QuickLogic PolarPro® II Device Data Sheet

Combining Low Power, Performance, Density, and Embedded RAM

Device Highlights

Low Power Programmable Logic

- As low as ***TBD*** µA
- 0.18 µm, six layer metal CMOS process
- 1.5 V or 1.8 V core voltage, 1.8/2.5/3.3 V drive capable I/Os
- Up to 27 kilobits of SRAM
- Up to 85 I/Os available
- Up to 150,000 system gates
- Nonvolatile, instant-on
- IEEE 1149.1 boundary scan testing compliant

Embedded Dual-Port SRAM

- Up to four dual-port 4-kilobit and four 2-kilobit high performance SRAM blocks
- True dual-port capability for RAM and FIFOs
- Embedded synchronous/asynchronous FIFO controller
- Configurable and cascadable aspect ratio

Programmable I/O

- Bank programmable slew rate control
- Eight independent I/O banks capable of supporting multiple I/O standards in one device
- Bank programmable I/O standards: LVTTL, LVCMOS, LVCMOS18, and PCI

Advanced Clock Network

- Multiple low skew clock networks
  - 1 dedicated global clock network
  - 4 programmable global clock networks
- Quadrant-based segmentable clock networks
  - 20 quad clock networks per device
  - 4 quad clock networks per quadrant
  - 1 dedicated clock network per quadrant
- One user Configurable Clock Manager (CCM)

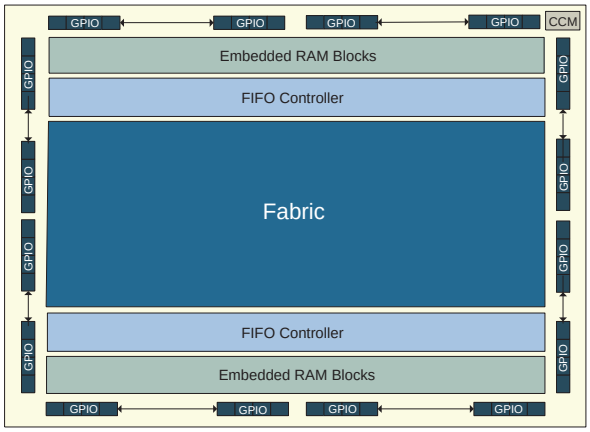
Very Low Power (VLP) Mode

- QuickLogic PolarPro II has a special VLP pin which can enable a low power sleep mode that significantly reduces the overall power consumption of the device by placing the device in standby
- Enter VLP mode from normal operation in less than 10 µs (typical)
- Exit from VLP mode to normal operation in less than 10 µs (typical)

Security Links

There are several security links to disable JTAG access to the device. Programming these optional links completely disables access to the device from the outside world and provides an extra level of design security not possible in SRAM-based FPGAs.

Figure 1: QuickLogic PolarPro II Block Diagram



PRELIMINARY

Ultra-Low Power FPGA Combining Performance, Density, and Embedded RAM

Table 1: PolarPro II QL2P150

Features		QL2P150
Max Gates		150,000
Logic Cells		864
Max I/O		85
RAM Modules		8
FIFO Controllers		8
RAM bits		27,648
CCMs		1
Packages	TFBGA (0.5 mm)	121
	TFBGA (0.4 mm)	121

Process Data

The QuickLogic PolarPro II is fabricated on a 0.18µ, six layer metal CMOS process. The core voltage is 1.5 V or 1.8 V. The I/O voltage input tolerance and output drive can be set as 1.8 V, 2.5 V, and 3.3 V.

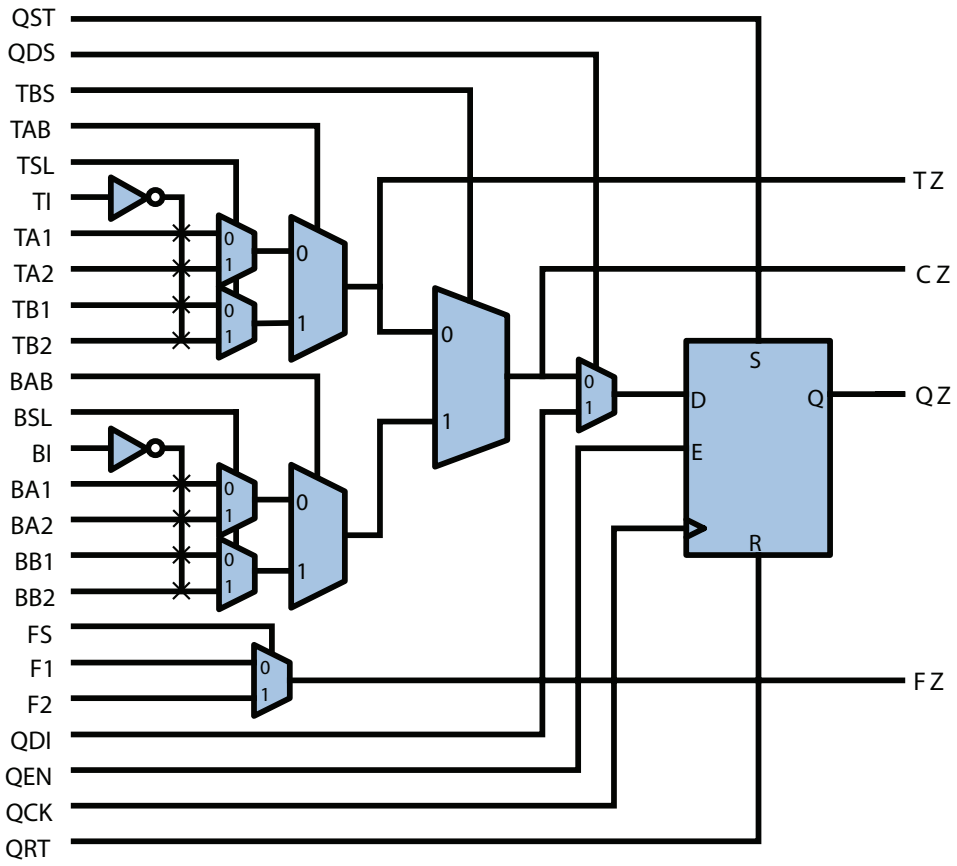
Programmable Logic Architectural Overview

The QuickLogic PolarPro II logic cell structure presented in **Figure 2** is a single register, multiplexer-based logic cell. It is designed for wide fan-in and multiple, simultaneous output functions. The cell has a high fan-in, fits a wide range of functions with up to 24 simultaneous inputs (including register control lines), and four outputs (three combinatorial and one registered). The high logic capacity and fan-in of the logic cell accommodates many user functions with a single level of logic delay.

The QuickLogic PolarPro II logic cell can implement:

- Two independent 3-input functions
- Any 4-input function
- 8 to 1 mux function
- Independent 2 to 1 mux function
- Single dedicated register with clock enable, active high set and reset signals
- Direct input selection to the register, which allows combinatorial and register logic to be used separately
- Combinatorial logic that can also be configured as an edge-triggered master-slave D flip-flop

Figure 2: PolarPro II Logic Cell



RAM Modules

The PolarPro II QL2P150 device has four 4-kilobit (4608 bits) as shown in **Figure 3**, and four 2-kilobit (2304) RAM blocks as shown in **Figure 4**.

The RAM features include:

- Independently configurable read and write data bus widths
- Independent read and write clocks
- Maximum of two RAM blocks can be concatenated horizontally or vertically
  - 4 kilobits for two 2-kilobit RAM blocks and 8 kilobits for two 4-kilobit RAM blocks
- Write byte enables
- Selectable pipelined or non-pipelined read data
- True dual-port RAM functionality
- Clock disabling during idle operation

Figure 3: 4-Kilobit Dual-Port RAM Block

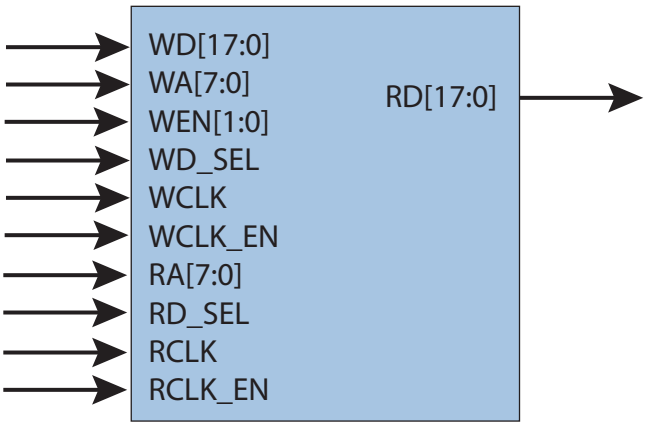


Figure 4: 2-Kilobit Dual-Port RAM Block

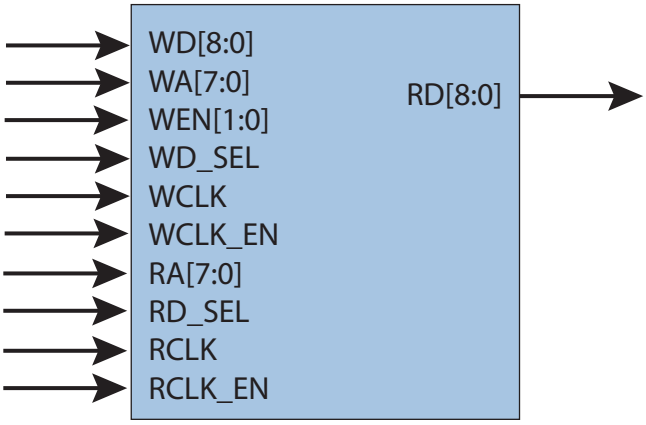


Table 2 describes the RAM interface signals.

Table 2: RAM Interface Signals

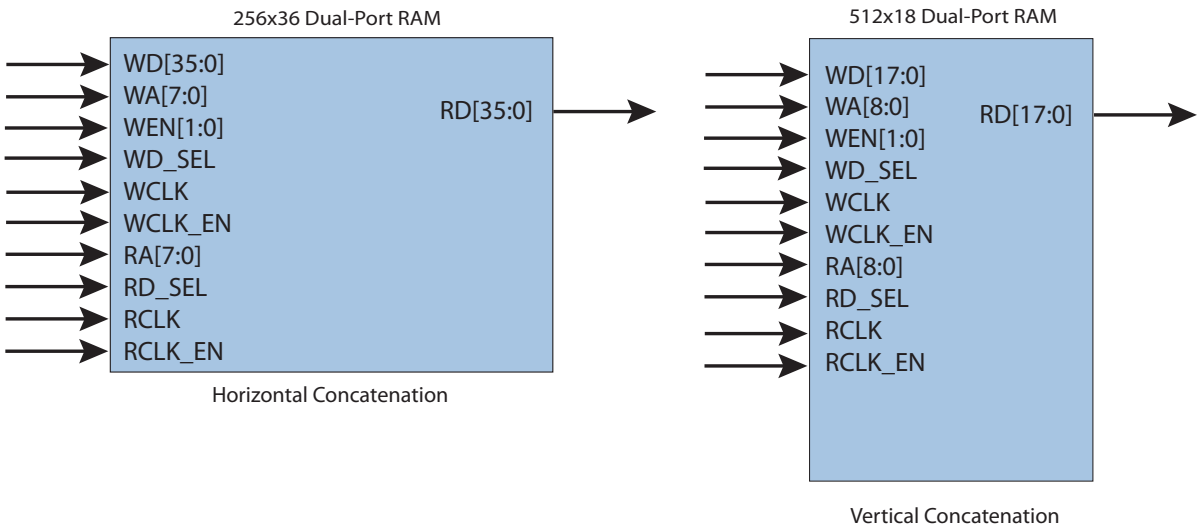
Signal Name	Function
Inputs	
WD	Write Data
WA	Write Address
WEN	Write Enable
WD_SEL	Write Chip Select
WCLK	Write Clock
WCLK_EN	Write Clock Enable
RA	Read Address
RD_SEL	Read Chip Select
RCLK	Read Clock
RCLK_EN	Read Clock Enable
Output	
RD	Read Data

The read and write data buses of a RAM block can be arranged to variable bus widths. The bus widths can be configured using the RAM Wizard available in QuickWorks, QuickLogic's development software. The selection of the RAM depth and width determines how the data is addressed.

