

## Description

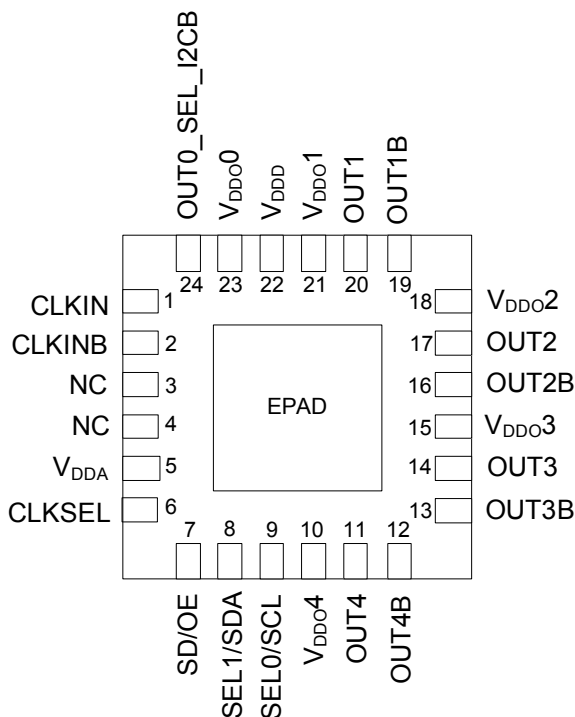
The 5P49V5935 is a programmable clock generator intended for high-performance consumer, networking, industrial, computing, and data-communications applications. Configurations may be stored in on-chip One-Time Programmable (OTP) memory or changed using I<sup>2</sup>C interface. This is IDT's fifth generation of programmable clock technology (VersaClock® 5).

The 5P49V5935 by default uses an integrated 25MHz crystal as input reference. It also has a redundant external clock input. A glitchless manual switchover functions allows selection of either one as mentioned above as input reference during normal operation.

Two select pins allow up to 4 different configurations to be programmed and accessible using processor GPIOs or bootstrapping. The different selections may be used for different operating modes (full function, partial function, partial power-down), regional standards (US, Japan, Europe) or system production margin testing.

The device may be configured to use one of two I<sup>2</sup>C addresses to allow multiple devices to be used in a system.

## Pin Assignment

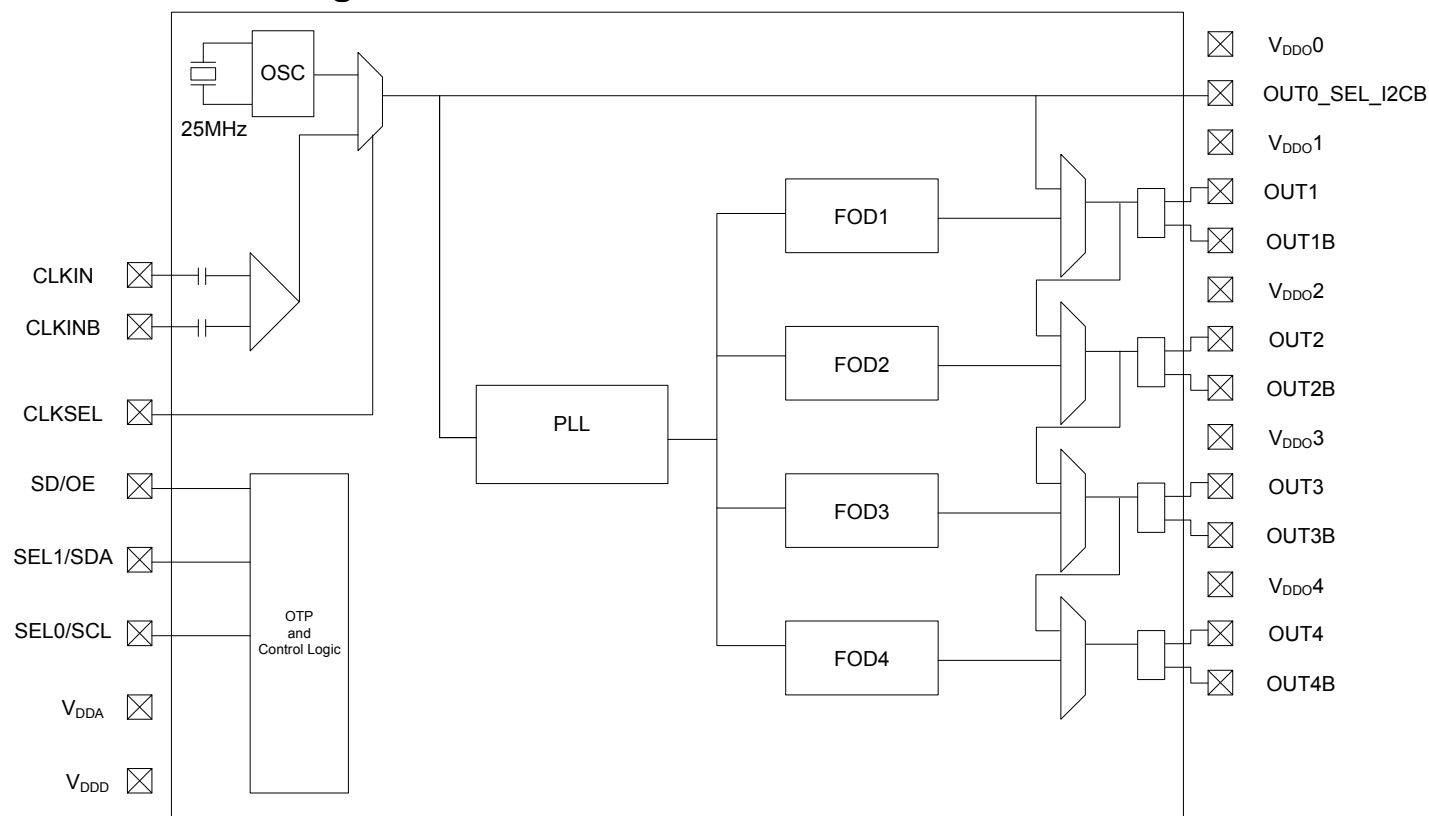


4 × 4 mm 24-LGA

## Features

- Generates up to four independent output frequencies
- High-performance, low phase noise PLL, < 0.7 ps RMS typical phase jitter on outputs:
  - PCIe Gen1, 2, 3 compliant clock capability
  - USB 3.0 compliant clock capability
  - 1GbE and 10GbE
- Four fractional output dividers (FODs)
- Independent spread spectrum capability on each output pair
- Four banks of internal non-volatile in-system programmable or factory programmable OTP memory
- I<sup>2</sup>C serial programming interface
- One reference LVCMOS output clock
- Four universal output pairs:
  - Each configurable as one differential output pair or two LVCMOS outputs
- I/O standards:
  - Single-ended I/Os: 1.8V to 3.3V LVCMOS
  - Differential I/Os: LVPECL, LVDS and HCSL
- Input frequency ranges:
  - LVDS, LVPECL, HCSL differential clock input (CLKIN, CLKINB) – 1MHz to 350MHz
- Output frequency ranges:
  - LVCMOS clock outputs: 1MHz to 200MHz
  - LVDS, LVPECL, HCSL differential clock outputs: 1MHz to 350MHz
- Individually selectable output voltage (1.8V, 2.5V, 3.3V) for each output pair
- Redundant clock inputs with manual switchover
- Programmable loop bandwidth
- Programmable output to output skew
- Programmable slew rate control
- Individual output enable/disable
- Power-down mode
- 1.8V, 2.5V or 3.3V core V<sub>DDO</sub>, V<sub>DDA</sub>
- 4 × 4 mm 24-LGA package
- -40° to +85°C industrial temperature operation

## Functional Block Diagram



## Applications

- Ethernet switch/router
- PCI Express 1.0/2.0/3.0
- Broadcast video/audio timing
- Multi-function printer
- Processor and FPGA clocking
- Any-frequency clock conversion
- MSAN/DSLAM/PON
- Fiber Channel, SAN
- Telecom line cards
- 1GbE and 10GbE

**Table 1: Pin Descriptions**

| Number | Name          | Type         |           | Description  |
|--------|---------------|--------------|-----------|--|
| 1      | CLKIN         | Input        | Pull-down | Differential clock input. Weak 100kohms internal pull-down.  |
| 2      | CLKINB        | Input        | Pull-down | Complementary differential clock input. Weak 100kohms internal pull-down.  |
| 3      | NC            | --           |           | No connect.  |
| 4      | NC            | --           |           | No connect.  |
| 5      | VDDA          | Power        |           | Analog functions power supply pin. Connect to 1.8V to 3.3V. VDDA and VDDD should have the same voltage applied.  |
| 6      | CLKSEL        | Input        | Pull-down | Input clock select. Selects the active input reference source, when in Manual switchover mode.<br>0 = Integrated crystal (default)<br>1 = CLKIN, CLKINB<br>CLKSEL Polarity can be changed by I2C programming as shown in Table 4.  |
| 7      | SD/OE         | Input        | Pull-down | Enables/disables the outputs (OE) or powers down the chip (SD). The SH bit controls the configuration of the SD/OE pin. The SH bit needs to be high for SD/OE pin to be configured as SD. The SP bit (0x02) controls the polarity of the signal to be either active HIGH or LOW only when pin is configured as OE (Default is active LOW.) Weak internal pull down resistor. When configured as SD, device is shut down, differential outputs are driven high/low, and the single-ended LVCMOS outputs are driven low. When configured as OE, and outputs are disabled, the outputs can be selected to be tri-stated or driven high/low, depending on the programming bits as shown in the SD/OE Pin Function Truth table. |
| 8      | SEL1/SDA      | Input        | Pull-down | Configuration select pin, or I2C SDA input as selected by OUT0_SEL_I2CB. Weak internal pull down resistor.   |
| 9      | SEL0/SCL      | Input        | Pull-down | Configuration select pin, or I2C SCL input as selected by OUT0_SEL_I2CB. Weak internal pull down resistor.   |
| 10     | VDDO4         | Power        |           | Output power supply. Connect to 1.8 to 3.3V. Sets output voltage levels for OUT4/OUT4B.  |
| 11     | OUT4          | Output       |           | Output Clock 4. Please refer to the Output Drivers section for more details.   |
| 12     | OUT4B         | Output       |           | Complementary Output Clock 4. Please refer to the Output Drivers section for more details.   |
| 13     | OUT3B         | Output       |           | Complementary Output Clock 3. Please refer to the Output Drivers section for more details.   |
| 14     | OUT3          | Output       |           | Output Clock 3. Please refer to the Output Drivers section for more details.   |
| 15     | VDDO3         | Power        |           | Output power supply. Connect to 1.8 to 3.3V. Sets output voltage levels for OUT3/OUT3B.  |
| 16     | OUT2B         | Output       |           | Complementary Output Clock 2. Please refer to the Output Drivers section for more details.   |
| 17     | OUT2          | Output       |           | Output Clock 2. Please refer to the Output Drivers section for more details.   |
| 18     | VDDO2         | Power        |           | Output power supply. Connect to 1.8 to 3.3V. Sets output voltage levels for OUT2/OUT2B.  |
| 19     | OUT1B         | Output       |           | Complementary Output Clock 1. Please refer to the Output Drivers section for more details.   |
| 20     | OUT1          | Output       |           | Output Clock 1. Please refer to the Output Drivers section for more details.   |
| 21     | VDDO1         | Power        |           | Output power supply. Connect to 1.8 to 3.3V. Sets output voltage levels for OUT1/OUT1B.  |
| 22     | VDDD          | Power        |           | Digital functions power supply pin. Connect to 1.8 to 3.3V. VDDA and VDDB should have the same voltage applied.  |
| 23     | VDDO0         | Power        |           | Power supply pin for OUT0_SEL_I2CB. Connect to 1.8 to 3.3V. Sets output voltage levels for OUT0.   |
| 24     | OUT0_SEL_I2CB | Input/Output | Pull-down | Latched input/LVCMOS Output. At power up, the voltage at the pin OUT0_SEL_I2CB is latched by the part and used to select the state of pins 8 and 9. If a weak pull up (10Kohms) is placed on OUT0_SEL_I2CB, pins 8 and 9 will be configured as hardware select pins, SEL1 and SEL0. If a weak pull down (10Kohms) is placed on OUT0_SEL_I2CB or it is left floating, pins 8 and 9 will act as the SDA and SCL pins of an I2C interface. After power up, the pin acts as a LVCMOS reference output which is the same frequency as the input reference. At default, 25MHz integrated crystal is used so OUT0 will also be 25MHz.   |
| EPAD   | VEE           | Power        |           | Connect to ground pad.   |

## PLL Features and Descriptions

### Spread Spectrum

To help reduce electromagnetic interference (EMI), the 5P49V5935 supports spread spectrum modulation. The output clock frequencies can be modulated to spread energy across a broader range of frequencies, lowering system EMI. The 5P49V5935 implements spread spectrum using the Fractional-N output divide, to achieve controllable modulation rate and spreading magnitude. The Spread spectrum can be applied to any output clock, any clock frequency, and any spread amount from  $\pm 0.25\%$  to  $\pm 2.5\%$  center spread and  $-0.5\%$  to  $-5\%$  down spread.

