

# Dual Output Phase Controlled SSTL\_3/PECL Clock Generator

## General Description

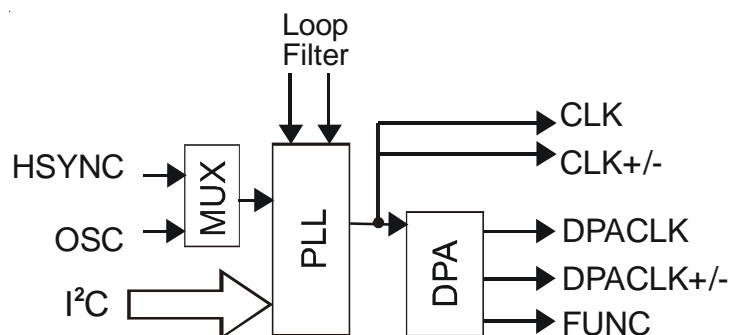
The **ICS1524A** is a low-cost, very high-performance frequency generator and phase controlled clock synthesizer. It is perfectly suited to phase controlled clock synthesis and distribution as well as line-locked and genlocked applications.

The **ICS1524A** offers two channels of clock phase controlled outputs; CLK and DPACLK. These two output channels have both 250 MHz PECL differential and 150 MHz SSTL\_3 single-ended output pins. The CLK output channel has a fixed phase relationship to the PLL's input and the DPACLK uses the Dynamic Phase Adjust circuitry to allow control of the clock phase relative to input signal.

Optionally, the CLK outputs can operate at half the clock rate and phase aligned with the DPACLK channel, enabling deMUXing of multiplexed analog-to-digital converters. The FUNC pin provides either the regenerated input from the phase-locked loop (PLL) divider chain output or a re-synchronized and sharpened input HSYNC.

The advanced PLL uses either its internal programmable feedback divider or an external divider and is programmed by a standard I<sup>2</sup>C-bus™ serial interface.

## Block Diagram



I<sup>2</sup>C-bus is a trademark of Philips Corporation.

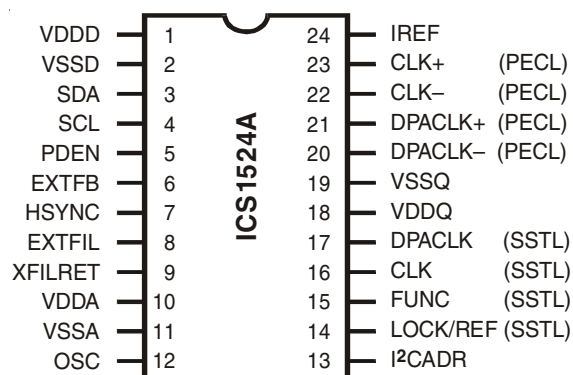
## Features

- Wide input frequency range
  - 8 kHz to 100 MHz
- 250 MHz balanced PECL differential outputs
- 150 MHz single-ended SSTL\_3 clock outputs
- Dynamic Phase Adjust (DPA) for DPACLK outputs
  - Software controlled phase adjustment
  - 360° Adjustment down to 1/64 clock increments
- External or internal loop filter selection
- Uses 3.3 VDC Inputs are 5 volt tolerant.
- I<sup>2</sup>C-bus serial interface runs at either low speed (100 kHz) or high speed (400 kHz).
- Hardware and Software PLL Lock detection

## Applications

- Generic Frequency Synthesis
- LCD Monitors and Projectors
- Genlocking Multiple Video Systems

## Pin Configuration



24 Pin 300-mil SOIC

## Document Revision History

### Rev A

ICS1523 Rev T Datasheet used as a starting template  
New Block Diagram substituted for old 1523 one  
    Removed reference to CLK / 2 Functionality  
    Created a set of clock outputs that bypass the DPA  
    External PDEN is now the IN-SEL MUX control bit  
Text descriptions changed to support new 1524 block diagram

### Rev B

Replaced page 15 “Layout Guidelines”  
Replaced SIOC Package diagram on page 22  
“Advanced Status” removed  
Redrew front page graphics for clarity

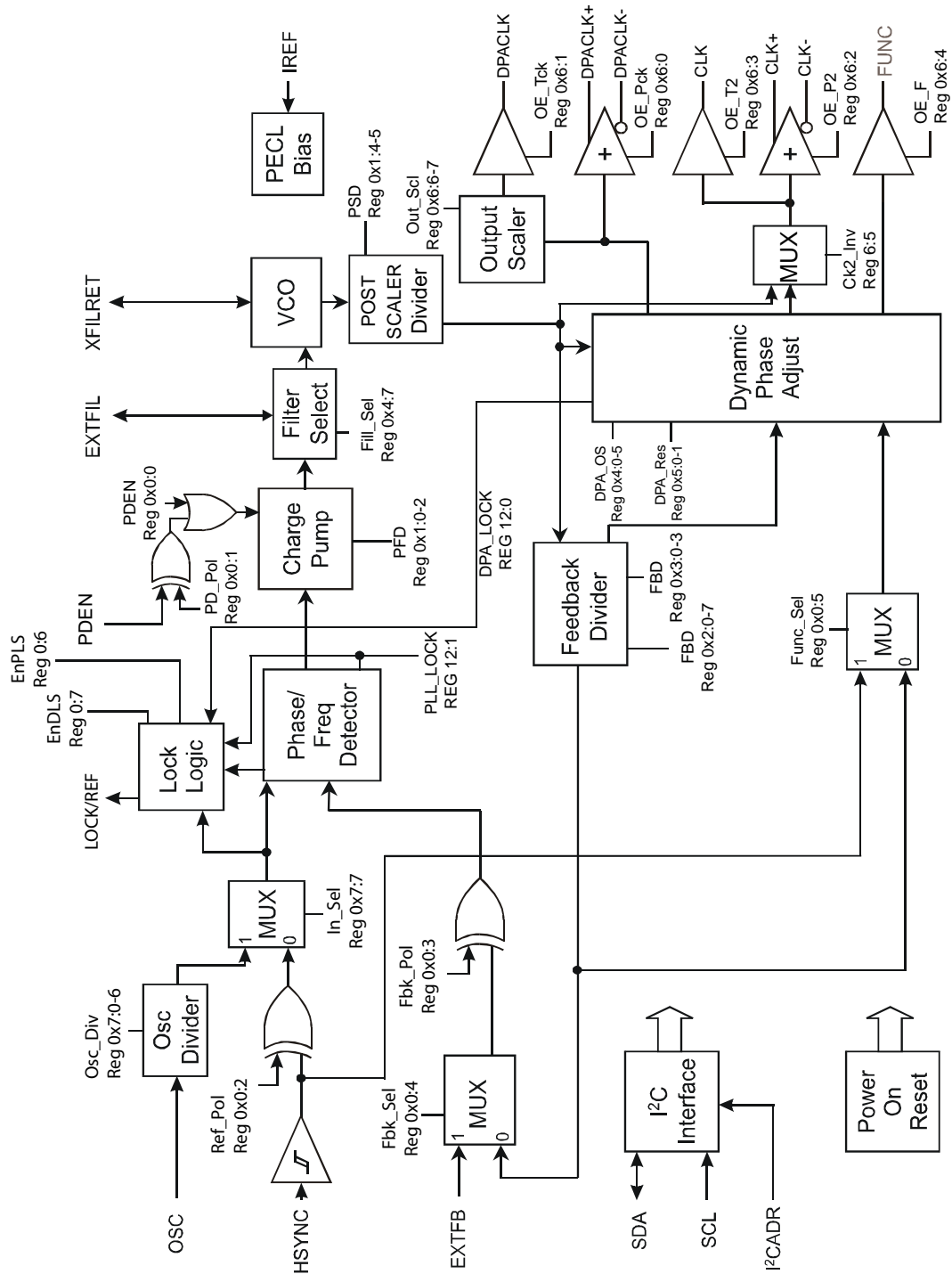
### Rev C

Corrected Chip Revision and Chip Version values on page 5  
Changed Title on Page 1  
Minor format changes to pages 8 and 21  
Corrected pin names on page 10

