

# FPGA Design Flow

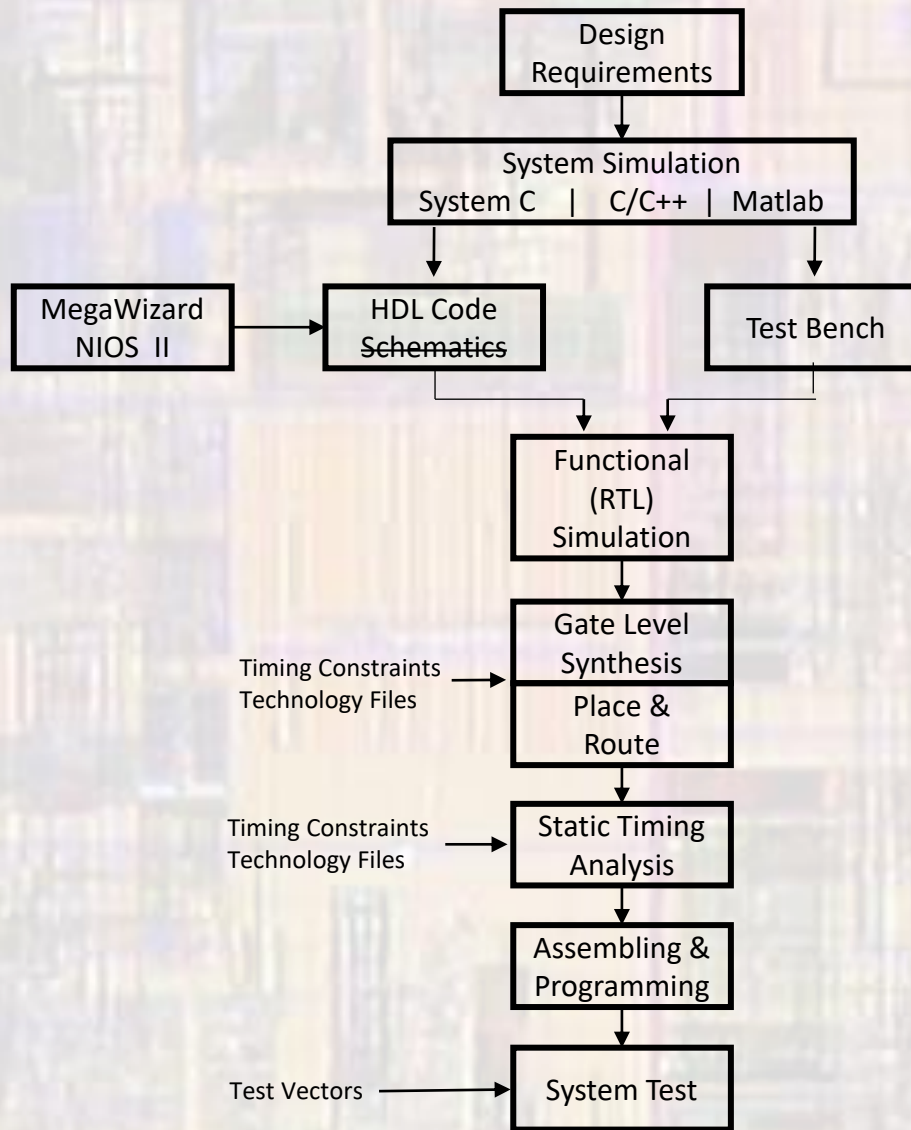
Last updated 7/14/23

# FPGA Design Flow

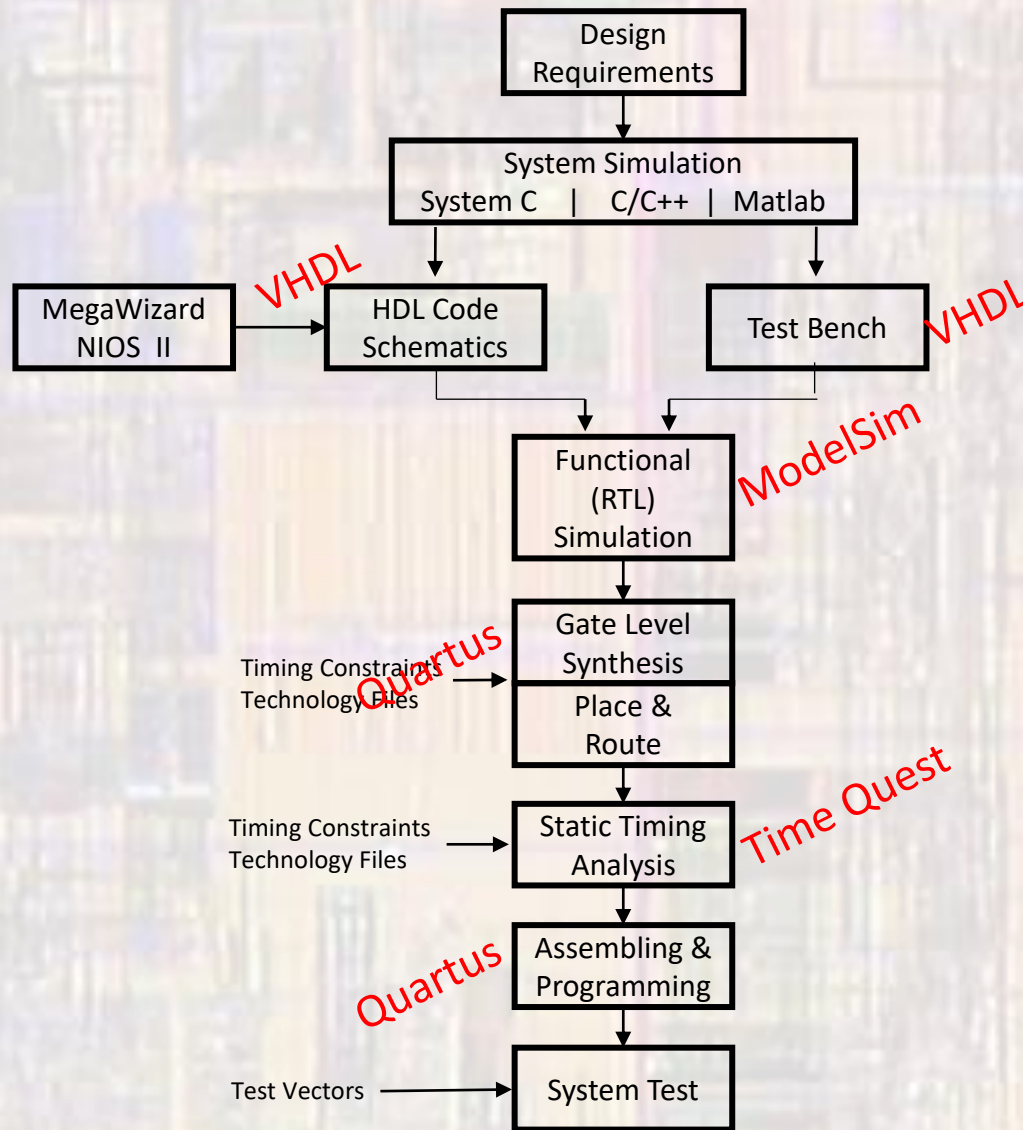
These slides outline the FPGA design flow used in this class

