FPGA Design Flow

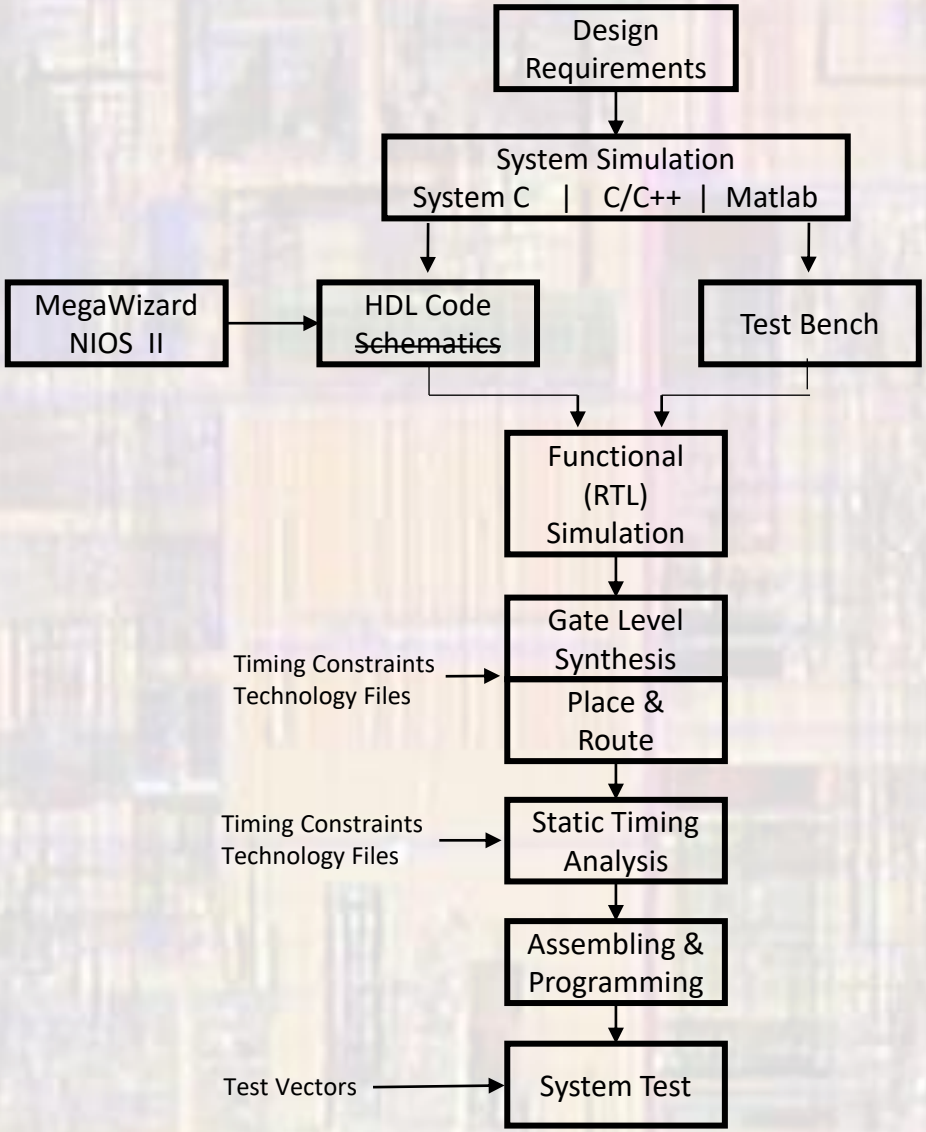
Last updated 7/14/23

FPGA Design Flow

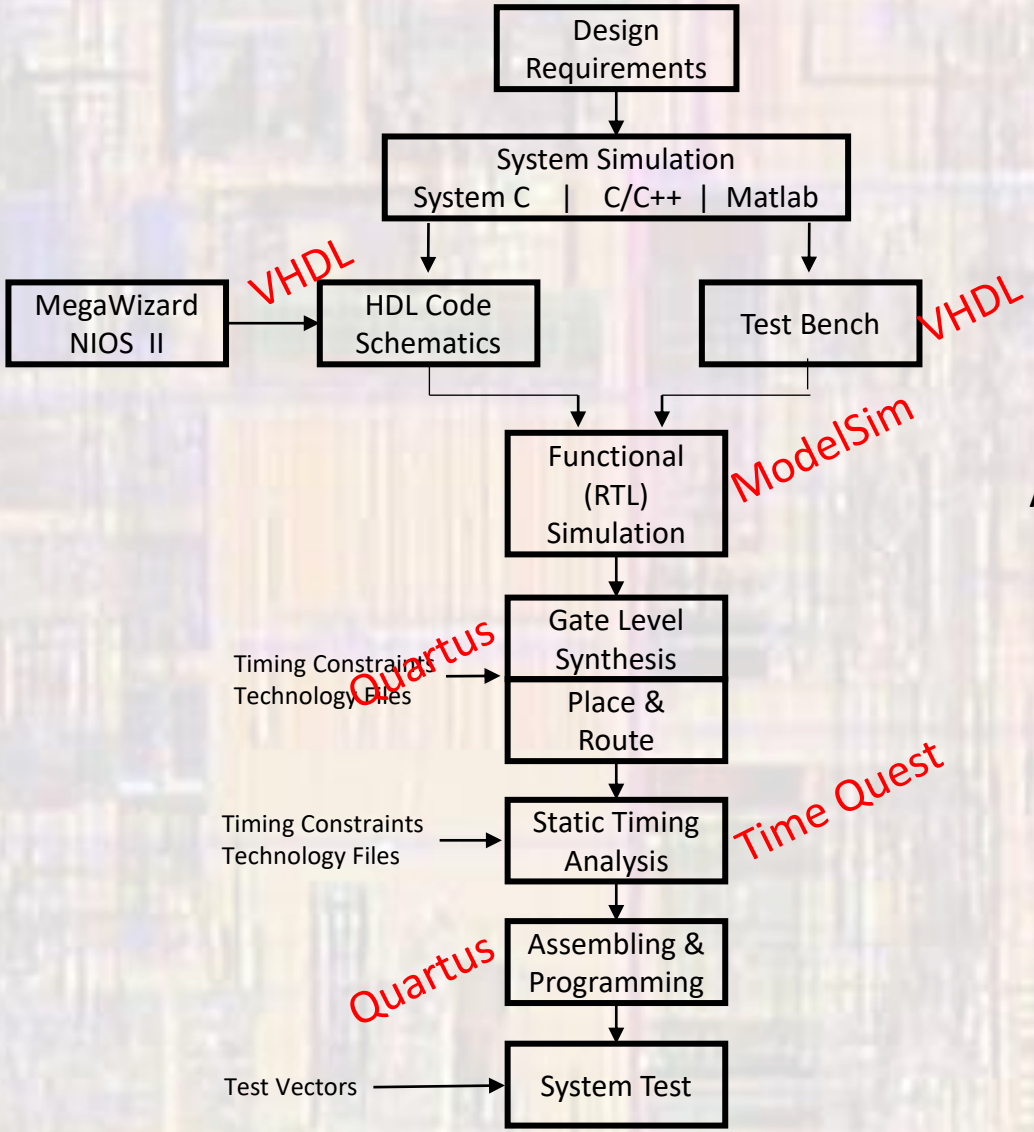
These slides outline the FPGA design flow used in this class