**Table 2: Loop Filter**

PLL loop bandwidth range depends on the input reference frequency (Fref) and can be set between the loop bandwidth range as shown in the table below.

| Input Reference Frequency—Fref (MHz) | Loop Bandwidth Min (kHz) | Loop Bandwidth Max (kHz) |
|--------------------------------------|--------------------------|--------------------------|
| 1                                    | 40                       | 126                      |
| 350                                  | 300                      | 1000                     |

**Table 3: Configuration Table**

This table shows the SEL1, SEL0 settings to select the configuration stored in OTP. Four configurations can be stored in OTP. These can be factory programmed or user programmed.

| OUT0_SEL_I2CB at POR | SEL1 | SEL0 | I <sup>2</sup> C Access | REG0:7 | Config                    |
|----------------------|------|------|-------------------------|--------|---------------------------|
| 1                    | 0    | 0    | No                      | 0      | 0                         |
| 1                    | 0    | 1    | No                      | 0      | 1                         |
| 1                    | 1    | 0    | No                      | 0      | 2                         |
| 1                    | 1    | 1    | No                      | 0      | 3                         |
| 0                    | X    | X    | Yes                     | 1      | I <sup>2</sup> C defaults |
| 0                    | X    | X    | Yes                     | 0      | 0                         |

At power up time, the SEL0 and SEL1 pins must be tied to either the VDDD/VDDA power supply so that they ramp with that supply or are tied low (this is the same as floating the pins). This will cause the register configuration to be loaded that is selected according to Table 3 above. Providing that OUT0\_SEL\_I2CB was 1 at POR and OTP register 0:7 = 0, after the first 10ms of operation the levels of the SELx pins can be changed, either to low or to the same level as VDDD/VDDA. The SELx pins must be driven with a digital signal of < 300ns Rise/Fall time and only a single pin can be changed at a time. After a pin level change, the device must not be interrupted for at least 1ms so that the new values have time to load and take effect.

If OUT0\_SEL\_I2CB was 0 at POR, alternate configurations can only be loaded via the I2C interface.

**Table 4: Input Clock Select**

Input clock select. Selects the active input reference source in manual switchover mode.

0 = Integrated XTAL (default)

1 = CLKIN, CLKINB

CLKSEL polarity can be changed by I<sup>2</sup>C programming as shown in the table below.

| PRIMSRC | CLKSEL | Source          |
|---------|--------|-----------------|
| 0       | 0      | Integrated XTAL |
| 0       | 1      | CLKIN, CLKINB   |
| 1       | 0      | CLKIN, CLKINB   |
| 1       | 1      | Integrated XTAL |

PRIMSRC is bit 1 of Register 0x13.

### Reference Clock Input Pins and Selection

The 5P49V5935 by default uses an integrated 25MHz crystal as input reference. It also has a redundant external clock input. A glitchless manual switchover functions allows selection of either one as mentioned above as input reference during normal operation.

Either clock input can be set as the primary clock. The primary clock designation is to establish which is the main reference clock to the PLL. The non-primary clock is designated as the secondary clock in case the primary clock goes absent and a backup is needed. The PRIMSRC bit determines which clock input will be selected as primary clock. When PRIMSRC bit is “0”, integrated crystal is selected as the primary clock, and when “1”, (CLKIN, CLKINB) as the primary clock.

The two reference inputs can be manually selected using the CLKSEL pin. The SM bits must be set to “0x” for manual switchover which is detailed in Manual Switchover Mode section.

### Manual Switchover Mode

When SM[1:0] is “0x”, the redundant inputs are in manual switchover mode. In this mode, CLKSEL pin is used to switch between the primary and secondary clock sources. The primary and secondary clock source setting is determined by the PRIMSRC bit. During the switchover, no glitches will occur at the output of the device, although there may be frequency and phase drift, depending on the exact phase and frequency relationship between the primary and secondary clocks.

## OTP Interface

The 5P49V5935 can also store its configuration in an internal OTP. The contents of the device's internal programming registers can be saved to the OTP by setting burn\_start (W114[3]) to high and can be loaded back to the internal programming registers by setting usr\_rd\_start(W114[0]) to high.

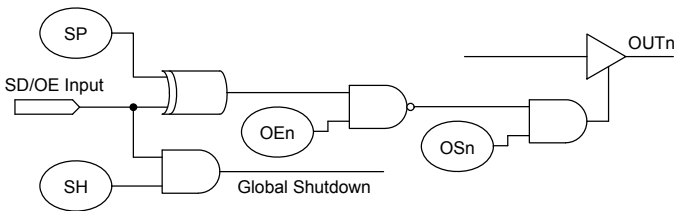
To initiate a save or restore using I<sup>2</sup>C, only two bytes are transferred. The Device Address is issued with the read/write bit set to "0", followed by the appropriate command code. The save or restore instruction executes after the STOP condition is issued by the Master, during which time the 5P49V5935 will not generate Acknowledge bits. The 5P49V5935 will acknowledge the instructions after it has completed execution of them. During that time, the I<sup>2</sup>C bus should be interpreted as busy by all other users of the bus.

On power-up of the 5P49V5935, an automatic restore is performed to load the OTP contents into the internal programming registers. The 5P49V5935 will be ready to accept a programming instruction once it acknowledges its 7-bit I<sup>2</sup>C address.

Availability of Primary and Secondary I<sup>2</sup>C addresses to allow programming for multiple devices in a system. The I<sup>2</sup>C slave address can be changed from the default 0xD4 to 0xD0 by programming the I2C\_ADDR bit D0. *VersaClock 5 Programming Guide* provides detailed I<sup>2</sup>C programming guidelines and register map.

## SD/OE Pin Function

The polarity of the SD/OE signal pin can be programmed to be either active HIGH or LOW with the SP bit (W16[1]). When SP is "0" (default), the pin becomes active LOW and when SP is "1", the pin becomes active HIGH. The SD/OE pin can be configured as either to shutdown the PLL or to enable/disable the outputs. The SH bit controls the configuration of the SD/OE pin. The SH bit needs to be high for SD/OE pin to be configured as SD.



When configured as SD, device is shut down, differential outputs are driven High/low, and the single-ended LVCMOS outputs are driven low. When configured as OE, and outputs are disabled, the outputs are driven high/low.

**Table 5: SD/OE Pin Function Truth Table**

| SH bit | SP bit | OSn bit | OEn bit | SD/OE | OUTn                                |
|--------|--------|---------|---------|-------|-------------------------------------|
| 0      | 0      | 0       | x       | x     | Tri-state <sup>2</sup>              |
| 0      | 0      | 1       | 0       | x     | Output active                       |
| 0      | 0      | 1       | 1       | 0     | Output active                       |
| 0      | 0      | 1       | 1       | 1     | Output driven High Low              |
| 0      | 1      | 0       | x       | x     | Tri-state <sup>2</sup>              |
| 0      | 1      | 1       | 0       | x     | Output active                       |
| 0      | 1      | 1       | 1       | 0     | Output driven High Low              |
| 0      | 1      | 1       | 1       | 1     | Output active                       |
| 1      | 0      | 0       | x       | 0     | Tri-state <sup>2</sup>              |
| 1      | 0      | 1       | 0       | 0     | Output active                       |
| 1      | 0      | 1       | 1       | 0     | Output active                       |
| 1      | 1      | 0       | x       | 0     | Tri-state <sup>2</sup>              |
| 1      | 1      | 1       | 0       | 0     | Output active                       |
| 1      | 1      | 1       | 1       | 0     | Output driven High Low              |
| 1      | x      | x       | x       | 1     | Output driven High Low <sup>1</sup> |

Note 1 : Global Shutdown

Note 2 : Tri-state regardless of OEn bits

## Output Alignment

Each output divider block has a synchronizing POR pulse to provide startup alignment between outputs. This allows alignment of outputs for low skew performance. The phase alignment works both for integer output divider values and for fractional output divider values.

Besides the POR at power up, the same synchronization reset is also triggered when switching between configurations with the SEL0/1 pins. This ensures that the outputs remain aligned in every configuration. This reset causes the outputs to suspend for a few hundred microseconds so the switchover is not glitch-less. The reset can be disabled for applications where glitch-less switch over is required and alignment is not critical.

When using I<sup>2</sup>C to reprogram an output divider during operation, alignment can be lost. Alignment can be restored by manually triggering the reset through I<sup>2</sup>C.

When alignment is required for outputs with different frequencies, the outputs are actually aligned on the falling edges of each output by default. Rising edge alignment can also be achieved by utilizing the programmable skew feature to delay the faster clock by 180 degrees. The programmable skew feature also allows for fine tuning of the alignment.

For details of register programming, please see [VersaClock 5 Family Register Descriptions and Programming Guide](#) for details.

## Output Divides

Each of the four output divides are comprised of a 12-bit integer counter, and a 24-bit fractional counter. The output divide can operate in integer divide only mode for improved performance, or utilize the fractional counters to generate any frequency with a synthesis accuracy better than 50ppb.

The Output Divide also has the capability to apply a spread modulation to the output frequency. Independent of output frequency, a triangle wave modulation between 30 and 63kHz may be generated.

## Output Skew

For outputs that share a common output divide value, there will be the ability to skew outputs by quadrature values to minimize interaction on the PCB. The skew on each output can be adjusted from 0 to 360 degrees. Skew is adjusted in units equal to 1/32 of the VCO period. So, for 100MHz output and a 2800MHz VCO, you can select how many 11.161ps units you want added to your skew (resulting in units of 0.402 degrees). For example, 0, 0.402, 0.804, 1.206, 1.408, and so on. The granularity of the skew adjustment is always dependent on the VCO period and the output period.

## Output Drivers

The OUT1 to OUT4 clock outputs are provided with register-controlled output drivers. By selecting the output drive type in the appropriate register, any of these outputs can support LVCMOS, LVPECL, HCSL or LVDS logic levels

The operating voltage ranges of each output is determined by its independent output power pin ( $V_{DDO}$ ) and thus each can have different output voltage levels. Output voltage levels of 2.5V or 3.3V are supported for differential HCSL, LVPECL operation, and 1.8V, 2.5V, or 3.3V are supported for LVCMOS and differential LVDS operation.

Each output may be enabled or disabled by register bits. When disabled an output will be in a logic 0 state as determined by the programming bit table shown on page 6.

## LVCMOS Operation

When a given output is configured to provide LVCMOS levels, then both the OUTx and OUTxB outputs will toggle at the selected output frequency. All the previously described configuration and control apply equally to both outputs. Frequency, phase alignment, voltage levels and enable / disable status apply to both the OUTx and OUTxB pins. The OUTx and OUTxB outputs can be selected to be phase-aligned with each other or inverted relative to one another by register programming bits. Selection of phase-alignment may have negative effects on the phase noise performance of any part of the device due to increased simultaneous switching noise within the device.

## Device Hardware Configuration

The 5P49V5935 supports an internal One-Time Programmable (OTP) memory that can be pre-programmed at the factory with up to 4 complete device configuration.

These configurations can be over-written using the serial interface once reset is complete. Any configuration written via the programming interface needs to be re-written after any power cycle or reset. Contact IDT if a specific factory-programmed configuration is desired.

## Device Start-up & Reset Behavior

The 5P49V5935 has an internal power-up reset (POR) circuit. The POR circuit will remain active for a maximum of 10ms after device power-up.

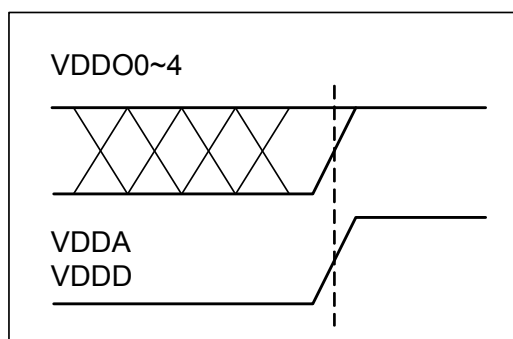
Upon internal POR circuit expiring, the device will exit reset and begin self-configuration.

The device will load internal registers according to [Table 3](#).

Once the full configuration has been loaded, the device will respond to accesses on the serial port and will attempt to lock the PLL to the selected source and begin operation.

## Power Up Ramp Sequence

VDDA and VDDD must ramp up together. VDDO0–4 must ramp up before, or concurrently with, VDDA and VDDD. All power supply pins must be connected to a power rail even if the output is unused. All power supplies must ramp in a linear fashion and ramp monotonically.



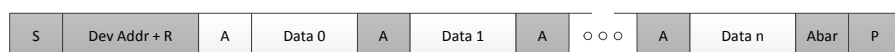


# I<sup>2</sup>C Mode Operation

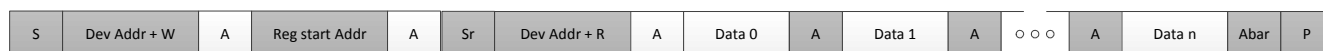
The device acts as a slave device on the I<sup>2</sup>C bus using one of the two I<sup>2</sup>C addresses (0xD0 or 0xD4) to allow multiple devices to be used in the system. The interface accepts byte-oriented block write and block read operations. Two address bytes specify the register address of the byte position of the first register to write or read. Data bytes (registers) are accessed in sequential order from the lowest to the highest byte (most significant bit first). Read and write block transfers can be stopped after any complete byte transfer. During a write operation, data will not be moved into the registers until the STOP bit is received, at which point, all data received in the block write will be written simultaneously.

