National Semiconductor

PRELIMINARY
July 2004

FPD87346BXA
Low EMI, Low Dynamic Power (SVGA) XGA/WXGA TFT-LCD Timing Controller with Reduced Swing Differential Signaling (RSDS™) Outputs

General Description

The FPD87346BXA is a timing controller that combines an LVDS single pixel input interface with National's Reduced Swing Differential Signaling (RSDS™) output driver interface for (SVGA) XGA and Wide XGA resolutions. It resides on the TFT-LCD panel and provides the data buffering and control signal generation for (SVGA) 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 8-bit color data for (SVGA) XGA, and Wide XGA panels at 170 Mb/s when using VESA 60 Hz standard timing.

Features

- Reduced Swing Differential Signalling (RSDS™) digital bus reduces dynamic power, EMI and bus width from the timing controller
- LVDS single pixel input interface system
- Input clock range from 40 MHz to 85 MHz
- Drives RSDS™ Column Drivers at 170 Mb/s with an 85 MHz clock (Max.)
- Virtual 8 bit color depth in FRC/Dithering mode
- Single narrow 9-bit differential Source Driver bus minimizes width of Source PCB
- Ability to drive (SVGA) XGA and Wide XGA TFT-LCD Systems
- Failure detect function in DE mode (Bonding Option)
- CMOS circuitry operates from a 3.0V–3.6V supply

System Diagram

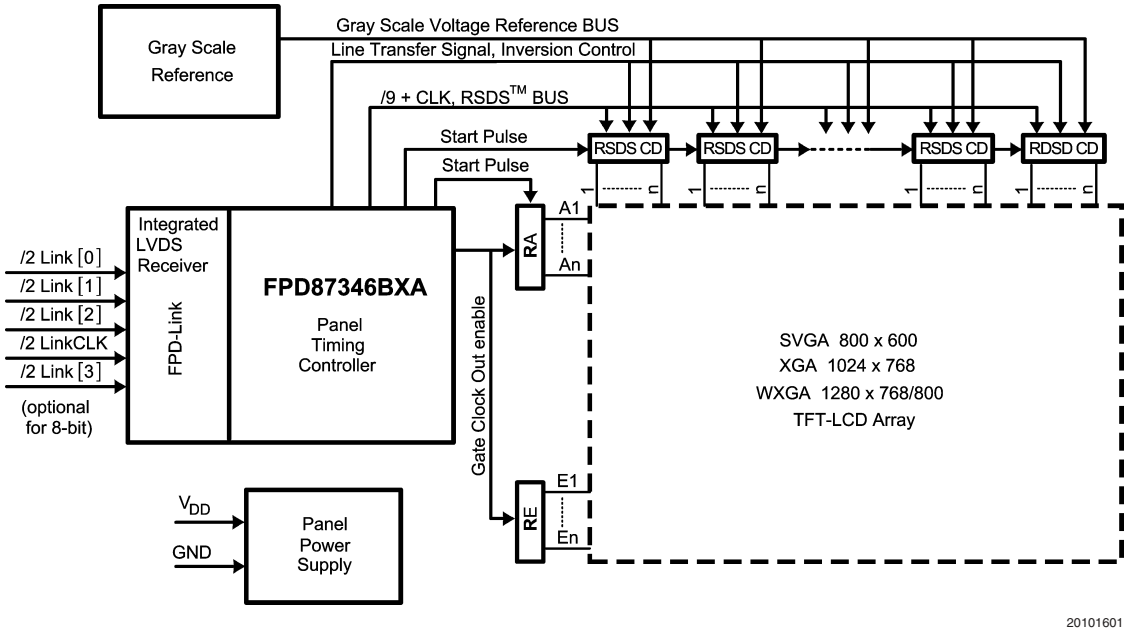


FIGURE 1. Block Diagram of the LCD Module

RSDS™ is a trademark of National Semiconductor Corporation

FPD87346BXA Low EMI, Low Dynamic Power (SVGA) XGA/WXGA TFT-LCD Timing Controller with Reduced Swing Differential Signaling (RSDS™) Outputs

Block Diagram

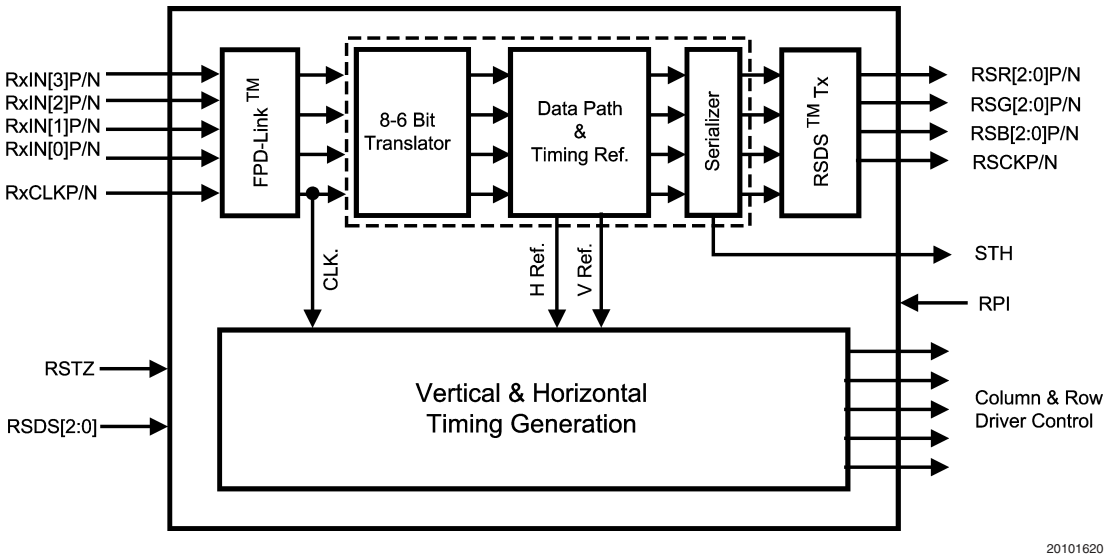


FIGURE 2. Block Diagram

Functional Description

FPD-LINK RECEIVER

The FPD87346BXA is TFT-LCD Timing Controller (TCON) that is based on National Semiconductor's Embedded Logic Array family of TCON devices. The logic architecture is implemented using standard and default timing controller functionality based on an Embedded Gate Array. In it's standard configuration the Gate Driver Control, Column Driver Control signals, and Logic Functions of the device are preset. Customization of control signal timing and other logic functions of the device are reconfigurable through customer supplied Verilog/RTL Code or User-defined specifications. The combination of Embedded Logic Array and National Semiconductor's world class Mixed-signal Analog functional blocks such as LVDS and RSDS™ provides a flexible platform to meet the needs of TFT-LCD Manufacturers.

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 deviation of ±2% center spread or -4% down spread is supported at a frequency modulation of 100 kHz 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 pixel rate. The data is delayed to align the Column Driver Start Pulse with the Column Driver data. The data bus (RSR[2:0]P/N, RSG[2:0]P/N, RSB[2:0]P/N) outputs at a 170 MHz rate on 9 differential output channels. The clock is output on the RSCKP/N differential pair. The RSDS Column Drivers latch data on both positive and negative edges of the clock. The RSDS™ output setup/hold timings are also adjustable through the RSDS[2:0] input pins.

