

# iCE40™ LP Series Ultra Low-Power FPGA Family

October 03, 2012 (1.32)

Data Sheet

- LP-Series - optimized for low power
- Ultra-small footprints
- 30% faster than iCE65
- Proven, high-volume 40 nm, low-power CMOS technology
- Integrated Phase-Locked Loop (PLL)
  - ◆ Clock multiplication/division for display, SerDes and memory interface applications
- Up to 533 MHz PLL Output
- Reprogrammable from a variety of methods and sources
- Flexible programmable logic and programmable interconnect fabric
  - ◆ 8K look-up tables (LUT4) and flip-flops
  - ◆ Low-power logic and interconnect
- Complete iCEcube2™ development system
  - ◆ Windows® and Linux® support
  - ◆ VHDL and Verilog logic synthesis
  - ◆ Place and route software
  - ◆ Design and IP core libraries
  - ◆ Low-cost iCEman40LP development board

Figure 1: iCE40 LP-Series Family Architectural Features

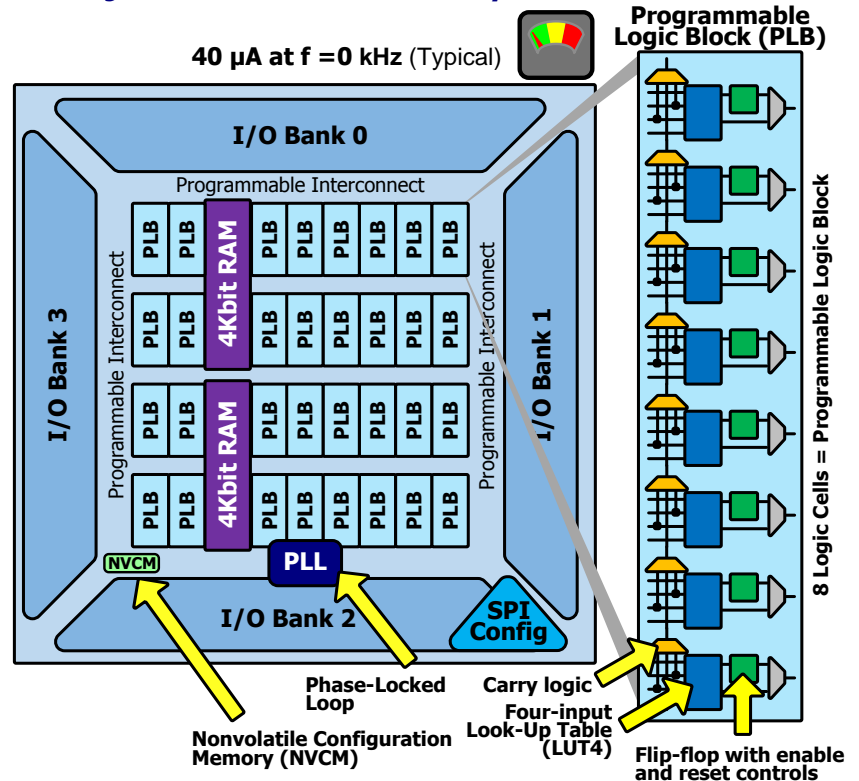


Table 1: iCE40LP Ultra Low-Power Programmable Logic Family Summary

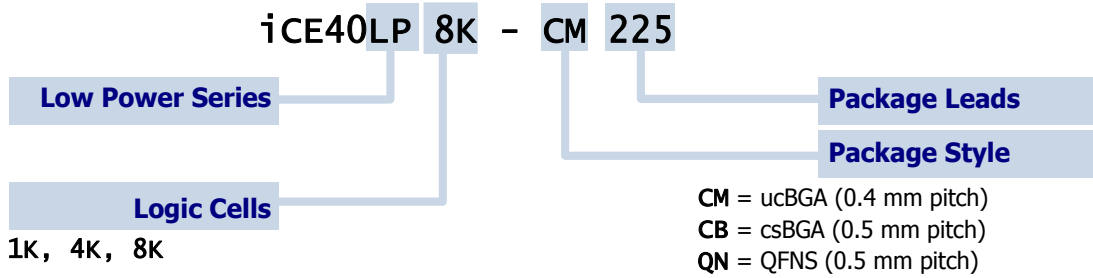
| Part Number                                   |       |         |          | LP1K                  | LP4K               | LP8K     |
|---|-------|---------|----------|-----------------------|--------------------|----------|
| <b>Logic Cells (LUT + Flip-Flop)</b>          |       |         |          | 1,280                 | 3,520              | 7,680    |
| <b>RAM4K Memory Blocks</b>                    |       |         |          | 16                    | 20                 | 32       |
| <b>RAM4K RAM bits</b>                         |       |         |          | 64K                   | 80K                | 128K     |
| <b>Phase-Locked Loops (PLLs)</b>              |       |         |          | 1                     | 2                  | 2        |
| <b>Configuration bits (maximum)</b>           |       |         |          | 245 Kb                | 533 Kb             | 1,057 Kb |
| <b>Core Operating Power 0 KHz<sup>1</sup></b> |       |         |          | 40 µA                 | 140 µA             | 160 µA   |
| <b>Maximum Programmable I/O Pins</b>          |       |         |          | 95                    | 167                | 178      |
| <b>Maximum Differential Input Pairs</b>       |       |         |          | 12                    | 20                 | 23       |
| Package                                       | Code  | Area mm | Pitch mm | Programmable I/O: Max |                    |          |
| 36 <sup>2</sup> -ball ucBGA                   | CM36  | 2.5x2.5 | 0.4      | 25(3)                 |                    |          |
| 49-ball ucBGA                                 | CM49  | 3x3     | 0.4      | 35(5)                 |                    |          |
| 81-ball ucBGA                                 | CM81  | 4x4     | 0.4      | 63(8)                 | 63(9) <sup>3</sup> |          |
| 81-ball csBGA                                 | CB81  | 5x5     | 0.5      | 62(8)                 |                    |          |
| 121-ball ucBGA                                | CM121 | 5x5     | 0.4      | 95 (12)               | 93 (13)            | 93 (13)  |
| 121-ball csBGA                                | CB121 | 6x6     | 0.5      | 92 (12)               |                    |          |
| 225-ball ucBGA                                | CM225 | 7x7     | 0.4      |                       | 167 (20)           | 178 (23) |
| 84 <sup>2</sup> -pin QFNS                     | QN84  | 7x7     | 0.5      | 67(7)                 |                    |          |

