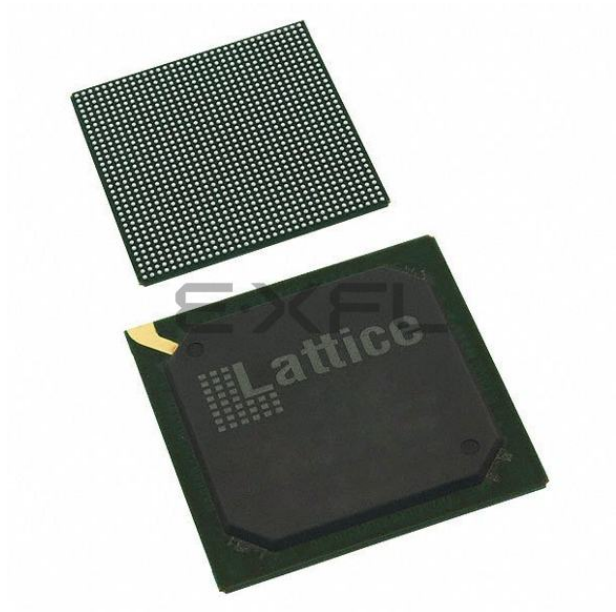
Lattice Semiconductor Corporation - LFE3-95E-6FN1156I Datasheet



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Details	
Product Status	Obsolete
Number of LABs/CLBs	11500
Number of Logic Elements/Cells	92000
Total RAM Bits	4526080
Number of I/O	490
Number of Gates	-
Voltage - Supply	1.14V ~ 1.26V
Mounting Type	Surface Mount
Operating Temperature	-40°C ~ 100°C (TJ)
Package / Case	1156-BBGA
Supplier Device Package	1156-FPBGA (35x35)
Purchase URL	https://www.e-xfl.com/product-detail/lattice-semiconductor/lfe3-95e-6fn1156i

LatticeECP3 Family Data Sheet Architecture

March 2010 Preliminary Data Sheet DS1021

Architecture Overview

Each LatticeECP3 device contains an array of logic blocks surrounded by Programmable I/O Cells (PIC). Interspersed between the rows of logic blocks are rows of sysMEM™ Embedded Block RAM (EBR) and rows of sysDSP™ Digital Signal Processing slices, as shown in Figure 2-1. In addition, the LatticeECP3 family contains SERDES Quads on the bottom of the device.

There are two kinds of logic blocks, the Programmable Functional Unit (PFU) and Programmable Functional Unit without RAM (PFF). The PFU contains the building blocks for logic, arithmetic, RAM and ROM functions. The PFF block contains building blocks for logic, arithmetic and ROM functions. Both PFU and PFF blocks are optimized for flexibility, allowing complex designs to be implemented quickly and efficiently. Logic Blocks are arranged in a two-dimensional array. Only one type of block is used per row.

The LatticeECP3 devices contain one or more rows of sysMEM EBR blocks. sysMEM EBRs are large, dedicated 18Kbit fast memory blocks. Each sysMEM block can be configured in a variety of depths and widths as RAM or ROM. In addition, LatticeECP3 devices contain up to two rows of DSP slices. Each DSP slice has multipliers and adder/accumulators, which are the building blocks for complex signal processing capabilities.

The LatticeECP3 devices feature up to 16 embedded 3.2Gbps SERDES (Serializer / Deserializer) channels. Each SERDES channel contains independent 8b/10b encoding / decoding, polarity adjust and elastic buffer logic. Each group of four SERDES channels, along with its Physical Coding Sub-layer (PCS) block, creates a quad. The functionality of the SERDES/PCS quads can be controlled by memory cells set during device configuration or by registers that are addressable during device operation. The registers in every quad can be programmed via the SERDES Client Interface (SCI). These quads (up to four) are located at the bottom of the devices.

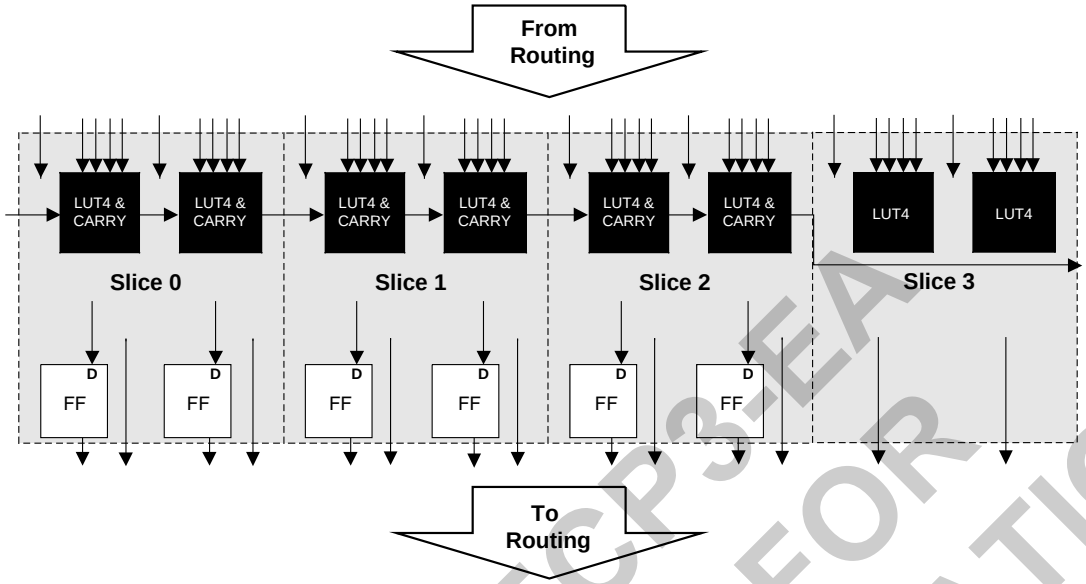
Each PIC block encompasses two PIOs (PIO pairs) with their respective sysI/O buffers. The sysI/O buffers of the LatticeECP3 devices are arranged in seven banks, allowing the implementation of a wide variety of I/O standards. In addition, a separate I/O bank is provided for the programming interfaces. 50% of the PIO pairs on the left and right edges of the device can be configured as LVDS transmit/receive pairs. The PIC logic also includes pre-engineered support to aid in the implementation of high speed source synchronous standards such as XGMII, 7:1 LVDS, along with memory interfaces including DDR3.

Other blocks provided include PLLs, DLLs and configuration functions. The LatticeECP3 architecture provides two Delay Locked Loops (DLLs) and up to ten Phase Locked Loops (PLLs). In addition, each LatticeECP3 family member provides two DLLs per device. The PLL and DLL blocks are located at the end of the EBR/DSP rows.

The configuration block that supports features such as configuration bit-stream decryption, transparent updates and dual-boot support is located toward the center of this EBR row. Every device in the LatticeECP3 family supports a sysCONFIG™ port located in the corner between banks one and two, which allows for serial or parallel device configuration.

In addition, every device in the family has a JTAG port. This family also provides an on-chip oscillator and soft error detect capability. The LatticeECP3 devices use 1.2V as their core voltage.

Figure 2-2. PFU Diagram



Slice

Slice 0 through Slice 2 contain two LUT4s feeding two registers, whereas Slice 3 contains two LUT4s only. For PFUs, Slice 0 through Slice 2 can be configured as distributed memory, a capability not available in the PFF. Table 2-1 shows the capability of the slices in both PFF and PFU blocks along with the operation modes they enable. In addition, each PFU contains logic that allows the LUTs to be combined to perform functions such as LUT5, LUT6, LUT7 and LUT8. There is control logic to perform set/reset functions (programmable as synchronous/ asynchronous), clock select, chip-select and wider RAM/ROM functions.