TIMING CONTROL FUNCTION

The Timing Controller Functional Block generates all the necessary control signals to the Column Driver (TP, STH, and REV) and Gate Drivers (STV, CPV, and OE) to interface with a TFT-LCD panel.

RSDS OUTPUT VOLTAGE CONTROL

The RSDS™ output voltage swing is controlled through an external load resistor connected to the R_{PI} 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 R_{PI} value. Lower R_{PI} 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 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} = 1500Ω)	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 (V_{DD})		200	mV_{PP}
Spread Spectrum Support, LVDS			
Spreading Range		± 2.0	%
Modulation Rate		100	kHz
Operating Frequency (f)	40	85	MHz

DC Electrical Characteristics

T_A = 0˚C to 70˚C, V_{DD} = 3.3V ± 0.3V, I_{PI} = 100 µA (Unless otherwise specified).

TTL DC ELECTRICAL CHARACTERISTICS

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_{OH}	Minimum High Level Output Voltage	STV, CPV, OE	I_{OH} = -6 mA	2.4			V
		TP, REV	I_{OH} = -8 mA				
		STH	I_{OH} = -24 mA				
V_{OL}	Maximum Low Level Output Voltage	STV, CPV, OE	I_{OL} = +6 mA			0.4	V
		TP, REV	I_{OL} = +8 mA				
		STH	I_{OL} = +24 mA				
V_{IH}	Minimum High Level Input Voltage			2.0			V
V_{IL}	Maximum Low Level Input Voltage					0.8	V
I_{IN}	Input Current	V_{IN} = V_{DD}, GND		−10		+10	µA
I_{DD}	Average Supply Current	f = 85 MHz V_{DD} = 3.6V, $C_{L(TTL)}$ = 15 pF, I_{PI} = 100 µA (Typically PI pin connected to 13 kΩ to ground) $R_{L(RSDS)}$ = 100Ω and $C_{L(RSDS)}$ = 5 pF (jig & test fixture capacitance), See *Figure 3* for input conditions			85	150	mA

Note 1: "Absolute Maximum Rating" 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

T_A = 0˚C to 70˚C, V_{DD} = 3.3V ± 0.3V, I_{PI} = 100 µA (Unless otherwise specified). (Continued)

FPD-Link Receiver Input Pattern Used to Measure I_{DD}

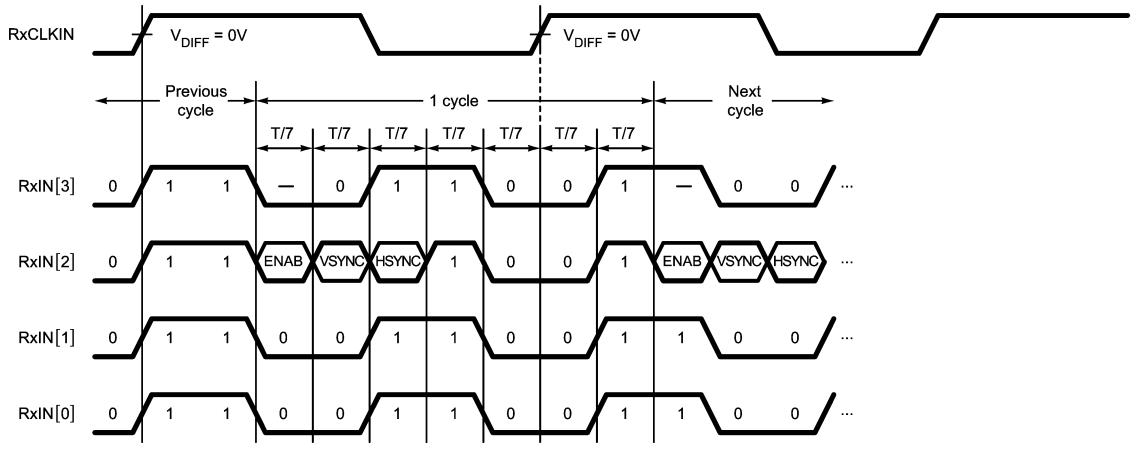


FIGURE 3. FPD-Link Receiver I_{DD} Pattern

FPD-Link (LVDS) RECEIVER INPUT (RxCLK+/-, RxIN[y]+/-; y = 0, 1, 2, 3)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
LVDS RECEIVER DC SPECIFICATIONS (Note 2)						
$V_{TH_{LVDS}}$	Differential Input High Threshold Voltage	V_{CM} = 1.2V			+100	mV
$V_{TL_{LVDS}}$	Differential Input Low Threshold Voltage		−100			mV
I_{IN}	Input Current	V_{IN} = 2.4V, V_{DD} = 3.6V	−10		+10	µA
		V_{IN} = 0V, V_{DD} = 3.6V	−10		+10	µA
V_{IN}	Input Voltage Range (Single-ended)		0		2.4	V
$\|V_{ID}\|$	Differential Input Voltage		0.100		0.600	V
V_{CM}	Common Mode Voltage Offset		$0+\|V_{ID}\|/2$		$2.4-\|V_{ID}\|/2$	V

Note 2: LVDS Receiver DC parameters are measured under static and steady state conditions which may not reflect the actual performance in the end application.

$|V_{ID}|$ and V_{CM} Definitions Using Single-End Signals

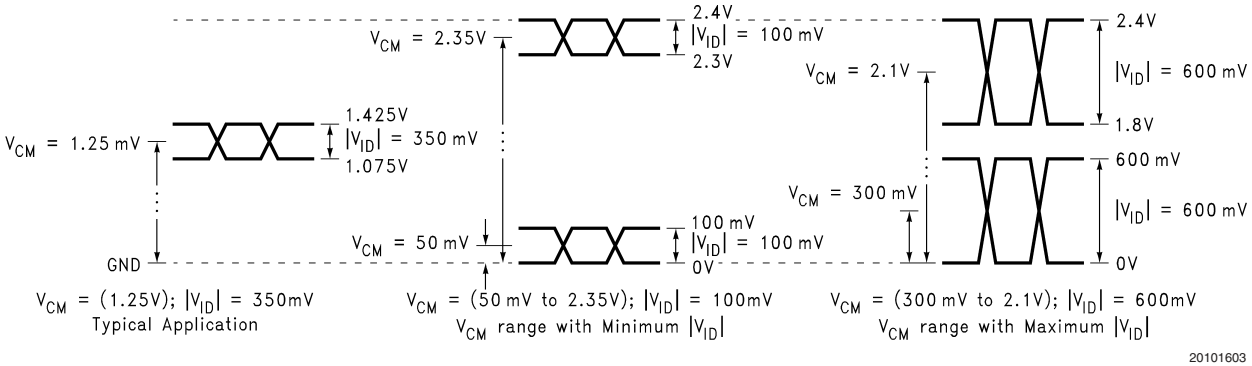


FIGURE 4. $|V_{ID}|$ and V_{CM} Allowable Operating Range

DC Electrical Characteristics

T_A = 0˚C to 70˚C, V_{DD} = 3.3V ± 0.3V, I_{PI} = 100 µA (Unless otherwise specified). (Continued)

RSDS TRANSMITTER OUTPUT (RSCKP/N, RSx[y]P/N; x = R, G, B y = 0, 1, 2)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$V_{OD_{RSDS}}$	Differential Output Voltage	R_L = 100Ω R_{PI} = 13 kΩ		±200 (Note 3) and (*Figure 5*)		mV
$V_{OS_{RSDS}}$	Offset Voltage		1.1	1.3	1.5	V

Note 3: VOSRSDS = (V(F&B)CLKP + V(F&B)CLKN)/2 or VOSRSDS = (V(F&B)XYP + V(F&B)XYN)/2.
VODRSDS = V(F&B)CLKP − V(F&B)CLKN or VODRSDS = V(F&B)XYP − V(F&B)XYN.
The load between the positive and negative output is 100Ω.