Note 1: At 1.2V VCC, 25°C Note 2: No PLL Available Note 3: Only 1 PLL Available

## Ordering Information

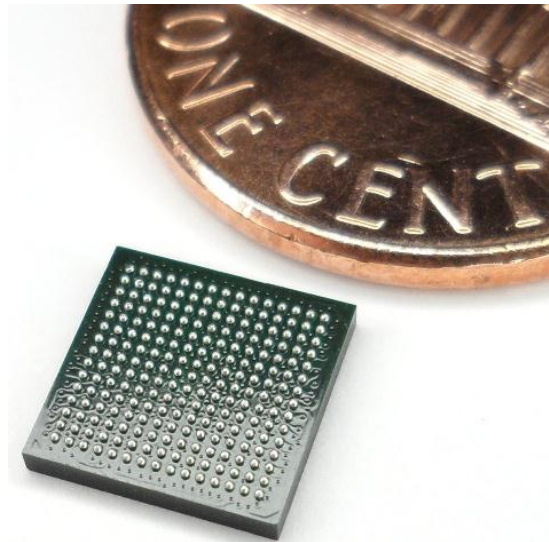
Figure 2 describes the iCE40LP ordering codes for all packaged components. See the separate DiePlus data sheets when ordering die-based products. See the separate iCE40 Pinout Excel files for package and pinout specifications.

Figure 2: iCE40P Ordering Codes (packaged, non-die components)



| Part Number     | LUTs  | Supply Voltage | Temp. |
|-----------------|-------|----------------|-------|
| iCE40LP1K-CM36  | 1,280 | 1.2V           | IND   |
| iCE40LP1K-CM49  | 1,280 | 1.2V           | IND   |
| iCE40LP1K-CM81  | 1,280 | 1.2V           | IND   |
| iCE40LP1K-CM121 | 1,280 | 1.2V           | IND   |
| iCE40LP1K-CB81  | 1,280 | 1.2V           | IND   |
| iCE40LP1K-CB121 | 1,280 | 1.2V           | IND   |
| iCE40LP1K-QN84  | 1,280 | 1.2V           | IND   |
| iCE40LP4K-CM81  | 3,520 | 1.2V           | IND   |
| iCE40LP4K-CM121 | 3,520 | 1.2V           | IND   |
| iCE40LP4K-CM225 | 3,520 | 1.2V           | IND   |
| iCE40LP8K-CM121 | 7,680 | 1.2V           | IND   |
| iCE40LP8K-CM225 | 7,680 | 1.2V           | IND   |

iCE40LP8K-CM225  
 225-ball Chip-Scale BGA Package  
 (7x7 mm footprint, 0.4 mm pitch)



## Electrical Characteristics

All parameter limits are specified under worst-case supply voltage, junction temperature, and processing conditions.

### Absolute Maximum Ratings

Stresses beyond those listed under Table 2 may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions beyond those listed under the Recommended Operating Conditions is not implied. Exposure to absolute maximum conditions for extended periods of time adversely affects device reliability.

Table 2: Absolute Maximum Ratings

| Symbol   | Description  | Minimum | Maximum | Units |
|--|--|---------|---------|-------|
| <b>VCC</b>   | Core supply Voltage  | -0.5    | 1.42    | V     |
| <b>VPP_2V5</b>   | VPP_2V5 NVCM programming and operating supply  |         |         | V     |
| <b>VPP_FAST</b>  | Optional fast NVCM programming supply  |         |         | V     |
| <b>VCCIO_0</b><br><b>VCCIO_1</b><br><b>VCCIO_2</b><br><b>VCCIO_3</b><br><b>SPI_VCC</b> | I/O bank supply voltage (I/O Banks 0, 1, 2 and 3 plus SPI interface)                               | -0.5    | 4.00    | V     |
| <b>VIN_0</b><br><b>VIN_1</b><br><b>VIN_2</b><br><b>VIN_SPI</b><br><b>VIN_3</b>         | Voltage applied to PIO pin within a specific I/O bank (I/O Banks 0, 1, 2 and 3 plus SPI interface) | -1.0    | 3.6     | V     |
| <b>VCCPLL</b>  | Analog voltage supply to the Phase Locked Loop (PLL)   | -0.5    | 1.30    | V     |
| <b>I<sub>OUT</sub></b>   | DC output current per pin  | —       | 20      | mA    |
| <b>T<sub>J</sub></b>   | Junction temperature   | -55     | 125     | °C    |
| <b>T<sub>STG</sub></b>   | Storage temperature, no bias   | -65     | 150     | °C    |

