Prototyping: Considerations From the Bread Board for the Final Product

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Prepared For:
DFW Sensor & IoT Technology Meetup

Background Image: TRL8 Energy Saving Control Unit Developed by Newman *et al.*

May 11th 2017

Outline

- About Me

- If I Could Only Tell You 2 Things…

- Breadboarding – The First Step

- Circuit Design/Schematic Capture

- PCB Design

- Final Assembly

- Free Tools

- Design For Manufacture

About Me

Education

- Ph.D. Applied Mathematics, RPI - 2013

- M.S. Mechanical Engineering, UB - 2010

- B.T. Electrical Eng. Tech., Buff. State - 2008

- B.T. Mechanical Eng. Tech., Buff. State - 2007

- A.A.S. Drafting Tech., ECC – 2005

Professional

- UTD ARC - Principal Investigator

- Applied Research Associates –

- Group Leader

- Cameron Compression – Designer
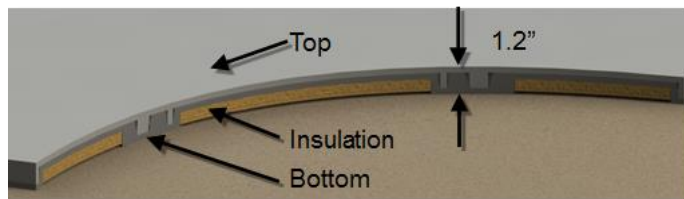
- ATSI – Piping Engineer

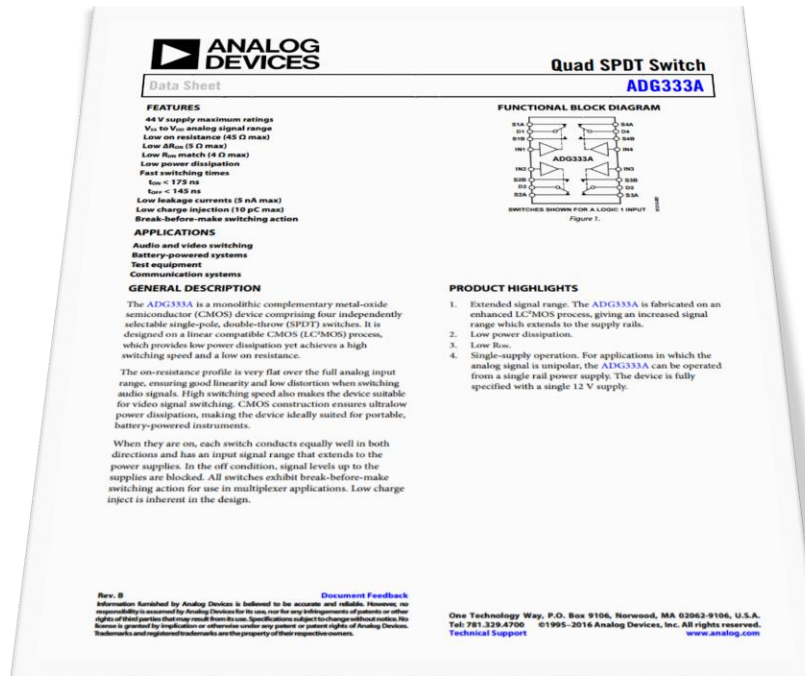# These are a Few of My Recent Projects

Multi-Functional Transcranial Electrical Stimulation System

Energy Savings Control Unit
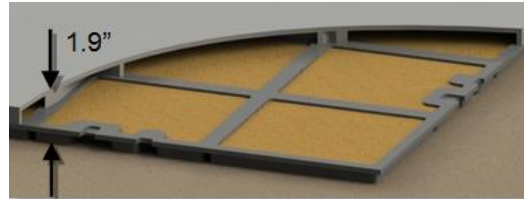
Energy Efficient Expeditionary Flooring

If I Could Only Tell you Two Things… (1)

If I Could Only Tell you Two Things… (2)

You Will Check. The Only Question is: Do You Check Before or After Something Breaks?