For full electrical I<sup>2</sup>C compliance, it is recommended to use external pull-up resistors for SDATA and SCLK. The internal pull-down resistors have a size of 100kΩ typical.

Current Read



Sequential Read



Sequential Write



- from master to slave
- from slave to master
- S = start
- Sr = repeated start
- A = acknowledge
- Abar = none acknowledge
- P = stop

## I<sup>2</sup>C Slave Read and Write Cycle Sequencing

**Table 6: I<sup>2</sup>C Bus DC Characteristics**

| Symbol | Parameter             | Conditions                         | Min       | Typ | Max              | Unit |
|--------|-----------------------|------------------------------------|-----------|-----|------------------|------|
| VIH    | Input HIGH Level      | For SEL1/SDA pin and SEL0/SCL pin. | 0.7xVDDD  |     | 5.5 <sup>2</sup> | V    |
| VIL    | Input LOW Level       | For SEL1/SDA pin and SEL0/SCL pin. | GND-0.3   |     | 0.3xVDDD         | V    |
| VHYS   | Hysteresis of Inputs  |                                    | 0.05xVDDD |     |                  | V    |
| IIN    | Input Leakage Current |                                    | -1        |     | 30               | μA   |
| VOL    | Output LOW Voltage    | IOL = 3mA                          |           |     | 0.4              | V    |

**Table 7: I<sup>2</sup>C Bus AC Characteristics**

| Symbol    | Parameter                            |  | Min         | Typ | Max | Unit |
|-----------|--------------------------------------|--|-------------|-----|-----|------|
| FCLK      | Serial Clock Frequency (SCL)         |  | 10          |     | 400 | kHz  |
| tBUF      | Bus free time between STOP and START |  | 1.3         |     |     | μs   |
| tSU:START | Setup Time, START                    |  | 0.6         |     |     | μs   |
| tHD:START | Hold Time, START                     |  | 0.6         |     |     | μs   |
| tSU:DATA  | Setup Time, data input (SDA)         |  | 0.1         |     |     | μs   |
| tHD:DATA  | Hold Time, data input (SDA) 1        |  | 0           |     |     | μs   |
| tOVD      | Output data valid from clock         |  |             |     | 0.9 | μs   |
| CB        | Capacitive Load for Each Bus Line    |  |             |     | 400 | pF   |
| tR        | Rise Time, data and clock (SDA, SCL) |  | 20 + 0.1xCB |     | 300 | ns   |
| tF        | Fall Time, data and clock (SDA, SCL) |  | 20 + 0.1xCB |     | 300 | ns   |
| tHIGH     | HIGH Time, clock (SCL)               |  | 0.6         |     |     | μs   |
| tLOW      | LOW Time, clock (SCL)                |  | 1.3         |     |     | μs   |
| tSU:STOP  | Setup Time, STOP                     |  | 0.6         |     |     | μs   |

Note 1: A device must internally provide a hold time of at least 300ns for the SDA signal (referred to the V<sub>IH</sub>(MIN) of the SCL signal) to bridge the undefined region of the falling edge of SCL.

Note 2: I<sup>2</sup>C inputs are 5V tolerant.



## Table 8: Absolute Maximum Ratings

Stresses above the ratings listed below can cause permanent damage to the 5P49V5935. These ratings, which are standard values for IDT commercially rated parts, are stress ratings only. Functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods can affect product reliability. Electrical parameters are guaranteed only over the recommended operating temperature range.

| Item  | Rating  |
|---|---|
| Supply Voltage, $V_{DDA}$ , $V_{DDD}$ , $V_{DDO}$ | 3.465V  |
| Inputs<br>CLKIN, CLKINB<br>Other inputs           | 0V to 1.2V voltage swing single-ended<br>-0.5V to $V_{DDD}$ |
| Outputs, $V_{DDO}$ (LVCMOS)                       | -0.5V to $V_{DDO} + 0.5V$                                   |
| Outputs, $I_O$ (SDA)                              | 10mA  |
| Package Thermal Impedance, $\theta_{JA}$          | 62°C/W (0 mps)  |
| Package Thermal Impedance, $\theta_{JC}$          | 55°C/W (0 mps)  |
| Storage Temperature, $T_{STG}$                    | -65°C to 150°C  |
| ESD Human Body Model                              | 2000V   |
| Junction Temperature                              | 125°C   |

## Table 9: Recommended Operation Conditions

| Symbol          | Parameter   | Min   | Typ | Max   | Unit |
|-----------------|---|-------|-----|-------|------|
| $V_{DDOX}$      | Power supply voltage for supporting 1.8V outputs.   | 1.71  | 1.8 | 1.89  | V    |
| $V_{DDOX}$      | Power supply voltage for supporting 2.5V outputs.   | 2.375 | 2.5 | 2.625 | V    |
| $V_{DDOX}$      | Power supply voltage for supporting 3.3V outputs.   | 3.135 | 3.3 | 3.465 | V    |
| $V_{DDD}$       | Power supply voltage for core logic functions.  | 1.71  |     | 3.465 | V    |
| $V_{DDA}$       | Analog power supply voltage. Use filtered analog power supply.                                      | 1.71  |     | 3.465 | V    |
| $T_A$           | Operating temperature, ambient.   | -40   |     | +85   | °C   |
| $C_{LOAD\_OUT}$ | Maximum load capacitance (3.3V LVCMOS only).  |       |     | 15    | pF   |
| $F_{IN}$        | Integrated reference crystal.   | 8     | 25  | 40    | MHz  |
|                 | External reference clock CLKIN, CLKINB.   | 1     |     | 350   |      |
| $t_{PU}$        | Power up time for all $V_{DDs}$ to reach minimum specified voltage (power ramps must be monotonic). | 0.05  |     | 5     | ms   |

Note:  $V_{DDO1}$  and  $V_{DDO2}$  must be powered on either before or simultaneously with  $V_{DDD}$ ,  $V_{DDA}$  and  $V_{DDO0}$ .

**Table 10: Input Capacitance, LVCMOS Output Impedance, and Internal Pull-down Resistance** ( $T_A = +25\text{ }^{\circ}\text{C}$ )

| Symbol             | Parameter  | Min | Typ | Max | Unit       |
|--------------------|--|-----|-----|-----|------------|
| CIN                | Input Capacitance (CLKIN, CLKINB, CLKSEL, SD/OE, SEL1/SDA, SEL0/SCL) |     | 3   | 7   | pF         |
| Pull-down Resistor | CLKSEL, SD/OE, SEL1/SDA, SEL0/SCL, CLKIN, CLKINB, OUT0_SEL_I2CB      | 100 |     | 300 | k $\Omega$ |
| ROUT               | LVCMOS Output Driver Impedance (VDDO = 1.8V, 2.5V, 3.3V)             |     | 17  |     | $\Omega$   |

**Table 11: DC Electrical Characteristics**

| Symbol               | Parameter                    | Test Conditions                           | Min | Typ | Max | Unit |
|----------------------|------------------------------|---|-----|-----|-----|------|
| Iddcore <sup>3</sup> | Core Supply Current          | 100MHz on all outputs, 25MHz REFCLK       |     | 30  | 34  | mA   |
| Iddox                | Output Buffer Supply Current | LVPECL, 350MHz, 3.3V VDDOx                |     | 42  | 47  | mA   |
|                      |                              | LVPECL, 350MHz, 2.5V VDDOx                |     | 37  | 42  | mA   |
|                      |                              | LVDS, 350MHz, 3.3V VDDOx                  |     | 18  | 21  | mA   |
|                      |                              | LVDS, 350MHz, 2.5V VDDOx                  |     | 17  | 20  | mA   |
|                      |                              | LVDS, 350MHz, 1.8V VDDOx                  |     | 16  | 19  | mA   |
|                      |                              | HCSL, 250MHz, 3.3V VDDOx, 2 pF load       |     | 29  | 33  | mA   |
|                      |                              | HCSL, 250MHz, 2.5V VDDOx, 2 pF load       |     | 28  | 33  | mA   |
|                      |                              | LVCMOS, 50MHz, 3.3V, VDDOx <sup>1,2</sup> |     | 16  | 18  | mA   |
|                      |                              | LVCMOS, 50MHz, 2.5V, VDDOx <sup>1,2</sup> |     | 14  | 16  | mA   |
|                      |                              | LVCMOS, 50MHz, 1.8V, VDDOx <sup>1,2</sup> |     | 12  | 14  | mA   |
|                      |                              | LVCMOS, 200MHz, 3.3V VDDOx <sup>1</sup>   |     | 36  | 42  | mA   |
|                      |                              | LVCMOS, 200MHz, 2.5V VDDOx <sup>1,2</sup> |     | 27  | 32  | mA   |
|                      |                              | LVCMOS, 200MHz, 1.8V VDDOx <sup>1,2</sup> |     | 16  | 19  | mA   |
| Iddpd                | Power Down Current           | SD asserted, I2C programming              |     | 10  | 14  | mA   |

1. Single CMOS driver active.

2. Measured into a 5" 50 Ohm trace with 2 pF load.

3. Iddcore = IddA+ IddD, no loads.

**Table 12:Electrical Characteristics – Differential Clock Input Parameters** <sup>1,2</sup> (Supply Voltage  $V_{DDA}$ ,  $V_{DDD}$ ,  $V_{DDO0}$  = 3.3V  $\pm$ 5%, 2.5V  $\pm$ 5%, 1.8V  $\pm$ 5%,  $T_A$  = -40°C to +85°C)

| Symbol | Parameter                          | Test Conditions                        | Min       | Typ | Max  | Unit    |
|--------|------------------------------------|--|-----------|-----|------|---------|
| VIH    | Input High Voltage - CLKIN, CLKINB | Single-ended input                     | 0.55      |     | 1.7  | V       |
| VIL    | Input Low Voltage - CLKIN, CLKINB  | Single-ended input                     | GND - 0.3 |     | 0.4  | V       |
| VSWING | Input Amplitude - CLKIN, CLKINB    | Peak to Peak value, single-ended       | 200       |     | 1200 | mV      |
| dv/dt  | Input Slew Rate - CLKIN, CLKINB    | Measured differentially                | 0.4       |     | 8    | V/ns    |
| IIL    | Input Leakage Low Current          | VIN = GND                              | -5        |     | 5    | $\mu$ A |
| IIH    | Input Leakage High Current         | VIN = 1.7V                             |           |     | 20   | $\mu$ A |
| dTIN   | Input Duty Cycle                   | Measurement from differential waveform | 45        |     | 55   | %       |

1. Guaranteed by design and characterization, not 100% tested in production.  
2. Slew rate measured through  $\pm$ 75mV window centered around differential zero.

**Table 13:DC Electrical Characteristics for 3.3V LVCMOS** ( $V_{DDO}$  = 3.3V  $\pm$ 5%,  $T_A$  = -40°C to +85°C) <sup>1</sup>

| Symbol | Parameter                       | Test Conditions                     | Min       | Typ | Max         | Unit    |
|--------|---------------------------------|-------------------------------------|-----------|-----|-------------|---------|
| VOH    | Output HIGH Voltage             | IOH = -15mA                         | 2.4       |     | VDDO        | V       |
| VOL    | Output LOW Voltage              | IOL = 15mA                          |           |     | 0.4         | V       |
| IOZDD  | Output Leakage Current (OUT1~4) | Tri-state outputs, VDDO = 3.465V    |           |     | 5           | $\mu$ A |
| IOZDD  | Output Leakage Current (OUT0)   | Tri-state outputs, VDDO = 3.465V    |           |     | 30          | $\mu$ A |
| VIH    | Input HIGH Voltage              | Single-ended inputs - CLKSEL, SD/OE | 0.7xVDDD  |     | VDDD + 0.3  | V       |
| VIL    | Input LOW Voltage               | Single-ended inputs - CLKSEL, SD/OE | GND - 0.3 |     | 0.3xVDDD    | V       |
| VIH    | Input HIGH Voltage              | Single-ended input OUT0_SEL_I2CB    | 2         |     | VDDO0 + 0.3 | V       |
| VIL    | Input LOW Voltage               | Single-ended input OUT0_SEL_I2CB    | GND - 0.3 |     | 0.4         | V       |
| TR/TF  | Input Rise/Fall Time            | CLKSEL, SD/OE, SEL1/SDA, SEL0/SCL   |           |     | 300         | ns      |