The RAM blocks also support data concatenation. Designers can cascade multiple RAM modules to increase the depth or width by connecting corresponding address lines together and dividing the words between modules. Generally, this requires the use of additional programmable logic resources. However, when concatenating only two 4-kilobit RAM blocks or two 2-kilobit RAM blocks, they can be concatenated horizontally or vertically without using any additional programmable fabric resources.

For example, two internal 4-kilobit dual-port RAM blocks can be concatenated vertically to create a 512x18 RAM block or horizontally to create a 256x36 RAM block. **Figure 5** displays a block diagram of 4-kilobit RAM blocks horizontal and vertical concatenation.

Figure 5: 4-Kilobit Horizontal and Vertical Concatenation Examples



For example, two internal 2-kilobit dual-port RAM blocks can be concatenated vertically to create a 256x18 RAM block or horizontally to create a 128x36 RAM block. **Figure 6** displays a block diagram of 2-kilobit RAM blocks horizontal and vertical concatenation.

Figure 6: 2-Kilobit Horizontal and Vertical Concatenation Examples

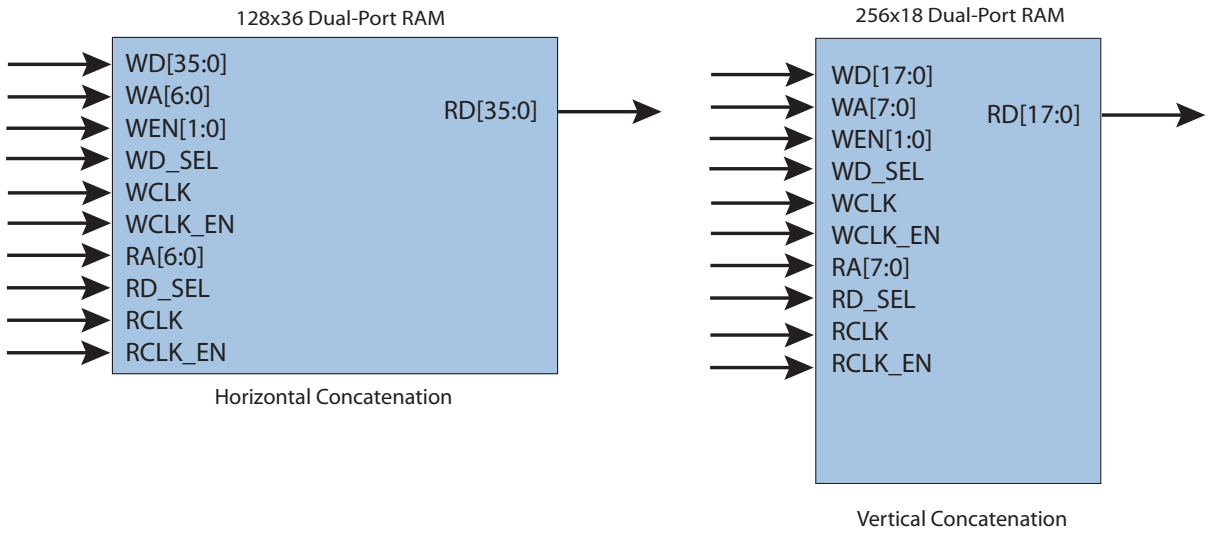


Table 3 shows the various RAM configurations supported by the PolarPro II 4-kilobit RAM modules.

Table 3: Available 4-Kilobit RAM Configurations

Device	Number of RAM Blocks	Depth	Width	Description
QL2P150	1	256	1-18	No concantenation
	1	512	1-9	No concantenation
	2	256	1-36	Horizontal concantenation
	2	512	1-18	Vertical concantenation
	2	1024	1-9	Vertical concantenation

Table 4 shows the various RAM configurations supported by the PolarPro II 2-kilobit RAM modules.

Table 4: Available 2-Kilobit RAM Configurations

Device	Number of RAM Blocks	Depth	Width	Description
QL2P150	1	128	1-18	No concantenation
	1	256	1-9	No concantenation
	2	128	1-36	Horizontal concantenation
	2	256	1-18	Vertical concantenation
	2	512	1-9	Vertical concantenation

True Dual-Port RAM

PolarPro II dual-port RAM modules can also be concatenated to generate true dual-port RAMs. The true dual-port RAM module's Port1 and Port2 have completely independent read and write ports, and separate read and write clocks. This allows Port1 and Port2 to have different data widths and clock domains. It is important to note that there is no circuitry preventing a write and read operation to the same address space at the same time. Therefore, it is up to the designer to ensure that the same address is not read from and written to simultaneously, otherwise the data is considered invalid. Likewise, the same address must not be written to from both ports at the same time. However, it is possible to read from the same address.

Figure 7 shows an example of a 512x18 true dual-port RAM.

Figure 7: 512x18 4-Kilobit True Dual-Port RAM Block

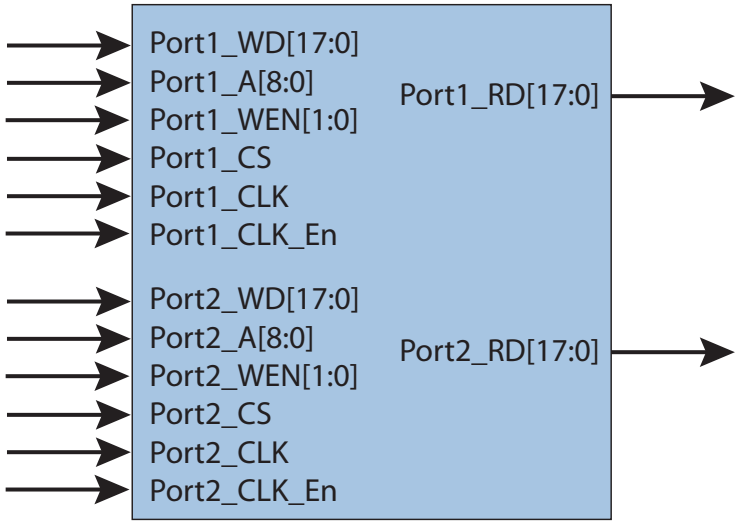


Figure 8 shows an example of a 256x18 true dual-port RAM.

Figure 8: 256x18 2-Kilobit True Dual-Port RAM Block

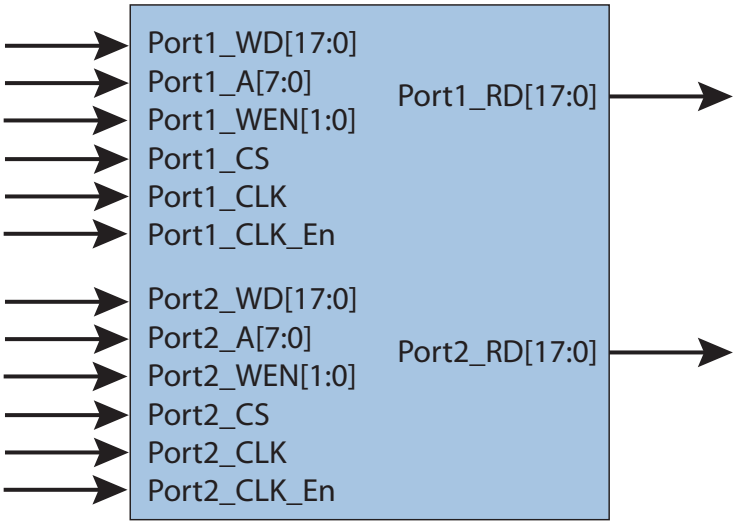


Table 5 describes the true dual-port RAM interface signals.

Table 5: True Dual-Port RAM Interface Signals

Port	Signal Name	Function
Port1	**Inputs**	
	Port1_WD	Write Data
	Port1_A	Write Address
	Port1_WEN	Write Enable
	Port1_CS	Chip Select
	Port1_CLK	Clock
	Port1_CLK_En	Clock Enable
	Output	
	Port1_RD	Read Data
Port2	**Inputs**	
	Port2_WD	Write Data
	Port2_A	Write Address
	Port2_WEN	Write Enable
	Port2_CS	Chip Select
	Port2_CLK	Clock
	Port2_CLK_En	Clock Enable
	Output	
	Port2_RD	Read Data

Table 6 lists the 4-kilobit true dual-port RAM configurations that are available.

Table 6: Available 4-Kilobit True Dual-Port RAM Configurations

Device	Depth	Width
QL2P150	512	1-18
	1024	1-9

Table 7 lists the 2-kilobit true dual-port RAM configurations that are available.

Table 7: Available 2-Kilobit True Dual-Port RAM Configurations

Device	Depth	Width
QL2P150	256	1-18
	512	1-9

Embedded FIFO Controllers

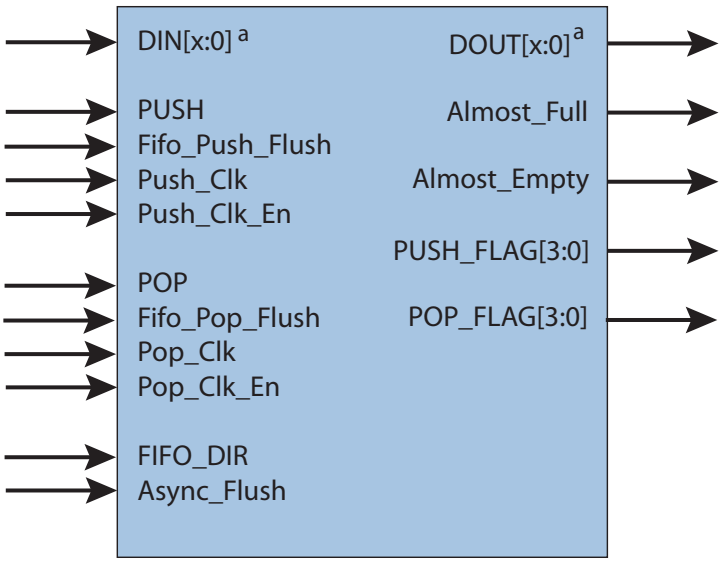
Every RAM block can be implemented as a synchronous or asynchronous FIFO. There are built-in FIFO controllers that allow for varying depths and widths without requiring programmable fabric resources.

The PolarPro II FIFO controller features include:

- x9, x18 and x36 data bus widths.
- Independent PUSH and POP clocks
- Independent programmable data width on PUSH and POP sides.
- Configurable synchronous or asynchronous FIFO operation
- 4-bit PUSH and POP level indicators to provide FIFO status outputs for each port
- Pipelined read data to improve timing
- Switchable clock domain between PUSH and POP side during asynchronous operation
- Clock disabling during idle operation
- Asynchronous reset (apart from the synchronous FLUSH) going to the pointers

Figure 9 shows an example a FIFO module.

Figure 9: FIFO Module



a. x = {1,2,3,....35}.

Table 8 lists the FIFO configurations that are available.

Table 8: Available FIFO Configurations

Device	Number of RAM Blocks	Depth	Supported Widths
QL2P150	1 (2-kilobit RAM block)	128	1-18 bits
	1 (2-kilobit RAM block)	256	1-9 bits
	2 (2-kilobit RAM block)	128	1-36 bits
	2 (2-kilobit RAM block)	256	1-18 bits
	2 (2-kilobit RAM block)	512	1-9 bits
	1 (4-kilobit RAM block)	256	1-18 bits
	1 (4-kilobit RAM block)	512	1-9 bits
	2 (4-kilobit RAM block)	256	1-36 bits
	2 (4-kilobit RAM block)	512	1-18 bits
	2 (4-kilobit RAM block)	1024	1-9 bits

Table 9 lists the FIFO controller interface signals.

