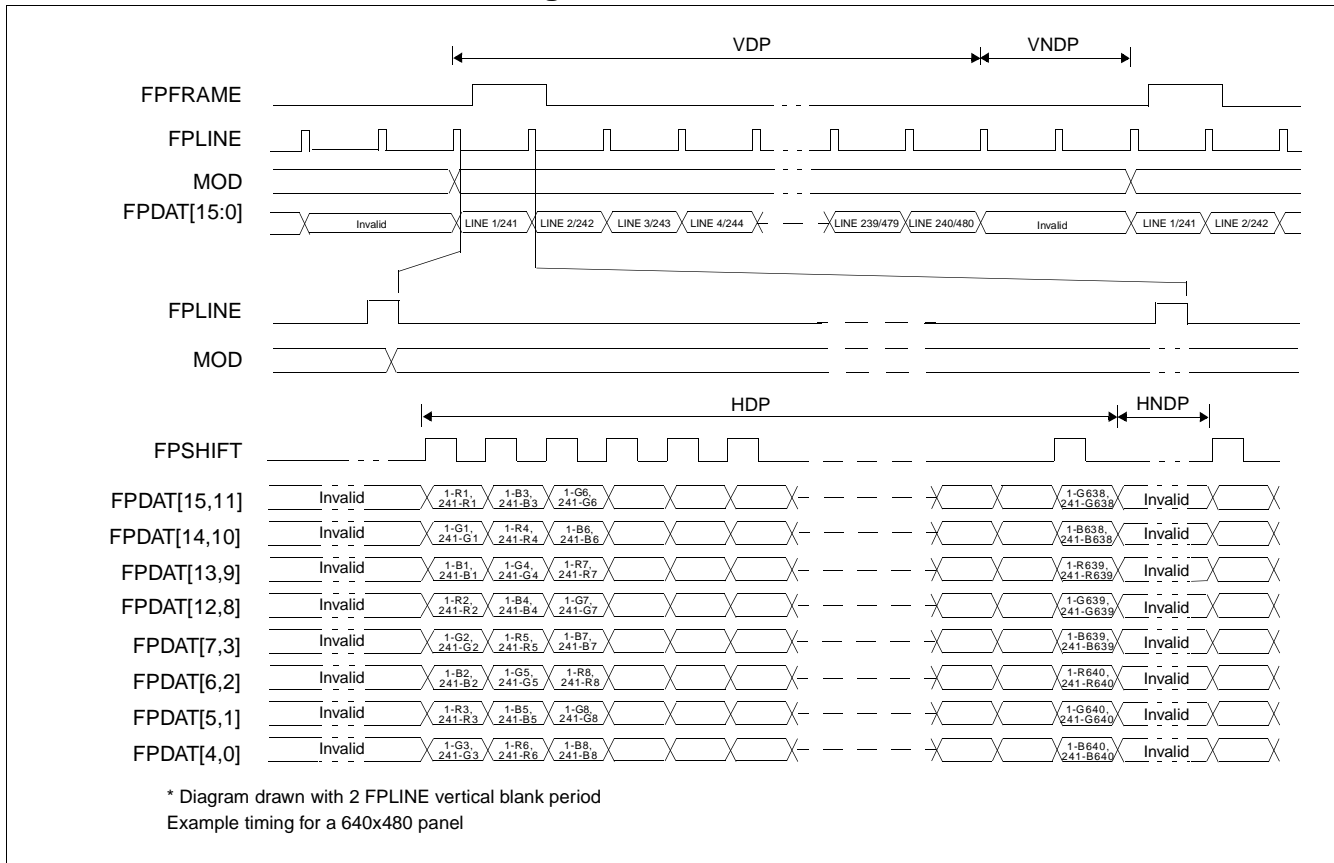


Figure 6-30: Dual Color 16-Bit Panel Timing

VDP	= Vertical Display Period	= ((REG[039h] bits [1:0], REG[038h] bits [7:0]) + 1) ÷ 2
VNDP	= Vertical Non-Display Period	= (REG[03Ah] bits [5:0]) + 1
HDP	= Horizontal Display Period	= ((REG[032h] bits [6:0]) + 1) × 8Ts
HNDP	= Horizontal Non-Display Period	= ((REG[034h] bits [4:0]) + 1) × 8Ts



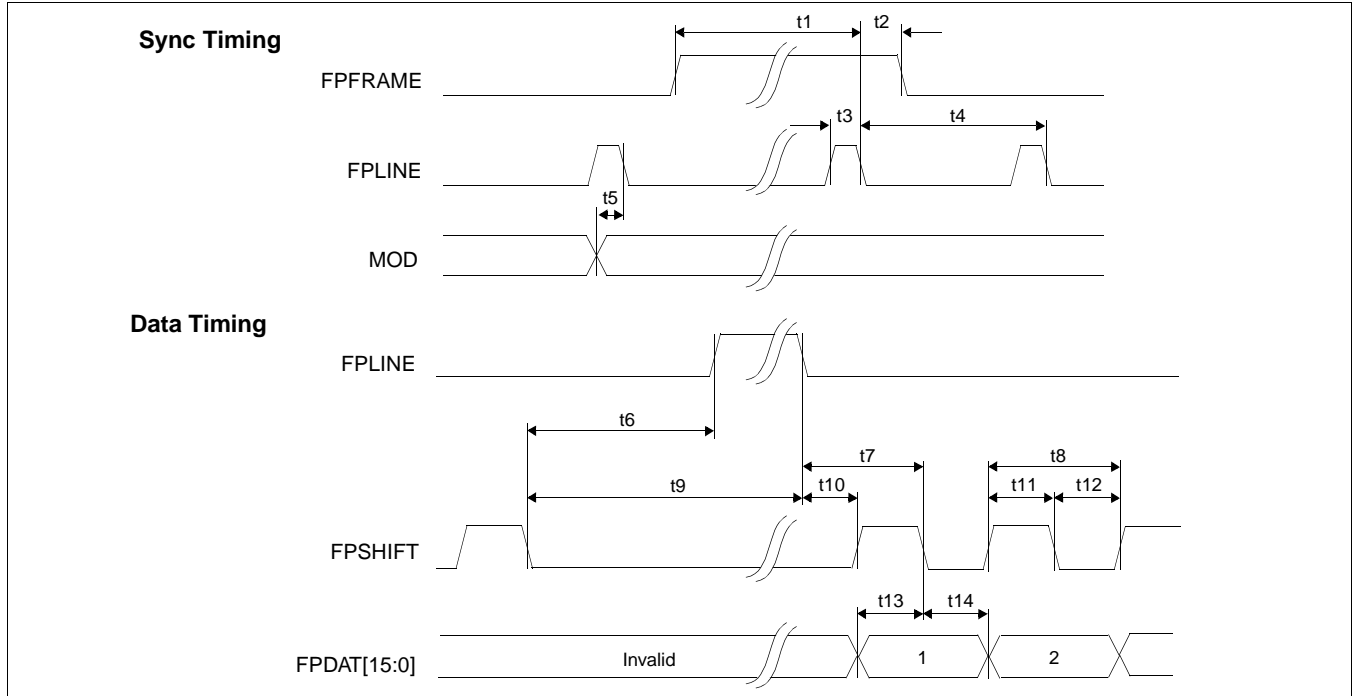


Figure 6-31: Dual Color 16-Bit Panel A.C. Timing

Table 6-26 : Dual Color 16-Bit Panel A.C. Timing

Symbol	Parameter	Min	Typ	Max	Units
t1	FPFRAME setup to FPLINE falling edge	note 2			Ts (note 1)
t2	FPFRAME hold from FPLINE falling edge	12			Ts
t3	FPLINE pulse width	11			Ts
t4	FPLINE period	note 3			Ts
t5	MOD transition to FPLINE falling edge	3		note 4	Ts
t6	FPSHIFT falling edge to FPLINE rising edge	note 5			Ts
t7	FPLINE falling edge to FPSHIFT falling edge	t10 + 2			Ts
t8	FPSHIFT period	2			Ts
t9	FPSHIFT falling edge to FPLINE falling edge	note 6			Ts
t10	FPLINE falling edge to FPSHIFT rising edge	note 7			Ts
t11	FPSHIFT pulse width high	1			Ts
t12	FPSHIFT pulse width low	1			Ts
t13	FPDAT[15:0] setup to FPSHIFT falling edge	1			Ts
t14	FPDAT[15:0] hold to FPSHIFT falling edge	1			Ts

1. Ts = LCD pixel clock period. LCD pixel clock frequency is source divided by 1, 2, 3 or 4(see REG[014h]).
2.  $t1_{min} = t3_{min} - 12$
3.  $t3_{min} = [(((REG[032h] \text{ bits } [6:0]) + 1) \times 8 + ((REG[034h] \text{ bits } [4:0]) + 1) \times 8]$
4.  $t5_{max} = [(((REG[034h] \text{ bits } [4:0]) + 1) \times 8 + 3]$
5.  $t6_{min} = [(((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 19]$  for 4 bpp or 8 bpp color depth  
 $= [(((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 18]$  for 16 bpp color depth
6.  $t9_{min} = [(((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 8]$  for 4 bpp or 8 bpp color depth  
 $= [(((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - 7]$  for 16 bpp color depth
7.  $t10_{min} = 9$  for 4 bpp or 8 bpp color depth  
 $= 8$  for 16 bpp color depth

## 6.5.10 TFT/D-TFD Panel Timing

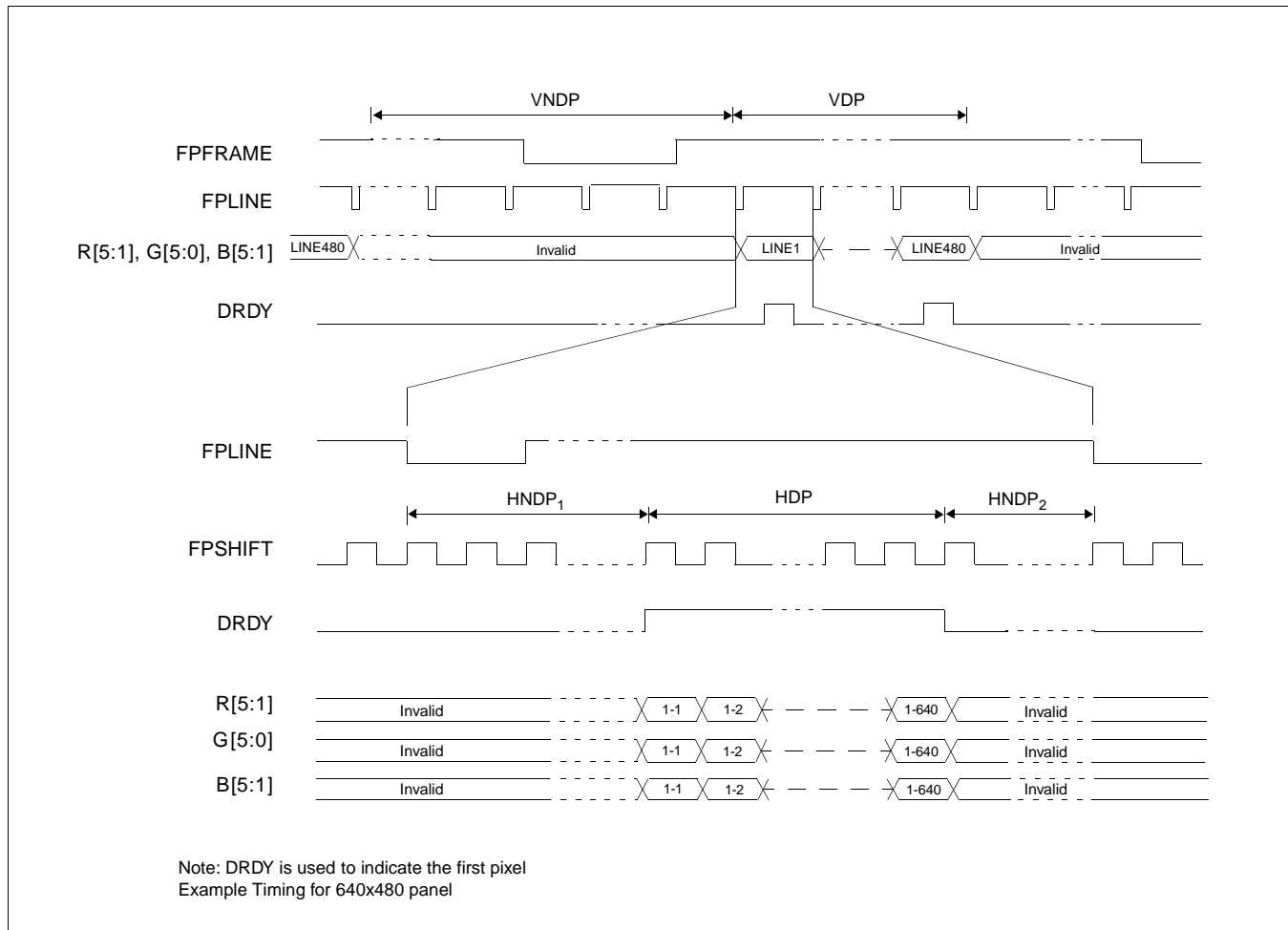


Figure 6-32: TFT/D-TFD Panel Timing

VDP	= Vertical Display Period	= (REG[039h] bits [1:0], REG[038h] bits [7:0]) + 1
VNDP	= Vertical Non-Display Period	= (REG[03Ah] bits [5:0]) + 1
HDP	= Horizontal Display Period	= ((REG[032h] bits [6:0]) + 1) × 8Ts
HNDP	= Horizontal Non-Display Period	= HNDP <sub>1</sub> + HNDP <sub>2</sub> = ((REG[034h] bits [4:0]) + 1) × 8Ts

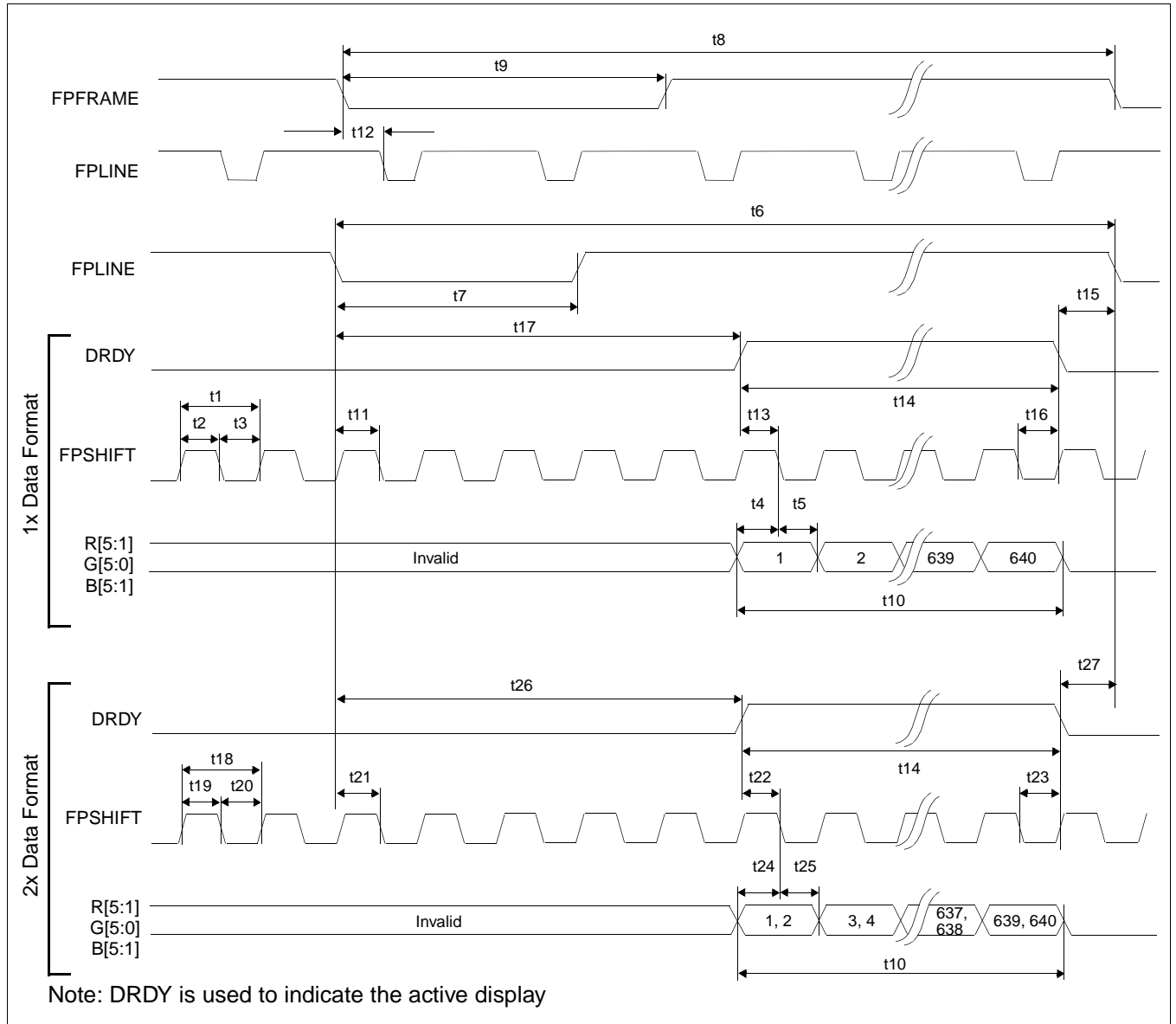


Figure 6-33: TFT/D-TFD A.C. Timing

Table 6-27 : TFT/D-TFD A.C. Timing

Symbol	Parameter	Min	Typ	Max	Units
t1	FPSHIFT period	1			Ts (note 1)
t2	FPSHIFT pulse width high	0.45			Ts
t3	FPSHIFT pulse width low	0.45			Ts
t4	data setup to FPSHIFT falling edge	0.45			Ts
t5	data hold from FPSHIFT falling edge	0.45			Ts
t6	FPLINE cycle time	note 2			Ts
t7	FPLINE pulse width low	note 3			Ts
t8	FPPFRAME cycle time	note 4			lines
t9	FPPFRAME pulse width low	note 5			lines
t10	horizontal display period	note 6			Ts
t11	FPLINE setup to FPSHIFT falling edge	0.45			Ts
t12	FPPFRAME falling edge to FPLINE falling edge phase difference	note 7			Ts
t13	DRDY to FPSHIFT falling edge setup time	0.45			Ts
t14	DRDY pulse width	note 8			Ts
t15	DRDY falling edge to FPLINE falling edge (1x)	note 9			Ts
t16	DRDY hold from FPSHIFT falling edge	0.45			Ts
t17	FPLINE Falling edge to DRDY active (1x)	note 10			Ts
t18	FPSHIFT period	2			Ts
t19	FPSHIFT pulse width high	1			Ts
t20	FPSHIFT pulse width low	1			Ts
t21	FPLINE setup to FPSHIFT falling edge	note 11			Ts
t22	DRDY to FPSHIFT falling edge setup time	1			Ts
t23	DRDY hold from FPSHIFT falling edge	1			Ts
t24	data setup to FPSHIFT falling edge	1			Ts
t25	data hold from FPSHIFT falling edge	1			Ts
t26	FPLINE Falling edge to DRDY active (2x)	note 12			Ts
t27	DRDY falling edge to FPLINE falling edge (2x)	note 13			Ts

1.  $T_s$  = LCD pixel clock period. LCD pixel clock frequency is source divided by 1, 2, 3 or 4(see REG[014h]).
2.  $t_{6_{min}} = [((REG[032h] \text{ bits } [6:0]) + 1) \times 8 + ((REG[034h] \text{ bits } [4:0]) + 1) \times 8]$
3.  $t_{7_{min}} = [((REG[036h] \text{ bits } [3:0]) + 1) \times 8]$
4.  $t_{8_{min}} = [((REG[039h] \text{ bits } [1:0], REG[038h] \text{ bits } [7:0]) + 1) + ((REG[03Ah] \text{ bits } [5:0]) + 1)]$
5.  $t_{9_{min}} = [((REG[03Ch] \text{ bits } [2:0]) + 1)]$
6.  $t_{10_{min}} = [((REG[032h] \text{ bits } [6:0]) + 1) \times 8]$
7.  $t_{12_{min}} = [(REG[035h] \text{ bits } [4:0]) \times 8 + 1]$
8.  $t_{14_{min}} = [((REG[032h] \text{ bits } [6:0]) + 1) \times 8]$
9.  $t_{15_{min}} = [(REG[035h] \text{ bits } [4:0]) \times 8 + 5]$  for 4 bpp or 8 bpp color depth  
 $= [(REG[035h] \text{ bits } [4:0]) \times 8 + 6]$  for 16 bpp color depth
10.  $t_{17_{min}} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - (REG[035h] \text{ bits } [4:0]) \times 8 - 5]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - (REG[035h] \text{ bits } [4:0]) \times 8 - 6]$  for 16 bpp color depth
11.  $t_{21_{min}} = 1$  for 4 bpp or 8 bpp color depth  
 $= 0$  for 16 bpp color depth
12.  $t_{26_{min}} = [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - (REG[035h] \text{ bits } [4:0]) \times 8 - 4]$  for 4 bpp or 8 bpp color depth  
 $= [((REG[034h] \text{ bits } [4:0]) + 1) \times 8 - (REG[035h] \text{ bits } [4:0]) \times 8 - 5]$  for 16 bpp color depth
13.  $t_{27_{min}} = [(REG[035h] \text{ bits } [4:0]) \times 8 + 4]$  for 4 bpp or 8 bpp color depth  
 $= [(REG[035h] \text{ bits } [4:0]) \times 8 + 5]$  for 16 bpp color depth

### 6.5.11 CRT Timing

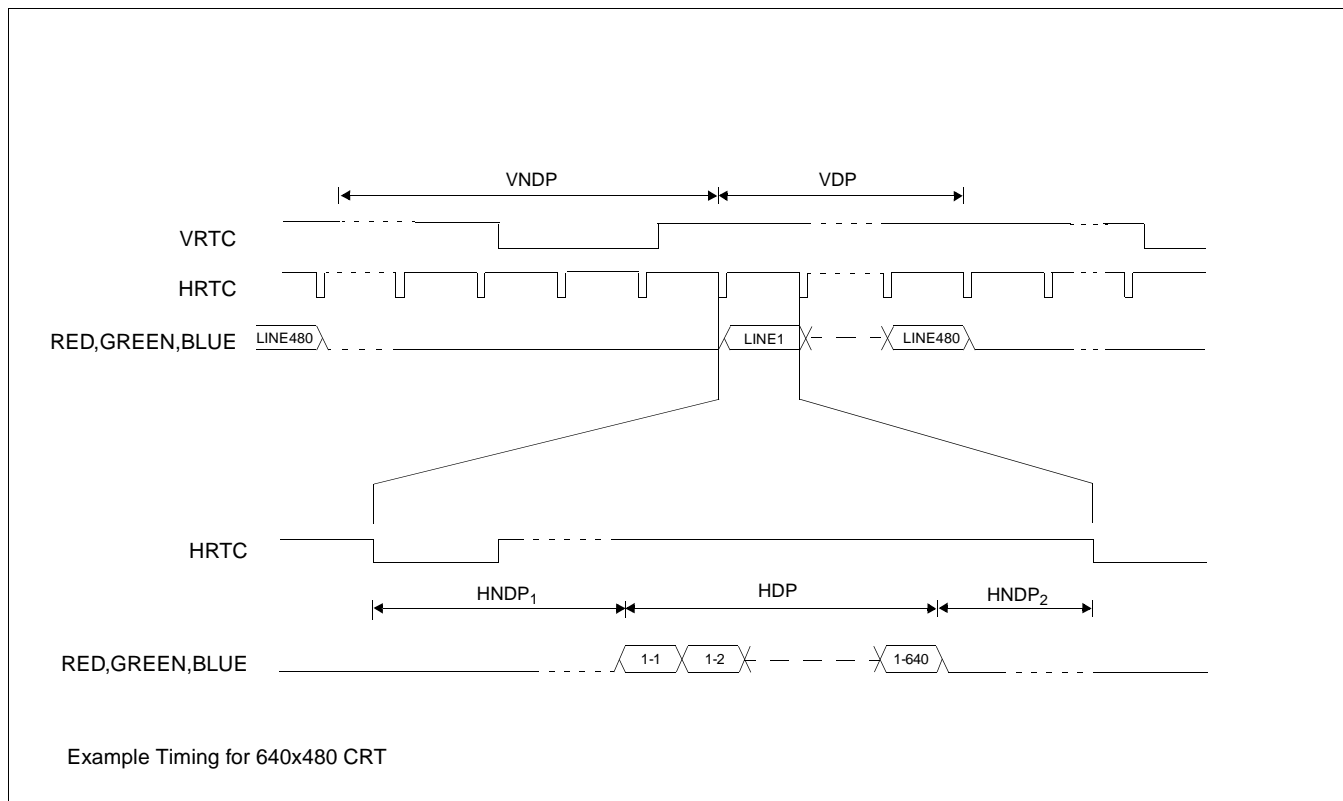


Figure 6-34: CRT Timing

VDP	= Vertical Display Period	= (REG[057h] bits [1:0], REG[056h] bits [7:0]) + 1
VNDP	= Vertical Non-Display Period	= (REG[058h] bits [6:0]) + 1
HDP	= Horizontal Display Period	= ((REG[050h] bits [6:0]) + 1) × 8Ts
HNDP	= Horizontal Non-Display Period	= HNDP <sub>1</sub> + HNDP <sub>2</sub>
		= ((REG[052h] bits [5:0]) + 1) × 8Ts
HNDP <sub>2</sub>	= HRTC Start Position	= (REG[053h] bits [5:0]) × 8 + 4Ts for 4/8 bpp
		= (REG[053h] bits [5:0]) × 8 + 5Ts for 16 bpp

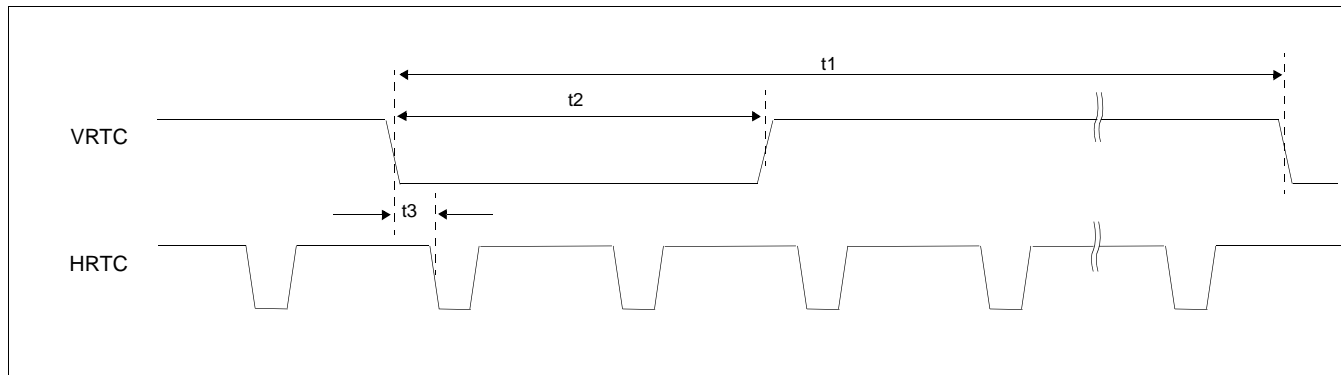


Figure 6-35: CRT A.C. Timing

Table 6-28 : CRT A.C. Timing

Symbol	Parameter	Min	Typ	Max	Units
t1	VRTC cycle time		note 1		lines
t2	VRTC pulse width low		note 2		lines
t3	VRTC falling edge to FPLINE falling edge phase difference		note 3		Ts

1.  $t_1 = [((\text{REG}[057\text{h}] \text{ bits } 1:0, \text{REG}[056\text{h}] \text{ bits } 7:0) + 1) + ((\text{REG}[058\text{h}] \text{ bits } 6:0) + 1)]$
2.  $t_2 = [((\text{REG}[05A\text{h}] \text{ bits } 2:0) + 1)]$
3.  $t_3 = [((\text{REG}[053\text{h}] \text{ bits } 4:0) + 1) \times 8]$

## 6.6 TV Timing

### 6.6.1 TV Output Timing

The overall NTSC and PAL video timing is shown in Figure 6-36: and Figure 6-37: respectively.

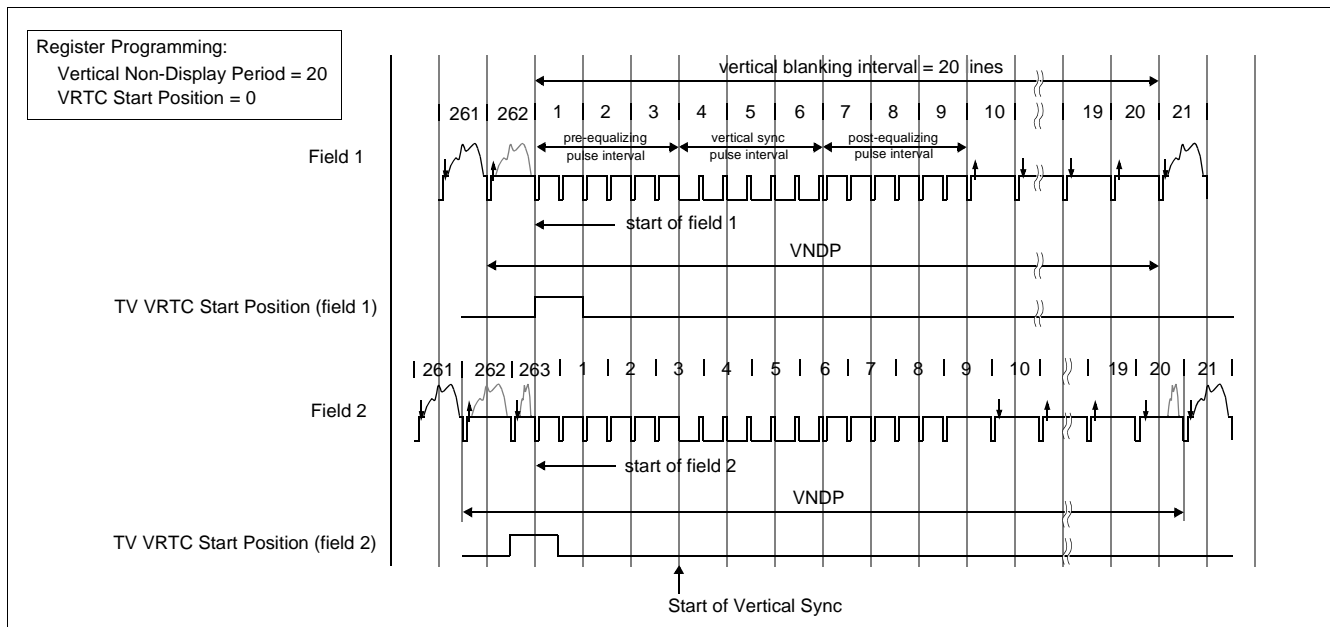


Figure 6-36: NTSC Video Timing

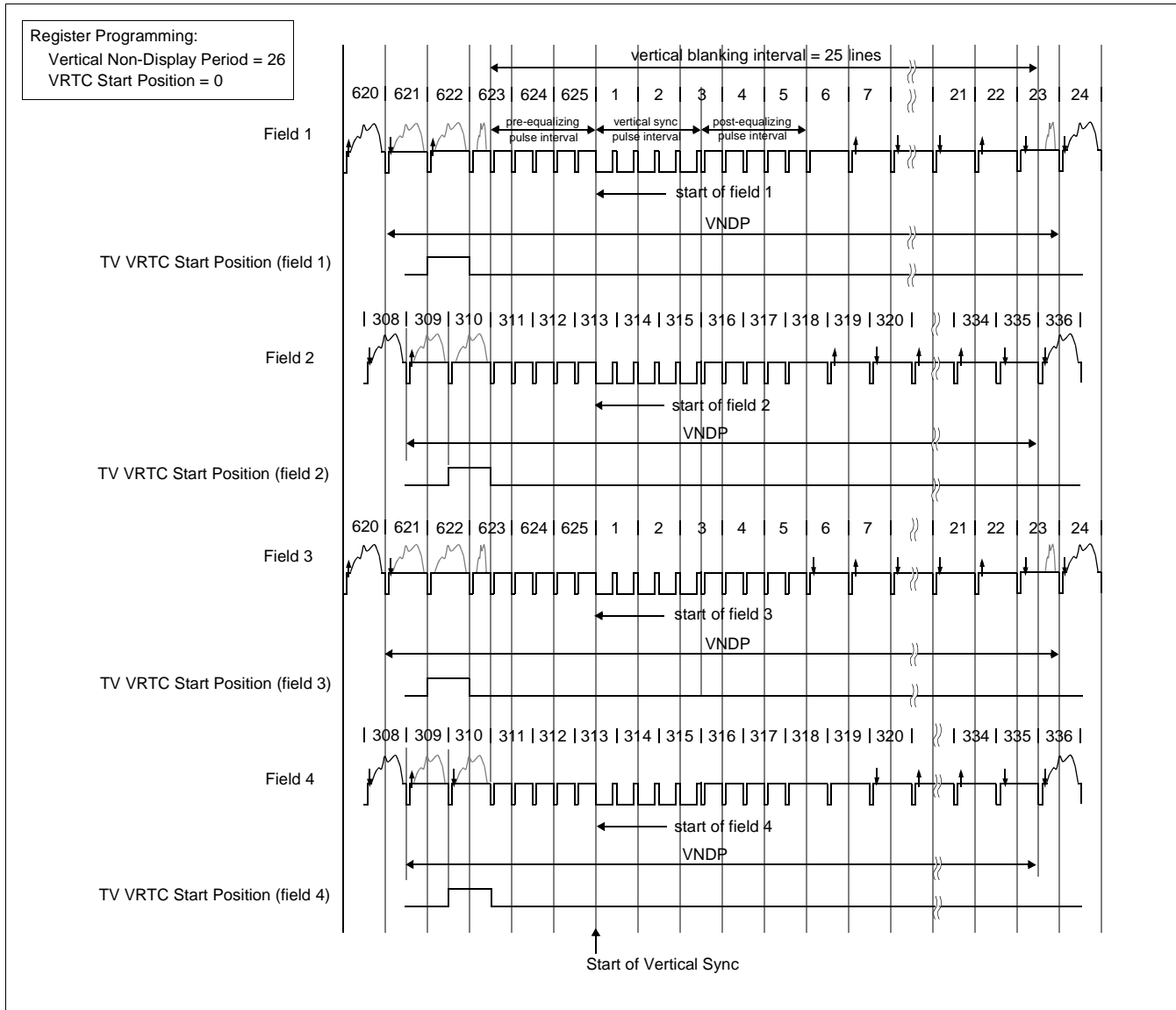


Figure 6-37: PAL Video Timing



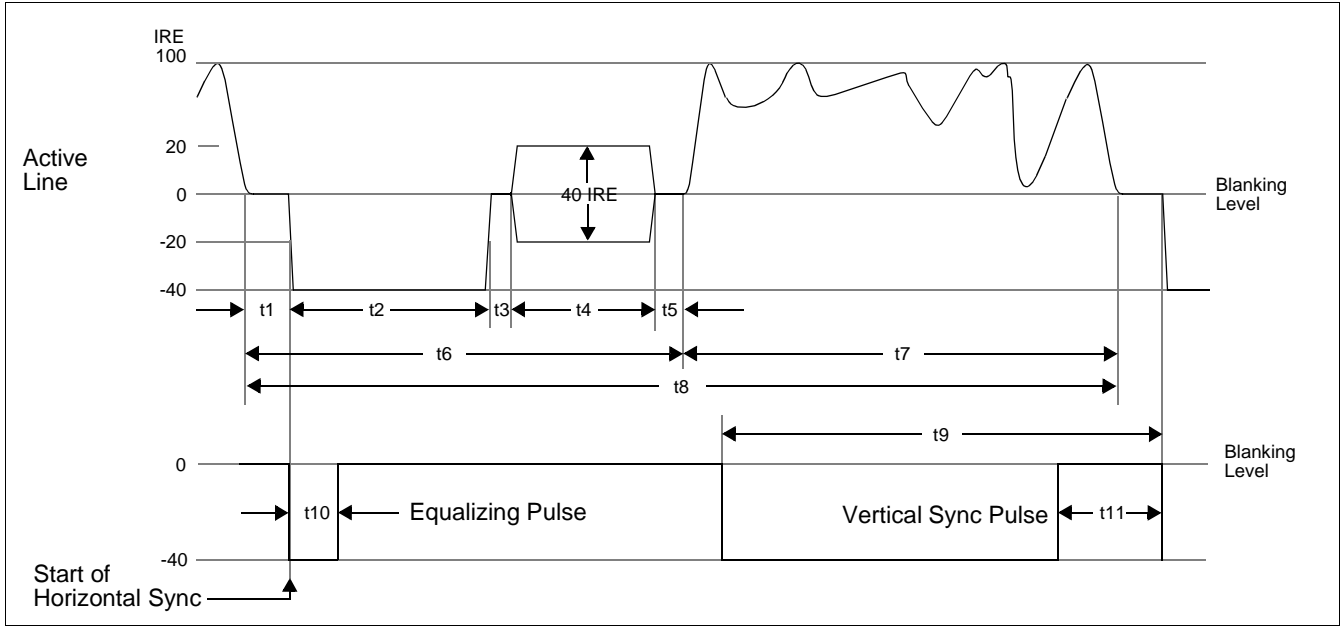


Figure 6-38: Horizontal Timing for NTSC/PAL

Table 6-29 : Horizontal Timing for NTSC/PAL

Symbol	Parameter	NTSC	PAL	Units
$T_{4SC}$	(4x Subcarrier clock) period	69.841	56.387	ns
t1	Front Porch	note 1	note 1	$T_{4SC}$
t2	Horizontal Sync	67	83	$T_{4SC}$
t3	Breezeway	9	16	$T_{4SC}$
t4	Color Burst	39	44	$T_{4SC}$
t5	Color Back Porch	note 2	note 3	$T_{4SC}$
t6	Horizontal Blanking	note 4	note 5	$T_{4SC}$
t7	Active Video	note 6	note 6	$T_{4SC}$
t8	Line Period	910	1135	$T_{4SC}$
t9	Half Line Period	455	568 / 567	$T_{4SC}$
t10	Equalizing Pulse	33	41	$T_{4SC}$
t11	Vertical Serration	67	83	$T_{4SC}$

- t1 = ((REG[053] bits[5:0]) + 1) × 8 - 6 (4bpp, 8bpp modes)  
= ((REG[053] bits[5:0]) + 1) × 8 - 5 (16bpp mode)
- t5<sub>NTSC</sub> = (((REG[052] bits[5:0]) × 8) + 6) - (((REG[053] bits[5:0]) + 1) × 8) - 109 (4bpp, 8bpp modes)  
= (((REG[052] bits[5:0]) × 8) + 6) - (((REG[053] bits[5:0]) + 1) × 8) - 110 (16bpp mode)
- t5<sub>PAL</sub> = (((REG[052] bits[5:0]) × 8) + 7) - (((REG[053] bits[5:0]) + 1) × 8) - 137 (4bpp, 8bpp modes)  
= (((REG[052] bits[5:0]) × 8) + 7) - (((REG[053] bits[5:0]) + 1) × 8) - 138 (16bpp mode)
- t6<sub>NTSC</sub> = ((REG[052] bits[5:0]) × 8) + 6
- t6<sub>PAL</sub> = ((REG[052] bits[5:0]) × 8) + 7
- t7 = ((REG[050] bits[6:0]) + 1) × 8

**Important:**

REG[050] and REG[052] must be programmed to satisfy the Line Period (t8).

