



July 2004

## FPD87392BXB +3.3V TFT-LCD Timing Controller with Dual LVDS Inputs/Dual RSDS™ Outputs for TFT-LCD Monitor and Notebook (SXGA/SXGA+/UXGA)

### General Description

The FPD87392BXB Panel Timing Controller is an integrated FPD-Link + RSDS™ + TFT-LCD Timing Controller. The logic architecture is implemented using standard and default timing controller functionality based on an Embedded Gate Array. The device is reconfigurable to the needs of a specific application by providing user-defined specifications or customer supplied VHDL/Verilog code.

The FPD87392BXB is a timing controller that combines an LVDS dual pixel input interface with National's Reduced Swing Differential Signaling (RSDS™) output column driver interface for SXGA, SXGA+ and UXGA resolutions. It resides on the TFT-LCD panel and provides the data buffering and control signal generation. The RSDS™ data path to the column driver contributes toward lowering radiated EMI and reduced system dynamic power consumption. The RSDS™ dual 12 pair differential bus conveys up to 24-bit color data for SXGA/SXGA+/UXGA panels when using VESA 60Hz standard timing.

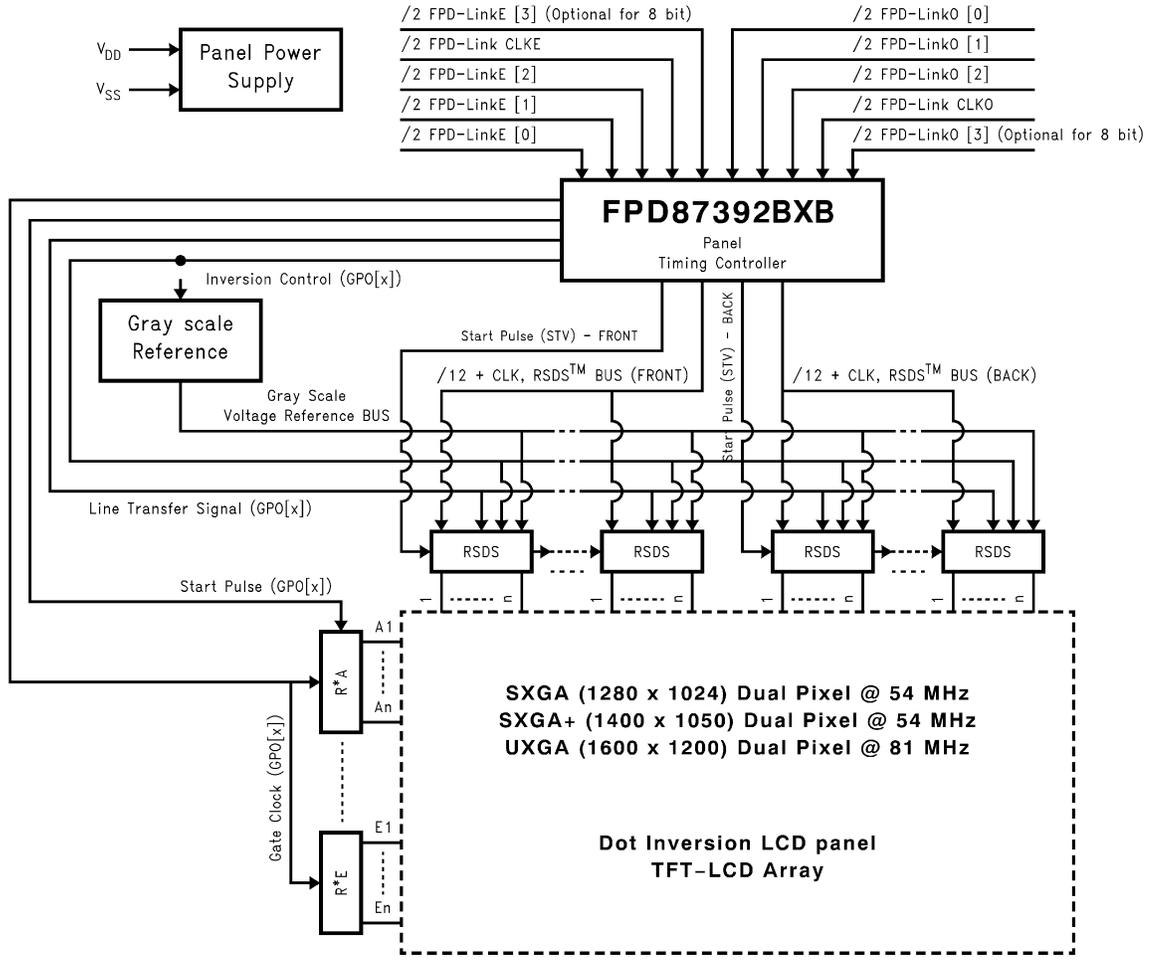
### Features

- Input frequency range from 25 MHz to 85 MHz
- Support display resolutions SXGA (1280x1024), SXGA+ (1400x1050) and UXGA (1600x1200)
- Embedded gate array for custom panel timing
- RSDS™ (Reduced Swing Differential Signaling) Column Driver bus for low power and reduced EMI
- Drives RSDS™ column driver up to 170 Mb/s with an 85 MHz clock
- 6 or 8 bit LVDS dual pixel input interface (FPD-Link)
- Virtual 8-bit color depth in FRC mode
- Flexible RSDS™ data output mapping for Bottom or Top mount
- Supports 1 and 2 line inversion mode for RVS output
- Supports Graphics Controllers with spread spectrum interface for lower EMI
- Free Run Mode Function
- Fail-safe function in DE mode (Bonding Option)
- Supports DE mode and SYNC only mode (Bonding Option)
- Power-On-Reset Support
- CMOS circuitry operates from a 3.0V to 3.6V supply
- 128 TQFP package with body size 14mm x 14mm x 1.0mm, 0.4mm Pitch

FPD87392BXB +3.3V TFT-LCD Timing Controller with Dual LVDS Inputs/Dual RSDS™ Outputs for TFT-LCD Monitor and Notebook (SXGA/SXGA+/UXGA)



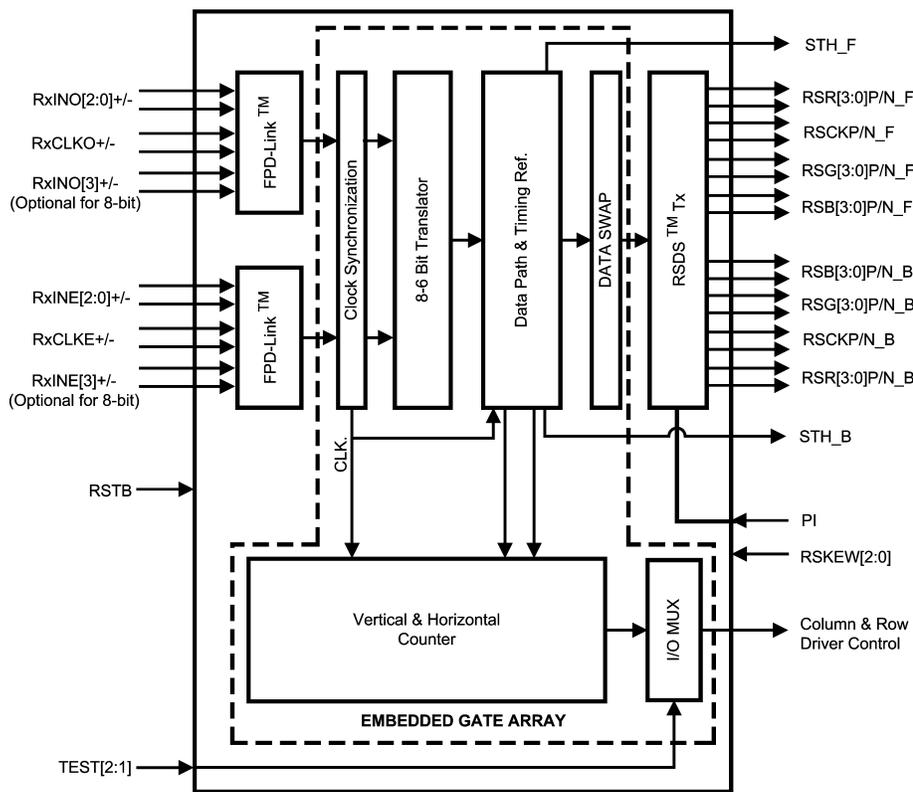
# System Diagram



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FIGURE 1. Block Diagram of the LCD Module

## Block Diagram



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FIGURE 2. Block Diagram

## Functional Description

### DUAL FPD-LINK RECEIVERS

The LVDS based FPD-Link Receivers inputs video data and control timing through 8 pairs of LVDS channels plus 2 pairs of LVDS clocks to provide 24-bit color or use only 6 pairs of LVDS channels plus 2 LVDS clocks to provide 18-bit color. The video data is converted to a parallel data stream and routed to the 8-6 bit translator.

### SPREAD SPECTRUM SUPPORT

The FPD-Link receiver supports graphics controllers with Spread Spectrum interfaces for reducing EMI. The Spread Spectrum methods supported are Center and Down Spread. A maximum of 2% total is supported at a frequency modulation of 100kHz maximum.

### 8-6 BIT TRANSLATOR

8-bit data is reduced to a 6-bit data path via a time multiplexed dithering technique or simple truncation of the LSBs. This function is enabled via the input control pins.

### DATAPATH BLOCK AND RSDS TRANSMITTER

6(8)-bit video data (RGB) is input to the Datapath Block supports up to an 85 MHz dual pixel rate. The data is delayed to align the Column Driver Start Pulse (STH) with the Column Driver data. The dual data bus (RSR[3:0]P/N, RSG[3:0]P/N, RSB[3:0]P/N) outputs at a 170 MHz rate on 24 differential output channels. The clock is output on the

(Front, Back) RSCKP/N differential pairs. The RSDS Column Drivers latch data on both positive and negative edges of the clock. The swap function provides flexible RSDS data output mappings for either Top or Bottom mount. The RSDS output setup/hold timings are also adjustable through the RSKEW[2:0] input pins.

### TIMING CONTROL FUNCTION

The Timing Control function generates control to Column Drivers, Row Drivers, and power supply. The GPOs (General Purpose Outputs) provide for CD latch pulse, REV, and Row Driver control generation. The General Purpose Outputs allow the user to generate control anywhere within the frame data. Standard Row Driver interface or Custom Row Driver interfaces can be implemented with the GPOs (General Purpose Outputs).

### RSDS OUTPUT VOLTAGE CONTROL

The RSDS output voltage swing is controlled through an external load resistor connected to the RPI pin. The RSDS output signal levels can be adjusted to suit the particular application. This is dependent on overall LCD module design characteristics such as trace impedance, termination, etc. The RSDS output voltage is inversely related to the RPI value. Lower RPI values will increase the RSDS output voltage swing and consequently overall power consumption will also increase.

### 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 ( $V_{DD}$ )	-0.3V to +4.0V
DC TTL Input Voltage ( $V_{IN}$ )	-0.3V to ( $V_{DD} + 0.3V$ )
DC LVDS Input Voltage ( $V_{IN}$ )	-0.3V to ( $V_{DD} + 0.3V$ )
DC Output Voltage ( $V_{OUT}$ )	-0.3V to ( $V_{DD} + 0.3V$ )
Junction Temperature	+150°C
Storage Temperature Range ( $T_{STG}$ )	-65°C to +150°C
Lead Temperature ( $T_L$ ) (Soldering 10 sec.)	260°C

ESD Rating:

( $C_{ZAP} = 120$  pF,  
 $R_{ZAP} = 1500W$ )

MM = 200V,  
HBM = 2000V

### Operating Conditions

	Min	Max	Units
Supply Voltage ( $V_{DD}$ )	3.0	3.6	V
Operating Temp. Range ( $T_A$ )	0	70	°C
Supply Noise Voltage		100	mV <sub>PP</sub>

### DC Electrical Characteristics

$T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$ ,  $V_{DD} = 3.0V$  to  $3.6V$ ,  $I_{PI} = 100 \mu\text{A}$  (Unless otherwise specified)

### TTL DC Electrical Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$V_{DD}$	Core Supply Voltage		3.0	3.3	3.6	V
$V_{IH}$	Minimum Input High Voltage		2.0			V
$V_{IL}$	Maximum Input Low Voltage				0.8	V
$V_{OH}$	Output High Voltage	$I_{OH} = -8\text{mA}$	$V_{DD} - 0.6$			V
$V_{OL}$	Output Low Voltage	$I_{OL} = 8 \text{mA}$			0.4	V
$I_{IN}$	Input Current	$V_{IN} = V_{DD}, \text{GND}$			$\pm 10$	$\mu\text{A}$
$I_{PU}$	Pull-Up Current	$V_{DD} = 3.3V, V_{IN} = V_{DD}$			-50	$\mu\text{A}$
$I_{PD}$	Pull-Down Current	$V_{DD} = 3.3V, V_{IN} = \text{GND}$			+50	$\mu\text{A}$
$I_{DD}$	Average Supply Current	$C_{L(TTL)} = 15 \text{pF}$ , $R_{L(RSDS)} = 100\Omega$ and $C_{L(RSDS)} = 5 \text{pF}$ (jig & test fixture capacitance), $I_{PI} = 100 \mu\text{A}$ (Typically PI pin connected to 13 k $\Omega$ to ground), See Figure 3 for input conditions		170 (CLK = 65 MHz, $V_{DD} = 3.3V$ )	250 (CLK = 85 MHz, $V_{DD} = 3.6V$ )	mA

**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 devices should be operated at these limits. The table of "Electrical Characteristics" specifies conditions of device operation.

