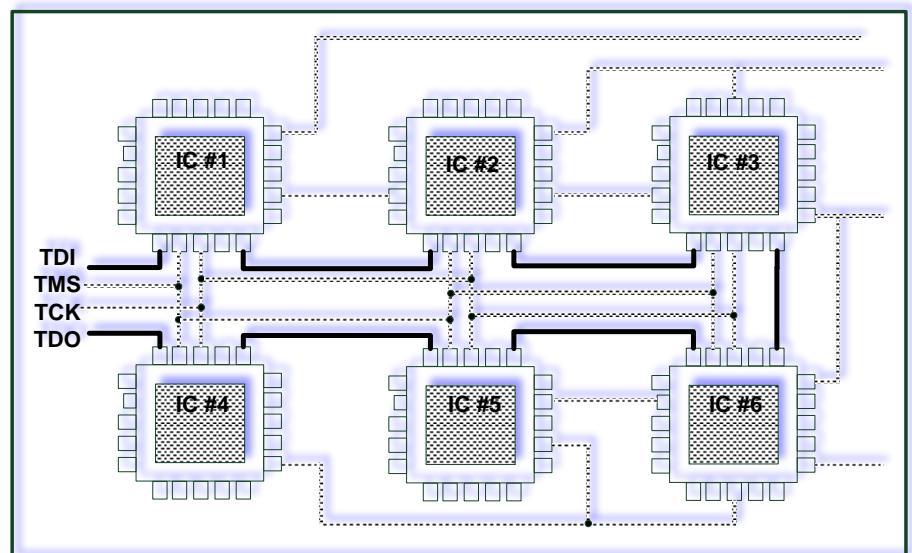


DFT – Part 2

- Introduction
- Components of JTAG
- **JTAG Instructions**
 - ◆ Mandatory Instructions
 - ◆ Optional Instructions
- Conclusion

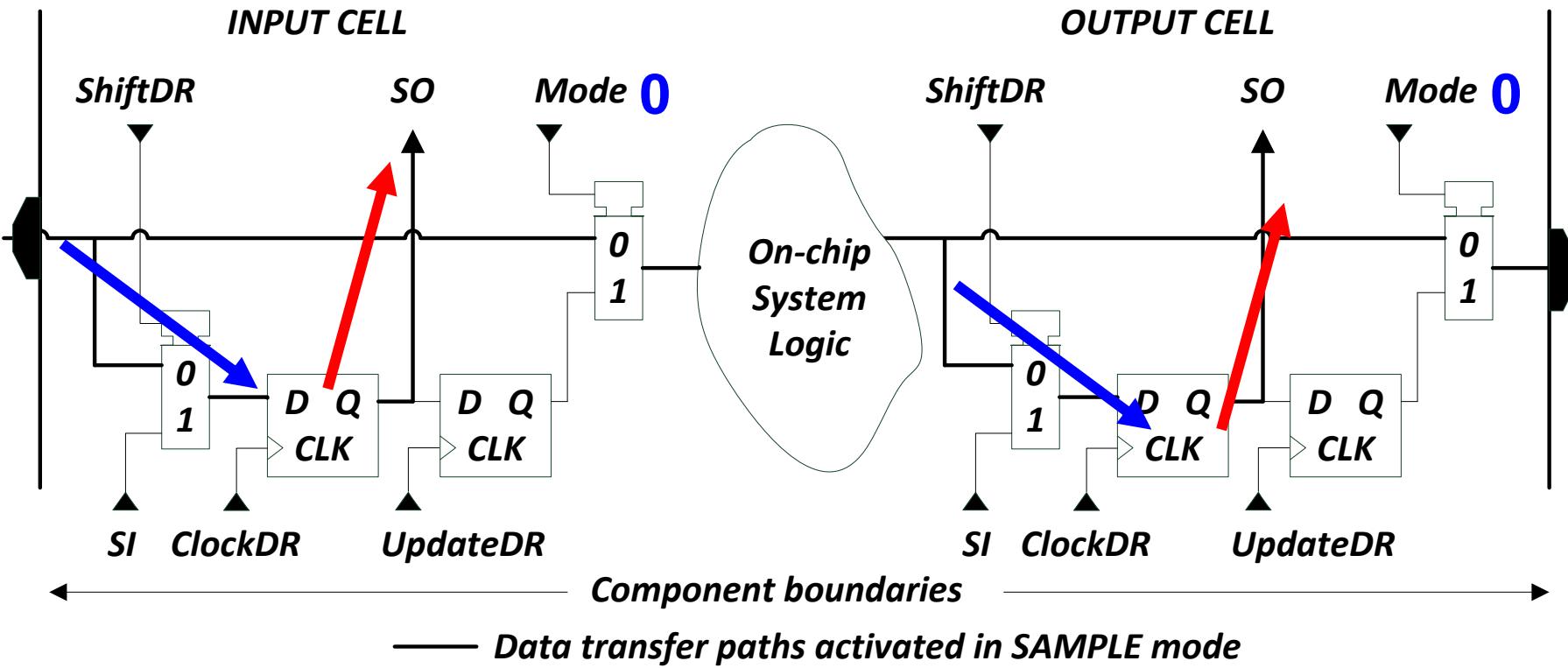


Mandatory Instructions

- EXTEST (000...0)
 - ◆ Selects Boundary-Scan Register, External Test
- BYPASS (111...1)
 - ◆ Selects Bypass Register
- SAMPLE/PRELOAD (instruction code decided by designer)
 - ◆ SAMPLE: Take snapshot of system I/O pins
 - ◆ PRELOAD: Control system I/O pins

