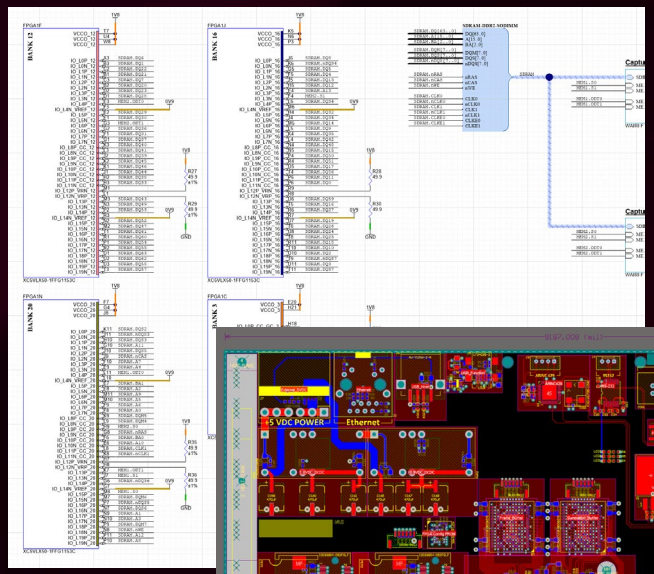
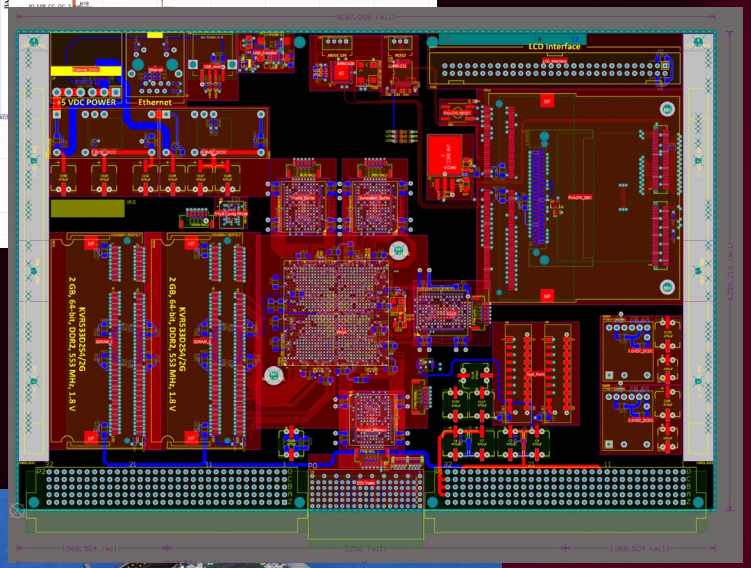
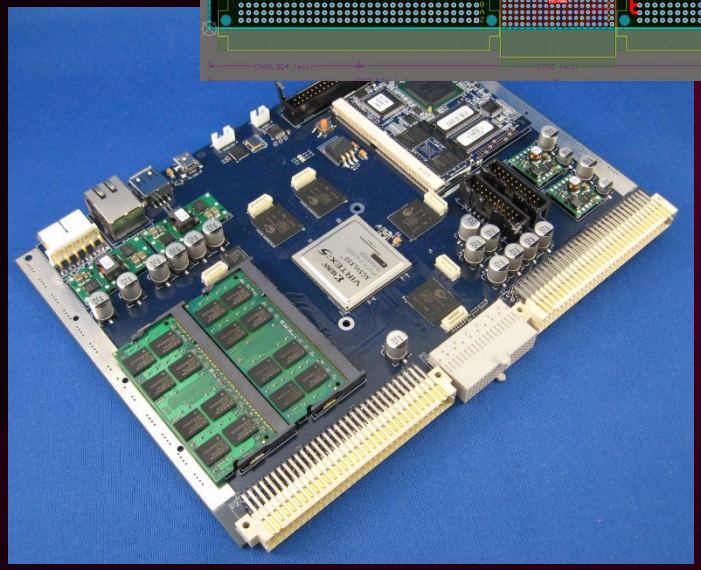






Dwight Look College of
ENGINEERING
TEXAS A&M UNIVERSITY

Schematic Capture
PCB Design
Assembly Tips

Dr. John Lusher II, P.E.

Outline

- PCB Design Process
- Recommended Software
- Common Mistakes
- Assembly Tips
- Debugging PCBs and Systems

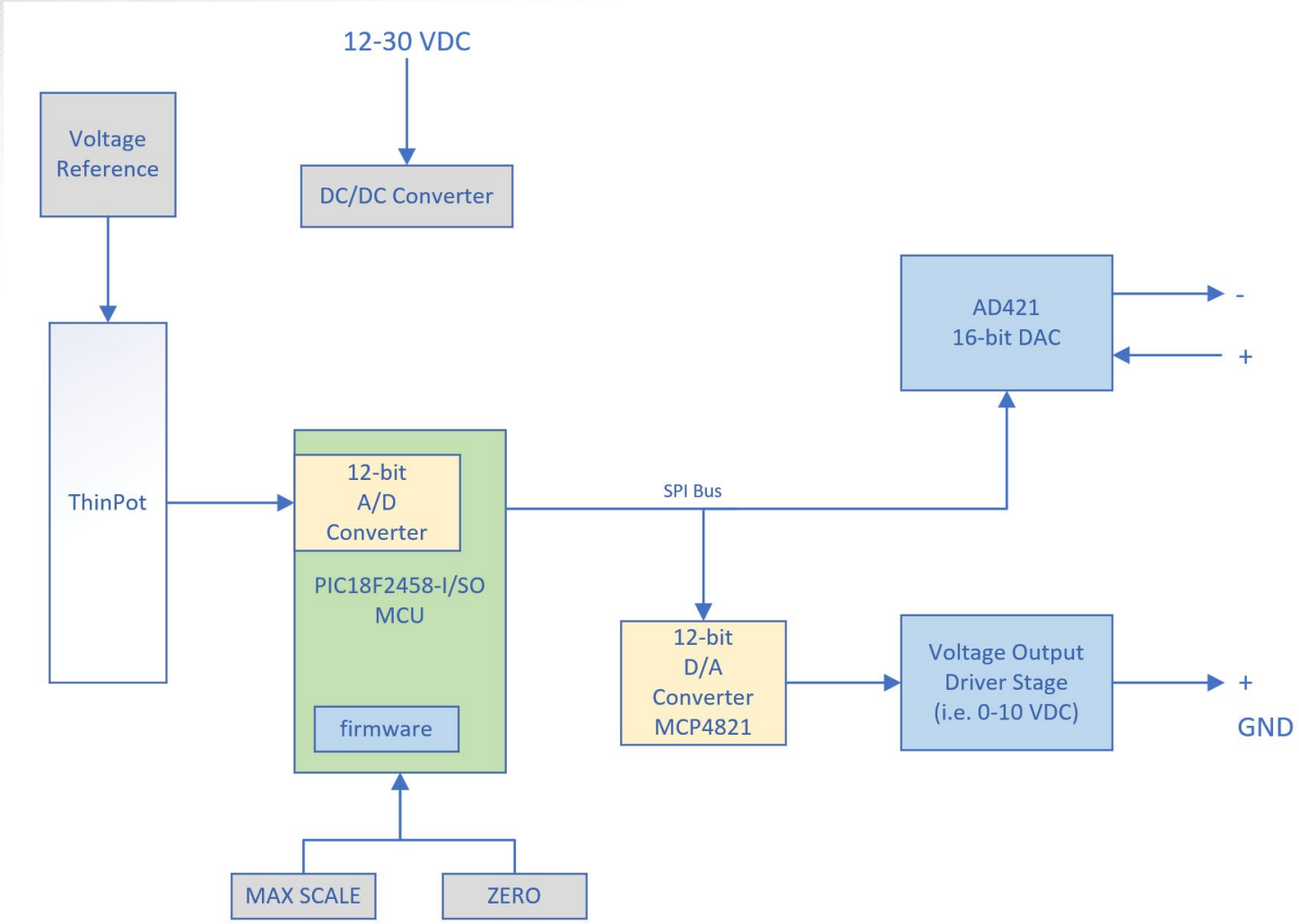
Process of PCB Design

1. Capture the schematic for the PCB
2. Produce a netlist
3. Place and Route the PCB
4. Verify PCB meets manufacturing rules
5. Produce CAM files for manufacturing

Schematic Capture

- Start with block diagram of system
- **Select all parts FIRST!**
  - This includes resistors, capacitors, ICs, etc..
- Create or get symbols for the part.
- Design the schematic
- If a complicated board then use a hierarchal based design

Schematic Capture: Block Diagram



Schematic Capture: Select Parts

Ceramic Capacitors

Results: 423,529

Search Within Results

Filter Options: Stacked | Scrolling

Manufacturer	Packaging	Series	Part Status
American Technical Ceramics	-	AH	Active
AVX Corporation	Bag	APS	Discontinued at Digi-Key
Cornell Dubilier Electronics (CDE)	Bulk	AQ	Last Time Buy
Johanson Dielectrics Inc.	Cut Tape (CT)	ARA Indust X7R HT200C	Not For New Designs
Johanson Technology Inc.	Digi-Reel®	ArcShield SMD Comm X7R HV	Obsolete
KEMET	Tape & Box (TB)	ARR Indust X7R HT200C	Preliminary
Knowles Dielectric Labs	Tape & Reel (TR)	AS	
Knowles Novacap	Tray	AT	
Knowles Syfer	Tube	ATC 100C	
Kyocera International Inc. Electronic Components		ATC 100E	

More Filters

View Prices At: Enter Quantity

Stock Status	Media Available	Environmental
In Stock	Datasheet	RoHS Compliant
Normally Stocking	Photo	Non-RoHS Compliant
New Products	EDA / CAD Models	