Table 2-1. Resources and Modes Available per Slice

Slice	PFU BLock		PFF Block	
	Resources	Modes	Resources	Modes
Slice 0	2 LUT4s and 2 Registers	Logic, Ripple, RAM, ROM	2 LUT4s and 2 Registers	Logic, Ripple, ROM
Slice 1	2 LUT4s and 2 Registers	Logic, Ripple, RAM, ROM	2 LUT4s and 2 Registers	Logic, Ripple, ROM
Slice 2	2 LUT4s and 2 Registers	Logic, Ripple, RAM, ROM	2 LUT4s and 2 Registers	Logic, Ripple, ROM
Slice 3	2 LUT4s	Logic, ROM	2 LUT4s	Logic, ROM

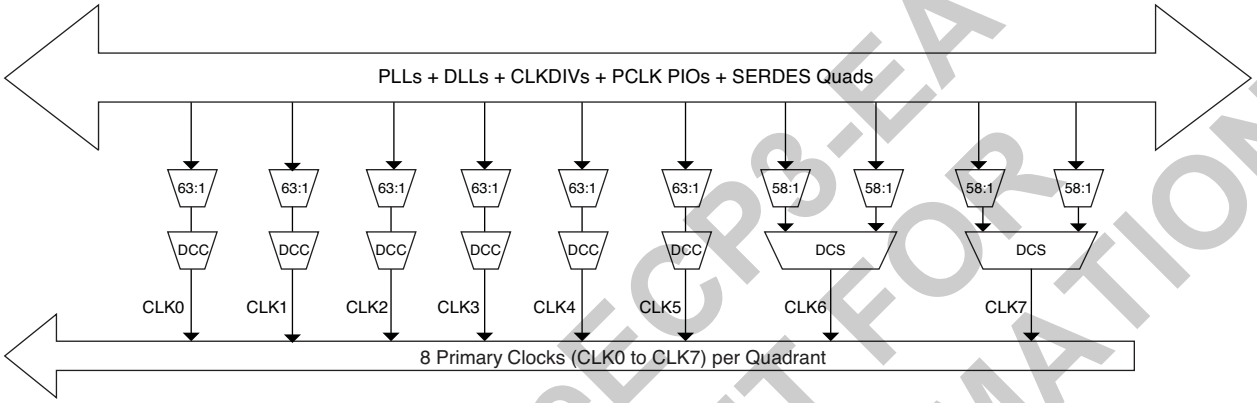
Figure 2-3 shows an overview of the internal logic of the slice. The registers in the slice can be configured for positive/negative and edge triggered or level sensitive clocks.

Slices 0, 1 and 2 have 14 input signals: 13 signals from routing and one from the carry-chain (from the adjacent slice or PFU). There are seven outputs: six to routing and one to carry-chain (to the adjacent PFU). Slice 3 has 10 input signals from routing and four signals to routing. Table 2-2 lists the signals associated with Slice 0 to Slice 2.

Primary Clock Routing

The purpose of the primary clock routing is to distribute primary clock sources to the destination quadrants of the device. A global primary clock is a primary clock that is distributed to all quadrants. The clock routing structure in LatticeECP3 devices consists of a network of eight primary clock lines (CLK0 through CLK7) per quadrant. The primary clocks of each quadrant are generated from muxes located in the center of the device. All the clock sources are connected to these muxes. Figure 2-12 shows the clock routing for one quadrant. Each quadrant mux is identical. If desired, any clock can be routed globally.

Figure 2-12. Per Quadrant Primary Clock Selection



Dynamic Clock Control (DCC)

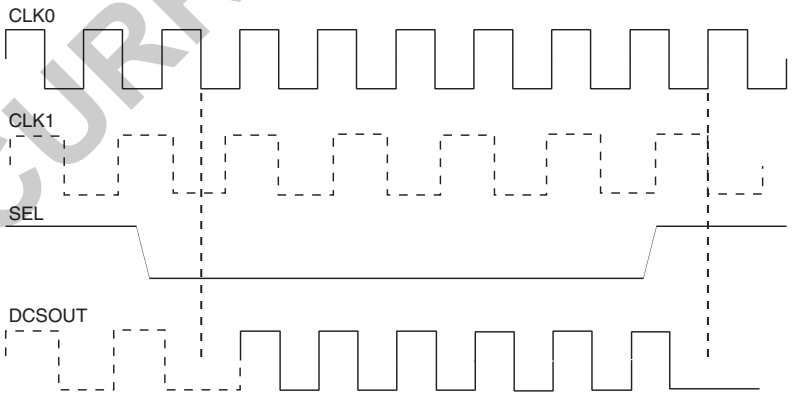
The DCC (Quadrant Clock Enable/Disable) feature allows internal logic control of the quadrant primary clock network. When a clock network is disabled, all the logic fed by that clock does not toggle, reducing the overall power consumption of the device.

Dynamic Clock Select (DCS)

The DCS is a smart multiplexer function available in the primary clock routing. It switches between two independent input clock sources without any glitches or runt pulses. This is achieved regardless of when the select signal is toggled. There are two DCS blocks per quadrant; in total, there are eight DCS blocks per device. The inputs to the DCS block come from the center muxes. The output of the DCS is connected to primary clocks CLK6 and CLK7 (see Figure 2-12).

Figure 2-13 shows the timing waveforms of the default DCS operating mode. The DCS block can be programmed to other modes. For more information about the DCS, please see the list of technical documentation at the end of this data sheet.

Figure 2-13. DCS Waveforms



Single, Dual and Pseudo-Dual Port Modes

In all the sysMEM RAM modes the input data and address for the ports are registered at the input of the memory array. The output data of the memory is optionally registered at the output.

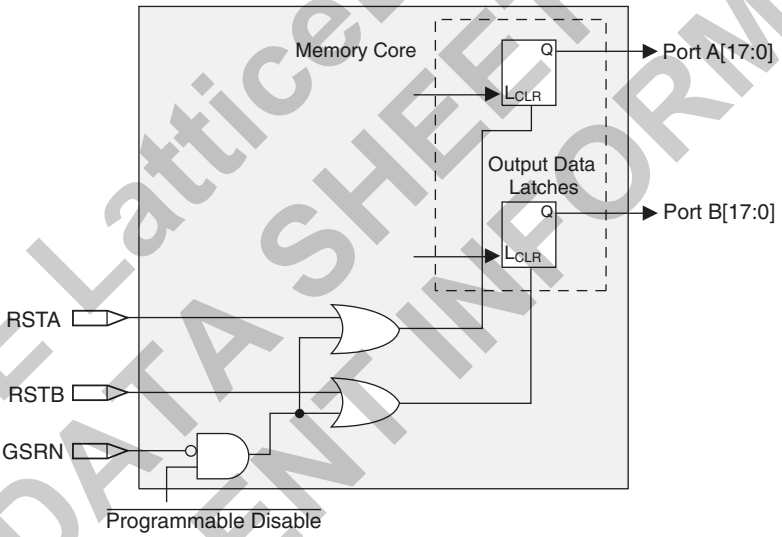
EBR memory supports the following forms of write behavior for single port or dual port operation:

1. **Normal** – Data on the output appears only during a read cycle. During a write cycle, the data (at the current address) does not appear on the output. This mode is supported for all data widths.
2. **Write Through** – A copy of the input data appears at the output of the same port during a write cycle. This mode is supported for all data widths.
3. **Read-Before-Write (EA devices only)** – When new data is written, the old content of the address appears at the output. This mode is supported for x9, x18, and x36 data widths.

Memory Core Reset

The memory array in the EBR utilizes latches at the A and B output ports. These latches can be reset asynchronously or synchronously. RSTA and RSTB are local signals, which reset the output latches associated with Port A and Port B, respectively. The Global Reset (GSRN) signal can reset both ports. The output data latches and associated resets for both ports are as shown in Figure 2-22.

Figure 2-22. Memory Core Reset



For further information on the sysMEM EBR block, please see the list of technical documentation at the end of this data sheet.

sysDSP™ Slice

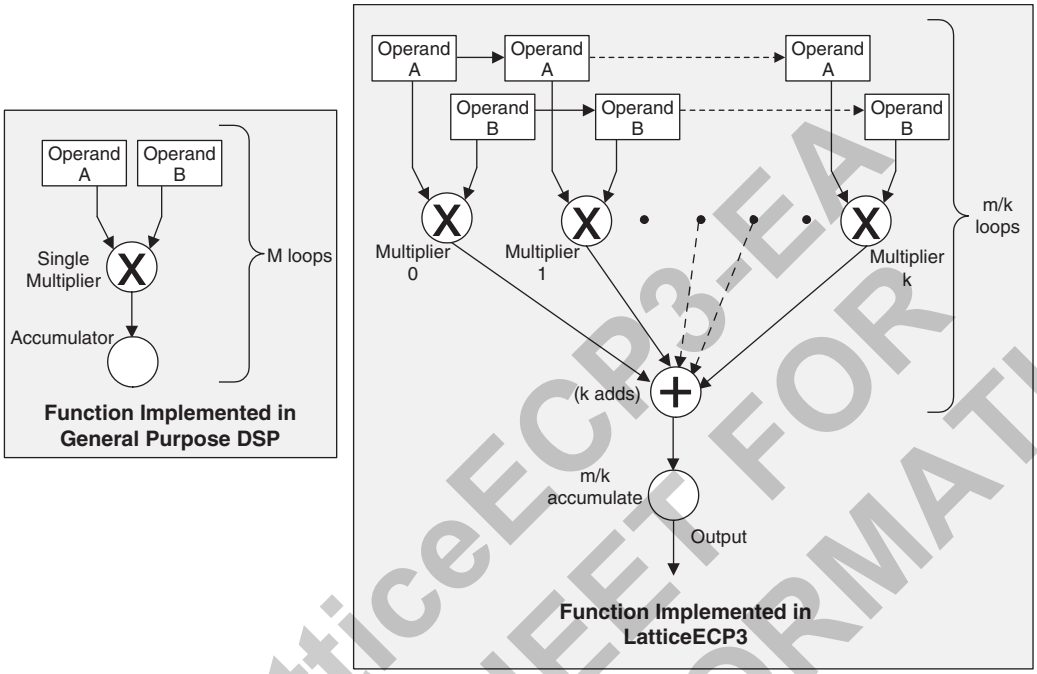
The LatticeECP3 family provides an enhanced sysDSP architecture, making it ideally suited for low-cost, high-performance Digital Signal Processing (DSP) applications. Typical functions used in these applications are Finite Impulse Response (FIR) filters, Fast Fourier Transforms (FFT) functions, Correlators, Reed-Solomon/Turbo/Convolution encoders and decoders. These complex signal processing functions use similar building blocks such as multiply-adders and multiply-accumulators.