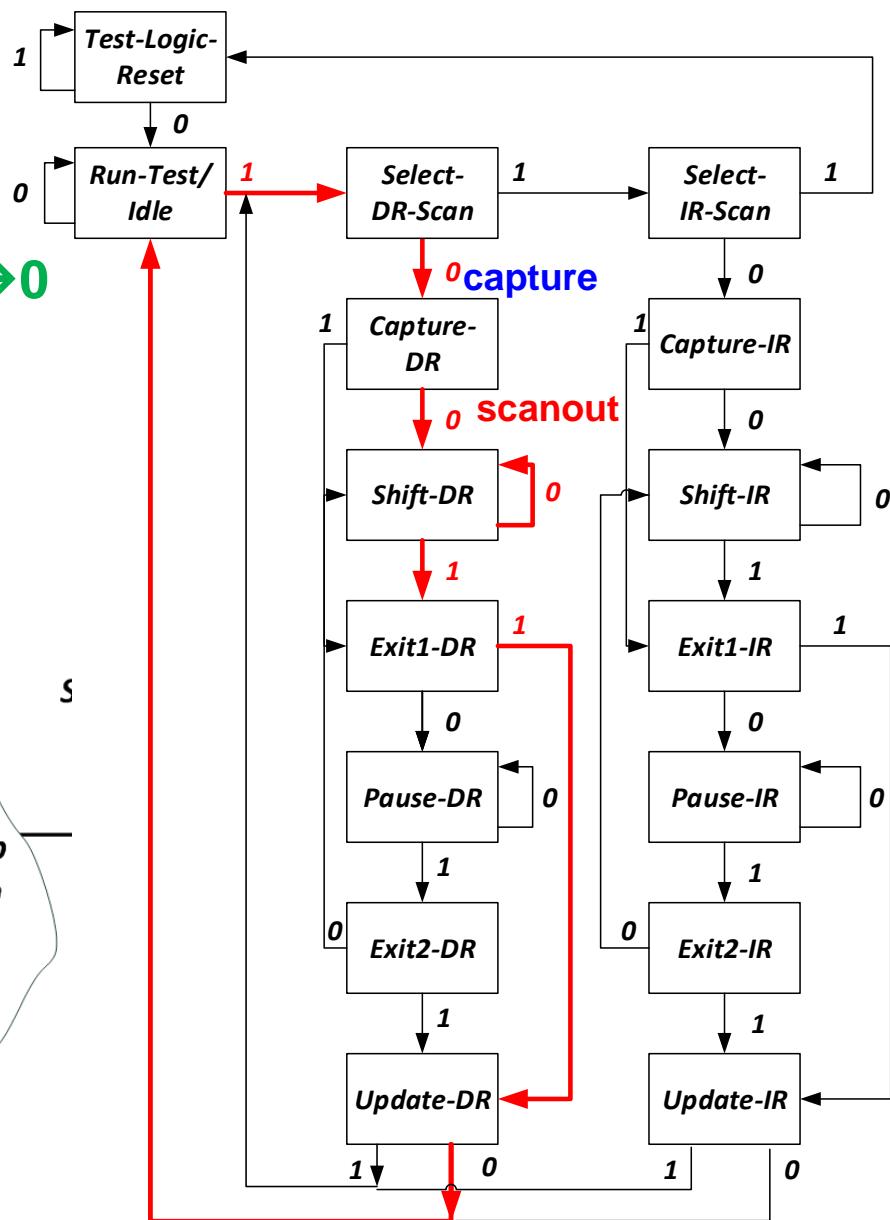
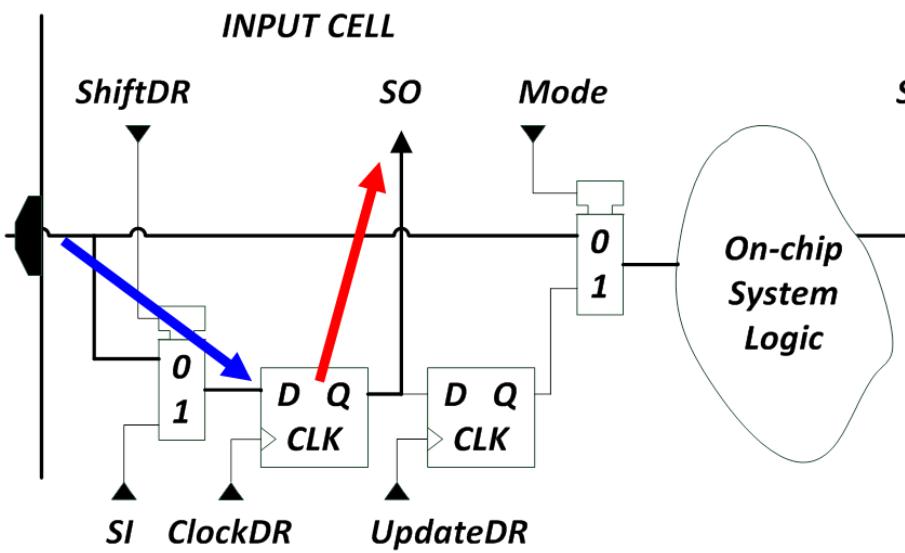
SAMPLE (1/3)

- Step1: **Capture**: ShiftDR=0, ClockDR
- Step2: **Scan out**: ShiftDR=1, ClockDR ...
- **Mode = 0** to isolate system logic
 - ◆ Does not interfere with normal operation of system logic



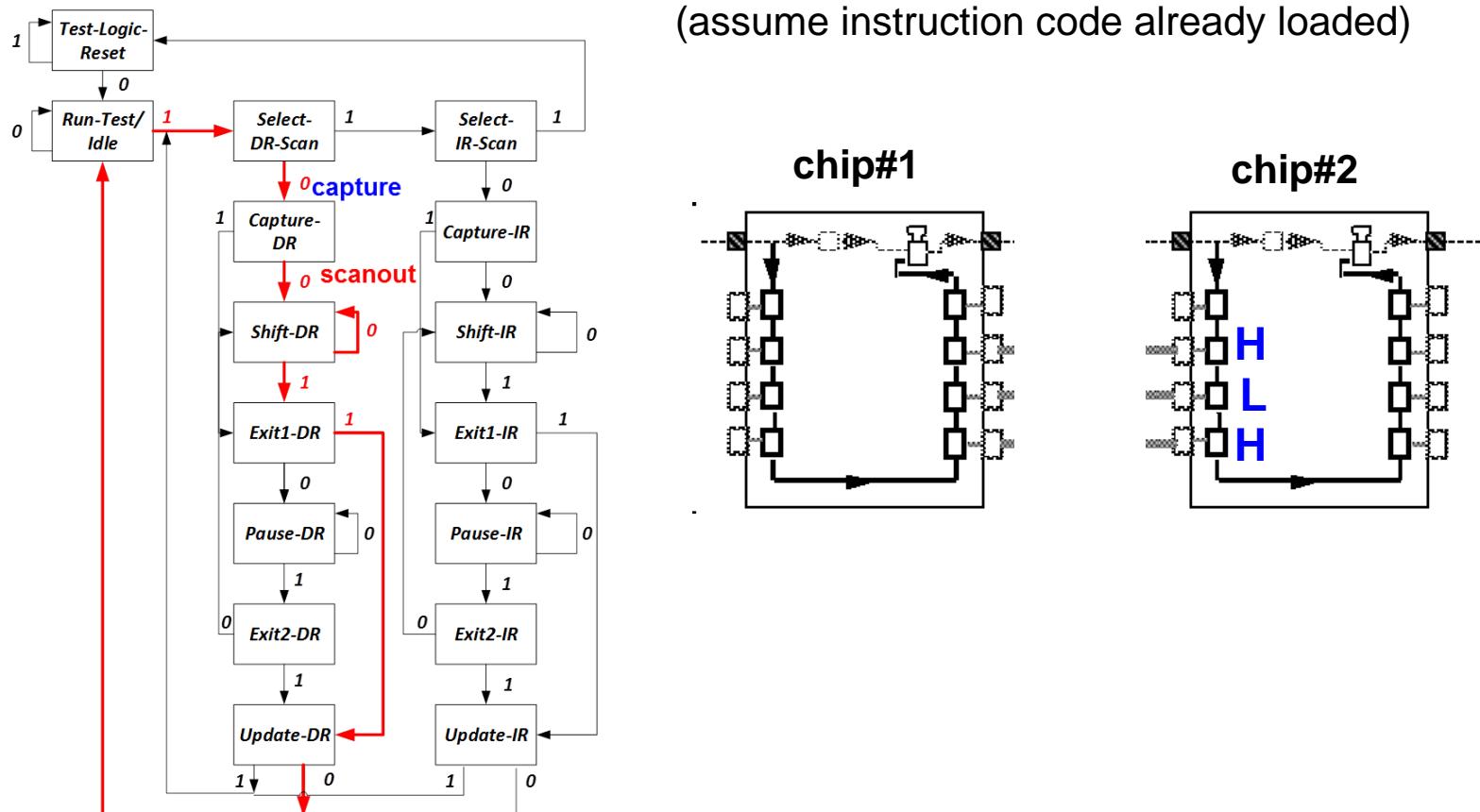
SAMPLE (2/3)

- After instruction loaded
 - Start from Run-test/Idle
- TMS = **1->0->0->0.....0→1→1→0**
- Ends at Run-test/Idle



SAMPLE (3/3)

	Capture		Scan out	
TMS	10	0	0000 0000 0000 0000	110
TDI				
TDO			xxxx HLHx xxxx xxxx	
Final state	Capture-DR		Shift-DR	run-test/Idle

