

## LCK4993/LCK4994 Low-Voltage PLL Clock Drivers

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### 1 Features

- 12 MHz—100 MHz (LCK4993), or 24 MHz—200 MHz (LCK4994) output operation
- Matched pair output skew <200 ps
- Zero input-to-output delay
- 18 LVTTTL 50% duty-cycle outputs capable of driving 50  $\Omega$  terminated lines
- 3.3 V/2.5 V LVTTTL/LV differential (LVPECL) fault tolerant and hot insertable reference inputs
- Phase adjustments from 625 ps up to 1300 ps steps up to  $\pm 10.4$  ns
- Output divide ratios of (1—6, 8, 10, 12)
- Multiply ratios of (1—6, 8) x input frequency
- Individual output bank disable for aggressive power management and EMI reduction
- Output high-impedance (HI-Z) option for testing purposes
- Fully integrated PLL with lock indicator
- Single 3.3 V/2.5 V  $\pm 10\%$  supply
- 100-pin TQFP package
- 100-ball FSBGA package
- Pin-for-pin compatible with CYPRESS® CY7B993V and CY7B994V

### 2 Description

The LCK4993 and LCK4994 low-voltage PLL clock drivers offer user-selectable control over system clock functions. The multiple-output clock drivers provide the system integrator with functions necessary to optimize the timing of high-performance computer and communication systems.

Each of the eighteen configurable outputs drive terminated transmission lines with impedances as low as 50  $\Omega$  while delivering minimal and specified output skews at LVTTTL levels. The outputs are arranged in five banks. Banks 1—4 allow a divide function of 1 to 12, while simultaneously allowing phase adjustments in 625 ps—1300 ps increments up to 10.4 ns. One of the output banks also includes an independent clock invert function. The feedback bank consists of two outputs that allow divide-by functionality from 1 to 12 and limited phase adjustments. Any one of these eighteen outputs can be connected to the feedback input or drive other inputs.

Selectable reference input is a fault tolerance feature that allows smooth change over to the secondary clock source when the primary clock source is not in operation. The reference inputs and feedback inputs are configurable to accommodate both LVTTTL or differential (LVPECL) inputs. The completely integrated PLL reduces jitter and simplifies board layout.

## Table of Contents

| Contents   | Page |
|--|------|
| 1 Features .....   | 1    |
| 2 Description .....  | 1    |
| 3 Functional Block Diagram .....                           | 3    |
| 4 Pin Information .....                                    | 4    |
| 4.1 100-Pin TQFP Diagram .....                             | 4    |
| 4.2 Pin Descriptions .....                                 | 5    |
| 5 Functional Description .....                             | 7    |
| 5.1 Phase Frequency Detector and Filter .....              | 7    |
| 5.2 VCO, Control Logic, Divider, and Phase Generator ..... | 7    |
| 5.3 Time Unit Definition .....                             | 7    |
| 5.4 Divide and Phase Select Matrix .....                   | 8    |
| 5.5 Timing Relationship of Programmable Skew Outputs ..... | 9    |
| 5.6 Output Disable Description .....                       | 10   |
| 5.7 INV3 Pin Function .....                                | 10   |
| 5.8 Lock Detect Output Description .....                   | 10   |
| 5.9 Factory Test Mode Description .....                    | 11   |
| 5.9.1 Factory Test Reset .....                             | 11   |
| 5.10 Absolute Maximum Ratings .....                        | 11   |
| 5.11 Handling Precautions .....                            | 12   |
| 5.12 Thermal Parameters (Definitions and Values) .....     | 12   |
| 6 Electrical Characteristics .....                         | 14   |
| 7 Timing .....   | 18   |
| 7.1 Switching Characteristics .....                        | 18   |
| 7.2 ac Test Loads and Waveforms .....                      | 21   |
| 7.3 ac Timing Diagrams .....                               | 22   |
| 8 Outline Diagrams .....                                   | 23   |
| 8.1 100-Pin TQFP .....                                     | 23   |
| 8.2 100-Ball FSBGA .....                                   | 24   |
| 9 Ordering Information .....                               | 25   |

## Tables

|  |    |
|--|----|
| Table 4-1. 100-Pin FSBGA Pin Assignments .....                                       | 4  |
| Table 4-2. 100-Pin TQFP Descriptions .....   | 5  |
| Table 5-1. Frequency Range Select .....  | 7  |
| Table 5-2. N Factor Determination .....  | 7  |
| Table 5-3. Output Skew Select Function .....   | 8  |
| Table 5-4. Output Divider Function .....   | 8  |
| Table 5-5. DIS[1:4]/FBDIS Pin Functionality .....                                    | 10 |
| Table 5-6. Factory Test Mode Frequency Divide Select .....                           | 11 |
| Table 5-7. Absolute Maximum Ratings .....  | 11 |
| Table 5-8. Handling Precautions .....  | 12 |
| Table 5-9. Thermal Parameter Values .....  | 13 |
| Table 6-1. Electrical Characteristics (TA –40 °C to +85 °C, VDD = 3.3 V ± 10%) ..... | 14 |
| Table 6-2. Electrical Characteristics (TA –40 °C to +85 °C, VDD = 2.5 V ± 10%) ..... | 16 |
| Table 7-1. Switching Characteristics (TA –40 °C to +85 °C, VDD = 3.3 V ± 10%) .....  | 18 |
| Table 7-2. Switching Characteristics (TA –40 °C to +85 °C, VDD = 2.5 V ± 10%) .....  | 20 |
| Table 9-1. LCK4993 Ordering Information .....  | 25 |
| Table 9-2. LCK4994 Ordering Information .....  | 25 |

## Figures

|   |    |
|---|----|
| Figure 3-1. LCK4993 and LCK4994 Functional Block Diagram .....            | 3  |
| Figure 4-1. 100-Pin TQFP Package (Top View) .....                         | 4  |
| Figure 5-1. Typical Outputs with FB Connected to a Zero-Skew Output ..... | 9  |
| Figure 7-1. ac Test Loads and Waveforms .....                             | 21 |
| Figure 7-2. ac Timing Diagrams .....                                      | 22 |

### 3 Functional Block Diagram

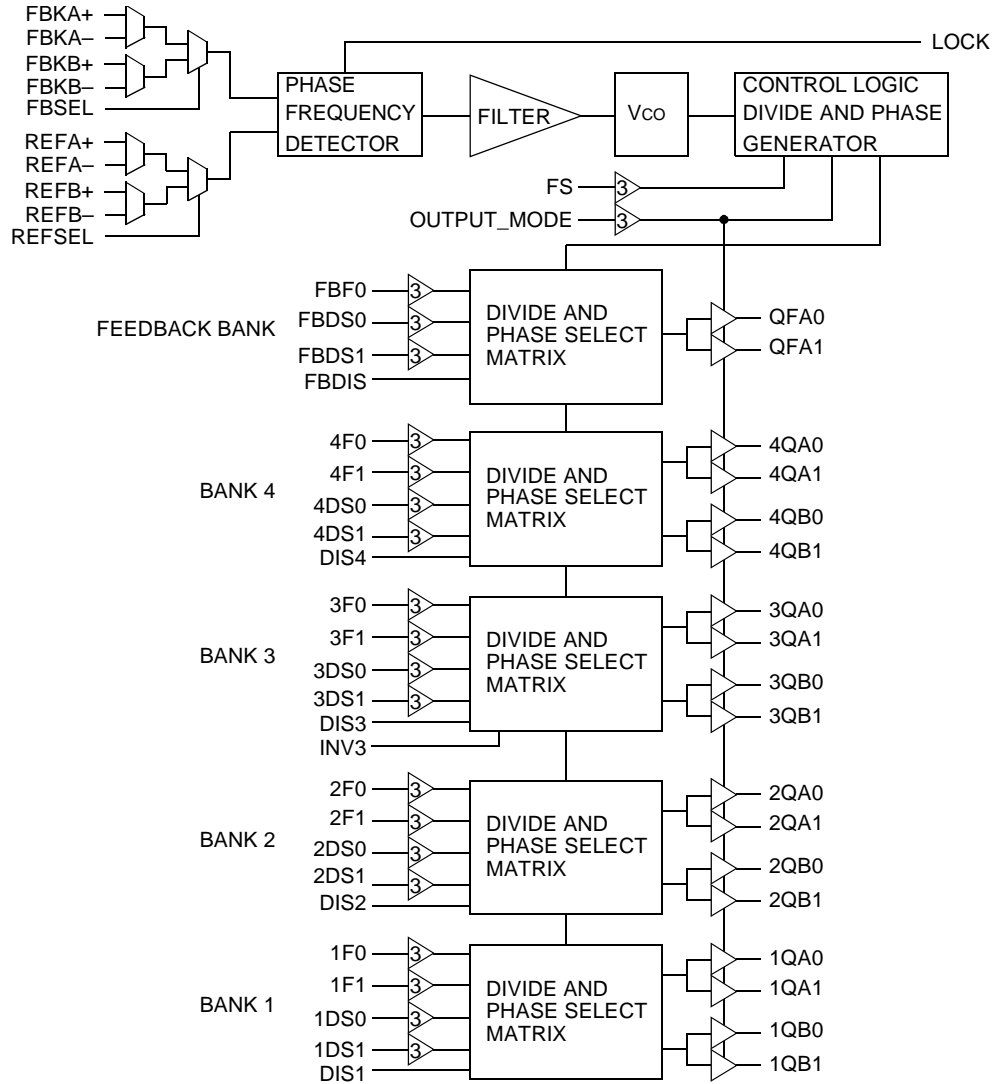
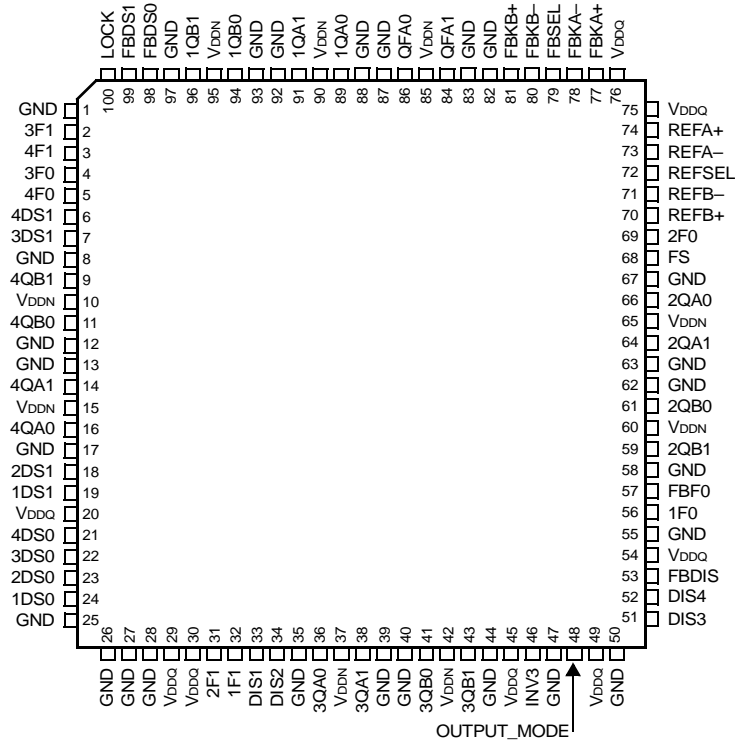