1. See "Recommended Operating Conditions" table.

**Table 14:DC Electrical Characteristics for 2.5V LVCMOS** ( $V_{DDO}$  = 2.5V  $\pm$ 5%,  $T_A$  = -40°C to +85°C)

| Symbol | Parameter                       | Test Conditions                     | Min       | Typ | Max         | Unit    |
|--------|---------------------------------|-------------------------------------|-----------|-----|-------------|---------|
| VOH    | Output HIGH Voltage             | IOH = -12mA                         | 0.7xVDDO  |     |             | V       |
| VOL    | Output LOW Voltage              | IOL = 12mA                          |           |     | 0.4         | V       |
| IOZDD  | Output Leakage Current (OUT1~4) | Tri-state outputs, VDDO = 2.625V    |           |     | 5           | $\mu$ A |
| IOZDD  | Output Leakage Current (OUT0)   | Tri-state outputs, VDDO = 2.625V    |           |     | 30          | $\mu$ A |
| VIH    | Input HIGH Voltage              | Single-ended inputs - CLKSEL, SD/OE | 0.7xVDDD  |     | VDDD + 0.3  | V       |
| VIL    | Input LOW Voltage               | Single-ended inputs - CLKSEL, SD/OE | GND - 0.3 |     | 0.3xVDDD    | V       |
| VIH    | Input HIGH Voltage              | Single-ended input OUT0_SEL_I2CB    | 1.7       |     | VDDO0 + 0.3 | V       |
| VIL    | Input LOW Voltage               | Single-ended input OUT0_SEL_I2CB    | GND - 0.3 |     | 0.4         | V       |
| TR/TF  | Input Rise/Fall Time            | CLKSEL, SD/OE, SEL1/SDA, SEL0/SCL   |           |     | 300         | ns      |

**Table 15:DC Electrical Characteristics for 1.8V LVCMOS** ( $V_{DDO} = 1.8V \pm 5\%$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ )

| Symbol | Parameter                       | Test Conditions                     | Min          | Typ | Max         | Unit    |
|--------|---------------------------------|-------------------------------------|--------------|-----|-------------|---------|
| VOH    | Output HIGH Voltage             | IOH = -8mA                          | 0.7 x VDDO   |     | VDDO        | V       |
| VOL    | Output LOW Voltage              | IOL = 8mA                           |              |     | 0.25 x VDDO | V       |
| IOZDD  | Output Leakage Current (OUT1~4) | Tri-state outputs, VDDO = 3.465V    |              |     | 5           | $\mu A$ |
| IOZDD  | Output Leakage Current (OUT0)   | Tri-state outputs, VDDO = 3.465V    |              |     | 30          | $\mu A$ |
| VIH    | Input HIGH Voltage              | Single-ended inputs - CLKSEL, SD/OE | 0.7 * VDDD   |     | VDDD + 0.3  | V       |
| VIL    | Input LOW Voltage               | Single-ended inputs - CLKSEL, SD/OE | GND - 0.3    |     | 0.3 * VDDD  | V       |
| VIH    | Input HIGH Voltage              | Single-ended input OUT0_SEL_I2CB    | 0.65 * VDDO0 |     | VDDO0 + 0.3 | V       |
| VIL    | Input LOW Voltage               | Single-ended input OUT0_SEL_I2CB    | GND - 0.3    |     | 0.4         | V       |
| TR/Tf  | Input Rise/Fall Time            | CLKSEL, SD/OE, SEL1/SDA, SEL0/SCL   |              |     | 300         | ns      |

**Table 16:DC Electrical Characteristics for LVDS** ( $V_{DDO} = 3.3V \pm 5\%$  or  $2.5V \pm 5\%$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ )

| Symbol              | Parameter  | Min   | Typ  | Max   | Unit |
|---------------------|--|-------|------|-------|------|
| V <sub>OT</sub> (+) | Differential Output Voltage for the TRUE binary state  | 247   |      | 454   | mV   |
| V <sub>OT</sub> (-) | Differential Output Voltage for the FALSE binary state   | -247  |      | -454  | mV   |
| $\Delta V_{OT}$     | Change in V <sub>OT</sub> between Complimentary Output States                                  |       |      | 50    | mV   |
| V <sub>OS</sub>     | Output Common Mode Voltage (Offset Voltage)  | 1.125 | 1.25 | 1.375 | V    |
| $\Delta V_{OS}$     | Change in V <sub>OS</sub> between Complimentary Output States                                  |       |      | 50    | mV   |
| I <sub>OS</sub>     | Outputs Short Circuit Current, V <sub>OUT+</sub> or V <sub>OUT-</sub> = 0V or V <sub>DDO</sub> |       | 9    | 24    | mA   |
| I <sub>OSD</sub>    | Differential Outputs Short Circuit Current, V <sub>OUT+</sub> = V <sub>OUT-</sub>              |       | 6    | 12    | mA   |

**Table 17:DC Electrical Characteristics for LVDS** ( $V_{DDO} = 1.8V \pm 5\%$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ )

| Symbol              | Parameter  | Min  | Typ   | Max  | Unit |
|---------------------|--|------|-------|------|------|
| V <sub>OT</sub> (+) | Differential Output Voltage for the TRUE binary state  | 247  |       | 454  | mV   |
| V <sub>OT</sub> (-) | Differential Output Voltage for the FALSE binary state   | -247 |       | -454 | mV   |
| $\Delta V_{OT}$     | Change in V <sub>OT</sub> between Complimentary Output States                                  |      |       | 50   | mV   |
| V <sub>OS</sub>     | Output Common Mode Voltage (Offset Voltage)  | 0.8  | 0.875 | 0.95 | V    |
| $\Delta V_{OS}$     | Change in V <sub>OS</sub> between Complimentary Output States                                  |      |       | 50   | mV   |
| I <sub>OS</sub>     | Outputs Short Circuit Current, V <sub>OUT+</sub> or V <sub>OUT-</sub> = 0V or V <sub>DDO</sub> |      | 9     | 24   | mA   |
| I <sub>OSD</sub>    | Differential Outputs Short Circuit Current, V <sub>OUT+</sub> = V <sub>OUT-</sub>              |      | 6     | 12   | mA   |

**Table 18:DC Electrical Characteristics for LVPECL** ( $V_{DDO} = 3.3V \pm 5\%$  or  $2.5V \pm 5\%$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ )

| Symbol             | Parameter  | Min                     | Typ | Max                     | Unit |
|--------------------|--|-------------------------|-----|-------------------------|------|
| V <sub>OH</sub>    | Output Voltage HIGH, terminated through 50 $\Omega$ tied to V <sub>DD</sub> - 2V | V <sub>DDO</sub> - 1.19 |     | V <sub>DDO</sub> - 0.69 | V    |
| V <sub>OL</sub>    | Output Voltage LOW, terminated through 50 $\Omega$ tied to V <sub>DD</sub> - 2V  | V <sub>DDO</sub> - 1.94 |     | V <sub>DDO</sub> - 1.4  | V    |
| V <sub>SWING</sub> | Peak-to-Peak Output Voltage Swing  | 0.55                    |     | 0.993                   | V    |

**Table 19:Electrical Characteristics – DIF 0.7V Low Power HCSL Differential Outputs**
 $(V_{DDO} = 3.3V \pm 5\%, 2.5V \pm 5\%, T_A = -40^{\circ}C \text{ to } +85^{\circ}C)$ 

| Symbol          | Parameter                  | Conditions   | Min  | Typ | Max  | Units | Notes |
|-----------------|----------------------------|--|------|-----|------|-------|-------|
| dV/dt           | Slew Rate                  | Scope averaging on   | 1    |     | 4    | V/ns  | 1,2,3 |
| $\Delta dV/dt$  | Slew Rate                  | Scope averaging on   |      |     | 20   | %     | 1,2,3 |
| VHIGH           | Voltage High               | Statistical measurement on single-ended signal using oscilloscope math function (Scope averaging ON) | 660  |     | 850  | mV    | 1,6,7 |
| VLOW            | Voltage Low                |  | -150 |     | 150  | mV    | 1,6   |
| VMAX            | Maximum Voltage            | Measurement on single-ended signal using absolute value (Scope averaging off)                        |      |     | 1150 | mV    | 1     |
| VMIN            | Minimum Voltage            |  | -300 |     |      | mV    | 1     |
| VSWING          | Voltage Swing              | Scope averaging off  | 300  |     |      | mV    | 1,2,6 |
| VCROSS          | Crossing Voltage Value     | Scope averaging off  | 250  |     | 550  | mV    | 1,4,6 |
| $\Delta VCROSS$ | Crossing Voltage variation | Scope averaging off  |      |     | 140  | mV    | 1,5   |

1. Guaranteed by design and characterization. Not 100% tested in production
2. Measured from differential waveform.
3. Slew rate is measured through the  $V_{SWING}$  voltage range centered around differential 0V. This results in a  $\pm 150mV$  window around differential 0V.
4.  $V_{CROSS}$  is defined as voltage where Clock = Clock# measured on a component test board and only applies to the differential rising edge (i.e. Clock rising and Clock# falling).
5. The total variation of all  $V_{CROSS}$  measurements in any particular system. Note that this is a subset of  $V_{CROSS}$  min/max ( $V_{CROSS}$  absolute) allowed. The intent is to limit  $V_{CROSS}$  induced modulation by setting  $\Delta V_{CROSS}$  to be smaller than  $V_{CROSS}$  absolute.
6. Measured from single-ended waveform.
7. Measured with scope averaging off, using statistics function. Variation is difference between min. and max.

**Table 20:AC Timing Electrical Characteristics**

( $V_{DDO} = 3.3V \pm 5\%$  or  $2.5V \pm 5\%$  or  $1.8V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ )

(Spread spectrum generation = OFF)

| Symbol     | Parameter                 | Test Conditions   | Min.           | Typ. | Max. | Units |
|------------|---------------------------|---|----------------|------|------|-------|
| $f_{IN}^1$ | Input Frequency           | Input frequency limit (CLKIN, CLKINB)   | 1              |      | 350  | MHz   |
| $f_{OUT}$  | Output Frequency          | Single ended clock output limit (LVCMOS)  | 1              |      | 200  | MHz   |
|            |                           | Differential clock output limit (LVPECL/ LVDS/HCSL)   | 1              |      | 350  |       |
| $f_{VCO}$  | VCO Frequency             | VCO operating frequency range   | 2600           |      | 2900 | MHz   |
| $f_{PFD}$  | PFD Frequency             | PFD operating frequency range   | 1 <sup>1</sup> |      | 150  | MHz   |
| $f_{BW}$   | Loop Bandwidth            | Input frequency = 25MHz   | 0.06           |      | 0.9  | MHz   |
| $t_2$      | Input Duty Cycle          | Duty Cycle  | 45             | 50   | 55   | %     |
| $t_3^5$    | Output Duty Cycle         | Measured at $V_{DD}/2$ , all outputs except Reference output OUT0, $V_{DDOX} = 2.5V$ or $3.3V$                              | 45             | 50   | 55   | %     |
|            |                           | Measured at $V_{DD}/2$ , all outputs except Reference output OUT0, $V_{DDOX} = 1.8V$  | 40             | 50   | 60   | %     |
|            |                           | Measured at $V_{DD}/2$ , Reference output OUT0 (5MHz - 120MHz) with 50% duty cycle input                                    | 40             | 50   | 60   | %     |
|            |                           | Measured at $V_{DD}/2$ , Reference output OUT0 (150.1MHz - 200MHz) with 50% duty cycle input                                | 30             | 50   | 70   | %     |
| $t_4^2$    | Slew Rate, SLEW[1:0] = 00 | Single-ended 3.3V LVCMOS output clock rise and fall time, 20% to 80% of $V_{DDO}$<br>(Output Load = 5 pF) $V_{DDOX} = 3.3V$ | 1.0            | 2.2  |      | V/ns  |
|            | Slew Rate, SLEW[1:0] = 01 |   | 1.2            | 2.3  |      |       |
|            | Slew Rate, SLEW[1:0] = 10 |   | 1.3            | 2.4  |      |       |
|            | Slew Rate, SLEW[1:0] = 11 |   | 1.7            | 2.7  |      |       |
|            | Slew Rate, SLEW[1:0] = 00 | Single-ended 2.5V LVCMOS output clock rise and fall time, 20% to 80% of $V_{DDO}$<br>(Output Load = 5 pF) $V_{DDOX} = 2.5V$ | 0.6            | 1.3  |      |       |
|            | Slew Rate, SLEW[1:0] = 01 |   | 0.7            | 1.4  |      |       |
|            | Slew Rate, SLEW[1:0] = 10 |   | 0.6            | 1.4  |      |       |
|            | Slew Rate, SLEW[1:0] = 11 |   | 1.0            | 1.7  |      |       |
|            | Slew Rate, SLEW[1:0] = 00 | Single-ended 1.8V LVCMOS output clock rise and fall time, 20% to 80% of $V_{DDO}$<br>(Output Load = 5 pF) $V_{DDOX} = 1.8V$ | 0.3            | 0.7  |      |       |
|            | Slew Rate, SLEW[1:0] = 01 |   | 0.4            | 0.8  |      |       |
|            | Slew Rate, SLEW[1:0] = 10 |   | 0.4            | 0.9  |      |       |
|            | Slew Rate, SLEW[1:0] = 11 |   | 0.7            | 1.2  |      |       |
| $t_5$      | Rise Times                | LVDS, 20% to 80%  |                | 300  |      | ps    |
|            | Fall Times                | LVDS, 80% to 20%  |                | 300  |      |       |
|            | Rise Times                | LVPECL, 20% to 80%  |                | 400  |      |       |
|            | Fall Times                | LVPECL, 80% to 20%  |                | 400  |      |       |