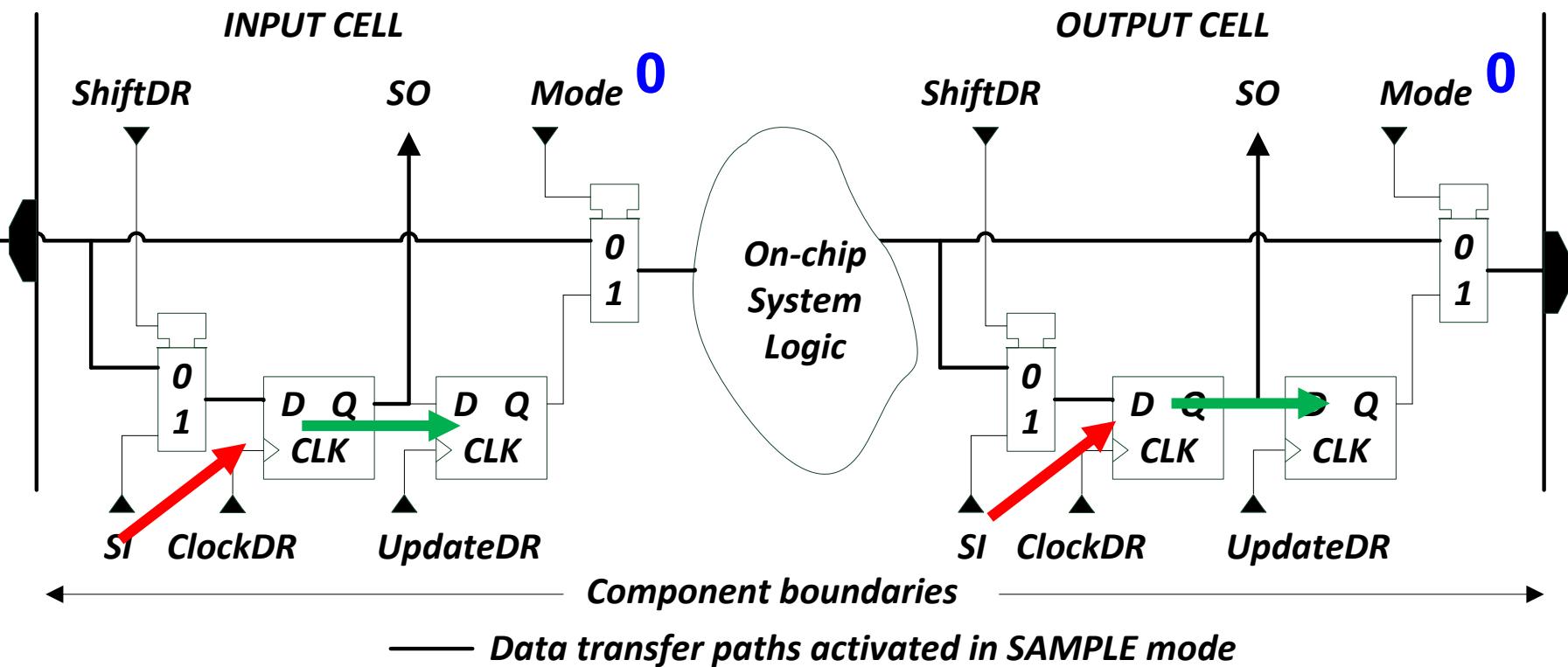


Mandatory Instructions

- EXTEST (000...0)*
 - ◆ Selects Boundary-Scan Register, External Test
- BYPASS (111...1)
 - ◆ Selects Bypass Register
- SAMPLE/PRELOAD (instruction code decided by designer)
 - ◆ SAMPLE: Take snapshot of system I/O pins
 - ◆ PRELOAD: Control system I/O pins (by output FF of BSC)

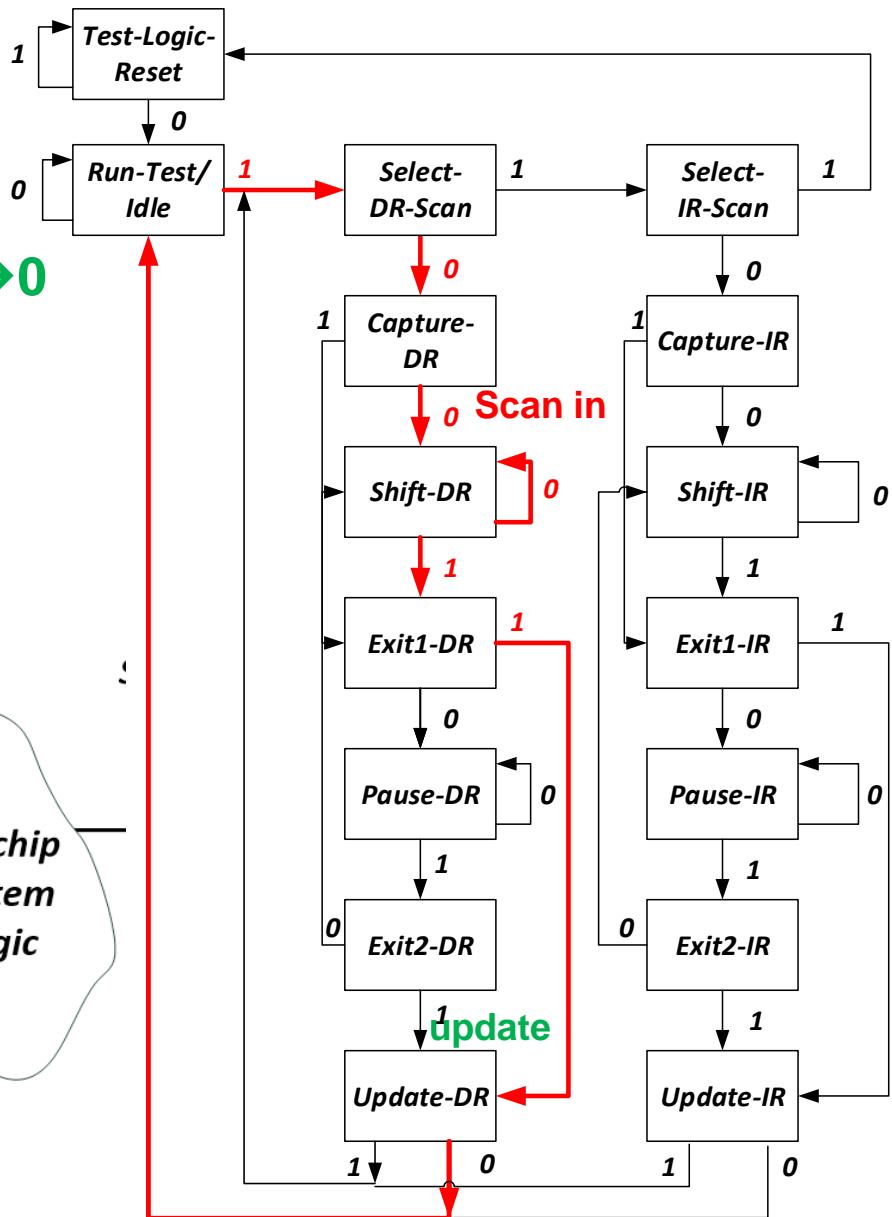
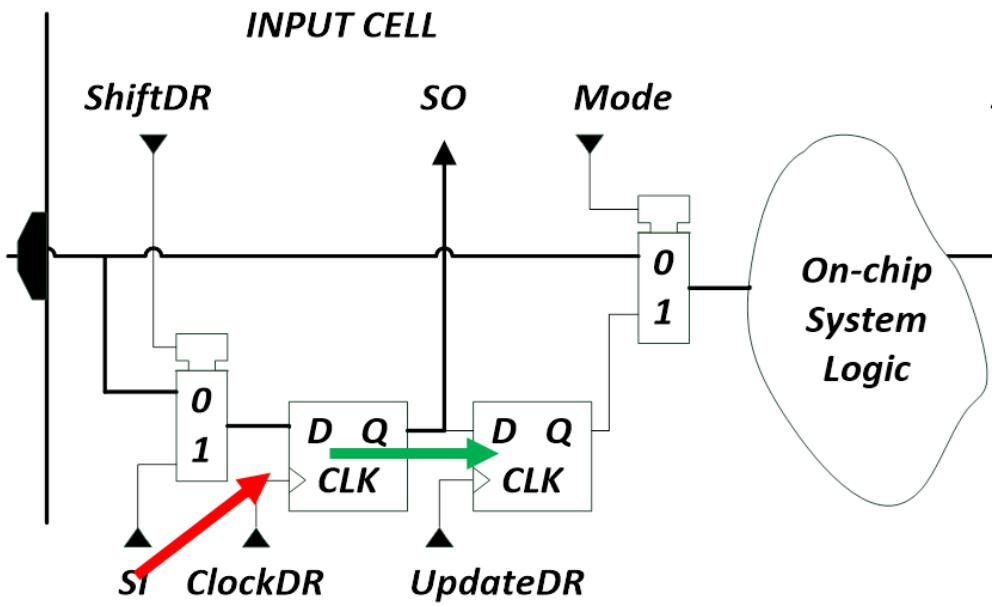
PRELOAD (1/2)

