



October 2003

# DS90C2501

## Transmitter with built-in scaler for LVDS Display Interface (LDI)

### General Description

The DS90C2501 is a highly integrated scaling IC with LVDS transmitter with a scaled resolution up to SXGA+ for single pixel input. The DS90C2501 is a video controller hub designed to be compatible with Graphic Memory Controller Hub (GMCH). The input interface can be single or dual DVO port (12 pin per port). The high quality cubic zoom engine scales the input graphics into the desired/optimal output resolution up to 1400x1050 resolution. Advanced video digital signal processing provides gamma correction, and dithering for the display output. A two-wire serial interface is used to communicate with the host system. The dual high speed LVDS channels supports single pixel in-single pixel out, single pixel in-dual pixel out, and dual pixel in-dual pixel out transmission modes. The DS90C2501 complies to Open LDI standard, and can be paired up with DS90CF388 receiver or FPD8531x/FPD8731x series integrated timing controller or FPDLink LVDS receivers such as DS90CF364/DS90CF384A/DS90CF384/DS90CF384A. The LVDS output is similar to DS90C387 and DS90C387R. Thus, this transmitter can be paired up with DS90CF388, receiver of 112MHz LDI chipset or FPD-Link Receivers in non-DC Balance mode operation which provides GUI/LCD panel/mother board vendors a wide choice of inter-operation with LVDS based TFT panels.

This chip is an ideal solution to solve EMI and cable size problems for high-resolution flat panel applications. It provides a reliable industry standard interface based on LVDS technology that delivers the bandwidth needed for high-resolution panels while maximizing bit times, and keeping clock rates low to reduce EMI and shielding requirements. For more details, please refer to the "Applications Information" section of this datasheet.

### Features

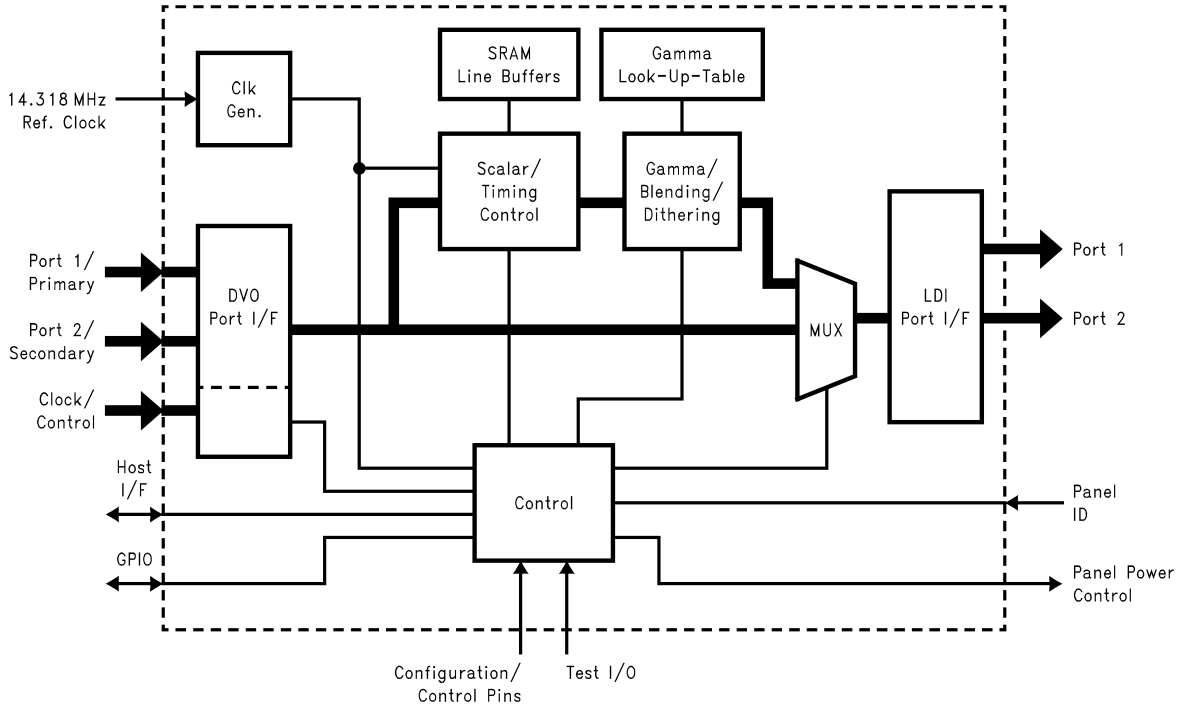
- Complies with Open LDI and GMCH DVO specification for digital display interfaces
- 25 to 65 MHz clock in single pixel in to single pixel out operation.
- 50 to 130 MHz clock in single pixel in to dual pixel out operation.
- Support 24bit/48bit color TFT LCD with Conventional and Non-Conventional Color Mappings.
- Support 16bit/32bit color TFT LCD.
- Single pixel transmitter inputs support single pixel GUI interface.
- Up scaling/panel fitting supports VGA to SXGA+ output in single pixel input mode at 640x480@60Hz, 800x600@60Hz, 1024x768@60Hz, 1280x1024@60Hz, 1400x1050@60Hz.
- Independent horizontal and vertical scaling.
- Support dithering (available for 6-bit color only), programmable smoothing and anti-aliasing filter.
- Programmable digital sharpness, edge enhancement and contrast control via gamma correction.
- Allow 2% at 200KHz spread spectrum clocking, rejects cycle-to-cycle jitter (+/- 20% of input data bit time).
- Programmable LCD panel power sequencing.
- Support low voltage swing signal level (1V to 1.8V), 2.5V and 3.3V LVTTTL level on CLKINP, CLKINM, D0 to D23, DE, HSYNC and VSYNC pins
- Support 2.5V/3.3V LVTTTL level on configuration pins
- Support 3.3V LVTTTL level on GPIO pins
- Available in 10mm x 10mm x 1mm 128pin thermally enhanced CSP package.
- Two-wire serial communication interface is active during normal as well as power down mode and support data rates up to 400KHz.
- TIA/EIA-644, Open LDI, DVO compliance.

DS90C2501 Transmitter with built-in scaler for LVDS Display Interface (LDI)



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# Block Diagram



20004552

## Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

|                                      |                              |
|--------------------------------------|------------------------------|
| Supply Voltage ( $V_{CC}$ )          | -0.3V to +2.8V               |
| Supply Voltage ( $V_{CC3V}$ )        | -0.3V to +3.6V               |
| CMOS/TTL Input Voltage               | -0.3V to $V_{CC3V}$          |
| CMOS/TTL Output Voltage              | -0.3V to ( $V_{CC} + 0.3V$ ) |
| LVDS Driver Output Voltage           | -0.3V to ( $V_{CC} + 0.3V$ ) |
| LVDS Output Short Circuit Duration   | Continuous                   |
| Junction Temperature                 | +150°C                       |
| Storage Temperature                  | -65°C to +150°C              |
| Lead Temperature (Soldering, 4 sec.) | +260°C                       |

Typical Package Power Dissipation Capacity @ 70°C and Max  $V_{CC}$

128 CSP Package:

DS90C2501 1.8W

Maximum Operating Case Temperature: 97°C (measured at top center of package)

ESD Rating:

DS90C2501

(HBM, 1.5kΩ, 100pF) > 2 kV

(EIAJ, 0Ω, 200pF) > 250 V

## Recommended Operating Conditions

|   | Min   | Nom | Max                   | Units |
|---|-------|-----|-----------------------|-------|
| All Supply Voltage except ( $V_{CC3V}$ )      | 2.250 | 2.5 | 2.750                 | V     |
| $V_{CC3V}$ Supply Voltage                     | 3.0   | 3.3 | 3.6                   | V     |
| Operating Free Air Temperature ( $T_A$ )      | 0     | +25 | +70                   | °C    |
| Supply Noise Voltage ( $V_{CC}$ ) up to 33Mhz |       |     | 100 mV <sub>P-P</sub> |       |

## DC Characteristics

Over recommended operating supply and temperature ranges unless otherwise specified.

| Symbol   | Parameter   | Conditions                    | Min                     | Typ                 | Max                     | Units |
|--|---|-------------------------------|-------------------------|---------------------|-------------------------|-------|
| <b>LVC MOS/LVTTL DC SPECIFICATIONS (All input pins when operate in LV TTL level except DUAL pin. Note: On ID0, ID1 pins have typical 30K ohm internal pull-down, and ID2 and ID3 pins have typical 3K ohm internal pull-down.)</b> |   |                               |                         |                     |                         |       |
| $V_{IH}$   | High Level Input Voltage  | $V_{REF} = V_{CC3V}$          | 2.0                     |                     | $V_{CC3V}$              | V     |
| $V_{IL}$   | Low Level Input Voltage   | $V_{REF} = V_{CC3V}$          | -0.3                    |                     | 0.8                     | V     |
| $V_{CL}$   | Input Clamp Voltage   | $I_{CL} = 18$ mA              |                         | -0.9                | -1.5                    | V     |
| $I_{IN}$   | Input Current   | $V_{IN} = 0.4V$ , or $V_{CC}$ |                         | +1.8                | +15                     | μA    |
|  |   | $V_{IN} = GND$                | -15                     | 0                   |                         | μA    |
| <b>LVC MOS/LVTTL DC SPECIFICATIONS for DUAL pin, pin35</b>   |   |                               |                         |                     |                         |       |
| $V_{IH}$ DUAL  | High Level Input Voltage (for dual pixel in to dual pixel out).     | $\overline{PD} = V_{CC3V}$    | 2.0                     |                     | $V_{CC}$                | V     |
| $V_{IM}$ DUAL  | High Level Input Voltage (for single pixel in to dual pixel out).   | $\overline{PD} = V_{CC3V}$    | $\frac{1}{2}V_{CC}-0.1$ | $\frac{1}{2}V_{CC}$ | $\frac{1}{2}V_{CC}+0.1$ | V     |
| $V_{IL}$ DUAL  | High Level Input Voltage (for single pixel in to single pixel out). | $\overline{PD} = V_{CC3V}$    | 0                       |                     | 0.4                     | V     |
| $V_{CL}$   | Input Clamp Voltage   | $I_{CL} = 18$ mA              |                         | -0.9                | -1.5                    | V     |
| $I_{IN}$   | Input Current   | $V_{IN} = 0.4V$ , $V_{CC}$    |                         | 1.8                 | 15                      | μA    |
|  |   | $V_{IN} = Gnd$                | -15                     | 0                   |                         | μA    |
| <b>LVC MOS/LVTTL DC SPECIFICATIONS for MSEN, pin 98</b>  |   |                               |                         |                     |                         |       |
| $V_{OL}$   | Low level Open Drain Output Voltage                                 | $I_{OL} = 2$ mA               |                         | 0.1                 | 0.3                     | V     |
| <b>LVC MOS/LVTTL DC SPECIFICATIONS (Pin 62 to pin 69 when operate in 3.3V LV TTL level)</b>  |   |                               |                         |                     |                         |       |
| $V_{OH}$   | High Level Input Voltage  | $I_{OL} = 2$ mA               | 2.2                     | 2.95                |                         | V     |
| $V_{OL}$   | Low Level Input Voltage   |                               |                         | 0.055               | 0.4                     | V     |
| $I_{OS}$   | Output Short Circuit Current  | $V_{OUT} = 0V$                |                         | -50                 | -120                    | mA    |

**DC Characteristics** (Continued)

Over recommended operating supply and temperature ranges unless otherwise specified.

| Symbol  | Parameter  | Conditions  | Min                                   | Typ               | Max                        | Units |    |
|---|--|---|---------------------------------------|-------------------|----------------------------|-------|----|
| <b>Low Voltage Level DC SPECIFICATIONS (pins D0 to D23, CLKINP, CLKINM, DE, HSYNC, VSYNC)</b> |  |   |                                       |                   |                            |       |    |
| V <sub>DDQ</sub>  | Low Swing Voltage  | from GMCH   | 1                                     |                   | +1.8                       | V     |    |
| V <sub>I<sub>LSH</sub></sub>  | Low Swing High Level Input Voltage   |   | V <sub>REF+</sub><br>100mV            |                   | V <sub>DDQ</sub>           | V     |    |
| V <sub>I<sub>LSL</sub></sub>  | Low Swing Low Level Input Voltage  |   | 0                                     |                   | V <sub>REF-</sub><br>100mV | V     |    |
| V <sub>REF</sub>  | Differential Input Reference Voltage   |   | 0.475                                 | ½V <sub>DDQ</sub> | 0.945                      | V     |    |
| <b>LVDS DRIVER DC SPECIFICATIONS (Output pins AnP, AnM, CLKnP and CLKnM)</b>                  |  |   |                                       |                   |                            |       |    |
| V <sub>OD</sub>   | Differential Output Voltage  | R <sub>L</sub> = 100Ω   | 250                                   | 345               | 450                        | mV    |    |
| ΔV <sub>OD</sub>  | Change in V <sub>OD</sub> between Complimentary Output States                      |   |                                       | 3                 | 35                         | mV    |    |
| V <sub>OS</sub>   | Offset Voltage   |   | 1.125                                 | 1.32              | 1.475                      | V     |    |
| ΔV <sub>OS</sub>  | Change in V <sub>OS</sub> between Complimentary Output States                      |   |                                       | 1.5               | 35                         | mV    |    |
| I <sub>OS</sub>   | Output Short Circuit Current   | V <sub>OUT</sub> = 0V   | 0                                     | -8.5              | -15                        | mA    |    |
| I <sub>OZ</sub>   | Output TRI-STATE Current   | $\overline{PD}$ = 0V, V <sub>OUT</sub> = 0V or V <sub>CC</sub>  |                                       | ±0.1              | ±10                        | μA    |    |
| <b>SUPPLY CURRENT</b>   |  |   |                                       |                   |                            |       |    |
| I <sub>CC1</sub>  | Transmitter Supply Current when data input and clock input are at Low Swing level. | R <sub>L</sub> = 100Ω, C <sub>L</sub> = 5 pF, DUAL pin = GND, BAL = GND, one 12bit input, Pattern <i>Figure 1</i>   | f = 65MHz, scaler off, 2.75V supply   |                   | 70                         | 120   | mA |
|   |  |   | f = 65 MHz, scaler off, 3.6V supply   |                   | 38                         | 90    | mA |
| I <sub>CC2</sub>  | Transmitter Supply Current when data input and clock input are at Low Swing level. | R <sub>L</sub> = 100Ω, C <sub>L</sub> = 5 pF, DUAL pin = ½ VCC, BAL = GND, one 12bit input, Pattern <i>Figure 1</i> | f = 108MHz, scaler off, 2.75V supply  |                   | 85                         | 130   | mA |
|   |  |   | f = 108 MHz, scaler off, 3.6V supply. |                   | 75                         | 130   | mA |
| I <sub>CC3</sub>  | Transmitter Supply Current when data input and clock input are at Low Swing level. | R <sub>L</sub> = 100Ω, C <sub>L</sub> = 5 pF, DUAL pin = GND, BAL = GND, one 12bit input                            | f = 65 MHz, scaler on, 2.75V supply   |                   | 330                        | 415   | mA |
| I <sub>CC4</sub>  | Transmitter Supply Current when data input and clock input are at Low Swing level. | R <sub>L</sub> = 100Ω, C <sub>L</sub> = 5 pF, DUAL pin = ½V <sub>CC</sub> , BAL = GND, one 12bit input              | f = 108 MHz, scaler on, 2.75V supply  |                   | 483                        | 610   | mA |
| ICCTZ   | Transmitter Supply Current Power Down  | $\overline{PD}$ = GND. TST1, TST2, TST3, ID0, ID1, ID2, ID3, A0, A1, A2, RES1, RES2, RES3, RES4 = GND, BAL = GND.   |                                       |                   | 75                         |       | μA |

## Two-Wire Serial Communication Interface

Unless otherwise noted, below specifications apply for  $V_{CC3V}$  pin = 3.0V to 3.6V.

| Symbol      | Parameter                           | Conditions     | Min | Typ  | Max | Units |
|-------------|-------------------------------------|----------------|-----|------|-----|-------|
| $V_{IN(1)}$ | Logical " 1 " input voltage         |                | 2.1 |      |     | V     |
| $V_{IN(0)}$ | Logical " 0 " input voltage         |                |     |      | 0.8 | V     |
| $V_{OL}$    | Serial Bus Low level output voltage | $I_{OL} = 3mA$ |     | 0.1  | 0.4 | V     |
|             |                                     | $I_{OL} = 6mA$ |     | 0.15 | 0.6 | V     |

## Recommended DVO Port Input Characteristics

Over recommended operating supply and temperature ranges unless otherwise specified.

| Symbol | Parameter                                    | Conditions | Min   | Typ  | Max   | Units |
|--------|--|------------|-------|------|-------|-------|
| TCIT   | TxCLK IN Transition Time ( <i>Figure 4</i> ) | DUAL = Gnd | 0.8   | 1.2  | 2.4   | ns    |
| TCIP   | TxCLK IN Period ( <i>Figure 5</i> )          | DUAL = Gnd | 5.9   | T    | 40    | ns    |
| TCIH   | TxCLK in High Time ( <i>Figure 5</i> )       |            | 0.35T | 0.5T | 0.65T | ns    |
| TCIL   | TxCLK in Low Time ( <i>Figure 5</i> )        |            | 0.35T | 0.5T | 0.65T | ns    |
| TXIT   | D0 to D23 Transition Time                    |            |       | 1    |       | ns    |
| VDDQ   | Low Swing Voltage Amplitude from GMCH        |            | 1.0   |      | 1.8   | V     |