Clear All Selections | Apply Filters

Search Entry: 0.1 uF Cap

Results per Page 500 | Page 1/848 | |< < 1 2 3 4 5 > >|

Download Table

Compare Parts	Image	Digi-Key Part Number	Manufacturer Part Number	Manufacturer	Description	Quantity Available	Unit Price USD	Minimum Quantity	Packaging	Series	Part Status	Capacitance
		490-3160-2-ND	GRM0335C1E101JA01D	Murata Electronics	CAP CER 100PF 25V C0G/NP0 0201	1,782,893 - Immediate	$0.00180	15,000	Tape & Reel (TR) Alternate Packaging	GRM	Active	100pF
		490-3160-1-ND	GRM0335C1E101JA01D	Murata Electronics	CAP CER 100PF 25V C0G/NP0 0201	1,782,293 - Immediate	$0.10000	1	Cut Tape (CT) Alternate Packaging	GRM	Active	100pF
		490-3160-6-ND	GRM0335C1E101JA01D	Murata	CAP CER 100PF 25V	1,782,793 -			Digi-Reel®	GRM	Active	100pF

Feedback | Live Chat

Embedded - Microcontrollers

Results: 85,883

Search Within Results

Filter Options: Stacked | Scrolling

Manufacturer	Packaging	Series
Adafruit Industries LLC	-	*
Ambiq Micro, Inc.	Bag	-
Analog Devices Inc.	Box	568xx
Arduino	Bulk	56F836xx
Bridgetek Pte Ltd.	Cut Tape (CT)	56F837xx
Cypress Semiconductor Corp	Digi-Reel®	56F8xx
Epson Electronics America Inc-Semiconductor Div	Strip	56F8xxx
Fujitsu Electronics America, Inc.	Tape & Box (TB)	720/4500
Honeywell Aerospace	Tape & Reel (TR)	73S11xx
Infineon Technologies	Tray	73S12xx

More Filters

View Prices At: Enter Quantity

Stock Status	Media Available	Environmental
In Stock	Datasheet	RoHS Compliant
Normally Stocking	Photo	Non-RoHS Compliant
New Products	EDA / CAD Models	

Clear All Selections | Apply Filters

Search Entry: Microcontroller

Results per Page 500 | Page 1/172 | |< < 1 2 3 4 5 > >|

Download Table

Compare Parts	Image	Digi-Key Part Number	Manufacturer Part Number	Manufacturer	Description	Quantity Available	Unit Price USD	Minimum Quantity	Packaging	Ser
		PIC10F200T-I/OTTR-ND	PIC10F200T-I/OT	Microchip Technology	IC MCU 8BIT 384B FLASH SOT236	51,000 - Immediate	$0.38750	3,000	Tape & Reel (TR) Alternate Packaging	PIC® 10F
		PIC10F200T-I/OTCT-ND	PIC10F200T-I/OT	Microchip Technology	IC MCU 8BIT 384B FLASH SOT236	53,113 - Immediate	$0.45000	1	Cut Tape (CT) Alternate Packaging	PIC® 10F
		PIC10F200T-I/OTDKR-ND	PIC10F200T-I/OT	Microchip Technology	IC MCU 8BIT 384B FLASH SOT236	53,113 - Immediate	Digi-Reel®	1	Digi-Reel® Alternate	PIC® 10F

Feedback | Live Chat

Schematic Capture: Examine Datasheet

MICROCHIP

PIC10F200/202/204/206

6-Pin, 8-Bit Flash Microcontrollers

Devices Included In This Data Sheet:

- PIC10F200
- PIC10F202
- PIC10F204
- PIC10F206

High-Performance RISC CPU:

- Only 33 Single-Word Instructions to Learn
- All Single-Cycle Instructions except for Program Branches, which are Two-Cycle
- 12-Bit Wide Instructions
- 2-Level Deep Hardware Stack
- Direct, Indirect and Relative Addressing modes for Data and Instructions
- 8-Bit Wide Data Path

Low-Power Features/CMOS Technology:

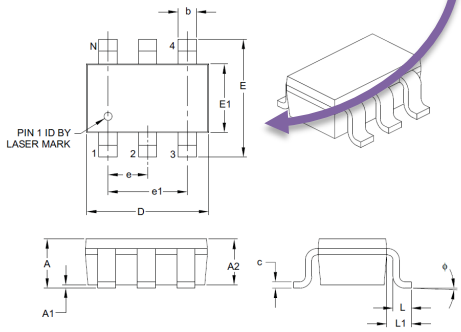
- Operating Curre
  - < 175 µA @ 2
- Standby Current
  - 100 nA @ 2V,
- Low-Power, Higl
  - 100,000 Flash
  - > 40 year rete
- Fully Static Desi
- Wide Operating
- Wide Temperatu
  - Industrial: -40
  - Extended: -40

14.2 Package Details

The following sections give the technical details of the packages.

6-Lead Plastic Small Outline Transistor (OT) [SOT-23]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging

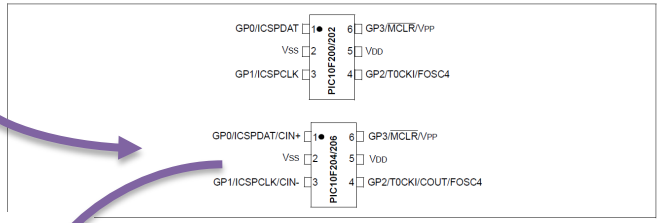


Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		6	
Pitch	e		0.95 BSC	
Outside Lead Pitch	e1		1.90 BSC	
Overall Height	A	0.90	–	1.45
Molded Package Thickness	A2	0.89	–	1.30
Standoff	A1	0.00	–	0.15
Overall Width	E	2.20	–	3.20
Molded Package Width	E1	1.30	–	1.80
Overall Length	D	2.70	–	3.10
Foot Length	L	0.10	–	0.60
Footprint	L1	0.35	–	0.80
Foot Angle	φ	0°	–	30°
Lead Thickness	c	0.08	–	0.26
Lead Width	b	0.20	–	0.51

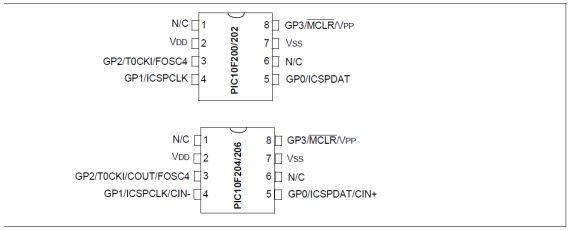
Notes:
1. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.127 mm per side.
2. Dimensioning and tolerancing per ASME Y14.5M.
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-028B

