Lattice Semiconductor Corporation - ICE5LP4K-CM36ITR Datasheet

Welcome to E-XFL.COM

Understanding Embedded - FPGAs (Field Programmable Gate Array)

Embedded - FPGAs, or Field Programmable Gate Arrays, are advanced integrated circuits that offer unparalleled flexibility and performance for digital systems. Unlike traditional fixed-function logic devices, FPGAs can be programmed and reprogrammed to execute a wide array of logical operations, enabling customized functionality tailored to specific applications. This reprogrammability allows developers to iterate designs quickly and implement complex functions without the need for custom hardware.

Applications of Embedded - FPGAs

The versatility of Embedded - FPGAs makes them indispensable in numerous fields. In telecommunications.

Details	
Product Status	Active
Number of LABs/CLBs	440
Number of Logic Elements/Cells	3520
Total RAM Bits	81920
Number of I/O	26
Number of Gates	-
Voltage - Supply	1.14V ~ 1.26V
Mounting Type	Surface Mount
Operating Temperature	-40°C ~ 100°C (TJ)
Package / Case	36-VFBGA
Supplier Device Package	36-UCFBGA (2.5x2.5)
Purchase URL	https://www.e-xfl.com/product-detail/lattice-semiconductor/ice5lp4k-cm36itr

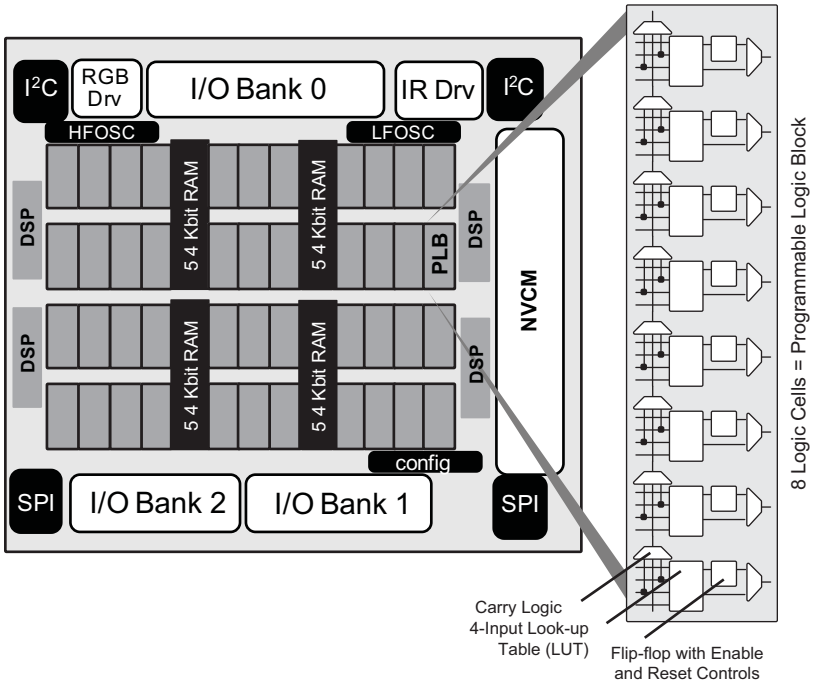
iCE40 Ultra Family Data Sheet Architecture

June 2016 Data Sheet DS1048

Architecture Overview

The iCE40 Ultra family architecture contains an array of Programmable Logic Blocks (PLB), two Oscillator Generators, two user configurable I²C controllers, two user configurable SPI controllers, and blocks of sysMEM™ Embedded Block RAM (EBR) surrounded by Programmable I/O (PIO). Figure 2-1shows the block diagram of the iCE5LP-4K device.

Figure 2-1. iCE5LP-4K Device, Top View



The Programmable Logic Blocks (PLB) and sysMEM EBR blocks, are arranged in a two-dimensional grid with rows and columns. Each column has either PLB or EBR blocks. The PIO cells are located at the top and bottom of the device, arranged in banks. The PLB contains the building blocks for logic, arithmetic, and register functions. The PIOs utilize a flexible I/O buffer referred to as a sysIO buffer that supports operation with a variety of interface standards. The blocks are connected with many vertical and horizontal routing channel resources. The place and route software tool automatically allocates these routing resources.

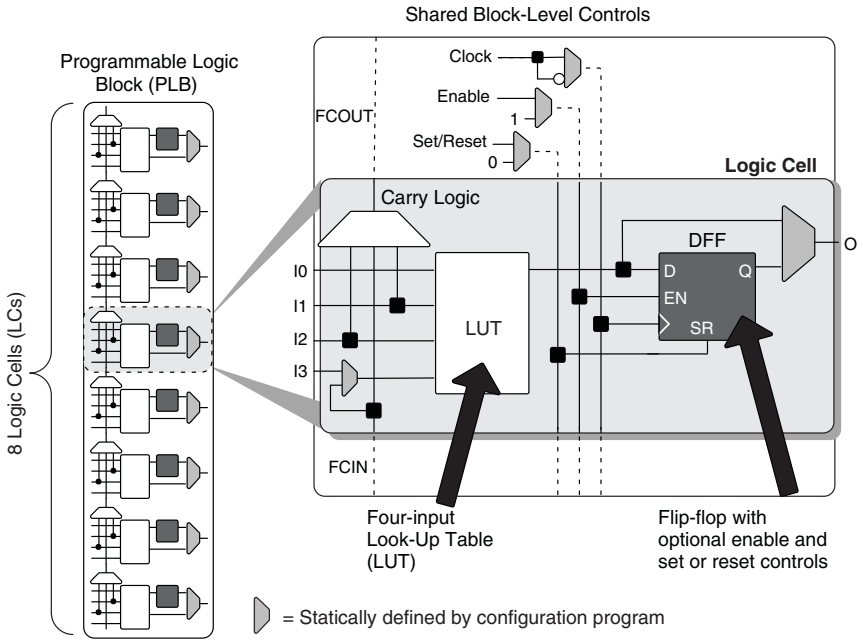
In the iCE40 Ultra family, there are three sysIO banks, one on top and two at the bottom. User can connect some V_{CCIO}s together, if all the I/Os are using the same voltage standard. Refer to the details in later sections of this document on Power Up Sequence. The sysMEM EBRs are large 4 kbit, dedicated fast memory blocks. These blocks can be configured as RAM, ROM or FIFO with user logic using PLBs.

Every device in the family has two user SPI ports, one of these (right side) SPI port also supports programming and configuration of the device. The iCE40 Ultra also includes two user I²C ports, two Oscillators, and high current RGB and IR LED sinks.

PLB Blocks

The core of the iCE40 Ultra device consists of Programmable Logic Blocks (PLB) which can be programmed to perform logic and arithmetic functions. Each PLB consists of eight interconnected Logic Cells (LC) as shown in Figure 2-2. Each LC contains one LUT and one register.