Upon completion: You should be able to describe each step of the design flow and identify the appropriate tools used in each step

FPGA Design Flow



FPGA Design Flow



Additional Tools:

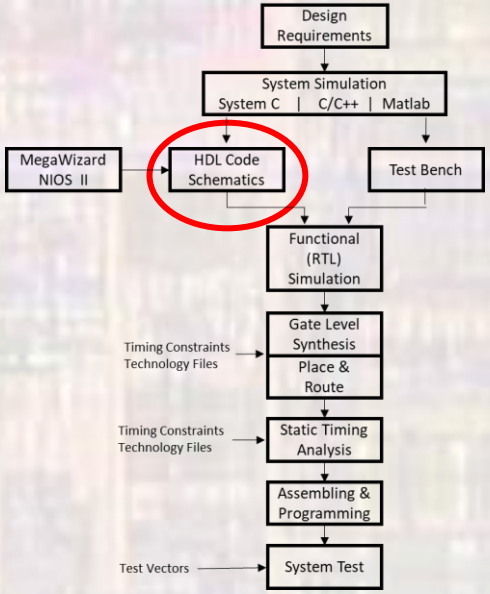
Design – SOPC Builder

Debug – Signal Tap

FPGA Design Flow

- Design Entry
  - Text entry
    - Hardware Description Language
    - VHDL , Verilog, System C, …
    - Hierarchical instantiation of blocks

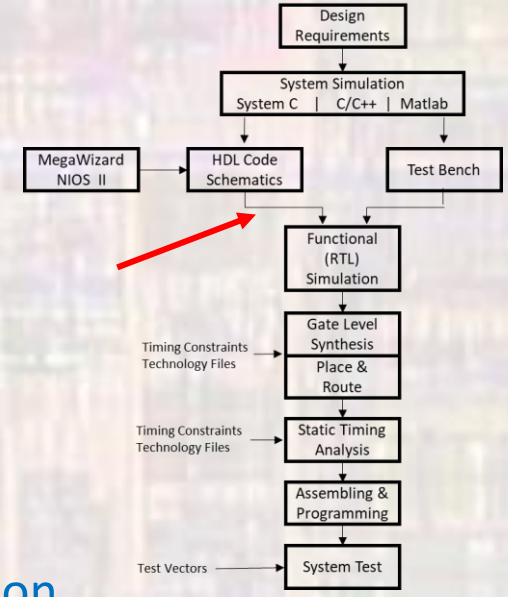
```
count: process(i_clk, i_rstb)
begin
   if(i_rstb = '0') then
      cnt_sig <= (others => '0');
   elsif(rising_edge(i_clk)) then
      if(i_dir = '0') then
         cnt_sig <= cnt_sig + 1;
      else
         cnt_sig <= cnt_sig - 1;
      end if;
   end if;
end process;
```



  - Schematic entry
    - Quartus Block Editor
      - Create bdf schematic files
    - Quartus Symbol Editor
      - Create / modify symbols for the block editor (bsf file)

FPGA Design Flow

- RTL Synthesis
  - Analyze VHDL
    - Processing -> Analyze Current File
    - Finds syntax errors
    - Does not check for synthesizability
  - Analysis and Elaboration
    - Processing -> Start -> Start Analysis and Elaboration
    - Finds syntax errors
    - Check for synthesizability
    - Creates RTL
      - Check for errors – especially unintended latches