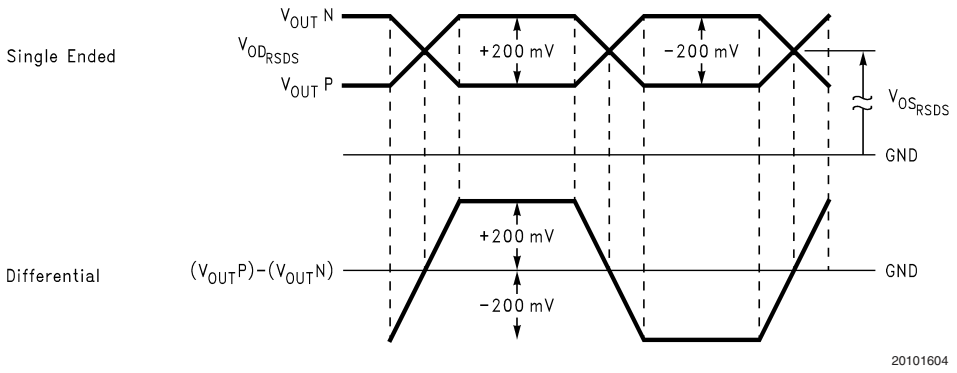


FIGURE 5. RSDS Waveform - Single Ended and Differential

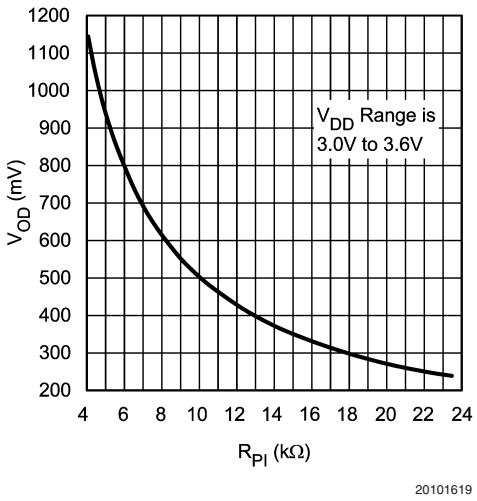


FIGURE 6. Typical $RSDS_{VOD}$ vs. R_{PI} Response Curve

AC Electrical Characteristics

T_A = 0˚C to 70˚C, V_{DD} = 3.3V ± 0.3V, I_{PI} = 100 µA (Unless otherwise specified).

LVDS Data Input

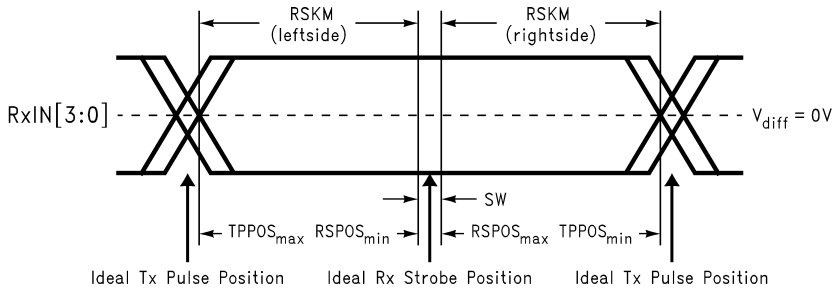
Symbol	Parameter	Conditions	Min	Max	Units
RSCLKOUTDLY	FPD-Link Receiver Phase Lock Loop Wake-up Time	*Figure 9*		10	ms
RSKM	RxIN Skew Margin (Note 4) and (*Figure 7*)	f = 85 MHz, V_{DD} = 3.3V	220		ps

Note 4: 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 (less than 190 ps). 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 (≥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 **R**eceiver **Sk**ew **M**argin
TPPOS **T**ransmitter **P**ulse **Pos**ition
RSPOS **R**eceiver **S**trobe **Pos**ition
SW **S**trobe **W**idth

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 (≥0)

Cable Skew Typically 10 ps – 40 ps per foot.

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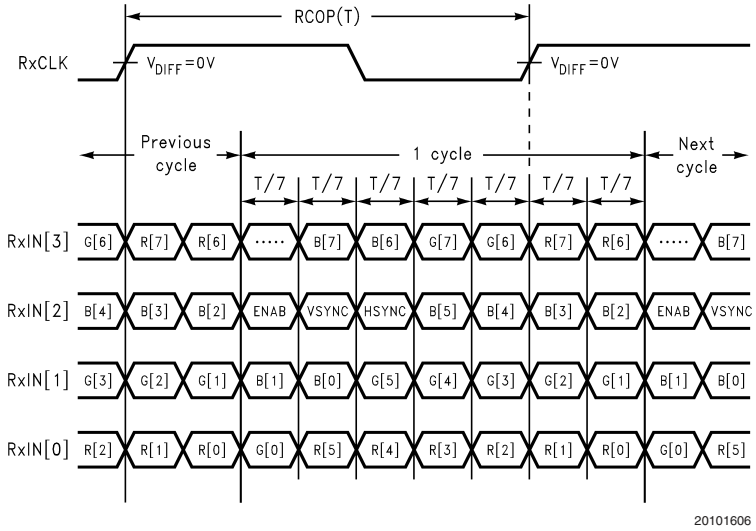
FIGURE 7. FPD87346BXA (FPD-Link Receiver) Input Skew Margin

AC Electrical Characteristics

T_A = 0˚C to 70˚C, V_{DD} = 3.3V ± 0.3V, I_{PI} = 100 µA (Unless otherwise specified). (Continued)



Note 5: R/G/B[7]s are MSBs and R/G/B/[0]s are LSBs

FIGURE 8. FPD87346BXA (FPD-Link Receiver) Input Data Mapping

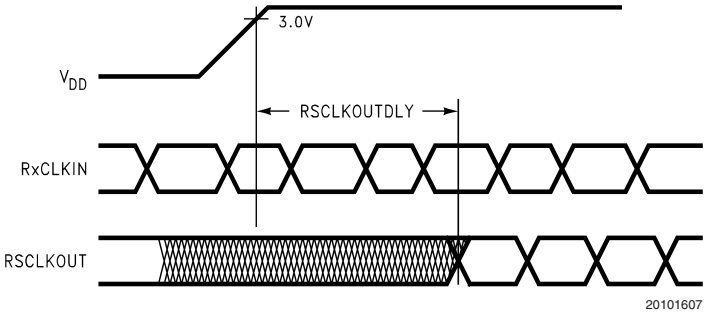


FIGURE 9. FPD87346BXA (FPD-Link Receiver) Phase Lock Loop Wake-up Time

AC Electrical Characteristics

T_A = 0˚C to 70˚C, V_{DD} = 3.3V ± 0.3V, I_{PI} = 100 µA (Unless otherwise specified). (Continued)