For NTSC, (((REG[050] bits[6:0]) + 1) × 8) + (((REG[052] bits[5:0]) × 8) + 6) = 910.

For PAL, (((REG[050] bits[6:0]) + 1) × 8) + (((REG[052] bits[5:0]) × 8) + 7) = 1135.

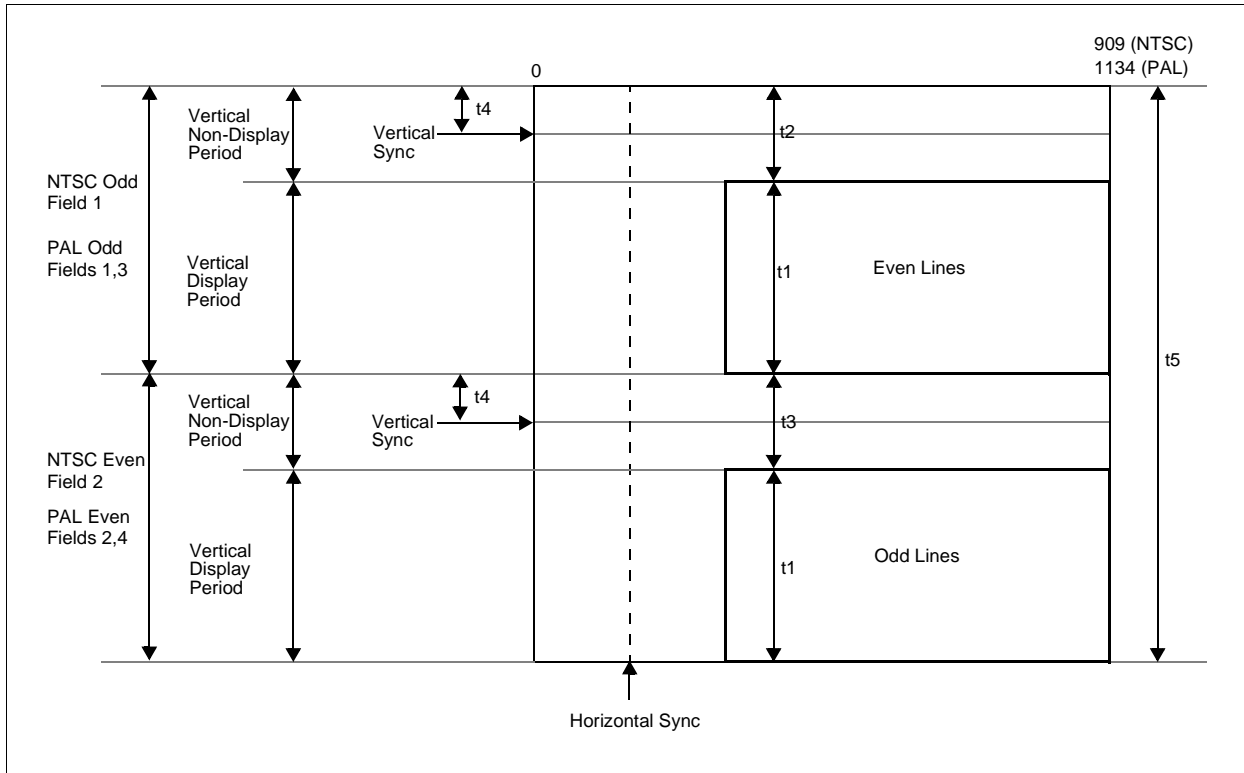


Figure 6-39: Vertical Timing for NTSC/PAL

Table 6-30 : Vertical Timing for NTSC/PAL

Symbol	Parameter	NTSC	PAL	Units
$T_{LINE}$	Line Period	63.55556	63.99964	us
t1	Vertical Field Period	note 1	note 1	$T_{LINE}$
t2	Vertical Even Blanking	note 2	note 2	$T_{LINE}$
t3	Vertical Odd Blanking	note 3	note 3	$T_{LINE}$
t4	Vertical Sync Position	note 4	note 5	$T_{LINE}$
t5	Frame Period	525	625	$T_{LINE}$

- t1 =  $\left( \left( \text{REG}[057\text{h}] \text{ bits}[1:0] \right), \left( \text{REG}[056] \text{ bits}[7:0] \right) \right) + 1 \div 2$  (rounded up)
- t2 =  $\left( \left( \text{REG}[058\text{h}] \text{ bits}[6:0] \right) + 1 \right)$  for NTSC field 1  
=  $\left( \left( \text{REG}[058\text{h}] \text{ bits}[6:0] \right) + 2 \right)$  for PAL fields 1 and 3
- t3 =  $\left( \left( \text{REG}[058\text{h}] \text{ bits}[6:0] \right) + 2 \right)$  for NTSC field 2  
=  $\left( \left( \text{REG}[058\text{h}] \text{ bits}[6:0] \right) + 1 \right)$  for PAL fields 2 and 4
- t4<sub>NTSC</sub> =  $\left( \left( \text{REG}[059\text{h}] \text{ bits}[6:0] \right) + 4 \right)$  for field 1  
=  $\left( \left( \text{REG}[059\text{h}] \text{ bits}[6:0] \right) + 4.5 \right)$  for field 2
- t4<sub>PAL</sub> =  $\left( \left( \text{REG}[059\text{h}] \text{ bits}[6:0] \right) + 5 \right)$  for field 1 and field 3  
=  $\left( \left( \text{REG}[059\text{h}] \text{ bits}[6:0] \right) + 4.5 \right)$  for field 2 and field 4

**Important**

REG[056], REG[057], and REG[058] must be programmed to satisfy the Frame Period (t5).

For NTSC,  $\left( \left( \left( \text{REG}[057] \text{ bits}[1:0] \right), \left( \text{REG}[056] \text{ bits}[7:0] \right) \right) + 1 \right) + \left( \left( \text{REG}[058] \text{ bits}[6:0] \right) + 1 \right) \times 2 + 1 = 525$

For PAL,  $\left( \left( \left( \text{REG}[057] \text{ bits}[1:0] \right), \left( \text{REG}[056] \text{ bits}[7:0] \right) \right) + 1 \right) + \left( \left( \text{REG}[058] \text{ bits}[6:0] \right) + 1 \right) \times 2 + 1 = 625$ .

## 6.7 MediaPlug Interface Timing

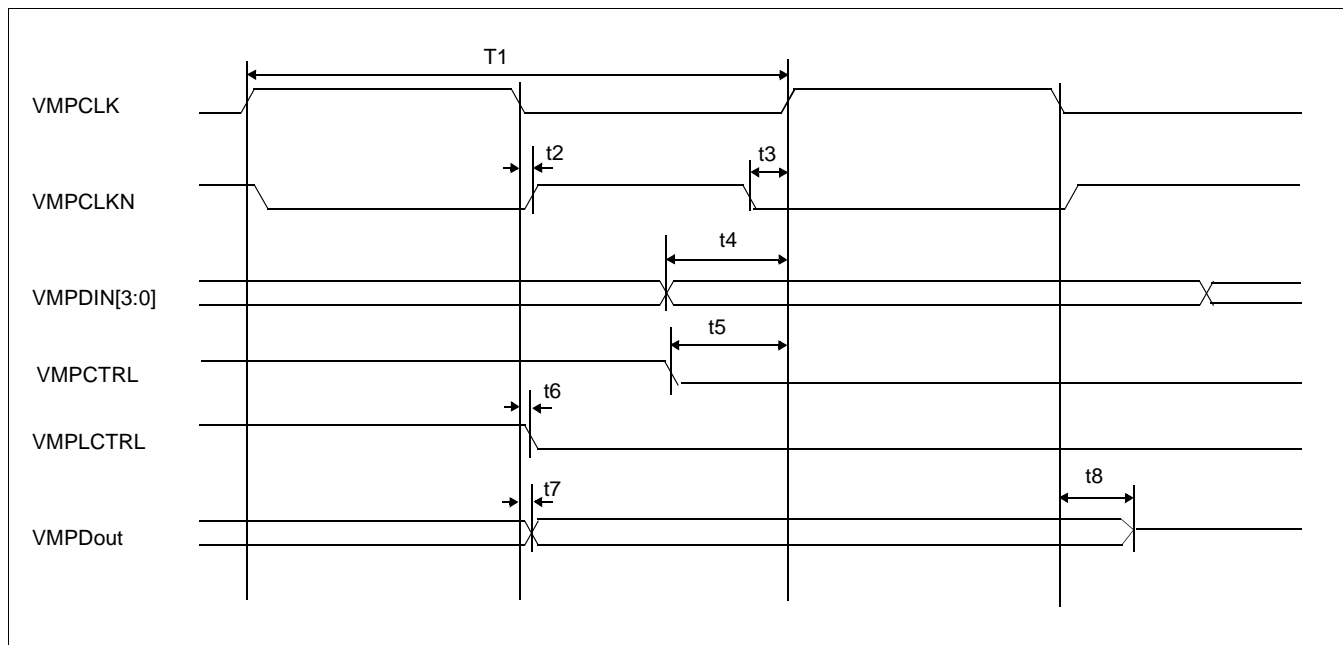


Figure 6-40: MediaPlug A.C. Timing

**Note**

The above timing diagram assumes no load.

Table 6-31: MediaPlug A.C. Timing

Symbol	Parameter	Min	Max	Units
T1	VMPCLK clock period	50		ns
t2	VMPCLK falling edge to VMPCLKN rising edge skew	0.1	0.6	ns
t3	VMPCLKN falling edge to VMPCLK rising edge skew	.3	1.1	ns
t4	Input data setup	17		ns
t5	VMPCTRL setup	16		ns
t6	Local control signal delay from VMPCLK falling edge	0	1.1	ns
t7	Output data delay from VMPCLK falling edge	0	1.1	ns
t8	Output data tristate delay from VMPCLK falling edge	0.4	1.4	ns

**Note**

VMPCLK, VMPCLKN are twice the period of the MediaPlug Clock. See Section 7, “Clocks” on page 92.

# 7 Clocks

## 7.1 Clock Overview

The following diagram provides a logical representation of the S1D13806 internal clocks.

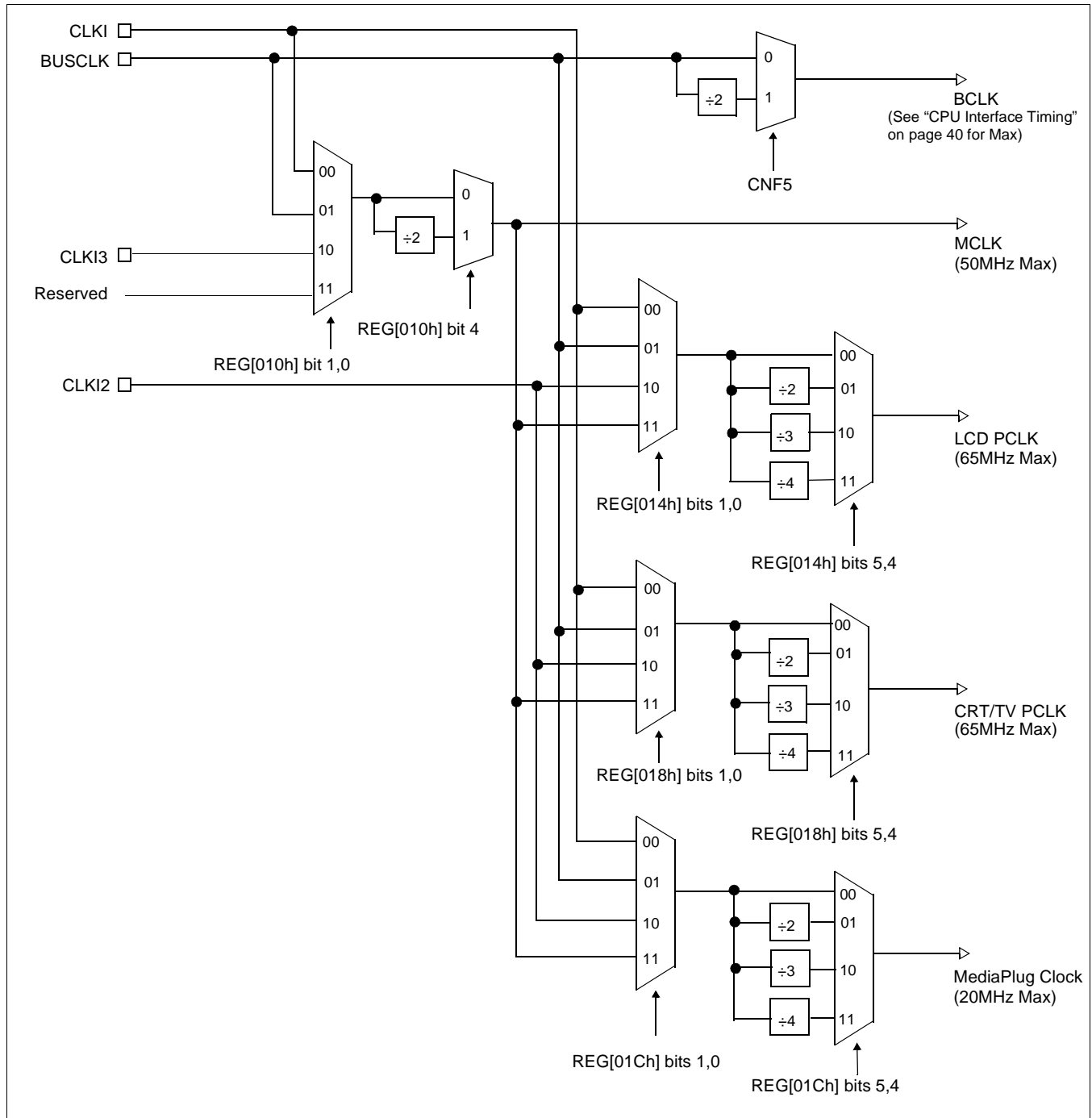


Figure 7-1: Clock Overview Diagram

## 7.2 Clock Descriptions

### 7.2.1 MCLK

MCLK should be configured as close to its maximum (50MHz) as possible. The S1D13806 contains sophisticated clock management, therefore, very little power is saved by reducing the MCLK frequency.

The frequency of MCLK is directly proportional to the bandwidth of the video memory. The bandwidth available to the CPU (for screen updates) is that left over after screen refresh takes its share. CPU bandwidth can be seriously reduced when the MCLK frequency is reduced, especially for high-resolution, high-color modes where screen refresh has high bandwidth requirements.

### 7.2.2 LCD PCLK

LCD PCLK should be chosen to match the optimum frame rate of the panel. See Section 18, “Clocking” on page 189 for details on the relationship between PCLK and frame rate, and for the maximum supportable PCLK frequencies for any given video mode.

Some flexibility is possible in the selection of PCLK. Firstly, panels typically have a range of permissible frame rates. Secondly, it may be possible to choose a higher PCLK frequency and tailor the horizontal non-display period (see REG[052h]) to bring down the frame-rate to its optimal value.

### 7.2.3 CRT/TV PCLK

TVs and older CRTs usually have very precise frequency requirements, so it may be necessary to dedicate one of the clock inputs to this function. More recent CRTs work within a range of frequencies, so it may be possible to support them with the BUSCLK or MCLK.

### 7.2.4 MediaPlug Clock

The MediaPlug Clock frequency is internally divided by 2 to provide the output signals VMPCLK and VMPCLKN for the MediaPlug interface. VMPCLK requires a clock in the range of 6-8MHz, therefore the MediaPlug Clock must be in the range of 12-16MHz. For AC timing see Section 6.7, “MediaPlug Interface Timing” on page 91.

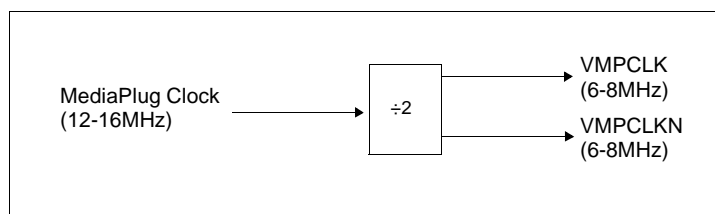


Figure 7-2: MediaPlug Clock Output Signals

## 7.3 Clock Selection

Table 7-1 : Clock Selection

Clock Source Options	Internal Clocks			
	MCLK	LCD PCLK	CRT/TV PCLK <sup>1</sup>	MediaPlug Clock
<b>CLKI</b>	REG[010h] = 00h	REG[014h] = 00h	REG[018h] = 00h	REG[01Ch] = 00h
<b>CLKI ÷ 2</b>	REG[010h] = 10h	REG[014h] = 10h	REG[018h] = 10h	REG[01Ch] = 10h
<b>CLKI ÷ 3</b>	—	REG[014h] = 20h	REG[018h] = 20h	REG[01Ch] = 20h
<b>CLKI ÷ 4</b>	—	REG[014h] = 30h	REG[018h] = 30h	REG[01Ch] = 30h
<b>CLKI2</b>	—	REG[014h] = 02h	REG[018h] = 02h	REG[01Ch] = 02h
<b>CLKI2 ÷ 2</b>	—	REG[014h] = 12h	REG[018h] = 12h	REG[01Ch] = 12h
<b>CLKI2 ÷ 3</b>	—	REG[014h] = 22h	REG[018h] = 22h	REG[01Ch] = 22h
<b>CLKI2 ÷ 4</b>	—	REG[014h] = 32h	REG[018h] = 32h	REG[01Ch] = 32h
<b>CLKI3</b>	REG[010h] = 02h	—	—	—
<b>CLKI3 ÷ 2</b>	REG[010h] = 12h	—	—	—
<b>BUSCLK</b>	REG[010h] = 01h	REG[014h] = 01h	REG[018h] = 01h	REG[01Ch] = 01h
<b>BUSCLK ÷ 2</b>	REG[010h] = 11h	REG[014h] = 11h	REG[018h] = 11h	REG[01Ch] = 11h
<b>BUSCLK ÷ 3</b>	—	REG[014h] = 21h	REG[018h] = 21h	REG[01Ch] = 21h
<b>BUSCLK ÷ 4</b>	—	REG[014h] = 31h	REG[018h] = 31h	REG[01Ch] = 31h
<b>MCLK<sup>2</sup></b>	—	REG[014h] = 03h	REG[018h] = 03h	REG[01Ch] = 03h
<b>MCLK ÷ 2<sup>2</sup></b>	—	REG[014h] = 13h	REG[018h] = 13h	REG[01Ch] = 13h
<b>MCLK ÷ 3<sup>2</sup></b>	—	REG[014h] = 23h	REG[018h] = 23h	REG[01Ch] = 23h
<b>MCLK ÷ 4<sup>2</sup></b>	—	REG[014h] = 33h	REG[018h] = 33h	REG[01Ch] = 33h

### Note

1. The CRT/TV pixel clock may be further multiplied by 2 when TV with Flicker Filter is enabled using REG[018h] bit 7.
2. MCLK may be a previously divided down version of CLKI, CLKI3, or BUSCLK.

## 7.4 Clocks vs. Functions

The S1D13806 has five clock signals. Not all clock signals must be active for certain functions to be carried out. The following table shows which clocks are required for each function.

Table 7-2: Clocks vs. Functions

Function	Required Clocks <sup>1</sup>				
	BUSCLK	LCD PCLK	CRT/TV PCLK	MCLK	MediaPlug Clock
Register read/write	Yes <sup>2</sup>	No	No	No	No
LCD LUT read/write	Yes	Yes	--	--	--
CRT/TV LUT read/write	Yes	--	Yes	--	--
Memory read/write	Yes	--	--	Yes <sup>3</sup>	--
2D Operation	Yes	--	--	Yes	--
MediaPlug Registers read/write	Yes	--	--	--	Yes
Power Save Mode	see Section 19, "Power Save Mode" on page 202				

### Note

- <sup>1</sup> The S1D13806 contains sophisticated power management that dynamically shuts down clocks when not required.
- <sup>2</sup> Before turning off the BUSCLK source externally, wait a minimum of 3 BUSCLK after a register read and a minimum of 4 BUSCLK after a register write.
- <sup>3</sup> Before turning off the MCLK source externally, wait a minimum of 6 MCLK after a memory read and a minimum of 16 MCLK after a memory write.

## 8 Registers

This section discusses how and where to access the S1D13806 registers. It also provides detailed information about the layout and usage of each register.

### 8.1 Initializing the S1D13806

Before programming the S1D13806 registers, the following bits must be set.

- Register/Memory Select bit (REG[001h] bit 7)
- SDRAM Initialization bit (REG[020h] bit 7)

#### 8.1.1 Register Memory Select Bit

At reset, the Register/Memory Select bit is set to 1. This means that only REG[000h] (read-only) and REG[001h] are accessible **until a write to REG[001h] sets bit 7 to 0 making all registers and memory accessible**. When debugging a new hardware design, this can sometimes give the appearance that the interface is not working, so it is important to remember to clear this bit before proceeding with debugging.

#### 8.1.2 SDRAM Initialization Bit

To initialize the embedded SDRAM in the S1D13806, this bit must be set to 1 a minimum of 200 $\mu$ s after reset. **This bit must be set to 1 before memory access is performed.**



## 8.2 Register Mapping

The S1D13806 registers are memory-mapped. When the system decodes the input pins as CS# = 0 and M/R# = 0, the registers may be accessed. The register space is decoded by A[20:0].

When A20 = 1 the BitBLT data register ports are decoded allowing the system to access the display buffer through the 2D BitBLT engine using address lines A[19:0]. When A20 = 0 and A12 = 0 the registers are decoded using A[8:0] as an index. When A20 = 0 and A12 = 1 the MediaPlug register ports are decoded using A[11:0].

The MediaPlug register ports are defined only when the configuration input CONF7 = 1 on reset. When CONF7 = 0 on reset, A12 is always treated as 0 and the MediaPlug register space is not available - see Table 4-9, “Summary of Power-On/Reset Options,” on page 33.

Table 8-1, “Register Mapping with CS# = 0 and M/R# = 0” shows the decoding for each register type.

*Table 8-1 : Register Mapping with CS# = 0 and M/R# = 0*

Register Types (Range)	Address A20-A0 Decoding
BitBLT data registers (1M byte)	10 0000 to 1F FFFFh
MediaPlug registers (4K bytes)	1000h to 1FFFh
On-chip registers (512 bytes)	0 to 1FFh

### Note

The registers may be aliased within the allocated register space. If aliasing is undesirable, the register space must be fully decoded.

## 8.3 Register Set

The S1D13806 register set is as follows.

Table 8-2 : S1D13806 Register Set

Register	Pg	Register	Pg
<b>Basic Registers</b>			
REG[000h] Revision Code Register	101	REG[001h] Miscellaneous Register	101
<b>General IO Pins Registers</b>			
REG[004h] General IO Pins Configuration Register 0	102	REG[005h] General IO Pins Configuration Register 1	102
REG[008h] General IO Pins Control Register 0	102	REG[009h] General IO Pins Control Register 1	103
<b>Configuration Readback Register</b>			
REG[00Ch] Configuration Status Register	103		
<b>Clock Configuration Registers</b>			
REG[010h] Memory Clock Configuration Register	103	REG[014h] LCD Pixel Clock Configuration Register	104
REG[018h] CRT/TV Pixel Clock Configuration Register	105	REG[01Ch] MediaPlug Clock Configuration Register	106
REG[01Eh] CPU To memory Wait State Select Register	107		
<b>Memory Configuration Registers</b>			
REG[020h] Memory Configuration Register	108	REG[021h] SDRAM Refresh Rate Register	109
REG[02Ah] SDRAM Timing Control Register 0	109	REG[02Bh] SDRAM Timing Control Register 1	109
<b>Panel Configuration Registers</b>			
REG[030h] Panel Type Register	110	REG[031h] MOD Rate Register	111
REG[032h] LCD Horizontal Display Width Register	111	REG[034h] LCD Horizontal Non-Display Period Register	112
REG[036h] TFT FPLINE Pulse Width Register	113	REG[038h] LCD Vertical Display Height Register 0	113
REG[039h] LCD Vertical Display Height Register 1	113	REG[03Ah] LCD Vertical Non-Display Period Register	114
REG[03Bh] TFT FPFAME Start Position Register	114	REG[03Ch] TFT FPFAME Pulse Width Register	115
<b>LCD Display Mode Registers</b>			
REG[040h] LCD Display Mode Register	115	REG[041h] LCD Miscellaneous Register	117
REG[042h] LCD Display Start Address Register 0	118	REG[043h] LCD Display Start Address Register 1	118
REG[044h] LCD Display Start Address Register 2	118	REG[046h] LCD Memory Address Offset Register 0	118
REG[047h] LCD Memory Address Offset Register 1	118	REG[048h] LCD Pixel Panning Register	119
REG[04Ah] LCD Display FIFO High Threshold Control Register	119	REG[04Bh] LCD Display FIFO Low Threshold Control Register	120
<b>CRT/TV Configuration Registers</b>			
REG[050h] CRT/TV Horizontal Display Width Register	120	REG[052h] CRT/TV Horizontal Non-Display Period Register	120
REG[053h] CRT/TV HRTC Start Position Register	121	REG[054h] CRT/TV HRTC Pulse Width Register	121
REG[056h] CRT/TV Vertical Display Height Register 0	122	REG[057h] CRT/TV Vertical Display Height Register 1	122
REG[058h] CRT/TV Vertical Non-Display Period Register	122	REG[059h] CRT/TV VRTC Start Position Register	123
REG[05Ah] CRT VRTC Pulse Width Register	123	REG[05Bh] TV Output Control Register	124
<b>CRT/TV Display Mode Registers</b>			
REG[060h] CRT/TV Display Mode Register	125	REG[062h] CRT/TV Display Start Address Register 0	126
REG[063h] CRT/TV Display Start Address Register 1	126	REG[064h] CRT/TV Display Start Address Register 2	126
REG[066h] CRT/TV Memory Address Offset Register 0	126	REG[067h] CRT/TV Memory Address Offset Register 1	126
REG[068h] CRT/TV Pixel Panning Register	127	REG[06Ah] CRT/TV FIFO High Threshold Control Register	127
REG[06Bh] CRT/TV FIFO Low Threshold Control Register	128		

Table 8-2 : SID13806 Register Set

Register	Pg	Register	Pg
<b>LCD Ink/Cursor Registers</b>			
REG[070h] LCD Ink/Cursor Control Register	128	REG[071h] LCD Ink/Cursor Start Address Register	129
REG[072h] LCD Cursor X Position Register 0	129	REG[073h] LCD Cursor X Position Register 1	129
REG[074h] LCD Cursor Y Position Register 0	130	REG[075h] LCD Cursor Y Position Register 1	130
REG[076h] LCD Ink/Cursor Blue Color 0 Register	130	REG[077h] LCD Ink/Cursor Green Color 0 Register	131
REG[078h] LCD Ink/Cursor Red Color 0 Register	131	REG[07Ah] LCD Ink/Cursor Blue Color 1 Register	131
REG[07Bh] LCD Ink/Cursor Green Color 1 Register	131	REG[07Ch] LCD Ink/Cursor Red Color 1 Register	131
REG[07Eh] LCD Ink/Cursor FIFO High Threshold Register	132		
<b>CRT/TV Ink/Cursor Registers</b>			
REG[080h] CRT/TV Ink/Cursor Control Register	132	REG[081h] CRT/TV Ink/Cursor Start Address Register	133
REG[082h] CRT/TV Cursor X Position Register 0	133	REG[083h] CRT/TV Cursor X Position Register 1	133
REG[084h] CRT/TV Cursor Y Position Register 0	134	REG[085h] CRT/TV Cursor Y Position Register 1	134
REG[086h] CRT/TV Ink/Cursor Blue Color 0 Register	135	REG[087h] CRT/TV Ink/Cursor Green Color 0 Register	135
REG[088h] CRT/TV Ink/Cursor Red Color 0 Register	135	REG[08Ah] CRT/TV Ink/Cursor Blue Color 1 Register	135
REG[08Bh] CRT/TV Ink/Cursor Green Color 1 Register	135	REG[08Ch] CRT/TV Ink/Cursor Red Color 1 Register	136
REG[08Eh] CRT/TV Ink/Cursor FIFO High Threshold Register	136		
<b>BitBLT Configuration Registers</b>			
REG[100h] BitBLT Control Register 0	137	REG[101h] BitBLT Control Register 1	138
REG[102h] BitBLT ROP Code/Color Expansion Register	139	REG[103h] BitBLT Operation Register	140
REG[104h] BitBLT Source Start Address Register 0	141	REG[105h] BitBLT Source Start Address Register 1	141
REG[106h] BitBLT Source Start Address Register 2	141	REG[108h] BitBLT Destination Start Address Register 0	142
REG[109h] BitBLT Destination Start Address Register 1	142	REG[10Ah] BitBLT Destination Start Address Register 2	142
REG[10Ch] BitBLT Memory Address Offset Register 0	142	REG[10Dh] BitBLT Memory Address Offset Register 1	142
REG[110h] BitBLT Width Register 0	143	REG[111h] BitBLT Width Register 1	143
REG[112h] BitBLT Height Register 0	143	REG[113h] BitBLT Height Register 1	143
REG[114h] BitBLT Background Color Register 0	144	REG[115h] BitBLT Background Color Register 1	144
REG[118h] BitBLT Foreground Color Register 0	144	REG[119h] BitBLT Foreground Color Register 1	144
<b>Look-Up Table Registers</b>			
REG[1E0h] Look-Up Table Mode Register	145	REG[1E2h] Look-Up Table Address Register	145
REG[1E4h] Look-Up Table Data Register	146		
<b>Power Save Configuration Registers</b>			
REG[1F0h] Power Save Configuration Register	146	REG[1F1h] Power Save Status Register	147
<b>Miscellaneous Register</b>			
REG[1F4h] CPU-To-Memory Access Watchdog Timer Register	148		
<b>Common Display Mode Register</b>			
REG[1FCh] Display Mode Register	149		
<b>MediaPlug Control Registers</b>			
REG[1000h] MediaPlug LCMD Register	150	REG[1002h] MediaPlug Reserved LCMD Register	153
REG[1004h] MediaPlug CMD Register	153	REG[1006h] MediaPlug Reserved CMD Register	154

*Table 8-2 : S1D13806 Register Set*

<b>Register</b>	<b>Pg</b>	<b>Register</b>	<b>Pg</b>
<b>MediaPlug Data Registers</b>			
REG[1008h] to REG[1FFEh] MediaPlug Data Registers	155		
<b>BitBLT Data Registers</b>			
REG[100000h] to REG[1FFFEh] BitBLT Data Registers	155		

## 8.4 Register Descriptions

### 8.4.1 Basic Registers

Revision Code Register REG[000h]							RO
Product Code Bit 5	Product Code Bit 4	Product Code Bit 3	Product Code Bit 2	Product Code Bit 1	Product Code Bit 0	Revision Code Bit 1	Revision Code Bit 0

- bits 7-2                      Product Code Bits [5:0]  
This read-only register indicates the product code of the controller. The product code for S1D13806 is 000111b.
- bits 1-0                      Revision Code Bits [1:0]  
This read-only register indicates the revision code of the controller. The revision code is 00b.

Miscellaneous Register REG[001h]							RW
Register/ Memory Select	n/a	n/a	n/a	n/a	Reserved	Reserved	Reserved

- bit 7                              Register/Memory Select Bit  
At reset, the Register/Memory Select bit is set to 1. This means that only REG[000h] (read-only) and REG[001h] are accessible **until a write to REG[001h] sets bit 7 to 0 making all registers and memory accessible**. When debugging a new hardware design, this can sometimes give the appearance that the interface is not working, so it is important to remember to clear this bit before proceeding with debugging.
- bit 2                              Reserved.  
This bit must be set to 0.
- bit 1                              Reserved.  
This bit must be set to 0.
- bit 0                              Reserved.  
This bit must be set to 0.

## 8.4.2 General IO Pins Registers

General IO Pins Configuration Register 0							
REG[004h]							RW
GPIO7 Pin IO Config.	GPIO6 Pin IO Config.	GPIO5 Pin IO Config.	GPIO4 Pin IO Config.	GPIO3 Pin IO Config.	GPIO2 Pin IO Config.	GPIO1 Pin IO Config.	GPIO0 Pin IO Config.

bit 7-0                      GPIO[7:0] Pin IO Configuration Bits  
 When bit  $n = 1$ , GPIO[ $n$ ] is configured as an output pin. (where  $n$  ranges from 0 to 7)  
 When bit  $n = 0$  (default), GPIO[ $n$ ] is configured as an input pin. (where  $n$  ranges from 0 to 7).

General IO Pins Configuration Register 1							
REG[005h]							RW
n/a	n/a	n/a	GPIO12 Pin IO Config.	GPIO11 Pin IO Config.	GPIO10 Pin IO Config.	GPIO9 Pin IO Config.	GPIO8 Pin IO Config.

bit 4-0                      GPIO[12:8] Pin IO Configuration Bits  
 When bit  $n = 1$ , GPIO[ $n+8$ ] is configured as an output pin. (where  $n$  ranges from 0 to 4)  
 When bit  $n = 0$  (default), GPIO[ $n+8$ ] is configured as an input pin. (where  $n$  ranges from 0 to 4)

### Note

Note that CONF7 must be properly configured at the rising edge of RESET# to enable GPIO12 as an IO pin, otherwise GPIO12 is used for the Media Plug interface and this register has no effect. The following table shows GPIO12 usage.

Table 8-3 : Media Plug/GPIO12 Pin Functionality

Pin	CONF7 on Reset	
	0	1
GPIO12	GPIO12	VMPEPWR

General IO Pins Control Register 0							
REG[008h]							RW
GPIO7 Pin IO Status	GPIO6 Pin IO Status	GPIO5 Pin IO Status	GPIO4Pin IO Status	GPIO3 Pin IO Status	GPIO2 Pin IO Status	GPIO1 Pin IO Status	GPIO0 Pin IO Status

bit 7-0                      GPIO[7:0] Pin IO Status Bits  
 When GPIO[ $n$ ] is configured as an output, writing a 1 to bit  $n$  drives GPIO[ $n$ ] high and writing a 0 to this bit drives GPIO[ $n$ ] low. ( $n$  ranges from 0 to 7)  
 When GPIO[ $n$ ] is configured as an input, a read from bit  $n$  returns the status of GPIO[ $n$ ]. ( $n$  ranges from 0 to 7)

General IO Pins Control Register 1							RW
REG[009h]							
n/a	n/a	n/a	GPIO12 Pin IO Status	GPIO11 Pin IO Status	GPIO10 Pin IO Status	GPIO9 Pin IO Status	GPIO8 Pin IO Status

bit 4-0 GPIO[12:8] Pin IO Status Bits  
When GPIO[ $n+8$ ] is configured as an output, writing a 1 to bit  $n$  drives GPIO[ $n+8$ ] high and writing a 0 to this bit drives GPIO[ $n+8$ ] low. ( $n$  ranges from 0 to 4)  
When GPIO[ $n+8$ ] is configured as an input, a read from bit  $n+8$  returns the status of GPIO[ $n+8$ ]. ( $n$  ranges from 0 to 4)

**Note**

CONF7 must be properly configured at the rising edge of RESET# to enable GPIO12 as an IO pin, otherwise GPIO12 is used for the Media Plug interface and this register has no effect on GPIO12. See Table 8-3, “Media Plug/GPIO12 Pin Functionality” for GPIO12 usage.

