



July 2004

FPD87208AXA

+2.5V Low EMI, Low Dynamic Power XGA/WXGA TFT-LCD Timing Controller with Reduced Swing Differential Signaling RSDS™ Outputs

General Description

The FPD87208AXA is a timing controller that combines an LVDS single pixel input interface with National Reduced Swing Differential Signaling (RSDS™) output driver interface for XGA and Wide XGA resolutions. It resides on the TFT-LCD panel and provides the data buffering and control signal generation for XGA, and Wide XGA graphic modes. The RSDS path to the column driver contributes toward lowering radiated EMI and reducing system dynamic power consumption.

This single RSDS bus conveys the 6-bit color data for XGA, and three different WXGA resolutions.

Features

- Reduced Swing Differential Signaling (RSDS) digital bus reduces dynamic power, EMI and bus-width from the timing controller
- LVDS single pixel input interface system
- Input clock range from 25 MHz to 85 MHz
- Drives RSDS column drivers at 170 Mb/s with an 85 MHz clock (Max)
- BIST Function
- CMOS circuitry operates from a 2.25V–2.75V; 0°C–70°C
- 64 TQFP package with body size 10 mm x 10 mm x 1.0 mm

System Diagram

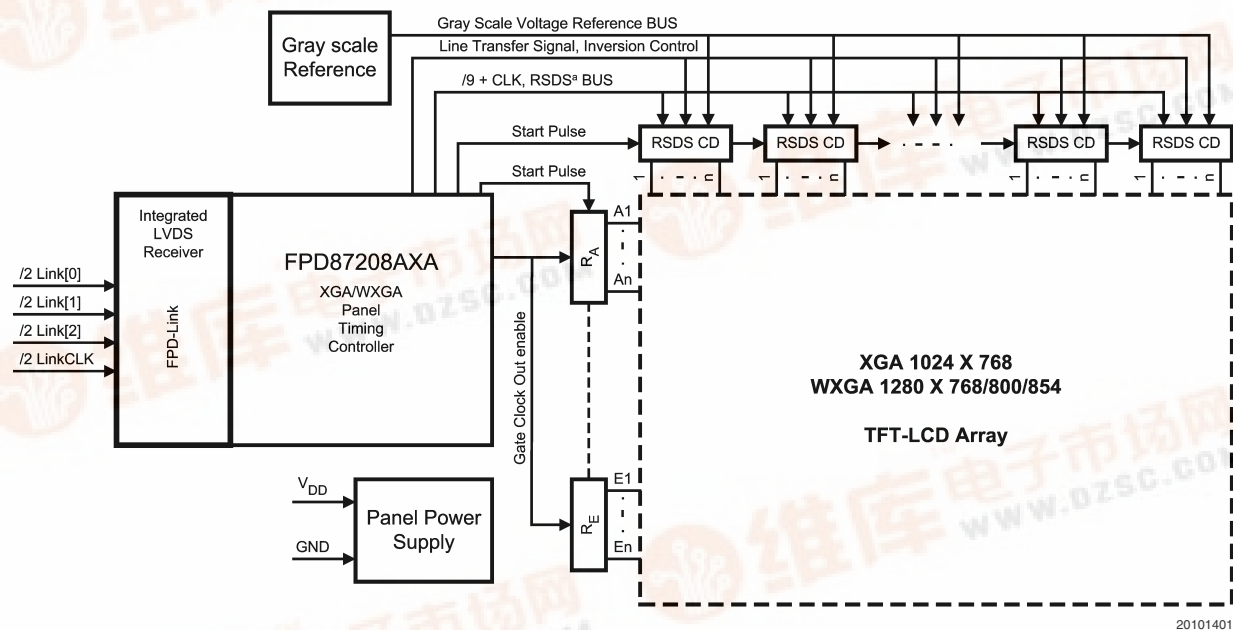


FIGURE 1. Block Diagram of the LCD Module

FPD87208AXA +2.5V Low EMI, Low Dynamic Power XGA/WXGA TFT-LCD Timing Controller with Reduced Swing Differential Signaling RSDS Outputs

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 +3.0V
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:

HBM: 2 kV
MM: 200V

(HBM: $R_{ZAP} = 1.5\text{ k}\Omega$, $C_{ZAP} = 100\text{ pF}$,MM: $R_{ZAP} = 0\Omega$, $C_{ZAP} = 200\text{ pF}$)**Operating Conditions**

	Min	Max	Units
Supply Voltage (V_{DD})	2.25	2.75	V
Operating Temp. Range (T_A)	0	70	°C
Supply Noise Voltage		200	mV _{PP}

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.

DC Electrical Characteristics $V_{DD} = 2.5V \pm 0.25V$, $T_A = 0^\circ\text{C}$ to 70°C , $I_{PI} = 100\text{ }\mu\text{A}$ (Unless otherwise specified)**TTL DC Electrical Characteristics**

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{DD}	Supply Voltage		2.25	2.5	2.75	
V_{IH}	Minimum Input High Voltage		1.8			V
V_{IL}	Maximum Input Low Voltage				0.7	V
V_{OH}	Output High Voltage	$I_{OH} = -8\text{ mA}$	$0.8 \times V_{DD}$			
V_{OL}	Output Low Voltage	$I_{OL} = 8\text{ mA}$			0.4	
I_{IN}	Input Current	$V_{IN} = V_{DD}$			10	μA
		$V_{IN} = \text{GND}$			10	μA
I_{DD}	Average Supply Current	CLK = 85 MHz, RPI = 12.3k $C_{L(TTL)} = 50\text{ pF}$, $R_{L(RSDS)} = 100\Omega$ and $C_{L(RSDS)} = 5\text{ pF}$ (jig & test fixture capacitance), See Figure 3 for input conditions		80 $I_P = 100\text{ }\mu\text{A}$ $V_{DD} = 2.5V$	120 $I_P = 100\text{ }\mu\text{A}$ $V_{DD} = 2.75V$	mA

FPD-Link (LVDS) Receiver Input (RxCLKP/N; RxIN[y]P/N, y = 0,1,2)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
LVDS RECEIVER DC SPECIFICATIONS						
Note: LVDS Receiver DC parameters are measured under Static and Steady state conditions which may not be reflective of its performance in the end application.						
This device is compatible with TIA644 SPEC. V0 and V2.4.						
V_{THLVDS}	Differential Input High Threshold Voltage	$V_{CM} = 1.2V$			+100	mV
V_{TLVDS}	Differential Input Low Threshold Voltage		-100			mV
I_{IN}	INput Current	$V_{IN} = V_{DD} - 0.4V$, $V_{DD} = 2.75V$			± 10	μA
		$V_{IN} = 0V$, $V_{DD} = 2.75V$			± 10	μA
V_{IN}	INput Voltage Range		0		$V_{DD} - 0.4$	V
$ V_{ID} $	Differential Input Voltage		0.100		0.600	V
V_{CM}	Common Mode Voltage Offset		$0 + V_{ID} /2$		$(V_{DD} - 0.4) - V_{ID} /2$	V

DC Electrical Characteristics $V_{DD} = 2.5V \pm 0.25V$, $T_A = 0^\circ C$ to $70^\circ C$, $I_{PI} = 100 \mu A$ (Unless otherwise specified) (Continued)

