

# 7-Series Architecture Overview



# Objectives

- > **After completing this module, you will be able to:**
  - >> Describe the basic slice resources available in 7-Series FPGAs
  - >> List memory hierarchy and various memory resources available
  - >> Identify the basic I/O resources available in 7-Series FPGAs
  - >> List some of the dedicated hardware features of 7-Series FPGAs
  - >> Identify latest members of Virtex-7 device family
  - >> Identify the MMCM, PLL, and clock routing resources included with these families
  - >> Describe the additional dedicated hardware for all the 7-series family members
  - >> Understand the Zynq-7000 SoC architecture

# Outline

- > *Introduction to 7-Series FPGA*
- > Logic Resources
- > I/O Resources
- > Memory and DSP48 Resources
- > XADC
- > Clocking Resources
- > Zynq SoC
- > Summary

# Introduction

## > All Xilinx FPGAs contain the same basic resources

### >> Logic Resources

- Slices (grouped into configurable logic blocks (CLB))
  - Containing combinatorial logic and register resources
- Memory
- Multipliers

### >> Interconnect Resources

- Programmable interconnect
- IOBs
  - Interfaces between the FPGA and the outside world

### >> Other resources

- Global clock buffers
- Boundary scan logic

## > Through various generations, Xilinx added new architectural resources to target various markets and application areas

# 7-Series FPGA Families

Max. Capability	Spartan-7	Artix-7	Kintex-7	Virtex-7
Logic Cells	102K	215K	478K	1,955K
Block RAM <sup>(1)</sup>	4.2 Mb	13 Mb	34 Mb	68 Mb
DSP Slices	160	740	1,920	3,600
DSP Performance <sup>(2)</sup>	176 GMAC/s	929 GMAC/s	2,845 GMAC/s	5,335 GMAC/s
MicroBlaze CPU <sup>(3)</sup>	260 DMIPs	303 DMIPs	438 DMIPs	441 DMIPs
Transceivers	–	16	32	96
Transceiver Speed	–	6.6 Gb/s	12.5 Gb/s	28.05 Gb/s
Serial Bandwidth	–	211 Gb/s	800 Gb/s	2,784 Gb/s
PCIe Interface	–	x4 Gen2	x8 Gen2	x8 Gen3
Memory Interface	800 Mb/s	1,066 Mb/s	1,866 Mb/s	1,866 Mb/s
I/O Pins	400	500	500	1,200
I/O Voltage	1.2V–3.3V	1.2V–3.3V	1.2V–3.3V	1.2V–3.3V
Package Options	Low-Cost, Wire-Bond	Low-Cost, Wire-Bond, Bare-Die Flip-Chip	Bare-Die Flip-Chip and High- Performance Flip-Chip	Highest Performance Flip-Chip

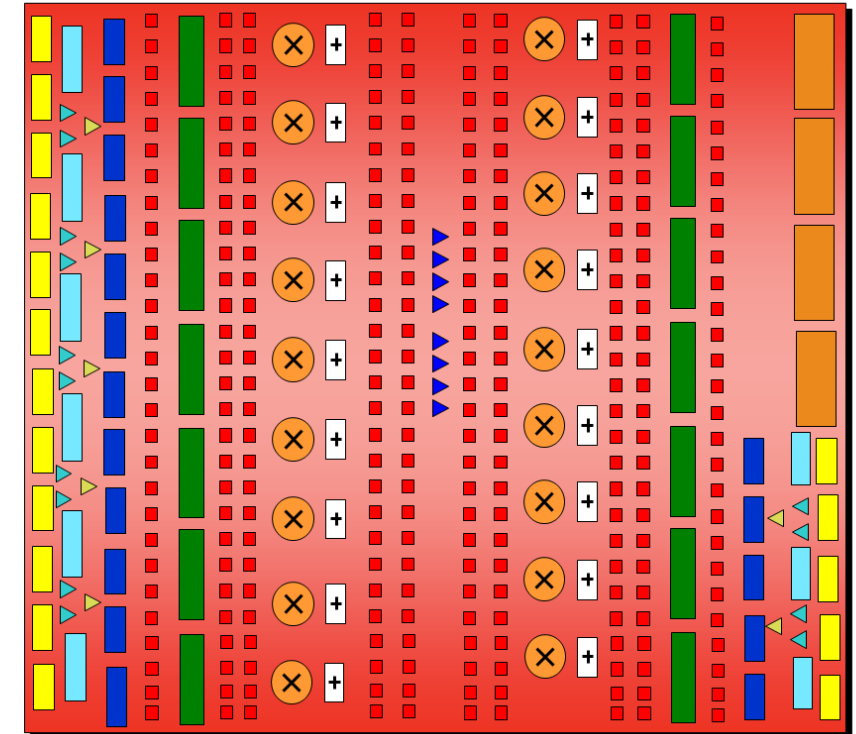
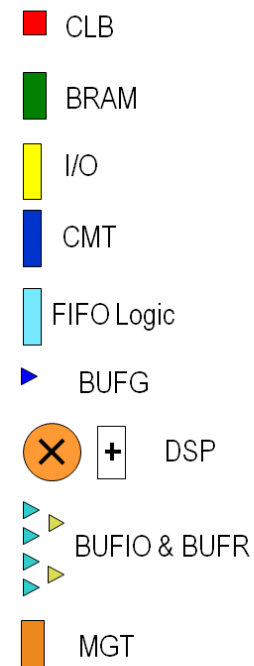
# 7-Series SoC Families

		Cost-Optimized Devices						Mid-Range Devices			
Device Name		Z-7007S	Z-7012S	Z-7014S	Z-7010	Z-7015	Z-7020	Z-7030	Z-7035	Z-7045	Z-7100
Part Number		XC7Z007S	XC7Z012S	XC7Z014S	XC7Z010	XC7Z015	XC7Z020	XC7Z030	XC7Z035	XC7Z045	XC7Z100
Processing System (PS)	Processor Core	Single-Core ARM® Cortex™-A9 MPCore™ Up to 766MHz			Dual-Core ARM Cortex-A9 MPCore Up to 866MHz			Dual-Core ARM Cortex-A9 MPCore Up to 1GHz <sup>(1)</sup>			
	Processor Extensions	NEON™ SIMD Engine and Single/Double Precision Floating Point Unit per processor									
	L1 Cache	32KB Instruction, 32KB Data per processor									
	L2 Cache	512KB									
	On-Chip Memory	256KB									
	External Memory Support <sup>(2)</sup>	DDR3, DDR3L, DDR2, LPDDR2									
	External Static Memory Support <sup>(2)</sup>	2x Quad-SPI, NAND, NOR									
	DMA Channels	8 (4 dedicated to PL)									
	Peripherals	2x UART, 2x CAN 2.0B, 2x I2C, 2x SPI, 4x 32b GPIO									
	Peripherals w/ built-in DMA <sup>(2)</sup>	2x USB 2.0 (OTG), 2x Tri-mode Gigabit Ethernet, 2x SD/SDIO									
Security <sup>(3)</sup>	RSA Authentication of First Stage Boot Loader, AES and SHA 256b Decryption and Authentication for Secure Boot										
	2x AXI 32b Master, 2x AXI 32b Slave 4x AXI 64b/32b Memory AXI 64b ACP 16 Interrupts										
	Processing System to Programmable Logic Interface Ports (Primary Interfaces & Interrupts Only)										
Programmable Logic (PL)	7 Series PL Equivalent	Artix®-7	Artix-7	Artix-7	Artix-7	Artix-7	Artix-7	Kintex®-7	Kintex-7	Kintex-7	Kintex-7
	Logic Cells	23K	55K	65K	28K	74K	85K	125K	275K	350K	444K
	Look-Up Tables (LUTs)	14,400	34,400	40,600	17,600	46,200	53,200	78,600	171,900	218,600	277,400
	Flip-Flops	28,800	68,800	81,200	35,200	92,400	106,400	157,200	343,800	437,200	554,800
	Total Block RAM (# 36Kb Blocks)	1.8Mb (50)	2.5Mb (72)	3.8Mb (107)	2.1Mb (60)	3.3Mb (95)	4.9Mb (140)	9.3Mb (265)	17.6Mb (500)	19.2Mb (545)	26.5Mb (755)
	DSP Slices	66	120	170	80	160	220	400	900	900	2,020
	PCI Express®	—	Gen2 x4	—	—	Gen2 x4	—	Gen2 x4	Gen2 x8	Gen2 x8	Gen2 x8
	Analog Mixed Signal (AMS) / XADC <sup>(2)</sup>	2x 12 bit, MSPS ADCs with up to 17 Differential Inputs									
	Security <sup>(3)</sup>	AES & SHA 256b Decryption & Authentication for Secure Programmable Logic Config									
	Speed Grades	Commercial	-1			-1			-1		
Extended		-2			-2,-3			-2,-3			-2
Industrial		-1, -2			-1, -2, -1L			-1, -2, -2L			-1, -2, -2L

# 7-Series Architecture Alignment

## > Common elements enable easy IP reuse for quick design portability across all 7-series families

- >> Design scalability from low-cost to high-performance
- >> Expanded eco-system support
- >> Quickest time to market



Artix-7 Architecture Overview

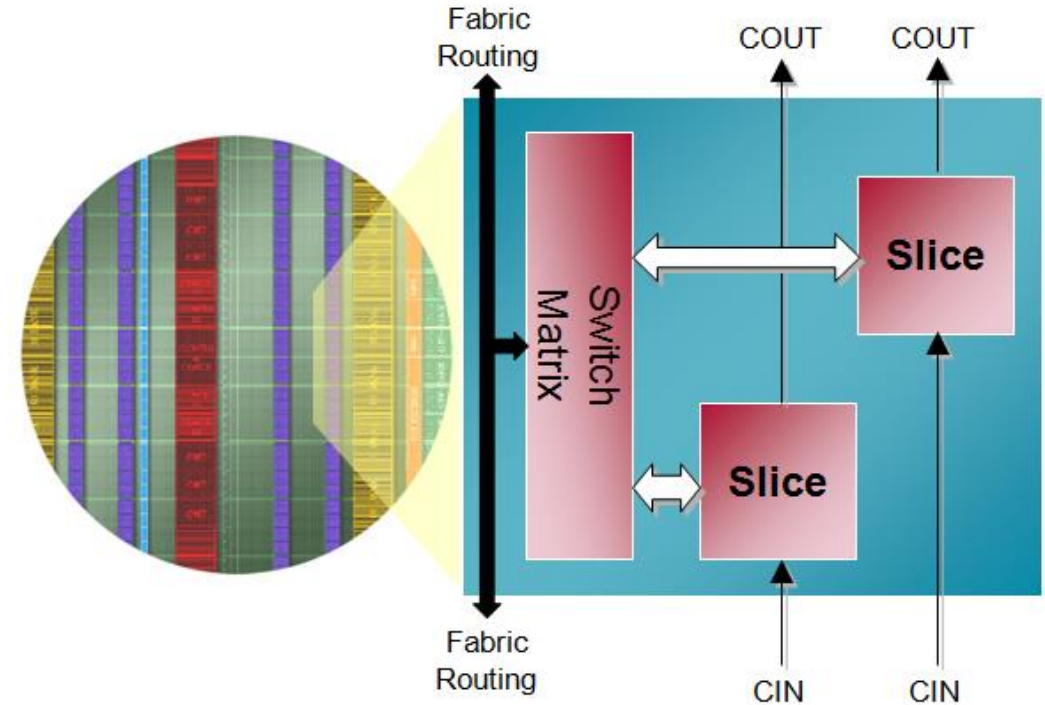
# Logic Resources





# Configurable Logic Block (CLB) in 7-Series FPGAs

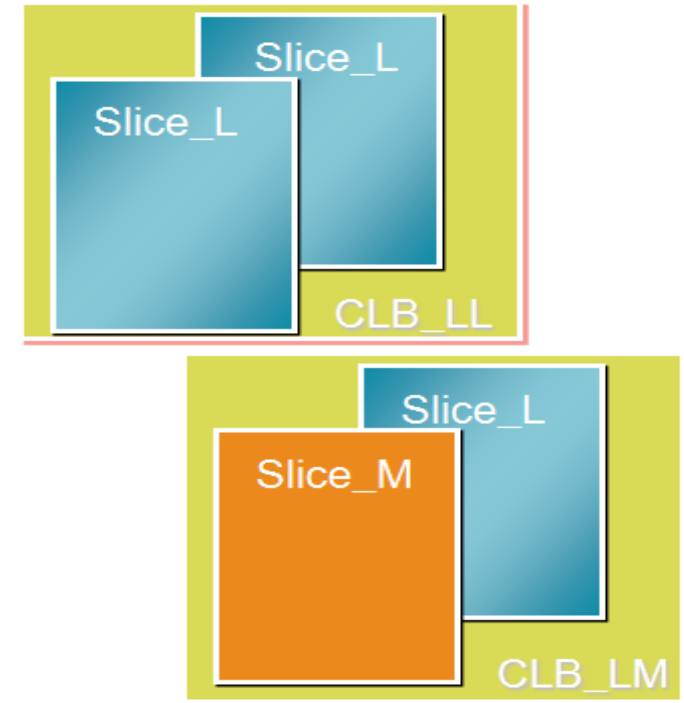
- > **Primary resource for design in Xilinx FPGAs**
  - >> Combinatorial functions
  - >> Flip-flops
- > **CLB contains two slices**
- > **Connected to switch matrix for routing to other FPGA resources**
  - >> Carry chain runs vertically in a column from one slice to the one above