### Rev D

Miscellaneous updates to Block Diagram on page 3  
Changed reference from “Phase Detector” to “Charge Pump”. Pages 4-7, 10

## Block Diagram



## Pin Descriptions

| PIN NO. | PIN NAME            | TYPE   | DESCRIPTION              | COMMENTS  |
|---------|---------------------|--------|--------------------------|---|
| 1       | VDDD                | PWR    | Digital supply           | 3.3V to digital sections  |
| 2       | VSSD                | PWR    | Digital ground           | Ground for digital sections   |
| 3       | SDA                 | IN/OUT | Serial data              | I <sup>2</sup> C-bus <sup>1</sup>   |
| 4       | SCL                 | IN     | Serial clock             | I <sup>2</sup> C-bus <sup>1</sup>   |
| 5       | PDEN                | IN     | Charge Pump              | Suspends charge pump <sup>1</sup>   |
| 6       | EXTFB               | IN     | External feedback        | External divider input to PFD <sup>1</sup>  |
| 7       | HSYNC               | IN     | Horizontal sync          | Clock input to PLL <sup>1</sup>   |
| 8       | EXTFIL              | IN     | External filter          | External PLL loop filter  |
| 9       | XFILRET             | IN     | External filter return   | External PLL loop filter return   |
| 10      | VDDA                | PWR    | Analog supply            | 3.3V for analog circuitry   |
| 11      | VSSA                | PWR    | Analog ground            | Ground for analog circuitry   |
| 12      | OSC                 | IN     | Oscillator               | Input from crystal oscillator package <sup>1, 2</sup>   |
| 13      | I <sup>2</sup> CADR | IN     | I <sup>2</sup> C address | Chip I <sup>2</sup> C address select<br>Low = 4Dh read, 4Ch write<br>High = 4Fh read, 4Eh write |
| 14      | LOCK/REF            | SSTL   | Lock indicator/reference | Displays PLL or DPA lock or REF input   |
| 15      | FUNC                | SSTL   | Function output          | SSTL_3 selectable HSYNC output  |
| 16      | CLK                 | SSTL   | Pixel clock              | Non-Delayed SSTL_3 Clock  |
| 17      | DPACLK              | SSTL   | DPA Delayed Clock        | DPA Delayed SSTL_3 Clock  |
| 18      | VDDQ                | PWR    | Output driver supply     | 3.3V VDD for output drivers   |
| 19      | VSSQ                | PWR    | Output driver ground     | Ground for output drivers   |
| 20      | DPACLK–             | PECL   | DPA Delayed PECL clock - | DPA Delayed Inverted PECL Clock    Open drain.  |
| 21      | DPACLK+             | PECL   | DPA Delayed PECL clock + | DPA Delayed PECL Clock    Open drain.   |
| 22      | CLK–                | PECL   | PECL clock -             | Non-Delayed Inverted PECL Clock    Open drain.  |
| 23      | CLK+                | PECL   | PECL clock +             | Non-Delayed PECL Clock    Open drain.   |
| 24      | IREF                | IN     | Reference current        | Reference current for PECL outputs  |

### Notes:

1. These LVTTTL inputs are 5 V-tolerant.
2. Connect to ground if unused.

## I<sup>2</sup>C Register Map Summary

| Register Index | Name           | Access   | Bit Name    | Bit # | Reset Value | Description  |
|----------------|----------------|----------|-------------|-------|-------------|--|
| 0h             | Input Control  | R / W    | PDen        | 0     | 1           | Charge Pump Enable (0=Disable 1=Enable)                          |
|                |                |          | PD_Pol      | 1     | 0           | Charge Pump Enable Polarity                                      |
|                |                |          | Ref_Pol     | 2     | 0           | External Reference Polarity (0=Positive Edge, 1=Negative Edge)   |
|                |                |          | Fbk_Pol     | 3     | 0           | External Feedback Polarity (0=Positive Edge, 1=Negative Edge)    |
|                |                |          | Fbk_Sel     | 4     | 0           | External Feedback Select (0=Internal Feedback, 1=External)       |
|                |                |          | Func_Sel    | 5     | 0           | Function Out Select (0=Recovered HSYNC, 1=Input HSYNC)           |
|                |                |          | EnPLS       | 6     | 1           | Enable PLL Lock/Ref Status Output (0=Disable 1=Enable)           |
| 1h             | Loop Control   | R / W *  | EnDLS       | 7     | 0           | Enable DPA Lock/Ref Status Output (0=Disable 1=Enable)           |
|                |                |          | PFD0-2      | 0-2   | 0           | Charge Pump Gain   |
|                |                |          | Reserved    | 3     | 0           | Reserved   |
|                |                |          | PSD0-1      | 4-5   | 0           | Post-Scaler Divider (0 = /2, 1 = /4, 2 = /8, 3 = /16)            |
| 2h             | FdBk Div 0     | R / W *  | Reserved    | 6-7   | 0           | Reserved   |
|                |                |          | FBD0-7      | 0-7   | FF          | PLL FeedBack Divider LSBs (bits 0-7) *                           |
|                |                |          | FBD8-11     | 0-3   | F           | PLL Feedback Divider MSBs (bits 8-11) *                          |
|                |                |          | Reserved    | 4-7   | 0           | Reserved   |
| 4h             | DPA Offset     | R / W    | DPA_OS0-5   | 0-5   | 0           | Dynamic Phase Aligner Offset                                     |
|                |                |          | Reserved    | 6     | 0           | Reserved   |
|                |                |          | Fil_Sel     | 7     | 1           | Loop Filter Select (0=External, 1=Internal)                      |
| 5h             | DPA Control    | R / W ** | DPA_Res0-1  | 0-1   | 3           | DPA Resolution (0=16 delay elements, 1=32, 2=Reserved, 3=64)     |
|                |                |          | Metal_Rev   | 2-7   | 0           | Metal Mask Revision Number                                       |
| 6h             | Output Enables | R / W    | OE_Pck      | 0     | 1           | Output Enable for PECL DPACLK (0=High Z, 1=Enabled)              |
|                |                |          | OE_Tck      | 1     | 1           | Output Enable for STTL_3 DPACLK (0=High Z, 1=Enabled)            |
|                |                |          | OE_P2       | 2     | 1           | Output Enable for PECL CLK (0=High Z, 1=Enabled)                 |
|                |                |          | OE_T2       | 3     | 1           | Output Enable for STTL_3 CLK (0=High Z, 1=Enabled)               |
|                |                |          | OE_F        | 4     | 1           | Output Enable for STTL_3 FUNC (0=High Z, 1=Enabled)              |
|                |                |          | Ck2_Inv     | 5     | 0           | Select non-delayed CLK (1) or DPA delayed CLK/2 (0) on CLKx pins |
|                |                |          | Out_Scl     | 6-7   | 0           | SSTL DPACLK (Pin 17) Scaler (0 = ÷1, 1 = ÷2, 2 = ÷4, 3 = ÷8)     |
| 7h             | Osc_Div        | R / W    | Osc_Div 0-6 | 0-6   | 0           | Osc Divider modulus  |
|                |                |          | In-Sel      | 7     | 1           | RESERVED   |
| 8h             | Reset          | Write    | DPA         | 0-3   | x           | Writing xA hex resets DPA and loads working register 5           |
|                |                |          | PLL         | 4-7   | x           | Writing 5x hex resets PLL and loads working registers 1-3        |
| 10h            | Chip Ver       | Read     | Chip Ver    | 0-7   | 18          | Chip Version 17 hex  |
| 11h            | Chip Rev       | Read     | Chip Rev    | 0-7   | 01          | Chip Revision C2 hex   |
| 12h            | Rd_Reg         | Read     | DPA_Lock    | 0     | N/A         | DPA Lock Status (0=Unlocked, 1=Locked)                           |
|                |                |          | PLL_Lock    | 1     | N/A         | PLL Lock Status (0=Unlocked, 1=Locked)                           |
|                |                |          | Reserved    | 2-7   | 0           | Reserved   |

\* Identifies double-buffered registers. Working registers are loaded during software PLL reset.