Figure 2-2. PLB Block Diagram



Logic Cells

Each Logic Cell includes three primary logic elements shown in Figure 2-2.

- A four-input Look-Up Table (LUT) builds any combinational logic function, of any complexity, requiring up to four inputs. Similarly, the LUT element behaves as a 16x1 Read-Only Memory (ROM). Combine and cascade multiple LUTs to create wider logic functions.
- A 'D'-style Flip-Flop (DFF), with an optional clock-enable and reset control input, builds sequential logic functions. Each DFF also connects to a global reset signal that is automatically asserted immediately following device configuration.
- Carry Logic boosts the logic efficiency and performance of arithmetic functions, including adders, subtracters, comparators, binary counters and some wide, cascaded logic functions.

Table 2-1. Logic Cell Signal Descriptions

Function	Type	Signal Names	Description
Input	Data signal	I0, I1, I2, I3	Inputs to LUT
Input	Control signal	Enable	Clock enable shared by all LCs in the PLB
Input	Control signal	Set/Reset[1]	Asynchronous or synchronous local set/reset shared by all LCs in the PLB.
Input	Control signal	Clock	Clock one of the eight Global Buffers, or from the general-purpose interconnects fabric shared by all LCs in the PLB
Input	Inter-PLB signal	FCIN	Fast carry in
Output	Data signals	O	LUT or registered output
Output	Inter-PFU signal	FCOUT	Fast carry out

1. If Set/Reset is not used, then the flip-flop is never set/reset, except when cleared immediately after configuration.

Routing

There are many resources provided in the iCE40 Ultra devices to route signals individually with related control signals. The routing resources consist of switching circuitry, buffers and metal interconnect (routing) segments.

The inter-PLB connections are made with three different types of routing resources: Adjacent (spans two PLBs), x4 (spans five PLBs) and x12 (spans thirteen PLBs). The Adjacent, x4 and x12 connections provide fast and efficient connections in the diagonal, horizontal and vertical directions.

The design tool takes the output of the synthesis tool and places and routes the design.

Clock/Control Distribution Network

Each iCE40 Ultra device has six global inputs, two pins on the top bank and four pins on the bottom bank

These global inputs can be used as high fanout nets, clock, reset or enable signals. The dedicated global pins are identified as Gxx and each drives one of the eight global buffers. The global buffers are identified as GBUF[7:0]. These six inputs may be used as general purpose I/O if they are not used to drive the clock nets.

Table 2-2 lists the connections between a specific global buffer and the inputs on a PLB. All global buffers optionally connect to the PLB CLK input. Any four of the eight global buffers can drive logic inputs to a PLB. Even-numbered global buffers optionally drive the Set/Reset input to a PLB. Similarly, odd-numbered buffers optionally drive the PLB clock-enable input. GBUF[7:6, 3:0] can connect directly to G[7:6, 3:0] pins respectively. GBUF4 and GBUF5 can connect to the two on-chip Oscillator Generators (GBUF4 connects to LFOSC, GBUF5 connects to HFOSC).

Table 2-2. Global Buffer (GBUF) Connections to Programmable Logic Blocks

Global Buffer	LUT Inputs	Clock	Clock Enable	Reset
GBUF0	Yes, any 4 of 8 GBUF Inputs	✓	✓	
GBUF1		✓		✓
GBUF2		✓	✓	
GBUF3		✓		✓
GBUF4		✓	✓	
GBUF5		✓		✓
GBUF6		✓	✓	
GBUF7		✓		✓

The maximum frequency for the global buffers are shown in the iCE40 Ultra External Switching Characteristics tables later in this document.

Global Hi-Z Control

The global high-impedance control signal, GHIZ, connects to all I/O pins on the iCE40 Ultra device. This GHIZ signal is automatically asserted throughout the configuration process, forcing all user I/O pins into their high-impedance state.

Global Reset Control

The global reset control signal connects to all PLB and PIO flip-flops on the iCE40 Ultra device. The global reset signal is automatically asserted throughout the configuration process, forcing all flip-flops to their defined wake-up state. For PLB flip-flops, the wake-up state is always reset, regardless of the PLB flip-flop primitive used in the application.

Figure 2-6. sysDSP 8-bit x 8-bit Multiplier

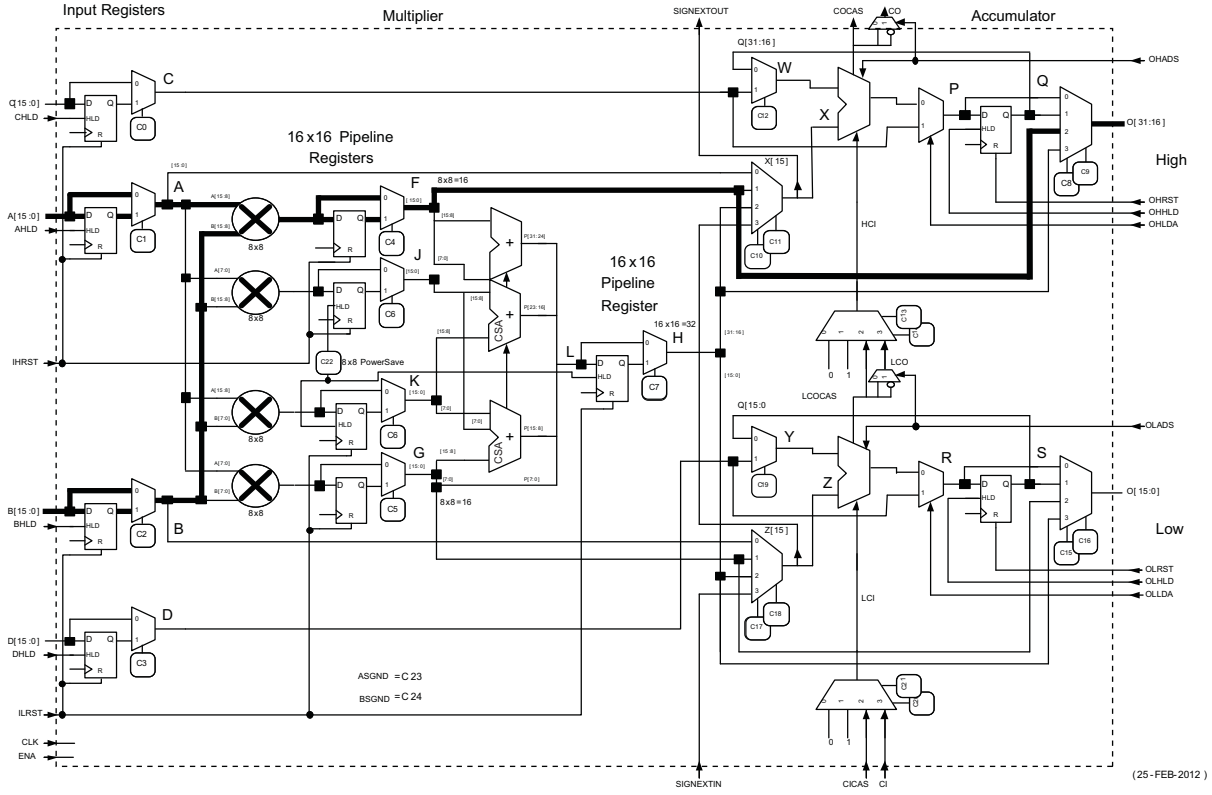


Figure 2-7 shows the path for an 16-bit x 16-bit Multiplier using the upper half of sysDSP block.