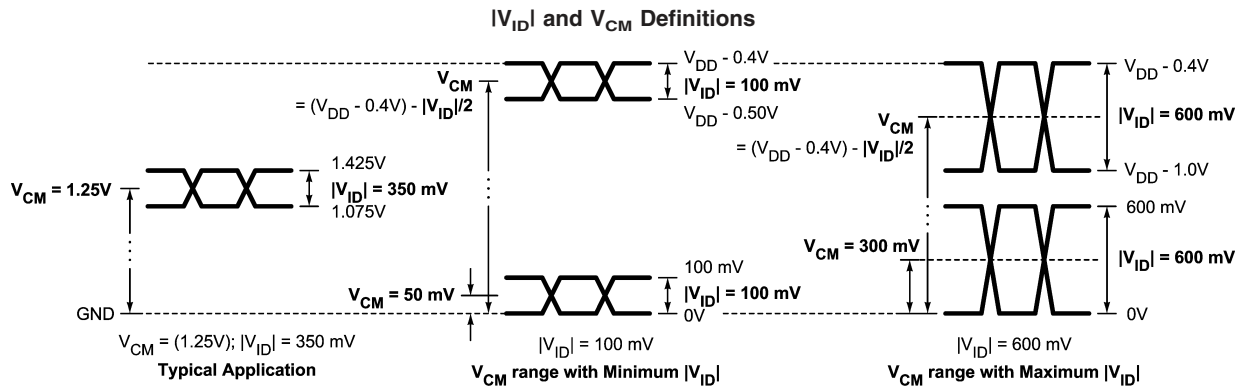


FIGURE 2. LVDS V_{ID} and V_{CM} Allowable Operating Range

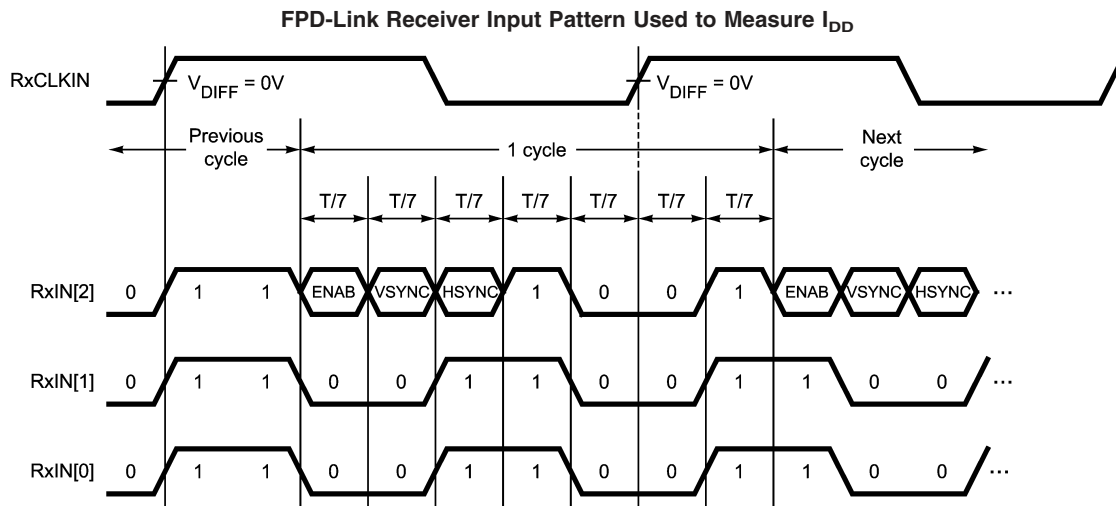


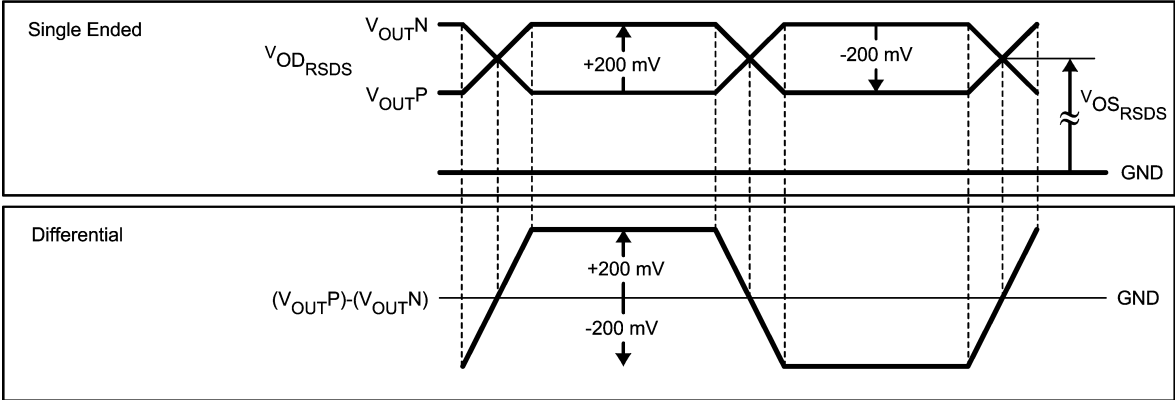
FIGURE 3. FPD-Link Receiver I_{DD} Pattern

DC Electrical Characteristics $V_{DD} = 2.5V \pm 0.25V$, $T_A = 0^{\circ}C$ to $70^{\circ}C$, $I_{PI} = 100 \mu A$ (Unless otherwise specified) (Continued)

RSDS Output

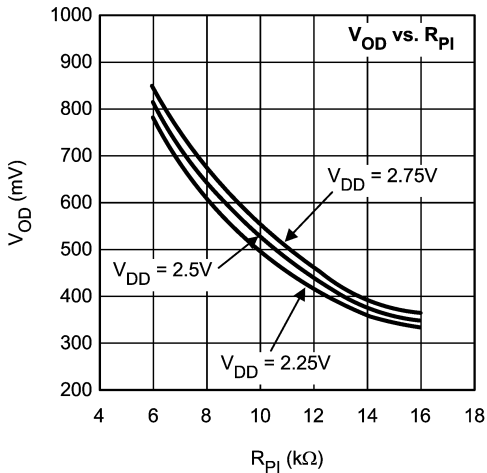
(CLKP/N, xyP/N; x = R, G, B; y = 0, 1, 2), $V_{DD} = 2.25V$ to $2.75V$ (Unless otherwise specified)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$ V_{OD_{RSDS}} $	Differential Output Voltage Typ.	$R_L = 100\Omega$		200 (Figure 4)		mV
$V_{OS_{RSDS}}$	Offset Voltage	$I_{PI} = 100 \mu A$		1.2		V



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FIGURE 4. RSDS Output Waveforms: Single Ended vs Differential



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FIGURE 5. Typical RSDS V_{OD} vs R_{PI} Response Curve

DC Electrical Characteristics $V_{DD} = 2.5V \pm 0.25V$, $T_A = 0^\circ C$ to $70^\circ C$, $I_{PI} = 100 \mu A$ (Unless otherwise specified) (Continued)

Schmitt Trigger

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_H	Hysteresis Voltage	$V_{T+} - V_{T-}$		0.4		V
V_{T-}	Hysteresis Low Threshold Voltage			1.2		V
V_{T+}	Hysteresis High Threshold Voltage			1.6		V
I_{INHYS}	Input Current	$V_{IN} = V_{DD}$			20	μA
		$V_{IN} = V_{SS}$	-20	0		μA

