

## PCI-EXPRESS GEN 1, GEN 2, & GEN 3 SIX OUTPUT CLOCK GENERATOR

### Features

- PCI-Express Gen 1, Gen 2, & Gen 3 compliant
- Supports Serial-ATA (SATA) at 100 MHz
- Low power push-pull type differential output buffers
- No termination resistors required
- Dedicated output enable pins for each clock
- Pin selectable spread control
- Up to six PCI-Express clocks
- 25 MHz crystal input or clock input
- I<sup>2</sup>C support with readback capabilities
- Triangular spread spectrum profile for maximum electromagnetic interference (EMI) reduction
- Industrial temperature: -40 to 85 °C
- 3.3 V Power supply
- 32-pin QFN package



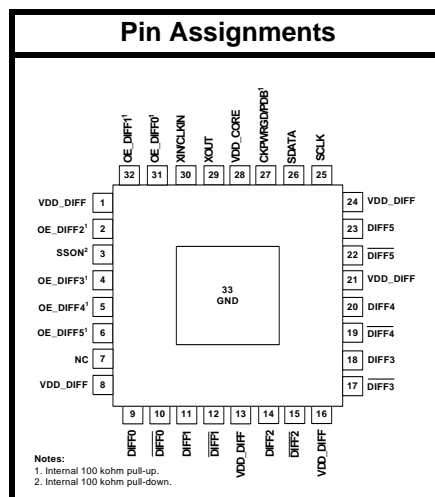
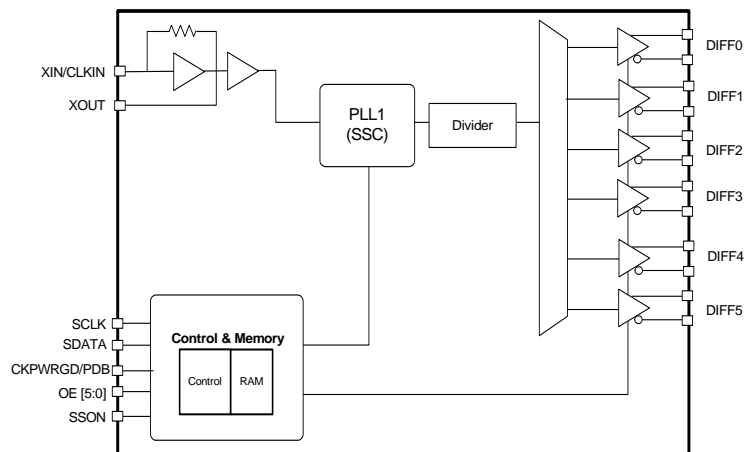
### Applications

- Network attached storage
- Multi-function printer
- Wireless access point
- Switches

### Description

The Si52146 is a high-performance, PCIe clock generator that can source six PCIe clocks from a 25 MHz crystal or clock input. The clock outputs are compliant to PCIe Gen 1, Gen 2, and Gen 3 specifications. The device has six output enable control pins for enabling and disabling differential outputs. A spread spectrum control pin for EMI reduction is also available. The small footprint and low power consumption makes the Si52146 the ideal clock solution for consumer and embedded applications.

### Functional Block Diagram



Patents pending



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## 1. Electrical Specifications

**Table 1. DC Electrical Specifications**

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
3.3 V Operating Voltage	VDD core	3.3 ±5%	3.135	3.3	3.465	V
3.3 V Input High Voltage	V <sub>IH</sub>	Control input pins	2.0	—	V <sub>DD</sub> + 0.3	V
3.3 V Input Low Voltage	V <sub>IL</sub>	Control input pins	V <sub>SS</sub> - 0.3	—	0.8	V
Input High Voltage	V <sub>IHI2C</sub>	SDATA, SCLK	2.2	—	—	V
Input Low Voltage	V <sub>ILI2C</sub>	SDATA, SCLK	—	—	1.0	V
Input High Leakage Current	I <sub>IH</sub>	Except internal pull-down resistors, 0 < V <sub>IN</sub> < V <sub>DD</sub>	—	—	5	μA
Input Low Leakage Current	I <sub>IL</sub>	Except internal pull-up resistors, 0 < V <sub>IN</sub> < V <sub>DD</sub>	-5	—	—	μA
High-impedance Output Current	I <sub>OZ</sub>		-10	—	10	μA
Input Pin Capacitance	C <sub>IN</sub>		1.5	—	5	pF
Output Pin Capacitance	C <sub>OUT</sub>		—	—	6	pF
Pin Inductance	L <sub>IN</sub>		—	—	7	nH
Power Down Current	I <sub>DD-PD</sub>		—	—	1	mA
Dynamic Supply Current	I <sub>DD_3.3V</sub>	All outputs enabled. Differential clocks with 5" traces and 2 pF load.	—	—	60	mA