### Recommended Operating Conditions

Table 3: Recommended Operating Conditions

| Symbol  | Description  |                                  | Minimum | Nominal | Maximum | Units |
|---|--|----------------------------------|---------|---------|---------|-------|
| VCC   | Core supply voltage                                  | High Performance, low-power      | 1.14    | 1.20    | 1.26    | V     |
| VPP_2V5 <sup>1</sup>                                | VPP_2V5 NVCM programming and operating supply        | Release from Power-on Reset      | 1.30    | —       | 3.47    | V     |
|   |  | Configure from NVCM              | 2.30    | —       | 3.47    | V     |
|   |  | NVCM programming                 | 2.30    | —       | 3.00    | V     |
| VPP_FAST <sup>2</sup>                               | Optional fast NVCM programming supply                | Leave unconnected in application |         |         |         |       |
| SPI_VCC   | SPI interface supply voltage                         |                                  | 1.71    | —       | 3.47    | V     |
| VCCIO_0<br>VCCIO_1<br>VCCIO_2<br>VCCIO_3<br>SPI_VCC | I/O standards, all banks                             | <b>LVC MOS33</b>                 | 2.70    | 3.30    | 3.47    | V     |
|   |  | <b>LVC MOS25, LVDS</b>           | 2.38    | 2.50    | 2.63    | V     |
|   |  | <b>LVC MOS18, SubLVDS</b>        | 1.71    | 1.80    | 1.89    | V     |
|   |  | <b>LVC MOS15</b>                 | 1.43    | 1.50    | 1.58    | V     |
| <b>VCCPLL</b> <sup>3</sup>                          | Analog voltage supply to the Phase Locked Loop (PLL) |                                  | 1.14    | 1.20    | 1.26    | V     |
| T <sub>A</sub>                                      | Ambient temperature                                  |                                  | -40     | —       | 85      | °C    |
| T <sub>PROG</sub>                                   | NVCM programming temperature                         |                                  | 10      | 25      | 30      | °C    |

#### Notes:

- VPP\_2V5 must be connected to a valid voltage, when the iCE40LP device is active.
- VPP\_FAST, used only for fast production programming, must be left floating or unconnected in application, except CM36 and CM49 packages MUST have VPP\_FAST ball connected to VCCIO\_0 ball externally.
- VCCPLL must be tied to VCC when PLL is not used.

## I/O Characteristics

Table 4: PIO Pin Electrical Characteristics

| Symbol       | Description  | Conditions                       | Minimum | Nominal | Maximum  | Units      |
|--------------|--|----------------------------------|---------|---------|----------|------------|
| $I_I$        | Input pin leakage current                            | $V_{IN} = V_{CCIO_{max}}$ to 0 V |         |         | $\pm 10$ | $\mu A$    |
| $I_{OZ}$     | Three-state I/O pin (Hi-Z) leakage current           | $V_O = V_{CCIO_{max}}$ to 0 V    |         |         | $\pm 10$ | $\mu A$    |
| $C_{PIO}$    | PIO pin input capacitance                            |                                  |         | 6       |          | pF         |
| $C_{GBIN}$   | GBIN global buffer pin input capacitance             |                                  |         | 6       |          | pF         |
| $R_{PULLUP}$ | Internal PIO pull-up resistance during configuration | $V_{CCIO} = 3.3V$                |         | 60      |          | k $\Omega$ |
|              |  | $V_{CCIO} = 2.5V$                |         | 80      |          | k $\Omega$ |
|              |  | $V_{CCIO} = 1.8V$                |         | 120     |          | k $\Omega$ |
|              |  | $V_{CCIO} = 1.5V$                |         | 160     |          | k $\Omega$ |
| $V_{HYST}$   | Input hysteresis                                     | $V_{CCIO} = 1.5V$ to 3.3V        |         | 50      |          | mV         |

**NOTE:** All characteristics are characterized and may or may not be tested on each pin on each device.

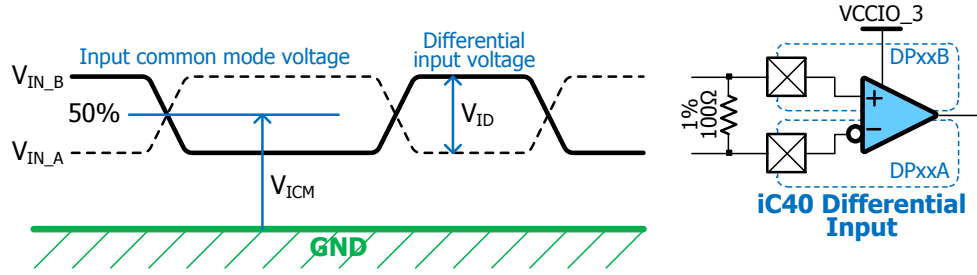
## Single-ended I/O Characteristics

Table 5: I/O Characteristics

| I/O Standard | Nominal I/O Bank Supply Voltage | Input Voltage (V) |           | Output Voltage (V) |          | Output Current at Voltage (mA) |          |
|--------------|---------------------------------|-------------------|-----------|--------------------|----------|--------------------------------|----------|
|              |                                 | $V_{IL}$          | $V_{IH}$  | $V_{OL}$           | $V_{OH}$ | $I_{OL}$                       | $I_{OH}$ |
| LVC MOS33    | 3.3V                            | 0.80              | 2.00      | 0.4                | 2.40     | 8                              | 8        |
| LVC MOS25    | 2.5V                            | 0.70              | 1.70      | 0.4                | 2.00     | 6                              | 6        |
| LVC MOS18    | 1.8V                            | 35% VCCIO         | 65% VCCIO | 0.4                | 1.40     | 4                              | 4        |
| LVC MOS15    | 1.5V                            | 35% VCCIO         | 65% VCCIO | 0.4                | 1.20     | 2                              | 2        |