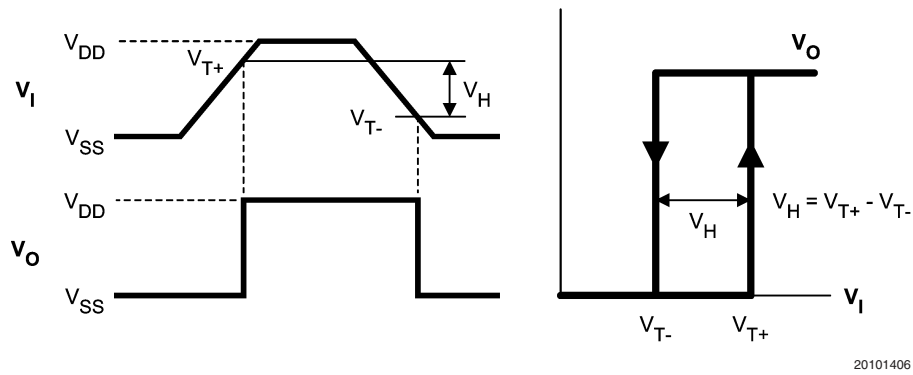


FIGURE 6. Hysteresis Definition

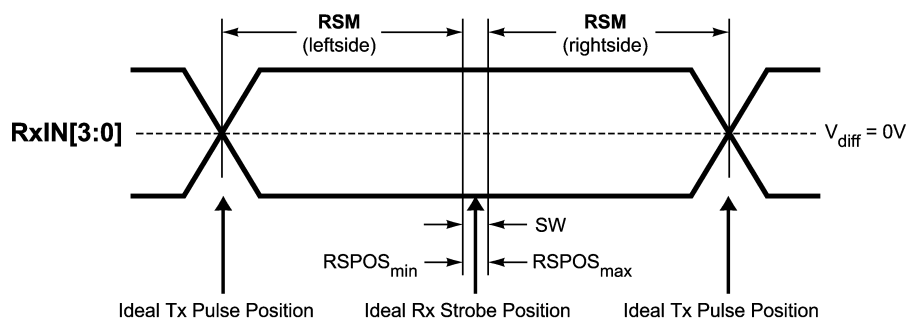
AC Electrical Characteristics

$T_A = 0^{\circ}\text{C}$ to 70°C , $V_{DD} = 2.5\text{V} \pm 0.25\text{V}$, $I_{PI} = 100\text{ }\mu\text{A}$ (Unless otherwise specified)

LVDS Data Input

Symbol	Parameter	Conditions	Min	Max	Units
F_{RXCLK}	RxCLK Frequency (LVDS)		25	85	MHz
RPLLS	FPD-Link Receiver Phase Lock Loop Wake-Up Time			10	ms
RMS	RxIN Strobe Margin (Note 2) and (Figure 7)	$F = 85\text{ MHz}$	400		ps

Note 2: Receiver Strobe Margin is defined as the valid data sampling region at the receiver inputs.



Acronyms:

RSM Receiver Strobe Margin
RSPOS Receiver Strobe Position
SW Strobe Width

Definitions:

SW Setup and Hold Time (Internal data sampling window)

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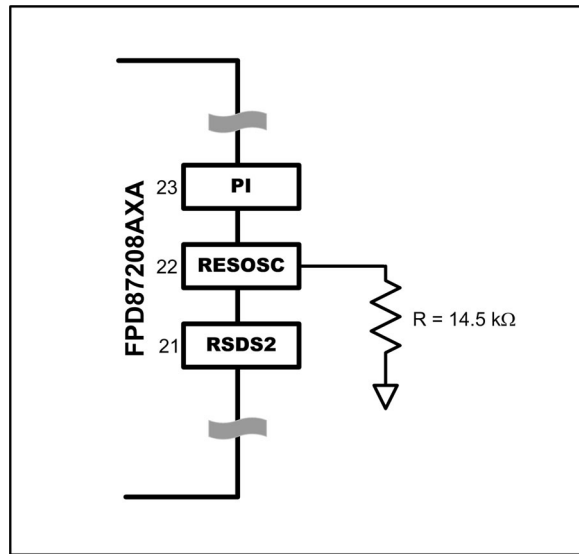
FIGURE 7. FPD-Link Receiver Input Skew Margin

AC Electrical Characteristics

$T_A = 0^\circ\text{C}$ to 70°C , $V_{DD} = 2.5\text{V} \pm 0.25\text{V}$, $I_{PI} = 100\text{ }\mu\text{A}$ (Unless otherwise specified) (Continued)

Ring Oscillator Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Units
RESOSC	Ring Oscillator Clock Frequency	$R = 14.5\text{K}\Omega$; $V_{DD} = 2.5\text{V}$		40		MHz



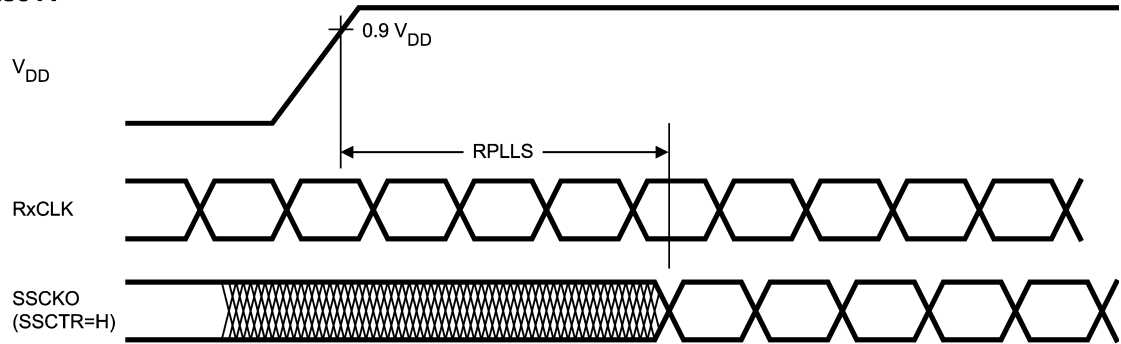
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FIGURE 8. Application diagram of Ring Oscillator

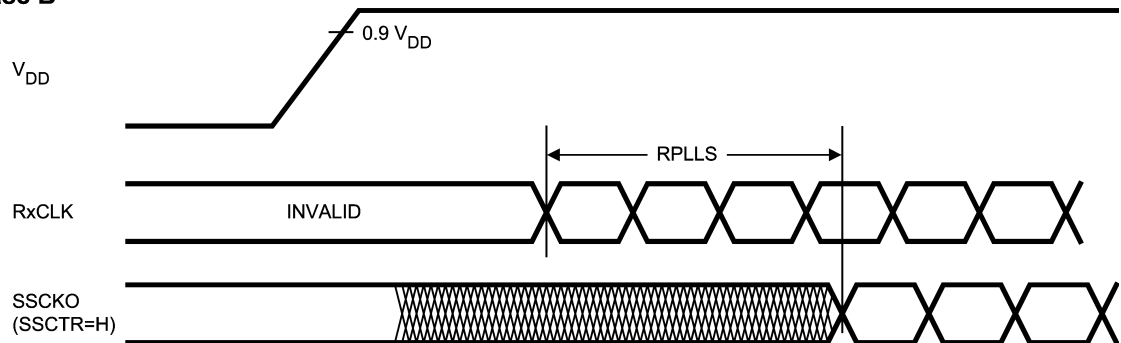
AC Electrical Characteristics

$T_A = 0^\circ\text{C}$ to 70°C , $V_{DD} = 2.5\text{V} \pm 0.25\text{V}$, $I_{PI} = 100\ \mu\text{A}$ (Unless otherwise specified) (Continued)