Breadboarding
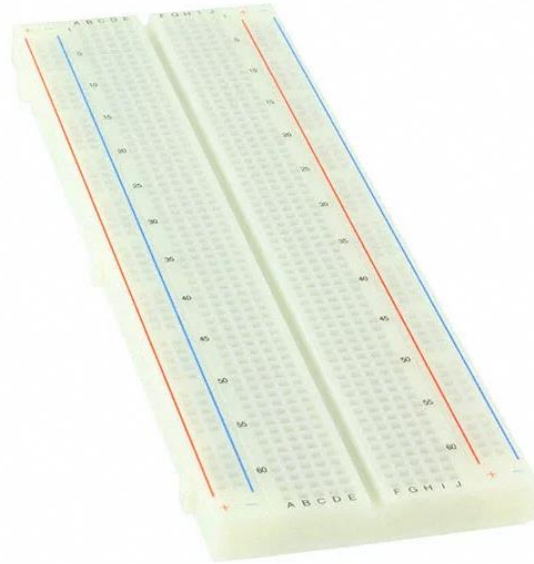
Always Use an ESD Wrist Strap

Digikey PN
16-1087-ND

You will not always see a spark if an ESD event occurs

Knowing these Breadboard Specs Will Help You Pick the Right Parts

- 100 mil pitch
- Center is 300 mil pitch
- 1.5 A capacity
- Look for parts with lead dia. < 40 mil, length >=138 mil (3.5mm)
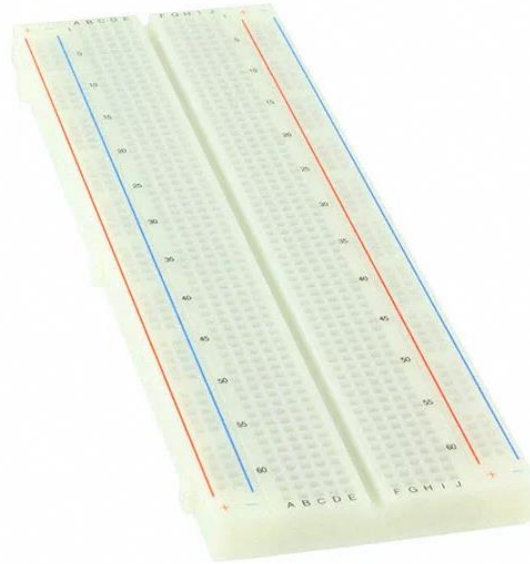
Digikey PN
BKGS-830-ND

Use Wire to Board Terminal Blocks If Connecting to Breadboard

Item	Digikey PN
15A 12-30 AWG	277-5911-ND
10A 14-30 AWG (low profile)	277-6270-ND

Rising Edge Cage Clamp

Look for Parts Available in Both DIP and SMT

Compare Parts		Image	Digi-Key Part Number	Manufacturer Part Number	Manufacturer	Description	Quantity Available	Unit Price USD	Minimum Quantity	Packaging	Package / Case	Supplier Device Package
☐			ADG436BRZ-ND	ADG436BRZ	Analog Devices Inc.	IC SWITCH DUAL SPDT 16SOIC	890 - Immediate	6.90000	1	Tube Alternate Packaging	16-SOIC (0.154", 3.90mm Width)	16-SOIC
☐			ADG436BNZ-ND	ADG436BNZ	Analog Devices Inc.	IC SWITCH DUAL SPDT 16DIP	133 - Immediate 2,500 - Factory Stock	7.47000	1	Tube	16-DIP (0.300", 7.62mm)	16-PDIP

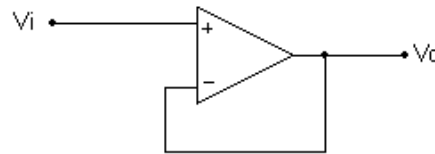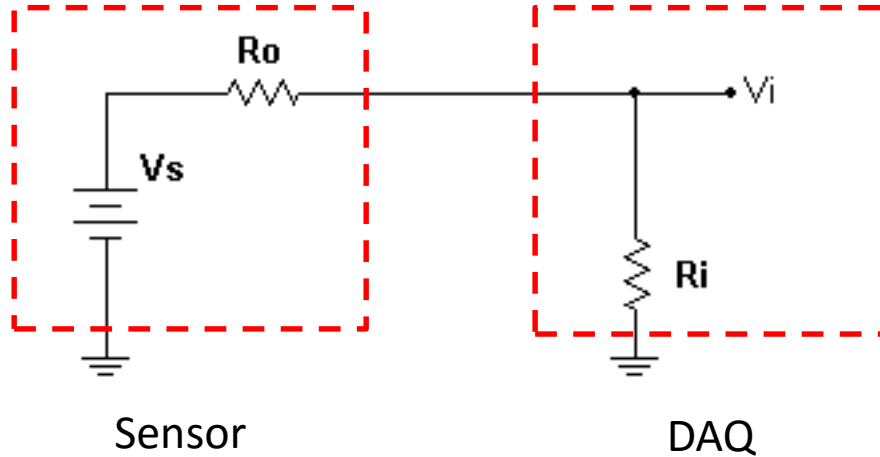| Common SMT Packages |
|---|
| SOIC |
| SWD |
| QFN |
| TSSOP |
| 1206 |