Differential Inputs

Figure 3: Differential Input Specifications



Input common mode voltage: 
$$V_{ICM} = \frac{VCCIO\_3}{2} \pm \Delta V_{ICM}$$

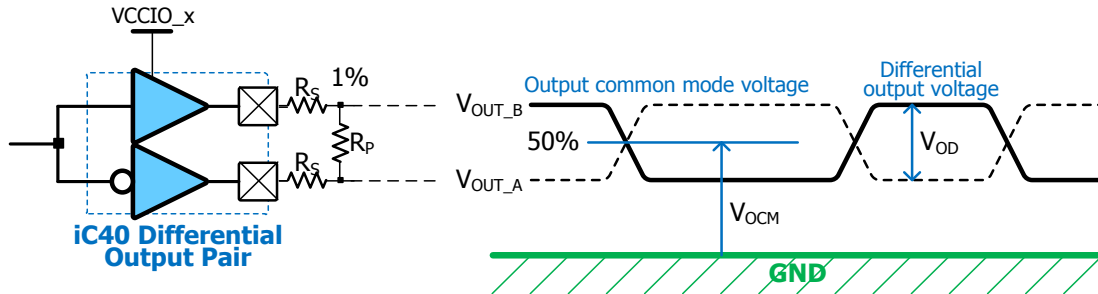
Differential input voltage: 
$$V_{ID} = |V_{IN\_B} - V_{IN\_A}|$$

Table 6: Recommended Operating Conditions for Differential Inputs

| I/O Standard   | VCCIO_3 (V) |      |      | V <sub>ID</sub> (mV) |     |     | V <sub>ICM</sub> (V)        |                      |                             |
|----------------|-------------|------|------|----------------------|-----|-----|-----------------------------|----------------------|-----------------------------|
|                | Min         | Nom  | Max  | Min                  | Nom | Max | Min                         | Nom                  | Max                         |
| <b>LVDS</b>    | 2.38        | 2.50 | 2.63 | 250                  | 350 | 450 | $\frac{VCCIO\_3}{2} - 0.30$ | $\frac{VCCIO\_3}{2}$ | $\frac{VCCIO\_3}{2} + 0.30$ |
| <b>SubLVDS</b> | 1.71        | 1.80 | 1.89 | 100                  | 150 | 200 | $\frac{VCCIO\_3}{2} - 0.25$ | $\frac{VCCIO\_3}{2}$ | $\frac{VCCIO\_3}{2} + 0.25$ |

Differential Outputs

Figure 4: Differential Output Specifications



Output common mode voltage: 
$$V_{OCM} = \frac{VCCIO\_x}{2} \pm \Delta V_{OCM}$$

Differential output voltage: 
$$V_{OD} = |V_{OUT\_B} - V_{OUT\_A}|$$

Table 7: Recommended Operating Conditions for Differential Outputs

| I/O Standard   | VCCIO_x (V) |      |      | Ω              |                | V <sub>OD</sub> (mV) |     |     | V <sub>OCM</sub> (V)     |                   |                          |
|----------------|-------------|------|------|----------------|----------------|----------------------|-----|-----|--------------------------|-------------------|--------------------------|
|                | Min         | Nom  | Max  | R <sub>S</sub> | R <sub>P</sub> | Min                  | Nom | Max | Min                      | Nom               | Max                      |
| <b>LVDS</b>    | 2.38        | 2.50 | 2.63 | 150            | 140            | 300                  | 350 | 400 | $\frac{VCCIO}{2} - 0.15$ | $\frac{VCCIO}{2}$ | $\frac{VCCIO}{2} + 0.15$ |
| <b>SubLVDS</b> | 1.71        | 1.80 | 1.89 | 270            | 120            | 100                  | 150 | 200 | $\frac{VCCIO}{2} - 0.10$ | $\frac{VCCIO}{2}$ | $\frac{VCCIO}{2} + 0.10$ |

## AC Timing Guidelines

The following examples provide some guidelines of device performance. The actual performance depends on the specific application and how it is physically implemented in the iCE40 FPGA using the Lattice iCEcube2 software. The following guidelines assume typical conditions ( $V_{CC} = 1.0\text{ V}$  or  $1.2\text{ V}$  as specified, temperature =  $25\text{ }^{\circ}\text{C}$ ). Apply derating factors using the iCEcube2 timing analyzer to adjust to other operating regimes.

### Programmable Logic Block (PLB) Timing

Table 8 provides timing information for the logic in a Programmable Logic Block (PLB), which includes the paths shown in Figure 5 and Figure 6.