Case A

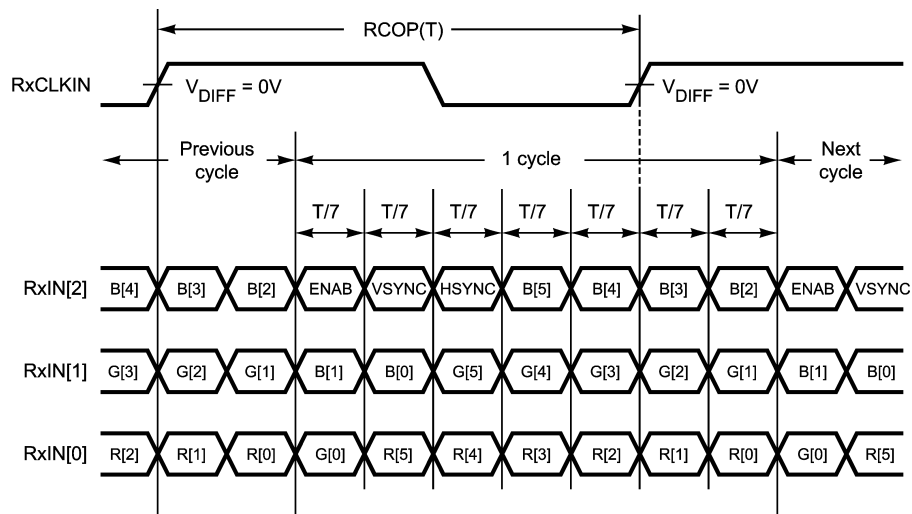


Case B



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FIGURE 9. FPD-Link Receiver Phase Lock Loop Wake-Up Time



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Note: R/G/B[7]s are MSBs and R/G/B[0]s are LSBs

FIGURE 10. FPD-Link Receiver Input Data Mapping

AC Electrical Characteristics

$T_A = 0^{\circ}\text{C}$ to 70°C , $V_{DD} = 2.5\text{V} \pm 0.25\text{V}$, $I_{PI} = 100\text{ }\mu\text{A}$ (Unless otherwise specified) (Continued)

Output Timing

$R_T = 100\Omega$, $I_{PI} = 100\text{ }\mu\text{A}$, $f = 85\text{ MHz}$ (Unless otherwise specified)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
RCHP	RSDS Clock (RSCK) High Period	$C_{L(RSDS)} = 5\text{ pF}$		5.8		ns
RCLP	RSDS Clock (RSCK) Low Period	$C_{L(RSDS)} = 5\text{ pF}$		5.8		ns
SPSTU	STH Rising to RSCK Falling	$C_{L(TTL)} = 15\text{ pF}$	4.0			ns
SPHLD	STH Falling to RSCK Falling		4.0			ns
RSTU (Note 3)	RSDS Setup to Falling or Rising Edge of RSCK	$C_{L(RSDS)} = 5\text{ pF}$ RSDS[2:0]=[011]		3.3		ns
RHLD (Note 3)	RSDS Hold from Falling or Rising Edge of RSCK			2.1		ns

Note 3: Refer to the table "RSDS Setup and Hold Time with Data Skew Control Values" for each skew control.

RSDS Setup and Hold Time with Data Skew Control Values—Reference Only

($R_{xCLKP/N} = 85\text{ MHz}$, $R_T = 100\Omega$, $I_{PI} = 100\text{ }\mu\text{A}$, $V_{DD} = 2.5\text{V}$; Duty Clock = 50%/50%, $\pm 2\%$; 25°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.

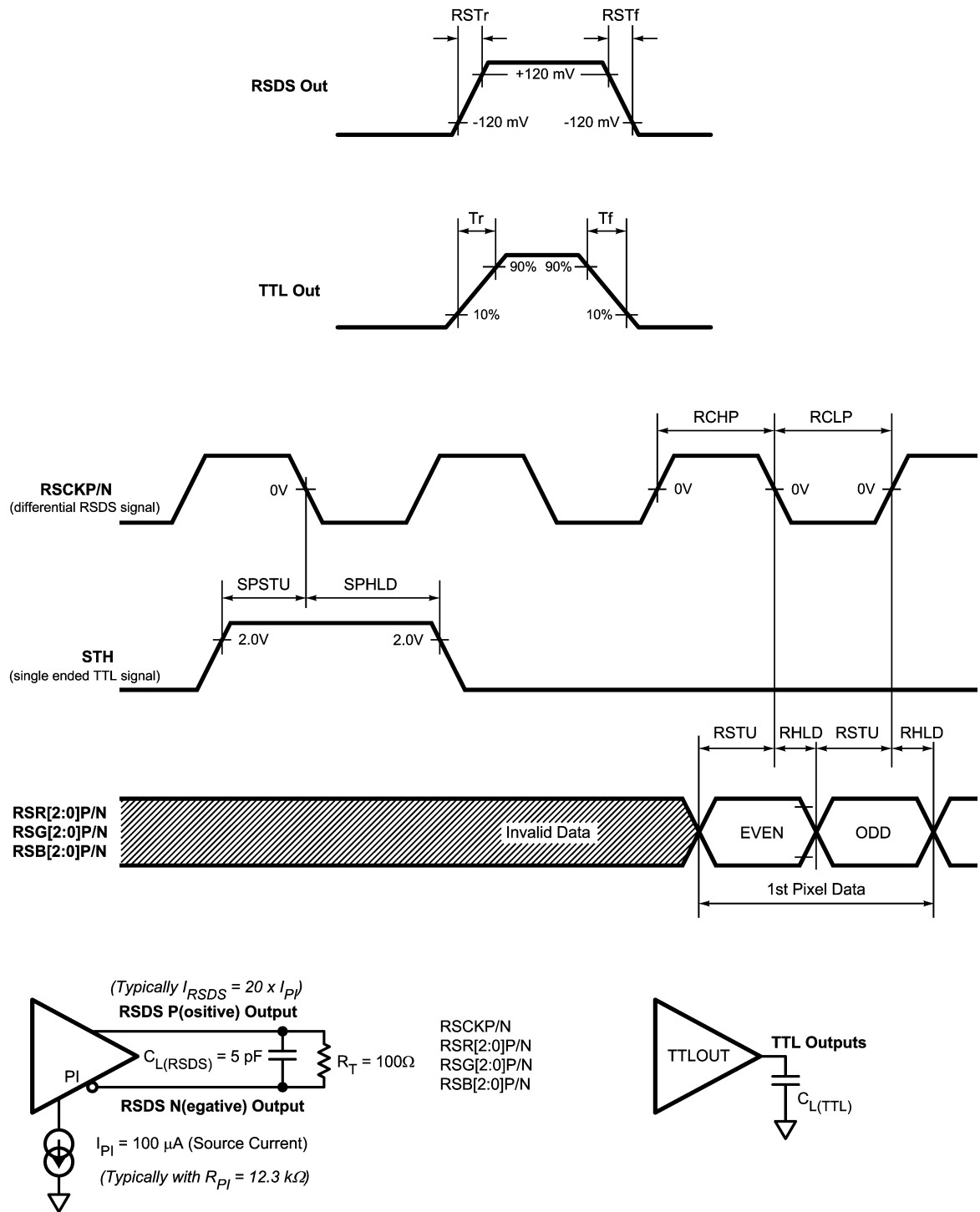
RSDS[2:0]	Setup Time (RSTU, ns)			Hold Time (RHLD, ns)			Units
	Min	Typ	Max	Min	Typ	Max	
000		1.83			3.61		ns
001		2.33			3.09		
010		2.83			2.61		
011		3.31			2.10		
100		3.85			1.55		
101		4.34			1.03		
110		4.81			0.53		
111		5.33			0.01		