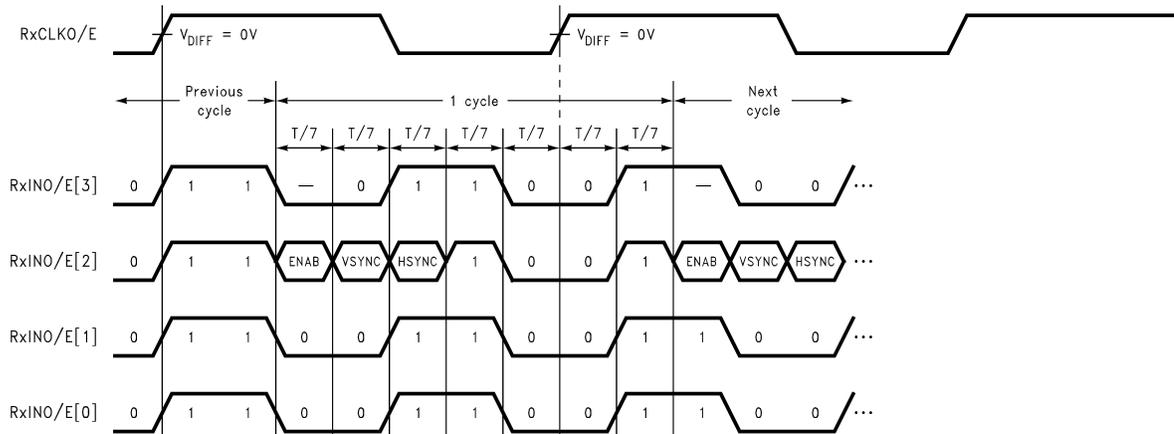


FIGURE 3. FPD-Link Receiver Input Pattern Used to Measure  $I_{DD}$

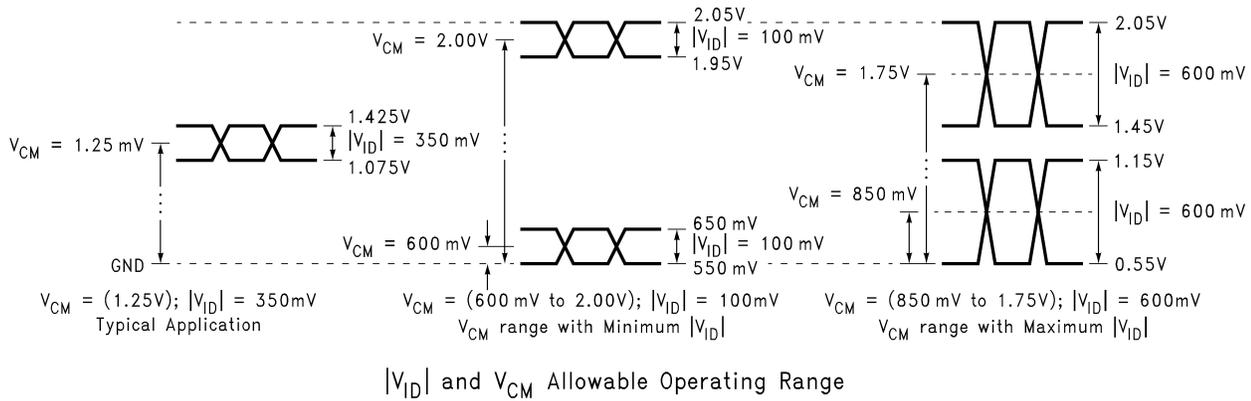
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## DC Electrical Characteristics

$T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$ ,  $V_{DD} = 3.0\text{V}$  to  $3.6\text{V}$ ,  $I_{PI} = 100\ \mu\text{A}$  (Unless otherwise specified) (Continued)

### FPD-Link (LVDS) Receiver Input Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>LVDS RECEIVER DC SPECIFICATIONS</b>						
<b>Note: LVDS Receiver DC parameters are measured under static and steady state conditions which may not reflect the actual performance in the end application.</b>						
$V_{THLVDS}$	Differential Input High Threshold Voltage	$V_{CM} = 1.2\text{V}$			+100	mV
$V_{TLVDS}$	Differential Input Low Threshold Voltage		-100			mV
$I_{IN}$	Input Current	$V_{IN} = 2.05\text{V}$ , $V_{DD} = 3.6\text{V}$			$\pm 10$	$\mu\text{A}$
		$V_{IN} = 0.55\text{V}$ , $V_{DD} = 3.6\text{V}$			$\pm 10$	$\mu\text{A}$
$V_{IN}$	Input Voltage Range (Single-ended)	$V_{DD} = 3.0 - 3.6\text{V}$	0.55		2.00	V
$ V_{ID} $	Differential Input Voltage		0.100		0.600	V
$V_{CM}$	Common Mode Voltage Offset	$V_{DD} = 3.0 - 3.6\text{V}$	$0.55 +  V_{ID} /2$		$2.05 -  V_{ID} /2$	V



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**FIGURE 4. FPD-Link Receiver  $V_{ID}$  and  $V_{CM}$  Definitions**

## DC Electrical Characteristics

$T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$ ,  $V_{DD} = 3.0\text{V}$  to  $3.6\text{V}$ ,  $I_{PI} = 100\ \mu\text{A}$  (Unless otherwise specified) (Continued)

### RSDS Output

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$V_{OD_{RSDS}}$	Differential Output Voltage	$R_L = 100\ \Omega$		$\pm 200$		mV
$V_{OS_{RSDS}}$	Offset Voltage		1.1	1.3	1.5	V

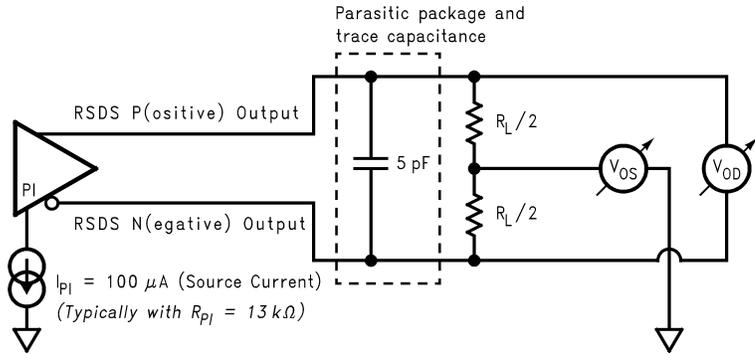


FIGURE 5. RSDS  $V_{OD}$  and  $V_{OS}$  Test Circuit

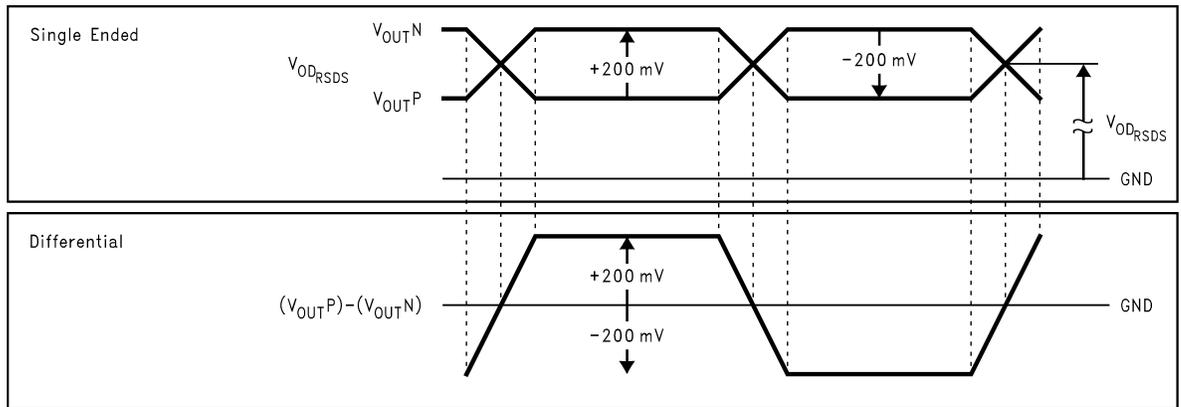


FIGURE 6. RSDS Output Waveforms: Single Ended vs Differential

# AC Electrical Characteristics

$T_A = 0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ ,  $V_{DD} = 3.0\text{V}$  to  $3.6\text{V}$ ,  $I_{PI} = 100\ \mu\text{A}$  (Unless otherwise specified)

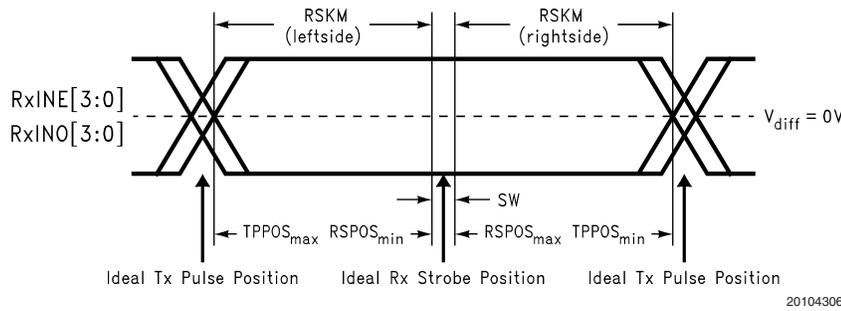
## LVDS Data Input

Symbol	Parameter	Conditions	Min	Max	Units
RPLLS	FPD-Link Receiver Phase Lock Loop Wake-up Time			10	ms
RSKM	RxIN Skew Margin (Note 2) and (Figure 7)	$V_{DD} = 3.3\text{V}$ , $\text{CLK} = 85\ \text{MHz}$	240		ps

**Note 2:** Receiver Skew Margin is defined as the valid data sampling region at the receiver inputs. This margin takes into account transmitter 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 and length of cable), and source clock (FPD-Link Transmitter TxCLK IN) jitter. The specified RSKM minimum assumes a TPPOS max of 200 ps.

**RSKM = cable skew (type, length) + source clock jitter (cycle to cycle) + remaining margin for data sampling ( $\geq 0$ )**

This parameter is guaranteed by design. The limits are based on statistical analysis of the device performance over PVT (Process, Voltage, Temperature) range.



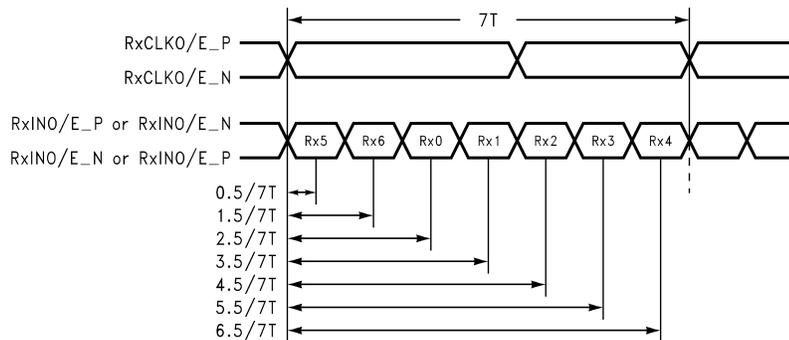
**Acronyms:**

- RSKM Receiver Skew Margin
- TPPOS Transmitter Pulse Position
- RSPOS Receiver Strobe Position
- SW Strobe Width

**Definitions:**

- SW: Setup and Hold Time (Internal data sampling window)
- RSKM: Cable Skew (type, length) + Source Clock Jitter (cycle to cycle) + Remaining margin for data sampling ( $\geq 0$ )
- Cable Skew: Typically 10 ps – 40 ps per foot.