- Step1: Scan in: ShiftDR=1, ClockDR...
- Step2: Update: UpdateDR
- Mode = 0 to isolate system logic



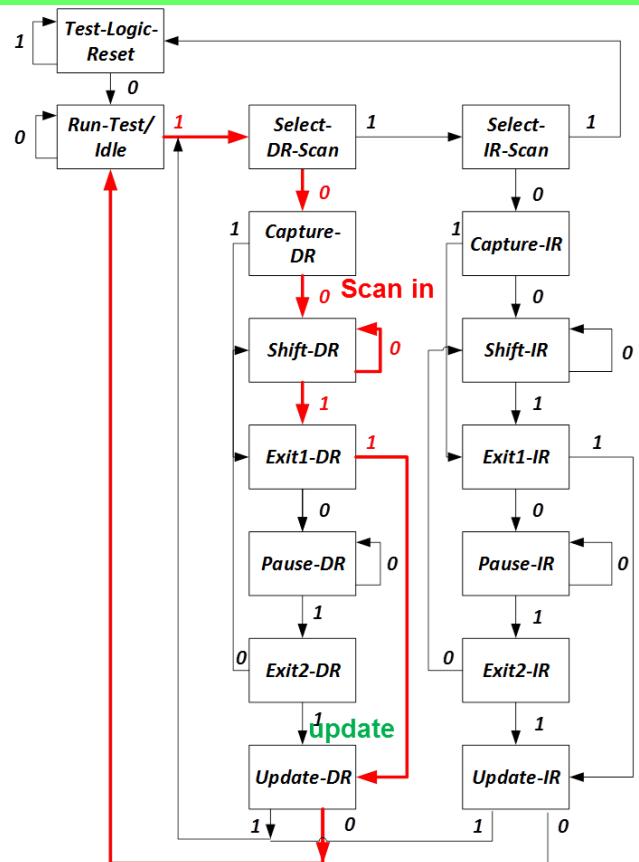
PRELOAD (2/2)

- After instruction loaded
 - Start from Run-test Idle
- TMS = **1->0->0->0.....0→1→1→0**
- Ends at Run-test/Idle



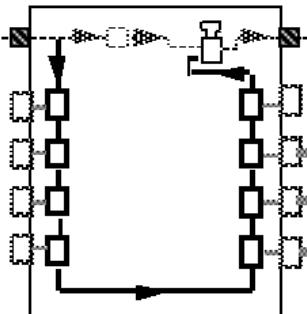
Quiz

		Scan in	Update
TMS			
TDI			
TDO			
Final state	Capture-DR	Shift-DR	run-test/Idle

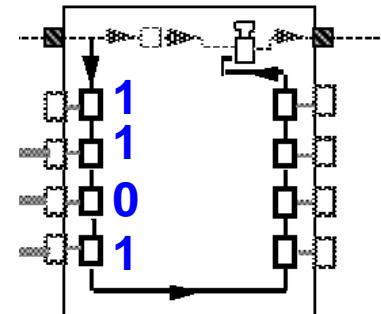


Q: Suppose we want to preload chip #2 by '1011'. Please fill in blanks. (assume instruction code already loaded)

chip#1

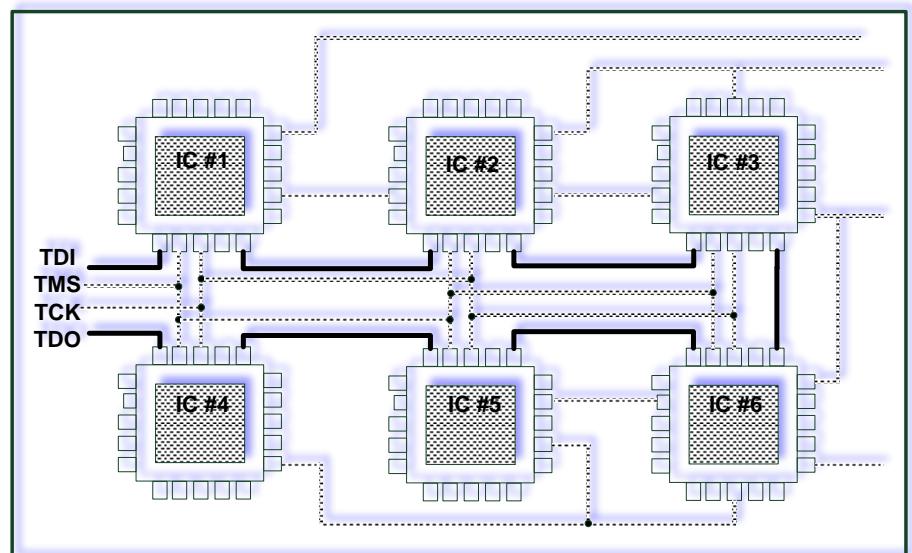


chip#2



DFT – Part 2

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- **JTAG Instructions**
 - ◆ Mandatory Instructions
 - ◆ Optional Instructions
- Conclusion

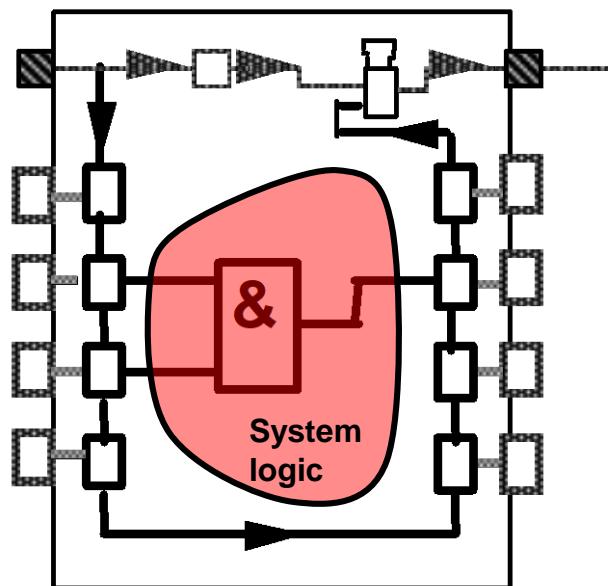


Optional Instructions

- **INTEST**
 - ◆ Selects Boundary scan register. Internal test of system logic
- **RUNBIST**
 - ◆ Runs built-in self-test (BIST)
- **IDCODE**
 - ◆ Selects device identification register
- **Design Specific**
 - ◆ Designer's Choice