RSDS and TTL Output Tr/Tf

Symbol	Parameter	Conditions	Min	Typ	Max	Units
RSTr/RSTf	RSDS Output Rising/Falling Time (All RSDS Outputs)	$C_{L(RSDS)} = 5\text{ pF}$		1.5		ns
TTL Tr/Tf	TTL Output Rising and Falling Time	$C_L = 15\text{ pF}$ (20%–80%)		2.0		ns

AC Electrical Characteristics

$T_A = 0^\circ\text{C}$ to 70°C , $V_{DD} = 2.5\text{V} \pm 0.25\text{V}$, $I_{PI} = 100\text{ }\mu\text{A}$ (Unless otherwise specified) (Continued)

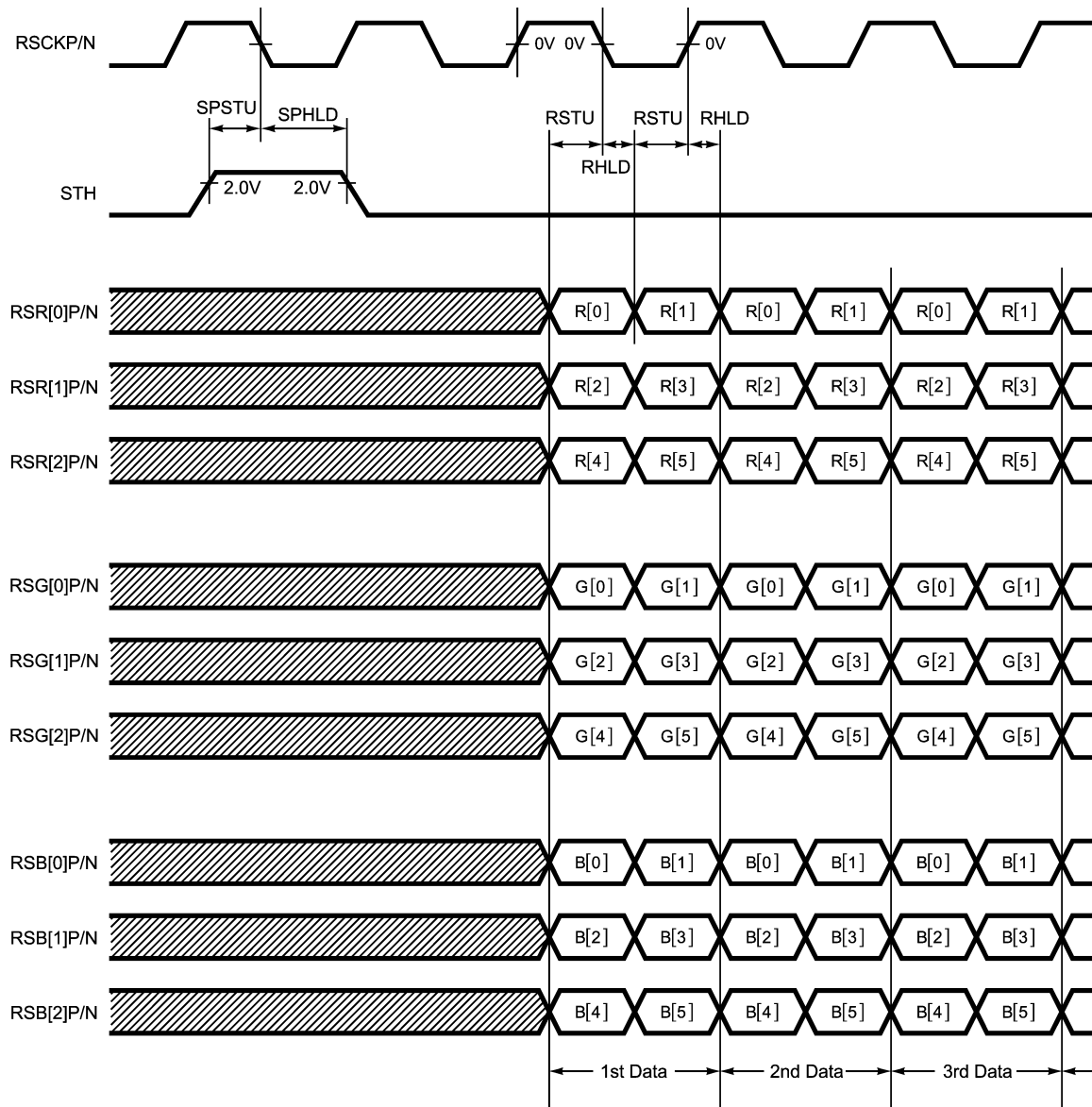


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FIGURE 11. RS and TTL Output Timing Diagram

AC Electrical Characteristics

$T_A = 0^{\circ}\text{C}$ to 70°C , $V_{DD} = 2.5\text{V} \pm 0.25\text{V}$, $I_{PI} = 100\text{ }\mu\text{A}$ (Unless otherwise specified) (Continued)



Note: RSCKP/N, RSR[2:0]P/N, RSG[2:0]P/N and RSB[2:0]P/N are differential outputs, STH is a single ended TTL output.

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FIGURE 12. RSDS Output Data Mapping

AC Electrical Characteristics

$T_A = 0^\circ\text{C}$ to 70°C , $V_{DD} = 2.5\text{V} \pm 0.25\text{V}$, $I_{PI} = 100\text{ }\mu\text{A}$ (Unless otherwise specified) (Continued)

Input Signal Timing—Reference Only

Signal	Item	Symbol		XGA (1024 x 768)	WXGA1 (1280 x 768)	WXGA2 (1280 x 800)	WXGA3 (1280 x 854)	Unit
Clock Frequency	1/Tclk	F	Typ	65	82	68	69	MHz
Vertical Timing	Total	Tv	Min	774	774	806	860	Th
			Typ	806	806	816	880	
			Max	1024	1024	1024	1024	
	Active	Tvact	Min	-	-	-	-	
			Typ	768	768	800	854	
			Max	-	-	-	-	
Horizontal Timing	Total	Th	Min	1078	1334	1334	1334	Tclk
			Typ	1344	1688	1408	1408	
			Max	2047	2047	2047	2047	
	Active	Thact	Min	100	100	100	100	
			Typ	1024	1280	1280	1280	
			Max	-	-	-	-	

Output Timing—TTL

Display Resolution Selection Control

DTM1	DTM0	Display Mode	Resolution
0	0	WXGA1	1280 x 768
0	1	WXGA2	1280 x 800
1	0	XGA	1024 x 768
1	1	WXGA3	1280 x 854

TTL Timing Selection Control: RO[2:0]

XGA									
RO[2:0]	000	001	010	011	100	101	110	111	Unit
T1	2	2	2	2	2	2	2	TEST MODE	T _{CLK}
T2	1	1	1	1	1	1	1		T _{CLK}
T3	1030	1030	1030	1030	1030	1030	1030		T _{CLK}
T4	16	24	16	24	32	48	42		T _{CLK}
T5	912	960	960	912	842	912	802		T _{CLK}
T5'	782	830	830	782	712	782	672		T _{CLK}
T6	200	160	160	130	220	220	260		T _{CLK}
T6'	130	130	130	130	130	130	130		T _{CLK}
T7	1038	1056	1056	976	874	976	834		T _{CLK}
T8	650	650	650	650	680	680	725		T _{CLK}
T9	348	348	348	348	348	348	348		T _{CLK}
T10	1	1	1	1	1	1	1		HLINE
T11	348	348	348	348	348	348	348		T _{CLK}
T12	1	1	1	1	1	1	1		HLINE
T13*	567	567	567	567	567	567	567		T _{CLK}
T14*	2	2	2	2	2	2	2		HLINE