sysDSP Slice Approach Compared to General DSP

Conventional general-purpose DSP chips typically contain one to four (Multiply and Accumulate) MAC units with fixed data-width multipliers; this leads to limited parallelism and limited throughput. Their throughput is increased by higher clock speeds. The LatticeECP3, on the other hand, has many DSP slices that support different data widths.

This allows designers to use highly parallel implementations of DSP functions. Designers can optimize DSP performance vs. area by choosing appropriate levels of parallelism. Figure 2-23 compares the fully serial implementation to the mixed parallel and serial implementation.

Figure 2-23. Comparison of General DSP and LatticeECP3 Approaches



LatticeECP3 sysDSP Slice Architecture Features

The LatticeECP3 sysDSP Slice has been significantly enhanced to provide functions needed for advanced processing applications. These enhancements provide improved flexibility and resource utilization.

The LatticeECP3 sysDSP Slice supports many functions that include the following:

- Multiply (one 18x36, two 18x18 or four 9x9 Multiplies per Slice)
- Multiply (36x36 by cascading across two sysDSP slices)
- Multiply Accumulate (up to 18x36 Multipliers feeding an Accumulator that can have up to 54-bit resolution)
- Two Multiplies feeding one Accumulate per cycle for increased processing with lower latency (two 18x18 Multiplies feed into an accumulator that can accumulate up to 52 bits)
- Flexible saturation and rounding options to satisfy a diverse set of applications situations
- Flexible cascading across DSP slices
  - Minimizes fabric use for common DSP and ALU functions
  - Enables implementation of FIR Filter or similar structures using dedicated sysDSP slice resources only
  - Provides matching pipeline registers
  - Can be configured to continue cascading from one row of sysDSP slices to another for longer cascade chains
- Flexible and Powerful Arithmetic Logic Unit (ALU) Supports:
  - Dynamically selectable ALU OPCODE
  - Ternary arithmetic (addition/subtraction of three inputs)
  - Bit-wise two-input logic operations (AND, OR, NAND, NOR, XOR and XNOR)
  - Eight flexible and programmable ALU flags that can be used for multiple pattern detection scenarios, such

as, overflow, underflow and convergent rounding, etc.
– Flexible cascading across slices to get larger functions

- RTL Synthesis friendly synchronous reset on all registers, while still supporting asynchronous reset for legacy users
- Dynamic MUX selection to allow Time Division Multiplexing (TDM) of resources for applications that require processor-like flexibility that enables different functions for each clock cycle

For most cases, as shown in Figure 2-24, the LatticeECP3 DSP slice is backwards-compatible with the LatticeECP2™ sysDSP block, such that, legacy applications can be targeted to the LatticeECP3 sysDSP slice. The functionality of one LatticeECP2 sysDSP Block can be mapped into two adjacent LatticeECP3 sysDSP slices, as shown in Figure 2-25.

Figure 2-24. Simplified sysDSP Slice Block Diagram

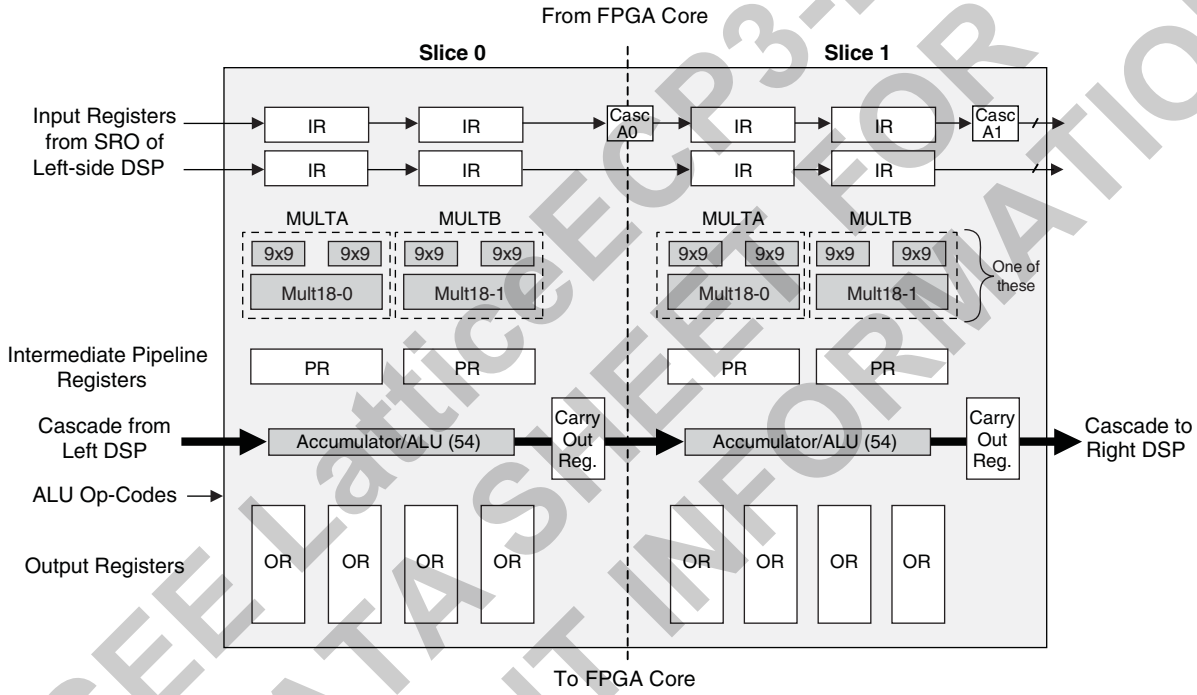
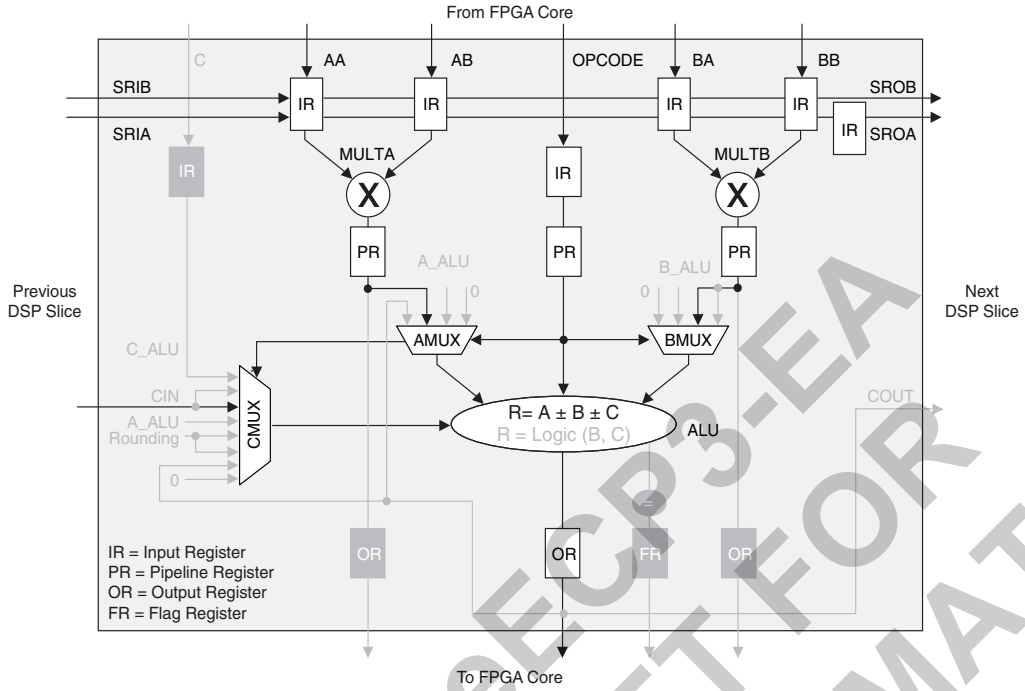


Figure 2-31. MULTADDSUBSUM Slice 1



Advanced sysDSP Slice Features

Cascading

The LatticeECP3 sysDSP slice has been enhanced to allow cascading. Adder trees are implemented fully in sysDSP slices, improving the performance. Cascading of slices uses the signals CIN, COUT and C Mux of the slice.