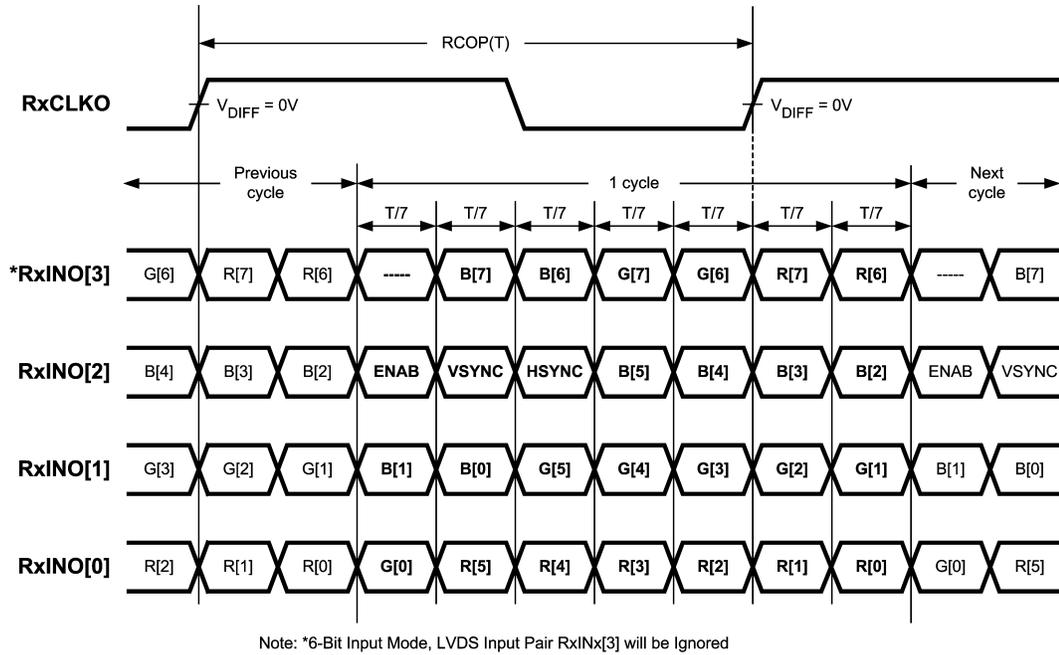
**FIGURE 7. FPD-Link Receiver Input Skew Margin**



**FIGURE 8. Ideal Strobe Position for LVDS Input**

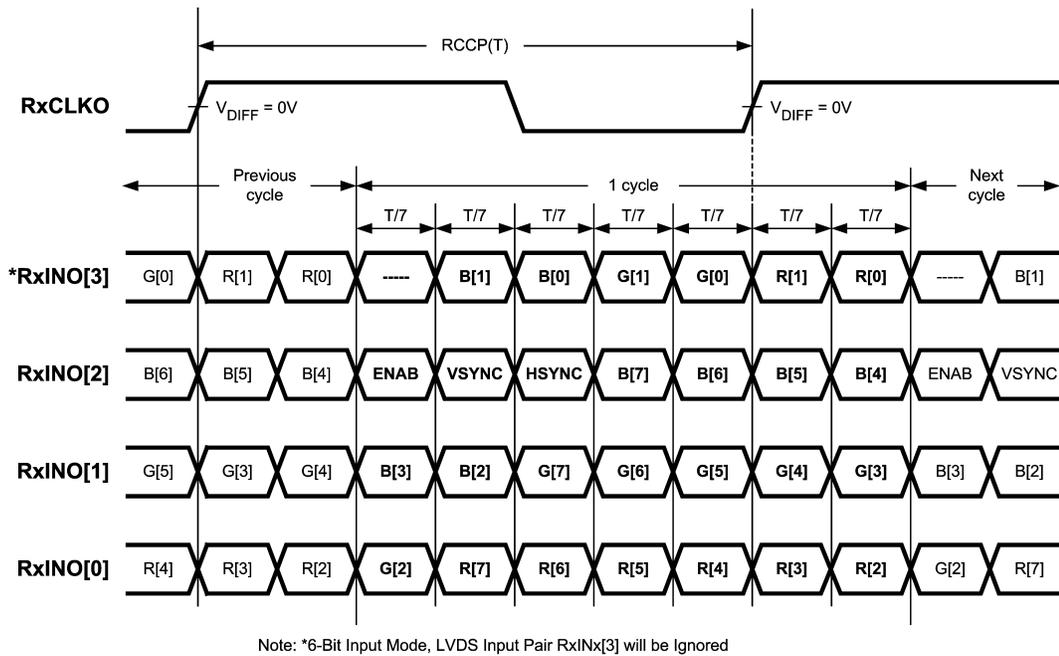
## AC Electrical Characteristics

$T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$ ,  $V_{DD} = 3.0\text{V}$  to  $3.6\text{V}$ ,  $I_{PI} = 100\ \mu\text{A}$  (Unless otherwise specified) (Continued)



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FIGURE 9. FPD-Link ReceiverSS Input Data Mappings (Default)



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FIGURE 10. FPD-Link Receiver NS Input Data Mappings

### AC Electrical Characteristics

$T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$ ,  $V_{DD} = 3.0\text{V}$  to  $3.6\text{V}$ ,  $I_{PI} = 100\ \mu\text{A}$  (Unless otherwise specified) (Continued)

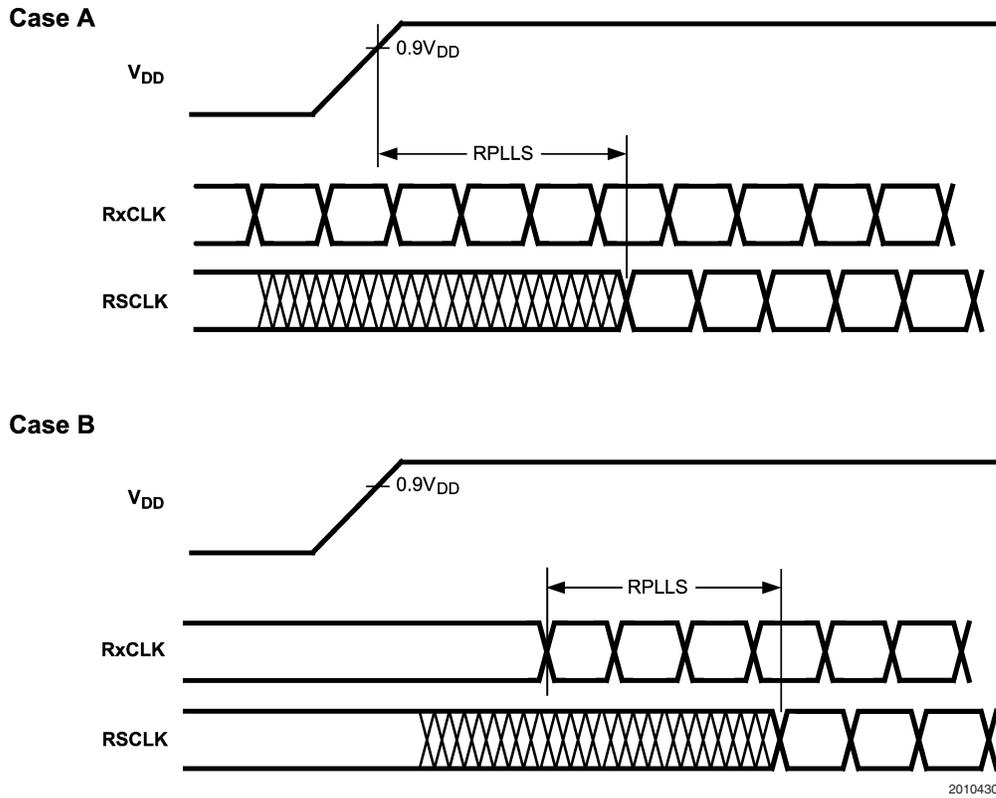


FIGURE 11. FPD-Link Receiver Phase Lock Loop Wake-up Time

## AC Electrical Characteristics

$T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$ ,  $V_{DD} = 3.0\text{V}$  to  $3.6\text{V}$ ,  $I_{PI} = 100\ \mu\text{A}$  (Unless otherwise specified) (Continued)

### Output Timing

Symbol	Parameter	Conditions	Min	Typ	Max	Units
RCHP	RS DS Clock (RSCK) High Period	$R_T = 100\ \Omega$ , $I_{PI} = 100\ \mu\text{A}$ , CLK = 85 MHz		5.7		ns
RCLP	RS DS Clock (RSCK) Low Period	$R_T = 100\ \Omega$ , $I_{PI} = 100\ \mu\text{A}$ , CLK = 85 MHz		5.8		ns
SPSTU	STH Rising to RSCK Falling	$R_T = 100\ \Omega$ , $I_{PI} = 100\ \mu\text{A}$ , CLK = 85 MHz	3.0			ns
SPHLD	STH Falling to RSCK Falling	$R_T = 100\ \Omega$ , $I_{PI} = 100\ \mu\text{A}$ , CLK = 85 MHz	3.0			ns
RSTU	RS(R, G, B) Setup to Falling or Rising Edge of RSCK	$R_T = 100\ \Omega$ , $C_{L(RS DS)} = 5\ \text{pF}$ , $I_{PI} = 100\ \mu\text{A}$ , CLK = 85 MHz, RS DS[2:0] = "100"		3.28		ns
RHLD	RS(R, G, B) Hold from Falling or Rising Edge of RSCK	$R_T = 100\ \Omega$ , $C_{L(RS DS)} = 5\ \text{pF}$ , $I_{PI} = 100\ \mu\text{A}$ , CLK = 85 MHz, RS DS[2:0] = "100"		1.87		ns

### RS DS Setup and Hold Time with Data Skew Control Values - Reference Only

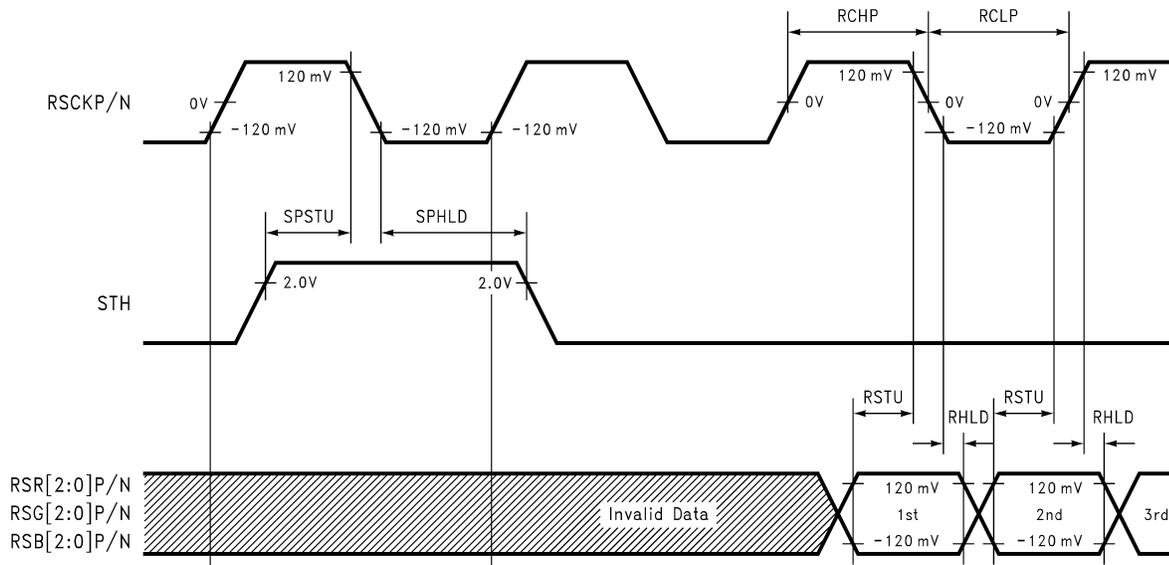
(RxCLKP/N = 85 MHz;  $V_{DD} = 3.0$  to  $3.6\text{V}$ ,  $R_T = 100\ \Omega$ ;  $I_{PI} = 100\ \mu\text{A}$ ; Duty Clock = 50%/50%,  $\pm 5\%$ ;  $25^\circ\text{C}$ )

Note: Typical values on this table are measured under Static and Steady state conditions which may not be reflective of its performance in the end application.