Figure 3-1. LCK4993 and LCK4994 Functional Block Diagram

## 4 Pin Information

### 4.1 100-Pin TQFP Diagram



5-8885 (F) r.1

Figure 4-1. 100-Pin TQFP Package (Top View)

Table 4-1. 100-Pin FSBGA Pin Assignments

|          | 1    | 2    | 3    | 4    | 5     | 6     | 7     | 8               | 9      | 10    |
|----------|------|------|------|------|-------|-------|-------|-----------------|--------|-------|
| <b>A</b> | 1QB1 | 1QB0 | 1QA1 | 1QA0 | QFA0  | QFA1  | FBKB+ | VDDQ            | FBKA-  | FBKA+ |
| <b>B</b> | VDDN | VDDN | VDDN | VDDN | VDDN  | VDDN  | VDDQ  | FBKB-           | FBSEL  | REFA+ |
| <b>C</b> | GND  | GND  | GND  | GND  | GND   | GND   | VDDQ  | GND             | GND    | REFA- |
| <b>D</b> | LOCK | 4F0  | 3F1  | GND  | FBDS1 | FBDS0 | 2F0   | VDDQ            | REFSEL | REFB- |
| <b>E</b> | 4QB1 | VDDN | 4DS1 | GND  | 3F0   | 4F1   | GND   | FS              | VDDN   | REFB+ |
| <b>F</b> | 4QB0 | VDDN | 3DS1 | GND  | GND   | GND   | GND   | FBF0            | VDDN   | 2QA0  |
| <b>G</b> | 4QA1 | 2DS1 | VDDQ | GND  | GND   | GND   | GND   | VDDQ            | 1F0    | 2QA1  |
| <b>H</b> | 4QA0 | 1DS1 | 1DS0 | VDDQ | GND   | GND   | VDDQ  | OUTPUT_<br>MODE | FBDIS  | 2QB0  |
| <b>J</b> | 4DS0 | 3DS0 | 2DS0 | DIS1 | VDDN  | VDDN  | GND   | INV3            | DIS3   | 2QB1  |
| <b>K</b> | 2F1  | 1F1  | DIS2 | VDDN | 3QA0  | 3QA1  | GND   | 3QB0            | 3QB1   | DIS4  |

## 4.2 Pin Descriptions

For all 3-state inputs, low indicates a connection to GND, mid indicates an open connection, and high indicates a connection to VDD. Internal termination circuitry holds an unconnected input to VDD/2.

**Table 4-2. 100-Pin TQFP Descriptions**

| Pin   | Symbol                     | Type             | I/O            | Description  |
|---|----------------------------|------------------|----------------|--|
| 1, 8, 12, 13, 17, 25—28, 35, 39, 40, 44, 47, 50, 55, 58, 62, 63, 67, 82, 83, 87, 88, 92, 93, 97 | GND                        | Power            | —              | <b>Ground.</b>   |
| 2—5, 31, 32, 56, 69   | [1:4]F[0:1]                | 3-Level Input    | I              | <b>Output Phase Function Select.</b> Each pair controls the phase function of the respective bank of outputs, see <a href="#">Table 5-3</a> .  |
| 6, 7, 18, 19, 21—24   | [1:4]DS[0:1]               | 3-Level Input    | I              | <b>Output Divider Function Select.</b> Each pair controls the divide function of the respective bank of outputs, see <a href="#">Table 5-4</a> .   |
| 9, 11, 14, 16, 36, 38, 41, 43, 59, 61, 64, 66, 89, 91, 94, 96                                   | [1:4]Q[A:B][0:1]           | LVTTL            | O              | <b>Clock Output.</b> These outputs provide numerous divide and phase select functions determined by the [1:4]DS[0:1] and [1:4]F[0:1] inputs.   |
| 10, 15, 37, 42, 60, 65, 85, 90, 95  | VDDN                       | Power            | —              | <b>Output Buffer Power.</b> Power supply for each output pair.   |
| 20, 29, 30, 45, 49, 54, 75, 76  | VDDQ                       | Power            | —              | <b>Internal Power.</b> Power supply for the internal circuitry.  |
| 33, 34, 51, 52  | DIS[1:4]                   | LVTTL            | I <sup>d</sup> | <b>Output Disable.</b> Each input controls the state of the respective output bank.<br>Low = the [1:4]Q[A:B][0:1] is enabled, see <a href="#">Table 5-5</a> .<br>High = the output bank is disabled to the hold-off or HI-Z state; the disable state is determined by OUTPUT_MODE. |
| 46  | INV3                       | 3-Level Input    | I              | <b>Invert Mode.</b> This input only affects Bank3.<br>Low = each matched output pair will become complementary (3QA0+, 3QA1–, 3QB0+, 3QB1–).<br>Mid = all four outputs will be noninverting.<br>High = all four outputs in the same bank will be inverted.                         |
| 48  | OUTPUT_MODE                | 3-Level Input    | I              | <b>Output Mode.</b> This pin determines the clock outputs' disable state.<br>Low = the clock outputs will disable to hold-off mode.<br>Mid = the device enters factory test mode.<br>High = the clock outputs will disable to HI-Z.  |
| 53  | FBDIS                      | LVTTL            | I <sup>d</sup> | <b>Feedback Disable.</b> This input controls the state of QFA[0:1].<br>Low = the QFA[0:1] is enabled, see <a href="#">Table 5-5</a> .<br>High = the QFA[0:1] is disabled to the hold-off or HI-Z state; the disable state is determined by OUTPUT_MODE.                            |
| 57  | FBF0                       | 3-Level Input    | I              | <b>Feedback Output Phase Function Select.</b> This input determines the phase function of the feedback banks QFA[0:1] outputs, see <a href="#">Table 5-3</a> .   |
| 68  | FS                         | 3-Level Input    | I              | <b>Frequency Select.</b> This input must be set according to the nominal frequency (f <sub>NOM</sub> ), see <a href="#">Table 5-1</a> .  |
| 70, 71, 73, 74  | REFB+, REFB–, REFA–, REFA+ | LVTTL/<br>LVDIFF | I              | <b>Reference Inputs.</b> These inputs can operate as differential PECL or single-ended TTL reference inputs to the PLL. When operating as a single-ended LVTTL input, the complementary input must be left open.   |

Note: I<sup>d</sup> = each input has an internal pull-down resistor.

Table 4-2. 100-Pin TQFP Descriptions (continued)

| Pin            | Symbol                        | Type             | I/O            | Description  |
|----------------|-------------------------------|------------------|----------------|--|
| 72             | REFSEL                        | LVTTL            | I <sup>d</sup> | <b>Reference Input Select.</b> The REFSEL input controls how the reference input is configured.<br><br>Low = REFSEL uses the REFA pair as the reference input.<br>High = REFSEL uses the REFB pair as the reference input.   |
| 77, 78, 80, 81 | FBKA+, FBKA-,<br>FBKB-, FBKB+ | LVTTL/<br>LVDIFF | I              | <b>Feedback Inputs.</b> One pair of inputs selected by the FBSEL is used to feedback the clock output xQn to the phase detector. The PLL will operate so that the rising edges of the reference and feedback signals are aligned in both phase and frequency. These inputs can operate as differential PECL or single-ended TTL inputs. When operating as a single-ended LVTTL input, the complementary input must be left open. |
| 79             | FBSEL                         | LVTTL            | I <sup>d</sup> | <b>Feedback Input Select.</b><br><br>Low = FBKA inputs are selected.<br>High = FBKB inputs are selected.   |
| 84, 86         | QFA[0:1]                      | LVTTL            | O              | <b>Clock Feedback Output.</b> This pair of clock outputs is intended to be connected to the FB input. These outputs have numerous divide options and three choices of phase adjustments. The function is determined by setting the FBDS[0:1] pins and FBF0.  |
| 98, 99         | FBDS[0:1]                     | 3-Level<br>Input | I              | <b>Feedback Divider Function Select.</b> These inputs determine the function of the QFA0 and QFA1 outputs, see <a href="#">Table 5-4</a> .   |
| 100            | LOCK                          | LVTTL            | O              | <b>PLL Lock Indicator.</b><br><br>Low = the PLL is attempting to acquire lock.<br>High = this output indicates the internal PLL is locked to the reference signal.   |

Note: I<sup>d</sup> = each input has an internal pull-down resistor.

## 5 Functional Description

### 5.1 Phase Frequency Detector and Filter

These two blocks accept signals from the REF inputs (REFA+, REFA-, REFB+, or REFB-) and the FB inputs (FBKA+, FBKA-, FBKB+, or FBKB-). Correction information is then generated to control the frequency of the voltage-controlled oscillator (VCO). These two blocks, along with the VCO, form a phase-locked loop (PLL) that tracks the incoming REF signal.

The devices have a flexible REF and FB input scheme. These inputs allow using either differential LVPECL or single-ended LVTTTL inputs. To configure as single-ended LVTTTL inputs, the complementary input pin must be left open (internally pulled to 1.5 V), and the other input pin can then be used as an LVTTTL input. The REF inputs are also tolerant to hot insertion.

The REF inputs can be changed dynamically. When changing from one reference input to the other reference input of the same frequency, the PLL is optimized to ensure that the clock output period will not be less than the calculated system budget ( $t_{MIN} = t_{REF}$  (nominal reference clock period) –  $t_{CCJ}$  (cycle-to-cycle jitter) –  $t_{PDEV}$  (maximum period deviation)) while reacquiring lock.