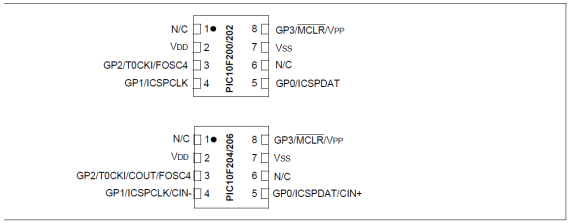
FIGURE 1: 6-PIN SOT-23



8-PIN PDIP

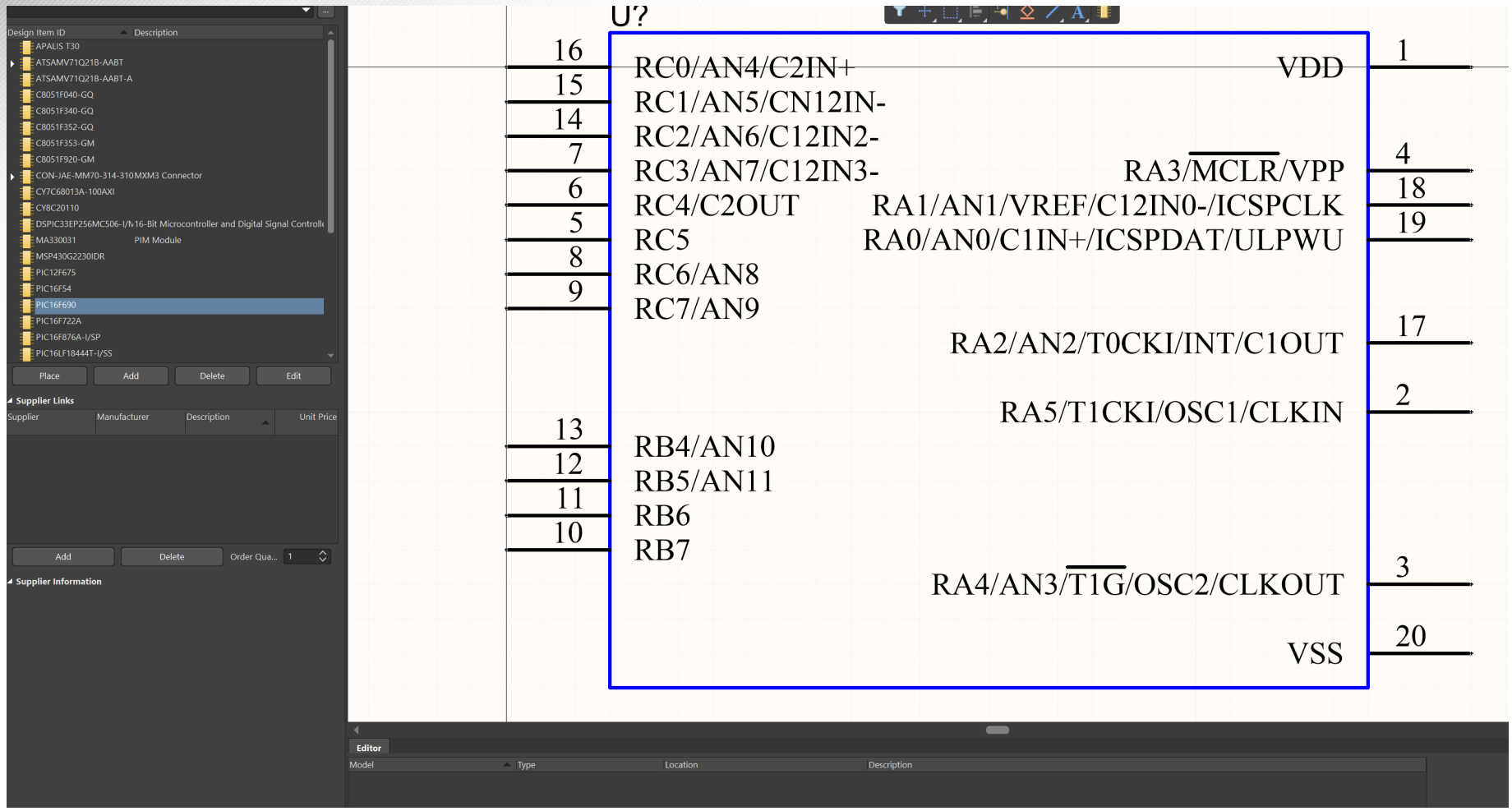


8-PIN DFN

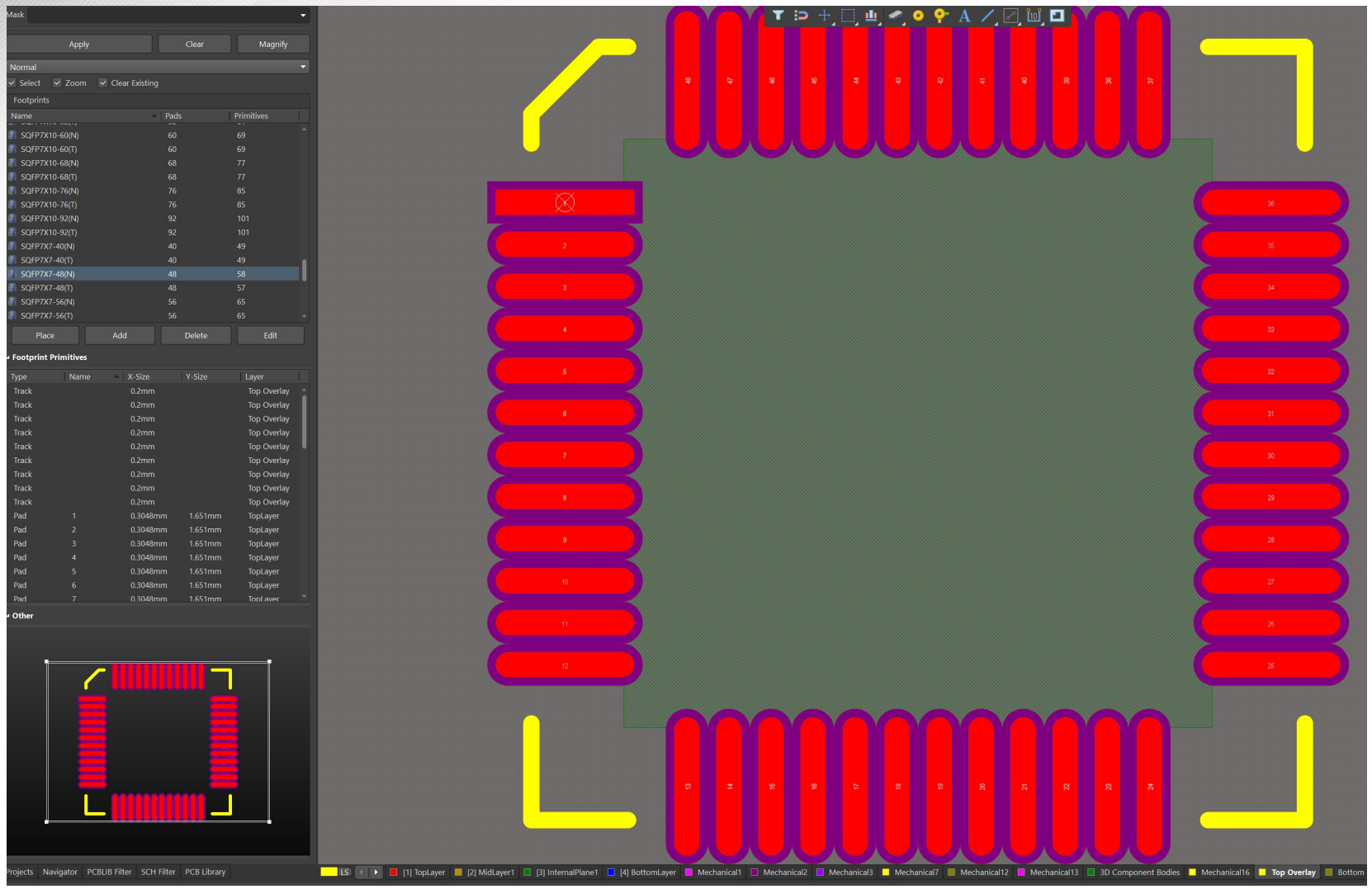


- Determine part type, review specifications, etc…
- Select symbol
  - The symbol can be modified to fit your schematic style.
- Create the PCB footprint