\*\* Identifies double-buffered register. Working registers are loaded during software DPA reset.

## Detailed Register Description

**Name:** Input Control

**Register:** 0h

**Index:** Read/Write

| Bit Name | Bit # | Reset Value | Description |
|----------|-------|-------------|-------------|
|----------|-------|-------------|-------------|

|          |   |   |   |
|----------|---|---|---|
| PDen     | 0 | 1 | Charge Pump Enable                            |
| PD_Pol   | 1 | 0 | Charge Pump Enable Polarity                   |
| Ref_Pol  | 2 | 0 | External Reference Polarity                   |
| Fbk_Pol  | 3 | 0 | External Reference Feedback Polarity          |
| Fbk_Sel  | 4 | 0 | External Feedback Select                      |
| Func_Sel | 5 | 0 | Function Output Select                        |
| EnPLS    | 6 | 1 | Enable PLL Lock Status Output on LOCK/REF pin |
| EnDLS    | 7 | 0 | Enable DPA Lock Status Output on LOCK/REF pin |

| Bit | Name | Description |
|-----|------|-------------|
|-----|------|-------------|

|   |          |  |
|---|----------|--|
| 0 | PDen     | Charge Pump Enable<br>0 = External Enable via PDEN pin<br>1 = Always Enable  |
| 1 | PD_Pol   | Charge Pump Enable Polarity<br>0 = Active High<br>1 = Active Low   |
| 2 | Ref_Pol  | External Reference Polarity —<br>Edge of input signal on which Phase/Frequency Detector triggers.<br>0 = Rising Edge (default)<br>1 = Falling Edge   |
| 3 | Fbk_Pol  | External Reference Feedback Polarity — Edge of EXTFB (pin 6) signal on which<br>Phase/Frequency Detector triggers when external feedback is used (Reg0 [4]=1).<br>0 = Positive Edge (default)<br>1 = Negative Edge |
| 4 | Fbk_Sel  | External Feedback Select<br>0 = Internal Feedback (default)<br>1 = External Feedback   |
| 5 | Func_Sel | Function Output Select — Selects re-clocked output to FUNC (pin 15).<br>0 = Recovered HSYNC (default). Regenerated HSYNC output.<br>1 = External HSYNC. Schmitt-trigger conditioned input from HSYNC (pin 7).      |

6 EnPLS Enable LOCK/REF (pin14) Output

|   |       |       |       |        |  |
|---|-------|-------|-------|--------|--|
| 7 | EnDLS | EnPLS | EnDLS | IN_SEL | LOCK/REF(14)                                 |
|   |       | 0     | 0     | N/A    | 0  |
|   |       | 0     | 1     | N/A    | 1 if DPA locked, 0 otherwise                 |
|   |       | 1     | 0     | N/A    | 1 if PLL locked, 0 otherwise                 |
|   |       | 1     | 1     | 0      | Post Schmitt trigger<br>HSYNC(7) XOR Ref_Pol |
|   |       | 1     | 1     | 1      | $F_{osc} \div Osc\ Div$                      |

**Name:** Loop Control Register  
**Register:** 1h  
**Index:** Read/Write\*

| Bit Name | Bit # | Reset Value | Description         |
|----------|-------|-------------|---------------------|
| PFD0-2   | 0-2   | 0           | Charge Pump Gain    |
| Reserved | 3     | 0           | Reserved            |
| PSD0-1   | 4-5   | 0           | Post-Scaler Divider |
| Reserved | 6-7   | 0           | Reserved            |

| Bit | Name | Description |
|-----|------|-------------|
|-----|------|-------------|

|     |        |                  |
|-----|--------|------------------|
| 0-2 | PFD0-2 | Charge Pump Gain |
|-----|--------|------------------|

| Bit 2 | Bit 1 | Bit 0 | CP Gain ( $\mu\text{A}/2\pi \text{ rad}$ ) |
|-------|-------|-------|--|
| 0     | 0     | 0     | 1  |
| 0     | 0     | 1     | 2  |
| 0     | 1     | 0     | 4  |
| 0     | 1     | 1     | 8  |
| 1     | 0     | 0     | 16   |
| 1     | 0     | 1     | 32   |
| 1     | 1     | 0     | 64   |
| 1     | 1     | 1     | 128  |

|   |          |
|---|----------|
| 3 | Reserved |
|---|----------|

|     |        |  |
|-----|--------|--|
| 4-5 | PSD0-1 | Post-Scaler Divider — Divides the output of the VCO to the DPA and Feedback Divider. |
|-----|--------|--|

| Bit 5 | Bit 4 | PSD Divider |
|-------|-------|-------------|
| 0     | 0     | 2 (default) |
| 0     | 1     | 4           |
| 1     | 0     | 8           |
| 1     | 1     | 16          |

|     |          |
|-----|----------|
| 6-7 | Reserved |
|-----|----------|

\*Double-buffered register. Actual working registers are loaded during software PLL reset.  
 See register 8h for details.

**Name:** Feedback Divider 0 Register / Feedback Divider 1 Register  
**Register:** 2h, 3h  
**Index:** Read/Write\*

| Bit Name | Index | Bit # | Reset Value | Description   |
|----------|-------|-------|-------------|---|
| FBD 0-7  | 2     | 0-7   | FF          | PLL Feedback Divider LSBs (0-7).* When Bit 0 = 0, then the total number of clocks per line is even. When Bit 0 = 1, then the total number of clocks is odd. |
| FBD 8-11 | 3     | 0-3   | F           | PLL Feedback Divider MSBs (8-11)*   |
| Reserved | 3     | 4-7   |             | Reserved  |

The value that is programmed into these two registers, plus a value of 8, defines the total number of clock periods that the ICS 1524 generates between HSYNCs. Program these registers with the total number of horizontal clocks per line minus 8.

$$\text{Feedback Divider Modulus} = \begin{array}{|c|c|c|c|c|c|c|c|c|c|c|c|} \hline \text{Reg 3} & & & & \text{Reg 2} & & & & & & & \\ \hline 3 & 2 & 1 & 0 & 7 & 6 & 5 & 4 & 3 & 2 & 1 & 0 \\ \hline \end{array} + 8$$

$$12 \leq \text{Feedback Divider Modulus} \leq 4103$$

\*Double-buffered registers. Actual working registers are loaded during software PLL reset.  
 See Register 8h for details.

**Name:** DPA Offset Register  
**Register:** 4h  
**Index:** Read/Write

| Bit Name  | Bit # | Reset Value | Description                 |
|-----------|-------|-------------|-----------------------------|
| DPA_OS0-5 | 0-5   | 0           | Dynamic Phase Adjust Offset |
| Reserved  | 6     | 0           | Reserved                    |
| Fil_Sel   | 7     | 0           | Loop Filter Select          |




| Bit | Name      | Description  |
|-----|-----------|--|
| 0-5 | DPA_OS0-5 | Dynamic Phase Adjust Offset.<br>Selects clock edge offset in discrete steps from zero to one clock period minus one step.<br>Resolution (number of delay elements per clock cycle) is selected by DPA_Res0-1 (Reg 5:0-1).<br>Note: Offsets equal to or greater than one clock period are neither recommended nor supported.<br>Example: For DPA_Res0-1=01H, the clock can be delayed from 0 to 31 steps. |
| 7   | Fil_Sel   | Selects external loop filter (0) or internal loop filter (1).<br>The use of an external loop filter is strongly recommended for all designs. Typical loop filter values are 6.8K Ohms for the series resistor, 3300 pF RF-type capacitor for the series capacitor, and 33 pF for the shunt capacitor.  |