Figure 5 PLB Sequential Timing Circuit

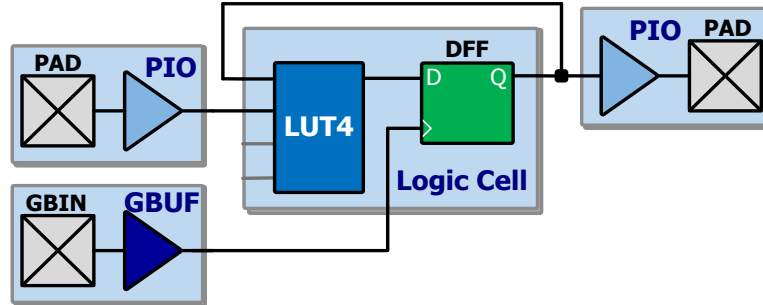


Figure 6 PLB Combinational Timing Circuit

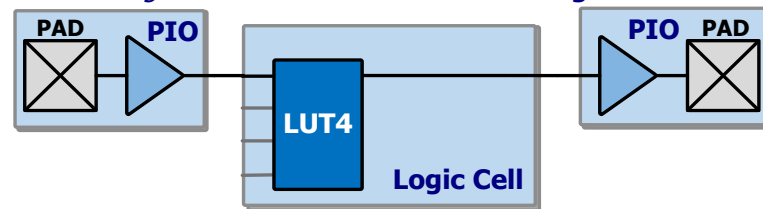


Table 8: Typical Programmable Logic Block (PLB) Timing

|                                  |                 |                 | Nominal $V_{CC}$  | 1.2 V |       |
|----------------------------------|-----------------|-----------------|---|-------|-------|
| Description                      |                 |                 |   | Typ.  | units |
| <b>Sequential Logic Paths</b>    |                 |                 |   |       |       |
| $F_{TOGGLE}$                     | GBIN input      | GBIN input      | Flip-flop toggle frequency. DFF flip-flop output fed back to LUT4 input with 4-input XOR, clocked on same clock edge                              | 256   | MHz   |
| $t_{CKO}$                        | DFF clock input | PIO output      | Logic cell flip-flop (DFF) clock-to-output time, measured from the DFF CLK input to PIO output, including interconnect delay.                     | 5.5   | ns    |
| $t_{GBCKLC}$                     | GBIN input      | DFF clock input | Global Buffer Input (GBIN) delay, through Global Buffer (GBUF) clock network to clock input on the logic cell DFF flip-flop.                      | 2.1   | ns    |
| $t_{SULT}$                       | PIO input       | GBIN input      | Minimum setup time on PIO input, through LUT4, to DFF flip-flop D-input before active clock edge on the GBIN input, including interconnect delay. | 0.9   | ns    |
| $t_{HDLI}$                       | GBIN input      | PIO input       | Minimum hold time on PIO input, through LUT4, to DFF flip-flop D-input after active clock edge on the GBIN input, including interconnect delay.   | 0     | ns    |
| <b>Combinational Logic Paths</b> |                 |                 |   |       |       |
| $t_{LUT4IN}$                     | PIO input       | LUT4 input      | Asynchronous delay from PIO input pad to adjacent PLB interconnect.   | 2.5   | ns    |
| $t_{LO}$                         | LUT4 input      | LUT4 output     | Logic cell LUT4 combinational logic propagation delay, regardless of logic complexity from input to output.                                       | 0.48  | ns    |
| $t_{LUT4IN}$                     | LUT4 output     | PIO output      | Asynchronous delay from adjacent PLB interconnect to PIO output pad.  | 5.1   | ns    |

**Programmable Input/Output (PIO) Block**

Table 9 provides timing information for the logic in a Programmable Logic Block (PLB), which includes the paths shown in Figure 7 and Figure 8. The timing shown is for the LVCMOS25 I/O standard in all I/O banks. The iCEcube2 development software reports timing adjustments for other I/O standards.

Figure 7: Programmable I/O (PIO) Pad-to-Pad Timing Circuit

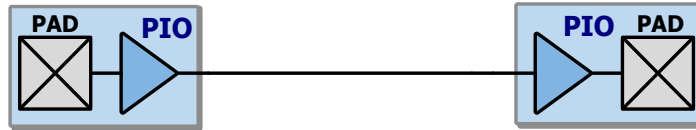


Figure 8: Programmable I/O (PIO) Sequential Timing Circuit

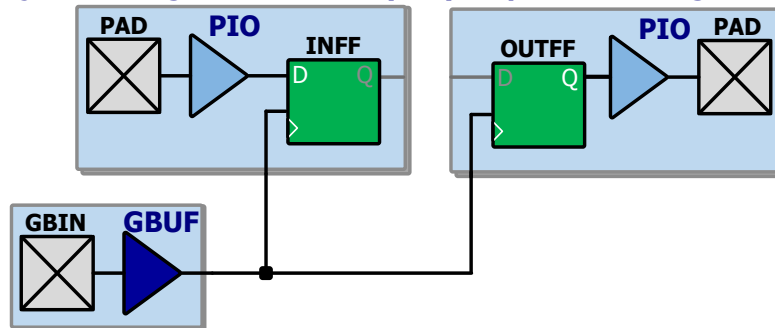


Table 9: Typical Programmable Input/Output (PIO) Timing (LVCMOS25)