Table 2. AC Electrical Specifications

Parameter	Symbol	Condition	Min	Typ	Max	Unit
<b>Crystal</b>						
Long-term Accuracy	$L_{ACC}$	Measured at $V_{DD}/2$ differential	—	—	250	ppm
<b>Clock Input</b>						
CLKIN Duty Cycle	$T_{DC}$	Measured at $V_{DD}/2$	47	—	53	%
CLKIN Rise and Fall Times	$T_R/T_F$	Measured between $0.2 V_{DD}$ and $0.8 V_{DD}$	0.5	—	4.0	V/ns
CLKIN Cycle to Cycle Jitter	$T_{CCJ}$	Measured at $V_{DD}/2$	—	—	250	ps
CLKIN Long Term Jitter	$T_{LTJ}$	Measured at $V_{DD}/2$	—	—	350	ps
Input High Voltage	$V_{IH}$	XIN/CLKIN pin	2	—	$V_{DD}+0.3$	V
Input Low Voltage	$V_{IL}$	XIN/CLKIN pin	—	—	0.8	V
Input High Current	$I_{IH}$	XIN/CLKIN pin, $V_{IN} = V_{DD}$	—	—	35	uA
Input Low Current	$I_{IL}$	XIN/CLKIN pin, $0 < V_{IN} < 0.8$	-35	—	—	uA
<b>DIFF at 0.7 V</b>						
Duty Cycle	$T_{DC}$	Measured at 0 V differential	45	—	55	%
Any Clock Skew from the Earliest Bank to the Latest Bank	$T_{SKEW}$	Measured at 0 V differential	—	—	50	ps
DIFF Cycle to Cycle Jitter	$T_{CCJ}$	Measured at 0 V differential	—	35	50	ps
PCIe Gen 1 Pk-Pk	Pk-Pk	PCIe Gen 1	0	40	86	ps
PCIe Gen 2 Phase Jitter	$RMS_{GEN2}$	$10 \text{ kHz} < F < 1.5 \text{ MHz}$	0	2	3.0	ps
PCIe Gen 2 Phase Jitter	$RMS_{GEN2}$	$1.5 \text{ MHz} < F < \text{Nyquist}$	0	2	3.1	ps
PCIe Gen 3 Phase Jitter	$RMS_{GEN3}$	Includes PLL BW 2–4 MHz, CDR = 10 MHz)	0	0.5	1.0	ps
Long Term Accuracy	$L_{ACC}$	Measured at 0 V differential	—	—	100	ppm
Rising/Falling Slew Rate	$T_R/T_F$	Measured differentially from $\pm 150 \text{ mV}$	1	—	8	V/ns
Voltage High	$V_{HIGH}$		—	—	1.15	V
Voltage Low	$V_{LOW}$		-0.3	—	—	V
Crossing Point Voltage at 0.7 V Swing	$V_{OX}$		300	—	550	mV
Spread Range	SPR-2	Down spread	—	-0.5	—	%
Modulation Frequency	$F_{MOD}$		30	31.5	33	kHz
<b>Enable/Disable and Setup</b>						
Clock Stabilization from Power-up	$T_{STABLE}$		—	—	1.8	ms
Stopclock Set-up Time	$T_{SS}$		10.0	—	—	ns
<b>Note:</b> Visit <a href="http://www.pcisig.com">www.pcisig.com</a> for complete PCIe specifications.						

**Table 3. Absolute Maximum Conditions**

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Main Supply Voltage	$V_{DD\_3.3V}$	Functional	—	—	4.6	V
Input Voltage	$V_{IN}$	Relative to $V_{SS}$	-0.5	—	4.6	$V_{DC}$
Temperature, Storage	$T_S$	Non-functional	-65	—	150	°C
Temperature, Operating Ambient	$T_A$	Functional	-40	—	85	°C
Temperature, Junction	$T_J$	Functional	—	—	150	°C
Dissipation, Junction to Case	$\theta_{JC}$	JEDEC (JESD 51)	—	—	17	°C/W
Dissipation, Junction to Ambient	$\theta_{JA}$	JEDEC (JESD 51)	—	—	35	°C/W
ESD Protection (Human Body Model)	$ESD_{HBM}$	JEDEC (JESD 22-A114)	2000	—	—	V
Flammability Rating	UL-94	UL (Class)	V-0			
Moisture Sensitivity Level	MSL	JEDEC (J-STD-020)	1			
<p><b>Note:</b> While using multiple power supplies, the voltage on any input or I/O pin cannot exceed the power pin during power-up. Power supply sequencing is not required.</p>						

## 2. Functional Description

### 2.1. Crystal Recommendations

The clock device requires a parallel resonance crystal.