FPGA Design Flow

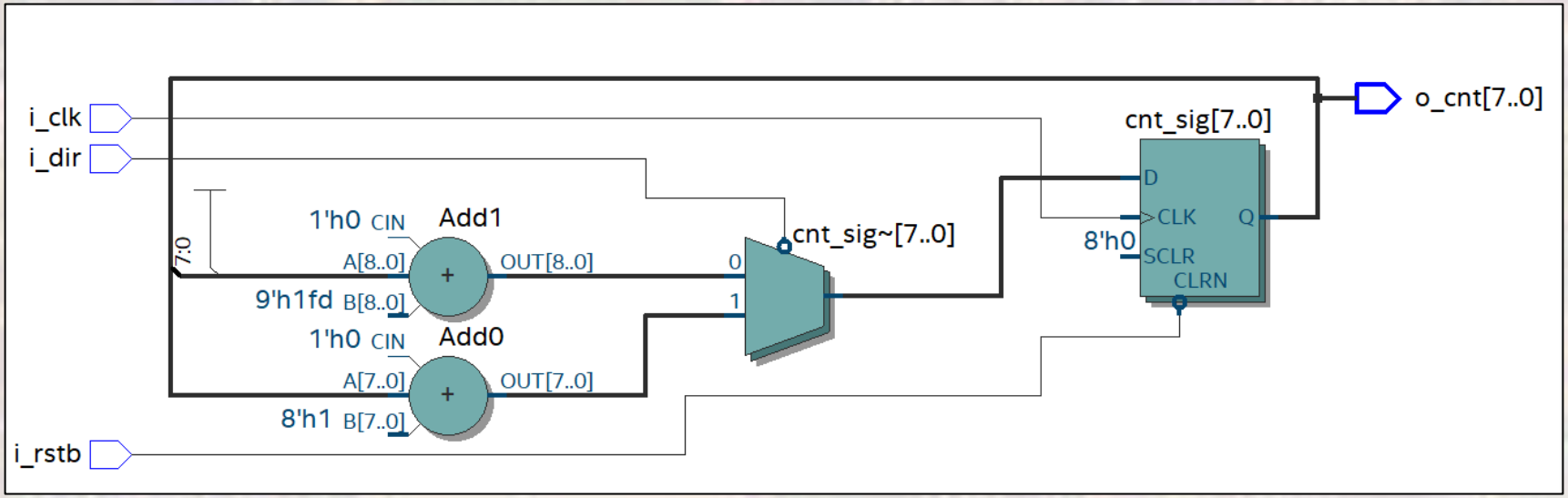
- RTL Synthesis
  - What is RTL
    - Register Transfer Level
    - Set of design abstractions (primitive elements) and the rules that govern input/output relationships
    - Describes the operation of registers and intermediate logic between registers
    - Abstractions range from NAND/NOR gates through adders/subtractors to memories
    - It is NOT a physical implementation
      - An adder primitive is a mathematical model used to describe the action of addition
      - It is not tied to any circuit implementation

FPGA Design Flow

- RTL Synthesis
  - View RTL
    - Tools-> Netlist Viewer -> RTL Viewer
    - Does this make sense?
  - View State Machines
    - Tools-> Netlist Viewer -> State Machine Viewer
    - Does this make sense?