|                 |                     |   |  |      |     |     |
|-----------------|---------------------|---|--|------|-----|-----|
| t6              | Clock Jitter        | Cycle-to-Cycle jitter (Peak-to-Peak), multiple output frequencies switching, differential outputs (1.8V to 3.3V nominal output voltage)<br>OUT0 = 25MHz<br>OUT1 = 100MHz<br>OUT2 = 125MHz<br>OUT3 = 156.25MHz   |  | 46   |     | ps  |
|                 |                     | Cycle-to-Cycle jitter (Peak-to-Peak), multiple output frequencies switching, LVCMOS outputs (1.8 to 3.3V nominal output voltage)<br>OUT0 = 25MHz<br>OUT1 = 100MHz<br>OUT2 = 125MHz<br>OUT3 = 156.25MHz          |  | 74   |     | ps  |
|                 |                     | RMS Phase Jitter (12kHz to 5MHz integration range) reference clock (OUT0),<br>25 MHz LVCMOS outputs (1.8 to 3.3V nominal output voltage).<br>OUT0 = 25MHz<br>OUT1 = 100MHz<br>OUT2 = 125MHz<br>OUT3 = 156.25MHz |  | 0.5  |     | ps  |
|                 |                     | RMS Phase Jitter (12kHz to 20MHz integration range) differential output, VDDO = 3.465V, 25MHz crystal, 156.25MHz output frequency<br>OUT0 = 25MHz<br>OUT1 = 100MHz<br>OUT2 = 125MHz<br>OUT3 = 156.25MHz         |  | 0.75 | 1.5 | ps  |
| t7              | Output Skew         | Skew between the same frequencies, with outputs using the same driver format and phase delay set to 0 ns.   |  | 75   |     | ps  |
| t8 <sup>3</sup> | Startup Time        | PLL lock time from power-up, measured after all VDD's have raised above 90% of their target value.  |  |      | 10  | ms  |
| t9 <sup>4</sup> | Startup Time        | PLL lock time from shutdown mode.   |  | 3    | 4   | ms  |
| t10             | Frequency Stability | Initial frequency accuracy at 25°C.   |  | ±2   |     | ppm |
|                 |                     | Initial frequency stability across temperature.   |  |      | ±20 |     |
|                 |                     | Integrated crystal aging 1 year.  |  | ±3   |     |     |
|                 |                     | Integrated crystal aging 2 years (total, first year aging included).  |  | ±5   |     |     |
|                 |                     | Integrated crystal aging 3 years (total, first two years aging included).   |  | ±7   |     |     |
|                 |                     | Frequency stability over 10 years all inclusive (accuracy, stability and aging).  |  |      | ±50 |     |

1. Practical lower frequency is determined by loop filter settings.
2. A slew rate of 2.75V/ns or greater should be selected for output frequencies of 100MHz or higher.
3. Includes loading the configuration bits from EPROM to PLL registers. It does not include EPROM programming/write time.
4. Actual PLL lock time depends on the loop configuration.
5. Duty Cycle is only guaranteed at max slew rate settings.

**Table 21:PCI Express Jitter Specifications** ( $V_{DDO} = 3.3V \pm 5\%$  or  $2.5V \pm 5\%$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ )

| Symbol                               | Parameter                    | Conditions  | Min | Typ  | Max | PCIe Industry Specification | Units | Notes |
|--------------------------------------|------------------------------|---|-----|------|-----|-----------------------------|-------|-------|
| $t_J$<br>(PCIe Gen1)                 | Phase Jitter<br>Peak-to-Peak | $f = 100MHz$ , 25MHz crystal input<br>evaluation band: 0Hz - Nyquist<br>(clock frequency/2) |     | 30   |     | 86                          | ps    | 1,4   |
| $t_{REFCLK\_HF\_RMS}$<br>(PCIe Gen2) | Phase Jitter RMS             | $f = 100MHz$ , 25MHz crystal input<br>High band: 1.5MHz - Nyquist (clock<br>frequency/2)    |     | 2.56 |     | 3.10                        | ps    | 2,4   |
| $t_{REFCLK\_LF\_RMS}$<br>(PCIe Gen2) | Phase Jitter RMS             | $f = 100MHz$ , 25MHz crystal input<br>Low band: 10kHz - 1.5MHz                              |     | 0.27 |     | 3.0                         | ps    | 2,4   |
| $t_{REFCLK\_RMS}$<br>(PCIe Gen3)     | Phase Jitter RMS             | $f = 100MHz$ , 25MHz crystal input<br>evaluation band: 0Hz - Nyquist (clock<br>frequency/2) |     | 0.8  |     | 1.0                         | ps    | 3,4   |

Note: Electrical parameters are guaranteed over the specified ambient operating temperature range, which is established when the device is mounted in a test socket with maintained transverse airflow greater than 500 lfm. The device will meet specifications after thermal equilibrium has been reached under these conditions.

1. Peak-to-Peak jitter after applying system transfer function for the Common Clock architecture. Maximum limit for PCI Express Gen1.
2. RMS jitter after applying the two evaluation bands to the two transfer functions defined in the Common Clock architecture and reporting the worst case results for each evaluation band. Maximum limit for PCI Express Gen2 is 3.1ps RMS for  $t_{REFCLK\_HF\_RMS}$  (High Band) and 3.0ps RMS for  $t_{REFCLK\_LF\_RMS}$  (Low Band).
3. RMS jitter after applying system transfer function for the common clock architecture. This specification is based on the PCI\_Express\_Base\_r3.0 10 Nov, 2010 specification, and is subject to change pending the final release version of the specification.
4. This parameter is guaranteed by characterization. Not tested in production.

**Table 22:Jitter Specifications** <sup>1,2,3</sup>

( $V_{DDx} = 3.3V \pm 5\%$  or  $2.5V \pm 5\%$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ )

| Parameter                                    | Symbol     | Test Condition   | Min | Typ  | Max  | Unit |
|--|------------|--|-----|------|------|------|
| GbE Random Jitter (12kHz–20MHz) <sup>4</sup> | $J_{GbE}$  | Crystal in = 25MHz, All CLK <sub>n</sub> at 125MHz <sup>5</sup>  | -   | 0.79 | 0.95 | ps   |
| GbE Random Jitter (1.875–20MHz)              | $R_{JGbE}$ | Crystal in = 25MHz, All CLK <sub>n</sub> at 125MHz <sup>5</sup>  | -   | 0.32 | 0.5  | ps   |
| OC-12 Random Jitter (12kHz–5MHz)             | $J_{OC12}$ | CLKIN = 19.44MHz, All CLK <sub>n</sub> at 155.52MHz <sup>5</sup> | -   | 0.69 | 0.95 | ps   |
| PCI Express 1.1 Common Clocked               |            | Total Jitter <sup>6</sup>  | -   | 9.1  | 12   | ps   |
| PCI Express 2.1 Common Clocked               |            | RMS Jitter <sup>6</sup> , 10kHz to 1.5MHz                        | -   | 0.1  | 0.3  | ps   |
|  |            | RMS Jitter <sup>6</sup> , 1.5MHz to 50MHz                        | -   | 0.9  | 1.1  | ps   |
| PCI Express 3.0 Common Clocked               |            | RMS Jitter <sup>6</sup>  | -   | 0.2  | 0.4  | ps   |

Notes:

<sup>1</sup> All measurements with spread spectrum Off.

<sup>2</sup> For best jitter performance, keep the single ended clock input slew rates at more than 1.0V/ns and the differential clock input slew rates more than 0.3V/ns.

<sup>3</sup> All jitter data in this table is based upon all output formats being differential. When single-ended outputs are used, there is the potential that the output jitter may increase due to the nature of single-ended outputs. If your configuration implements any single-ended output and any output is required to have jitter less than 3 ps rms, contact IDT for support to validate your configuration and ensure the best jitter performance. In many configurations, CMOS outputs have little to no effect upon jitter.

<sup>4</sup> DJ for PCI and GbE is < 5ps p-p.

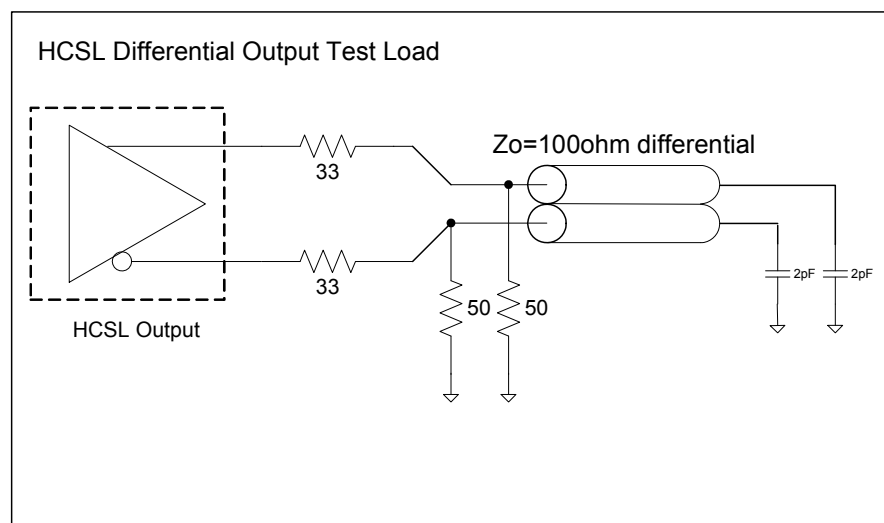
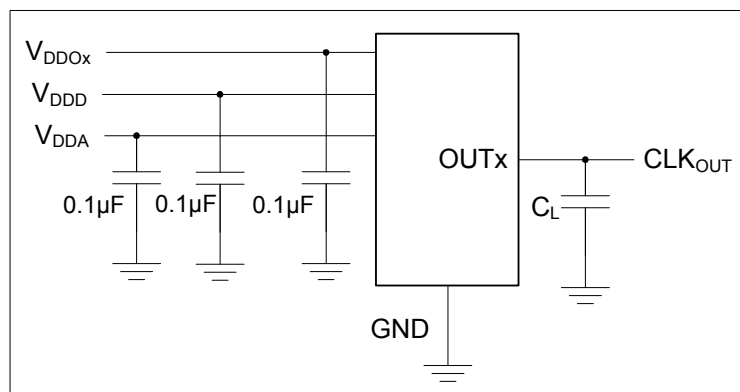
<sup>5</sup> Output FOD in Integer mode.

<sup>6</sup> All output clocks 100MHz HCSL format. Jitter is from the PCIe jitter filter combination that produces the highest jitter. Jitter is measured with the Intel Clock Jitter Tool, Ver. 1.6.6.

**Table 23: Spread Spectrum Generation Specifications**

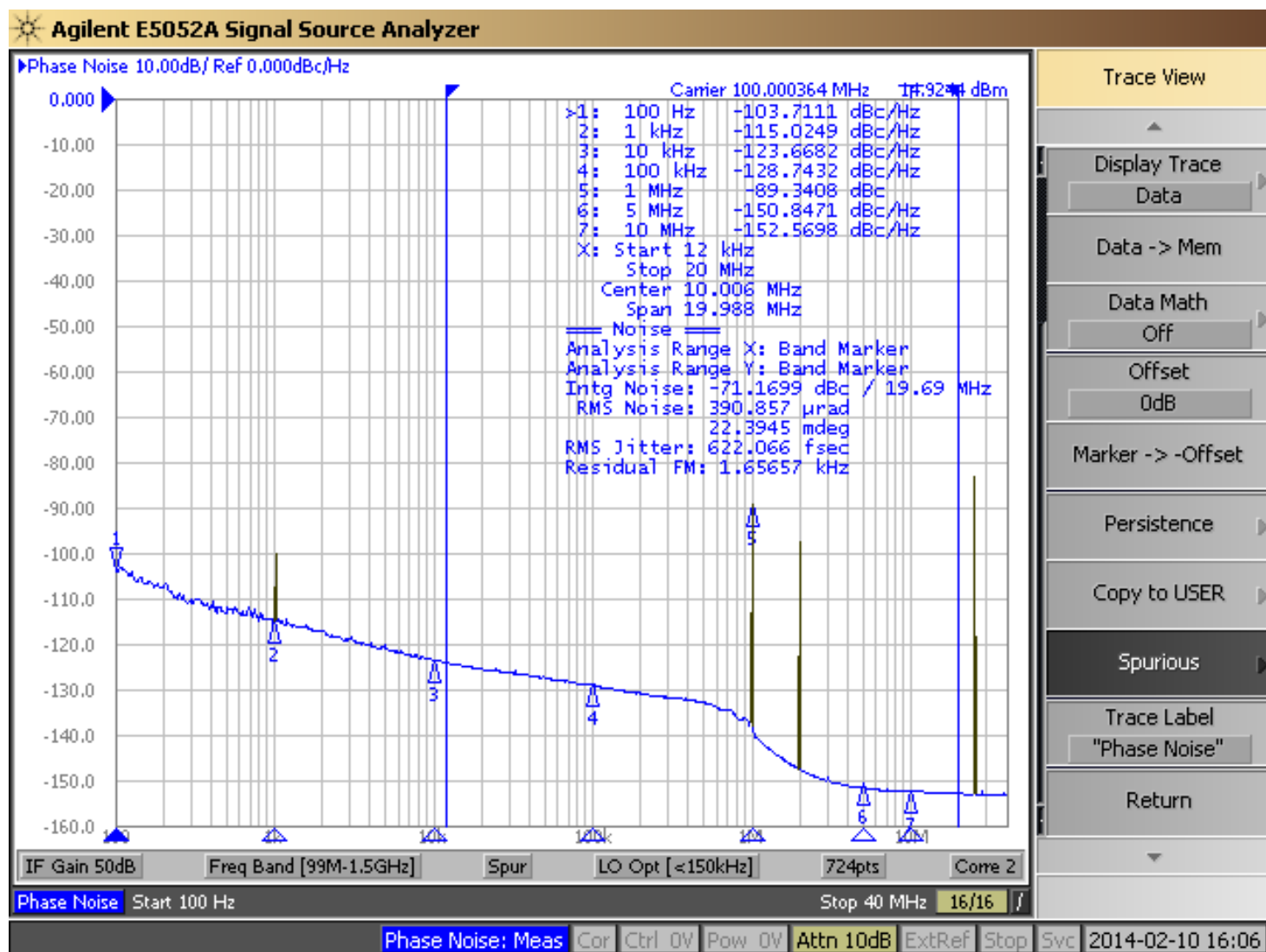
| Symbol              | Parameter        | Description   | Min             | Typ | Max | Unit              |
|---------------------|------------------|---|-----------------|-----|-----|-------------------|
| f <sub>OUT</sub>    | Output Frequency | Output frequency range                                | 5               |     | 300 | MHz               |
| f <sub>MOD</sub>    | Mod Frequency    | Modulation frequency                                  | 30 to 63        |     |     | kHz               |
| f <sub>SPREAD</sub> | Spread Value     | Amount of spread value (programmable) - center spread | ±0.25% to ±2.5% |     |     | %f <sub>OUT</sub> |
|                     |                  | Amount of spread value (programmable) - down spread   | -0.5% to -5%    |     |     |                   |