### 8.4.3 Configuration Readback Register

Configuration Status Register							RO
REG[00Ch]							
CONF[7] Config. Status	CONF[6] Config. Status	CONF[5] Config. Status	CONF[4] Config. Status	CONF[3] Config. Status	CONF[2] Config. Status	CONF[1] Config. Status	CONF[0] Config. Status

bits 7-0 CONF[7:0] Configuration Status Bits  
These read-only bits return the status of CONF[7:0] at the rising edge of RESET#.

### 8.4.4 Clock Configuration Registers

Memory Clock Configuration Register							RW
REG[010h]							
n/a	n/a	n/a	MCLK Divide Select	n/a	n/a	MCLK Source Select Bit 1	MCLK Source Select Bit 0

**Note**

For further information on MCLK, see Section 7.2, “Clock Descriptions” on page 93.

bit 4 MCLK Divide Select  
When this bit = 1, the internal memory clock (MCLK) frequency is half of the MCLK source frequency.  
When this bit = 0, the memory clock frequency is equal to the MCLK source frequency.

**Note**

The MCLK frequency should always be set to the maximum frequency allowed by the SDRAM. This provides maximum performance and minimizes overall system power consumption.

bit 1-0

MCLK Source Select Bits [1:0]

These bits determine the source of the internal memory clock (MCLK).

Table 8-4 : MCLK Source Select

MCLK Source Select Bits	MCLK Source
00	CLKI
01	BUSCLK
10	CLKI3
11	Reserved

**Note**

The MCLK Divide Select bit must be set to 1 before changing the MCLK Source Select bits.

LCD Pixel Clock Configuration Register							
REG[014h]							RW
n/a	n/a	LCD PCLK Divide Select Bit 1	LCD PCLK Divide Select Bit 0	n/a	n/a	LCD PCLK Source Select Bit 1	LCD PCLK Source Select Bit 0

**Note**

For further information on the LCD PCLK, refer to Section 7.2, “Clock Descriptions” on page 93.

bits 5-4

LCD PCLK Divide Select Bits [1:0]

These bits determine the divide used to generate the LCD pixel clock from the LCD pixel clock source.

Table 8-5 : LCD PCLK Divide Selection

LCD PCLK Divide Select Bits	LCD PCLK Source to LPCLK Frequency Ratio
00	1:1
01	2:1
10	3:1
11	4:1



bits 1-0

**LCD PCLK Source Select Bits [1:0]**

These bits determine the source of the pixel clock for the LCD display.

*Table 8-6 : LCD PCLK Source Selection*

LCD PCLK Source Select Bits	LCD PCLK Source
00	CLKI
01	BUSCLK
10	CLKI2
11	MCLK

**Note**

MCLK may be a previously divided down version of CLKI, CLKI3, or BUSCLK.

CRT/TV Pixel Clock Configuration Register							RW
REG[018h]							
Flicker Filter Clock Enable	n/a	CRT/TV PCLK Divide Select Bit 1	CRT/TV PCLK Divide Select Bit 0	n/a	n/a	CRT/TV PCLK Source Select Bit 1	CRT/TV PCLK Source Select Bit 0

**Note**

For further information on the CRT/TV PCLK, refer to Section 7.2, “Clock Descriptions” on page 93.

bit 7

**Flicker Filter Clock Enable**

This bit must be set to 1 when TV with flicker filter is enabled. For details on TV with flicker filter, see REG[1FCh] bits 2-0.

bits 5-4

**CRT/TV PCLK Divide Select Bits[1:0]**

These bits determine the divide used to generate the CRT/TV pixel clock from the CRT/TV pixel clock source.

*Table 8-7 : CRT/TV PCLK Divide Selection*

CRT/TV PCLK Divide Select Bits	CRT/TV PCLK Source to DPCLK Frequency Ratio
00	1:1
01	2:1
10	3:1
11	4:1

bits 1-0

CRT/TV PCLK Source Select Bits [1:0]

These bits determine the source of the pixel clock for the CRT/TV display.

Table 8-8 : CRT/TV PCLK Source Selection

CRT/TV PCLK Source Select Bits	CRT/TV PCLK Source
00	CLKI
01	BUSCLK
10	CLKI2
11	MCLK

**Note**

MCLK may be a previously divided down version of CLKI, CLKI3, or BUSCLK.

MediaPlug Clock Configuration Register							RW
REG[01Ch]							
n/a	n/a	MediaPlug Clock Divide Select Bit 1	MediaPlug Clock Divide Select Bit 0	n/a	n/a	MediaPlug Clock Source Select Bit 1	MediaPlug Clock Source Select Bit 0

**Note**

For further information on the MediaPlug Clock, refer to Section 7.2, “Clock Descriptions” on page 93.

bits 5-4

MediaPlug Clock Divide Select Bits [1:0]

These bits determine the divide used to generate the MediaPlug Clock from the MediaPlug Clock source.

Table 8-9 : MediaPlug Clock Divide Selection

MediaPlug Clock Divide Select Bits	MediaPlug Clock Source to MediaPlug Clock Frequency Ratio
00	1:1
01	2:1
10	3:1
11	4:1

bits 1-0                      MediaPlug Clock Source Select Bits [1:0]  
 These bits determine the source of the MediaPlug Clock for the MediaPlug Interface.  
 See Section 6.7, “MediaPlug Interface Timing” on page 91 for AC Timing.

*Table 8-10 : MediaPlug Clock Source Selection*

MediaPlug Clock Source Select Bits	MediaPlug Clock Source
00	CLKI
01	BUSCLK
10	CLKI2
11	MCLK

**Note**

MCLK may be a previously divided down version of CLKI, CLKI3, or BUSCLK.

CPU To Memory Wait State Select Register							RW	
REG[01Eh]								
n/a	n/a	n/a	n/a	n/a	n/a	CPU to Memory Wait State Select Bit 1	CPU to Memory Wait State Select Bit 0	

bits 1-0                      CPU to Memory Wait State Select Bits [1:0]  
 These bits are used to optimize the handshaking between the host interface and the mem-  
 ory controller. The bits should be set according to the relationship between BCLK and  
 MCLK (memory clock)

**Note**

BCLK can be either BUSCLK or  $BUSCLK \div 2$  depending on the setting of CONF5 (see  
 Table 4-9, “Summary of Power-On/Reset Options,” on page 33).

Failure to meet the following conditions may lead to system crash which is recoverable  
 only by RESET.

*Table 8-11 : Minimum Memory Timing Selection*

Wait State Bits [1:0]	Condition
00	no restrictions
01	$2 \times \text{period (MCLK)} - 4\text{ns} > \text{period(BCLK)}$
10	$\text{period(MCLK)} - 4\text{ns} > \text{period(BCLK)}$
11	Reserved

## 8.4.5 Memory Configuration Registers

Memory Configuration Register REG[020h]							RW
SDRAM Init	n/a	n/a	n/a	n/a	n/a	n/a	n/a

bit 7

SDRAM Initialization

**This bit must be set to 1 before memory accesses are performed.** Setting this bit to 1 after reset initializes the embedded SDRAM. Subsequent toggling of this bit after the first initialization has no effect.

When the SDRAM Initialization bit is set, the actual initialization sequence occurs at the first SDRAM refresh cycle. The initialization sequence requires approximately 16 MCLKs to complete and memory accesses cannot be made while the initialization is in progress. Any concurrently issued memory access will occur after the completion of the initialization sequence. At least one SDRAM refresh period must happen before issuing any memory accesses.

### Note

The default SDRAM refresh rate is based on the MCLK source frequency and is set using REG[21h] bits 2-0. If the refresh rate or MCLK rate is changed, the wait time will be different.

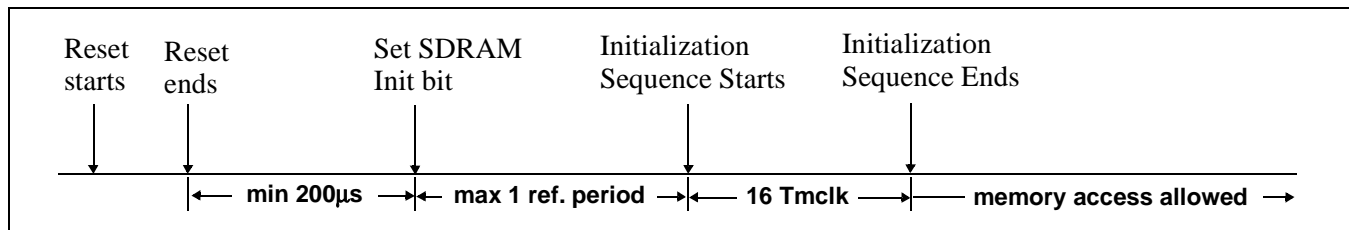


Figure 8-1: SDRAM Initialization Sequence

SDRAM Refresh Rate Register							RW	
REG[021h]								
n/a	Reserved	n/a	n/a	n/a	Reserved	SDRAM Refresh Rate Bit 1	SDRAM Refresh Rate Bit 0	

- bit 6 Reserved.  
This bit must be set to 0.
- bit 2 Reserved.  
This bit must be set to 0.
- bits 1-0 SDRAM Refresh Rate Select Bits [2:0]  
These bits are set according to the MCLK source frequency (i.e., BUSCLK, CLKI, or CLKI3 as determined by REG[010h] bits 1-0).

Table 8-12 : SDRAM Refresh Rate Selection

SDRAM Refresh Rate Bits [1:0]	MCLK Source Frequency (MHz)
00	4.096 <= MClk < 8.192
01	8.192 <= MClk < 16.384
10	16.384 <= MClk < 32.768
11	32.768 <= MClk <= 50.000

SDRAM Timing Control Register 0							RW	
REG[02Ah]								
SDRAM Timing Control Bit 7	SDRAM Timing Control Bit 6	SDRAM Timing Control Bit 5	SDRAM Timing Control Bit 4	SDRAM Timing Control Bit 3	SDRAM Timing Control Bit 2	SDRAM Timing Control Bit 1	SDRAM Timing Control Bit 0	

SDRAM Timing Control Register 1							RW	
REG[02Bh]								
n/a	n/a	n/a	SDRAM Timing Control Bit 12	SDRAM Timing Control Bit 11	SDRAM Timing Control Bit 10	SDRAM Timing Control Bit 9	SDRAM Timing Control Bit 8	

- REG[02Ah] bits 7-0 SDRAM Timing Control Bits [12:0]
- REG[02Bh] bits 4-0 The SDRAM Timing Control registers must be set according to the frequency of MCLK as follows.

Table 8-13 : SDRAM Timings Control Register Settings

MCLK Source Frequency (MHz)	REG[02Ah]	REG[02Bh]
42 ≤ MCLK ≤ 50	00h	01h
33 ≤ MCLK < 42	00h	12h
MCLK < 33	11h	13h

## 8.4.6 Panel Configuration Registers

Panel Type Register REG[030h]							RW
EL Panel Mode Enable	TFT 2x Data Format Select	Panel Data Width Bit 1	Panel Data Width Bit 0	Panel Data Format Select	Color/Mono. Panel Select	Dual/Single Panel Select	TFT/ Passive LCD Panel Select

- bit 7                      EL Panel Mode Enable  
When this bit = 1, EL Panel support circuit is enabled.  
When this bit = 0, there is no hardware effect.  
This bit enables the S1D13806 built-in circuit for EL panels which require the Frame Rate Modulation (FRM) to remain static for one frame every 262143 frames (approximately 1 hour at 60Hz refresh). When this bit is enabled, the need for external circuitry to perform the above function is eliminated.
- bit 6                      TFT 2x Data Format Select  
**For TFT/D-TFD only.**  
When this bit = 1, the TFT 2x Data format is selected.  
When this bit = 0, the standard TFT Data format is selected.  
  
For details on the TFT 2x Data format, see Section 6.5.10, “TFT/D-TFD Panel Timing” on page 82.
- bits 5-4                  Panel Data Width Bits [1:0]  
These bits select passive LCD/TFT/D-TFD panel data width size.

Table 8-14 : Panel Data Width Selection

Panel Data Width Bits [1:0]	Passive LCD Panel Data Width	TFT/D-TFD Panel Data Width	
		1x Data Format	2x Data Format
00	4-bit	9-bit	2 x 9-bit
01	8-bit	12-bit	2 x 12-bit
10	16-bit	18-bit	Reserved
11	Reserved	Reserved	Reserved

- bit 3                      Panel Data Format Select  
When this bit = 1, 8-bit single color passive LCD panel data format 2 is selected. For AC timing see Section 6.5.5, “Single Color 8-Bit Panel Timing (Format 2)” on page 72.  
When this bit = 0, 8-bit single color passive LCD panel data format 1 is selected. For AC timing see Section 6.5.4, “Single Color 8-Bit Panel Timing (Format 1)” on page 70.
- bit 2                      Color/Mono Panel Select  
When this bit = 1, color passive LCD panel is selected.  
When this bit = 0, monochrome passive LCD panel is selected.
- bit 1                      Dual/Single Panel Select  
When this bit = 1, dual passive LCD panel is selected.  
When this bit = 0, single passive LCD panel is selected.

bit 0 TFT/Passive LCD Panel Select  
When this bit = 1, TFT/D-TFD panel is selected.  
When this bit = 0, passive LCD panel is selected.

MOD Rate Register							RW
REG[031h]							
n/a	n/a	MOD Rate Bit 5	MOD Rate Bit 4	MOD Rate Bit 3	MOD Rate Bit 2	MOD Rate Bit 1	MOD Rate Bit 0

bits 5-0 MOD Rate Bits [5:0]  
For a non-zero value these bits specify the number of FPLINE between toggles of the MOD output signal (DRDY).  
When these bits are all 0's the MOD output signal toggles every FPFRAME. These bits are for passive LCD panels only.

LCD Horizontal Display Width Register							RW
REG[032h]							
n/a	LCD Horizontal Display Width Bit 6	LCD Horizontal Display Width Bit 5	LCD Horizontal Display Width Bit 4	LCD Horizontal Display Width Bit 3	LCD Horizontal Display Width Bit 2	LCD Horizontal Display Width Bit 1	LCD Horizontal Display Width Bit 0

bits 6-0 LCD Horizontal Display Width Bits [6:0]  
These bits specify the LCD panel horizontal display width, in 8 pixel resolution.  
Horizontal display width in number of pixels = ((ContentsOfThisRegister)+ 1) × 8  
The Horizontal Display Width has certain limitations on the values that may be used for each type of LCD panel. Use of values that do not meet the limitations listed in the following table result in undefined behavior.

Table 8-15: Horizontal Display Width (Pixels)

Panel Type	Horizontal Display Width (Pixels)
Passive Single	must be divisible by 16
Passive Dual	must be divisible by 32
TFT	must be divisible by 8

**Note**

This register must be programmed such that REG[032h] ≥ 3 (32 pixels).

LCD Horizontal Non-Display Period Register							RW
REG[034h]							
n/a	n/a	n/a	LCD Horizontal Non-Display Period Bit 4	LCD Horizontal Non-Display Period Bit 3	LCD Horizontal Non-Display Period Bit 2	LCD Horizontal Non-Display Period Bit 1	LCD Horizontal Non-Display Period Bit 0

bits 4-0

LCD Horizontal Non-Display Period Bits [4:0]

These bits specify the LCD panel HNDP width in 8 pixel resolution.

HNDP width in number of pixels = ((ContentsOfThisRegister) + 1) × 8

**Note**

This register must be programmed such that REG[034h] ≥ 3 (32 pixels).

**Note**

For TFT/D-TFD only:

REG[034h] + 1 ≥ (REG[035h] + 1) + (REG[036h] bits 3-0 + 1)

TFT FPLINE Start Position Register							RW
REG[035h]							
n/a	n/a	n/a	TFT FPLINE Start Position Bit 4	TFT FPLINE Start Position Bit 3	TFT FPLINE Start Position Bit 2	TFT FPLINE Start Position Bit 1	TFT FPLINE Start Position Bit 0

bits 4-0

TFT FPLINE Start Position Bits [4:0]

**For TFT/D-TFD panels only**, these bits specify the delay, in 8 pixel resolution, from the start of the horizontal non-display period to the leading edge of the FPLINE pulse.

For TFT 1x Data Format at 4/8 bpp color depth:

FPLINE start position in number of pixels = [(ContentsOfThisRegister) × 8 + 5]

For TFT 1x Data Format at 16 bpp color depth:

FPLINE start position in number of pixels = [(ContentsOfThisRegister) × 8 + 6]

For TFT 2x Data Format at 4/8 bpp color depth:

FPLINE start position in number of pixels = [(ContentsOfThisRegister) × 8 + 4]

For TFT 2x Data Format at 16 bpp color depth:

FPLINE start position in number of pixels = [(ContentsOfThisRegister) × 8 + 5]

**Note**

REG[034h] + 1 ≥ (REG[035h] + 1) + (REG[036h] bits 3-0 + 1)



TFT FPLINE Pulse Width Register							RW
REG[036h]							
LCD FPLINE Polarity Select	n/a	n/a	n/a	TFT FPLINE Pulse Width Bit 3	TFT FPLINE Pulse Width Bit 2	TFT FPLINE Pulse Width Bit 1	TFT FPLINE Pulse Width Bit 0

bit 7 LCD FPLINE Polarity Select  
This bit selects the polarity of FPLINE for all LCD panels.  
When this bit = 1, the FPLINE pulse is active high for TFT/D-TFD and active low for passive LCD.  
When this bit = 0, the FPLINE pulse is active low for TFT/D-TFD and active high for passive LCD.

Table 8-16 : LCD FPLINE Polarity Selection

LCD FPLINE Polarity Select	Passive LCD FPLINE Polarity	TFT FPLINE Polarity
0	active high	active low
1	active low	active high

bits 3-0 TFT FPLINE Pulse Width Bits [3:0]  
**For TFT/D-TFD panels only**, these bits specify the pulse width of the FPLINE output signal in 8 pixel resolution.  
FPLINE pulse width in number of pixels = ((ContentsOfThisRegister) + 1) × 8  
The maximum FPLINE pulse width is 128 pixels.

**Note**

$$\text{REG}[034h] + 1 \geq (\text{REG}[035h] + 1) + (\text{REG}[036h] \text{ bits } 3-0 + 1)$$

LCD Vertical Display Height Register 0								RW
REG[038h]								
LCD Vertical Display Height Bit 7	LCD Vertical Display Height Bit 6	LCD Vertical Display Height Bit 5	LCD Vertical Display Height Bit 4	LCD Vertical Display Height Bit 3	LCD Vertical Display Height Bit 2	LCD Vertical Display Height Bit 1	LCD Vertical Display Height Bit 0	

LCD Vertical Display Height Register 1							RW
REG[039h]							
n/a	n/a	n/a	n/a	n/a	n/a	LCD Vertical Display Height Bit 9	LCD Vertical Display Height Bit 8

REG[038h] bits 7-0 LCD Vertical Display Height Bits [9:0]  
REG[039h] bits 1-0 These bits specify the LCD panel vertical display height, in 1 line resolution.  
Vertical display height in number of lines = (ContentsOfThisRegister) + 1

LCD Vertical Non-Display Period Register							RW
REG[03Ah]							
LCD Vertical Non-Display Period Status (RO)	n/a	LCD Vertical Non-Display Period Bit 5	LCD Vertical Non-Display Period Bit 4	LCD Vertical Non-Display Period Bit 3	LCD Vertical Non-Display Period Bit 2	LCD Vertical Non-Display Period Bit 1	LCD Vertical Non-Display Period Bit 0

- bit 7 LCD Vertical Non-Display Period Status  
This is a read-only status bit.  
When a read from this bit = 1, a LCD panel vertical non-display period is occurring.  
When a read from this bit = 0, the LCD panel output is in a vertical display period.
- bits 5-0 LCD Vertical Non-Display Period Bits [5:0]  
These bits specify the LCD panel vertical non-display period height in 1 line resolution.  
Vertical non-display period height in number of lines = (ContentsOfThisRegister) + 1

**Note**

For TFT/D-TFD only:

$$(\text{REG}[03\text{Ah}] \text{ bits } 5-0 + 1) \geq (\text{REG}[03\text{Bh}] + 1) + (\text{REG}[03\text{Ch}] \text{ bits } 2-0 + 1)$$

TFT FPFRAME Start Position Register							RW
REG[03Bh]							
n/a	n/a	TFT FPFRAME Start Position Bit 5	TFT FPFRAME Start Position Bit 4	TFT FPFRAME Start Position Bit 3	TFT FPFRAME Start Position Bit 2	TFT FPFRAME Start Position Bit 1	TFT FPFRAME Start Position Bit 0

- bits 5-0 TFT FPFRAME Start Position Bits [5:0]  
**For TFT/D-TFD panels only**, these bits specify the delay in lines from the start of the vertical non-display period to the leading edge of the FPFRAME pulse.  
FPFRAME start position in number of lines = (ContentsOfThisRegister) + 1

**Note**

$$(\text{REG}[03\text{Ah}] \text{ bits } 5-0 + 1) \geq (\text{REG}[03\text{Bh}] + 1) + (\text{REG}[03\text{Ch}] \text{ bits } 2-0 + 1)$$

TFT FPFAME Pulse Width Register							RW
REG[03Ch]							
LCD FPFAME Polarity Select	n/a	n/a	n/a	n/a	TFT FPFAME Pulse Width Bit 2	TFT FPFAME Pulse Width Bit 1	TFT FPFAME Pulse Width Bit 0

bit 7 LCD FPFAME Polarity Select  
This bit selects the polarity of FPFAME for all LCD panels.  
When this bit = 1, the FPFAME pulse is active high for TFT/D-TFD and active low for passive LCD.  
When this bit = 0, the FPFAME pulse is active low for TFT/D-TFD and active high for passive LCD.

Table 8-17 : LCD FPFAME Polarity Selection

LCD FPFAME Polarity Select	Passive LCD FPFAME Polarity	TFT FPFAME Polarity
0	active high	active low
1	active low	active high

bits 2-0 TFT FPFAME Pulse Width Bits [2:0]  
**For TFT/D-TFD panels only**, these bits specify the pulse width of the FPFAME output signal in number of lines.

$$\text{FPFAME pulse width in number of lines} = (\text{ContentsOfThisRegister}) + 1$$

**Note**

$$(\text{REG}[03Ah] \text{ bits } 5-0 + 1) \geq (\text{REG}[03Bh] + 1) + (\text{REG}[03Ch] \text{ bits } 2-0 + 1)$$

### 8.4.7 LCD Display Mode Registers

LCD Display Mode Register							RW
REG[040h]							
LCD Display Blank	n/a	n/a	SwivelView Enable Bit 1	n/a	LCD Bit-per-pixel Select Bit 2	LCD Bit-per-pixel Select Bit 1	LCD Bit-per-pixel Select Bit 0

bit 7 LCD Display Blank  
When this bit = 1, the LCD display pipeline is disabled and all LCD data outputs are forced to zero (i.e. the screen is blanked).  
When this bit = 0, the LCD display pipeline is enabled.

**Note**

If a dual panel is used, the Dual Panel Buffer (REG[041h] bit 0) must be disabled (set to 1) before blanking the LCD display.

bit 4

**SwivelView Enable Bit 1**

When this bit = 1, the LCD display image is rotated 180° clockwise. Please refer to Section 15, “SwivelView™” on page 177 for application and limitations.

When this bit = 0, there is no hardware effect.

This bit in conjunction with SwivelView™ Enable Bit 0 achieves the following hardware rotations.

*Table 8-18: Setting SwivelView Modes*

SwivelView Enable Bits	SwivelView™ Modes			
	Normal	SwivelView 90°	SwivelView 180°	SwivelView 270°
SwivelView Enable Bit 0 (REG[1FCh] bit 6)	0	1	0	1
SwivelView Enable Bit 1 (REG[040h] bit 4)	0	0	1	1

bits 2-0

**LCD Bit-per-pixel Select Bits [2:0]**

These bits select the color depth (bit-per-pixel) for the displayed data.

**Note**

16 bpp color depth bypasses the LUT and supports up to 64K colors (4096 colors if dithering disabled, see REG[041h] bit 1). TFT/D-TFD panels support up to 64K colors.

*Table 8-19 : LCD Bit-per-pixel Selection*

Bit-per-pixel Select Bits [1:0]	Color Depth (bpp)
000-001	Reserved
010	4 bpp
011	8 bpp
100	Reserved
101	16 bpp
110-111	Reserved

LCD Miscellaneous Register							RW	
REG[041h]								
n/a	n/a	n/a	n/a	n/a	n/a	Dithering Disable	Dual Panel Buffer Disable	

**bit 1** Dithering Disable  
 When this bit = 0, dithering on the passive LCD panel for 16 bpp mode is enabled allowing a maximum of 64K colors ( $2^{16}$ ) or 64 gray shades.  
 When this bit = 1, dithering on the passive LCD panel for 16 bpp mode is disabled, allowing a maximum of 4096 colors ( $2^{12}$ ) or 16 gray shades.  
 The dithering algorithm provides more shades of each primary color when in 16 bpp mode. This bit has no effect in 4/8 bpp modes where dithering is not supported.

All passive STN color panels are controlled using 3 bits for each pixel (RGB) for a total of 8 possible colors. LCD controllers use a combination of Frame Rate Modulation (FRM) and dithering to achieve more than 8 colors per pixel. FRM can achieve 16 shades of color for each RGB component resulting in a total of 4096 possible colors ( $16 \times 16 \times 16$ ). Dithering uses a 4 pixel square formation and applies a set of 4 hard-coded patterns for each of the 16 shades of color. This expands the original 16 shades of color from the FRM logic to 64 shades per RGB component which results in 256K colors per pixel ( $64 \times 64 \times 64$ ).

For the S1D13806, 16 bpp is arranged as 5-6-5 RGB. In this mode, when dithering is enabled, the LUT is bypassed and the original 16-bit data is used as a pointer into the 64 shades per color in the following manner.

(5-6-5 RGB) 32 possible Red, 64 possible Green, 32 possible Blue

This combination of FRM and dithering results in 256K colors/pixel, however, the 16 bpp limitation of the S1D13806 limits this to 64K colors/pixel.

**bit 0** Dual Panel Buffer Disable  
 This bit is used to disable the dual panel buffer.  
 When this bit = 1, the dual panel buffer is disabled.  
 When this bit = 0, the dual panel buffer is enabled.  
 When a single panel is selected, the dual panel buffer is automatically disabled and this bit has no effect.

**Note**

The dual panel buffer is needed to fully support dual panels. Disabling the dual panel buffer may allow higher resolution/color display modes than would otherwise be possible. However, disabling the dual panel buffer reduces image contrast and overall display quality. For details on Frame Rate Calculation, see Section 18, “Clocking” on page 189.

LCD Display Start Address Register 0							
REG[042h]							RW
LCD Display Start Address Bit 7	LCD Display Start Address Bit 6	LCD Display Start Address Bit 5	LCD Display Start Address Bit 4	LCD Display Start Address Bit 3	LCD Display Start Address Bit 2	LCD Display Start Address Bit 1	LCD Display Start Address Bit 0

LCD Display Start Address Register 1							
REG[043h]							RW
LCD Display Start Address Bit 15	LCD Display Start Address Bit 14	LCD Display Start Address Bit 13	LCD Display Start Address Bit 12	LCD Display Start Address Bit 11	LCD Display Start Address Bit 10	LCD Display Start Address Bit 9	LCD Display Start Address Bit 8

LCD Display Start Address Register 2							
REG[044h]							RW
n/a	n/a	n/a	n/a	LCD Display Start Address Bit 19	LCD Display Start Address Bit 18	LCD Display Start Address Bit 17	LCD Display Start Address Bit 16

REG[042h] bits 7-0 LCD Display Start Address Bits [19:0]  
 REG[043h] bits 7-0 This register forms the 20-bit address of the starting word of the LCD image in the display buffer.  
 REG[044h] bits 3-0

**This is a word address.** An entry of 0 0000h into these registers represents the first word of the display buffer, an entry of 0 0001h represents the second word of the display buffer, and so on.

LCD Memory Address Offset Register 0							
REG[046h]							RW
LCD Memory Address Offset Bit 7	LCD Memory Address Offset Bit 6	LCD Memory Address Offset Bit 5	LCD Memory Address Offset Bit 4	LCD Memory Address Offset Bit 3	LCD Memory Address Offset Bit 2	LCD Memory Address Offset Bit 1	LCD Memory Address Offset Bit 0

LCD Memory Address Offset Register 1							
REG[047h]							RW
n/a	n/a	n/a	n/a	n/a	LCD Memory Address Offset Bit 10	LCD Memory Address Offset Bit 9	LCD Memory Address Offset Bit 8

REG[046h] bits 7-0 LCD Memory Address Offset Bits [10:0]  
 REG[047h] bits 2-0 These bits are the LCD display's 11-bit address offset from the starting word of line "n" to the starting word of line "n + 1".

A virtual image can be formed by setting this register to a value greater than the width of the display. The displayed image is a window into the larger virtual image.

LCD Pixel Panning Register							RW
REG[048h]							
n/a	n/a	n/a	n/a	n/a	n/a	LCD Pixel Panning Bit 1	LCD Pixel Panning Bit 0

bits 1-0

**LCD Pixel Panning Bits [1:0]**

This register is used to control the horizontal pixel panning of the LCD display. The display can be panned to the left by programming its respective Pixel Panning Bits to a non-zero value. This value represents the number of pixels panned. The maximum pan value is dependent on the display mode as shown in the table below.

*Table 8-20 : LCD Pixel Panning Selection*

Color Depth (bpp)	Screen 2 Pixel Panning Bits Used
4 bpp	Bits [1:0]
8 bpp	Bit 0
16 bpp	---

**Note**

Smooth horizontal panning can be achieved by a combination of this register and the LCD Display Start Address registers (REG[042h], REG[043h], REG[044h]).

LCD Display FIFO High Threshold Control Register								RW
REG[04Ah]								
n/a	n/a	LCD Display FIFO High Threshold Bit 5	LCD Display FIFO High Threshold Bit 4	LCD Display FIFO High Threshold Bit 3	LCD Display FIFO High Threshold Bit 2	LCD Display FIFO High Threshold Bit 1	LCD Display FIFO High Threshold Bit 0	

bits 5-0

**LCD Display FIFO High Threshold Bits [5:0]**

These bits are used to optimize the display memory request arbitration. When this register is set to 00h, the threshold is automatically set in hardware. However, programming may be required if screen corruption is present (see Section 18.2, “Example Frame Rates” on page 192).

**Note**

This register does not need to be used in single display modes and may only be required in some display modes where two displays are active (see Section 16.3, “Bandwidth Limitation” on page 187).

LCD Display FIFO Low Threshold Control Register							
REG[04Bh]							RW
n/a	n/a	LCD Display FIFO Low Threshold Bit 5	LCD Display FIFO Low Threshold Bit 4	LCD Display FIFO Low Threshold Bit 3	LCD Display FIFO Low Threshold Bit 2	LCD Display FIFO Low Threshold Bit 1	LCD Display FIFO Low Threshold Bit 0

bits 5-0 LCD Display FIFO Low Threshold Bits [5:0]  
When this register is set to 00h, the threshold is automatically set in hardware. If it becomes necessary to adjust REG[04Ah] from its default value, then the following formula must be maintained:

$$\text{REG}[04\text{Bh}] \geq \text{REG}[04\text{Ah}] \text{ and } \text{REG}[04\text{Bh}] \leq 3\text{Ch}$$

## 8.4.8 CRT/TV Configuration Registers

CRT/TV Horizontal Display Width Register							
REG[050h]							RW
n/a	CRT/TV Horizontal Display Width Bit 6	CRT/TV Horizontal Display Width Bit 5	CRT/TV Horizontal Display Width Bit 4	CRT/TV Horizontal Display Width Bit 3	CRT/TV Horizontal Display Width Bit 2	CRT/TV Horizontal Display Width Bit 1	CRT/TV Horizontal Display Width Bit 0

bits 6-0 CRT/TV Horizontal Display Width Bits [6:0]  
These bits specify the CRT/TV horizontal display width, in 8 pixel resolution.  
Horizontal display width in number of pixels = ((ContentsOfThisRegister) + 1) × 8

CRT/TV Horizontal Non-Display Period Register							
REG[052h]							RW
n/a	n/a	CRT/TV Horizontal Non-Display Period Bit 5	CRT/TV Horizontal Non-Display Period Bit 4	CRT/TV Horizontal Non-Display Period Bit 3	CRT/TV Horizontal Non-Display Period Bit 2	CRT/TV Horizontal Non-Display Period Bit 1	CRT/TV Horizontal Non-Display Period Bit 0

bits 5-0 CRT/TV Horizontal Non-Display Period Bits [5:0]  
These bits specify the CRT/TV horizontal non-display period width in 8 pixel resolution.  
Horizontal non-display period width in number of pixels =  
 $((\text{ContentsOfThisRegister}) + 1) \times 8$  for CRT mode  
 $(\text{ContentsOfThisRegister}) \times 8 + 6$  for TV mode with NTSC output  
 $(\text{ContentsOfThisRegister}) \times 8 + 7$  for TV mode with PAL output

### Note

For CRT, the recommended minimum value which should be programmed into this register is 3 (32 pixels).

### Note

$$\text{REG}[052\text{h}] + 1 \geq (\text{REG}[053\text{h}] + 1) + (\text{REG}[054\text{h}] \text{ bits } 3\text{-}0 + 1)$$



CRT/TV HRTC Start Position Register							RW
REG[053h]							
n/a	n/a	CRT/TV HRTC Start Position Bit 5	CRT/TV HRTC Start Position Bit 4	CRT/TV HRTC Start Position Bit 3	CRT/TV HRTC Start Position Bit 2	CRT/TV HRTC Start Position Bit 1	CRT/TV HRTC Start Position Bit 0

bits 5-0 CRT/TV HRTC Start Position Bits [5:0]  
For CRT/TV, these bits specify the delay, in 8 pixel resolution, from the start of the horizontal non-display period to the leading edge of the HRTC pulse.

The following equations can be used to determine the HRTC start position in number of pixels for each display type:

HRTC start position in number of pixels=:

- [(ContentsOfThisRegister) x 8 + 4] for CRT with 4/8 bpp color depth
- [(ContentsOfThisRegister) x 8 + 5] for CRT in 16 bpp color depth
- [((ContentsOfThisRegister) + 1) x 8 - 7] for TV-NTSC in 4/8 bpp color depth
- [((ContentsOfThisRegister) + 1) x 8 - 5] for TV-NTSC in 16 bpp color depth
- [((ContentsOfThisRegister) + 1) x 8 - 7] for TV-PAL in 4/8 bpp color depth
- [((ContentsOfThisRegister) + 1) x 8 - 5] for TV-PAL in 16 bpp color depth

**Note**

$$\text{REG}[052\text{h}] + 1 \geq (\text{REG}[053\text{h}] + 1) + (\text{REG}[054\text{h}] \text{ bits } 3-0 + 1)$$

CRT/TV HRTC Pulse Width Register							RW
REG[054h]							
CRT HRTC Polarity Select	n/a	n/a	n/a	CRT HRTC Pulse Width Bit 3	CRT HRTC Pulse Width Bit 2	CRT HRTC Pulse Width Bit 1	CRT HRTC Pulse Width Bit 0

bit 7 CRT HRTC Polarity Select  
This bit selects the polarity of HRTC for CRTs.  
When this bit = 1, the HRTC pulse is active high.  
When this bit = 0, the HRTC pulse is active low.

**Note**

For TV, this bit must be set to 0.

bits 3-0 CRT HRTC Pulse Width Bits [3:0]  
These bits specify the pulse width of the CRT HRTC output signal in 8 pixel resolution.  
HRTC pulse width in number of pixels = ((ContentsOfThisRegister) + 1) x 8

**Note**

For TV, these bits must be set to 0.

**Note**

$$\text{REG}[052\text{h}] + 1 \geq (\text{REG}[053\text{h}] + 1) + (\text{REG}[054\text{h}] \text{ bits } 3-0 + 1)$$

CRT/TV Vertical Display Height Register 0							
REG[056h]							RW
CRT/TV Vertical Display Height Bit 7	CRT/TV Vertical Display Height Bit 6	CRT/TV Vertical Display Height Bit 5	CRT/TV Vertical Display Height Bit 4	CRT/TV Vertical Display Height Bit 3	CRT/TV Vertical Display Height Bit 2	CRT/TV Vertical Display Height Bit 1	CRT/TV Vertical Display Height Bit 0

CRT/TV Vertical Display Height Register 1							
REG[057h]							RW
n/a	n/a	n/a	n/a	n/a	n/a	CRT/TV Vertical Display Height Bit 9	CRT/TV Vertical Display Height Bit 8

REG[056h] bits 7-0 CRT/TV Vertical Display Height Bits [9:0]

REG[057h] bits 1-0 These bits specify the CRT/TV vertical display height, in 1 line resolution.

Vertical display height in number of lines = (ContentsOfThisRegister) + 1

CRT/TV Vertical Non-Display Period Register							
REG[058h]							RW
CRT/TV Vertical Non- Display Period Status (RO)	CRT/TV Vertical Non- Display Period Bit 6	CRT/TV Vertical Non- Display Period Bit 5	CRT/TV Vertical Non- Display Period Bit 4	CRT/TV Vertical Non- Display Period Bit 3	CRT/TV Vertical Non- Display Period Bit 2	CRT/TV Vertical Non- Display Period Bit 1	CRT/TV Vertical Non- Display Period Bit 0

bit 7 CRT/TV Vertical Non-Display Period Status

This is a read-only status bit.

When a read from this bit = 1, a CRT/TV vertical non-display period is occurring.

When a read from this bit = 0, the CRT/TV output is in a vertical display period.

bits 6-0 CRT/TV Vertical Non-Display Period Bits [6:0]

These bits specify the CRT/TV vertical non-display period height in 1 line resolution.