Output Timing

Symbol	Parameter	Conditions	Min	Typ	Max	Units
TO1	TTL Output Rising from RSCLK Rising	$C_{L(TTL)}$ = 15 pF, R_T = 100Ω, $C_{L(RSDS)}$ = 5 pF, I_{PI} = 100 µA, f = 85 MHz	0.0		11.25	ns
TO2	TTL Output Falling from RSCK Rising	$C_{L(TTL)}$ = 15 pF, R_T = 100Ω, $C_{L(RSDS)}$ = 5 pF, I_{PI} = 100 µA, f = 85 MHz	0.0		11.25	ns
RCHP	RSDS Clock (RSCK) High Period	R_T = 100Ω, $C_{L(RSDS)}$ = 5 pF, I_{PI} = 100 µA, f = 85 MHz		5.7		ns
RCLP	RSDS Clock (RSCK) Low Period	R_T = 100Ω, $C_{L(RSDS)}$ = 5 pF, I_{PI} = 100 µA, f = 85 MHz		5.8		ns
RSTU	RS(R,G,B) Setup to Falling or Rising Edge of RSCK	R_T = 100Ω, $C_{L(RSDS)}$ = 5 pF, I_{PI} = 100 µA, f = 85 MHz, RSDS[2:0] = [000]		3.2		ns
RHLD	RS(R,G,B) Hold from Falling or Rising Edge of RSCK	R_T = 100Ω, $C_{L(RSDS)}$ = 5 pF, I_{PI} = 100 µA, f = 85 MHz, RSDS[2:0] = [000]		1.8		ns
SPSTU	STH Rising to RSCK Falling	R_T = 100Ω, $C_{L(RSDS)}$ = 5 pF, I_{PI} = 100 µA, f = 85 MHz	5.0			ns
SPHLD	STH Falling to RSCK Falling	R_T = 100Ω, $C_{L(RSDS)}$ = 5 pF, I_{PI} = 100 µA, f = 85 MHz	4.0			ns

TABLE 1.

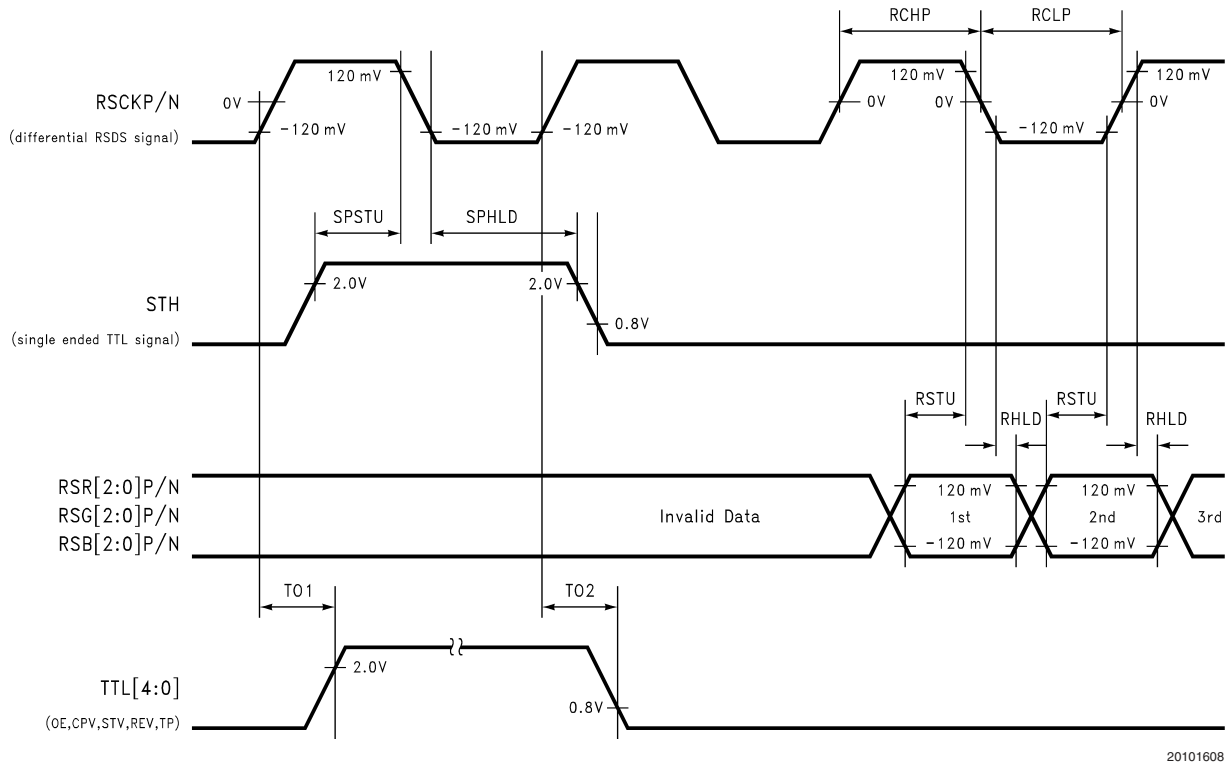
Typical Simulation Results of RSDS Skew Control Values* (V_{DD} = 3.3V; R_T = 100ohms; I_{PI} = 100 µA; 25˚C)

RSDS[2:0]	f = 65 MHz		f = 85 MHz		Unit
	RSTU	RHLD	RSTU	RHLD	
000	5.03	1.83	3.23	1.83	ns
001	5.26	1.31	3.75	1.31	
010	6.03	0.83	4.23	0.83	
011	6.53	0.33	4.73	0.33	
100	3.01	3.77	1.21	3.77	ns
101	3.49	3.33	1.69	3.33	
110	4.00	2.86	2.20	2.86	
111	4.50	2.36	2.70	2.36	

*The skew control value in the table are only sampling values of a specific condition and is not a parametric value. 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.

AC Electrical Characteristics

T_A = 0˚C to 70˚C, V_{DD} = 3.3V ± 0.3V, I_{PI} = 100 µA (Unless otherwise specified). (Continued)