### 5.2 VCO, Control Logic, Divider, and Phase Generator

The VCO accepts analog control inputs from the PLL filter block. The FS control pin setting determines the nominal operational frequency ( $f_{NOM}$ ) range of the divide-by-one output of the device.  $f_{NOM}$  is directly related to the VCO frequency. There are two versions of the device, a low-speed device (LCK4993) where  $f_{NOM}$  ranges from 12 MHz to 100 MHz, and a high-speed device (LCK4994) where  $f_{NOM}$  ranges from 24 MHz to 200 MHz. The FS setting for each device is shown in Table 5-1.

The  $f_{NOM}$  frequency is seen on divide-by-one outputs. For the LCK4994, the upper  $f_{NOM}$  range extends from 96 MHz to 200 MHz.

**Table 5-1. Frequency Range Select**

| FS*  | LCK4993                |     | LCK4994                |     |
|------|------------------------|-----|------------------------|-----|
|      | f <sub>NOM</sub> (MHz) |     | f <sub>NOM</sub> (MHz) |     |
|      | Min                    | Max | Min                    | Max |
| Low  | 12                     | 26  | 24                     | 52  |
| Mid  | 24                     | 52  | 48                     | 100 |
| High | 48                     | 100 | 96                     | 200 |

\* The level to be set on FS is determined by the  $f_{NOM}$  of the VCO and phase generator.  $f_{NOM}$  always appears on an output when the output is operating in the divide by 1 mode. The REF and FB are at  $f_{NOM}$  when the output connected to FB is in the divide by 1 mode.

### 5.3 Time Unit Definition

Selectable skew is in discrete increments of time unit (tu). The value of tu is determined by the FS setting and the  $f_{NOM}$  frequency. The equation to be used to determine the tu is as follows:

$$tu = \frac{1}{f_{NOM} \times N} \quad (\text{eq. 1})$$

Where N is a multiplication factor, determined by the FS setting and is defined in Table 5-2; where  $f_{NOM}$  is the nominal operating frequency of the VCO.

**Table 5-2. N Factor Determination**

| FS   | LCK4993 |   | LCK4994 |   |
|------|---------|---|---------|---|
|      | N       | f <sub>NOM</sub> (MHz) at which tu = 1.0 ns | N       | f <sub>NOM</sub> (MHz) at which tu = 1.0 ns |
| Low  | 64      | 15.265                                      | 32      | 31.25                                       |
| Mid  | 32      | 31.25                                       | 16      | 62.5  |
| High | 16      | 62.5  | 8       | 125   |

## 5.4 Divide and Phase Select Matrix

The divide and phase select matrix is comprised of five independent banks as follows: four banks for clock outputs and one bank for feedback. Each clock output bank has two pairs of low-skew, high-fanout output buffers ([1:4]Q[A:B][0:1]), two phase function select inputs ([1:4]F[0:1]), two divider function selects ([1:4]DS[0:1]), and one output disable (DIS[1:4]).

The feedback bank has one pair of low-skew, high-fanout output buffers (QFA[0:1]). One of these outputs may connect to the selected feedback input (FBK[A:B]±). This feedback bank also has one phase function select input (FBF0), two divider function selects FSDS[0:1], and one output disable (FBDIS).

The phase capabilities that are chosen by the phase function select pins are shown in Table 5-3. The divide capabilities for each bank are shown in Table 5-4.

**Table 5-3. Output Skew Select Function**

| Function Selects |                  | Output Skew Function |       |       |       |               |
|------------------|------------------|----------------------|-------|-------|-------|---------------|
| [1:4]F1          | [1:4]F0 and FBF0 | Bank1                | Bank2 | Bank3 | Bank4 | Feedback Bank |
| Low              | Low              | -4 tu                | -4 tu | -8 tu | -8 tu | -4 tu         |
| Low              | Mid              | -3 tu                | -3 tu | -7 tu | -7 tu | NA            |
| Low              | High             | -2 tu                | -2 tu | -6 tu | -6 tu | NA            |
| Mid              | Low              | -1 tu                | -1 tu | BK1*  | BK1*  | NA            |
| Mid              | Mid              | 0 tu                 | 0 tu  | 0 tu  | 0 tu  | 0 tu          |
| Mid              | High             | 1 tu                 | 1 tu  | BK2†  | BK2†  | NA            |
| High             | Low              | 2 tu                 | 2 tu  | 6 tu  | 6 tu  | NA            |
| High             | Mid              | 3 tu                 | 3 tu  | 7 tu  | 7 tu  | NA            |
| High             | High             | 4 tu                 | 4 tu  | 8 tu  | 8 tu  | 4 tu          |

\* BK1 denotes following the skew of Bank1.

† BK2 denotes following the skew of Bank2.

**Table 5-4. Output Divider Function**

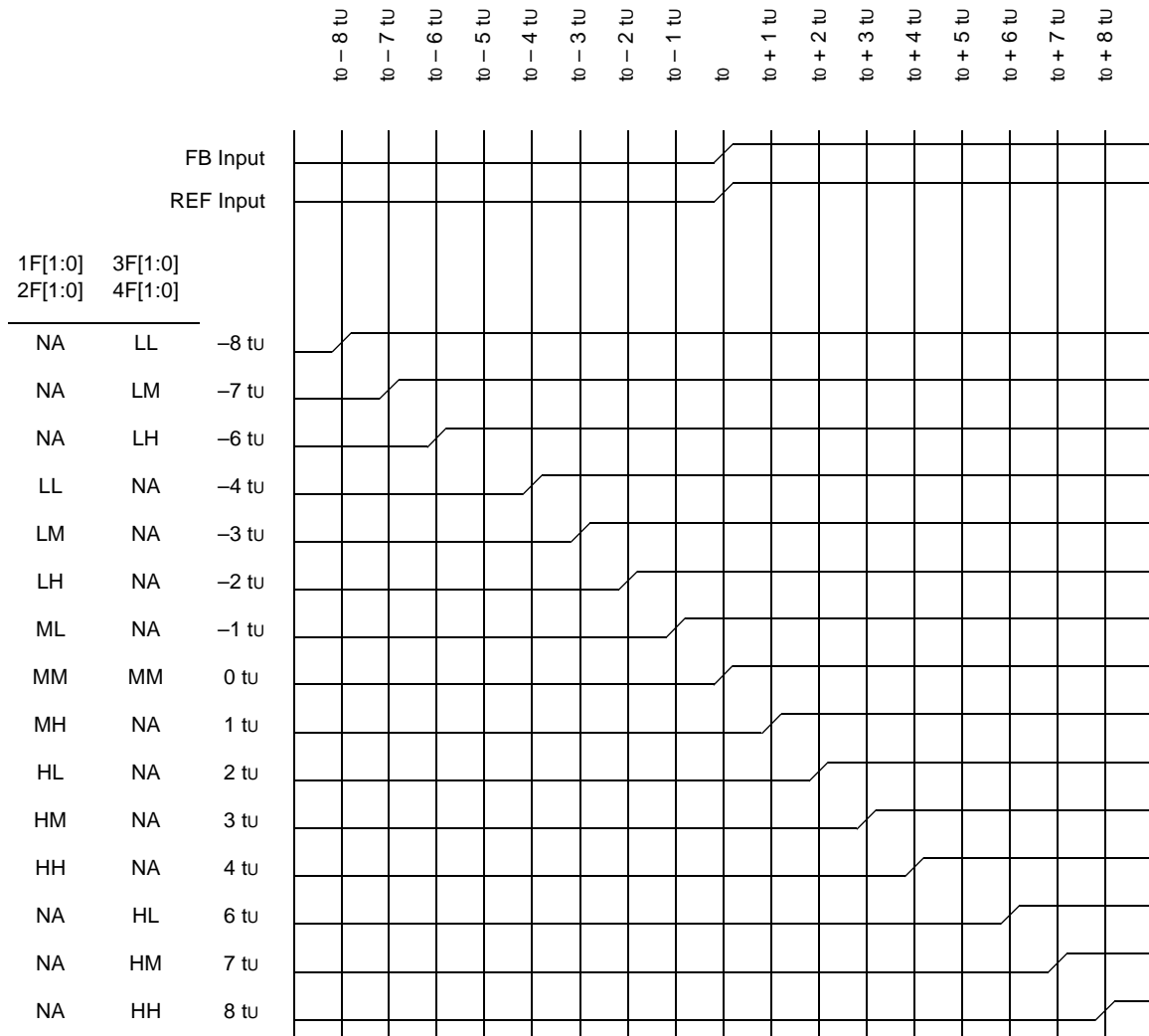
| Function Selects*  |                    | Output Divider Function |       |       |       |               |
|--------------------|--------------------|-------------------------|-------|-------|-------|---------------|
| [1:4]DS1 and FBDS1 | [1:4]DS0 and FBDS0 | Bank1                   | Bank2 | Bank3 | Bank4 | Feedback Bank |
| Low                | Low                | /1                      | /1    | /1    | /1    | /1            |
| Low                | Mid                | /2                      | /2    | /2    | /2    | /2            |
| Low                | High               | /3                      | /3    | /3    | /3    | /3            |
| Mid                | Low                | /4                      | /4    | /4    | /4    | /4            |
| Mid                | Mid                | /5                      | /5    | /5    | /5    | /5            |
| Mid                | High               | /6                      | /6    | /6    | /6    | /6            |
| High               | Low                | /8                      | /8    | /8    | /8    | /8            |
| High               | Mid                | /10                     | /10   | /10   | /10   | /10           |
| High               | High               | /12                     | /12   | /12   | /12   | /12           |

\* Output frequency =  $f_{NOM}$  (VCO frequency)/value of output divisor.



### 5.5 Timing Relationship of Programmable Skew Outputs

Figure 5-1 illustrates the timing relationship of programmable skew outputs. All times are measured with respect to REF, with the output used for feedback programmed with 0 tu skew. The PLL naturally aligns the rising edge of the FB input and REF input. If the output used for feedback is programmed to another skew position, then the whole tu matrix will shift with respect to REF. For example, if the output used for feedback is programmed to shift -8 tu, then the whole matrix is shifted forward in time by 8 tu. Therefore, an output programmed with 8 tu of skew will effectively be skewed 16 tu with respect to REF.