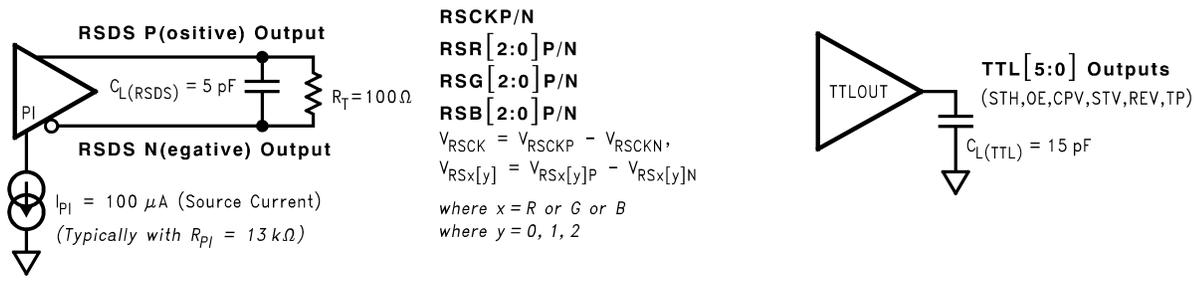
RS DS[2:0]	Setup Time (RSTU)			Hold Time (RHLD)			Units
	Min	Typ	Max	Min	Typ	Max	
000		1.26			3.91		ns
001		1.75			3.41		
010		2.30			2.90		
011		2.77			2.41		
100		3.28			1.87		
101		3.79			1.37		
110		4.27			0.89		
111		4.77			0.76		

### AC Electrical Characteristics

$T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$ ,  $V_{DD} = 3.0\text{V}$  to  $3.6\text{V}$ ,  $I_{PI} = 100\ \mu\text{A}$  (Unless otherwise specified) (Continued)



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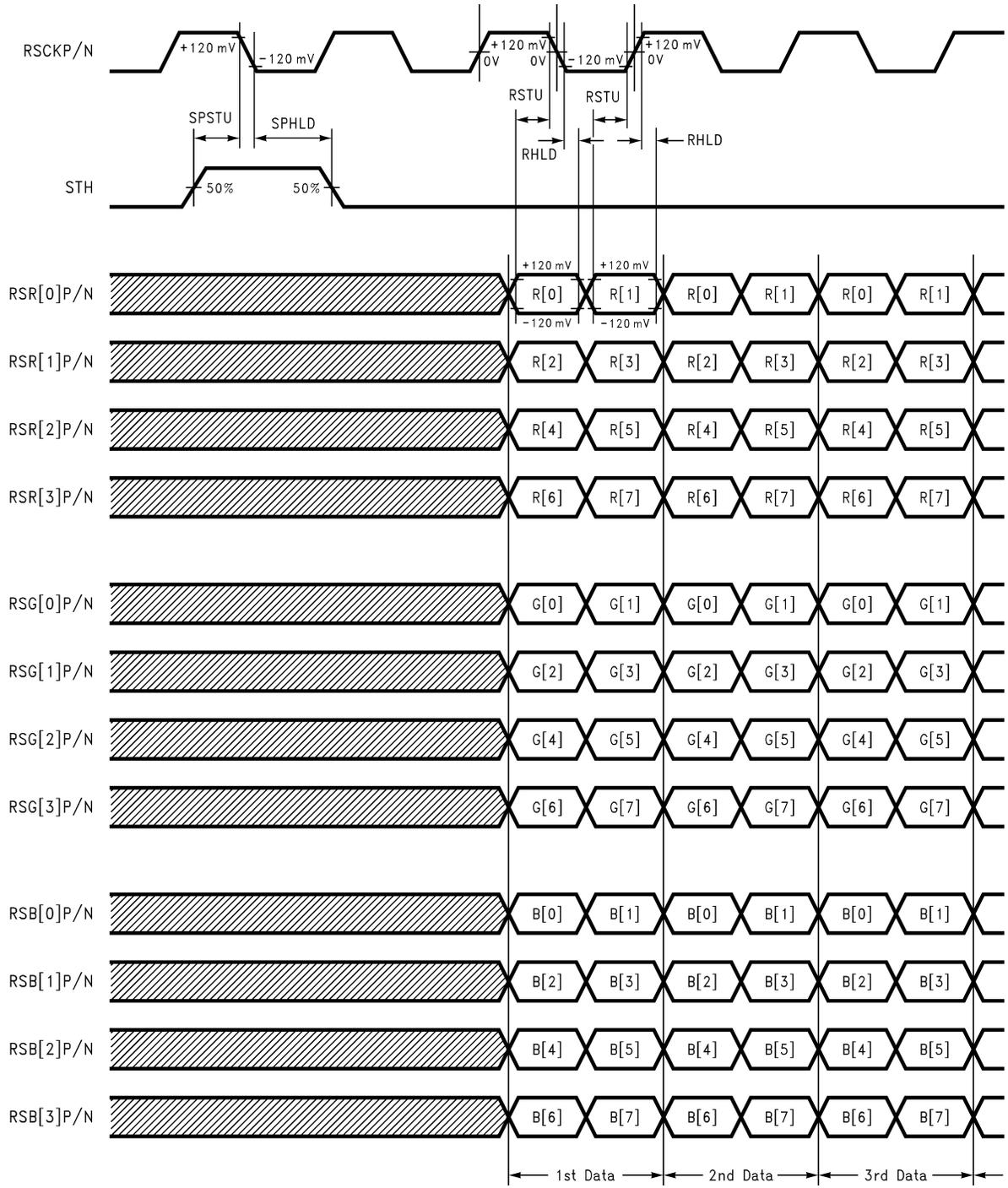


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FIGURE 12. RSDS and TTL (CMOS) Output Timing Diagram

### AC Electrical Characteristics

T<sub>A</sub> = 0°C to 70°C, V<sub>DD</sub> = 3.0V to 3.6V, I<sub>PI</sub> = 100 μA (Unless otherwise specified) (Continued)



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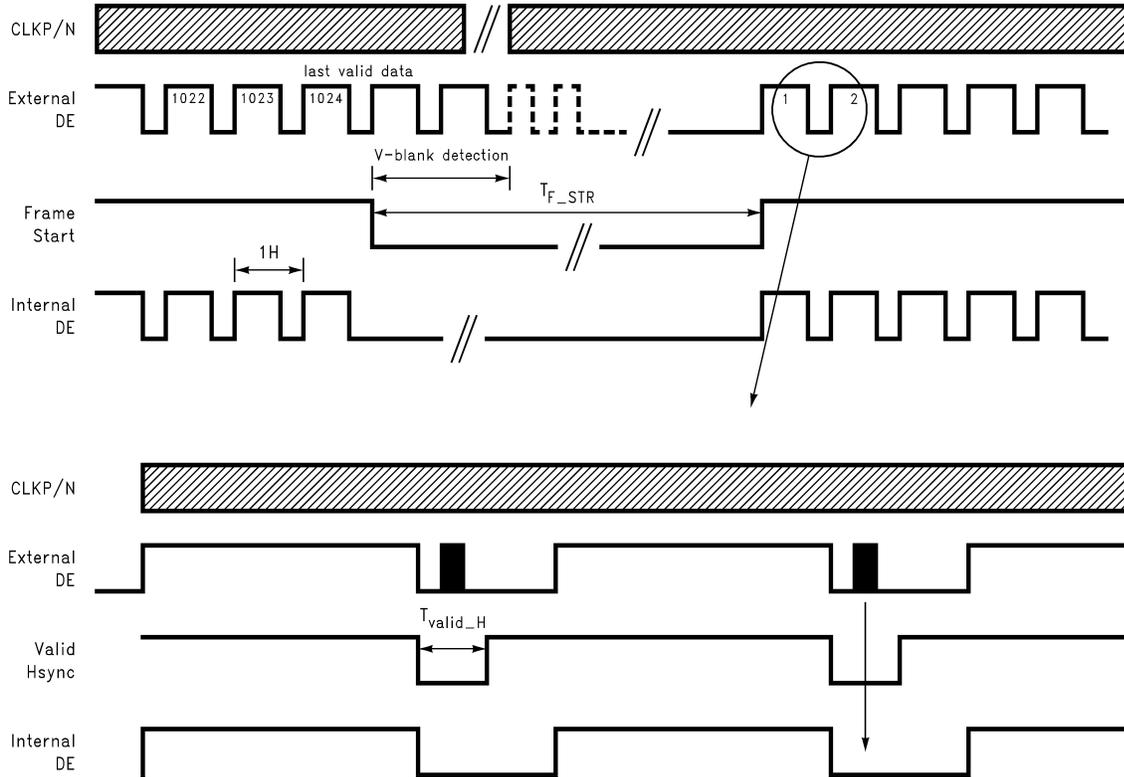
FIGURE 13. RSRS Output Data Mapping

## AC Electrical Characteristics

$T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$ ,  $V_{DD} = 3.0\text{V}$  to  $3.6\text{V}$ ,  $I_{PI} = 100\ \mu\text{A}$  (Unless otherwise specified) (Continued)

### Failure Detect (B/O pin "FDE" = High)

This function is valid in DE mode and FDE pin set to "High". Invalid external DE pulse does not affect the internal operation during failure zone.



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Graphic Mode	$T_{F\_STR}$ (Lines)	$T_{valid\_H}$ (Clocks)
SXGA	12	74
SXGA+	12	74
UXGA	12	101

**Note:**  $T_{F\_STR}$  (Frame Start Time) and  $T_{valid\_H}$  (Valid H Time) is estimated numbers. These values may not work properly for the specific application and needs optimization procedure on the actual system.

## Output Timing—TTL

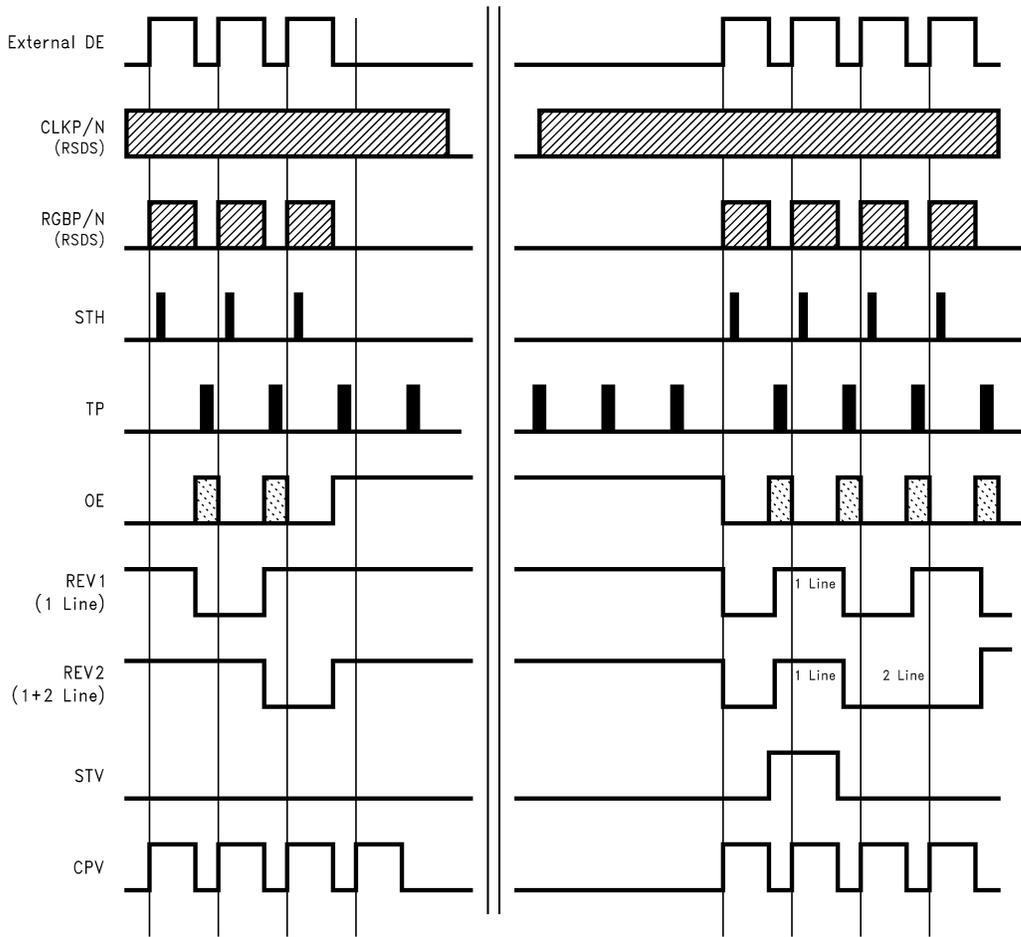
Parameter	Comments (TPW, OE2, OE1 : 3'b000)	SXGA @ 54 MHz	SXGA+ @ 54 MHz	UXGA @ 81 MHz	Remarks/ Unit
t1	STH Rising to Active Data	2	2	2	CLKP/N
t2	High Duration of STH	1	1	1	CLKP/N
t3	STH Rising to TP Rising	660	720	820	CLKP/N
t4	High Duration of TP	54	54	81	CLKP/N
t5	STH Rising to OE Falling	687	747	861	CLKP/N
t6	High Duration of OE	189	189	284	CLKP/N
t7	STH Rising to CPV	660	720	820	CLKP/N
t8	High Duration of CPV	422	422	540	CLKP/N
t9	STH Rising to STV	238	298	280	CLKP/N
t10	High Duration of STV	1 (844)	1 (844)	1 (1080)	Line (CLKP/N)
t11	STH Rising to REV (1 LINE)	645	705	805	CLKP/N
t12	High/Low Duration of REV (1 LINE)	1 (844)	1 (844)	1 (1080)	Line (CLKP/N)
t13	STH Rising to REV2 (1 + 2 LINE)	645	705	805	CLKP/N
t14	High/Low Duration of REV2 (1 + 2 LINE)	1 (the first line)/2 (844/1688)	1 (the first line)/2 (844/1688)	1 (the first line)/2 (1080/2160)	Line (CLKP/N)

Line = Hsync Cycle

## TP/OE Duty Control Configuration

Resolution	TPW	OE2	OE1	TP	OE ( $\mu$ s)	@ 54 MHz (CLK)	@ 81 MHz (CLK)
SXGA, SXGA+ @ 54 MHz	0	0	0	1.0 $\mu$ s 54 CLK @ 54 MHz 27 CLK @ 81 MHz	3.5	189	284
	0	0	1		3.0	162	243
	0	1	0		2.5	135	203
	0	1	1		2.0	108	162
UXGA @ 81 MHz	1	0	0	0.5 $\mu$ s 27 CLK @ 54 MHz 41 CLK @ 81 MHz	3.5	189	284
	1	0	1		3.0	162	243
	1	1	0		2.5	135	203
	1	1	1		2.0	108	162