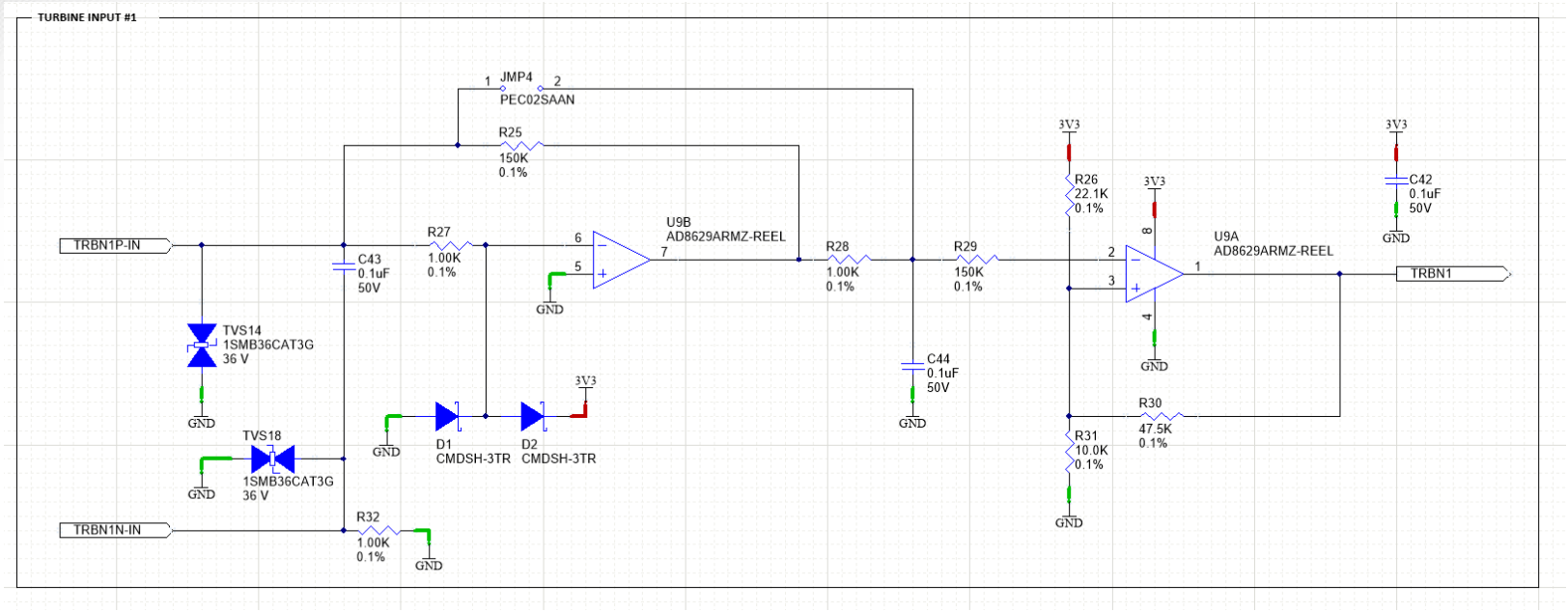
Schematic Capture: Creating Symbols



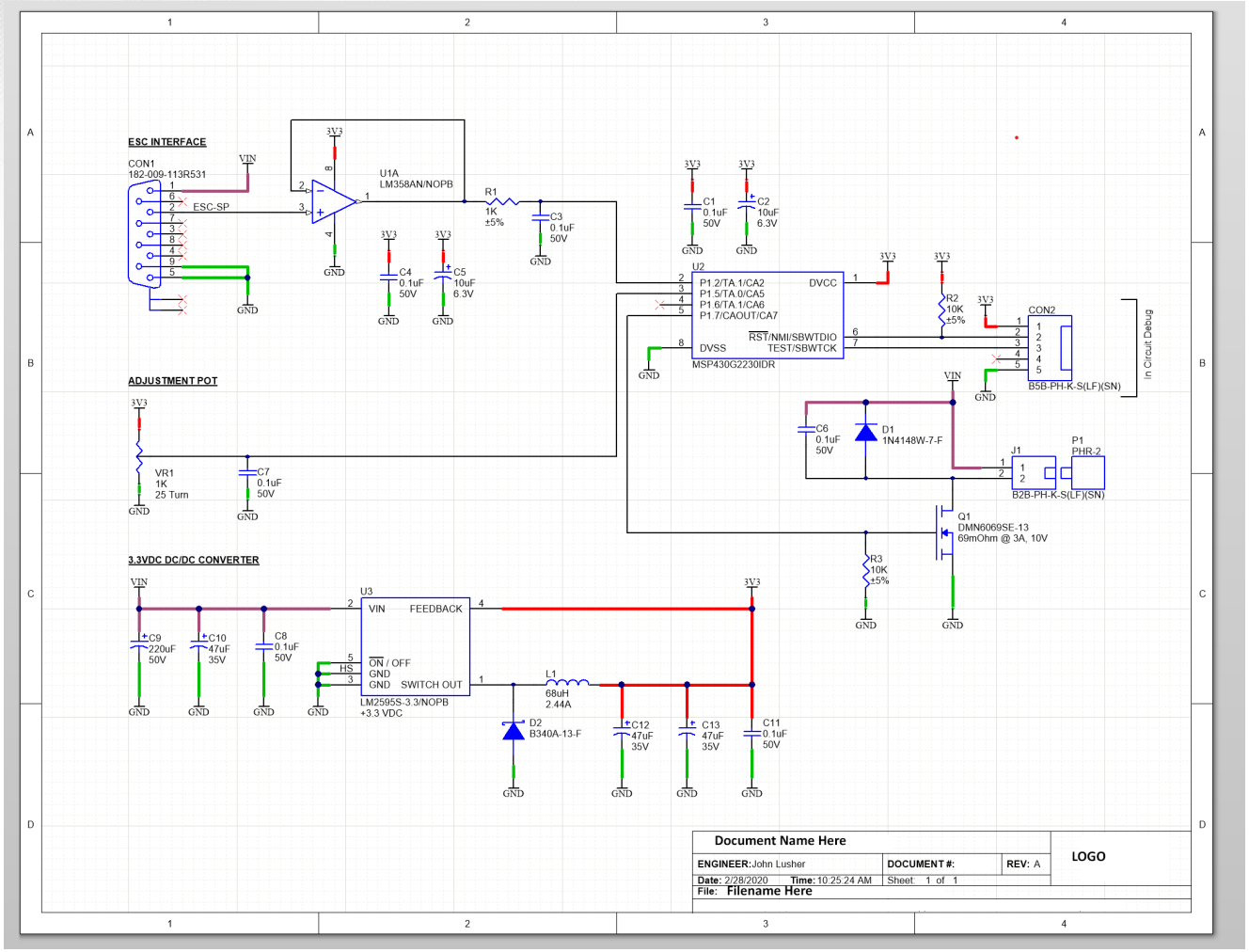
Schematic Capture: Creating Footprints



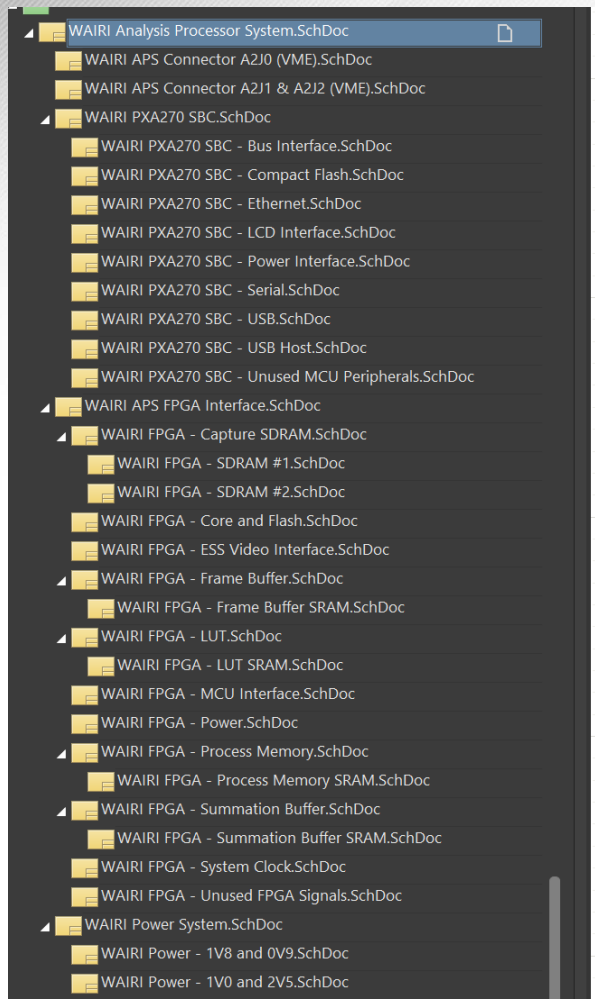
Schematic Capture

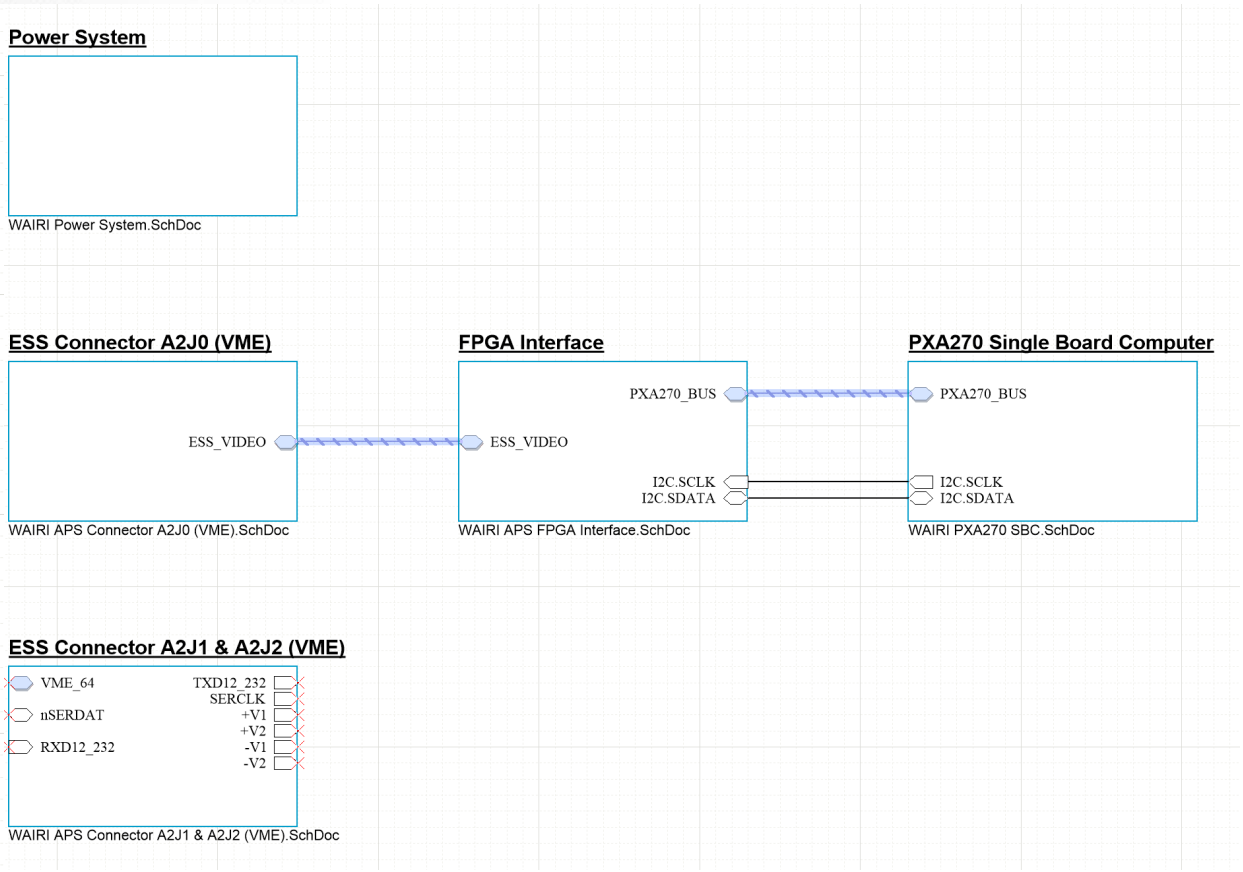


Schematic Capture



Schematic Capture: Hierarchical Design

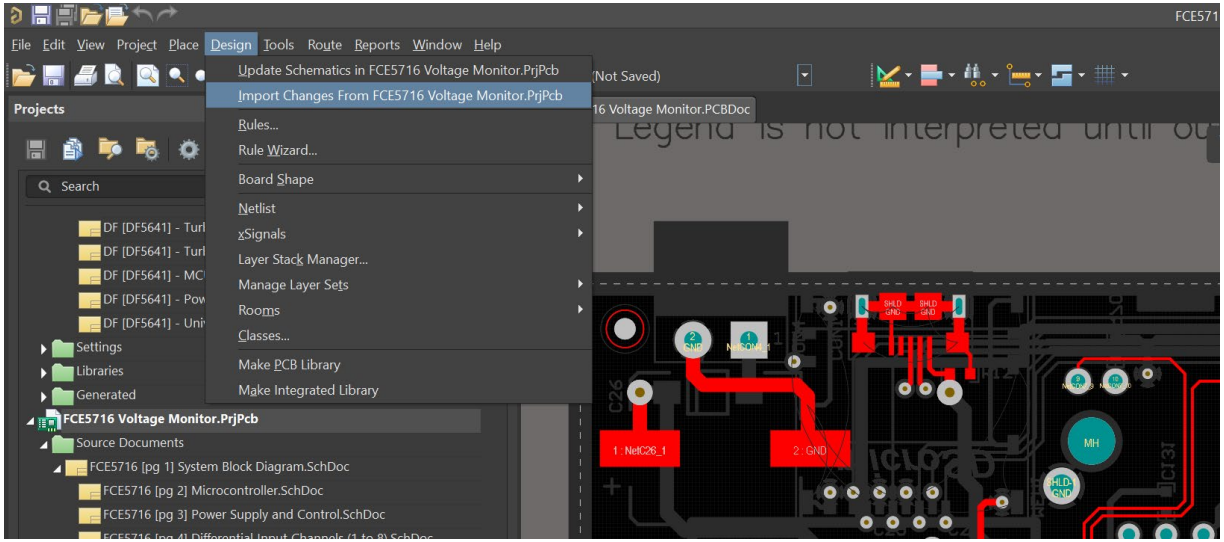




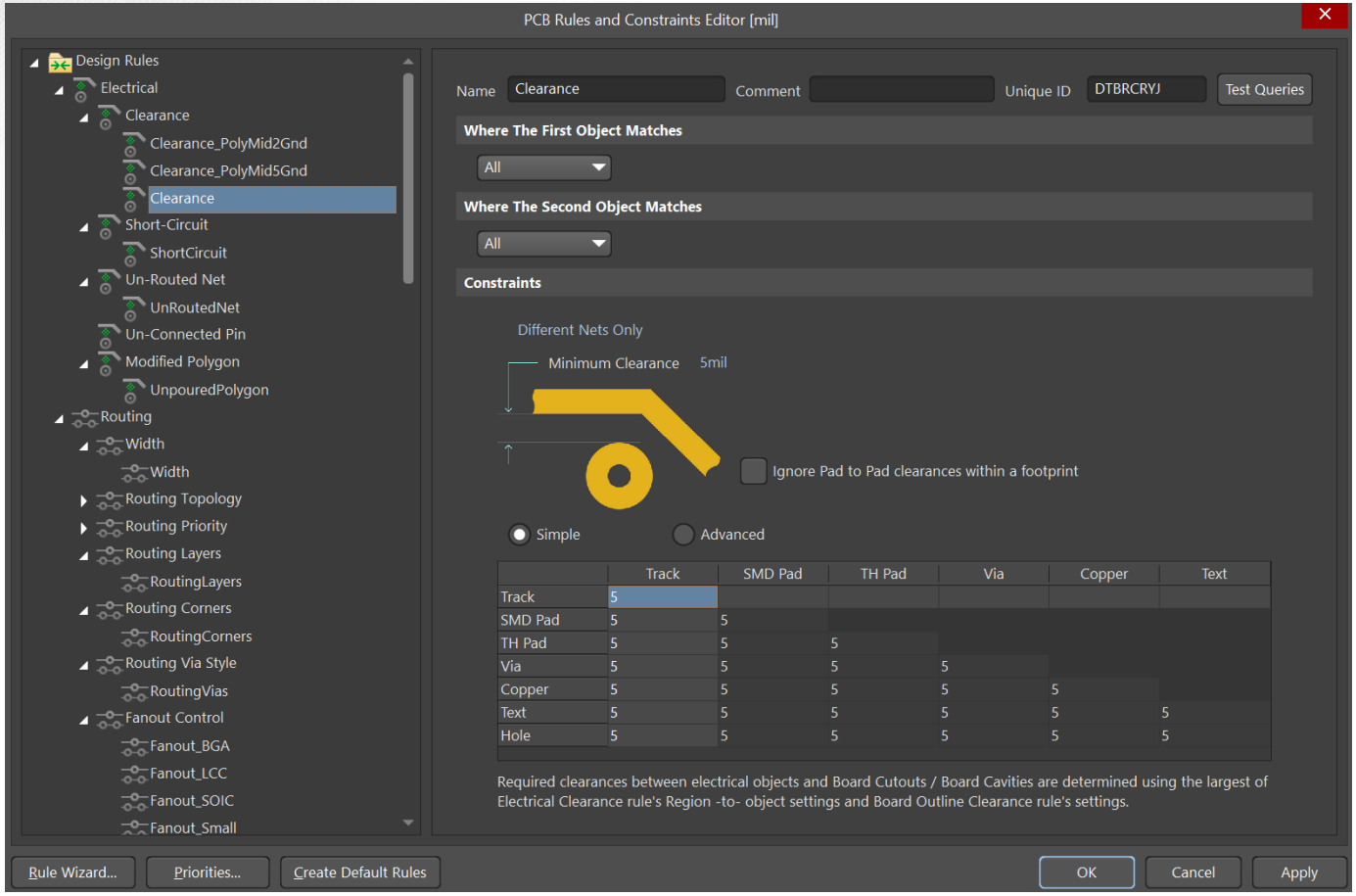
Create A Netlist

- This step may be automatic based upon the software being used.

- Altium “compiles” the schematic and then you import the design into the PCB editor.



PCB Place and Route: Set Design Rules

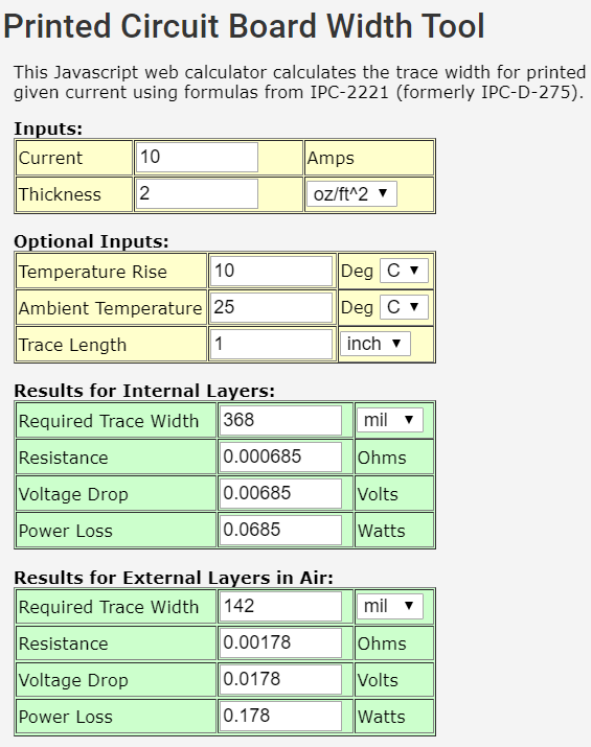


PCB Place and Route: Placement

- Define board shape and mounting holes. Typically driven by mechanical design constraints.
- Import netlist into PCB design.
- Place components
  - Some parts have required position, like connectors, or due to airflow, etc…
  - Examine your design and group parts together
  - Look at “rats-nest” to place parts that do not have a required placements to balance out the routing.

PCB Place and Route: Routing

- **DO NOT USE AUTO-ROUTER!**
  - Unless you are good at setting appropriate design rules.