**Name:** DPA Control Register  
**Register:** 5h  
**Index:** Read/Write\*

| Bit Name   | Bit # | Reset Value | Description                             |
|------------|-------|-------------|---|
| DPA_Res0-1 | 0-1   | 3           | Dynamic Phase Adjust Resolution Select. |
| Metal_Rev  | 2-7   | 0           | Metal Mask Revision Number.             |

| Bit | Name       | Description  |
|-----|------------|--|
| 0-1 | DPA_Res0-1 | Dynamic Phase Adjust (DPA) Resolution Select.<br>It is not recommended to use the DPA above 160 MHz. |

| Bit 1 | Bit 0 | Delay Elements | CLK Range, MHz   |
|-------|-------|----------------|--|
| 0     | 0     | 16             | 48  160 |
| 0     | 1     | 32             | 24  80   |
| 1     | 0     | Reserved       |  |
| 1     | 1     | 64             | 12  40  |

2-7 Metal\_Rev Metal Mask Revision Number.  
 After power-up, register bits 7:2 must be written with 11111. After this write, a read indicates the metal mask revision, as below.

| Revision | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 |
|----------|-------|-------|-------|-------|-------|-------|
| A        | 1     | 1     | 1     | 1     | 1     | 1     |
| B        | 0     | 1     | 1     | 1     | 1     | 1     |
| C1       | 1     | 0     | 1     | 1     | 1     | 1     |
| C2       | 0     | 0     | 1     | 1     | 1     | 1     |
| D        | 1     | 1     | 0     | 1     | 1     | 1     |
| E        | 1     | 1     | 1     | 0     | 1     | 1     |
| F        | 1     | 1     | 1     | 1     | 0     | 1     |
| G        | 1     | 1     | 1     | 1     | 1     | 0     |

\* Double-buffered register. Actual working registers are loaded during software DPA reset.  
 See register 8h for details.

**Name:** Output Enable Register  
**Register:** 6h  
**Index:** Read/Write

| Bit Name | Bit # | Reset Value | Description   |
|----------|-------|-------------|---|
| OE_Pck   | 0     | 0           | Output Enable for DPACLK Outputs (PECL, Pins 21, 20 ) |
| OE_Tck   | 1     | 0           | Output Enable for DPACLK Output (SSTL_3 Pin 17)       |
| OE_P2    | 2     | 0           | Output Enable for CLK Outputs (PECL, Pins 23, 22)     |
| OE_T2    | 3     | 0           | Output Enable for CLK Output (SSTL_3, Pin 16)         |
| OE_F     | 4     | 0           | Output Enable for FUNC Output (SSTL_3, Pin 15)        |
| CK2_Inv  | 5     | 0           | Select CLK Output Source (Pins 23, 22, 16)            |
| Out_Scl  | 6-7   | 0           | DPACLK Output Scaler (SSTL_3, Pin 17)                 |

| Bit | Name    | Description  |
|-----|---------|--|
| 0   | OE_Pck  | Output Enable for DPACLK Outputs (PECL)<br>0 = High Z<br>1 = Enabled   |
| 1   | OE_Tck  | Output Enable for DPACLK Output (SSTL_3)<br>0 = High Z<br>1 = Enabled  |
| 2   | OE_P2   | Output Enable for CLK Outputs (PECL)<br>0 = High Z<br>1 = Enabled  |
| 3   | OE_T2   | Output Enable for CLK Output (SSTL_3)<br>0 = High Z<br>1 = Enabled   |
| 4   | OE_F    | Output Enable for FUNC Output (SSTL_3)<br>0 = High Z<br>1 = Enabled  |
| 5   | Ck2_Inv | Select CLK Output Source (Pins 23, 22, 16)<br>0 = Half Speed DPA Delayed clock to CLK outputs<br>1 = Full Speed non-DPA Delayed clock to CLK outputs |
| 6-7 | Out_Scl | Clock (DPACLK, pin 17) Scaler  |

| Bit 7 | Bit 6 | DPACLK Divider |
|-------|-------|----------------|
| 0     | 0     | 1              |
| 0     | 1     | 2              |
| 1     | 0     | 4              |
| 1     | 1     | 8              |

**Name:** Oscillator Divider Register  
**Register:** 7h  
**Index:** Read/Write

| Bit Name    | Bit # | Reset Value | Description         |
|-------------|-------|-------------|---------------------|
| Osc_Div 0-6 | 0-6   | 0           | Osc Divider Modulus |
| In_Sel      | 7     | 1           | Input Select        |

| Bit | Name        | Description  |
|-----|-------------|--|
| 0-6 | Osc_Div 0-6 | Oscillator Divider Modulus.<br>Divides the input from OSC (pin 12) by the set modulus.<br>The modulus equals the programmed value, plus 2.<br>Therefore, the modulus range is from 3 to 129. |
| 7   | In_Sel      | Input Select — Selects the input to the Phase/Frequency Detector<br>0 = HSYNC<br>1 = Osc Divider   |

**Name:** RESET Register  
**Register:** 8h  
**Index:** Write

| Bit Name  | Bit # | Reset Value | Description   |
|-----------|-------|-------------|---|
| DPA Reset | 0-3   | x           | Writing xAh to this register resets DPA working register 5    |
| PLL Reset | 4-7   | x           | Writing 5xh to this register resets PLL working registers 1-3 |

| Bit | Name | Description   |
|-----|------|---|
| 0-3 | DPA  | Writing xAh to this register resets DPA working register 5    |
| 4-7 | PLL  | Writing 5xh to this register resets PLL working registers 1-3 |

| Value | Resets      |
|-------|-------------|
| xA    | DPA         |
| 5x    | PLL         |
| 5A    | DPA and PLL |

**Name:** Chip Version Register  
**Register:** 10h  
**Index:** Read

| Bit Name | Bit # | Reset Value | Description           |
|----------|-------|-------------|-----------------------|
| Chip Ver | 0-7   | 17          | Chip Version 24 (18h) |

**Name:** Chip Revision Register  
**Register:** 11h  
**Index:** Read

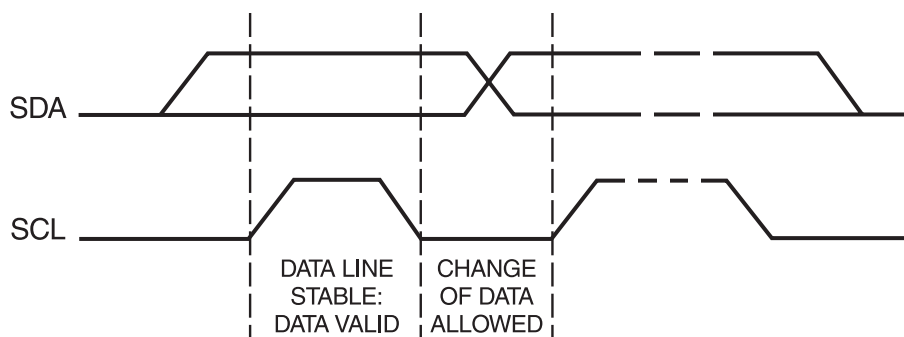
| Bit Name | Bit # | Reset Value | Description  |
|----------|-------|-------------|--|
| Chip Rev | 0-7   | 01+         | Initial value 01h.<br>+ Value increments with each all-layer change. |