# Two Types of CLB Slices

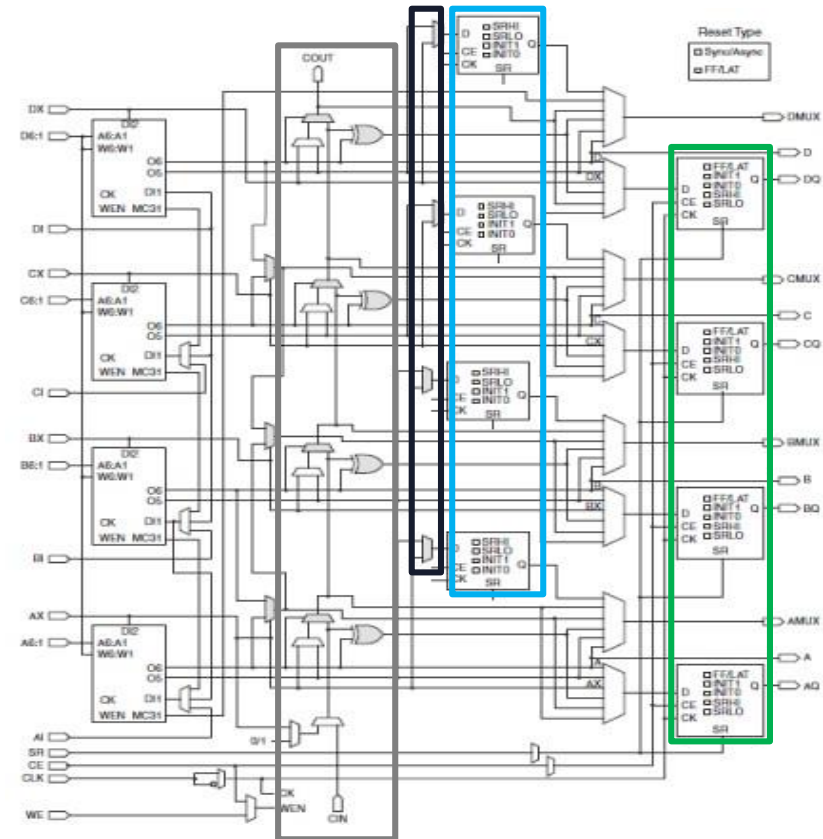
## > Two types of CLB slices

- >> SLICEM: Full slice
  - LUT can be used for logic and memory/SRL
  - Has wide multiplexers and carry chain
- >> SLICEL: Logic and arithmetic only
  - LUT can only be used for logic (not memory)
  - Has wide multiplexers and carry chain



# Slice Resource

- > Four six-input Look-Up Tables (LUT)
- > Multiplexers
- > Carry chains
- > SRL
  - >> Cascade path is not shown
- > Four flip-flops/latches
  - >> Four additional flip-flops
- > The implementation tool will pack multiple slices in the same CLB if certain rules are followed

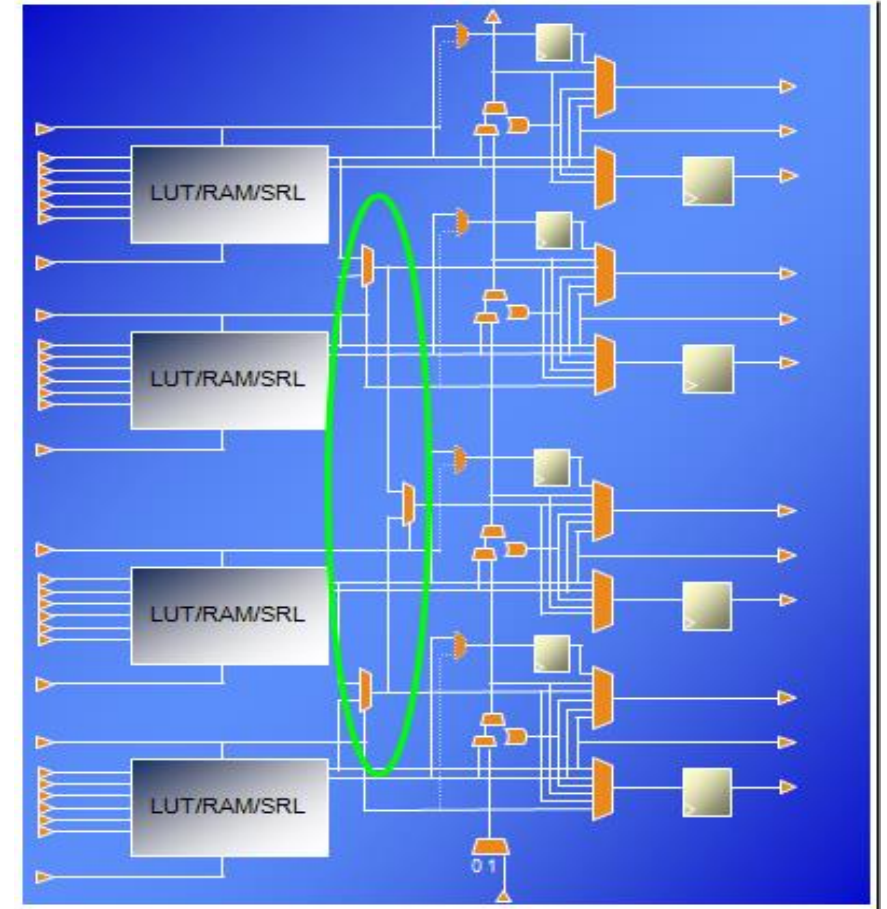


# 6-Input LUT with Dual Output

- > **LUTs can be two 5-input LUTs with common input**
  - >> Minimal speed impact to a 6-input LUT
  - >> One or two outputs
- > **Any combinatorial function of six variables or two functions of five variables**

# Wide Multiplexers

- > **Each F7MUX combines the outputs of two LUTs together**
  - >> Can implement an arbitrary 7-input function
  - >> Can implement an 8-1 multiplexer
- > **The F8MUX combines the outputs of the two F7MUXes**
  - >> Can implement an arbitrary 8-input function
  - >> Can implement a 16-1 multiplexer
- > **MUX is controlled by the BX/CX/DX slice input**
- > **MUX output can drive out combinatorially or to the flip-flop/latch**



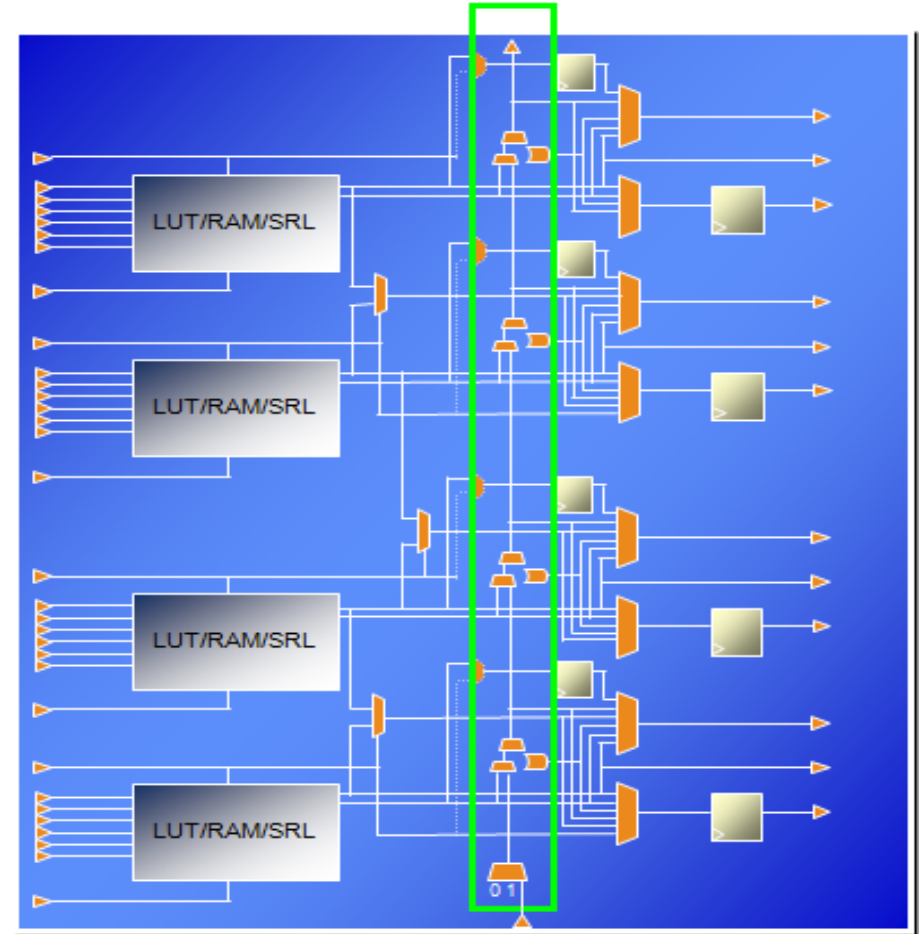
# Carry Chain

## > Carry chain can implement fast arithmetic addition and subtraction

- >> Carry out is propagated vertically through the four LUTs in a slice
- >> The carry chain propagates from one slice to the slice in the same column in the CLB above

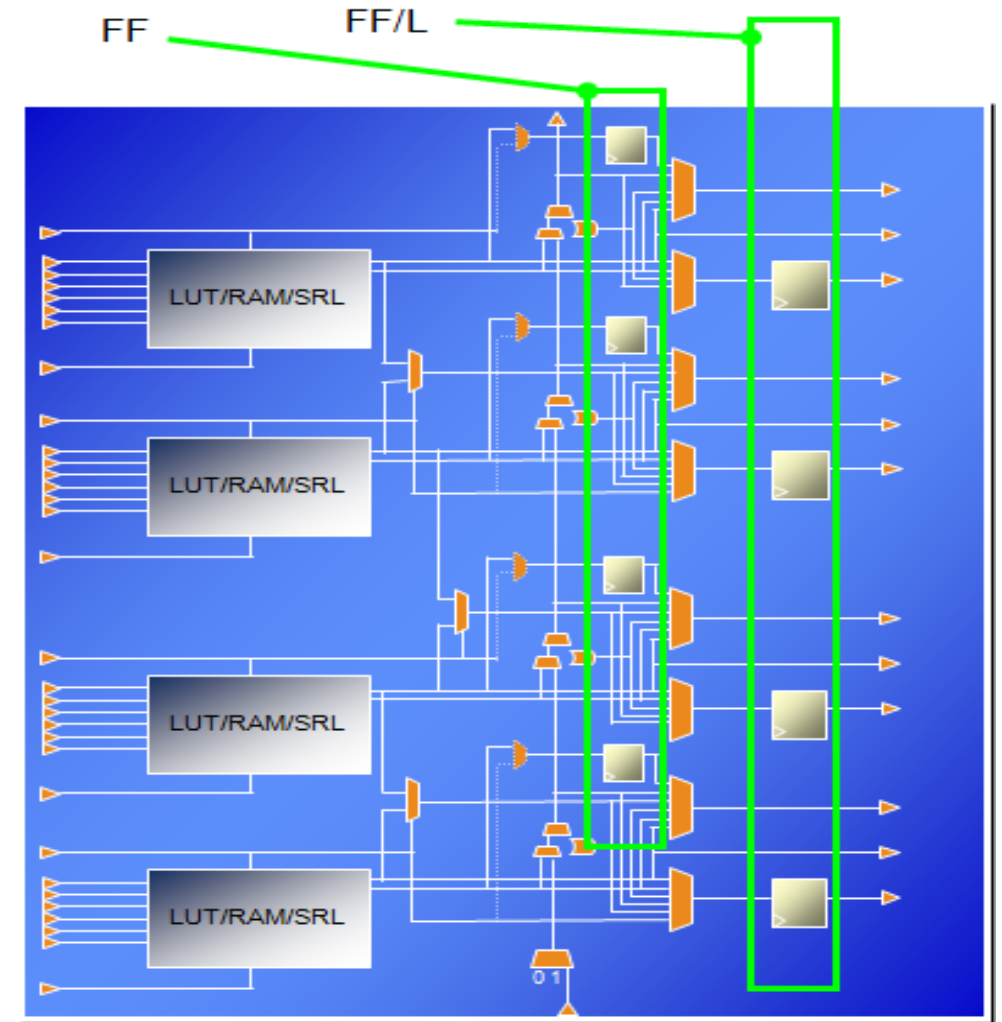
## > Carry look-ahead

- >> Combinatorial carry look-ahead over the four LUTs in a slice
- >> Implements faster carry cascading from slice to slice



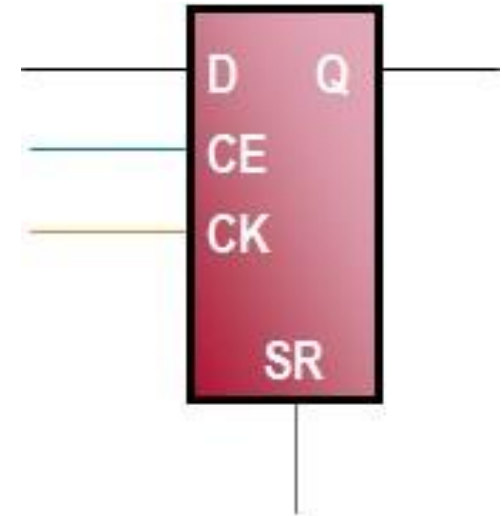
# Slice Flip-Flops and Flip-Flop/Latches

