



## 3.3V ZERO DELAY CLOCK BUFFER, SPREAD SPECTRUM COMPATIBLE

**IDT23S09**

### FEATURES:

- Phase-Lock Loop Clock Distribution
- 10MHz to 133MHz operating frequency
- Distributes one clock input to one bank of five and one bank of four outputs
- Separate output enable for each output bank
- Output Skew < 250ps
- Low jitter < 200 ps cycle-to-cycle
- IDT23S09-1 for Standard Drive
- IDT23S09-1H for High Drive
- No external RC network required
- Operates at 3.3V V<sub>DD</sub>
- Spread spectrum compatible
- Available in SOIC and TSSOP packages

**NOTE: EOL for non-green parts to occur on 5/13/10 per PDNU-09-01**

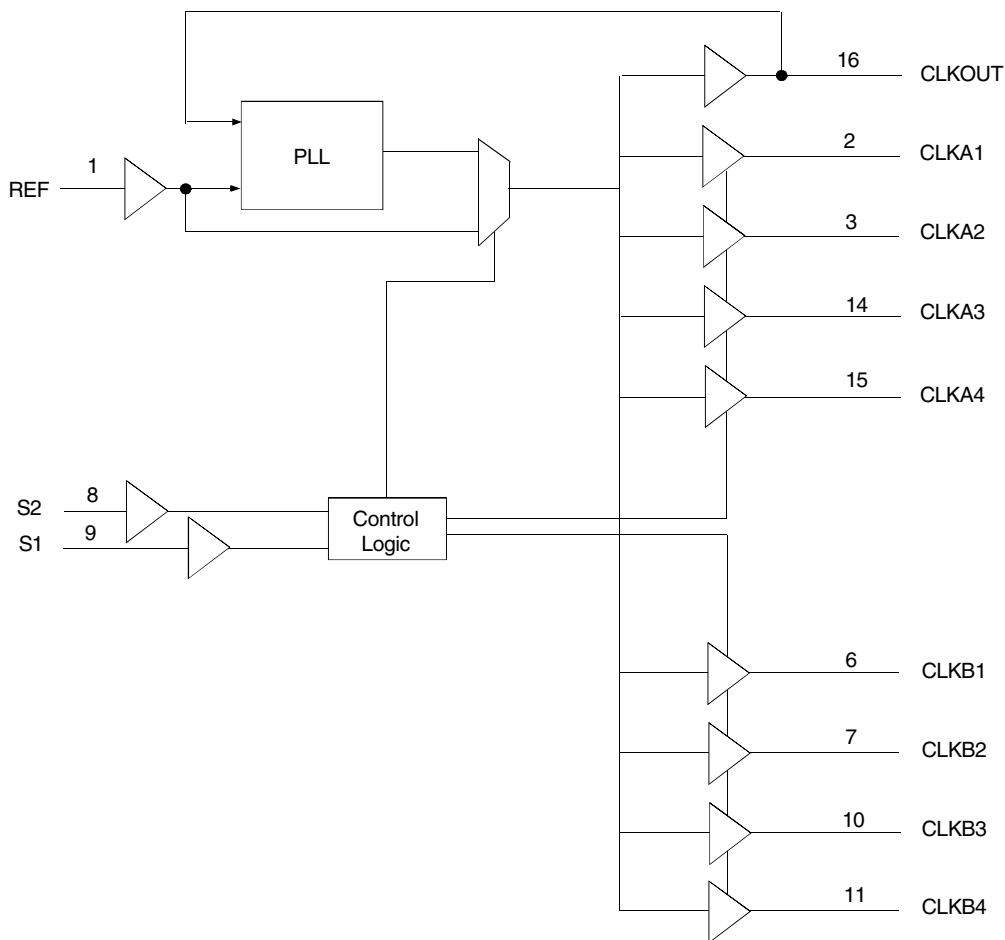
### DESCRIPTION:

The IDT23S09 is a high-speed phase-lock loop (PLL) clock buffer, designed to address high-speed clock distribution applications. The zero delay is achieved by aligning the phase between the incoming clock and the output clock, operable within the range of 10 to 133MHz.