Double Check Your Packaging and Footprints

**DIP: Dual In-Line Plastic
SMT: Surface Mount Technology**

Avoid Plastic Ball Gated Array (PBGA)

Watch out for Low Input Impedances; Avoid Sensors That Output Voltage

Ro

Vs

Vi
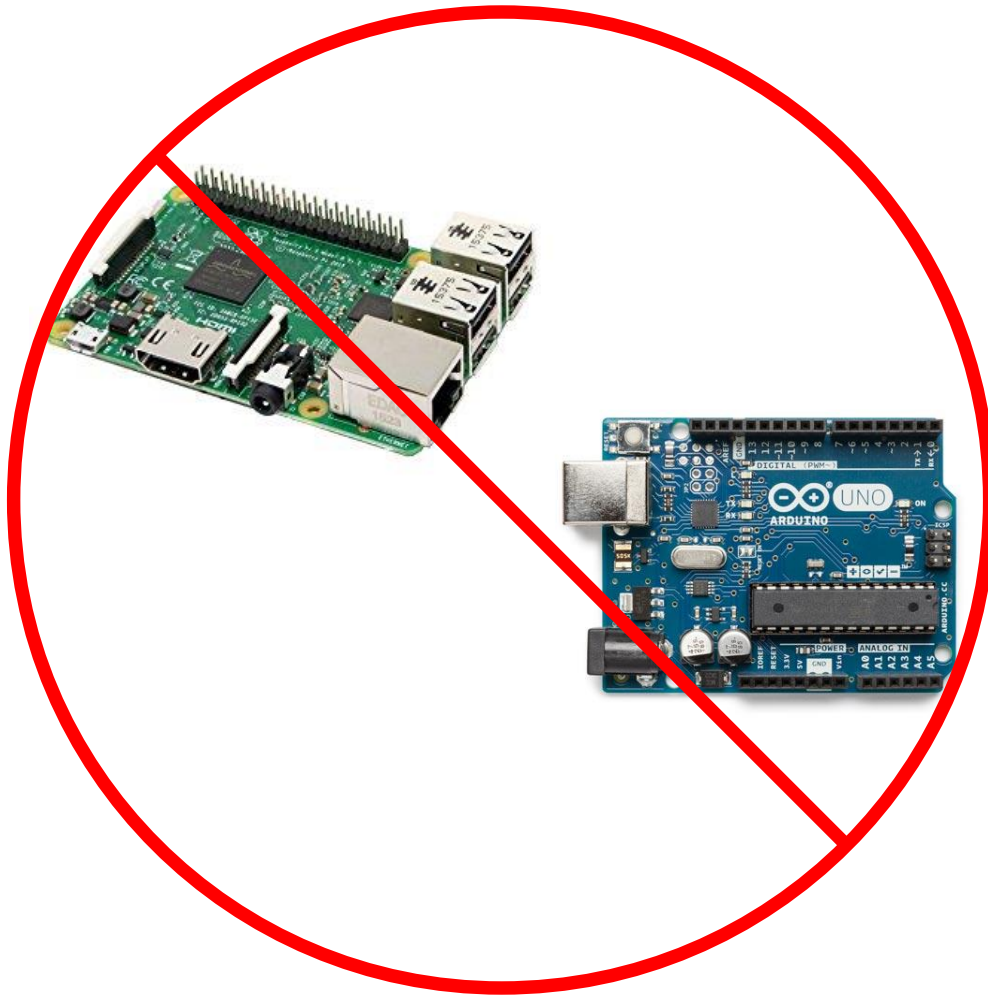
Ri

Sensor

DAQ

Vi

Vo