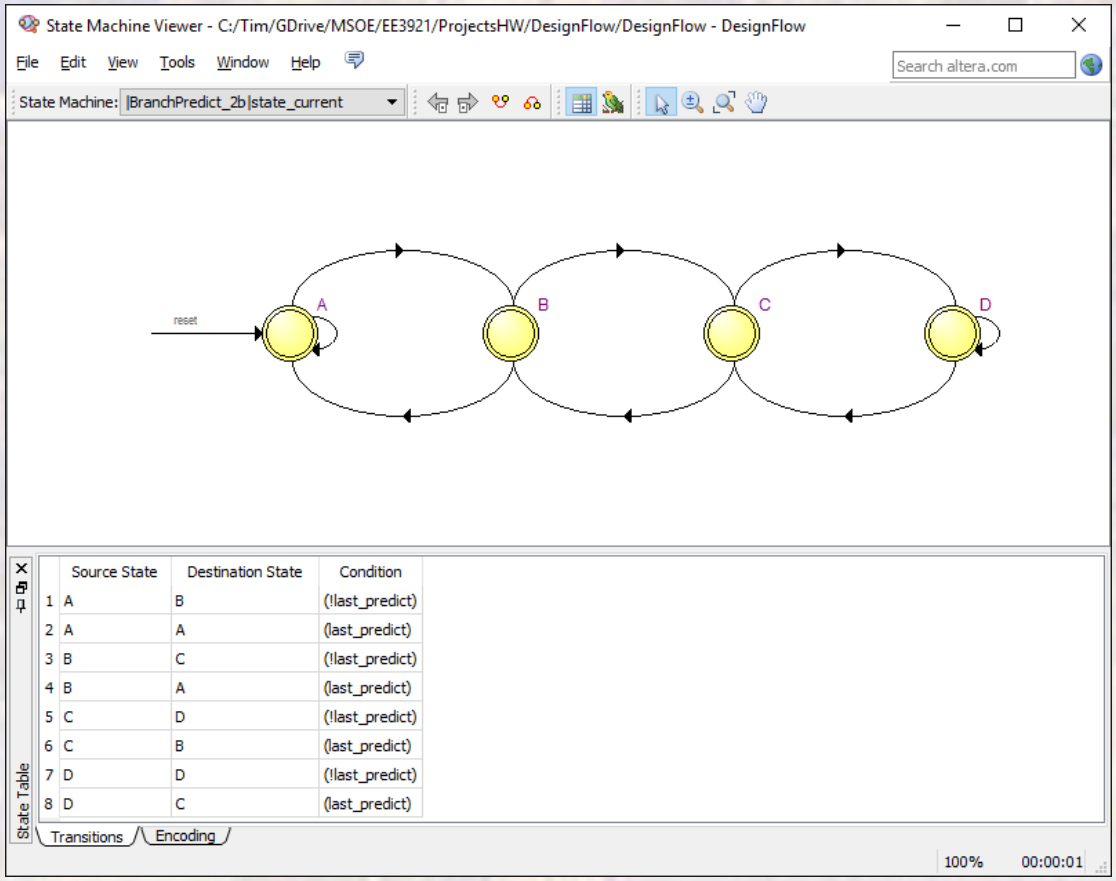
FPGA Design Flow

- RTL Synthesis
  - View RTL
    - Up down counter



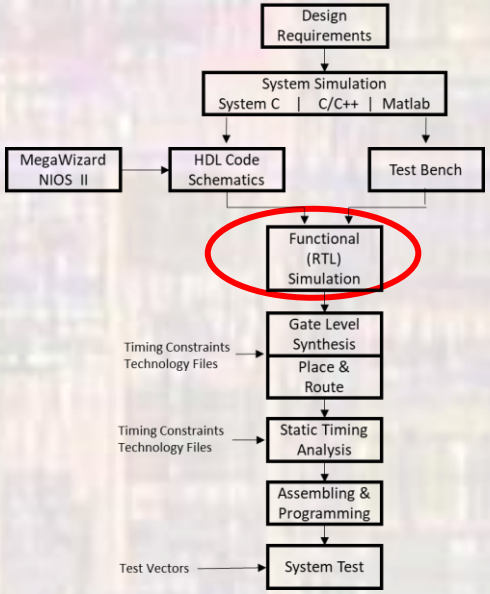
FPGA Design Flow

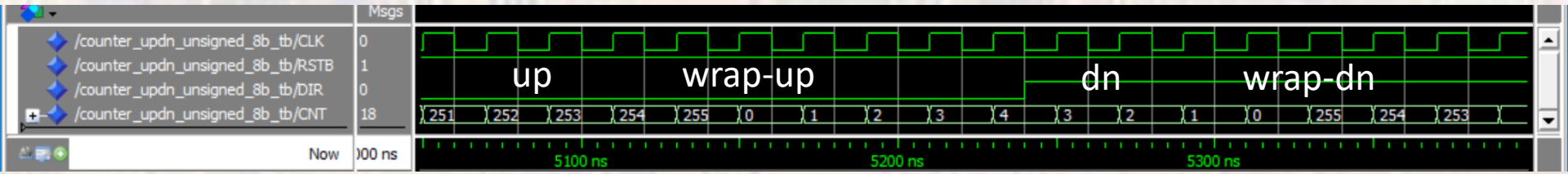
- RTL Synthesis
  - View State Machine
    - Branch predictor



FPGA Design Flow

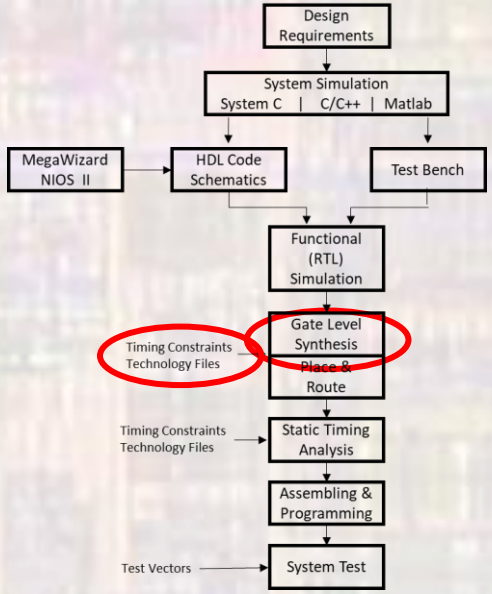
- Functional Simulation
  - ModelSim via Quartus
    - Tools -> Run Simulation Tool-> RTL Simulation
  - ModelSim stand alone
  - RTL simulations uses the mathematical abstractions supported by the tool to simulate the actions of the circuit
    - There is NO defined circuit information in these simulations





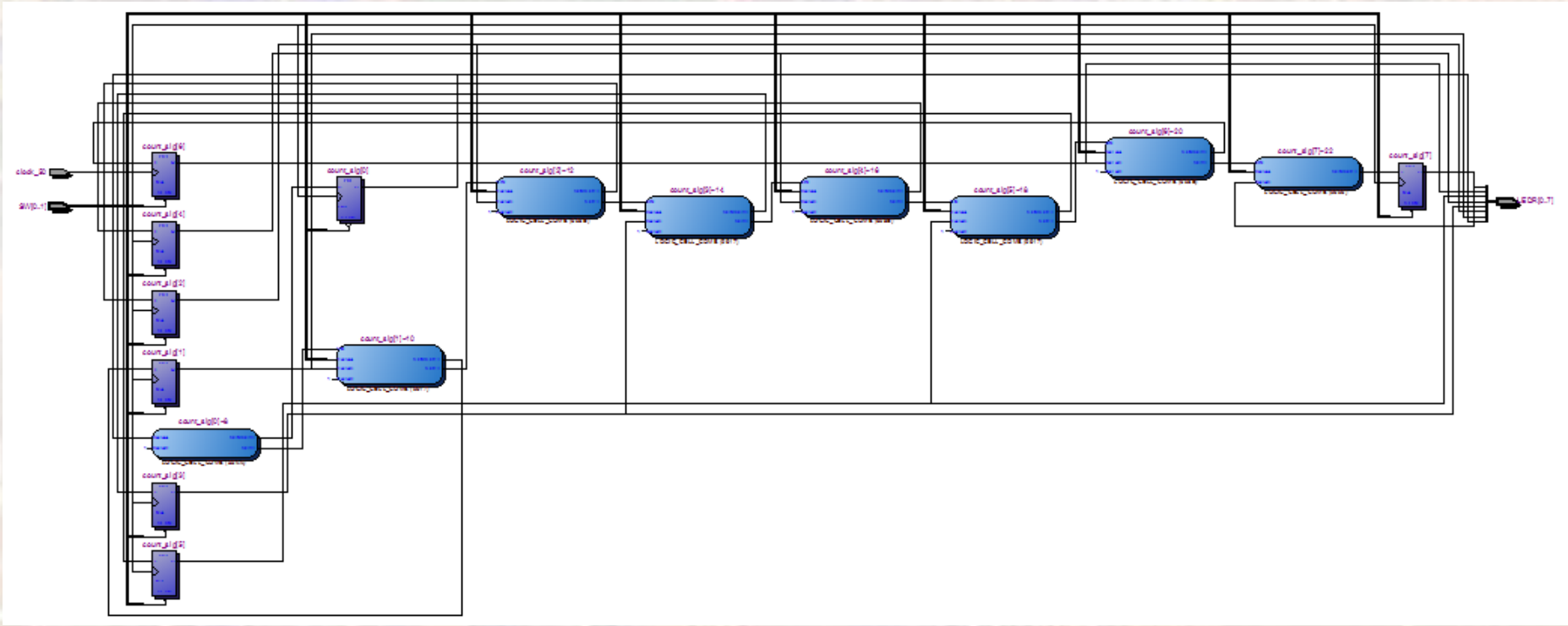
FPGA Design Flow

- Gate Level Implementation
  - Analysis and Synthesis
    - Processing -> Start -> Analysis and Synthesis
    - Maps the RTL to non-specific FPGA blocks
  - Partition and Merge
    - Processing -> Start -> Partition and Merge
    - Allows for incremental synthesis
  - Optional Gate Level Simulation
    - ModelSim via Quartus
    - Tools -> Run Simulation Tool-> Gate Level Simulation
    - New work directory : gate_work