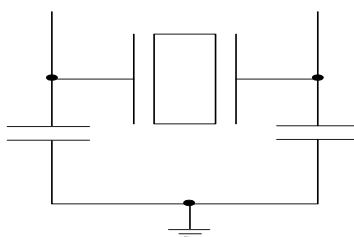
**Table 4. Crystal Recommendations**

Frequency (Fund)	Cut	Loading	Load Cap	Shunt Cap (max)	Motional (max)	Tolerance (max)	Stability (max)	Aging (max)
25 MHz	AT	Parallel	12–15 pF	5 pF	0.016 pF	35 ppm	30 ppm	5 ppm

#### 2.1.1. Crystal Loading

Crystal loading is critical in achieving low ppm performance. To realize low ppm performance, use the total capacitance the crystal sees to calculate the appropriate capacitive loading (CL).

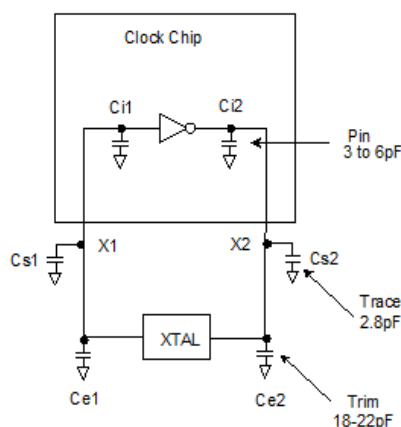
Figure 1 shows a typical crystal configuration using the two trim capacitors. It is important that the trim capacitors are in series with the crystal.



**Figure 1. Crystal Capacitive Clarification**

#### 2.1.2. Calculating Load Capacitors

In addition to the standard external trim capacitors, consider the trace capacitance and pin capacitance to calculate the crystal loading correctly. Again, the capacitance on each side is in series with the crystal. The total capacitance on both side is twice the specified crystal load capacitance (CL). Trim capacitors are calculated to provide equal capacitive loading on both sides.



**Figure 2. Crystal Loading Example**

Use the following formulas to calculate the trim capacitor values for Ce1 and Ce2.

## Load Capacitance (each side)

$$C_e = 2 \times CL - (C_s + C_i)$$

## Total Capacitance (as seen by the crystal)

$$CL_e = \frac{1}{\left( \frac{1}{C_{e1} + C_{s1} + C_{i1}} + \frac{1}{C_{e2} + C_{s2} + C_{i2}} \right)}$$

- CL: Crystal load capacitance
- CL<sub>e</sub>: Actual loading seen by crystal using standard value trim capacitors
- C<sub>e</sub>: External trim capacitors
- C<sub>s</sub>: Stray capacitance (terraced)
- C<sub>i</sub>: Internal capacitance (lead frame, bond wires, etc.)

## 2.2. CKPWRGD/PDB (Power Down) Pin

The CKPWRGD/PDB pin is a dual-function pin. During initial power up, the pin functions as the CKPWRGD pin. Upon the first power up, if the CKPWRGD pin is low, the outputs will be disabled, but the crystal oscillator and I<sup>2</sup>C logics will be active. Once the CKPWRGD pin has been sampled high by the clock chip, the pin assumes a PDB functionality. When the pin has assumed a PDB functionality and is pulled low, the device will be placed in power down mode. The CKPWRGD/PDB pin is required to be driven at all times even though it has an internal 100 kΩ resistor.

## 2.3. PDB (Power Down) Assertion

The PDB pin is an asynchronous active low input used to disable all output clocks in a glitch-free manner. All outputs will be driven low in power down mode. In power down mode, all outputs, the crystal oscillator, and the I<sup>2</sup>C logic are disabled.

## 2.4. PDB Deassertion

When a valid rising edge on CKPWRGD/PDB pin is applied, all outputs are enabled in a glitch-free manner within two to six output clock cycles.

## 2.5. OE Pin

The OE pin is an active high input used to enable and disable the output clock. To enable the output clock, the OE pin and the I<sup>2</sup>C OE bit need to be a logic high. By default, the OE pin and the I<sup>2</sup>C OE bit are set to a logic high. There are two methods to disable the output clock: the OE pin is pulled to a logic low, or the I<sup>2</sup>C OE bit is set to a logic low. The OE pin is required to be driven at all times even though it has an internal 100 kΩ resistor.