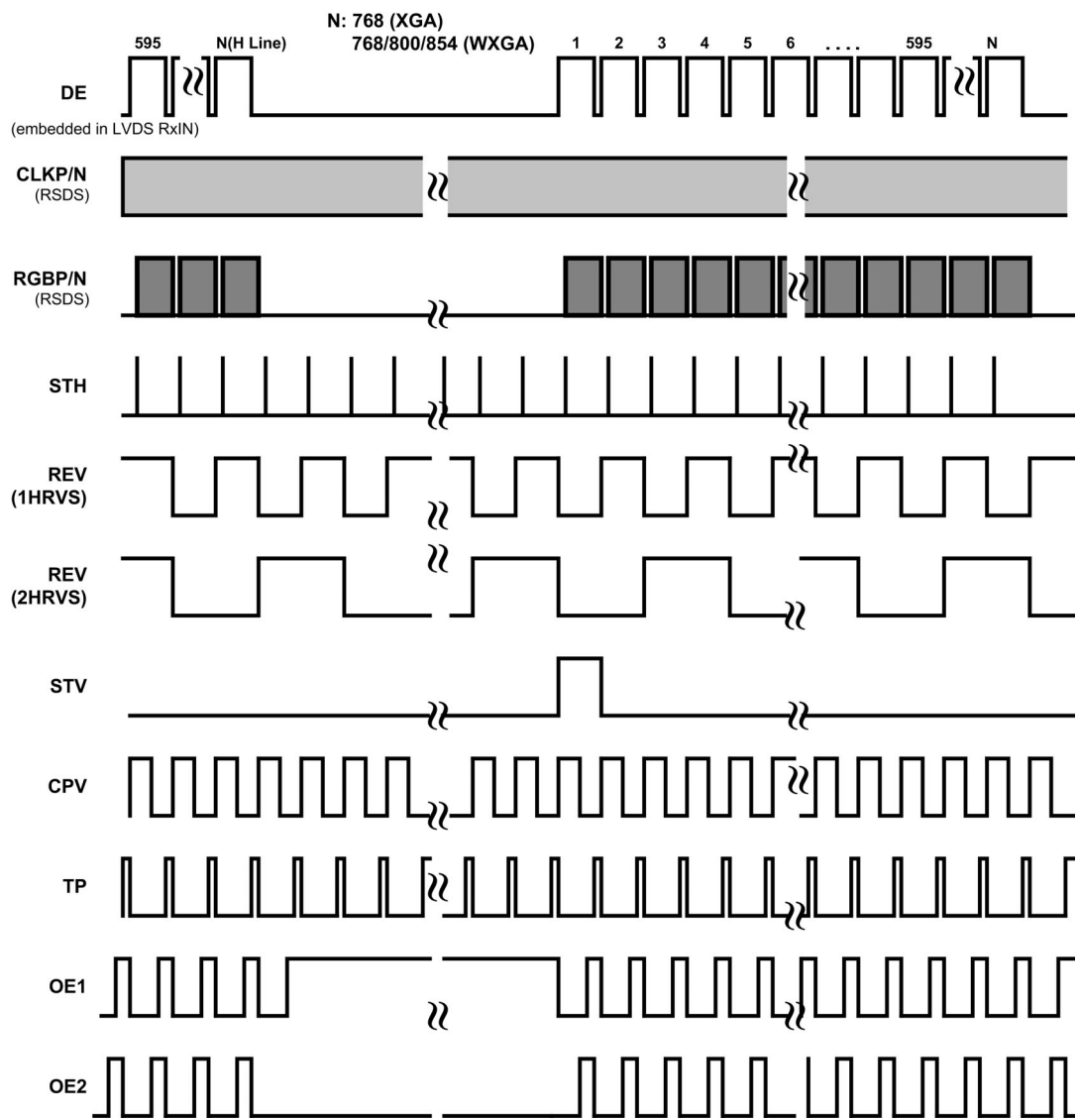
*Timing based on first occurrence of STH.

Output Timing—TTL (Continued)

WXGA									
RO[2:0]	000	001	010	011	100	101	110	111	Unit
T1	2	2	2	2	2	2	2	TEST MODE	T _{CLK}
T2	1	1	1	1	1	1	1		T _{CLK}
T3	1286	1286	1286	1286	1286	1286	1286		T _{CLK}
T4	16	24	16	24	32	48	42		T _{CLK}
T5	1168	1216	1216	1168	1098	1168	1058		T _{CLK}
T5'	1038	1086	1086	1038	968	1038	928		T _{CLK}
T6	200	160	160	130	220	220	260		T _{CLK}
T6'	130	130	130	130	130	130	130		T _{CLK}
T7	1294	1312	1312	1232	1130	1232	1090		T _{CLK}
T8	650	650	650	650	680	680	725		T _{CLK}
T9	348	348	348	348	348	348	348		T _{CLK}
T10	1	1	1	1	1	1	1		HLINE
T11	348	348	348	348	348	348	348		T _{CLK}
T12	1	1	1	1	1	1	1		HLINE
T13*	567	567	567	567	567	567	567		T _{CLK}
T14*	2	2	2	2	2	2	2		HLINE

*Timing based on first occurrence of STH.

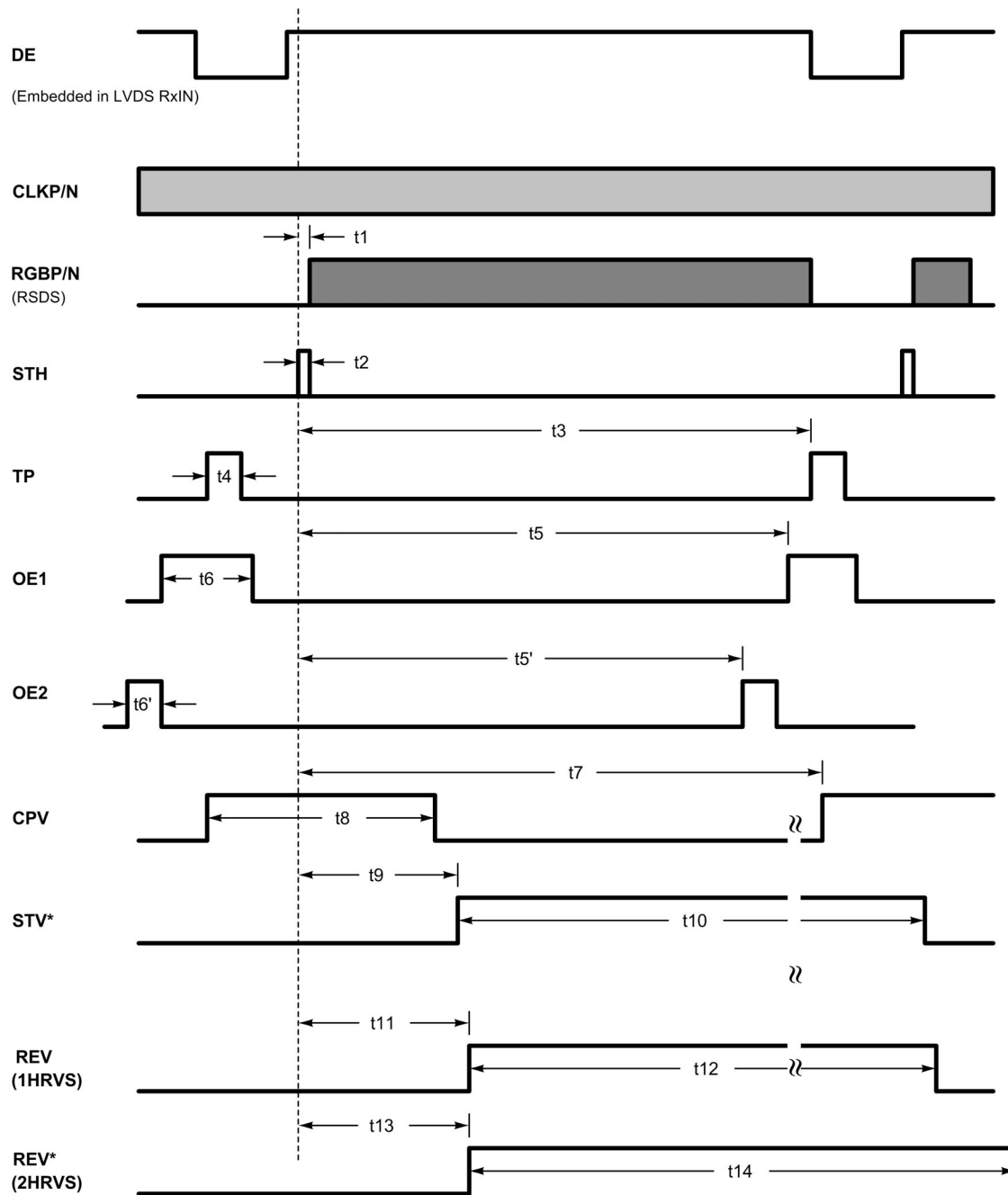
Output Timing—TTL (Continued)