Voltage Follower

Voltage is Follower is one of My Favorite Circuits; Output Z:Input Z = 1:100

# Avoid Raspberry Pi or Arduino if Trying to Bring a Product to Market

Not Available at MFG Quantities. You Will Have to Port
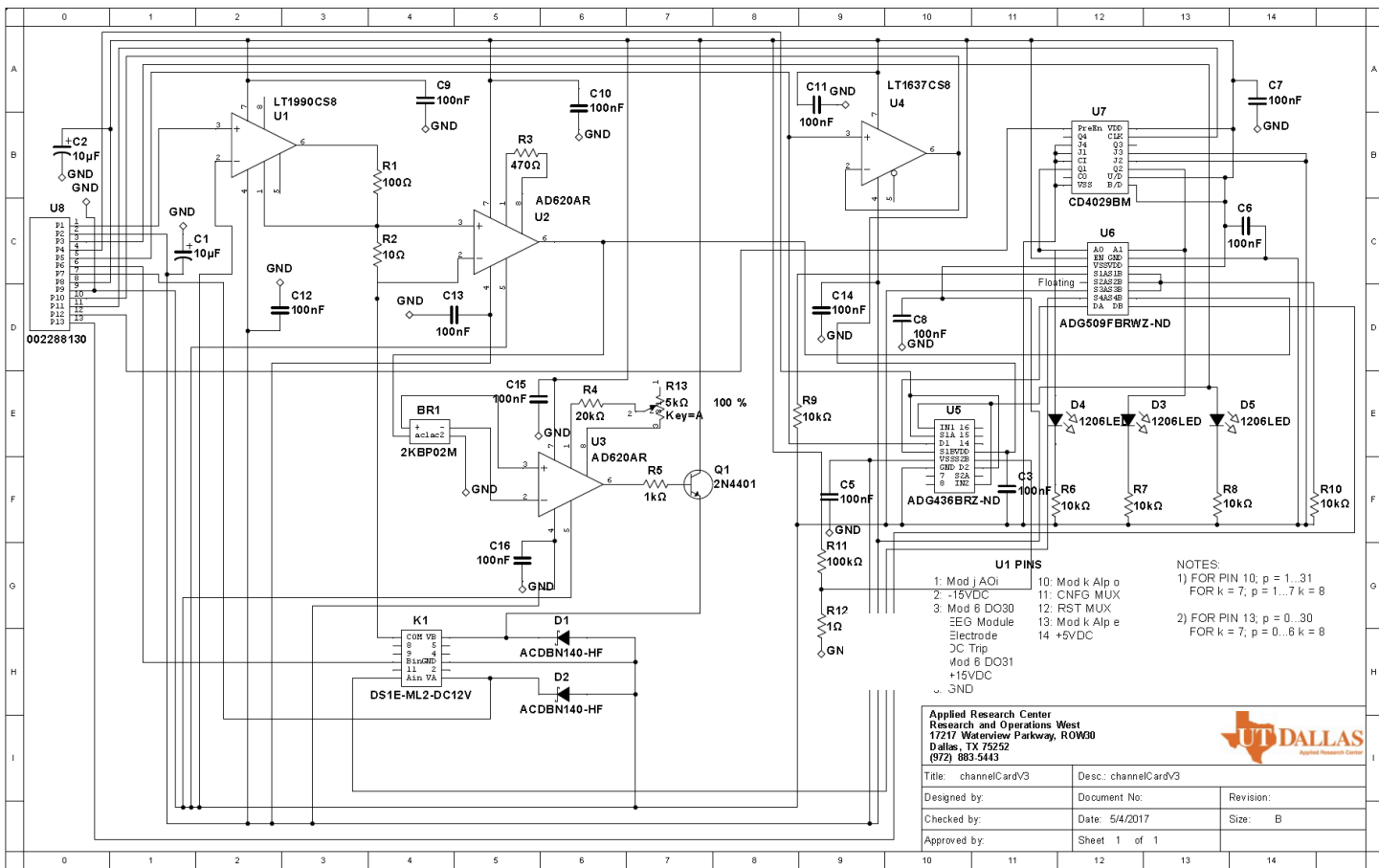
General Breadboarding Guidlines