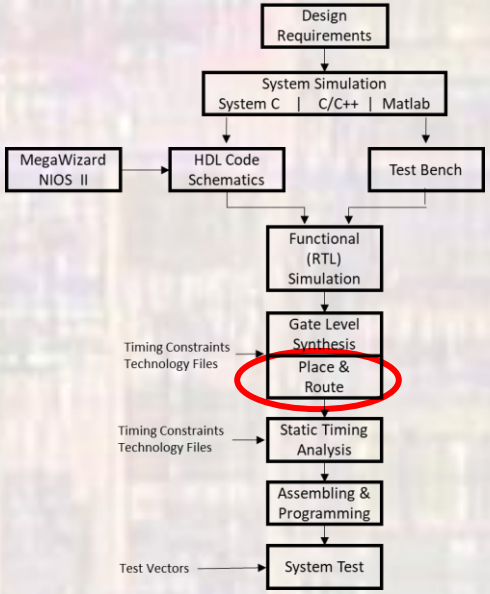
FPGA Design Flow

- Gate Level Implementation
  - Technology Map Viewer – Post Mapping
    - Up/Down Counter



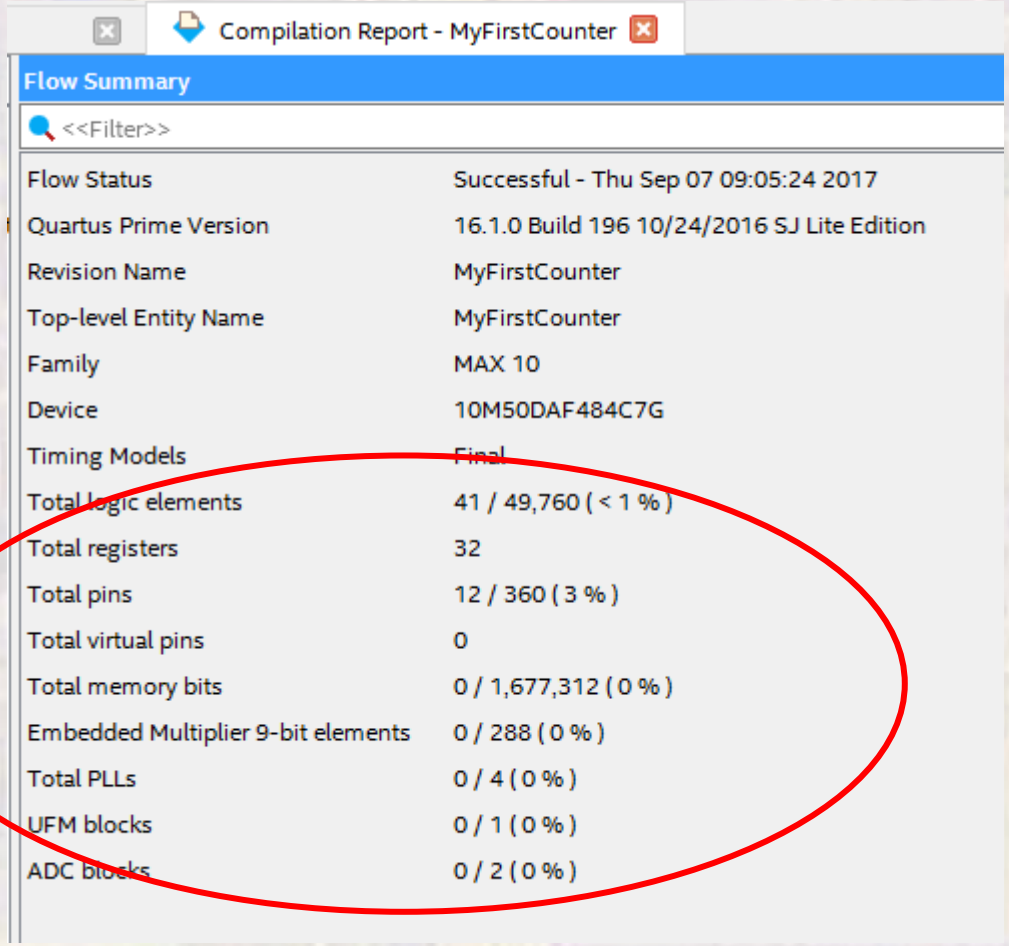
FPGA Design Flow

- FPGA Implementation
  - Timing Constraints
    - Load via TimeQuest
  - Fitter
    - Processing -> Start -> Start Fitter
    - Maps the generalized gate level logic to specific FPGA blocks
    - Accounts for loading and timing constraints
  - Chip Planner
    - Tools -> Chip Planner
    - View the physical implementation
    - Cross Probe via Locate -> Locate in …