- > **Each slice has four flip-flop/latches (FF/L)**
  - >> Can be configured as either flip-flops or latches
  - >> The D input can come from the O6 LUT output, the carry chain, the wide multiplexer, or the AX/BX/CX/DX slice input
- > **Each slice also has four flip-flops (FF)**
  - >> D input can come from O5 output or the AX/BX/CX/DX input
    - These don't have access to the carry chain, wide multiplexers, or the slice inputs
- > **If any of the FF/L are configured as latches, the four FFs are not available**



# Slice Flip-Flop Capabilities

- > **All flip-flops are D type**
  - >> With Q output
- > **All flip-flops have a single clock input (CK)**
  - >> Clock can be inverted at the slice boundary
- > **All flip-flops have an active high chip enable (CE)**
- > **All flip-flops have an active high SR input**
  - >> Input can be synchronous or asynchronous as determined by the corresponding configuration bit
  - >> Sets the flip-flop value to a pre-determined state as determined by the corresponding configuration bit





# Control Sets

- > **All flip-flops and flip-flop/latches share the same CK, SR, and CE signals**

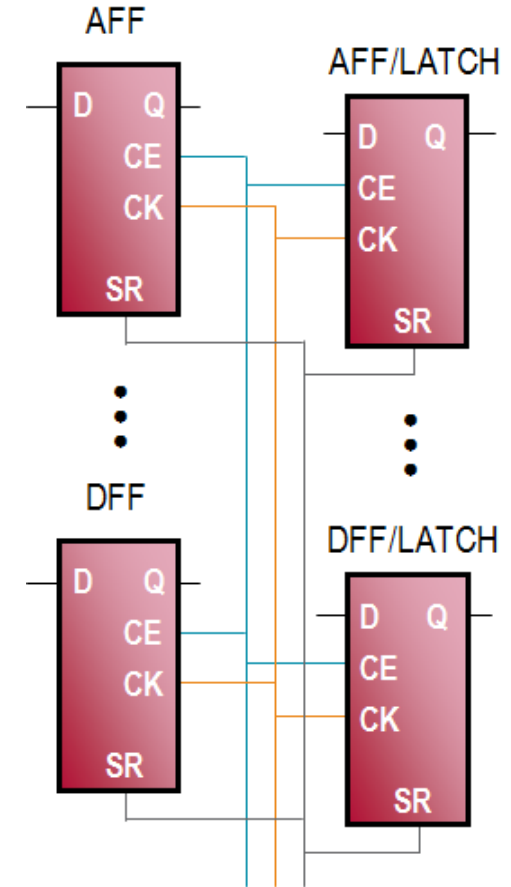
- >> This is referred to as the "control set" of the flip-flops
- >> CE and SR are active high
- >> CK can be inverted at the slice boundary

- > **If any one flip-flop uses a CE, all others must use the same CE**

- > CE gates the clock at the slice boundary
- > Saves power

- > **If any one flip-flop uses the SR, all others must use the same SR**

- >> The reset value used for each flip-flop is individually set by the SRVAL attribute



# SLICEM Used as a Distributed SelectRAM Memory

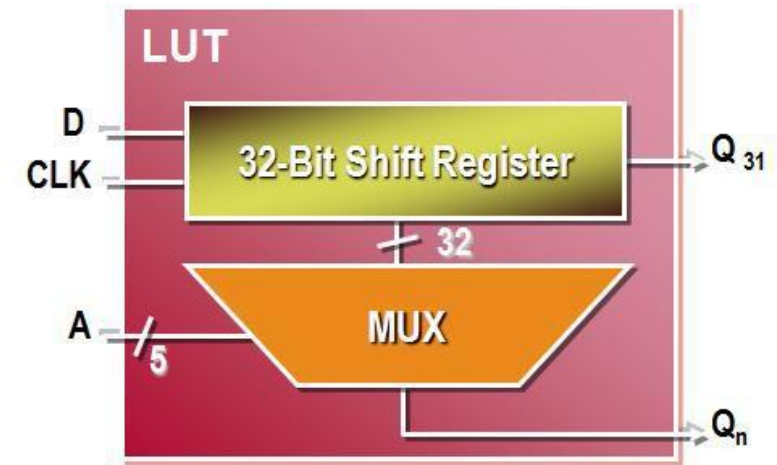
- > **SLICEM can be used for memory**
- > **Synchronous write, asynchronous read**
  - >> Can be converted to synchronous read using the flip-flops available in the slice
- > **Various configurations**
  - >> Single port
    - One LUT6 = 64x1 or 32x2 RAM
    - Cascadable up to 256x1 RAM
  - >> Dual port (D)
    - 1 read / write port + 1 read-only port
  - >> Simple dual port (SDP)
    - 1 write-only port + 1 read-only port
  - >> Quad-port (Q)
    - 1 read / write port + 3 read-only ports

Single Port	Dual Port	Simple Dual Port	Quad Port
32x2	32x2D	32x6SDP	32x2Q
32x4	32x4D	64x3SDP	64x1Q
32x6	64x1D		
32x8	64x2D		
64x1	128x1D		
64x2			
64x3			
64x4			
128x1			
128x2			
256x1			

**Each Port Has Independent Address Inputs**

# SLICEM Used as 32-bit Shift Register

- > **SRL = Shift Register Lut**
- > **Versatile SRL-type shift registers**
  - >> Variable-length shift register
  - >> Synchronous FIFOs
  - >> Content-Addressable Memory (CAM)
  - >> Pattern generator
  - >> Compensate for delay / latency
- > **Shift register length is determined by the address**
  - >> Constant value giving fixed delay line
  - >> Dynamic addressing for elastic buffer
- > **Cascadable up to 128x1 shift register in one slice**

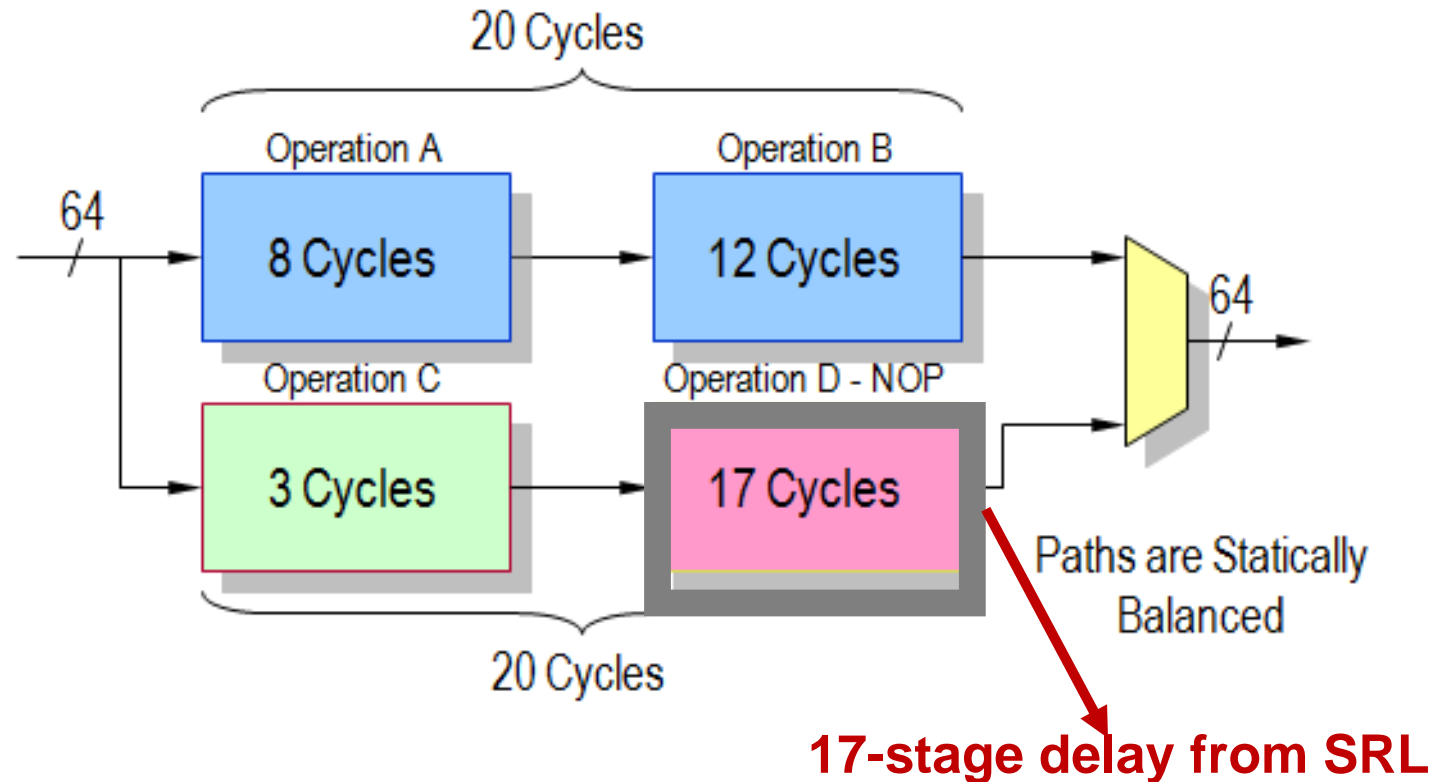


SRL Configurations in One Slice (4 LUTs)
16x1, 16x2, 16x4, 16x6, 16x8
32x1, 32x2, 32x3, 32x4
64x1, 64x2
96x1
128x1

# Shift Register LUT Example

> **Operation D - NOP** must add 17 pipeline stages of 64 bits each

- >> 1,088 flip-flops (hence 136 slices) or
- >> 64 SRLs (hence 16 slices)



# I/O Resources

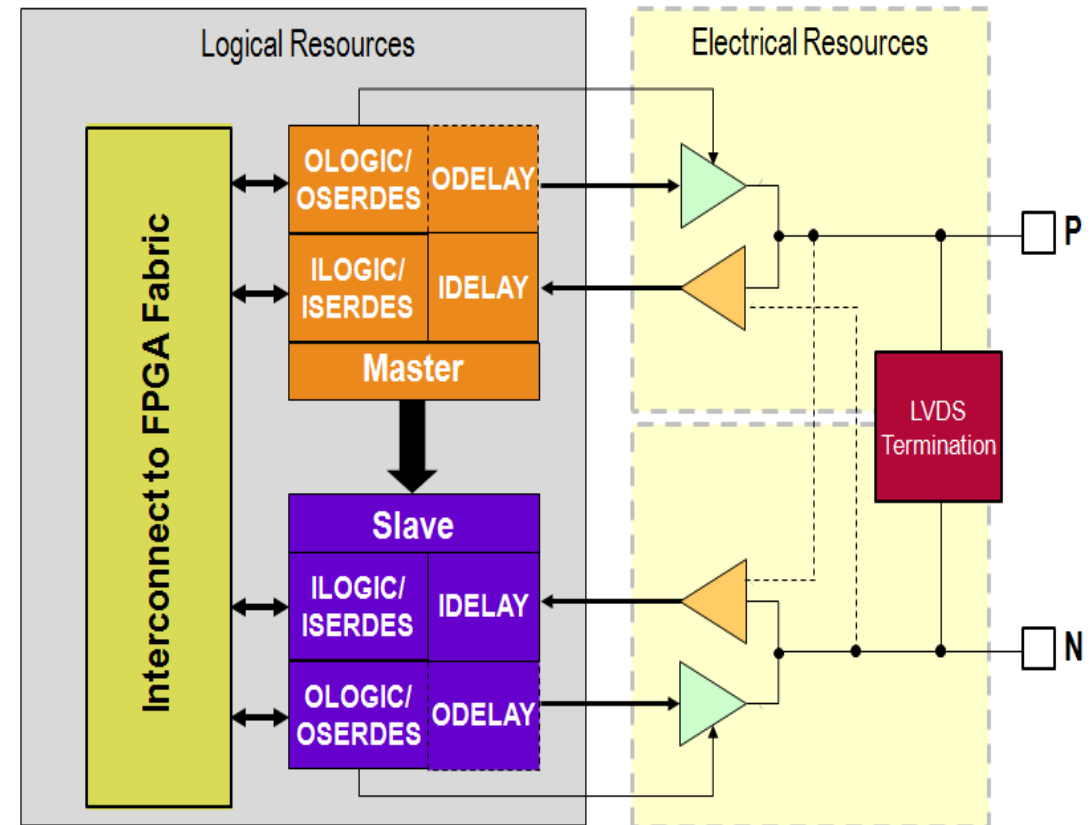


# I/O Interface Challenges

- > **High-speed operation with maintained signal integrity**
  - >> Source-synchronous operation (clock forwarding)
  - >> System-synchronous operation (common systems clock)
  - >> Terminate transmission lines to avoid signal reflections
- > **Drive and receive data on wide parallel buses**
  - >> Compensate for bus skew and clock timing errors
  - >> Conversion between serial and parallel data
  - >> Achieve very high bit rate (> 1 Gbps)
- > **Single Data Rate (SDR) or Double Data Rate (DDR) interfaces**
- > **Interface to many different standards**
  - >> Different voltages, drive strengths and protocols

# 7-Series FPGA I/O

- > **Wide range of voltages**
  - >> 1.2V to 3.3V operation
- > **Wide I/O standards support**
  - >> Single ended and differential
  - >> Referenced voltage inputs
  - >> 3-state capability
- > **Very high performance**
  - >> Up to 1600 Mbps LVDS
  - >> Up to 1866 Mbps single-ended for DDR3
- > **Easy memory interfacing**
  - >> Hardware support for QDRII+ and DDR3
- > **Digitally controlled impedance**
- > **Power reduction features**