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FIGURE 13. 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 14. TTL Output Timing Diagram (Continued)

Output Timing—Power-Up Sequence (reference only)

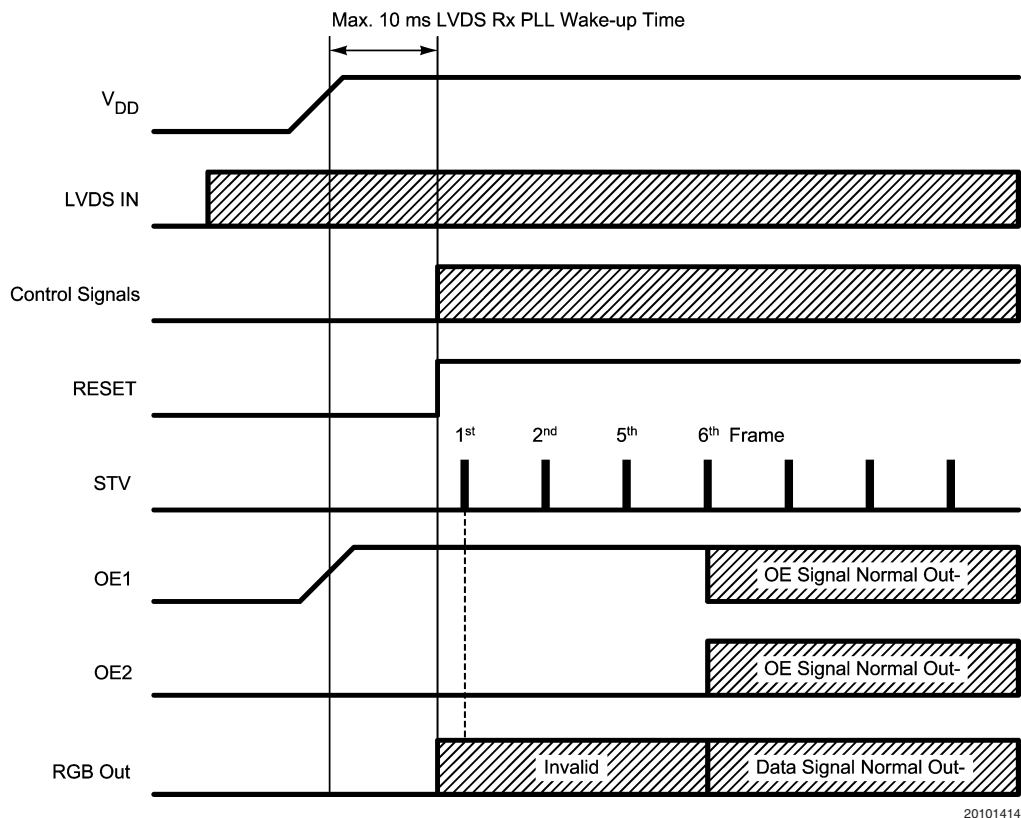
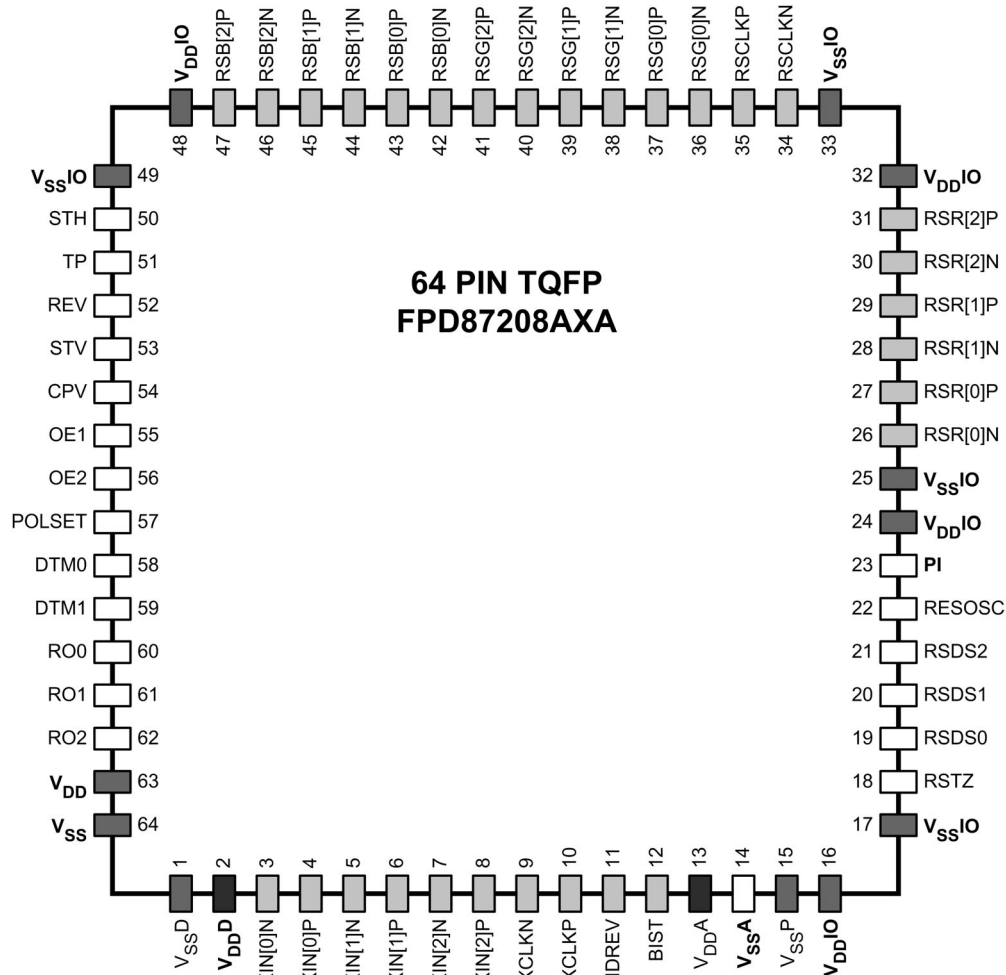