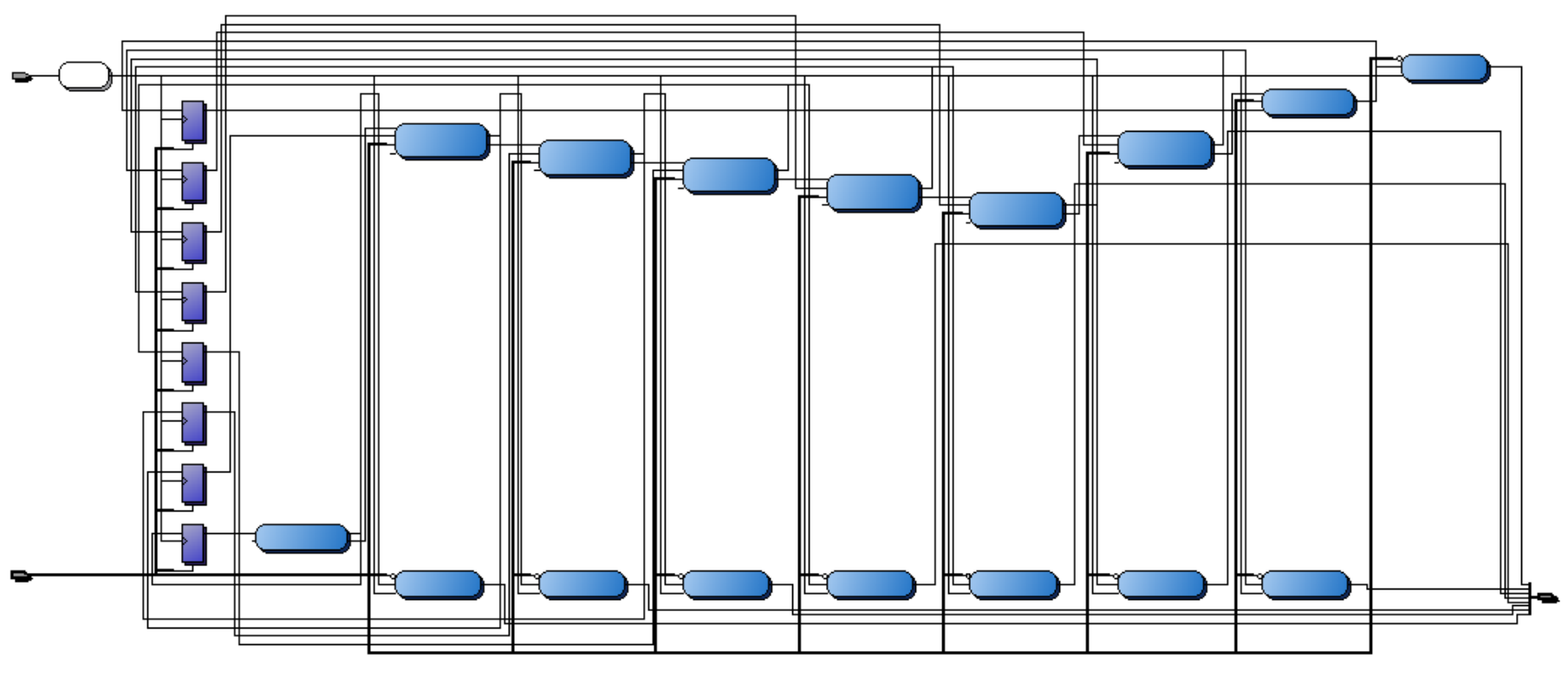
FPGA Design Flow

- FPGA Implementation
  - Fitter – Resource Usage



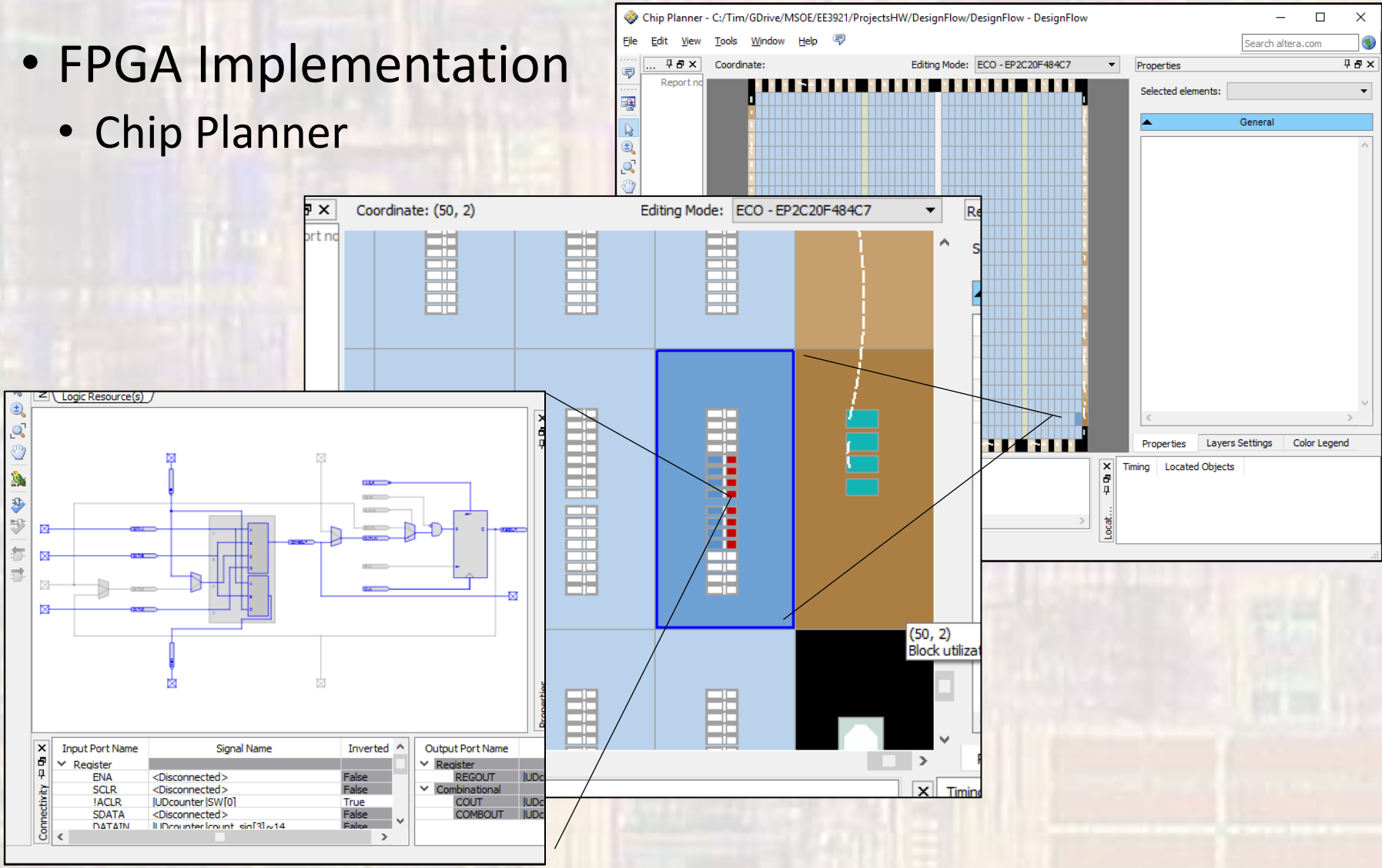
FPGA Design Flow

- FPGA Implementation
  - Technology Map Viewer – Post Fitting
    - Up/Down Counter