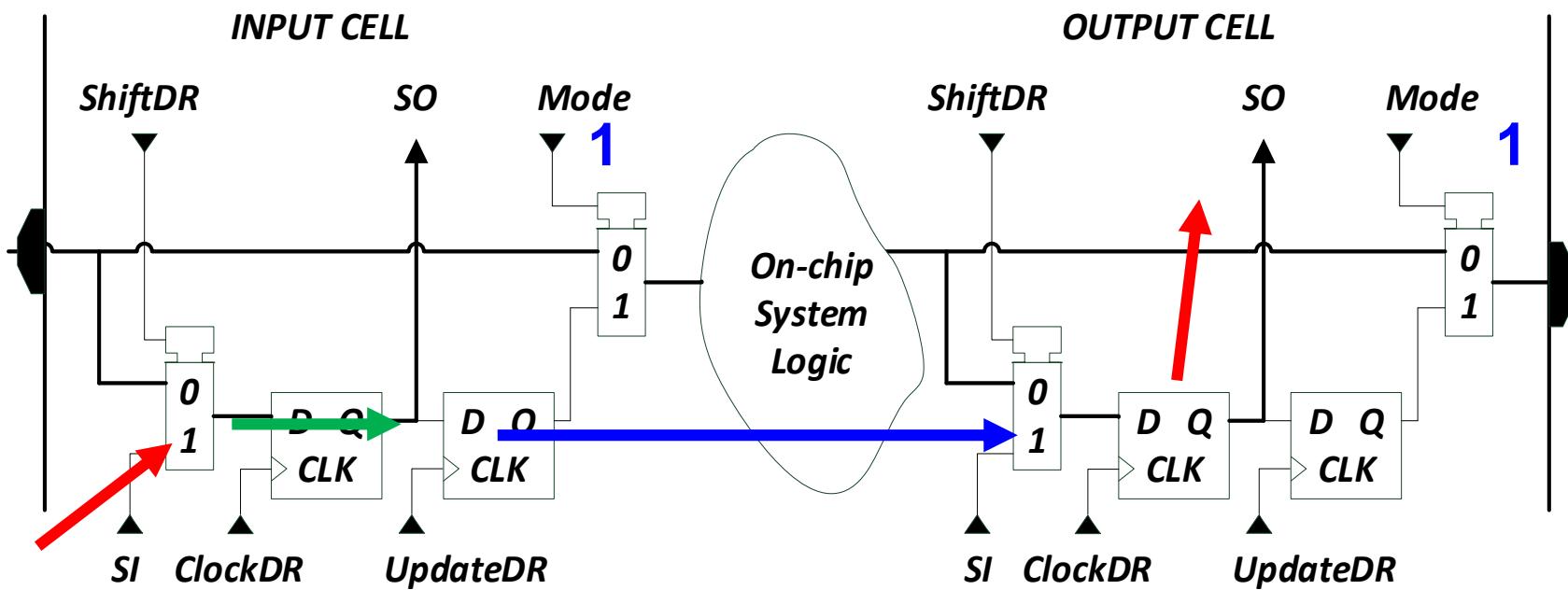
INTEST (1/4)

- Purpose: Test on-chip system logic



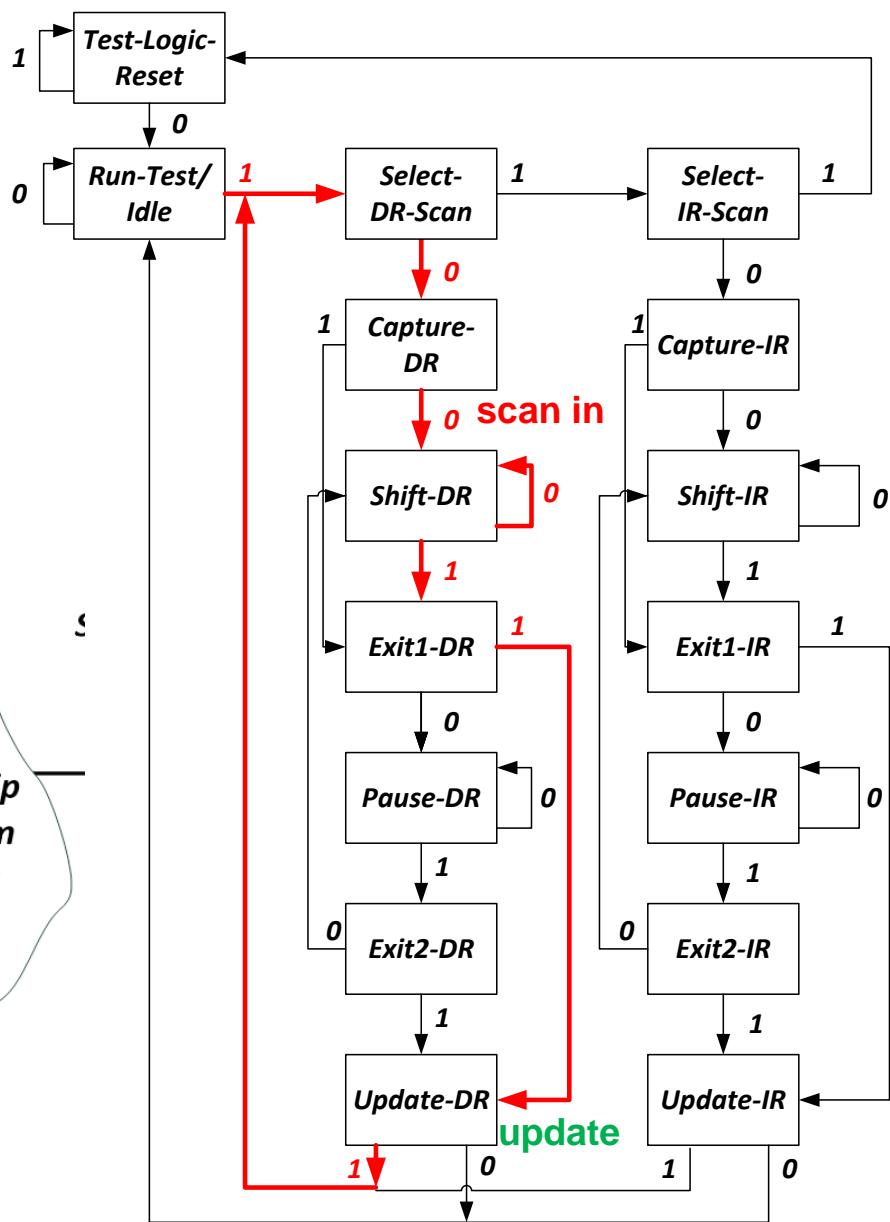
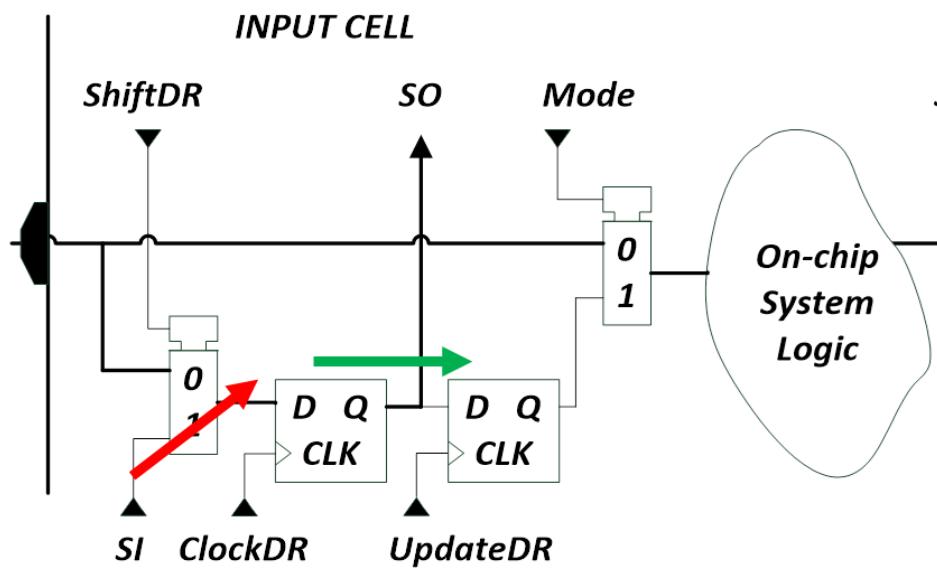
INTEST (2/4)

- Step 1: **Scan in**: ShiftDR=1 ClockDR ...
- Step 2: **Update Input BSR**: UpdateDR
- Step 3: **Capture Output BSR**: ShiftDR=0 ClockDR
- Step 4: **Scan out**: ShiftDR=1 ClockDR ...
- **Mode = 1**