**Name:** Status Register  
**Register:** 12h  
**Index:** Read

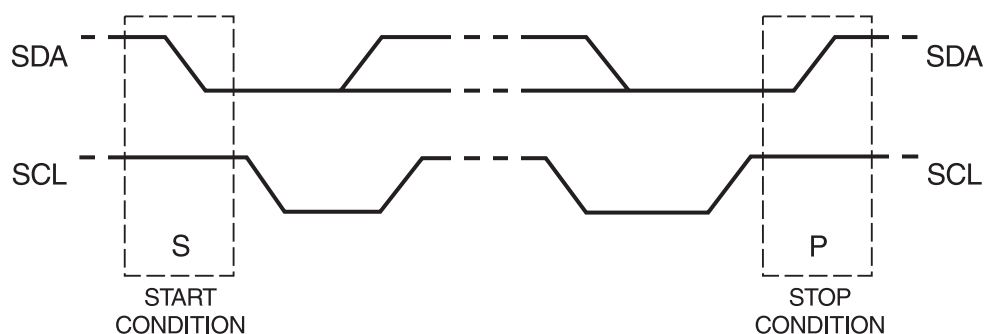
| Bit Name | Bit # | Reset Value | Description     |
|----------|-------|-------------|-----------------|
| DPA_Lock | 0     | N/A         | DPA Lock Status |
| PLL_Lock | 1     | N/A         | PLL Lock Status |
| Reserved | 2-7   | 0           | Reserved        |

| Bit | Name     | Description  |
|-----|----------|--|
| 0   | DPA_Lock | DPA Lock Status. (Refer to Register 0h, bits 6 and 7.)<br>0 = Unlocked<br>1 = Locked |
| 1   | PLL_Lock | PLL Lock Status. (Refer to Register 0h, bits 6 and 7.)<br>0 = Unlocked<br>1 = Locked |
| 2-7 | Reserved |  |

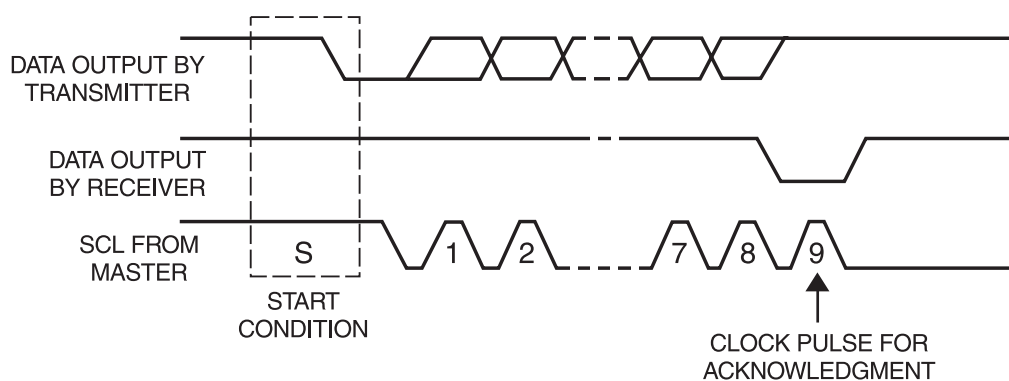
## I<sup>2</sup>C Data Characteristics



**Bit transfer on the I<sup>2</sup>C-bus**



**START and STOP conditions**

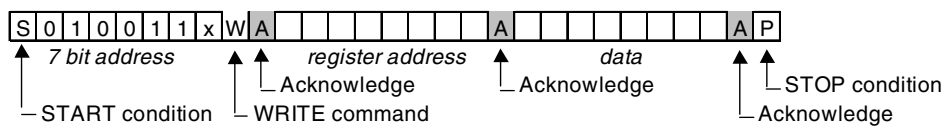


**Acknowledge on the I<sup>2</sup>C-bus**

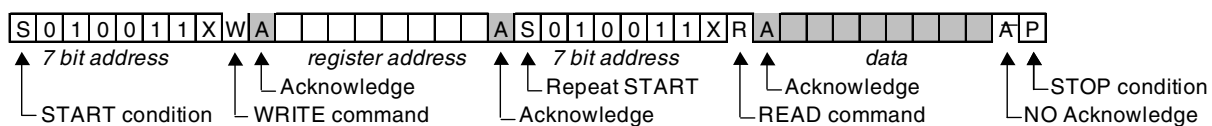
These waveforms are from "The I<sup>2</sup>C-bus and how to use it," published by Philips Semiconductor.  
The document can be obtained from [http://www-us2.semiconductors.philips.com/acrobat/various/i2c\\_bus\\_specification\\_1995.pdf](http://www-us2.semiconductors.philips.com/acrobat/various/i2c_bus_specification_1995.pdf)

## I<sup>2</sup>C Data Format

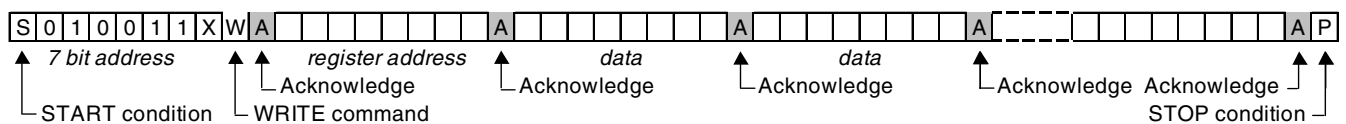
### RANDOM REGISTER WRITE PROCEDURE



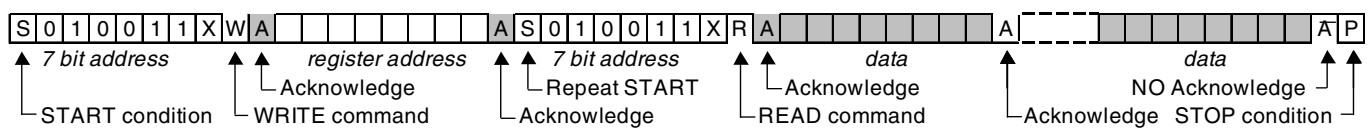
### RANDOM REGISTER READ PROCEDURE



### SEQUENTIAL REGISTER WRITE PROCEDURE



### SEQUENTIAL REGISTER READ PROCEDURE



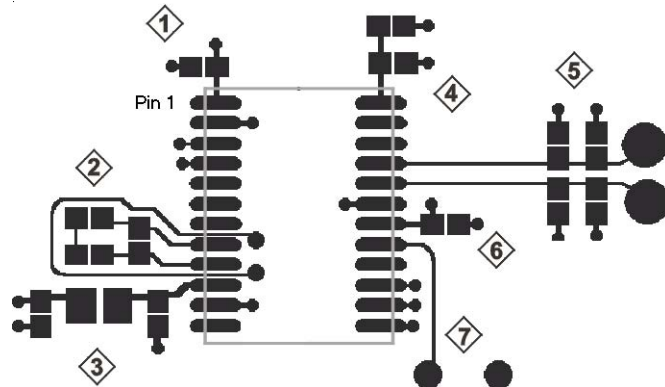
Direction: ☐ From bus host to device ☒ From device to bus host

Note:

1. All values are transmitted with the most-significant bit first and the least-significant bit last.
2. The value of the X bit equals the logic state of pin 13 (I<sup>2</sup>CADR).
3. R = READ = 1 and W = WRITE = 0

## General Layout Guidelines

- Use a PC board with at least four layers: one power, one ground, and two signal.
- Use at least one 4.7  $\mu\text{F}$  Tantalum (or similar) capacitor for global VDD bulk decoupling.
- All supply voltages must be supplied from a common source and must ramp together.
- Any flux or other board surface debris can degrade the performance of the external loop filter.
- Ensure that the 1524A area of the board is free of contaminants.