## AC Switching Characteristics

Over recommended operating supply and temperature ranges unless otherwise specified.

| Symbol | Parameter   |                                 | Min                | Typ              | Max                | Units |
|--------|---|---------------------------------|--------------------|------------------|--------------------|-------|
| LLHT   | LVDS Low-to-High Transition Time ( <i>Figure 3</i> ). (Note 7)                                |                                 |                    | 0.14             | 0.8                | ns    |
| LHLT   | LVDS High-to-Low Transition Time ( <i>Figure 3</i> ). (Note 7)                                |                                 |                    | 0.11             | 0.8                | ns    |
| TBIT   | Transmitter Output Bit Width  | DUAL pin = $V_{CC}$ or Gnd      |                    | 1/7 TCIP         |                    | ns    |
|        |   | DUAL pin = $\frac{1}{2}V_{CC}$  |                    | 2/7 TCIP         |                    | ns    |
| TCCS   | TxOUT Channel to Channel Skew   |                                 |                    | 100              |                    | ps    |
| TPPOS0 | Transmitter Output Pulse Position for Bit 0 (previous cycle) from CLK1P rising edge (Note 7). | f = 65 MHz, DUAL pin = $V_{CC}$ | -0.49              | 0                | +0.49              | ns    |
| TPPOS1 | Transmitter Output Pulse Position for Bit1 (previous cycle) from CLK1P rising edge. (Note 7)  | f = 65 MHz, DUAL pin = $V_{CC}$ | (1/7)TCIP<br>-0.49 | (1/7)TCIP        | (1/7)TCIP<br>+0.49 | ns    |
| TPPOS2 | Transmitter Output Pulse Position for Bit2 from CLK1P rising edge. (Note 7)                   | f = 65 MHz, DUAL pin = $V_{CC}$ | (2/7)TCIP<br>-0.49 | (2/7)TCIP        | (2/7)TCIP<br>+0.49 | ns    |
| TPPOS3 | Transmitter Output Pulse Position for Bit3 from CLK1P rising edge. (Note 7)                   | f = 65 MHz, DUAL pin = $V_{CC}$ | (3/7)TCIP<br>-0.49 | (3/7)TCIP        | (3/7)TCIP<br>+0.49 | ns    |
| TPPOS4 | Transmitter Output Pulse Position for Bit4 from CLK1P rising edge. (Note 7)                   | f = 65 MHz, DUAL pin = $V_{CC}$ | (4/7)TCIP<br>-0.49 | (4/7)TCIP        | (4/7)TCIP<br>+0.49 | ns    |
| TPPOS5 | Transmitter Output Pulse Position for Bit5 from CLK1P rising edge. (Note 7)                   | f = 65 MHz, DUAL pin = $V_{CC}$ | (5/7)TCIP<br>-0.49 | (5/7)TCIP        | (5/7)TCIP<br>+0.49 | ns    |
| TPPOS6 | Transmitter Output Pulse Position for Bit6 from CLK1P rising edge. (Note 7)                   | f = 65 MHz, DUAL pin = $V_{CC}$ | (6/7)TCIP<br>-0.49 | (6/7)TCIP        | (6/7)TCIP<br>+0.49 | ns    |
| TSTC   | DxIN Setup to CLKINP ( <i>Figure 6</i> ) (Note 7)   |                                 | 0.8                |                  |                    | ns    |
| THTC   | DxIN Hold to CLKINP ( <i>Figure 6</i> ) (Note 7)  |                                 | 0.8                |                  |                    | ns    |
| TJCC   | Transmitter Jitter Cycle-to-cycle (Note 4)  | f = 85 MHz, DUAL pin = Gnd      |                    | 114              |                    | ps    |
|        |   | f = 54 MHz, DUAL pin = $V_{CC}$ |                    | 114              |                    | ps    |
| TPLLS  | Transmitter Phase Lock Loop Set ( <i>Figure 7</i> ) (Note 7)                                  |                                 |                    |                  | 10                 | ms    |
| TPDD   | Transmitter Powerdown Delay ( <i>Figure 8</i> ) (Note 7)                                      |                                 |                    |                  | 100                | ns    |
|        | Transmitter Input to Output Latency for single in-to-dual out mode. <i>Figure 9</i>           | f = 170 MHz (Note 6)            |                    | 1.5 TCIP<br>+4.1 |                    | ns    |

## Two-Wire Serial Communication Interface Switching Characteristics

Unless otherwise noted, below specifications apply for  $V_{CC3V}$  pin = +3.3V, load capacitance on output lines = 80 pF. Load capacitance on output lines can be up to 400pF provided that external pull-up is on board. The following parameters are the timing relationship between SCL and SDA signals related to the DS90C2501.

| Symbol | Parameter  | Min | Typ | Max              | Units   |
|--------|--|-----|-----|------------------|---------|
| $t_1$  | SCL (Clock) Period                                 | 2.5 |     | 2000<br>(Note 7) | $\mu$ s |
| $t_2$  | Data in Set-Up Time to SCL High                    | 100 |     |                  | ns      |
| $t_3$  | Data Out Stable after SCL Low                      | 0   |     |                  | ns      |
| $t_4$  | SDA Low Set-Up Time to SCL Low (Start Condition)   | 100 |     |                  | ns      |
| $t_5$  | SDA High Hold Time after SCL High (Stop Condition) | 100 |     |                  | ns      |

**Note 1:** “Absolute Maximum Ratings” are those values beyond which the safety of the device cannot be guaranteed. They are not meant to imply that the device should be operated at these limits. The tables of “Electrical Characteristics” specify conditions for device operation.

**Note 2:** Typical values are given for  $V_{CC} = 2.5V$  and  $V_{CC3V} = 3.3V$  at  $T_A = +25^\circ C$ .

**Note 3:** Current into device pins is defined as positive. Current out of device pins is defined as negative. Voltages are referenced to ground unless otherwise specified (except  $V_{OD}$  and  $\Delta V_{OD}$ ).

**Note 4:** The limits are based on bench characterization of the device's jitter response over the power supply voltage range. Output clock jitter is measured with a cycle-to-cycle jitter of  $\pm 20\%$  data input bit time applied to the input clock signal while data inputs are switching (see figures 11 and 12). This parameter is used when calculating system margin as described in AN-1059.

**Note 5:** Receiver Skew Margin is defined as the valid data sampling region at the receiver inputs. This margin takes into account transmitter output pulse positions (min and max) and the receiver input setup and hold time (internal data sampling window - RSPOS). This margin allows for LVDS interconnect skew, inter-symbol interference (both dependent on type/length of cable) and clock jitter.

$RSKM \geq$  cable skew (type, length) + source clock jitter (cycle to cycle).

**Note 6:** From  $V = 1.25V$  of CLKINP to  $V_{DIFF} = 0V$  of CLK1P when EDGE pin = Gnd, DUAL pin = Gnd or  $V_{CC}$  or  $\frac{1}{2}V_{CC}$ , BAL pin = Gnd.

**Note 7:** Guaranteed by Design

## AC Timing Diagrams

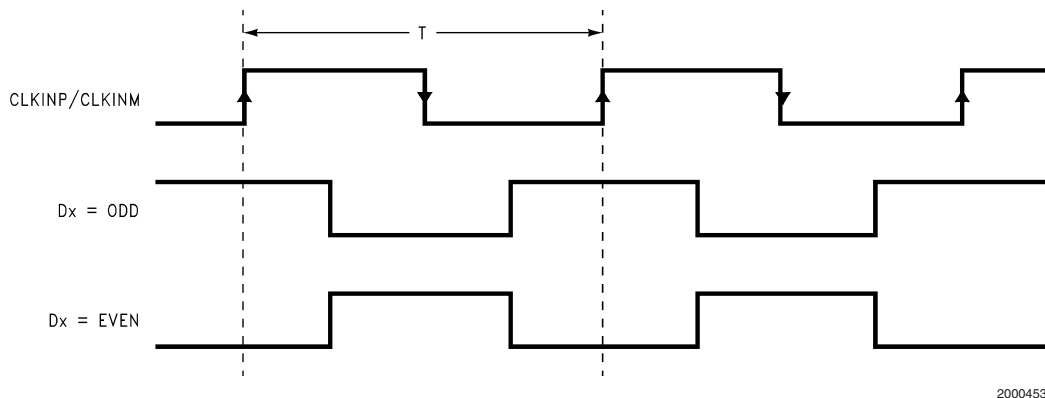


FIGURE 1. “Alternate High/Low” Test Pattern in 12-bit Input Mode (Note 8)





AC Timing Diagrams (Continued)

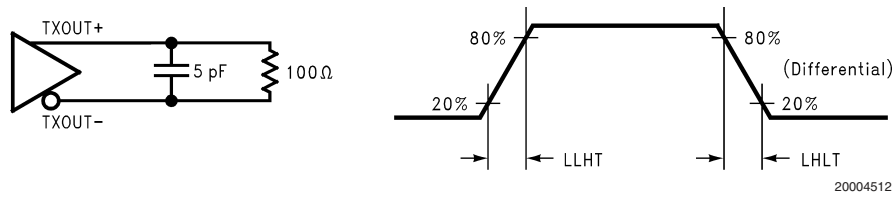


FIGURE 3. DS90C2501 (Transmitter) LVDS Output Load and Transition Times

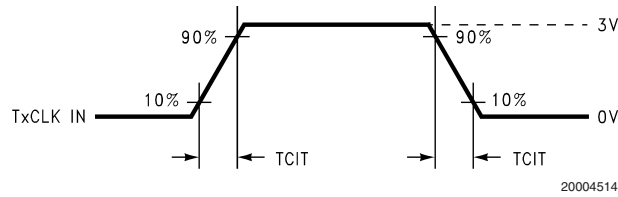


FIGURE 4. DS90C2501 (Transmitter) Input Clock Transition Time

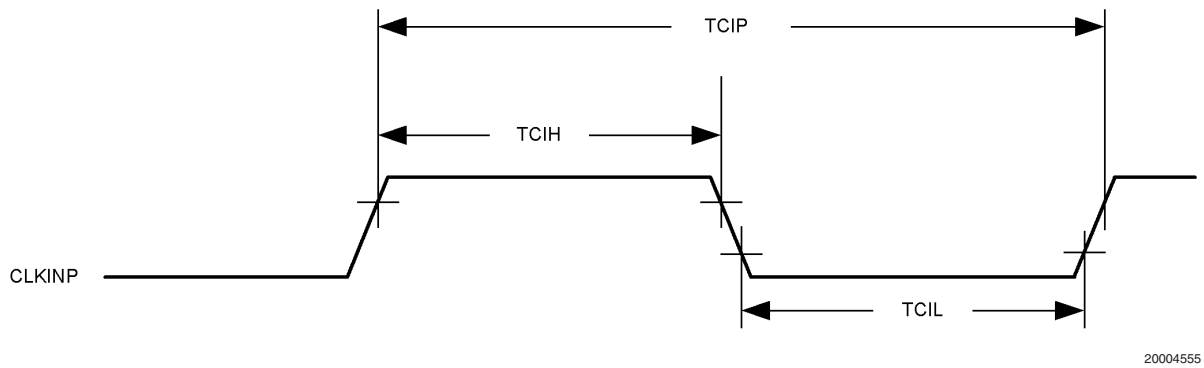


FIGURE 5. DS90C2501 (Transmitter) Input Clock High/Low Times

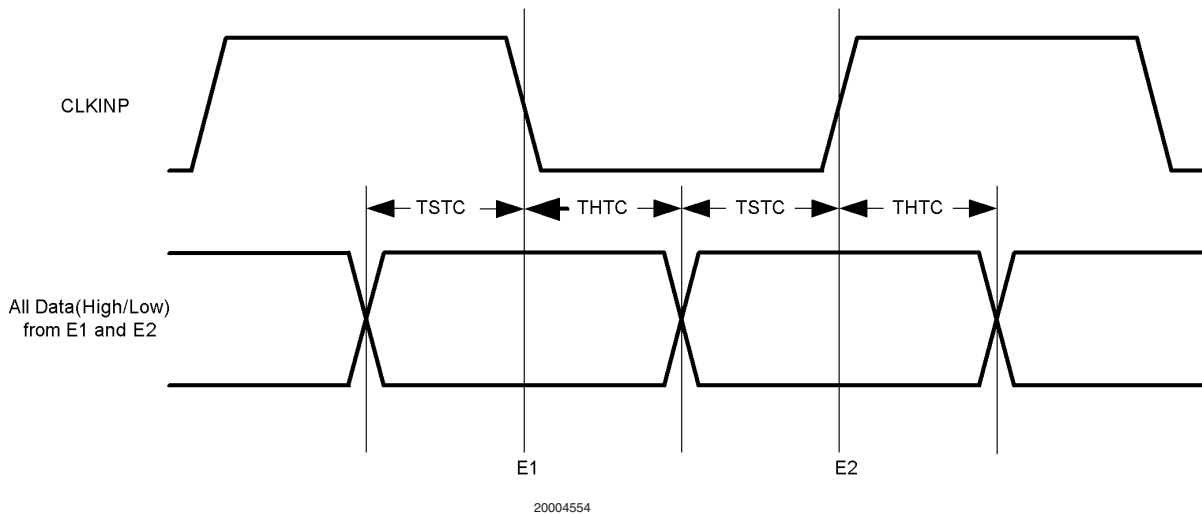


FIGURE 6. Setup/Hold Times,  $V_{REF} = 0.900V$ ,  $EDGE = Gnd$ ,  $DUAL = V_{CC}$ ,  $BAL = Gnd$

# AC Timing Diagrams (Continued)

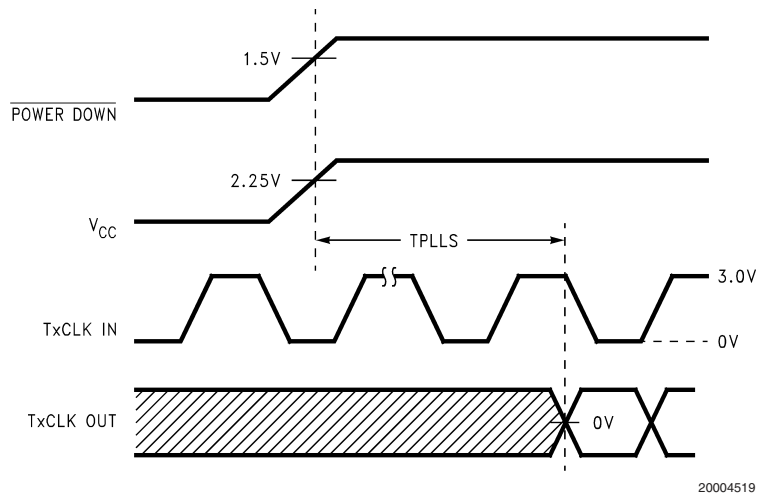


FIGURE 7. DS90C2501 (Transmitter) Phase Lock Loop Set Time

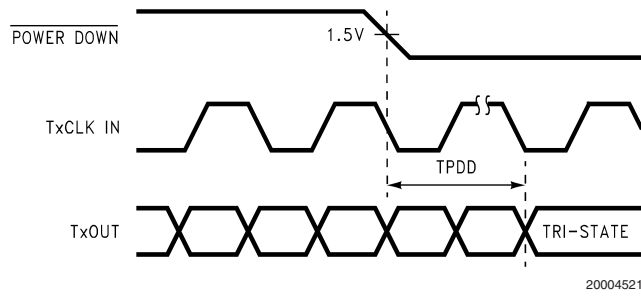


FIGURE 8. Transmitter Power Down Delay

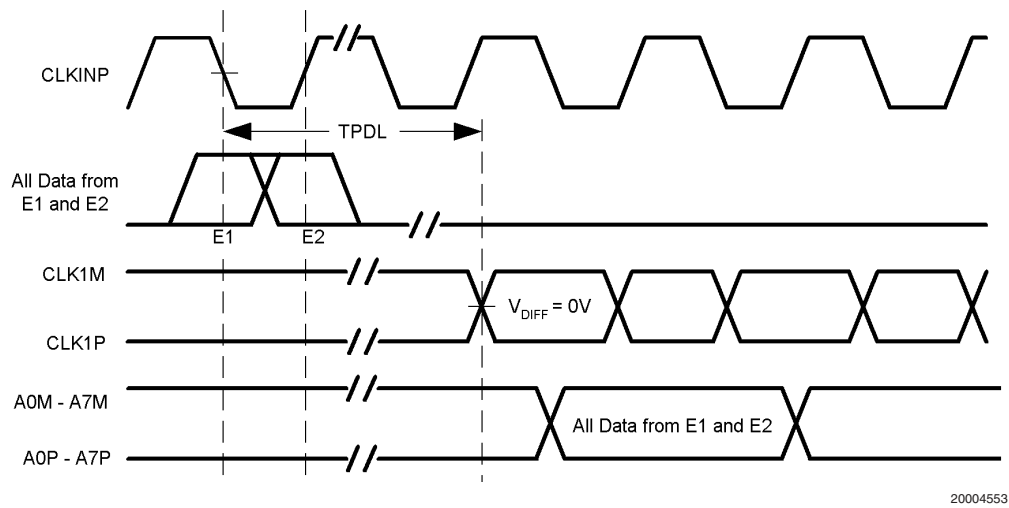
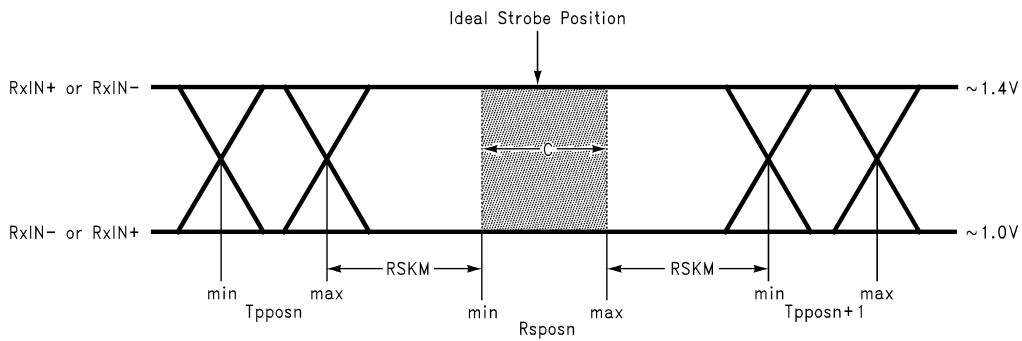