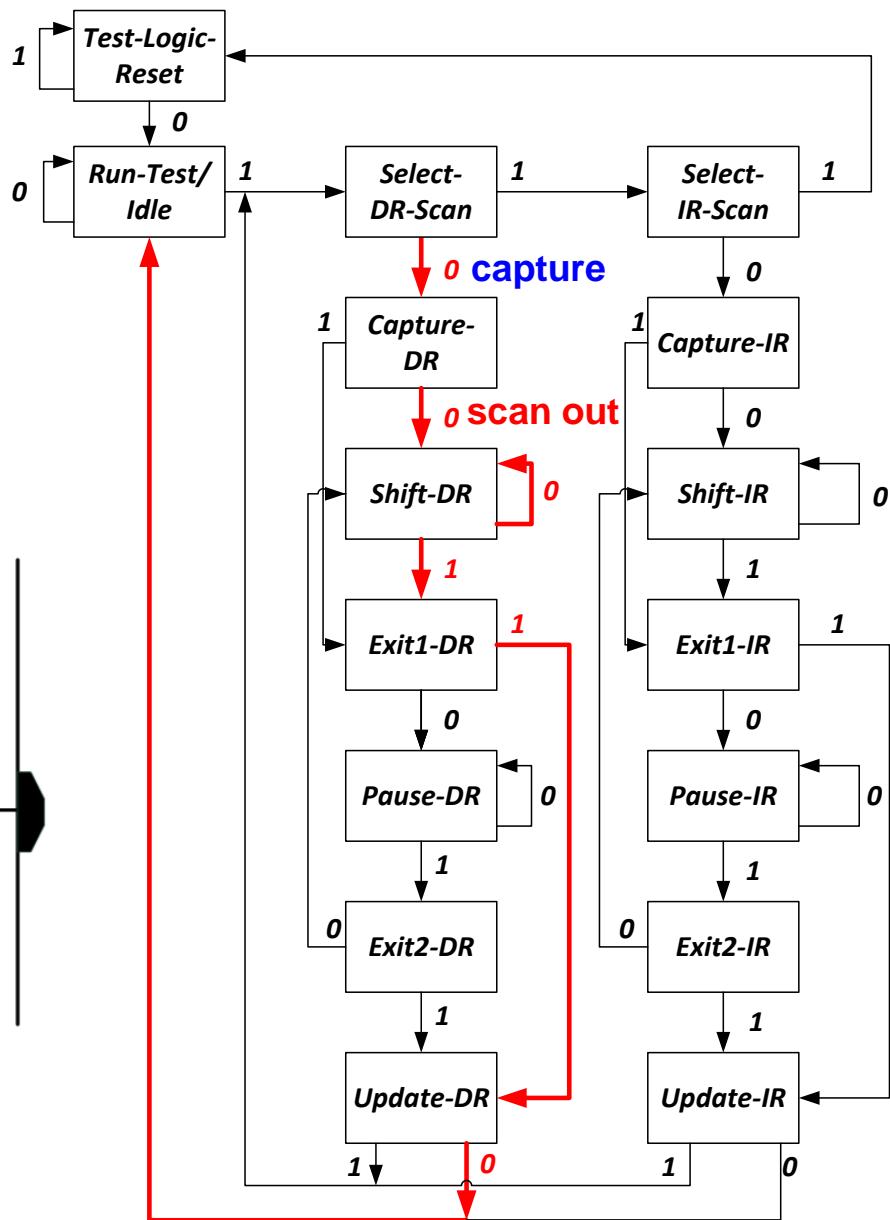
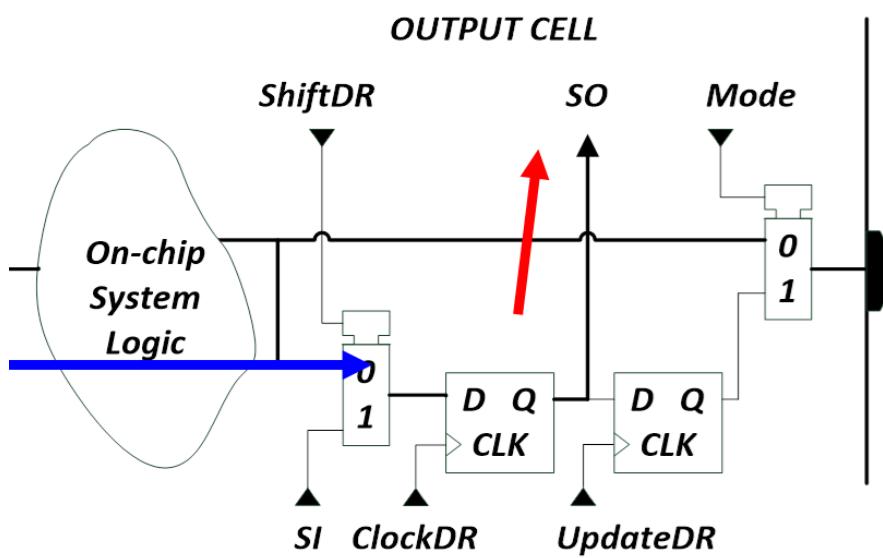
INTEST (3/4)

- After instruction loaded
 - ◆ Start from Run-test/Idle
 - TMS = 1 → 0 → 0 → 0...0 → 1 → 1 → 1



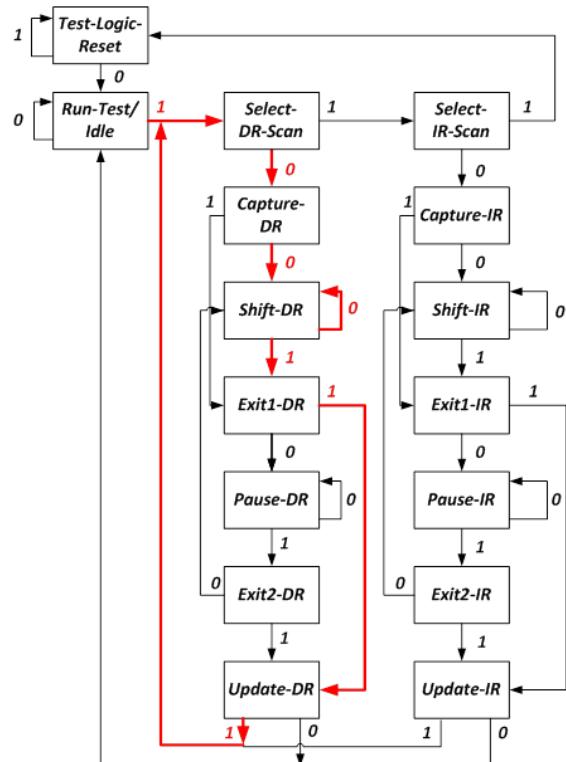
INTEST (4/4)

- TMS = $0 \rightarrow 0 \rightarrow 0 \dots 0 \rightarrow 1 \rightarrow 1 \rightarrow 0$
- Ends at Run-test/Idle

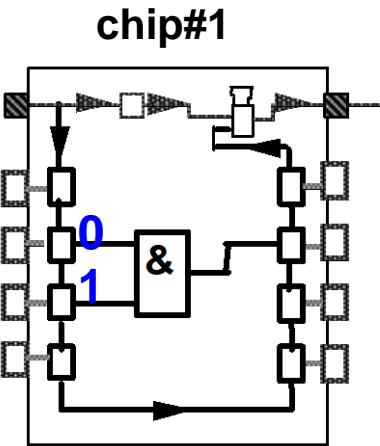


Quiz

		Scan in	Update Capture	Scan-out
TMS				
TDI				
TDO				
Final state	Capture-DR	Shift-DR		Run-test Idle