Vertical non-display period height in number of lines = (ContentsOfThisRegister) + 1

**Note**

$(\text{REG}[058\text{h}] \text{ bits } 6-0 + 1) \geq (\text{REG}[059\text{h}] + 1) + (\text{REG}[05\text{A}\text{h}] \text{ bits } 2-0 + 1)$

CRT/TV VRTC Start Position Register							RW
REG[059h]							
n/a	CRT/TV VRTC Start Position Bit 6	CRT/TV VRTC Start Position Bit 5	CRT/TV VRTC Start Position Bit 4	CRT/TV VRTC Start Position Bit 3	CRT/TV VRTC Start Position Bit 2	CRT/TV VRTC Start Position Bit 1	CRT/TV VRTC Start Position Bit 0

bits 6-0 CRT/TV VRTC Start Position Bits [6:0]  
For CRT/TV, these bits specify the delay in lines from the start of the vertical non-display period to the leading edge of the VRTC pulse.

$$\text{VRTC start position in number of lines} = (\text{ContentsOfThisRegister}) + 1$$

**Note**

$$(\text{REG}[058\text{h}] \text{ bits } 6-0 + 1) \geq (\text{REG}[059\text{h}] + 1) + (\text{REG}[05\text{Ah}] \text{ bits } 2-0 + 1)$$

CRT VRTC Pulse Width Register						RW	
REG[05Ah]							
CRT VRTC Polarity Select	n/a	n/a	n/a	n/a	CRT VRTC Pulse Width Bit 2	CRT VRTC Pulse Width Bit 1	CRT VRTC Pulse Width Bit 0

bit 7 CRT VRTC Polarity Select  
This bit selects the polarity of VRTC for CRT.  
When this bit = 1, the VRTC pulse is active high.  
When this bit = 0, the VRTC pulse is active low.

**Note**

For TV, this bit must be set to 0.

bits 2-0 CRT VRTC Pulse Width Bits [2:0]  
These bits specify the pulse width of the CRT VRTC output signal in number of lines.  
VRTC pulse width in number of lines = (ContentsOfThisRegister) + 1

**Note**

For TV, these bits must be set to 0.

**Note**

$$(\text{REG}[058\text{h}] \text{ bits } 6-0 + 1) \geq (\text{REG}[059\text{h}] + 1) + (\text{REG}[05\text{Ah}] \text{ bits } 2-0 + 1)$$

TV Output Control Register							RW
REG[05Bh]							
n/a	n/a	TV Chrominance Filter Enable	TV Luminance Filter Enable	DAC Output Level Select	n/a	TV S-Video/Composite Output Select	TV PAL/NTSC Output Select

- bit 5            TV Chrominance Filter Enable  
When this bit = 1, the TV chrominance filter is enabled.  
When this bit = 0, the TV chrominance filter is disabled.  
The chrominance filter adjusts the color of the TV by limiting the bandwidth of the chrominance signal (reducing cross-luminance distortion). This reduces the “ragged edges” seen at boundaries between sharp color transitions. This filter is most useful for composite video output.
- bit 4            TV Luminance Filter Enable  
When this bit = 1, the TV luminance filter is enabled.  
When this bit = 0, the TV luminance filter is disabled.  
The luminance filter adjusts the brightness of the TV by limiting the bandwidth of the luminance signal (reducing cross-chrominance distortion). This reduces the “rainbow-like” colors at boundaries between sharp luminance transitions. This filter is most useful for composite video output.
- bit 3            DAC Output Level Select  
When this bit is set to 1 it allows IREF to be reduced. This bit should be set as described in the following table.

Table 8-21: DAC Output Level Selection

LCD	CRT	TV	REG[05Bh] bit 3	IREF (mA)
Enabled	Disabled	Disabled	x	x
x	Enabled	Disabled	1	4.6
x	Enabled	Enabled	0	9.2

x	= don't care
---	--------------

**Note**

Figure 4-3: “External Circuitry for CRT Interface” on page 36 shows an example implementation of the required external CRT/TV IREF circuitry.

- bit 1            TV S-Video/Composite Output Select  
When this bit = 1, S-Video TV signal output is selected.  
When this bit = 0, Composite TV signal output is selected.
- bit 0            TV PAL/NTSC Output Select  
When this bit = 1, PAL format TV signal output is selected.  
When this bit = 0, NTSC format TV signal output is selected.  
**This bit must be set to 0 when CRT is enabled.**

### 8.4.9 CRT/TV Display Mode Registers

CRT/TV Display Mode Register REG[060h]							RW
CRT/TV Display Blank	n/a	n/a	n/a	n/a	CRT/TV Bit-per-pixel Select Bit 2	CRT/TV Bit-per-pixel Select Bit 1	CRT/TV Bit-per-pixel Select Bit 0

bit 7 CRT/TV Display Blank  
When this bit = 1 the CRT/TV display pipeline is disabled and all CRT/TV data outputs are forced to zero (the screen is blanked).  
When this bit = 0 the CRT display pipeline is enabled.

bits 2-0 CRT/TV Bit-per-pixel Select Bits [2:0]  
These bits select the bit-per-pixel for the displayed data.

**Note**

Color depth of 16 bpp bypasses the LUT and support up to 64K colors on the CRT/TV.

Table 8-22 : CRT/TV Bit-per-pixel Selection

Bit-per-pixel Select Bits 1:0	Color Depth (bpp)
000	Reserved
001	Reserved
010	4 bpp
011	8 bpp
100	Reserved
101	16 bpp
110-111	Reserved

<b>CRT/TV Display Start Address Register 0</b>							
REG[062h]							RW

CRT/TV Display Start Address Bit 7	CRT/TV Display Start Address Bit 6	CRT/TV Display Start Address Bit 5	CRT/TV Display Start Address Bit 4	CRT/TV Display Start Address Bit 3	CRT/TV Display Start Address Bit 2	CRT/TV Display Start Address Bit 1	CRT/TV Display Start Address Bit 0
---	---	---	---	---	---	---	---

<b>CRT/TV Display Start Address Register 1</b>							
REG[063h]							RW

CRT/TV Display Start Address Bit 15	CRT/TV Display Start Address Bit 14	CRT/TV Display Start Address Bit 13	CRT/TV Display Start Address Bit 12	CRT/TV Display Start Address Bit 11	CRT/TV Display Start Address Bit 10	CRT/TV Display Start Address Bit 9	CRT/TV Display Start Address Bit 8
--	--	--	--	--	--	---	---

<b>CRT/TV Display Start Address Register 2</b>							
REG[064h]							RW

n/a	n/a	n/a	n/a	CRT/TV Display Start Address Bit 19	CRT/TV Display Start Address Bit 18	CRT/TV Display Start Address Bit 17	CRT/TV Display Start Address Bit 16
-----	-----	-----	-----	--	--	--	--

REG[062h] bits 7-0 CRT/TV Start Address Bits [19:0]

REG[063h] bits 7-0 This register forms the 20-bit address for the starting word of the CRT/TV image in the

REG[064h] bits 3-0 display buffer.

**This is a word address.** An entry of 00000h into these registers represents the first word of the display buffer, an entry of 00001h represents the second word of the display buffer, and so on.

<b>CRT/TV Memory Address Offset Register 0</b>							
REG[066h]							RW

CRT/TV Memory Address Offset Bit 7	CRT/TV Memory Address Offset Bit 6	CRT/TV Memory Address Offset Bit 5	CRT/TV Memory Address Offset Bit 4	CRT/TV Memory Address Offset Bit 3	CRT/TV Memory Address Offset Bit 2	CRT/TV Memory Address Offset Bit 1	CRT/TV Memory Address Offset Bit 0
---	---	---	---	---	---	---	---

<b>CRT/TV Memory Address Offset Register 1</b>							
REG[067h]							RW

n/a	n/a	n/a	n/a	n/a	CRT/TV Memory Address Offset Bit 10	CRT/TV Memory Address Offset Bit 9	CRT/TV Memory Address Offset Bit 8
-----	-----	-----	-----	-----	--	---	---

REG[066h] bits 7-0 CRT/TV Memory Address Offset Bits [10:0]

REG[067h] bits 2-0 These bits are the CRT/TV display's 11-bit address offset from the starting word of line "n" to the starting word of line "n + 1". A virtual image can be formed by setting this register to a value greater than the width of the display. The displayed image is a window into the larger virtual image.

CRT/TV Pixel Panning Register							RW
REG[068h]							
n/a	n/a	n/a	n/a	n/a	n/a	CRT/TV Pixel Panning Bit 1	CRT/TV Pixel Panning Bit 0

bits 1-0

**CRT/TV Pixel Panning Bits [1:0]**

This register is used to control the horizontal pixel panning of the CRT/TV display. The display can be panned to the left by programming its respective Pixel Panning Bits to a non-zero value. This value represents the number of pixels panned. The maximum pan value is dependent on the display mode as shown in the table below.

*Table 8-23 : CRT/TV Pixel Panning Selection*

Color Depth (bpp)	Screen 2 Pixel Panning Bits Used
4 bpp	Bits [1:0]
8 bpp	Bit 0
16 bpp	---

**Note**

Smooth horizontal panning can be achieved by a combination of this register and the CRT/TV Display Start Address registers (REG[062h], REG[063h], REG[064h]).

CRT/TV Display FIFO High Threshold Control Register								RW
REG[06Ah]								
n/a	n/a	CRT/TV Display FIFO High Threshold Bit 5	CRT/TV Display FIFO High Threshold Bit 4	CRT/TV Display FIFO High Threshold Bit 3	CRT/TV Display FIFO High Threshold Bit 2	CRT/TV Display FIFO High Threshold Bit 1	CRT/TV Display FIFO High Threshold Bit 0	

bits 5-0

**CRT/TV Display FIFO High Threshold Bits [5:0]**

These bits are used to optimize the display memory request arbitration. When this register is set to 00h, the threshold is automatically set in hardware. However, programming may be required if screen corruption is present (see Section 18.2, “Example Frame Rates” on page 192).

**Note**

This register does not need to be used in single display modes and may only be required in some display modes where two displays are active (see Section 16.3, “Bandwidth Limitation” on page 187).

CRT/TV Display FIFO Low Threshold Control Register								RW
REG[06Bh]								
n/a	n/a	CRT/TV Display FIFO Low Threshold Bit 5	CRT/TV Display FIFO Low Threshold Bit 4	CRT/TV Display FIFO Low Threshold Bit 3	CRT/TV Display FIFO Low Threshold Bit 2	CRT/TV Display FIFO Low Threshold Bit 1	CRT/TV Display FIFO Low Threshold Bit 0	

bits 5-0

CRT/TV Display FIFO Low Threshold Bits [5:0]

When this register is set to 00h, the threshold is automatically set in hardware. If it becomes necessary to adjust REG[06Ah] from its default value, then the following formula must be maintained.

$$\text{REG}[06\text{Bh}] \geq \text{REG}[06\text{Ah}] \text{ and } \text{REG}[06\text{Bh}] \leq 3\text{Ch}$$

### 8.4.10 LCD Ink/Cursor Registers

LCD Ink/Cursor Control Register								RW
REG[070h]								
n/a	n/a	n/a	n/a	n/a	n/a	LCD Ink/Cursor Mode Bit 1	LCD Ink/Cursor Mode Bit 0	

bits 1-0

LCD Ink/Cursor Control Bits [1:0]

These bits enable the LCD Ink/Cursor circuitry.

Table 8-24 : LCD Ink/Cursor Selection

LCD Ink/Cursor Bits [1:0]	Mode
00	Inactive
01	Cursor
10	Ink
11	Reserved

#### Note

While in Ink mode, the Cursor X and Y Position registers must be set to 00h.



LCD Ink/Cursor Start Address Register							RW
REG[071h]							
LCD Ink/Cursor Start Address Bit 7	LCD Ink/Cursor Start Address Bit 6	LCD Ink/Cursor Start Address Bit 5	LCD Ink/Cursor Start Address Bit 4	LCD Ink/Cursor Start Address Bit 3	LCD Ink/Cursor Start Address Bit 2	LCD Ink/Cursor Start Address Bit 1	LCD Ink/Cursor Start Address Bit 0

bits 7-0

LCD Ink/Cursor Start Address Bits [7:0]

Encoded bits defining the start address for the LCD Ink/Cursor. For Cursor modes, a start address of 0 should be valid for most applications. For Ink or special Cursor modes, the start address should be set at an address location that does not conflict with the display memory of dual panel buffer, which always takes the top M memory locations in bytes.

$$M = (\text{Panel Height} \times \text{Panel Width} / 16) \times c$$

where

- c = 1 for monochrome panel
- = 4 for color panel

Table 8-25 : LCD Ink/Cursor Start Address Encoding

LCD Ink/Cursor Start Address Bits [7:0]	Start Address
0	Memory Size - 1024
n = 160...1	Memory Size - n × 8192
n = 255...161	invalid

**Note**

The effect of this register takes place at the next LCD vertical non-display period.

**Note**

See Section 10, “Display Buffer” on page 157 for display buffer organization.

LCD Cursor X Position Register 0							RW
REG[072h]							
LCD Cursor X Position Bit 7	LCD Cursor X Position Bit 6	LCD Cursor X Position Bit 5	LCD Cursor X Position Bit 4	LCD Cursor X Position Bit 3	LCD Cursor X Position Bit 2	LCD Cursor X Position Bit 1	LCD Cursor X Position Bit 0

LCD Cursor X Position Register 1							RW
REG[073h]							
LCD Cursor X Sign	n/a	n/a	n/a	n/a	n/a	LCD Cursor X Position Bit 9	LCD Cursor X Position Bit 8

REG[073h] bit 7

LCD Cursor X Sign

When this bit = 1, it defines the LCD Cursor X Position register to be a negative number. The negative number shall not exceed 63 decimal.

When this bit = 0, it defines the LCD Cursor X Position register to be a positive number.

REG[072h] bits 7-0 LCD Cursor X Position Bits [9:0]  
 REG[073h] bits 1-0 A 10-bit register that defines the horizontal position of the LCD Cursor's top left hand corner in pixel units. This register is only valid when Cursor has been selected in the LCD Ink/Cursor select registers.

**Note**

The effect of REG[072h] through REG[074h] takes place only after REG[075h] is written and at the next LCD vertical non-display period. The effect of REG[075h] takes place at the next LCD vertical non-display period.

LCD Cursor Y Position Register 0 REG[074h]								RW
LCD Cursor Y Position Bit 7	LCD Cursor Y Position Bit 6	LCD Cursor Y Position Bit 5	LCD Cursor Y Position Bit 4	LCD Cursor Y Position Bit 3	LCD Cursor Y Position Bit 2	LCD Cursor Y Position Bit 1	LCD Cursor Y Position Bit 0	

LCD Cursor Y Position Register 1 REG[075h]								RW
LCD Cursor Y Sign	n/a	n/a	n/a	n/a	n/a	LCD Cursor Y Position Bit 9	LCD Cursor Y Position Bit 8	

REG[075h] bit 7 LCD Cursor Y Sign  
 When this bit = 1, it defines the LCD Cursor Y Position register to be a negative number. The negative number shall not exceed 63 decimal.  
 When this bit = 0, it defines the LCD Cursor Y Position register to be a positive number.

REG[074h] bits 7-0 LCD Cursor Y Position Bits [9:0]  
 REG[075h] bits 1-0 A 10-bit register that defines the vertical position of the LCD Cursor's top left hand corner in pixel units. This register is only valid when Cursor has been selected in the LCD Ink/Cursor select registers.

**Note**

The effect of REG[072h] through REG[074h] takes place only after REG[075h] is written and at the next LCD vertical non-display period. The effect of REG[075h] takes place at the next LCD vertical non-display period.

LCD Ink/Cursor Blue Color 0 Register REG[076h]								RW
n/a	n/a	n/a	LCD Ink/Cursor Blue Color 0 Bit 4	LCD Ink/Cursor Blue Color 0 Bit 3	LCD Ink/Cursor Blue Color 0 Bit 2	LCD Ink/Cursor Blue Color 0 Bit 1	LCD Ink/Cursor Blue Color 0 Bit 0	

bits 4-0 LCD Ink/Cursor Blue Color 0 Bits[4:0]  
 These bits define the blue LCD Ink/Cursor color 0.

<b>LCD Ink/Cursor Green Color 0 Register</b>							
REG[077h]							RW
n/a	n/a	LCD Ink/Cursor Green Color 0 Bit 5	LCD Ink/Cursor Green Color 0 Bit 4	LCD Ink/Cursor Green Color 0 Bit 3	LCD Ink/Cursor Green Color 0 Bit 2	LCD Ink/Cursor Green Color 0 Bit 1	LCD Ink/Cursor Green Color 0 Bit 0

bits 5-0 LCD Ink/Cursor Green Color 0 Bits[5:0]  
These bits define the green LCD ink/Cursor color 0.

<b>LCD Ink/Cursor Red Color 0 Register</b>							
REG[078h]							RW
n/a	n/a	n/a	LCD Ink/Cursor Red Color 0 Bit 4	LCD Ink/Cursor Red Color 0 Bit 3	LCD Ink/Cursor Red Color 0 Bit 2	LCD Ink/Cursor Red Color 0 Bit 1	LCD Ink/Cursor Red Color 0 Bit 0

bits 4-0 LCD Ink/Cursor Red Color 0 Bits[4:0]  
These bits define the red LCD Ink/Cursor color 0.

<b>LCD Ink/Cursor Blue Color 1 Register</b>							
REG[07Ah]							RW
n/a	n/a	n/a	LCD Ink/Cursor Blue Color 1 Bit 4	LCD Ink/Cursor Blue Color 1 Bit 3	LCD Ink/Cursor Blue Color 1 Bit 2	LCD Ink/Cursor Blue Color 1 Bit 1	LCD Ink/Cursor Blue Color 1 Bit 0

bits 4-0 LCD Ink/Cursor Blue Color 1 Bits[4:0]  
These bits define the blue LCD Ink/Cursor color 1.

<b>LCD Ink/Cursor Green Color 1 Register</b>							
REG[07Bh]							RW
n/a	n/a	LCD Ink/Cursor Green Color 1 Bit 5	LCD Ink/Cursor Green Color 1 Bit 4	LCD Ink/Cursor Green Color 1 Bit 3	LCD Ink/Cursor Green Color 1 Bit 2	LCD Ink/Cursor Green Color 1 Bit 1	LCD Ink/Cursor Green Color 1 Bit 0

bits 5-0 LCD Ink/Cursor Green Color 1 Bits[5:0]  
These bits define the green LCD Ink/Cursor color 1.

<b>LCD Ink/Cursor Red Color 1 Register</b>							
REG[07Ch]							RW
n/a	n/a	n/a	LCD Ink/Cursor Red Color 1 Bit 4	LCD Ink/Cursor Red Color 1 Bit 3	LCD Ink/Cursor Red Color 1 Bit 2	LCD Ink/Cursor Red Color 1 Bit 1	LCD Ink/Cursor Red Color 1 Bit 0

bits 4-0 LCD Ink/Cursor Red Color 1 Bits[4:0]  
These bits define the red LCD Ink/Cursor color 1.

LCD Ink/Cursor FIFO High Threshold Register							
REG[07Eh]							RW
n/a	n/a	n/a	n/a	LCD Ink/Cursor FIFO High Threshold Bit 3	LCD Ink/Cursor FIFO High Threshold Bit 2	LCD Ink/Cursor FIFO High Threshold Bit 1	LCD Ink/Cursor FIFO High Threshold Bit 0

bits 3-0

LCD Ink/Cursor FIFO High Threshold Bits [3:0]

These bits are used to optimize the display memory request arbitration for the Hardware Cursor/Ink Layer. When this register is set to 00h, the threshold is automatically set in hardware.

### 8.4.11 CRT/TV Ink/Cursor Registers

CRT/TV Ink/Cursor Control Register							
REG[080h]							RW
n/a	n/a	n/a	n/a	n/a	n/a	CRT/TV Ink/Cursor Mode Bit 1	CRT/TV Ink/Cursor Mode Bit 0

bits 1-0

CRT/TV Ink/Cursor Control Bits [1:0]

These bits enable the CRT/TV Ink/Cursor circuitry.

Table 8-26 : CRT/TV Ink/Cursor Selection

CRT/TV Ink/Cursor Bits [1:0]	Mode
00	Inactive
01	Cursor
10	Ink
11	Reserved

#### Note

While in Ink mode, the Cursor X and Y Position registers must be set to 00h.

CRT/TV Ink/Cursor Start Address Register							RW
REG[081h]							
CRT/TV Ink/Cursor Start Address Bit 7	CRT/TV Ink/Cursor Start Address Bit 6	CRT/TV Ink/Cursor Start Address Bit 5	CRT/TV Ink/Cursor Start Address Bit 4	CRT/TV Ink/Cursor Start Address Bit 3	CRT/TV Ink/Cursor Start Address Bit 2	CRT/TV Ink/Cursor Start Address Bit 1	CRT/TV Ink/Cursor Start Address Bit 0

bits 7-0

CRT/TV Ink/Cursor Start Address Bits [7:0]

Encoded bits defining the start address for the CRT/TV Ink/Cursor. For Cursor modes, a start address of 0 should be valid for most applications. For Ink or special Cursor modes, the start address should be set at an address location that does not conflict with the display memory of dual panel buffer, which always takes the top memory locations (M) in bytes.

$$M = (\text{Panel Height} \times \text{Panel Width} / 16) \times c$$

where

- c = 1 for monochrome panel
- = 4 for color panel

Table 8-27 : CRT/TV Ink/Cursor Start Address Encoding

CRT/TV Ink/Cursor Start Address Bits [7:0]	Start Address
0	Memory Size - 1024
n = 160...1	Memory Size - n × 8192
n = 255...161	Invalid

**Note**

The effect of this register takes place at the next CRT/TV vertical non-display period.

**Note**

See Section 10, “Display Buffer” on page 157 for display buffer organization.

CRT/TV Cursor X Position Register 0							RW
REG[082h]							
CRT/TV Cursor X Position Bit 7	CRT/TV Cursor X Position Bit 6	CRT/TV Cursor X Position Bit 5	CRT/TV Cursor X Position Bit 4	CRT/TV Cursor X Position Bit 3	CRT/TV Cursor X Position Bit 2	CRT/TV Cursor X Position Bit 1	CRT/TV Cursor X Position Bit 0

CRT/TV Cursor X Position Register 1							RW
REG[083h]							
CRT/TV Cursor X Sign	n/a	n/a	n/a	n/a	n/a	CRT/TV Cursor X Position Bit 9	CRT/TV Cursor X Position Bit 8

REG[083h] bit 7 CRT/TV Cursor X Sign  
When this bit = 1, it defines the CRT/TV Cursor X Position register to be a negative number. The negative number should not exceed 63 decimal.  
When this bit = 0, it defines the CRT/TV Cursor X Position register to be a positive number.

REG[082h] bits 7-0 CRT/TV Cursor X Position Bits [9:0]  
REG[083h] bits 1-0 A 10-bit register that defines the horizontal position of the CRT/TV Cursor's top left hand corner in pixel units. This register is only valid when Cursor has been selected in the CRT/TV Ink/Cursor select registers.

**Note**

The effect of REG[082h] through REG[084h] takes place only after REG[085h] is written to and at the next CRT/TV vertical non-display period. The effect of REG[085h] takes place at the next CRT/TV vertical non-display period.

CRT/TV Cursor Y Position Register 0							
REG[084h]							RW
CRT/TV Cursor Y Position Bit 7	CRT/TV Cursor Y Position Bit 6	CRT/TV Cursor Y Position Bit 5	CRT/TV Cursor Y Position Bit 4	CRT/TV Cursor Y Position Bit 3	CRT/TV Cursor Y Position Bit 2	CRT/TV Cursor Y Position Bit 1	CRT/TV Cursor Y Position Bit 0

CRT/TV Cursor Y Position Register 1							
REG[085h]							RW
CRT/TV Cursor Y Sign	n/a	n/a	n/a	n/a	n/a	CRT/TV Cursor Y Position Bit 9	CRT/TV Cursor Y Position Bit 8

REG[084h] bit 7 CRT/TV Cursor Y Sign  
When this bit = 1, it defines the CRT/TV Cursor Y Position register to be a negative number. The negative number shall not exceed 63 decimal.  
When this bit = 0, it defines the CRT/TV Cursor Y Position register to be a positive number.

REG[084h] bits 7-0 CRT/TV Cursor Y Position Bits [9:0]  
REG[085h] bits 1-0 A 10-bit register that defines the vertical position of the CRT/TV Cursor's top left hand corner in pixel units. This register is only valid when Cursor has been selected in the CRT/TV Ink/Cursor select registers.

**Note**

The effect of REG[082h] through REG[084h] takes place only after REG[085h] is written to and at the next CRT/TV vertical non-display period. The effect of REG[085h] takes place at the next CRT/TV vertical non-display period.

<b>CRT/TV Ink/Cursor Blue Color 0 Register</b>								RW
REG[086h]								
n/a	n/a	n/a	CRT/TV Ink/Cursor Blue Color 0 Bit 4	CRT/TV Ink/Cursor Blue Color 0 Bit 3	CRT/TV Ink/Cursor Blue Color 0 Bit 2	CRT/TV Ink/Cursor Blue Color 0 Bit 1	CRT/TV Ink/Cursor Blue Color 0 Bit 0	

bits 4-0 CRT/TV Ink/Cursor Blue Color 0 Bits[4:0]  
These bits define the blue CRT/TV Ink/Cursor color 0.

<b>CRT/TV Ink/Cursor Green Color 0 Register</b>								RW
REG[087h]								
n/a	n/a	CRT/TV Ink/Cursor Green Color 0 Bit 5	CRT/TV Ink/Cursor Green Color 0 Bit 4	CRT/TV Ink/Cursor Green Color 0 Bit 3	CRT/TV Ink/Cursor Green Color 0 Bit 2	CRT/TV Ink/Cursor Green Color 0 Bit 1	CRT/TV Ink/Cursor Green Color 0 Bit 0	

bits 5-0 CRT/TV Ink/Cursor Green Color 0 Bits[5:0]  
These bits define the green CRT/TV Ink/Cursor color 0.

<b>CRT/TV Ink/Cursor Red Color 0 Register</b>								RW
REG[088h]								
n/a	n/a	n/a	CRT/TV Ink/Cursor Red Color 0 Bit 4	CRT/TV Ink/Cursor Red Color 0 Bit 3	CRT/TV Ink/Cursor Red Color 0 Bit 2	CRT/TV Ink/Cursor Red Color 0 Bit 1	CRT/TV Ink/Cursor Red Color 0 Bit 0	

bits 4-0 CRT/TV Ink/Cursor Red Color 0 Bits[4:0]  
These bits define the red CRT/TV Ink/Cursor color 0.

<b>CRT/TV Ink/Cursor Blue Color 1 Register</b>								RW
REG[08Ah]								
n/a	n/a	n/a	CRT/TV Ink/Cursor Blue Color 1 Bit 4	CRT/TV Ink/Cursor Blue Color 1 Bit 3	CRT/TV Ink/Cursor Blue Color 1 Bit 2	CRT/TV Ink/Cursor Blue Color 1 Bit 1	CRT/TV Ink/Cursor Blue Color 1 Bit 0	

bits 4-0 CRT/TV Ink/Cursor Blue Color 1 Bits[4:0]  
These bits define the blue CRT/TV Ink/Cursor color 1.

<b>CRT/TV Ink/Cursor Green Color 1 Register</b>								RW
REG[08Bh]								
n/a	n/a	CRT/TV Ink/Cursor Green Color 1 Bit 5	CRT/TV Ink/Cursor Green Color 1 Bit 4	CRT/TV Ink/Cursor Green Color 1 Bit 3	CRT/TV Ink/Cursor Green Color 1 Bit 2	CRT/TV Ink/Cursor Green Color 1 Bit 1	CRT/TV Ink/Cursor Green Color 1 Bit 0	

bits 5-0 CRT/TV Ink/Cursor Green Color 1 Bits[5:0]  
These bits define the green CRT/TV Ink/Cursor color 1.

<b>CRT/TV Ink/Cursor Red Color 1 Register</b>							RW
REG[08Ch]							
n/a	n/a	n/a	CRT/TV Ink/Cursor Red Color 1 Bit 4	CRT/TV Ink/Cursor Red Color 1 Bit 3	CRT/TV Ink/Cursor Red Color 1 Bit 2	CRT/TV Ink/Cursor Red Color 1 Bit 1	CRT/TV Ink/Cursor Red Color 1 Bit 0

bits 4-0

CRT/TV Ink/Cursor Red Color 1 Bits[4:0]

These bits define the red CRT/TV Ink/Cursor color 1.

<b>CRT/TV Ink/Cursor FIFO High Threshold Register</b>							RW
REG[08Eh]							
n/a	n/a	n/a	n/a	CRT/TV Ink/Cursor FIFO High Threshold Bit 3	CRT/TV Ink/Cursor FIFO High Threshold Bit 2	CRT/TV Ink/Cursor FIFO High Threshold Bit 1	CRT/TV Ink/Cursor FIFO High Threshold Bit 0

bits 3-0

CRT/TV Ink/Cursor FIFO High Threshold Bits [5:0]

These bits are used to optimize the display memory request arbitration for the Hardware Cursor/Ink Layer. When this register is set to 00h, the threshold is automatically set in hardware.



## 8.4.12 BitBLT Configuration Registers

BitBLT Control Register 0 REG[100h]							RW
BitBLT Active Status	BitBLT FIFO Not Empty Status (RO)	BitBLT FIFO Half Full Status (RO)	BitBLT FIFO Full Status(RO)	n/a	n/a	BitBLT Destination Linear Select	BitBLT Source Linear Select

bit 7 **BitBLT Active Status**  
This register bit has two data paths, one for write, the other for read.

**Write Data Path**  
When software writes a one to this bit, it initiates the 2D operation.

**Read Data Path**  
The read back of this register indicates the status of the 2D engine.  
When a read from this bit = 1, the 2D engine is busy.  
When a read from this bit = 0, the 2D engine is idle and is ready for the next operation.

Table 8-28 : BitBLT Active Status

BitBLT Active Status		State
Write	Read	
0	0	Idle
0	1	Reserved
1	0	Initiating operation
1	1	Operation in progress

bit 6 **BitBLT FIFO Not-Empty Status**  
This is a read-only status bit.  
When this bit = 0, the BitBLT FIFO is empty.  
When this bit = 1, the BitBLT FIFO has at least one data.  
To reduce system memory read latency, software can monitor this bit prior to a BitBLT read burst operation.

The following table shows the number of words available in BitBLT FIFO under different status conditions.

Table 8-29: BitBLT FIFO Words Available

BitBLT FIFO Full Status (REG[100h] Bit 4)	BitBLT FIFO Half Full Status (REG[100h] Bit 5)	BitBLT FIFO Not Empty Status (REG[100h] Bit 6)	Number of Words available in BitBLT FIFO
0	0	0	0
0	0	1	1 to 6
0	1	1	7 to 14
1	1	1	15 to 16

- bit 5            BitBLT FIFO Half Full Status  
This is a read-only status bit.  
When this bit = 1, the BitBLT FIFO is half full or greater than half full.  
When this bit = 0, the BitBLT FIFO is less than half full.
- bit 4            BitBLT FIFO Full Status  
This is a read-only status bit.  
When this bit = 1, the BitBLT FIFO is full.  
When this bit = 0, the BitBLT FIFO is not full.
- bit 1            BitBLT Destination Linear Select  
When this bit = 1, the Destination BitBLT is stored as a contiguous linear block of memory.  
When this bit = 0, the Destination BitBLT is stored as a rectangular region of memory.  
The BitBLT Memory Address Offset (REG[10Ch], REG[10Dh]) determines the address offset from the start of one line to the next line.
- bit 0            BitBLT Source Linear Select  
When this bit = 1, the Source BitBLT is stored as a contiguous linear block of memory.  
When this bit = 0, the Source BitBLT is stored as a rectangular region of memory.  
The BitBLT Memory Address Offset (REG[10Ch], REG[10Dh]) determines the address offset from the start of one line to the next line.

BitBLT Control Register 1							RW
REG[101h]							
n/a	n/a	n/a	Reserved	n/a	n/a	n/a	BitBLT Color Format Select

- bit 4            Reserved.  
This bit must be set to 0.
- bit 0            BitBLT Color Format Select  
This bit selects the color format that the 2D operation is applied to.  
When this bit = 0, 8 bpp (256 color) format is selected.  
When this bit = 1, 16 bpp (64K color) format is selected.

BitBLT ROP Code/Color Expansion Register							
REG[102h]							RW
n/a	n/a	n/a	n/a	BitBLT ROP Code Bit 3	BitBLT ROP Code Bit 2	BitBLT ROP Code Bit 1	BitBLT ROP Code Bit 0

bits 3-0 BitBLT Raster Operation Code/Color Expansion Bits [3:0]  
ROP Code for Write BitBLT and Move BitBLT. Bits 2-0 also specify the start bit position for Color Expansion.

Table 8-30 : BitBLT ROP Code/Color Expansion Function Selection

BitBLT ROP Code Bits [3:0]	Boolean Function for Write BitBLT and Move BitBLT	Boolean Function for Pattern Fill	Start Bit Position for Color Expansion
0000	0 (Blackness)	0 (Blackness)	bit 0
0001	$\sim S \cdot \sim D$ or $\sim(S + D)$	$\sim P \cdot \sim D$ or $\sim(P + D)$	bit 1
0010	$\sim S \cdot D$	$\sim P \cdot D$	bit 2
0011	$\sim S$	$\sim P$	bit 3
0100	$S \cdot \sim D$	$P \cdot \sim D$	bit 4
0101	$\sim D$	$\sim D$	bit 5
0110	$S \wedge D$	$P \wedge D$	bit 6
0111	$\sim S + \sim D$ or $\sim(S \cdot D)$	$\sim P + \sim D$ or $\sim(P \cdot D)$	bit 7
1000	$S \cdot D$	$P \cdot D$	bit 0
1001	$\sim(S \wedge D)$	$\sim(P \wedge D)$	bit 1
1010	D	D	bit 2
1011	$\sim S + D$	$\sim P + D$	bit 3
1100	S	P	bit 4
1101	$S + \sim D$	$P + \sim D$	bit 5
1110	$S + D$	$P + D$	bit 6
1111	1 (Whiteness)	1 (Whiteness)	bit 7

**Note**

S = Source, D = Destination, P = Pattern.

BitBLT Operation Register							RW
REG[103h]							
n/a	n/a	n/a	n/a	BitBLT Operation Bit 3	BitBLT Operation Bit 2	BitBLT Operation Bit 1	BitBLT Operation Bit 0

bits 3-0

BitBLT Operation Bits [3:0]

Specifies the 2D Operation to be carried out based on the following table.

*Table 8-31 : BitBLT Operation Selection*

BitBLT Operation Bits [3:0]	BitBLT Operation
0000	Write BitBLT with ROP.
0001	Read BitBLT.
0010	Move BitBLT in positive direction with ROP.
0011	Move BitBLT in negative direction with ROP.
0100	Transparent Write BitBLT.
0101	Transparent Move BitBLT in positive direction.
0110	Pattern Fill with ROP.
0111	Pattern Fill with transparency.
1000	Color Expansion.
1001	Color Expansion with transparency.
1010	Move BitBLT with Color Expansion.
1011	Move BitBLT with Color Expansion and transparency.
1100	Solid Fill.
Other combinations	Reserved

**Note**

The BitBLT operations Pattern Fill with ROP and Pattern Fill with transparency require a BitBLT width > 2 for 8 bpp color depths and a BitBLT width > 1 for 16 bpp color depths. The BitBLT width is set in REG[110h], REG[111h].

BitBLT Source Start Address Register 0							
REG[104h]							RW
BitBLT Source Start Address Bit 7	BitBLT Source Start Address Bit 6	BitBLT Source Start Address Bit 5	BitBLT Source Start Address Bit 4	BitBLT Source Start Address Bit 3	BitBLT Source Start Address Bit 2	BitBLT Source Start Address Bit 1	BitBLT Source Start Address Bit 0

BitBLT Source Start Address Register 1							
REG[105h]							RW
BitBLT Source Start Address Bit 15	BitBLT Source Start Address Bit 14	BitBLT Source Start Address Bit 13	BitBLT Source Start Address Bit 12	BitBLT Source Start Address Bit 11	BitBLT Source Start Address Bit 10	BitBLT Source Start Address Bit 9	BitBLT Source Start Address Bit 8

BitBLT Source Start Address Register 2							
REG[106h]							RW
n/a	n/a	n/a	BitBLT Source Start Address Bit 20	BitBLT Source Start Address Bit 19	BitBLT Source Start Address Bit 18	BitBLT Source Start Address Bit 17	BitBLT Source Start Address Bit 16

REG[104h] bits 7-0

BitBLT Source Start Address Bits [20:0]

REG[105h] bits 7-0

A 21-bit register that specifies the source start address for the BitBLT operation.

REG[106h] bits 4-0

If data is sourced from the CPU, then bit 0 is used for byte alignment within a 16-bit word and the other address bits are ignored. In pattern fill operation, the BitBLT Source Start Address is defined by the following equation.

$$\text{Value programmed to the Source Start Address Register} = \text{Pattern Base Address} + \text{Pattern Line Offset} + \text{Pixel Offset.}$$

The following table shows how Source Start Address Register is defined for 8 and 16 bpp color depths.

Table 8-32 : BitBLT Source Start Address Selection

Color Format	Pattern Base Address[20:0]	Pattern Line Offset[2:0]	Pixel Offset[3:0]
8 bpp	BitBLT Source Start Address[20:6]	BitBLT Source Start Address[5:3]	BitBLT Source Start Address[2:0]
16 bpp	BitBLT Source Start Address[20:7]	BitBLT Source Start Address[6:4]	BitBLT Source Start Address[3:0]

**Note**

For further information on the BitBLT Source Start Address register, see the *S1D13806 Programming Notes and Examples*, document number X28B-G-003-xx.