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

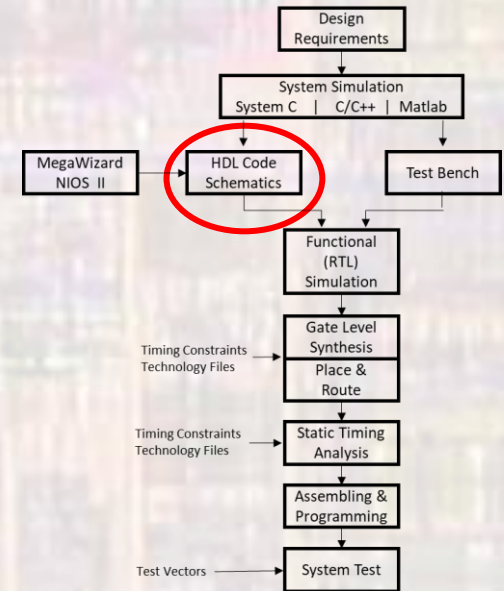
- Text entry

- 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

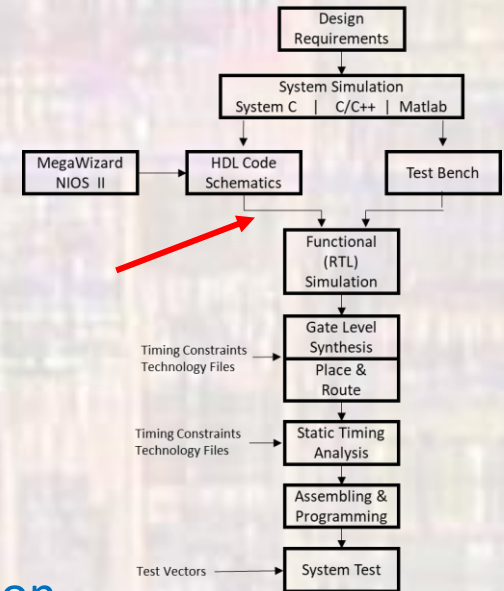
- RTL Synthesis

- 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

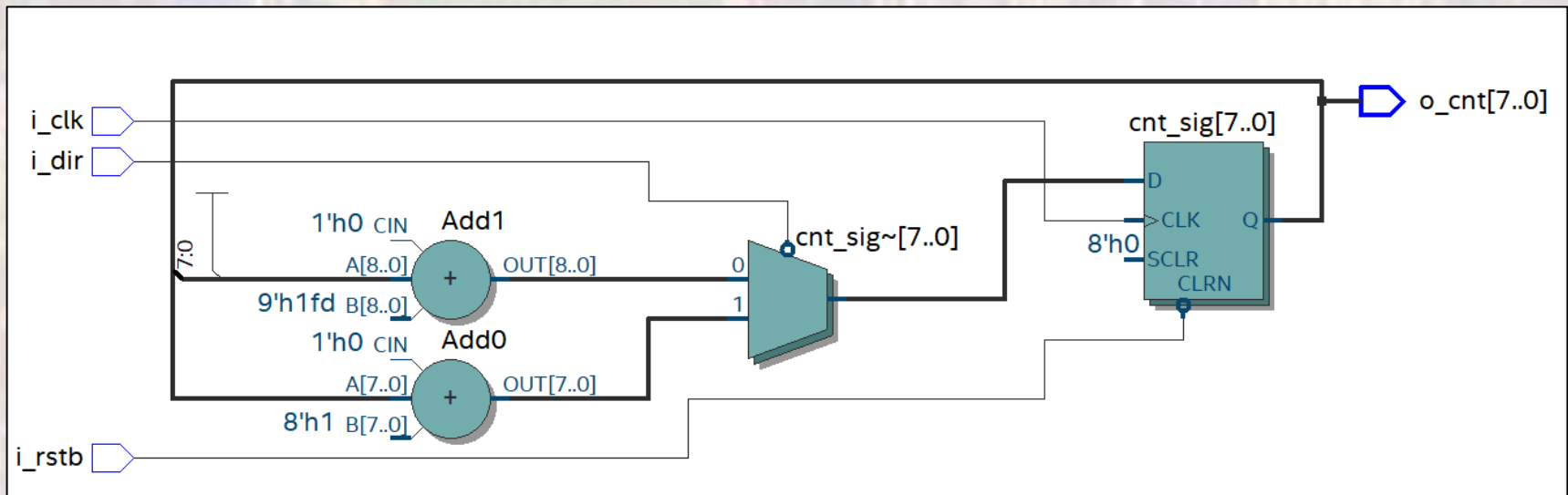
# FPGA Design Flow

- 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?