# I/O Types

## > Two different types of I/O in 7-series FPGAs

- >> High Range (HR)
  - Supports I/O standards with Vcco voltages up to 3.3V
- >> High Performance (HP)
  - Supports I/O standards with Vcco voltages up to 1.8V only
  - Designed for the highest performance
  - Has ODELAY and DCI capability

I/O Types	Artix-7 Family	Kintex-7 Family	Virtex-7 Family	Virtex-7 XT/HT Family
High Range	All	Most	Some	
High Performance		Some	Most	All



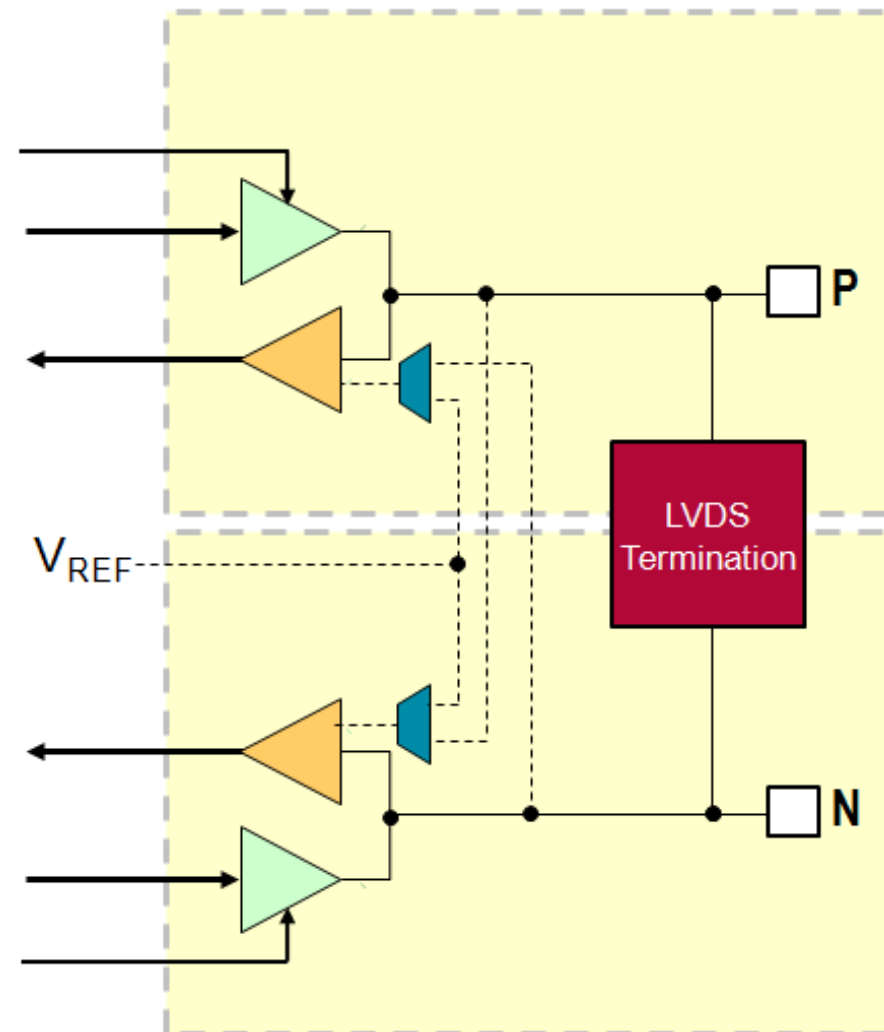
# I/O Electrical Resources

## > P and N pins can be configured as

- >> Individual single-ended signals or
- >> Differential pair

## > Receiver can be standard CMOS or voltage comparator

- >> When standard CMOS
  - Logic 0 when "near" ground
  - Logic 1 when "near"  $V_{CC0}$
- >> Referenced to  $V_{REF}$ 
  - Logic 0 when below  $V_{REF}$
  - Logic 1 when above  $V_{REF}$
- >> Differential
  - Logic 0 when  $V_P < V_N$
  - Logic 1 when  $V_P > V_N$



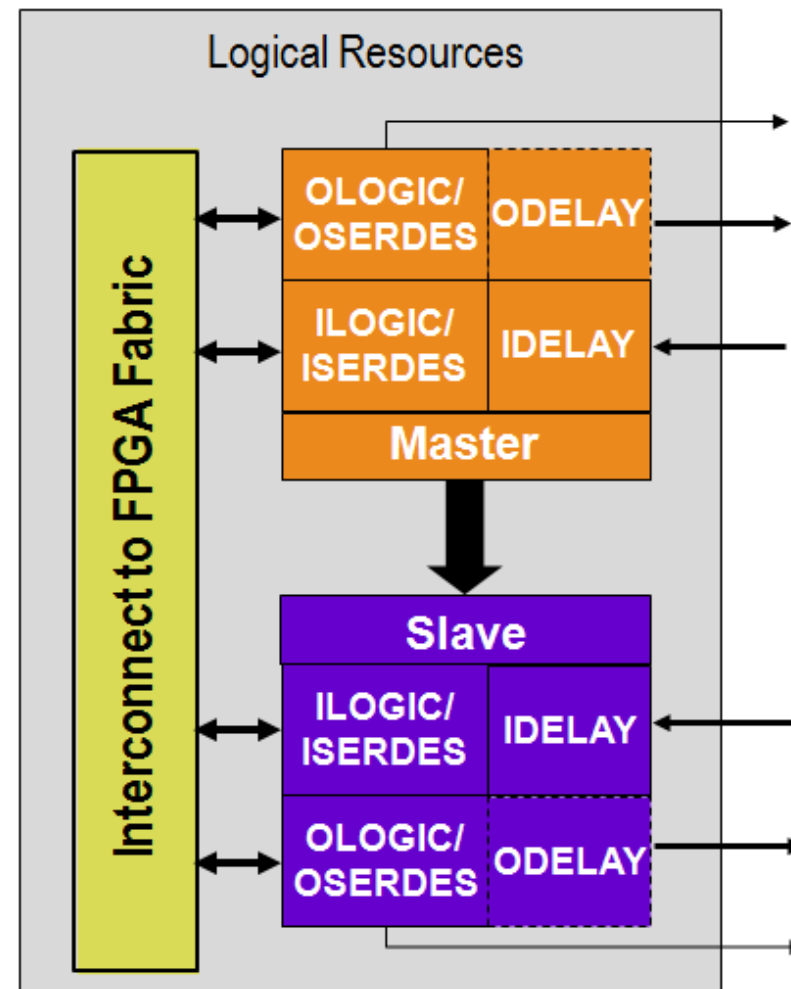
# I/O Logical Resources

## > Two blocks of logic per I/O pair

- >> Master and slave
- >> Can operate independently or concatenated

## > Each block contains

- >> ILOGIC/ISERDES
  - SDR, DDR, or high-speed serial input logic
- >> OLOGIC/OSERDES
  - SDR, DDR, or high-speed serial output logic
- >> IDELAY
  - Selectable fine-grained input delay
- >> ODELAY
  - Selectable fine-grained output delay
  - Only available on High Performance I/O



# ILOGIC: Input SDR and DDR Logic

## > Two types of ILOGIC blocks

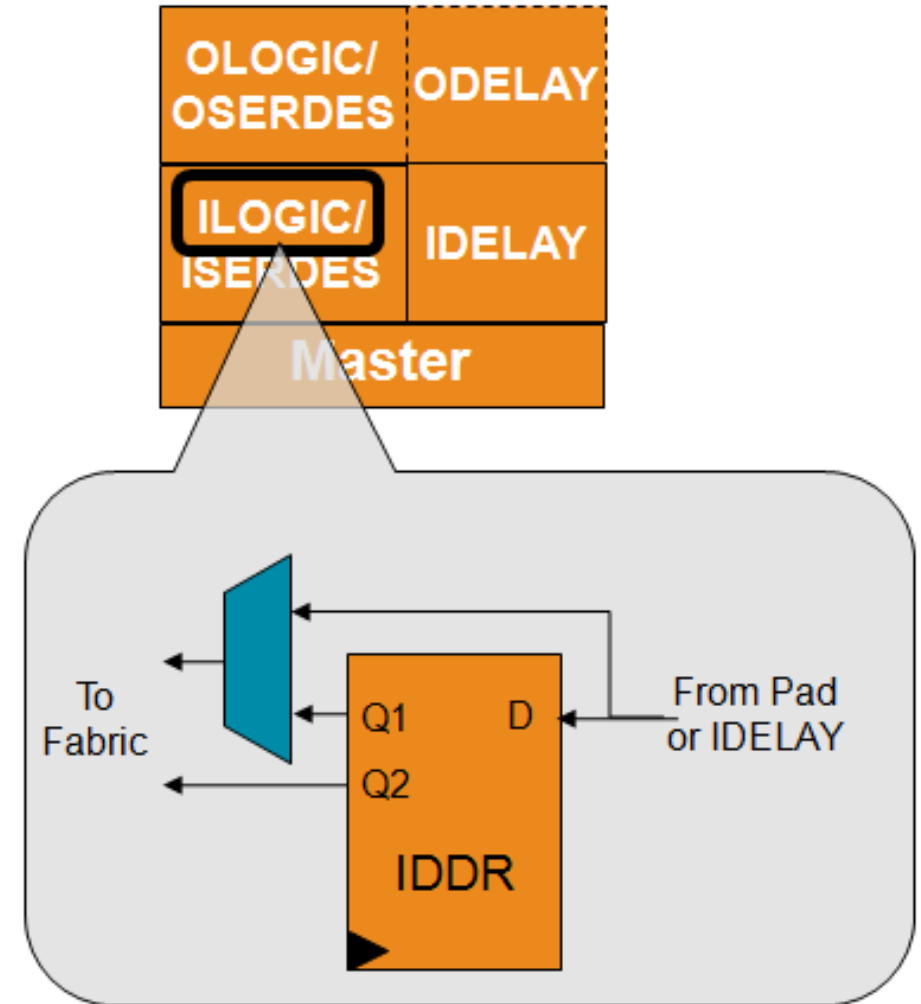
- >> ILOGICE2 for High Performance banks
- >> ILOGICE3 for High Range banks
  - Has zero hold delay capability

## > ILOGIC inputs come from the input receiver

- >> Directly or via the IDELAY block

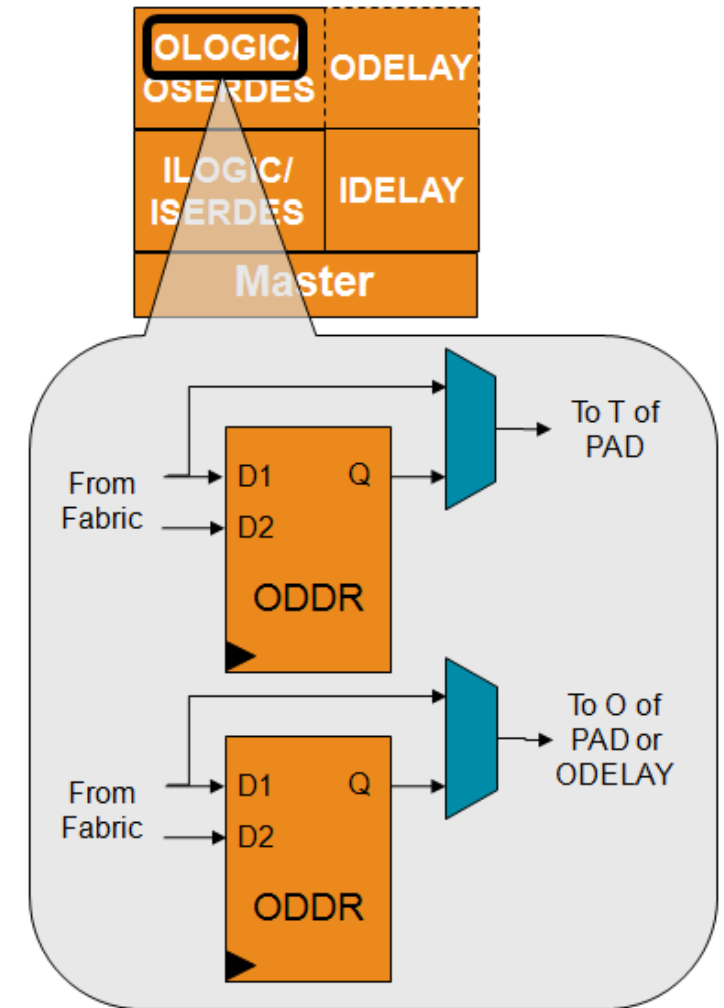
## > Outputs drive the FPGA fabric

- >> Directly (no clocked logic) or
- >> Via the IDDR
  - In SDR mode on rising or falling edge of clock
  - In DDR mode on both edges of clock
    - Can also use two clocks, 180° out of phase