The IDT23S09 is a 16-pin version of the IDT23S05. The IDT23S09 accepts one reference input, and drives two banks of four low skew clocks. The -1H version of this device operates up to 133MHz frequency and has higher drive than the -1 device. All parts have on-chip PLLs which lock to an input clock on the REF pin. The PLL feedback is on-chip and is obtained from the CLKOUT pad. In the absence of an input clock, the IDT23S09 enters power down. In this mode, the device will draw less than 12µA for Commercial Temperature range and less than 25µA for Industrial temperature range, and the outputs are tri-stated.

The IDT23S09 is characterized for both Industrial and Commercial operation.

### FUNCTIONAL BLOCK DIAGRAM

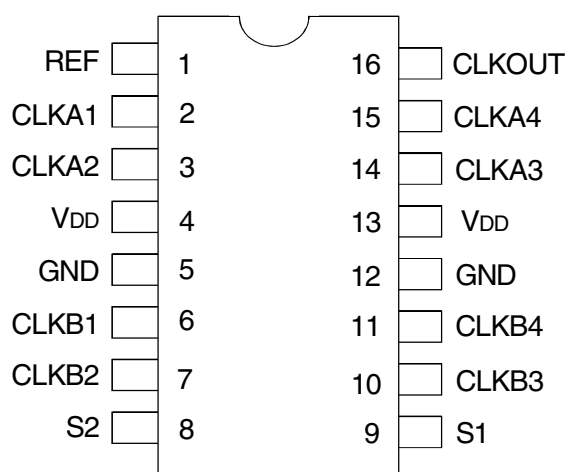


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COMMERCIAL AND INDUSTRIAL TEMPERATURE RANGES

AUGUST 2009

## PIN CONFIGURATION



SOIC/ TSSOP  
TOP VIEW

## APPLICATIONS:

- SDRAM
- Telecom
- Datacom
- PC Motherboards/Workstations
- Critical Path Delay Designs

## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

| Symbol                                                  | Rating                           | Max.                         | Unit |
|---------------------------------------------------------|----------------------------------|------------------------------|------|
| V <sub>DD</sub>                                         | Supply Voltage Range             | −0.5 to +4.6                 | V    |
| V <sub>I</sub> <sup>(2)</sup>                           | Input Voltage Range (REF)        | −0.5 to +5.5                 | V    |
| V <sub>I</sub>                                          | Input Voltage Range (except REF) | −0.5 to V <sub>DD</sub> +0.5 | V    |
| I <sub>IK</sub> (V <sub>I</sub> < 0)                    | Input Clamp Current              | −50                          | mA   |
| I <sub>O</sub> (V <sub>O</sub> = 0 to V <sub>DD</sub> ) | Continuous Output Current        | ±50                          | mA   |
| V <sub>DD</sub> or GND                                  | Continuous Current               | ±100                         | mA   |
| T <sub>A</sub> = 55°C (in still air) <sup>(3)</sup>     | Maximum Power Dissipation        | 0.7                          | W    |
| T <sub>STG</sub>                                        | Storage Temperature Range        | −65 to +150                  | °C   |
| Operating Temperature                                   | Commercial Temperature Range     | 0 to +70                     | °C   |
| Operating Temperature                                   | Industrial Temperature Range     | −40 to +85                   | °C   |

### NOTES:

1. Stresses greater than those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.
2. The input and output negative-voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
3. The maximum package power dissipation is calculated using a junction temperature of 150°C and a board trace length of 750 mils.