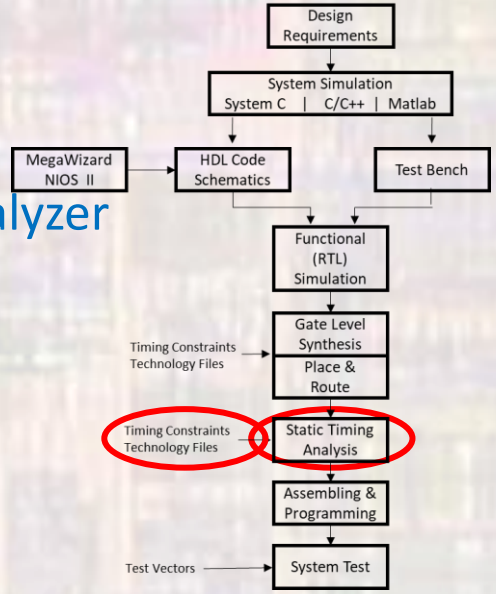
FPGA Design Flow

- FPGA Implementation
  - Chip Planner



FPGA Design Flow

- FPGA Implementation
  - Static Timing Analysis
    - Processing -> Start -> Start TimeQuest Timing Analyzer
    - Run automatically with the fitter
    - Results are saved in a report file
      - *myDesign*.sta.rpt
    - Runs across process, temperature and voltage variations
      - Fast/typ/slow process
      - High/typ/low temp
      - High/typ/low voltage



FPGA Design Flow

- FPGA Implementation
  - Static Timing Analysis
    - Positive Slack - good
    - Negative Slack – bad

DesignFlow.sta.rpt - Notepad

File Edit Format View Help

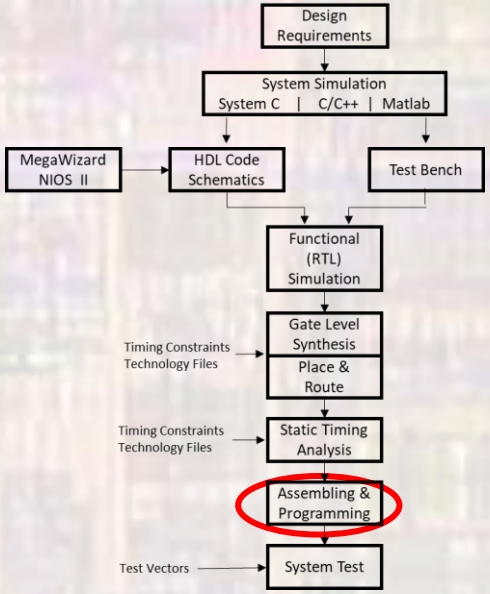
```
; clock_50 ; 1.666 ; 0.000         ;
+----------+-------+---------------+


+---------------------------------------+
; Slow Model Minimum Pulse Width Summary ;
+----------+-------+---------------------+
; Clock    ; Slack ; End Point TNS       ;
+----------+-------+---------------------+
; clock_50 ; 8.889 ; 0.000               ;
+----------+-------+---------------------+


+-------------------------------------------------------------------------------
; Slow Model Setup: 'clock_50'
+--------+----------------------------+----------------------------+-------------
; Slack  ; From Node                  ; To Node                    ; Launch Clock
+--------+----------------------------+----------------------------+-------------
; 11.000 ; count_sig[3]               ; LEDR[3]                    ; clock_50
; 11.010 ; count_sig[5]               ; LEDR[5]                    ; clock_50
; 11.010 ; count_sig[6]               ; LEDR[6]                    ; clock_50
; 11.016 ; count_sig[2]               ; LEDR[2]                    ; clock_50
; 11.017 ; count_sig[0]               ; LEDR[0]                    ; clock_50
; 11.022 ; count_sig[4]               ; LEDR[4]                    ; clock_50
; 11.022 ; count_sig[7]               ; LEDR[7]                    ; clock_50
; 11.036 ; count_sig[1]               ; LEDR[1]                    ; clock_50
; 14.234 ; SW[1]                      ; count_sig[7]               ; clock_50
; 14.424 ; SW[1]                      ; count_sig[4]               ; clock_50
; 14.771 ; SW[1]                      ; count_sig[6]               ; clock_50
; 14.832 ; SW[1]                      ; count_sig[2]               ; clock_50
```