BitBLT Destination Start Address Register 0							
REG[108h]							RW
BitBLT Destination Start Address Bit 7	BitBLT Destination Start Address Bit 6	BitBLT Destination Start Address Bit 5	BitBLT Destination Start Address Bit 4	BitBLT Destination Start Address Bit 3	BitBLT Destination Start Address Bit 2	BitBLT Destination Start Address Bit 1	BitBLT Destination Start Address Bit 0

BitBLT Destination Start Address Register 1							
REG[109h]							RW
BitBLT Destination Start Address Bit 15	BitBLT Destination Start Address Bit 14	BitBLT Destination Start Address Bit 13	BitBLT Destination Start Address Bit 12	BitBLT Destination Start Address Bit 11	BitBLT Destination Start Address Bit 10	BitBLT Destination Start Address Bit 9	BitBLT Destination Start Address Bit 8

BitBLT Destination Start Address Register 2							
REG[10Ah]							RW
n/a	n/a	n/a	BitBLT Destination Start Address Bit 20	BitBLT Destination Start Address Bit 19	BitBLT Destination Start Address Bit 18	BitBLT Destination Start Address Bit 17	BitBLT Destination Start Address Bit 16

REG[108h] bits 7-0 BitBLT Destination Start Address Bits [20:0]

REG[109h] bits 7-0 A 21-bit register that specifies the destination start address for the BitBLT operation.

REG[10Ah] bits 4-0

BitBLT Memory Address Offset Register 0							
REG[10Ch]							RW
BitBLT Memory Address Offset Bit 7	BitBLT Memory Address Offset Bit 6	BitBLT Memory Address Offset Bit 5	BitBLT Memory Address Offset Bit 4	BitBLT Memory Address Offset Bit 3	BitBLT Memory Address Offset Bit 2	BitBLT Memory Address Offset Bit 1	BitBLT Memory Address Offset Bit 0

BitBLT Memory Address Offset Register 1							
REG[10Dh]							RW
n/a	n/a	n/a	n/a	n/a	BitBLT Memory Address Offset Bit 10	BitBLT Memory Address Offset Bit 9	BitBLT Memory Address Offset Bit 8

REG[10Ch] bits 7-0 BitBLT Memory Address Offset Bits [10:0]

REG[10Dh] bits 2-0 These bits are the display's 11-bit address offset from the starting word of line  $n$  to the starting word of line  $n + 1$ . They are used only for address calculation when the BitBLT is configured as a rectangular region of memory.

BitBLT Width Register 0							
REG[110h]							RW
BitBLT Width Bit 7	BitBLT Width Bit 6	BitBLT Width Bit 5	BitBLT Width Bit 4	BitBLT Width Bit 3	BitBLT Width Bit 2	BitBLT Width Bit 1	BitBLT Width Bit 0

BitBLT Width Register 1							
REG[111h]							RW
n/a	n/a	n/a	n/a	n/a	n/a	BitBLT Width Bit 9	BitBLT Width Bit 8

REG[110h] bits 7-0      BitBLT Width Bits [9:0]  
 REG[111h] bits 1-0      A 10-bit register that specifies the BitBLT width in pixels - 1.

$$\text{BitBLT width in pixels} = (\text{ContentsOfThisRegister}) + 1$$

**Note**

The BitBLT operations Pattern Fill with ROP and Pattern Fill with transparency require a BitBLT width > 2 for 8 bpp color depths and a BitBLT width > 1 for 16 bpp color depths.

BitBLT Height Register 0							
REG[112h]							RW
BitBLT Height Bit 7	BitBLT Height Bit 6	BitBLT Height Bit 5	BitBLT Height Bit 4	BitBLT Height Bit 3	BitBLT Height Bit 2	BitBLT Height Bit 1	BitBLT Height Bit 0

BitBLT Height Register 1							
REG[113h]							RW
n/a	n/a	n/a	n/a	n/a	n/a	BitBLT Height Bit 9	BitBLT Height Bit 8

REG[112h] bits 7-0      BitBLT Height Bits [9:0]  
 REG[113h] bits 1-0      A 10-bit register that specifies the BitBLT height in lines - 1.

$$\text{BitBLT height in lines} = (\text{ContentsOfThisRegister}) + 1$$

<b>BitBLT Background Color Register 0</b>							
REG[114h]							RW
BitBLT Background Color Bit 7	BitBLT Background Color Bit 6	BitBLT Background Color Bit 5	BitBLT Background Color Bit 4	BitBLT Background Color Bit 3	BitBLT Background Color Bit 2	BitBLT Background Color Bit 1	BitBLT Background Color Bit 0

<b>BitBLT Background Color Register 1</b>							
REG[115h]							RW
BitBLT Background Color Bit 15	BitBLT Background Color Bit 14	BitBLT Background Color Bit 13	BitBLT Background Color Bit 12	BitBLT Background Color Bit 11	BitBLT Background Color Bit 10	BitBLT Background Color Bit 9	BitBLT Background Color Bit 8

REG[114h] bits 7-0 BitBLT Background Color Bits [15:0]

REG[115h] bits 15-8 A 16-bit register that specifies the BitBLT background color for Color Expansion or key color for Transparent BitBLT. For 16 bpp color depths (REG[101h] bit 0 = 1), all 16 bits are used. For 8 bpp color depths (REG[101h] bit 0 = 0), only bits 7-0 are used.

<b>BitBLT Foreground Color Register 0</b>							
REG[118h]							RW
BitBLT Foreground Color Bit 7	BitBLT Foreground Color Bit 6	BitBLT Foreground Color Bit 5	BitBLT Foreground Color Bit 4	BitBLT Foreground Color Bit 3	BitBLT Foreground Color Bit 2	BitBLT Foreground Color Bit 1	BitBLT Foreground Color Bit 0

<b>BitBLT Foreground Color Register 1</b>							
REG[119h]							RW
BitBLT Foreground Color Bit 15	BitBLT Foreground Color Bit 14	BitBLT Foreground Color Bit 13	BitBLT Foreground Color Bit 12	BitBLT Foreground Color Bit 11	BitBLT Foreground Color Bit 10	BitBLT Foreground Color Bit 9	BitBLT Foreground Color Bit 8

REG[118h] bits 7-0 BitBLT Foreground Color Bits [15:0]

REG[119h] bits 7-0 A 16-bit register that specifies the BitBLT foreground color for Color Expansion or Solid Fill. For 16 bpp color depths (REG[101h] bit 0 = 1), all 16 bits are used. For 8 bpp color depths (REG[101h] bit 0 = 0), only bits 7-0 are used.



## 8.4.13 Look-Up Table Registers

### Note

Accessing the LCD Look-Up Table (LUT) requires an active LCD PCLK and accessing the CRT/TV LUT requires an active CRT/TV PCLK. For further information on the clocks, see Section 7, “Clocks” on page 92.

Look-Up Table Mode Register							RW
REG[1E0h]							
n/a	n/a	n/a	n/a	n/a	n/a	LUT Mode Bit 1	LUT Mode Bit 0

bits 1-0

Look-Up Table Mode Bits [1:0]

These bits determine which of the on-chip Look-Up Tables (LUT) (LCD and CRT/TV) are accessible by REG[1E2h] and REG[1E4h].

Table 8-33 : LUT Mode Selection

LUT Mode Bits [1:0]	Read	Write
00	LCD LUT	LCD and CRT/TV LUT's
01	LCD LUT	LCD LUT
10	CRT/TV LUT	CRT/TV LUT
11	Reserved	Reserved

Look-Up Table Address Register							RW
REG[1E2h]							
LUT Address Bit 7	LUT Address Bit 6	LUT Address Bit 5	LUT Address Bit 4	LUT Address Bit 3	LUT Address Bit 2	LUT Address Bit 1	LUT Address Bit 0

bits 7-0

LUT Address Bits [7:0]

These 8 bits control a pointer into the Look-Up Tables (LUT). The S1D13806 has three 256-position, 4-bit wide LUTs, one for each of red, green, and blue – refer to Section 12, “Look-Up Table Architecture” on page 161 for details.

This register selects which LUT entry is read/write accessible through the LUT Data Register (REG[1E4h]). Writing the LUT Address Register automatically sets the pointer to the Red LUT. Accesses to the LUT Data Register automatically increment the pointer.

For example, writing a value 03h into the LUT Address Register sets the pointer to R[3]. A subsequent access to the LUT Data Register accesses R[3] and moves the pointer onto G[3]. Subsequent accesses to the LUT Data Register move the pointer onto B[3], R[4], G[4], B[4], R[5], etc.

### Note

The RGB data is inserted into the LUT after the Blue data is written, i.e. all three colors must be written before the LUT is updated.

Look-Up Table Data Register							RW
REG[1E4h]							
LUT Data Bit 3	LUT Data Bit 2	LUT Data Bit 1	LUT Data Bit 0	n/a	n/a	n/a	n/a

bits 7-4

LUT Data Bits [3:0]

This register is used to read/write the RGB Look-Up Tables. This register accesses the entry at the pointer controlled by the Look-Up Table Address register (REG[1E2h]). Accesses to the Look-Up Table Data register automatically increment the pointer.

**Note**

The RGB data is inserted into the LUT after the Blue data is written, i.e. all three colors must be written before the LUT is updated.

### 8.4.14 Power Save Configuration Registers

For further information on Power Save Mode, refer to Section 19, “Power Save Mode” on page 202.

Power Save Configuration Register							RW
REG[1F0h]							
n/a	n/a	n/a	Reserved	n/a	n/a	n/a	Power Save Mode Enable

bit 4

Reserved.

This bit must be set to 1.

bit 0

Power Save Mode Enable

When this bit = 1, power save mode is enabled.

When this bit = 0, power save mode is disabled.

**Note**

For details on Power Save Mode, see Section 19, “Power Save Mode” on page 202.

Power Save Status Register							RO
REG[1F1h]							
n/a	n/a	n/a	n/a	n/a	n/a	LCD Power Save Status	Memory Controller Power Save Status

bit 1 LCD Power Save Status  
 This bit indicates the power save state of the LCD panel.  
 When this bit = 1, the panel is powered down.  
 When this bit = 0, the panel is powered up, or in transition of powering up or down.

**Note**  
 When this bit reads a 1, the system may safely shut down the LCD pixel clock source.

**Note**  
 When the LCD panel is not enabled (REG[1FCh] bit 0 = 0), this bit returns a 1.

bit 0 Memory Controller Power Save Status  
 This bit indicates the power save state of the memory controller.  
 When this bit = 1, the memory controller is powered down and the SDRAM is in self refresh mode.  
 When this bit = 0, the memory controller is powered up and is in normal mode.

**Note**  
 When this bit reads a 1, the system may safely shut down the memory clock source.

## 8.4.15 Miscellaneous Registers

CPU-to-Memory Access Watchdog Timer Register							RW
REG[1F4h]							
n/a	n/a	Mem. Access Watchdog Timer bit 5	Mem. Access Watchdog Timer bit 4	Mem. Access Watchdog Timer bit 3	Mem. Access Watchdog Timer bit 2	Mem. Access Watchdog Timer bit 1	Mem. Access Watchdog Timer bit 0

bits 5-0

CPU-to-Memory Access Watchdog Timer Bits [5:0]

A non-zero value in this register enables the watchdog timer for CPU-to-memory access. When enabled, any CPU-to-memory access cycle is completed successfully within a time determined by the following equation.

$$\text{Maximum CPU-to-memory access cycle time} = (8n + 7) \times T_{\text{bclk}} + 13 \times T_{\text{mclk}}$$

where:

n = A non-zero value in this register

 $T_{\text{bclk}}$  = Bus clock period, or Bus clock period x 2 (if CONF5 = 1, see Table 4-9 on page 33)

 $T_{\text{mclk}}$  = Memory clock period

This function is required by some busses which time-out if the cycle duration exceeds a certain time period. This function is **not intended to arbitrarily shorten the CPU-to-memory access cycle time** in order gain higher CPU bandwidth. Doing so may significantly reduce the available display refresh bandwidth which may cause display corruption. This register does not affect CPU-to-register access or BitBLT access.

## 8.4.16 Common Display Mode Register

Display Mode Register REG[1FCh]							RW
n/a	SwivelView Enable Bit 0	n/a	n/a	n/a	Display Mode Select Bit 2	Display Mode Select Bit 1	Display Mode Select Bit 0

bit 6 SwivelView Enable Bit 0  
When this bit = 1, the LCD and CRT display image is rotated 90° clockwise.  
When this bit = 0, there is no hardware effect.  
This bit in conjunction with SwivelView™ Enable Bit 1 achieves the following hardware rotations.

Table 8-34: Setting SwivelView Modes

SwivelView Enable Bits	SwivelView™ Modes			
	Normal	SwivelView 90°	SwivelView 180°	SwivelView 270°
SwivelView Enable Bit 0 (REG[1FCh] bit 6)	0	1	0	1
SwivelView Enable Bit 1 (REG[040h] bit 4)	0	0	1	1

**Note**

Please refer to Section 15, “SwivelView™” on page 177 for application and limitations.

bits 2-0 Display Mode Select Bits [2:0]  
These bits select the display model according to the following table. The LCD display mode is enabled/disabled using bit 0.

Table 8-35: Display Mode Selection

Display Mode Select Bits [2:0]	Display Mode Enabled
000	no display
001	LCD only
010	CRT only
011	EISD (CRT and LCD)
100	TV with flicker filter off
101	EISD (TV with flicker filter off and LCD)
110	TV with flicker filter on
111	EISD (TV with flicker filter on and LCD)

**Note**

REG[018h] bit 7 must be set to 1 when the flicker filter is enabled.

**Note**

The **Flicker Filter** reduces the “flickering” effect seen on interlaced displays by averaging adjacent lines on the TV display. This “flickering” is caused by sharp vertical image transitions that occur over one line (1 vertical pixel). For example, one pixel high lines, edges of window boxes, etc. Flickering occurs because these high resolution lines are effectively displayed at half the refresh frequency due to interlacing.

## 8.5 MediaPlug Registers Descriptions

The S1D13806 has built-in support for Winnov’s MediaPlug connection designed for video cameras. The following registers are used to control the connection and accept data from the camera. The MediaPlug registers decode A11-A0 and require A20 = 0 and A12 = 1. The MediaPlug registers are 16-bit wide. Byte access to the MediaPlug registers is not allowed. For further information, see Section 17, “MediaPlug Interface” on page 188.

**Note**

The MediaPlug control registers must not be accessed while Power Save Mode is enabled (REG[1F0h] bit 0 = 1).

### 8.5.1 MediaPlug Control Registers

MediaPlug LCMD Register REG[1000h]							RW
LCMD Bit 7	LCMD Bit 6	LCMD Bit 5	LCMD Bit 4	LCMD Bit 3	LCMD Bit 2	LCMD Bit 1	LCMD Bit 0
LCMD Bit 15	LCMD Bit 14	LCMD Bit 13	LCMD Bit 12	LCMD Bit 11	LCMD Bit 10	LCMD Bit 9	LCMD Bit 8

REG[1000h] bits 15-0 MediaPlug LCMD Bits [15:0]

A 16-bit register for setting and detecting various modes of operation of the MediaPlug Local Slave. This register is handled differently for reads and writes. The following table shows the MediaPlug description of the LCMD Register. See bit descriptions for details.

Table 8-36: MediaPlug LCMD Read/Write Descriptions

Data	D15	D14	D13	D12	D11	D10	D9	D8
Write	TO[2:0]		Xxxxxx					
Read	TO[2:0]		00b		Rev[3:0]			
Data	D7	D6	D5	D4	D3	D2	D1	D0
Write	Xxxx				IC	MC	P	W
Read	Rstat[2:0]			0b	IC	MC	P	W

bits 15-14

Timeout Option

These bits select the timeout delay in MediaPlug clock cycles.

Table 8-37: Timeout Option Delay

Timeout Option Bits[15:14]	Timeout (MediaPlug clock cycles)
00	1023 (default)
01	64
10	128
11	64

- bits 13-12 A read from these bits always returns 00b.  
A write to these bits has no hardware effect.
- bits 11-8 MediaPlug IC Revision  
The revision for this MediaPlug IC is “0011b”.  
A write to these bits has no hardware effect.
- bit 7 Cable Detected Status  
The cable detected status as determined by the MPD(1) pin.  
When this bit = 0, a MediaPlug cable is connected.  
When this bit = 1, a MediaPlug cable is not detected.  
A write to this bit has no hardware effect.
- bit 6 A read from this bit always returns 0b.  
A write to this bit has no hardware effect.
- bit 5 Remote Powered Status  
The remote powered status as determined by the RCTRL pin.  
When this bit = 0, the remote is not powered.  
When this bit = 1, the remote is powered and connected.  
A write to this bit has no hardware effect.

Table 8-38: Cable Detect and Remote Powered Status

Cable Detected Status [bit 7]	Remote Powered Status [bit 5]	Status
0	0	cable connected but remote not powered
0	1	cable connected and remote powered
1	x	cable not connected

- bit 4 A read from this bit always returns 0b.  
A write to this bit has no hardware effect.
- bit 3 MediaPlug Clock Enable  
When this bit = 0, the MediaPlug clock is disabled (default).  
When this bit = 1, the MediaPlug clock is enabled.
- bit 2 MediaPlug Clock  
When this bit = 0, the MediaPlug cable clock (VMPCLK) is disabled (default).  
When this bit = 1, the MediaPlug cable clock (VMPCLK) is enabled.

- bit 1                    Power Enable to Remote  
When this bit = 0, power to remote is off (default).  
When this bit =1, power to remote is on.
- bit 0                    Watchdog Disable  
When this bit = 0, the MediaPlug watchdog is enabled (default).  
When this bit = 1, the MediaPlug watchdog is disabled.



MediaPlug Reserved LCMD Register							
REG[1002h]							RW
LCMD Bit 23	LCMD Bit 22	LCMD Bit 21	LCMD Bit 20	LCMD Bit 19	LCMD Bit 18	LCMD Bit 17	LCMD Bit 16
LCMD Bit 31	LCMD Bit 30	LCMD Bit 29	LCMD Bit 28	LCMD Bit 27	LCMD Bit 26	LCMD Bit 25	LCMD Bit 24

REG[1002h] bits 15-0 MediaPlug Reserved LCMD Bits [15:0]  
This register is not implemented and is reserved for future expansion of the LCMD register. A write to this register has no hardware effect. A read from this register always return 0000h.

MediaPlug CMD Register							
REG[1004h]							RW
CMD Bit 7	CMD Bit 6	CMD Bit 5	CMD Bit 4	CMD Bit 3	CMD Bit 2	CMD Bit 1	CMD Bit 0
CMD Bit 15	CMD Bit 14	CMD Bit 13	CMD Bit 12	CMD Bit 11	CMD Bit 10	CMD Bit 9	CMD Bit 8

REG[1002h] bits 15-0 MediaPlug CMD Bits [15:0]  
A 16-bit register for setting the MediaPlug commands. This register is handled differently for reads and writes. The following table shows the MediaPlug description of the CMD Register. See bit descriptions for details.

Table 8-39: MediaPlug CMD Read/Write Descriptions

Data	D15	D14	D13	D12	D11	D10	D9	D8
Write	I[12:5]							
Read	D	T	I[10:5]					
Data	D7	D6	D5	D4	D3	D2	D1	D0
Write	I[4:0]					C[2:0]		
Read	I[4:0]					C[2:0]		

bit 15 Dirty Bit  
This bit is set by the hardware when the command register is written. It is cleared by hardware by the following conditions:

1. Remote-Reset (After this command has been acknowledged by remote.
2. End\_Stream (After this command has been acknowledged by remote.
3. Write to DATA register if the CCC field is Write\_Reg.
4. Read to DATA register if the CCC field is Read\_Reg.

It is also set when the Remote Machine loses power or the cable is disconnected.

- bit 14                      Timeout Bit  
It is set when Watchdog is enabled and MediaPlug read or write cycle takes longer than 64, 128, 1024 cycles of MediaPlug clock depending on LCMD register settings.  
It is also set when the remote is not powered.  
It is cleared at the beginning of every command write by the host.
- bits 13-3                 Index Field  
This field is the address presented by the remote to the remote function. MediaPlug transmits the entire 16-bits of the first word of the command Register as written, but I12 (D15) and I11 (D14) are hidden from readback by the dirty bit and Watchdog error bit.
- bit 2-0                    Command Field  
Selects the command as follows:

Table 8-40: MediaPlug Commands

Command Field [bits 2:0]	Command
000	Remote-Reset: Hardware reset of remote.
001	Stream-End: Indicates end of data streaming operation.
010	Write-Register: Write remote register INDEX[5:0] with DATA.
011	Read-Register: Read remote register INDEX[5:0] to DATA.
100	Write_Stream: Begin streaming data to the remote.
101	NOP: The command is sent across the MediaPlug. There is no other effect.
110	NOP: The command is sent across the MediaPlug. There is no other effect.
111	Read-Stream: Begin streaming data from the remote.

MediaPlug Reserved CMD Register REG[1006h]							RW
CMD Bit 23	CMD Bit 22	CMD Bit 21	CMD Bit 20	CMD Bit 19	CMD Bit 18	CMD Bit 17	CMD Bit 16
CMD Bit 31	CMD Bit 30	CMD Bit 29	CMD Bit 28	CMD Bit 27	CMD Bit 26	CMD Bit 25	CMD Bit 24

REG[1006h] bits 15-0    MediaPlug Reserved CMD Bits [15:0]

This register is not implemented and is reserved for future expansion of the CMD register. A write to this register has no hardware effect. A read from this register always return 0000h.

## 8.5.2 MediaPlug Data Registers

<b>MediaPlug Data Register</b> REG[1008h] to REG[1FFEh], even address								RW
Data Bit 7	Data Bit 6	Data Bit 5	Data Bit 4	Data Bit 3	Data Bit 2	Data Bit 1	Data Bit 0	
Data Bit 15	Data Bit 14	Data Bit 13	Data Bit 12	Data Bit 11	Data Bit 10	Data Bit 9	Data Bit 8	

Data Register bits 15-0 MediaPlug Data Bits [15:0]

A 16-bit register used for read/write and streaming read/write of MediaPlug data. This register is loosely decoded from 1008h to 1FFEh so that the port may be accessed using DWORD block transfer instructions.

## 8.6 BitBLT Data Registers Descriptions

The BitBLT data registers decode A19-A0 and require A20 = 1. The BitBLT data registers are 16-bit wide. Byte access to the BitBLT data registers is not allowed.

<b>BitBLT Data Register 0</b> A20-A0 = 100000h-1FFFFEh, even address								RW
Data Bit 7	Data Bit 6	Data Bit 5	Data Bit 4	Data Bit 3	Data Bit 2	Data Bit 1	Data Bit 0	
Data Bit 15	Data Bit 14	Data Bit 13	Data Bit 12	Data Bit 11	Data Bit 10	Data Bit 9	Data Bit 8	

Data Register bits 15-0 BitBLT Data Bits [15:0]

A 16-bit register that specifies the BitBLT data. This register is loosely decoded from 100000h to 1FFFFEh.

## 9 2D BitBLT Engine

### 9.1 Overview

The S1D13806 is designed with a built-in 2D BitBLT engine which increases the performance of Bit Block Transfers (BitBLT). It supports 8 and 16 bit-per-pixel color depths.

The BitBLT engine supports rectangular and linear addressing modes for source and destination in a positive direction for all BitBLT operations except the move BitBLT which also supports in a negative direction.

The BitBLT operations support byte alignment of all types. The BitBLT engine has a dedicated BitBLT IO access space allowing it to support multi-tasking applications. This allows the BitBLT engine to support simultaneous BitBLT and CPU read/write operations.

### 9.2 BitBLT Operations

The S1D13806 2D BitBLT engine supports the following BitBLTs. For detailed information on using the individual BitBLT operations, refer to the S1D13806 Programming Notes and Examples, document number X28B-G-003-xx.

- Write BitBLT.
- Move BitBLT.
- Solid Fill BitBLT.
- Pattern Fill BitBLT.
- Transparent Write BitBLT.
- Transparent Move BitBLT.
- Read BitBLT.
- Color Expansion BitBLT.
- Move BitBLT with Color Expansion.

#### Note

For details on the BitBLT registers, see Section 8.4.12, “BitBLT Configuration Registers” on page 137.

# 10 Display Buffer

The system addresses the display buffer using CS#, M/R#, and the input pins AB[20:0]. When CS# = 0 and M/R# = 1, the display buffer is addressed by bits AB[20:0]. See the table below:

Table 10-1 : S1D13806 Addressing

CS#	M/R#	Access
0	0	Register access - see Section 8.2, "Register Mapping" on page 97. <ul style="list-style-type: none"> <li>• REG[000h] is addressed when AB[12:0] = 0</li> <li>• REG[001h] is addressed when AB[12:0] = 1</li> <li>• REG[n] is addressed when AB[12:0] = n</li> </ul>
0	1	Memory access: the 1.25M byte display buffer is addressed by AB[20:0]
1	X	S1D13806 not selected

The display buffer address space is always 2M bytes. However, the physical display buffer is 1280k bytes. The space above the 1280k boundary is unavailable (see Figure 10-1: "Display Buffer Addressing").

The display buffer can contain an image buffer, one or more Ink Layer/Hardware Cursor buffers, and a dual panel buffer.

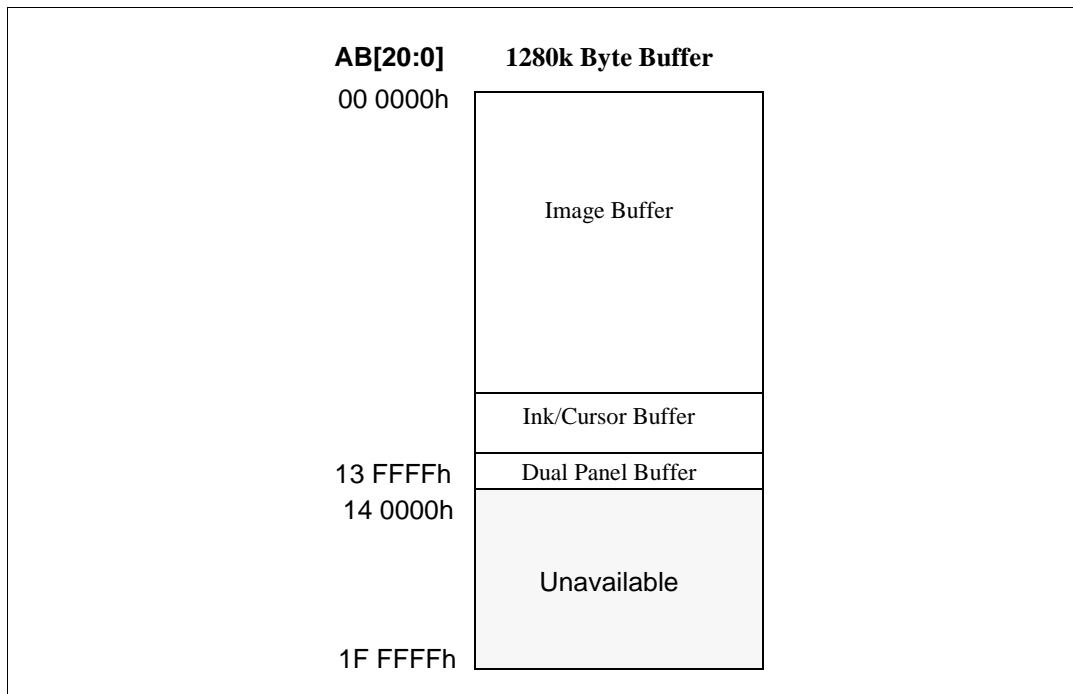


Figure 10-1: Display Buffer Addressing

## 10.1 Image Buffer

The image buffer contains the formatted display mode data – see Section 11.1, “Display Mode Data Format” on page 159.

The displayed image(s) may occupy only a portion of this space with the remaining area used for multiple images – possibly for animation or general storage. Section 11, “Display Configuration” on page 159 for the relationship between the image buffer and the displayed image.

## 10.2 Ink Layer/Hardware Cursor Buffers

The Ink Layer/Hardware Cursor buffers contain formatted image data for the Ink Layer and Hardware Cursor. There may be several Ink Layer/Hardware Cursor images stored in the display buffer but only one may be active at any given time.

For further information, see Section 14, “Ink Layer/Hardware Cursor Architecture” on page 173.

## 10.3 Dual Panel Buffer

In dual panel mode with the dual panel buffer enabled, the top of the display buffer is allocated to the dual panel buffer. The size of the dual panel buffer is a function of the panel resolution and the type of panel (color or monochrome).

Dual Panel Buffer Size (in bytes) = (panel width x panel height) × factor ÷ 16

where factor: = 4 for color panel  
= 1 for monochrome panel

### Note

Calculating the size of the dual panel buffer is required to avoid overwriting the Hardware Cursor/Ink Layer buffer.

**Example 1: For a 800x600 color panel the dual panel buffer size is 120,000 bytes. With a 1280k byte display buffer, the dual panel buffer resides from 12 2b40h to 13 FFFFh.**

# 11 Display Configuration

## 11.1 Display Mode Data Format

The following diagram show the display mode data formats for a little endian system.

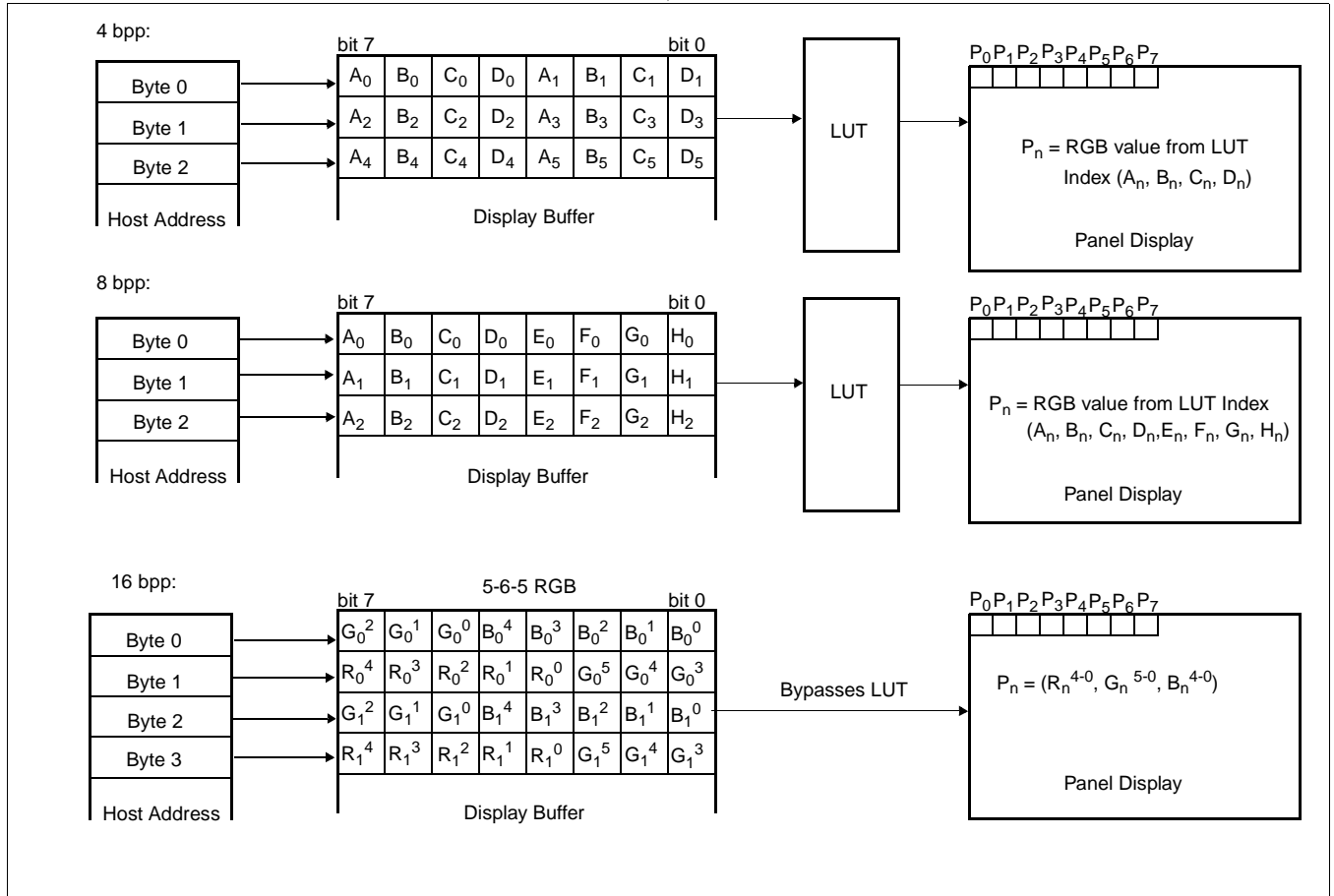


Figure 11-1: 4/8/16 Bit-per-pixel Format Memory Organization

### Note

1. The Host-to-Display mapping shown here is for a little endian system.
2. For the 16 bit-per-pixel format, R<sub>n</sub>, G<sub>n</sub>, B<sub>n</sub> represent the red, green, and blue color components.

## 11.2 Image Manipulation

The figure below shows how the screen image is stored in the image buffer and positioned on the LCD display. The screen image on the CRT/TV is manipulated similarly. When EISD is enabled (see Section 16, “EPSON Independent Simultaneous Display (EISD)” on page 186), the images on the LCD and on the CRT/TV are independent of each other.

- For LCD: (REG[047h], REG[046h]) define the width of the virtual image.  
For CRT/TV: (REG[067h], REG[066h]) define the width of the virtual image.
- For LCD: (REG[044h], REG[043h], REG[042h]) define the starting word of the displayed image.  
For CRT/TV: (REG[064h], REG[063h], REG[062h]) define the starting word of the displayed image.
- For LCD: REG[048h] defines the starting pixel within the starting word.  
For CRT/TV: REG[068h] defines the starting pixel within the starting word.
- For LCD: REG[032h] defines the width of the LCD display.  
For CRT/TV: REG[050h] defines the width of the CRT/TV display.
- For LCD: (REG[039h], REG[038h]) define the height of the LCD display.  
For CRT/TV: (REG[057h], REG[056h]) define the height of the CRT/TV display.

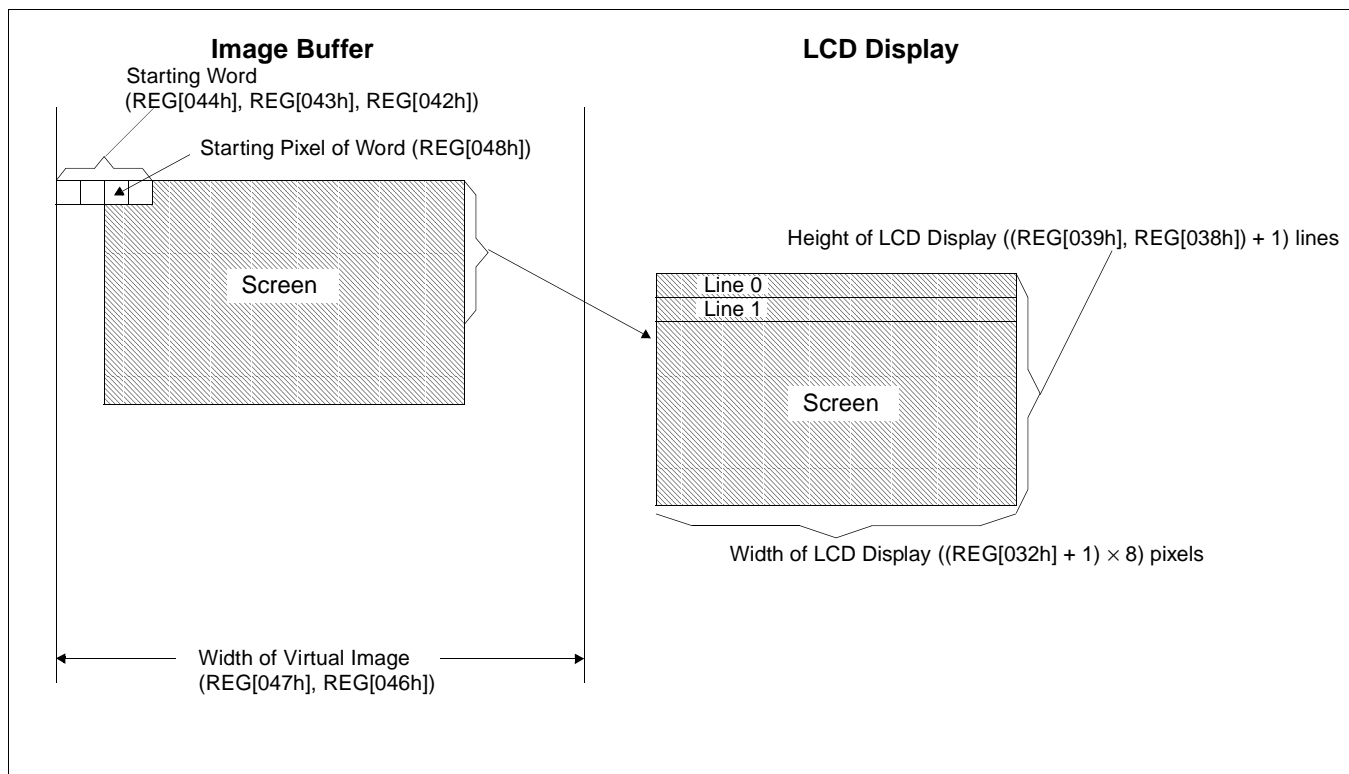


Figure 11-2: Image Manipulation



# 12 Look-Up Table Architecture

The following depictions are intended to show the display data output path only.