## PIN DESCRIPTION

| Pin Name              | Pin Number | Type | Functional Description                       |
|-----------------------|------------|------|----------------------------------------------|
| REF <sup>(1)</sup>    | 1          | IN   | Input reference clock, 5 Volt tolerant input |
| CLKA1 <sup>(2)</sup>  | 2          | Out  | Output clock for bank A                      |
| CLKA2 <sup>(2)</sup>  | 3          | Out  | Output clock for bank A                      |
| V <sub>DD</sub>       | 4, 13      | PWR  | 3.3V Supply                                  |
| GND                   | 5, 12      | GND  | Ground                                       |
| CLKB1 <sup>(2)</sup>  | 6          | Out  | Output clock for bank B                      |
| CLKB2 <sup>(2)</sup>  | 7          | Out  | Output clock for bank B                      |
| S2 <sup>(3)</sup>     | 8          | IN   | Select input Bit 2                           |
| S1 <sup>(3)</sup>     | 9          | IN   | Select input Bit 1                           |
| CLKB3 <sup>(2)</sup>  | 10         | Out  | Output clock for bank B                      |
| CLKB4 <sup>(2)</sup>  | 11         | Out  | Output clock for bank B                      |
| CLKA3 <sup>(2)</sup>  | 14         | Out  | Output clock for bank A                      |
| CLKA4 <sup>(2)</sup>  | 15         | Out  | Output clock for bank A                      |
| CLKOUT <sup>(2)</sup> | 16         | Out  | Output clock, internal feedback on this pin  |

### NOTES:

1. Weak pull down.
2. Weak pull down on all outputs.
3. Weak pull ups on these inputs.

## FUNCTION TABLE<sup>(1)</sup>

| S2 | S1 | CLKA      | CLKB      | CLKOUT <sup>(2)</sup> | Output Source | PLL Shut Down |
|----|----|-----------|-----------|-----------------------|---------------|---------------|
| L  | L  | Tri-State | Tri-State | Driven                | PLL           | N             |
| L  | H  | Driven    | Tri-State | Driven                | PLL           | N             |
| H  | L  | Driven    | Driven    | Driven                | REF           | Y             |
| H  | H  | Driven    | Driven    | Driven                | PLL           | N             |

### NOTES:

- H = HIGH Voltage Level.  
L = LOW Voltage Level
- This output is driven and has an internal feedback for the PLL. The load on this output can be adjusted to change the skew between the REF and the output.

## DC ELECTRICAL CHARACTERISTICS - COMMERCIAL

| Symbol             | Parameter                | Conditions                                                         |                               | Min. | Max. | Unit |
|--------------------|--------------------------|--------------------------------------------------------------------|-------------------------------|------|------|------|
| V <sub>IL</sub>    | Input LOW Voltage Level  |                                                                    |                               | —    | 0.8  | V    |
| V <sub>IH</sub>    | Input HIGH Voltage Level |                                                                    |                               | 2    | —    | V    |
| I <sub>IL</sub>    | Input LOW Current        | V <sub>IN</sub> = 0V                                               |                               | —    | 50   | μA   |
| I <sub>IH</sub>    | Input HIGH Current       | V <sub>IN</sub> = V <sub>DD</sub>                                  |                               | —    | 100  | μA   |
| V <sub>OL</sub>    | Output LOW Voltage       | Standard Drive                                                     | I <sub>OL</sub> = 8mA         | —    | 0.4  | V    |
|                    |                          | High Drive                                                         | I <sub>OL</sub> = 12mA (-1H)  |      |      |      |
| V <sub>OH</sub>    | Output HIGH Voltage      | Standard Drive                                                     | I <sub>OH</sub> = -8mA        | 2.4  | —    | V    |
|                    |                          | High Drive                                                         | I <sub>OH</sub> = -12mA (-1H) |      |      |      |
| I <sub>DD_PD</sub> | Power Down Current       | REF = 0MHz (S2 = S1 = H)                                           |                               | —    | 12   | μA   |
| I <sub>DD</sub>    | Supply Current           | Unloaded Outputs at 66.66MHz, SEL inputs at V <sub>DD</sub> or GND |                               | —    | 32   | mA   |

## OPERATING CONDITIONS - COMMERCIAL

| Symbol          | Parameter                                   | Min. | Max. | Unit |
|-----------------|---------------------------------------------|------|------|------|
| V <sub>DD</sub> | Supply Voltage                              | 3    | 3.6  | V    |
| T <sub>A</sub>  | Operating Temperature (Ambient Temperature) | 0    | 70   | °C   |
| C <sub>L</sub>  | Load Capacitance < 100MHz                   | —    | 30   | pF   |
|                 | Load Capacitance 100MHz - 133MHz            | —    | 10   |      |
| C <sub>IN</sub> | Input Capacitance                           | —    | 7    | pF   |