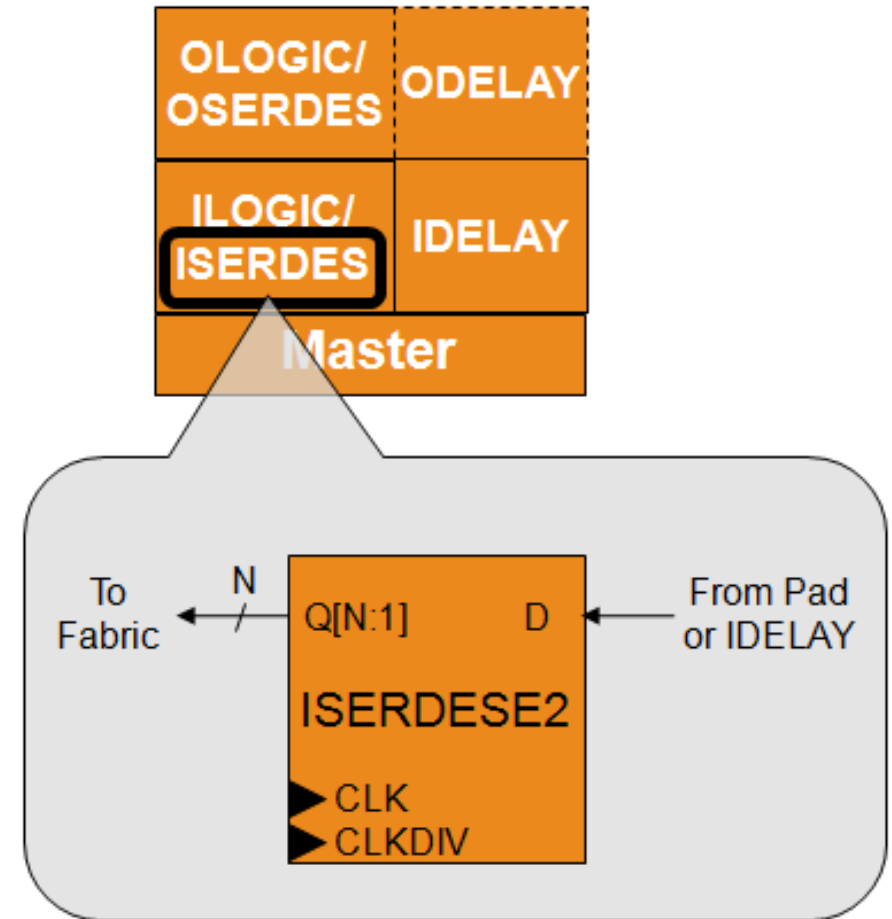
# OLOGIC: Output SDR and DDR Logic

- > OLOGICE2 for HP banks, OLOGICE3 for HR banks
  - >> ODELAY is available in HP banks only
- > Output of OLOGIC connects to the output driver directly, or via the ODELAY
  - >> ODELAY is available in HP banks only
- > Output is driven directly from the fabric
  - >> Directly, through an SDR flip-flop or via the ODDR using both edges of clock
- > Each OLOGIC block contains two ODDR
  - >> One for controlling the data to the output driver
  - >> One for controlling the 3-state enable
  - >> Both ODDR are driven by same clock and reset
- > SAME\_EDGE or OPPOSITE\_EDGE only



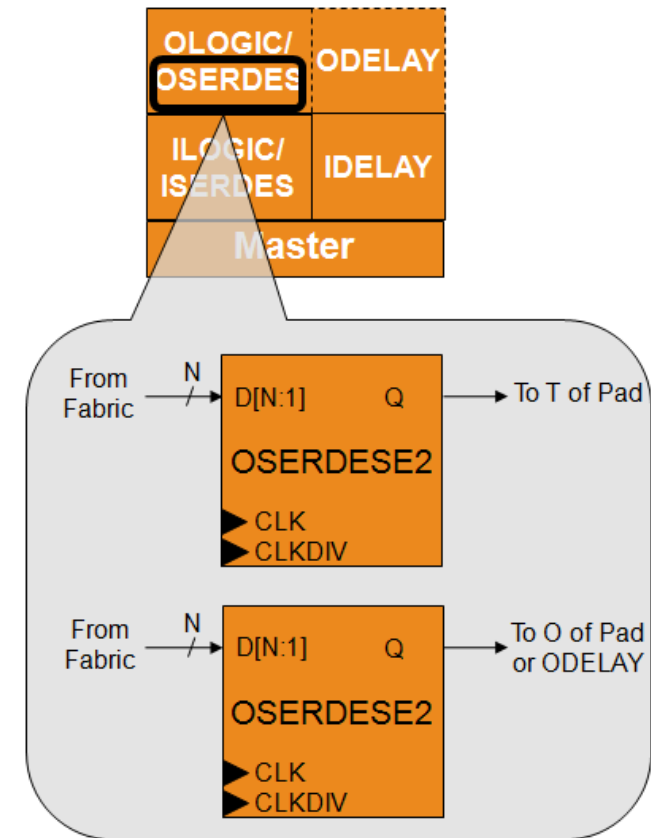
# ISERDES: Input Serial-to-Parallel Converter

- > **Clocks in data from input pad or IDELAY**
  - >> D is clocked on high speed clock (CLK)
  - >> Can be SDR or DDR
- > **Sends de-serialized data to fabric**
  - >> Q is clocked on low speed clock (CLKDIV)
- > **CLK and CLKDIV must be in phase**
- > **De-serializes data**
  - >> Single data rate: 2, 3, 4, 5, 6, 7, 8
  - >> Double data rate: 4, 6, 8
- > **Cascade with slave for wider ratios**
  - >> Double data rate: 10, 14
- > **Has BITSLIP logic for framing parallel data**



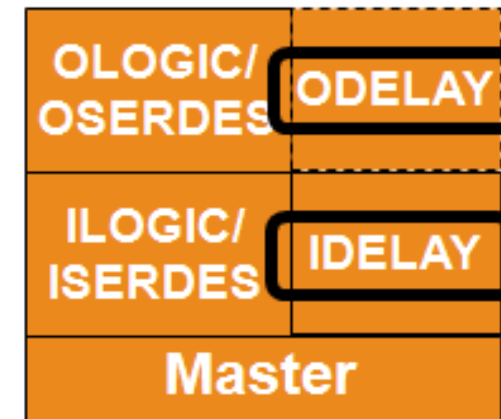
# OSERDES: Output Parallel-to-Serial Converter

- > **Serializes out data to output pad or ODELAY**
  - >> Q is clocked on high speed clock (CLK)
  - >> Can be SDR or DDR
- > **Parallel data comes from fabric**
  - >> D is synchronous to low speed clock (CLKDIV)
- > **CLK and CLKDIV must be in phase**
- > **Serializes data**
  - >> Single data rate: 2, 3, 4, 5, 6, 7, 8
  - >> Double data rate: 4, 6, 8
- > **Cascade with slave for wider ratios**
  - >> Double data rate: 10, 14
- > **When using 3-state serializer, both the data and 3-state width must be 4**
  - >> Clocks are shared between both serializers



# IDELAY and ODELAY

- > **Separate IDELAY and ODELAY delay lines**
  - >> IDELAY is available in both HR and HP banks
  - >> ODELAY is only available in HP banks
- > **Delay line elements are calibrated using the IDELAYCTRL cell**
  - >> Delay is process, temperature, and voltage independent
- > **IDELAY and ODELAY have almost identical capabilities**
  - >> IDELAY can also be accessed from the fabric
- > **Tap counter value can be accessed via FPGA fabric**
  - >> Monitor, increment, decrement, or set the tap value; tap value can be from 0 to 31
- > **Reference frequency can be 200 MHz in all speed grades; 300 MHz is also allowed in fastest speed grade**
  - >> Results in 78 ps or 52 ps per tap



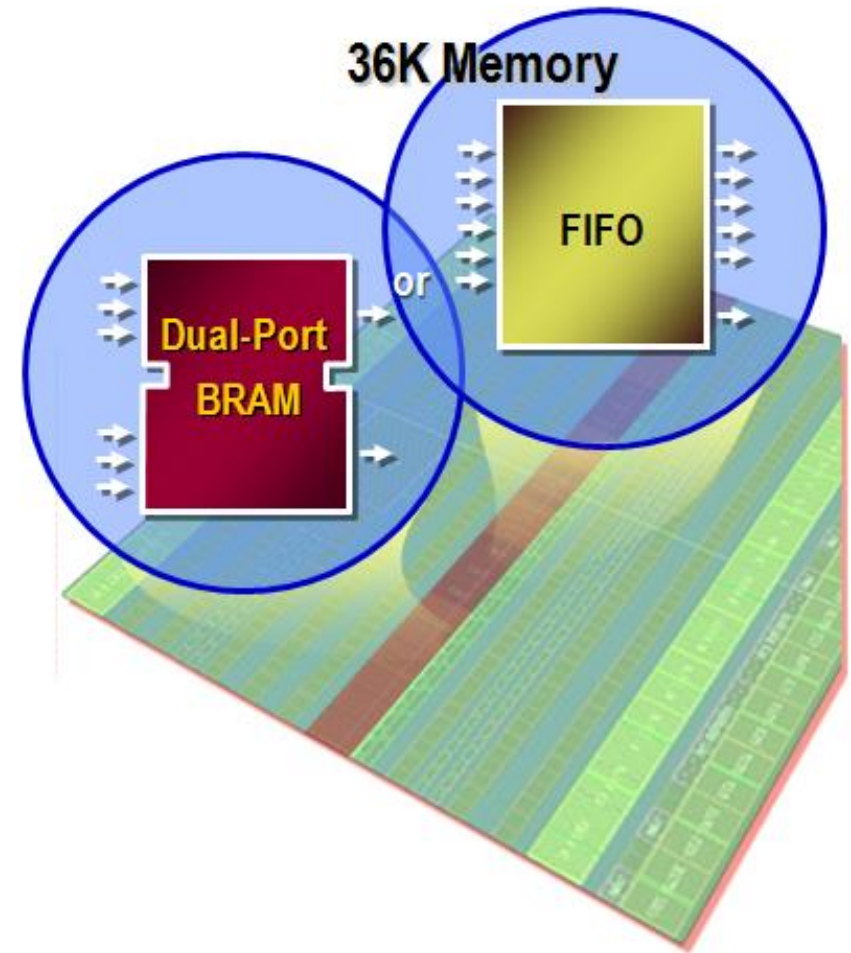
# Memory and DSP48 Resources





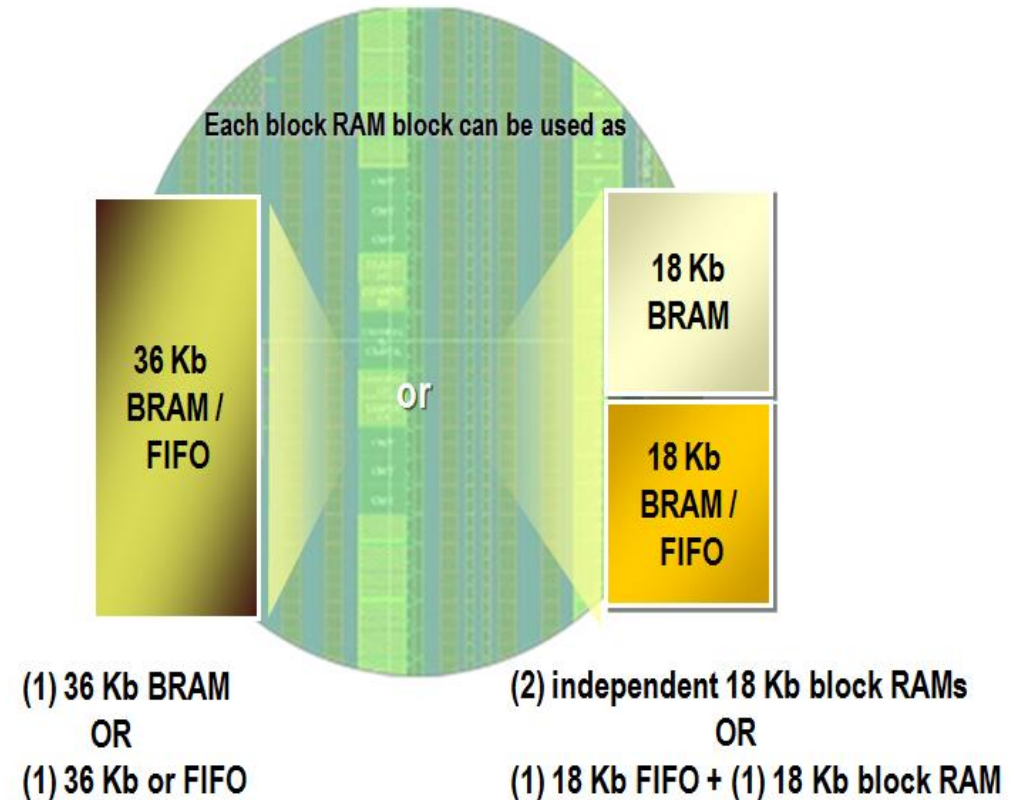
# 7-Series Block RAM and FIFO

- > All members of the 7-series families have the same Block RAM/FIFO
- > Fully synchronous operation
  - >> All operations are synchronous; all outputs are latched
- > Optional internal pipeline register for higher frequency operation
- > Two independent ports access common data
  - >> Individual address, clock, write enable, clock enable
  - >> Independent data widths for each port



# 7-Series Block RAM and FIFO

- > **Multiple configuration options**
  - >> True dual-port, simple dual-port, single-port
- > **Integrated cascade logic**
- > **Byte-write enable in wider configurations**
- > **Integrated control for fast and efficient FIFOs**
- > **Integrated 64 / 72-bit Hamming error correction**
- > **Separate Vbram voltage supply rail to ensure block memory functionality in -1L**



# Single-Port Block RAM

## > Single read/write port

- >> Clock: CLKA, Address: ADDRA, Write enable: WEA
- >> Write data: DIA, Read data: DOA