FIGURE 9. Transmitter Input to Output Latency

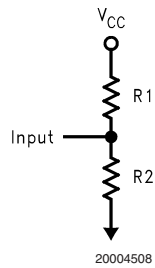
AC Timing Diagrams (Continued)



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C—Setup and Hold Time (Internal data sampling window) defined by Rspn (receiver input strobe position) min and max  
 Tppos — Transmitter output pulse position (min and max)  
 RSKM = Cable Skew (type, length) + Source Clock Jitter (cycle to cycle) + ISI (Inter-symbol interference) (Note 10)  
 Cable Skew — typically 10 ps–40 ps per foot, media dependent  
**Note 10:** ISI is dependent on interconnect length; may be zero

FIGURE 10. Receiver Skew Margin



20004508

FIGURE 11. Resistor Network for “DUAL” pin input - recommend using R1=R2=10kΩ ±1% for single to dual mode

## DS90C2501 Pin Description

| Pin Name              | Pin No.   | I/O Type   | Description   |
|-----------------------|---|--|---|
| <b>DVO INTERFACE</b>  |   |  |   |
| D0–D23                | 17, 16,<br>15, 14,<br>13, 12, 9,<br>8, 7, 6, 5,<br>4, 32, 31,<br>30, 29,<br>28, 27,<br>26, 25,<br>24, 23,<br>22, 21 | I-LVTTL/ Low<br>Swing (See<br>$V_{REF}$ signal<br>description<br>for more<br>information<br>on Low<br>Swing) | DVO Port RGB input data<br>When DUAL pin = GND inputs D0–D11 correspond to LVDS ports A0–A3.<br>When DUAL pin = $\frac{1}{2}V_{CC}$ , 1st pixel from D0–D11 corresponds to LVDS ports A0–A3, 2nd pixel from D0–D11 corresponds to LVDS ports A4–A7.<br>When DUAL pin = $V_{CC}$ , 1st pixel from D0–D11 corresponds to LVDS ports A0–A3, 2nd pixel from D12–D23 corresponds to LVDS ports A4–A7.<br><b>Note:</b> Ports refer to the corresponding differential LVDS pin pairs. The port A nomenclature should not be confused with the serial interface slave address pins AO-A2.   |
| DE                    | 3   | I-LVTTL/ Low<br>Swing  | Display Data Enable. When High, input pixel data is valid to DS90C2501 when R_FDE bit = High (default). See RFDE register field for more information .  |
| HSYNC                 | 2   | I-LVTTL/ Low<br>Swing  | Display Horizontal Sync input control signal.   |
| VSYN                  | 1   | I-LVTTL/ Low<br>Swing  | Display Vertical Sync input control signal.   |
| CLKINP                | 10  | I-LVTTL/ Low<br>Swing<br>Differential  | “Positive” differential pixel clock input. A differential clock is recommended for applications 65 MHz or higher.   |
| CLKINM                | 11  | I-LVTTL/ Low<br>Swing<br>Differential  | “Minus” differential pixel clock input. A differential clock is recommended for applications 65 MHz or higher.  |
| <b>HOST INTERFACE</b> |   |  |   |
| RESETN                | 61  | I-LVTTL 2.5  | Active low RESET signal. Asserting <u>RESETN</u> will reset all internal logic and clear the Host Interface registers.  |
| S2CLK                 | 72  | I-LVTTL3V  | This is the clock line for the two-wire serial communication interface. Normally a pull-up resistor is required in the system.  |
| S2DAT                 | 71  | I/O-LVTTL3V  | This is the data line for two-wire serial communication interface. A Pull-up resistor is normally required in the system.   |
| MSEN                  | 98  | O-LVTTL 2.5  | Interrupt signal. This is an open drain output, a pull-up resistor is required. Please refer to MDI, RSEN, TSEL and MSEL register fields in Register Field Definitions for more information. This signal requires support from host software.   |
| PD                    | 99  | I-LVTTL 2.5  | Power Down Signal. A logic “0” will place the device in power down mode per <i>Table 1</i> below.<br>When maximum power savings is desired, the PD pin or soft power down bit (Reg 08h bit 0) should be used to power down the DS90C2501.<br>LVDS outputs of the device will be in TRI-STATE.<br>Scaling engine will be powered down, and retain all register values.<br>PLL will be powered down.<br>All data input pads will be powered down. $V_{REF}$ circuit is powered down. The two-wire serial communication interface remains active and all register contents will be retained.<br>All GPIO pins will be disabled (tri-state if programmed as an output).<br>ENAVDD, ENABKL, PWM, VSTALL and HIRQ pins remain active and can be accessed through the two-wire serial communication interface. |
| <b>CLOCK</b>          |   |  |   |
| REFCLK1               | 18  | I-LVTTL3V  | Reference clock, — A 3V, 14.318 MHz clock is required for internal control and timing. This clock must be stable when the DS90C2501 is powered-up.  |

## DS90C2501 Pin Description (Continued)

| Pin Name                | Pin No.           | I/O Type    | Description   |
|-------------------------|-------------------|-------------|---|
| <b>OPTION SELECTION</b> |                   |             |   |
| BAL                     | 97                | I-LVTTL 2.5 | Tie this pin to GND.  |
| DUAL                    | 35                | I-LVTTL 2.5 | <p>LVTTL level input.</p> <p>Input = GND for single pixel in-to-single pixel out mode. LVDS output channels A0 to A3 are enabled, A4 to A7 are CLK2 are disable.</p> <p>Input = <math>V_{CC}</math> for dual pixel in-to-dual pixel out mode. LVDS output channel A0 to A7, CLK1 and CLK2 are enable. Use a 10K typ. pull-up resistor.</p> <p>Input = <math>\frac{1}{2}V_{CC}</math> for single pixel in-to-dual pixel out mode. LVDS output channel A0 to A7, CLK1 and CLK2 are enabled. See register CFG1 (08h) BPASS field for more information.</p> <p>See <i>Figure 11</i> for example interface circuit.</p>  |
| COLOR                   | 34                | I-LVTTL 2.5 | <p>LVTTL level input to select RGB to LVDS color mapping.</p> <p>Tie to GND for 18-bit/36-bit LCD.</p> <p>Tie to GND to select conventional color mapping for 24-bit/48-bit LCD.</p> <p>Tie to Logic "1" to select non-conventional color mapping for 24-bit/48-bit LCD.</p>  |
| A0, A1, A2              | 115, 116,<br>117  | I-LVTTL 2.5 | These are input pins to select the 2-wire Serial Communication Slave Device Address Lower Bits.   |
| EDGE                    | 36                | I-LVTTL 2.5 | <p>Selects primary clock edge E1.</p> <p>Tie to Logic "1" to select Rising edge for E1.</p> <p>Tie to ground to select Falling edge for E1.</p>   |
| <b>PANEL INTERFACE</b>  |                   |             |   |
| A0P, A1P,<br>A2P, A3P   | 55, 53,<br>51, 47 | O-LVDS      | <p>Positive LVDS differential data output.</p> <p>When DUAL pin = GND, input to D0–D11 will be coming out of A0P to A3P. For 6-bit color application, no connect for channel A3P.</p> <p>When DUAL pin = <math>\frac{1}{2}V_{CC}</math>, the first pixel going in D0–D11 will be coming out of A0P to A3P, and the second pixel going in D0–D11 will come out of A4P to A7P. For 6-bit color application, no connect for channels A3P and A7P.</p> <p>When DUAL pin = <math>V_{CC}</math>, the first pixel going in D0–D11 will be coming out of A0P to A3P, the second pixel going in D12–D23 will be coming out of A4P to A7P. For 6-bit color application, no connect for channels A3P and A7P.</p>                  |
| A0M, A1M,<br>A2M, A3M   | 56, 54,<br>52, 48 | O-LVDS      | <p>Negative LVDS differential data output.</p> <p>When DUAL pin = GND, input to D0–D11 will be coming out of A0M to A3M. For 6-bit color application, no connect for channel A3M.</p> <p>When DUAL pin = <math>\frac{1}{2}V_{CC}</math>, the first pixel going in D0–D11 will be coming out of A0M to A3M, and the second pixel going in D0–D11 will come out of A4M to A7M. For 6-bit color application, no connect for channels A3M and A7M.</p> <p>When DUAL pin = <math>V_{CC}</math>, the first pixel going in D0–D11 will be coming out of A0M to A3M, the second pixel going in D12–D23 will be coming out of A4M to A7M. For 6-bit color application, no connect for channels A3M and A7M.</p>                  |
| A4P, A5P,<br>A6P, A7P   | 45, 43,<br>41, 39 | O-LVDS      | <p>Positive LVDS differential data output for second pixel.</p> <p>When DUAL pin = GND, input to D0–D11 will be coming out of A0P to A3P. For 6-bit color application, no connect for channel A3P.</p> <p>When DUAL pin = <math>\frac{1}{2}V_{CC}</math>, the first pixel going in D0–D11 will be coming out of A0P to A3P, and the second pixel going in D0–D11 will come out of A4P to A7P. For 6-bit color application, no connect for channels A3P and A7P.</p> <p>When DUAL pin = <math>V_{CC}</math>, the first pixel going in D0–D11 will be coming out of A0P to A3P, the second pixel going in D12–D23 will be coming out of A4P to A7P. For 6-bit color application, no connect for channels A3P and A7P.</p> |

## DS90C2501 Pin Description (Continued)

| Pin Name                  | Pin No.           | I/O Type     | Description  |
|---------------------------|-------------------|--------------|--|
| <b>OPTION SELECTION</b>   |                   |              |  |
| A4M, A5M,<br>A6M, A7M     | 46, 44,<br>42, 40 | O-LVDS       | Negative LVDS differential data output for second pixel.<br>When DUAL pin = GND, input to D0–D11 will be coming out of A0M to A3M. For 6-bit color application, no connect for channel A3M.<br>When DUAL pin = $\frac{1}{2}V_{CC}$ , the first pixel going in D0–D11 will be coming out of A0M to A3M, and the second pixel going in D0–D11 will come out of A4M to A7M. For 6-bit color application, no connect for channels A3M and A7M.<br>When DUAL pin = $V_{CC}$ , the first pixel going in D0–D11 will be coming out of A0M to A3M, the second pixel going in D12–D23 will be coming out of A4M to A7M. For 6-bit color application, no connect for channels A3M and A7M. |
| CLK1P                     | 49                | O-LVDS       | Positive LVDS differential clock output.   |
| CLK1M                     | 50                | O-LVDS       | Negative LVDS differential clock output.   |
| CLK2P                     | 37                | O-LVDS       | Additional positive LVDS differential clock output pin. Identical to CLK1P. No connect if not used.  |
| CLK2M                     | 38                | O-LVDS       | Additional negative LVDS differential clock output pin. Identical to CLK1M. No connect if not used.  |
| ID0, ID1, ID2,<br>ID3     | 57, 58,<br>59, 60 | I-LVTTL 2.5  | These four pins are used to select one out of 16 pre-determined LCD display timing information. The values are from 0 to 15. This function requires support from VBIOS or display driver. Tie these pins to GND when not in use. Tie these four pins [ID3, ID2, ID1, ID0] to High or Low for selecting LCD panel. ID0 is the LSB, and ID3 is the MSB. For example: 1000 will select the 9th LCD panel.<br>A 4-bit register field [3:0] will be used to store the selected value for the host to read. See PANEL field for more information.  |
| ENAVDD                    | 69                | O-LVTTL 2.5  | Output to control LCD panel power under software control. Typically, this output is used with a power switch such as a FET circuit to control LCD panel $V_{CC}$ (Note 11).  |
| ENABKL                    | 68                | O-LVTTL 2.5  | Output to control LCD panel back light power under software control. Typically, this output is used to control the enable on a backlight inverter (Note 11).   |
| <b>MISCELLANEOUS/TEST</b> |                   |              |  |
| GPIO1,<br>GPIO2,<br>GPIO3 | 64, 63, 62        | I/O-LVTTL 3V | General purpose inputs or outputs referenced to GND.<br>When the device is powered up, this pin defaults to an input.<br>When the scaler is in the power down state these signals are tri-state if programmed as outputs (Note 11).  |
| CLK_INV                   | 114               | I-LVTTL 2.5  | This pin is used to invert the polarity of the incoming pixel CLK (CLKINP/CLKINM). A logic 0 = Normal, Logic 1 = Invert.   |
| RES2                      | 70                | I-LVTTL 2.5  | This pin is used in production testing and should be tied to GND in normal operation.  |
| RES3                      | 113               | I-LVTTL 2.5  | This pin is used in production testing and should be tied to GND in normal operation.  |
| RES4                      | 100               | I-LVTTL 2.5  | This pin is used in production testing and should be tied to GND in normal operation.  |
| PWM                       | 67                | O-LVTTL 3V   | This signal was provided for legacy support and is no longer required. This pin should be left open in normal operation.   |
| VSTALL                    | 66                | O-LVTTL 3V   | This signal was provided for legacy support and is no longer required. This pin should be left open in normal operation.   |
| HIRQ                      | 65                | O-LVTTL 3V   | This signal was provided for legacy support and is no longer required. This pin should be left open in normal operation.   |

## DS90C2501 Pin Description (Continued)

| Pin Name  | Pin No.                                       | I/O Type     | Description  |
|---|---|--------------|--|
| <b>OPTION SELECTION</b>   |   |              |  |
| V <sub>REF</sub>  | 83  | I-ANALOG     | This pin is never to be left floating and never tie to GND.<br>For LVTTTL level data input, tie V <sub>REF</sub> to V <sub>CC3V</sub> . When V <sub>REF</sub> > 1.8V, input data is set to LVTTTL level.<br>For low voltage swing level data input, tie V <sub>REF</sub> to ½V <sub>DDQ</sub> (V <sub>DDQ</sub> provided by host interface) V <sub>DDQ</sub> is from the host. When V <sub>REF</sub> ≤ 1.0V, indicates input data is in low voltage swing mode.<br>Input data = logic High = V <sub>REF</sub> +100 mV in low voltage swing level.<br>Input data = logic Low = V <sub>REF</sub> -100 mV in low voltage swing level. |
| TST1, TST2, TST3  | 19, 20, 85                                    | I-LVTTTL 2.5 | These pins are used in production testing and should be tied to GND in normal operation.   |
| <b>POWER (See Application Information for power supply decoupling requirements)</b> |   |              |  |
| V <sub>CC</sub> /DV <sub>CC</sub>   | 81, 82, 75, 77, 96, 119, 123, 125             | PWR          | Power supply pins (pin 75, 77, 81, 82, 96, 119, 123, and 125) for 2.5V LVTTTL inputs and digital circuitry.  |
| GND/DGND  | 33, 73, 74, 76, 78, 79, 80, 84, 118, 122, 124 | PWR          | GND or DGND reference for 2.5V TTL inputs and digital circuitry.   |
| V <sub>CC3V</sub>   | 121, 127                                      | PWR          | The V <sub>CC3V</sub> is required for internal logic and certain 3V I/O.<br>During power up stage, voltage readings on these pins must be higher than 2.5V pins.   |
| GND3V   | 120, 126, 128                                 | PWR          | Ground return pins for V <sub>CC3V</sub> powered logic.  |
| SPLL <sub>VCC</sub>   | 87, 89  | PWR          | 2.5V power supply pins for scaler PLL circuitry. It is not recommended to share this power with PLL <sub>VCC</sub> .   |
| SPLL <sub>GND</sub>   | 86, 88, 90                                    | PWR          | Ground returns for scaler PLL circuitry.   |
| PLL <sub>VCC</sub>  | 92, 94  | PWR          | 2.5V power supply pins for Tx PLL circuitry. It is not recommended to share this power with SPLL <sub>VCC</sub> .  |
| PLL <sub>GND</sub>  | 91, 93, 95                                    | PWR          | Ground returns for Tx PLL circuitry.   |
| LVDS <sub>VCC</sub>   | 105, 109                                      | PWR          | Power supply pins for LVDS output drivers.   |
| LVDS <sub>GND</sub>   | 104, 108                                      | PWR          | Ground return pins for LVDS output drivers.  |
| LVDS <sub>VCC3V</sub>   | 101, 103, 107, 111                            | PWR          | 3V power supply pins for LVDS output drivers.<br>During power up stage, voltage readings on these pins must be higher than 2.5V pins.  |
| LVDS <sub>GND3V</sub>   | 102, 106, 110, 112                            | PWR          | Ground return pins for 3V LVDS outputs.  |

**Note 11:** When device power is applied, it is possible for these outputs to switch to a logic "1" momentarily as the 3.3V is rising and before 2.5V reaches at least 0.8V. During this brief period, the pad control logic could be non-deterministic, RESETN will have no effect. It is recommended these outputs are gated externally if the system design requires them to remain in the inactive logic "0" state during power-on.