## 2.6. OE Assertion

The OE pin is an active high input used for synchronous stopping and starting the respective output clock while the rest of the clock generator continues to function. The assertion of the OE function is achieved by pulling the OE pin and the I<sup>2</sup>C OE bit high which causes the respective stopped output to resume normal operation. No short or stretched clock pulses are produced when the clocks resume. The maximum latency from the assertion to active outputs is no more than two to six output clock cycles.

## 2.7. OE Deassertion

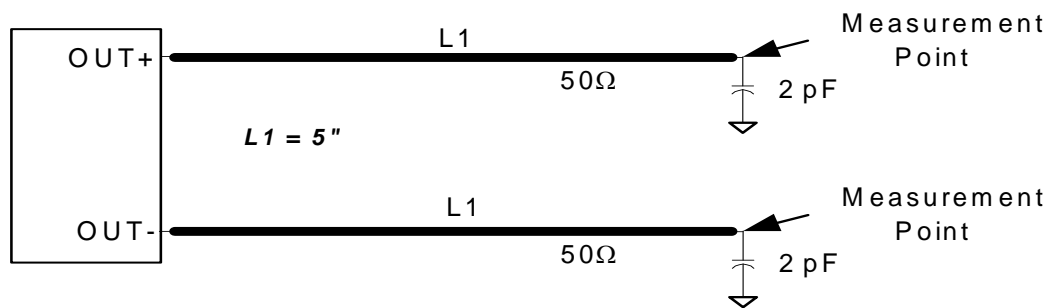
The OE function is deasserted by pulling the pin or the I<sup>2</sup>C OE bit to a logic low. The corresponding output is stopped cleanly and the final output state is driven low.

## 2.8. SSON Pin

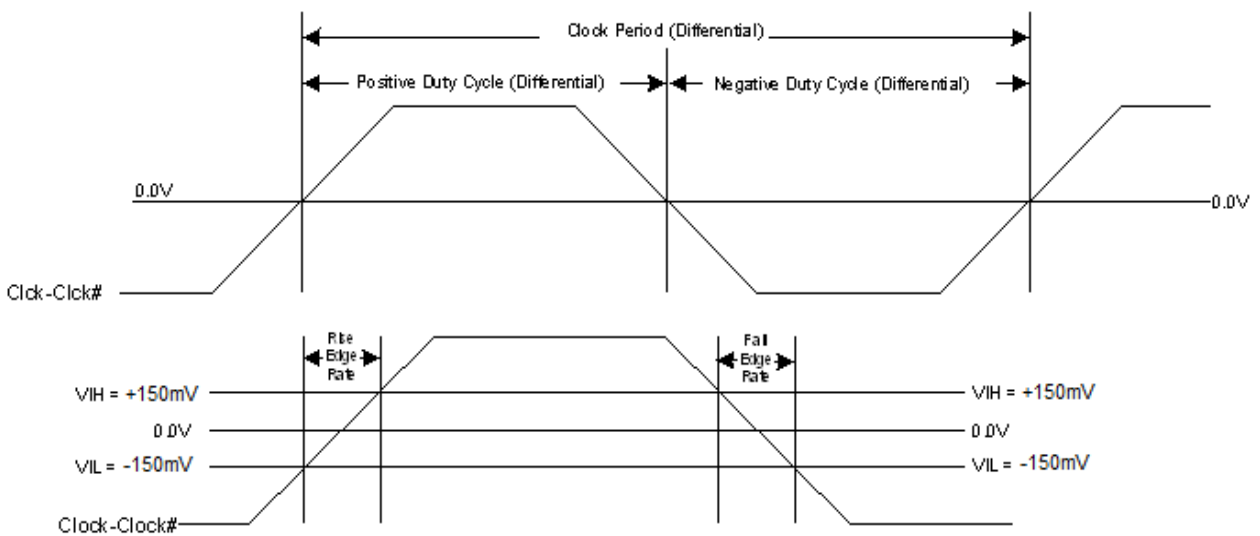
The SSON pin is an active input used to enable –0.5% spread spectrum on the outputs. When sampled high, –0.5% spread is enabled on the output clocks. When sampled low, the output clocks are non-spread.