Note: FB connected to an output selected for zero skew (i.e., FBF0 = mid or xF[1:0] = mid).

Figure 5-1. Typical Outputs with FB Connected to a Zero-Skew Output

## 5.6 Output Disable Description

The feedback divide and phase select matrix bank has two outputs, each of the four divide and phase select matrix banks have four outputs. The outputs of each bank can be independently put into a hold-off, or HI-Z state. The combination of the OUTPUT\_MODE and DIS[1:4]/FBDIS inputs determines the clock outputs' state for each bank. When the DIS[1:4]/FBDIS is low, the outputs of the corresponding bank will be enabled. When the DIS[1:4]/FBDIS is high the outputs for that bank will be disabled to a HI-Z or hold-off state, depending on the OUTPUT\_MODE input. Table 5-5 defines the disabled output functions.

The hold-off state is intended to be a power saving feature. An output bank is disabled to the hold-off state in a maximum of six output clock cycles from the time when the disable input (DIS[1:4]/FBDIS) is high. When disabled to the hold-off state, noninverting outputs are driven to a logic-low state on its falling edge. Inverting outputs are driven to a logic-high state on its rising edge. This ensures the output clocks are stopped without a glitch. When a bank of outputs is disabled to a HI-Z state, the respective bank of outputs will go HI-Z immediately.

**Table 5-5. DIS[1:4]/FBDIS Pin Functionality**

| OUTPUT_MODE | DIS[1:4]/FBDIS | Output Mode  |
|-------------|----------------|--------------|
| High/Low    | Low            | Enabled      |
| High        | High           | HI-Z         |
| Low         | High           | Hold-off     |
| Mid         | X              | Factory Test |

## 5.7 INV3 Pin Function

Bank3 has signal invert capability. The four outputs of Bank3 will act as two pairs of complementary outputs when the INV3 pin is driven low. In complementary output mode, 3QA0 and 3QB0 are noninverting; 3QA1 and 3QB1 are inverting outputs. All four outputs will be inverted when the INV3 pin is driven high. When the INV3 pin is left in mid, the outputs will not invert. Inversion of the outputs are independent of the skew and divide functions. Therefore, clock outputs of Bank3 can be inverted, divided, and skewed at the same time.

## 5.8 Lock Detect Output Description

The LOCK detect output indicates the lock condition of the integrated PLL. Lock detection is accomplished by comparing the phase difference between the reference and feedback inputs. Phase error is declared when the phase difference between the two inputs is greater than the specified device propagation delay limit (TPD).

When in the locked state, after four or more consecutive feedback clock cycles with phase-errors, the LOCK output will be forced low to indicate out-of-lock state.

When in the out-of-lock state, 32 consecutive phase-errorless feedback clock cycles are required to allow the LOCK output to indicate lock condition (LOCK = high).

If the feedback clock is removed after LOCK has gone high, a watchdog circuit is implemented to indicate the out-of-lock condition after a time-out period by deasserting LOCK low. This time-out period is based on a divided down reference clock. This assumes that there is activity on the selected REF input. If there is no activity on the selected REF input, then the LOCK detect pin may not accurately reflect the state of the internal PLL.

## 5.9 Factory Test Mode Description

The device will enter factory test mode when the OUTPUT\_MODE input is driven to a mid level. In factory test mode, the device will operate with its internal PLL disconnected. The reference input will replace the PLL output. While operating in factory test mode, the selected FB input(s) must both be tied low. The output frequency is a function of the input level set on the FS pin (see Table 5-6). When operating in factory test mode, all outputs must be set to the divide by 1 function. Output skew select function operates normally, output bank disable is unavailable while operating in factory test mode. The OUTPUT\_MODE input is designed to be a static input. Dynamically toggling this input from low to high may temporarily cause the device to go into factory test mode (when passing through the mid state).

### 5.9.1 Factory Test Reset

When operating in factory test mode (OUTPUT\_MODE = mid), the device can be reset to a deterministic state by forcing the DIS4 input to a logic high. With DIS4 in a logic high state, all clock outputs will go to HI-Z. After the selected reference clock pin has five positive transitions, all the internal finite state machines (FSM) will be set to a deterministic state. The deterministic state of the state machines will depend on the configuration of the divide select, skew select, and frequency select inputs. All clock outputs will stay in high-impedance mode, and all FSMs will stay in the deterministic state until DIS4 is deasserted. When DIS4 is deasserted (with OUTPUT\_MODE still at mid), the device will re-enter factory test mode.

**Table 5-6. Factory Test Mode Frequency Divide Select**

| FS   | LCK4993          | LCK4994          |
|------|------------------|------------------|
|      | Output Frequency | Output Frequency |
|      | Divide By        | Divide By        |
| Low  | 32               | 16               |
| Mid  | 16               | 8                |
| High | 8                | 4                |

## 5.10 Absolute Maximum Ratings

Stresses in excess of the absolute maximum ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of the data sheet. Exposure to absolute maximum ratings for extended periods can adversely affect device reliability.

**Table 5-7. Absolute Maximum Ratings**

| Parameter                         | Symbol           | Min  | Max                   | Unit |
|-----------------------------------|------------------|------|-----------------------|------|
| Storage Temperature               | T <sub>stg</sub> | -40  | 125                   | °C   |
| Supply Voltage                    | V <sub>DD</sub>  | -0.5 | 4.6                   | V    |
| dc Input Voltage                  | V <sub>DC</sub>  | -0.3 | V <sub>DD</sub> + 0.5 | V    |
| Output Current into Outputs (low) | I <sub>OUT</sub> | —    | 40                    | mA   |
| Latch-Up Current                  | I <sub>L</sub>   | —    | ±200                  | mA   |

## 5.11 Handling Precautions

Although electrostatic discharge (ESD) protection circuitry has been designed into this device, proper precautions must be taken to avoid exposure to ESD and electrical overstress (EOS) during all handling, assembly, and test operations. Agere employs both a human-body model (HBM) and a charged-device model (CDM) qualification requirement in order to determine ESD susceptibility limits and protection design evaluation. ESD voltage thresholds are dependent on the circuit parameters used in each of the models, as defined by JEDEC's JESD22-A114 (HBM) and JESD22-C101 (CDM) standards.

**Table 5-8. Handling Precautions**

| Device  | Minimum Threshold |       |
|---------|-------------------|-------|
|         | HBM               | CDM   |
| LCK4993 | 2000 V            | 500 V |
| LCK4994 | 2000 V            | 500 V |

**Caution:** MOS devices are susceptible to damage from electrostatic charge. Reasonable precautions in handling and packaging MOS devices should be observed.

## 5.12 Thermal Parameters (Definitions and Values)

System and circuit board level performance depends not only on device electrical characteristics, but also on device thermal characteristics. The thermal characteristics frequently determine the limits of circuit board or system performance, and they can be a major cost adder or cost avoidance factor. When the die temperature is kept below 125 °C, temperature-activated failure mechanisms are minimized. The thermal parameters that Agere provides for its packages help the chip and system designer choose the best package for their applications, including allowing the system designer to thermally design and integrate their systems.

It should be noted that all the parameters listed below are affected, to varying degrees, by package design (including paddle size) and choice of materials, the amount of copper in the test board or system board, and system airflow.

### Θ<sub>JA</sub> - Junction to Air Thermal Resistance

Θ<sub>JA</sub> is a number used to express the thermal performance of a part under JEDEC standard natural convection conditions. Θ<sub>JA</sub> is calculated using the following formula:

$$\Theta_{JA} = (T_J - T_{amb}) / P; \text{ where } P = \text{power}$$

### Θ<sub>JMA</sub> - Junction to Moving Air Thermal Resistance

Θ<sub>JMA</sub> is effectively identical to Θ<sub>JA</sub> but represents performance of a part mounted on a JEDEC four-layer board inside a wind tunnel with forced air convection. Θ<sub>JMA</sub> is reported at airflows of 200 LFPM and 500 LFPM (linear feet per minute), which roughly correspond to 1 m/s and 2.5 m/s (respectively). Θ<sub>JMA</sub> is calculated using the following formula:

$$\Theta_{JMA} = (T_J - T_{amb}) / P$$

### Θ<sub>JC</sub> - Junction to Case Thermal Resistance

Θ<sub>JC</sub> is the thermal resistance from junction to the top of the case. This number is determined by forcing nearly 100% of the heat generated in the die out the top of the package by lowering the top case temperature. This is done by placing the top of the package in contact with a copper slug kept at room temperature using a liquid refrigeration unit. Θ<sub>JC</sub> is calculated using the following formula:

$$\Theta_{JC} = (T_J - T_C) / P$$

**$\Theta_{JB}$  - Junction to Board Thermal Resistance**

$\Theta_{JB}$  is the thermal resistance from junction to board. This number is determined by forcing the heat generated in the die out of the package through the leads or balls by lowering the board temperature and insulating the package top. This is done using a special fixture, which keeps the board in contact with a water chilled copper slug around the perimeter of the package while insulating the package top.  $\Theta_{JB}$  is calculated using the following formula:

$$\Theta_{JB} = (T_J - T_B) / P$$

**$\Psi_{JT}$**

$\Psi_{JT}$  correlates the junction temperature to the case temperature. It is generally used by the customer to infer the junction temperature while the part is operating in their system. It is not considered a true thermal resistance.  $\Psi_{JT}$  is calculated using the following formula:

$$\Psi_{JT} = (T_J - T_C) / P$$

**Table 5-9. Thermal Parameter Values**

| Parameter                | Temperature °C/Watt |                |
|--------------------------|---------------------|----------------|
|                          | 100-Pin TQFP        | 100-Ball FSBGA |
| $\Theta_{JA}$            | 38                  | 71.9           |
| $\Theta_{JMA}$ (1 m/s)   | 32.9                | 66.6           |
| $\Theta_{JMA}$ (2.5 m/s) | 30.4                | 64.7           |
| $\Theta_{JC}$            | 32.9                | 24.5           |
| $\Theta_{JB}$            | 29.9                | 56.8           |
| $\Psi_{JT}$              | 1                   | 1              |