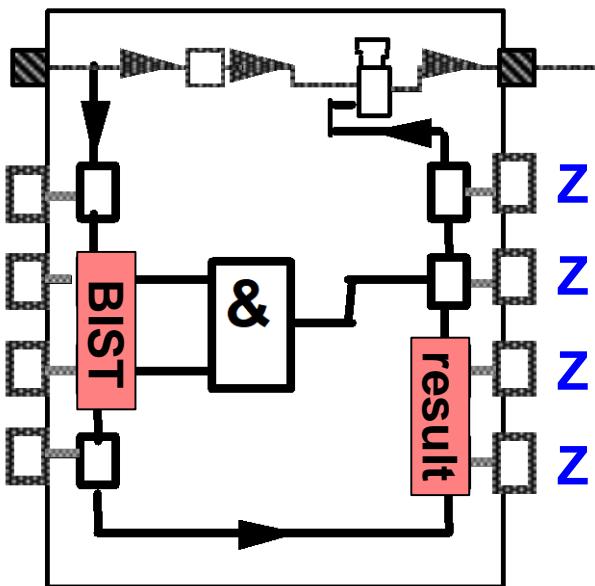


Q: Suppose we want to test AND gate by '10'. Please fill in blanks.
(assume instruction code already loaded)



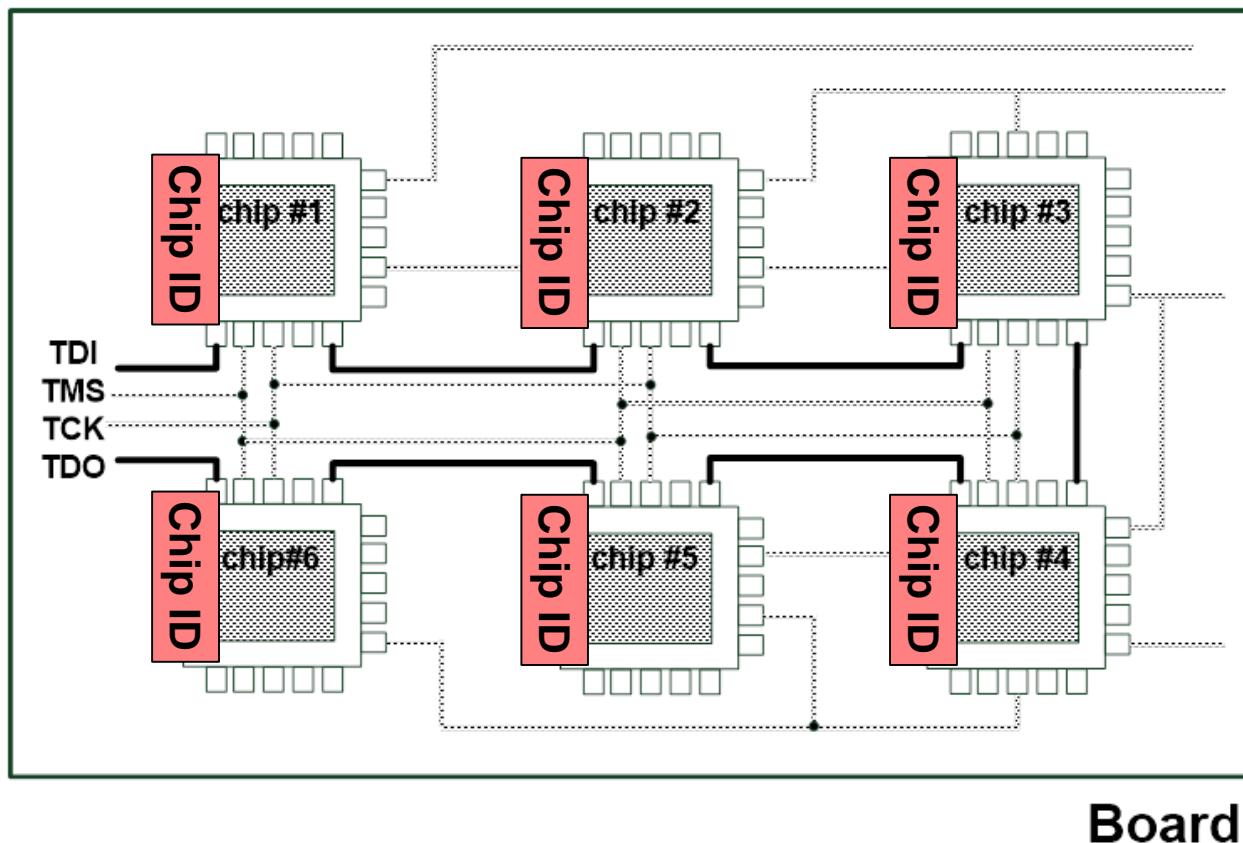
RUNBIST Instruction* not in exam

- Purpose: Run BIST commands
- To avoid random system logic outputs during BIST
 - ◆ (1) BSR controls system output pins. (PRELOAD), or
 - ◆ (2) Put all output BSR to high-impedance (Z)
- BIST results (PASS or FAIL) can be left in BSR or internal cell
 - ◆ Shift out through boundary scan chain



IDCODE Instruction* not in exam

- Purpose: Connects **chip ID register** serially between TDI and TDO
 - ◆ Read out chip ID
- Device ID standard by **JEDEC** (Joint Electron Device Engineering Council)

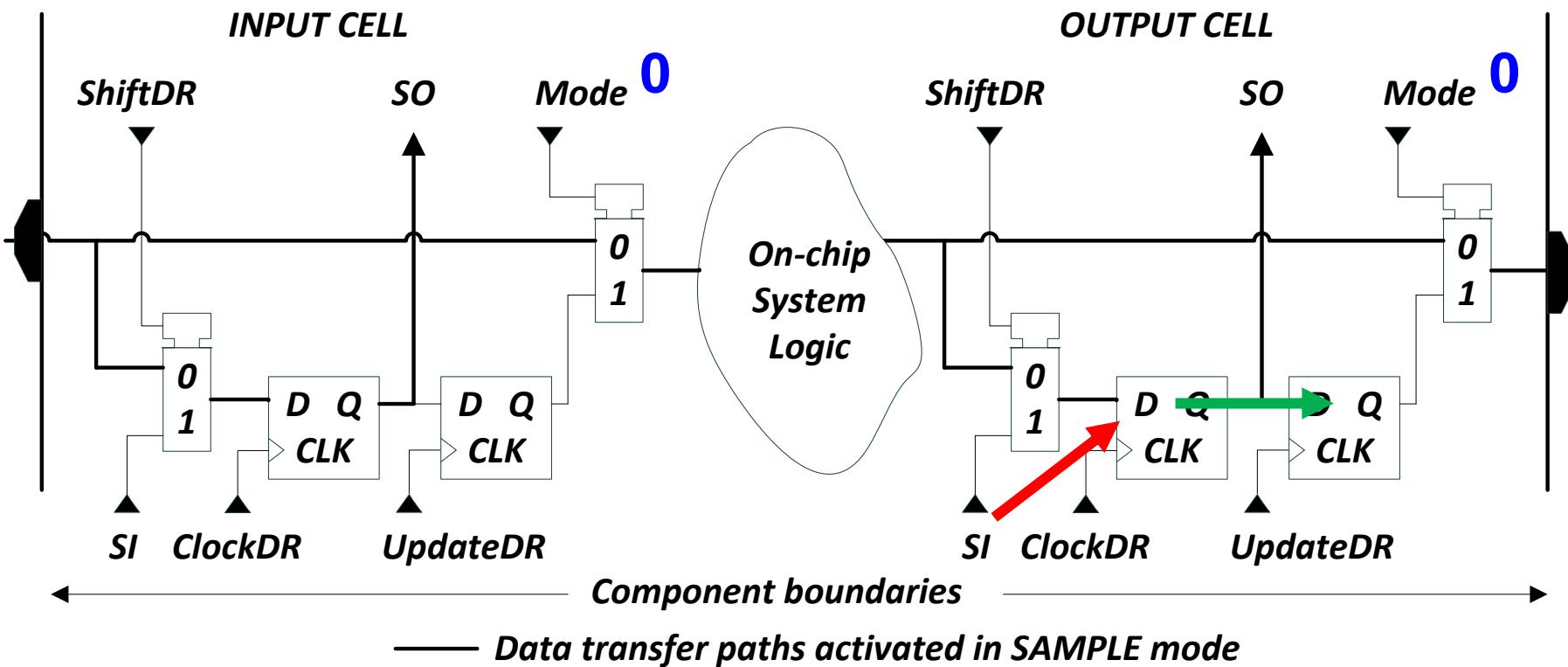


Conclusion

- JTAG IEEE 1149.1 standard
 - ◆ Boundary scan for board-level testing
- Components
 - ◆ TAP ports, TAP controller
 - ◆ Registers (BSR/BR/IR), Instruction decoder
- Instructions
 - ◆ Mandatory: EXTEST, BYPASS, SAMPLE/PRELOAD
 - ◆ Optional: INTEST, RUNBIST, IDCODE ...
- JTAG area overhead is small
 - ◆ Has been widely adopted by industry
 - ◆ Automatic compiler is widely available