## SWITCHING CHARACTERISTICS (23S09-1) - COMMERCIAL<sup>(1,2)</sup>

| Symbol            | Parameter                                                   | Conditions                                                        | Min. | Typ. | Max. | Unit |
|-------------------|-------------------------------------------------------------|-------------------------------------------------------------------|------|------|------|------|
| t <sub>1</sub>    | Output Frequency                                            | 10pF Load                                                         | 10   | —    | 133  | MHz  |
|                   |                                                             | 30pF Load                                                         | 10   | —    | 100  |      |
|                   | Duty Cycle = t <sub>2</sub> ÷ t <sub>1</sub>                | Measured at 1.4V, F <sub>OUT</sub> = 66.66MHz                     | 40   | 50   | 60   | %    |
| t <sub>3</sub>    | Rise Time                                                   | Measured between 0.8V and 2V                                      | —    | —    | 2.5  | ns   |
| t <sub>4</sub>    | Fall Time                                                   | Measured between 0.8V and 2V                                      | —    | —    | 2.5  | ns   |
| t <sub>5</sub>    | Output to Output Skew                                       | All outputs equally loaded                                        | —    | —    | 250  | ps   |
| t <sub>6A</sub>   | Delay, REF Rising Edge to CLKOUT Rising Edge <sup>(2)</sup> | Measured at V <sub>DD</sub> /2                                    | —    | 0    | ±350 | ps   |
| t <sub>6B</sub>   | Delay, REF Rising Edge to CLKOUT Rising Edge <sup>(2)</sup> | Measured at V <sub>DD</sub> /2 in PLL bypass mode (IDT23S09 only) | 1    | 5    | 8.7  | ns   |
| t <sub>7</sub>    | Device-to-Device Skew                                       | Measured at V <sub>DD</sub> /2 on the CLKOUT pins of devices      | —    | 0    | 700  | ps   |
| t <sub>1</sub>    | Cycle-to-Cycle Jitter                                       | Measured at 66.66MHz, loaded outputs                              | —    | —    | 200  | ps   |
| t <sub>LOCK</sub> | PLL Lock Time                                               | Stable power supply, valid clock presented on REF pin             | —    | —    | 1    | ms   |

### NOTES:

- REF Input has a threshold voltage of V<sub>DD</sub>/2.
- All parameters specified with loaded outputs.

## SWITCHING CHARACTERISTICS (23S09-1H) - COMMERCIAL <sup>(1,2)</sup>

| Symbol            | Parameter                                    | Conditions                                                        | Min. | Typ. | Max. | Unit |
|-------------------|----------------------------------------------|-------------------------------------------------------------------|------|------|------|------|
| t <sub>f</sub>    | Output Frequency                             | 10pF Load                                                         | 10   | —    | 133  | MHz  |
|                   |                                              | 30pF Load                                                         | 10   | —    | 100  |      |
|                   | Duty Cycle = t <sub>2</sub> ÷ t <sub>1</sub> | Measured at 1.4V, F <sub>OUT</sub> = 66.66MHz                     | 40   | 50   | 60   | %    |
|                   | Duty Cycle = t <sub>2</sub> ÷ t <sub>1</sub> | Measured at 1.4V, F <sub>OUT</sub> < 50MHz                        | 45   | 50   | 55   | %    |
| t <sub>3</sub>    | Rise Time                                    | Measured between 0.8V and 2V                                      | —    | —    | 1.5  | ns   |
| t <sub>4</sub>    | Fall Time                                    | Measured between 0.8V and 2V                                      | —    | —    | 1.5  | ns   |
| t <sub>5</sub>    | Output to Output Skew                        | All outputs equally loaded                                        | —    | —    | 250  | ps   |
| t <sub>6A</sub>   | Delay, REF Rising Edge to CLKOUT Rising Edge | Measured at V <sub>DD</sub> /2                                    | —    | 0    | ±350 | ps   |
| t <sub>6B</sub>   | Delay, REF Rising Edge to CLKOUT Rising Edge | Measured at V <sub>DD</sub> /2 in PLL bypass mode (IDT23S09 only) | 1    | 5    | 8.7  | ns   |
| t <sub>7</sub>    | Device-to-Device Skew                        | Measured at V <sub>DD</sub> /2 on the CLKOUT pins of devices      | —    | 0    | 700  | ps   |
| t <sub>8</sub>    | Output Slew Rate                             | Measured between 0.8V and 2V using Test Circuit 2                 | 1    | —    | —    | V/ns |
| t <sub>j</sub>    | Cycle-to-Cycle Jitter                        | Measured at 66.66MHz, loaded outputs                              | —    | —    | 200  | ps   |
| t <sub>LOCK</sub> | PLL Lock Time                                | Stable power supply, valid clock presented on REF pin             | —    | —    | 1    | ms   |