## > 36-kbit configurations

- >> 32k x 1, 16k x 2, 8k x 4, 4k x 9, 2k x 18, 1k x 36

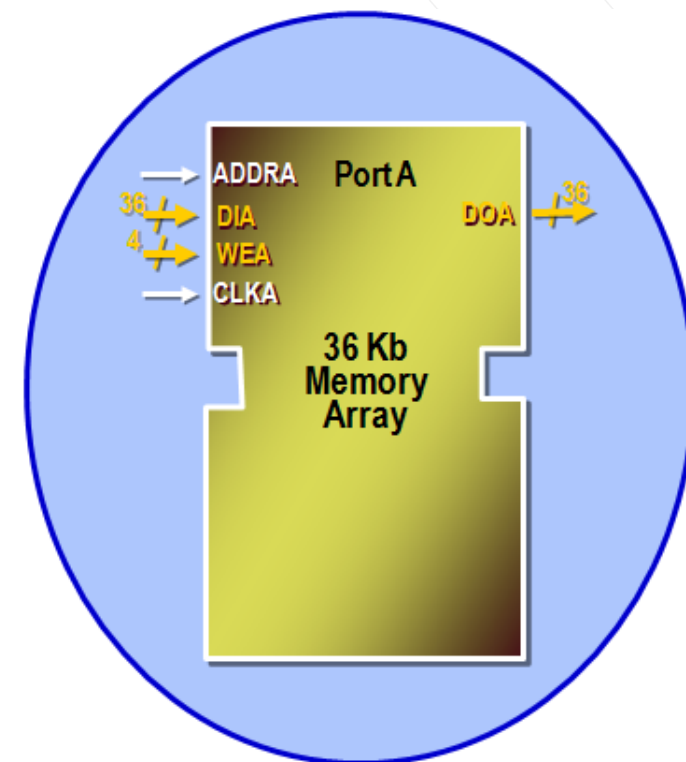
## > 18-kbit configurations

- >> 16k x 1, 8k x 2, 4k x 4, 2k x 9, 1k x 18, 512 x 36

## > Configurable write mode

- >> WRITE\_FIRST: Data written on DIA is available on DOA
- >> READ\_FIRST: Old contents of RAM at ADDRA is presented on DOA
- >> NO\_CHANGE: The DOA holds its previous value (saves power)

## > Optional output register for maximum performance (DOA\_REG=1)



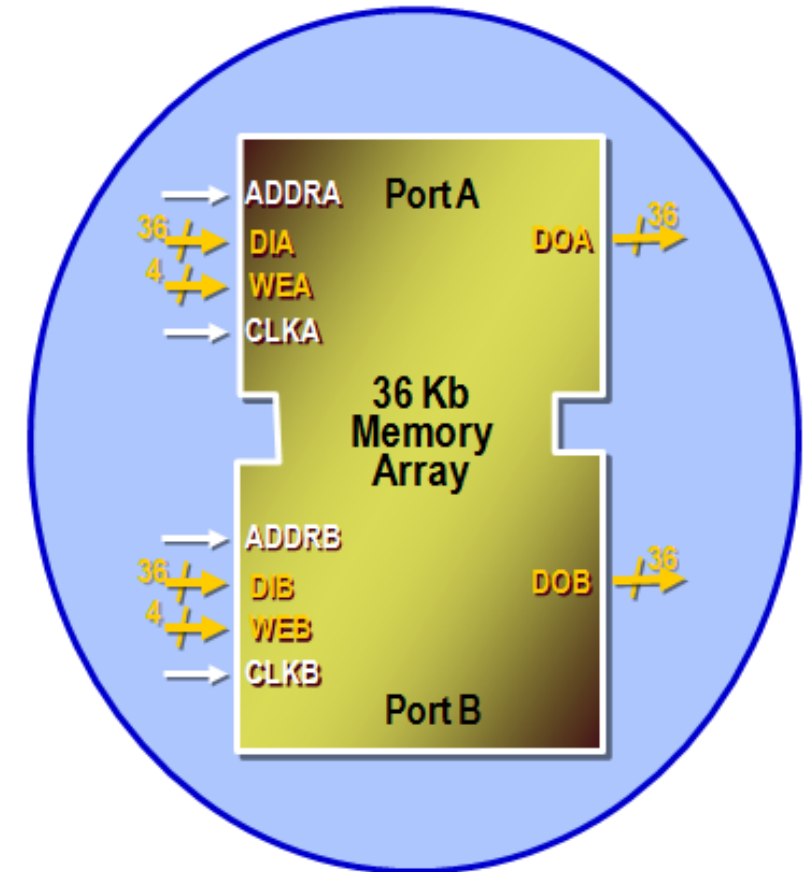
# Dual-Port Block RAM

## > Two separate read/write ports

- >> Each port has separate clock, address, data in, data out, write enable...
  - Clocks can be asynchronous to each other
- >> The two ports can have different widths
  - Same configurations as when single ported
- >> The two ports can have different write modes

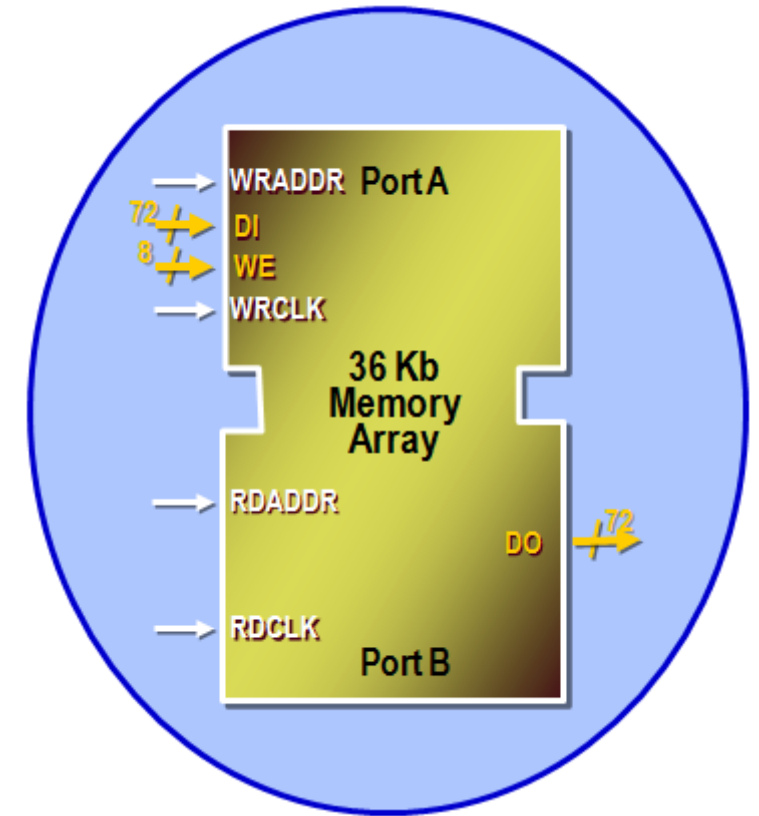
## > No contention avoidance when both ports access the same address, except

- >> If clocked by the same clock, and the write port is READ\_FIRST, the read port gets the old data



# Simple Dual-Port Block RAM

- > **One read port and one write port**
  - >> Each port has separate clock and address
- > **In 36-kbit configuration, one of the two ports must be 72 bits wide**
  - >> The other port can be x1, x2, x4, x9, x18, x36, or x72
- > **In 18-kbit configuration, one of the two ports must be 36 bits wide**
  - >> The other port can be x1, x2, x4, x9, x18, or x36



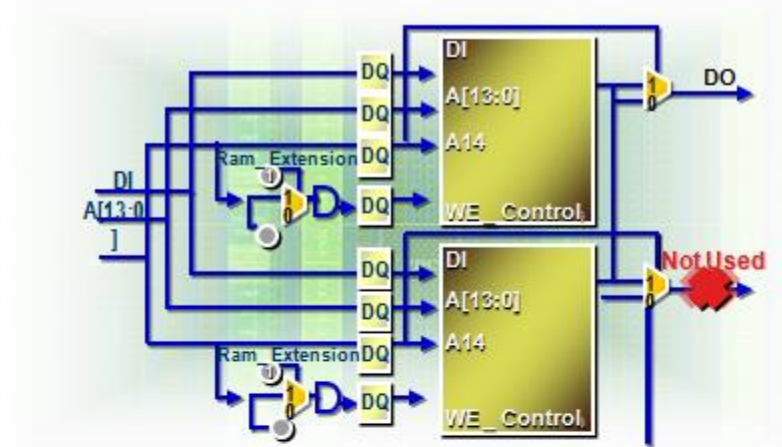
# Block RAM Cascading

## > Built-in cascade logic for 64Kx1

- >> Cascade *two* vertically adjacent 32Kx1 block RAMs without using external CLB logic or compromising performance
- >> Saves resources and improves speed of larger memories

## > Cascade option for larger arrays

- >> 128Kb, 256Kb, 512Kb, 1 Mb, ...
- >> Using external CLB logic for depth expansion
  - Not quite as fast as cascaded block RAMs
- >> Width expansion uses parallel block RAMs



**Example: Cascade 8 block RAMs to build 256-Kb memory**



# FIFO

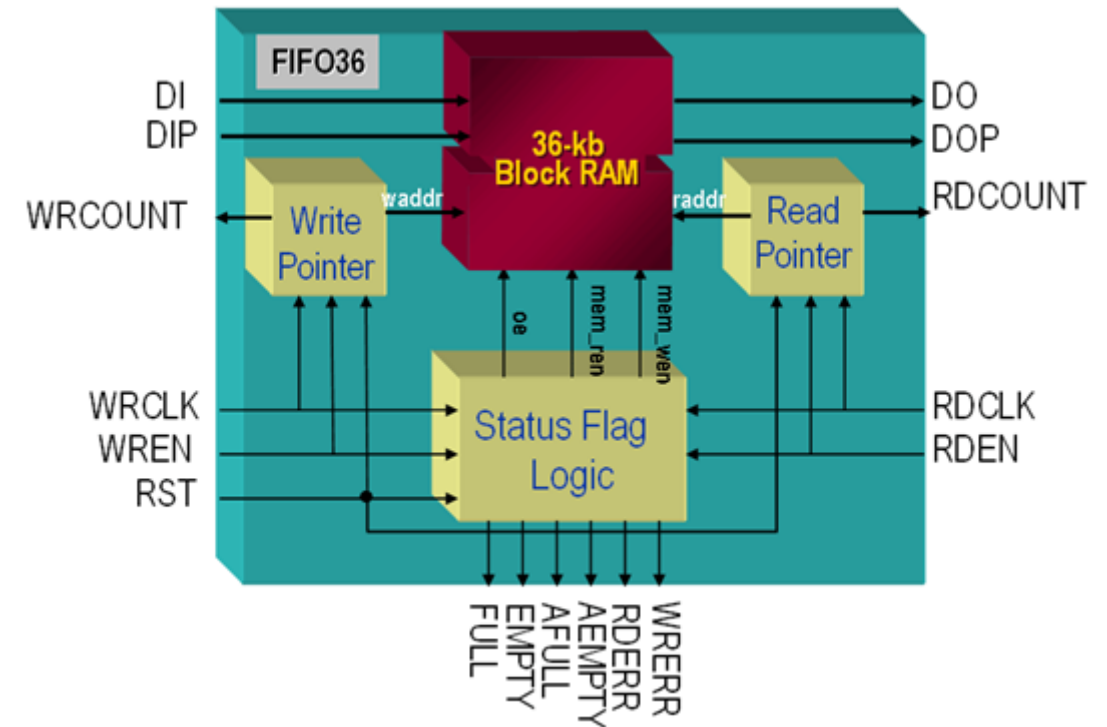
## > Full featured

- >> Synchronous or asynchronous read and write clocks
- >> Four flags
  - Full, empty, programmable almost-full/empty
- >> Optional first-word-fall-through

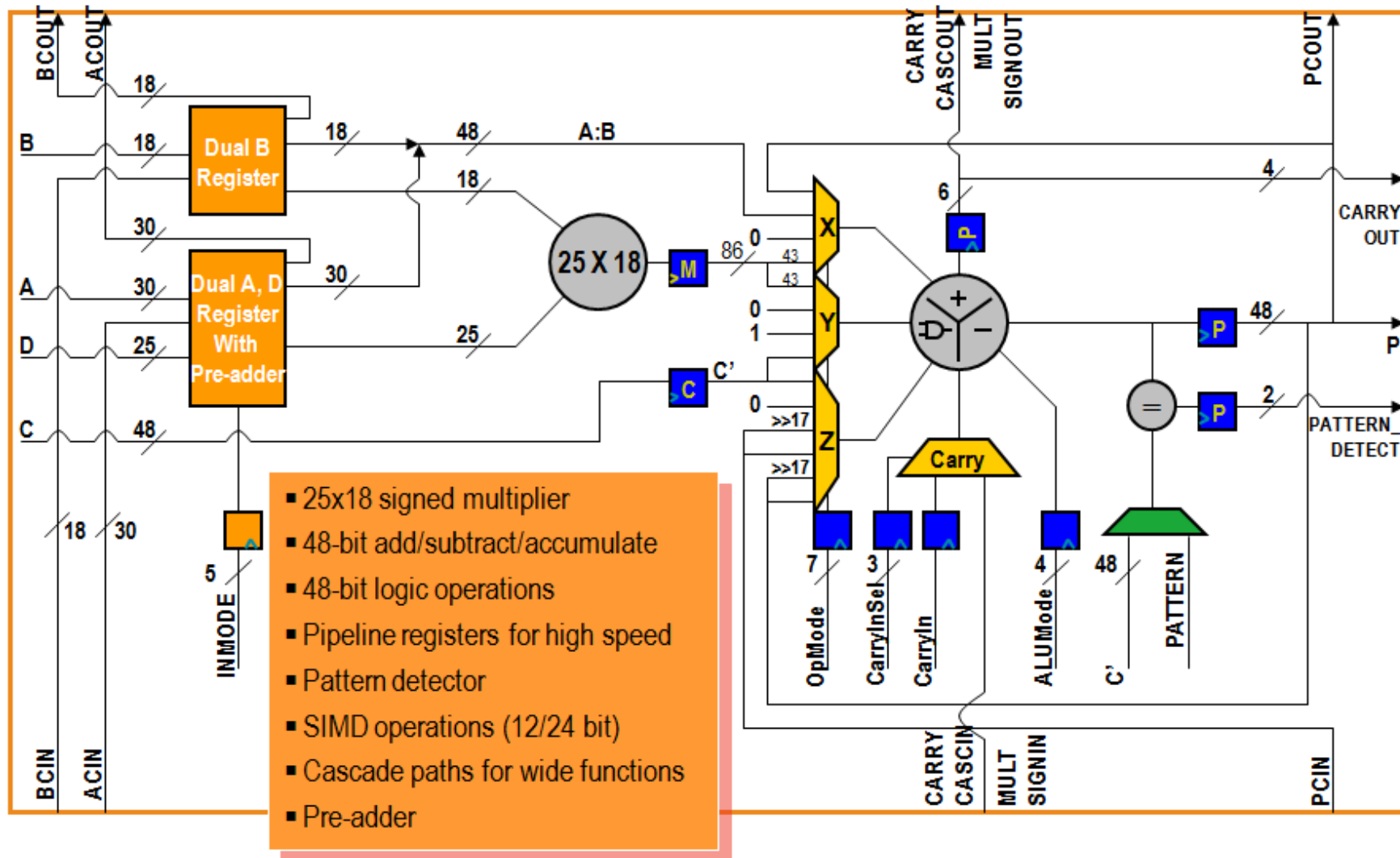
## > FIFO configurations

- >> Any 36-Kb block RAM: 8Kx4, 4Kx9, 2Kx18, 1Kx36, 512x72
- >> Any 18-Kb block RAM: 4Kx4, 2Kx9, 1Kx18, 512x36
- >> Write and read width must be equal