Figure 2-7. DSP 16-bit x 16-bit Multiplier

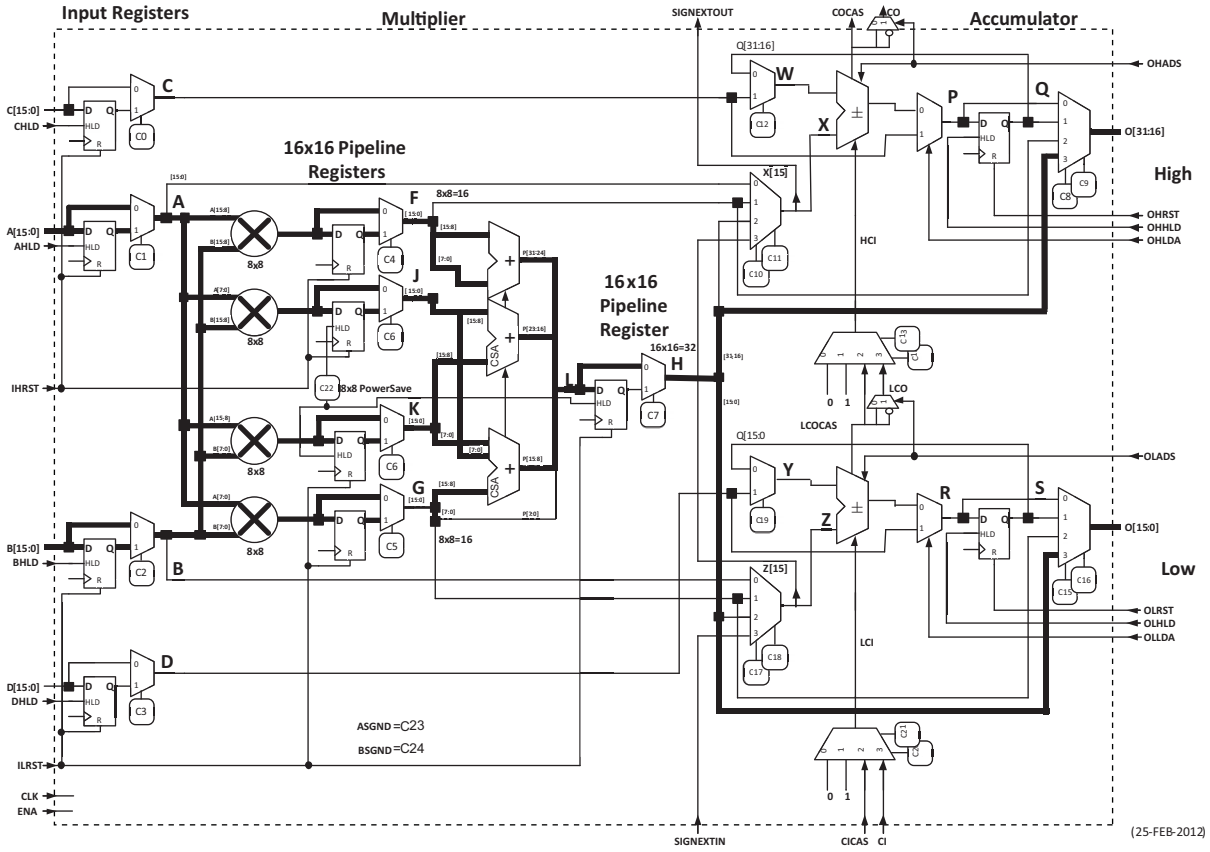


Figure 2-9. iCE I/O Register Block Diagram

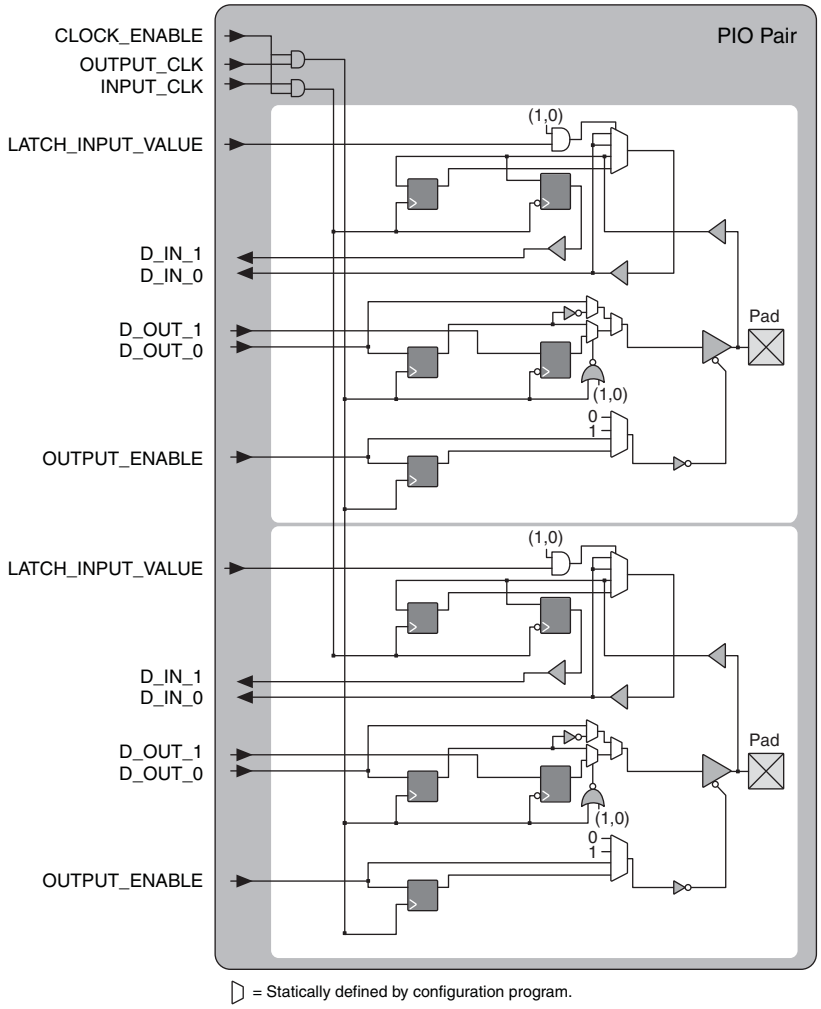


Table 2-7. PIO Signal List

Pin Name	I/O Type	Description
OUTPUT_CLK	Input	Output register clock
CLOCK_ENABLE	Input	Clock enable
INPUT_CLK	Input	Input register clock
OUTPUT_ENABLE	Input	Output enable
D_OUT_0/1	Input	Data from the core
D_IN_0/1	Output	Data to the core
LATCH_INPUT_VALUE	Input	Latches/holds the Input Value

sysIO Buffer

Each I/O is associated with a flexible buffer referred to as a sysIO buffer. These buffers are arranged around the periphery of the device in groups referred to as banks. The sysIO buffers allow users to implement a wide variety of standards that are found in today's systems with LVCMOS interfaces.