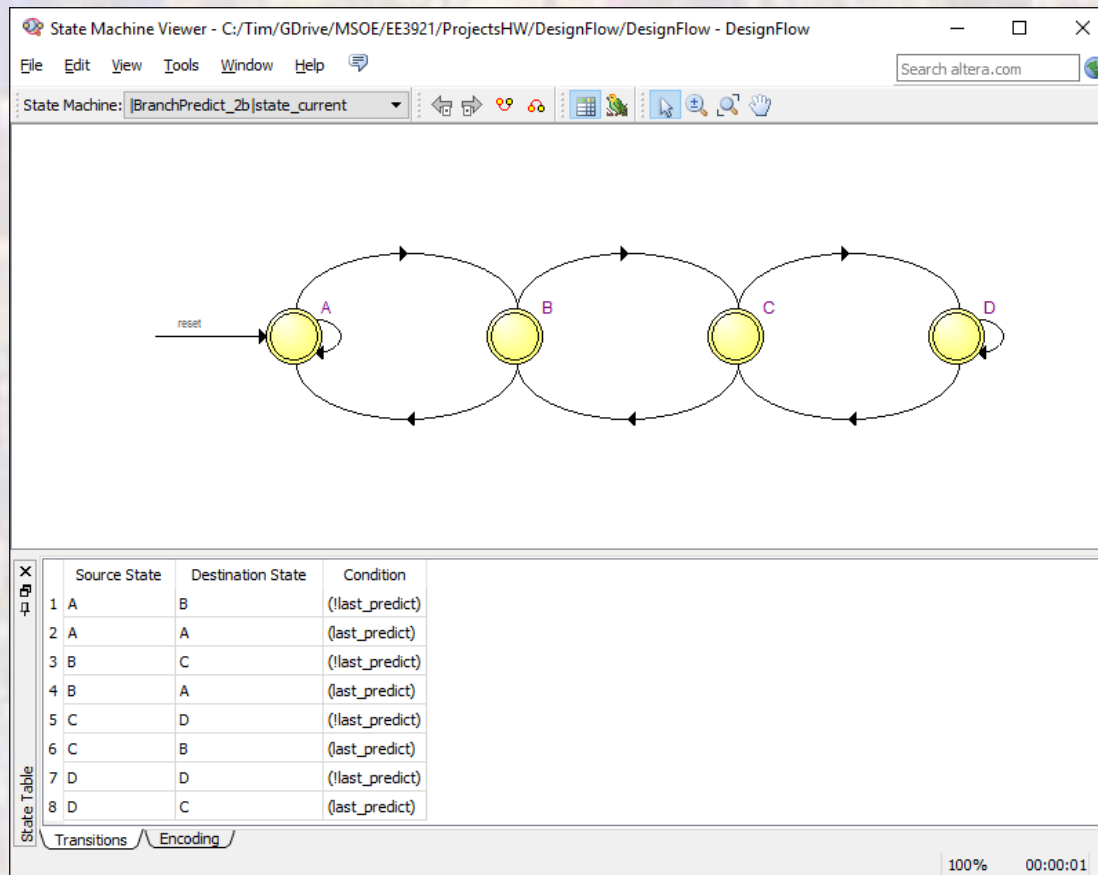
# FPGA Design Flow

- RTL Synthesis
  - View RTL
    - Up down counter



# FPGA Design Flow

- RTL Synthesis
  - View State Machine
    - Branch predictor



# FPGA Design Flow

- Functional Simulation

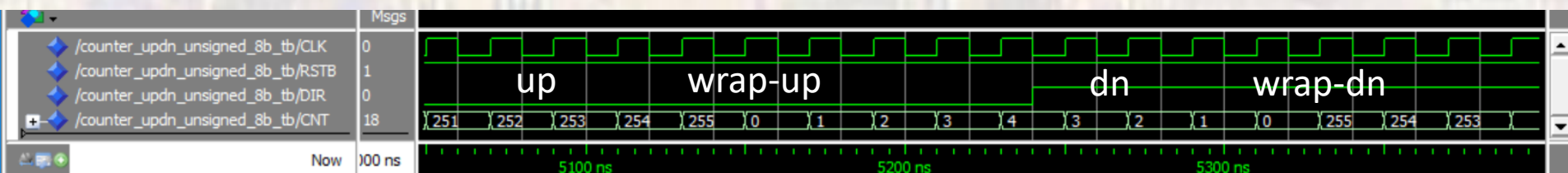
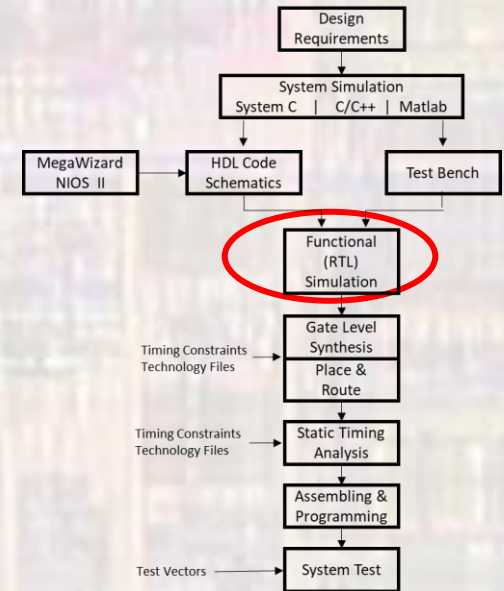
- ModelSim via Quartus