|                                 |                   |                   | Nominal VCC   | 1.2 V | units |
|---------------------------------|-------------------|-------------------|---|-------|-------|
| Description                     |                   |                   |   | Typ.  |       |
| <b>Synchronous Output Paths</b> |                   |                   |   |       |       |
| $t_{\text{OCLK}}$               | OUTFF clock input | PIO output        | Delay from clock input on OUTFF output flip-flop to PIO output pad.   | 4.3   | ns    |
| $t_{\text{GBCKIO}}$             | GBIN input        | OUTFF clock input | Global Buffer Input (GBIN) delay, though Global Buffer (GBUF) clock network to clock input on the PIO OUTFF output flip-flop. | 2.0   | ns    |
| <b>Synchronous Input Paths</b>  |                   |                   |   |       |       |
| $t_{\text{SUPDIN}}$             | PIO input         | GBIN input        | Setup time on PIO input pin to INFF input flip-flop before active clock edge on GBIN input, including interconnect delay.     | 0     | ns    |
| $t_{\text{HDPDIN}}$             | GBIN input        | PIO input         | Hold time on PIO input to INFF input flip-flop after active clock edge on the GBIN input, including interconnect delay.       | 2.2   | ns    |
| <b>Pad to Pad</b>               |                   |                   |   |       |       |
| $t_{\text{PADIN}}$              | PIO input         | Inter-connect     | Asynchronous delay from PIO input pad to adjacent interconnect.   | 2.5   | ns    |
| $t_{\text{PADO}}$               | Inter-connect     | PIO output        | Asynchronous delay from adjacent interconnect to PIO output pad including interconnect delay.                                 | 4.8   | ns    |

**RAM4K Block**

Table 10 provides timing information for the logic in a RAM4K block, which includes the paths shown in Figure 9.

Figure 9: RAM4K Timing Circuit

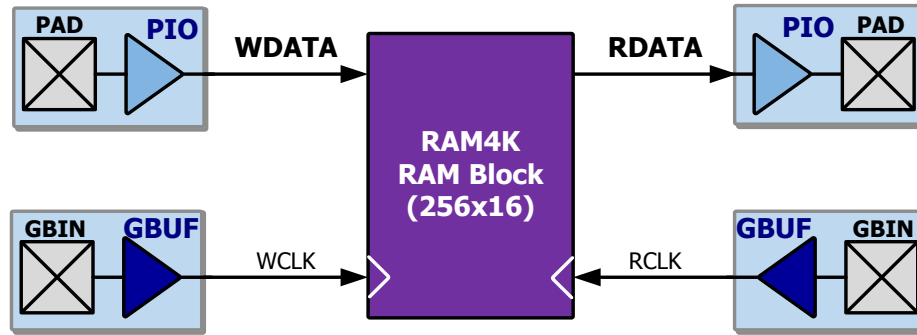


Table 10: Typical RAM4K Block Timing

|   |                  |                  | Nominal VCC  | 1.2 V |     |
|---|------------------|------------------|--|-------|-----|
| Description                                 |                  |                  |  | Typ.  |     |
| <b>Write Setup/Hold Time</b>                |                  |                  |  |       |     |
| $t_{SUWD}$                                  | PIO input        | GBIN input       | Minimum write data setup time on PIO inputs before active clock edge on GBIN input, include interconnect delay.                  | 0.62  | ns  |
| $t_{HDWD}$                                  | GBIN input       | PIO input        | Minimum write data hold time on PIO inputs after active clock edge on GBIN input, including interconnect delay.                  | 0     | ns  |
| <b>Read Clock-Output-Time</b>               |                  |                  |  |       |     |
| $t_{CKORD}$                                 | RCLK clock input | PIO output       | Clock-to-output delay from RCLK input pin, through RAM4K RDATA output flip-flop to PIO output pad, including interconnect delay. | 5.6   | ns  |
| $t_{GBCKRM}$                                | GBIN input       | RCLK clock input | Global Buffer Input (GBIN) delay, though Global Buffer (GBUF) clock network to the RCLK clock input.                             | 2.0   | ns  |
| <b>Write and Read Clock Characteristics</b> |                  |                  |  |       |     |
| $t_{RMWCKH}$                                | WCLK             | WCLK             | Write clock High time  | 0.42  | ns  |
| $t_{RMWCKL}$                                | RCLK             | RCLK             | Write clock Low time   | 0.48  | ns  |
| $t_{RMWCYC}$                                |                  |                  | Write clock cycle time   | 0.98  | ns  |
| $F_{WMAX}$                                  |                  |                  | Sustained write clock frequency  | 256   | MHz |



## Phase-Locked Loop (PLL) Block

Table 11 provides timing information for the Phase-Locked Loop (PLL) block shown in Figure 10.

Figure 10: Phase-Locked Loop (PLL)