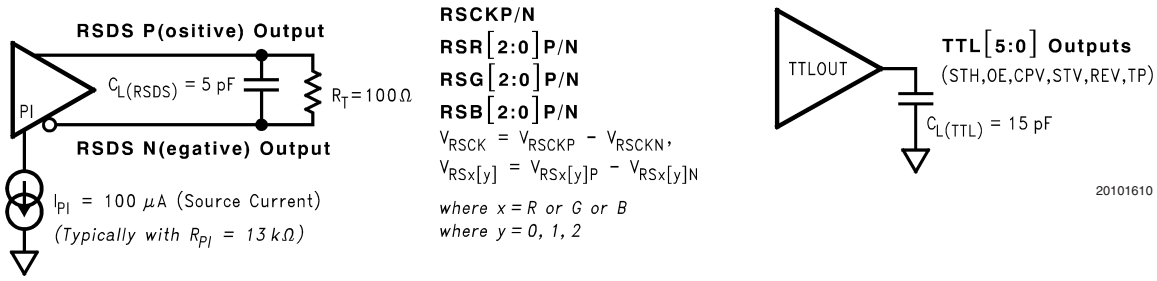
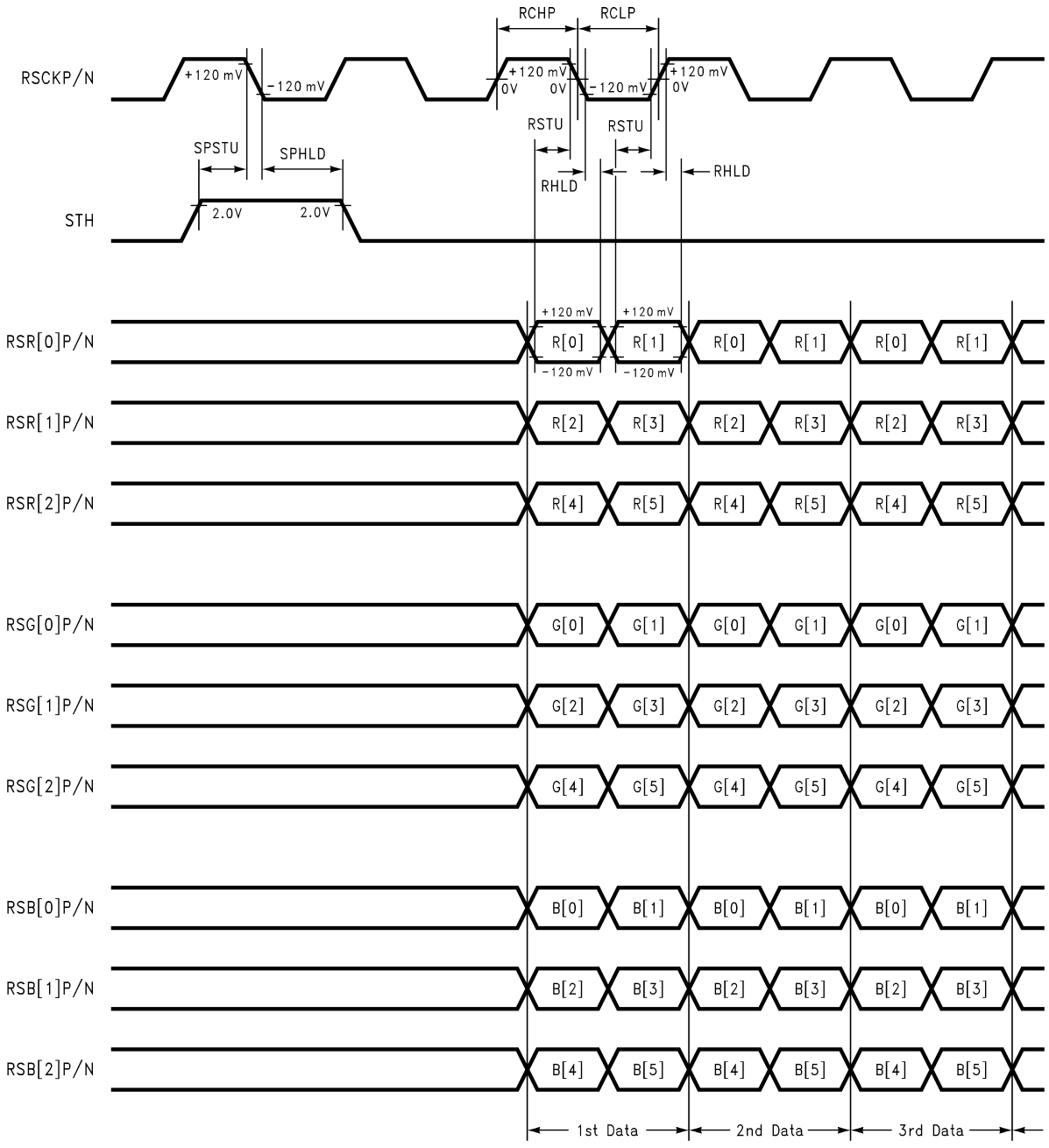


FIGURE 10. FPD87346BXA RSDS and TTL Output Timing Diagram

AC Electrical Characteristics

T_A = 0˚C to 70˚C, V_{DD} = 3.3V ± 0.3V, I_{PI} = 100 µA (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.

FIGURE 11. FPD87346BXA RSDS Output Data Mapping

AC Electrical Characteristics

T_A = 0˚C to 70˚C, V_{DD} = 3.3V ± 0.3V, I_{PI} = 100 µA (Unless otherwise specified). (Continued)

FPD87346BXA Failure Detect (Internal Bonding Option)

This function is valid in DE mode. As shown in *Figure 12*, invalid external DE pulse will not affect the internal operation during failure zone.

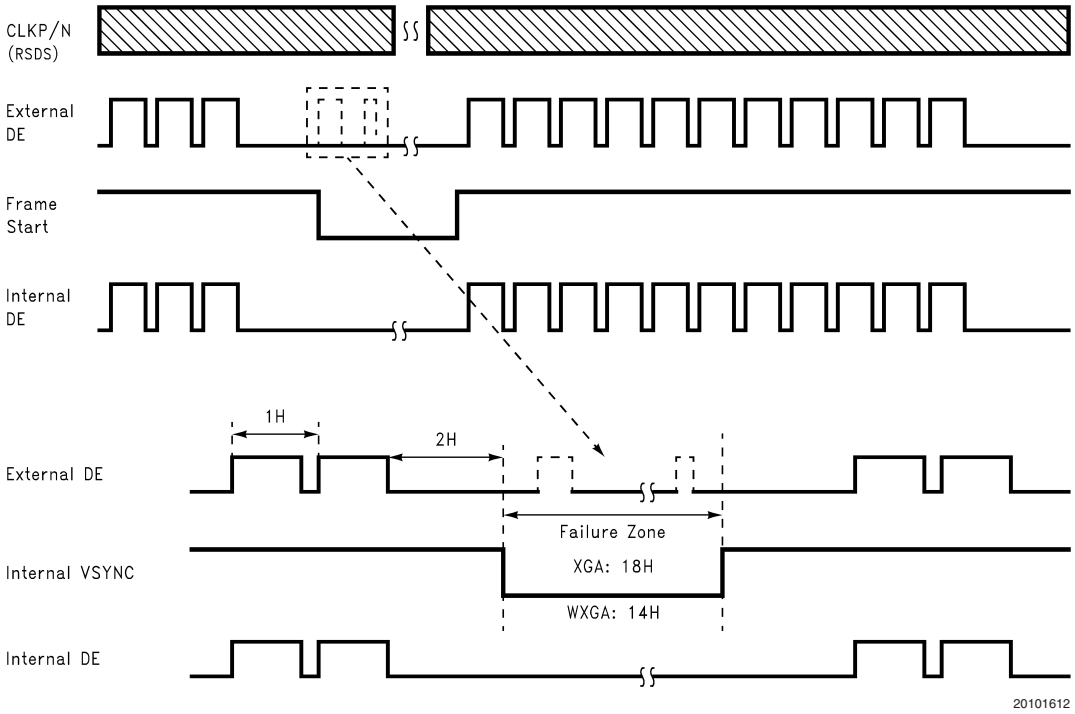


FIGURE 12. FPD87346BXA Failure Detection

Input Signal Timing

Signal	Item	Symbol		SVGA (800 x 600)	XGA (1024 x 768)	WXGA I (1280 x 768)	WXGA II (1280 x 800)	Unit
Clock Frequency	**1/Tclk**	**f**	**typ**	**40**	**65**	**82**	**69**	**MHz**
Vertical Timing	Total	Tv	min	620	772	772	804	Th
			typ	628	806	806	816	
			max	664	850	850	900	
	Active	Tvact	min	–	–	–	–	
			typ	600	768	768	800	
			max	–	–	–	–	
Horizontal Timing	Total	Th	min	1050	1050	1320	1320	Tclk
			typ	1056	1344	1688	1408	
			max	1056	1800	2000	2000	
	Active	Thact	min	–	–	–	–	
			typ	800	1024	1280	1280	
			max	–	–	–	–	