## > Can use the integrated error correction when used in the x72 width



# 7-Series DSP48E1 Slice

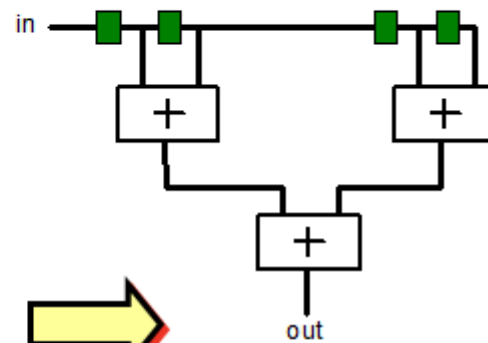




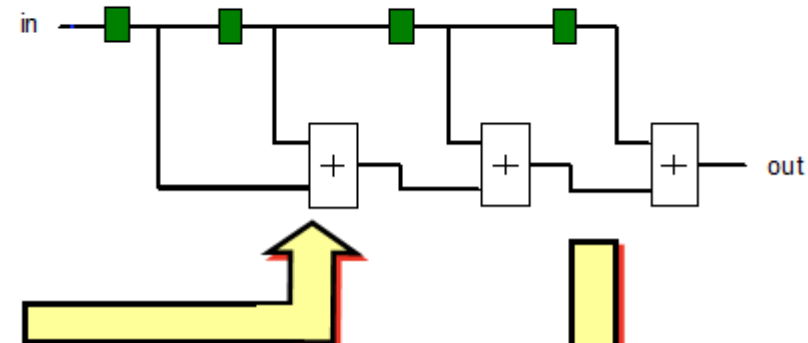
# Using DSP48 for Non-DSP Function

**START:** This is the typical adder tree found in many signal processing designs

**1** Remove all **pipelining** from the tree. This makes it easier to understand and visualize the changes

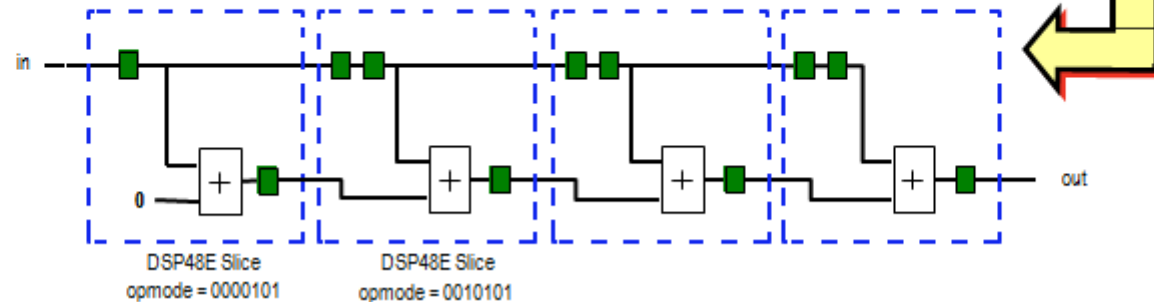


**2** Rearrange the tree. Notice that functionally has not changed. The diagram has just been redrawn



**3**

**Pipelining** is required for performance. Adding one in the chain requires one in the data path delay as well. Determining mapping to DSP48E is easy now



# XADC



# XADC and AMS

## > **XADC is a high quality and flexible analog interface new to the 7-series**

- >> Dual 12-bit 1Msps ADCs, on-chip sensors, 17 flexible analog inputs, and track & holds with programmable signal conditioning
- >> 1V input range
- >> 16-bit resolution conversion
- >> Built in digital gain and offset calibration

## > **Analog Mixed Signal (AMS)**

- >> Using the FPGA programmable logic to customize the XADC and replace other external analog functions; for example, linearization, calibration, filtering, and DC balancing to improve data conversion resolution

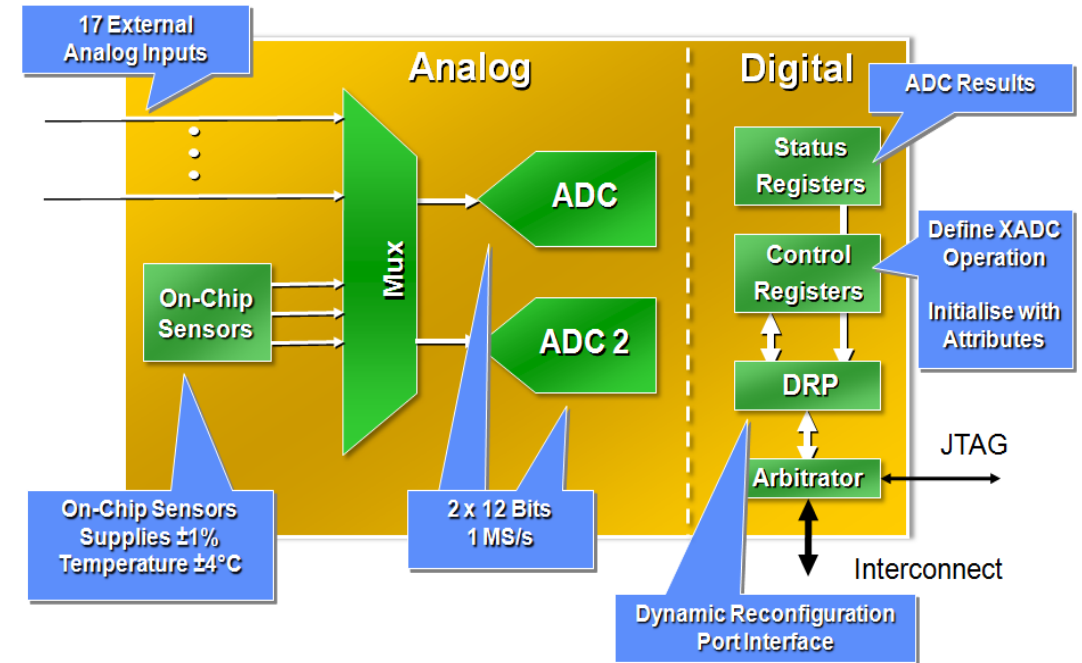
# XADC Block Diagram

## > Fast sampling

- >> Conversion time of 1  $\mu$ s with support for simultaneous sampling
- >> Flexible timing modes (self and externally triggered sampling modes)
- >> Separate track/hold amplifier for each ADC ensures maximum throughput using multiplexed analog input channels

## > Flexible analog inputs

- >> Differential analog inputs with high common mode noise rejection
- >> Support for unipolar, bipolar, and true differential input signal types



# XADC's Other Features

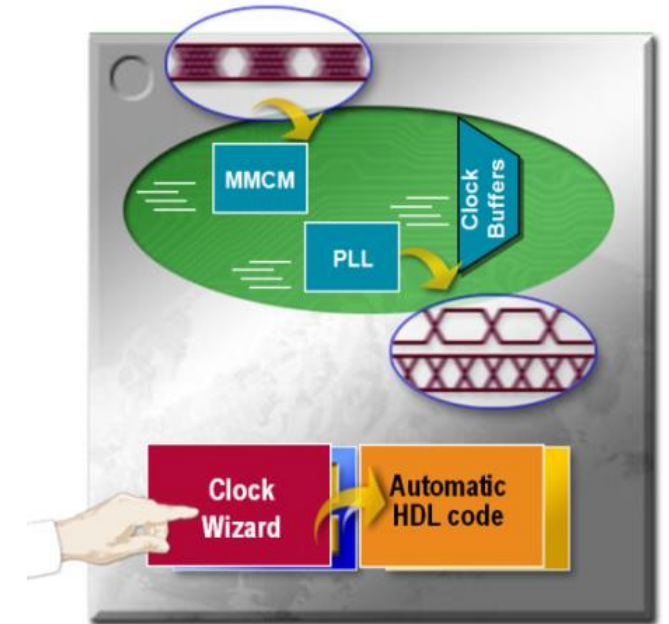
- > **Internal and external multiplexing and sampling**
  - >> Can sample internal power supplies and temperature
  - >> Multiplexes internal sources and 17 external analog inputs
  - >> Can control an external analog multiplexer to reduce pin count
- > **Flexible triggering**
  - >> Conversion data is stored in internal status registers
  - >> Internal control registers control source selection, sampling, and alarms
  - >> Registers can be accessed internally via the dynamic reconfiguration port (DRP)
  - >> Register can be accessed via JTAG
    - Available on power up, before configuration
- > **Operates over a wide temperature range (–40°C to +125°C)**

# Clocking Resources



# 7-Series FPGAs Clock Management

- > **Global clock buffers**
  - >> High fanout clock distribution buffer
- > **Low-skew clock distribution**
  - >> Regional clock routing
- > **Clock regions**
  - >> Each clock region is 50 CLBs high and spans half the device
- > **Clock management tile (CMT)**
  - >> One Mixed-Mode Clock Managers (MMCMs) and one Phase Locked Loop (PLL) in each Clock
  - >> Performs frequency synthesis, clock de-skew, and jitter-filtering
  - >> High input frequency range
- > **Simple design creation through the Clocking Wizard**



# Clock-Capable Inputs

## > All synchronous designs need at least one external clock reference

- >> These clocks need to be brought into the FPGA

## > Every 7-series FPGA has clock-capable inputs in every I/O bank

- >> These inputs are regular I/O pins with dedicated connections to internal clock resources
- >> Each I/O bank has 4 clock capable pins
  - 2x Multi-Region Clock Capable (MRCC)
  - 2x Single Region Clock Capable (SRCC)
- >> Each clock input can be used as a single-ended clock input, or can be paired with an adjacent pin to form a differential clock input
  - Each bank can therefore have four single-ended or four differential clock inputs

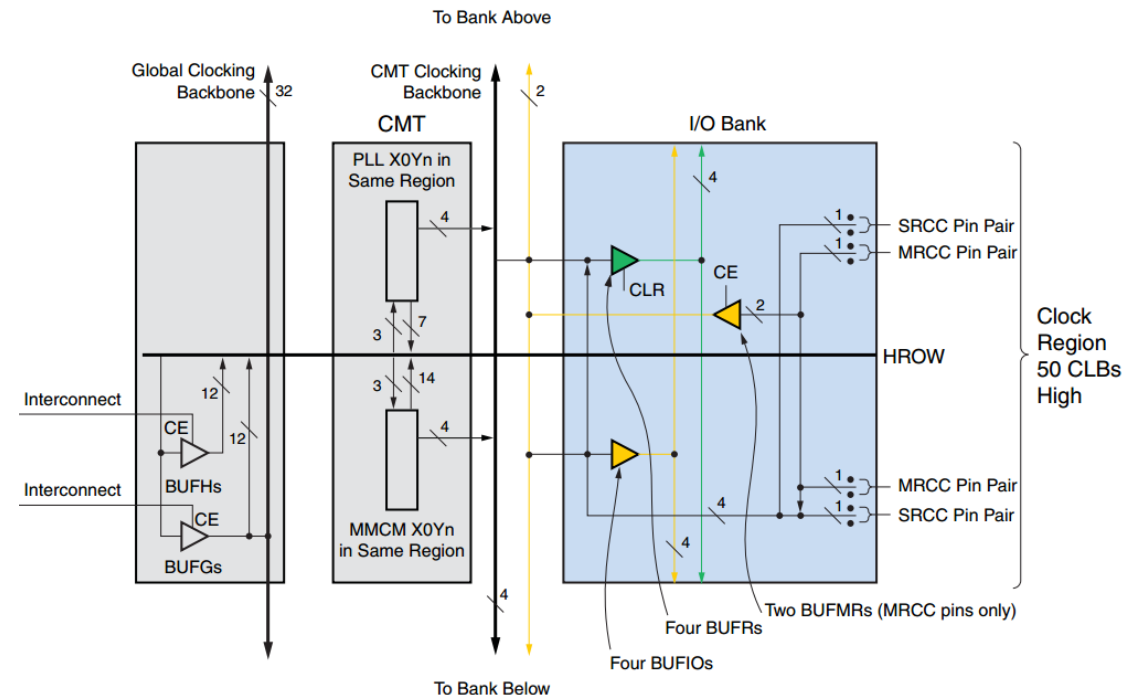


Figure 1-3: Single Clock Region (Right Side of the Device)