## DS90C2501 Pin Description (Continued)

**TABLE 1. scaler is powered down under these conditions**

|  | scaler is On             | scaler is OFF                   |
|--|--------------------------|---------------------------------|
| /PD pin  | H                        | L                               |
| DUAL pin provided that PD bit is 1 and BYPASS bit is 0 | L or $\frac{1}{2}V_{CC}$ | L or $\frac{1}{2}V_{CC}$ or VCC |
| No input clock is detected                             | NO                       | YES                             |
| PD bit issued by host                                  | 1                        | 0                               |
| BYPASS bit issued by host.                             | 0                        | 1                               |

### Two-Wire Serial Communication Interface Description

There are two register sets on DS90C2501. One set is for controlling the input and output blocks as shown below, and one set is for controlling the scaler which is not shown on this datasheet. Both register sets are accessible by the host system through the Two-Wire Serial Communication Interface. The DS90C2501 operates as a slave on the Serial Bus, so the SCL line is an input (no clock is generated by the DS90C2501) and the SDA line is bi-directional. DS90C2501 has a 7-bit slave address. The address bits are controlled by the state of the address select pins A2, A1 and A0, and are set by connecting these pins to ground for a LOW, (0) , to  $V_{CC}3V$  pin for a HIGH, (1).

Therefore, the complete slave address is:

|     |    |    |     |    |    |    |
|-----|----|----|-----|----|----|----|
| A6  | A5 | A4 | A3  | A2 | A1 | A0 |
| MSB |    |    | LSB |    |    |    |

and is selected as follows:

| Address Select Pin State |    |    | DS90C2501 Serial Bus Slave Address (A6:A3 are hardwired to "0111") |
|--------------------------|----|----|--|
| A2                       | A1 | A0 | A6:A0 binary   |
| 0                        | 0  | 0  | 0111000  |
| 0                        | 0  | 1  | 0111001  |
| 0                        | 1  | 0  | 0111010  |
| 0                        | 1  | 1  | 0111011  |
| 1                        | 0  | 0  | 0111100  |
| 1                        | 0  | 1  | 0111101  |
| 1                        | 1  | 0  | 0111110  |
| 1                        | 1  | 1  | 0111111  |

The DS90C2501 latches the state of the address select pins during the first read or write on the Serial Bus. Changing the state of the address select pins after the first read or write to any device on the Serial Bus will not change the slave address of the DS90C2501.

#### Communicating with the DS90C2501 Control Registers

All registers are predefined as read only, or read and write. The Serial Interface will always attempt to detect if a LCD panel/monitor is connected.

A **Write** to the DS90C2501 will always include the slave address byte, data register address byte, a data byte.

A **Read** from the DS90C2501 can take place either of two ways:

1. If the location latched in the data register addresses is correct , then the read can simply consist of a slave address byte, followed by retrieving the data byte.
2. If the data register address needs to be set, then a slave address byte, data register address will be sent first, then the master will repeat start, send the slave address byte and receive data byte to accomplish a read.

The data byte has the most significant bit first. At the end of a read, the DS90C2501 can accept either Acknowledge or No Acknowledge from the Master (No Acknowledge is typically used as a signal for the slave that the Master has read its last byte).

### Serial Bus Protocol

The DS90C2501 slave state machine does not require an internal clock, and supports only byte read and write. Page mode is not supported. The 7-bit binary address is "0111A<sub>2</sub>A<sub>1</sub>A<sub>0</sub>", where A<sub>2</sub>A<sub>1</sub>A<sub>0</sub> are pin programmable and A6:A3 are hardwired internally to "0111"



## Serial Bus Protocol (Continued)

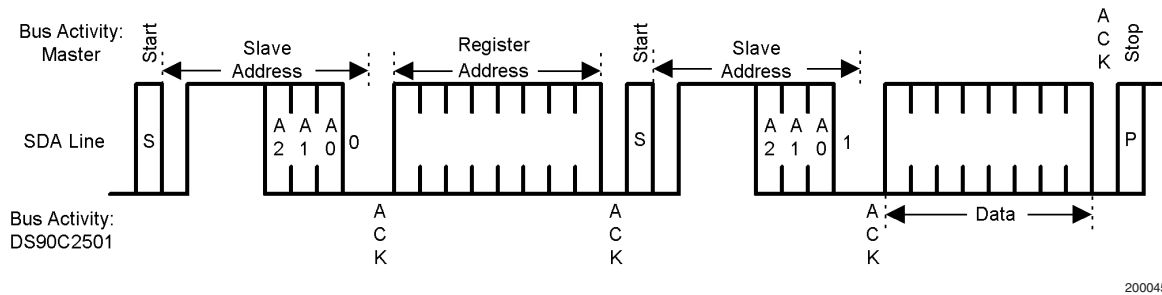


FIGURE 12. Byte Read

The master must generate a “ Start ”, and send the 7-bit slave address plus a 0 first, and wait for acknowledge from DS90C2501. When DS90C2501 acknowledges (the 1st ACK) that the master is calling, the master then sends the data register address byte, and waits for acknowledge from the slave. When the slave acknowledges (the 2nd ACK), the master repeats the “ Start ” by sending the 7-bit slave address plus a 1 (indicating that READ operation is in progress), and waits for acknowledge from DS90C2501. After the slave responds (the 3rd ACK), the slave sends the

data to the bus, and waits for acknowledge from the master. When the master acknowledges (the 4th ACK), and generates a “ Stop ”, this completes the “ READ ”.

If the 4th ACK is received from the master and no “ Stop ” follows it, the slave will keep sending the data of next register until “ Stop ” is received from the master. If the 4th ACK is not received from the master, the slave will terminate the Serial Bus communication, and giving the bus control back to the master.

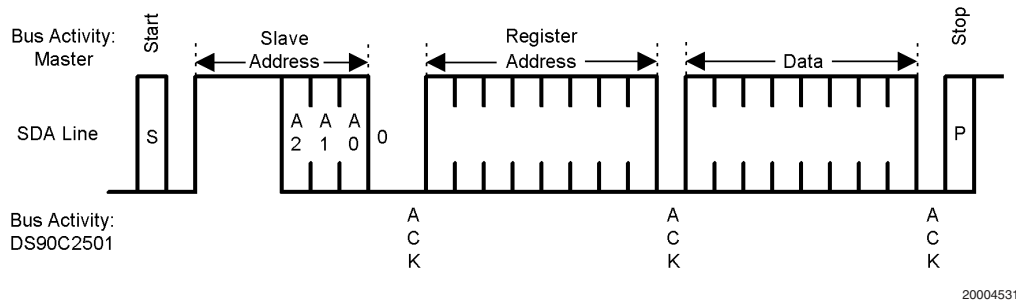


FIGURE 13. Byte Write

slave. If the slave acknowledges, the master can send data to the next register address (Register Address + 2). If the slave doesn't acknowledge, the master will have the control of the bus and can generate a “ Stop ” to end the “ WRITE ” operation. During the process, if the master attempts to send data to “ Read Only ” registers, the slave will not acknowledge and return the bus control back to the master. A complete programming guide is available for the DS90C2501 to OEM customers. This can be obtained by contacting your local National Semiconductor sales representative.

## Host Control Register Descriptions

Register Name: VND\_IDL  
 Address Offset: 00h  
 Default Value: 05h  
 Access Method: Read Only

## Host Control Register Descriptions (Continued)

| Bit | Description        |
|-----|--------------------|
| 7:0 | Vendor ID Low Byte |

Register Name: VND\_IDH

Address Offset: 01h

Default Value: 13h

Access Method: Read Only

| Bit | Description         |
|-----|---------------------|
| 7:0 | Vendor ID High Byte |

Register Name: DEV\_IDL

Address Offset: 02h

Default Value: 26h

Access Method: Read Only

| Bit | Description        |
|-----|--------------------|
| 7:0 | Device ID Low Byte |

Register Name: DEV\_IDH

Address Offset: 03h

Default Value: 67h

Access Method: R/W

| Bit | Description         |
|-----|---------------------|
| 7:0 | Device ID High Byte |

Register Name: DEVICE REVISION

Address Offset: 04h

Default Value: 01h

Access Method: R/W

| Bit | Description           |
|-----|-----------------------|
| 7:0 | Device Revision Value |

Register Name: RESERVED

Address Offset: 05h

Default Value: A5h

Access Method: Read Only

| Bit | Description |
|-----|-------------|
| 7:0 | Reserved    |

Register Name: FRQ\_LOW

Address Offset: 06h

Default Value: 19h

Access Method: Read Only

| Bit | Description                            |
|-----|--|
| 7:0 | Minimum LVDS Output Frequency (25 MHz) |

Register Name: FRQ\_HIGH

Address Offset: 07h

Default Value: See Description

Access Method: Read Only

| Bit | Description   |
|-----|---|
| 7:0 | Maximum LVDS Output Frequency                       |
|     | If DUAL = GND or $V_{CC}$ value is A2h (162 MHz)    |
|     | If DUAL = $\frac{1}{2}V_{CC}$ value is 55h (85 MHz) |

## Host Control Register Descriptions (Continued)

Register Name: CFG1

Address Offset: 08h

Default Value: 39h

Access Method: R/W

| Bit | Description  |
|-----|--|
| 0   | Soft Power Down; 0 = Power Down, 1 = Normal Operation  |
| 1   | Reserved   |
| 2   | BPASS (1 = bypass, 0 = non-bypass)<br>This field is valid only when DUAL pin is 0V or $\frac{1}{2}V_{CC}$ . Note: When image scaling is not required power savings can be achieved in bypass mode. |
| 3   | DSEL<br>0= Input clock is differential (recommended for clocks above 65 MHz),<br>1= input clock is single-ended  |
| 4   | HEN (HSYNC enable)<br>0= HSYNC is transmitted as a fixed low,<br>1= HSYNC is same as input   |
| 5   | VEN (VSYNC enable)<br>0= VSYNC is transmitted as a fixed low,<br>1= VSYNC is same as input   |
| 7:6 | Reserved   |

## Host Control Register Descriptions (Continued)

Register Name: CFG2

Address Offset: 09h

Default Value: 95h

Access Method: R/W

| Bit | Description  |
|-----|--|
| 0   | MDI (read only)  |
| 1   | Reserved   |
| 2   | RSEN (read only)— Receiver Sense<br>0= LVDS receiver connected to transmitter output,<br>1= No receiver connected<br>Note: this function is valid only with DC coupled systems |
| 3   | TSEL — Interrupt generation<br>0= Interrupt bit (MDI) is generated by monitoring RSEN, fixed valve   |
| 4:6 | MSEL (R/W)— Selects source for MSEL output pin<br>000= MSEN disabled<br>001= Output the MDI bit - interrupt<br>010= Output the RSEN bit - receiver detect<br>011–111= Reserved |
| 7   | VLOW (read only)<br>1= $V_{REF}$ set for low swing,<br>0= $V_{REF}$ set for LVTTTL   |

Register Name: CFG3

Address Offset: 0Ah

Default Value: 81H

Access Method: R/W

| Bit | Description  |
|-----|--|
| 0   | R_FDE- Input DE strobe Polarity Select<br>0 = DE active Low,<br>1 = DE active High |
| 3:1 | Reserved   |
| 7:4 | Reserved   |

Register Name: CFG

Address Offset: 0Bh

Default Value: See Description

Access Method: Read Only

| Bit | Description                             |
|-----|---|
| 7:0 | Contains state of input data bits 23:16 |

Register Name: PANEL

Address Offset: 0Ch

Default Value: See Description

Access Method: R/W

| Bit | Description  |
|-----|--|
| 0:3 | System defined Panel ID values set on ID0:3 pins (Read Only)       |
| 4:7 | System defined Panel ID field which can be written/ read from host |

## Host Control Register Descriptions (Continued)

Register Name: DEBUG\_A

Address Offset: 0Dh

Default Value: See Description—Depends on pin state

Access Method: Mixed

| Bit | Description   |
|-----|---|
| 1:0 | DUAL (1:0), State of DUAL pin (Read Only)<br>00= SISO<br>01= SIDO<br>11= DIDO |
| 2   | PLLOCK (Read Only)  |
| 3   | Reserved (Read Only)  |
| 7:4 | Reserved (R/W)  |

Register Name: RESERVED

Address Offset: 0Eh–0Fh

Default Value: 00h

Access Method: R/W

| Bit | Description |
|-----|-------------|
| 7:0 | Reserved    |

## LVDS Interface

TABLE 2. LVDS data bit naming convention

| X   | Y   | Z     | Description                                     |
|-----|-----|-------|---|
| X=R |     |       | Red   |
| X=G |     |       | Green   |
| X=B |     |       | Blue  |
|     | Y=1 |       | Odd (First) Pixel                               |
|     | Y=2 |       | Even (Second) Pixel                             |
|     |     | Z=0-7 | LVDS bit number (not VGA controller LSB to MSB) |

## LVDS Interface (Continued)

**TABLE 3. Conventional Data mapping for one 12-bit (two data per clock) single pixel in-to-single pixel out application (DUAL = Gnd, only Port1 A0-A3 are active, BAL = Gnd)**

| VGA - TFT Data Signals Color Bits |        |        | Transmitter input pin names | Receiver output pin names | TFT Panel Data Signals |        |
|-----------------------------------|--------|--------|-----------------------------|---------------------------|------------------------|--------|
|                                   | 24-bit | 18-bit | DS90C2501                   | DS90CF388                 | 18-bit                 | 24-bit |
| LSB                               | R0     |        | E2-D4                       | R16                       |                        | R0     |
|                                   | R1     |        | E2-D5                       | R17                       |                        | R1     |
|                                   | R2     | R0     | E2-D6                       | R10                       | R0                     | R2     |
|                                   | R3     | R1     | E2-D7                       | R11                       | R1                     | R3     |
|                                   | R4     | R2     | E2-D8                       | R12                       | R2                     | R4     |
|                                   | R5     | R3     | E2-D9                       | R13                       | R3                     | R5     |
|                                   | R6     | R4     | E2-D10                      | R14                       | R4                     | R6     |
| MSB                               | R7     | R5     | E2-D11                      | R15                       | R5                     | R7     |
| LSB                               | G0     |        | E1-D8                       | G16                       |                        | G0     |
|                                   | G1     |        | E1-D9                       | G17                       |                        | G1     |
|                                   | G2     | G0     | E1-D10                      | G10                       | G0                     | G2     |
|                                   | G3     | G1     | E1-D11                      | G11                       | G1                     | G3     |
|                                   | G4     | G2     | E2-D0                       | G12                       | G2                     | G4     |
|                                   | G5     | G3     | E2-D1                       | G13                       | G3                     | G5     |
|                                   | G6     | G4     | E2-D2                       | G14                       | G4                     | G6     |
| MSB                               | G7     | G5     | E2-D3                       | G15                       | G5                     | G7     |
| LSB                               | B0     |        | E1-D0                       | B16                       |                        | B0     |
|                                   | B1     |        | E1-D1                       | B17                       |                        | B1     |
|                                   | B2     | B0     | E1-D2                       | B10                       | B0                     | B2     |
|                                   | B3     | B1     | E1-D3                       | B11                       | B1                     | B3     |
|                                   | B4     | B2     | E1-D4                       | B12                       | B2                     | B4     |
|                                   | B5     | B3     | E1-D5                       | B13                       | B3                     | B5     |
|                                   | B6     | B4     | E1-D6                       | B14                       | B4                     | B6     |
| MSB                               | B7     | B5     | E1-D7                       | B15                       | B5                     | B7     |