User I²C IP

The iCE40 Ultra devices have two I²C IP cores. Either of the two cores can be configured either as an I²C master or as an I²C slave. The pins for the I²C interface are not pre-assigned. User can use any General Purpose I/O pins.

In each of the two cores, there are options to delay the either the input or the output, or both, by 50 ns nominal, using dedicated on-chip delay elements. This provides an easier interface with any external I²C components.

When the IP core is configured as master, it will be able to control other devices on the I²C bus through the pre-assigned pin interface. When the core is configured as the slave, the device will be able to provide I/O expansion to an I²C Master. The I²C cores support the following functionality:

- Master and Slave operation
- 7-bit and 10-bit addressing
- Multi-master arbitration support
- Clock stretching
- Up to 400 kHz data transfer speed
- General Call support
- Optionally delaying input or output data, or both

For further information on the User I²C, please refer to TN1274, iCE40 SPI/I2C Hardened IP Usage Guide.

User SPI IP

The iCE40 Ultra devices have two SPI IP cores. The pins for the SPI interface are not pre-assigned. User can use any General Purpose I/O pins. Both SPI IP cores can be configured as a SPI master or as a slave. When the SPI IP core is configured as a master, it controls the other SPI enabled devices connected to the SPI Bus. When SPI IP core is configured as a slave, the device will be able to interface to an external SPI master.

The SPI IP core supports the following functions:

- Configurable Master and Slave modes
- Full-Duplex data transfer
- Mode fault error flag with CPU interrupt capability
- Double-buffered data register
- Serial clock with programmable polarity and phase
- LSB First or MSB First Data Transfer

For further information on the User SPI, please refer to TN1274, iCE40 SPI/I2C Hardened IP Usage Guide.

High Current LED Drive I/O Pins

The iCE40 Ultra family devices offer multiple high current LED drive outputs in each device in the family to allow the iCE40 Ultra product to drive LED signals directly on mobile applications.

There are three outputs on each device that can sink up to 24 mA current. These outputs are open-drain outputs, and provides sinking current to an LED connecting to the positive supply. These three outputs are designed to drive the RBG LEDs, such as the service LED found in a lot of mobile devices. An embedded RGB PWM IP is also offered in the family. This RGB drive current is user programmable from 4 mA to 24 mA, in increments of 4 mA. This output functions as General Purpose I/O with open-drain when the high current LED drive is not needed.

There is one output on each device that can sink up to 500 mA current. This output is open-drain, and provides sinking current to drive an external IR LED connecting to the positive supply. This IR drive current is user programmable from 50 mA to 500 mA in increments of 50 mA. This output functions as General Purpose I/O with open-drain when the high current LED drive is not needed.

Embedded PWM IP

To provide an easier usage of the RGB high current drivers to drive RGB LED, a Pulse-Width Modulator IP can be embedded into the user design. This PWM IP provides the flexibility for user to dynamically change the settings on the ON-time duration, OFF-time duration, and ability to turn the LED lights on and off gradually with user set breath-on and breath-off time.

For additional information on the embedded PWM IP, please refer to TN1288, iCE40 LED Driver Usage Guide.

Non-Volatile Configuration Memory

All iCE40 Ultra devices provide a Non-Volatile Configuration Memory (NVCM) block which can be used to configure the device.

For more information on the NVCM, please refer to TN1248, iCE40 Programming and Configuration.

iCE40 Ultra Programming and Configuration

This section describes the programming and configuration of the iCE40 Ultra family.

Device Programming

The NVCM memory can be programmed through the SPI port. The SPI port is located in Bank 1, using SPI_V_{CCIO1} power supply.

Device Configuration

There are various ways to configure the Configuration RAM (CRAM), using SPI port, including:

- From a SPI Flash (Master SPI mode)
- System microprocessor to drive a Serial Slave SPI port (SSPI mode)

For more details on configuring the iCE40 Ultra, please see TN1248, iCE40 Programming and Configuration.

Power Saving Options

The iCE40 Ultra devices feature iCEGate and PLL low power mode to allow users to meet the static and dynamic power requirements of their applications. Table 2-10 describes the function of these features.

Table 2-10. iCE40 Ultra Power Saving Features Description

Device Subsystem	Feature Description
PLL	When LATCHINPUTVALUE is enabled, puts the PLL into low-power mode; PLL output held static at last input clock value.
iCEGate	To save power, the optional iCEGate latch can selectively freeze the state of individual, non-registered inputs within an I/O bank. Registered inputs are effectively frozen by their associated clock or clock-enable control.

Power-On Reset

All iCE40 Ultra devices have on-chip Power-On-Reset (POR) circuitry to ensure proper initialization of the device. Only three supply rails are monitored by the POR circuitry as follows: (1) V_{CC}, (2) SPI_V_{CCIO1} and (3) V_{PP_2V5}. All other supply pins have no effect on the power-on reset feature of the device. Note that all supply voltage pins must be connected to power supplies for normal operation (including device configuration).

Power-Up Supply Sequencing

It is recommended to bring up the power supplies in the following order. Note that there is no specified timing delay between the power supplies, however, there is a requirement for each supply to reach a level of 0.5V, or higher, before any subsequent power supplies in the sequence are applied.

1. **V_{CC}** and **V_{CCPLL}** should be the first two supplies to be applied. Note that these two supplies can be tied together subject to the recommendation to include a RC-based noise filter on the V_{CCPLL} (Please refer to TN1252, iCE40 Hardware Checklist.)

2. **SPI_V_{CCIO1}** should be the next supply, and can be applied any time after the previous supplies (V_{CC} and V_{CCPLL}) have reached as level of 0.5 V or higher.

3. **V_{PP_2V5}** should be the next supply, and can be applied any time after previous supplies (V_{CC}, V_{CCPLL} and SPI_V_{CCIO1}) have reached a level of 0.5 V or higher.

