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# DS90C365A +3.3V Programmable LVDS Transmitter 18-Bit Flat Panel Display Link-87.5 MHz

## General Description

The DS90C365A is a pin to pin compatible replacement for DS90C363, DS90C363A and DS90C365. The DS90C365A has additional features and improvements making it an ideal replacement for DS90C363, DS90C363A and DS90C365. family of LVDS Transmitters.

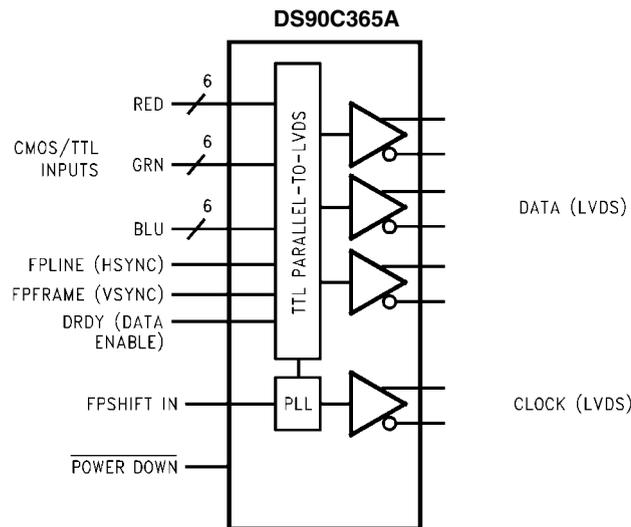
The DS90C365A transmitter converts 21 bits of LVCMOS/LVTTL data into four LVDS (Low Voltage Differential Signaling) data streams. A phase-locked transmit clock is transmitted in parallel with the data streams over the fourth LVDS link. Every cycle of the transmit clock 21 bits RGB of input data are sampled and transmitted. At a transmit clock frequency of 87.5 MHz, 21 bits of RGB data and 3 bits of LCD timing and control data (FPLINE, FPFRAME, DRDY) are transmitted at a rate of 612.5 Mbps per LVDS data channel. Using a 87.5 MHz clock, the data throughput is 229.687 Mbytes/sec. This transmitter can be programmed for Rising edge strobe or Falling edge strobe through a dedicated pin. A Rising edge or Falling edge strobe transmitter will interoperate with a Falling edge strobe FPDLink Receiver without any translation logic.

This chipset is an ideal means to solve EMI and cable size problems associated with wide, high-speed TTL interfaces with added Spread Spectrum Clocking support..

## Features

- Pin-to-pin compatible to DS90C363, DS90C363A and DS90C365 .
- No special start-up sequence required between clock/data and /PD pins. Input signals (clock and data) can be applied either before or after the device is powered.
- Support Spread Spectrum Clocking up to 100kHz frequency modulation & deviations of  $\pm 2.5\%$  center spread or -5% down spread.
- "Input Clock Detection" feature will pull all LVDS pairs to logic low when input clock is missing and when /PD pin is logic high.
- 18 to 87.5 MHz shift clock support
- Tx power consumption < 146 mW (typ) @ 87.5 MHz Grayscale
- Tx Power-down mode < 37 uW (typ)
- Supports VGA, SVGA, XGA, SXGA(dual pixel), SXGA+ (dual pixel), UXGA(dual pixel).
- Narrow bus reduces cable size and cost
- Up to 1.785 Gbps throughput
- Up to 223.125 Megabytes/sec bandwidth
- 345 mV (typ) swing LVDS devices for low EMI
- PLL requires no external components
- Compliant to TIA/EIA-644 LVDS standard
- Low profile 48-lead TSSOP package

## Block Diagram



Order Number DS90C365AMT  
See NS Package Number MTD48

20100539

**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 +4V
CMOS/TTL Input Voltage	-0.5V 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
Maximum Package Power Dissipation Capacity @ 25°C	
MTD48 (TSSOP) Package:	
DS90C365AMT	1.98 W
Package Derating:	
DS90C365AMT	16 mW/°C above +25°C

## ESD Rating

(HBM, 1.5k $\Omega$ , 100pF)

7kV

(EIAJ, 0 $\Omega$ , 200 pF)

500V

Latch Up Tolerance @ 25°C

 $\pm 100$ mA**Recommended Operating Conditions**

	Min	Nom	Max	Units
Supply Voltage ( $V_{CC}$ )	3.0	3.3	3.6	V
Operating Free Air Temperature ( $T_A$ )	-10	+25	+70	°C
Supply Noise Voltage ( $V_{CC}$ )			200	mV <sub>PP</sub>
TxCLKIN frequency	18		85	MHz