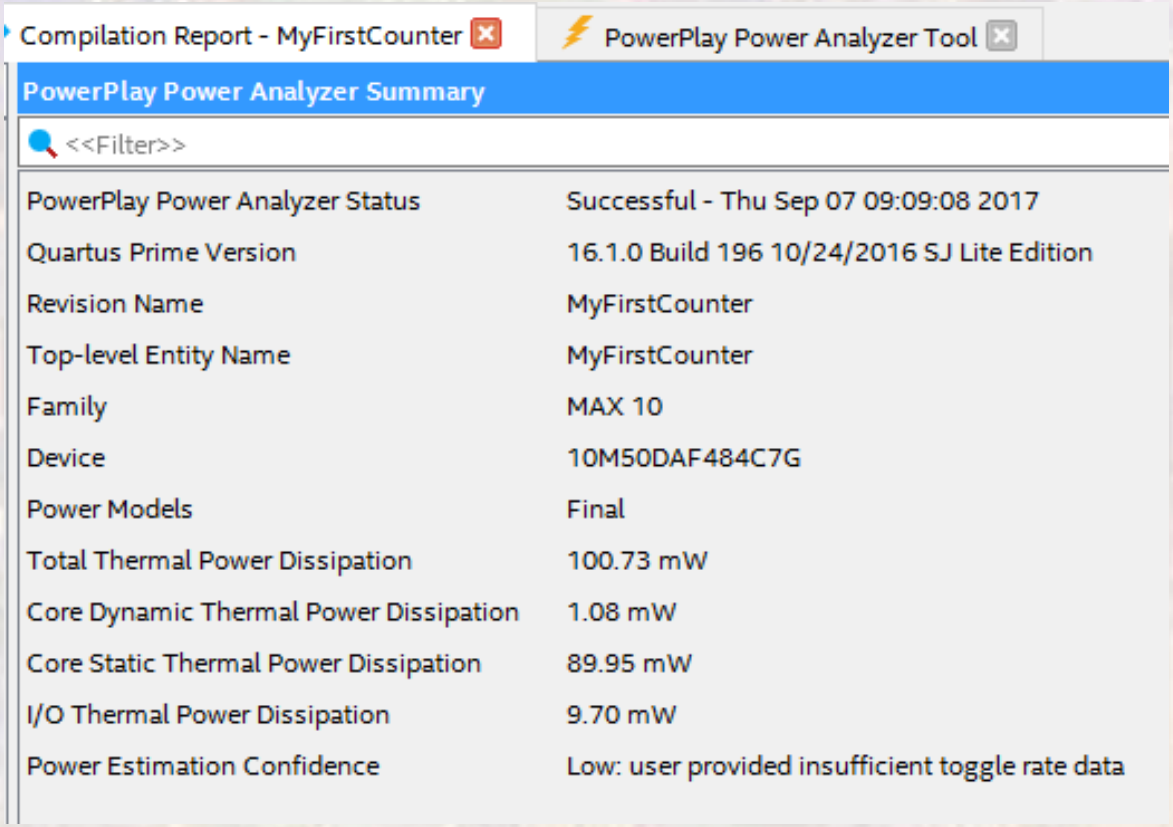
FPGA Design Flow

- FPGA Implementation
  - Assembler
    - Processing -> Start -> Start Assembler
    - Creates the programming file
    - Prepares for additional power analysis
  - Programming
    - Tools -> Programmer



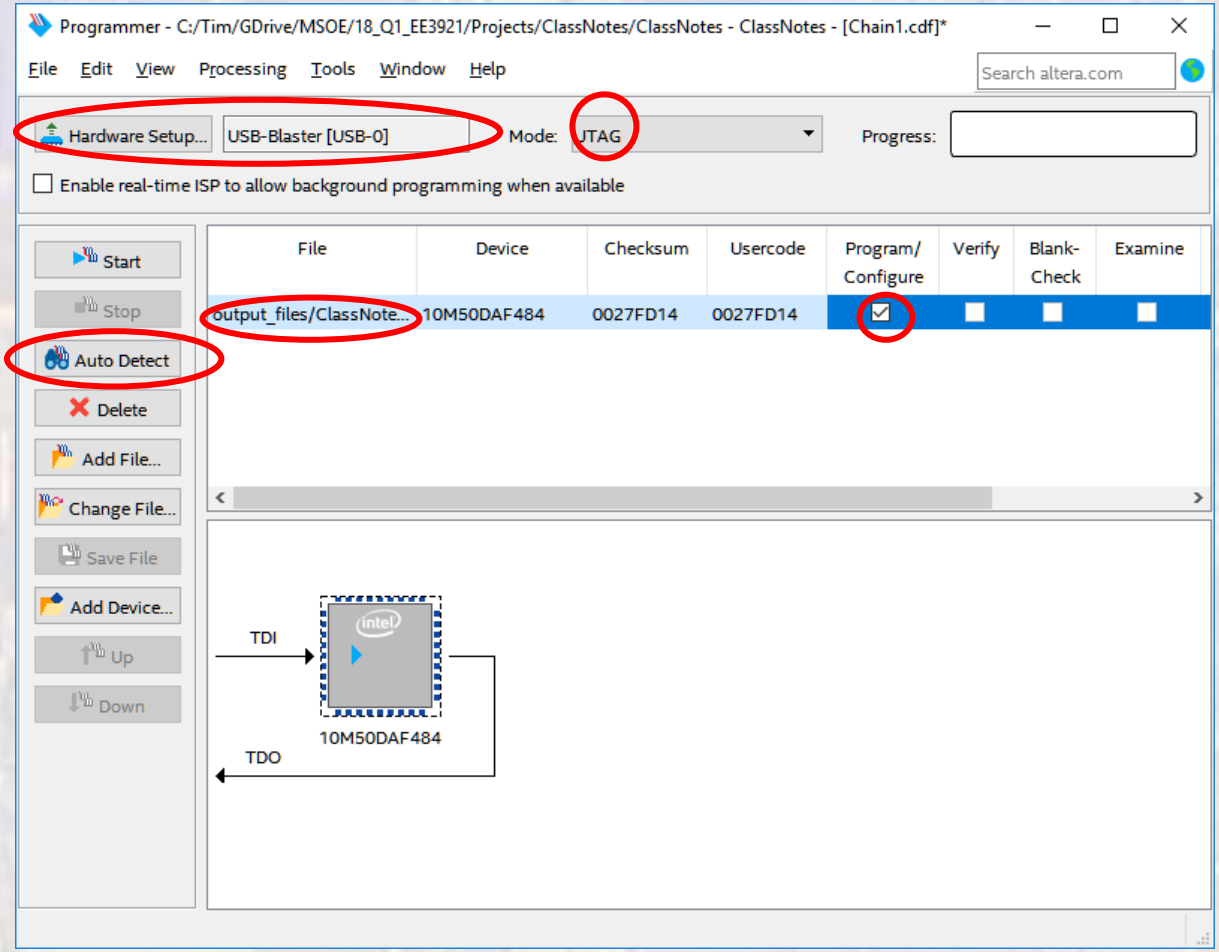
FPGA Design Flow

- FPGA Implementation
  - Assembler
    - Processing -> PowerPlay Power Analyzer Tool



FPGA Design Flow

- FPGA Implementation
  - Programmer



FPGA Design Flow

- FPGA Implementation
  - Programmer