Addition

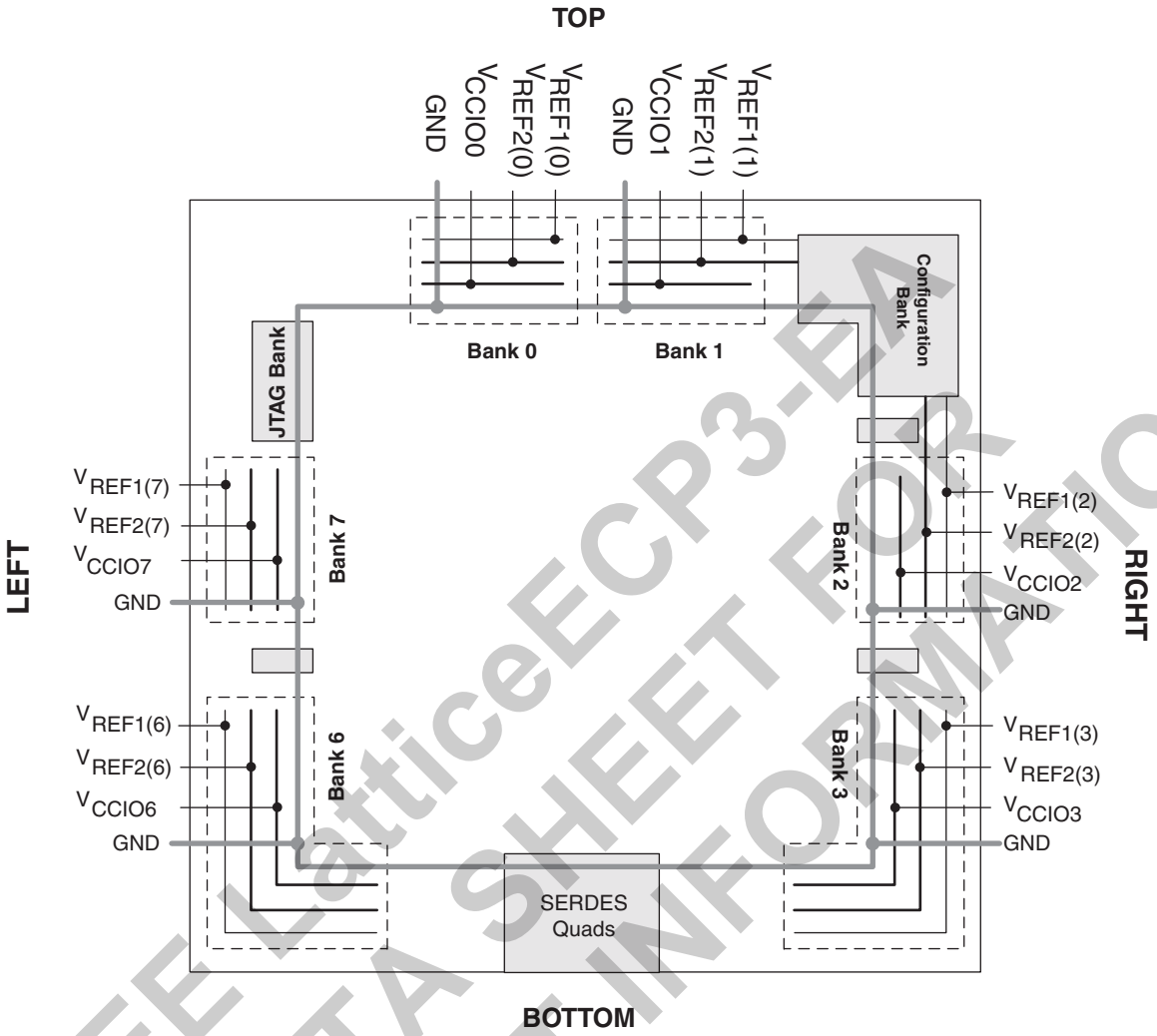
The LatticeECP3 sysDSP slice allows for the bypassing of multipliers and cascading of adder logic. High performance adder functions are implemented without the use of LUTs. The maximum width adders that can be implemented are 54-bit.

Rounding

The rounding operation is implemented in the ALU and is done by adding a constant followed by a truncation operation. The rounding methods supported are:

- Rounding to zero (RTZ)
- Rounding to infinity (RTI)
- Dynamic rounding
- Random rounding
- Convergent rounding

Figure 2-38. LatticeECP3 Banks



LatticeECP3 devices contain two types of sysI/O buffer pairs.

1. **Top (Bank 0 and Bank 1) and Bottom sysI/O Buffer Pairs (Single-Ended Outputs Only)**
   The sysI/O buffer pairs in the top banks of the device consist of two single-ended output drivers and two sets of single-ended input buffers (both ratioed and referenced). One of the referenced input buffers can also be configured as a differential input. Only the top edge buffers have a programmable PCI clamp.

   The two pads in the pair are described as “true” and “comp”, where the true pad is associated with the positive side of the differential input buffer and the comp (complementary) pad is associated with the negative side of the differential input buffer.

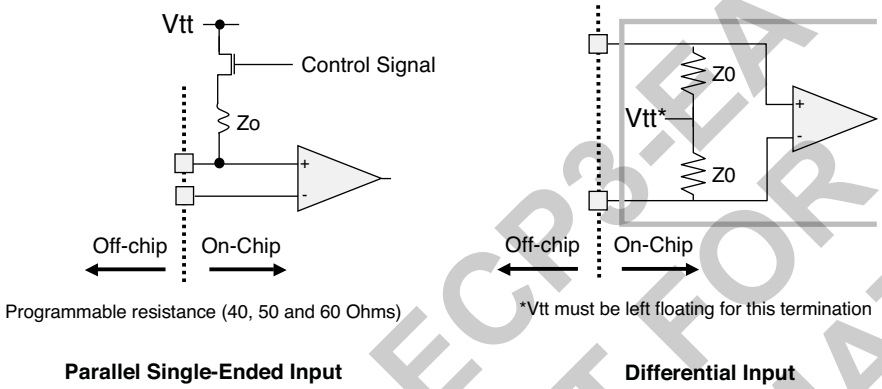
   On the top and bottom sides, there is no support for programmable on-chip input termination, which is required for DQ and DQS pins for DDR3 interface. This side is ideal for ADDR/CMD signals of DDR3, general purpose I/O, PCI, TR-LVDS (transition reduced LVDS) or LVDS inputs. Only the top I/O banks support hot socketing with I_{DK} specified under the Hot Socketing Specifications. The configuration bank is not hot-socketable.

On-Chip Programmable Termination

The LatticeECP3 supports a variety of programmable on-chip terminations options, including:

- Dynamically switchable Single Ended Termination for SSTL15 inputs with programmable resistor values of 40, 50, or 60 ohms. This is particularly useful for low power JEDEC compliant DDR3 memory controller implementations. External termination to Vtt should be used for DDR2 memory controller implementation.
- Common mode termination of 80, 100, 120 ohms for differential inputs

Figure 2-39. On-Chip Termination



See Table 2-12 for termination options for input modes.