**Electrical Characteristics**

Over recommended operating supply and temperature ranges unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units	
<b>LVCMOS/LVTTL DC SPECIFICATIONS</b>							
$V_{IH}$	High Level Input Voltage		2.0		$V_{CC}$	V	
$V_{IL}$	Low Level Input Voltage		0		0.8	V	
$V_{CL}$	Input Clamp Voltage	$I_{CL} = -18$ mA		-0.79	-1.5	V	
$I_{IN}$	Input Current	$V_{IN} = 0.4V, 2.5V$ or $V_{CC}$		+1.8	+10	$\mu$ A	
		$V_{IN} = GND$	-10	0		$\mu$ A	
<b>LVDS DC SPECIFICATIONS</b>							
$V_{OD}$	Differential Output Voltage	$R_L = 100\Omega$	250	345	450	mV	
$\Delta V_{OD}$	Change in $V_{OD}$ between complimentary output states				35	mV	
$V_{OS}$	Offset Voltage (Note 4)		1.13	1.25	1.38	V	
$\Delta V_{OS}$	Change in $V_{OS}$ between complimentary output states				35	mV	
$I_{OS}$	Output Short Circuit Current	$V_{OUT} = 0V, R_L = 100\Omega$		-3.5	-5	mA	
$I_{OZ}$	Output TRI-STATE® Current	Power Down = 0V, $V_{OUT} = 0V$ or $V_{CC}$		$\pm 1$	$\pm 10$	$\mu$ A	
<b>TRANSMITTER SUPPLY CURRENT</b>							
ICCTW	Transmitter Supply Current Worst Case	$R_L = 100\Omega,$ $C_L = 5$ pF, Worst Case Pattern (Figures 1, 3) "Typ" values are given for $V_{CC} = 3.6V$ and $T_A = +25^\circ C,$ "Max" values are given for $V_{CC} = 3.6V$ and $T_A = -10^\circ C$	$f = 25$ MHz		29	40	mA
			$f = 40$ MHz		34	45	mA
			$f = 65$ MHz		42	55	mA
			$f = 87.5$ MHz		48	60	mA

Symbol	Parameter	Conditions	Min	Typ	Max	Units	
ICCTG	Transmitter Supply Current 16 Grayscale	$R_L = 100\Omega$ , $C_L = 5\text{ pF}$ , 16 Grayscale Pattern (Figures 2, 3) "Typ" values are given for $V_{CC} = 3.6\text{V}$ and $T_A = +25^\circ\text{C}$ , "Max" values are given for $V_{CC} = 3.6\text{V}$ and $T_A = -10^\circ\text{C}$	$f = 25\text{ MHz}$		28	40	mA
			$f = 40\text{ MHz}$		32	45	mA
			$f = 65\text{ MHz}$		39	50	mA
			$f = 87.5\text{ MHz}$		44	56	mA
ICCTZ	Transmitter Supply Current Power Down	Power Down = Low Driver Outputs in TRI-STATE under Power Down Mode		11	150	$\mu\text{A}$	

**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  $V_{CC} = 3.3\text{V}$  and  $T_A = +25^\circ\text{C}$  unless specified otherwise.

**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:**  $V_{OS}$  previously referred as  $V_{CM}$ .

## Recommended Transmitter Input Characteristics

Over recommended operating supply and temperature ranges unless otherwise specified

Symbol	Parameter	Min	Typ	Max	Units
TCIT	TxCLK IN Transition Time (Figure 5)	1.0		6.0	ns
TCIP	TxCLK IN Period (Figure 6)	11.76	T	50	ns
TCIH	TxCLK IN High Time (Figure 6)	0.35T	0.5T	0.65T	ns
TCIL	TxCLK IN Low Time (Figure 6)	0.35T	0.5T	0.65T	ns
TXIT	TxIN, and /PD pin Transition Time	1.5		6.0	ns
TXPD	Minimum pulse width for PWR DOWN pin signal.	1			us

## Transmitter Switching Characteristics

Over recommended operating supply and temperature ranges unless otherwise specified