### 3. Test and Measurement Setup

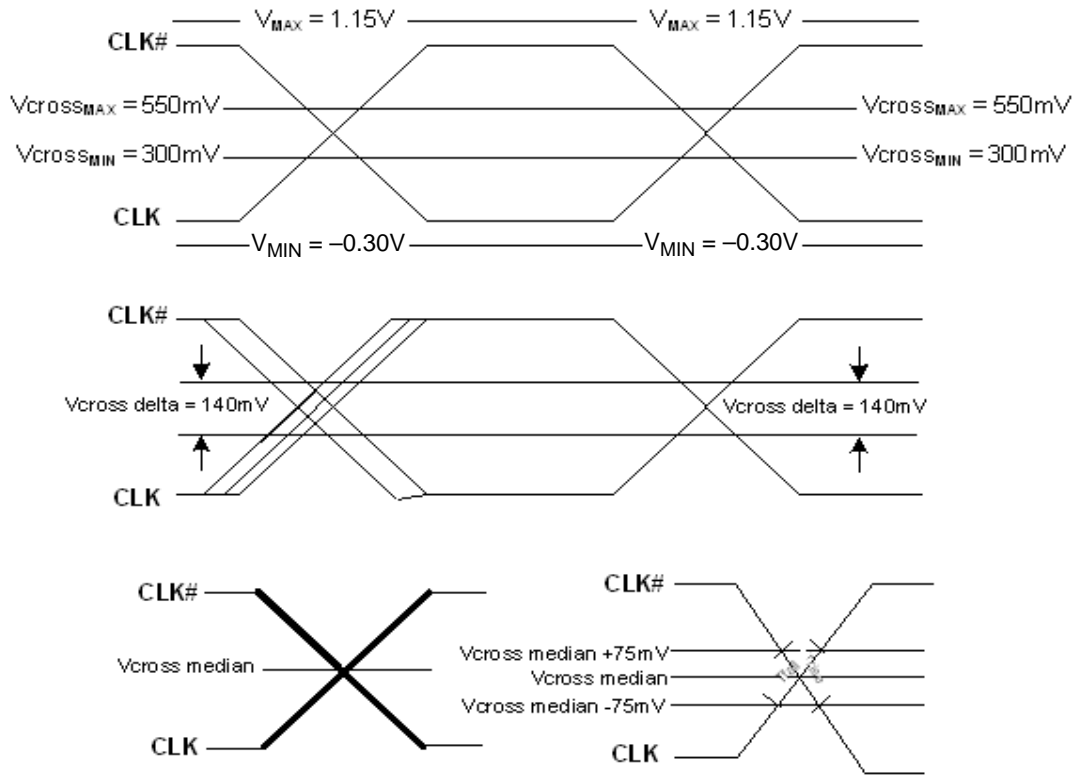
This diagram shows the test load configuration for the differential clock signals.



**Figure 3. 0.7 V Differential Load Configuration**



**Figure 4. Differential Output Signals (for AC Parameters Measurement)**



**Figure 5. Single-ended Measurement for Differential Output Signals (for AC Parameters Measurement)**

## 4. Control Registers

### 4.1. I<sup>2</sup>C Interface

To enhance the flexibility and function of the clock synthesizer, an I<sup>2</sup>C interface is provided. Through the I<sup>2</sup>C interface, various device functions, such as individual clock output buffers are individually enabled or disabled. The registers associated with the I<sup>2</sup>C interface initialize to their default setting at power-up. The use of this interface is optional. Clock device register changes are normally made at system initialization, if any are required.

### 4.2. Data Protocol

The clock driver I<sup>2</sup>C protocol accepts byte write, byte read, block write, and block read operations from the controller. For block write/read operation, access the bytes in sequential order from lowest to highest (most significant bit first) with the ability to stop after any complete byte is transferred. For byte write and byte read operations, the system controller can access individually indexed bytes. .

The block write and block read protocol is outlined in Table 5 while Table 6 outlines byte write and byte read protocol. The slave receiver address is 11010110 (D6h).

**Table 5. Block Read and Block Write Protocol**

Block Write Protocol		Block Read Protocol	
Bit	Description	Bit	Description
1	Start	1	Start
8:2	Slave address—7 bits	8:2	Slave address—7 bits
9	Write	9	Write
10	Acknowledge from slave	10	Acknowledge from slave
18:11	Command Code—8 bits	18:11	Command Code—8 bits
19	Acknowledge from slave	19	Acknowledge from slave
27:20	Byte Count—8 bits	20	Repeat start
28	Acknowledge from slave	27:21	Slave address—7 bits
36:29	Data byte 1—8 bits	28	Read = 1
37	Acknowledge from slave	29	Acknowledge from slave
45:38	Data byte 2—8 bits	37:30	Byte Count from slave—8 bits
46	Acknowledge from slave	38	Acknowledge
....	Data Byte/Slave Acknowledges	46:39	Data byte 1 from slave—8 bits
....	Data Byte N—8 bits	47	Acknowledge
....	Acknowledge from slave	55:48	Data byte 2 from slave—8 bits
....	Stop	56	Acknowledge
		....	Data bytes from slave/Acknowledge
		....	Data Byte N from slave—8 bits
		....	NOT Acknowledge
		....	Stop