Output Timing—TTL

DE (Data Enable) Mode Only

Parameter	Comments	Display Mode WIDE(0/1) (Pin 57)			
		SVGA (WIDE=0)	XGA (WIDE=0)	WXGA (WIDE=1)	Remarks/ Unit
t1	STH Rising to Active Data	2	2	2	RxCLKP/N
t2	High Duration of STH	1	1	1	RxCLKP/N
t3	STH Rising to TP	1031	1031	1285	RxCLKP/N
t4	High Duration of TP	8	8	10	RxCLKP/N
t5	STH Rising to OE	904	904	1147	RxCLKP/N
t6	High Duration of OE	159	159	180	RxCLKP/N
t7	STH Rising to CPV	1031	1031	1283	RxCLKP/N
t8	High Duration of CPV	684	684	724	RxCLKP/N
t9	STH Rising to STV	368	368	565	RxCLKP/N
t10	High Duration of STV	1	1	1	H Line (Note 6)
t11	STH Rising to REV (1HRVS)	390	390	567	RxCLKP/N
t12	High/Low Duration of REV (1HRVS)	1	1	1	H Line (Note 6)
t13	STH Rising to REV (2HRVS)	371	371	567	RxCLKP/N
t14	High/Low Duration of REV (2HRVS)	2	2	2	H Line (Note 6)

Note 6: H Line: Hsync Cycle

Output Timing—TTL (Continued)

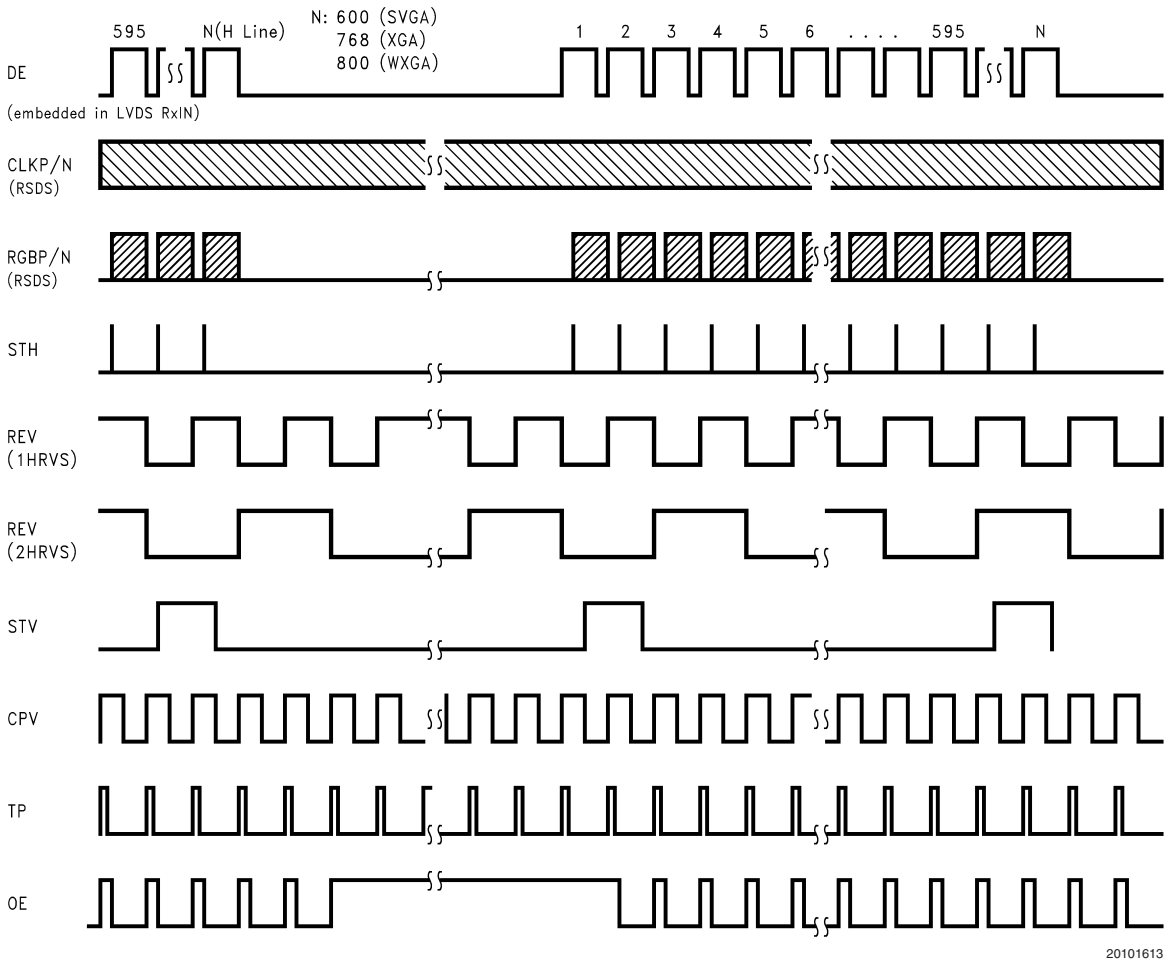
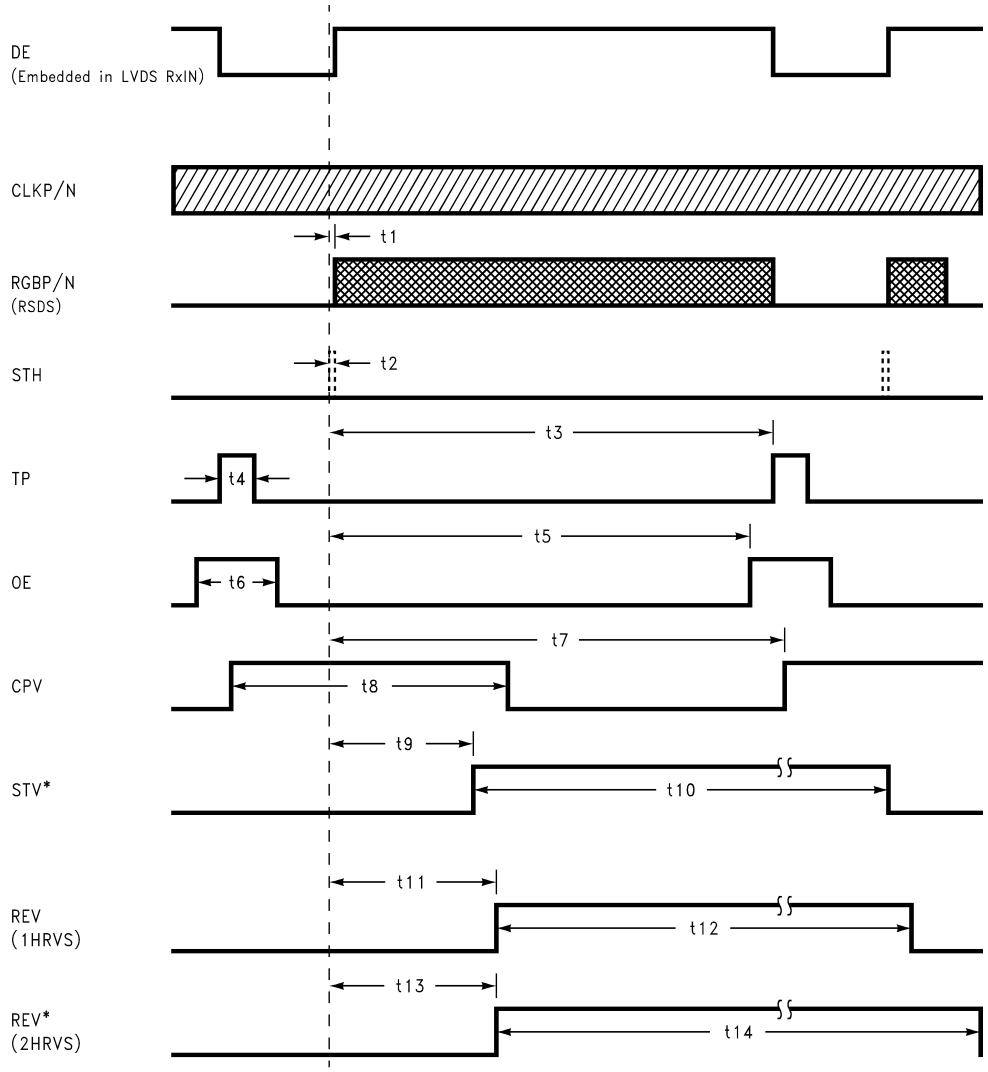