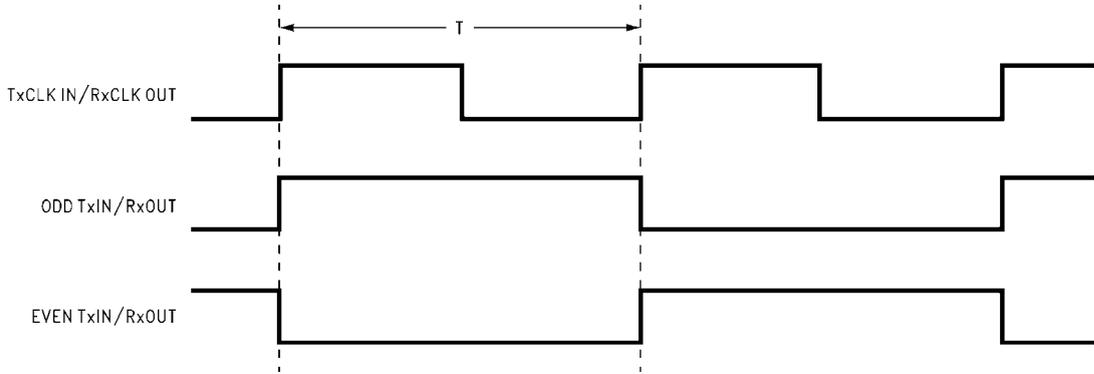
Symbol	Parameter	Min	Typ	Max	Units	
LLHT	LVDS Low-to-High Transition Time ( <i>Figure 4</i> )		0.75	1.4	ns	
LHLT	LVDS High-to-Low Transition Time ( <i>Figure 4</i> )		0.75	1.4	ns	
TPPos0	Transmitter Output Pulse Position ( <i>Figure 12</i> ) (Note 5)	f = 25MHz	-0.45	0	+0.45	ns
TPPos1	Transmitter Output Pulse Position		5.26	5.71	6.16	ns
TPPos2	Transmitter Output Pulse Position		10.98	11.43	11.88	ns
TPPos3	Transmitter Output Pulse Position		16.69	17.14	17.59	ns
TPPos4	Transmitter Output Pulse Position		22.41	22.86	23.31	ns
TPPos5	Transmitter Output Pulse Position		28.12	28.57	29.02	ns
TPPos6	Transmitter Output Pulse Position		33.84	34.29	34.74	ns
TPPos0	Transmitter Output Pulse Position ( <i>Figure 12</i> ) (Note 5)	f = 40 MHz	-0.25	0	+0.25	ns
TPPos1	Transmitter Output Pulse Position		3.32	3.57	3.82	ns
TPPos2	Transmitter Output Pulse Position		6.89	7.14	7.39	ns
TPPos3	Transmitter Output Pulse Position		10.46	10.71	10.96	ns
TPPos4	Transmitter Output Pulse Position		14.04	14.29	14.54	ns
TPPos5	Transmitter Output Pulse Position		17.61	17.86	18.11	ns
TPPos6	Transmitter Output Pulse Position		21.18	21.43	21.68	ns
TPPos0	Transmitter Output Pulse Position ( <i>Figure 12</i> ) (Note 5)	f = 65 MHz	-0.20	0	+0.20	ns
TPPos1	Transmitter Output Pulse Position		2.00	2.20	2.40	ns
TPPos2	Transmitter Output Pulse Position for Bit 2		4.20	4.40	4.60	ns
TPPos3	Transmitter Output Pulse Position for Bit 3		6.39	6.59	6.79	ns
TPPos4	Transmitter Output Pulse Position		8.59	8.79	8.99	ns
TPPos5	Transmitter Output Pulse Position		10.79	10.99	11.19	ns
TPPos6	Transmitter Output Pulse Position		12.99	13.19	13.39	ns
TPPos0	Transmitter Output Pulse Position ( <i>Figure 12</i> ) (Note 5)	f = 87.5 MHz	-0.20	0	+0.20	ns
TPPos1	Transmitter Output Pulse Position		1.48	1.68	1.88	ns
TPPos2	Transmitter Output Pulse Position		3.16	3.36	3.56	ns
TPPos3	Transmitter Output Pulse Position		4.84	5.04	5.24	ns
TPPos4	Transmitter Output Pulse Position		6.52	6.72	6.92	ns
TPPos5	Transmitter Output Pulse Position		8.20	8.40	8.60	ns
TPPos6	Transmitter Output Pulse Position		9.88	10.08	10.28	ns
TSTC	Required TxIN Setup to TxCLK IN ( <i>Figure 6</i> ) at 85MHz		2.5		ns	
THTC	Required TxIN Hold to TxCLK IN ( <i>Figure 6</i> ) at 87.5 MHz		0.5		ns	

Symbol	Parameter	Min	Typ	Max	Units	
TCCD	TxCLK IN to TxCLK OUT Delay. Measure from TxCLK IN edge to immediately crossing point of differential TxCLK OUT by following the positive TxCLK OUT. 50% duty cycle input clock is assumed. (Figure 7)	$T_A = -10^\circ\text{C}$ , and 85MHz for "Min" $T_A = 70^\circ\text{C}$ , and 25MHz for "Max", $V_{CC} = 3.6\text{V}$ , R_FB pin = VCC	3.086		7.211	ns
	Measure from TxCLK IN edge to immediately crossing point of differential TxCLK OUT by following the positive TxCLK OUT. 50% duty cycle input clock is assumed. (Figure 8)	$T_A = -10^\circ\text{C}$ , and 85MHz for "Min" $T_A = 70^\circ\text{C}$ , and 25MHz for "Max", $V_{CC} = 3.6\text{V}$ , R_FB pin = GND	2.868		6.062	ns
SSCG	Spread Spectrum Clock support; Modulation frequency with a linear profile.(Note 6)	f = 25 MHz		100kHz $\pm$ 2.5%/-5%		
		f = 40 MHz		100kHz $\pm$ 2.5%/-5%		
		f = 65 MHz		100kHz $\pm$ 2.5%/-5%		
		f = 87.5 MHz		100kHz $\pm$ 2.5%/-5%		
TPLLS	Transmitter Phase Lock Loop Set (Figure 9)			10	ms	
TPDD	Transmitter Power Down Delay (Figure 11)			100	ns	

**Note 5:** The Minimum and Maximum Limits are based on statistical analysis of the device performance over process, voltage, and temperature ranges. This parameter is functionality tested only on Automatic Test Equipment (ATE).