- Tools -> Run Simulation Tool-> RTL Simulation

- ModelSim stand alone

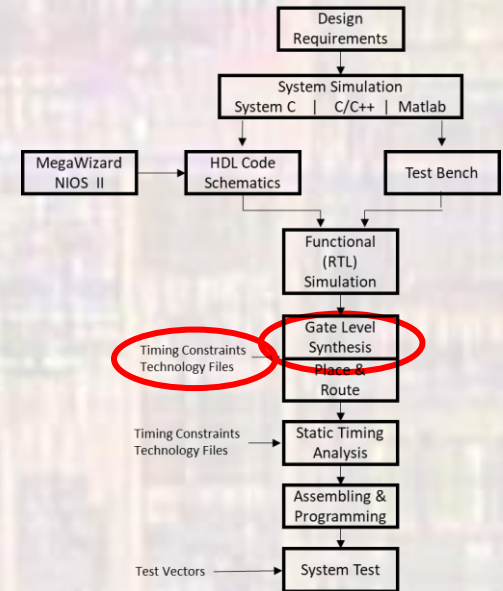
- RTL simulations uses the mathematical abstractions supported by the tool to simulate the actions of the circuit

- There is NO defined circuit information in these simulations



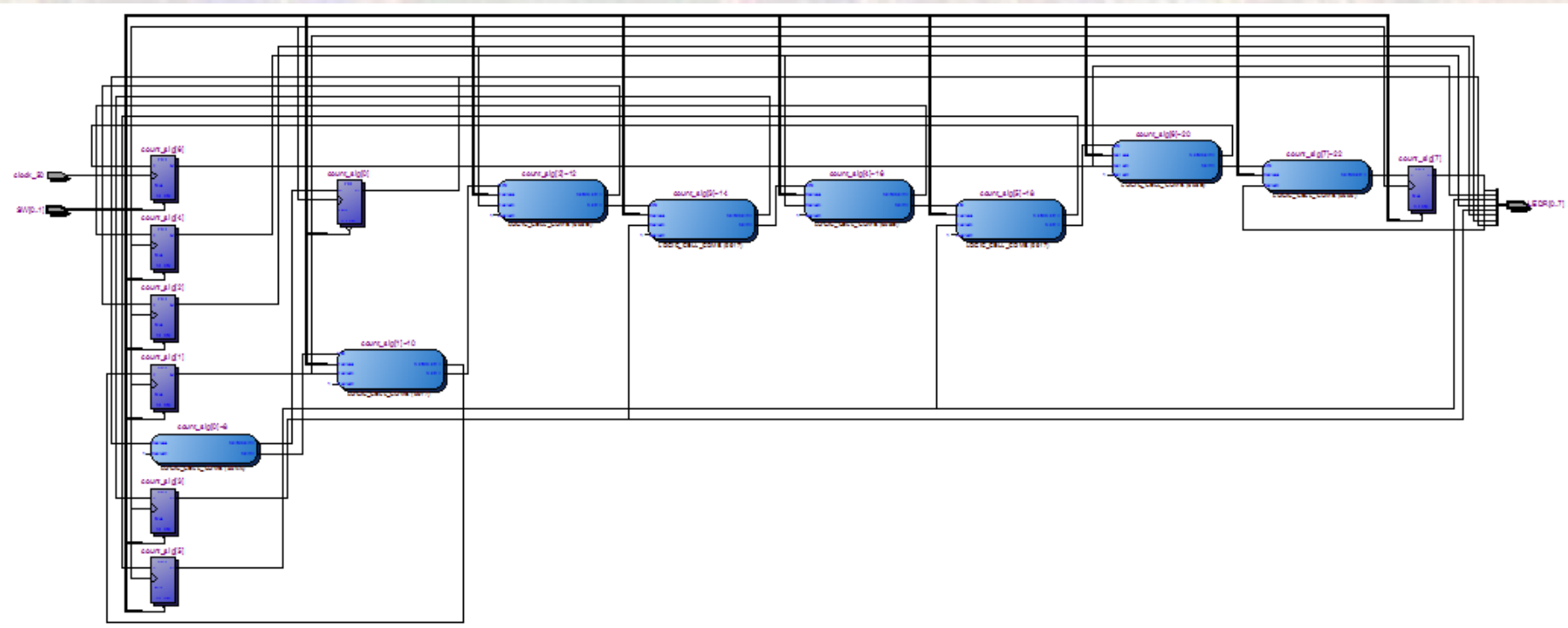
# FPGA Design Flow

- 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



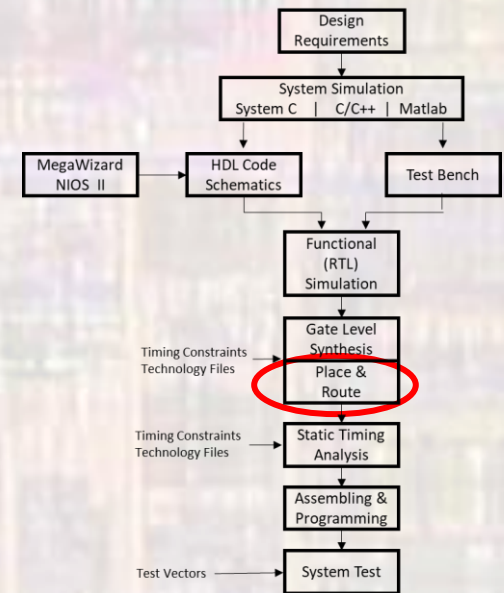
# FPGA Design Flow

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



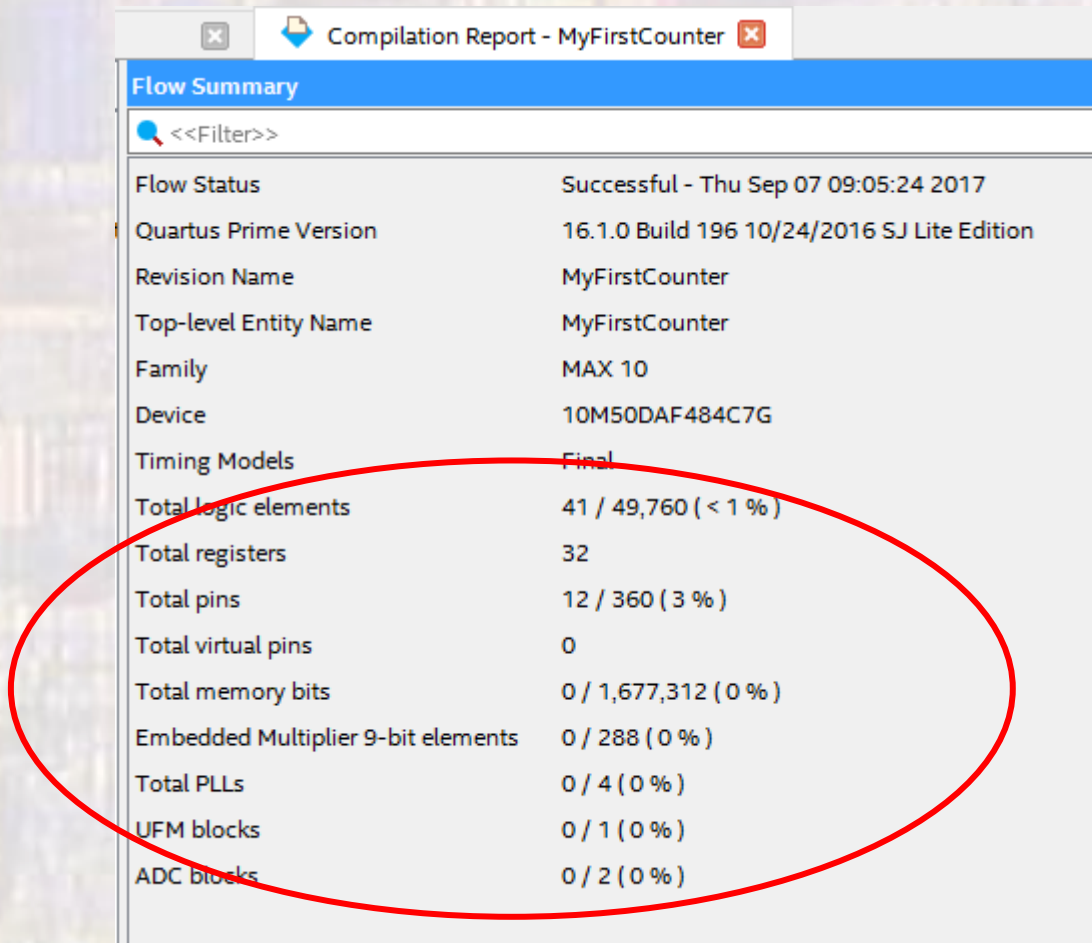
# FPGA Design Flow

- 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



Compilation Report - MyFirstCounter