## LVDS Interface (Continued)

**TABLE 4. Conventional Data mapping for one 12-bit (two data per clock )single pixel in-to-dual pixel out application  
(DUAL = 1/2V<sub>CC</sub>, Port1 A0-A3 and Port2 A4-A7 are active, BAL = Gnd)**

| VGA - TFT Data Signals Color Bits              |        | Transmitter input pin names | Receiver output pin names | TFT Panel Data Signals |        |
|--|--------|-----------------------------|---------------------------|------------------------|--------|
|  | 24-bit | DS90C2501                   | DS90CF388                 | 18-bit                 | 24-bit |
| Port 1-Primary (the first active RGB pixel)    |        |                             |                           |                        |        |
| LSB  | R0     | E2-D4                       | R16                       |                        | RO0    |
|  | R1     | E2-D5                       | R17                       |                        | RO1    |
|  | R2     | E2-D6                       | R10                       | RO0                    | RO2    |
|  | R3     | E2-D7                       | R11                       | RO1                    | RO3    |
|  | R4     | E2-D8                       | R12                       | RO2                    | RO4    |
|  | R5     | E2-D9                       | R13                       | RO3                    | RO5    |
|  | R6     | E2-D10                      | R14                       | RO4                    | RO6    |
| MSB  | R7     | E2-D11                      | R15                       | RO5                    | RO7    |
| LSB  | G0     | E1-D8                       | G16                       |                        | GO0    |
|  | G1     | E1-D9                       | G17                       |                        | GO1    |
|  | G2     | E1-D10                      | G10                       | GO0                    | GO2    |
|  | G3     | E1-D11                      | G11                       | GO1                    | GO3    |
|  | G4     | E2-D0                       | G12                       | GO2                    | GO4    |
|  | G5     | E2-D1                       | G13                       | GO3                    | GO5    |
|  | G6     | E2-D2                       | G14                       | GO4                    | GO6    |
| MSB  | G7     | E2-D3                       | G15                       | GO5                    | GO7    |
| LSB  | B0     | E1-D0                       | B16                       |                        | BO0    |
|  | B1     | E1-D1                       | B17                       |                        | BO1    |
|  | B2     | E1-D2                       | B10                       | BO0                    | BO2    |
|  | B3     | E1-D3                       | B11                       | BO1                    | BO3    |
|  | B4     | E1-D4                       | B12                       | BO2                    | BO4    |
|  | B5     | E1-D5                       | B13                       | BO3                    | BO5    |
|  | B6     | E1-D6                       | B14                       | BO4                    | BO6    |
| MSB  | B7     | E1-D7                       | B15                       | BO5                    | BO7    |
| Port 2-Secondary (the second active RGB pixel) |        |                             |                           |                        |        |
| LSB  | R0     | E4-D4                       | R26                       |                        | RE0    |
|  | R1     | E4-D5                       | R27                       |                        | RE1    |
|  | R2     | E4-D6                       | R20                       | RE0                    | RE2    |
|  | R3     | E4-D7                       | R21                       | RE1                    | RE3    |
|  | R4     | E4-D8                       | R22                       | RE2                    | RE4    |
|  | R5     | E4-D9                       | R23                       | RE3                    | RE5    |
|  | R6     | E4-D10                      | R24                       | RE4                    | RE6    |
| MSB  | R7     | E4-D11                      | R25                       | RE5                    | RE7    |
| LSB  | G0     | E3-D8                       | G26                       |                        | GE0    |
|  | G1     | E3-D9                       | G27                       |                        | GE1    |
|  | G2     | E3-D10                      | G20                       | GE0                    | GE2    |
|  | G3     | E3-D11                      | G21                       | GE1                    | GE3    |
|  | G4     | E4-D0                       | G22                       | GE2                    | GE4    |
|  | G5     | E4-D1                       | G23                       | GE3                    | GE5    |
|  | G6     | E4-D2                       | G24                       | GE4                    | GE6    |
| MSB  | G7     | E4-D3                       | G25                       | GE5                    | GE7    |
| LSB  | B0     | E3-D0                       | B26                       |                        | BE0    |
|  | B1     | E3-D1                       | B27                       |                        | BE1    |
|  | B2     | E3-D2                       | B20                       | BE0                    | BE2    |

## LVDS Interface (Continued)

TABLE 4. Conventional Data mapping for one 12-bit (two data per clock )single pixel in-to-dual pixel out application  
(DUAL =  $1/2V_{CC}$ , Port1 A0-A3 and Port2 A4-A7 are active, BAL = Gnd) (Continued)

| VGA - TFT Data Signals Color Bits |    | Transmitter input pin names | Receiver output pin names | TFT Panel Data Signals |     |
|-----------------------------------|----|-----------------------------|---------------------------|------------------------|-----|
|                                   | B3 | E3-D3                       | B21                       | BE1                    | BE3 |
|                                   | B4 | E3-D4                       | B22                       | BE2                    | BE4 |
|                                   | B5 | E3-D5                       | B23                       | BE3                    | BE5 |
|                                   | B6 | E3-D6                       | B24                       | BE4                    | BE6 |
| MSB                               | B7 | E3-D7                       | B25                       | BE5                    | BE7 |



## LVDS Interface (Continued)

**TABLE 5. Conventional Data Mapping for two 12-bit (two data per clock)dual pixel in-to-dual pixel out application(DUAL = V<sub>CC</sub>, Port1 A0-A3 and Port2 A4-A7 are active, BAL = Gnd. )**

| VGA - TFT Data Signals Color Bits               |        | Transmitter input pin names | Receiver output pin names | TFT Panel Data Signals |        |
|---|--------|-----------------------------|---------------------------|------------------------|--------|
|   | 24-bit | DS90C2501                   | DS90CF388                 | 18-bit                 | 24-bit |
| Port 1-Primary ( the first active RGB pixel)    |        |                             |                           |                        |        |
| LSB   | R0     | E2-D4                       | R16                       |                        | R0     |
|   | R1     | E2-D5                       | R17                       |                        | R1     |
|   | R2     | E2-D6                       | R10                       | R0                     | R2     |
|   | R3     | E2-D7                       | R11                       | R1                     | R3     |
|   | R4     | E2-D8                       | R12                       | R2                     | R4     |
|   | R5     | E2-D9                       | R13                       | R3                     | R5     |
|   | R6     | E2-D10                      | R14                       | R4                     | R6     |
| MSB   | R7     | E2-D11                      | R15                       | R5                     | R7     |
| LSB   | G0     | E1-D8                       | G16                       |                        | G0     |
|   | G1     | E1-D9                       | G17                       |                        | G1     |
|   | G2     | E1-D10                      | G10                       | G0                     | G2     |
|   | G3     | E1-D11                      | G11                       | G1                     | G3     |
|   | G4     | E2-D0                       | G12                       | G2                     | G4     |
|   | G5     | E2-D1                       | G13                       | G3                     | G5     |
|   | G6     | E2-D2                       | G14                       | G4                     | G6     |
| MSB   | G7     | E2-D3                       | G15                       | G5                     | G7     |
| LSB   | B0     | E1-D0                       | B16                       |                        | B0     |
|   | B1     | E1-D1                       | B17                       |                        | B1     |
|   | B2     | E1-D2                       | B10                       | B0                     | B2     |
|   | B3     | E1-D3                       | B11                       | B1                     | B3     |
|   | B4     | E1-D4                       | B12                       | B2                     | B4     |
|   | B5     | E1-D5                       | B13                       | B3                     | B5     |
|   | B6     | E1-D6                       | B14                       | B4                     | B6     |
| MSB   | B7     | E1-D7                       | B15                       | B5                     | B7     |
| Port 2-Secondary ( the second active RGB pixel) |        |                             |                           |                        |        |
| LSB   | R0     | E2-D16                      | R26                       |                        | R0     |
|   | R1     | E2-D17                      | R27                       |                        | R1     |
|   | R2     | E2-D18                      | R20                       | R0                     | R2     |
|   | R3     | E2-D19                      | R21                       | R1                     | R3     |
|   | R4     | E2-D20                      | R22                       | R2                     | R4     |
|   | R5     | E2-D21                      | R23                       | R3                     | R5     |
|   | R6     | E2-D22                      | R24                       | R4                     | R6     |
| MSB   | R7     | E2-D23                      | R25                       | R5                     | R7     |
| LSB   | G0     | E1-D20                      | G26                       |                        | G0     |
|   | G1     | E1-D21                      | G27                       |                        | G1     |
|   | G2     | E1-D22                      | G20                       | G0                     | G2     |
|   | G3     | E1-D23                      | G21                       | G1                     | G3     |
|   | G4     | E2-D12                      | G22                       | G2                     | G4     |
|   | G5     | E2-D13                      | G23                       | G3                     | G5     |
|   | G6     | E2-D14                      | G24                       | G4                     | G6     |
| MSB   | G7     | E2-D15                      | G25                       | G5                     | G7     |
| LSB   | B0     | E1-D12                      | B26                       |                        | B0     |
|   | B1     | E1-D13                      | B27                       |                        | B1     |
|   | B2     | E1-D14                      | B20                       | B0                     | B2     |

## LVDS Interface (Continued)

**TABLE 5. Conventional Data Mapping for two 12-bit (two data per clock)dual pixel in-to-dual pixel out application(DUAL =  $V_{CC}$ , Port1 A0-A3 and Port2 A4-A7 are active, BAL = Gnd. ) (Continued)**

| VGA - TFT Data Signals Color Bits |    | Transmitter input pin names | Receiver output pin names | TFT Panel Data Signals |    |
|-----------------------------------|----|-----------------------------|---------------------------|------------------------|----|
|                                   | B3 | E1-D15                      | B21                       | B1                     | B3 |
|                                   | B4 | E1-D16                      | B22                       | B2                     | B4 |
|                                   | B5 | E1-D17                      | B23                       | B3                     | B5 |
|                                   | B6 | E1-D18                      | B24                       | B4                     | B6 |
| MSB                               | B7 | E1-D19                      | B25                       | B5                     | B7 |

## LVDS Interface (Continued)

**TABLE 6. Non-Conventional Data mapping for one 12-bit (two data per clock )single pixel in-to-single pixel out application (DUAL = Gnd, only Port1 A0-A3 are active, BAL= Gnd)**

| VGA - TFT Data Signals Color Bits |        | Transmitter input pin names |           | Receiver output pin names |        | TFT Panel Data Signals |  |
|-----------------------------------|--------|-----------------------------|-----------|---------------------------|--------|------------------------|--|
|                                   | 24-bit | 18-bit                      | DS90C2501 | DS90CF388                 | 18-bit | 24-bit                 |  |
| LSB                               | R0     |                             | E2-D4     | R16                       |        | R0                     |  |
|                                   | R1     |                             | E2-D5     | R17                       |        | R1                     |  |
|                                   | R2     | R0                          | E2-D6     | R10                       | R0     | R2                     |  |
|                                   | R3     | R1                          | E2-D7     | R11                       | R1     | R3                     |  |
|                                   | R4     | R2                          | E2-D8     | R12                       | R2     | R4                     |  |
|                                   | R5     | R3                          | E2-D9     | R13                       | R3     | R5                     |  |
|                                   | R6     | R4                          | E2-D10    | R14                       | R4     | R6                     |  |
| MSB                               | R7     | R5                          | E2-D11    | R15                       | R5     | R7                     |  |
| LSB                               | G0     |                             | E1-D8     | G16                       |        | G0                     |  |
|                                   | G1     |                             | E1-D9     | G17                       |        | G1                     |  |
|                                   | G2     | G0                          | E1-D10    | G10                       | G0     | G2                     |  |
|                                   | G3     | G1                          | E1-D11    | G11                       | G1     | G3                     |  |
|                                   | G4     | G2                          | E2-D0     | G12                       | G2     | G4                     |  |
|                                   | G5     | G3                          | E2-D1     | G13                       | G3     | G5                     |  |
|                                   | G6     | G4                          | E2-D2     | G14                       | G4     | G6                     |  |
| MSB                               | G7     | G5                          | E2-D3     | G15                       | G5     | G7                     |  |
| LSB                               | B0     |                             | E1-D0     | B16                       |        | B0                     |  |
|                                   | B1     |                             | E1-D1     | B17                       |        | B1                     |  |
|                                   | B2     | B0                          | E1-D2     | B10                       | B0     | B2                     |  |
|                                   | B3     | B1                          | E1-D3     | B11                       | B1     | B3                     |  |
|                                   | B4     | B2                          | E1-D4     | B12                       | B2     | B4                     |  |
|                                   | B5     | B3                          | E1-D5     | B13                       | B3     | B5                     |  |
|                                   | B6     | B4                          | E1-D6     | B14                       | B4     | B6                     |  |
| MSB                               | B7     | B5                          | E1-D7     | B15                       | B5     | B7                     |  |

## LVDS Interface (Continued)

**TABLE 7. Non-Conventional Data mapping for one 12-bit (two data per clock) single pixel in-to-dual pixel out application (DUAL = 1/2V<sub>CC</sub>, Port1 A0-A3 and Port2 A4-A7 are active, BAL = Gnd)**

| VGA - TFT Data Signals Color Bits               |        | Transmitter input pin names | Receiver output pin names | TFT Panel Data Signals |        |
|---|--------|-----------------------------|---------------------------|------------------------|--------|
|   | 24-bit | DS90C2501                   | DS90CF388                 | 18-bit                 | 24-bit |
| Port 1-Primary ( the first active RGB pixel)    |        |                             |                           |                        |        |
| LSB   | R0     | E2-D4                       | R16                       |                        | RO0    |
|   | R1     | E2-D5                       | R17                       |                        | RO1    |
|   | R2     | E2-D6                       | R10                       | RO0                    | RO2    |
|   | R3     | E2-D7                       | R11                       | RO1                    | RO3    |
|   | R4     | E2-D8                       | R12                       | RO2                    | RO4    |
|   | R5     | E2-D9                       | R13                       | RO3                    | RO5    |
|   | R6     | E2-D10                      | R14                       | RO4                    | RO6    |
| MSB   | R7     | E2-D11                      | R15                       | RO5                    | RO7    |
| LSB   | G0     | E1-D8                       | G16                       |                        | GO0    |
|   | G1     | E1-D9                       | G17                       |                        | GO1    |
|   | G2     | E1-D10                      | G10                       | GO0                    | GO2    |
|   | G3     | E1-D11                      | G11                       | GO1                    | GO3    |
|   | G4     | E2-D0                       | G12                       | GO2                    | GO4    |
|   | G5     | E2-D1                       | G13                       | GO3                    | GO5    |
|   | G6     | E2-D2                       | G14                       | GO4                    | GO6    |
| MSB   | G7     | E2-D3                       | G15                       | GO5                    | GO7    |
| LSB   | B0     | E1-D0                       | B16                       |                        | BO0    |
|   | B1     | E1-D1                       | B17                       |                        | BO1    |
|   | B2     | E1-D2                       | B10                       | BO0                    | BO2    |
|   | B3     | E1-D3                       | B11                       | BO1                    | BO3    |
|   | B4     | E1-D4                       | B12                       | BO2                    | BO4    |
|   | B5     | E1-D5                       | B13                       | BO3                    | BO5    |
|   | B6     | E1-D6                       | B14                       | BO4                    | BO6    |
| MSB   | B7     | E1-D7                       | B15                       | BO5                    | BO7    |
| Port 2-Secondary ( the second active RGB pixel) |        |                             |                           |                        |        |
| LSB   | R0     | E4-D4                       | R26                       |                        | RE0    |
|   | R1     | E4-D5                       | R27                       |                        | RE1    |
|   | R2     | E4-D6                       | R20                       | RE0                    | RE2    |
|   | R3     | E4-D7                       | R21                       | RE1                    | RE3    |
|   | R4     | E4-D8                       | R22                       | RE2                    | RE4    |
|   | R5     | E4-D9                       | R23                       | RE3                    | RE5    |
|   | R6     | E4-D10                      | R24                       | RE4                    | RE6    |
| MSB   | R7     | E4-D11                      | R25                       | RE5                    | RE7    |
| LSB   | G0     | E3-D8                       | G26                       |                        | GE0    |
|   | G1     | E3-D9                       | G27                       |                        | GE1    |
|   | G2     | E3-D10                      | G20                       | GE0                    | GE2    |
|   | G3     | E3-D11                      | G21                       | GE1                    | GE3    |
|   | G4     | E4-D0                       | G22                       | GE2                    | GE4    |
|   | G5     | E4-D1                       | G23                       | GE3                    | GE5    |
|   | G6     | E4-D2                       | G24                       | GE4                    | GE6    |
| MSB   | G7     | E4-D3                       | G25                       | GE5                    | GE7    |
| LSB   | B0     | E3-D0                       | B26                       |                        | BE0    |
|   | B1     | E3-D1                       | B27                       |                        | BE1    |
|   | B2     | E3-D2                       | B20                       | BE0                    | BE2    |

## LVDS Interface (Continued)

**TABLE 7. Non-Conventional Data mapping for one 12-bit (two data per clock )single pixel in-to-dual pixel out application (DUAL =  $1/2V_{CC}$ , Port1 A0-A3 and Port2 A4-A7 are active, BAL = Gnd) (Continued)**

| VGA - TFT Data Signals Color Bits |    | Transmitter input pin names | Receiver output pin names | TFT Panel Data Signals |     |
|-----------------------------------|----|-----------------------------|---------------------------|------------------------|-----|
|                                   | B3 | E3-D3                       | B21                       | BE1                    | BE3 |
|                                   | B4 | E3-D4                       | B22                       | BE2                    | BE4 |
|                                   | B5 | E3-D5                       | B23                       | BE3                    | BE5 |
|                                   | B6 | E3-D6                       | B24                       | BE4                    | BE6 |
| MSB                               | B7 | E3-D7                       | B25                       | BE5                    | BE7 |

## LVDS Interface (Continued)

**TABLE 8. Non-Conventional Data Mapping for two 12-bit (two data per clock)dual pixel in-to-dual pixel out application (DUAL= V<sub>CC</sub>, Port1 A0-A3 and Port2 A4-A7 are active, BAL= Gnd. )**