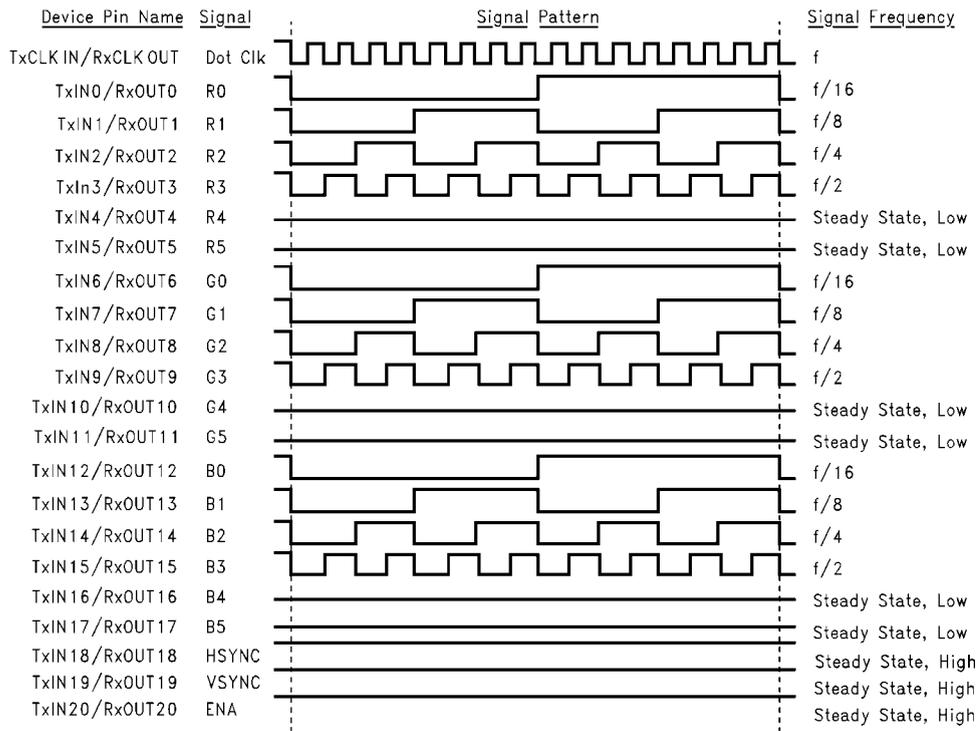
**Note 6:** Care must be taken to ensure TSTC and THTC are met so input data are sampling correctly. This SSCG parameter only shows the performance of tracking Spread Spectrum Clock applied to TxCLK IN pin, and reflects the result on TxCLKOUT+ and TxCLKOUT- pins.

# AC Timing Diagrams



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FIGURE 1. “Worst Case” Test Pattern (Note 7)



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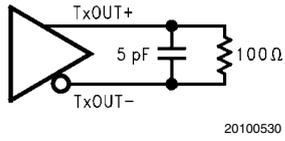
FIGURE 2. “16 Grayscale” Test Pattern - DS90C365A (Notes 8, 9, 10)

**Note 7:** The worst case test pattern produces a maximum toggling of digital circuits, LVDS I/O and LVC MOS/LVTTL I/O.

**Note 8:** The 16 grayscale test pattern tests device power consumption for a “typical” LCD display pattern. The test pattern approximates signal switching needed to produce groups of 16 vertical stripes across the display.

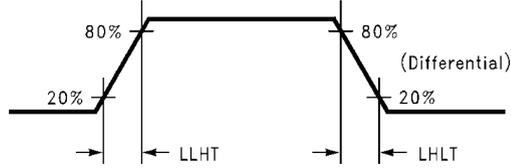
**Note 9:** Figures 1, 2 show a falling edge data strobe (TxCLK IN/RxCLK OUT).

**Note 10:** Recommended pin to signal mapping. Customer may choose to define differently.



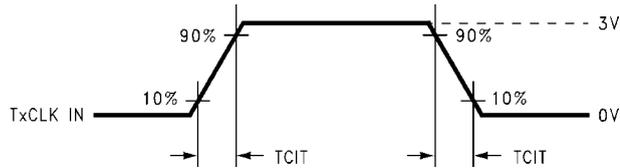
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FIGURE 3. DS90C365A (Transmitter) LVDS Output Load. 5pF is shown as board loading