## Specific Layout Guidelines

- Digital Supply (VDD)** – Bypass pin 1 (VDD) to pin 2 (VSS) a 0.1- $\mu\text{F}$  capacitor, located as close as possible to the pins. A 0.01- $\mu\text{F}$  capacitor may be added for additional high frequency rejection.
- External Loop Filter** – **Strongly recommended in All Designs.** Locate loop filter components as close to pins 8 and 9 (EXTFIL and EXTFILRET) as possible with minimum length traces. Typical loop filter values are 6.8K Ohms for the series resistor, 3300 pF RF-type capacitor for the series capacitor, and 33 pF for the shunt capacitor. (For details, see the *Frequently Asked Questions* part of the *ICS1523 Applications Guide*, FAQ2 and FAQ3.) A ground isolated, surface trace can be useful to isolate this section from the rest of the board.
- Analog PLL Supply (VDDA)** – Decouple main VDD from pin 10 (VDDA) with a series ferrite bead. Bypass the supply end of the bead with 4.7- $\mu\text{F}$ . Bypass pin 10 to pin 11 (VSSA) with a 0.1- $\mu\text{F}$  capacitor. A 0.01- $\mu\text{F}$  capacitor may be added for additional high frequency rejection. Locate these components as close as possible to the pins.
- PECL Current Set Resistor** – Locate PECL current-set resistor as close as possible to pin 24 (IREF). Bypass pin 24 to ground with a 0.1- $\mu\text{F}$  capacitor.
- PECL Outputs** – Implement these outputs as microstrip transmission lines. The trace widths shown are for 75 Ohm characteristic impedance. Locate any optional series “snubbing” resistors as close as possible to the source pins. If the termination resistors are included on-board, locate them as close as possible to the load and connect directly to the power and ground planes.  
  
[These termination resistors are omitted if the load device implements them internally. For details, see the ICS application note on microstrip and striplines (1572AN1) and within the *ICS1523 Applications Guide*, the application note on *Designing a Custom Interface for the ICS1523* (1523AN4).]
- Output Driver Supply** – Bypass pin 18 (VDDQ) to pin 19 (VSSQ) with a 0.1- $\mu\text{F}$  capacitor, located as close as possible to the pins. A 0.01- $\mu\text{F}$  capacitor may be added for additional high frequency rejection.
- SSTL\_3 Outputs** – SSTL\_3 outputs can be used like conventional CMOS rail-to-rail logic or as a terminated transmission line system at higher-output frequencies. With terminated outputs, the considerations of item 5, “PECL Outputs” apply. See JEDEC documents JESD8-A and JESD8-8.

## PECL Outputs

For information on using the ICS1524A's PECL output pins, please refer to Application Note 4: Designing a Custom PECL Interface for the ICS1523

## SSTL\_3 Outputs

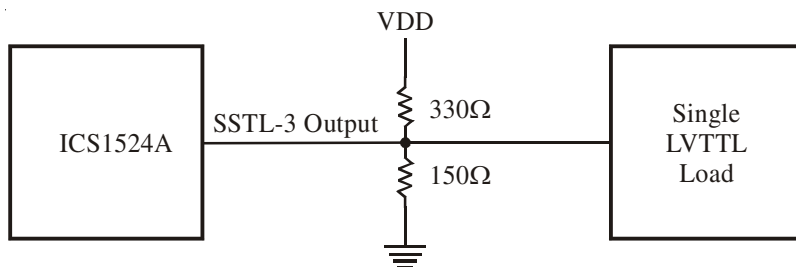
### Unterminated Outputs

In the ICS1524A, unterminated SSTL\_3 output pins display exponential transitions similar to those of rectangular pulses presented to RC loads. The 10-90% rise time is typically 1.6 ns, and the corresponding fall time is typically 700 ps. In turn, this asymmetry contributes to duty cycle asymmetry at higher output frequencies. In the absence of significant load capacitance (which can further increase rise and fall time), this asymmetry is the dominant factor determining high-frequency performance of these single-ended outputs. Typically, no termination is required either for the LOCK/REF, FUNC, and CLK/2 outputs or for CLK outputs up to approximately 135 MHz.

### Terminated Outputs

SSTL\_3 outputs are intended to terminate in low impedances to reduce the effect of external circuit capacitance. Use of transmission line techniques enables use of longer traces between source and driver without increasing ringing due to reflections. Where external capacitance is minimal and substantial voltage swing is required to meet LVTTTL  $V_{IH}$  and  $V_{OL}$  requirements, the intrinsic rise and fall times of ICS1524A SSTL outputs are only slightly improved by termination in a low impedance.

The ICS1524A SSTL output source impedance is typically less than 60 Ohms. Termination impedance of 100 Ohms reduces output swing by less than 30% which is more than enough to drive a single load of LVTTTL inputs.

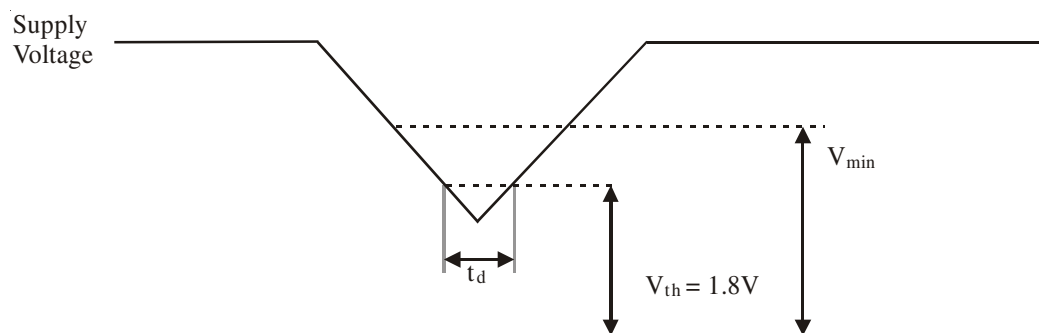


For more information on using the ICS1524A's SSTL output pins, please refer to Application Note 3: Using SSTL\_3 Outputs with CMOS or LVTTTL Inputs



## Power Supply Considerations

The ICS1524A incorporates special internal power-on reset circuitry that requires no external reset signal connection. The supply voltage (VDD) must remain within the recommended operating conditions during normal operation. To reset the ICS1524A, the supply voltage at the part must be reduced below the threshold voltage ( $V_{th}$ ) of the power-on reset circuit. The supply voltage must remain below that threshold voltage such that board power conditioning capacitors are drained and the proper reset state is latched. The amount of time ( $t_d$ ) to hold the voltage in a reset state varies with the design. However, a typical value of 10 ms should be sufficient.



## Absolute Maximum Ratings

|                                   |                            |
|-----------------------------------|----------------------------|
| VDD, VDDA, VDDQ (measured to VSS) | 4.3 V                      |
| Digital Inputs                    | VSS – 0.3V to 5.5V         |
| Analog Outputs                    | VSSA – 0.3V to VDDA + 0.3V |
| Digital Outputs                   | VSSQ – 0.3V to VDDQ + 0.3V |
| Storage Temperature               | –65°C to +150°C            |
| Junction Temperature              | 175°C                      |
| Soldering Temperature             | 260°C                      |
| ESD Susceptibility*               | > 2 KV                     |

(\*Electrostatic-sensitive devices. Do not open or handle except in a static-free workstation.)

## Recommended Operating Conditions

VDD, VDDQ, VDDA (measured to VSS) . 3.0 to 3.6 V

Operating Temperature (Ambient) . . . . . 0 to +70°C

### DC Supply Current

| PARAMETER                      | SYMBOL | CONDITIONS                              | MIN | MAX | UNITS |
|--------------------------------|--------|---|-----|-----|-------|
| Supply Current, Digital        | IDDD   | VDDD = 3.6V                             | —   | 25  | mA    |
| Supply Current, Output Drivers | IDDQ   | VDDQ = 3.6V, no output drivers enabled. | —   | 6   | mA    |
| Supply Current, Analog         | IDDA   | VDDA = 3.6V                             | —   | 5   | mA    |

### Digital Inputs (SDA, SCL, PDEN, EXTFB, HSYNC, OSC, I<sup>2</sup>CADR)

| PARAMETER          | SYMBOL | CONDITIONS            | MIN     | MAX  | UNITS |
|--------------------|--------|-----------------------|---------|------|-------|
| Input High Voltage | VIH    |                       | 2       | 5.5  | V     |
| Input Low Voltage  | VIL    |                       | VSS-0.3 | 0.8  | V     |
| Input Hysteresis   |        |                       | 0.2     | 0.6  | V     |
| Input High Current | IIH    | V <sub>IH</sub> = VDD | —       | ±10  | μA    |
| Input Low Current  | IIL    | V <sub>IL</sub> = 0   | —       | ±200 | μA    |
| Input Capacitance  | Cin    |                       | —       | 10   | pF    |