## 12.1 Monochrome Modes

The green LUT is used for all monochrome modes.

### 4 Bit-Per-Pixel Monochrome Mode

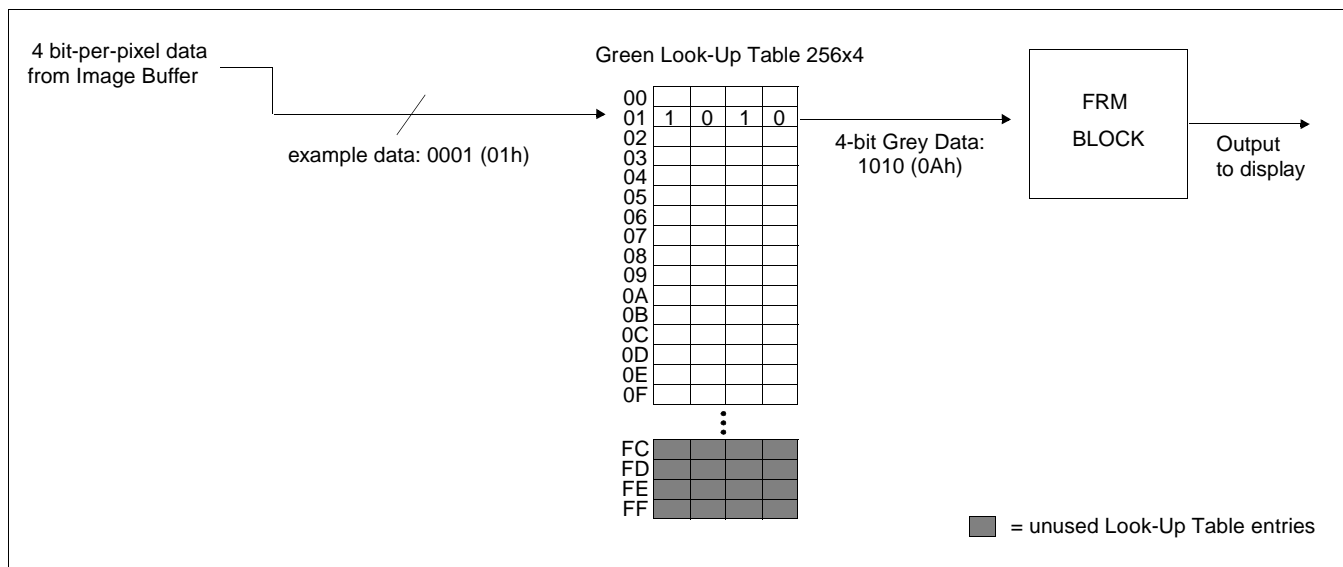


Figure 12-1: 4 Bit-Per-Pixel Monochrome Mode Data Output Path

### 8 Bit-Per-Pixel Monochrome Mode

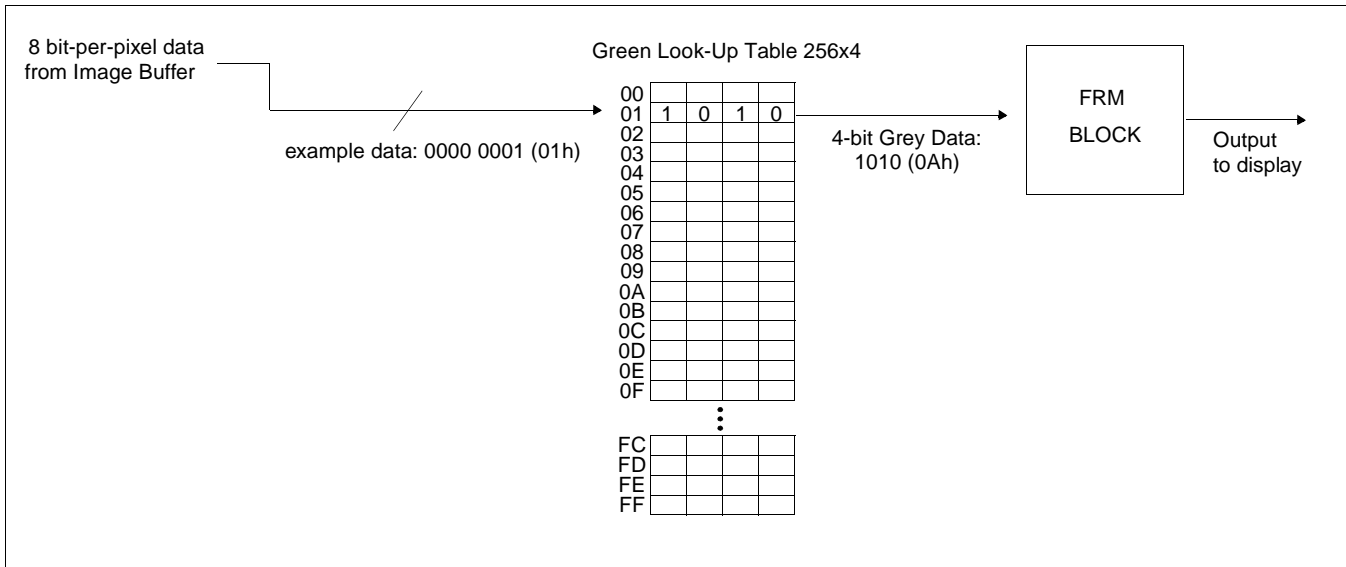


Figure 12-2: 8 Bit-Per-Pixel Monochrome Mode Data Output Path

### 16 Bit-Per-Pixel Monochrome Mode

A color depth of 16 bpp is required to achieve 64 gray shades in monochrome mode. In this mode the LUT is bypassed and the green component of the pixel is mapped to the FRM.

## 12.2 Color Modes

### 4 Bit-Per-Pixel Color Mode

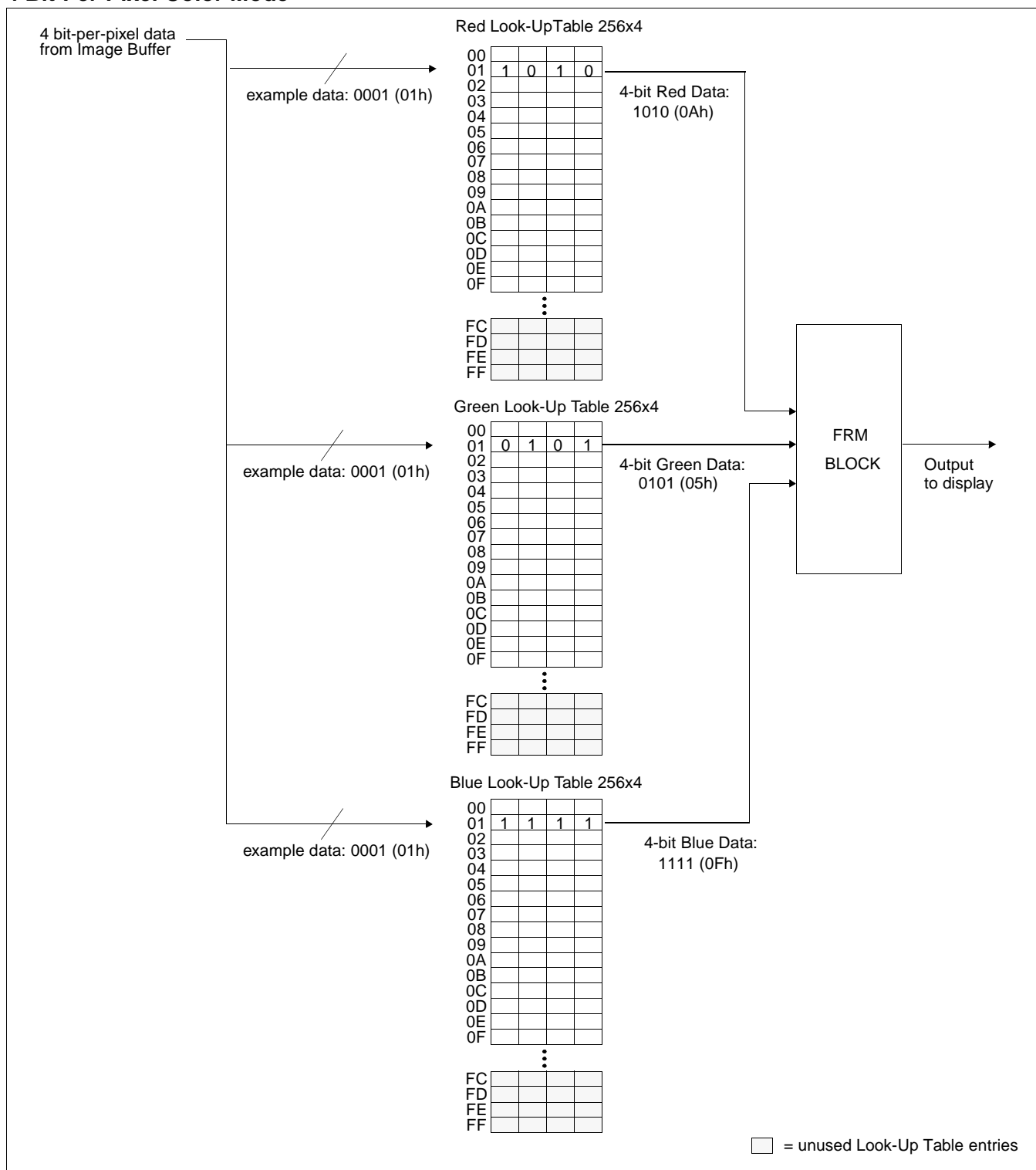


Figure 12-3: 4 Bit-Per-Pixel Color Mode Data Output Path

### 8 Bit-Per-Pixel Color Mode

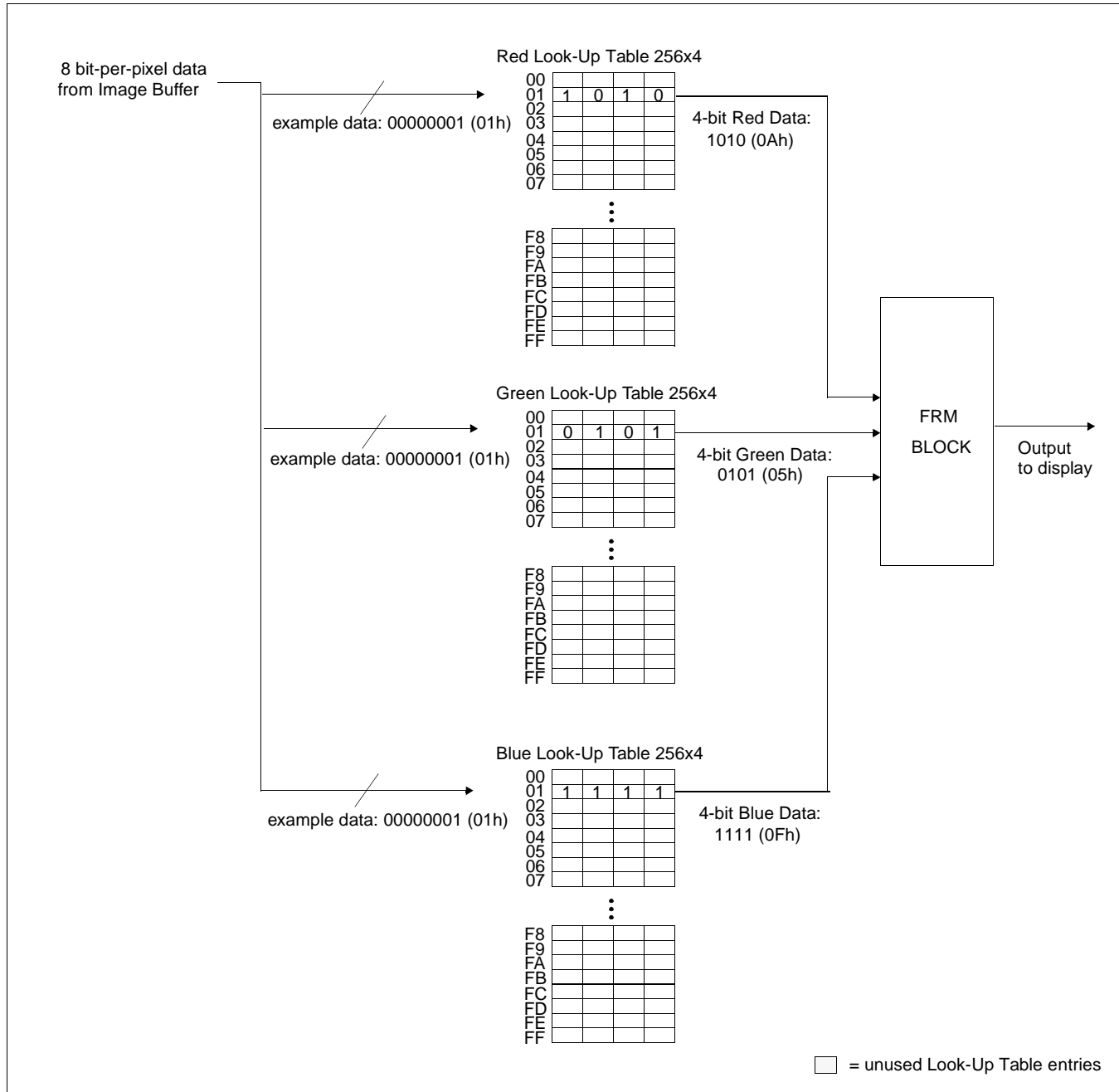


Figure 12-4: 8 Bit-Per-Pixel Color Mode Data Output Path

### 16 Bit-Per-Pixel Color Modes

The LUT is bypassed and the color data is directly mapped for this color mode – Section 11, “Display Configuration” on page 159.

## 13 TV Considerations

### 13.1 NTSC/PAL Operation

NTSC or PAL video is supported in either composite or S-video format. Filters may be enabled to reduce the distortion associated with displaying high resolution computer images on an interlaced TV display. The image can be vertically and horizontally positioned on the TV. Additionally, a dedicated Hardware Cursor (independent from the LCD display) is supported.

### 13.2 Clock Source

The required clock frequencies for NTSC/PAL are given in the following table.

*Table 13-1 : Required Clock Frequencies for NTSC/PAL*

TV Format	Required Clock Frequency
NTSC	14.318180 MHz (3.579545 MHz subcarrier)
PAL	17.734475 MHz (4.43361875 MHz subcarrier)

## 13.3 Filters

When displaying computer images on a TV, several image distortions are likely to arise:

- cross-luminance distortion.
- cross-chrominance distortion.
- flickering.

These distortions are caused by the high-resolution nature of computer images which typically contain sharp color transitions, and sharp luminance transitions (e.g., high contrast one pixel wide lines and fonts, window edges, etc.). Three filters are available to reduce these distortions.

### 13.3.1 Chrominance Filter (REG[05Bh] bit 5)

The chrominance filter adjusts the color of the TV by limiting the bandwidth of the chrominance signal (reducing cross-luminance distortion). This reduces the “ragged edges” seen at boundaries between sharp color transitions. This filter is controlled using REG[05Bh] bit 5 and is most useful for composite video output.

### 13.3.2 Luminance Filter (REG[05Bh] bit 4)

The luminance filter adjusts the brightness of the TV by limiting the bandwidth of the luminance signal (reducing cross-chrominance distortion). This reduces the “rainbow-like” colors at boundaries between sharp luminance transitions. This filter is controlled using REG[05Bh] bit 4 and is most useful for composite video output.

### 13.3.3 Anti-flicker Filter (REG[1FCh] bits [2:1])

The “flickering” effect seen on interlaced displays is caused by sharp vertical image transitions that occur over one line (1 vertical pixel). For example, one pixel high lines, edges of window boxes, etc. Flickering occurs because these high resolution lines are effectively displayed at half the refresh frequency due to interlacing. The anti-flicker filter averages adjacent lines on the TV display to reduce flickering. This filter is controlled using the Display Mode register (REG[1FCh] bits [2:1]).

#### Note

When TV with anti-flicker filter is enabled, the Flicker Filter Clock Enable bit (REG[18h] bit 7) must be set to 1.

## 13.4 TV Output Levels

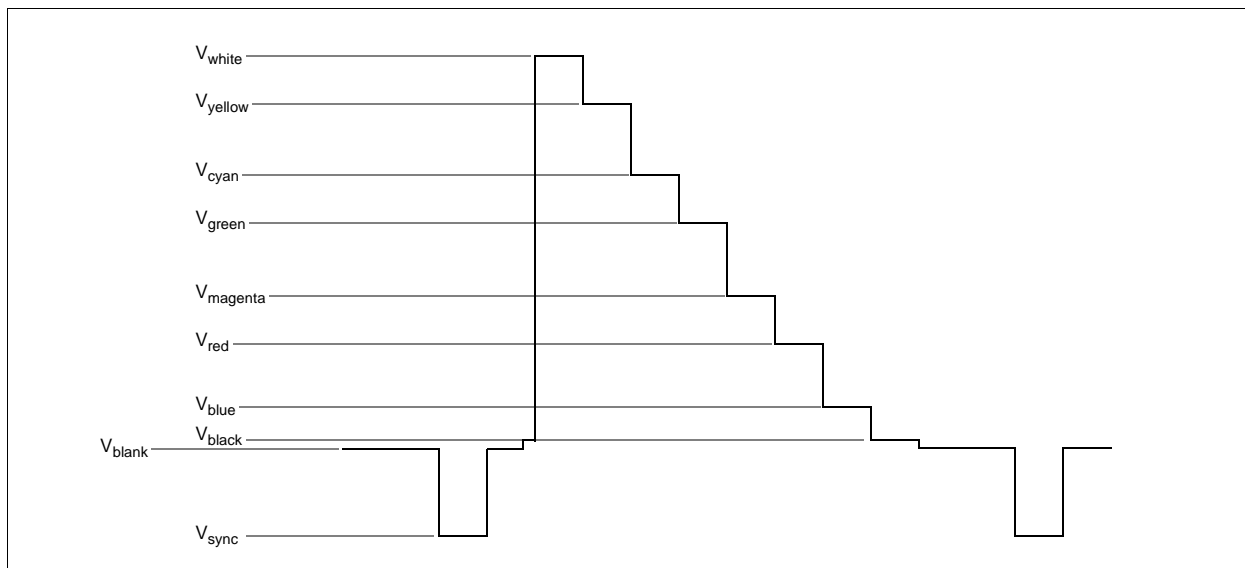


Figure 13-1: NTSC/PAL SVideo-Y (Luminance) Output Levels

Table 13-2 : NTSC/PAL SVideo-Y (Luminance) Output Levels

Symbol	Parameter	RGB	NTSC / PAL (mv)	NTSC / PAL (IRE)
V <sub>white</sub>	White	1F 3F 1F	996	99.5
V <sub>yellow</sub>	Yellow	1F 3F 00	923	89
V <sub>cyan</sub>	Cyan	00 3F 1F	798	72
V <sub>green</sub>	Green	00 3F 00	725	62
V <sub>magenta</sub>	Magenta	1F 00 1F	608	45
V <sub>red</sub>	Red	1F 00 00	536	35
V <sub>blue</sub>	Blue	00 00 1F	410	17
V <sub>black</sub>	Black	00 00 00	338	7.3
V <sub>blanking</sub>	Blanking	N.A.	284	0
V <sub>sync</sub>	Sync Tip	N.A.	0	-40

**Note**

RGB values assume a 16 bpp color depth with 5-6-5 pixel packing.

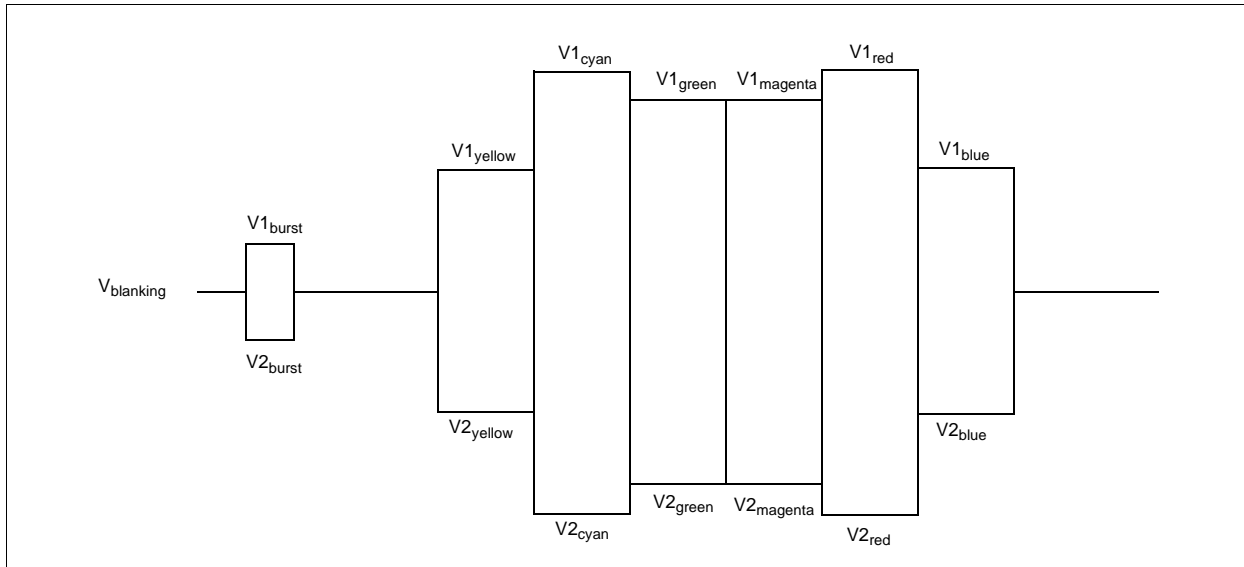


Figure 13-2: NTSC/PAL SVideo-C (Chrominance) Output Levels

Table 13-3 : NTSC/PAL SVideo-C (Chrominance) Output Levels

Symbol	Parameter	RGB	NTSC / PAL (mv)	NTSC / PAL (IRE)
V1 <sub>burst</sub>	Burst positive peak	N.A.	552 / 541	20 / 18.5
V1 <sub>yellow</sub>	Yellow positive peak	1F 3F 00	700	40.8
V1 <sub>cyan</sub>	Cyan positive peak	00 3F 1F	815	57
V1 <sub>green</sub>	Green positive peak	00 3F 00	751	48
V1 <sub>magenta</sub>	Magenta positive peak	1F 00 1F	751	48
V1 <sub>red</sub>	Red positive peak	1F 00 00	815	57
V1 <sub>blue</sub>	Blue positive peak	00 00 1F	700	40.8
V <sub>blanking</sub>	Blanking	N.A.	410	0
V2 <sub>burst</sub>	Burst negative peak	N.A.	268 / 279	-20 / -18.5
V2 <sub>yellow</sub>	Yellow negative peak	1F 3F 00	121	-40.8
V2 <sub>cyan</sub>	Cyan negative peak	00 3F 1F	5	-57
V2 <sub>green</sub>	Green negative peak	00 3F 00	70	-48
V2 <sub>magenta</sub>	Magenta negative peak	1F 00 1F	70	-48
V2 <sub>red</sub>	Red negative peak	1F 00 00	5	-57
V2 <sub>blue</sub>	Blue negative peak	00 00 1F	121	-40.8

**Note**

RGB values assume a 16 bpp color depth with 5-6-5 pixel packing.



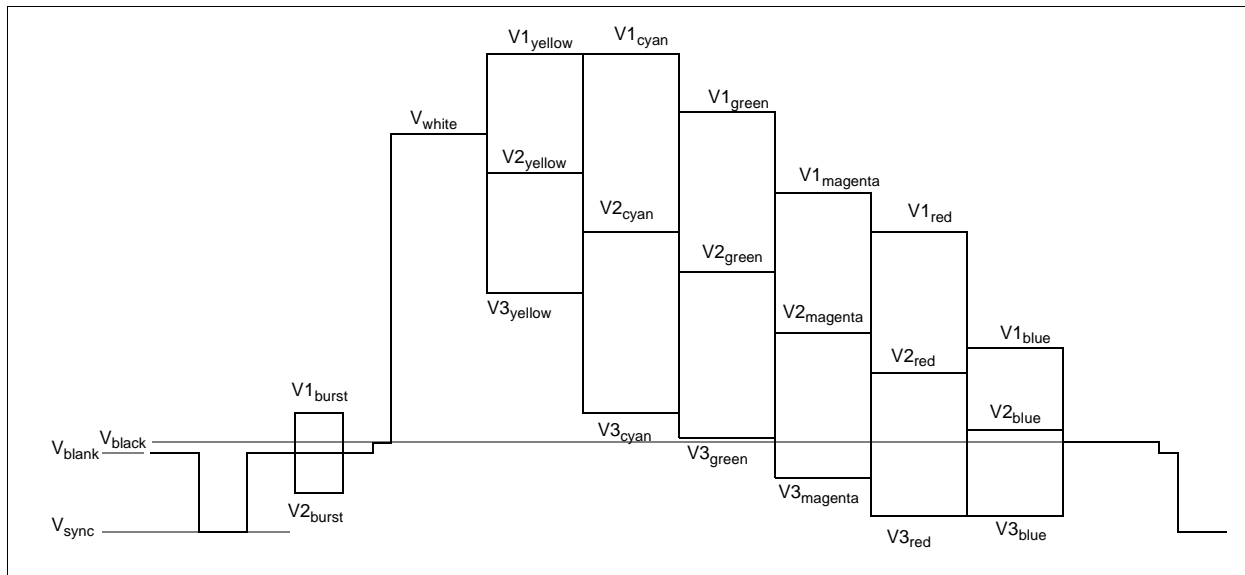


Figure 13-3: NTSC/PAL Composite Output Levels

Table 13-4 : NTSC/PAL Composite Output Levels

Symbol	Parameter	RGB	NTSC / PAL (mv)	NTSC / PAL (IRE)
V1 <sub>yellow</sub>	Yellow chrominance positive peak	1F 3F 00	1211	130
V1 <sub>cyan</sub>	Cyan chrominance positive peak	00 3F 1F	1202	128
V1 <sub>green</sub>	Green chrominance positive peak	00 3F 00	1065	109
V1 <sub>magenta</sub>	Magenta chrominance positive peak	1F 00 1F	948	93
V1 <sub>red</sub>	Red chrominance positive peak	1F 00 00	939	92
V1 <sub>blue</sub>	Blue chrominance positive peak	00 00 1F	699	58
V <sub>white</sub>	White luminance level	1F 3F 1F	995	99
V2 <sub>yellow</sub>	Yellow luminance level	1F 3F 00	923	89
V2 <sub>cyan</sub>	Cyan luminance level	00 3F 1F	797	72
V2 <sub>green</sub>	Green luminance level	00 3F 00	725	62
V2 <sub>magenta</sub>	Magenta luminance level	1F 00 1F	608	45
V2 <sub>red</sub>	Red luminance level	1F 00 00	535	35
V2 <sub>blue</sub>	Blue luminance level	00 00 1F	411	18
V <sub>black</sub>	Black luminance level	00 00 00	338	7.3
V3 <sub>yellow</sub>	Yellow chrominance negative peak	1F 3F 00	634	49
V3 <sub>cyan</sub>	Cyan chrominance negative peak	00 3F 1F	392	15
V3 <sub>green</sub>	Green chrominance negative peak	00 3F 00	384	14
V3 <sub>magenta</sub>	Magenta chrominance negative peak	1F 00 1F	267	-2.6
V3 <sub>red</sub>	Red chrominance negative peak	1F 00 00	130	-22
V3 <sub>blue</sub>	Blue chrominance negative peak	00 00 1F	122	-23
V <sub>blank</sub>	Blank Level	N.A.	284	0
V1 <sub>burst</sub>	Burst positive peak	N.A.	426 / 415	20 / 18
V2 <sub>burst</sub>	Burst negative peak	N.A.	142 / 153	-20 / -19
V <sub>sync</sub>	Sync Tip	N.A.	0	-40

**Note**

RGB values assume a 16 bpp color depth with 5-6-5 pixel packing.

### 13.4.1 TV Image Display and Positioning

This section describes how to setup and position an image to be displayed on a TV. Figure 13-4: “NTSC/PAL Image Positioning” shows an image positioned in the TV display with the related programmable parameters. The TV display area is shaded.

The size of the display image determines the register values for the Horizontal Display Period, Horizontal Non-Display Period, Vertical Display Period, and Vertical Non-Display Period. The maximum and minimum values for these registers are given in Table 13-5, “Minimum and Maximum Values for NTSC/PAL TV,” on page 171. The line period and frame period determined by these registers must also satisfy the following equations.

NTSC:

$$(((\text{REG}[050] \text{ bits}[6:0]) + 1) \times 8) + (((\text{REG}[052] \text{ bits}[5:0]) \times 8) + 6) = 910$$

$$(((\text{REG}[057] \text{ bits}[1:0]), (\text{REG}[056] \text{ bits}[7:0])) + 1) + ((\text{REG}[058] \text{ bits}[6:0]) + 1) \times 2 + 1 = 525$$

PAL:

$$(((\text{REG}[050] \text{ bits}[6:0]) + 1) \times 8) + (((\text{REG}[052] \text{ bits}[5:0]) \times 8) + 7) = 1135$$

$$(((\text{REG}[057] \text{ bits}[1:0]), (\text{REG}[056] \text{ bits}[7:0])) + 1) + ((\text{REG}[058] \text{ bits}[6:0]) + 1) \times 2 + 1 = 625$$

The HRTC Start Position and VRTC Start Position registers position the image horizontally and vertically. The maximum and minimum register values for these registers are given in Table 13-5, “Minimum and Maximum Values for NTSC/PAL TV”. Increasing the HRTC Start Position moves the image left, while increasing the VRTC Start Position moves the image up.

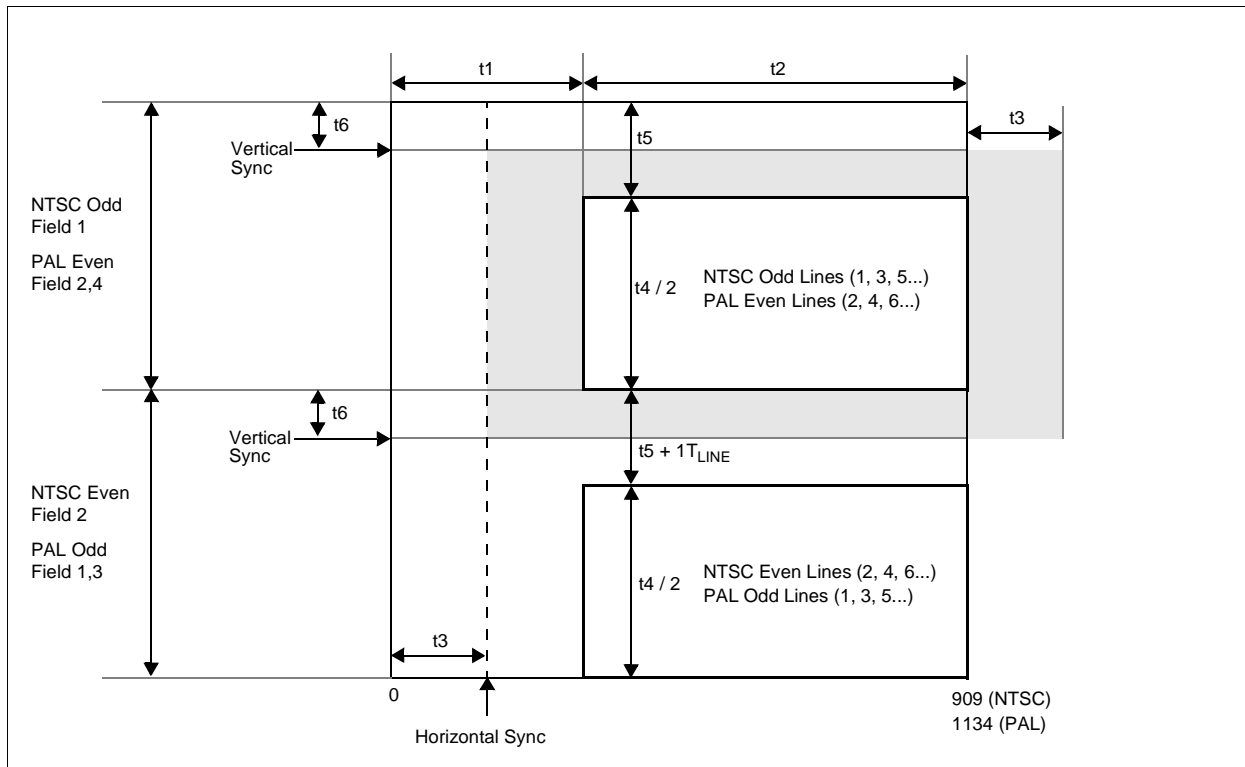


Figure 13-4: NTSC/PAL Image Positioning

The maximum Horizontal and Vertical Display Widths shown in Table 13-5, “Minimum and Maximum Values for NTSC/PAL TV” include display areas that are normally hidden by the edges of the TV. The visible display dimensions are shown in Figure 13-5: “Typical Display Dimensions and Visible Display Dimensions for NTSC and PAL” as a guideline. The actual visible display area for a particular television may differ slightly from those dimensions given. Table 13-6, “Register Values for Example NTSC/PAL Images” lists some register values for some example images.

Table 13-5 : Minimum and Maximum Values for NTSC/PAL TV

Symbol	Parameter	Register(s)	NTSC		PAL		Units
			min	max	min	max	
t1	TV Horizontal Non-Display Period	52	158	510	215	511	T <sub>4SC</sub>
t2	TV Horizontal Display Width	50	400	752	624	920	T <sub>4SC</sub>
t3	TV HRTC Start Position	53	25	t2 - 158	25	t2 - 215	T <sub>4SC</sub>
t4	TV Vertical Display Height	57, 56	270	484	370	572	T <sub>LINE</sub>
t5	TV Vertical Non-Display Period	58	20 (21)	127 (128)	26 (27)	127 (128)	T <sub>LINE</sub>
t6	TV Vertical Start Position	59	0	t5 - 20	0	t5 - 26	T <sub>LINE</sub>

**Note**

The TV Vertical Non-Display Period (t5) varies by 1 line depending on the field that it follows.

**Note**

For NTSC panels the minimum and maximum values will vary for each application.

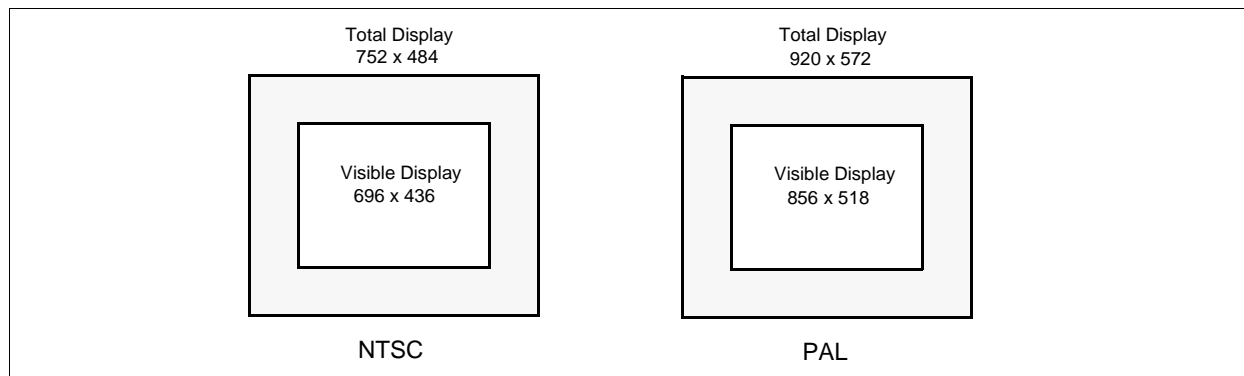


Figure 13-5: Typical Display Dimensions and Visible Display Dimensions for NTSC and PAL

#### Note

For most implementations, the visible display does not equal the total display. The total display dimensions and the visible display dimensions must be determined for each specific implementation.

Table 13-6 : Register Values for Example NTSC/PAL Images

Parameter	Register	NTSC			PAL			
		752x484	696x436	640x480	920x572	856x518	800x572	640x480
TV Horizontal Display Width	50	5Dh	56h	4Fh	72h	6Ah	63h	4Fh
TV Horizontal Non-Display Period	52	13h	1Ah	21h	1Ah	22h	29h	3Dh
TV HRTC Start Position	53	02h	04h	09h	02h	05h	09h	15h
TV Vertical Display Height	57	01h	01h	01h	02h	02h	02h	01h
	56	E3h	B3h	DFh	3Bh	05h	3Bh	DFh
TV Vertical Non-Display Period	58	13h	2Bh	15h	19h	34h	19h	47h
TV Vertical Start Position	59	00h	0Ch	00h	00h	0Dh	00h	17h

### 13.4.2 TV Cursor Operation

See Section 14, “Ink Layer/Hardware Cursor Architecture” on page 173.

## 14 Ink Layer/Hardware Cursor Architecture

### 14.1 Ink Layer/Hardware Cursor Buffers

The Ink Layer/Hardware Cursor buffers contain formatted image data for the Ink Layer or Hardware Cursor. There may be several Ink Layer/Hardware Cursor images stored in the display buffer but only one may be active at any given time. The active Ink Layer/Hardware Cursor buffer is selected by the Ink/Cursor Start Address register (REG[071h] for LCD, REG[081h] for CRT/TV). This register defines the start address for the active Ink/Cursor buffer. The Ink/Cursor buffer must be positioned where it does not conflict with the image buffer and dual panel buffer. The start address for the Ink/Cursor buffer is programmed as shown in the following table.