**Table 6. Byte Read and Byte Write Protocol**

Byte Write Protocol		Byte Read Protocol	
Bit	Description	Bit	Description
1	Start	1	Start
8:2	Slave address–7 bits	8:2	Slave address–7 bits
9	Write	9	Write
10	Acknowledge from slave	10	Acknowledge from slave
18:11	Command Code–8 bits	18:11	Command Code–8 bits
19	Acknowledge from slave	19	Acknowledge from slave
27:20	Data byte–8 bits	20	Repeated start
28	Acknowledge from slave	27:21	Slave address–7 bits
29	Stop	28	Read
		29	Acknowledge from slave
		37:30	Data from slave–8 bits
		38	NOT Acknowledge
		39	Stop

**Control Register 0. Byte 0**

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name								
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Reset settings = 00000000

Bit	Name	Function
7:0	Reserved	

**Control Register 1. Byte 1**

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name				DIFF0_OE		DIFF1_OE		DIFF2_OE
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Reset settings = 00010101

Bit	Name	Function
7:5	Reserved	
4	DIFF0_OE	<b>Output Enable for DIFF0.</b> 0: Output disabled. 1: Output Enabled.
3	Reserved	
2	DIFF1_OE	<b>Output Enable for DIFF1.</b> 0: Output disabled. 1: Output enabled.
1	Reserved	
0	DIFF2_OE	<b>Output Enable for DIFF2.</b> 0: Output disabled. 1: Output enabled.

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## Control Register 2. Byte 2

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	DIFF3_OE	DIFF4_OE	DIFF5_OE					
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Reset settings = 11100000

Bit	Name	Function
7	DIFF3_OE	<b>Output Enable for DIFF3.</b> 0: Output disabled. 1: Output enabled.
6	DIFF4_OE	<b>Output Enable for DIFF4.</b> 0: Output disabled. 1: Output enabled.
5	DIFF5_OE	<b>Output Enable for DIFF5.</b> 0: Output disabled. 1: Output enabled.
4:0	Reserved	

## Control Register 3. Byte 3

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	Rev Code[3:0]				Vendor ID[3:0]			
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Reset settings = 00001000

Bit	Name	Function
7:4	Rev Code[3:0]	<b>Program Revision Code.</b>
3:0	Vendor ID[3:0]	<b>Vendor Identification Code.</b>

**Control Register 4. Byte 4**

Bit	D7	D6	D5	D4	D3	D2	D1	D0
<b>Name</b>	BC[7:0]							
<b>Type</b>	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Reset settings = 00000110