Table 9: FIFO Interface Signals

Signal Name	Width (bits)	Direction	Function
PUSH Signals			
DIN	1 to 36	I	Data bus input
PUSH	1	I	Initiates a data push
Fifo_Push_Flush	1	I	Empties the FIFO
Push_Clk	1	I	Push data clock
Push_Clk_En	1	I	Push clock enable
POP Signals			
DOUT	1 to 36	O	Data bus output
POP	1	I	Initiates a data pop
Fifo_Pop_Flush	1	I	Empties the FIFO
Pop_Clk	1	I	Pop data clock
Pop_Clk_En	1	I	Pop clock enable
Common PORT Signals			
Fifo_Dir	1	I	Push-Pop domain switching
Async_Flush	1	I	Asynchronous input to flush FIFO
Status Flags			
Almost_Full	1	O	Asserted when FIFO has one location available
Almost_Empty	1	O	Asserted when FIFO has one location used
PUSH_FLAG	4	O	FIFO PUSH level indicator
POP_FLAG	4	O	FIFO POP level indicator

Table 10 and **Table 11** highlight the corresponding FIFO level indicator for each 4-bit value of the PUSH_FLAG and POP_FLAG outputs.

Table 10: FIFO PUSH Level Indicator Values

Value	Status
0000	Full
0001	Empty
0010	Room for more than one-half
0011	Room for more than one-forth
0100	Room for less than one-forth to 64[a]
1010	Room for 32 to 63[a]
1011	Room for 16 to 31
1100	Room for 8 to 15
1101	Room for 4 to 7
1110	Room for 2 to 3
1111	Room for 1
Others	Reserved

a. For a FIFO depth of 256, Value 0100 will not be asserted. The PUSH flag will shift directly from 0011 to 1010 as data is pushed. For a FIFO depth of 128, Values 0100 and 1010 will not be asserted. The PUSH flag will shift directly from 0011 to 1011 as data is pushed.

Table 11: FIFO POP Level Interface Signals

Value	Status
0000	Empty
0001	1 entry in FIFO
0010	At least 2 entries in FIFO
0011	At least 4 entries in FIFO
0100	At least 8 entries in FIFO
0101	At least 16 entries in FIFO
0110	At least 32 entries in FIFO[a]
1000	64 entries to less than one-forth full[a]
1101	One-forth or more full
1110	One-half or more full
1111	Full
Others	Reserved

a. For a FIFO depth of 256, Value 1000 will not be asserted. The POP Flag will shift directly from 1101 to 0110 as data is popped. For a FIFO depth of 128, Values 1000 and 0110 will not be asserted. The POP flag will shift directly from 1101 to 0101 as data is popped.

PUSH-POP Domain Switching

During asynchronous operation, the FIFO works in a half-duplex manner, meaning PUSH on one clock domain and POP on the other clock domain. To provide each domain the PUSH and POP capability, a DIR port is added to choose what function each clock domain will have. The DIR port determines the functions of P1 and P2, and the clock assigned to PORT1 and PORT2 of the FIFO. After the direction switches, the FIFO pointers must be reset.

Figure 10 shows the PUSH-POP domain switching operation.

Figure 10: PUSH-POP Domain Switching

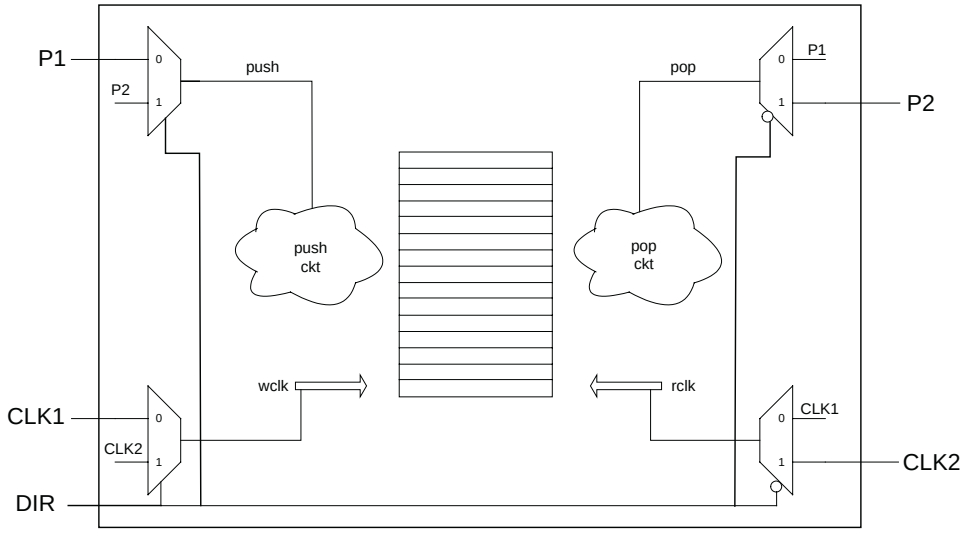


Table 12 shows the PUSH-POP direction switching.

Table 12: PUSH-POP Direction Switching

DIR	Direction
0	CLK1/P1 PUSH, CLK2/P2 POP
1	CLK1/P1 POP, CLK2/P2 PUSH

FIFO Synchronous Flush Procedure

Both PUSH and POP domains are provided with a flush input signal synchronized to their respective clocks. When a flush is triggered from one side of the FIFO, the signal propagates and re-synchronizes internally to the other clock domain. During a flush operation, the values of the FIFO flags are invalid for a specific number of cycles (see **Figure 11** and **Figure 12**).

As shown in **Figure 11**, when the **Fifo_Push_Flush** asserts, the **Almost_Full** and **PUSH_FLAG** signals become invalid until the FIFO can flush the data with regards to the Push clock domain as well as the Pop clock domain. After the **Fifo_Push_Flush** is asserted, the next rising edge of the Pop clock starts the Pop flush routine.

Figure 11 illustrates a FIFO Flush operation. After the **Fifo_Push_Flush** is asserted at 2 (**PUSH_Clk**), four POP clock cycles (12 through 15) are required to update the **POP_FLAG**, and **PUSH_FLAG** signals. The **Almost_Empty** signal is asserted to indicate that the push flush operation has been completed. On the following rising edge of the **PUSH_Clk** (8), the **PUSH_FLAG** is accordingly updated to reflect the successful flush operation.

Figure 11: FIFO Flush from PUSH Side

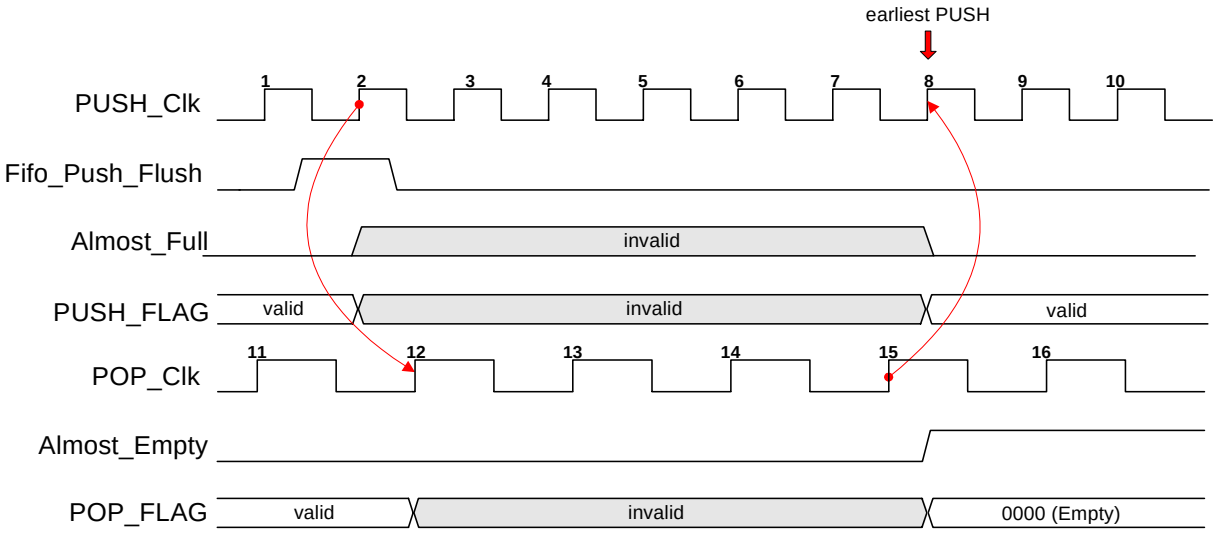


Figure 12 illustrates a POP flush operation. After the **Fifo_Pop_Flush** is asserted at 2 (**POP_Clk**), four PUSH clock cycles (12 through 15) are required to update the **POP_FLAG**, and **PUSH_FLAG** signals. The **Almost_Empty** signal is asserted to indicate that the pop flush operation has been completed. On the following rising edge of the **POP_Clk** (8), the **POP_FLAG** is updated accordingly to reflect the successful flush operation.

Figure 12: FIFO Flush from POP Side

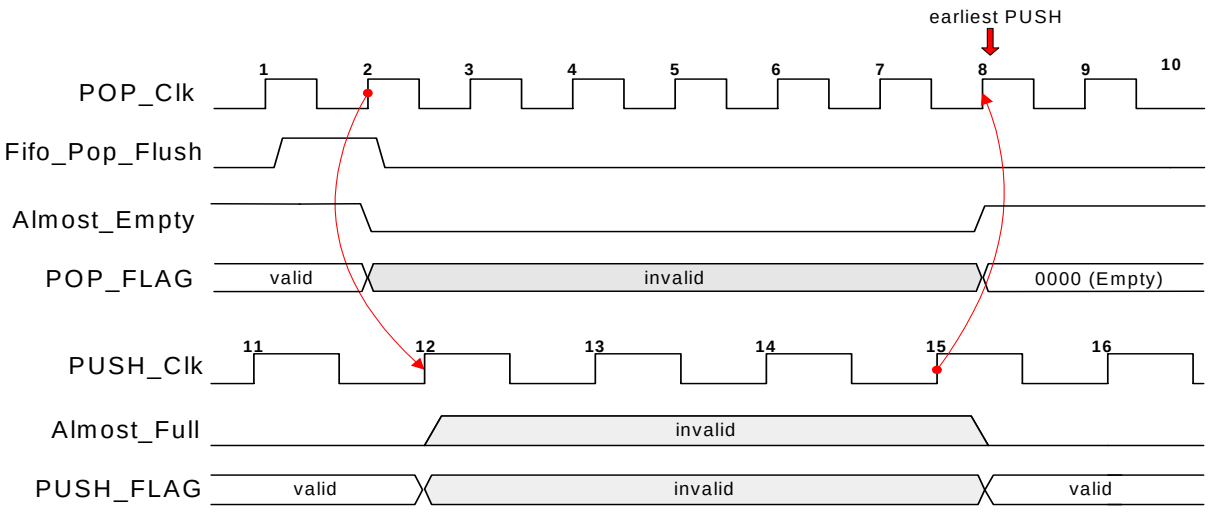


Figure 11 and **Figure 12** are only true for this particular PUSH-POP clock frequency combination. The clock frequency and phase difference between POP_Clk and PUSH_Clk can cause an additional flush delay of one clock cycle in either domain because of the asynchronous relationship between the two clocks.

Asynchronous Flush

Apart from the synchronous flush controls, an asynchronous flush is provided through the port ASYNC_FLUSH. Assertion of this signal flushes the FIFO PUSH and POP pointers.