- Avoid Touching Breadboard/Prototypes When Power is On (Even if it is low voltage)
- Set up your measurements first, then power on
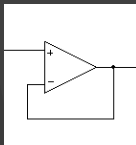- Switch off and unplug
- Order more parts than you need
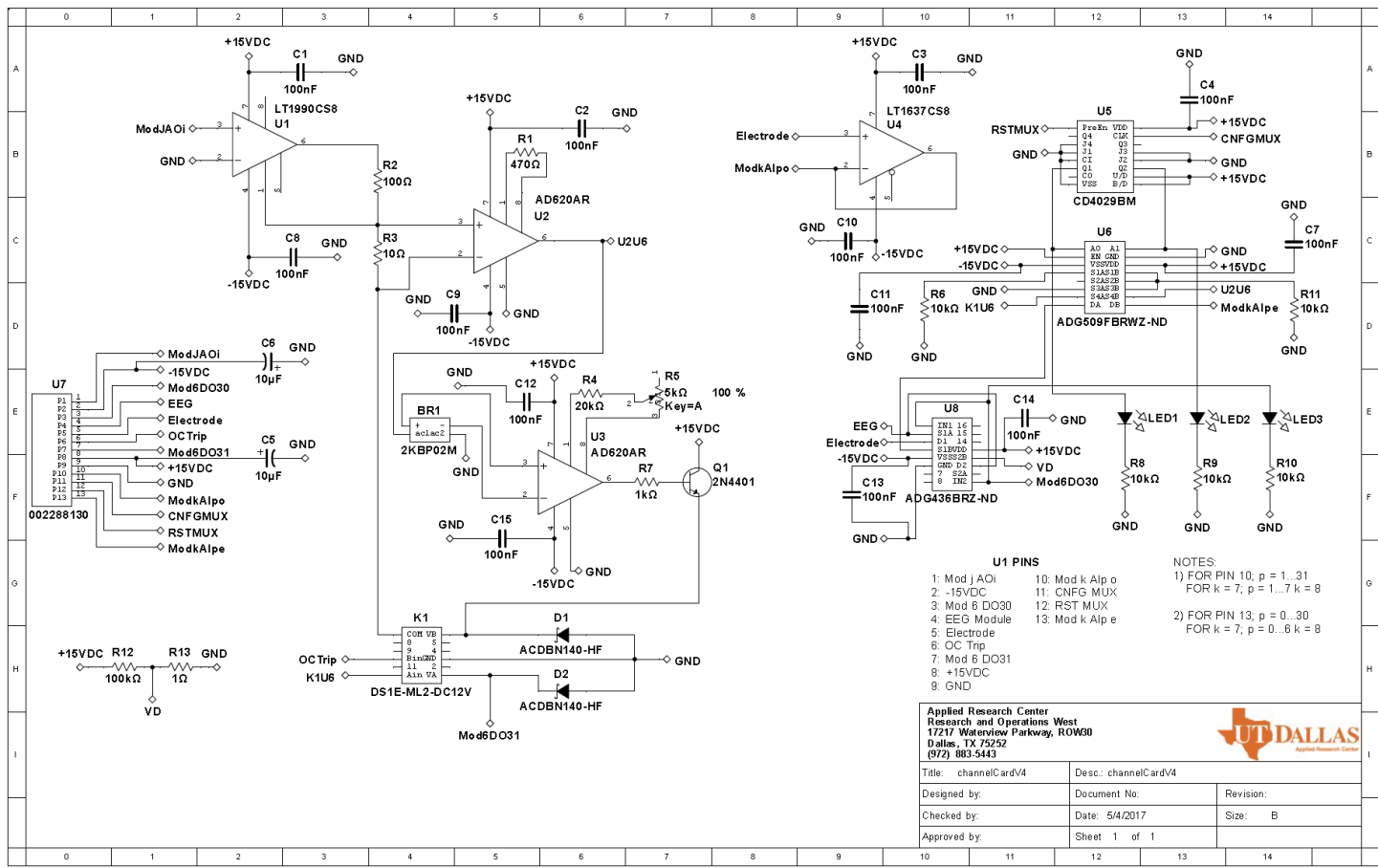
Circuit Design/Schematic Capture
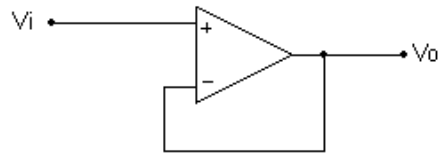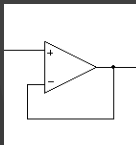
Use Named Nets Instead of Wires on Schematics

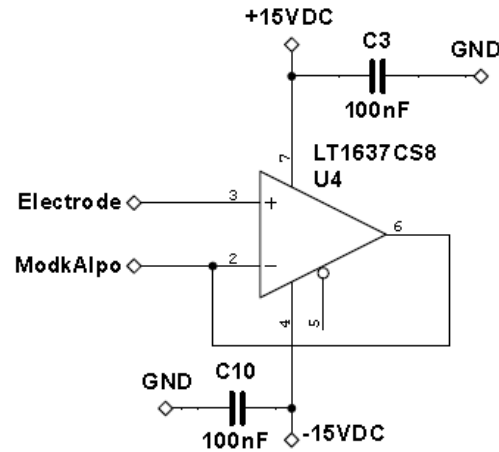**Before**

Use Named Nets Instead of Wires on Schematics

After

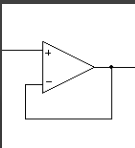# Bypass Caps Prevent Damage, and Ensure Proper IC Operation