Table 14-1 : Ink/Cursor Start Address Encoding

Ink/Cursor Start Address Bits [7:0]	Start Address (Bytes)	Comments
0	1280K - 1024	This default value is suitable for a Hardware Cursor when there is no dual panel buffer.
n = 160...1	1280K - (n × 8192)	These positions can be used to: <ul style="list-style-type: none"> <li>• position an Ink Layer buffer at the top of the display buffer;</li> <li>• position an Ink Layer buffer between the image and dual panel buffers;</li> <li>• position a Hardware Cursor buffer between the image and dual panel buffers;</li> <li>• select from a multiple of Hardware Cursor buffers.</li> </ul>
n = 255...161	Invalid	

The Ink/Cursor image is stored contiguously. The address offset from the starting word of line  $n$  to the starting word of line  $n+1$  is calculated as follows:

$$\begin{aligned} \text{LCD Ink Address Offset (words)} &= \text{REG}[032\text{h}] + 1 \\ \text{CRT/TV Ink Address Offset (words)} &= \text{REG}[050\text{h}] + 1 \\ \text{LCD or CRT/TV Cursor Address Offset (words)} &= 8 \end{aligned}$$

## 14.2 Ink/Cursor Data Format

The Ink/Cursor image is always 2 bit-per-pixel. The following diagram shows the Ink/Cursor data format for a little endian system.

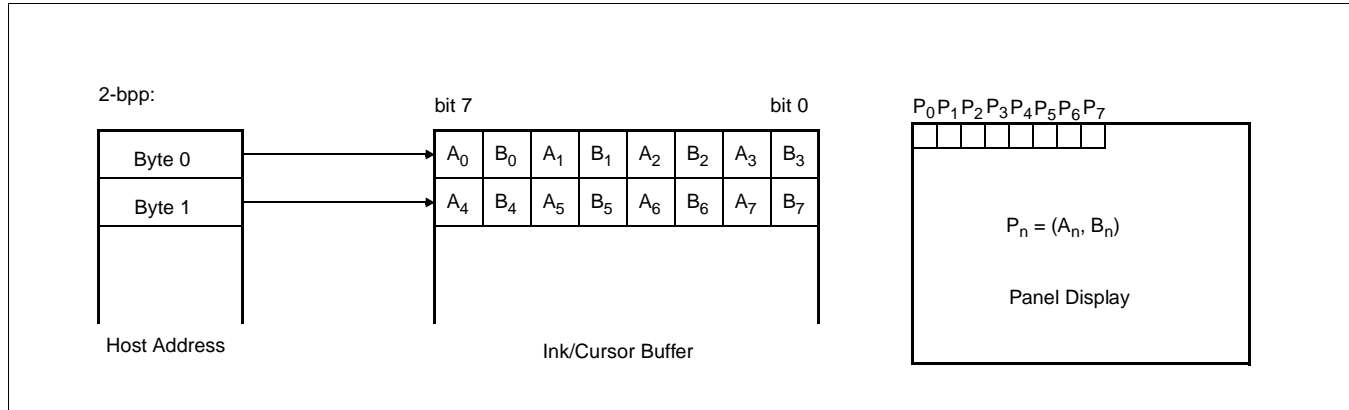


Figure 14-1: Ink/Cursor Data Format

The image data for pixel  $n$ ,  $(A_n, B_n)$ , selects the color for pixel  $n$  as follows.

Table 14-2 : Ink/Cursor Color Select

$(A_n, B_n)$	Color	Comments
00	Color 0	Ink/Cursor Color 0 Register, (REG[078h], REG[077h], REG[076h] for LCD, REG[088h], REG[087h], REG[086h] for CRT/TV)
01	Color 1	Ink/Cursor Color 1 Register, (REG[07Ah], REG[07Bh], REG[07Ah] for LCD, REG[08Ah], REG[08Bh], REG[08Ah] for CRT/TV)
10	Background	Ink/Cursor is transparent – show background
11	Inverted Background	Ink/Cursor is transparent – show inverted background

## 14.3 Ink/Cursor Image Manipulation

### 14.3.1 Ink Image

The Ink image should always start at the top left pixel (i.e. Cursor X Position and Cursor Y Position registers should always be set to zero). The width and height of the ink image are automatically calculated to completely cover the display.

### 14.3.2 Cursor Image

The Cursor image size is always 64 x 64 pixels. The Cursor X Position and Cursor Y Position registers specify the position of the top left pixel. The following diagram shows how to position an unclipped cursor.

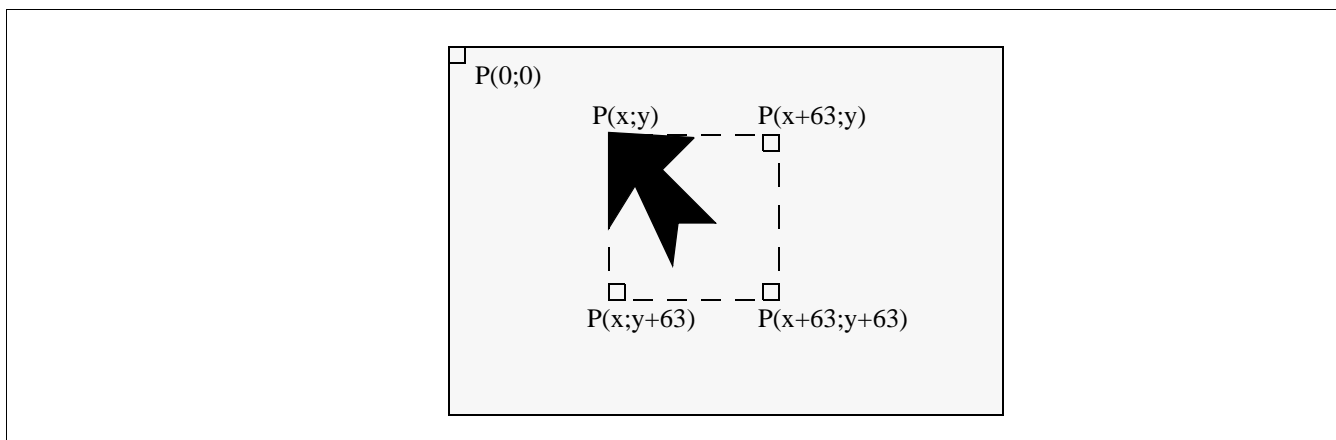


Figure 14-2: Unclipped Cursor Positioning

where

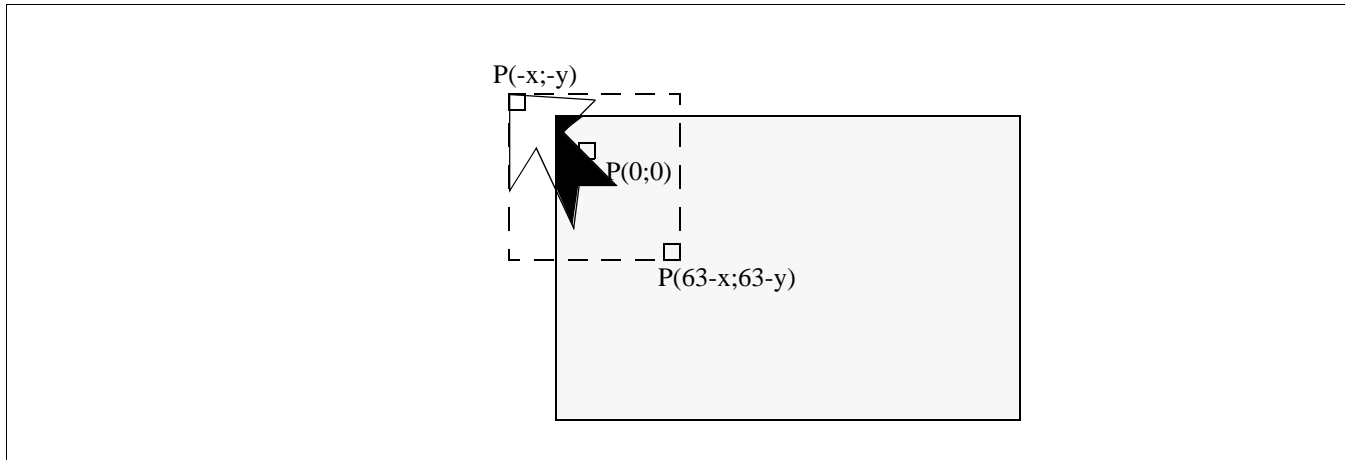
For LCD:

$x = (\text{REG}[073\text{h}] \text{ bits } [1:0], \text{REG}[072\text{h}])$  **and**  $\text{REG}[073\text{h}] \text{ bit } 7 = 0$   
 $y = (\text{REG}[075\text{h}] \text{ bits } [1:0], \text{REG}[074\text{h}])$  **and**  $\text{REG}[075\text{h}] \text{ bit } 7 = 0$

For CRT/TV:

$x = (\text{REG}[083\text{h}] \text{ bits } [1:0], \text{REG}[082\text{h}])$  **and**  $\text{REG}[083\text{h}] \text{ bit } 7 = 0$   
 $y = (\text{REG}[085\text{h}] \text{ bits } [1:0], \text{REG}[084\text{h}])$  **and**  $\text{REG}[085\text{h}] \text{ bit } 7 = 0$

The following diagram shows how to position a cursor that is clipped at the top and left sides of the display.



*Figure 14-3: Clipped Cursor Positioning*

where

For LCD:

$x = (\text{REG}[073\text{h}] \text{ bits } [1:0], \text{REG}[072\text{h}]) \leq 63$  **and**  $\text{REG}[073\text{h}] \text{ bit } 7 = 1$   
 $y = (\text{REG}[075\text{h}] \text{ bits } [1:0], \text{REG}[074\text{h}]) \leq 63$  **and**  $\text{REG}[075\text{h}] \text{ bit } 7 = 1$

For CRT/TV:

$x = (\text{REG}[083\text{h}] \text{ bits } [1:0], \text{REG}[082\text{h}]) \leq 63$  **and**  $\text{REG}[083\text{h}] \text{ bit } 7 = 1$   
 $y = (\text{REG}[085\text{h}] \text{ bits } [1:0], \text{REG}[084\text{h}]) \leq 63$  **and**  $\text{REG}[085\text{h}] \text{ bit } 7 = 1$



## 15 SwivelView™

### 15.1 Concept

Most computer displays are refreshed in landscape – from left to right and top to bottom. Computer images are stored in the same manner. SwivelView is designed to rotate the displayed image on an LCD by 90°, 180°, or 270° in a clockwise direction. 90° rotation is also available on CRT.

The rotation is done in hardware and is transparent to the user for all display buffer reads and writes. By processing the rotation in hardware, SwivelView offers a performance advantage over software rotation of the displayed image.

### 15.2 90° SwivelView

90° SwivelView uses a 1024 × 1024 pixel virtual window. The following figures show how the display buffer memory map changes in 90° SwivelView. The display is refreshed in the following sense: C–A–D–B. The application image is written to the S1D13806 in the following sense: A–B–C–D. The S1D13806 rotates and stores the application image in the following sense: C–A–D–B, the same sense as display refresh.

The user can read/write to the display buffer naturally, without the need to rotate the image first in software. The registers that control the panning and scrolling of the panel window are designed for a landscape window. However, it is still possible to pan and scroll the portrait window in 90° SwivelView, but the user must program these registers somewhat differently (See Section 15.2.1, “Register Programming” on page 178).

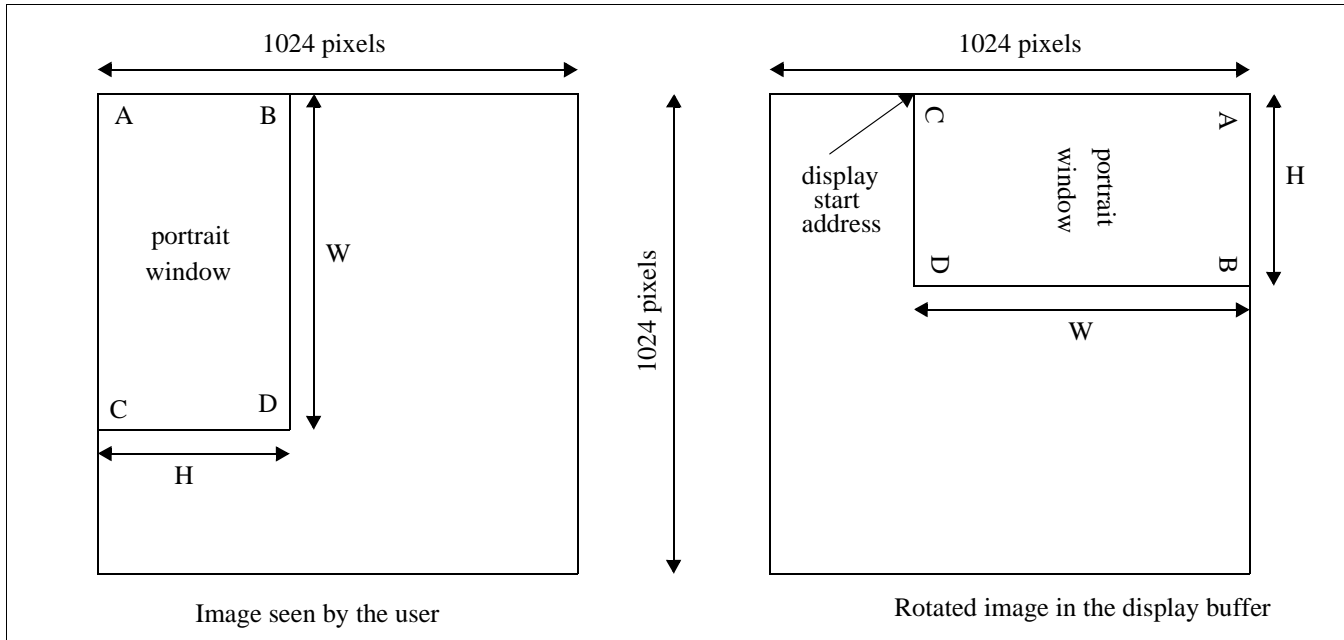


Figure 15-1: Relationship Between Screen Image and 90° Rotated Image in the Display Buffer

**Note**

W is the width of the LCD panel/CRT in number of pixels, (or the height of the portrait window in number of lines).

H is the height of the LCD panel/CRT in number of lines, (or the width of the portrait window in number of pixels).

**Note**

The image must be written with a 1024 pixel offset between adjacent lines (1024 bytes for 8 bpp color depth or 2048 bytes for 16 bpp color depth) and the display start address must be calculated (see below).

## 15.2.1 Register Programming

### Enabling 90° Rotation on CPU Read/Write to Display Buffer

Set SwivelView Enable bits 1:0 to 01b. All CPU accesses to the display buffer are translated to provide 90° clockwise rotation of the display image.

### Memory Address Offset

The LCD/CRT Memory Address Offset register (REG[046h], REG[047h] for LCD, or REG[066h], REG[067h] for CRT) must be set for a 1024 pixel offset:

LCD/CRT Memory Address Offset (words)

= 1024	for 16 bpp color depth
= 512	for 8 bpp color depth

## Display Start Address

As seen in Figure 15-1: “Relationship Between Screen Image and 90° Rotated Image in the Display Buffer” on page 178, the Display Start Address is determined by the location of the image corner “C”, and it is generally non-zero. The LCD/CRT Display Start Address register (REG[042h], REG[043h], REG[044h] for LCD, or REG[062h], REG[063h], REG[064h] for CRT) must be set accordingly.

$$\begin{aligned} \text{LCD/CRT Display Start Address (words)} \\ &= (1024 - W) && \text{for 16 bpp color depth} \\ &= (1024 - W) / 2 && \text{for 8 bpp color depth} \end{aligned}$$

where W is the width of the panel in number of pixels.

## Horizontal Panning

Horizontal panning is achieved by changing the LCD/CRT Display Start Address register:

- Increase/decrease LCD/CRT Display Start Address register by 1024 (16 bpp color depth) or 512 (8 bpp color depth) pans the display window to the right/left by 1 pixel.

The amount the display window can be panned to the right is limited to 1024 pixels and limited by the amount of physical memory installed.

## Vertical Scrolling

Vertical scrolling is achieved by changing the LCD/CRT Display Start Address register and/or the LCD/CRT Pixel Panning register:

- Increment/decrement LCD/CRT Display Start Address register in 8 bpp color depth scrolls the display window up/down by 2 lines.
- Increment/decrement LCD/CRT Display Start Address register in 16 bpp color depth scrolls the display window up/down by 1 line.
- Increment/decrement LCD/CRT Pixel Panning register in 8 bpp color depth scrolls the display window up/down by 1 line.

## 15.2.2 Physical Memory Requirement

Because the user must now deal with a virtual image of 1024×1024, the amount of image buffer required for a particular display mode has increased. The minimum amount of image buffer required is:

$$\begin{aligned} \text{Minimum Required Image Buffer (bytes)} \\ &= (1024 \times H) \times 2 && \text{for 16 bpp color depth} \\ &= (1024 \times H) && \text{for 8 bpp color depth} \end{aligned}$$

where H is the height of the panel in number of lines.

This minimum amount is required to display a 90° SwivelView image without panning; scrolling, however, is permissible. The degree an image can be panned depends on the amount of physical memory installed and how much of that is used by the dual panel buffer, Ink Layer, or Hardware Cursor. An image cannot be panned outside the 1024×1024 virtual display. Often it cannot be panned within the entire virtual display because part of the virtual display memory may be taken up by the dual panel buffer, Ink Layer, Hardware Cursor, or even the CRT/TV display buffer.

The dual panel buffer is used for dual panel mode and has the following memory requirements.

Dual Panel Buffer (bytes)

$$\begin{aligned} &= (W \times H) / 4 && \text{for color mode} \\ &= (W \times H) / 16 && \text{for monochrome mode} \end{aligned}$$

where W is the width of the panel in number of pixels, and H is the height of the panel in number of lines.

The dual panel buffer is always located at the end of the physical memory.

The Hardware Cursor or Ink Layer also takes up memory. If this memory is > 1KB, it must be located at an 8KB boundary, otherwise it may be located at the last 1KB area. The Hardware Cursor or Ink Layer must not overlap the image buffer or the dual panel buffer.

Even though the virtual display is 1024×1024 pixels, the actual panel window is always smaller. Thus it is possible for the display buffer to be smaller than the virtual display but large enough to fit both the required image buffer and the dual panel buffer. This situation limits the maximum “accessible” horizontal virtual size as follows.

Maximum Accessible Horizontal Virtual Size (pixels)

$$\begin{aligned} &= (\text{Physical Memory} - \text{Dual Panel Buffer} - \text{Ink Layer}) / 2048 \text{ for 16 bpp color depth} \\ &= (\text{Physical Memory} - \text{Dual Panel Buffer} - \text{Ink Layer}) / 1024 \text{ for 8 bpp color depth} \end{aligned}$$

For example, a 800×600 TFT panel running a color depth of 16 bpp requires 1200K byte of image buffer, 0K byte of dual panel buffer memory and 0K byte of ink layer memory (ink layer is not supported in this configuration, see Table 15-1, “Memory Size Required for SwivelView 90° and 270°,” on page181). The virtual display size is 2048×2048 = 2M byte. This display can still be supported by the 1280K embedded DRAM even though it is smaller than the 2M byte virtual display because the size of the embedded DRAM is larger than the 1200K byte minimum required image buffer. The maximum accessible horizontal virtual size is = (1280K byte - 0K byte - 0K byte) / 2048 = 640. The programmer therefore has room to pan the portrait window to the right by 640 - 600 = 40 pixels. The programmer also should not read/write to the memory beyond the maximum accessible horizontal virtual size because that memory is either reserved for the dual panel buffer or not associated with any real memory at all.

The following table summarizes the SwivelView 90° and 270° memory requirements for different panel sizes and display modes. Note that the S1D13806 memory size is 1280K byte. The calculation of the minimum required image buffer size is based on the image buffer and the dual panel buffer only. As noted in the table, the memory requirements of the Hardware Cursor/Ink Layer are not taken into account. The Hardware Cursor requires 1K byte of memory and the 2-bit Ink Layer requires  $(W \times H) / 4$  bytes of memory. Both the Hardware cursor and Ink Layer must reside at 8K byte boundaries, but only one is supported at a time. The following table shows only one possible Hardware Cursor/Ink Layer location – at the highest possible 8K byte boundary below the dual panel buffer which is always at the top.

Table 15-1 : Memory Size Required for SwivelView 90° and 270°

Panel Size	Panel Type		Color Depth	Image Buffer Size	Dual Panel Buffer Size	Ink/Cursor Buffer Size	Ink/Cursor Location
320 × 240	Single	Color	8 bpp	240KB	0KB	18.75KB/1KB	1256KB/1279KB
			16 bpp	480KB			
		Mono	8 bpp	240KB			
			16 bpp	480KB			
640 × 480	Single	Color	8 bpp	480KB	0KB	75KB/1KB	1200KB/1279KB
			16 bpp	960KB			
		Mono	8 bpp	480KB			
			16 bpp	960KB			
	Dual	Color	8 bpp	480KB	75KB	1128KB/1200KB	
			16 bpp	960KB			
		Mono	8 bpp	480KB	18.75KB		1184KB/1256KB
			16 bpp	960KB			
800 × 600	Single	Color	8 bpp	600KB	0KB	117.19KB/1KB	1160KB/1279KB
			16 bpp	1200KB			--/1279KB
		Mono	8 bpp	600KB			1160KB/1279KB
			16 bpp	1200KB			--/1279KB
	Dual	Color	8 bpp	600KB	117.19KB	1040KB/1160KB	
			16 bpp <sup>1</sup>	Not Supported			
		Mono	8 bpp	600KB	29.30KB		--/1248KB
			16 bpp	1200KB			

**Note**

1. 800x600 color 16bpp dual panel is not supported as there is not enough memory to support the Dual Panel Buffer.

**Note**

Where KB = 1024 bytes, and MB = 1024K bytes.

### 15.2.3 Limitations

The following limitations apply to 90° SwivelView:

- Only 8/16 bpp color depths are supported – 4 bpp color depth is not supported.
- Hardware cursor and ink images are not rotated – software rotation must be used. SwivelView Enable bit 0 must be set to 0 when the user is accessing the Hardware Cursor or the Ink Layer buffer.
- For 90° SwivelView modes, BitBLT (Bit Block Transfer) operations are still supported. However, the BitBLT data must first be rotated by software. For further information, refer to the *S1D13806 Programmers Notes And Examples*, document number X28B-G-003-xx.

## 15.3 180° SwivelView

180° SwivelView is where the image is simply **displayed** 180° clockwise rotated. For 180° SwivelView a virtual window is not required and all color depths (4/8/16 bpp) are supported.

### 15.3.1 Register Programming

#### Reverse Display Buffer Fetching Address Direction

Set SwivelView Enable bits 1:0 to 10b. During screen refresh, the direction of the address for display buffer fetching is reversed. This setting does not affect CPU to display buffer access in any way.

#### Display Start Address

The Display Start Address must be programmed to be at the bottom-right corner of the image, since the display is now refreshed in the reverse direction. The LCD Display Start Address register (REG[042h], REG[043h], REG[044h]) must be set accordingly.

LCD Display Start Address (words)

$$\begin{aligned}
 &= (\text{MA\_Offset} \times \text{H}) - (\text{MA\_Offset} - \text{W}) - 1 && \text{for 16 bpp color depth} \\
 &= (\text{MA\_Offset} \times \text{H}) - (\text{MA\_Offset} - \text{W}/2) - 1 && \text{for 8 bpp color depth} \\
 &= (\text{MA\_Offset} \times \text{H}) - (\text{MA\_Offset} - \text{W}/4) - 1 && \text{for 4 bpp color depth}
 \end{aligned}$$

where H is the height of the panel in number of lines, W is the width of the panel in number of pixels, and MA\_Offset is the LCD Memory Address Offset.

### Horizontal Panning

Horizontal panning works in the same way as when SwivelView is not enabled, except that the effect of the LCD Pixel Panning register is reversed:

- Increment/decrement LCD Display Start Address register pans the display window to the right/left.
- Increment/decrement LCD Pixel Panning register pans the display window to the left/right.

### Vertical Panning

Vertical panning works in the same way as when SwivelView is not enabled:

- Increase/decrease LCD Display Start Address register by one memory address offset scrolls the display window down/up by 1 line.

## 15.3.2 Physical Memory Requirement

180° SwivelView mode requires the same physical memory as 0° SwivelView (un-rotated display).

## 15.3.3 Limitations

The following limitations apply to 180° SwivelView:

- Hardware Cursor and Ink Layer images are not rotated – software rotation must be used.
- CRT/TV mode is not supported.
- For 180° SwivelView modes, BitBLT (Bit Block Transfer) operations are supported normally. For further information, refer to the *S1D13806 Programmers Notes And Examples*, document number X28B-G-003-xx.

## 15.4 270° SwivelView

270° SwivelView is where the image is displayed 270° clockwise rotated. A 1024 × 1024 pixel virtual window is required as in 90° SwivelView. See Figure 15-1: “Relationship Between Screen Image and 90° Rotated Image in the Display Buffer” on page 178.

## 15.4.1 Register Programming

### Enabling 270° Rotation on CPU Read/Write to Display Buffer

Set SwivelView Enable bits 1:0 to 11b.

The LCD Memory Address Offset register (REG[046h], REG[047h]) must be set for a 1024 pixel offset.

LCD Memory Address Offset (words)  
     = 1024                      for 16 bpp color depth  
     = 512                       for 8 bpp color depth

### Display Start Address

The Display Start Address must be programmed to be at the bottom-right corner of the image, since the display is now refreshed in the reverse direction. The LCD Display Start Address register (REG[042h], REG[043h], REG[044h]) must be set accordingly.

LCD Display Start Address (words)  
     = (LCD Memory Address Offset) × H – 1

where H is the height of the panel in number of lines.

### Horizontal Panning

Horizontal panning is achieved by changing the LCD Display Start Address register. It works in the same way as in 90° SwivelView mode:

- Increase/decrease LCD Display Start Address register by 1024 (16 bpp color depth) or 512 (8 bpp color depth) pans the display window to the right/left by 1 pixel.

The amount the display window can be panned to the right is limited to 1024 pixels and limited by the amount of physical memory installed.

### Vertical Scrolling

Vertical scrolling is achieved by changing the LCD Display Start Address register and/or the LCD Pixel Panning register. It works in the same way as in 90° SwivelView mode, except that the effect of the LCD Pixel Panning register is reversed:

- Increment/decrement LCD Display Start Address register in 8 bpp color depth scrolls the display window up/down by 2 lines.
- Increment/decrement LCD Display Start Address register in 16 bpp color depth scrolls the display window up/down by 1 line.
- Increment/decrement LCD Pixel Panning register in 8 bpp color depth scrolls the display window down/up by 1 line.



## 15.4.2 Physical Memory Requirement

270° SwivelView mode has the same physical memory requirement as in 90° SwivelView mode. See Section 15.2.2, “Physical Memory Requirement” on page 179.

## 15.4.3 Limitations

The following limitations apply to 270° SwivelView:

- Only 8/16 bpp color depths are supported – 4 bpp color depth is not supported.
- Hardware Cursor and Ink Layer images are not rotated – software rotation must be used. SwivelView Enable bit 0 must be set to 0 when the user is accessing the Hardware Cursor or the Ink Layer memory.
- CRT/TV mode is not supported. SwivelView Enable bit 0 must be set to 0 when the user is accessing the CRT/TV display buffer.
- For 270° SwivelView modes, BitBLT (Bit Block Transfer) operations are still supported. However, the BitBLT data must first be rotated by software. For further information, refer to the *S1D13806 Programmers Notes And Examples*, document number X28B-G-003-xx.

## 16 EPSON Independent Simultaneous Display (EISD)

EPSON Independent Simultaneous Display (EISD) allows the S1D13806 to display independent images on two different displays (LCD panel and CRT or TV).

### 16.1 Registers

The LCD panel timings and mode setup are programmed through the Panel Configuration Registers (REG[03Xh]) and the LCD Display Mode Registers (REG[04Xh]). The CRT/TV timings and mode setup are programmed through the CRT/TV Configuration Registers (REG[05Xh]) and the CRT/TV Display Mode Registers (REG[06Xh]). The Ink Layer or Hardware Cursor can also be independently controlled on the two displays. The LCD Ink/Cursor Registers (REG[07Xh]) control the Ink/Cursor on the LCD display; the CRT/TV Ink/Cursor Registers (REG[08Xh]) control the Ink/Cursor on the CRT or TV. Each display uses its own Look-Up Table (LUT), although there is only one set of LUT Registers (REG[1E0h], REG[1E2h], REG[1E4h]). Use the LUT Mode Register (REG[1E0h]) to select access to the LCD and/or CRT/TV LUTs.

The pixel clock source for the two displays may be independent. Use the Clock Configuration Registers (REG[014h], REG[018h]) to select the LCD pixel clock source and the CRT/TV pixel clock source, respectively. Typically, CLKI2 is used for the CRT/TV display, while CLKI is used for the LCD display. Memory clock may come from CLKI or BUSCLK.

### 16.2 Display Mapping

To display different images on the LCD and CRT/TV, the two images should reside in non-overlapping areas of the display buffer, and the display start addresses point to the corresponding areas. The display buffer is mapped to the CPU address AB[20:0] linearly.

The LCD and CRT/TV may display identical images by setting the display start addresses for the LCD and the CRT/TV to the same address. In this case only one image is needed in the display buffer.

## 16.3 Bandwidth Limitation

When EISD is enabled, the LCD and CRT/TV displays must share the total bandwidth available to the S1D13806. The result is that display modes with a high resolution or color depth may not be supported. In some cases, Ink Layers may not be possible on one or both of the displays. EISD increases the total demand for display refresh bandwidth and reduces CPU bandwidth, resulting in lower CPU performance.

In a few cases when EISD is enabled, the default LCD and CRT/TV Display FIFO High Threshold Control register values are not optimally set, causing display problems with one or both of the displays. This condition may be corrected by adjusting the values of the LCD and CRT/TV Display FIFO High Threshold Control registers (REG[04Ah] for LCD and REG[06Ah] for CRT/TV). See Section 18.2, “Example Frame Rates” on page 192 for required FIFO settings.

Changing this register to a non-zero value sets the high threshold FIFO level to this value. This register may not exceed 59 decimal. The high threshold FIFO level controls how often display fetch requests are issued by the FIFO. In general, a higher high threshold FIFO level increases the bandwidth to that display pipe, and a lower level reduces it.

When the FIFO High Threshold Control register is set to 00h (default), the following settings are used:

- 11h for 4 bpp color depth
- 21h for 8 bpp color depth
- 23h for 16 bpp color depth

Most display problems may be corrected by increasing the associated high threshold FIFO level for that display. However, because the total available bandwidth is fixed, this change may create display problem for the other display. In this case, reducing the high threshold FIFO level for the other display instead may work. Sometimes, a combination of these two methods is required. Correcting EISD display problems by adjusting the FIFO High Threshold Control registers is mostly a trial-and-error process.

### Note

While the user is free to experiment with these registers, recommended FIFO level settings for some of the more common EISD modes requiring non-default FIFO level settings are listed in Section 18.2, “Example Frame Rates” on page 192.

## 17 MediaPlug Interface

Winnov's MediaPlug Slave interface has been incorporated into the S1D13806. The MediaPlug Slave follows the *Specification For Winnov MediaPlug Slave, Local module*, Document Rev 0.3 with the following exceptions.

### 17.1 Revision Code

The MediaPlug Slave Revision Code can be determined by reading bits 11:8 of the LCMD register. The revision code for this implementation is 0011b.

### 17.2 How to enable the MediaPlug Slave

The MediaPlug Slave interface is enabled/disabled at the rising edge of RESET# by the state of CONF7. When CONF7 is set to 1, the MediaPlug functionality is enabled and GPIO12 is configured as the MediaPlug power control output pin (VMPEPWR) - see Table 4-9, "Summary of Power-On/Reset Options," on page 33.

### 17.3 MediaPlug Interface Pin Mapping

The S1D13806 provides 8 pins for use by the MediaPlug interface (VMP[7:0]). GPIO12 is also used as the MediaPlug power control output pin (VMPEPWR) when the MediaPlug interface is enabled. The following table lists the MediaPlug pin mapping when the interface is enabled.

*Table 17-1: MediaPlug Interface Pin Mapping*

S1D13806 Pin Names	IO Type	MediaPlug I/F
VMP0	O	VMPCLKN
VMP1	O	VMPCLK
VMP2	IO	VMPD3
VMP3	IO	VMPD2
VMP4	IO	VMPD1
VMP5	IO	VMPD0
VMP6	I	VMRCTL
VMP7	O	VMPLCRL
GPIO12	O	VMPEPWR

**Note**

VMPEPWR is controlled by bit 1 of the MediaPlug LCMD register.

# 18 Clocking

## 18.1 Frame Rate Calculation

### 18.1.1 LCD Frame Rate Calculation

The maximum LCD frame rate is calculated using the following formula.

$$\text{max. LCD Frame Rate} = \frac{\text{LPCLK}_{\text{max}}}{(\text{LHDP} + \text{LHNDP}) \times \left( \frac{\text{LVDP}}{n} + \text{LVNDP} \right)}$$

Where:

LPCLKmax = maximum LCD pixel clock frequency

LVDP = LCD Vertical Display Height  
= REG[039h] bits [1:0], REG[038h] bits [7:0] + 1

LVNDP = LCD Vertical Non-Display Period  
= REG[03Ah] bits [5:0] + 1

LHDP = LCD Horizontal Display Width  
= ((REG[032h] bits [6:0]) + 1) × 8Ts

LHNDP = LCD Horizontal Non-Display Period  
= ((REG[034h] bits [4:0]) + 1) × 8Ts

Ts = minimum LCD pixel clock (LPCLK) period

n = 1 for single panel  
= 2 for dual panel

## 18.1.2 CRT Frame Rate Calculation

The maximum CRT frame rate is calculated using the following formula.

$$\text{max. CRT Frame Rate} = \frac{\text{CPCLK}_{\text{max}}}{(\text{CHDP} + \text{CHNDP}) \times (\text{CVDP} + \text{CVNDP})}$$

Where:

CPCLKmax = maximum CRT pixel clock frequency

CVDP = CRT Vertical Display Height  
= REG[057h] bits [1:0], REG[056h] bits [7:0] + 1

CVNDP = CRT Vertical Non-Display Period  
= REG[058h] bits [6:0] + 1

CHDP = CRT Horizontal Display Width  
= ((REG[050h] bits [6:0]) + 1) × 8Ts

CHNDP = CRT Horizontal Non-Display Period  
= ((REG[052h] bits [5:0]) + 1) × 8Ts

Ts = minimum CRT pixel clock (CPCLK) period

### 18.1.3 TV Frame Rate Calculation

The maximum TV frame rate is calculated using the following formula.

$$\text{max. TV Frame Rate} = \frac{\text{TPCLK}_{\text{max}}}{(\text{THDP} + \text{THNDP}) \times \left( \frac{\text{TVDP}}{2} + \text{TVNDP} + 0.5 \right)}$$

Where:

TPCLKmax = maximum TV pixel clock frequency

TVDP = TV Vertical Display Height  
= REG[057h] bits [1:0], REG[056h] bits [7:0] + 1

TVNDP = TV Vertical Non-Display Period  
= REG[058h] bits [6:0] + 1

THDP = TV Horizontal Display Width  
= ((REG[050h] bits [6:0]) + 1) × 8Ts

THNDP = TV Horizontal Non-Display Period  
= for NTSC output use ((REG[052h] bits [5:0]) × 8Ts) + 6  
= for PAL output use ((REG[052h] bits [5:0]) × 8Ts) + 7

Ts = minimum TV pixel clock (TPCLK) period

## 18.2 Example Frame Rates

For all example frame rates the following conditions apply:

- Dual panel buffer is enabled for dual panel.
- TV Flicker Filter is enabled for TV.
- MCLK is 50MHz.