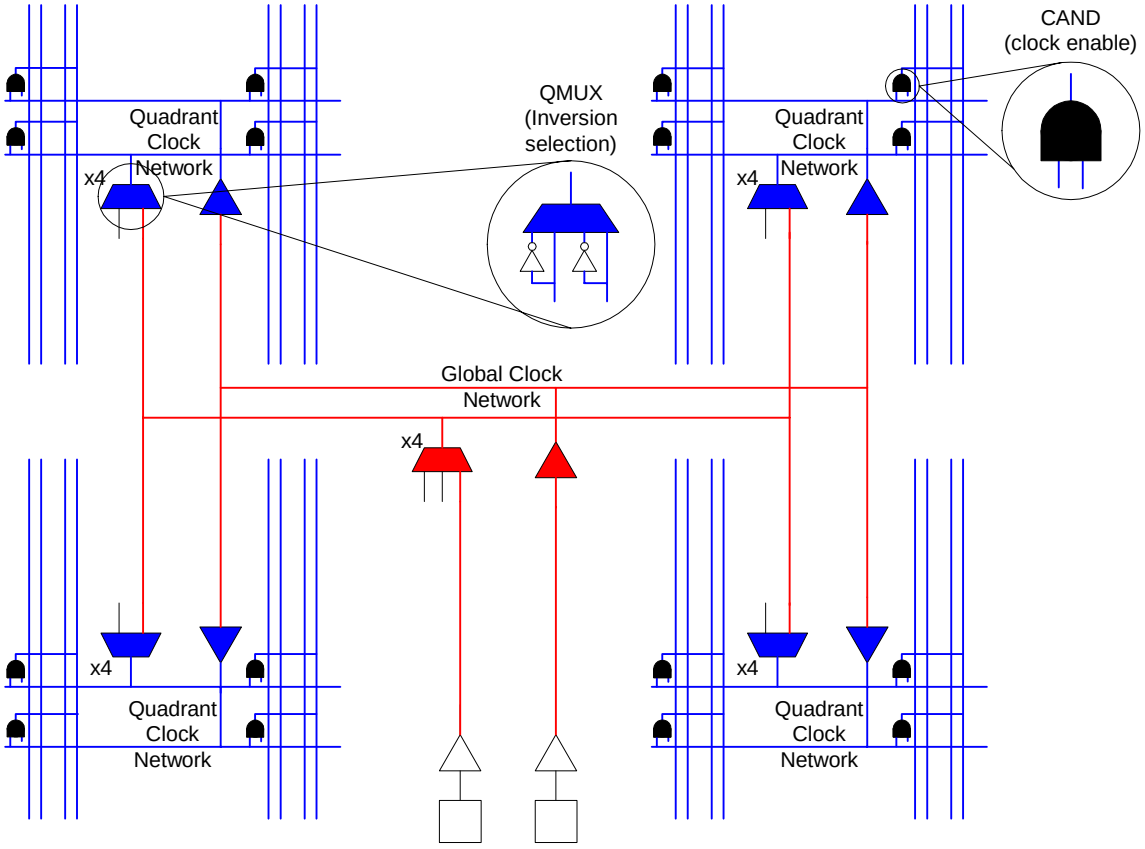
QL2P150 Clock Network Architecture

Clock Network Architecture

The PolarPro II clock network architecture consists of a 2-level H-tree network as shown in **Table 13**. The first level of each clock tree spans from the clock input pad to the global clock network and to the center of each quadrant of the chip. The second level spans from the quadrant clock network to every logic cell inside that quadrant. There are five global clocks in the global clock network, and five quadrant clocks in each quadrant clock network. All global clocks drive the quadrant clock network inputs.

The quadrant clock network passes either the original input clock or an inverted version of the input clock to the column clock buffer. The column clock buffer allows dynamically enabling or disabling all clocks in the column level. The global clocks can drive RAM block clock inputs and reset, set, enable, and clock inputs to I/O registers. Furthermore, the quadrant clock outputs can be routed to all logic cell inputs.

Figure 13: PolarPro II Clock Network Architecture



Of the five global clock networks:

- Two can be either driven directly by clock pads, Configurable Clock Manager (CCM) outputs, or internally generated signals. These two global clocks go through 3-input global clock muxes located in the middle of the die. See **Figure 14** for a diagram of a 3-input global clock mux.
- Two can be either driven directly by clock pads or internally generated signals.
- One is a dedicated global clock network that goes directly to the quadrant clock network and is used as a dedicated fast clock.

Figure 14: Global Clock Structure

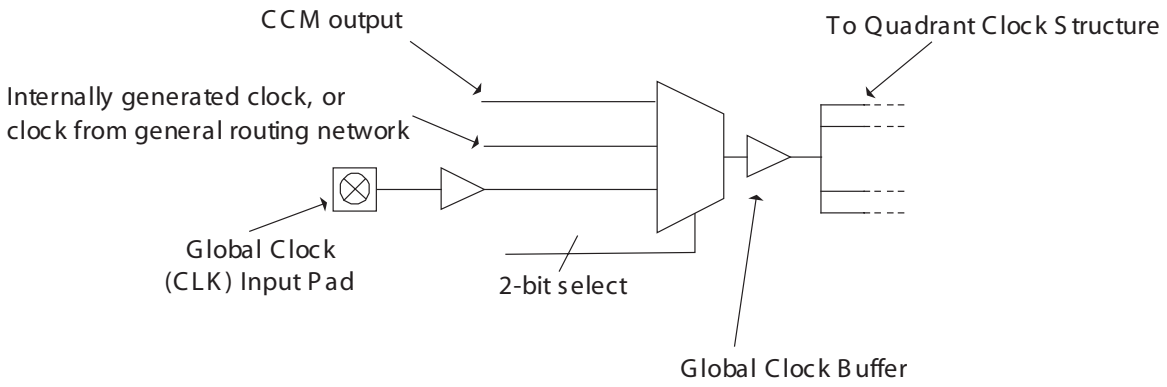
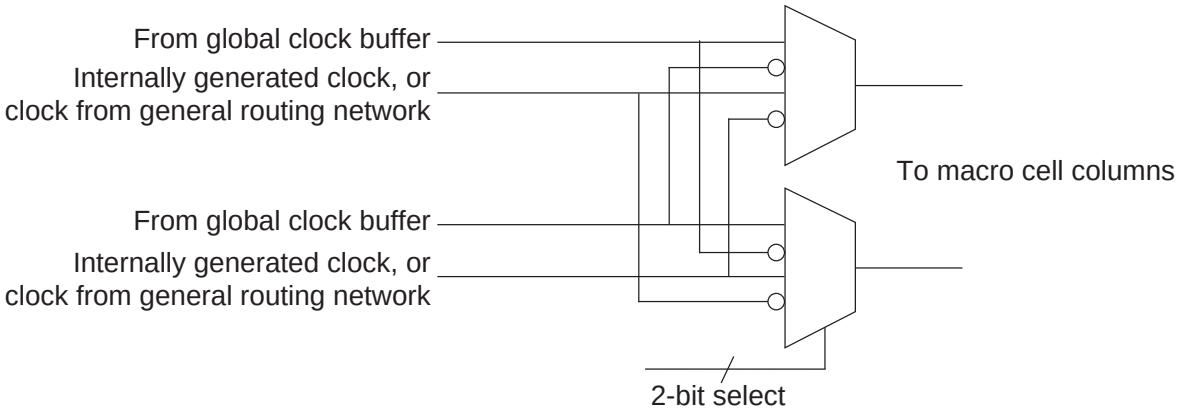


Figure 15 illustrates the quadrant HSCK 4-input mux.

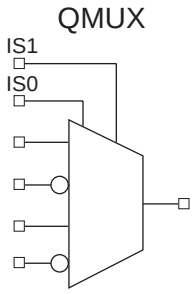
Figure 15: Quadrant Clock Structure



The quadrant HSCK mux is located at the middle of the quadrant. These 4-input HSCK muxes output inverted or non-inverted output from global HSCK, or inverted or non-inverted quad level HSCK depending on the 2-bit select line.

A quadrant HSCK mux can be implemented in Verilog, VHDL, and schematic designs by instantiating the quadrant HSCK mux macro, QMUX. **Figure 16** shows the schematic representation of the QMUX macro.

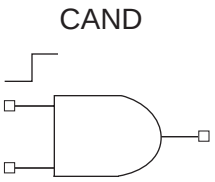
Figure 16: QMUX Macro



It is important to note that the select lines for the global clock and quadrant clock muxes are static signals and cannot be changed dynamically during device operation.

Using the column clock buffers, all clocks can be dynamically disabled at the column level. Column clock buffers can be implemented in Verilog, VHDL, and schematic designs by instantiating the column clock buffer macro, CAND. **Figure 17** shows the schematic representation of the CAND macro.

Figure 17: CAND Macro

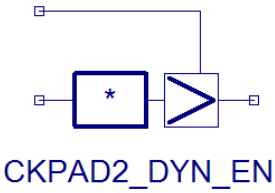


Dynamic Clock Enable

The QuickLogic PolarPro II QL2P150 devices provide a powerful dynamic clock enable feature that allows designers to dynamically enable and disable clocks routed into the QuickLogic device. Associated with each of the five clock inputs is a clock enable, which is an interface signal that can be either dynamically controlled via a routable signal or tied high or low. Once an incoming clock is disabled, the clock is driven low internally. All the logic that is driven by the clock is held at the state when the clock was disabled. If a reset signal is passed through the clock pad, the dynamic disable should not be used.

As an additional feature, PolarPro II devices have built-in deglitching circuitry to prevent clock glitching during transitions so that clocks can be enabled or disabled asynchronously without the possibility of false edge detection within the internal logic. The dynamic clock disable feature can be implemented in Verilog, VHDL, and schematic designs by instantiating the dynamic clock enable macro, CKPAD2_DYN_EN. **Figure 18** shows the schematic representation of the dynamic clock enable macro.

Figure 18: Clock Pad Macro for Dynamic Clock Enable

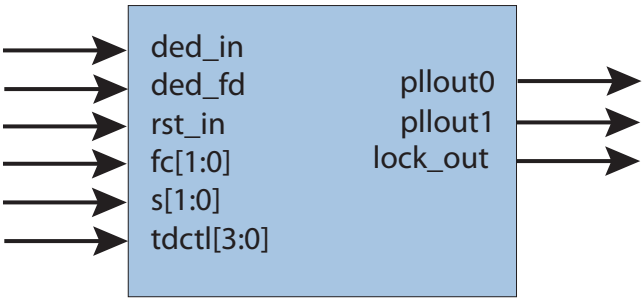


Configurable Clock Manager (CCM)

The CCM features include:

- Input frequency range from 10 MHz to 150 MHz
- Output frequency range from 25 MHz to 200 MHz
- Output jitter is less than 200 ps peak-to-peak
- Two outputs: pullout0 (with 0° phase shift), and pullout1 (with an option of 0°, 90°, 180°, or 270° phase shift plus a programmable delay).
- Programmable delay allows delays up to 2.5 ns at 250 ps intervals (typical)
- Fixed feedback path
- Output frequency lock time in less than 10 µs

Figure 19: Configurable Clock Manager



The reset signal can be routed from a clock pad or generated using internal logic. The lock_out signal can be routed to internal logic and/or an output pad. CCM clock outputs can drive the global clock networks, as well as any general purpose I/O pin. Once the CCM has synchronized the output clock to the incoming clock, the lock_out signal will be asserted to indicate that the output clock is valid. Lock detection requires at least 10 µs after reset to assert lock_out. The PolarPro II CCMs have three modes of operation, based on the input frequency and desired output frequency. **Table 13** indicates the features of each mode.

Table 13: CCM PLL Mode Frequencies

Output Frequency	Input Frequency Range	Output Frequency Range	PLL Mode
x1	25 MHz to 150 MHz	25 MHz to 150 MHz	PLL_MULT1
x2	15 MHz to 100 MHz	30 MHz to 200 MHz	PLL_MULT2
x4	10 MHz to 50 MHz	40 MHz to 200 MHz	PLL_MULT4

CCM Signals

Table 14 provides the name, direction, function and description of the CCM ports.

Table 14: CCM Signals

Signal Name	Direction	Function	Description
Routable Ports			
ded_in	I	Dedicated Input	Clock pad CCM input source.
rst_in	I	Reset	Active high reset: If rst_in is asserted, pllout0 and pllout1 are reset to 0. This signal must be asserted and then released for lock_out to assert.
pllout0	O	0° Phase Clock	0° phase clock output.
pllout1	O	Configurable Phase Clock	0°, 90°,180°, or 270° phase clock output with programmable delay.
lock_out	O	Lock Detect	Active high lock detection signal. Active when the pllout signals correctly output the configured functionality.
Static Ports			
fc[1:0]	I	Phase Shift Control	Determines whether pllout1 is 0°, 90°, 180°, or 270° degrees out of phase with pllout0[a].
s[1:0]	I	Set Mode	Determines pllout1 and pllout0 frequency multiplier (x1, x2, or x4).
tdctl[3:0]	I	Time Delay Control	Pllout1 programmable delay, configurable in 250 ps increments up to a maximum of 2.5 ns. NOTE: 250 ps can vary depending on process variation.

a. The pllout1 output can vary up to -5% with respect to the pllout0 output. Therefore, QuickLogic recommends thorough post-layout simulation in order to verify satisfactory operation of the CCMs.