- Every IC gets one
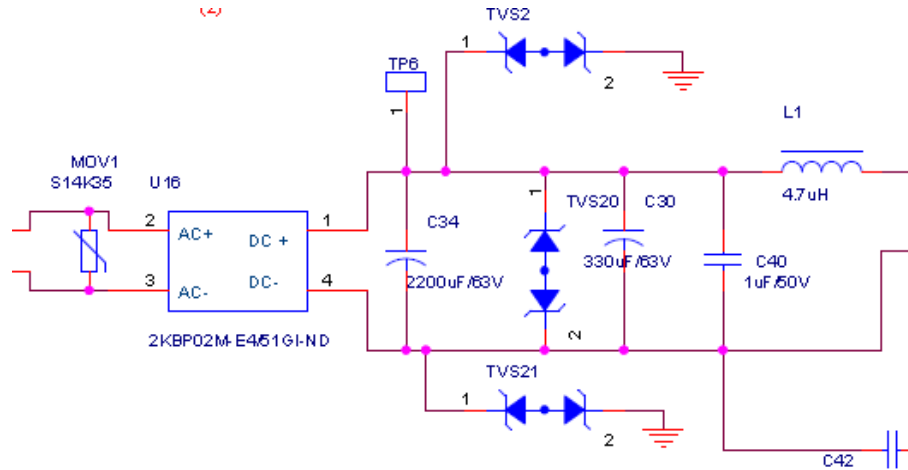- Dual voltage IC's get two

Item	Digikey PN
10 uF Tantalum Cap	PN 399-5152-1-ND
0.1 uF Ceramic Cap	399-1249-1-ND

Good Practice in Prototyping Too

Use TVS Diodes and Chokes
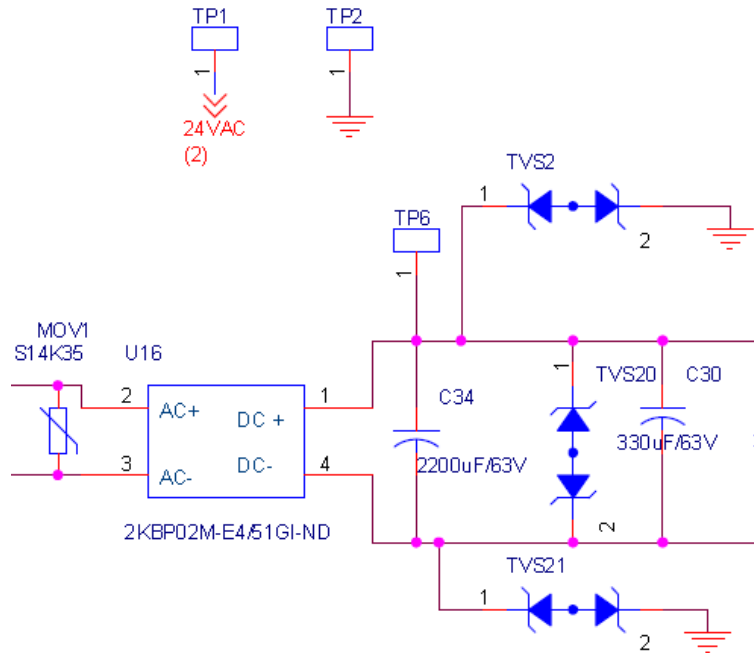

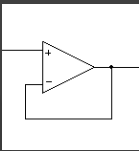| Item	Digikey PN
TVS Diode	296-41842-1-ND
Choke	PM3700-70-RCCT-ND

Good Practice in Prototyping Too
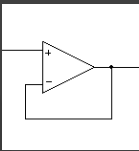
You can Never Have Too Many Test Points