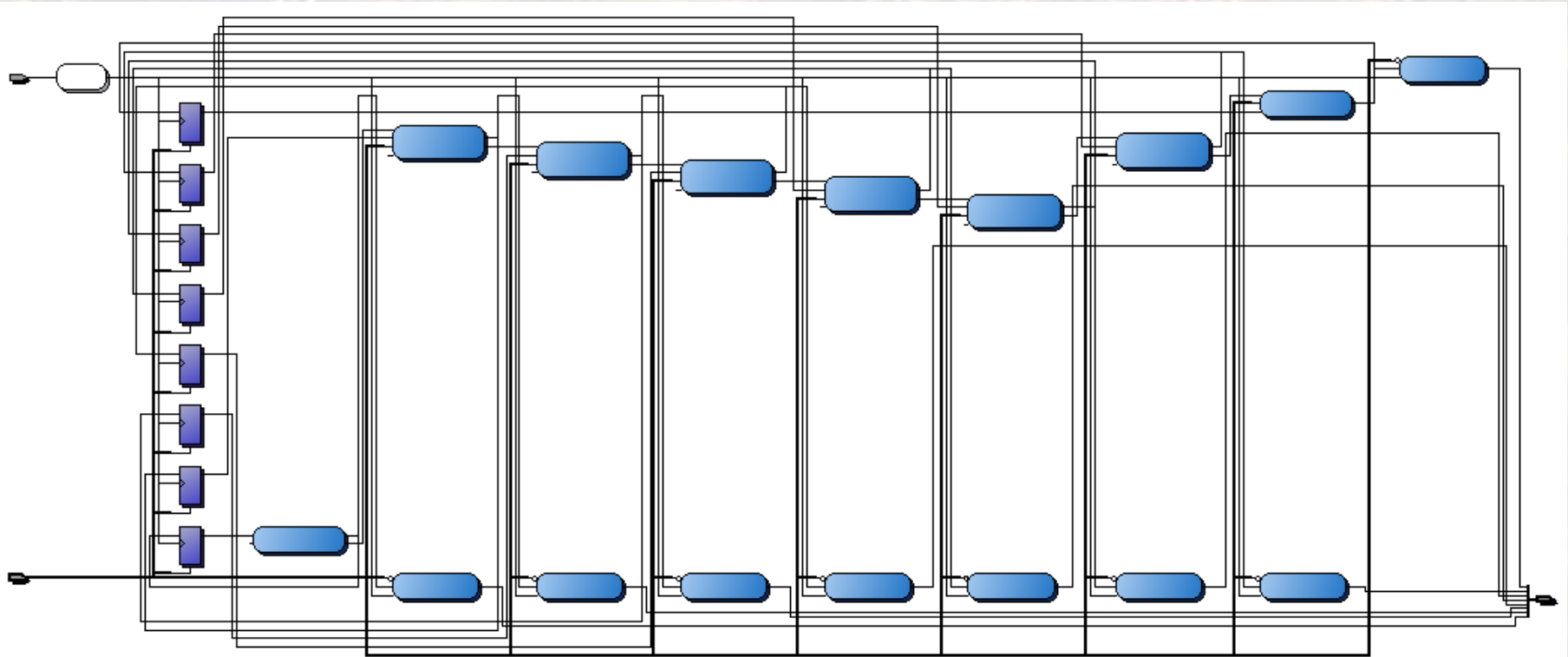
### Flow Summary

<<Filter>>

Flow Status	Successful - Thu Sep 07 09:05:24 2017
Quartus Prime Version	16.1.0 Build 196 10/24/2016 SJ Lite Edition
Revision Name	MyFirstCounter
Top-level Entity Name	MyFirstCounter
Family	MAX 10
Device	10M50DAF484C7G
Timing Models	Final
Total logic elements	41 / 49,760 (< 1 %)
Total registers	32
Total pins	12 / 360 (3 %)
Total virtual pins	0
Total memory bits	0 / 1,677,312 (0 %)
Embedded Multiplier 9-bit elements	0 / 288 (0 %)
Total PLLs	0 / 4 (0 %)
UFM blocks	0 / 1 (0 %)
ADC blocks	0 / 2 (0 %)

# FPGA Design Flow

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





# FPGA Design Flow

- FPGA Implementation
- Chip Planner

The screenshot displays the Chip Planner software interface for an EP2C20F484C7 device. The main window shows a grid of logic resources with a blue box highlighting a specific block at coordinate (50, 2). A callout window provides a detailed view of this block's internal logic, including a logic diagram and a table of input and output ports.

Input Port Name	Signal Name	Inverted
Register		
ENB	<Disconnected>	False
SCLR	<Disconnected>	False
IACLK	IUDcounter[SW[0]]	True
SDATA	<Disconnected>	False
DATIN	IUDcounter[out_sinf31~14]	False

Output Port Name	Signal Name
Register	
REGOUT	IUDc
Combinational	
COUT	IUDc
COMBOUT	IUDc