Table 2-12. On-Chip Termination Options for Input Modes

IO_TYPE	TERMINATE to VTT[1, 2]	DIFFRENTIAL TERMINATION RESISTOR[1]
LVDS25	þ	80, 100, 120
BLVDS25	þ	80, 100, 120
MLVDS	þ	80, 100, 120
HSTL18_I	40, 50, 60	þ
HSTL18_II	40, 50, 60	þ
HSTL18D_I	40, 50, 60	þ
HSTL18D_II	40, 50, 60	þ
HSTL15_I	40, 50, 60	þ
HSTL15D_I	40, 50, 60	þ
SSTL25_I	40, 50, 60	þ
SSTL25_II	40, 50, 60	þ
SSTL25D_I	40, 50, 60	þ
SSTL25D_II	40, 50, 60	þ
SSTL18_I	40, 50, 60	þ
SSTL18_II	40, 50, 60	þ
SSTL18D_I	40, 50, 60	þ
SSTL18D_II	40, 50, 60	þ
SSTL15	40, 50, 60	þ
SSTL15D	40, 50, 60	þ

1. TERMINATE to VTT and DIFFRENTIAL TERMINATION RESISTOR when turn on can only have one setting per bank. Only left and right banks have this feature.
   Use of TERMINATE to VTT and DIFFRENTIAL TERMINATION RESISTOR are mutually exclusive in an I/O bank.
   On-chip termination tolerance +/- 20%
2. External termination to VTT should be used when implementing DDR2 memory controller.

DC Electrical Characteristics

Over Recommended Operating Conditions

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
I_{IL}, I_{IH}[1, 4]	Input or I/O Low Leakage	$0 \le V_{IN} \le (V_{CCIO} - 0.2V)$	—	—	10	µA
I_{IH}[1, 3]	Input or I/O High Leakage	$(V_{CCIO} - 0.2V) < V_{IN} \le 3.6V$	—	—	150	µA
I_{PU}	I/O Active Pull-up Current	$0 \le V_{IN} \le 0.7\ V_{CCIO}$	-30	—	-210	µA
I_{PD}	I/O Active Pull-down Current	V_{IL} (MAX) $\le V_{IN} \le V_{CCIO}$	30	—	210	µA
I_{BHLS}	Bus Hold Low Sustaining Current	$V_{IN} = V_{IL}$ (MAX)	30	—	—	µA
I_{BHHS}	Bus Hold High Sustaining Current	$V_{IN} = 0.7\ V_{CCIO}$	-30	—	—	µA
I_{BHLO}	Bus Hold Low Overdrive Current	$0 \le V_{IN} \le V_{CCIO}$	—	—	210	µA
I_{BHHO}	Bus Hold High Overdrive Current	$0 \le V_{IN} \le V_{CCIO}$	—	—	-210	µA
V_{BHT}	Bus Hold Trip Points	$0 \le V_{IN} \le V_{IH}$ (MAX)	V_{IL} (MAX)	—	V_{IH} (MIN)	V
C1	I/O Capacitance[2]	V_{CCIO} = 3.3V, 2.5V, 1.8V, 1.5V, 1.2V, V_{CC} = 1.2V, V_{IO} = 0 to V_{IH} (MAX)	—	8	—	pf
C2	Dedicated Input Capacitance[2]	V_{CCIO} = 3.3V, 2.5V, 1.8V, 1.5V, 1.2V, V_{CC} = 1.2V, V_{IO} = 0 to V_{IH} (MAX)	—	6	—	pf

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. Bus maintenance circuits are disabled.
2. T_A 25°C, f = 1.0MHz.
3. Applicable to general purpose I/Os in top and bottom banks.
4. When used as V_{REF}, maximum leakage= 25µA.

LatticeECP3 Supply Current (Standby)[1, 2, 3, 4, 5, 6]

Over Recommended Operating Conditions

Symbol	Parameter	Device	Typical	Units
I_{CC}	Core Power Supply Current	ECP-17EA	89.30	mA
		ECP3-35EA	89.30	mA
		ECP3-70E	226.30	mA
		ECP3-70EA	230.60	mA
		ECP3-95E	226.30	mA
		ECP3-95EA	230.60	mA
		ECP3-150EA	370.80	mA
I_{CCAUX}	Auxiliary Power Supply Current	ECP-17EA	28.20	mA
		ECP3-35EA	28.20	mA
		ECP3-70E	30.60	mA
		ECP3-70EA	30.60	mA
		ECP3-95E	30.60	mA
		ECP3-95EA	30.60	mA
		ECP3-150EA	45.70	mA
I_{CCPLL}	PLL Power Supply Current (Per PLL)	ECP-17EA	0.05	mA
		ECP3-35EA	0.03	mA
		ECP3-70E	0.02	mA
		ECP3-70EA	0.02	mA
		ECP3-95E	0.02	mA
		ECP3-95EA	0.02	mA
		ECP3-150EA	0.02	mA
I_{CCIO}	Bank Power Supply Current (Per Bank)	ECP-17EA	1.38	mA
		ECP3-35EA	1.38	mA
		ECP3-70E	1.43	mA
		ECP3-70EA	1.43	mA
		ECP3-95E	1.43	mA
		ECP3-95EA	1.43	mA
		ECP3-150EA	1.46	mA
I_{CCJ}	JTAG Power Supply Current	All Devices	2.50	mA
I_{CCA}	Transmit, Receive, PLL and Reference Clock Buffer Power Supply	ECP-17EA	5.90	mA
		ECP3-35EA	5.90	mA
		ECP3-70E	17.80	mA
		ECP3-70EA	17.80	mA
		ECP3-95E	17.80	mA
		ECP3-95EA	17.80	mA
		ECP3-150EA	23.80	mA

1. For further information on supply current, please see the list of technical documentation at the end of this data sheet.
2. Assumes all outputs are tristated, all inputs are configured as LVCMOS and held at the V_{CCIO} or GND.
3. Frequency 0 MHz.
4. Pattern represents a “blank” configuration data file.
5. T_J = 85°C, power supplies at nominal voltage.
6. To determine the LatticeECP3 peak start-up current data, use the Power Calculator tool in ispLEVER.

LVDS25E

The top and bottom sides of LatticeECP3 devices support LVDS outputs via emulated complementary LVCMOS outputs in conjunction with a parallel resistor across the driver outputs. The scheme shown in Figure 3-1 is one possible solution for point-to-point signals.

Figure 3-1. LVDS25E Output Termination Example

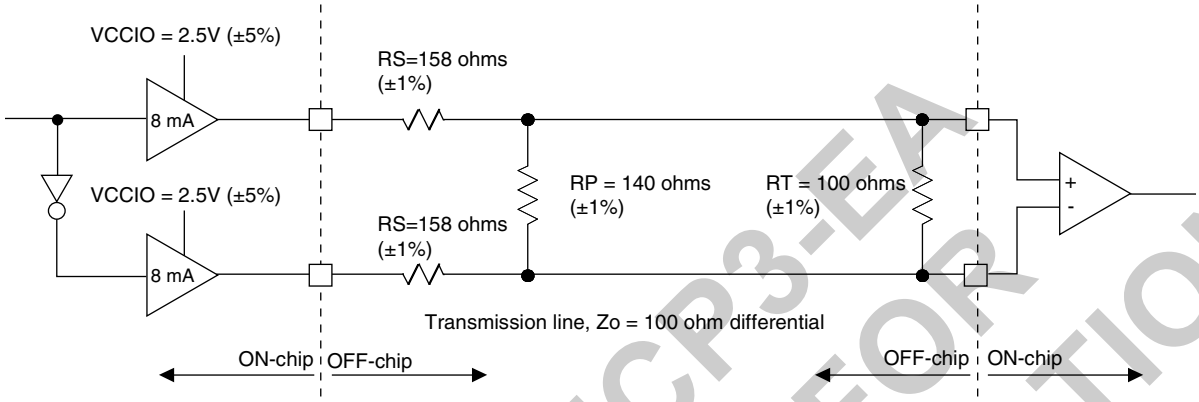


Table 3-1. LVDS25E DC Conditions

Parameter	Description	Typical	Units
V_{CCIO}	Output Driver Supply (+/-5%)	2.50	V
Z_{OUT}	Driver Impedance	20	Ω
R_S	Driver Series Resistor (+/-1%)	158	Ω
R_P	Driver Parallel Resistor (+/-1%)	140	Ω
R_T	Receiver Termination (+/-1%)	100	Ω
V_{OH}	Output High Voltage	1.43	V
V_{OL}	Output Low Voltage	1.07	V
V_{OD}	Output Differential Voltage	0.35	V
V_{CM}	Output Common Mode Voltage	1.25	V
Z_{BACK}	Back Impedance	100.5	Ω
I_{DC}	DC Output Current	6.03	mA

LVCMOS33D

All I/O banks support emulated differential I/O using the LVCMOS33D I/O type. This option, along with the external resistor network, provides the system designer the flexibility to place differential outputs on an I/O bank with 3.3V V_{CCIO}. The default drive current for LVCMOS33D output is 12mA with the option to change the device strength to 4mA, 8mA, 16mA or 20mA. Follow the LVCMOS33 specifications for the DC characteristics of the LVCMOS33D.