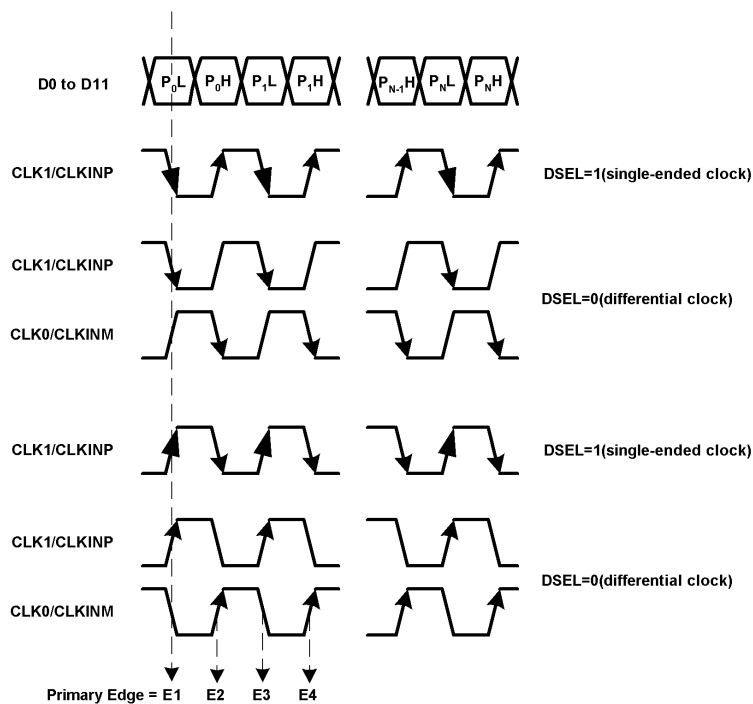
| VGA - TFT Data Signals Color Bits               |        | Transmitter input pin names | Receiver output pin names | TFT Panel Data Signals |        |
|---|--------|-----------------------------|---------------------------|------------------------|--------|
|   | 24-bit | DS90C2501                   | DS90CF388                 | 18-bit                 | 24-bit |
| Port 1-Primary (the first active RGB pixel)     |        |                             |                           |                        |        |
| LSB   | R0     | E2-D4                       | R16                       |                        | R0     |
|   | R1     | E2-D5                       | R17                       |                        | R1     |
|   | R2     | E2-D6                       | R10                       | R0                     | R2     |
|   | R3     | E2-D7                       | R11                       | R1                     | R3     |
|   | R4     | E2-D8                       | R12                       | R2                     | R4     |
|   | R5     | E2-D9                       | R13                       | R3                     | R5     |
|   | R6     | E2-D10                      | R14                       | R4                     | R6     |
| MSB   | R7     | E2-D11                      | R15                       | R5                     | R7     |
| LSB   | G0     | E1-D8                       | G16                       |                        | G0     |
|   | G1     | E1-D9                       | G17                       |                        | G1     |
|   | G2     | E1-D10                      | G10                       | G0                     | G2     |
|   | G3     | E1-D11                      | G11                       | G1                     | G3     |
|   | G4     | E2-D0                       | G12                       | G2                     | G4     |
|   | G5     | E2-D1                       | G13                       | G3                     | G5     |
|   | G6     | E2-D2                       | G14                       | G4                     | G6     |
| MSB   | G7     | E2-D3                       | G15                       | G5                     | G7     |
| LSB   | B0     | E1-D0                       | B16                       |                        | B0     |
|   | B1     | E1-D1                       | B17                       |                        | B1     |
|   | B2     | E1-D2                       | B10                       | B0                     | B2     |
|   | B3     | E1-D3                       | B11                       | B1                     | B3     |
|   | B4     | E1-D4                       | B12                       | B2                     | B4     |
|   | B5     | E1-D5                       | B13                       | B3                     | B5     |
|   | B6     | E1-D6                       | B14                       | B4                     | B6     |
| MSB   | B7     | E1-D7                       | B15                       | B5                     | B7     |
| Port 2-Secondary ( the second active RGB pixel) |        |                             |                           |                        |        |
| LSB   | R0     | E2-D16                      | R26                       |                        | R0     |
|   | R1     | E2-D17                      | R27                       |                        | R1     |
|   | R2     | E2-D18                      | R20                       | R0                     | R2     |
|   | R3     | E2-D19                      | R21                       | R1                     | R3     |
|   | R4     | E2-D20                      | R22                       | R2                     | R4     |
|   | R5     | E2-D21                      | R23                       | R3                     | R5     |
|   | R6     | E2-D22                      | R24                       | R4                     | R6     |
| MSB   | R7     | E2-D23                      | R25                       | R5                     | R7     |
| LSB   | G0     | E1-D20                      | G26                       |                        | G0     |
|   | G1     | E1-D21                      | G27                       |                        | G1     |
|   | G2     | E1-D22                      | G20                       | G0                     | G2     |
|   | G3     | E1-D23                      | G21                       | G1                     | G3     |
|   | G4     | E2-D12                      | G22                       | G2                     | G4     |
|   | G5     | E2-D13                      | G23                       | G3                     | G5     |
|   | G6     | E2-D14                      | G24                       | G4                     | G6     |
| MSB   | G7     | E2-D15                      | G25                       | G5                     | G7     |
| LSB   | B0     | E1-D12                      | B26                       |                        | B0     |
|   | B1     | E1-D13                      | B27                       |                        | B1     |
|   | B2     | E1-D14                      | B20                       | B0                     | B2     |

## LVDS Interface (Continued)

**TABLE 8. Non-Conventional Data Mapping for two 12-bit (two data per clock)dual pixel in-to-dual pixel out application  
(DUAL= V<sub>CC</sub>, Port1 A0-A3 and Port2 A4-A7 are active, BAL= Gnd. ) (Continued)**

| VGA - TFT Data<br>Signals Color Bits |    | Transmitter input pin names | Receiver output pin names | TFT Panel Data<br>Signals |    |
|--------------------------------------|----|-----------------------------|---------------------------|---------------------------|----|
|                                      | B3 | E1-D15                      | B21                       | B1                        | B3 |
|                                      | B4 | E1-D16                      | B22                       | B2                        | B4 |
|                                      | B5 | E1-D17                      | B23                       | B3                        | B5 |
|                                      | B6 | E1-D18                      | B24                       | B4                        | B6 |
| MSB                                  | B7 | E1-D19                      | B25                       | B5                        | B7 |

## LVDS Interface (Continued)



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**FIGURE 14. How Data is Latched in the DS90C2501**

**Note 12:** The lower half of the pixel is latched by the primary clock edge E1.

**Note 13:** E3 and E4 only apply when DUAL pin = 1/2 V<sub>CC</sub>.

**Note 14:** Above figure only valid when R\_FDE bit = V<sub>CC</sub>, DE signal from GUI is set to be active HIGH.

**Note 15:** D0 to D11 are clocked at the crossing point of CLKOUT+ and CLKOUT- when differential clock input is applied. This applies to D12 to D23 when DUAL pin = V<sub>CC</sub>.

**Note 16:** Single-ended clock is not recommended for operation above 65MHz by GMCH vendor.

**TABLE 9. 12-bit (two data per clock) input application data mapping with GMCH.**

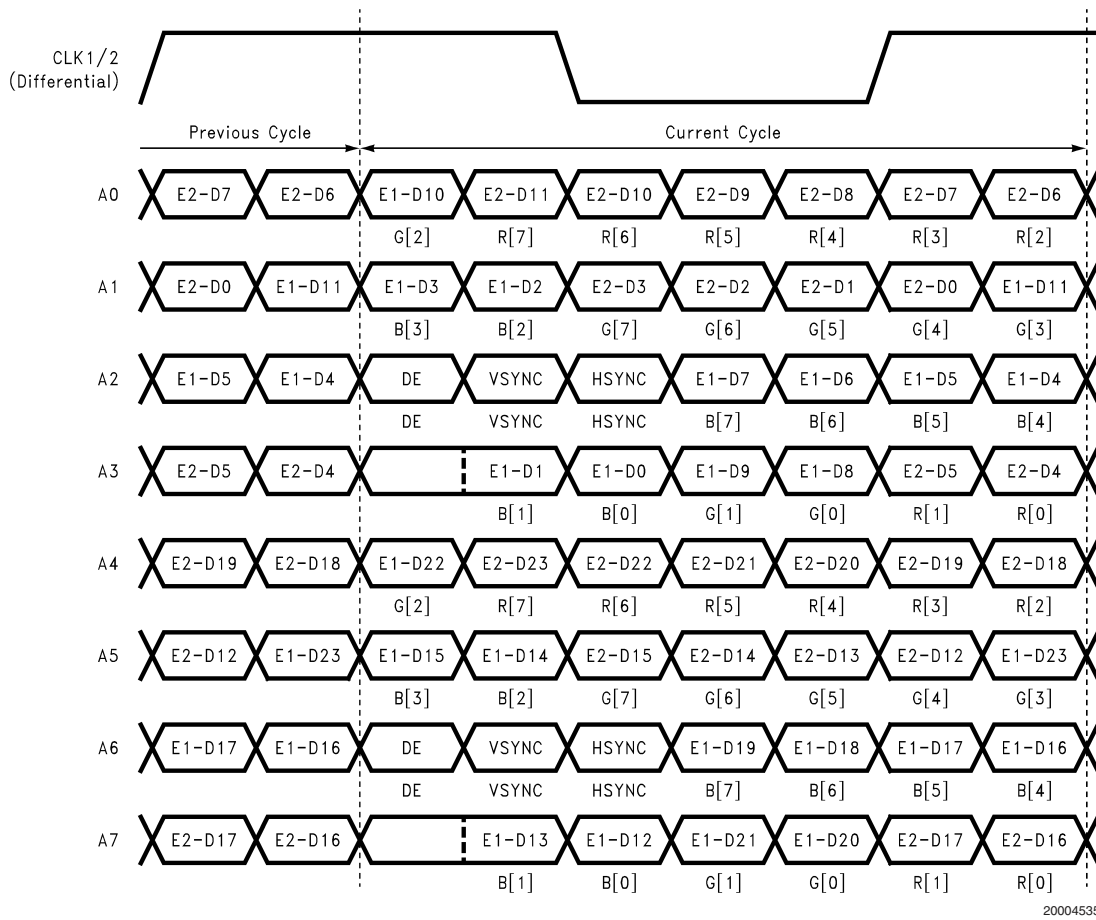
|          | P0    |       | P1    |       | P2    |       |
|----------|-------|-------|-------|-------|-------|-------|
|          | P0L   | P0H   | P1L   | P1H   | P2L   | P2H   |
| Pin Name | Low   | High  | Low   | High  | Low   | High  |
| D11      | G0[3] | R0[7] | G1[3] | R1[7] | G2[3] | R2[7] |
| D10      | G0[2] | R0[6] | G1[2] | R1[6] | G2[2] | R2[6] |
| D9       | G0[1] | R0[5] | G1[1] | R1[5] | G2[1] | R2[5] |
| D8       | G0[0] | R0[4] | G1[0] | R1[4] | G2[0] | R2[4] |
| D7       | B0[7] | R0[3] | B1[7] | R1[3] | B2[7] | R2[3] |
| D6       | B0[6] | R0[2] | B1[6] | R1[2] | B2[6] | R2[2] |
| D5       | B0[5] | R0[1] | B1[5] | R1[1] | B2[5] | R2[1] |
| D4       | B0[4] | R0[0] | B1[4] | R1[0] | B2[4] | R2[0] |
| D3       | B0[3] | G0[7] | B1[3] | G1[7] | B2[3] | G2[7] |
| D2       | B0[2] | G0[6] | B1[2] | G1[6] | B2[2] | G2[6] |
| D1       | B0[1] | G0[5] | B1[1] | G1[5] | B2[1] | G2[5] |
| D0       | B0[0] | G0[4] | B1[0] | G1[4] | B2[0] | G2[4] |

**Note 17:** Color notation: R = RED, G = GREEN, B = BLUE.

**Note 18:** Bit significance within a color: [7:0] = [MSB:LSB].

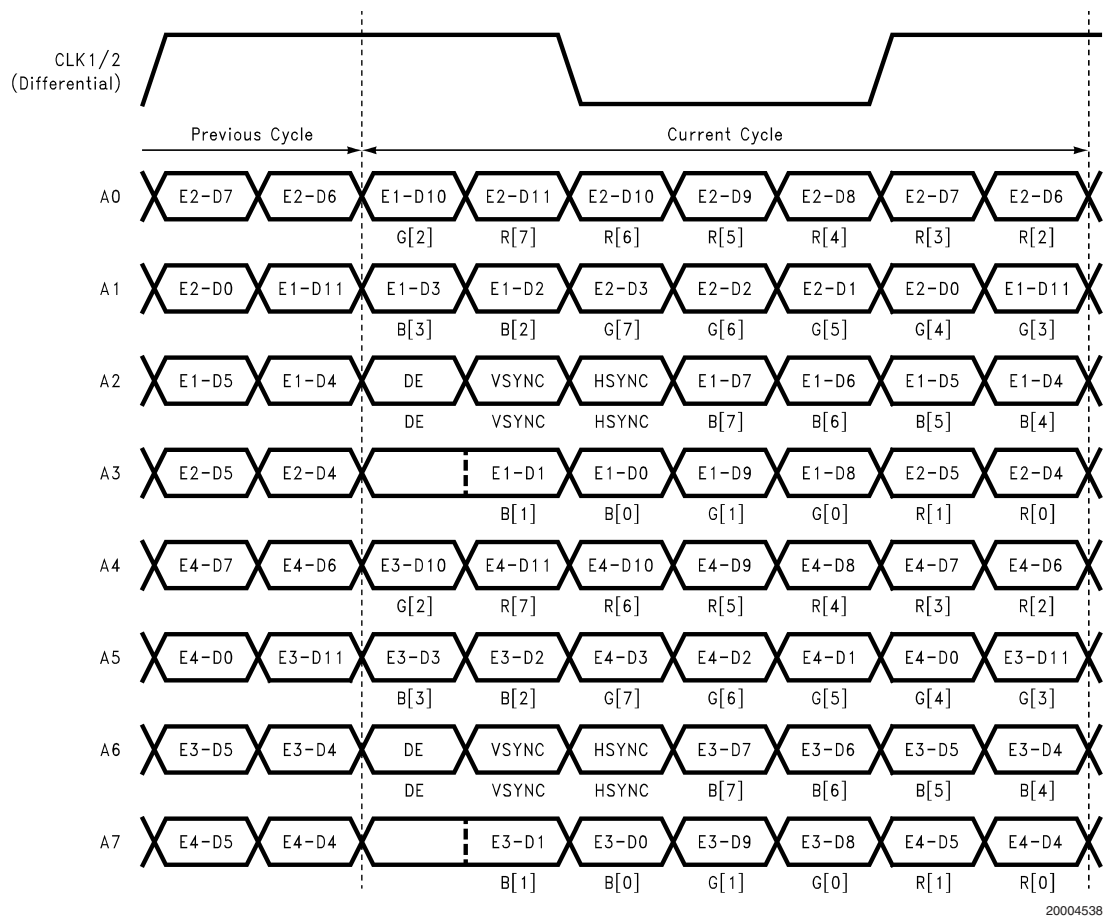


LVDS Interface (Continued)



**FIGURE 15. 24bit/48bit Conventional Data Inputs Mapped to LVDS Outputs**  
 (BAL = Gnd, DUAL = Gnd for A0 to A3-first pixel, DUAL = V<sub>CC</sub> for A0 to A7-first pixel and second pixel)

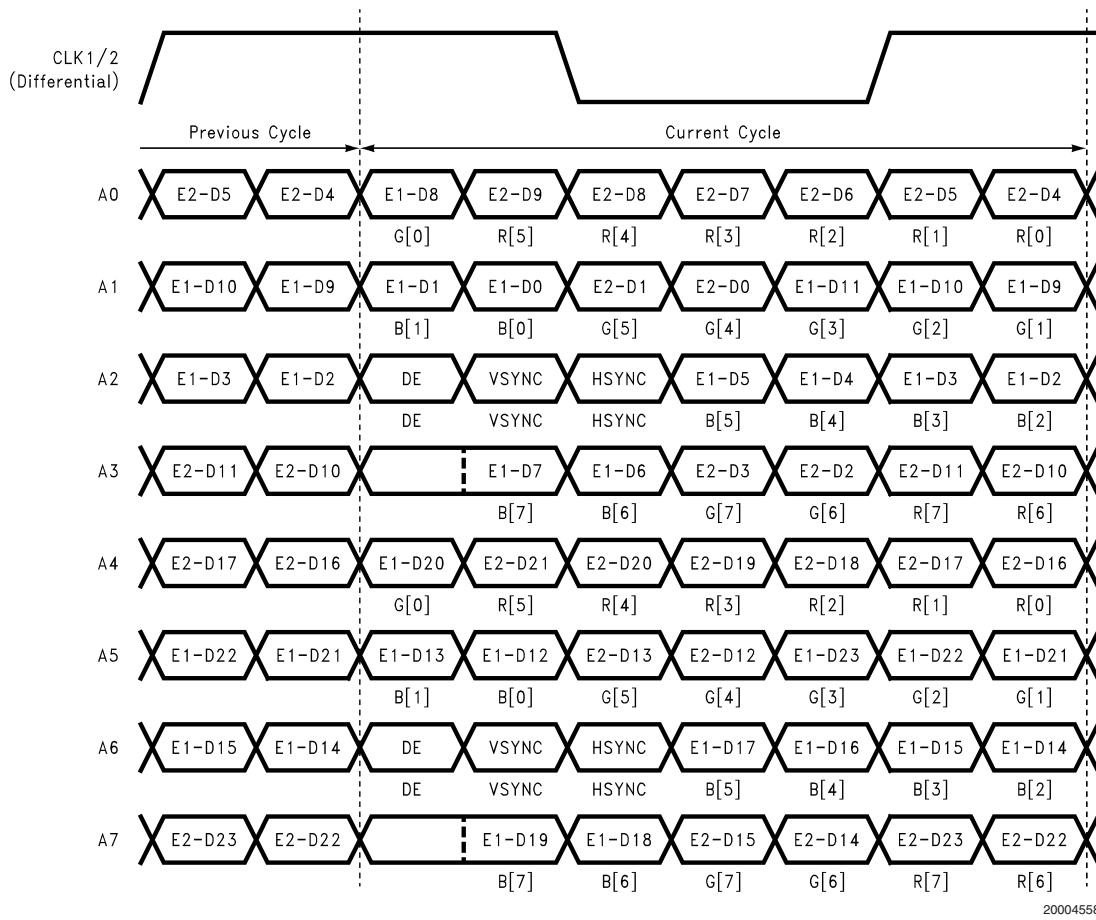
# LVDS Interface (Continued)