## 6 Electrical Characteristics

Table 6-1. Electrical Characteristics (TA –40 °C to +85 °C, VDD = 3.3 V ± 10%)

| Parameter   | Symbol | Description                       | Test Conditions         | Min        | Max        | Unit |
|---|--------|-----------------------------------|-------------------------|------------|------------|------|
| <b>LVTTL Compatible Output Pins (QFA[0:1], [1:4]Q[A:B], LOCK)</b>                             |        |                                   |                         |            |            |      |
| High-Voltage Output (LVTTL)   | VOH    | QFA[0:1], [1:4]Q[A:B][0:1]        | VDD = min, IOH = –30 mA | 2.4        | —          | V    |
|   |        | LOCK                              | VDD = min, IOH = –2 mA  | 2.4        | —          | V    |
| Low-Voltage Output (LVTTL)  | VOL    | QFA[0:1], [1:4]Q[A:B][0:1]        | VDD = min, IOH = 30 mA  | —          | 0.5        | V    |
|   |        | LOCK                              | VDD = min, IOH = 2 mA   | —          | 0.5        | V    |
| High-Impedance State Leakage Current  | IOZ    | —                                 | —                       | –100       | 100        | µA   |
| <b>LVTTL Compatible Pins (FBKA±, FBKB±, REFA±, REFB±, FBSEL, REFSEL, FBDIS, DIS[1:4])</b>     |        |                                   |                         |            |            |      |
| High-Voltage Input (LVTTL)  | VIH    | FBK[A:B]±, REF[A:B]±              | Min ≤ VDD ≤ max         | 2.0        | VDD + 0.3  | V    |
|   |        | REFSEL, FBSEL, FBDIS, DIS[1:4]    | —                       | 2.0        | VDD + 0.3  | V    |
| Low-Voltage Input (LVTTL)   | VIL    | FBK[A:B]±, REF[A:B]±              | Min ≤ VDD ≤ max         | –0.3       | 0.8        | V    |
|   |        | REFSEL, FBSEL, FBDIS, DIS[1:4]    | —                       | –0.3       | 0.8        | V    |
| High-Input Current (LVTTL)  | IIH    | FBK[A:B]±, REF[A:B]±              | VDD = max, VIN = VDD    | —          | 500        | µA   |
|   |        | REFSEL, FBSEL, FBDIS, DIS[1:4]    | VIN = VDD               | —          | 500        | µA   |
| Low-Input Current (LVTTL)   | IIL    | FBK[A:B]±, REF[A:B]±              | VDD = max, VIN = GND    | –500       | —          | µA   |
|   |        | REFSEL, FBSEL, FBDIS, DIS[1:4]    | VIN = GND               | –500       | —          | µA   |
| <b>3-Level Input Pins (FBF0, FBDS[0:1], [1:4]F[0:1], [1:4]DS[0:1], FS, OUTPUT_MODE(TEST))</b> |        |                                   |                         |            |            |      |
| Low-Voltage 3-Level Input <sup>1</sup>  | VILL   | —                                 | Min ≤ VDD ≤ max         | —          | 0.13 x VDD | V    |
| Mid-Voltage 3-Level Input <sup>1</sup>  | VIMM   | —                                 | Min ≤ VDD ≤ max         | 0.47 x VDD | 0.53 x VDD | V    |
| High-Voltage 3-Level Input <sup>1</sup>   | VIHH   | —                                 | Min ≤ VDD ≤ max         | 0.87 x VDD | —          | V    |
| Low-Current 3-Level Input   | IILL   | 3-level input pins excluding FBF0 | VIN = GND               | –200       | —          | µA   |
|   |        | FBF0                              | VIN = GND               | –400       | —          | µA   |
| Mid-Current 3-Level Input   | IIMM   | 3-level input pins excluding FBF0 | VIN = VDD/2             | –50        | 50         | µA   |
|   |        | FBF0                              | VIN = VDD/2             | –100       | 100        | µA   |
| High-Current 3-Level Input  | IIHH   | 3-level input pins excluding FBF0 | VIN = VDD               | —          | 200        | µA   |
|   |        | FBF0                              | VIN = VDD               | —          | 400        | µA   |

1. These inputs are normally wired to VDD, GND, or left unconnected (actual threshold voltages vary as a percentage of VDD). Internal termination resistors hold the unconnected inputs at VDD/2. If these inputs are switched, the function and timing of the outputs may glitch and the PLL may require an additional tLOCK time before all data sheet limits are achieved.

Table 6-1. Electrical Characteristics (TA = -40 °C to +85 °C, VDD = 3.3 V ± 10%) (continued)

| Parameter                                       | Symbol            | Description | Test Conditions   | Min | Max                   | Unit |
|---|-------------------|-------------|---|-----|-----------------------|------|
| <b>LVDIFF Input Pins (FBK[A:B]±, REF[A:B]±)</b> |                   |             |   |     |                       |      |
| Input Differential Voltage                      | V <sub>DIFF</sub> | —           | —   | 400 | V <sub>DD</sub>       | mV   |
| Lowest Input Low Voltage                        | V <sub>ILLP</sub> | —           | —   | GND | V <sub>DD</sub> - 0.4 | V    |
| Highest Input High Voltage                      | V <sub>IHHP</sub> | —           | —   | 1.0 | V <sub>DD</sub>       | V    |
| Common-mode Range (crossing voltage)            | V <sub>COM</sub>  | —           | —   | 0.8 | V <sub>DD</sub>       | V    |
| <b>Operating Current</b>                        |                   |             |   |     |                       |      |
| Internal Operating Current                      | I <sub>CCI</sub>  | LCK4993     | V <sub>DD</sub> = max, f <sub>max</sub>   | —   | 250                   | mA   |
|   |                   | LCK4994     | V <sub>DD</sub> = max, f <sub>max</sub> <sup>1</sup>  | —   | 250                   | mA   |
| Output Current Dissipation/Pair <sup>2</sup>    | I <sub>CCN</sub>  | LCK4993     | V <sub>DD</sub> = max,<br>C <sub>LOAD</sub> = 25 pF,<br>R <sub>LOAD</sub> = 50 Ω at<br>V <sub>DD</sub> /2, f <sub>max</sub> | —   | 40                    | mA   |
|   |                   | LCK4994     | V <sub>DD</sub> = max,<br>C <sub>LOAD</sub> = 25 pF,<br>R <sub>LOAD</sub> = 50 Ω at<br>V <sub>DD</sub> /2, f <sub>max</sub> | —   | 50                    | mA   |
| <b>Capacitance</b>                              |                   |             |   |     |                       |      |
| Input Capacitance                               | C <sub>IN</sub>   | —           | T <sub>A</sub> = 25 °C, f = 1 MHz,<br>V <sub>DD</sub> = 3.3 V/2.5 V   | —   | 5                     | pF   |

1. I<sub>CCI</sub> measurements are performed with Bank1 and FB bank configured to run at maximum frequency (f<sub>NOM</sub> = 100 MHz for LCK4993, f<sub>NOM</sub> = 200 MHz for LCK4994), and all other clock output banks to run at half the maximum frequency. FS and OUTPUT\_MODE are asserted to the high state.
2. This is dependent upon frequency and number of outputs of a bank being loaded. The value indicates maximum I<sub>CCN</sub> at maximum frequency and maximum load of 25 pF terminated to 50 Ω at V<sub>DD</sub>/2.

Table 6-2. Electrical Characteristics (TA –40 °C to +85 °C, VDD = 2.5 V ± 10%)

| Parameter   | Symbol | Description                       | Test Conditions         | Min        | Max        | Unit |
|---|--------|-----------------------------------|-------------------------|------------|------------|------|
| <b>LVTTL Compatible Output Pins (QFA[0:1], [1:4]Q[A:B], LOCK)</b>                             |        |                                   |                         |            |            |      |
| High-Voltage Output (LVTTL)   | VOH    | QFA[0:1], [1:4]Q[A:B][0:1]        | VDD = min, IOH = –30 mA | 1.6        | —          | V    |
|   |        | LOCK                              | VDD = min, IOH = –2 mA  | 1.6        | —          | V    |
| Low-Voltage Output (LVTTL)  | VOL    | QFA[0:1], [1:4]Q[A:B][0:1]        | VDD = min, IOH = 30 mA  | —          | 0.5        | V    |
|   |        | LOCK                              | VDD = min, IOH = 2 mA   | —          | 0.5        | V    |
| High-Impedance State Leakage Current  | IOZ    | —                                 | —                       | –100       | 100        | µA   |
| <b>LVTTL Compatible Pins (FBKA±, FBKB±, REFA±, REFB±, FBSEL, REFSEL, FBDIS, DIS[1:4])</b>     |        |                                   |                         |            |            |      |
| High-Voltage Input (LVTTL)  | VIH    | FBK[A:B]±, REF[A:B]±              | Min ≤ VDD ≤ max         | 2.0        | VDD + 0.3  | V    |
|   |        | REFSEL, FBSEL, FBDIS, DIS[1:4]    | —                       | 2.0        | VDD + 0.3  | V    |
| Low-Voltage Input (LVTTL)   | VIL    | FBK[A:B]±, REF[A:B]±              | Min ≤ VDD ≤ max         | –0.3       | 0.8        | V    |
|   |        | REFSEL, FBSEL, FBDIS, DIS[1:4]    | —                       | –0.3       | 0.8        | V    |
| High-Input Current (LVTTL)  | IIH    | FBK[A:B]±, REF[A:B]±              | VDD = max, VIN = VDD    | —          | 500        | µA   |
|   |        | REFSEL, FBSEL, FBDIS, DIS[1:4]    | VIN = VDD               | —          | 500        | µA   |
| Low-Input Current (LVTTL)   | IIL    | FBK[A:B]±, REF[A:B]±              | VDD = max, VIN = GND    | —          | 500        | µA   |
|   |        | REFSEL, FBSEL, FBDIS, DIS[1:4]    | —                       | –500       | —          | µA   |
| <b>3-Level Input Pins (FBF0, FBDS[0:1], [1:4]F[0:1], [1:4]DS[0:1], FS, OUTPUT_MODE(TEST))</b> |        |                                   |                         |            |            |      |
| Low-Voltage 3-Level Input <sup>1</sup>  | VILL   | —                                 | Min ≤ VDD ≤ max         | —          | 0.13 x VDD | V    |
| Mid-Voltage 3-Level Input <sup>1</sup>  | VIMM   | —                                 | Min ≤ VDD ≤ max         | 0.47 x VDD | 0.53 x VDD | V    |
| High-Voltage 3-Level Input <sup>1</sup>   | VIHH   | —                                 | Min ≤ VDD ≤ max         | 0.87 x VDD | —          | V    |
| Low-Current 3-Level Input   | IILL   | 3-level input pins excluding FBF0 | VIN = GND               | –200       | —          | µA   |
|   |        | FBF0                              | VIN = GND               | –400       | —          | µA   |
| Mid-Current 3-Level Input   | IIMM   | 3-level input pins excluding FBF0 | VIN = VDD/2             | –50        | 50         | µA   |
|   |        | FBF0                              | VIN = VDD/2             | –100       | 100        | µA   |
| High-Current 3-Level Input  | IIHH   | 3-level input pins excluding FBF0 | VIN = VDD               | —          | 200        | µA   |
|   |        | FBF0                              | VIN = VDD               | —          | 400        | µA   |

1. These inputs are normally wired to VDD, GND, or left unconnected (actual threshold voltages vary as a percentage of VDD). Internal termination resistors hold the unconnected inputs at VDD/2. If these inputs are switched, the function and timing of the outputs may glitch and the PLL may require an additional tLOCK time before all data sheet limits are achieved.