LatticeECP3 External Switching Characteristics [1, 2]

Over Recommended Commercial Operating Conditions

Parameter	Description	Device	-8		-7		-6		Units
			Min.	Max.	Min.	Max.	Min.	Max.	
Clocks									
Primary Clock[6]									
f_{MAX_PRI}	Frequency for Primary Clock Tree	ECP3-150EA	—	500	—	420	—	375	MHz
t_{W_PRI}	Clock Pulse Width for Primary Clock	ECP3-150EA	0.8	—	0.9	—	1.0	—	ns
t_{SKEW_PRI}	Primary Clock Skew Within a Device	ECP3-150EA	—	300	—	330	—	360	ps
t_{SKEW_PRIB}	Primary Clock Skew Within a Bank	ECP3-150EA	—	250	—	280	—	300	ps
t_{W_PRI}	Frequency for Primary Clock Tree	ECP3-70E/95E	—	500	—	420	—	375	MHz
f_{MAX_PRI}	Frequency for Primary Clock Tree	ECP3-70E/95E	0.8	—	0.9	—	1.0	—	ns
t_{SKEW_PRI}	Primary Clock Skew Within a Device	ECP3-70E/95E	—	300	—	330	—	360	ps
t_{SKEW_PRIB}	Primary Clock Skew Within a Bank	ECP3-70E/95E	—	250	—	280	—	300	ps
Edge Clock[6]									
f_{MAX_EDGE}	Frequency for Edge Clock	ECP3-150EA	—	500	—	420	—	375	MHz
t_{W_EDGE}	Clock Pulse Width for Edge Clock	ECP3-150EA	0.9	—	1.0	—	1.2	—	ns
$t_{SKEW\_EDGE\_DQS}$	Edge Clock Skew Within an Edge of the Device	ECP3-150EA	—	200	—	210	—	220	ps
f_{MAX_EDGE}	Frequency for Edge Clock	ECP3-70E/95E	—	500	—	420	—	375	MHz
t_{W_EDGE}	Clock Pulse Width for Edge Clock	ECP3-70E/95E	0.9	—	1.0	—	1.2	—	ns
$t_{SKEW\_EDGE\_DQS}$	Edge Clock Skew Within an Edge of the Device	ECP3-70E/95E	—	200	—	225	—	250	ps

Parameter	Description	Device	-8		-7		-6		Units
			Min.	Max.	Min.	Max.	Min.	Max.	
Generic SDR									
General I/O Pin Parameters Using Dedicated Clock Input Primary Clock Without PLL[2]									
t_{CO}	Clock to Output - PIO Output Register	ECP3-150EA	—	4.0	—	4.4	—	4.8	ns
t_{SU}	Clock to Data Setup - PIO Input Register	ECP3-150EA	0.0	—	0.0	—	0.0	—	ns
t_{H}	Clock to Data Hold - PIO Input Register	ECP3-150EA	1.6	—	1.8	—	2.1	—	ns
t_{SU_DEL}	Clock to Data Setup - PIO Input Register with Data Input Delay	ECP3-150EA	1.2	—	1.3	—	1.5	—	ns
t_{H_DEL}	Clock to Data Hold - PIO Input Register with Input Data Delay	ECP3-150EA	0.1	—	0.1	—	0.1	—	ns
f_{MAX_IO}	Clock Frequency of I/O and PFU Register	ECP3-150EA	—	500	—	420	—	375	MHz
t_{CO}	Clock to Output - PIO Output Register	ECP3-70E/95E	—	3.9	—	4.3	-—	4.7	ns
t_{SU}	Clock to Data Setup - PIO Input Register	ECP3-70E/95E	0.0	—	0.0	—	0.0	—	ns
t_{H}	Clock to Data Hold - PIO Input Register	ECP3-70E/95E	1.5	—	1.8	—	2.0	—	ns
t_{SU_DEL}	Clock to Data Setup - PIO Input Register with Data Input Delay	ECP3-70E/95E	1.3	—	1.5	—	1.8	—	ns
t_{H_DEL}	Clock to Data Hold - PIO Input Register with Input Data Delay	ECP3-70E/95E	0.0	—	0.0	—	0.0	—	ns

LatticeECP3 External Switching Characteristics (Continued)[1, 2]

Over Recommended Commercial Operating Conditions

Parameter	Description	Device	-8		-7		-6		Units
			Min.	Max.	Min.	Max.	Min.	Max.	
f_{MAX_IO}	Clock Frequency of I/O and PFU Register	ECP3-70E/95E	—	500	—	420	—	375	Mhz
General I/O Pin Parameters Using Dedicated Clock Input Primary Clock with PLL with Clock Injection Removal Setting[2]									
t_{COPLL}	Clock to Output - PIO Output Register	ECP3-150EA	—	2.5	—	2.7	—	3.1	ns
t_{SUPLL}	Clock to Data Setup - PIO Input Register	ECP3-150EA	0.6	—	0.6	—	0.7	—	ns
t_{HPLL}	Clock to Data Hold - PIO Input Register	ECP3-150EA	0.9	—	1.0	—	1.1	—	ns
t_{SU_DELPLL}	Clock to Data Setup - PIO Input Register with Data Input Delay	ECP3-150EA	1.5	—	1.6	—	1.8	—	ns
t_{H_DELPLL}	Clock to Data Hold - PIO Input Register with Input Data Delay	ECP3-150EA	—	0.1	—	0.1	—	0.1	ns
t_{COPLL}	Clock to Output - PIO Output Register	ECP3-70E/95E	—	2.2	—	2.3	—	2.5	ns
t_{SUPLL}	Clock to Data Setup - PIO Input Register	ECP3-70E/95E	0.6	—	0.7	—	0.8	—	ns
t_{HPLL}	Clock to Data Hold - PIO Input Register	ECP3-70E/95E	0.9	—	1.1	—	1.3	—	ns
t_{SU_DELPLL}	Clock to Data Setup - PIO Input Register with Data Input Delay	ECP3-70E/95E	1.6	—	1.9	—	2.1	—	ns
t_{H_DELPLL}	Clock to Data Hold - PIO Input Register with Input Data Delay	ECP3-70E/95E	0.0	—	0.0	—	0.0	—	ns

Parameter	Description	Device	-8		-7		-6		Units
			Min.	Max.	Min.	Max.	Min.	Max.	
Generic DDR									
Generic DDRX1 Inputs with Clock and Data (>10 Bits Wide) Centered at Pin (GDDRX1_RX.SCLK.Centered) Using PCLK Pin for Clock Input									
Data Left, Right and Top Sides & Clock Left, Right and Top Sides									
t_{SUGDDR}	Data Setup Before CLK	ECP3-150EA		—		—		—	ps
t_{HGDDR}	Data Hold After CLK	ECP3-150EA		—		—		—	ps
f_{MAX_GDDR}	DDRX1 Clock Frequency	ECP3-150EA	—		—		—		MHz
Generic DDRX1 Inputs with Clock in the Center of Data Window, without DLL (GDDRX1_RX.ECLK.Centered)									
t_{SUGDDR}	Data Setup Before CLK	ECP3-70E/95E	515	—	515	—	515	—	ps
t_{HOGDDR}	Data Hold After CLK	ECP3-70E/95E	515	—	515	—	515	—	ps
f_{MAX_GDDR}	DDRX1 Clock Frequency	ECP3-70E/95E	—	250	—	250	—	250	MHz
Generic DDRX1 Inputs with Clock and Data (> 10 Bits Wide) Aligned at Pin (GDDRX1_RX.SCLK.Aligned) using DLL-CLKIN Pin for Clock Input									
Data Left, Right and Top Sides & Clock Left and Right Sides									
$t_{DVACLKGDDR}$	Data Setup Before CLK	ECP3-150EA	—		—		—		UI
$t_{DVECLKGDDR}$	Data Hold After CLK	ECP3-150EA		—		—		—	UI
f_{MAX_GDDR}	DDRX1 Clock Frequency	ECP3-150EA	—		—		—		MHz
Generic DDRX1 Inputs with Clock and Data Aligned, with DLL (GDDRX1_RX.ECLK.Aligned)									
$t_{DVACLKGDDR}$	Data Setup Before CLK	ECP3-70E/95E	—	0.235	—	0.235	—	0.235	UI
$t_{DVECLKGDDR}$	Data Hold After CLK	ECP3-70E/95E	0.765	—	0.765	—	0.765	—	UI

LatticeECP3 External Switching Characteristics (Continued)[1, 2]