## Test Circuits and Loads



## Test Circuits and Loads for Outputs

# Typical Phase Noise at 100MHz (3.3V, 25°C)



**NOTE:** All outputs operational at 100MHz, phase noise plot with spurs on.

## 5P49V5935 Application Schematic

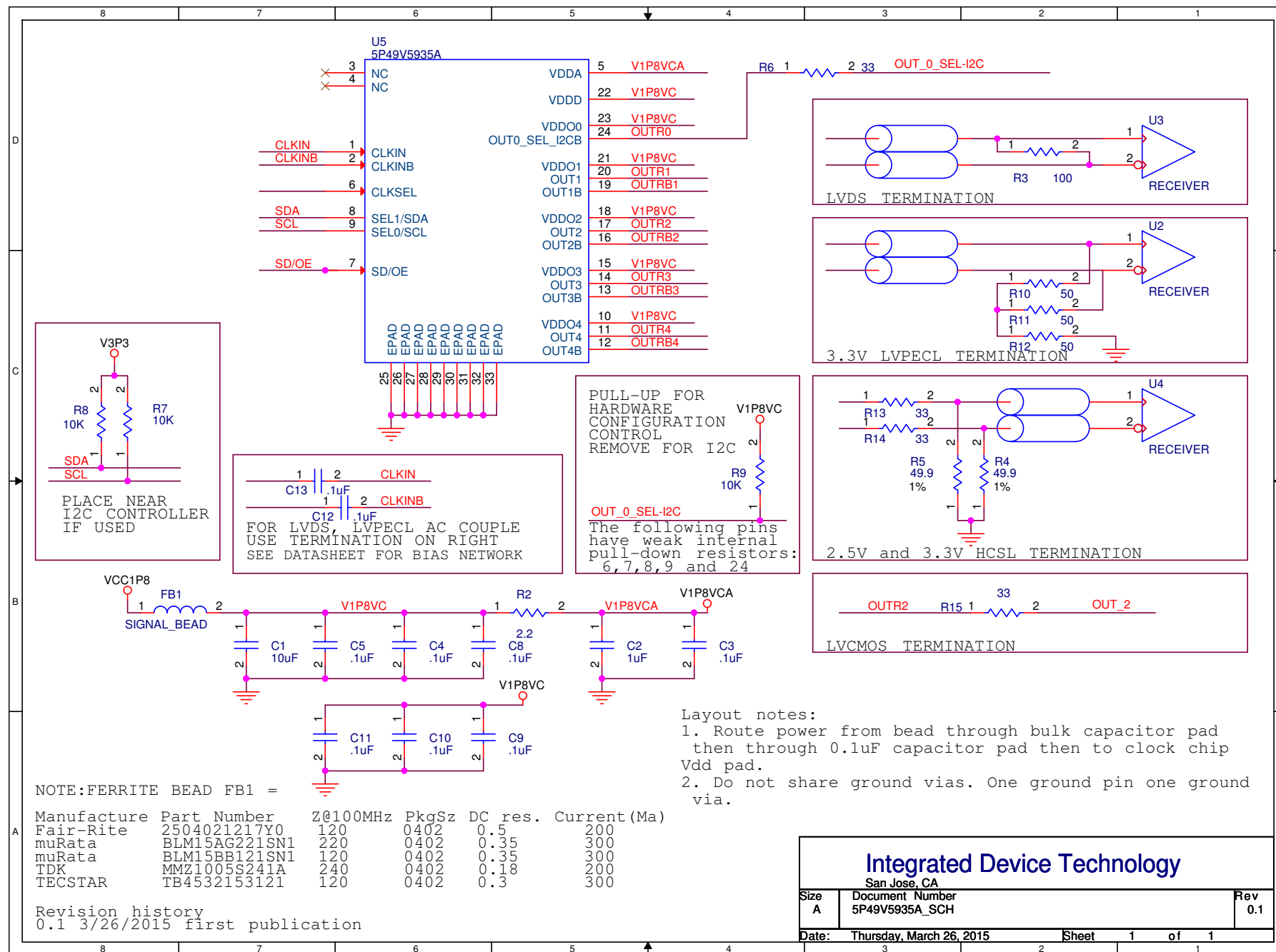
The following figure shows an example of 5P49V5935 application schematic. Input and output terminations shown are intended as examples only and may not represent the exact user configuration. In this example, the device is operated at  $V_{DD3}, V_{DDA} = 3.3V$ . The decoupling capacitors should be located as close as possible to the power pin. For different board layout, the C1 and C2 may be slightly adjusted for optimizing frequency accuracy.

As with any high speed analog circuitry, the power supply pins are vulnerable to random noise. To achieve optimum jitter performance, power supply isolation is required. 5P49V5935 provides separate power supplies to isolate any high switching noise from coupling into the internal PLL.

In order to achieve the best possible filtering, it is recommended that the placement of the filter components be on the device side of the PCB as close to the power pins as possible. If space is limited, the 0.1uf capacitor in each power pin filter should be placed on the device side. The other components can be on the opposite side of the PCB.

Power supply filter recommendations are a general guideline to be used for reducing external noise from coupling into the devices. The filter performance is designed for a wide range of noise frequencies. This low-pass filter starts to attenuate noise at approximately 10 kHz. If a specific frequency noise component is known, such as switching power supply frequencies, it is recommended that component values be adjusted and if required, additional filtering be added. Additionally, good general design practices for power plane voltage stability suggests adding bulk capacitance in the local area of all devices.

The schematic example focuses on functional connections and is not configuration specific. Refer to the pin description and functional tables in the datasheet to ensure the logic control inputs are properly set.

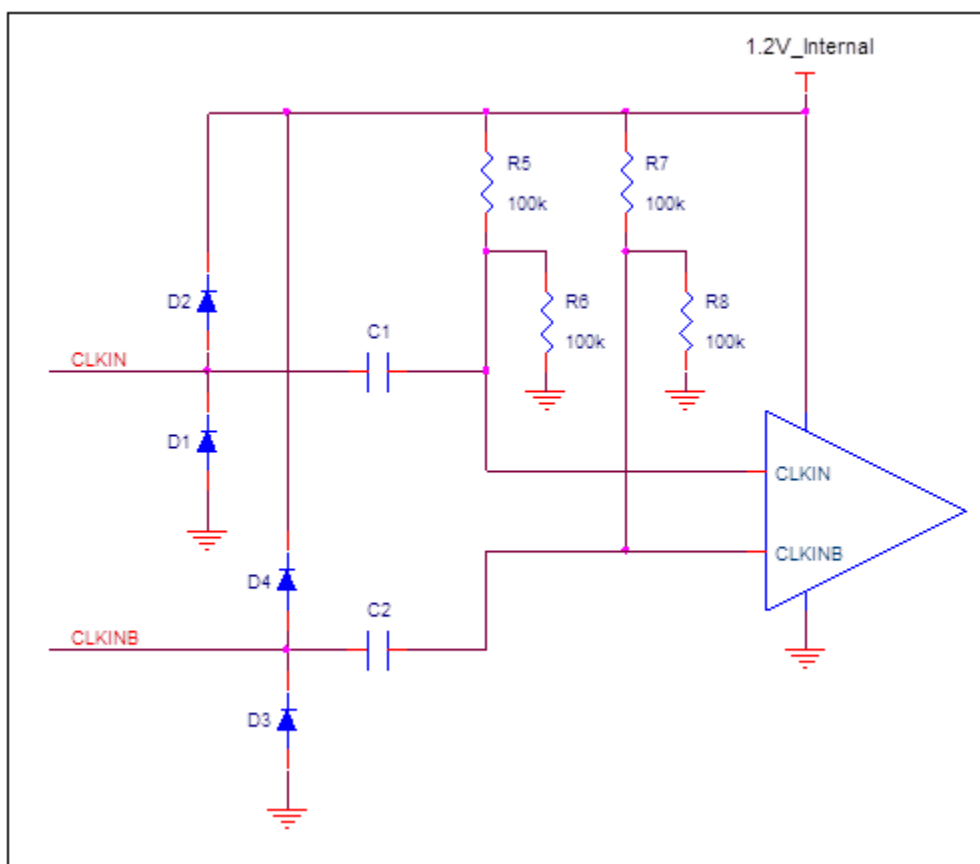




## CLKIN Equivalent Schematic

Figure *CLKIN Equivalent Schematic* below shows the basis of the requirements on VIH maximum, VIL minimum and the 1200mV p-p single-ended Vswing maximum.

- The CLKIN and CLKINB VIH maximum specification comes from the cathode voltage on the input ESD diodes D2 and D4, which are referenced to the internal 1.2V supply. CLKIN or CLKINB voltages greater than 1.2V + 0.5V = 1.7V will be clamped by these diodes. CLKIN and CLKINB input voltages less than -0.3V will be clamped by diodes D1 and D3.
- The 1.2V p-p maximum Vswing input requirement is determined by the internally regulated 1.2V supply for the actual clock receiver. This is the basis of the Vswing specification in Table 13.

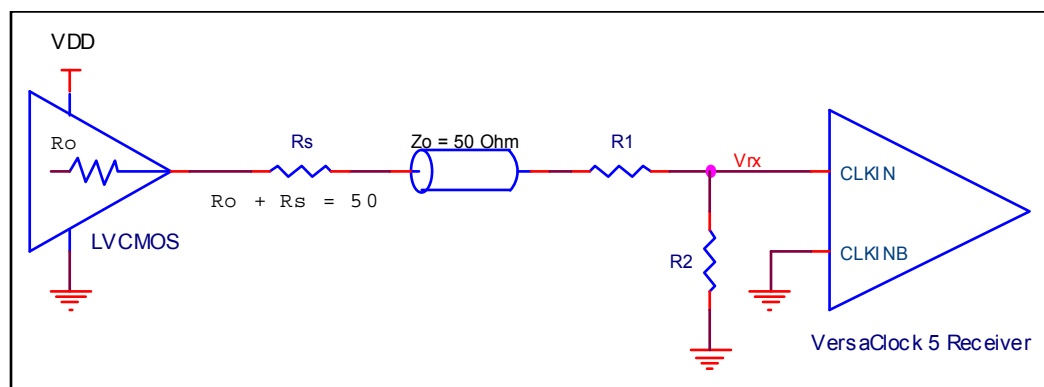


CLKIN Equivalent Schematic

# Wiring the Differential Input to Accept Single-Ended Levels

Figure *Recommended Schematic for Wiring a Differential Input to Accept Single-ended Levels* shows how a differential input can be wired to accept single-ended levels. This configuration has three properties; the total output impedance of  $R_o$  and  $R_s$  matches the  $50\Omega$  transmission line impedance,

the  $V_{rx}$  voltage is generated at the CLKIN inputs which maintains the LVCMOS driver voltage level across the transmission line for best S/N and the  $R_1$ – $R_2$  voltage divider values ensure that  $V_{rx}$  p-p at CLKIN is less than the maximum value of 1.2V.