FFT

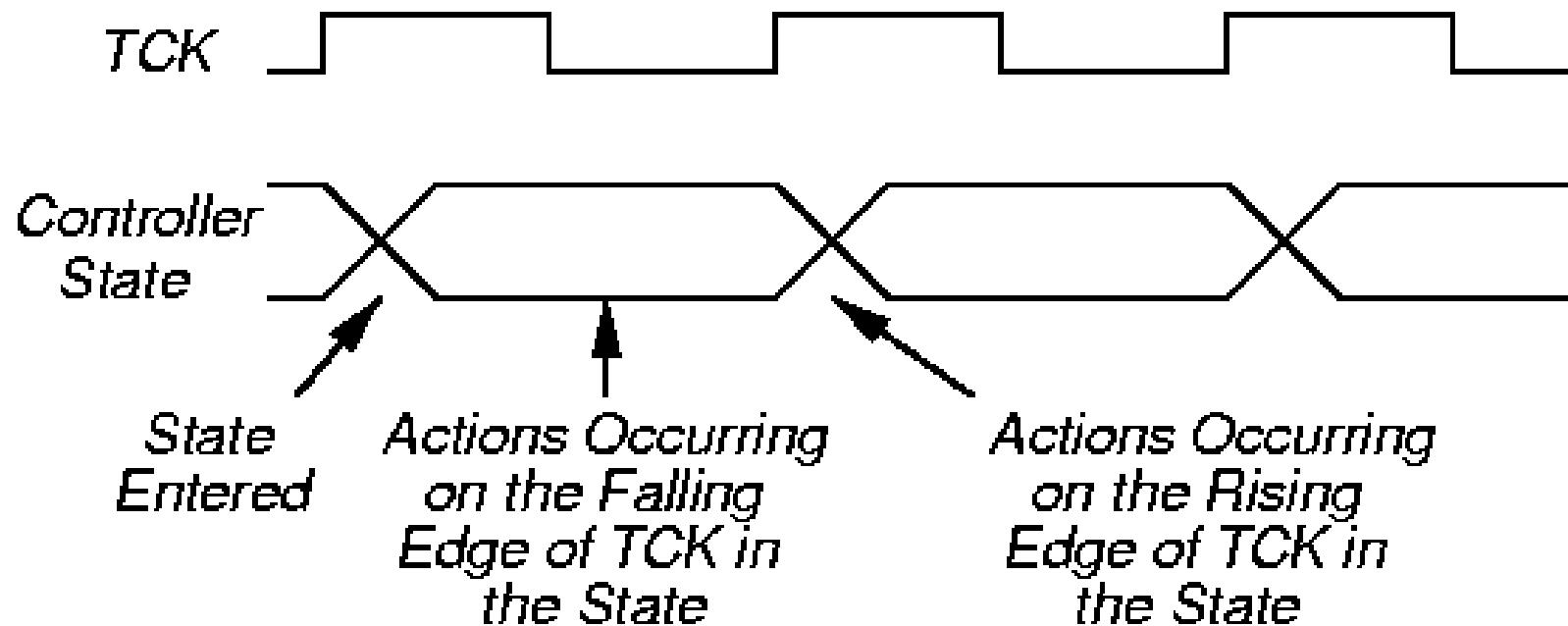
- Q1: INTEST is exactly the same as EXTEST, why?
- Q2: Why INTEST is optional, not mandatory?
- Q3: During PRELOAD, Why do we need to control system output?



Reference

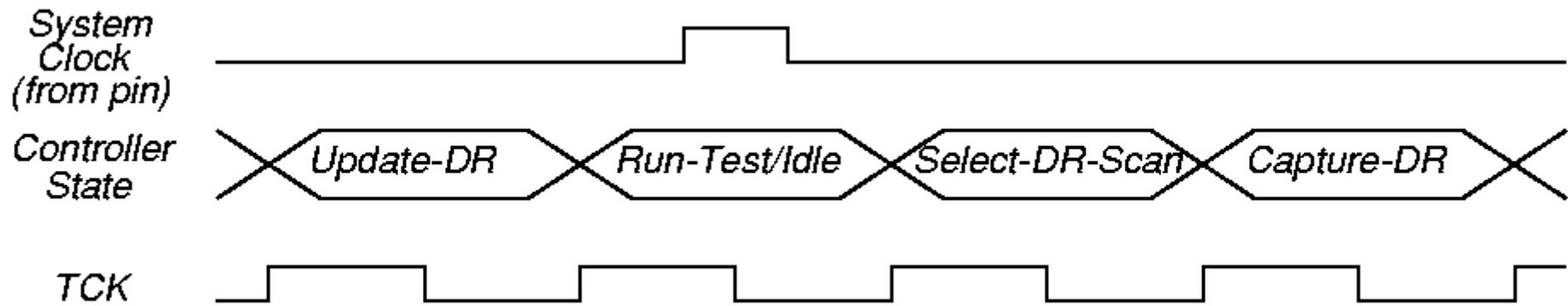
- **JTAG Verilog Code Example**
 - ◆ M. D. Ciletti, “Advance Digital Design with the Verilog HDL,” Prentice Hall, 2002, Ch11.
- K.P. Parker, *The Boundary Scan Handbook*, Springer.

Appendix: TAP controller timing

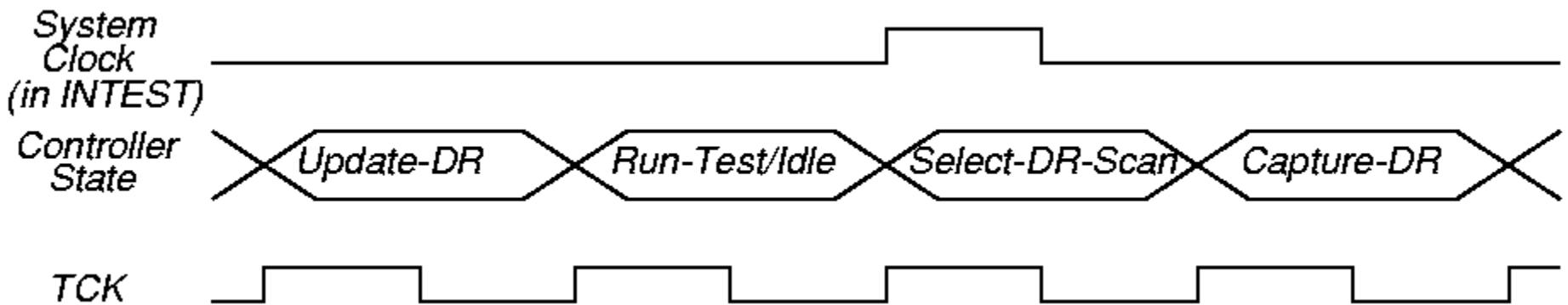


INTEST Instruction Clocks

■ Control of applied system clock during ***INTEST***



■ Use of **TCK** for on-chip system logic clock



CLAMP Instruction

- Purpose: Forces chip outputs to be driven by BSR
- Can bypass boundary scan chain by using one-bit Bypass Register
- May have to add RESET hardware to control on-chip system logic
 - ◆ so that it does not get damaged (by shorting 0's and 1's onto an internal bus, etc.)