Especially ground points (you want to avoid making large loops with scope cables)
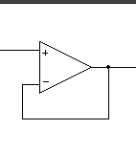
Provide Jumpers to Ground JTAG Lines, Especially Clock, When Using MCUs
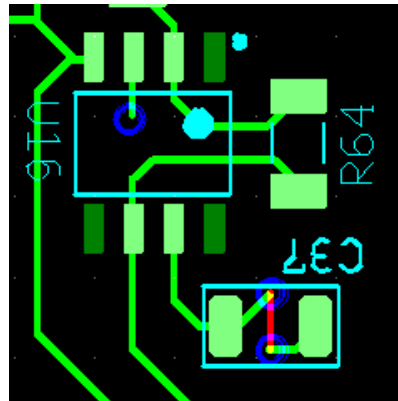
Define JTAG

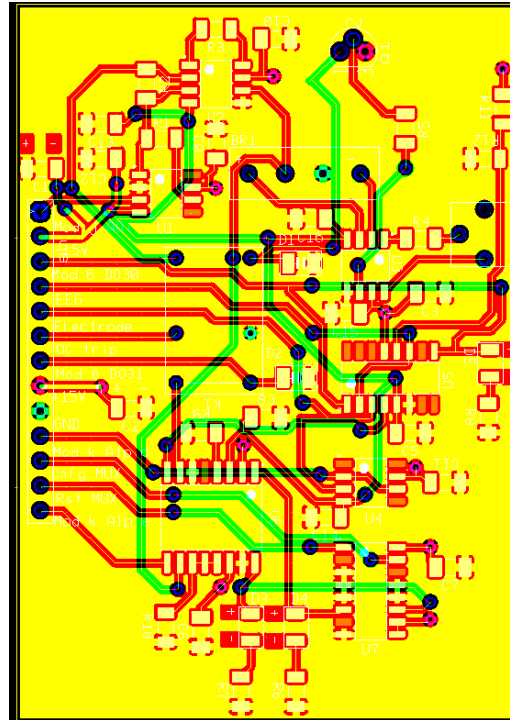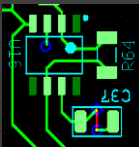| Digikey PN |
|------------|
| S3404-ND |

PCB Design

Always Use Copper Planes

- At Least Two – One for Vdd and one for VSS
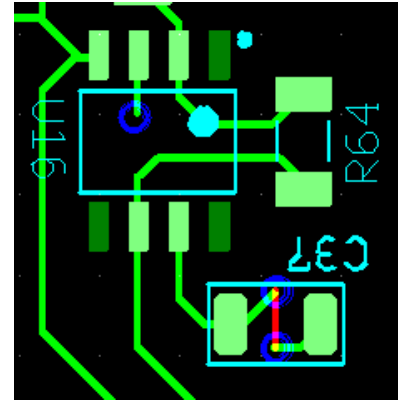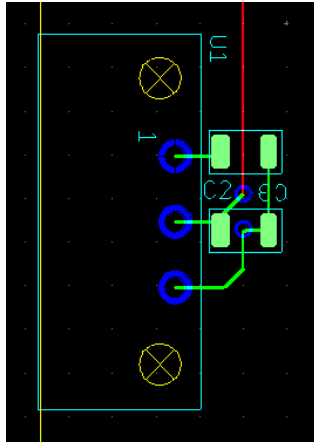- Do Not run Copper Planes to Edges

If using a 4 layer board make the two internal layers power and ground plane – No signals on internal layers

By-Pass Caps Should be as Close to IC's/Power Entry as possible

- Every IC gets one
- Dual voltage IC's get two

Item	Digikey PN
10 uF Tantalum Cap	PN 399-5152-1-ND
0.1 uF Ceramic Cap	399-1249-1-ND
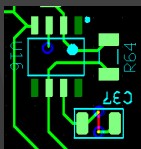
Avoid Routing Traces Through Mounting Holes/Pads
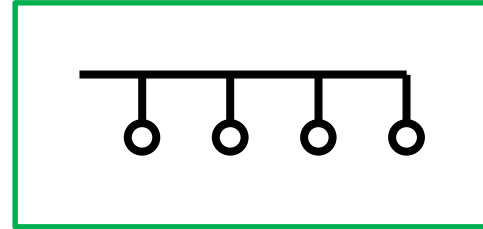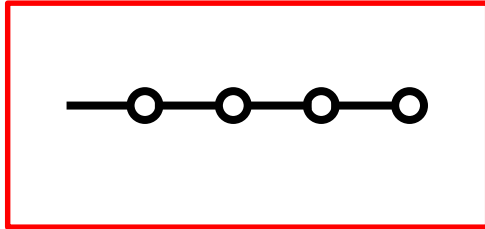
No.
Removing one pad requires two cuts and a bridge.
Also, Trace and pads act like a heat sink – harder to solder.