### SDA (In Output Mode: SDA is Bidirectional)

| PARAMETER          | SYMBOL | CONDITIONS  | MIN | MAX | UNITS |
|--------------------|--------|---|-----|-----|-------|
| Output Low Voltage | VOL    | IOUT = 3 mA. VOH = 6.0V maximum as determined by the external pull-up resistor. |     | 0.4 | V     |

### PECL Outputs (DPACLK+, DPACLK-, CLK+, CLK -)

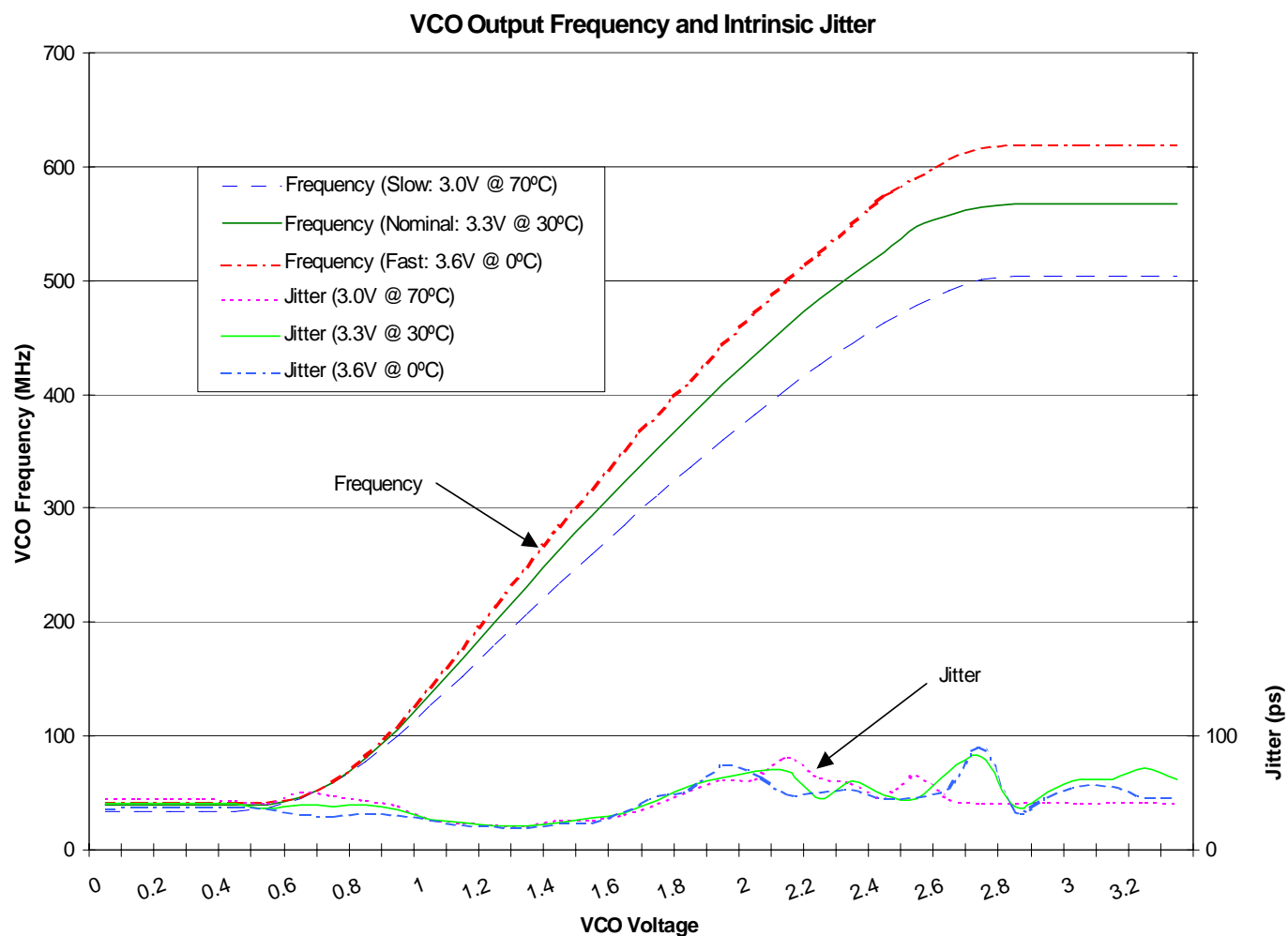
| PARAMETER   | SYMBOL | CONDITIONS              | MIN | MAX | UNITS |
|---|--------|-------------------------|-----|-----|-------|
| Output High Voltage   | VOH    | IOUT = 0                | —   | VDD | V     |
| Maximum Output Frequency  | Fp MAX | VDDD = 3.3V             | —   | 250 | MHz   |
| Output Low Voltage<br>(Note: VOL must not fall below the level given so that the correct value for IOUT can be maintained.) | VOL    | IOUT = programmed value | 1.0 | —   | V     |

### SSTL-3 Outputs (DPACLK, CLK, FUNC, LOCK/REF)

| PARAMETER                | SYMBOL | CONDITIONS              | MIN | MAX | UNITS |
|--------------------------|--------|-------------------------|-----|-----|-------|
| Output Resistance        | RO     | 1 < V <sub>O</sub> < 2V | —   | 80  | Ω     |
| Maximum Output Frequency | Fs MAX | VDDD = 3.3V             | —   | 150 | MHz   |

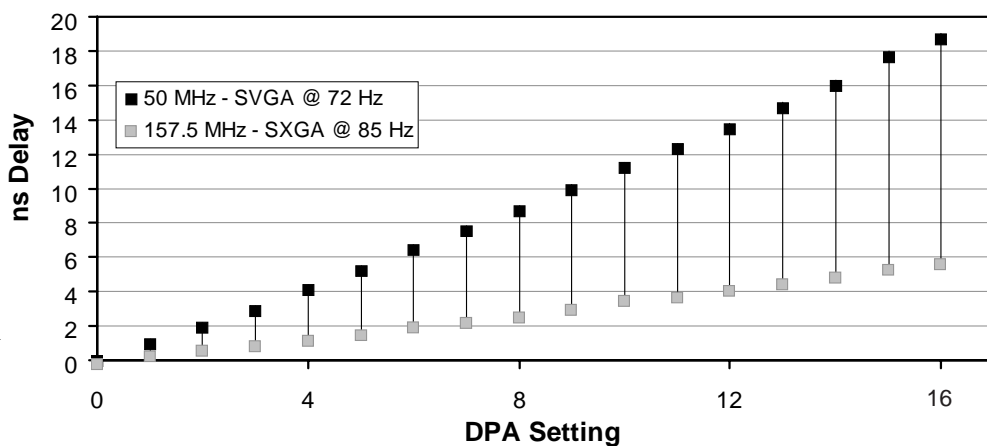
### AC Input Characteristics

| PARAMETER             | SYMBOL             | CONDITIONS | MIN  | MAX | UNITS |
|-----------------------|--------------------|------------|------|-----|-------|
| HSYNC Input Frequency | f <sub>HSYNC</sub> |            | .008 | 10  | MHz   |
| OSC Input Frequency   | f <sub>OSC</sub>   |            | .02  | 100 | MHz   |