### NOTES:

1. REF Input has a threshold voltage of V<sub>DD</sub>/2.
2. All parameters specified with loaded outputs.

## DC ELECTRICAL CHARACTERISTICS - INDUSTRIAL

| Symbol             | Parameter                | Conditions                                                         | Min. | Max. | Unit |
|--------------------|--------------------------|--------------------------------------------------------------------|------|------|------|
| V <sub>IL</sub>    | Input LOW Voltage Level  |                                                                    | —    | 0.8  | V    |
| V <sub>IH</sub>    | Input HIGH Voltage Level |                                                                    | 2    | —    | V    |
| I <sub>IL</sub>    | Input LOW Current        | V <sub>IN</sub> = 0V                                               | —    | 50   | μA   |
| I <sub>IH</sub>    | Input HIGH Current       | V <sub>IN</sub> = V <sub>DD</sub>                                  | —    | 100  | μA   |
| V <sub>OL</sub>    | Output LOW Voltage       | Standard Drive                                                     | —    | 0.4  | V    |
|                    |                          | High Drive                                                         |      |      |      |
| V <sub>OH</sub>    | Output HIGH Voltage      | Standard Drive                                                     | 2.4  | —    | V    |
|                    |                          | High Drive                                                         |      |      |      |
| I <sub>DD_PD</sub> | Power Down Current       | REF = 0MHz (S2 = S1 = H)                                           | —    | 25   | μA   |
| I <sub>DD</sub>    | Supply Current           | Unloaded Outputs at 66.66MHz, SEL inputs at V <sub>DD</sub> or GND | —    | 35   | mA   |

## OPERATING CONDITIONS - INDUSTRIAL

| Symbol          | Parameter                                   | Min. | Max. | Unit |
|-----------------|---------------------------------------------|------|------|------|
| V <sub>DD</sub> | Supply Voltage                              | 3    | 3.6  | V    |
| T <sub>A</sub>  | Operating Temperature (Ambient Temperature) | -40  | +85  | °C   |
| C <sub>L</sub>  | Load Capacitance < 100MHz                   | —    | 30   | pF   |
|                 | Load Capacitance 100MHz - 133MHz            | —    | 10   |      |
| C <sub>IN</sub> | Input Capacitance                           | —    | 7    | pF   |