Table 6-2. Electrical Characteristics (TA –40 °C to +85 °C, VDD = 2.5 V ± 10%) (continued)

| Parameter                                       | Symbol            | Description | Test Conditions   | Min | Max                   | Unit |
|---|-------------------|-------------|---|-----|-----------------------|------|
| <b>LVDIFF Input Pins (FBK[A:B]±, REF[A:B]±)</b> |                   |             |   |     |                       |      |
| Input Differential Voltage                      | V <sub>DIFF</sub> | —           | —   | 400 | V <sub>DD</sub>       | mV   |
| Lowest Input Low Voltage                        | V <sub>ILLP</sub> | —           | —   | GND | V <sub>DD</sub> – 0.4 | V    |
| Highest Input High Voltage                      | V <sub>IHHP</sub> | —           | —   | 1.0 | V <sub>DD</sub>       | V    |
| Common-mode Range (crossing voltage)            | V <sub>COM</sub>  | —           | —   | 0.8 | V <sub>DD</sub>       | V    |
| <b>Operating Current</b>                        |                   |             |   |     |                       |      |
| Internal Operating Current                      | I <sub>CCI</sub>  | LCK4993     | V <sub>DD</sub> = max, f <sub>max</sub>   | —   | 250                   | mA   |
|   |                   | LCK4994     | V <sub>DD</sub> = max, f <sub>max</sub> <sup>1</sup>  | —   | 250                   | mA   |
| Output Current Dissipation/Pair <sup>2</sup>    | I <sub>CCN</sub>  | LCK4993     | V <sub>DD</sub> = max,<br>C <sub>LOAD</sub> = 25 pF,<br>R <sub>LOAD</sub> = 50 Ω at<br>V <sub>DD</sub> /2, f <sub>max</sub> | —   | 40                    | mA   |
|   |                   | LCK4994     | V <sub>DD</sub> = max,<br>C <sub>LOAD</sub> = 25 pF,<br>R <sub>LOAD</sub> = 50 Ω at<br>V <sub>DD</sub> /2, f <sub>max</sub> | —   | 50                    | mA   |
| <b>Capacitance</b>                              |                   |             |   |     |                       |      |
| Input Capacitance                               | C <sub>IN</sub>   | —           | T <sub>A</sub> = 25 °C, f = 1 MHz,<br>V <sub>DD</sub> = 3.3 V/2.5 V   | —   | 5                     | pF   |

1. I<sub>CCI</sub> measurements are performed with Bank1 and FB bank configured to run at maximum frequency (f<sub>NOM</sub> = 100 MHz for LCK4993, f<sub>NOM</sub> = 200 MHz for LCK4994), and all other clock output banks to run at half the maximum frequency. FS and OUTPUT\_MODE are asserted to the high state.
2. This is dependent upon frequency and number of outputs of a bank being loaded. The value indicates maximum I<sub>CCN</sub> at maximum frequency and maximum load of 25 pF terminated to 50 Ω at V<sub>DD</sub>/2.

## 7 Timing

### 7.1 Switching Characteristics

The following switching characteristics and assumptions apply for non 3-level inputs.

- A maximum 25 pF load capacitance is used for frequencies up to 185 MHz. A maximum 10 pF load capacitance is used for the frequency of 200 MHz.
- Both outputs of the pair must be terminated, even if only one is being used.
- ac parameters are measured at 50%, unless otherwise indicated.

**Table 7-1. Switching Characteristics (TA –40 °C to +85 °C, VDD = 3.3 V ± 10%)**

| Parameter                          | Symbol           | Description   | Min  | Max | Unit |
|------------------------------------|------------------|---|------|-----|------|
| Clock Input Frequency              | f <sub>IN</sub>  | LCK4993   | 12   | 100 | MHz  |
|                                    |                  | LCK4994   | 24   | 200 | MHz  |
| Clock Output Frequency             | f <sub>OUT</sub> | LCK4993   | 12   | 100 | MHz  |
|                                    |                  | LCK4994   | 24   | 200 | MHz  |
| REF Input                          | tREFPWL          | Pulse width low. <sup>8</sup>   | 2.0  | —   | ns   |
|                                    | tREFPWH          | Pulse width high. <sup>8</sup>  | 2.0  | —   | ns   |
| Matched-Pair Skew <sup>1, 2</sup>  | tsKEWPR          | Same frequency and phase, rise-to-rise and fall-to-fall. (Matched pair outputs within a bank.) <sup>1, 2</sup>    | —    | 200 | ps   |
| Interbank Skew                     | tsKEWBNK         | Same frequency and phase, rise-to-rise and fall-to-fall. (All outputs within a bank.) <sup>1, 2</sup>             | —    | 200 | ps   |
| Output-Output Skew                 | tsKEW0           | Same frequency and phase, rise-to-rise and fall-to-fall. (All outputs across all banks.) <sup>1, 2</sup>          | —    | 250 | ps   |
|                                    | tsKEW1           | Different frequency same phase, rise-to-rise and fall-to-fall. (All outputs all banks.) <sup>1, 2</sup>           | —    | 250 | ps   |
|                                    | tsKEW2           | Same frequency and phase, rise-to-fall and fall-to-rise. (Bank 3 inverted to all other banks.) <sup>1, 2, 3</sup> | —    | 250 | ps   |
|                                    | tsKEW3           | All output configurations outside tsKEW1 and tsKEW2. <sup>1, 2</sup>  | —    | 500 | ps   |
| Complementary Outputs Skew         | tsKEWCPR         | Crossing to crossing, complementary outputs. (Bank 3 only.) <sup>1, 2, 3, 4</sup>                                 | —    | 200 | ps   |
| Cycle-to-Cycle Jitter              | tCCJ             | Divide by 1 output frequency, FB = divide by 1—8.   | —    | 150 | ps   |
| Propagation Delay                  | tpD              | REF to FB rise.   | –250 | 250 | ps   |
|                                    | tpDELTA          | Difference between two devices. <sup>4</sup>  | —    | 200 | ps   |
| Output Rise/Fall Time <sup>5</sup> | tR/tF            | —   | 0.15 | 2.0 | ns   |

1. Test load CL maximum 25 pF (f<sub>nom</sub> ≤ 185 MHz) and maximum 10 pF (f<sub>nom</sub> = 200 MHz) both terminated 50 Ω to V<sub>DD</sub>/2.
2. SKEW is defined as the time between the earliest and latest output transition among all outputs for which the same phase delay has been selected and all outputs are equally loaded and properly terminated.
3. Complementary output skews are measured at complementary signal pair intersections.
4. Guaranteed by statistical correlation. Tested initially and after any design or process changes that may affect these parameters.
5. Rise and fall times are measured at 20% and 80% of the output voltage swing.
6. f<sub>NOM</sub> must be within the frequency range defined by the FS state (see Table 5-1).
7. ac parameters are measured at 50%, unless otherwise indicated.
8. t<sub>PWL</sub> is measured at 20%. t<sub>PWH</sub> is measured at 80%.
9. UI = unit interval. Examples: 1 UI is a full period. 0.1 UI is 10% of a period.
10. Measured at 0.5 V deviation from starting voltage.
11. For t<sub>oZA</sub> minimum, CL = 0 pF. For t<sub>oZA</sub> maximum, CL = 25 pF to 185 MHz or 10 pF at 200 MHz.

Table 7-1. Switching Characteristics (TA –40 °C to +85 °C, VDD = 3.3 V ± 10%) (continued)

| Parameter                      | Symbol   | Description   | Min | Max   | Unit            |
|--------------------------------|----------|---|-----|-------|-----------------|
| PLL Lock Time from Powerup     | tLOCK    | —   | —   | 10    | ms              |
| PLL Relock Time                | tRELOCK1 | From same frequency, different phase, and with stable power supply.                   | —   | 500   | µs              |
|                                | tRELOCK2 | From different frequency, different phase, and with stable power supply. <sup>6</sup> | —   | 1000  | µs              |
| Output Duty Cycle <sup>7</sup> | tODCV    | —   | 45  | 55    | %               |
| Period Deviation               | tpDEV    | When changing from reference to reference.  | —   | 0.025 | UI <sup>9</sup> |
| Output Disable Time            | toZA     | DIS[1:4]/FBDIS low to output active from output is high-impedance. <sup>10, 11</sup>  | 0.5 | 14    | ns              |
| Output Enable Time             | toAZ     | DIS[1:4]/FBDIS high to output high-impedance from active. <sup>1, 10</sup>            | 1.0 | 10    | ns              |

1. Test load CL maximum 25 pF (f<sub>nom</sub> ≤ 185 MHz) and maximum 10 pF (f<sub>nom</sub> = 200 MHz) both terminated 50 Ω to V<sub>DD</sub>/2.
2. SKEW is defined as the time between the earliest and latest output transition among all outputs for which the same phase delay has been selected and all outputs are equally loaded and properly terminated.
3. Complementary output skews are measured at complementary signal pair intersections.
4. Guaranteed by statistical correlation. Tested initially and after any design or process changes that may affect these parameters.
5. Rise and fall times are measured at 20% and 80% of the output voltage swing.
6. f<sub>NOM</sub> must be within the frequency range defined by the FS state (see Table 5-1).
7. ac parameters are measured at 50%, unless otherwise indicated.
8. t<sub>PWL</sub> is measured at 20%. t<sub>PWH</sub> is measured at 80%.
9. UI = unit interval. Examples: 1 UI is a full period. 0.1 UI is 10% of a period.
10. Measured at 0.5 V deviation from starting voltage.
11. For toZA minimum, CL = 0 pF. For toZA maximum, CL = 25 pF to 185 MHz or 10 pF at 200 MHz.