- Trace Size Matters!
  - Trace width is set by the current being used in the track. There are tools to determine the appropriate track width:
  - https://www.4pcb.com/trace-width-calculator.html



Printed Circuit Board Width Tool

This Javascript web calculator calculates the trace width for printed given current using formulas from IPC-2221 (formerly IPC-D-275).

Inputs:

Current	10	Amps
Thickness	2	oz/ft^2

Optional Inputs:

Temperature Rise	10	Deg C
Ambient Temperature	25	Deg C
Trace Length	1	inch

Results for Internal Layers:

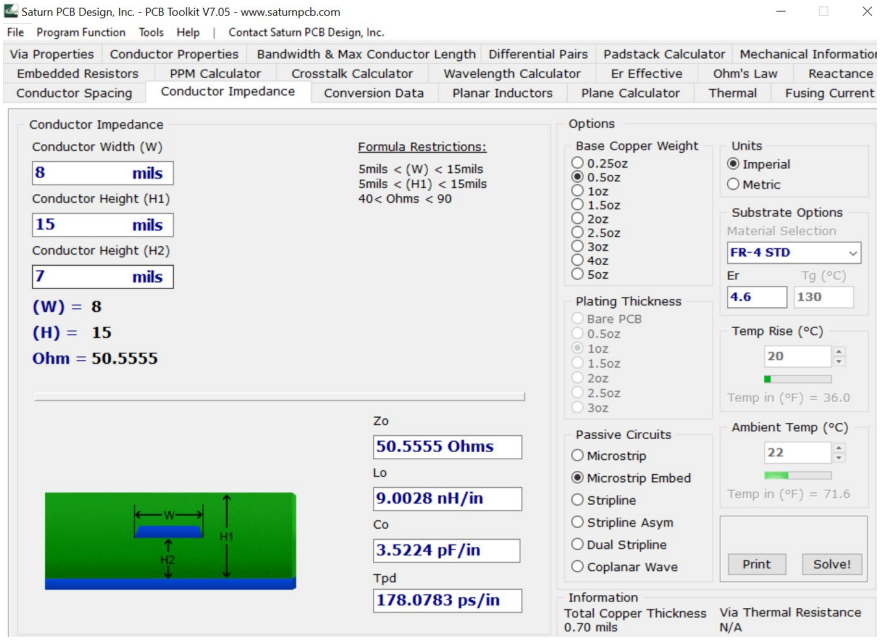
Required Trace Width	368	mil
Resistance	0.000685	Ohms
Voltage Drop	0.00685	Volts
Power Loss	0.0685	Watts

Results for External Layers in Air:

Required Trace Width	142	mil
Resistance	0.00178	Ohms
Voltage Drop	0.0178	Volts
Power Loss	0.178	Watts

PCB Place and Route: Routing

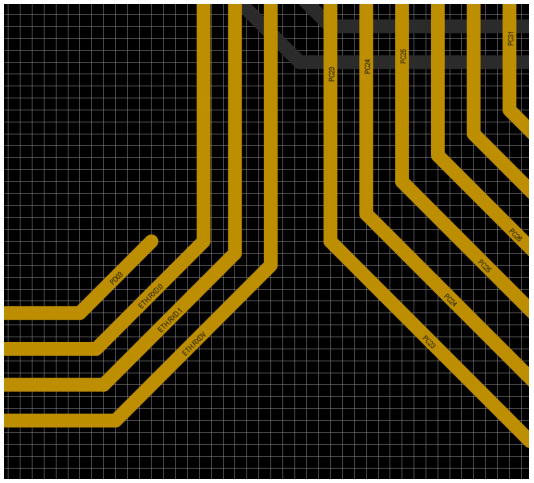
- The layout process will take time! Be Patient!
- Physics matters!
  - Hence, signal speed, voltages, currents, impedance does enter the design. If you have high speed signals you will need to calculate the impedance of a trace and possibly keep signals the same length.