4. **Other Supplies** (V_{CCIO0} and V_{CCIO2}) do not affect device power-up functionality, and they can be applied any time after the initial power supplies (V_{CC} and V_{CCPLL}) have reached a level of 0.5 V or greater.

There is no power down sequence required. However, when partial power supplies are powered down, it is required the above sequence to be followed when these supplies are repowered up again.

External Reset

When all power supplies have reached to their minimum operating voltage defined in Minimum Operation Condition Table, it is required to either keep CRESET_B LOW, or toggle CRESET_B from HIGH to LOW, for a duration of t_{CRESET_B}, and release it to go HIGH, to start configuration download from either the internal NVCM or the external Flash memory.

Figure 3-1 shows Power-Up sequence when SPI_V_{CCIO1} and V_{PP_2V5} are connected separately, and the CRESET_B signal triggers configuration download. Figure 3-2 shows when SPI_V_{CCIO1} and V_{PP_2V5} connected together.

All power supplies should be powered up during configuration. Before and during configuration, the I/Os are held in tri-state. I/Os are released to user functionality once the device has finished configuration.

Figure 3-1. Power Up Sequence with SPI_V_{CCIO1} and V_{PP_2V5} Not Connected Together

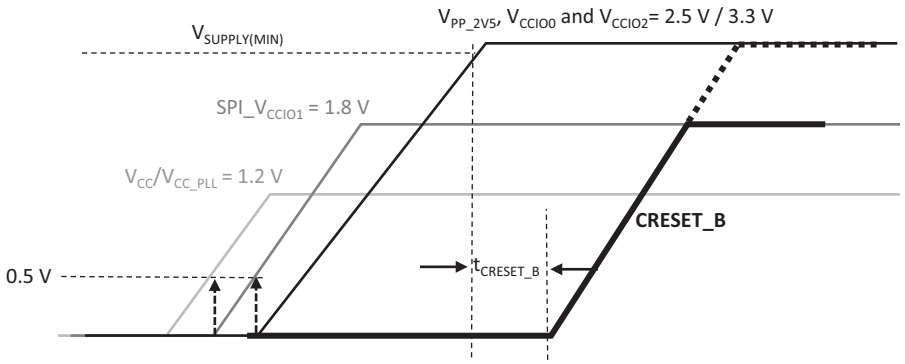
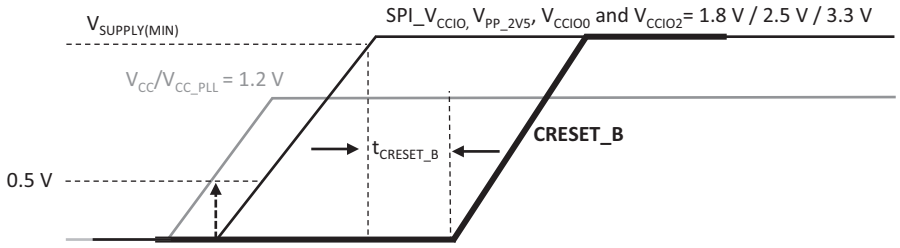


Figure 3-2. Power Up Sequence with All Supplies Connected Together



Power-On-Reset Voltage Levels[1]

Symbol	Parameter		Min.	Max.	Units
V_{PORUP}	Power-On-Reset ramp-up trip point (circuit monitoring V_{CC}, SPI_V_{CCIO1}, V_{PP_2V5})	V_{CC}	0.62	0.92	V
		SPI_V_{CCIO1}	0.87	1.50	V
		V_{PP_2V5}	0.90	1.53	V
V_{PORDN}	Power-On-Reset ramp-down trip point (circuit monitoring V_{CC}, SPI_V_{CCIO1}, V_{PP_2V5})	V_{CC}	—	0.79	V
		SPI_V_{CCIO1}	—	1.50	V
		V_{PP_2V5}	—	1.53	V

1. These POR trip points are only provided for guidance. Device operation is only characterized for power supply voltages specified under recommended operating conditions.

ESD Performance

Please contact Lattice Semiconductor for additional information.

DC Electrical Characteristics

Over Recommended Operating Conditions

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
I_{IL}, I_{IH}[1, 3, 4]	Input or I/O Leakage	0V < V_{IN} < V_{CCIO} + 0.2 V	—	—	+/–10	µA
C_1	I/O Capacitance, excluding LED Drivers[2]	V_{CCIO} = 3.3 V, 2.5 V, 1.8 V V_{CC} = Typ., V_{IO} = 0 to V_{CCIO} + 0.2 V	—	6	—	pF
C_2	Global Input Buffer Capacitance[2]	V_{CCIO} = 3.3 V, 2.5 V, 1.8 V V_{CC} = Typ., V_{IO} = 0 to V_{CCIO} + 0.2 V	—	6	—	pF
C_3	RGB Pin Capacitance[2]	V_{CC} = Typ., V_{IO} = 0 to 3.5 V	—	15	—	pF
C_4	IRLED Pin Capacitance[2]	V_{CC} = Typ., V_{IO} = 0 to 3.5 V	—	53	—	pF
V_{HYST}	Input Hysteresis	V_{CCIO} = 1.8 V, 2.5 V, 3.3 V	—	200	—	mV
I_{PU}	Internal PIO Pull-up Current	V_{CCIO} = 1.8 V, 0=<V_{IN}<=0.65 V_{CCIO}	–3	—	–31	µA
		V_{CCIO} = 2.5 V, 0=<V_{IN}<=0.65 V_{CCIO}	–8	—	–72	µA
		V_{CCIO} = 3.3 V, 0=<V_{IN}<=0.65 V_{CCIO}	–11	—	–128	µA

1. Input or I/O leakage current is measured with the pin configured as an input or as an I/O with the output driver tri-stated. It is not measured with the output driver active. Internal pull-up resistors are disabled.
2. T_J 25 °C, f = 1.0 MHz.
3. Please refer to V_{IL} and V_{IH} in the sysIO Single-Ended DC Electrical Characteristics table of this document.
4. Input pins are clamped to V_{CCIO} and GND by a diode. When input is higher than V_{CCIO} or lower than GND, the Input Leakage current will be higher than the I_{IL} and I_{IH}.