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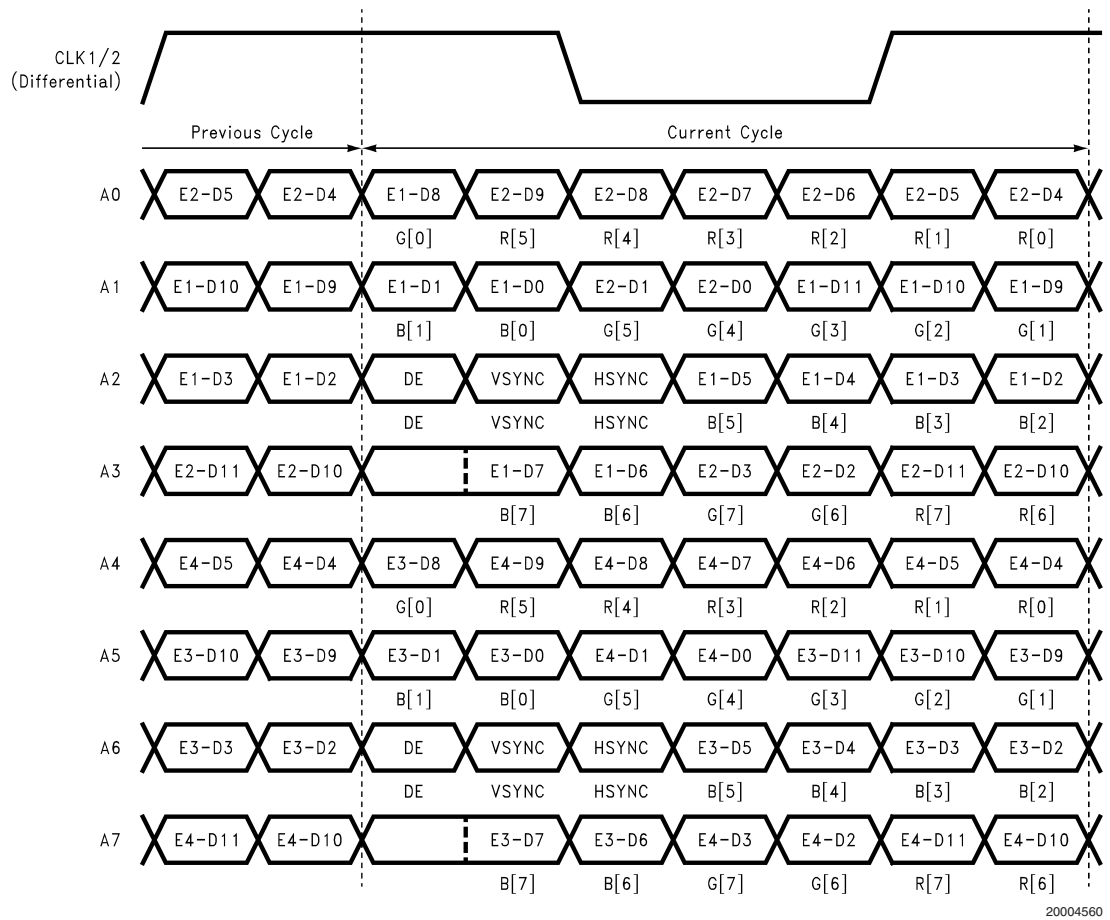
**FIGURE 16. 24bit/48bit Conventional Data Inputs Mapped to LVDS Outputs**  
 ( BAL = Gnd, DUAL = 1/2V<sub>CC</sub> for A0 to A7-first pixel and second pixel)

**LVDS Interface** (Continued)



**FIGURE 17. 24bit/48bit Non-Conventional Data Inputs Mapped to LVDS Outputs**  
 (BAL = Gnd, DUAL = Gnd for A0 to A3-first pixel, DUAL = V<sub>CC</sub> for A0 to A7-first pixel and second pixel)

# LVDS Interface (Continued)



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**FIGURE 18. 24bit/48bit Non-Conventional Data Inputs Mapped to LVDS Outputs**  
 (BAL = Gnd, DUAL = 1/2V<sub>CC</sub> for A0 to A7-first pixel and second pixel)

## Scaler Information

### DVO Input and Bypass Mode:

The input single port DVO data is translated into 18bit/24bit RGB data for scaling. Single port data over 108MHz or dual port data will be bypassed and not scaled. The LVDS output can be single or dual port.

### Input Timing Control:

The DS90C2501 input timing control can detect the input timing information such as horizontal and vertical sync width, pixel-total and line-total count and the active video starting and ending positions. Such information can be provided to the host through two-wire serial communication Interface to help determine the input mode.

### Display Synchronization

The DS90C2501 synchronizes the display timing with input graphics timing so that no external frame buffer is needed. There are three operation modes:

**Free-run mode:** No synchronization. Output timing is generated from external 14.318MHz reference clock.

**Line lock mode:** the display Hsync is synchronized with the input line rate.

**Frame lock mode:** the display Vsync is synchronized with the input frame rate.

In free-run mode, the display timing is decided by the values programmed into the various timing registers. In line-lock mode, the display line rate is a function of the selected input clock, forcing the output frame rate to be locked to input

frame rate. Timing management is more complicated. The frame-lock mode is used more often. The output pixel clock and Hsync are generated from the external 14.318MHz reference clock and the embedded PLL, but the Vsync is refreshed at the input frame rate.

### Gamma Look-up Table (LUT):

The DS90C2501 provides an 8-bit look-up-table (LUT) for each input color channel in case gamma correction is needed. The LUT is user programmable to provide an arbitrary transfer function.

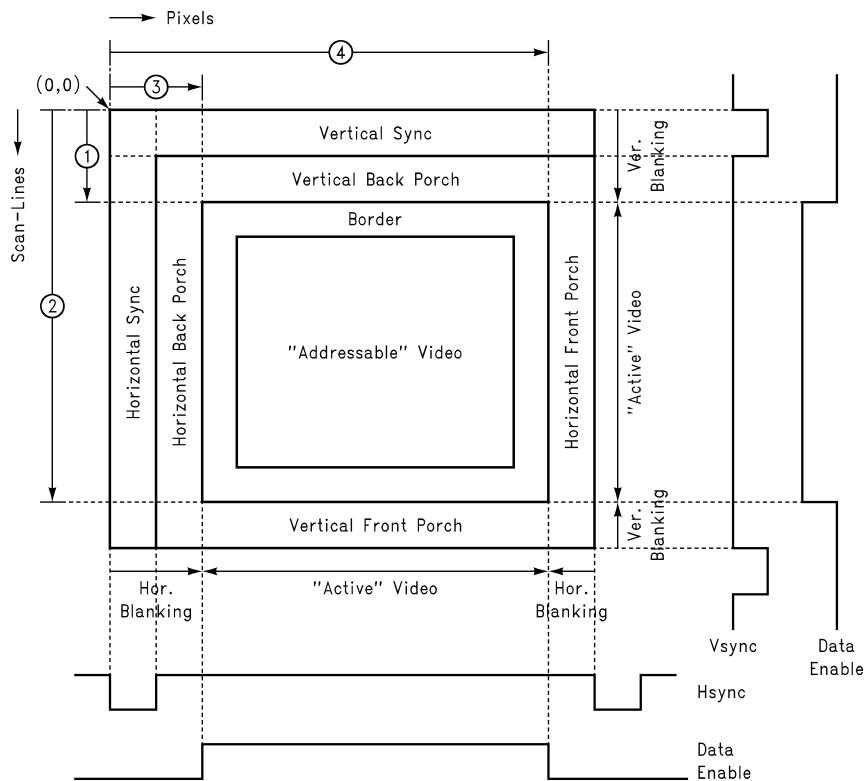
The transmitter is offered with programmable edge data strobes for convenient interface with a variety of graphics controllers. The transmitter can be programmed for rising edge strobe or falling edge strobe through a dedicated pin. A rising edge transmitter will inter-operate with a falling edge receiver without any translation logic.

### Output Timing Control:

The DS90C2501 output timing is fully programmable through two-wire serial communication Interface for different panel requirements. When 6-bit color LCD is used, dithering (FRC) can be turned on via two-wire serial communication programming interface. The least two LSB of each color are default to be logic low all the time. When 8-bit color LCD is used, dithering (FRC) is not needed, and can be turned off via two-wire serial communication programming interface.

See DS90C2501 guide for further information on programming these features.

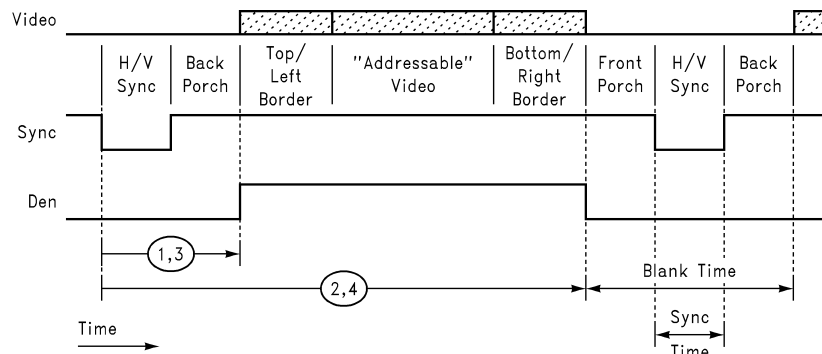
# Scaler Information (Continued)



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|   |                                 |
|---|---------------------------------|
| 1 | Vertical Scaling Region Start   |
| 2 | Vertical Scaling Region End     |
| 3 | Horizontal Scaling Region Start |
| 4 | Horizontal Scaling Region End   |

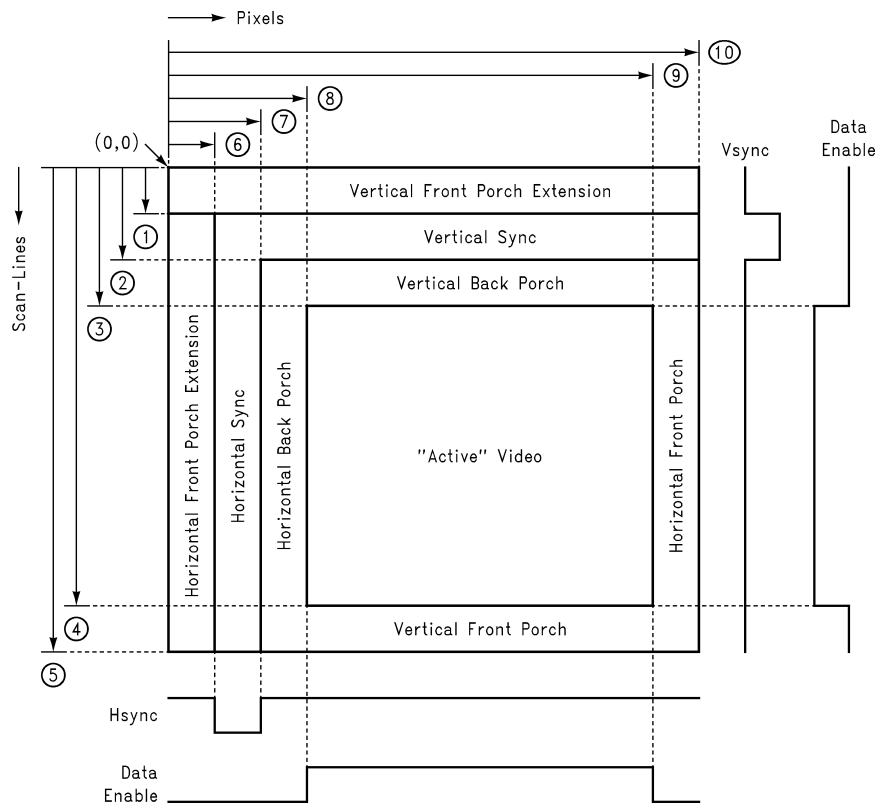
FIGURE 19. Input Timing of DS90C2501 scaler 1 of 2



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FIGURE 20. Input Timing of DS90C2501 scaler 2 of 2

Scaler Information (Continued)

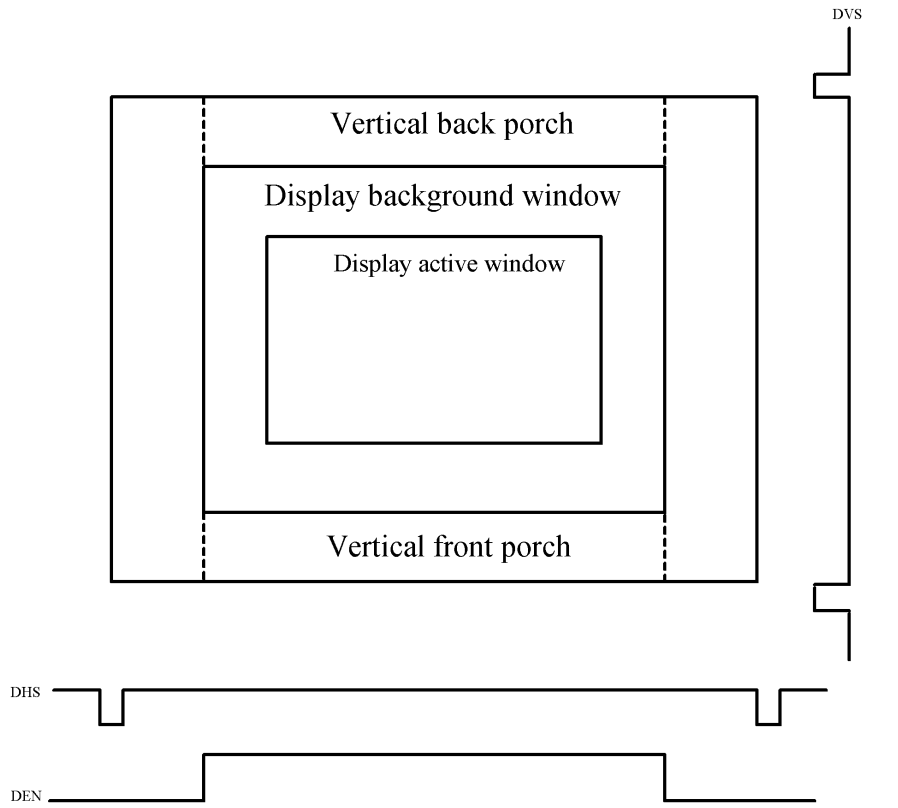


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|    |   |
|----|---|
| 1  | Vsync start.                            |
| 2  | Vsync end.                              |
| 3  | Vertical action region start.           |
| 4  | Vertical action region end.             |
| 5  | Total vertical scan-lines in a frame.   |
| 6  | Hsync start.                            |
| 7  | Hsync end.                              |
| 8  | Horizontal active region start.         |
| 9  | Horizontal active region end.           |
| 10 | Total horizontal pixels in a scan-line. |

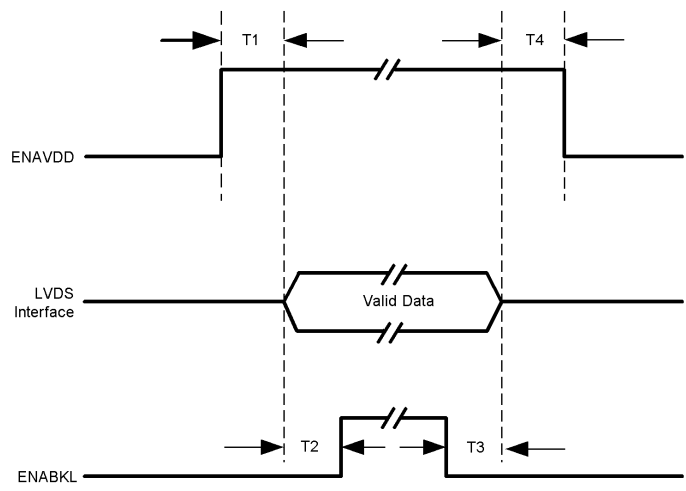
FIGURE 21. Display Signal Timing of DS90C2501 scaler 1 of 2

**Scaler Information** (Continued)



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**FIGURE 22. Display Signal Timing of DS90C2501 scaler 2 of 2**



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**FIGURE 23. Sample LCD Power Up Sequence**



## Applications Information

How to configure the DS90C2501 with DS90C364 or DS90CF364A or DS90CF366 for most common application:

1. To configure for single pixel in to single pixel out application using the DS90C2501 with DS90CF364 or DS90CF364A or DS90CF366, the "DUAL" pin must be set to Gnd (single). In this mode, outputs A0-to-A3 and CLK1 are enabled, and outputs A4-to-A7 and CLK2 are disabled which reduces power dissipation.

### Features Description:

**2. Programmable Primary Edge E1:** The transmitter is latching data on both the rising and falling edges of clock signal coming in on CLKINP pin. The EDGE pin can be used to program to select the rising edge of CLKINP as the primary edge E1 or to have the falling edge of CLKINP as the primary edge E1. However, the logic state of the EDGE pin must agree with the GUI to generate the correct display.