FIGURE 13. FPD87346BXA TTL Output Timing Diagram

Output Timing—TTL (Continued)



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

Unit: Output pixel clock; CLKP/N: RxCLKP/N

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FIGURE 14. FPD87346BXA TTL Output Timing Diagram (continued)

Output Timing—TTL (Continued)

TABLE 2.

RO*n* (S*n*) Configuration (T_A = 25˚C; XGA: RxCLKP/N = 65 MHz; WXGA: RxCLKP/N = 85 MHz)

RO2 (S2)	RO1 (S1)	RO0 (S0)	REV	OE		TP		Unit
				XGA (Front)	WXGA (Back)	XGA	WXGA	
0	0	0	1HRVS	2.4	2.1	0.12	0.12	µs
0	0	1	2HRVS			0.12	0.12	
0	1	0	2HRVS			*0.25*	*0.50*	
0	1	1	1HRVS	2.9	2.6	0.12	0.12	
1	0	0	2HRVS			0.12	0.12	
1	0	1	2HRVS			*0.25*	*0.50*	
1	1	0	1HRVS	3.4	3.1	*0.25*	*0.50*	
1	1	1	2HRVS			*0.25*	*0.50*	

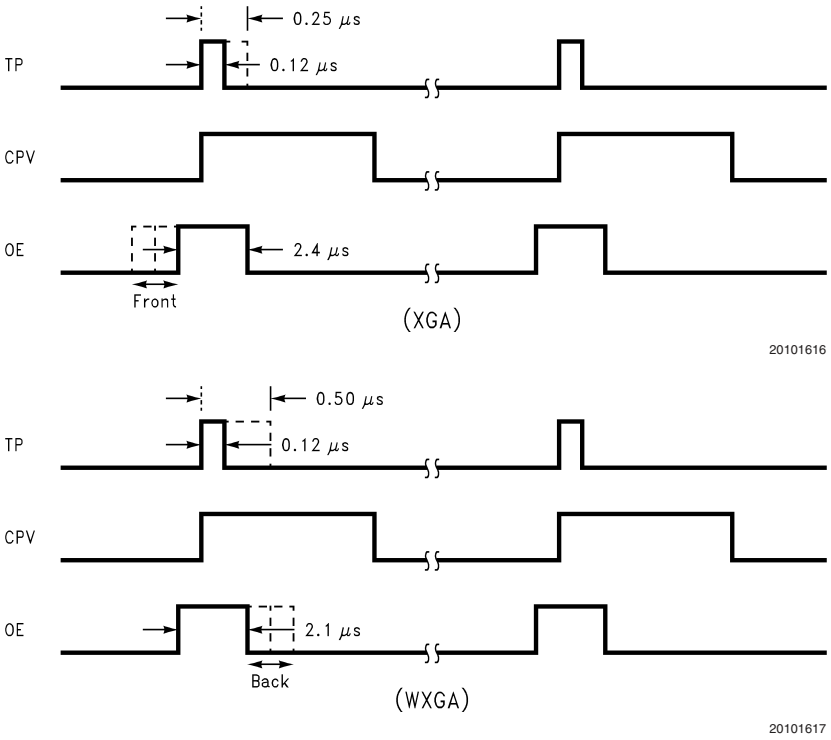


FIGURE 15. FPD87346BXA RO*n* (S*n*) Configuration Timing Diagrams

Pin Connection

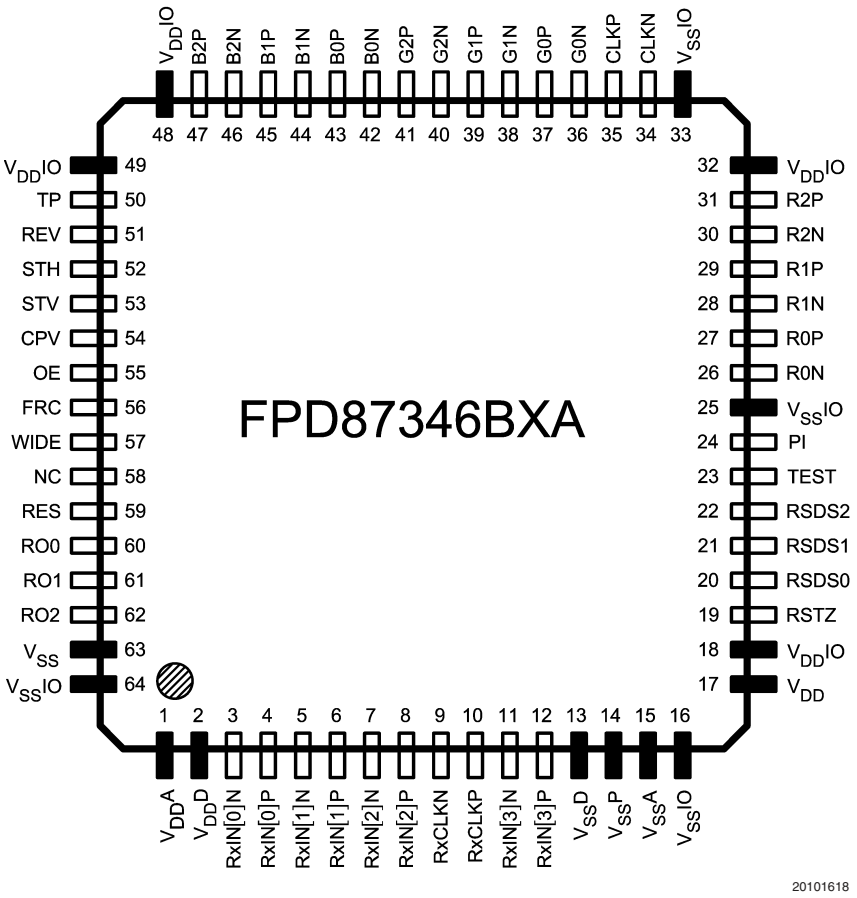


FIGURE 16. Pinout Assignments

Pin Description

System Interface

Symbol	Pin	Type	Function
RxIN[0]P/N	3, 4	LVDSI	FPD-Link Data Differential Pair 0 Input
RxIN[1]P/N	5, 6	LVDSI	FPD-Link Data Differential Pair 1 Input
RxIN[2]P/N	7, 8	LVDSI	FPD-Link Data Differential Pair 2 Input
RxIN[3]P/N	11, 12	LVDSI	FPD-Link Data Differential Pair 3 Input
RxCLKP/N	9, 10	LVDSI	PFD-Link Clock Differential Pair Input
Sub-Total Pin Count	***10***		