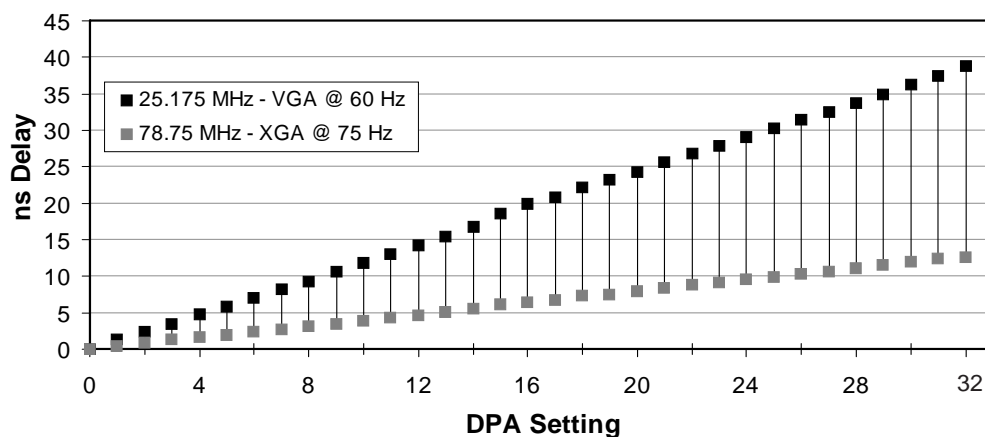


Note: Measured with an Externally Forced Filter Voltage

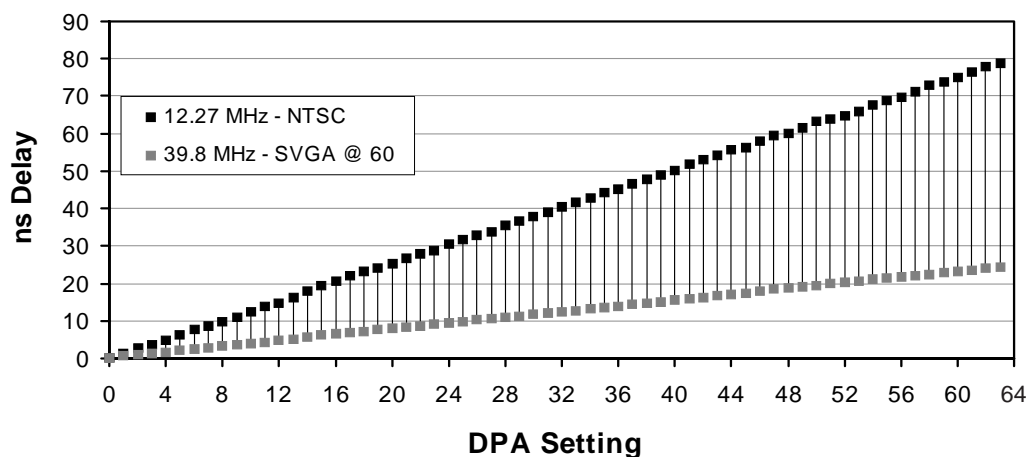
DPA Delay-16 Element Resolution



DPA Delay - 32 Element Resolution

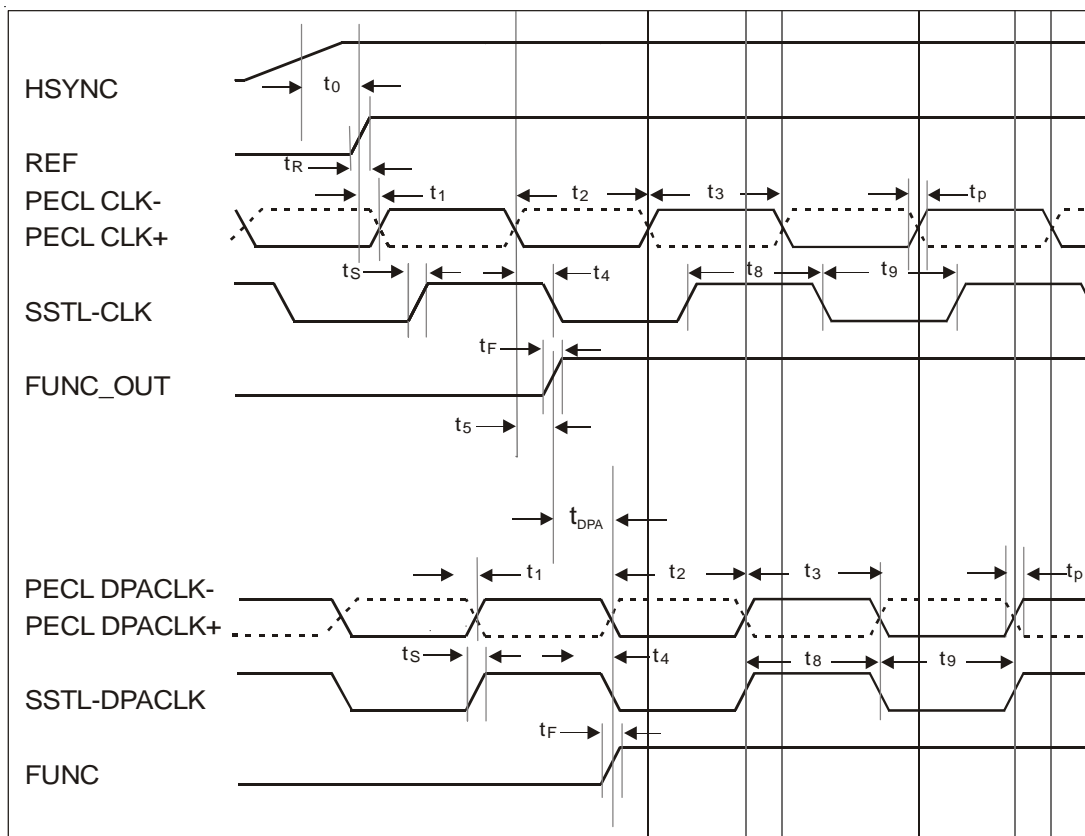


DPA Delay - 64 Element Resolution



Note:  
Maximum number of data points used for this graph.

Output Timing Diagram



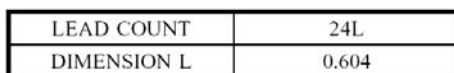
Typical Transition Times\*

| Symbol | Timing Description | Rise | Fall | Units |
|--------|--------------------|------|------|-------|
| $t_R$  | REF                | 2.8  | 1.8  | ns    |
| $t_P$  | PECL CLK           | 1.0  | 1.2  | ns    |
| $t_S$  | SSTL-CLK           | 1.6  | 0.7  | ns    |
| $t_F$  | FUNC_OUT           | 1.2  | 1.0  | ns    |

Output Timing\*

| Symbol     | Timing Description               | Min  | Typ  | Max | Units |
|------------|----------------------------------|------|------|-----|-------|
| $t_0$      | HSYNC to REF delay               | 11.3 | 11.5 | 12  | ns    |
| $t_1$      | REF to PECL clock delay          | -1.0 | 0.8  | 2.2 | ns    |
| $t_2, t_3$ | PECL clock duty cycle            | 45   | 50   | 55  | %     |
| $t_4$      | PECL clock to SSTL_3 clock delay | 0.2  | 0.75 | 1.2 | ns    |
| $t_5$      | PECL clock to FUNC_OUT delay     | 1.5  | 1.9  | 2.3 | ns    |
| $t_6$      | PECL clock to PECL/2 clock       | 1.0  | 1.3  | 1.5 | ns    |
| $t_7$      | PECL clock to SSTL_3-CLK/2 delay | 1.1  | 1.4  | 1.8 | ns    |
| $t_8, t_9$ | SSTL clock duty cycle            | 45   | 50   | 55  | %     |

\*Note: Measured at 3.6V 0°C, 135-MHz output frequency, PECL clock lines to 75  $\Omega$  termination, SSTL\_3 clock lines unterminated, 20-pF load. Transition times vary based on termination.



## Ordering Information

| Part/Order Number | Marking  | Package | Shipping      |
|-------------------|----------|---------|---------------|
| ICS1524AMLF       | 1524AMLF | SIOC-24 | Tubes         |
| ICS1524AMLFT      | 1524AMLF | SIOC-24 | Tape and Reel |

## NOTES





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