Table 15, and **Table 16** and **Table 17** give the values used to configure the Set Mode, and Phase Shift Control and Time Delay Control bits.

Table 15: Set Mode Values

s[1:0]	Multiplier
00	x1
01	x2
10	x4
11	Reserved

Table 16: Phase Shift Control Values

fc[1:0]	Phase Shift (Deg.)
00	0
01	90
10	180
11	270

Table 17: Time Delay Control Values

tdctl[3:0]	Time Delay (ps)
0000	0
0001	250
0010	500
0011	750
0100	1000
0101	1250
0110	1500
0111	1750
1000	2000
1001	2250
1010	2500
1011	Reserved
1100	Reserved
1101	Reserved
1110	Reserved
1111	Reserved

CCM Configurations

The main purpose of the CCM is to align the clock arrival times of two separate clock destinations, whether it is within the FPGA or external to the chip. The difference between the two clock destinations is referred to as clock skew. To correct for clock skew the CCMs can be configured to shift the phase and/or delay of the pllout1 clock output.

In most cases the desired phase or added delay can be accomplished by configuring both the clock source input and feedback input as dedicated. In the case of a dedicated clock source and dedicated feedback, the QuickLogic development software calculates and generates all of the required routing delays to produce the requested configuration.

Table 18: Available Configurations

Clock	Feedback	Example Usage	Comments
Dedicated clock pad	Dedicated feedback	Standard PLL application. Reduce set-up or clock-to-out time.	If the clock pad and destination are in phase.

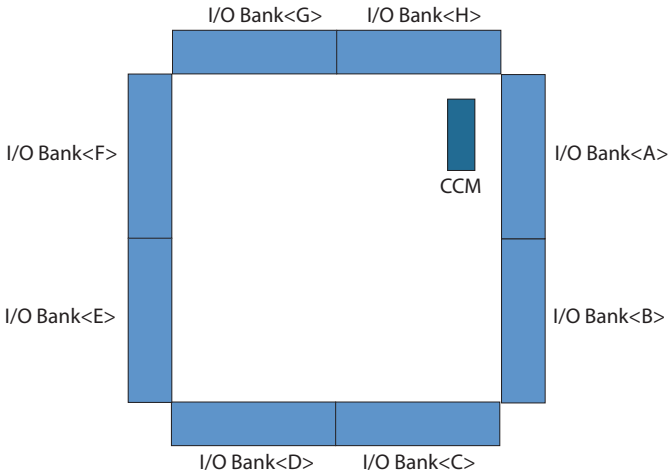
For more information on CCMs and how to use them in QuickWorks, refer to *Application Note 87 Configurable Clock Managers*.

Simultaneously Switching Outputs (SSOs) While Using a CCM

SSOs are outputs that transition at the same time in the same direction (either from VCC to GND or GND to VCC). To ensure that the CCM never loses lock over all possible frequencies of operation, designers must follow the guidelines specified in this section when using the FPGA outputs as SSOs. These guidelines include the number of SSOs placed adjacent to the CCM and the quality of the power filtering circuit sourcing the CCM block.

Figure 20 shows a basic layout of the eight I/O banks available in PolarPro II devices and the relative placement of the CCM.

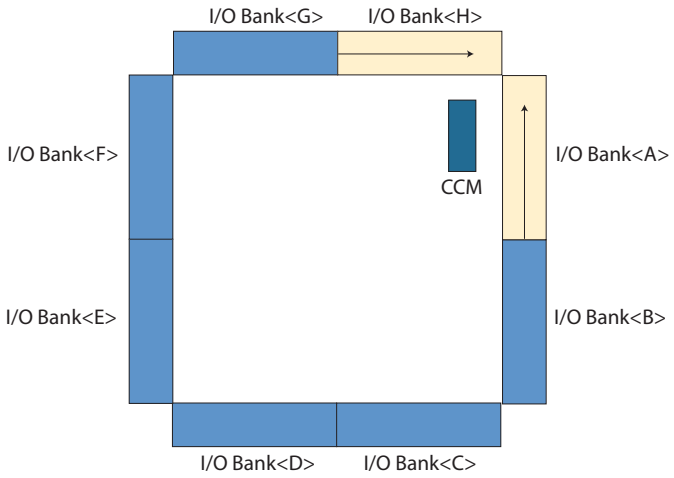
Figure 20: Basic Layout of I/O Banks and CCMs



SSOs placed in I/O Bank<A> and I/O Bank<H> in close proximity to the CCM can affect the CCM's functionality.

NOTE: To define the boundary of operation when using SSOs in conjunction with the CCM add SSOs starting from the far end of a bank relative to the CCM's location.

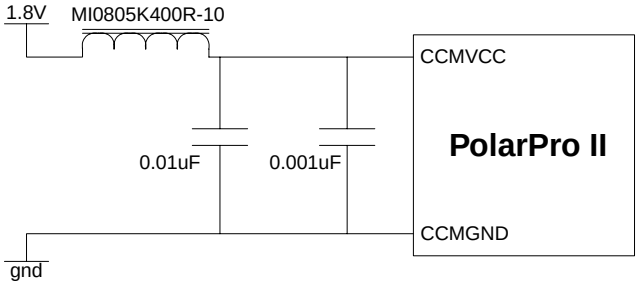
Figure 21: Adding SSOs When Using the CCM



To ensure proper operation of the CCM:

1. Limit the number of SSOs in I/O Bank<A> and I/O Bank<H> that are synchronous to the CCM (i.e., clocked by CCM outputs).
2. Limit the number of SSOs in I/O Bank<A> and I/O Bank<H> that are asynchronous to CCM (i.e., not clocked by CCM<B> outputs).
3. The power supply to the CCMs must have adequate noise filtering circuits. QuickLogic Reference Design boards use the noise filtering circuit shown in **Figure 22**.

Figure 22: Noise Filtering Circuit

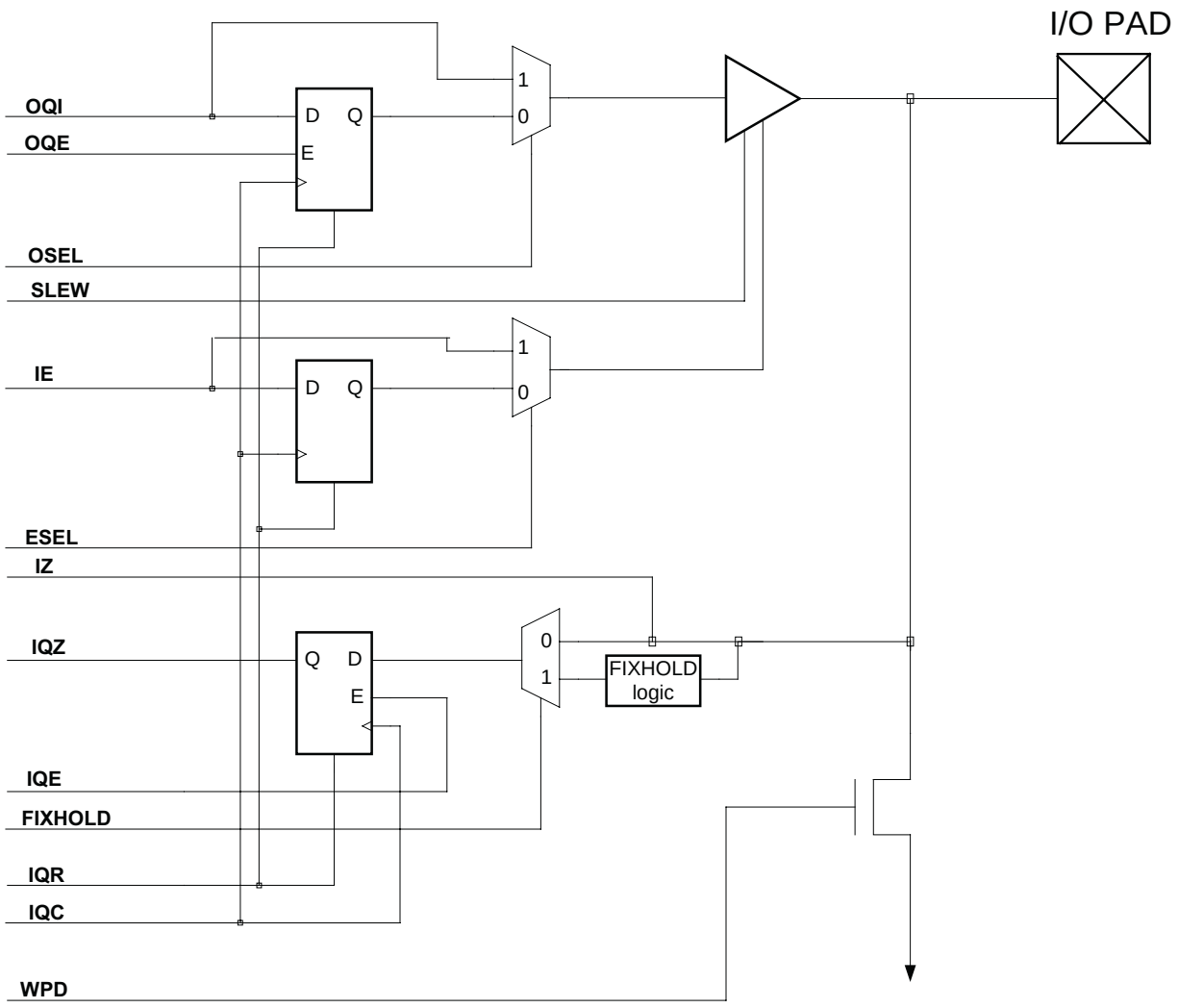


General Purpose Input Output (GPIO) Cell Structure

The GPIO features include:

- Direct or registered input with input path select
- Direct or registered output with output path select
- Direct or registered output enable with OE path select
- Input buffer enable to reduce power
- Programmable pull-down control
- Configurable slew rate
- Support for JTAG boundary scan

Figure 23: PolarPro II GPIO Cell



With bi-directional I/O pins and global clock input pins, the PolarPro II device maximizes I/O performance, functionality, and flexibility. All input and I/O pins are 1.8 V, 2.5 V, and 3.3 V tolerant and comply with the specific I/O standard selected. For single-ended I/O standards, the corresponding VCCIO bank input specifies the input tolerance and the output drive voltage. A weak pull-down function can be configured for an individual I/O. **Table 19** lists the GPIO interface signals.

Table 19: GPIO Interface Signals

Signal Name	Direction	Function
Routable Signals		
OQI	I	Output path input
OQE	I	Output register enable signal
IE	I	Enable path input
IZ	O	Input path combinatorial output to routing
IQZ	O	Input path register output to routing
IQE	I	Input register enable signal
IQC	I	Register clock
IQR	I	Register reset
PAD	I/O	I/O pad
Static Signals		
ESEL	I	Enable register/combinatorial path select '1' : combinatorial '0' : register
OSEL	I	Output register/combinatorial path select '1' : combinatorial '0' : register
SLEW	I	SLEW selection '0' : Slow slew '1' : Fast slew
FIX_HOLD	I	Input delay path selection '0' : Non-delay '1' : Delayed
WPD	I	Weak pull-down '0' : Disable - no weak pull-down '1' : Enable - weak pull-down enabled

Programmable Pull-Down

PolarPro II I/O support Weak Pull-Down. A programmable Weak Pull-Down resistor is available on each I/O. The I/O Weak Pull-Down eliminates the need for external pull-down resistors. When WPD= 1 Weak Pull-Down is enabled.