## Recommended Schematic for Wiring a Differential Input to Accept Single-ended Levels

Table 24 *Nominal Voltage Divider Values vs Driver VDD* shows resistor values that ensure the maximum drive level for the CLKIN port is not exceeded for all combinations of 5% tolerance on the driver VDD, the VersaClock Vddo\_0 and 5% resistor tolerances. The values of the resistors can be

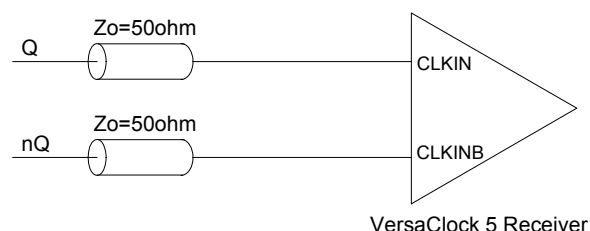
adjusted to reduce the loading for slower and weaker LVCMOS driver by increasing the impedance of the  $R_1$ – $R_2$  divider. To assist this assessment, the total load on the driver is included in the table.

**Table 24: Nominal Voltage Divider Values vs Driver VDD**

| LVCMOS Driver VDD | $R_o + R_s$ | $R_1$ | $R_2$ | $V_{rx}$ (peak) | $R_o + R_s + R_1 + R_2$ |
|-------------------|-------------|-------|-------|-----------------|-------------------------|
| 3.3               | 50.0        | 130   | 75    | 0.97            | 255                     |
| 2.5               | 50.0        | 100   | 100   | 1.00            | 250                     |
| 1.8               | 50.0        | 62    | 130   | 0.97            | 242                     |

## HCSL Differential Clock Input Interface

CLKIN/CLKINB will accept DC coupled HCSL signals.

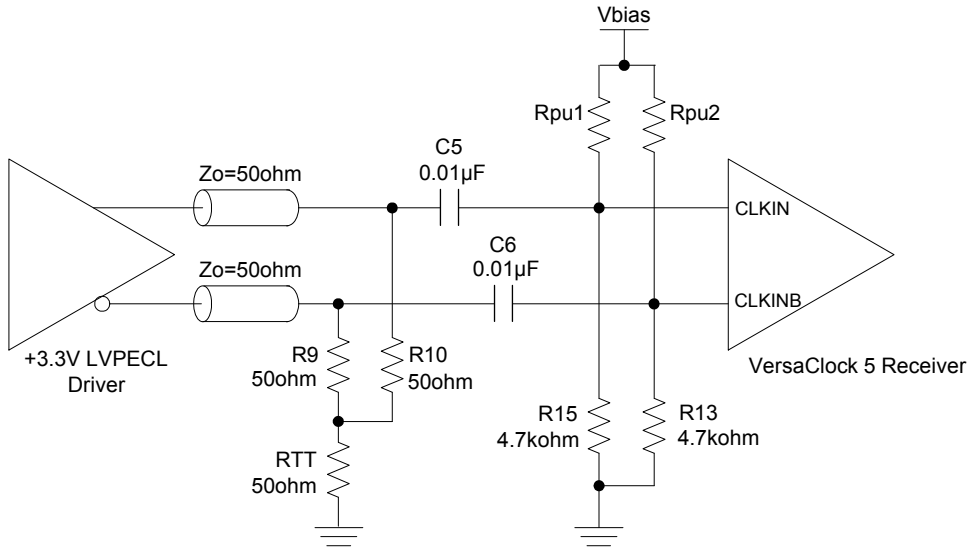


## CLKIN, CLKINB Input Driven by an HCSL Driver

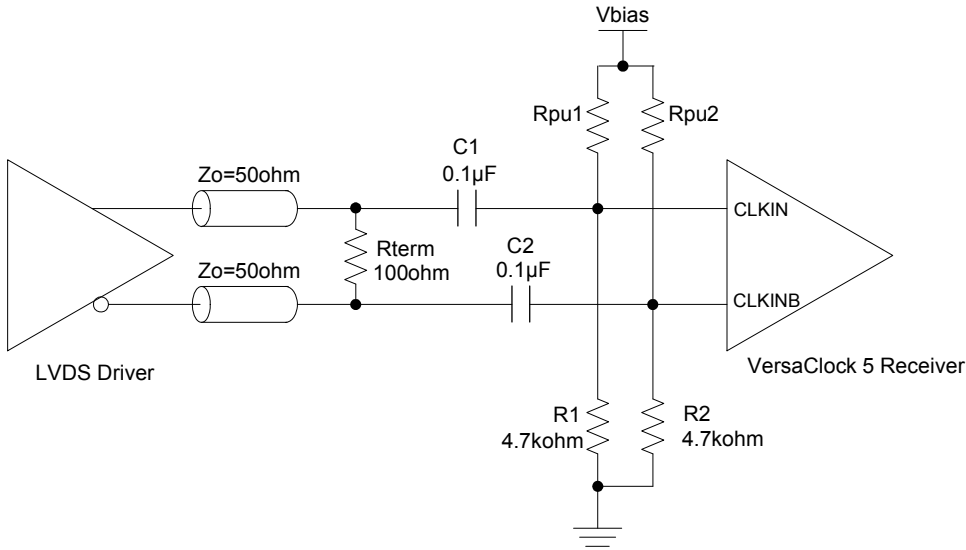
### 3.3V Differential LVPECL Clock Input Interface

The logic levels of 3.3V LVPECL and LVDS can exceed  $V_{IH}$  maximum for the CLKIN/B pins. Therefore the LVPECL levels must be AC coupled to the VersaClock differential input and the DC bias restored with external voltage dividers. A single

table of bias resistor values is provided below for both for 3.3V LVPECL and LVDS.  $V_{bias}$  can be  $V_{DDD}$ ,  $V_{DDOX}$  or any other available voltage at the VersaClock receiver that is most conveniently accessible in layout.



**CLKIN, CLKINB Input Driven by a 3.3V LVPECL Driver**



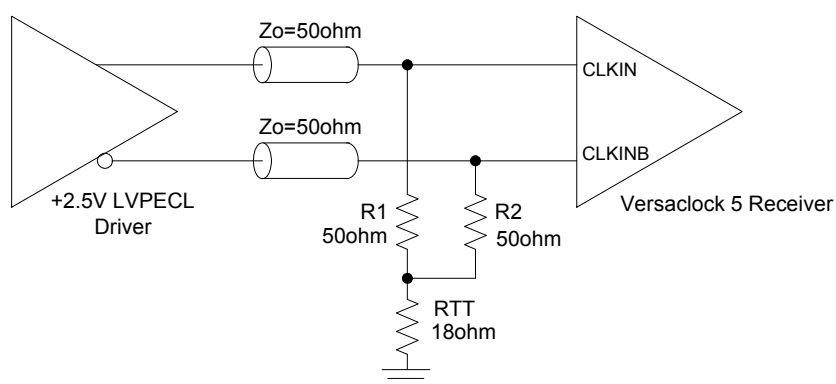
**CLKIN, CLKINB Input Driven by an LVDS Driver**

**Table 25: Bias Resistors for 3.3V LVPECL and LVDS Drive to CLKIN/B**

| Vbias<br>(V) | Rpu1/2<br>(kohm) | CLKIN/B Bias Voltage<br>(V) |
|--------------|------------------|-----------------------------|
| 3.3          | 22               | 0.58                        |
| 2.5          | 15               | 0.60                        |
| 1.8          | 10               | 0.58                        |

## 2.5V Differential LVPECL Clock Input Interface

The maximum DC 2.5V LVPECL voltage meets the  $V_{IH\ max}$  CLKIN requirement. Therefore 2.5V LVPECL can be connected directly to the CLKIN terminals without AC coupling

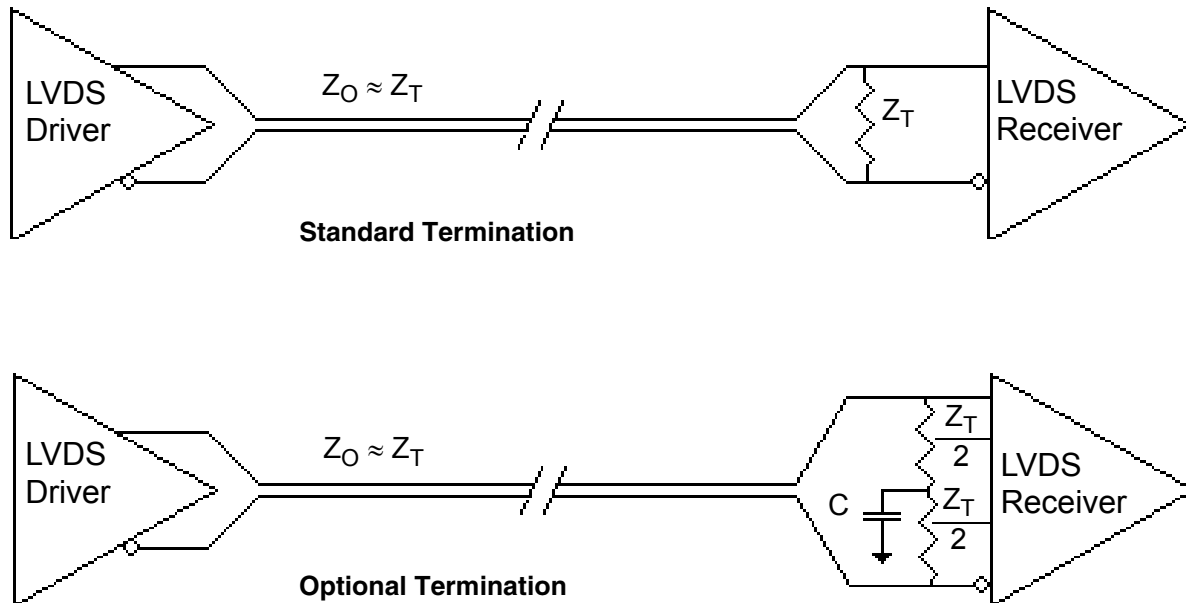


### CLKIN, CLKINB Input Driven by a 2.5V LVPECL Driver

## LVDS Driver Termination

For a general LVDS interface, the recommended value for the termination impedance ( $Z_T$ ) is between  $90\Omega$  and  $132\Omega$ . The actual value should be selected to match the differential impedance ( $Z_O$ ) of your transmission line. A typical point-to-point LVDS design uses a  $100\Omega$  parallel resistor at the receiver and a  $100\Omega$  differential transmission-line environment. In order to avoid any transmission-line reflection issues, the components should be surface mounted and must be placed as close to the receiver as possible. The standard termination schematic as shown in figure *Standard Termination* or the termination of figure *Optional Termination* can be used, which uses a center tap capacitance to help filter

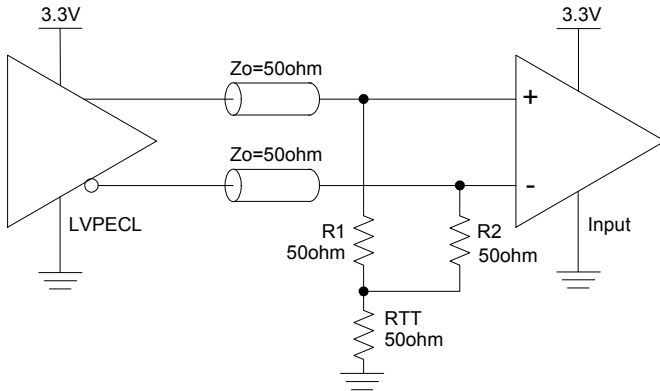
common mode noise. The capacitor value should be approximately  $50\text{pF}$ . In addition, since these outputs are LVDS compatible, the input receiver's amplitude and common-mode input range should be verified for compatibility with the IDT LVDS output. If using a non-standard termination, it is recommended to contact IDT and confirm that the termination will function as intended. For example, the LVDS outputs cannot be AC coupled by placing capacitors between the LVDS outputs and the  $100\Omega$  shunt load. If AC coupling is required, the coupling caps must be placed between the  $100\Omega$  shunt termination and the receiver. In this manner the termination of the LVDS output remains DC coupled.



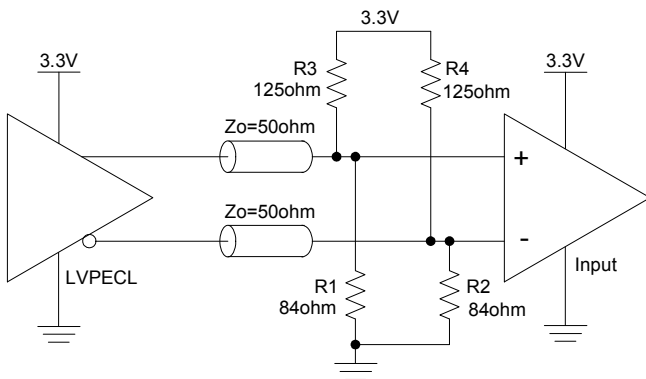
## Termination for 3.3V LVPECL Outputs

The clock layout topology shown below is a typical termination for LVPECL outputs. The two different layouts mentioned are recommended only as guidelines.

The differential outputs generate ECL/LVPECL compatible outputs. Therefore, terminating resistors (DC current path to ground) or current sources must be used for functionality. These outputs are designed to drive  $50\Omega$  transmission lines. Matched impedance techniques should be used to maximize operating frequency and minimize signal distortion. The figure below show two different layouts which are recommended only as guidelines. Other suitable clock layouts may exist and it would be recommended that the board designers simulate to guarantee compatibility across all printed circuit and clock component process variations.