PCB Place and Route: Routing

- Don’t use 90 degree turns!

- Instead, use 45 degree turns!



PCB Place and Route: Routing

- It is ok to have extra parts on the PCB! Once the shape of the PCB is set, copper is “free.”
- If you are defining the layout of a connector this also means you can change to suit the layout.
- I/O can also be remapped on most MCUs and FPGAs, take. Remap your I/O to make routing the most effective.

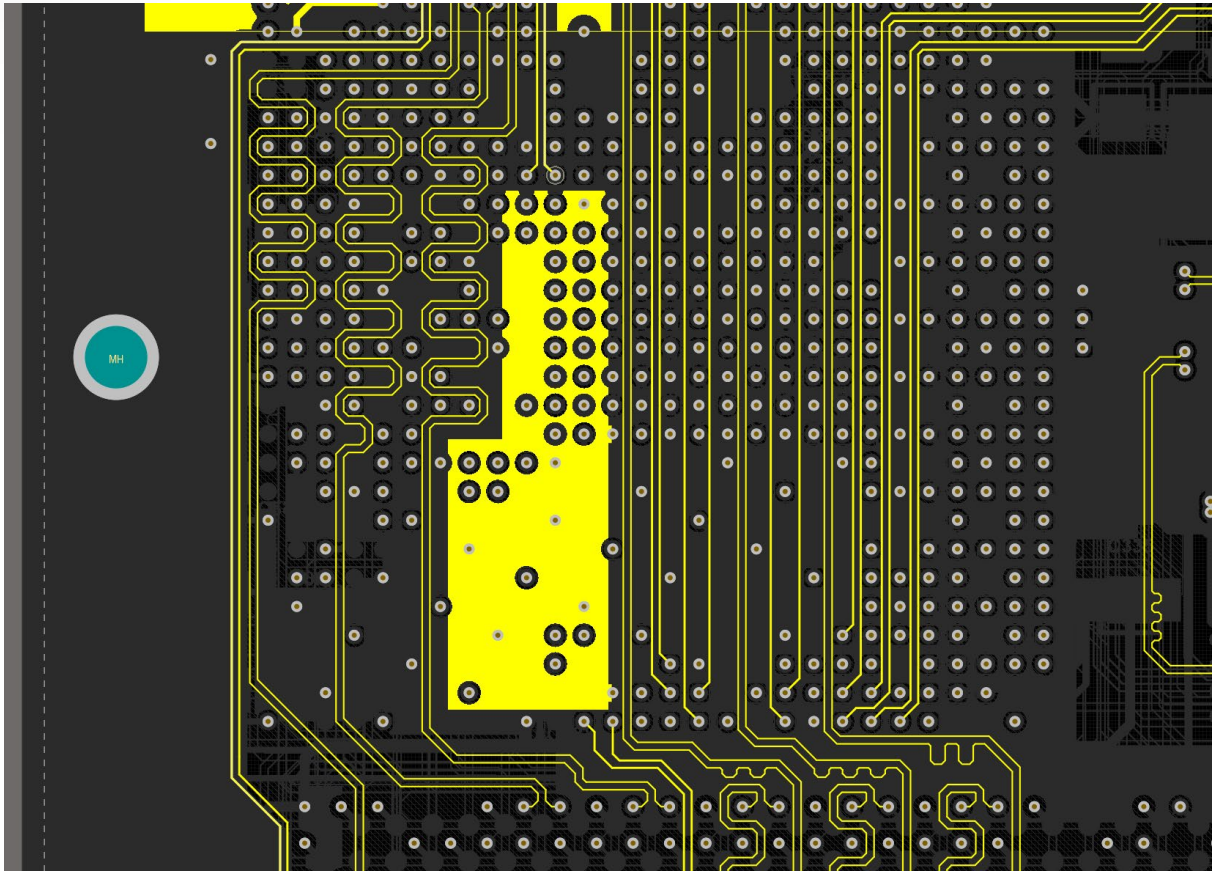
PCB Place and Route: Routing

- Don’t just pour a ground plane polygon to “reduce noise,” because that is what you have seen everyone else do.

- Think of how you will assemble the board when designing.

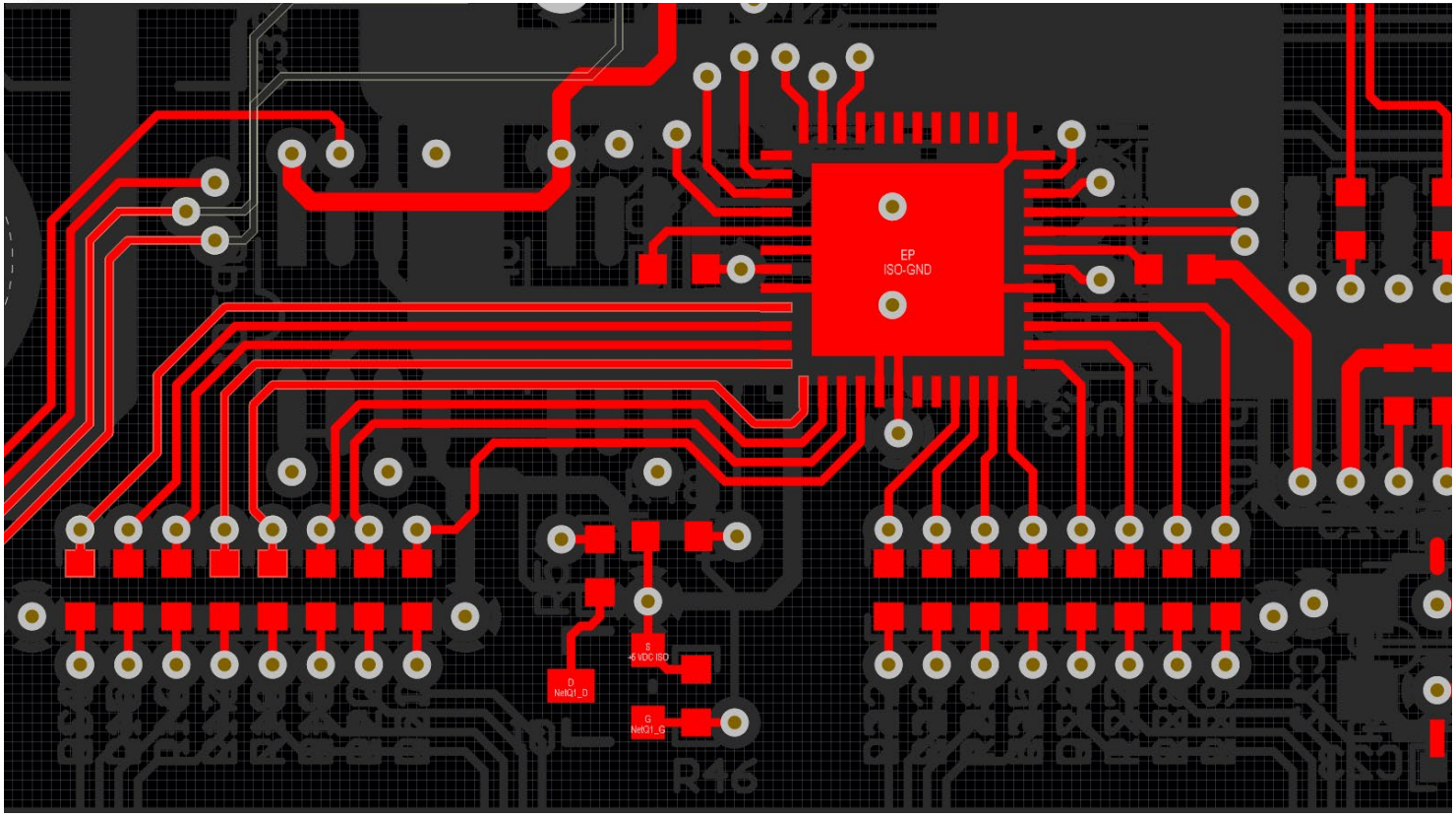
PCB Place and Route: Routing

- Consider track lengths. At high frequency trace length matters and you may have to match lengths!