Column Driver Interface

Symbol	Pin	Type	Function
R[2:0]P/N	26–31	RSO	Red Reduced Swing Differential Outputs to Column Drivers
G[2:0]P/N	36–41	RSO	Green Reduced Swing Differential Outputs to Column Drivers
B[2:0]P/N	42–47	RSO	Blue Reduced Swing Differential Outputs to Column Drivers
CLKP/N	34, 35	RSO	Clock Reduced Swing Differential Outputs to Column Drivers
TP	50	TO, 8mA	Line Latch Signal Output to Column Drivers
STH	52	TO, 24mA	Horizontal Start Signal Output to Column Drivers
REV	51	TO, 8mA	Alternative Signal Output for each 1 or 2 Horizontal Line to Column Drivers and LC Control

Pin Description (Continued)

Column Driver Interface

Symbol	Pin	Type	Function
Sub-Total Pin Count	***23***		

Row Driver Interface

Symbol	Pin	Type	Function
STV	53	TO, 6mA	Row Driver Start Pulse
CPV	54	TO, 6mA	Row Driver Shift Clock
OE	55	TO, 6mA	Control TFT Gate Pulse Width to Row Drivers
Sub-Total Pin Count	***3***		

Control Pins

Symbol	Pin	Type	Function
FRC	56	I	Data Dithering Option: 0: 8-Bit Input, Dithering (FRC) 1: 6-Bit Input, Non Dithering (No FRC)
RSDS[2:0]	20–22	I	RSDS Skew/Timing Control (See *Table 1*)
WIDE	57	I	0: SVGA (800 x 600) 0: XGA (1024 x 768) 1: WXGA (1280 x 768/800)
RO[2:0]	60–62	I	Alternate each 1 Horizontal/2 Horizontal on REV with OE Timing (See *Table 2* and *Figure 15*)
RES	59	I	Reserved pin, tie to high (V_{DD})
TEST	23	I	0: Normal Operation 1: Test Mode
Sub-Total Pin Count	***10***		

Power Supply

Symbol	Pin	Type	Function
V_{DD}	17	P	Digital Power for Logic Core and LVDS Deserializer
V_{SS}	63	G	Digital Ground for Logic Core and LVDS Deserializer
V_{DDIO}	18, 32, 48, 49	P	Digital I/O Power and RSDS Outputs
V_{SSIO}	16, 25, 33, 64	G	Digital I/O Ground and RSDS Outputs
V_{DDA}	1	P	Power for LVDS PLL and Analog Bandgap
V_{DDD}	2	P	Digital Power for LVDS Input Buffer
V_{SSD}	13	G	Digital Ground for LVDS Input Buffer
V_{SSP}	15	G	Ground for LVDS PLL and Analog Bandgap
V_{SSA}	14	G	Ground for LVDS PLL and Analog Bandgap
Sub-Total Pin Count	***15***		

Pin Description (Continued)

Other

Symbol	Pin	Type	Function
PI	24	I	Reference for Reduced Swing Differential Outputs
RSTZ	19	I	System Reset; Active Low
NC	58	I	No Connect
Sub-Total Pin Count	***3***		
Total Pin Count	**64**		**System Interface = 10** **Column Driver = 23** **Row Driver = 3** **Control Pins = 10** **Power Supply = 15** **Other = 3**

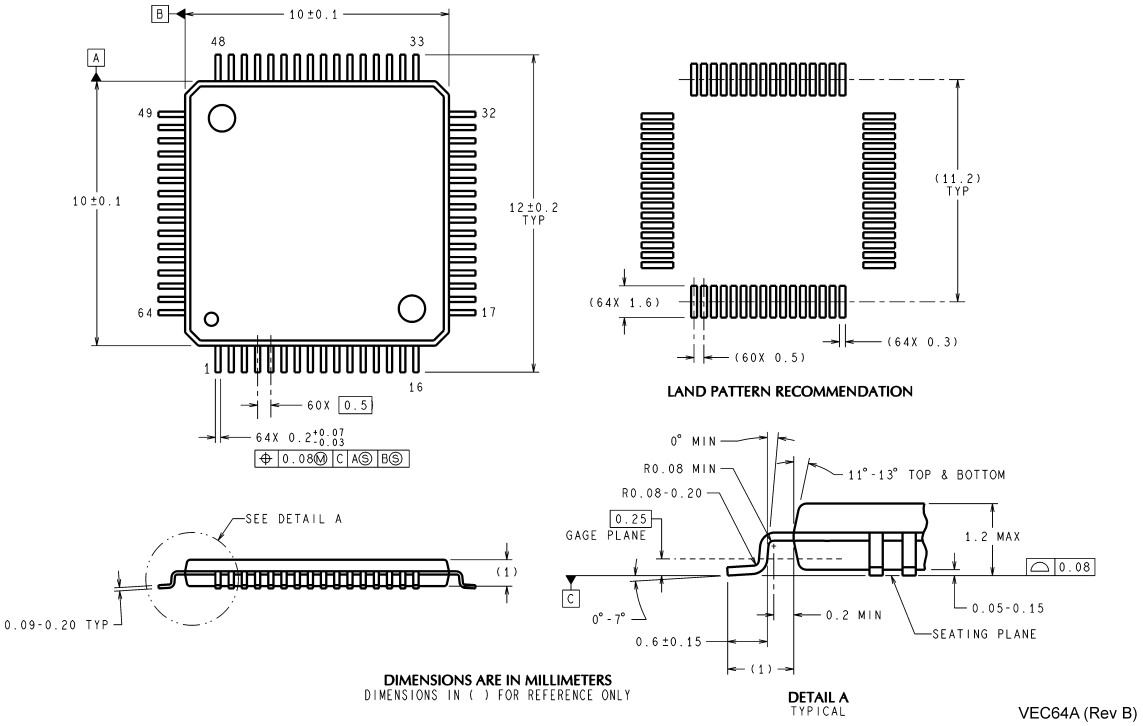
Bonding Options (B/O)

Symbol	Pin	Type	Function
FAIL_ON	B/O	PD	Failure Detect Function ON/OFF Low : OFF (Default) High : ON

Pin Types

I -Input (LVTTL-Compatible)
TO -TTL Output (LVTTL-Compatible)
LVDSI -Low Voltage Differential Signal Input
RSO -Reduced Swing Differential Output
P -Power
G -Ground
B/O -Bonding Option
PD -Internal Pull-Down
PU -Internal Pull-Up

Physical Dimensions inches (millimeters) unless otherwise noted



64-pin TQFP Package
Order Number FPD87346BXAVS
NS Package Number VEC-64A

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