Internal Oscillators (HFOSC, LFOSC)[1]

Parameter		Parameter Description	Spec/Recommended			Units
Symbol	Conditions		Min	Typ	Max	
f_{CLKHF}	Commercial Temp	HFOSC clock frequency (t_J = 0 °C–85 °C)	–10%	48	10%	MHz
	Industrial Temp	HFOSC clock frequency (t_J = –40 °C–100 °C)	–20%	48	20%	MHz
f_{CLKLF}		LFOSC CLKK clock frequency	–10%	10	10%	kHz
DCH_{CLKHF}	Commercial Temp	HFOSC clock frequency (t_J = 0 °C–85 °C)	45	50	55	%
	Industrial Temp	HFOSC clock frequency (t_J = –45 °C–100 °C)	40	50	60	%
DCH_{CLKLF}		LFOSC Duty Cycle (Clock High Period)	45	50	55	%
Tsync_on		Oscillator output synchronizer delay	—	—	5	Cycles
Tsync_off		Oscillator output disable delay	—	—	5	Cycles

1. Glitchless enabling and disabling OSC clock outputs.

sysIO Recommended Operating Conditions

Standard	V_{CCIO} (V)		
	Min.	Typ.	Max.
LVCMOS 3.3	3.14	3.3	3.46
LVCMOS 2.5	2.37	2.5	2.62
LVCMOS 1.8	1.71	1.8	1.89

sysIO Single-Ended DC Electrical Characteristics

Input/ Output Standard	V_{IL}		V_{IH}		V_{OL} Max. (V)	V_{OH} Min. (V)	I_{OL} Max. (mA)	I_{OH} Max. (mA)
	Min. (V)	Max. (V)	Min. (V)	Max. (V)				
LVCMOS 3.3	–0.3	0.8	2.0	V_{CCIO} + 0.2V	0.4	V_{CCIO} – 0.4	8	–8
					0.2	V_{CCIO} – 0.2	0.1	–0.1
LVCMOS 2.5	–0.3	0.7	1.7	V_{CCIO} + 0.2V	0.4	V_{CCIO} – 0.4	6	–6
					0.2	V_{CCIO} – 0.2	0.1	–0.1
LVCMOS 1.8	–0.3	$0.35V_{CCIO}$	$0.65V_{CCIO}$	V_{CCIO} + 0.2V	0.4	V_{CCIO} – 0.4	4	–4
					0.2	V_{CCIO} – 0.2	0.1	–0.1

Differential Comparator Electrical Characteristics

Parameter Symbol	Parameter Description	Test Conditions	Min.	Max.	Units
V_{REF}	Reference Voltage to compare, on V_{INM}	V_{CCIO} = 2.5 V	0.25	V_{CCIO} –0.25 V	V
V_{DIFFIN_H}	Differential input HIGH (V_{INP} - V_{INM})	V_{CCIO} = 2.5 V	250	—	mV
V_{DIFFIN_L}	Differential input LOW (V_{INP} - V_{INM})	V_{CCIO} = 2.5 V	—	–250	mV
I_{IN}	Input Current, V_{INP} and V_{INM}	V_{CCIO} = 2.5 V	–10	10	µA

Typical Building Block Function Performance[1, 2]

Pin-to-Pin Performance (LVCMOS25)

Function	Timing	Units
Basic Functions		
16-bit decoder	16.5	ns
4:1 MUX	18.0	ns
16:1 MUX	19.5	ns

Register-to-Register Performance

Function	Timing	Units
Basic Functions		
16:1 MUX	110	MHz
16-bit adder	100	MHz
16-bit counter	100	MHz
64-bit counter	40	MHz
Embedded Memory Functions		
256x16 Pseudo-Dual Port RAM	150	MHz

1. The above timing numbers are generated using the Lattice Design Software tool. Exact performance may vary with device and tool version. The tool uses internal parameters that have been characterized but are not tested on every device.
2. Under worst case operating conditions.

Derating Logic Timing

Logic timing provided in the following sections of the data sheet and the Lattice design tools are worst case numbers in the operating range. Actual delays may be much faster. Lattice design tools can provide logic timing numbers at a particular temperature and voltage.

Maximum sysIO Buffer Performance[1]

I/O Standard	Max. Speed	Units
Inputs		
LVCMOS33	250	MHz
LVCMOS25	250	MHz
LVCMOS18	250	MHz
Outputs		
LVCMOS33	250	MHz
LVCMOS25	250	MHz
LVCMOS18	155	MHz

1. Measured with a toggling pattern

iCE40 Ultra Family Timing Adders

Over Recommended Commercial Operating Conditions[1, 2, 3]

Buffer Type	Description	Timing (Typ.)	Units
Input Adjusters			
LVCMOS33	LVCMOS, V_{CCIO} = 3.3 V	0.18	ns
LVCMOS25	LVCMOS, V_{CCIO} = 2.5 V	0	ns
LVCMOS18	LVCMOS, V_{CCIO} = 1.8 V	0.19	ns
Output Adjusters			
LVCMOS33	LVCMOS, V_{CCIO} = 3.3 V	–0.12	ns
LVCMOS25	LVCMOS, V_{CCIO} = 2.5 V	0	ns
LVCMOS18	LVCMOS, V_{CCIO} = 1.8 V	1.32	ns

1. Timing adders are relative to LVCMOS25 and characterized but not tested on every device.
2. LVCMOS timing measured with the load specified in Switching Test Condition table.
3. Commercial timing numbers are shown.

iCE40 Ultra External Switching Characteristics

Over Recommended Commercial Operating Conditions

Parameter	Description	Device	Min	Max	Units
Clocks					
Global Clocks					
f_{MAX_GBUF}	Frequency for Global Buffer Clock network	All devices	—	185	MHz
t_{W_GBUF}	Clock Pulse Width for Global Buffer	All devices	2	—	ns
t_{SKEW_GBUF}	Global Buffer Clock Skew Within a Device	All devices	—	500	ps
Pin-LUT-Pin Propagation Delay					
t_{PD}	Best case propagation delay through one LUT logic	All devices	—	9.0	ns
General I/O Pin Parameters (Using Global Buffer Clock without PLL)[1]					
t_{SKEW_IO}	Data bus skew across a bank of IOs	All devices	—	410	ps
t_{CO}	Clock to Output – PIO Output Register	All devices	—	9.0	ns
t_{SU}	Clock to Data Setup – PIO Input Register	All devices	–0.5	—	ns
t_{H}	Clock to Data Hold – PIO Input Register	All devices	5.55	—	ns
General I/O Pin Parameters (Using Global Buffer Clock with PLL)					
t_{COPLL}	Clock to Output – PIO Output Register	All Devices	—	2.9	ns
t_{SUPLL}	Clock to Data Setup – PIO Input Register	All Devices	5.9	—	ns
t_{HPLL}	Clock to Data Hold – PIO Input Register	All Devices	–0.6	—	ns