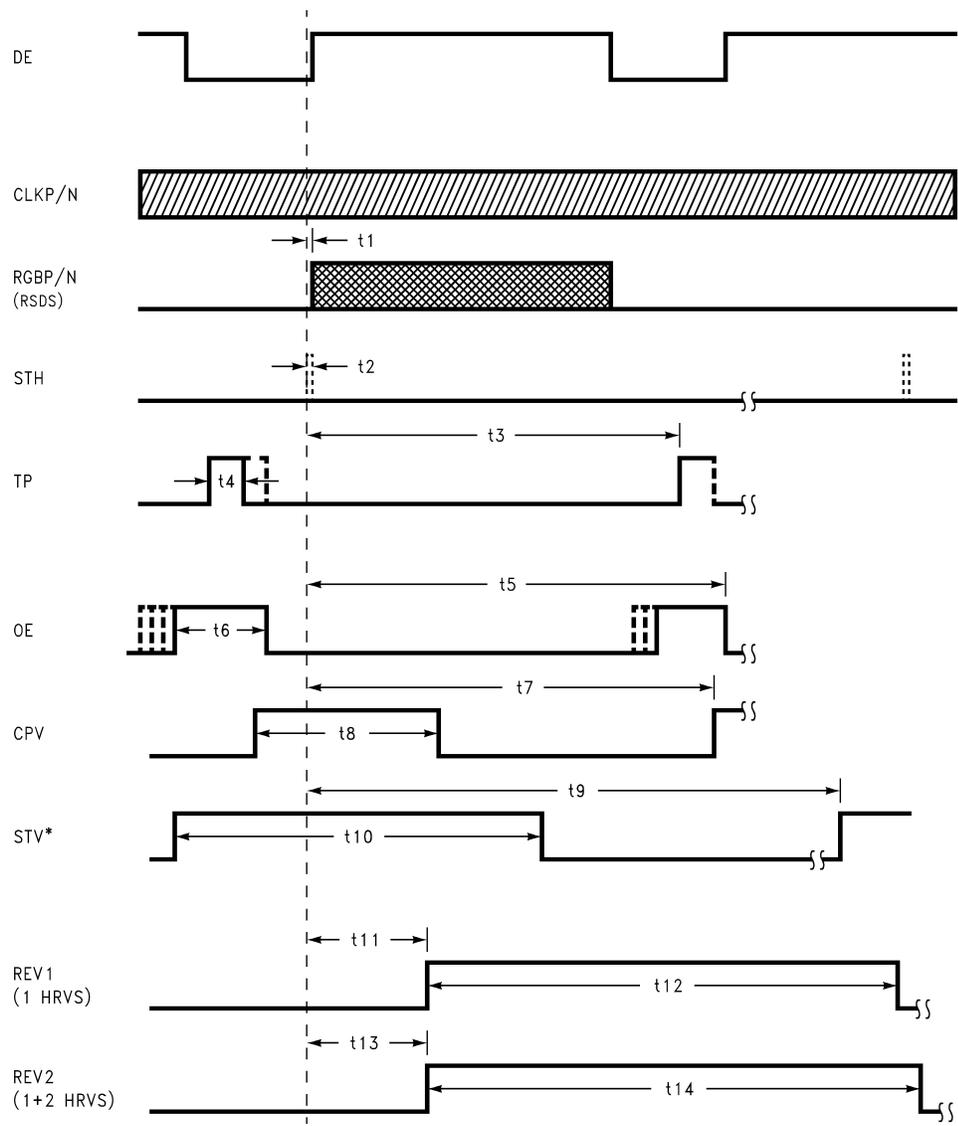
Output Timing—TTL (Continued)



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FIGURE 14. TTL Output Timing Diagram

### Output Timing—TTL (Continued)



\* Timing based on first occurrence of STH signal to the left of the measured output.

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**FIGURE 15. Typical TTL Output Timing Diagram (continued)**

### Output Timing—TTL (Continued)

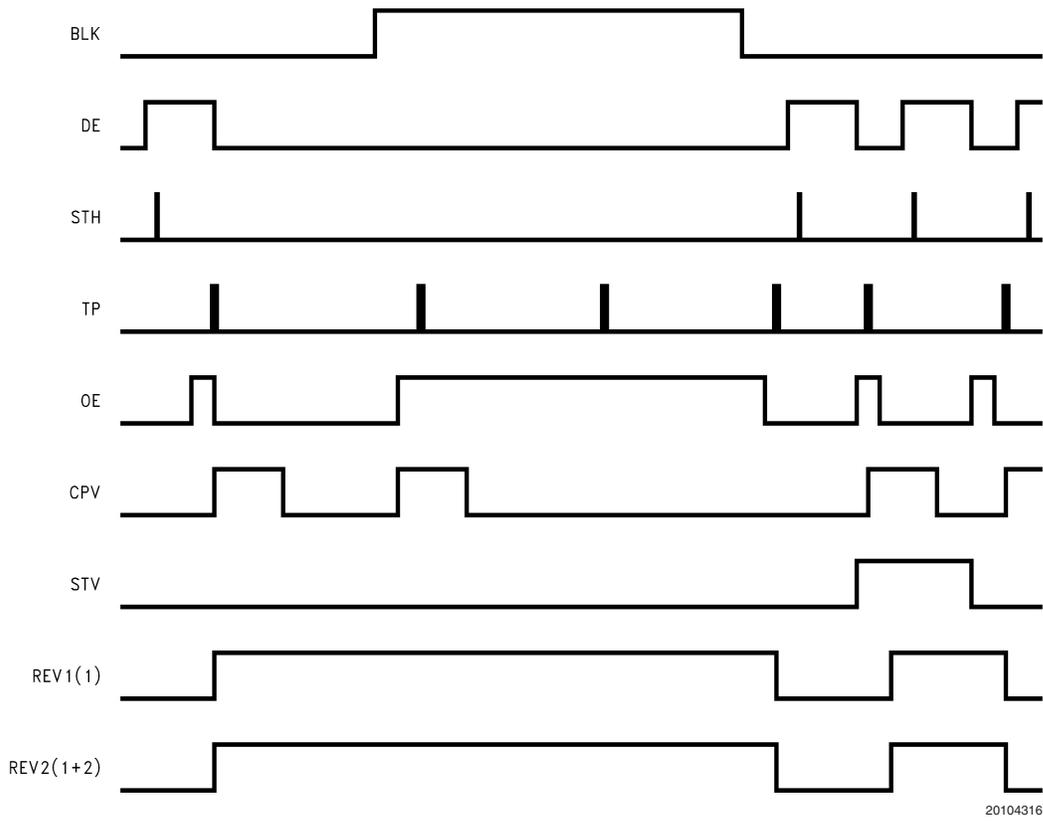


FIGURE 16. TTL Output Timing with Blanking

**Output Timing—TTL** (Continued)

**8-BIT RSDS Output Data Mapping**

Pin No.	DMAP2, DMAP1				Pin No.	DMAP2, DMAP1			
	00	01	10	11		00	01	10	11
	Top Mount		Bottom Mount			Top Mount		Bottom Mount	
47	R3P_F	R0N_F	B0N_B	B3P_B	78	R3P_B	R0N_B	B0N_F	B3P_F
48	R3N_F	R0P_F	B0P_B	B3N_B	79	R3N_B	R0P_B	B0P_F	B3N_F
49	R2P_F	R1N_F	B1N_B	B2P_B	80	R2P_B	R1N_B	B1N_F	B2P_F
50	R2N_F	R1P_F	B1P_B	B2N_B	81	R2N_B	R1P_B	B1P_F	B2N_F
51	R1P_F	R2N_F	B2N_B	B1P_B	82	R1P_B	R2N_B	B2N_F	B1P_F
52	R1N_F	R2P_F	B2P_B	B1N_B	83	R1N_B	R2P_B	B2P_F	B1N_F
53	R0P_F	R3N_F	B3N_B	B0P_B	84	R0P_B	R3N_B	B3N_F	B0P_F
54	R0N_F	R3P_F	B3P_B	B0N_B	85	R0N_B	R3P_B	B3P_F	B0N_F
56	G3P_F	G0N_F	G0N_B	G3P_B	87	G3P_B	G0N_B	G0N_F	G3P_F
57	G3N_F	G0P_F	G0P_B	G3N_B	88	G3N_B	G0P_B	G0P_F	G3N_F
58	G2P_F	G1N_F	G1N_B	G2P_B	89	G2P_B	G1N_B	G1N_F	G2P_F
59	G2N_F	G1P_F	G1P_B	G2N_B	90	G2N_B	G1P_B	G1P_F	G2N_F
60	G1P_F	G2N_F	G2N_B	G1P_B	91	G1P_B	G2N_B	G2N_F	G1P_F
61	G1N_F	G2P_F	G2P_B	G1N_B	92	G1N_B	G2P_B	G2P_F	G1N_F
62	G0P_F	G3N_F	G3N_B	G0P_B	93	G0P_B	G3N_B	G3N_F	G0P_F
63	G0N_F	G3P_F	G3P_B	G0N_B	94	G0N_B	G3P_B	G3P_F	G0N_F
65	CLKP_F		CLKP_B		95	CLKP_B		CLKP_F	
66	CLKN_F		CLKN_B		96	CLKN_B		CLKN_F	
67	B3P_F	B0N_F	R0N_B	R3P_B	98	B3P_B	B0N_B	R0N_F	R3P_F
68	B3N_F	B0P_F	R0P_B	R3N_B	99	B3N_B	B0P_B	R0P_F	R3N_F
69	B2P_F	B1N_F	R1N_B	R2P_B	100	B2P_B	B1N_B	R1N_F	R2P_F
70	B2N_F	B1P_F	R1P_B	R2N_B	101	B2N_B	B1P_B	R1P_F	R2N_F
71	B1P_F	B2N_F	R2N_B	R1P_B	102	B1P_B	B2N_B	R2N_F	R1P_F
72	B1N_F	B2P_F	R2P_B	R1N_B	103	B1N_B	B2P_B	R2P_F	R1N_F
73	B0P_F	B3N_F	R3N_B	R0P_B	104	B0P_B	B3N_B	R3N_F	R0P_F
74	B0N_F	B3P_F	R3P_B	R0N_B	105	B0N_B	B3P_B	R3P_F	R0N_F
107	STH_F		STH_B		108	STH_B		STH_F	

## Output Timing—TTL (Continued)

### 6-BIT RSDS Output Data Mapping

Pin No.	DMAP2, DMAP1				Pin No.	DMAP2, DMAP1			
	00	01	10	11		00	01	10	11
	Top Mount		Bottom Mount			Top Mount		Bottom Mount	
47	HI-Z	R0N_F	B0N_B	HI-Z	78	HI-Z	R0N_B	B0N_F	HI-Z
48	HI-Z	R0P_F	B0P_B	HI-Z	79	HI-Z	R0P_B	B0P_F	HI-Z
49	R2P_F	R1N_F	B1N_B	B2P_B	80	R2P_B	R1N_B	B1N_F	B2P_F
50	R2N_F	R1P_F	B1P_B	B2N_B	81	R2N_B	R1P_B	B1P_F	B2N_F
51	R1P_F	R2N_F	B2N_B	B1P_B	82	R1P_B	R2N_B	B2N_F	B1P_F
52	R1N_F	R2P_F	B2P_B	B1N_B	83	R1N_B	R2P_B	B2P_F	B1N_F
53	R0P_F	HI-Z	HI-Z	B0P_B	84	R0P_B	HI-Z	HI-Z	B0P_F
54	R0N_F	HI-Z	HI-Z	B0N_B	85	R0N_B	HI-Z	HI-Z	B0N_F
56	HI-Z	G0N_F	G0N_B	HI-Z	87	HI-Z	G0N_B	G0N_F	HI-Z
57	HI-Z	G0P_F	G0P_B	HI-Z	88	HI-Z	G0P_B	G0P_F	HI-Z
58	G2P_F	G1N_F	G1N_B	G2P_B	89	G2P_B	G1N_B	G1N_F	G2P_F
59	G2N_F	G1P_F	G1P_B	G2N_B	90	G2N_B	G1P_B	G1P_F	G2N_F
60	G1P_F	G2N_F	G2N_B	G1P_B	91	G1P_B	G2N_B	G2N_F	G1P_F
61	G1N_F	G2P_F	G2P_B	G1N_B	92	G1N_B	G2P_B	G2P_F	G1N_F
62	G0P_F	HI-Z	HI-Z	G0P_B	93	G0P_B	HI-Z	HI-Z	G0P_F
63	G0N_F	HI-Z	HI-Z	G0N_B	94	G0N_B	HI-Z	HI-Z	G0N_F
65	CLKP_F		CLKP_B		95	CLKP_B		CLKP_F	
66	CLKN_F		CLKN_B		96	CLKN_B		CLKN_F	
67	HI-Z	B0N_F	R0N_B	HI-Z	98	HI-Z	B0N_B	R0N_F	HI-Z
68	HI-Z	B0P_F	R0P_B	HI-Z	99	HI-Z	B0P_B	R0P_F	HI-Z
69	B2P_F	B1N_F	R1N_B	R2P_B	100	B2P_B	B1N_B	R1N_F	R2P_F
70	B2N_F	B1P_F	R1P_B	R2N_B	101	B2N_B	B1P_B	R1P_F	R2N_F
71	B1P_F	B2N_F	R2N_B	R1P_B	102	B1P_B	B2N_B	R2N_F	R1P_F
72	B1N_F	B2P_F	R2P_B	R1N_B	103	B1N_B	B2P_B	R2P_F	R1N_F
73	B0P_F	HI-Z	HI-Z	R0P_B	104	B0P_B	HI-Z	HI-Z	R0P_F
74	B0N_F	HI-Z	HI-Z	R0N_B	105	B0N_B	HI-Z	HI-Z	R0N_F
107	STH_F		STH_B		108	STH_B		STH_F	