FIGURE 15. Power-Up Sequence

Connection Diagram



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FIGURE 16. Pinout Assignment

Pin Descriptions

LVDS Rx Inputs

Symbol	Pin Count	Type	Function
RxIN[0]N/P	2	LVDSI	LVDS Rx Data Differential Input Pairs
RxIN[1]N/P	2	LVDSI	LVDS Rx Data Differential Input Pairs
RxIN[2]N/P	2	LVDSI	LVDS Rx Data Differential Input Pairs
RxCLKN/P	2	LVDSI	LVDS Rx Clock Differential Input Pairs
Sub-Total Pin Count	8		

Pin Descriptions (Continued)**RSDS Tx Outputs**

Symbol	Pin Count	Type	Function
R [2:0]P/N	6	RSO	Red Reduced Swing Differential Outputs to Column Drivers
G [2:0]P/N	6	RSO	Green Reduced Swing Differential Outputs to Column Drivers
B [2:0]P/N	6	RSO	Blue Reduced Swing Differential Outputs to Column Drivers
CLKP/N	2	RSO	Clock Reduced Swing Differential Outputs to Column Drivers
Sub-Total Pin Count	20		

RSDS Tx Bias Reference Input

Symbol	Pin Count	Type	Function
PI	1		Current Reference for RSDS Tx Output (1.23V)
Sub-Total Pin Count	1		

CMOS Input (2.75V Maximum)

Symbol	Pin Count	Type	Function
RSDS[2:0]	3	I	RSDS Skew/Timing Control
RO[2:0]	3	I	Display Timing Selection
POLSET	1	I	0: Two Line Inversion; 1: One Line Inversion
DTM[1:0]	2	I	Display Mode Selection (XGA, WXGA1, WXGA2, WXGA3)
RESOSC	1	AI	RC oscillator reference for BIST function. 14.5 k Ω = ~40 MHz
IDREV	1	PU	IDREV = HIGH (default, pull high): Output data is 3F during vertical blanking. IDREV = LOW: Output data is 00 during vertical blanking.
BIST	1	I	BIST Control Function (Active High), tied to ground for norm mode
RESETZ	1	Schmitt I	TCON Reset (Active Low)
Sub-Total Pin Count	13		

CMOS Outputs (2.75V Maximum)

Symbol	Pin Count	Type	Function
STV	1	TO	Row Driver Start Pulse
CPV	1	TO	Row Driver Shift Clock
TP	1	TO	Line Latch Signal Output to Column Drivers
STH	1	TO	Horizontal Start Signal Output to Column Drivers
REV	1	TO	Alternative Signal Output for each 1 or 2 Horizontal Line to Column Drivers
OE1	1	TO	Control TFT Gate Pulse Width to Row Drivers
OE2	1	TO	Control TFT Gate Pulse Width to Row Drivers
Sub-Total Pin Count	7		

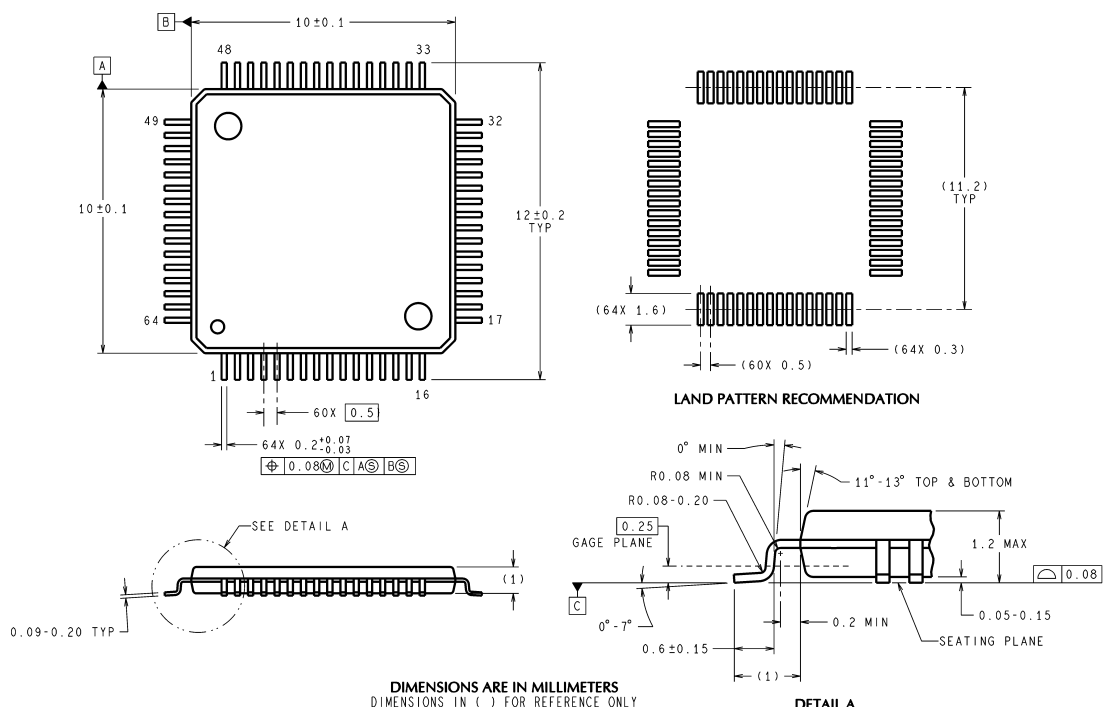
Pin Descriptions (Continued)**Power Supply**

Symbol	Pin Count	Type	Function
V _{DD}	1	P	Digital Power for Logic Core
V _{SS}	1	G	Digital Ground for Logic Core
V _{DDIO}	4	P	Digital I/O and RSDS Power
V _{SSIO}	4	G	Digital I/O and RSDS Ground
V _{DDA}	1	P	FPD Receiver—Power for Analog
V _{DDD}	1	P	FPD Receiver—Power for Digital
V _{SSD}	1	G	FPD Receiver—Ground for Digital
V _{SSP}	1	G	FPD Receiver—Ground for PLL
V _{SSA}	1	G	FPD Receiver—Ground for Analog
Sub-Total Pin Count	15		
Total Pin Count	64		System Interface = 8 RSDS Tx Out = 20 RSDS Tx Bias Reference Input = 1 CMOS Input (control) = 13 CMOS Output = 7 Power Supply = 15

Pin Types

AI	-Analog Input	P	-Power
I	-Input (LVTTTL)	G	-Ground
TO	-TTL Output (LVTTTL)	PD	-Pull Down
LVDSI	-Low Voltage Differential Signal Input	PU	-Pull Up
RSO	-Reduced Swing Differential Output	Schmitt I	-Schmitt Triggered Input

Physical Dimensions inches (millimeters) unless otherwise noted



VEC64A (Rev B)

64-Lead TQFP Package, JEDEC
Dimension in millimeters only
Order Number FPD87208AXAVS
NS Package Number VEC64A

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

BANNED SUBSTANCE COMPLIANCE

National Semiconductor certifies that the products and packing materials meet the provisions of the Customer Products Stewardship Specification (CSP-9-111C2) and the Banned Substances and Materials of Interest Specification (CSP-9-111S2) and contain no "Banned Substances" as defined in CSP-9-111S2.



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