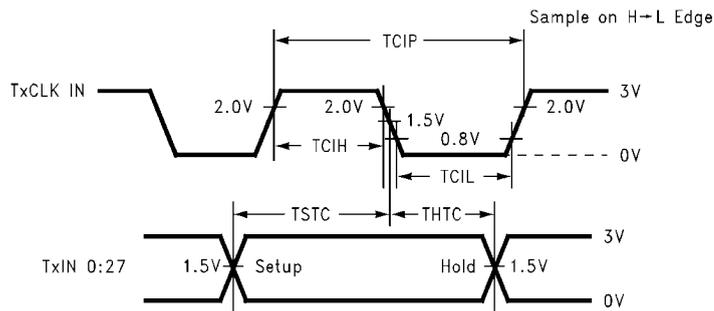
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FIGURE 4. DS90C365A (Transmitter) LVDS Transition Times



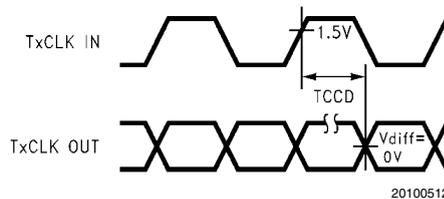
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FIGURE 5. DS90C365A (Transmitter) Input Clock Transition Time



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FIGURE 6. DS90C365A (Transmitter) Setup/Hold and High/Low Times with R\_FB pin = GND (Falling Edge Strobe)



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FIGURE 7. DS90C365A (Transmitter) Clock In to Clock Out Delay with R\_FB pin = VCC

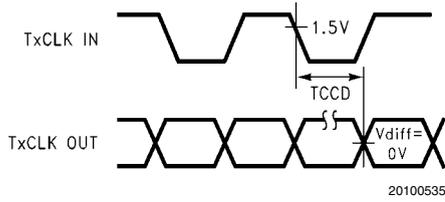


FIGURE 8. DS90C365A (Transmitter) Clock In to Clock Out Delay with R\_FB pin = GND