**Note:** Note: For 6-bit output mode, RSDS pair 3P/Ns will be in HI-Z mode.

### LVDS Input and RSDS Output Data

RxMap	BIT_CFG2	BIT_CFG1	Input Data	Output Data	Functional Description
0	0	0	8-bit	8-bit	Data is unchanged (NS mapping)
0	0	1	8-bit	6-bit	2 MSBs are HI-Z, FRC Enabled (NS)
0	1	0	6-bit	8-bit	2 LSBs are zero (NS)
0	1	1	6-bit	6-bit	2 MSBs are HI-Z (NS)
1	0	0	8-bit	8-bit	Data is unchanged (SS mapping)
1	0	1	8-bit	6-bit	2 MSBs are HI-Z, FRC Enabled (SS)
1	1	0	6-bit	8-bit	2 LSBs are zero (SS)
1	1	1	6-bit	6-bit	2 MSBs are HI-Z (SS)

## Input Signal Timing

Sync only mode, no DE inputted, is supported when the SYNC pin (Bonding Option pin) is enable high. Whenever DE signal is inputted, it works as DE mode. In the DE mode, H-blank min is considered with Failure detection mode enabled. In the defaults mode,  $T_{\text{valid\_H}}$  should be subtracted in the table below.

Graphic Mode	Sync Mode (Bonding Option)						DE Mode		Number of Total Horizontal Lines in a Frame	Number of Total Pixel Clocks in a Horizontal Line
	H-Timing (clocks)			V-Timing (lines)			H-Timing (clocks)	V-Timing (lines)		
	From Sync to Data	Total H-Timing		From Sync to Data	Total V-Timing		H-Blank	H-Blank Detection		
	Typ	Min	Max	Typ	Min	Max	Min	Min		
SXGA	248	1430	2047	38	1066	2047	150	2	1066	1688
SXGA+	128	1550	2047	12	1066	2047	150	2	1066	1688
UXGA	304	1804	4095	46	1250	2047	204	2	1250	2160

Note: H = Lines

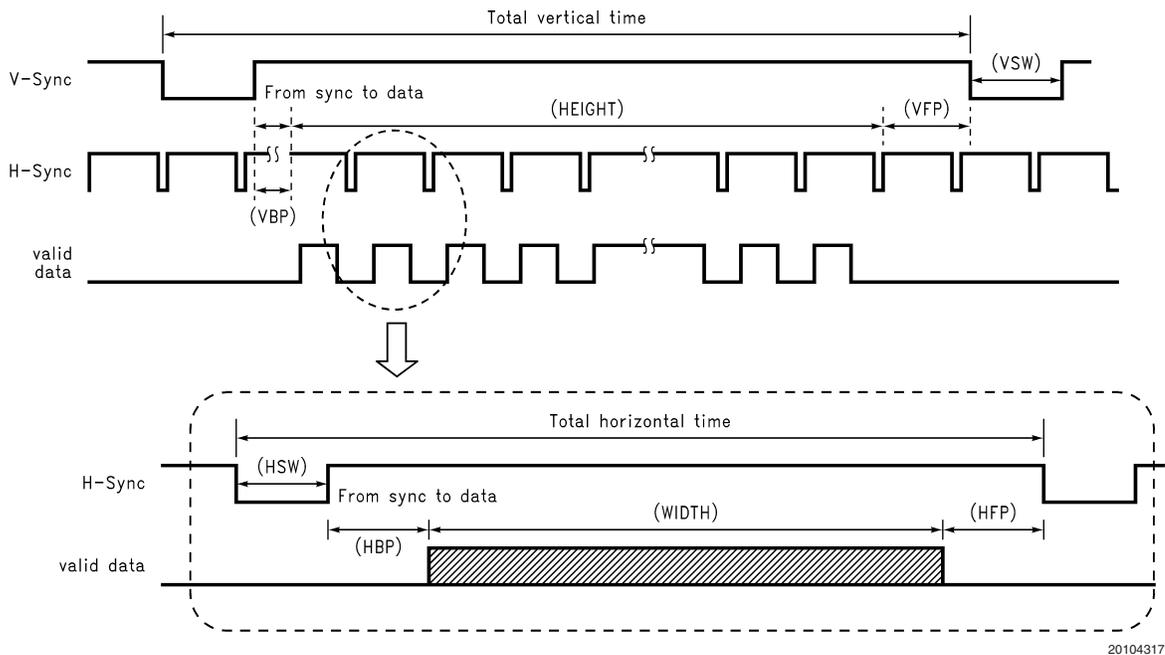


FIGURE 17. Video Signal Format

### Supports VESA Standard in SYNC Mode (B/O SYNC Pin = High)

		SXGA	SXGA+	UXGA	Unit
Horizontal	WIDTH	1280	1400	1600	clock
	HFP	48	48	64	clock
	HSW	112	112	192	clock
	HBP	248	128	304	clock
Vertical	HEIGHT	1024	1050	1200	Line
	VFP	1	1	1	Line
	VSW	3	3	3	Line
	VBP	38	12	46	Line

### Power Up Sequence (Defaults)

When Power is ON, the TCON start to operate and generate the control signals by inputted LVDS signals. LVDS Receiver will take maximum 10 ms for the PLL wake-up time. Whether LVDS signals exist before the power-on doesn't effect. When the Reset is reach to 2.0V, the R, G, B data and control signals are outputted sequentially and the sequence is just as following figure.

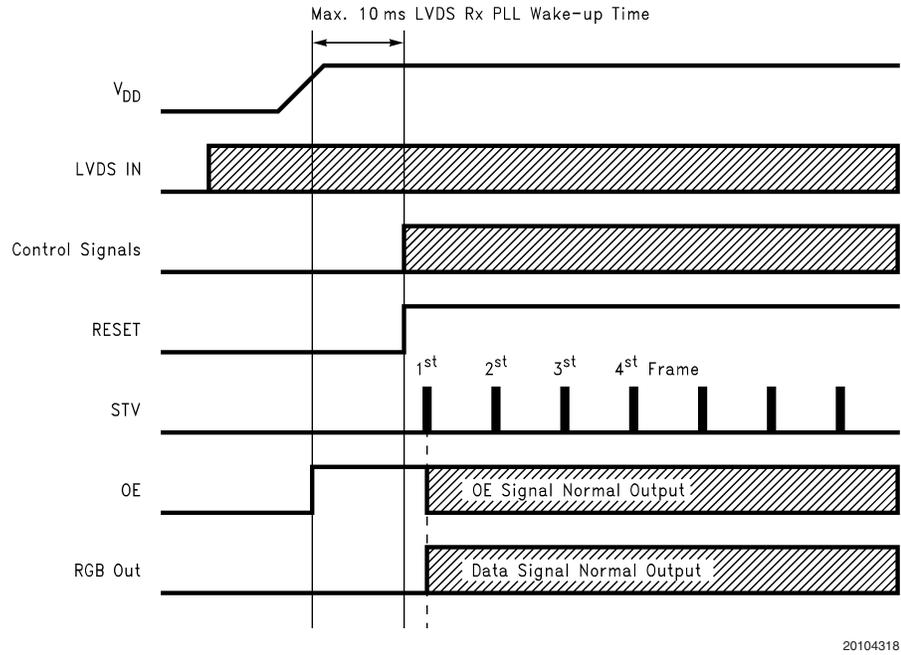
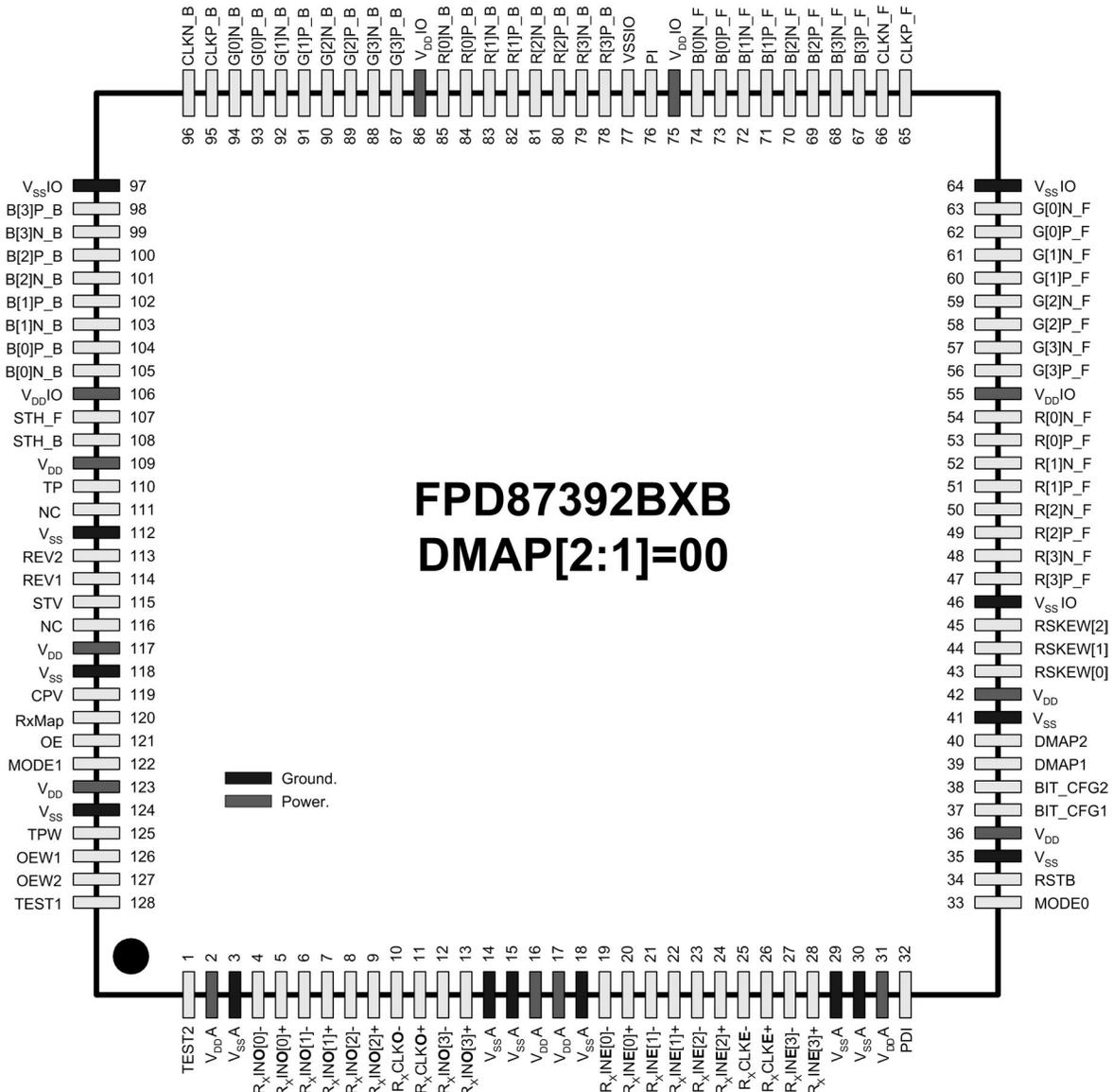
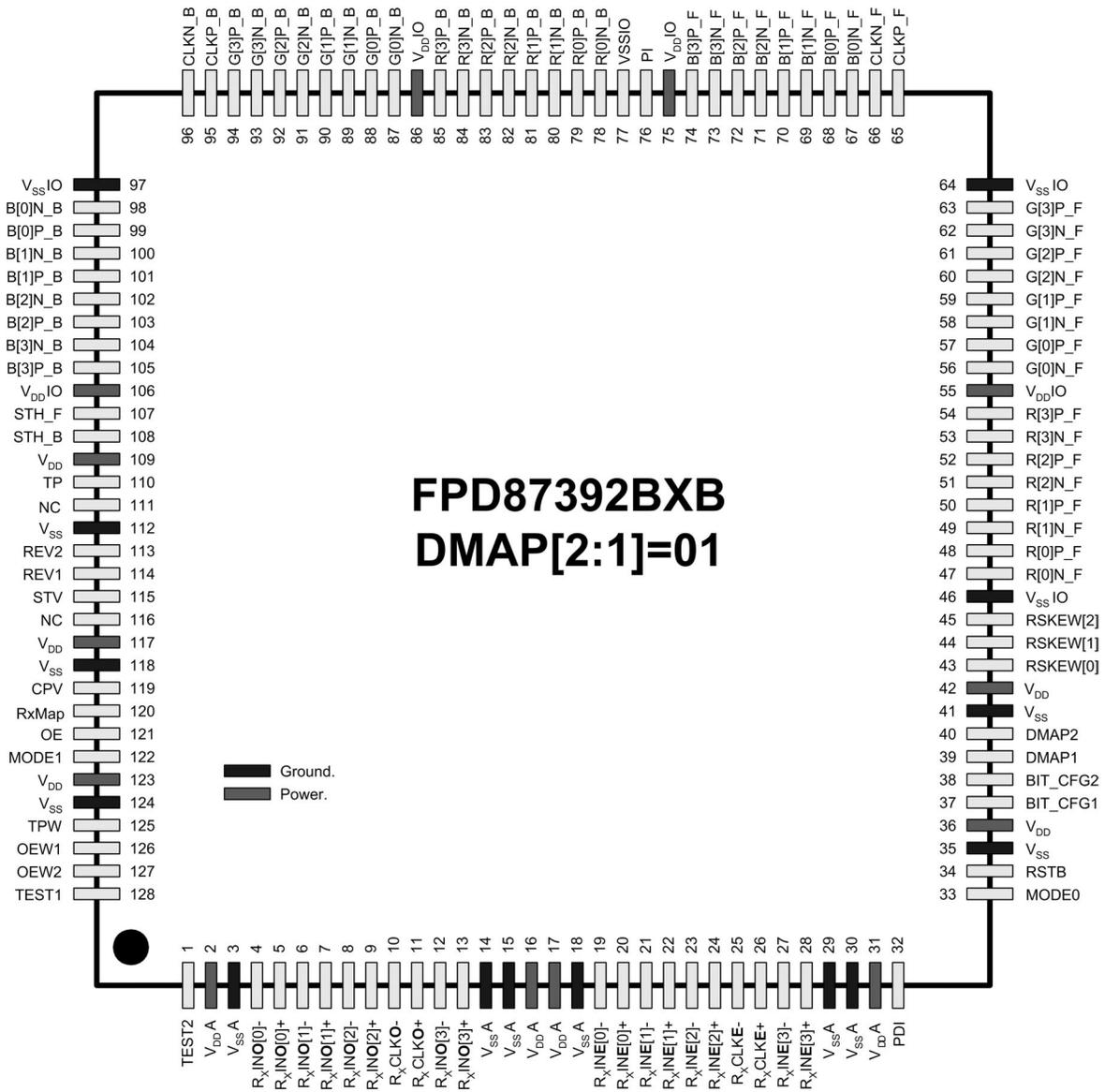