Programmable Slew Rate

Each I/O has programmable slew rate capability. The PolarPro II GPIOs allow up to two different slew rate speeds (slow and fast). Slow slew rates can be used to reduce noise caused by I/O switching.

I/O interface standards are programmable on a per bank basis. **Table 20** illustrates the I/O bank configurations available. Each I/O bank is independent of other I/O banks and each I/O bank has its own VCCIO supply inputs. A mixture of different I/O standards can be used on a PolarPro II device. However, there is a limitation as to which I/O standards can be supported within a given bank. Only standards that share a common VCCIO can be shared within the same bank (e.g., PCI and LVTTL).

Table 20: I/O Standards and Applications

I/O Standard	VCCIO Voltage	Application
LVTTL	3.3 V	General Purpose
LVCMOS25	2.5 V	General Purpose
LVCMOS18	1.8 V	General Purpose
PCI	3.3 V	PCI Bus Applications

Very Low Power (VLP) Mode

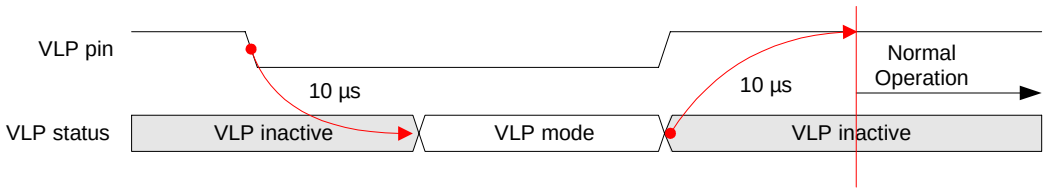
The QuickLogic PolarPro II devices have a unique feature, referred to as VLP mode, which reduces power consumption by placing the device in standby. Specifically, VLP mode can bring the total standby current down to less than 10 µA at room temperature when no incoming signals are toggled. The active low VLP pin controls VLP mode. For normal operation, the VLP pin must be driven to a voltage anywhere between 1.8 V and 3.3 V. At 1.8 V, the VPUMP pin can be tied to 3.3 V for data retention in VLP mode, or to 0 V which does not allow data retention in VLP mode and draws additional current during normal operation. If VLP is tied to 1.5 V, the VPUMP pin must be tied to 3.3 V for VLP mode to be operational.

When the PolarPro II device goes into VLP mode, the following occurs:

- All logic cell registers and GPIO registers values are held
- All RAM cell data is retained
- The outputs from all GPIO to the internal logic are tied to '0'
- GPIO outputs drive the previous values
- GPIO output enables retain the previous values
- Clock pad inputs are gated
- CCM is held in the reset state

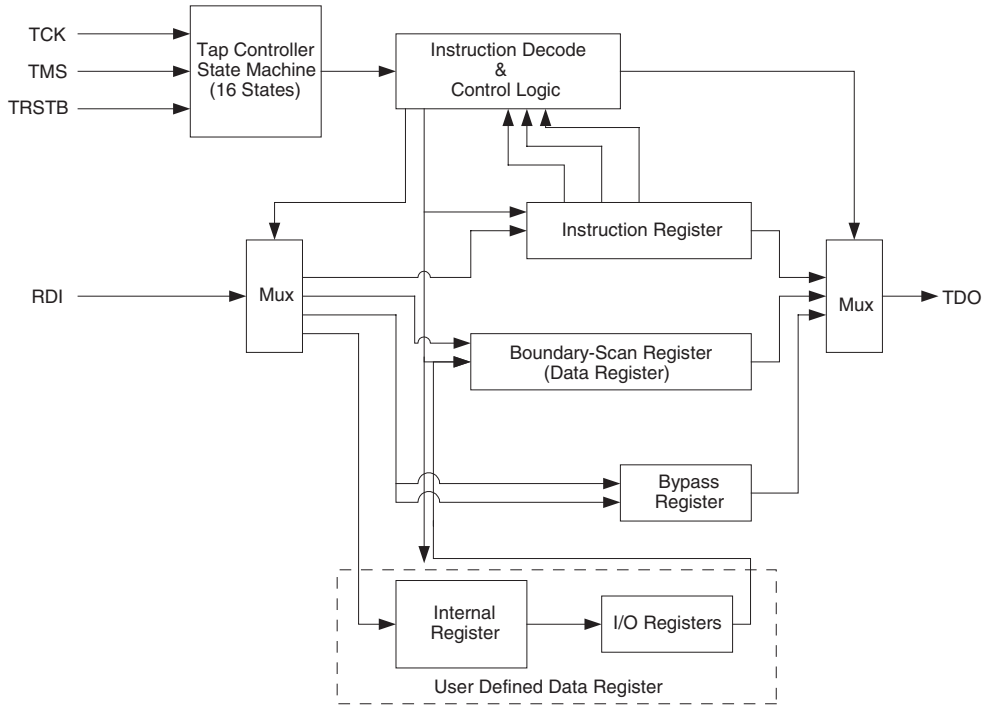
During the transition from VLP mode to normal operation, the VLP pin can draw up to 1.5 mA. Consequently, if using a pull-up resistor, use a pull-up resistor with a value that is less than 2 KΩ .The entire operation from normal mode to VLP mode requires 10 µs. As the device exits out of VLP mode, which also takes 10 µs, the data from the registers, RAM, and GPIO are used to recover the functionality of the device. Furthermore, since the CCM was in a reset state during VLP mode, it must re-acquire the correct output signal before asserting lock_out. **Figure 24** displays the delays associated with entering and exiting VLP mode.

Figure 24: Typical VLP Mode Timing



Joint Test Access Group (JTAG) Information

Figure 25: JTAG Block Diagram



QuickLogic's PolarPro II devices comply with IEEE standard 1149.1, the Standard Test Access Port and Boundary Scan Architecture. The JTAG boundary scan test methodology allows complete observation and control of the boundary pins of a JTAG-compatible device through JTAG software. A Test Access Port (TAP) controller works in concert with the Instruction Register (IR), which allow users to run three required tests along with several user-defined tests. JTAG tests allow users to reduce system debug time, reuse test platforms and tools, and reuse subsystem tests for comprehensive verification of higher level system elements.

The 1149.1 standard requires the following three tests:

- **Extest Instruction.** The Extest Instruction performs a printed circuit board (PCB) interconnect test. This test places a device into an external boundary test mode, selecting the boundary scan register to be connected between the TAP Test Data In (TDI) and Test Data Out (TDO) pins. Boundary scan cells are preloaded with test patterns (through the Sample/Preload Instruction), and input boundary cells capture the input data for analysis.
- **Sample/Preload Instruction.** The Sample/Preload Instruction allows a device to remain in its functional mode, while selecting the boundary scan register to be connected between the TDI and TDO pins. For this test, the boundary scan register can be accessed through a data scan operation, allowing users to sample the functional data entering and leaving the device.
- **Bypass Instruction.** The Bypass Instruction allows data to skip a device boundary scan entirely, so the data passes through the bypass register. The Bypass instruction allows users to test a device without passing through other devices. The bypass register is connected between the TDI and TDO pins, allowing serial data to be transferred through a device without affecting the operation of the device.

JTAG BSDL Support

- Boundary Scan Description Language (BSDL)
- Machine-readable data for test equipment to generate testing vectors and software
- BSDL files available for all device/package combinations from QuickLogic
- Extensive industry support available and ATVG (Automatic Test Vector Generation)

Electrical Specifications

DC Characteristics

The DC Specifications are provided in **Table 21** through **Table 24**.

Table 21: Absolute Maximum Ratings

Parameter	Value	Parameter	Value
VCC Voltage	-0.5 V to 2.2 V	ESD Pad Protection	*TBD*
VCCIO Voltage	-0.5 V to 4.0 V	Leaded Package Storage Temperature	-65° C to + 150° C
Input Voltage	-0.5 V to 4.0 V	Laminate Package (BGA) Storage Temperature	-55° C to + 125° C
Latch-up Immunity	±100 mA		

Table 22: Recommended Operating Range

Symbol	Parameter	Industrial		Commercial		Unit
		Min.	Max.	Min.	Max.	
VCC	Supply Voltage	1.43	1.89	1.43	1.89	V
VCCIO	I/O Input Tolerance Voltage	1.71	3.60	1.71	3.60	V
TJ	Junction Temperature	-40	100	0	85	°C

Table 23: DC Characteristics

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
I_I	I or I/O Input Leakage Current	VI = VCCIO or GND	*TBD*	*TBD*	*TBD*	µA
I_{OZ}	3-State Output Leakage Current	VI = VCCIO or GND				µA
C_I	I/O Input Capacitance	VCCIO = 3.6 V				pF
C_{CLOCK}	Clock Input Capacitance	VCCIO = 3.6 V				pF
I_{REF}	Quiescent Current on INREF	-				µA
I_{PD}	Current on programmable pull-down	VCCIO = 3.6 V				µA
		VCCIO = 2.75 V				µA
		VCCIO = 1.89 V				µA
I_{PU}	Current on programmable pull-up	VCCIO = 3.6 V				µA
		VCCIO = 2.75 V				µA
		VCCIO = 1.89 V				µA
I_{VLP}	Quiescent Current on VLP pin	VLP=3.3				µA
I_{CCM}	Quiescent Current on each CCMVCC	VCC=1.89 V				µA
I_{VCC}	Quiescent Current	VLP=GND				µA
		VLP=3.3V				µA
I_{VCCIO}	Quiescent Current on VCCIO	VCCIO = 3.6 V				µA
		VCCIO = 2.75 V				µA
		VCCIO = 1.89 V				*TBD* µA

Table 24: DC Input and Output Levels[a]

Symbol	INREF		V_{IL}		V_{IH}		V_{OL}	V_{OH}	I_{OL}	I_{OH}
	V_{MIN}	V_{MAX}	V_{MIN}	V_{MAX}	V_{MIN}	V_{MAX}	V_{MAX}	V_{MIN}	mA	mA
LVTTL	n/a	n/a	-0.3	0.8	2.2	VCCIO + 0.3	0.4	2.4	2.0	-2.0
LVCMOS2	n/a	n/a	-0.3	0.7	1.7	VCCIO + 0.3	0.7	1.7	2.0	-2.0
LVCMOS18	n/a	n/a	-0.3	0.63	1.2	VCCIO + 0.3	0.7	1.7	2.0	-2.0
PCI	n/a	n/a	-0.3	0.3 x VCCIO	0.6 x V_{CCIO}	VCCIO + 0.5	0.1 x VCCIO	0.9 x VCCIO	1.5	-0.5

a. The data provided in **Table 24** represents the JEDEC and PCI specification. QuickLogic devices either meet or exceed these requirements.

AC Characteristics

All AC data is TBD

Package Thermal Characteristics

The PolarPro II device is available for Commercial (0°C to 85°C Junction), Industrial (-40°C to 100°C Junction), and Military (-55°C to 125°C Junction) temperature ranges.

Thermal Resistance Equations:

$\theta_{JC} = (T_J - T_C)/P$
$\theta_{JA} = (TJ - TA)/P$
$P_{MAX} = (T_{JMAX} - T_{AMAX})/\theta_{JA}$

Parameter Description:

θ_{JC}: Junction-to-case thermal resistance

θ_{JA}: Junction-to-ambient thermal resistance

T_J: Junction temperature

T_A: Ambient temperature

P: Power dissipated by the device while operating

P_{MAX}: The maximum power dissipation for the device

T_{JMAX}: Maximum junction temperature

T_{AMAX}: Maximum ambient temperature

NOTE: Maximum junction temperature (T_{JMAX}) is 125°C. To calculate the maximum power dissipation for a device package look up θ_{JA} from **Table 25**, pick an appropriate T_{AMAX} and use: $P_{MAX} = (125°C - T_{AMAX})/ \theta_{JA}$.

Table 25: Package Thermal Characteristics

Package Description				Theta-JA (° C/W)		
Device	Package Code	Package Type	Pin Count	0 LFM	200 LFM	400 LFM
QL2P150	PU	TFBGA (6 mm x 6 mm)	121	*TBD*	*TBD*	*TBD*
QL2P150	PD	TFBGA (5 mm x 5 mm)	121	*TBD*	*TBD*	*TBD*

Moisture Sensitivity Level

All PolarPro II devices are Moisture Sensitivity Level 3.