Over Recommended Commercial Operating Conditions

Parameter	Description	Device	-8		-7		-6		Units
			Min.	Max.	Min.	Max.	Min.	Max.	
f_{MAX_GDDR}	DDRX1 Clock Frequency	ECP3-70E/95E	—	250	—	250	—	250	MHz
Generic DDRX1 Inputs with Clock and Data (<10 Bits Wide) Centered at Pin (GDDRX1_RX.DQS.Centered) Using DQS Pin for Clock Input									
Left, Right and Top for Data and Clock									
t_{SUGDDR}	Data Valid After CLK	ECP3-150EA		—		—		—	ns
t_{HGDDR}	Data Hold After CLK	ECP3-150EA		—		—		—	ns
f_{MAX_GDDR}	DDRX1 Clock Frequency	ECP3-150EA	—		—		—		ns
Generic DDRX1 Inputs with Clock and Data (<10 Bits Wide) Aligned at Pin (GDDRX1_RX.DQS.Aligned) Using DQS Pin for Clock Input									
Left and Right Sides									
$t_{DVACLKGDDR}$	Data Setup Before CLK (Left and Right Sides)	ECP3-150EA	—		—		—		UI
$t_{DVECLKGDDR}$	Data Hold After CLK (Left and Right Sides)	ECP3-150EA		—		—		—	UI
f_{MAX_GDDR}	DDRX1 Clock Frequency (Left and Right Sides)	ECP3-150EA	—		—		—		UI
Top Side									
$t_{DVACLKGDDR}$	Data Setup Before CLK (Top Side)	ECP3-150EA	—		—		—		UI
$t_{DVECLKGDDR}$	Data Hold After CLK (Top Side)	ECP3-150EA		—		—		—	UI
f_{MAX_GDDR}	DDRX1 Clock Frequency (Top Side)	ECP3-150EA	—		—		—		UI
Generic DDRX2 Inputs with Clock and Data (>10 Bits Wide) Centered at Pin (GDDRX2_RX.ECLK.Centered) Using PCLK Pin for Clock Input									
Left and Right Sides									
t_{SUGDDR}	Data Setup Before CLK	ECP3-150EA		—		—		—	ns
t_{HGDDR}	Data Hold After CLK	ECP3-150EA		—		—		—	ns
f_{MAX_GDDR}	DDRX2 Clock Frequency	ECP3-150EA	—		—		—		MHz
Generic DDRX2 Inputs with Clock in the Center of Data Window, Without DLL[3] (GDDRX2_RX.ECLK.Centered)									
t_{SUGDDR}	Data Setup Before CLK	ECP3-70E/95E	260	—	312	—	352	—	ps
t_{HOGDDR}	Data Hold After CLK	ECP3-70E/95E	260	—	312	—	352	—	ps
f_{MAX_GDDR}	DDR/DDRX2 Clock Frequency[8]	ECP3-70E/95E	—	500	—	420	—	375	MHz
Generic DDRX2 Inputs with Clock and Data (>10 Bits Wide) Aligned at Pin (GDDRX2_RX.ECLK.Aligned)									
Left and Right Side Using DLLCLKIN Pin for Clock Input									
$t_{DVACLKGDDR}$	Data Setup Before CLK (Left and Right Side)	ECP3-150EA	—		—		—		UI
$t_{DVECLKGDDR}$	Data Hold After CLK (Left and Right Side)	ECP3-150EA		—		—		—	UI
f_{MAX_GDDR}	DDRX1 Clock Frequency (Left and Right Side)	ECP3-150EA	—		—		—		MHz
Top Side Using PCLK Pin for Clock Input									
$t_{DVACLKGDDR}$	Data Setup Before CLK (Top Side)	ECP3-150EA	—		—		—		UI
$t_{DVECLKGDDR}$	Data Hold After CLK (Top Side)	ECP3-150EA		—		—		—	UI
f_{MAX_GDDR}	DDRX1 Clock Frequency (Top Side)	ECP3-150EA	—		—		—		MHz
Generic DDRX2 Inputs with Clock and Data Edges Aligned, with DLLDEL[3] (GDDRX2_RX.ECLK.Aligned)									
$t_{DVACLKGDDR}$	Data Valid After CLK	ECP3-70E/95E	—	0.235	—	0.235	—	0.235	UI

LatticeECP3 Internal Switching Characteristics[1, 2] (Continued)

Over Recommended Commercial Operating Conditions

Parameter	Description	-8		-7		-6		Units.
		Min.	Max.	Min.	Max.	Min.	Max.	
t_{HWREN_EBR}	Hold Write/Read Enable to PFU Memory	0.141	—	0.145	—	0.149	—	ns
t_{SUCE_EBR}	Clock Enable Setup Time to EBR Output Register	0.087		0.096		0.104		ns
t_{HCE_EBR}	Clock Enable Hold Time to EBR Output Register	-0.066		-0.080		-0.094		ns
t_{SUBE_EBR}	Byte Enable Set-Up Time to EBR Output Register	-0.071		-0.070		-0.068		ns
t_{HBE_EBR}	Byte Enable Hold Time to EBR Output Register	0.118		0.098		0.077		ns
DSP Block Timing[3]								
t_{SUI_DSP}	Input Register Setup Time	0.32	—	0.36	—	0.39	—	ns
t_{HI_DSP}	Input Register Hold Time	-0.17	—	-0.19	—	-0.21	—	ns
t_{SUP_DSP}	Pipeline Register Setup Time	2.23	—	2.30	—	2.37	—	ns
t_{HP_DSP}	Pipeline Register Hold Time	-1.02	—	-1.09	—	-1.15	—	ns
t_{SUO_DSP}	Output Register Setup Time	3.09	—	3.22	—	3.34	—	ns
t_{HO_DSP}	Output Register Hold Time	-1.67	—	-1.76	—	-1.84	—	ns
t_{COI_DSP}	Input Register Clock to Output Time	—	3.68	—	4.03	—	4.38	ns
t_{COP_DSP}	Pipeline Register Clock to Output Time	—	1.30	—	1.47	—	1.64	ns
t_{COO_DSP}	Output Register Clock to Output Time	—	0.58	—	0.60	—	0.62	ns
t_{SUOPT_DSP}	Opcode Register Setup Time	0.31	—	0.35	—	0.39	—	ns
t_{HOPT_DSP}	Opcode Register Hold Time	-0.20	—	-0.24	—	-0.27	—	ns
t_{SUDATA_DSP}	Cascade_data through ALU to Output Register Setup Time	1.55	—	1.67	—	1.78	—	ns
t_{HPDATA_DSP}	Cascade_data through ALU to Output Register Hold Time	-0.44	—	-0.53	—	-0.61	—	ns

1. Internal parameters are characterized but not tested on every device.
2. Commercial timing numbers are shown. Industrial timing numbers are typically slower and can be extracted from the ispLEVER software.
3. DSP slice is configured in Multiply Add/Sub 18x18 mode.
4. The output register is in Flip-flop mode.

Serial Rapid I/O Type 2 Electrical and Timing Characteristics

AC and DC Characteristics

Table 3-15. Transmit

Symbol	Description	Test Conditions	Min.	Typ.	Max.	Units
T_{RF}[1]	Differential rise/fall time	20%-80%	—	80	—	ps
$Z_{TX\_DIFF\_DC}$	Differential impedance		80	100	120	Ohms
J_{TX_DDJ}[3, 4, 5]	Output data deterministic jitter		—	—	0.17	UI
J_{TX_TJ}[2, 3, 4, 5]	Total output data jitter		—	—	0.35	UI

1. Rise and Fall times measured with board trace, connector and approximately 2.5pf load.
2. Total jitter includes both deterministic jitter and random jitter. The random jitter is the total jitter minus the actual deterministic jitter.
3. Jitter values are measured with each CML output AC coupled into a 50-ohm impedance (100-ohm differential impedance).
4. Jitter and skew are specified between differential crossings of the 50% threshold of the reference signal.
5. Values are measured at 2.5 Gbps.

Table 3-16. Receive and Jitter Tolerance

Symbol	Description	Test Conditions	Min.	Typ.	Max.	Units
RL_{RX_DIFF}	Differential return loss	From 100 MHz to 2.5 GHz	10	—	—	dB
RL_{RX_CM}	Common mode return loss	From 100 MHz to 2.5 GHz	6	—	—	dB
Z_{RX_DIFF}	Differential termination resistance		80	100	120	Ohms
J_{RX_DJ}[2, 3, 4, 5]	Deterministic jitter tolerance (peak-to-peak)		—	—	0.37	UI
J_{RX_RJ}[2, 3, 4, 5]	Random jitter tolerance (peak-to-peak)		—	—	0.18	UI
J_{RX_SJ}[2, 3, 4, 5]	Sinusoidal jitter tolerance (peak-to-peak)		—	—	0.10	UI
J_{RX_TJ}[1, 2, 3, 4, 5]	Total jitter tolerance (peak-to-peak)		—	—	0.65	UI
T_{RX_EYE}	Receiver eye opening		0.35	—	—	UI

1. Total jitter includes deterministic jitter, random jitter and sinusoidal jitter. The sinusoidal jitter tolerance mask is shown in Figure 3-14.
2. Jitter values are measured with each high-speed input AC coupled into a 50-ohm impedance.
3. Jitter and skew are specified between differential crossings of the 50% threshold of the reference signal.
4. Jitter tolerance, Differential Input Sensitivity and Receiver Eye Opening parameters are characterized when Full Rx Equalization is enabled.
5. Values are measured at 2.5 Gbps.