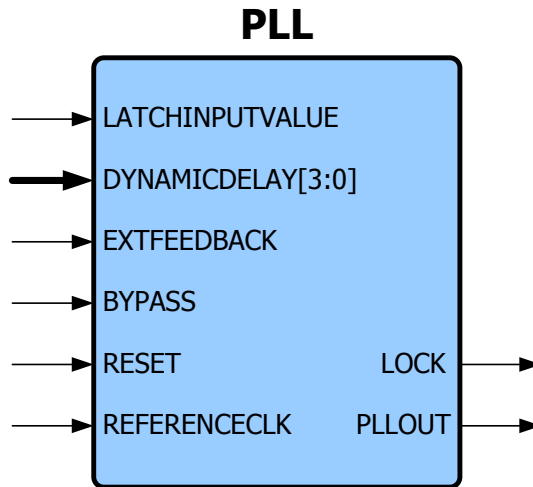


Table 11: Phase-Locked Loop (PLL) Block Timing

| Symbol                 | From | To | Nominal VCC  |      | 1.2 V            |                                      | Units   |
|------------------------|------|----|--|------|------------------|--------------------------------------|---------|
|                        |      |    | Description  | Min. | Typical          | Max.                                 |         |
| <b>Frequency Range</b> |      |    |  |      |                  |                                      |         |
| $F_{REF}$              |      |    | Input clock frequency range  | 10   | —                | 133                                  | MHz     |
| $F_{OUT}$              |      |    | Output clock frequency range (cannot exceed maximum frequency supported by global buffers) | 16   | —                | 533                                  | MHz     |
| <b>Duty Cycle</b>      |      |    |  |      |                  |                                      |         |
| $PLL_{IJ}$             |      |    | Input duty cycle   | 35   | —                | 65                                   | %       |
| $TW_{HI}$              |      |    | Input clock high time  | 2.5  | —                | —                                    | ns      |
| $TW_{LOW}$             |      |    | Input clock low time   | 2.5  | —                | —                                    | ns      |
| $PLL_{OJ}$             |      |    | Output duty cycle  | 45   | —                | 55                                   | %       |
| <b>Fine Delay</b>      |      |    |  |      |                  |                                      |         |
| $t_{FDAP}$             |      |    | Fine delay adjustment, per tap   |      | 165              |                                      | ps      |
| $PLL_{TAPS}$           |      |    | Fine delay adjustment settings   | 0    | —                | 15                                   | taps    |
| $PLL_{FDAM}$           |      |    | Maximum delay adjustment   |      | 2.5              |                                      | ns      |
| <b>Jitter</b>          |      |    |  |      |                  |                                      |         |
| $PLL_{IPJ}$            |      |    | Input clock period jitter  | —    | —                | +/- 300                              | ps      |
| $PLL_{OPJ}$            |      |    | PLLOUT output period jitter  | —    | 1% or $\leq 100$ | +/- 1.1% output period or $\geq 110$ | ps      |
| <b>Lock/Reset Time</b> |      |    |  |      |                  |                                      |         |
| $t_{LOCK}$             |      |    | PLL lock time after receive stable, monotonic REFERENCECLK input                           | —    | —                | 50                                   | $\mu$ s |
| $tW_{RST}$             |      |    | Minimum reset pulse width  | 20   | —                | —                                    | ns      |

Notes:

- Output jitter performance is affected by input jitter. A clean reference clock < 100ps jitter must be used to ensure best jitter performance.
- The output jitter specification refers to the intrinsic jitter of the PLL.

## Internal Configuration Oscillator Frequency

Table 12 shows the operating frequency for the iCE40's internal configuration oscillator.

Table 12: Internal Oscillator Frequency at VCC = 1.2V

| Symbol     | Oscillator Mode       | Frequency (MHz) |      | Description   |
|------------|-----------------------|-----------------|------|---|
|            |                       | Min.            | Max. |   |
| $f_{OSCD}$ | <b>Default</b>        | 7               | 10   | Default oscillator frequency. Slow enough to safely operate with any SPI serial PROM. |
| $f_{OSCL}$ | <b>Low Frequency</b>  | 21              | 30   | Supported by most SPI serial Flash PROMs  |
| $f_{OSCH}$ | <b>High Frequency</b> | 35              | 50   | Supported by some high-speed SPI serial Flash PROMs                                   |
|            | <b>Off</b>            | 0               | 0    | Oscillator turned off by default after configuration to save power.                   |

## Configuration Timing

Table 13 shows the maximum time to configure an iCE40LP device, by oscillator mode. The calculations use the slowest frequency for a given oscillator mode from Table 12 and the maximum configuration bitstream size from Table 1, which includes full RAM4K block initialization. The configuration bitstream selects the desired oscillator mode based on the performance of the configuration data source.

Table 13: Typical SPI Master or NVCM Configuration Timing by Oscillator Mode

| Symbol        | Description   | Device    | Default | Low Freq. | High Freq. | Units |
|---------------|---|-----------|---------|-----------|------------|-------|
| $t_{CONFIGL}$ | Time from when minimum Power-on Reset (POR) threshold is reached until user application starts. | iCE40LP1K | 53      | 25        | 11         | ms    |
|               |   | iCE40LP4K | 230     | 110       | 50         | ms    |
|               |   | iCE40LP8K | 230     | 110       | 50         | ms    |

Table 14 provides timing for the CRESET\_B and CDONE pins.

Table 14: General Configuration Timing

| Symbol          | From       | To              | Description  | All Grades                   |      | Units        |
|-----------------|------------|-----------------|--|------------------------------|------|--------------|
|                 |            |                 |  | Min.                         | Max. |              |
| $t_{CRESET\_B}$ | CRESET_B   | CRESET_B        | Minimum CRESET_B Low pulse width required to restart configuration, from falling edge to rising edge | 200                          | —    | ns           |
| $t_{DONE\_IO}$  | CDONE High | PIO pins active | Number of configuration clock cycles after CDONE goes High before the PIO pins are activated.        | —                            | 49   | Clock cycles |
|                 |            |                 | SPI Peripheral Mode (Clock = SPI_SCK, cycles measured rising-edge to rising-edge)                    | Depends on SPI_SCK frequency |      |              |

Table 15 provides various timing specifications for the SPI peripheral mode interface.