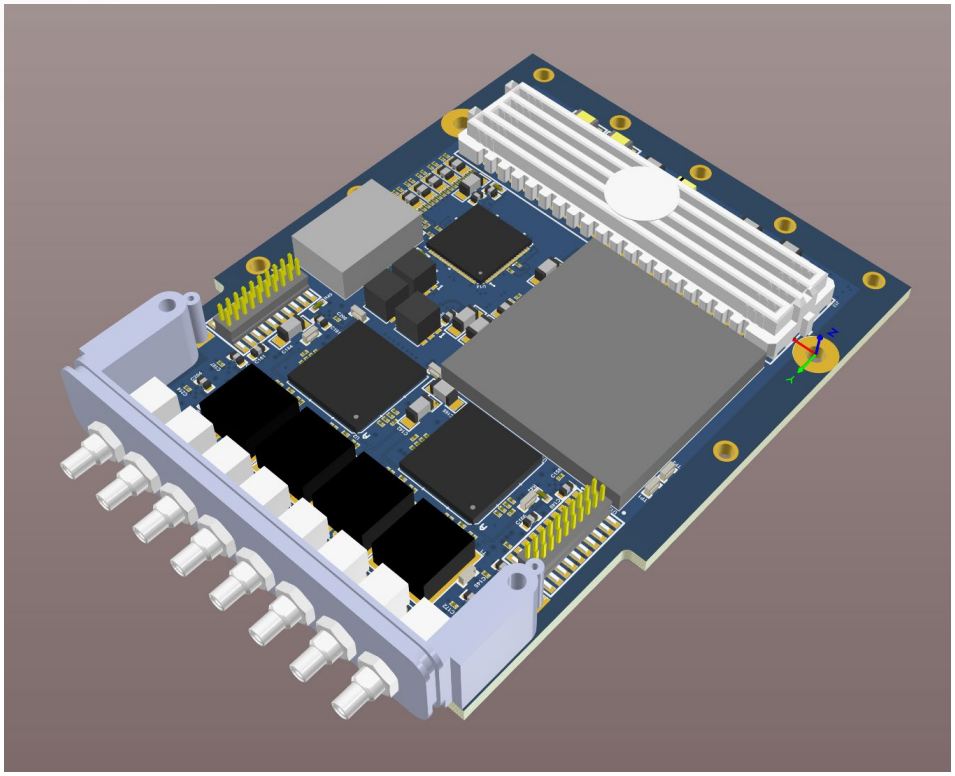
PCB Place and Route: Routing

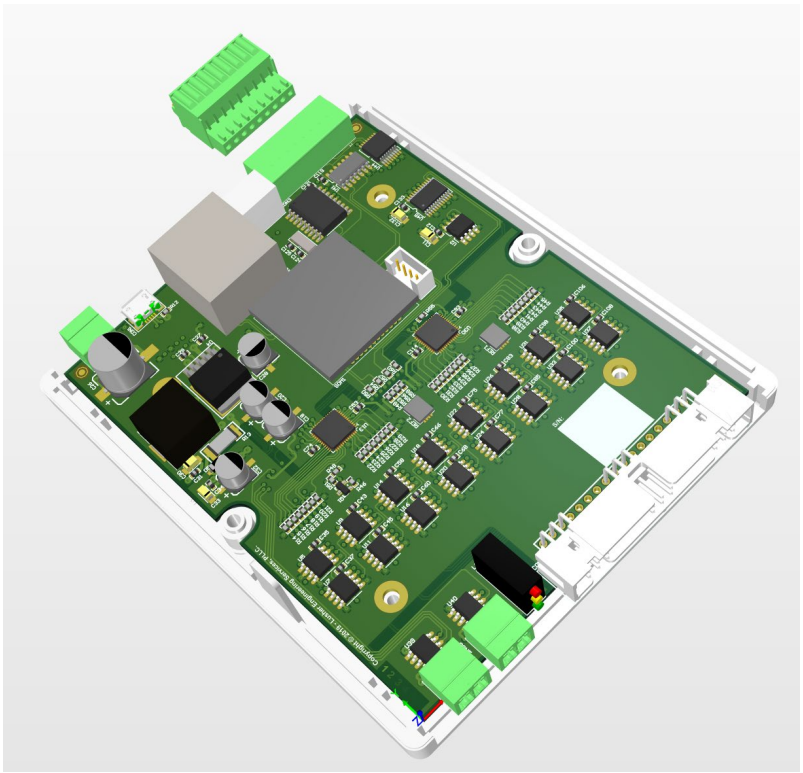
- Layout is part an art form. Take your time. Care about what you are doing…



PCB Place and Route: Routing

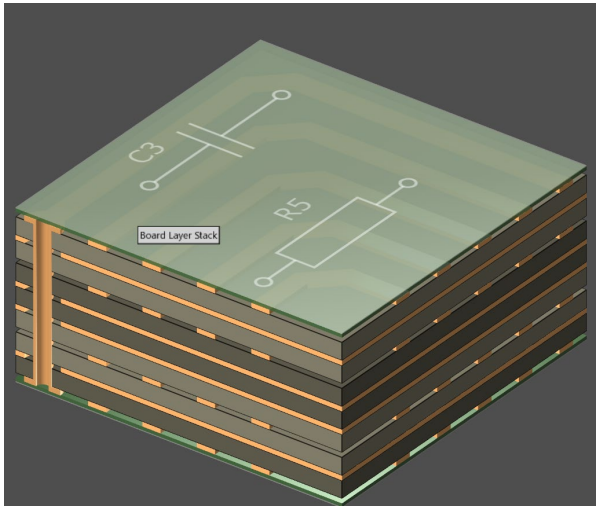
- Some PCB editors will allow you to view your board in 3D, which can be useful when working with complicated mechanical features.



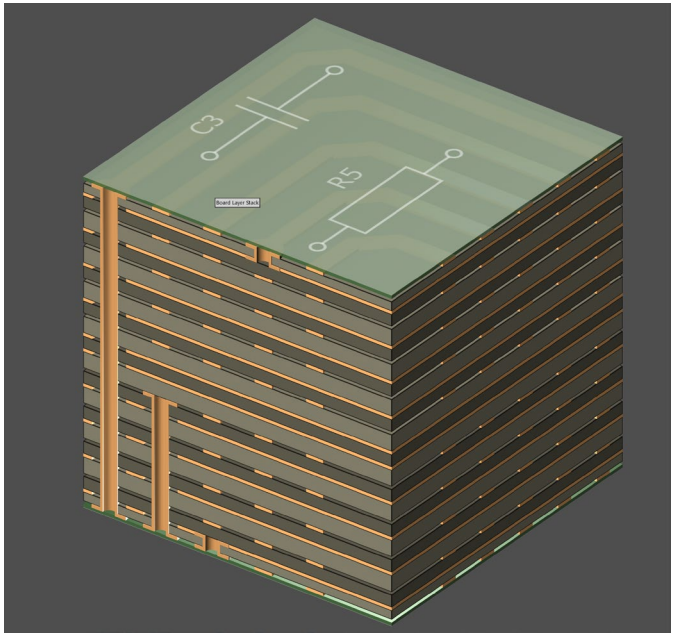


PCB Place and Route: Multi Layer PCBs

#	Name	Material	Type	Weight	Thickness	Dk	Df
	TopOverlay		Overlay				
	TopSolder	Solder Resist	Solder Mask		0.5mil	3.5	
1	TOP LAYER		Signal	1oz	1.7mil		
	Dielectric #1	FR-4	Prepreg		4mil	4.8	
2	GND PLANE		Plane	1oz	1.4mil		
	Dielectric 1	PP-006	Prepreg		2.8mil	4.1	0.02
3	MIDDLE LAYER #1	CF-004	Signal	1oz	1.378mil		
	Dielectric #2	FR-4	Prepreg		47mil	4.2	
4	MIDDLE LAYER #2	CF-004	Signal	1oz	1.378mil		
	Dielectric 2	PP-006	Prepreg		2.8mil	4.1	0.02
5	POWER PLANE		Plane	1oz	1.4mil		
	Dielectric #4	FR-4	Prepreg		4mil	4.2	
6	BOTTOM LAYER		Signal	1oz	1.7mil		
	BottomSolder	Solder Resist	Solder Mask		0.5mil	3.5	
	BottomOverlay		Overlay				



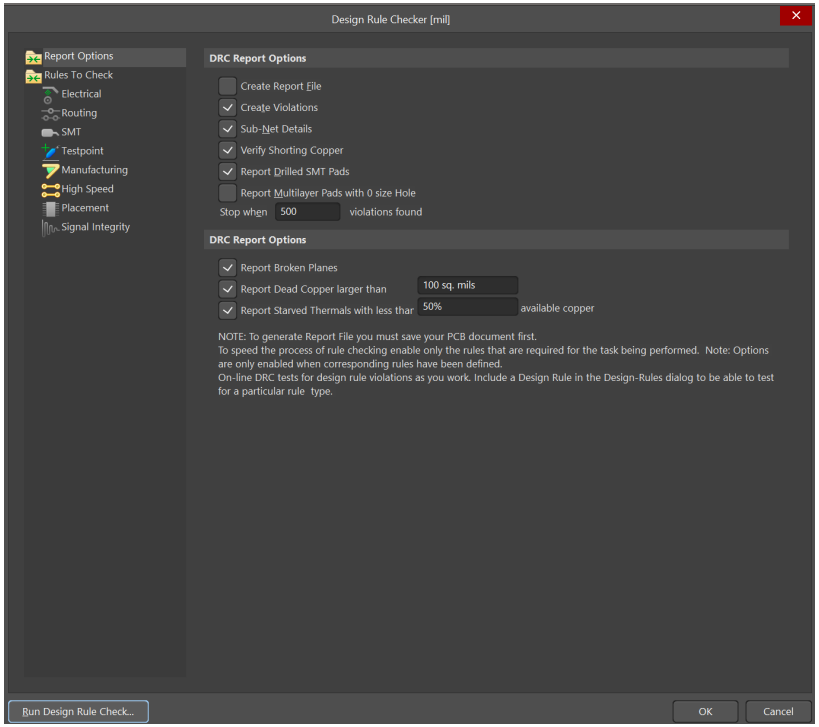
8-Layers



20-Layers
With blind and buried vias

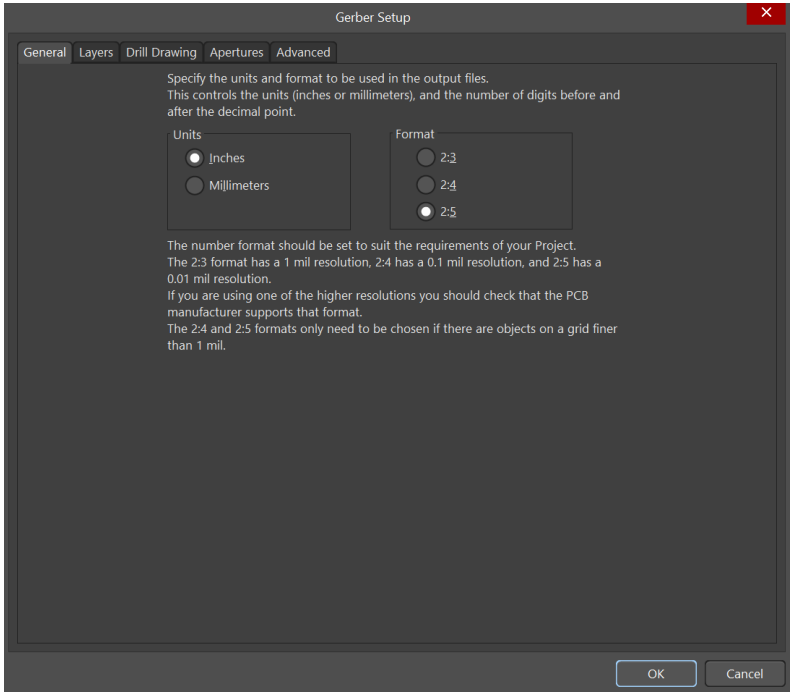
Perform a DRC Check

- If you fail the DRC, you must fix the errors!
  - The PCB manufacturer will not build it if it fails the DRC.
  - They will check against their own rule system.
  - Arguing with them is a waste of time! Just fix the issue.