1. All the data is from the worst case condition.

sysCLOCK PLL Timing

Over Recommended Operating Conditions

Parameter	Descriptions	Conditions	Min.	Max.	Units
f_{IN}	Input Clock Frequency (REFERENCECLK, EXTFEEDBACK)		10	133	MHz
f_{OUT}	Output Clock Frequency (PLLOUT)		16	275	MHz
f_{VCO}	PLL VCO Frequency		533	1066	MHz
f_{PFD}	Phase Detector Input Frequency		10	133	MHz
AC Characteristics					
t_{DT}	Output Clock Duty Cycle		40	60	%
t_{PH}	Output Phase Accuracy		—	+/–12	deg
t_{OPJIT}[1, 5, 6]	Output Clock Period Jitter	f_{OUT} >= 100 MHz	—	450	ps p-p
		f_{OUT} < 100 MHz	—	0.05	UIPP
	Output Clock Cycle-to-cycle Jitter	f_{OUT} >= 100 MHz	—	750	ps p-p
		f_{OUT} < 100 MHz	—	0.10	UIPP
	Output Clock Phase Jitter	f_{PFD} >= 25 MHz	—	275	ps p-p
		f_{PFD} < 25 MHz	—	0.05	UIPP
t_W	Output Clock Pulse Width	At 90% or 10%	1.33	—	ns
t_{LOCK}[2, 3]	PLL Lock-in Time		—	50	µs
t_{UNLOCK}	PLL Unlock Time		—	50	ns
t_{IPJIT}[4]	Input Clock Period Jitter	$f_{PFD} \geq 20$ MHz	—	1000	ps p-p
		f_{PFD} < 20 MHz	—	0.02	UIPP
t_{STABLE}[3]	LATCHINPUTVALUE LOW to PLL Stable		—	500	ns
t_{STABLE_PW}[3]	LATCHINPUTVALUE Pulse Width		100	—	ns
t_{RST}	RESET Pulse Width		10	—	ns
t_{RSTREC}	RESET Recovery Time		10	—	µs
$t_{DYNAMIC\_WD}$	DYNAMICDELAY Pulse Width		100	—	VCO Cycles

1. Period jitter sample is taken over 10,000 samples of the primary PLL output with a clean reference clock. Cycle-to-cycle jitter is taken over 1000 cycles. Phase jitter is taken over 2000 cycles. All values per JESD65B.
2. Output clock is valid after t_{LOCK} for PLL reset and dynamic delay adjustment.
3. At minimum f_{PFD}. As the f_{PFD} increases the time will decrease to approximately 60% the value listed.
4. Maximum limit to prevent PLL unlock from occurring. Does not imply the PLL will operate within the output specifications listed in this table.
5. The jitter values will increase with loading of the PLD fabric and in the presence of SSO noise.

sysDSP Timing

Over Recommended Operating Conditions

Parameter	Description	Min.	Max.	Units
$f_{MAX8x8SMULT}$	Max frequency signed MULT8x8 bypassing pipeline register	50	—	MHz
$f_{MAX16x16SMULT}$	Max frequency signed MULT16x16 bypassing pipeline register	50	—	MHz

SPI Master or NVCM Configuration Time[1, 2]

Symbol	Parameter	Conditions	Max.	Units
t_{CONFIG}	POR/CRESET_B to Device I/O Active	All devices – Low Frequency (Default)	95	ms
		All devices – Medium frequency	35	ms
		All devices – High frequency	18	ms

1. Assumes sysMEM Block is initialized to an all zero pattern if they are used.
2. The NVCM download time is measured with a fast ramp rate starting from the maximum voltage of POR trip point.

sysCONFIG Port Timing Specifications

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
All Configuration Modes						
t_{CRESET_B}	Minimum CRESET_B LOW pulse width required to restart configuration, from falling edge to rising edge		200	—	—	ns
t_{DONE_IO}	Number of configuration clock cycles after CDONE goes HIGH before the PIO pins are activated		49	—	—	Clock Cycles
Slave SPI						
t_{CR_SCK}	Minimum time from a rising edge on CRESET_B until the first SPI WRITE operation, first SPI_XCK clock. During this time, the iCE40 Ultra device is clearing its internal configuration memory		1200	—	—	µs
f_{MAX}	CCLK clock frequency	Write	1	—	25	MHz
		Read[1]	—	15	—	MHz
t_{CCLKH}	CCLK clock pulsewidth HIGH		20	—	—	ns
t_{CCLKL}	CCLK clock pulsewidth LOW		20	—	—	ns
t_{STSU}	CCLK setup time		12	—	—	ns
t_{STH}	CCLK hold time		12	—	—	ns
t_{STCO}	CCLK falling edge to valid output		13	—	—	ns
Master SPI[3]						
f_{MCLK}	MCLK clock frequency	Low Frequency (Default)	7.0	12.0	17.0	MHz
		Medium Frequency[2]	21.0	33.0	45.0	MHz
		High Frequency[2]	33.0	53.0	71.0	MHz
t_{MCLK}	CRESET_B HIGH to first MCLK edge		1200	—	—	µs
t_{SU}	CCLK setup time[4]		9.9	—	—	ns
t_{HD}	CCLK hold time		1	—	—	ns

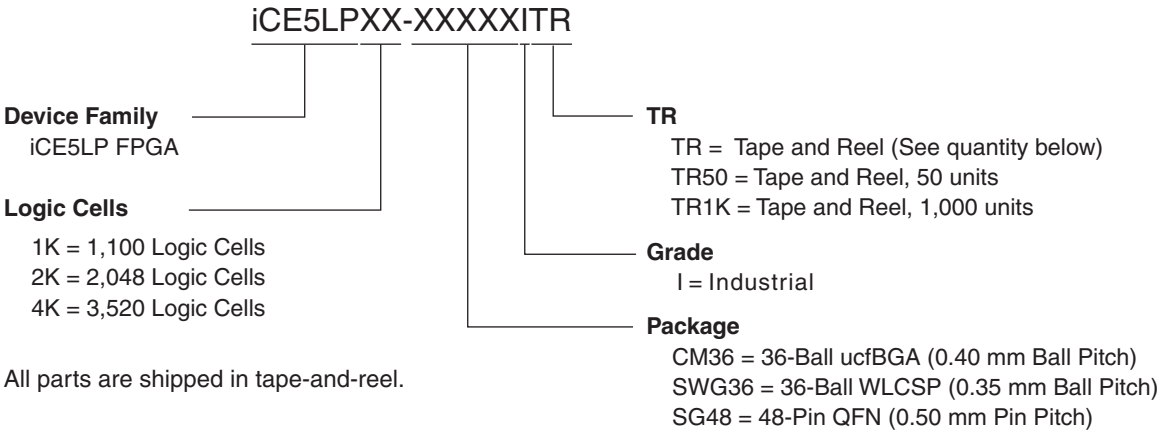
1. Supported with 1.2 V Vcc and at 25 °C.
2. Extended range fMAX Write operations support up to 53 MHz with 1.2 V Vcc and at 25 °C.
3. t_{SU} and t_{HD} timing must be met for all MCLK frequency choices.
4. For considerations of SPI Master Configuration Mode, please refer to TN1248, iCE40 Programming and Configuration.