Bit	Name	Function
7:0	BC[7:0]	<b>Byte Count Register.</b>

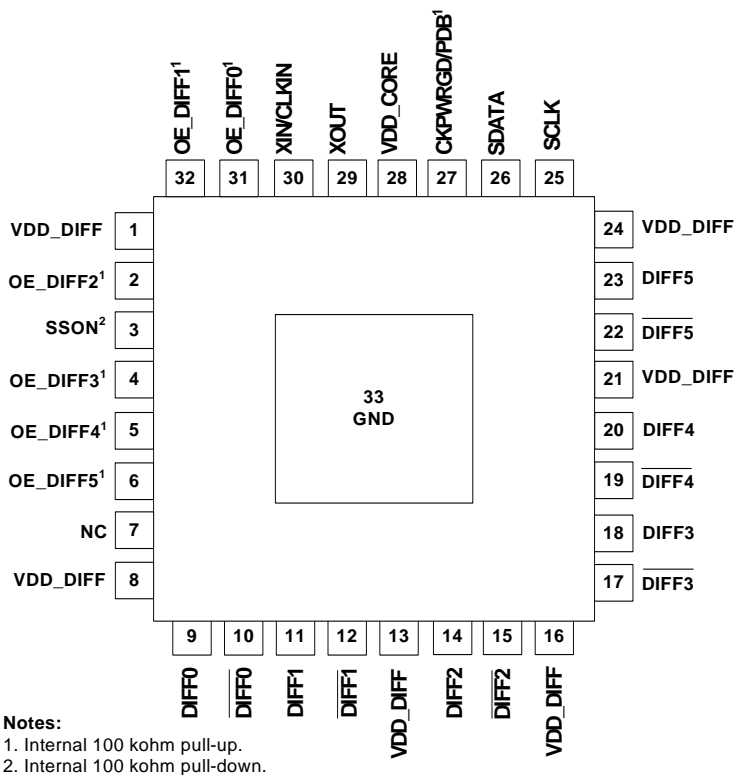
**Control Register 5. Byte 5**

Bit	D7	D6	D5	D4	D3	D2	D1	D0
<b>Name</b>	DIFF_Amp_Sel	DIFF_Amp_Cntl[2]	DIFF_Amp_Cntl[1]	DIFF_Amp_Cntl[0]				
<b>Type</b>	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Reset settings = 11011000

Bit	Name	Function
7	DIFF_Amp_Sel	<b>Amplitude Control for DIFF Differential Outputs.</b> 0: Differential outputs with Default amplitude. 1: Differential outputs amplitude is set by Byte 5[6:4].
6	DIFF_Amp_Cntl[2]	<b>DIFF Differential Outputs Amplitude Adjustment.</b> 000: 300 mV 001: 400 mV 010: 500 mV 011: 600 mV 100: 700 mV 101: 800 mV 110: 900 mV 111: 1000 mV
5	DIFF_Amp_Cntl[1]	
4	DIFF_Amp_Cntl[0]	
3:0	Reserved	

## 5. Pin Descriptions: 32-Pin QFN



**Table 7. Si52146 32-Pin QFN Descriptions**

Pin #	Name	Type	Description
1	VDD_DIFF	PWR	3.3 V power supply
2	OE_DIFF2	I,PU	Active high input pin enables DIFF2 (internal 100 kΩ pull-up).
3	SSON	I, PD	Active high input pin enables -0.5% spread on DIFF clocks (internal 100 kΩ pull-down)
4	OE_DIFF3	I,PU	Active high input pin enables DIFF3 (internal 100 kΩ pull-up).
5	OE_DIFF4	I,PU	Active high input pin enables DIFF4 (internal 100 kΩ pull-up).
6	OE_DIFF5	I,PU	Active high input pin enables DIFF5 (internal 100 kΩ pull-up).
7	NC	NC	No connect
8	VDD_DIFF	PWR	3.3 V power supply
9	DIFF0	O, DIF	0.7 V, 100 MHz differential clock
10	DIFF0	O, DIF	0.7 V, 100 MHz differential clock
11	DIFF1	O, DIF	0.7 V, 100 MHz differential clock
12	DIFF1	O, DIF	0.7 V, 100 MHz differential clock

Table 7. Si52146 32-Pin QFN Descriptions

Pin #	Name	Type	Description
13	VDD_DIFF	PWR	3.3 V power supply
14	DIFF2	O, DIF	0.7 V, 100 MHz differential clock
15	$\overline{\text{DIFF2}}$	O, DIF	0.7 V, 100 MHz differential clock
16	VDD_DIFF	PWR	3.3 V power supply
17	$\overline{\text{DIFF3}}$	O, DIF	0.7 V, 100 MHz differential clock
18	DIFF3	O, DIF	0.7 V, 100 MHz differential clock
19	$\overline{\text{DIFF4}}$	O, DIF	0.7 V, 100 MHz differential clock
20	DIFF4	O, DIF	0.7 V, 100 MHz differential clock
21	VDD_DIFF	PWR	3.3 V power supply
22	$\overline{\text{DIFF5}}$	O, DIF	0.7 V, 100 MHz differential clock
23	DIFF5	O, DIF	0.7 V, 100 MHz differential clock
24	VDD_DIFF	PWR	3.3 V power supply
25	SCLK	I	I <sup>2</sup> C compatible SCLOCK
26	SDATA	I/O	I <sup>2</sup> C compatible SDATA
27	CKPWRGD/PDB	I, PU	Active low input for asserting power down (PDB) and disabling all outputs (internal 100 k $\Omega$ pull-up).
28	VDD_CORE	PWR	3.3 V power supply
29	XOUT	O	25.00 MHz crystal output, Float XOUT if using only CLKIN (clock input)
30	XIN/CLKIN	I	25.00 MHz crystal input or 3.3 V, 25 MHz clock input
31	OE_DIFF0	I,PU	Active high input pin enables DIFF0 (internal 100 k $\Omega$ pull-up).
32	OE_DIFF1	I,PU	Active high input pin enables DIFF1 (internal 100 k $\Omega$ pull-up).
33	GND	GND	Ground for bottom pad of the IC.