Table 26: Solder Composition

Lead Type	Pb-Free
BGA Solder	Sn3AgCu:Sn4AgCu[a]

a. Sn3AgCu:Sn4AgCu means that Ag can range from 3% to 4%. Cu is always 0.5%.

Power-Up Sequencing

Figure 26: Power-Up Sequencing

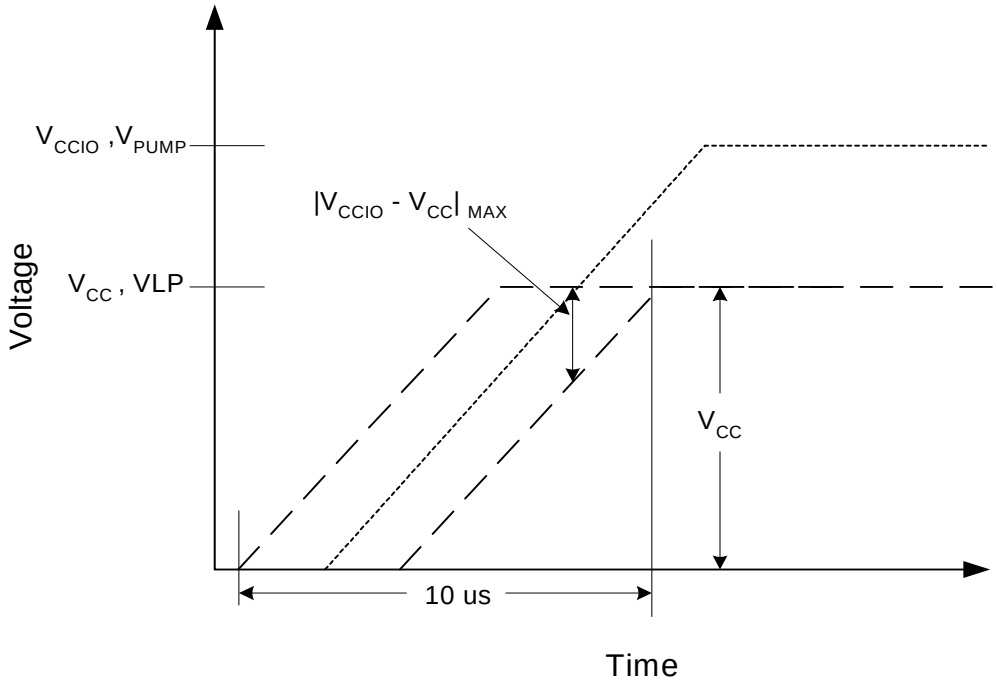


Figure 26 shows an example where all VCCIO = 3.3 V, VPUMP = 3.3 V and VLP = 1.8 V. When powering up a PolarPro II device, VCC, VCCIO rails must take 10 µs or longer to reach the maximum value (refer to **Figure 26**). Ramping VCC and VCCIO faster than 10 µs can cause the device to behave improperly.

It is also important to ensure VCCIO and VLP are within 500 mV of VCC when ramping up the power supplies. In the case where VCCIO or VLP are greater than VCC by more than 500 mV an additional current draw can occur as VCC passes its threshold voltage. In a case where VCC is greater than VCCIO by more than 500 mV the protection diodes between the power supplies become forward biased. If this occurs then there will be an additional current load on the power supply. Having the diodes on can cause a reliability problem, since it can wear out the diodes and subsequently damage the internal transistors.

Programming Stipulation

For PolarPro II devices to correctly program, there must not be any race conditions or internally generated free-running oscillators in the design. This will cause an ICC programming failure during the programming process. QuickLogic cannot guarantee the operation of any device that fails programming. Therefore, race conditions and free-running oscillators must be removed from designs so that PolarPro II devices can correctly pass programming.

Pin Descriptions

Table 27: Pin Descriptions

Pin	Direction	Function	Description
Dedicated Pin Descriptions			
GPIO(H:A)	I/O	General purpose input/output pin	The I/O pin is a bi-directional pin, configurable to either an input-only, output-only, or bi-directional pin. The letter inside the parenthesis means that the I/O is located in the bank with that letter. If an I/O is not used, the development software provides the option of tying that pin to GND, VCCIO, or Hi-Z.
CLK(H:G) CLK(D:C)	I	Global clock network pin low skew global clock	This pin provides access to a distributed network capable of driving the CLOCK, SET, RESET, all inputs to the logic cell, Read and Write clocks, Read and Write enables of the embedded RAM blocks, and I/O inputs.
DEDCLK(H)	I	Dedicated clock network pin low skew clock	This pin provides access to a distributed network capable of driving the CLOCK, SET, RESET, all inputs to the logic cell, Read and Write clocks, Read and Write enables of the embedded RAM blocks, and I/O inputs. The voltage tolerance of this pin is specified by VCCIO.
CCMIN(H)	I	CCM clock input	Input clock for CCM. The voltage tolerance for this pin is specified by VCCIO(H).
CCMVCC	I	Power supply pin for CCM	CCM input voltage level. Configurable as 1.8 V only.
CCMGND	I	Ground pin for CCM	Connect to ground.
VLP	I	Voltage low power	Active low. Therefore, when VLP is 0 V, the device will go into low power mode. Tie VLP to any voltage between 1.8 V and 3.3 V to disable low power mode.
VPUMP	I	Charge Pump Disable	This pin disables the internal charge pump, which lowers static power consumption. To disable the charge pump, connect VPUMP to 3.3 V. VPUMP must be connected to 3.3 V for data retention to work in VLP mode. If VCC is 1.5 V, VPUMP must be tied to 3.3 V for VLP mode to be available.
VCC	I	Power supply pin	Connect to 1.8 V or 1.5 V supply. When VCC is 1.5 V, it will adversely affect the timing by 40%.
VCCIO(H:A)	I	Input voltage tolerance pin	This pin provides the flexibility to interface the device with either a 3.3 V, 2.5 V, or 1.8 V device. The letter inside the parenthesis means that the VCCIO is located in the bank with that letter. Every I/O pin in the same bank will be tolerant of the same VCCIO input signals and will drive VCCIO level output signals. Even if certain VCCIO banks are not used, all VCCIO pins must be driven when the device is powered up.
GND	I	Ground pin	Connect to ground.

Table 27: Pin Descriptions *(Continued)*

Pin	Direction	Function	Description
JTAG Pin Descriptions			
TDI	I	Test data in for JTAG	Hold HIGH during normal operation. Connect to VCCIO(D) if unused.
TRSTB	I	Active low reset for JTAG	Hold LOW during normal operation. Connect to GND if unused. During JTAG, a high voltage is based on VCCIO(D).
TMS	I	Test mode select for JTAG	Hold HIGH during normal operation. Connect to VCCIO(D) if not used for JTAG.
TCK	I	Test clock for JTAG	Hold HIGH or LOW during normal operation. Connect to VCCIO(D) or GND if not used for JTAG.
TDO	O	Test data out for JTAG	Must be left unconnected if not used for JTAG. The output voltage drive is specified by VCCIO(D).

Recommended Unused Pin Terminations for PolarPro II Devices

All unused, general purpose I/O pins can be tied to VCCIO, GND, or Hi-Z (high impedance) internally. By default, QuickLogic QuickWorks software ties unused I/Os to GND.

Terminate the rest of the pins at the board level as recommended in **Table 28**.

Table 28: Recommended Unused Pin Terminations

Signal Name	Recommended Termination
CLK <x>	Connect to GND or VCCIO(x) if unused.
VLP	Tie VLP to any voltage between 1.8 V and 3.3 V to disable low power mode.
CCMVCC	If a CCM is not used, the corresponding CCMVCC must be tied to 1.8V. When a CCM is not used, the software tools will automatically configure the device to hold the CCM in a reset state.
TDI	Connect to VCCIO(D) if not used for JTAG.
TRSTB	Connect to GND if not used for JTAG.
TMS	Connect to VCCIO(D) if not used for JTAG
TCK	Connect to VCCIO(D) or GND if not used for JTAG.
TDO	Must be left unconnected if not used for JTAG.

PolarPro II QL2P150 - 121 (6 mm x 6 mm) TFBGA Pinout Table

Table 29: QL2P150 - 121 (6 mm x 6 mm) TFBGA Pinout Table

Pin	Function	Pin	Function	Pin	Function	Pin	Function
A1	VCC	C10	GPIO(H)	F8	VCC	J6	GND
A2	GPIO(G)	C11	GPIO(A)	F9	GPIO(A)	J7	GPIO(C)
A3	GPIO(G)	D1	GPIO(F)	F10	GPIO(A)	J8	GPIO(C)
A4	GPIO(G)	D2	GPIO(F)	F11	GPIO(A)	J9	GPIO(B)
A5	CLK(G)/GPIO(G)	D3	GPIO(F)	G1	TCK	J10	GPIO(B)
A6	DEDCLK(H)/GPIO(H)	D4	VCCIO(G)	G2	VCCIO(D)	J11	GPIO(B)
A7	GPIO(H)	D5	VCC	G3	GPIO(D)	K1	GND
A8	CCMIN(H)/CLK(H)/GPIO(H)	D6	GPIO(F)	G4	VCC	K2	GPIO(E)
A9	GPIO(H)	D7	GPIO(A)	G5	VCCIO(F)	K3	GPIO(D)
A10	GPIO(H)	D8	GPIO(C)	G6	GND	K4	GPIO(D)
A11	VCC	D9	GPIO(H)	G7	GND	K5	TDI
B1	VLP	D10	GPIO(A)	G8	VCC	K6	GPIO(D)
B2	GPIO(G)	D11	GPIO(A)	G9	TRSTB	K7	GPIO(C)
B3	GPIO(G)	E1	GPIO(F)	G10	GPIO(B)	K8	GPIO(C)
B4	GPIO(G)	E2	GPIO(F)	G11	GPIO(B)	K9	GPIO(C)
B5	GPIO(G)	E3	GPIO(F)	H1	GPIO(E)	K10	GPIO(B)
B6	TMS	E4	GPIO(F)	H2	GPIO(E)	K11	GPIO(B)
B7	GPIO(H)	E5	VCCIO(H)	H3	GPIO(E)	L1	VCC
B8	GPIO(H)	E6	GND	H4	GPIO(E)	L2	GPIO(D)
B9	GPIO(H)	E7	GND	H5	VCCIO(E)	L3	GPIO(D)
B10	CCMGND	E8	VCCIO(A)	H6	GND	L4	TDO
B11	GND	E9	VCCIO(B)	H7	VCCIO(D)	L5	CLK(C)/GPIO(C)
C1	GPIO(F)	E10	GPIO(A)	H8	VCCIO(C)	L6	CLK(D)/GPIO(D)
C2	GPIO(G)	E11	GPIO(A)	H9	VCCIO(D)	L7	GPIO(C)
C3	GPIO(G)	F1	GPIO(E)	H10	GPIO(B)	L8	GPIO(C)
C4	GPIO(G)	F2	GPIO(F)	H11	GPIO(B)	L9	VPUMP
C5	GPIO(G)	F3	GPIO(F)	J1	GPIO(E)	L10	GND
C6	GPIO(H)	F4	GND	J2	GPIO(E)	L11	VCC
C7	GPIO(H)	F5	GND	J3	GPIO(E)		
C8	GPIO(A)	F6	GND	J4	GPIO(D)		
C9	CCMVCC	F7	GND	J5	GPIO(D)		