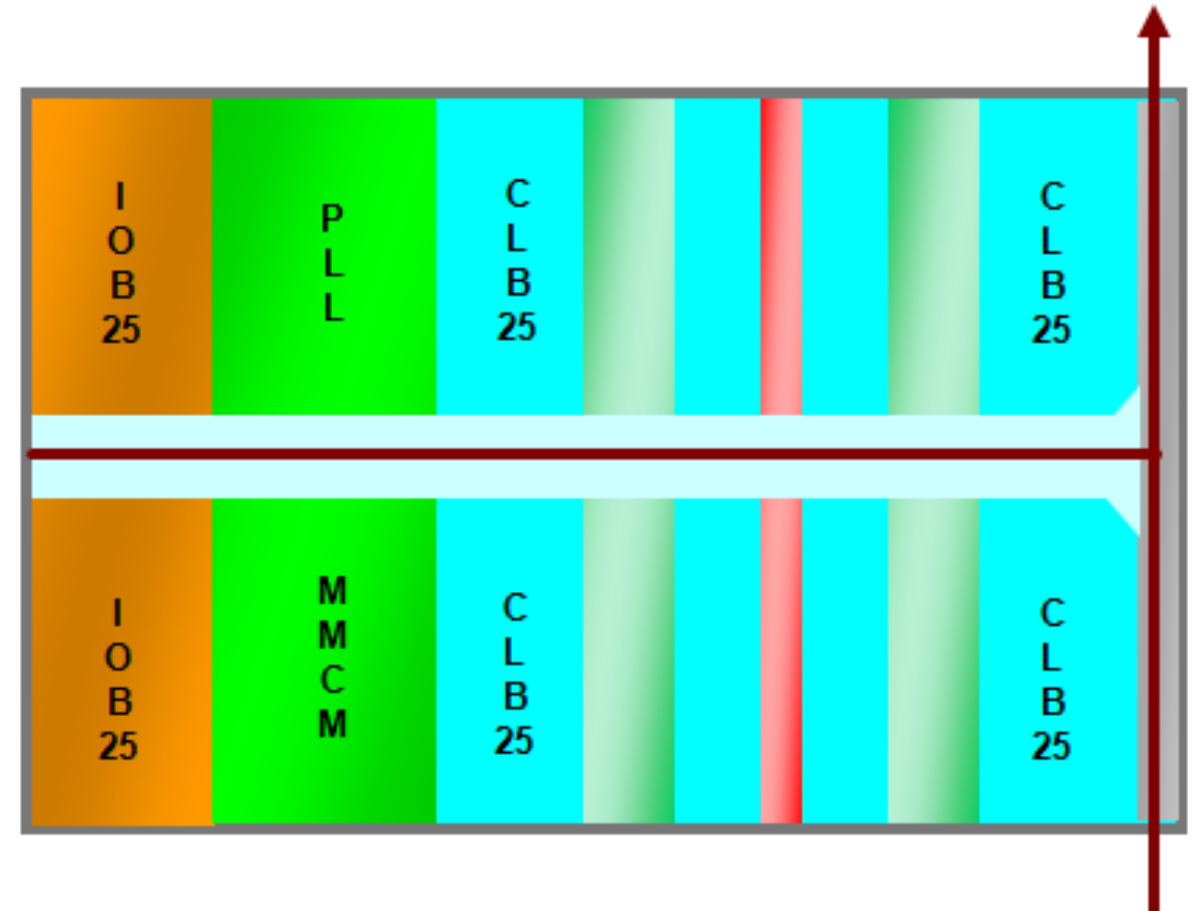
# 7-Series FPGA Clock Regions

## > Larger clock region than previous families

- >> 50 CLBs high, 50 I/Os high
- >> Same size as I/O bank
- >> Half width of device
- >> 2–24 regions per device for 7-Series

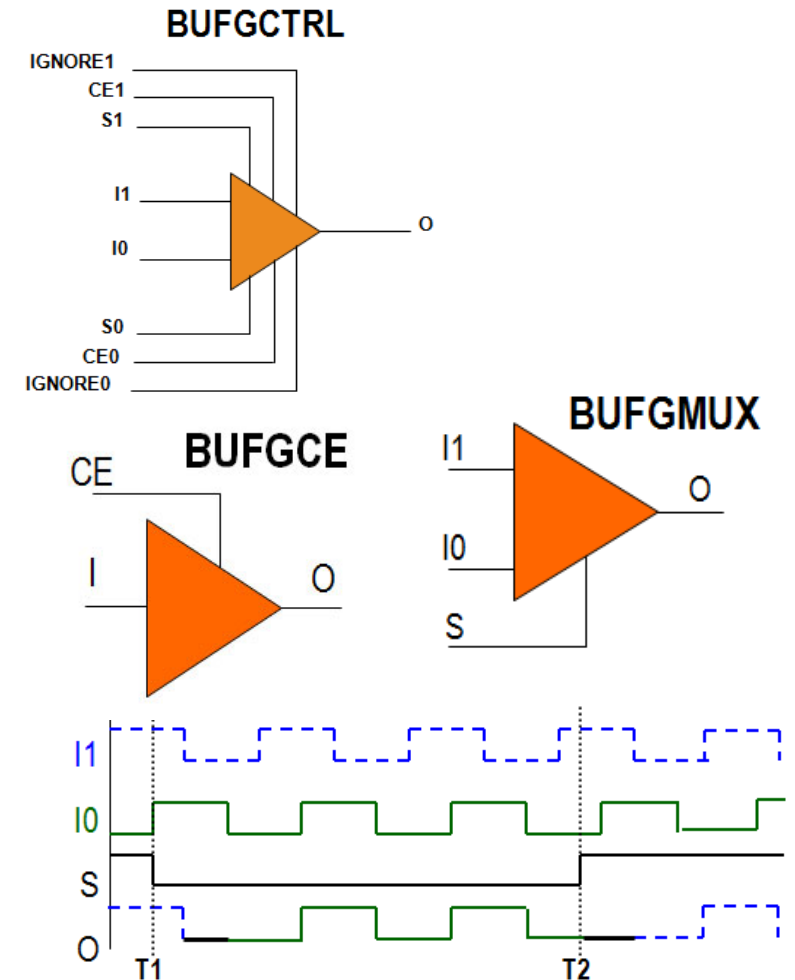
## > Resources per clock region

- >> 12 global clock networks
  - Driven by BUFH
- >> 4 regional clock networks
  - Driven by BUFR
- >> 4 I/O clock networks
  - Driven by BUFIO



# Global Clock Buffer (BUFGCTRL)

- > **BUFGCTRLs (or BUFG) reside in the center of the device**
- > **BUFGCTRLs can be driven by**
  - >> Clock-capable I/O (CCIO) in the same half
  - >> CMT outputs in the same half
  - >> Gigabit transceiver clocks in the same half
  - >> Other BUFG, interconnect, or BUFR
- > **BUFGCTRL outputs drive the vertical global clock spine**
- > **BUFGCTRL component implements**
  - >> Simple clock buffer (BUFG)
  - >> Clock buffer with clock switching (BUFGMUX or BUFGMUX\_CTRL)
  - >> Clock buffer with clock enable (BUFGCE)



# Zynq SoC



# Zynq-7000 Family Highlights

## > Complete ARM®-based processing system

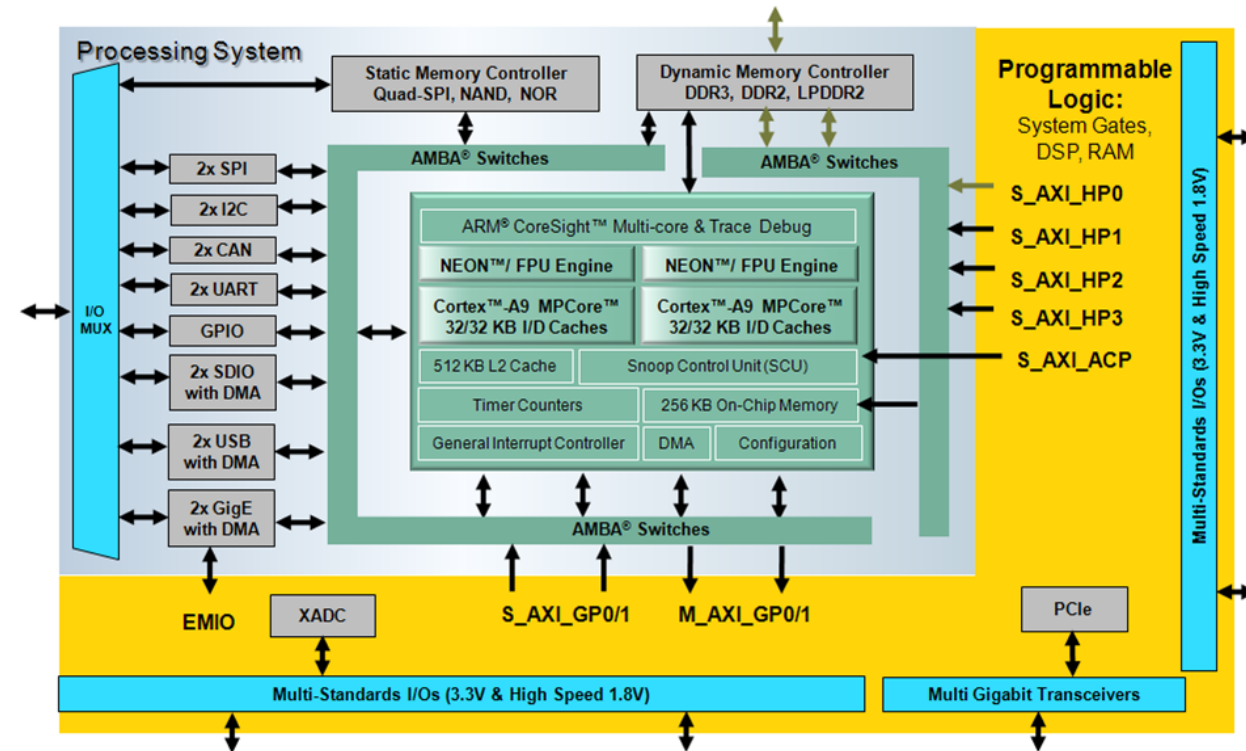
- >> Application Processor Unit (APU)
  - Dual ARM Cortex™-A9 processors
  - Caches and support blocks
- >> Fully integrated memory controllers
- >> I/O peripherals

## > Tightly integrated programmable logic

- >> Used to extend the processing system
- >> Scalable density and performance

## > Flexible array of I/O

- >> Wide range of external multi-standard I/O
- >> High-performance integrated serial transceivers
- >> Analog-to-digital converter inputs



# The PS and the PL

## > The Zynq-7000 SoC architecture consists of two major sections

### >> PS: Processing system

- Single/Dual ARM Cortex-A9 processor based
- Multiple peripherals
- Hard silicon core

### >> PL: Programmable logic

- Shares the same 7-series programmable logic as
  - Artix™-based devices: Z-7007S, Z-7012S, Z-7014S, Z-7010, Z-7015 and Z-7020
  - Kintex™-based devices: Z-7030, Z-7035, Z-7045 and Z-7100

Features	Zynq-7000S	Zynq-7000	
Devices	Z-7007S, Z-7012S, Z-7014S	Z-7010, Z-7015, Z-7020	Z-7030, Z-7035, Z-7045, Z-7100
Processor Core	Single-core ARM® Cortex™-A9 MPCore™	Dual-core ARM Cortex-A9 MPCore	
Maximum Frequency	Up to 766MHz	Up to 866 MHz	Up to 1GHz
External Memory Support	DDR3, DDR3L, DDR2, LPDDR2		
Key Peripherals	USB 2.0, Gigabit Ethernet, SD/SDIO		
Dedicated Peripheral Pins	Up to 128	Up to 128	128

# Summary



# Summary

- > **The 7-series FPGA slices contain four 6-input LUTs, eight registers, and carry logic**
  - >> LUTs can perform any combinatorial function of up to six inputs
  - >> LUTs are connected with dedicated multiplexers and carry logic
  - >> Some LUTs can be configured as shift registers or memories
  - >> Slices also contain carry logic and the MUXF7 and MUXF8 multiplexers
  - >> The MUXF7 multiplexers combine LUT outputs to create 7-input functions or 8-input multiplexers
  - >> The MUXF8 multiplexers combine the MUXF7 outputs to create 8-input functions or 16-input multiplexers
  - >> The carry logic can be used to implement fast addition, subtraction, and comparison operations
- > **The 7-series FPGA IOBs contain DDR registers as well as SERDES resources**
- > **The SelectIO™ interfaces enable direct connection to multiple I/O standards**

# Summary

- > The 7-series FPGA includes dedicated block RAM and DSP slice resources
- > The 7-series FPGAs includes dedicated MMCMs, PLLs, and routing resources to improve your system clock performance and generation capability
- > The 7-series FPGAs include other dedicated hardware such as XADC
- > The Zynq-7000 processing platform is a system on a chip (SoC) processor with embedded programmable logic fabric of either Artix or Kintex 7-series FPGA