FIGURE 18. Power Up Sequence

# Pin Connection

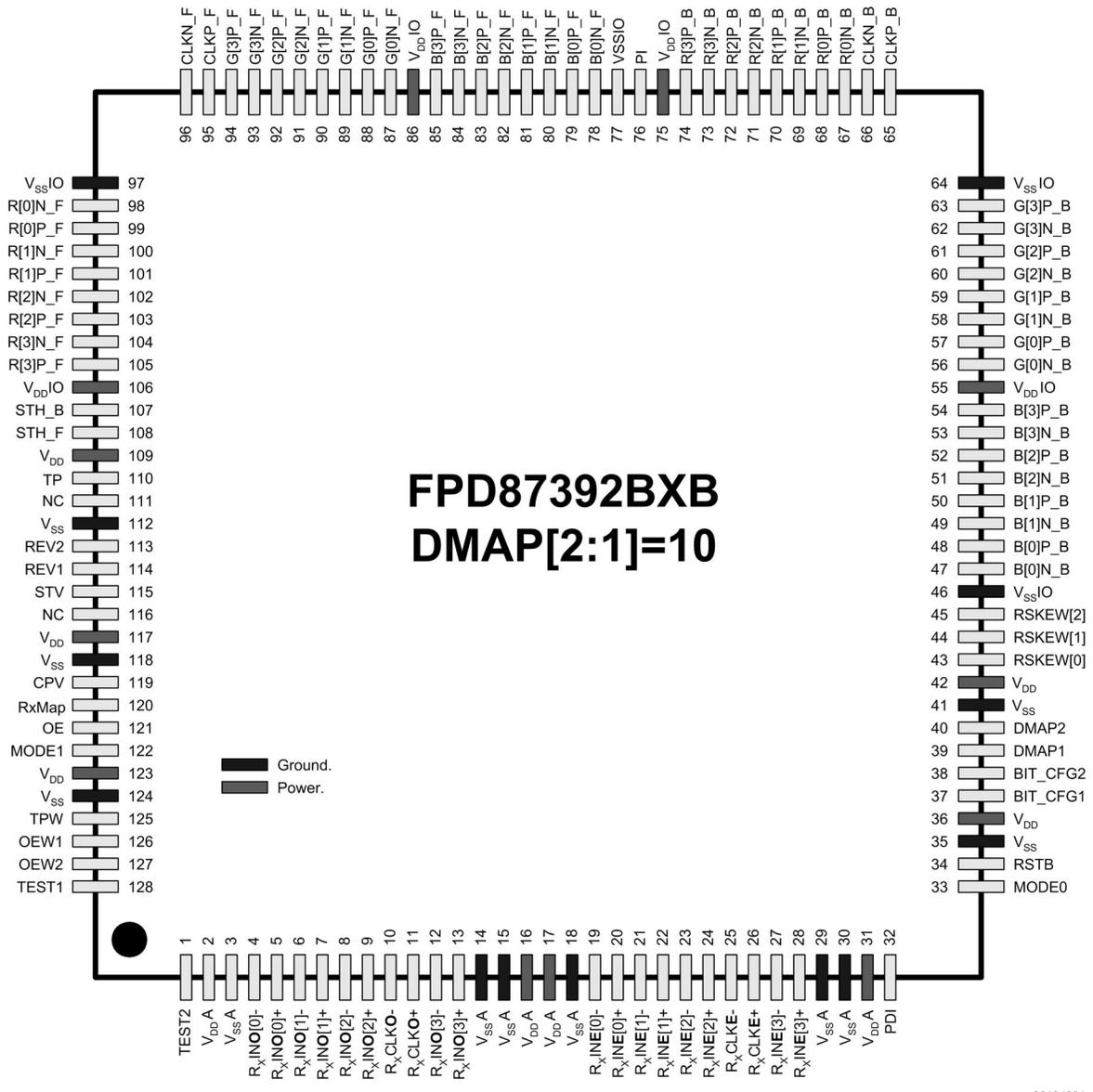


Pin Connection (Continued)



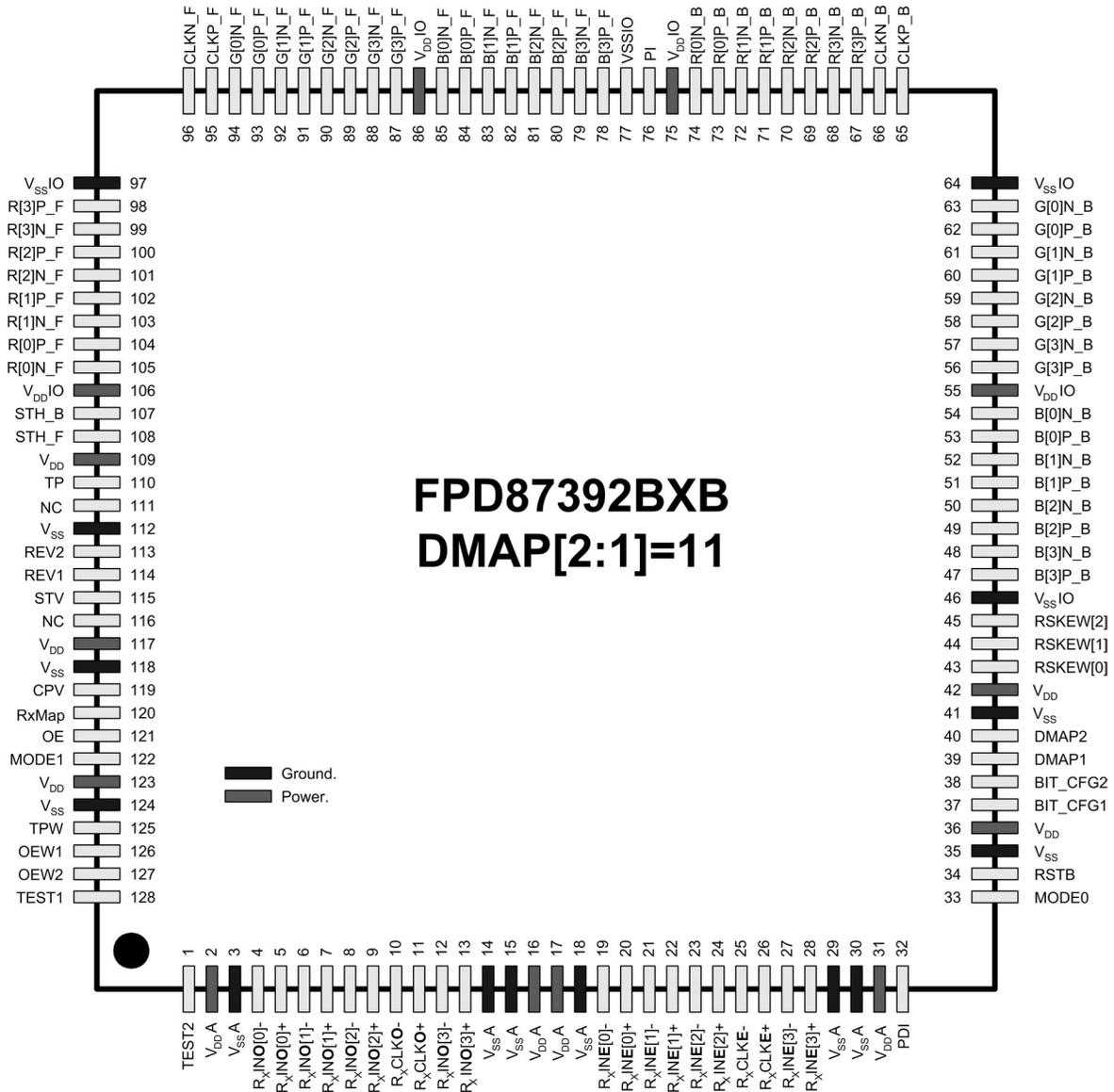
20104320

# Pin Connection (Continued)



20104321

Pin Connection (Continued)



20104322

## Pin Description System Interface

Symbol	Pin No.	Type	Function
RxINO[0]P/N and RxINE[0]P/N	4, 5 19, 20	LVDSI	FPD-Link Data Differential Pair 0 Input
RxINO[1]P/N and RxINE[1]P/N	6, 7 21, 22	LVDSI	FPD-Link Data Differential Pair 1 Input
RxINO[2]P/N and RxINE[2]P/N	8, 9 23, 24	LVDSI	FPD-Link Data Differential Pair 2 Input
RxINO[3]P/N and RxINE[3]P/N	12, 13 25, 26	LVDSI	FPD-Link Data Differential Pair 3 Input
RxCLKOP/N and RxCLKEP/N	10, 11 27, 28	LVDSI	FPD-Link Clock Differential Pair Input

## RSDS Interface

Symbol	Pin No.	Type	Function
B[3:0]P/N_B	47–54	RSO	Blue Reduced Swing Differential Outputs to Back Column Drivers
G[3:0]P/N_B	56–63	RSO	Green Reduced Swing Differential Outputs to Back Column Drivers
R[3:0]P/N_B	67–74	RSO	Red Reduced Swing Differential Outputs to Back Column Drivers
CLKP/N_B	65, 66	RSO	Clock Reduced Swing Differential Outputs to Back Column Drivers
B[3:0]P/N_F	78–85	RSO	Blue Reduced Swing Differential Outputs to Front Column Drivers
G[3:0]P/N_F	87–94	RSO	Green Reduced Swing Differential Outputs to Front Column Drivers
R[3:0]P/N_F	98–105	RSO	Red Reduced Swing Differential Outputs to Front Column Drivers
CLKP/N_F	95, 96	RSO	Clock Reduced Swing Differential Outputs to Front Column Drivers
PI	76	I	External Resistor Input for RSDS Output ( $V_{OD}$ ) Level Control
RSKEW[2:0]	43, 44, 45	I	Output RSDS Data Skew Control (Default 3'b000)

## Column/Row Driver Control

Symbol	Pin No.	Type	Function
TP	110	TO	Line Latch Signal Output to Column Drivers
STH_B	107	TO	Horizontal Start Signal Output to Back Column Drivers
STH_F	108	TO	Horizontal Start Signal Output to Front Column Drivers
REV1	114	TO	Data Inversion Output to Column Driver (1 Line)
REV2	113	TO	Data Inversion Output to Column Driver (1 + 2 Line)
STV	115	TO	Row Driver Start Pulse
CPV	119	TO	Row Driver Shift Clock
OE	121	TO	Control TFT Gate Pulse Width to Row Drivers