## SWITCHING CHARACTERISTICS (23S09-1) - INDUSTRIAL <sup>(1,2)</sup>

| Symbol            | Parameter                                    | Conditions                                                        | Min. | Typ. | Max. | Unit |
|-------------------|----------------------------------------------|-------------------------------------------------------------------|------|------|------|------|
| t <sub>f</sub>    | Output Frequency                             | 10pF Load                                                         | 10   | —    | 133  | MHz  |
|                   |                                              | 30pF Load                                                         | 10   | —    | 100  |      |
|                   | Duty Cycle = t <sub>2</sub> ÷ t <sub>1</sub> | Measured at 1.4V, F <sub>OUT</sub> = 66.66MHz                     | 40   | 50   | 60   | %    |
| t <sub>3</sub>    | Rise Time                                    | Measured between 0.8V and 2V                                      | —    | —    | 2.5  | ns   |
| t <sub>4</sub>    | Fall Time                                    | Measured between 0.8V and 2V                                      | —    | —    | 2.5  | ns   |
| t <sub>5</sub>    | Output to Output Skew                        | All outputs equally loaded                                        | —    | —    | 250  | ps   |
| t <sub>6A</sub>   | Delay, REF Rising Edge to CLKOUT Rising Edge | Measured at V <sub>DD</sub> /2                                    | —    | 0    | ±350 | ps   |
| t <sub>6B</sub>   | Delay, REF Rising Edge to CLKOUT Rising Edge | Measured at V <sub>DD</sub> /2 in PLL bypass mode (IDT23S09 only) | 1    | 5    | 8.7  | ns   |
| t <sub>7</sub>    | Device-to-Device Skew                        | Measured at V <sub>DD</sub> /2 on the CLKOUT pins of devices      | —    | 0    | 700  | ps   |
| t <sub>j</sub>    | Cycle-to-Cycle Jitter                        | Measured at 66.66MHz, loaded outputs                              | —    | —    | 200  | ps   |
| t <sub>LOCK</sub> | PLL Lock Time                                | Stable power supply, valid clock presented on REF pin             | —    | —    | 1    | ms   |

### NOTES:

1. REF Input has a threshold voltage of V<sub>DD</sub>/2.
2. All parameters specified with loaded outputs.

## SWITCHING CHARACTERISTICS (23S09-1H) - INDUSTRIAL <sup>(1,2)</sup>

| Symbol            | Parameter                                    | Conditions                                                        | Min. | Typ. | Max. | Unit |
|-------------------|----------------------------------------------|-------------------------------------------------------------------|------|------|------|------|
| t <sub>f</sub>    | Output Frequency                             | 10pF Load                                                         | 10   | —    | 133  | MHz  |
|                   |                                              | 30pF Load                                                         | 10   | —    | 100  |      |
|                   | Duty Cycle = t <sub>2</sub> ÷ t <sub>1</sub> | Measured at 1.4V, F <sub>OUT</sub> = 66.66MHz                     | 40   | 50   | 60   | %    |
|                   | Duty Cycle = t <sub>2</sub> ÷ t <sub>1</sub> | Measured at 1.4V, F <sub>OUT</sub> < 50MHz                        | 45   | 50   | 55   | %    |
| t <sub>3</sub>    | Rise Time                                    | Measured between 0.8V and 2V                                      | —    | —    | 1.5  | ns   |
| t <sub>4</sub>    | Fall Time                                    | Measured between 0.8V and 2V                                      | —    | —    | 1.5  | ns   |
| t <sub>5</sub>    | Output to Output Skew                        | All outputs equally loaded                                        | —    | —    | 250  | ps   |
| t <sub>6A</sub>   | Delay, REF Rising Edge to CLKOUT Rising Edge | Measured at V <sub>DD</sub> /2                                    | —    | 0    | ±350 | ps   |
| t <sub>6B</sub>   | Delay, REF Rising Edge to CLKOUT Rising Edge | Measured at V <sub>DD</sub> /2 in PLL bypass mode (IDT23S09 only) | 1    | 5    | 8.7  | ns   |
| t <sub>7</sub>    | Device-to-Device Skew                        | Measured at V <sub>DD</sub> /2 on the CLKOUT pins of devices      | —    | 0    | 700  | ps   |
| t <sub>8</sub>    | Output Slew Rate                             | Measured between 0.8V and 2V using Test Circuit 2                 | 1    | —    | —    | V/ns |
| t <sub>j</sub>    | Cycle-to-Cycle Jitter                        | Measured at 66.66MHz, loaded outputs                              | —    | —    | 200  | ps   |
| t <sub>LOCK</sub> | PLL Lock Time                                | Stable power supply, valid clock presented on REF pin             | —    | —    | 1    | ms   |

### NOTES:

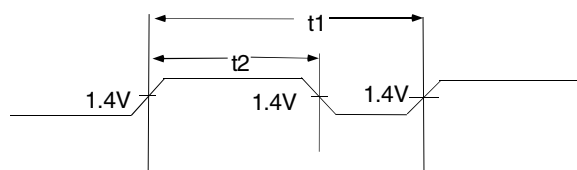
1. REF Input has a threshold voltage of V<sub>DD</sub>/2.
2. All parameters specified with loaded outputs.