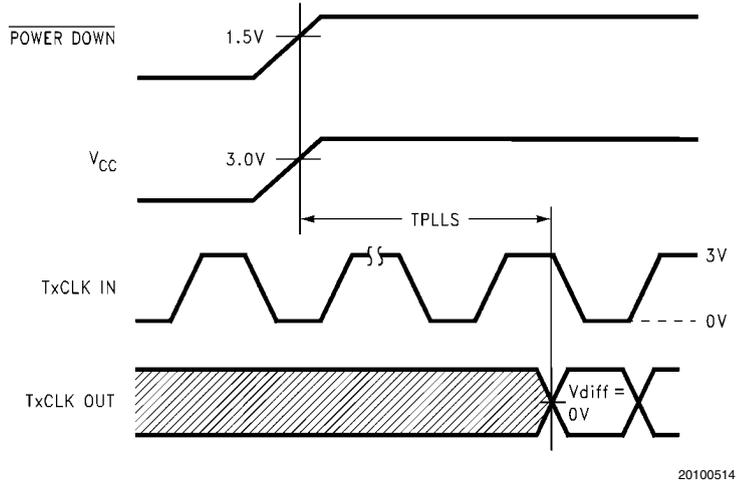


FIGURE 9. DS90C365A (Transmitter) Phase Lock Loop Set Time

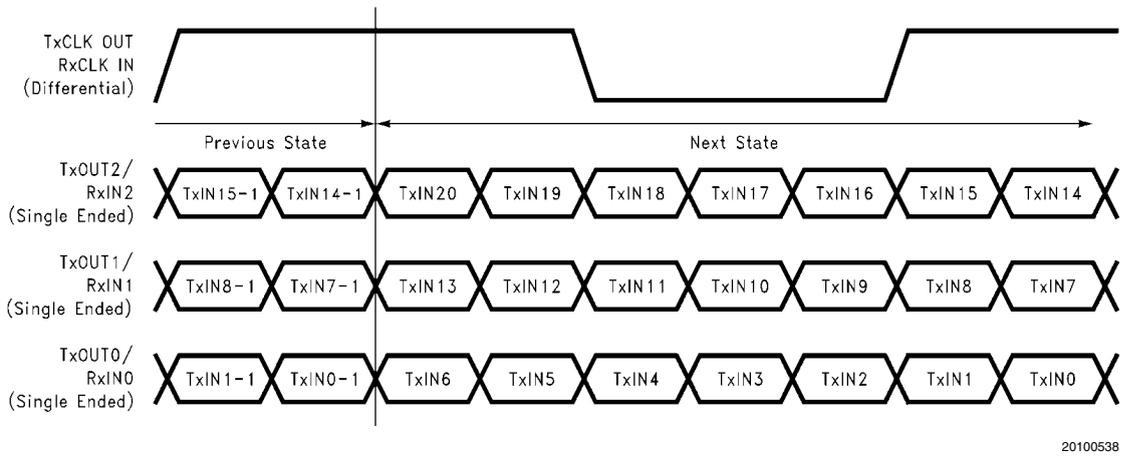


FIGURE 10. 21 Parallel TTL Data Inputs Mapped to LVDS Outputs - DS90C365A

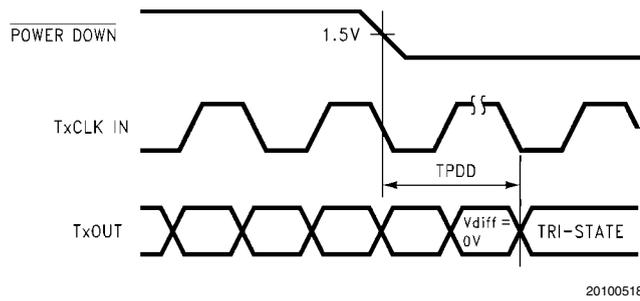


FIGURE 11. Transmitter Power Down Delay

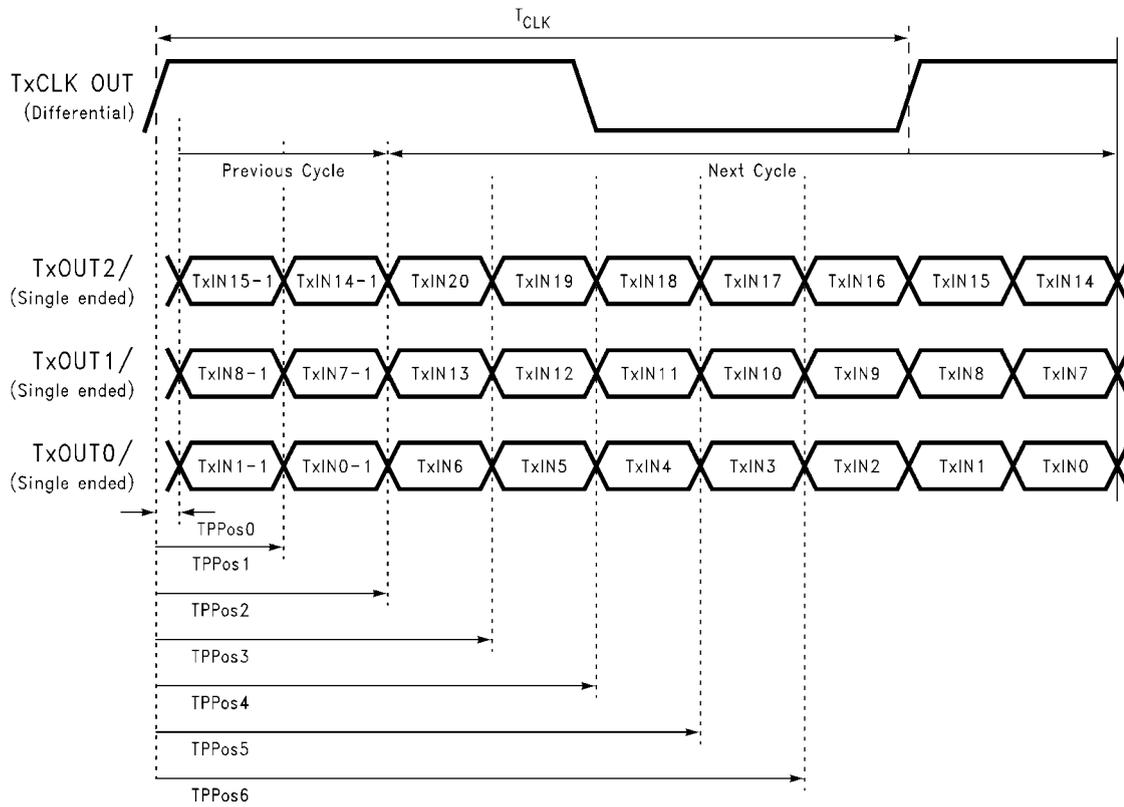


FIGURE 12. Transmitter LVDS Output Pulse Position Measurement - DS90C365A

## DS90C365A MTD48 (TSSOP) Package Pin Descriptions — FPD Link Transmitter

Pin Name	I/O	No.	Description
TxIN	I	21	LVTTTL level input. This includes: 6 Red, 6 Green, 6 Blue, and 3 control lines—FPLINE, FPFRAME and DRDY (also referred to as HSYNC, VSYNC, Data Enable).
TxOUT+	O	3	Positive LVDS differential data output.
TxOUT-	O	3	Negative LVDS differential data output.
TxCLKIN	I	1	LVTTTL level clock input. Pin name TxCLK IN.
R_FB	I	1	LVTTTL level programmable strobe select (See Table 1).
TxCLK OUT+	O	1	Positive LVDS differential clock output.
TxCLK OUT-	O	1	Negative LVDS differential clock output.
PWR DOWN	I	1	LVTTTL level input. When asserted (low input) TRI-STATES the outputs, ensuring low current at power down.
V <sub>CC</sub>	I	3	Power supply pins for LVTTTL inputs.
GND	I	5	Ground pins for LVTTTL inputs.
PLL V <sub>CC</sub>	I	1	Power supply pin for PLL.
PLL GND	I	2	Ground pins for PLL.
LVDS V <sub>CC</sub>	I	1	Power supply pin for LVDS outputs.
LVDS GND	I	3	Ground pins for LVDS outputs.
NC		1	No connect

## Applications Information

The DS90C365A is backward compatible with the DS90C365, DS90C363A, DS90C363 in TSSOP 48-lead package, and it is a pin-for-pin replacements.