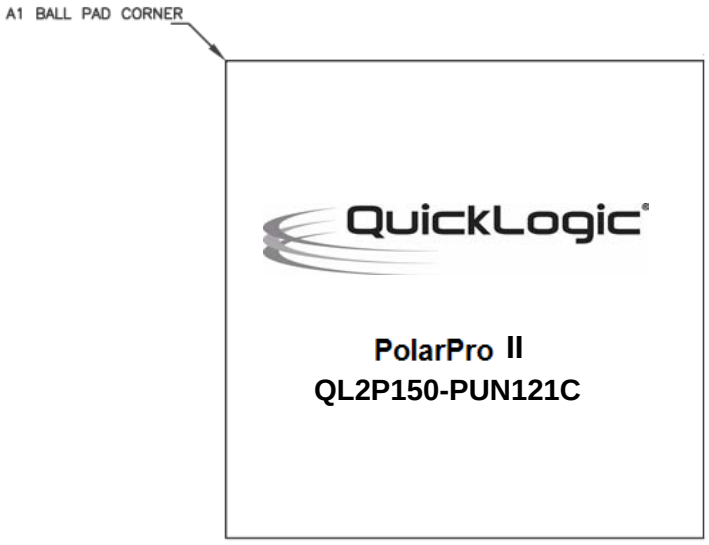
PolarPro II QL2P150 - 121 (5 mm x 5 mm) TFBGA Pinout Table

Table 30: QL2P150 - 121 (5 mm x 5 mm) TFBGA Pinout Table

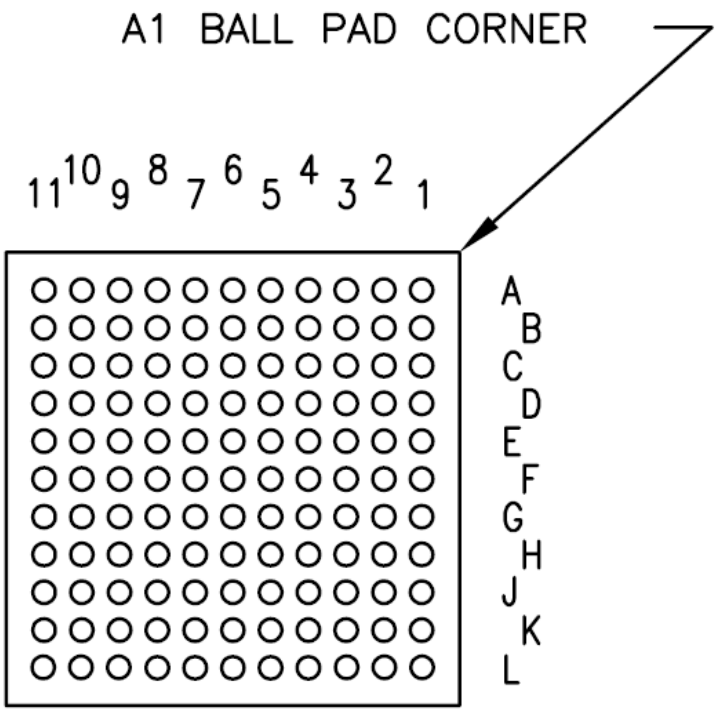
Pin	Function	Pin	Function	Pin	Function	Pin	Function
A1	GPIO(G)	C10	GPIO(A)	F8	VCCIO(A)	J6	GPIO(C)
A2	GPIO(G)	C11	GPIO(A)	F9	TRSTB	J7	GPIO(C)
A3	GPIO(G)	D1	GPIO(F)	F10	GPIO(A)	J8	GPIO(C)
A4	GPIO(G)	D2	GPIO(F)	F11	GPIO(A)	J9	GPIO(C)
A5	CLK(G)/GPIO(G)	D3	GPIO(F)	G1	GPIO(E)	J10	GPIO(B)
A6	DEDCLK(H)/GPIO(H)	D4	VCCIO(F)	G2	GPIO(E)	J11	GPIO(B)
A7	GPIO(H)	D5	VCC	G3	GPIO(E)	K1	GPIO(E)
A8	CCMIN(H)/CLK(H)/GPIO(H)	D6	VCCIO(G)	G4	TDO	K2	GPIO(D)
A9	GPIO(H)	D7	TMS	G5	GND	K3	GPIO(D)
A10	GPIO(H)	D8	VCCIO(H)	G6	GND	K4	GPIO(D)
A11	VCC	D9	GPIO(A)	G7	VCCIO(D)	K5	GPIO(D)
B1	VLP/VCCIO(D)	D10	GPIO(A)	G8	VCC	K6	GPIO(C)
B2	GPIO(G)	D11	GND	G9	GPIO(B)	K7	GPIO(C)
B3	GPIO(G)	E1	GPIO(F)	G10	GPIO(B)	K8	GPIO(C)
B4	GPIO(G)	E2	GPIO(F)	G11	GPIO(B)	K9	GPIO(C)
B5	GPIO(G)	E3	GPIO(F)	H1	GPIO(E)	K10	GPIO(B)
B6	GPIO(H)	E4	TCK	H2	GPIO(E)	K11	GPIO(B)
B7	GPIO(H)	E5	VCCIO(D)	H3	GPIO(E)	L1	GND
B8	GPIO(H)	E6	GND	H4	VCCIO(D)	L2	GPIO(D)
B9	GPIO(H)	E7	GND	H5	VCC	L3	GPIO(D)
B10	CCMGND	E8	VCC	H6	VCCIO(C)	L4	GPIO(D)
B11	CCMVCC	E9	GPIO(A)	H7	TDI	L5	CLK(D)/GPIO(D)
C1	GPIO(F)	E10	GPIO(A)	H8	VCCIO(B)	L6	CLK(C)/GPIO(C)
C2	GPIO(F)	E11	GPIO(A)	H9	GPIO(B)	L7	GND
C3	GPIO(G)	F1	GND	H10	GPIO(B)	L8	GPIO(C)
C4	GPIO(G)	F2	GPIO(F)	H11	GPIO(B)	L9	GPIO(C)
C5	GPIO(G)	F3	GPIO(F)	J1	GPIO(E)	L10	VPUMP/VCCIO(D)
C6	GPIO(H)	F4	VCCIO(E)	J2	GPIO(E)	L11	VCC
C7	GPIO(H)	F5	GND	J3	GPIO(E)		
C8	GPIO(H)	F6	GND	J4	GPIO(D)		
C9	GPIO(A)	F7	GND	J5	GPIO(D)		

PolarPro II QL2P150 - 121 TFBGA Pinout Diagram

Top

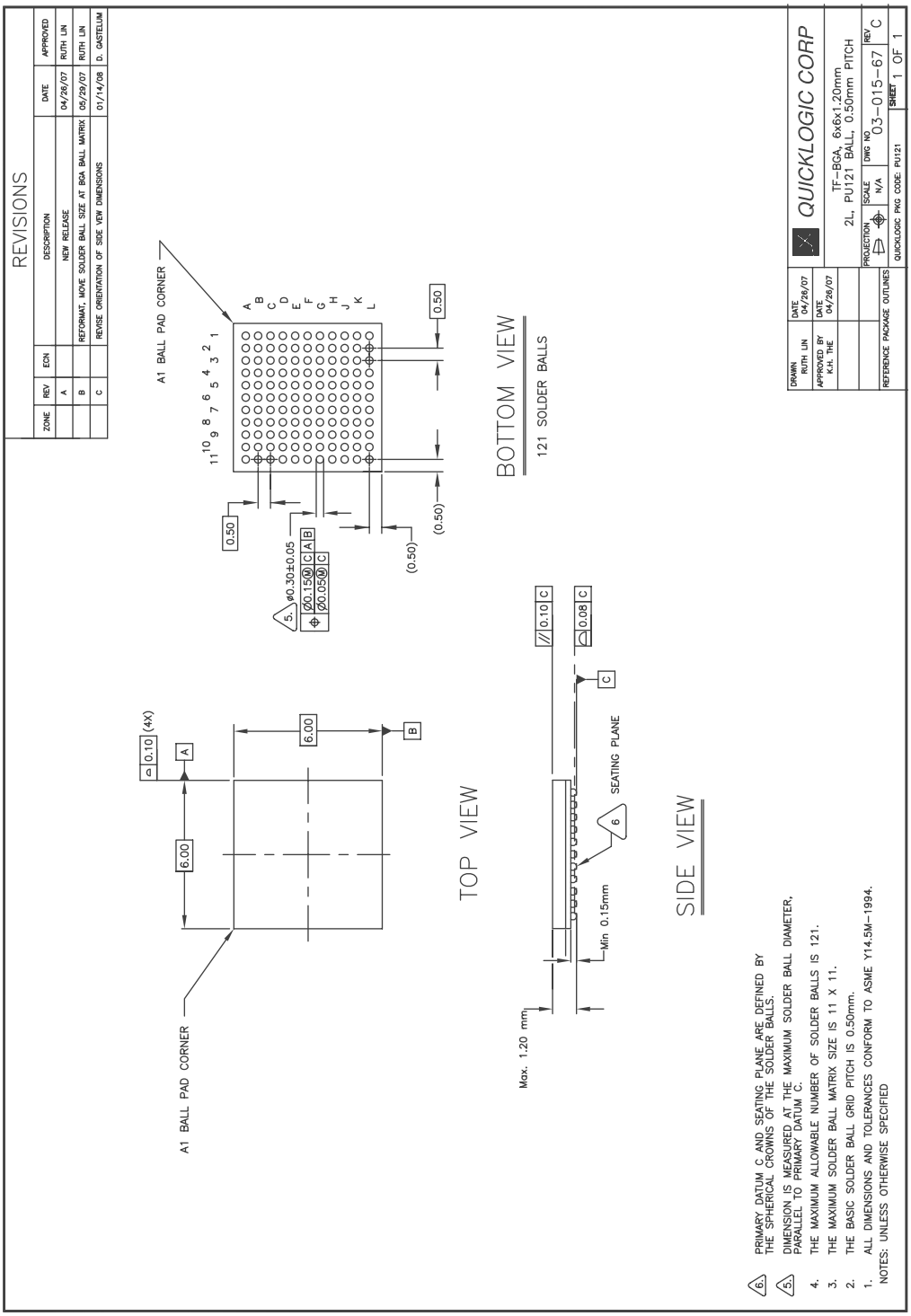


Bottom



Package Mechanical Drawing

121 TFBGA (6 mm x 6 mm) Packaging Drawing



121 TFBGA (5 mm x 5 mm) Packaging Drawing

TBD

Packaging Information

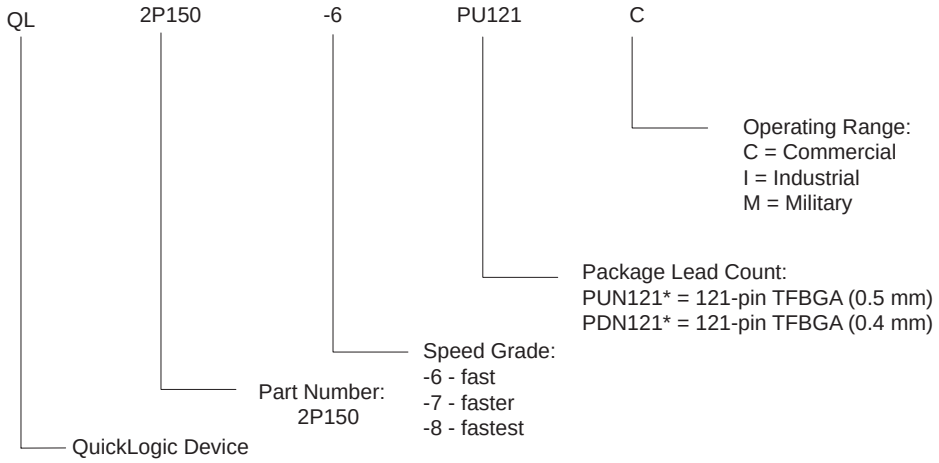
The PolarPro II QL2P150 device packaging information is presented in **Table 31**.

Table 31: QL2P150 Packaging Options

Device Information	Device		
	QL2P150		
	Pin	Pb	Pb-Free
Package Definitions[a]	121 TFBGA (6 mm x 6 mm) Pitch - 0.50 mm		X
	121 TFBGA (5 mm x 5 mm) Pitch - 0.40 mm		X

a. TFBGA = Thin Profile Fine Pitch Ball Grid Array

Ordering Information



* Lead-free packaging is denoted by the character 'N' preceding the number of pins.

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Revision History

Revision	Date	Originator and Comments
A	March 2008	Jason Lew and Kathleen Murchek - First release.

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