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## 6. Ordering Guide

Part Number	Package Type	Temperature
<b>Lead-free</b>		
Si52146-A01AGM	32-pin QFN	Industrial, -40 to 85 °C
Si52146-A01AGMR	32-pin QFN—Tape and Reel	Industrial, -40 to 85 °C

## 7. Package Outline

Figure 6 illustrates the package details for the Si52146. Table 8 lists the values for the dimensions shown in the illustration.

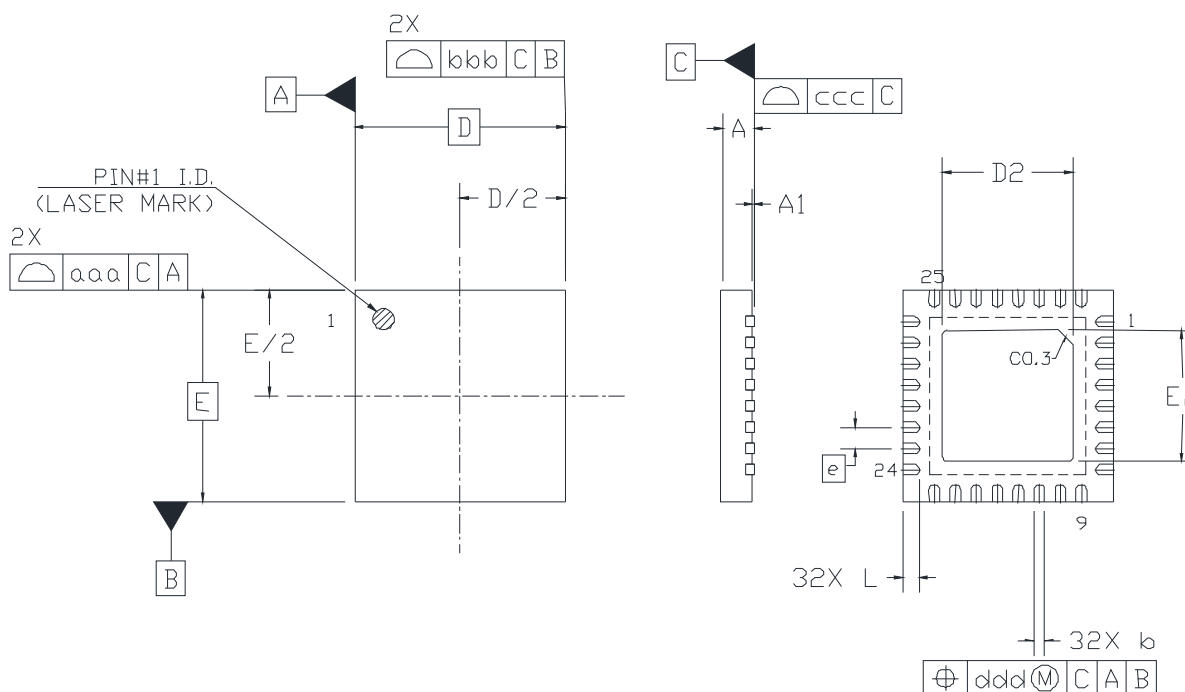


Figure 6. 32-Pin Quad Flat No Lead (QFN) Package

Table 8. Package Diagram Dimensions

Symbol	Millimeters		
	Min	Nom	Max
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
b	0.18	0.25	0.30
D	5.00 BSC		
D2	3.15	3.20	3.25
e	0.50 BSC		
E	5.00 BSC		
E2	3.15	3.20	3.25
L	0.30	0.40	0.50
aaa	0.10		
bbb	0.10		
ccc	0.08		
ddd	0.10		
<b>Notes:</b>			
1. All dimensions shown are in millimeters (mm) unless otherwise noted.			
2. Dimensioning and Tolerancing per ANSI Y14.5M-1994.			
3. Recommended card reflow profile is per the JEDEC/IPC J-STD-020 specification for Small Body Components.			
4. This drawing conforms to the JEDEC Solid State Outline MO-220.			

## DOCUMENT CHANGE LIST

### Revision 0.1 to Revision 1.0

- Updated Pin Names.
- Updated Table 1.
- Updated Table 2.
- Updated Table 3.
- Updated section 2.1.
- Updated section 2.1.1.
- Updated sections 2.2 through 2.8.
- Updated section 4.2.
- Updated Table 7.

NOTES:

## CONTACT INFORMATION

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and register to submit a technical support request.

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