### 18.2.1 Frame Rates for 640x480 with EISD Disabled

Table 18-1: Frame Rates for 640x480 with EISD Disabled

LCD Type	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	max PCLK (MHz)	min HNDP (pixels)	min VNDP (lines)	max Frame Rate (Hz)	CRT/ TV	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	PCLK (MHz)	HNDP (pixels)	VNDP (lines)	Frame Rate (Hz)
Passive Single / TFT	No	640	480	4	40	56	1	119.5	--	--	--	--	--	--	--	--	--
	No	640	480	8	40	64	1	118.1	--	--	--	--	--	--	--	--	--
	No	640	480	16	40	64	1	118.1	--	--	--	--	--	--	--	--	--
Mono Passive Dual	No	640	480	4	40	64	1	235.8	--	--	--	--	--	--	--	--	--
	No	640	480	8	40	72	1	233.1	--	--	--	--	--	--	--	--	--
	No	640	480	16	31	72	1	181.0	--	--	--	--	--	--	--	--	--
Color Passive Dual	No	640	480	4	40	64	1	235.8	--	--	--	--	--	--	--	--	--
	No	640	480	8	40	72	1	233.1	--	--	--	--	--	--	--	--	--
	No	640	480	16	30	64	1	176.8	--	--	--	--	--	--	--	--	--
Passive Single / TFT	Yes	640	480	4	40	56	1	119.5	--	--	--	--	--	--	--	--	--
	Yes	640	480	8	40	64	1	118.1	--	--	--	--	--	--	--	--	--
	Yes	640	480	16	40	64	1	118.1	--	--	--	--	--	--	--	--	--
Mono Passive Dual	Yes	640	480	4	40	64	1	235.8	--	--	--	--	--	--	--	--	--
	Yes	640	480	8	40	72	1	233.1	--	--	--	--	--	--	--	--	--
	Yes	640	480	16	30	64	1	176.8	--	--	--	--	--	--	--	--	--
Color Passive Dual	Yes	640	480	4	40	64	1	235.8	--	--	--	--	--	--	--	--	--
	Yes	640	480	8	36	72	1	209.8	--	--	--	--	--	--	--	--	--
	Yes	640	480	16	26	56	1	155.0	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	CRT	No	640	480	4	36	192	29	85.0
--	--	--	--	--	--	--	--	--	CRT	No	640	480	8	36	192	29	85.0
--	--	--	--	--	--	--	--	--	CRT	No	640	480	16	36	192	29	85.0
--	--	--	--	--	--	--	--	--	NTSC TV	No	640	480	4	14.32	270	22	60
--	--	--	--	--	--	--	--	--	NTSC TV	No	640	480	8	14.32	270	22	60
--	--	--	--	--	--	--	--	--	NTSC TV	No	640	480	16	14.32	270	22	60
--	--	--	--	--	--	--	--	--	PAL TV	No	640	480	4	17.73	495	72	50
--	--	--	--	--	--	--	--	--	PAL TV	No	640	480	8	17.73	495	72	50
--	--	--	--	--	--	--	--	--	PAL TV	No	640	480	16	17.73	495	72	50

Example Frame Rates with Ink Layer Enabled



Table 18-1: Frame Rates for 640x480 with EISD Disabled

LCD Type		Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	max PCLK (MHz)	min HNDP (pixels)	min VNDP (lines)	max Frame Rate (Hz)	CRT/ TV	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	PCLK (MHz)	HNDP (pixels)	VNDP (lines)	Frame Rate (Hz)
--	--	--	--	--	--	--	--	--	--	CRT	Yes	640	480	4	36	192	29	85.0
--	--	--	--	--	--	--	--	--	--	CRT	Yes	640	480	8	36	192	29	85.0
--	--	--	--	--	--	--	--	--	--	CRT	Yes	640	480	16	36	200	20	85.7
--	--	--	--	--	--	--	--	--	--	NTSC TV	Yes	640	480	4	14.32	270	22	60
--	--	--	--	--	--	--	--	--	--	NTSC TV	Yes	640	480	8	14.32	270	22	60
--	--	--	--	--	--	--	--	--	--	NTSC TV	Yes	640	480	16	14.32	270	22	60
--	--	--	--	--	--	--	--	--	--	PAL TV	Yes	640	480	4	17.73	495	72	50
--	--	--	--	--	--	--	--	--	--	PAL TV	Yes	640	480	8	17.73	495	72	50
--	--	--	--	--	--	--	--	--	--	PAL TV	Yes	640	480	16	17.73	495	72	50

Example Frame Rates with Ink Layer Enabled

## 18.2.2 Frame Rates for 800x600 with EISD Disabled

Table 18-2: Frame Rates for 800x600 with EISD Disabled

LCD Type	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	max PCLK (MHz)	min HNDP (pixels)	min VNDP (lines)	max Frame Rate (Hz)	CRT/ TV	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	PCLK (MHz)	HNDP (pixels)	VNDP (lines)	Frame Rate (Hz)
TFT	No	800	600	8	65	232	35	99.2									
	No	800	600	16	44.4	160	35	72.8									
Color Passive Dual	No	800	600	4	40	64	1	153.8	--	--	--	--	--	--	--	--	--
	No	800	600	8	40	72	1	152.4	--	--	--	--	--	--	--	--	--
	No	800	600	16	30	64	1	115.3	--	--	--	--	--	--	--	--	--
TFT	Yes	800	600	8	65	232	35	99.2									
TFT <sup>1</sup>	Yes	800	600	16	40	144	35	66.7									
Color Passive Dual	Yes	800	600	4	38	64	1	146.1	--	--	--	--	--	--	--	--	--
	Yes	800	600	8	36	72	1	137.2	--	--	--	--	--	--	--	--	--
	Yes	800	600	16	26	56	1	100.9	--	--	--	--	--	--	--	--	--
--	--	--	--	--	--	--	--	--	CRT	No	800	600	4	40	256	28	60.3
--	--	--	--	--	--	--	--	--	CRT	No	800	600	8	40	256	28	60.3
--	--	--	--	--	--	--	--	--	CRT	No	800	600	16	40	224	25	62.5
									CRT	No	800	600	4	49.5	256	28	74.6
									CRT	No	800	600	8	49.5	256	28	74.6
									CRT	No	800	600	4	56.25	256	28	84.8
									CRT	No	800	600	8	56.25	256	28	84.8
--	--	--	--	--	--	--	--	--	CRT	Yes	800	600	4	40	256	28	60.3
--	--	--	--	--	--	--	--	--	CRT	Yes	800	600	8	40	256	28	60.3
--	--	--	--	--	--	--	--	--	CRT <sup>2</sup>	Yes	800	600	16	40	224	25	62.5
									CRT	Yes	800	600	4	49.5	256	28	74.6
									CRT	Yes	800	600	8	49.5	256	28	74.6
									CRT	Yes	800	600	4	56.25	256	28	84.8
									CRT	Yes	800	600	8	56.25	256	28	84.8

Example Frame Rates with Ink Layer Enabled

The FIFO values for these display modes must be set as follows:

1. REG[07Eh] = 0Ch.
2. REG[08Eh] = 0Ah.

### 18.2.3 Frame Rates for 1024x768 with EISD Disabled

Table 18-3: Frame Rates for 1024x768 with EISD Disabled

LCD Type	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	max PCLK (MHz)	min HNDP (pixels)	min VNDP (lines)	max Frame Rate (Hz)	CRT/ TV	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	PCLK (MHz)	HNDP (pixels)	VNDP (lines)	Frame Rate (Hz)
TFT	No	1024	768	8	65	160	37	68.2									
TFT <sup>1</sup>	Yes	1024	768	8	65	160	37	68.2									
--	--	--	--	--	--	--	--	--	CRT	No	1024	768	4	65	320	41	59.8
--	--	--	--	--	--	--	--	--	CRT	No	1024	768	8	65	320	41	59.8
--	--	--	--	--	--	--	--	--	CRT	Yes	1024	768	4	65	320	41	59.8
--	--	--	--	--	--	--	--	--	CRT	Yes	1024	768	8	65	320	41	59.8

Example Frame Rates with Ink Layer Enabled

The FIFO values for these display modes must be set as follows:

1. REG[07Eh] = 0Ch.

## 18.2.4 Frame Rates for LCD and CRT (640x480) with EISD Enabled

Table 18-4: Frame Rates for LCD and CRT (640x480) with EISD Enabled

LCD Type	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	max PCLK (MHz)	min HNDP (pixels)	min VNDP (lines)	max Frame Rate (Hz)	CRT/ TV	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	PCLK (MHz)	HNDP (pixels)	VNDP (lines)	Frame Rate (Hz)
Passive Single	No	320	240	16	17	64	1	183.7	CRT	No	640	480	16	25.18	160	44	60.1
	No	640	240	16	17	64	1	100.2	CRT	No	640	480	16	25.18	160	44	60.1
	No	640	480	4	40	112	1	110.6	CRT	No	640	480	4	25.18	160	44	60.1
	No	640	480	8	40	144	1	106.1	CRT	No	640	480	8	25.18	160	44	60.1
Color Passive Dual	No	640	480	16	12	56	1	71.5	CRT	No	640	480	16	25.18	160	44	60.1
TFT	No	800	600	8	41	144	26	69.4	CRT	No	640	480	8	25.18	160	44	60.1
TFT	No	1024	768	8	41	112	37	44.8	CRT	No	640	480	8	25.18	160	44	60.1
Color Passive Dual	No	800	600	4	38	120	1	137.2	CRT	No	640	480	4	25.18	160	44	60.1
	No	800	600	8	27.6	104	1	101.4	CRT	No	640	480	8	25.18	160	44	60.1
Passive Single	Yes	640	480	4	40	112	1	110.6	CRT	No	640	480	4	25.18	160	44	60.1
	Yes	640	480	8	31.6	112	1	87.4	CRT	No	640	480	8	25.18	160	44	60.1
TFT	Yes	800	600	8	31.6	112	26	55.4	CRT	No	640	480	8	25.18	160	44	60.1
Mono Passive Dual	Yes	640	480	8	27.6	104	1	153.9	CRT	No	640	480	8	25.18	160	44	60.1
Color Passive Dual	Yes	640	480	8	23.2	88	1	132.2	CRT	No	640	480	8	25.18	160	44	60.1
Color Passive Dual <sup>1</sup>	Yes	640	480	16	11.6	48	1	70.0	CRT	No	640	480	16	25.18	160	44	60.1
Color Passive Dual	Yes	800	600	8	23.2	88	1	86.8	CRT	No	640	480	8	25.18	160	44	60.1
Passive Single <sup>2</sup>	No	640	240	16	13.7	56	1	81.7	CRT	Yes	640	480	16	25.18	160	44	60.1
Passive Single	No	640	480	8	31.7	112	1	87.6	CRT	Yes	640	480	8	25.18	160	44	60.1
Mono Passive Dual <sup>2</sup>	No	640	480	8	27.1	104	1	151.1	CRT	Yes	640	480	8	25.18	160	44	60.1
	No	640	480	16	11	48	1	66.4	CRT	Yes	640	480	16	25.18	160	44	60.1
Color Passive Dual	No	640	480	8	19	88	1	108.3	CRT	Yes	640	480	8	25.18	160	44	60.1
Color Passive Dual	No	800	600	4	33.2	104	1	122.0	CRT	Yes	640	480	4	25.18	160	44	60.1
Color Passive Dual <sup>2</sup>	No	800	600	8	22.6	88	1	84.6	CRT	Yes	640	480	8	25.18	160	44	60.1
Passive Single <sup>3</sup>	Yes	640	240	16	11.8	48	1	71.2	CRT	Yes	640	480	16	25.18	160	44	60.1
Passive Single	Yes	640	480	8	25.7	96	1	72.6	CRT	Yes	640	480	8	25.18	160	44	60.1
Mono Passive Dual <sup>2</sup>	Yes	640	480	8	22.6	88	1	128.8	CRT	Yes	640	480	8	25.18	160	44	60.1
Color Passive Dual	Yes	640	480	8	15	72	1	87.4	CRT	Yes	640	480	8	25.18	160	44	60.1

Example Frame Rates with Ink Layer Enabled

Table 18-4: Frame Rates for LCD and CRT (640x480) with EISD Enabled

LCD Type	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	max PCLK (MHz)	min HNDP (pixels)	min VNDP (lines)	max Frame Rate (Hz)	CRT/ TV	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	PCLK (MHz)	HNDP (pixels)	VNDP (lines)	Frame Rate (Hz)
Color Passive Dual <sup>3</sup>	Yes	640	480	16	9.57	40	1	58.4	CRT	Yes	640	480	16	25.18	160	44	60.1
Color Passive Dual <sup>2</sup>	Yes	800	600	8	19.4	72	1	73.9	CRT	Yes	640	480	8	25.18	160	44	60.1

Example Frame Rates with Ink Layer Enabled

**The FIFO values for these display modes must be set as follows:**

1. REG[06Ah] = 3Ch. REG[06Bh] = 3Ch.
2. REG[08Eh] = 0Ch.
3. REG[06Ah] = 3Ch. REG[06Bh] = 3Ch. REG[07Eh] = 0Ch. REG[08Eh] = 0Ch.

## 18.2.5 Frame Rates for LCD and CRT (800x600) with EISD Enabled

Table 18-5: Frame Rates for LCD and CRT (800x600) with EISD Enabled

LCD Type	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	max PCLK (MHz)	min HNDP (pixels)	min VNDP (lines)	max Frame Rate (Hz)	CRT/TV	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	PCLK (MHz)	HNDP (pixels)	VNDP (lines)	Frame Rate (Hz)
Passive Single	No	640	240	8	34	120	1	185.6	CRT	No	800	600	8	40	256	28	60.3
	No	640	480	8	34	120	1	93.0	CRT	No	800	600	8	40	256	28	60.3
Color Passive Dual	No	640	480	8	22.5	88	1	128.2	CRT	No	800	600	8	40	256	28	60.3
TFT <sup>1</sup>	No	800	600	8	34	120	28	58.8	CRT	No	800	600	8	40	256	28	60.3
Color Passive Dual	No	800	600	4	38.6	112	1	140.6	CRT	No	800	600	4	40	256	28	60.3
	No	800	600	8	22.5	88	1	84.2	CRT	No	800	600	8	40	256	28	60.3
Passive Single	Yes	640	240	8	26.2	96	1	147.7	CRT	No	800	600	8	40	256	28	60.3
	Yes	640	480	8	26.2	96	1	74.0	CRT	No	800	600	8	40	256	28	60.3
Mono Passive Dual	Yes	640	480	8	22.5	88	1	128.2	CRT	No	800	600	8	40	256	28	60.3
Color Passive Dual <sup>2</sup>	Yes	640	480	8	19	72	1	110.7	CRT	No	800	600	8	40	256	28	60.3
Passive Single <sup>3</sup>	No	640	240	8	24.4	88	1	139.1	CRT	Yes	800	600	8	40	256	28	60.3
Passive Single	No	640	480	8	24.4	88	1	69.7	CRT	Yes	800	600	8	40	256	28	60.3
Mono Passive Dual <sup>4</sup>	No	640	480	8	20.6	80	1	118.7	CRT	Yes	800	600	8	40	256	28	60.3
Color Passive Dual <sup>5</sup>	No	640	480	8	17.2	64	1	101.4	CRT	Yes	800	600	8	40	256	28	60.3
	No	800	600	8	17.2	64	1	66.1	CRT	Yes	800	600	8	40	256	28	60.3
Passive Single <sup>3</sup>	Yes	640	240	8	19.8	72	1	115.4	CRT	Yes	800	600	8	40	256	28	60.3
Passive Single	Yes	640	480	8	19.8	72	1	57.8	CRT	Yes	800	600	8	40	256	28	60.3
Mono Passive Dual <sup>6</sup>	Yes	640	480	8	17.2	64	1	101.4	CRT	Yes	800	600	8	40	256	28	60.3
Color Passive Dual <sup>6</sup>	Yes	640	480	8	14.7	56	1	87.6	CRT	Yes	800	600	8	40	256	28	60.3

Example Frame Rates with Ink Layer Enabled

The FIFO values for these display modes must be set as follows:

1. REG[04Ah] = 30h. REG[06Ah] = 30h. REG[04Bh] = 3Ch. REG[06Bh] = 3Ch.
2. REG[04Ah] = 1Ah. REG[06Bh] = 25h.
3. REG[06Ah] = 23h. REG[08Eh] = 0Ch.
4. REG[08Eh] = 0Ch.

## 18.2.6 Frame Rates for LCD and CRT (1024x768) with EISD Enabled

Table 18-6: Frame Rates for LCD and CRT (1024x768) with EISD Enabled

LCD Type	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	max PCLK (MHz)	min HNDP (pixels)	min VNDP (lines)	max Frame Rate (Hz)	CRT/ TV	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	PCLK (MHz)	HNDP (pixels)	VNDP (lines)	Frame Rate (Hz)
Passive Single <sup>1</sup>	No	320	240	8	31	144	1	277.2	CRT	No	1024	768	8	65	320	41	59.8
Passive Single <sup>2</sup>	No	640	240	8	21.1	80	1	121.6	CRT	No	1024	768	8	65	320	41	59.8
Passive Single	No	640	480	8	21.1	80	1	60.9	CRT	No	1024	768	8	65	320	41	59.8
Color Passive Dual <sup>2</sup>	No	640	480	8	13.8	56	1	82.3	CRT	No	1024	768	8	65	320	41	59.8
Passive Single <sup>3</sup>	Yes	320	240	8	16.2	56	1	178.8	CRT	No	1024	768	8	65	320	41	59.8
	Yes	640	240	8	16.2	56	1	96.6	CRT	No	1024	768	8	65	320	41	59.8
Passive Single	Yes	640	480	8	20	72	1	58.4	CRT	No	1024	768	8	65	320	41	59.8

Example Frame Rates with Ink Layer Enabled

The FIFO values for these display modes must be set as follows:

1. REG[04Ah] = 25h. REG[04Bh] = 3Ch. REG[06Ah] = 30h. REG[06Bh] = 3Ch.
2. REG[04Ah] = 1Ah. REG[06Ah] = 30h. REG[06Bh] = 3Ch.
3. REG[07Eh] = 0Ch.

## 18.2.7 Frame Rates for LCD and NTSC TV with EISD Enabled

Table 18-7: Frame Rates for LCD and NTSC TV with EISD Enabled

LCD Type	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	max PCLK (MHz)	min HNDP (pixels)	min VNDP (lines)	max Frame Rate (Hz)	CRT/TV	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	PCLK (MHz)	HNDP (pixels)	VNDP (lines)	Frame Rate (Hz)
Passive Single / TFT	No	320	240	16	10.7	56	1	118.1	NTSC TV	No	640	480	16	14.32	270	22	60
	No	640	240	16	10.7	56	1	63.8	NTSC TV	No	640	480	16	14.32	270	22	60
	No	640	480	4	40	152	1	105.0	NTSC TV	No	640	480	4	14.32	270	22	60
	No	640	480	8	27.6	136	1	73.9	NTSC TV	No	640	480	8	14.32	270	22	60
Mono Passive Dual	No	640	480	8	24	128	1	129.6	NTSC TV	No	640	480	8	14.32	270	22	60
Color Passive Dual	No	640	480	8	21.1	112	1	116.4	NTSC TV	No	640	480	8	14.32	270	22	60
TFT	No	800	600	8	27.6	136	35	46.4	NTSC TV	No	640	480	8	14.32	270	22	60
Color Passive Dual	No	800	600	8	21.1	112	1	76.9	NTSC TV	No	640	480	8	14.32	270	22	60
Passive Single	Yes	640	480	4	39	144	1	103.4	NTSC TV	No	640	480	4	14.32	270	22	60
Mono Passive Dual	Yes	640	480	8	20.5	112	1	113.1	NTSC TV	No	640	480	8	14.32	270	22	60
Color Passive Dual	Yes	640	480	4	28.1	112	1	155.0	NTSC TV	No	640	480	4	14.32	270	22	60
	Yes	640	480	8	18.2	96	1	102.6	NTSC TV	No	640	480	8	14.32	270	22	60
Passive Single	No	640	240	8	20.4	104	1	113.8	NTSC TV	Yes	640	480	8	14.32	270	22	60
	No	640	480	4	33.7	128	1	91.2	NTSC TV	Yes	640	480	4	14.32	270	22	60
Mono Passive Dual	No	640	480	8	18.4	96	1	103.7	NTSC TV	Yes	640	480	8	14.32	270	22	60
Color Passive Dual	No	640	480	4	23.7	96	1	133.6	NTSC TV	Yes	640	480	4	14.32	270	22	60
	No	640	480	8	16	88	1	91.2	NTSC TV	Yes	640	480	8	14.32	270	22	60
Passive Single	Yes	640	240	4	27.4	104	1	152.8	NTSC TV	Yes	640	480	4	14.32	270	22	60
Passive Single <sup>1</sup>	Yes	640	240	8	17.5	88	1	99.7	NTSC TV	Yes	640	480	8	14.32	270	22	60
Mono Passive Dual	Yes	640	480	4	23.7	96	1	133.6	NTSC TV	Yes	640	480	4	14.32	270	22	60
Mono Passive Dual <sup>1</sup>	Yes	640	480	8	15.6	80	1	89.9	NTSC TV	Yes	640	480	8	14.32	270	22	60
Color Passive Dual	Yes	640	480	4	20.4	88	1	116.3	NTSC TV	Yes	640	480	4	14.32	270	22	60
	Yes	640	480	8	14.2	80	1	81.8	NTSC TV	Yes	640	480	4	14.32	270	22	60

Example Frame Rates with Ink Layer Enabled

The FIFO values for these display modes must be set as follows:

1. REG[07Eh] = 0Ch.



## 18.2.8 Frame Rates for LCD and PAL TV with EISD Enabled

Table 18-8: Frame Rates for LCD and PAL TV with EISD Enabled

LCD Type	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	max PCLK (MHz)	min HNDP (pixels)	min VNDP (lines)	max Frame Rate (Hz)	CRT/ TV	Ink	Horiz Res (pixels)	Vert Res (lines)	bpp	PCLK (MHz)	HNDP (pixels)	VNDP (lines)	Frame Rate (Hz)
Passive Single	No	320	240	16	7.5	40	1	86.4	PAL TV	No	640	480	16	17.73	495	72	50
	No	640	240	16	9	40	1	55.0	PAL TV	No	640	480	16	17.73	495	72	50
	No	640	480	4	40	152	1	105.0	PAL TV	No	640	480	4	17.73	495	72	50
	No	640	480	8	25.8	128	1	69.8	PAL TV	No	640	480	8	17.73	495	72	50
Mono Passive Dual	No	640	480	8	22.2	120	1	121.2	PAL TV	No	640	480	8	17.73	495	72	50
Color Passive Dual	No	640	480	8	19	104	1	106.0	PAL TV	No	640	480	8	17.73	495	72	50
TFT <sup>1</sup>	No	800	600	8	43	136	35	72.3	PAL TV	No	640	480	8	17.73	495	72	50
Color Passive Dual	No	800	600	8	19	104	1	69.8	PAL TV	No	640	480	8	17.73	495	72	50
Passive Single	Yes	640	480	4	37.2	144	1	98.6	PAL TV	No	640	480	4	17.73	495	72	50
Mono Passive Dual <sup>2</sup>	Yes	640	480	8	19	104	1	106.0	PAL TV	No	640	480	8	17.73	495	72	50
Color Passive Dual	Yes	640	480	4	26.2	104	1	146.1	PAL TV	No	640	480	4	17.73	495	72	50
	Yes	640	480	8	16.3	88	1	92.9	PAL TV	No	640	480	8	17.73	495	72	50
Passive Single	No	640	240	8	18.1	96	1	102.0	PAL TV	Yes	640	480	8	17.73	495	72	50
	No	640	480	4	31.7	120	1	86.7	PAL TV	Yes	640	480	4	17.73	495	72	50
Mono Passive Dual	No	640	480	4	26	112	1	143.4	PAL TV	Yes	640	480	4	17.73	495	72	50
	No	640	480	8	16.1	88	1	91.8	PAL TV	Yes	640	480	8	17.73	495	72	50
Color Passive Dual	No	640	480	4	22.7	96	1	128.0	PAL TV	Yes	640	480	4	17.73	495	72	50
	No	640	480	8	13.9	72	1	81.0	PAL TV	Yes	640	480	8	17.73	495	72	50
Passive Single	Yes	640	240	4	21	96	1	118.4	PAL TV	Yes	640	480	4	17.73	495	72	50
Passive Single <sup>2</sup>	Yes	640	240	8	15.4	80	1	88.8	PAL TV	Yes	640	480	8	17.73	495	72	50
Mono Passive Dual	Yes	640	480	4	22.7	96	1	128.0	PAL TV	Yes	640	480	4	17.73	495	72	50
Mono Passive Dual <sup>2</sup>	Yes	640	480	8	13.9	72	1	81.0	PAL TV	Yes	640	480	8	17.73	495	72	50
Color Passive Dual	Yes	640	480	4	19.6	80	1	113.0	PAL TV	Yes	640	480	4	17.73	495	72	50
	Yes	640	480	8	12.3	64	1	72.5	PAL TV	Yes	640	480	4	17.73	495	72	50

Example Frame Rates with Ink Layer Enabled

The FIFO values for these display modes must be set as follows:

1. REG[04Ah] = 3Ch. REG[04Bh] = 3Ch.
2. REG[07Eh] = 7Ch.

## 19 Power Save Mode

The S1D13806 includes a software initiated power save mode designed for very low-power applications. In addition, the S1D13806 dynamically disables internal clock networks when not required. Similarly, the LCD and/or CRT/TV pipelines are shut down when not required for the selected display mode.

For power save mode AC Timing, see Section 6.4.2, “Power Save Status” on page 63.

### 19.1 Overview

Power save mode is initiated by setting REG[1F0h] bit 0 to 1. When power save mode is enabled the following conditions apply.

- LCD display is disabled.
- CRT/TV display is disabled.
- Memory access is not allowed.
- Memory is in self-refresh mode.
- Register access is allowed.

### 19.2 Power Save Status Bits

#### LCD Power Save Status bit

The LCD Power Save Status bit (REG[1F1h] bit 0) indicates the state of the LCD panel. When this bit returns a 1, the panel is powered down. When this bit returns a 0, the panel is powered up, or in transition of powering up or down.

The system may disable the LCD pixel clock source when this bit returns a 1. The LCD Power Save Status bit is set to 1 after chip reset.

#### Memory Controller Power Save Status bit

The Memory Controller Power Save Status bit (REG[1F1h] bit 1) indicates the state of the SDRAM interface. When this bit returns a 1, the SDRAM interface is powered down and the SDRAM is in self-refresh mode. This condition occurs shortly after power save mode is invoked. When this bit returns a 0, the SDRAM interface is active.

The system may disable the memory clock source when this bit returns a 1. The Memory Controller Power Save Status bit is set to 0 after chip reset.

## 19.3 Power Save Mode Summary

Table 19-1: Power Save Mode Summary

Function	LCD Disabled	CRT/TV Disabled	Power Save Mode Enabled
LCD Display Active?	no	--	No
CRT/TV Display Active?	--	no	No
Register Access Possible?	Yes	Yes	Yes
Memory Access Possible?	Yes	Yes	No
LCD LUT Access Possible?	Yes <sup>1</sup>	--	Yes
CRT/TV LUT Access Possible?	--	Yes <sup>2</sup>	Yes
LCD interface	Forced Low	--	Forced Low
CRT/TV interface	--	Disabled	Disabled
SDRAM interface	Active	Active	Self-Refresh
Host Interface	Active	Active	Active

**Note**

1. LCD pixel clock required.

**Note**

2. CRT/TV pixel clock required.

## 20 Mechanical Data

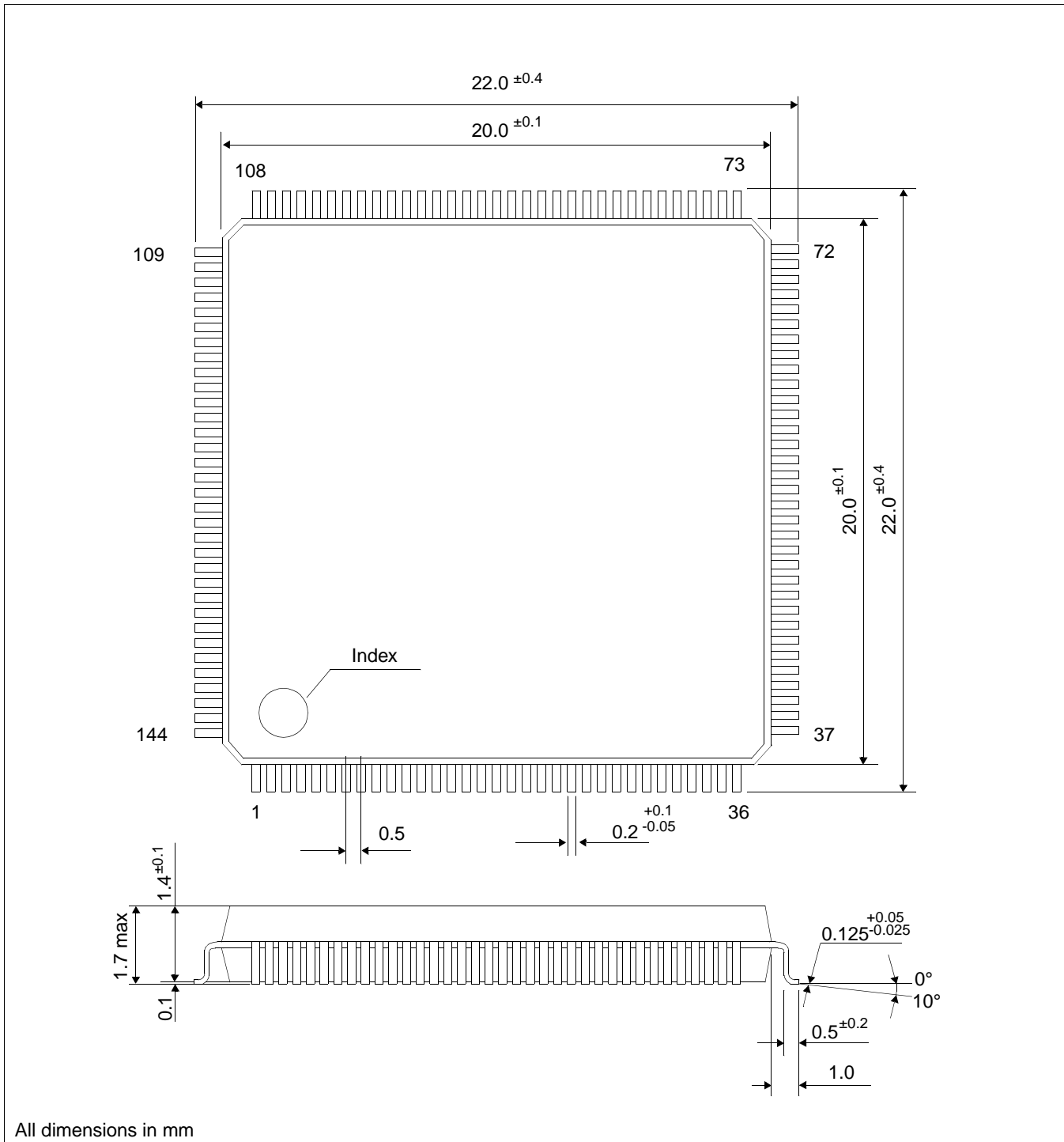


Figure 20-1: Mechanical Drawing 144-pin QFP20

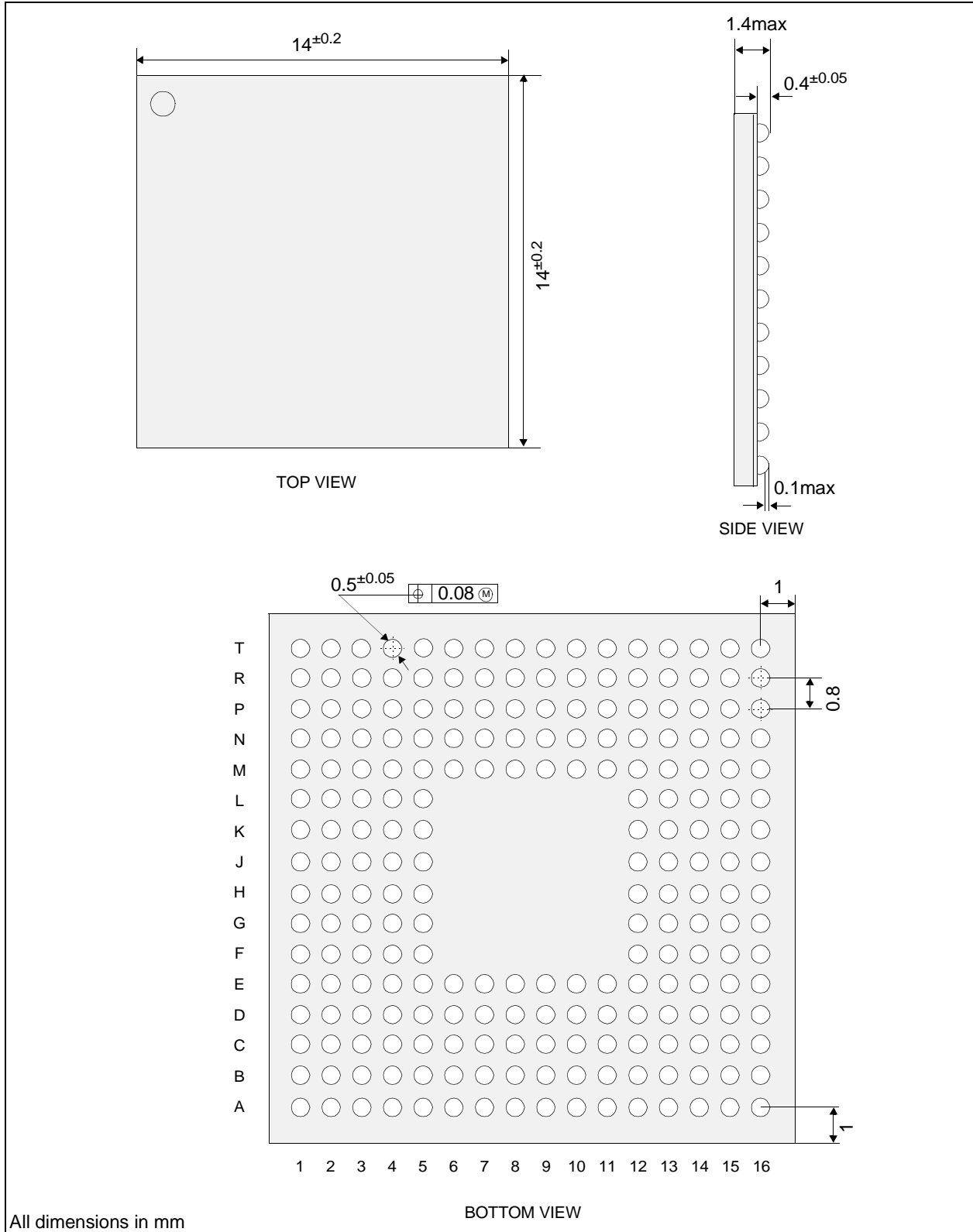


Figure 20-2: Mechanical Drawing 220-pin PFBGA

## 21 References

The following documents contain additional information related to the S1D13806. Document numbers are listed in parenthesis after the document name. All documents can be found at the Epson Electronics America website at [www.eea.epson.com](http://www.eea.epson.com) or the Epson Research and Development Website at [www.erd.epson.com](http://www.erd.epson.com).

- 13806CFG Configuration Utility Users Manual (X28B-B-001-xx)
- 13806SHOW Demonstration Program Users Manual (X28B-B-002-xx)
- 13806PLAY Diagnostic Utility Users Manual (X28B-B-003-xx)
- 13806BMP Demonstration Program Users Manual (X28B-B-004-xx)
- 13806FILT Test Utility Users Manual (X28B-B-005-xx)
- 13806SWIVEL Demonstration Utility Users Manual (X28B-B-006-xx)
- S1D13806 Product Brief (X28B-C-001-xx)
- S1D13806 Windows CE v2.x Display Driver (X28B-E-001-xx)
- S1D13806 Wind River WindML v2.0 Display Driver (X28B-E-002-xx)
- S1D13806 Wind River UGL v1.2 Display Driver (X28B-E-003-xx)
- S1D13806 Linux Console Driver (X28B-E-004-xx)
- S1D13806 QNX Photon v2.0 Display Driver (X28B-E-005-xx)
- S1D13806 Windows CE v3.x Display Driver (X28B-E-006-xx)
- S1D13806 Programming Notes And Examples (X28B-G-003-xx)
- S5U13806B00C Rev. 1.0 Evaluation Board User Manual (X28B-G-004-xx)
- Interfacing to the PC Card Bus (X28B-G-005-xx)
- S1D13806 Power Consumption (X28B-G-006-xx)
- Interfacing to the NEC VR4102/VR4111 Microprocessors (X28B-G-007-xx)
- Interfacing to the Motorola MPC821 Microprocessor (X28B-G-008-xx)
- Interfacing to the Philips MIPS PR31500/PR31700 Microprocessors (X28B-G-009-xx)
- Interfacing to the Toshiba MIPS TX3912 Microprocessor (X28B-G-010-xx)
- Interfacing to the NEC VR4121 Microprocessor (X28B-G-011-xx)
- Interfacing to the StrongArm SA-1110 Microprocessor (X28B-G-012-xx)
- S1D13806 Register Summary (X28B-R-001-xx)

## 22 Sales and Technical Support

### Japan

Seiko Epson Corporation  
Electronic Devices Marketing Division  
421-8, Hino, Hino-shi  
Tokyo 191-8501, Japan  
Tel: 042-587-5812  
Fax: 042-587-5564  
<http://www.epson.co.jp>

### North America

Epson Electronics America, Inc.  
150 River Oaks Parkway  
San Jose, CA 95134, USA  
Tel: (408) 922-0200  
Fax: (408) 922-0238  
<http://www.eea.epson.com>

### Taiwan

Epson Taiwan Technology  
& Trading Ltd.  
10F, No. 287  
Nanking East Road  
Sec. 3, Taipei, Taiwan  
Tel: 02-2717-7360  
Fax: 02-2712-9164  
<http://www.epson.com.tw/>

### Hong Kong

Epson Hong Kong Ltd.  
20/F., Harbour Centre  
25 Harbour Road  
Wanchai, Hong Kong  
Tel: 2585-4600  
Fax: 2827-4346  
<http://www.epson.com.hk/>

### Europe

Epson Europe Electronics GmbH  
Riesstrasse 15  
80992 Munich, Germany  
Tel: 089-14005-0  
Fax: 089-14005-110  
<http://www.epson-electronics.de>

### Singapore

Epson Singapore Pte., Ltd.  
No. 1  
Temasek Avenue #36-00  
Millenia Tower  
Singapore, 039192  
Tel: 337-7911  
Fax: 334-2716  
<http://www.epson.com.sg/>

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