# 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

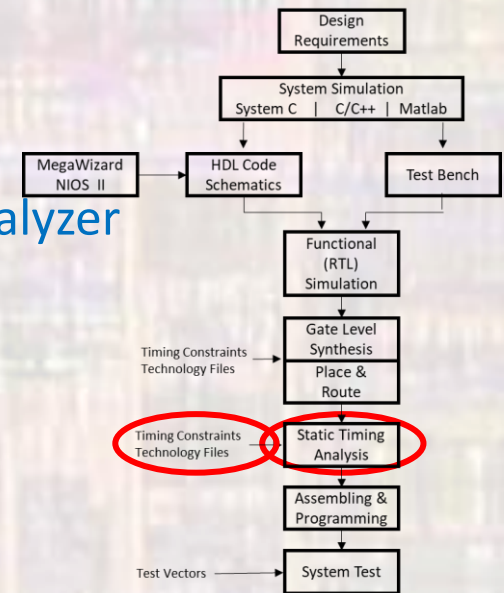
- *myDesign.sta.rpt*

- Runs across process, temperature and voltage variations

- Fast/typ/slow process

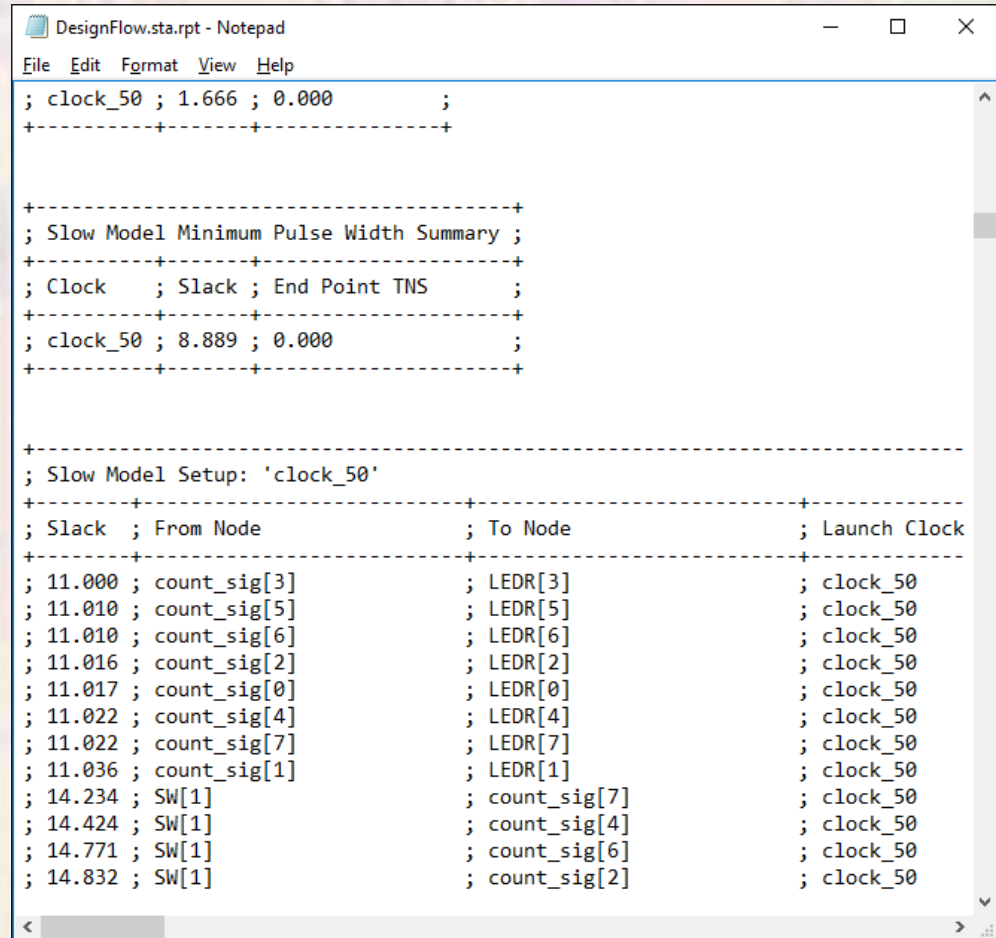
- High/typ/low temp

- High/typ/low voltage



# FPGA Design Flow

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

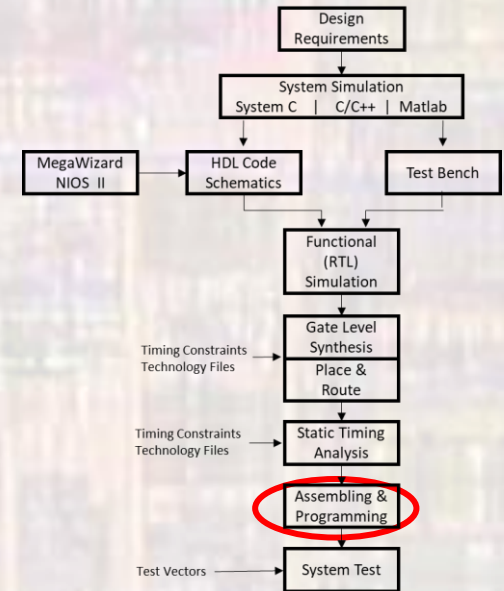


```
DesignFlow.sta.rpt - Notepad
File Edit Format View Help
; clock_50 ; 1.666 ; 0.000 ;
+-----+
+-----+
; Slow Model Minimum Pulse Width Summary ;
+-----+
; Clock ; Slack ; End Point TNS ;
+-----+
; clock_50 ; 8.889 ; 0.000 ;
+-----+

+-----+
; 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
```