## ZERO DELAY AND SKEW CONTROL

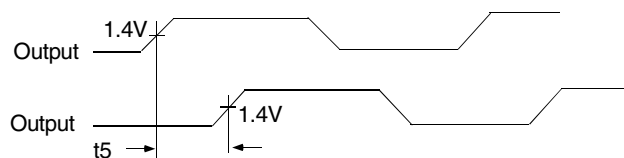
All outputs should be uniformly loaded in order to achieve Zero I/O Delay. Since the CLKOUT pin is the internal feedback for the PLL, its relative loading can affect and adjust the input/output delay. The Output Load Difference diagram illustrates the PLL's relative loading with respect to the other outputs that can adjust the Input-Output (I/O) Delay.

For designs utilizing zero I/O Delay, all outputs including CLKOUT must be equally loaded. Even if the output is not used, it must have a capacitive load equal to that on the other outputs in order to obtain true zero I/O Delay. For zero output-to-output skew, all outputs must be loaded equally.

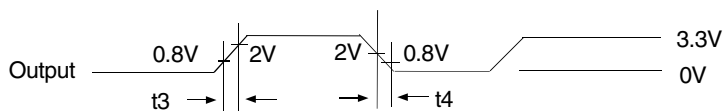
## SWITCHING WAVEFORMS



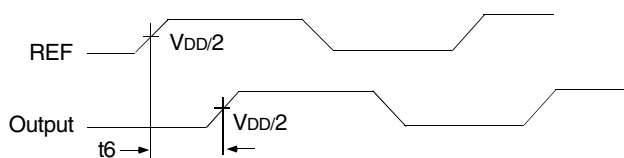
*Duty Cycle Timing*



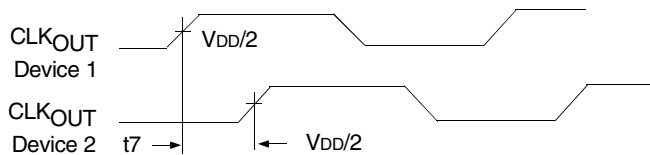
*Output to Output Skew*



*All Outputs Rise/Fall Time*

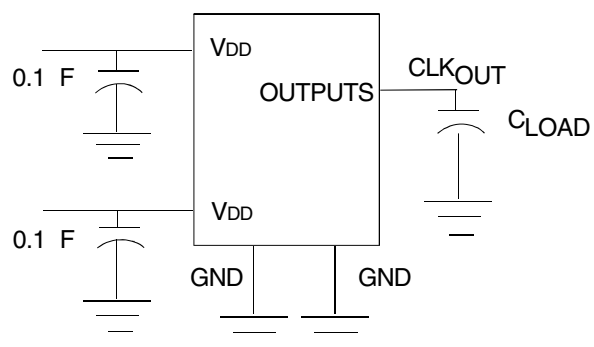


*Input to Output Propagation Delay*

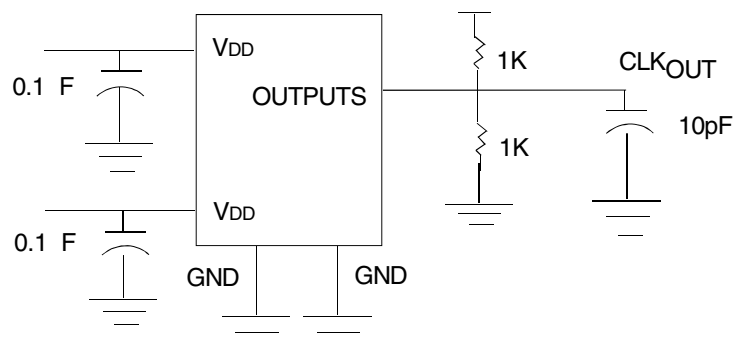


*Device to Device Skew*

## TEST CIRCUITS



*Test Circuit 1 (all Parameters Except  $t_8$ )*



*Test Circuit 2 ( $t_8$ , Output Slew Rate On -1H Devices)*

## ORDERING INFORMATION

| IDT | XXXXX       | XX      | X       |          |                                          |
|-----|-------------|---------|---------|----------|------------------------------------------|
|     | Device Type | Package | Process |          |                                          |
|     |             |         |         | Blank    | Commercial (0°C to +70°C)                |
|     |             |         |         | I        | Industrial (-40°C to +85°C)              |
|     |             |         |         | DC       | Small Outline                            |
|     |             |         |         | DCG      | SOIC - Green                             |
|     |             |         |         | PG       | Thin Shrink Small Outline Package        |
|     |             |         |         | PGG      | TSSOP - Green                            |
|     |             |         |         | 23S09-1  | Zero Delay Clock Buffer with High Drive, |