**Pin Description** (Continued)**Control Input**

Symbol	Pin No.	Type	Function
BIT_CFG1/2	37, 38	I	LVDS Input and RSDS Output Bit Selection
MODE[1:0]	122, 33	I	Graphic Mode Selection "00": SXGA, "01": SXGA+, "10": UXGA, "11": Don't Care
DMAP1/2	39, 40	I	RSDS Output Data Mapping
TPW	125	I	TP Duty Control (Default Low)
OEW1/2	126, 127	I	OE Duty Control (Default 2'b00)
TEST1/2	128, 1	I	Test Mode Low: Normal Operation, High: Test Mode
PDI	32	I	LVDS Power Down (Active Low)
RSTB	34	I	System Reset (Active Low)
RxMap	120	I	RxMap=1(SS Mapping); RxMap=0, NS Mapping
NC	111, 116		No Connect

**Power Supply**

Symbol	Pin No.	Type	Function
V <sub>DD</sub>	36, 42, 109, 117, 123	P	Digital Power for Logic Core and LVDS Deserializer
V <sub>SS</sub>	35, 41, 112, 118, 124	G	Digital Ground for Logic Core and LVDS Deserializer
V <sub>DDA</sub>	2, 16, 17, 31	P	Power for LVDS PLL and Analog Bandgap
V <sub>SSA</sub>	3, 14, 15, 18, 29, 30	G	Ground for LVDS PLL and Analog Bandgap
V <sub>DDIO</sub>	55, 75, 86, 106	P	Digital I/O Power and RSDS Outputs
V <sub>SSIO</sub>	46, 64, 77, 97	G	Digital I/O Ground and RSDS Outputs

**Bonding Option (B/O)**

Symbol	Pin No.	Type	Function
SYNC	B/O	PU	SYNC Mode High: Enable, Low: Disable
FRM	B/O	PU	Free Run Mode High: Enable, Low: Disable
FDE	B/O	PU	Failure Detection High: Enable, Low: Disable
POR	B/O	PU	Power-On-Reset High: Enable, Low: Disable

**Pin Types**

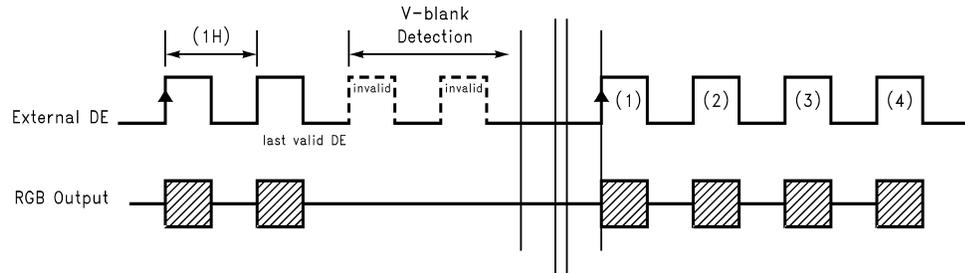
I	-Input (3.3V TTL-Compatible)	G	-Ground
TO	-TTL Output (3.3V TTL-Compatible)	PU	-Pull-Up
LVDSI	-Low Voltage Differential Signal Input	PD	-Pull-Down
RSO	-Reduced Swing Differential Output		
P	-Power		

## Appendix 1. DE Mode Timing Details

### DE Mode (Disabled SYNC Pin)

Always true whenever DE is exist as inputted signal. If  $V_{\text{SYNC}}$ ,  $H_{\text{SYNC}}$  and DE are available, DE mode is superior and generate the control timing. "V-blank Detection" period is two cycles of the previous DE signals. After the V-blank detection period, "Counter" start to count whenever DE signal available followed on the rising edge.

Case 1: Disabled Failure Detection Mode

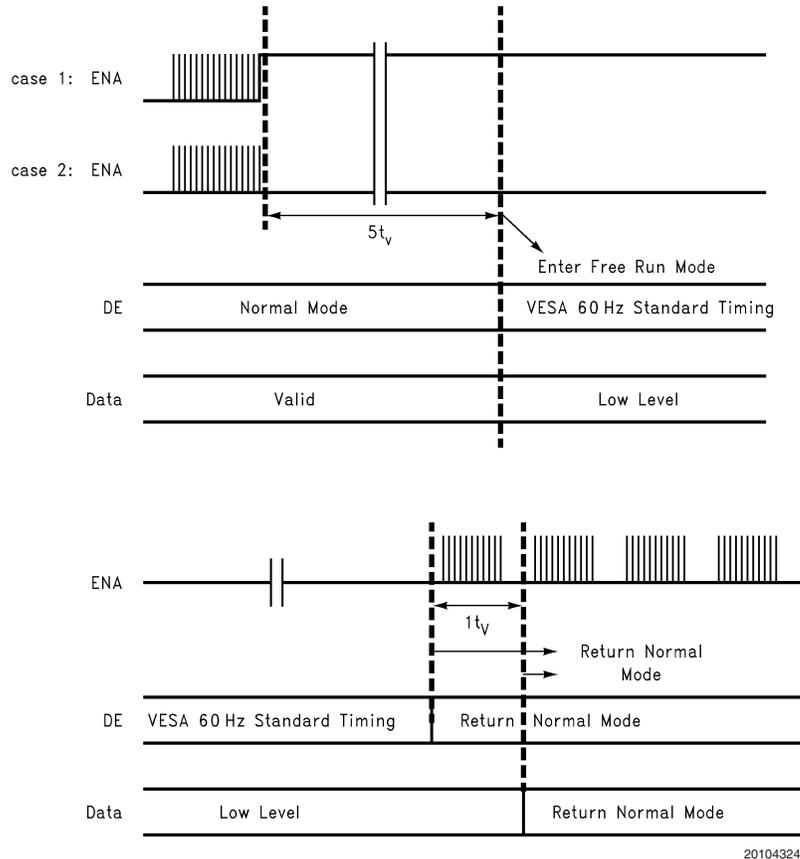


Case 2: Enabled Failure Detection Mode (SXGA). Please refer to the "Failure Detect" on page 10.

## Appendix 2. Free Run Mode Function (B/O Pin FRM "Low" to Disable)

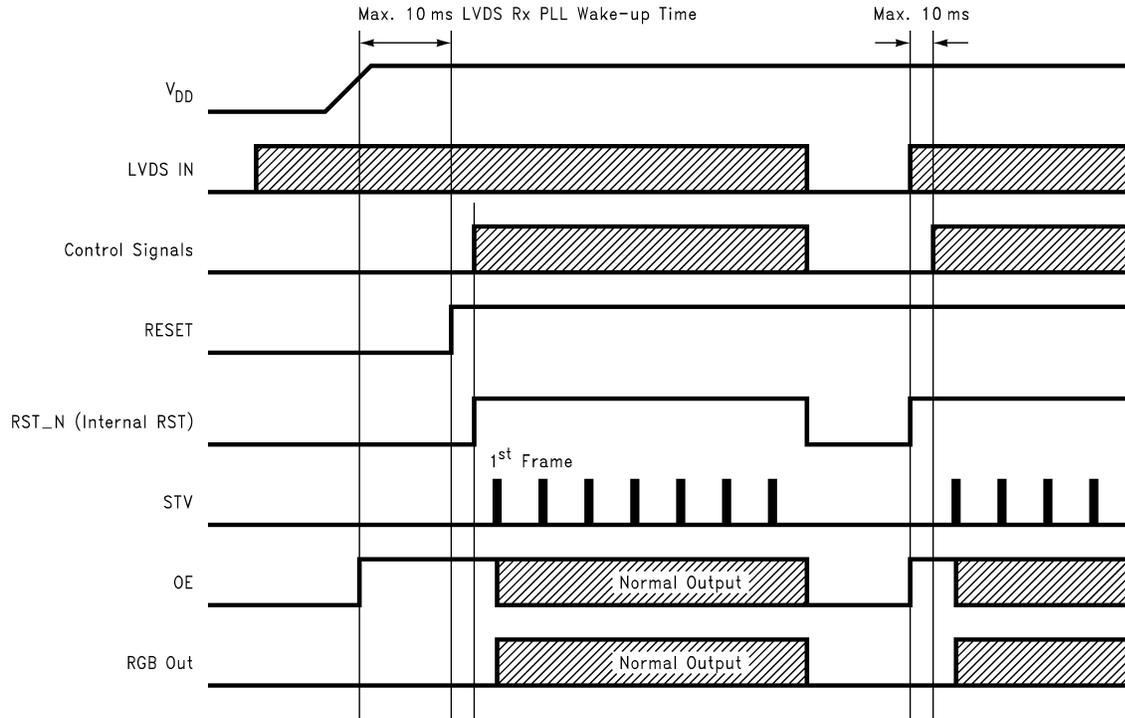
Either input DE signal, ENA, on the DE mode or  $V_{\text{SYNC}}$  on the SYNC mode are lost more than 5 frames (here, "lost" means ENA or  $V_{\text{SYNC}}$  signal more than 5 frames without change), then the TCON will enter the Free Run Mode. In the Free Run Mode, the vertical and horizontal period will follow VESA 60 Hz standard and output data will be in the Low Level.

When TCON detects input signal back to normal ("normal" means ENA or  $V_{\text{SYNC}}$  signal has to change from Low Level to High Level), then output control signals will return to the Normal Mode. In the next frame, output data will also return to Normal Mode.



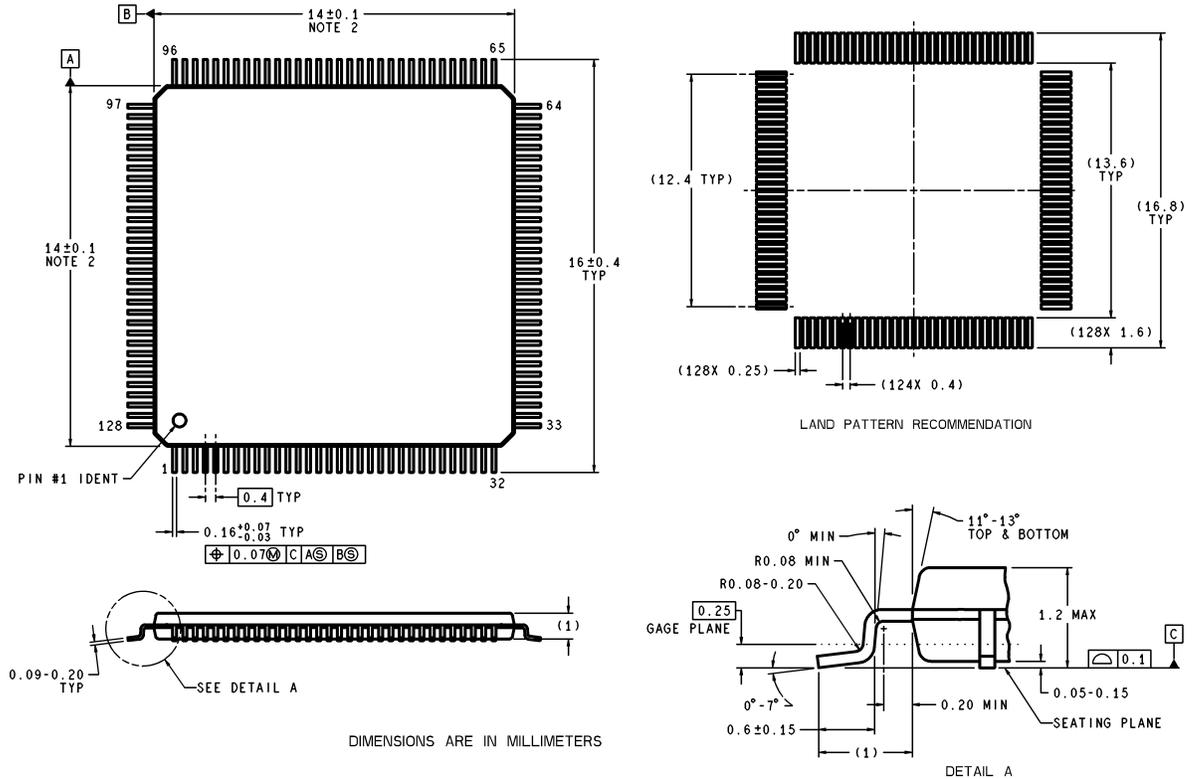
### Appendix 3. Power-Up Sequence on “POR Enabled” Mode

When Bonding option pins, POR (Power-On-Reset), enable set to “High”, TCON start running as POR mode. If the input LVDS clocks lost with any reasons during the normal operation, POR output signal (RST\_N) will be low until LVDS clock comeback again. The Reset counter start to count with LVDS clock resume then turn to normal operation mode before the 10 ms PLL Wake-Up time limits.



20104325

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



DIMENSIONS ARE IN MILLIMETERS

VJX128A (Rev A)

**128-lead Plastic Quad Flatpack, JEDEC**  
**Dimensions in millimeters only**  
**Order Number FPD87392BXBVQ**  
**NS Package Number VJX128A**

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