This device DS90C365A also features reduced variation of the TCCD parameter which is important for dual pixel applications. (See AN-1084)

This device may also be used as a replacement for the DS90CF563 (5V, 65MHz) and DS90CF561 (5V, 40MHz) FPD-Link Transmitters with certain considerations/modifications:

1. Change 5V power supply to 3.3V. Provide this 3.3V supply to the  $V_{CC}$ , LVDS  $V_{CC}$  and PLL  $V_{CC}$  of the transmitter.
2. The DS90C365A transmitter input and control inputs accept 3.3V LVTTTL/LVCMOS levels. They are not 5V tolerant.
3. To implement a falling edge device for the DS90C365A, the R\_FB pin may be tied to ground OR left unconnected (an internal pull-down resistor biases this pin low). Biasing this pin to Vcc implements a rising edge device.

### TRANSMITTER INPUT PINS

The TxIN and control input pins are compatible with LVCMOS and LVTTTL levels. These pins are not 5V tolerant.

### TRANSMITTER INPUT CLOCK/DATA SEQUENCING

Unlike the DS90C365, DS90C(F)383A/363A, the DS90C365A does not require any special requirement for sequencing of the input clock/data and PD (PowerDown) signal. The DS90C365A offers a more robust input sequencing fea-

ture where the input clock/data can be inserted after the release of the PD signal. In the case where the clock/data is stopped and reapplied, such as changing video mode within Graphics Controller, it is not necessary to cycle the PD signal. However, there are in certain cases where the PD may need to be asserted during these mode changes. In cases where the source (Graphics Source) may be supplying an unstable clock or spurious noisy clock output to the LVDS transmitter, the LVDS Transmitter may attempt to lock onto this unstable clock signal but is unable to do so due the instability or quality of the clock source. The PD signal in these cases should then be asserted once a stable clock is applied to the LVDS transmitter. Asserting the PWR DOWN pin will effectively place the device in reset and disable the PLL, enabling the LVDS Transmitter into a power saving standby mode. However, it is still generally a good practice to assert the PWR DOWN pin or reset the LVDS transmitter whenever the clock/data is stopped and reapplied but it is not mandatory for the DS90C365A.

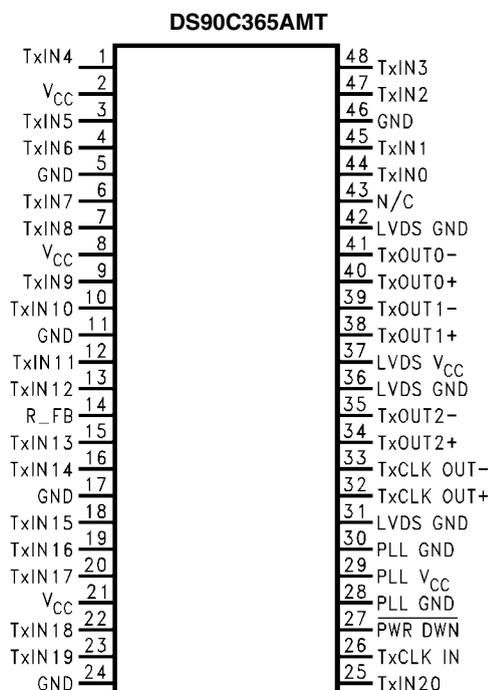
### SPREAD SPECTRUM CLOCK SUPPORT

The DS90C365A can support Spread Spectrum Clocking signal type inputs. The DS90C365A outputs will accurately track Spread Spectrum Clock/Data inputs with modulation frequencies of up to 100kHz (max.) with either center spread of  $\pm 2.5\%$  or down spread -5% deviations.

### POWER SOURCES SEQUENCE

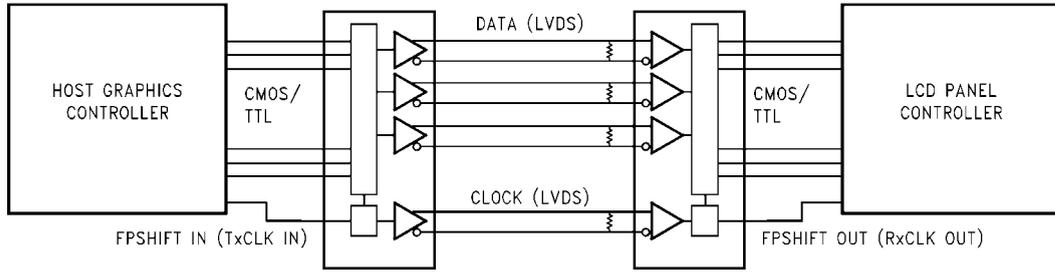
In typical applications, it is recommended to have  $V_{CC}$ , LVDS  $V_{CC}$  and PLL  $V_{CC}$  from the same power source with three separate de-coupling bypass capacitor groups. There is no requirement on which VCC entering the device first.