|     |             |         |         | 23S09-1H | Spread Spectrum Compatible               |

**\*NOTE: EOL for non-green parts to occur on 5/13/10 per PDNU-09-01**

| Part / Order Number | Shipping Packaging | Package      | Temperature    |
|---------------------|--------------------|--------------|----------------|
| 23S09-1DC*          | Tubes              | 16-pin SOIC  | 0° to +70° C   |
| 23S09-1DC8*         | Tape and Reel      | 16-pin SOIC  | 0° to +70° C   |
| 23S09-1DCI*         | Tubes              | 16-pin SOIC  | -40° to +85° C |
| 23S09-1DCI8*        | Tape and Reel      | 16-pin SOIC  | -40° to +85° C |
| 23S09-1HDC*         | Tubes              | 16-pin SOIC  | 0° to +70° C   |
| 23S09-1HDC8*        | Tape and Reel      | 16-pin SOIC  | 0° to +70° C   |
| 23S09-1HDCI*        | Tubes              | 16-pin SOIC  | -40° to +85° C |
| 23S09-1HDCI8*       | Tape and Reel      | 16-pin SOIC  | -40° to +85° C |
| 23S09-1HPG*         | Tubes              | 16-pin TSSOP | 0° to +70° C   |
| 23S09-1HPG8*        | Tape and Reel      | 16-pin TSSOP | 0° to +70° C   |
| 23S09-1HPGI*        | Tubes              | 16-pin TSSOP | -40° to +85° C |
| 23S09-1HPGI8*       | Tape and Reel      | 16-pin TSSOP | -40° to +85° C |
| 23S09-1DCG          | Tubes              | 16-pin SOIC  | 0° to +70° C   |
| 23S09-1DCG8         | Tape and Reel      | 16-pin SOIC  | 0° to +70° C   |
| 23S09-1DCGI         | Tubes              | 16-pin SOIC  | -40° to +85° C |
| 23S09-1DCGI8        | Tape and Reel      | 16-pin SOIC  | -40° to +85° C |
| 23S09-1HDCG         | Tubes              | 16-pin SOIC  | 0° to +70° C   |
| 23S09-1HDCG8        | Tape and Reel      | 16-pin SOIC  | 0° to +70° C   |
| 23S09-1HDCGI        | Tubes              | 16-pin SOIC  | -40° to +85° C |
| 23S09-1HDCGI8       | Tape and Reel      | 16-pin SOIC  | -40° to +85° C |
| 23S09-1HPGG         | Tubes              | 16-pin TSSOP | 0° to +70° C   |
| 23S09-1HPGG8        | Tape and Reel      | 16-pin TSSOP | 0° to +70° C   |
| 23S09-1HPGGI        | Tubes              | 16-pin TSSOP | -40° to +85° C |
| 23S09-1HPGGI8       | Tape and Reel      | 16-pin TSSOP | -40° to +85° C |



**CORPORATE HEADQUARTERS**  
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