Table 15: SPI Peripheral Mode Timing

| Symbol          | From     | To      | Description  | All Grades |       | Units   |
|-----------------|----------|---------|--|------------|-------|---------|
|                 |          |         |  | Min.       | Max.  |         |
| $t_{CR\_SCK}$   | CRESET_B | SPI_SCK | Minimum time from a rising edge on CRESET_B until the first SPI write operation, first SPI_SCK. During this time, the iCE40LP FPGA is clearing its internal configuration memory | 300        | —     | $\mu$ s |
| $t_{SUSPISI}$   | SPI_SI   | SPI_SCK | Setup time on SPI_SI before the rising SPI_SCK clock edge  | 12         | —     | ns      |
| $t_{HDSPISI}$   | SPI_SCK  | SPI_SI  | Hold time on SPI_SI after the rising SPI_SCK clock edge  | 12         | —     | ns      |
| $t_{SPISCKH}$   | SPI_SCK  | SPI_SCK | SPI_SCK clock High time  | 20         | —     | ns      |
| $t_{SPISCKL}$   | SPI_SCK  | SPI_SCK | SPI_SCK clock Low time   | 20         | —     | ns      |
| $t_{SPISCKCYC}$ | SPI_SCK  | SPI_SCK | SPI_SCK clock period*  | 40         | 1,000 | ns      |
| $F_{SPI\_SCK}$  | SPI_SCK  | SPI_SCK | Sustained SPI_SCK clock frequency*   | 1          | 25    | MHz     |

\* = Applies after sending the synchronization pattern.

## Power Consumption Characteristics

### Core Power

Table 16 shows the power consumed on the internal VCC supply rail when the device is filled with 16-bit binary counters, measured with a 32.768 kHz and at 32.0 MHz

**Table 16: VCC Power Consumption for Device Filled with 16-Bit Binary Counters**

| Symbol                   | Description    | VCC  | iCE40LP1K            | iCE40LP4K            | iCE40LP8K            | Units |
|--------------------------|----------------|------|----------------------|----------------------|----------------------|-------|
|                          |                |      | Typical <sup>1</sup> | Typical <sup>1</sup> | Typical <sup>1</sup> |       |
| <b>I<sub>CC0K</sub></b>  | f = 0          | 1.2V | 40                   | 140                  | 160                  | μA    |
| <b>I<sub>CC32K</sub></b> | f ≤ 32.768 kHz | 1.2V | 44                   | 156                  | 178                  | μA    |
| <b>I<sub>CC32M</sub></b> | f = 32.0 MHz   | 1.2V | 3                    | 11                   | 12                   | mA    |

Note 1: At 25°C

### I/O Power

Table 17 provides the static current by I/O bank. The typical current for I/O Banks 0, 1, 2 and the SPI bank is not measurable within the accuracy of the test environment. The PIOs in I/O Bank 3 use different circuitry and dissipate a small amount of static current.

**Table 17: I/O Bank Static Current (f = 0 MHz)**

| Symbol                     | Description | Typical | Maximum | Units |
|----------------------------|-------------|---------|---------|-------|
| <b>I<sub>CC0_0</sub></b>   | I/O Bank 0  | « 1     |         | μA    |
| <b>I<sub>CC0_1</sub></b>   | I/O Bank 1  | « 1     |         | μA    |
| <b>I<sub>CC0_2</sub></b>   | I/O Bank 2  | « 1     |         | μA    |
| <b>I<sub>CC0_3</sub></b>   | I/O Bank 3  | « 1     |         | μA    |
| <b>I<sub>CC0_SPI</sub></b> | SPI Bank    | « 1     |         | μA    |

NOTE: The typical static current for I/O Banks 0, 1, 2, and the SPI bank is less than the accuracy of the device tester.

### Power Estimator

To estimate the power consumption for a specific application, please download and use the iCE40LP Power Estimator Spreadsheet or use the power estimator built into the iCEcube2 software.

## Revision History

| Version     | Date        | Description  |
|-------------|-------------|--|
| <b>1.32</b> | 03-OCT-2012 | Updated <a href="#">Table 1</a> to remove iCE40LP640, add packages CB81 and CB121, note 1 to include 25°C, and unified package nomenclature. Updated <a href="#">Figure 2</a> Ordering codes to include all part numbers. Added Note 1: At 25°C to <a href="#">Table 16</a> VCC Power. |
| <b>1.31</b> | 30-MAR-2012 | Updated <a href="#">Table 1</a>  |
| <b>1.3</b>  | 22-MAR-2012 | Production Release.<br>Updated Notes on <a href="#">Table 3</a> : Recommended Operating Conditions<br>Updated values in <a href="#">Table 4</a> , <a href="#">Table 5</a> , <a href="#">Table 12</a> , <a href="#">Table 13</a> and <a href="#">Table 17</a>                           |
| <b>1.21</b> | 5-MAR-2012  | Updated <a href="#">Figure 3</a> and <a href="#">Figure 4</a> to specify iCE40   |
| <b>1.2</b>  | 13-FEB-2012 | Updated company name   |
| <b>1.1</b>  | 15-DEC-2011 | Moved package specifications to iCE40 Pinout Excel files.<br>Updated <a href="#">Table 1</a> maximum IOs.  |
| <b>1.01</b> | 31-OCT-2011 | Added 640, 1K and 4K to <a href="#">Table 13</a> configuration times. Updated <a href="#">Table 1</a> maximum IOs.   |
| <b>1.0</b>  | 11-JUL-2011 | Initial Release  |

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