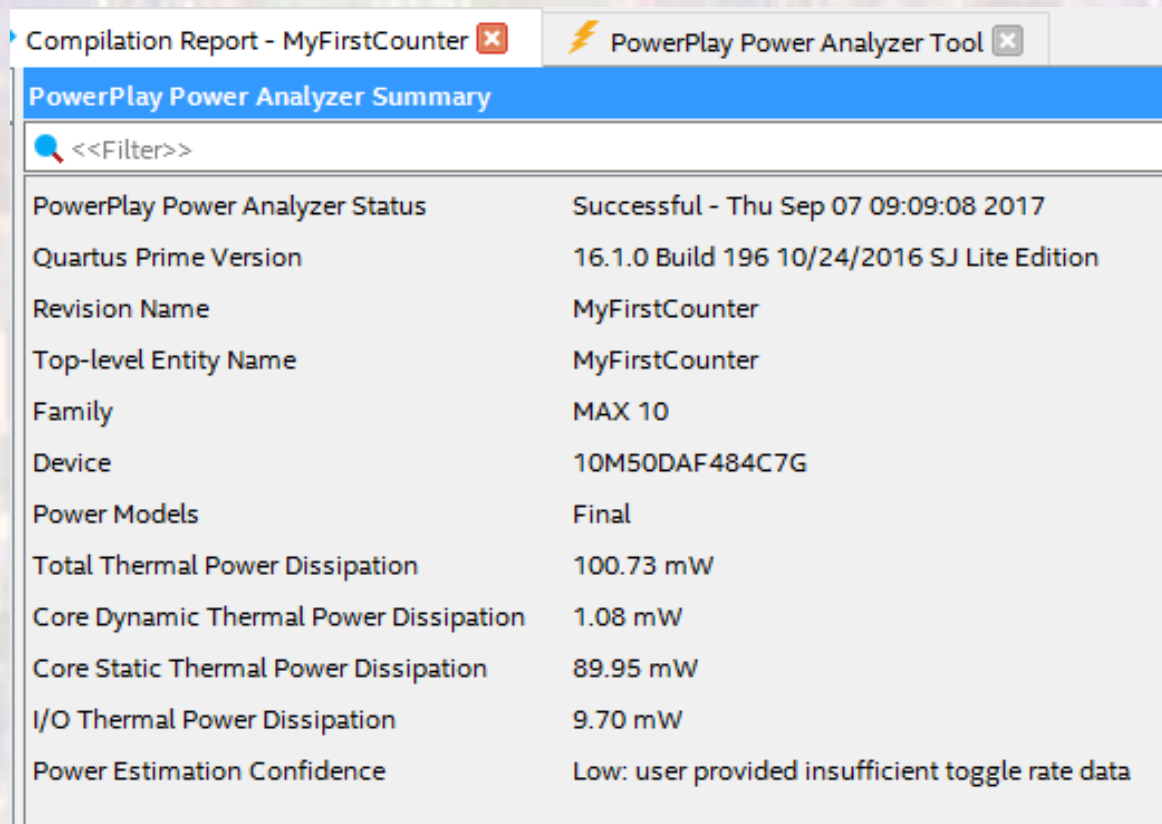
# FPGA Design Flow

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



# FPGA Design Flow

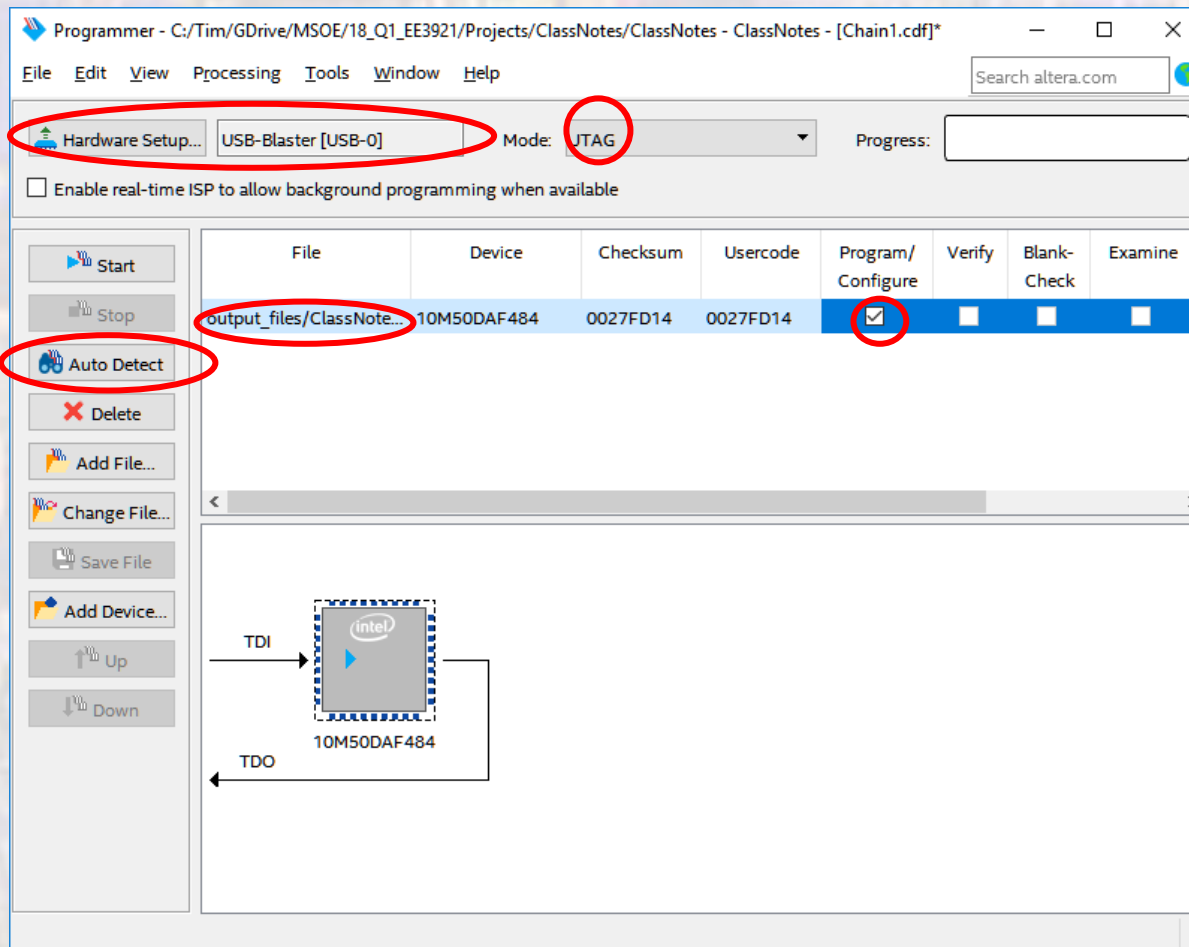
- FPGA Implementation
  - Assembler
    - Processing -> PowerPlay Power Analyzer Tool



PowerPlay Power Analyzer Status	Successful - Thu Sep 07 09:09:08 2017
Quartus Prime Version	16.1.0 Build 196 10/24/2016 SJ Lite Edition
Revision Name	MyFirstCounter
Top-level Entity Name	MyFirstCounter
Family	MAX 10
Device	10M50DAF484C7G
Power Models	Final
Total Thermal Power Dissipation	100.73 mW
Core Dynamic Thermal Power Dissipation	1.08 mW
Core Static Thermal Power Dissipation	89.95 mW
I/O Thermal Power Dissipation	9.70 mW
Power Estimation Confidence	Low: user provided insufficient toggle rate data

# FPGA Design Flow

- FPGA Implementation
  - Programmer



# FPGA Design Flow

- FPGA Implementation
- Programmer