**TABLE 10. Connection for SISO Operation**

| From DS90C2501             | To GMCH                                    |
|----------------------------|--|
| RGB data signal connection |  |
| D0                         | DVOxDATA0                                  |
| D1                         | DVOxDATA1                                  |
| D2                         | DVOxDATA2                                  |
| D3                         | DVOxDATA3                                  |
| D4                         | DVOxDATA4                                  |
| D5                         | DVOxDATA5                                  |
| D6                         | DVOxDATA6                                  |
| D7                         | DVOxDATA7                                  |
| D8                         | DVOxDATA8                                  |
| D9                         | DVOxDATA9                                  |
| D10                        | DVOxDATA10                                 |
| D11                        | DVOxDATA11                                 |
| D12 to D23                 | GND  |
| CLKINP                     | DVOxCLKOUT1                                |
| CLKINM                     | DVOxCLKOUT0                                |
| DE                         | DVOxBLANK                                  |
| HSYNC                      | DVOxHSYNC                                  |
| VSYNC                      | DVOxVYSNC                                  |
| connection for other pins  |  |
| DUAL                       | GND  |
| EDGE                       | GND  |
| BAL                        | GND  |
| A0                         | Pull Up/Pull Down, Based on Device Address |
| A1                         | Pull Up/Pull Down, Based on Device Address |
| A2                         | Pull Up/Pull Down, Based on Device Address |
| ID0                        | Pull Up/Pull Down, Based on Panel ID       |
| ID1                        | Pull Up/Pull Down, Based on Panel ID       |
| ID2                        | Pull Up/Pull Down, Based on Panel ID       |
| ID3                        | Pull Up/Pull Down, Based on Panel ID       |
| RES1                       | GND  |
| RES2                       | GND  |
| RES3                       | GND  |
| RES4                       | GND  |
| TST1                       | GND  |
| TST2                       | GND  |
| TST3                       | GND  |
| S2Cclk                     | I2CCLK                                     |
| S2Cdat                     | I2CDATA                                    |
| REFCLK                     | 3V 14.31818MHz                             |
| COLOR                      | GND  |

**Applications Information** (Continued)**TABLE 10. Connection for SISO Operation** (Continued)

|                           |                                     |
|---------------------------|-------------------------------------|
| $\overline{\text{PD}}$    | DVCC or equivalent                  |
| $\overline{\text{RSETN}}$ | DVCC or equivalent                  |
| VREF                      | $\frac{1}{2}V_{\text{DDQ}}$ of GMCH |

## Applications Information (Continued)

see *Table 10*. The “DUAL” pin must be set to Gnd. In this mode, outputs A0-to-A7, and CLK1, CLK2 are enabled.

3. To configure for single pixel in to dual pixel out application using the DS90C2501 for Single-In-Single-Out operation,

**TABLE 11. Connection for SIDO Operation**

| From DS90C2501             | To GMCH                                    |
|----------------------------|--|
| RGB data signal connection |  |
| D0                         | DVOxDATA0                                  |
| D1                         | DVOxDATA1                                  |
| D2                         | DVOxDATA2                                  |
| D3                         | DVOxDATA3                                  |
| D4                         | DVOxDATA4                                  |
| D5                         | DVOxDATA5                                  |
| D6                         | DVOxDATA6                                  |
| D7                         | DVOxDATA7                                  |
| D8                         | DVOxDATA8                                  |
| D9                         | DVOxDATA9                                  |
| D10                        | DVOxDATA10                                 |
| D11                        | DVOxDATA11                                 |
| D12 to D23                 | GND  |
| CLKINP                     | DVOxCLKOUT1                                |
| CLKINM                     | DVOxCLKOUT0                                |
| DE                         | DVOxBLANK                                  |
| HSYNC                      | DVOxHSYNC                                  |
| VSYNC                      | DVOxVYSNC                                  |
| connection for other pins  |  |
| DUAL                       | $\frac{1}{2}VCC$                           |
| EDGE                       | GND  |
| BAL                        | GND  |
| A0                         | Pull Up/Pull Down, Based on Device Address |
| A1                         | Pull Up/Pull Down, Based on Device Address |
| A2                         | Pull Up/Pull Down, Based on Device Address |
| ID0                        | Pull Up/Pull Down, Based on Panel ID       |
| ID1                        | Pull Up/Pull Down, Based on Panel ID       |
| ID2                        | Pull Up/Pull Down, Based on Panel ID       |
| ID3                        | Pull Up/Pull Down, Based on Panel ID       |
| RES1                       | GND  |
| RES2                       | GND  |
| RES3                       | GND  |
| RES4                       | GND  |
| TST1                       | GND  |
| TST2                       | GND  |
| TST3                       | GND  |
| S2Cclk                     | I2CCLK                                     |
| S2Cdat                     | I2CDATA                                    |
| REFCLK1                    | 3V 14.31818MHz                             |
| COLOR                      | GND  |
| $\overline{PD}$            | DVCC or equivalent                         |
| $\overline{RSETN}$         | DVCC or equivalent                         |
| VREF                       | $\frac{1}{2}V_{DDQ}$ of GMCH               |

## Applications Information (Continued)

4. To configure for dual pixel in to dual pixel out application using the DS90C2501 with DS90CF364 or DS90CF364A or DS90CF366, the "DUAL" pin must be set to  $V_{CC}$ . In this mode, outputs A0-to-A7, and CLK1, CLK2 are enabled. Do note that scaler will be shut down in this configuration.

### Board Layout and Thermal Considerations for the DS90C2501

Note: The thermal information listed in this document is based on preliminary simulation results and subject to change.

The thermal enhancement features of the (CSP) chip scale package require special considerations and guidelines to be observed to insure optimal thermal performance in applications where the cooling method is free-air convection.

The CSP128 package has a 5X5 matrix of thermal pads designed to efficiently conduct heat from the device to the plane of the printed circuit board. The package requires this thermal connection to increase the effective surface area of the package to maintain safe operating die temperatures. The vias of the thermal pads should be connected to the board's ground plane having a minimum effective area of 2000 mm<sup>2</sup>.

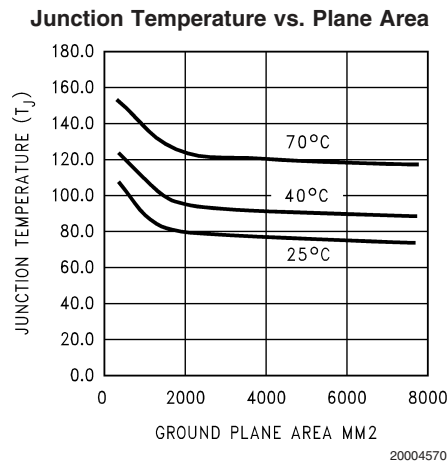
For more complex system thermal design situations, it is recommended that system level thermal analysis tools be utilized to insure the maximum junction temperature is not exceeded.

The graph in *Figure 24* shows the expected junction temperature for a given plane area under varying ambient temperature conditions. *Figure 25* shows the recommended PCB footprint for the DS90C2501. The following assumptions were used:

- Board Thickness = 1.6mm
- Board Area = 7742 sq. mm
- Copper Plane = 1 oz.
- Number of layers = 4
- Signal Trace Length = 25.4mm
- Maximum Junction Temperature = +150°C
- Package  $\theta_{JA} = 31.7^\circ\text{C/W}$  (Natural Convection)
- The example does not take heating effects from adjacent system components into consideration.
- Pd (max) = 1.8W\*

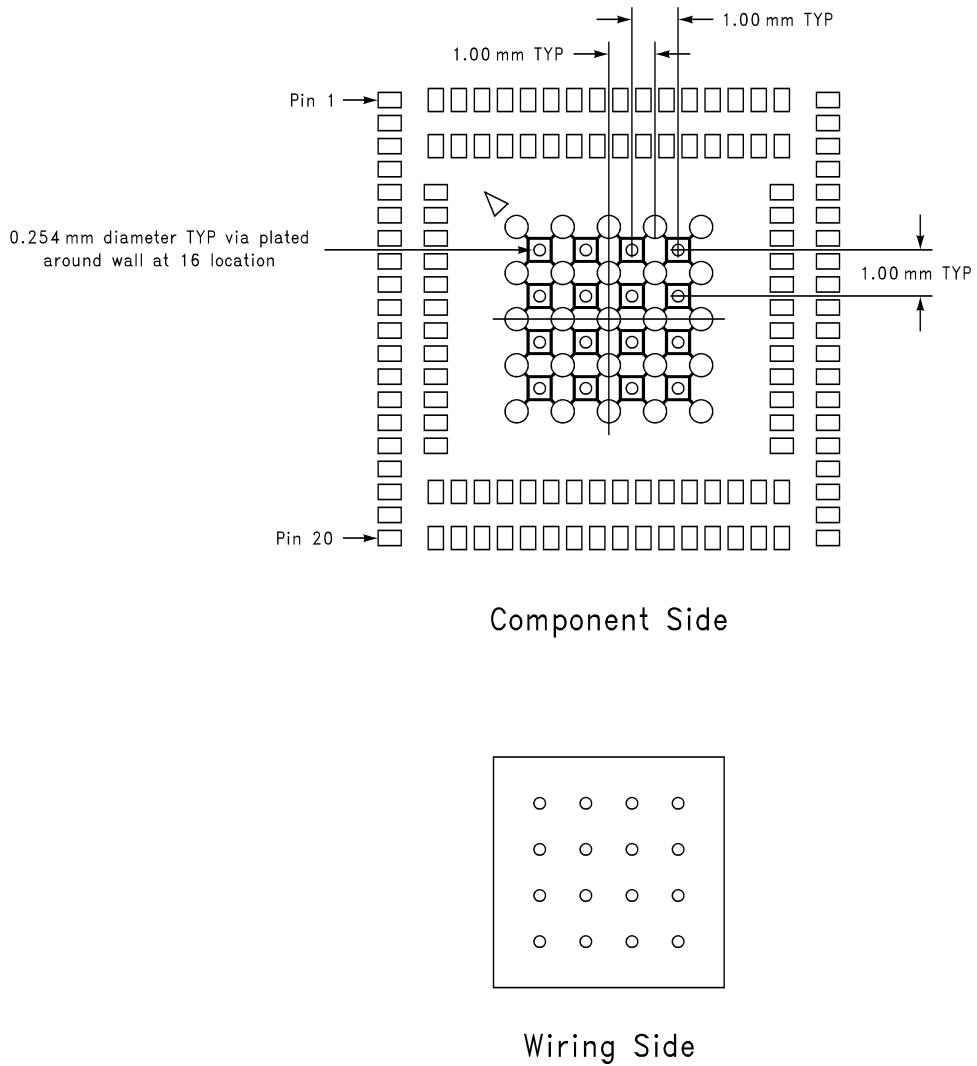
\*(scaler on, SXGA to SXGA+ scaling, single in -dual output port mode,  $V_{DD}2.5 +10\%$ ,  $V_{DD}3.3 +10\%$ , max. process variation)

As a final design verification, the temperature at the top-center of the case ( $T_{CASE}$ ) should not exceed 97°C.



**FIGURE 24. Junction Temperature vs. Ground Plane Area**

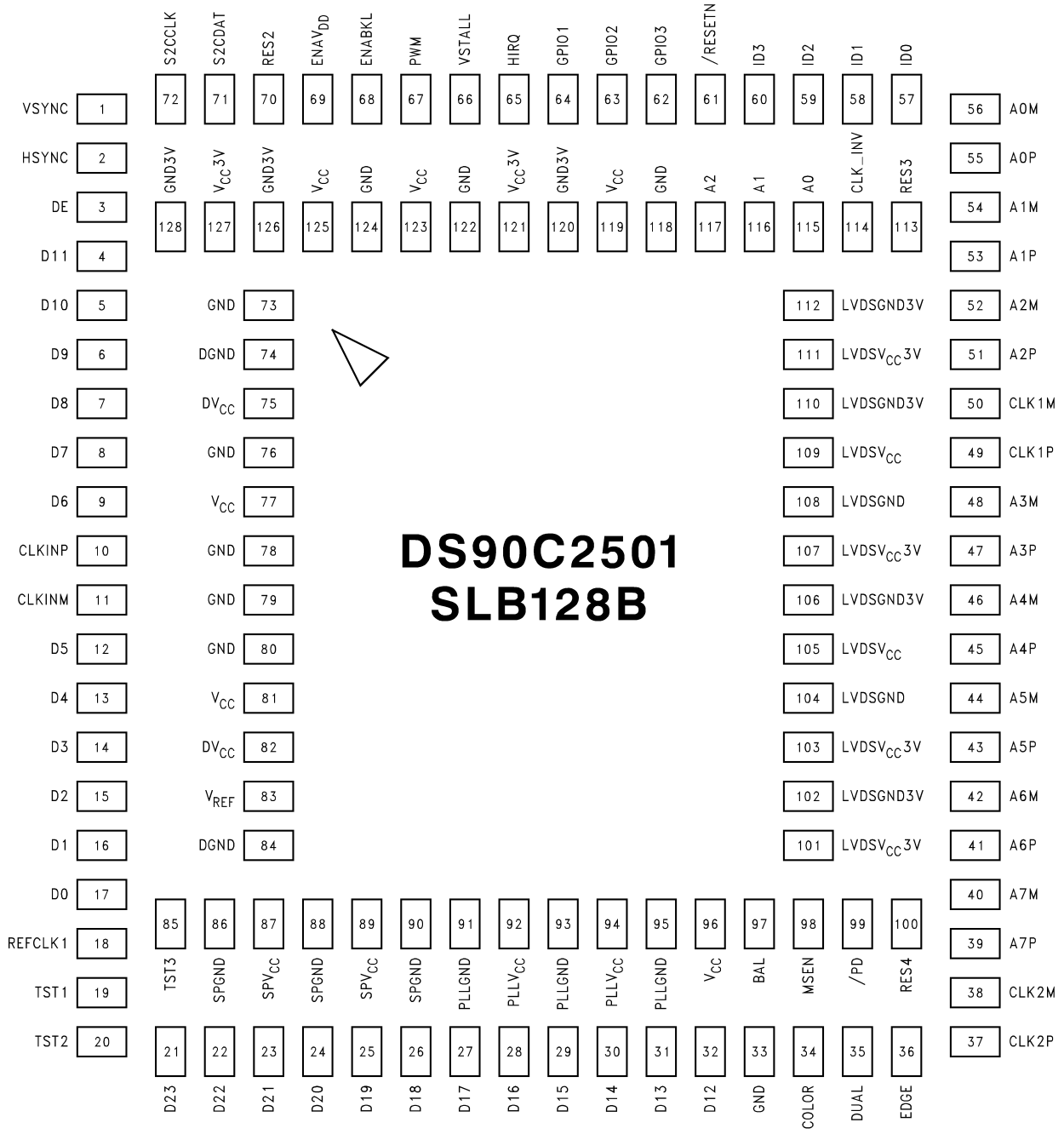
Applications Information (Continued)



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FIGURE 25. Recommended Land Pattern Component Side (1) and Wiring Side (2) of Board with Thermal Pads Connected to Ground Plane of PCB.

Pin Diagram

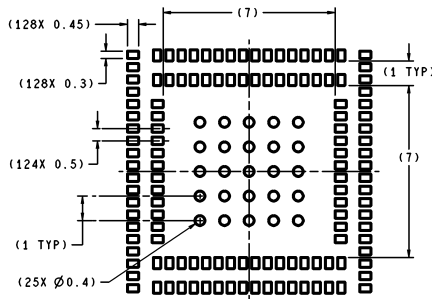


**DS90C2501  
SLB128B**

**Top View of DS90C2501**

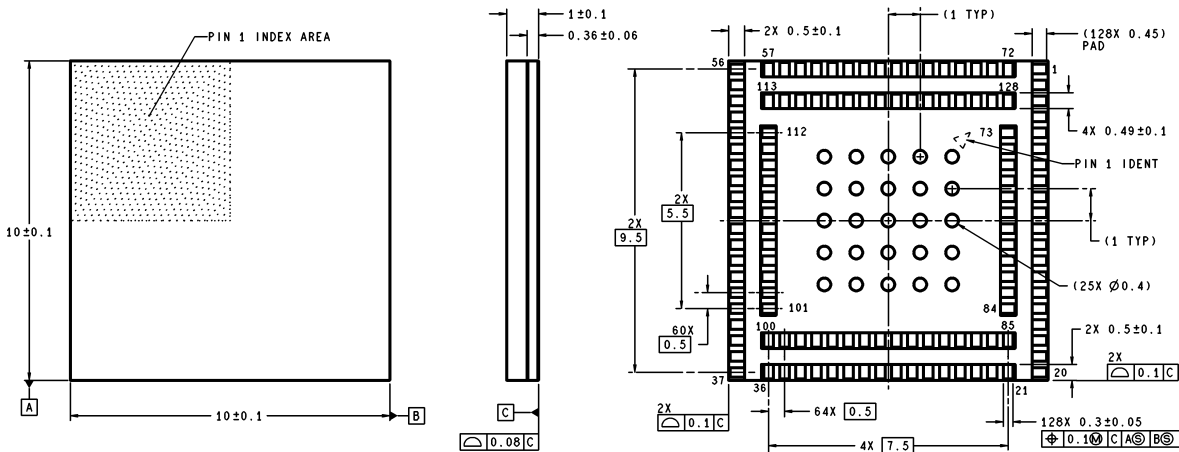
20004564

**Physical Dimensions** inches (millimeters) unless otherwise noted



RECOMMENDED LAND PATTERN  
1:1 RATIO WITH PACKAGE SOLDER PADS

DIMENSIONS ARE IN MILLIMETERS



SLB128B (Rev B)

Dimensions show in millimeters  
 Order Number DS90C2501SLB  
 NS Package Number SLB128B  
 Refer to Application Note AN1125 for more information

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# DS90C2501 Transmitter with built-in scaler for LVDS Display Interface (LDI)