Table 7-2. Switching Characteristics (TA –40 °C to +85 °C, VDD = 2.5 V ± 10%)

| Parameter                          | Symbol   | Description   | Min  | Max | Unit |
|------------------------------------|----------|---|------|-----|------|
| Clock Input Frequency              | fIN      | LCK4993.  | 12   | 100 | MHz  |
|                                    |          | LCK4994.  | 24   | 200 | MHz  |
| Clock Output Frequency             | fOUT     | LCK4993.  | 12   | 100 | MHz  |
|                                    |          | LCK4994.  | 24   | 200 | MHz  |
| REF Input                          | tREFPWL  | Pulse width low. <sup>8</sup>   | 2.0  | —   | ns   |
|                                    | tREFPWH  | Pulse width high. <sup>8</sup>  | 2.0  | —   | ns   |
| Matched-Pair Skew <sup>1, 2</sup>  | tSKEWPR  | Same frequency and phase, rise-to-rise and fall-to-fall. (Matched pair outputs within a bank.) <sup>1, 2</sup>    | —    | 200 | ps   |
| Interbank Skew                     | tSKEWBNK | Same frequency and phase, rise-to-rise and fall-to-fall. (All outputs within a bank.) <sup>1, 2</sup>             | —    | 200 | ps   |
| Output-Output Skew                 | tSKEW0   | Same frequency and phase, rise-to-rise and fall-to-fall. (All outputs across all banks.) <sup>1, 2</sup>          | —    | 250 | ps   |
|                                    | tSKEW1   | Different frequency same phase, rise-to-rise and fall-to-fall. (All outputs all banks.) <sup>1, 2</sup>           | —    | 250 | ps   |
|                                    | tSKEW2   | Same frequency and phase, rise-to-fall and fall-to-rise. (Bank 3 inverted to all other banks.) <sup>1, 2, 3</sup> | —    | 250 | ps   |
|                                    | tSKEW3   | All output configurations outside tSKEW1 and tSKEW2. <sup>1, 2</sup>  | —    | 500 | ps   |
| Complementary Outputs Skew         | tSKEWCPR | Crossing to crossing, complementary outputs. (Bank 3 only.) <sup>1, 2, 3, 4</sup>                                 | —    | 200 | ps   |
| Cycle-to-Cycle Jitter              | tCCJ1–3  | Divide by 1 output frequency, FB = divide by 1–8.   | —    | 150 | ps   |
| Propagation Delay                  | tPD      | REF to FB rise.   | –250 | 250 | ps   |
|                                    | tPDELTA  | Difference between two devices. <sup>4</sup>  | —    | 200 | ps   |
| Output Rise/Fall Time <sup>5</sup> | tR/tF    | —   | 0.15 | 2.0 | ns   |

1. Test load CL maximum 25 pF (fnom ≤185 MHz) and maximum 10 pF (fnom = 200 MHz) both terminated 50 Ω to VDD/2.
2. SKEW is defined as the time between the earliest and latest output transition among all outputs for which the same phase delay has been selected and all outputs are equally loaded and properly terminated.
3. Complementary output skews are measured at complementary signal pair intersections.
4. Guaranteed by statistical correlation. Tested initially and after any design or process changes that may affect these parameters.
5. Rise and fall times are measured at 20% and 80% of the output voltage swing.
6. fnom must be within the frequency range defined by the FS state (see Table 5-1).
7. ac parameters are measured at 50%, unless otherwise indicated.
8. tPWL is measured at 20%. tPWH is measured at 80%.
9. UI = unit interval. Examples: 1 UI is a full period. 0.1 UI is 10% of a period.
10. Measured at 0.5 V deviation from starting voltage.
11. For toZA minimum, CL = 0 pF. For toZA maximum, CL = 25 pF to 185 MHz or 10 pF at 200 MHz.

Table 7-2. Switching Characteristics (TA –40 °C to +85 °C, VDD = 2.5 V ± 10%) (continued)

| Parameter                      | Symbol   | Description   | Min | Max   | Unit            |
|--------------------------------|----------|---|-----|-------|-----------------|
| PLL Lock Time from Powerup     | tLOCK    | —   | —   | 10    | ms              |
| PLL Relock Time                | tRELOCK1 | From same frequency, different phase, and with stable power supply.                   | —   | 500   | µs              |
|                                | tRELOCK2 | From different frequency, different phase, and with stable power supply. <sup>6</sup> | —   | 1000  | µs              |
| Output Duty Cycle <sup>7</sup> | tODCV    | —   | 45  | 55    | %               |
| Period Deviation               | tPDEV    | When changing from reference to reference.  | —   | 0.025 | UI <sup>9</sup> |
| Output Disable Time            | toZA     | DIS[1:4]/FBDIS low to output active from output is high-impedance. <sup>10, 11</sup>  | 0.5 | 14    | ns              |
| Output Enable Time             | toAZ     | DIS[1:4]/FBDIS high to output high-impedance from active. <sup>1, 10</sup>            | 1.0 | 10    | ns              |

1. Test load CL maximum 25 pF (f<sub>NOM</sub> ≤ 185 MHz) and maximum 10 pF (f<sub>NOM</sub> = 200 MHz) both terminated 50 Ω to VDD/2.
2. SKEW is defined as the time between the earliest and latest output transition among all outputs for which the same phase delay has been selected and all outputs are equally loaded and properly terminated.
3. Complementary output skews are measured at complementary signal pair intersections.
4. Guaranteed by statistical correlation. Tested initially and after any design or process changes that may affect these parameters.
5. Rise and fall times are measured at 20% and 80% of the output voltage swing.
6. f<sub>NOM</sub> must be within the frequency range defined by the FS state (see Table 5-1).
7. ac parameters are measured at 50%, unless otherwise indicated.
8. t<sub>PWL</sub> is measured at 20%. t<sub>PWH</sub> is measured at 80%.
9. UI = unit interval. Examples: 1 UI is a full period. 0.1 UI is 10% of a period.
10. Measured at 0.5 V deviation from starting voltage.
11. For toZA minimum, CL = 0 pF. For toZA maximum, CL = 25 pF to 185 MHz or 10 pF at 200 MHz.

## 7.2 ac Test Loads and Waveforms

**Note:** Figure 7-1 is for illustrative purposes only. The actual ATE loads may vary.

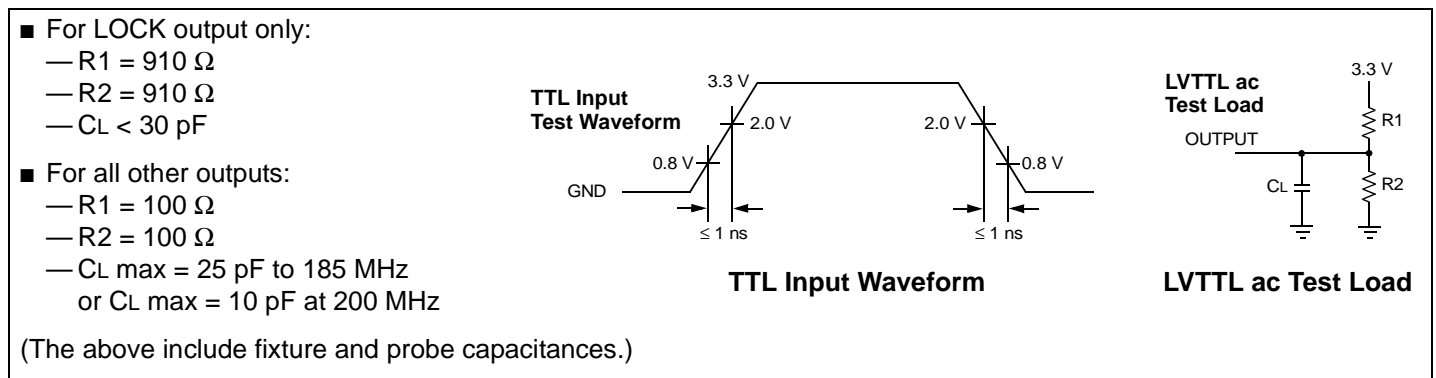


Figure 7-1. ac Test Loads and Waveforms

### 7.3 ac Timing Diagrams

ac parameters are measured at 50%, unless otherwise indicated.