### 3.3V LVPECL Output Termination (1)

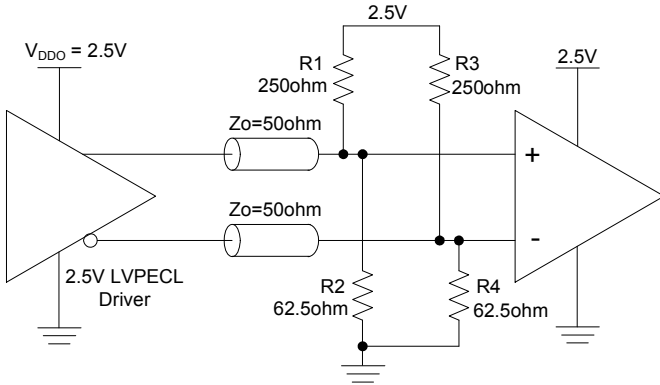


### 3.3V LVPECL Output Termination (2)

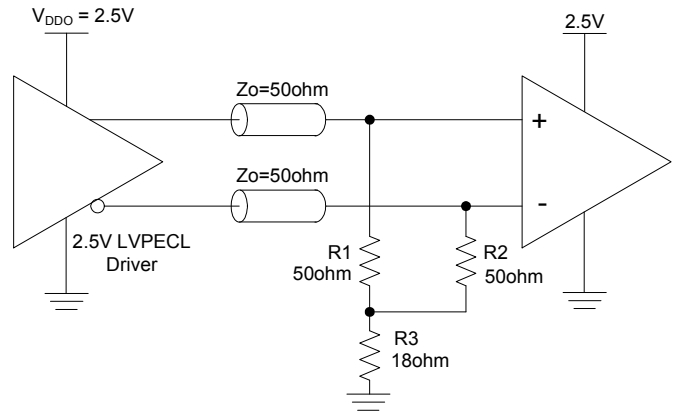


## Termination for 2.5V LVPECL Outputs

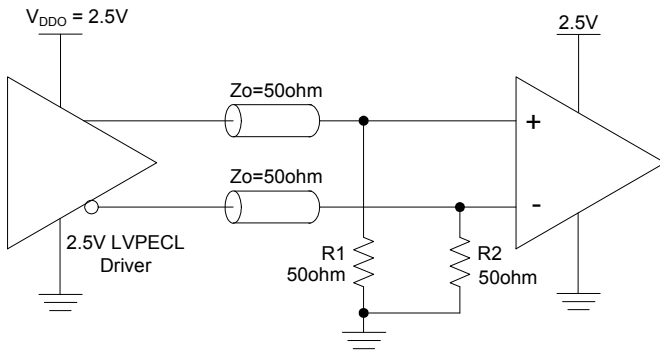
Figures 2.5V LVPECL Driver Termination Example (1) and (2) show examples of termination for 2.5V LVPECL driver. These terminations are equivalent to terminating  $50\Omega$  to  $V_{DDO} - 2V$ . For  $V_{DDO} = 2.5V$ , the  $V_{DDO} - 2V$  is very close to ground level. The R3 in Figure 2.5V LVPECL Driver Termination Example (3) can be eliminated and the termination is shown in example (2).



2.5V LVPECL Driver Termination Example (1)



2.5V LVPECL Driver Termination Example (3)



2.5V LVPECL Driver Termination Example (2)

## PCI Express Application Note

PCI Express jitter analysis methodology models the system response to reference clock jitter. The block diagram below shows the most frequently used Common Clock architecture in which a copy of the reference clock is provided to both ends of the PCI Express Link.

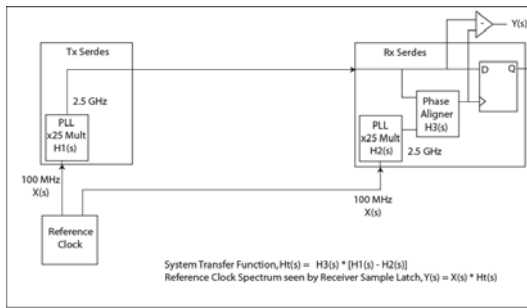
In the jitter analysis, the transmit (Tx) and receive (Rx) serdes PLLs are modeled as well as the phase interpolator in the receiver. These transfer functions are called H1, H2, and H3 respectively. The overall system transfer function at the receiver is:

$$H_t(s) = H_3(s) \times [H_1(s) - H_2(s)]$$

The jitter spectrum seen by the receiver is the result of applying this system transfer function to the clock spectrum X(s) and is:

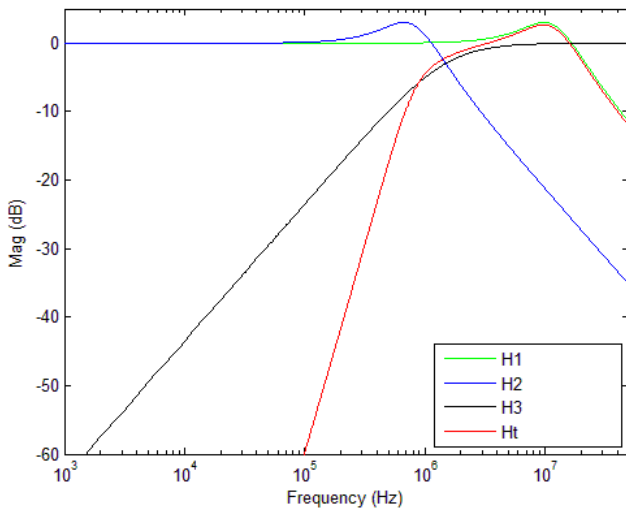
$$Y(s) = X(s) \times H_3(s) \times [H_1(s) - H_2(s)]$$

In order to generate time domain jitter numbers, an inverse Fourier Transform is performed on  $X(s) \times H_3(s) \times [H_1(s) - H_2(s)]$ .



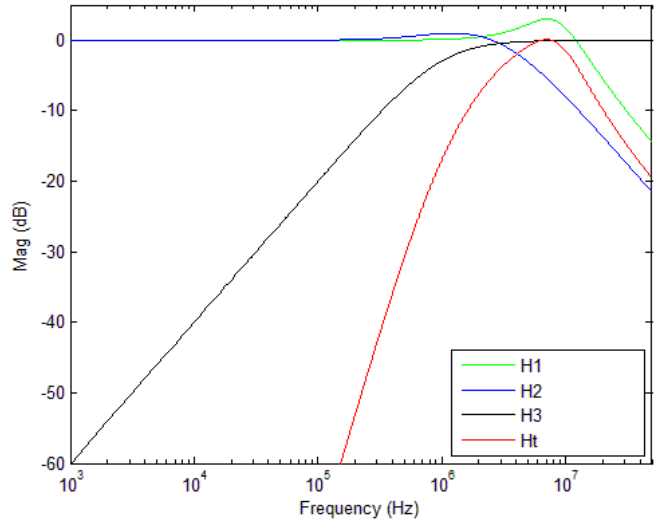
### PCI Express Common Clock Architecture

For PCI Express Gen1, one transfer function is defined and the evaluation is performed over the entire spectrum: DC to Nyquist (e.g for a 100MHz reference clock: 0Hz – 50MHz) and the jitter result is reported in peak-peak.

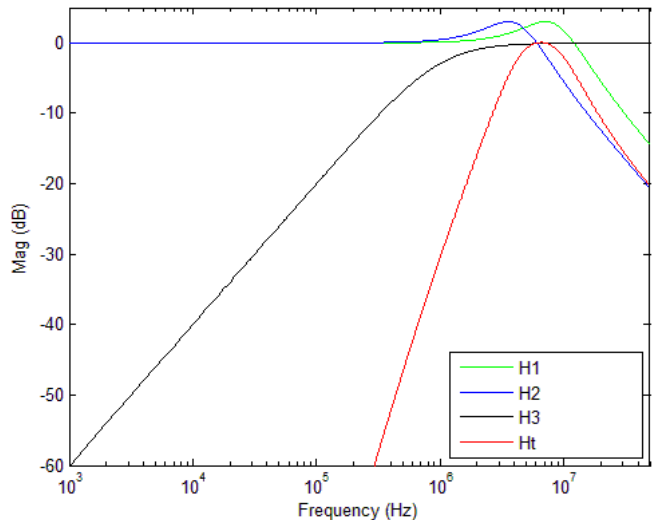


### PCIe Gen1 Magnitude of Transfer Function

For PCI Express Gen2, two transfer functions are defined with 2 evaluation ranges and the final jitter number is reported in RMS. The two evaluation ranges for PCI Express Gen2 are 10kHz – 1.5MHz (Low Band) and 1.5MHz – Nyquist (High Band). The plots show the individual transfer functions as well as the overall transfer function Ht.

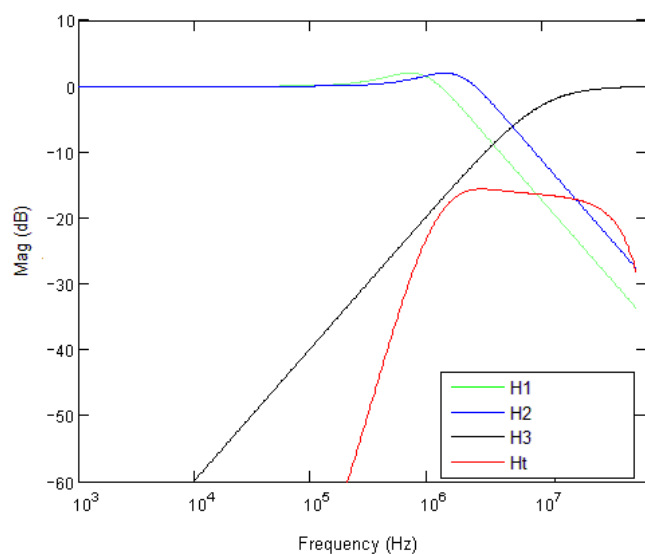


### PCIe Gen2A Magnitude of Transfer Function



### PCIe Gen2B Magnitude of Transfer Function

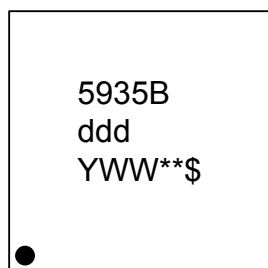
For PCI Express Gen3, one transfer function is defined and the evaluation is performed over the entire spectrum. The transfer function parameters are different from Gen 1 and the jitter result is reported in RMS.



## PCIe Gen3 Magnitude of Transfer Function

For a more thorough overview of PCI Express jitter analysis methodology, please refer to IDT Application Note *PCI Express Reference Clock Requirements*.

## Marking Diagram



1. Line 1 is the truncated part number.
2. "ddd" denotes dash code.
3. "YWW" is the last digit of the year and week that the part was assembled.
4. "\*\*" denotes sequential lot number.
5. "\$" denotes mark code.

## Package Drawings (4 x 4 mm 24-LGA, LTG24T2)

The package outline drawings are located at the end of this document. The package information is the most current data available and is subject to change without notice or revision of this document.

## Ordering Information

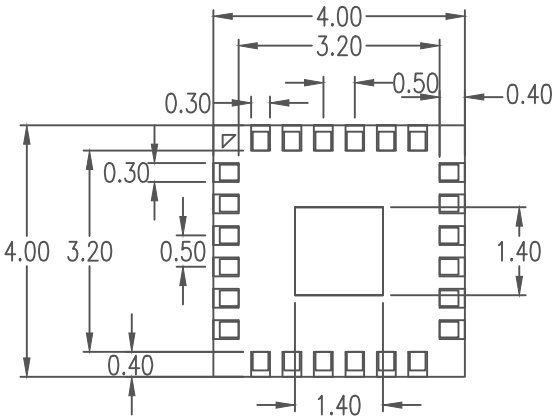
| Part / Order Number | Marking     | Shipping Packaging | Package         | Temperature   |
|---------------------|-------------|--------------------|-----------------|---------------|
| 5P49V5935BdddLTGI   | see page 29 | Trays              | 4 × 4 mm 24-LGA | -40° to +85°C |
| 5P49V5935BdddLTGI8  |             | Tape and Reel      | 4 × 4 mm 24-LGA | -40° to +85°C |

“G” after the two-letter package code denotes Pb-Free configuration, RoHS compliant.

## Revision History

| Date              | Description of Change   |
|-------------------|---|
| November 1, 2017  | 1. Changed package designator from VFQFPN to LGA.<br>2. Updated package outline drawings. |
| March 10, 2017    | 1. Updated unit typos and legal disclaimer.   |
| February 24, 2017 | 1. Added “Output Alignment” section.<br>2. Update “Output Divides” section.               |





RECOMMENDED LAND PATTERN DIMENSION

- NOTES:
- 1. ALL DIMENSION ARE IN mm. ANGLES IN DEGREES.
  - 2. TOP DOWN VIEW. AS VIEWED ON PCB.
  - 3. LAND PATTERN RECOMMENDATION PER IPC-7351B GENERIC REQUIREMENT FOR SURFACE MOUNT DESIGN AND LAND PATTERN.

| Package Revision History |         |                 |
|--------------------------|---------|-----------------|
| Date Created             | Rev No. | Description     |
|                          |         |                 |
| Sept 15, 2017            | Rev 00  | Initial Release |



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