Gigabit Ethernet/Serial Rapid I/O Type 1/SGMII Electrical and Timing Characteristics

AC and DC Characteristics

Table 3-17. Transmit

Symbol	Description	Test Conditions	Min.	Typ.	Max.	Units
T_{RF}	Differential rise/fall time	20%-80%	—	80	—	ps
$Z_{TX\_DIFF\_DC}$	Differential impedance		80	100	120	Ohms
J_{TX_DDJ}[3, 4, 5]	Output data deterministic jitter		—	—	0.10	UI
J_{TX_TJ}[2, 3, 4, 5]	Total output data jitter		—	—	0.24	UI

1. Rise and fall times measured with board trace, connector and approximately 2.5pf load.
2. Total jitter includes both deterministic jitter and random jitter. The random jitter is the total jitter minus the actual deterministic jitter.
3. Jitter values are measured with each CML output AC coupled into a 50-ohm impedance (100-ohm differential impedance).
4. Jitter and skew are specified between differential crossings of the 50% threshold of the reference signal.
5. Values are measured at 1.25 Gbps.

Table 3-18. Receive and Jitter Tolerance

Symbol	Description	Test Conditions	Min.	Typ.	Max.	Units
RL_{RX_DIFF}	Differential return loss	From 100 MHz to 1.25 GHz	10	—	—	dB
RL_{RX_CM}	Common mode return loss	From 100 MHz to 1.25 GHz	6	—	—	dB
Z_{RX_DIFF}	Differential termination resistance		80	100	120	Ohms
J_{RX_DJ}[1, 2, 3, 4, 5]	Deterministic jitter tolerance (peak-to-peak)		—	—	0.34	UI
J_{RX_RJ}[1, 2, 3, 4, 5]	Random jitter tolerance (peak-to-peak)		—	—	0.26	UI
J_{RX_SJ}[1, 2, 3, 4, 5]	Sinusoidal jitter tolerance (peak-to-peak)		—	—	0.11	UI
J_{RX_TJ}[1, 2, 3, 4, 5]	Total jitter tolerance (peak-to-peak)		—	—	0.71	UI
T_{RX_EYE}	Receiver eye opening		0.29	—	—	UI

1. Total jitter includes deterministic jitter, random jitter and sinusoidal jitter. The sinusoidal jitter tolerance mask is shown in Figure 3-14.
2. Jitter values are measured with each high-speed input AC coupled into a 50-ohm impedance.
3. Jitter and skew are specified between differential crossings of the 50% threshold of the reference signal.
4. Jitter tolerance, Differential Input Sensitivity and Receiver Eye Opening parameters are characterized when Full Rx Equalization is enabled.
5. Values are measured at 1.25 Gbps.

Signal Descriptions (Cont.)

Signal Name	I/O	Description
[LOC]DQS[num]	I/O	DQ input/output pads: T (top), R (right), B (bottom), L (left), DQS, num = ball function number.
[LOC]DQ[num]	I/O	DQ input/output pads: T (top), R (right), B (bottom), L (left), DQ, associated DQS number.
Test and Programming (Dedicated Pins)		
TMS	I	Test Mode Select input, used to control the 1149.1 state machine. Pull-up is enabled during configuration.
TCK	I	Test Clock input pin, used to clock the 1149.1 state machine. No pull-up enabled.
TDI	I	Test Data in pin. Used to load data into device using 1149.1 state machine. After power-up, this TAP port can be activated for configuration by sending appropriate command. (Note: once a configuration port is selected it is locked. Another configuration port cannot be selected until the power-up sequence). Pull-up is enabled during configuration.
TDO	O	Output pin. Test Data Out pin used to shift data out of a device using 1149.1.
VCCJ	—	Power supply pin for JTAG Test Access Port.
Configuration Pads (Used During sysCONFIG)		
CFG[2:0]	I	Mode pins used to specify configuration mode values latched on rising edge of INITN. During configuration, a pull-up is enabled. These are dedicated pins.
INITN	I/O	Open Drain pin. Indicates the FPGA is ready to be configured. During configuration, a pull-up is enabled. It is a dedicated pin.
PROGRAMN	I	Initiates configuration sequence when asserted low. This pin always has an active pull-up. It is a dedicated pin.
DONE	I/O	Open Drain pin. Indicates that the configuration sequence is complete, and the startup sequence is in progress. It is a dedicated pin.
CCLK	I	Input Configuration Clock for configuring an FPGA in Slave SPI, Serial, and CPU modes. It is a dedicated pin.
MCLK	I/O	Output Configuration Clock for configuring an FPGA in SPI, SPIm, and Master configuration modes.
BUSY/SISPI	O	Parallel configuration mode busy indicator. SPI/SPIm mode data output.
CSN/SN/OEN	I/O	Parallel configuration mode active-low chip select. Slave SPI chip select. Parallel burst Flash output enable.
CS1N/HOLDN/RDY	I	Parallel configuration mode active-low chip select. Slave SPI hold input.
WRITEN	I	Write enable for parallel configuration modes.
DOUT/CSON/CSSPI1N	O	Serial data output. Chip select output. SPI/SPIm mode chip select.
D[0]/SPIFASTN	I/O	sysCONFIG Port Data I/O for Parallel mode. Open drain during configuration. sysCONFIG Port Data I/O for SPI or SPIm. When using the SPI or SPIm mode, this pin should either be tied high or low, must not be left floating. Open drain during configuration.
D1	I/O	Parallel configuration I/O. Open drain during configuration.
D2	I/O	Parallel configuration I/O. Open drain during configuration.
D3/SI	I/O	Parallel configuration I/O. Slave SPI data input. Open drain during configuration.
D4/SO	I/O	Parallel configuration I/O. Slave SPI data output. Open drain during configuration.
D5	I/O	Parallel configuration I/O. Open drain during configuration.
D6/SPID1	I/O	Parallel configuration I/O. SPI/SPIm data input. Open drain during configuration.

Part Number	Voltage	Grade	Package	Pins	Temp.	LUTs (K)
LFE3-150EA-6FN672I	1.2V	-6	Lead-Free fpBGA	672	IND	149
LFE3-150EA-7FN672I	1.2V	-7	Lead-Free fpBGA	672	IND	149
LFE3-150EA-8FN672I	1.2V	-8	Lead-Free fpBGA	672	IND	149
LFE3-150EA-6FN1156I	1.2V	-6	Lead-Free fpBGA	1156	IND	149
LFE3-150EA-7FN1156I	1.2V	-7	Lead-Free fpBGA	1156	IND	149
LFE3-150EA-8FN1156I	1.2V	-8	Lead-Free fpBGA	1156	IND	149

Part Number	Voltage	Grade	Package	Pins	Temp.	LUTs (K)
LFE3-150EA-6FN672ITW*	1.2V	-6	Lead-Free fpBGA	672	IND	149
LFE3-150EA-7FN672ITW*	1.2V	-7	Lead-Free fpBGA	672	IND	149
LFE3-150EA-8FN672ITW*	1.2V	-8	Lead-Free fpBGA	672	IND	149
LFE3-150EA-6FN1156ITW*	1.2V	-6	Lead-Free fpBGA	1156	IND	149
LFE3-150EA-7FN1156ITW*	1.2V	-7	Lead-Free fpBGA	1156	IND	149
LFE3-150EA-8FN1156ITW*	1.2V	-8	Lead-Free fpBGA	1156	IND	149

*Note: Specifications for the LFE3-150EA-*sp*FN*pkg*CTW and LFE3-150EA-*sp*FN*pkg*ITW devices, (where *sp* is the speed and *pkg* is the package), are the same as the LFE3-150EA-*sp*FN*pkg*C and LFE3-150EA-*sp*FN*pkg*I devices respectively, except as specified below.

- The CTC (Clock Tolerance Circuit) inside the SERDES hard PCS in the TW device is not functional but it can be bypassed and implemented in soft IP.
- The SERDES XRES pin on the TW device passes CDM testing at 250V.