Signal Name		Function	I/O	Description
PIOB_33b	SPI_SI	Configuration	Input	This pin is shared with device configuration. During configuration: In Master SPI mode, this pin receives data from external SPI memory. In Slave SPI mode, this pin connects to the MOSI pin of the external processor.
		General I/O	I/O	In user mode, after configuration, this pin can be programmed as general I/O in user function.
PIOB_35b	SPI_SS_B	Configuration	I/O	This pin is shared with device configuration. During configuration: In Master SPI mode, this pin outputs to the external SPI memory. In Slave SPI mode, this pin inputs from the external processor.
		General I/O	I/O	In user mode, after configuration, this pin can be programmed as general I/O in user function.
Global Signals				
Primary	Secondary			
PIOT_46b	G0	General I/O	I/O	In user mode, after configuration, this pin can be programmed as general I/O in user function
		Global	Input	Global input used for high fanout, or clock/reset net. The G0 pin drives the GBUF0 global buffer
PIOT_45a	G1	General I/O	I/O	In user mode, after configuration, this pin can be programmed as general I/O in user function
		Global	Input	Global input used for high fanout, or clock/reset net. The G1 pin drives the GBUF1 global buffer
PIOT_25b	G3	General I/O	I/O	In user mode, after configuration, this pin can be programmed as general I/O in user function
		Global	Input	Global input used for high fanout, or clock/reset net. The G3 pin drives the GBUF3 global buffer
PIOT_12a	G4	General I/O	I/O	In user mode, after configuration, this pin can be programmed as general I/O in user function
		Global	Input	Global input used for high fanout, or clock/reset net. The G4 pin drives the GBUF4 global buffer
PIOT_11b	G5	General I/O	I/O	In user mode, after configuration, this pin can be programmed as general I/O in user function
		Global	Input	Global input used for high fanout, or clock/reset net. The G5 pin drives the GBUF5 global buffer
PIOB_3b	G6	General I/O	I/O	In user mode, after configuration, this pin can be programmed as general I/O in user function
		Global	Input	Global input used for high fanout, or clock/reset net. The G6 pin drives the GBUF6 global buffer
LED Signals				
RGB0		General I/O	Open-Drain I/O	In user mode, with user's choice, this pin can be programmed as open drain I/O in user function
		LED	Open-Drain Output	In user mode, with user's choice, this pin can be programmed as open drain 24mA output to drive external LED
RGB1		General I/O	Open-Drain I/O	In user mode, with user's choice, this pin can be programmed as open drain I/O in user function
		LED	Open-Drain Output	In user mode, with user's choice, this pin can be programmed as open drain 24mA output to drive external LED

Signal Name	Function	I/O	Description
RGB2	General I/O	Open-Drain I/O	In user mode, with user's choice, this pin can be programmed as open drain I/O in user function
	LED	Open-Drain Output	In user mode, with user's choice, this pin can be programmed as open drain 24mA output to drive external LED
IRLED	General I/O	Open-Drain I/O	In user mode, with user's choice, this pin can be programmed as open drain I/O in user function
	LED	Open-Drain Output	In user mode, with user's choice, this pin can be programmed as open drain 500mA output to drive external LED
PIOT_xx	General I/O	I/O	In user mode, with user's choice, this pin can be programmed as I/O in user function in the top (xx = I/O location)
PIOB_xx	General I/O	I/O	In user mode, with user's choice, this pin can be programmed as I/O in user function in the bottom (xx = I/O location)

iCE40 Ultra Family Data Sheet Ordering Information

iCE5LP Part Number Description



All parts are shipped in tape-and-reel.

Tape and Reel Quantity

Package	TR Quantity
CM36	4,000
SWG36	5,000
SG48	2,000

iCE40 Ultra Family Data Sheet Supplemental Information

October 2014 **Data Sheet DS1048**

For Further Information

A variety of technical notes for the iCE40 Ultra family are available on the Lattice web site.

- TN1248, iCE40 Programming and Configuration
- TN1274, iCE40 SPI/I2C Hardened IP Usage Guide
- TN1276, Advanced iCE40 SPI/I2C Hardened IP Usage Guide
- TN1250, Memory Usage Guide for iCE40 Devices
- TN1251, iCE40 sysCLOCK PLL Design and Usage Guide
- TN1252, iCE40 Hardware Checklist
- TN1288, iCE40 LED Driver Usage Guide
- TN1295, DSP Function Usage Guide for iCE40 Devices
- TN1296, iCE40 Oscillator Usage Guide
- iCE40 Ultra Pinout Files
- iCE40 Ultra Pin Migration Files
- Thermal Management document
- Lattice design tools
- Schematic Symbols

Date	Version	Section	Change Summary
August 2014	1.4	All	Removed Preliminary document status.
		Introduction	Updated General Description section. Added information on high current driver.
			Updated Features section. — Changed standby current typical to as low as 71 µA. — Changed feature to Embedded Memory. — Updated Table 1-1, iCE40 Ultra Family Selection Guide. Added NVCM and Embedded PWM IP rows. Added (MULT16 with 32-bit Accumulator) to DSP Block. Added Total I/O (Dedicated I/O) Count data.
			General update to Introduction section.
		Architecture	Updated Architecture Overview section. — Revised and added information on sysIO banks. — Updated reference for embedded PWM IP.
			Updated iCE40 Ultra Programming and Configuration section. — Changed SPI1 to SPI. — Changed VCCIO_1 to SPI_V_{CCIO1}.
		DC and Switching Characteristics	Updated Absolute Maximum Ratings section. Changed PLL Supply Voltage VCCPLL value.
			Updated Recommended Operating Conditions section. Added footnote to VCCPLL.
			Updated Power-up Sequence section. General update.
			Updated Power-On-Reset Voltage Levels section. Changed the V_{PORUP} V_{CC} Max.value.
			Updated DC Electrical Characteristics section. Added C_3 and C_4 information.
			Updated Supply Current section. — Completed Typ. VCC =1.2 V4 data. — Changed symbols to $I_{SPI\_VCCIO1STDBY}$ and $I_{SPI\_VCCIO1PEAK}$. — Added information to footnote 3.
			Updated Internal Oscillators (HFOSC, LFOSC) section. General update.
			Updated iCE40 Ultra External Switching Characteristics section. Added Max. value for t_{COPLL}. Added Min. values for t_{SUPLL} and t_{HPLL}.
			Updated sysCLOCK PLL Timing section. Added Max. value for t_{OPJIT}.
			Updated sysCONFIG Port Timing Specifications section. — Added T_{SU} and T_{HD} information. — Added footnote 3 to Master SPI.
			Updated High Current LED and IR LED Drive section. Updated Min. value.
July 2014	1.3	All	Changed document status from Advance to Preliminary.
		Introduction	Updated Features section. Adjusted Ultra-low Power Devices standby current.
		DC and Switching Characteristics	Updated AC/DC specifications numbers.