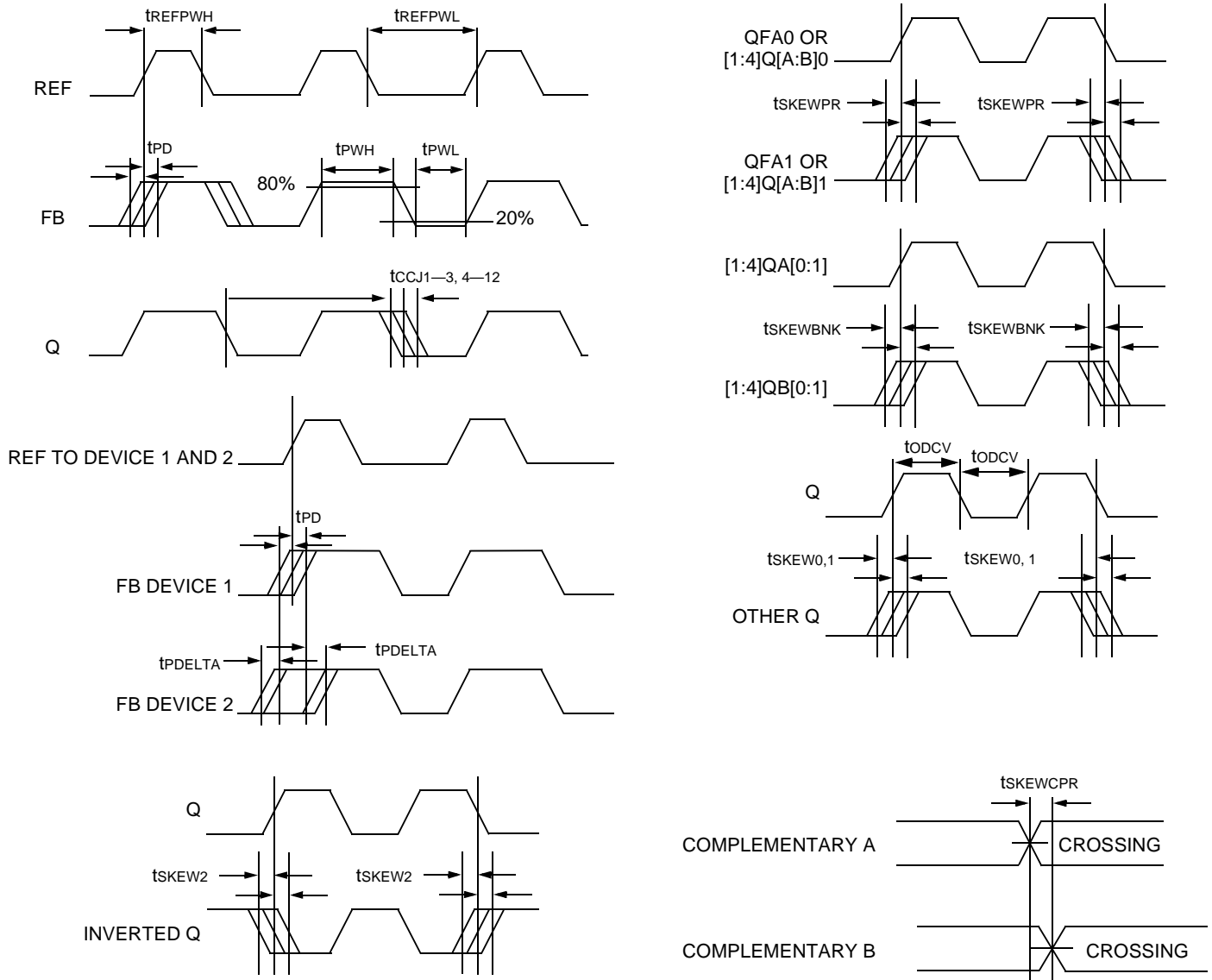
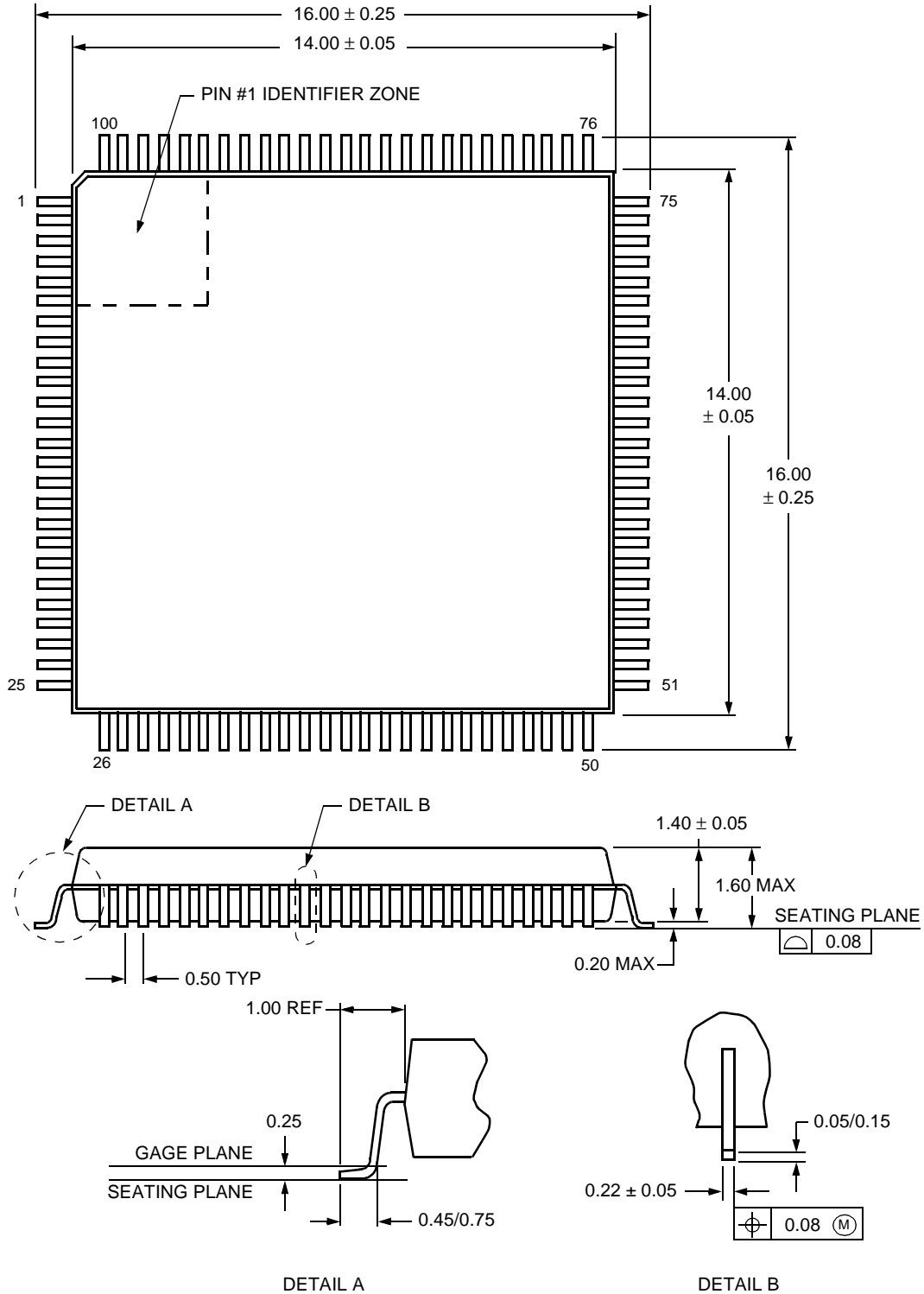


Figure 7-2. ac Timing Diagrams

## 8 Outline Diagrams

### 8.1 100-Pin TQFP

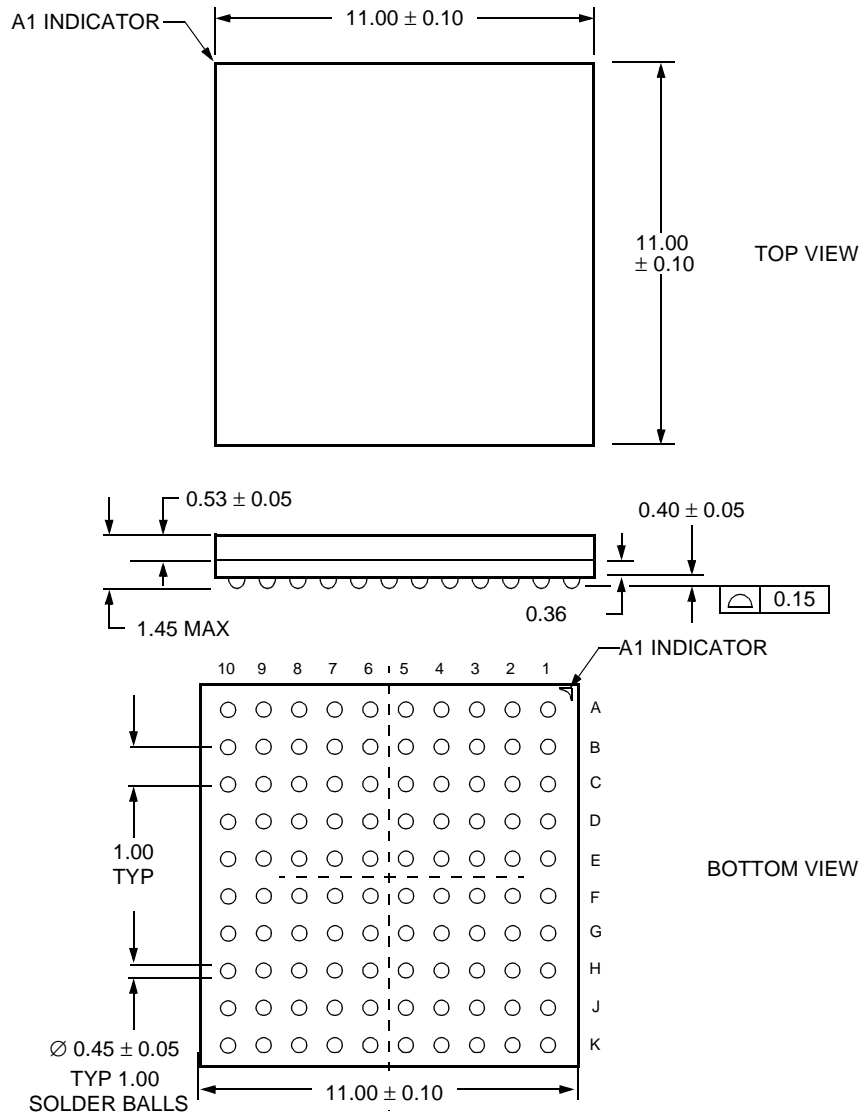
Controlling dimensions are in millimeters.



5-2146 (F) r.1

8.2 100-Ball FSBGA

Controlling dimensions are in millimeters.



5-8159.a (F) r.1

**Note:** The ball diameter, ball pitch, and stand-off and package thicknesses are different from JEDEC spec M0192 (low-profile BGA family).



## 9 Ordering Information

Table 9-1. LCK4993 Ordering Information

| Device       | Package Type | Comcode   | Delivery |
|--------------|--------------|-----------|----------|
| LCK4993YH-DB | 100FSBGA     | 700034618 | Tray     |
| LCK4993YH-DT | 100FSBGA     | 700034619 | Tape     |
| LCK4993KB-DB | 100TQFP      | 700024614 | Tray     |
| LCK4993KB-DT | 100TQFP      | 700024615 | Tape     |

Table 9-2. LCK4994 Ordering Information

| Device       | Package Type | Comcode   | Delivery |
|--------------|--------------|-----------|----------|
| LCK4994YH-DB | 100FSBGA     | 700042835 | Tray     |
| LCK4994YH-DT | 100FSBGA     | 700042836 | Tape     |
| LCK4994KB-DB | 100TQFP      | 700025705 | Tray     |
| LCK4994KB-DT | 100TQFP      | 700025708 | Tape     |

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