## Pin Diagram for TSSOP Packages



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## Typical Application



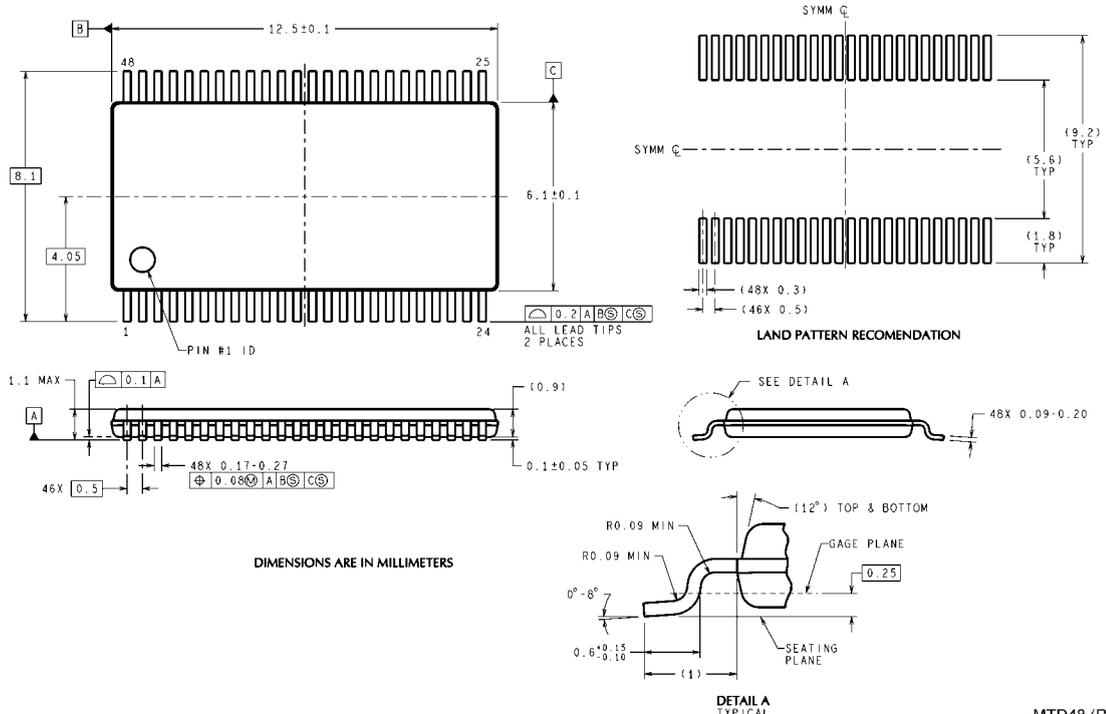
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## Truth Table

**TABLE 1. Programmable Transmitter (DS90C365A)**

Pin	Condition	Strobe Status
R_FB	R_FB = $V_{CC}$	Rising edge strobe
R_FB	R_FB = GND or NC	Falling edge strobe

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



**48-Lead Molded Thin Shrink Small Outline Package, JEDEC**  
**Dimensions in millimeters only**  
**Order Number DS90C365AMT**  
**NS Package Number MTD48**

MTD48 (Rev E)

## Notes

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Clock Conditioners	<a href="http://www.national.com/timing">www.national.com/timing</a>	App Notes	<a href="http://www.national.com/appnotes">www.national.com/appnotes</a>
Data Converters	<a href="http://www.national.com/adc">www.national.com/adc</a>	Distributors	<a href="http://www.national.com/contacts">www.national.com/contacts</a>
Displays	<a href="http://www.national.com/displays">www.national.com/displays</a>	Green Compliance	<a href="http://www.national.com/quality/green">www.national.com/quality/green</a>
Ethernet	<a href="http://www.national.com/ethernet">www.national.com/ethernet</a>	Packaging	<a href="http://www.national.com/packaging">www.national.com/packaging</a>
Interface	<a href="http://www.national.com/interface">www.national.com/interface</a>	Quality and Reliability	<a href="http://www.national.com/quality">www.national.com/quality</a>
LVDS	<a href="http://www.national.com/lvds">www.national.com/lvds</a>	Reference Designs	<a href="http://www.national.com/refdesigns">www.national.com/refdesigns</a>
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LDOs	<a href="http://www.national.com/lido">www.national.com/lido</a>		
LED Lighting	<a href="http://www.national.com/led">www.national.com/led</a>		
PowerWise	<a href="http://www.national.com/powerwise">www.national.com/powerwise</a>		
Serial Digital Interface (SDI)	<a href="http://www.national.com/sdi">www.national.com/sdi</a>		
Temperature Sensors	<a href="http://www.national.com/tempsensors">www.national.com/tempsensors</a>		
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