PCB Place and Route: CAM

- You need to produce files that the manufacturer will use. This is not your design files.



- Minimum CAM Files include:
  - Gerber files
    - An ASCII Vector file format used in the creating the photo plot files for the layers.
  - NC Drill files

Recommend Software

- Professional Software Tools:
  - Altium Designer
  - Cadence OrCAD
  - Cadence Allegro PCB Designer
  - Mentor Graphics PADS

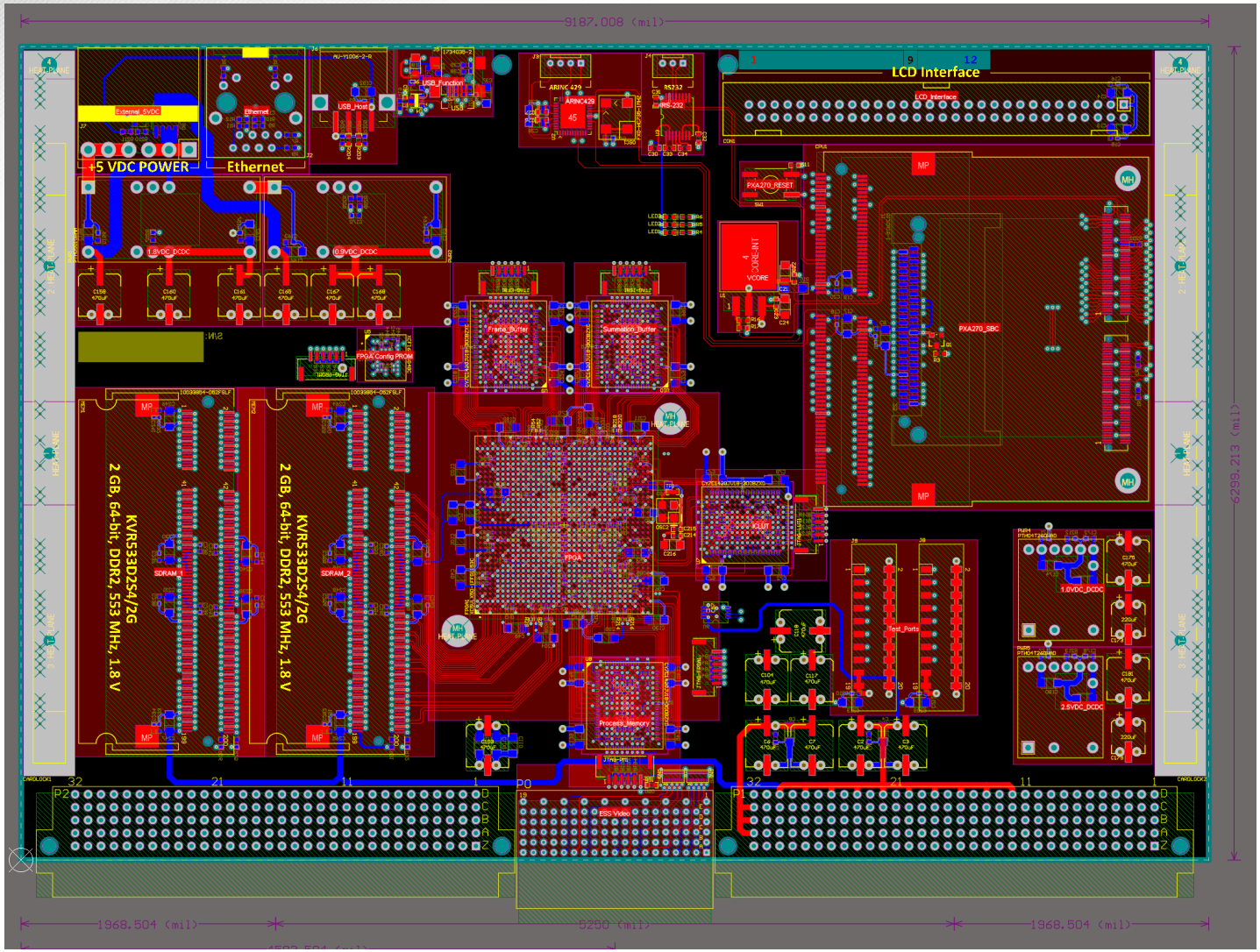
Common Mistakes

- Rushing the design.
- Not doing a design review.
- Trusting online symbols and footprints without verification.
- Using the auto router without setting up all of the design rules.

Common Mistakes

- Ignoring physics.
- Trace widths being too small.
- Hole sizes being too small.
- Not doing a practice PCB design first.
- Not caring about your job!

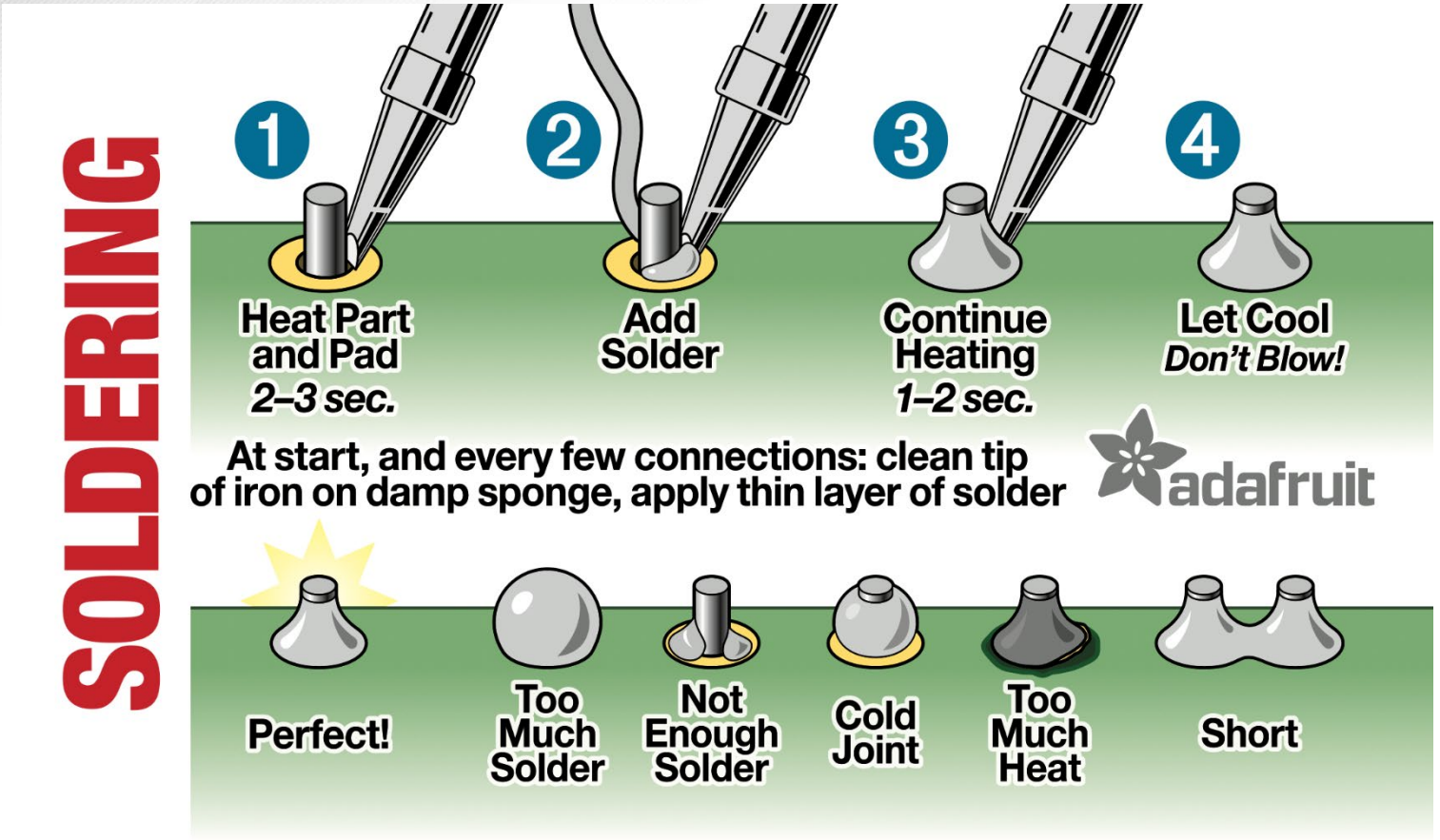
Questions on PCB Design?



Assembly Tips

- Take your time! Do not rush assembly.
- Practice soldering with a practice board first.
- Start with the SMT ICs first, especially QFNs, TQFPs, etc.., then SMT devices, then finally all THT.

Assembly Tips



Assembly Tips

- Use flux as necessary to make soldering easier. Most times flux in solder is sufficient for most joints.

- Purchase some extra parts, such as SMT caps and resistors and sometimes there is waste.

Assembly Tips

- Use the microscope in 113B for fine pitch parts. There are also various magnifying lenses that work as well.

- Print out your BOM and verify parts placement in the assembly drawing.

Assembly Tips

- You must clean your assembled PCB when done. No exceptions! Flux can be conductive and will cause circuit issue.

- Start with the SMT ICs first, especially QFNs, TQFPs, etc.., then rest of SMT devices, then finally all THT.