Yes.
Removing one pad requires one cut.
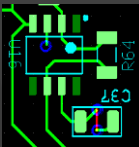
Avoid Placing Vias Under ICs, Esp. For Reflow
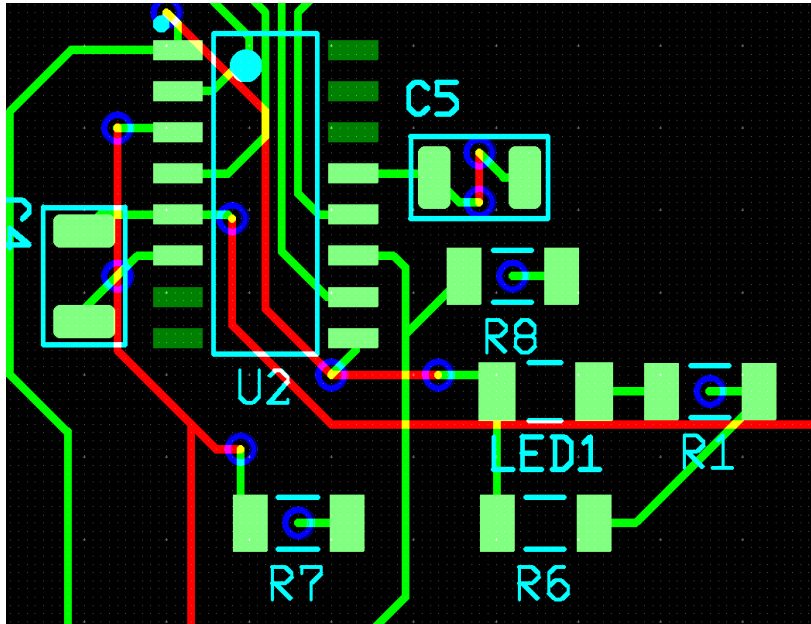
Solder can Bridge and You Will Not Know

Make Sure Copper Plane Connections Have Thermal Relief

Connection to Copper Plane

Use Connectors When Connecting Wires to PCB
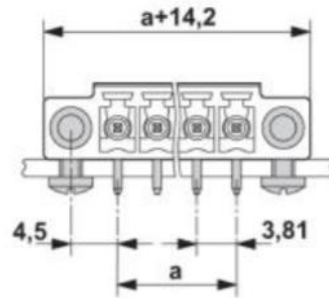
Item	Digikey PN
Male	277-5764-ND
Female	277-5714-ND

Require No Special Tools

These Are Some General PCB Guidelines

- Use double sided board with power and ground planes on top and bottom
- Use Informative Silkscreen Labels Excessively
- If using a 4 layer board make the two internal layers power and ground plane – No signals on internal layers
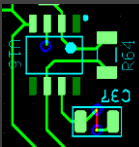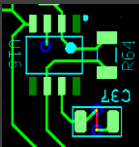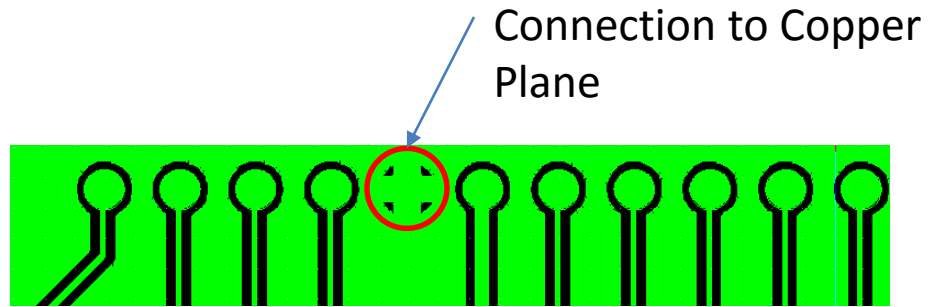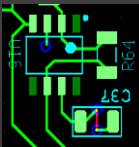- Use plated holes connected to ground for mounting holes watch your screw head size though (remember key takeaway #2)
- Hole diameter = 40 mils
- Track width = 10-60 mils (10 mil traces with 10 mil spacing is a good one, beef up any power traces)
- Circular pads = 80-120 mils
- Width/height for rectangular pads = 80-120 mils
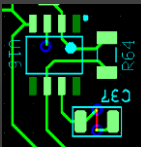
Final Assembly

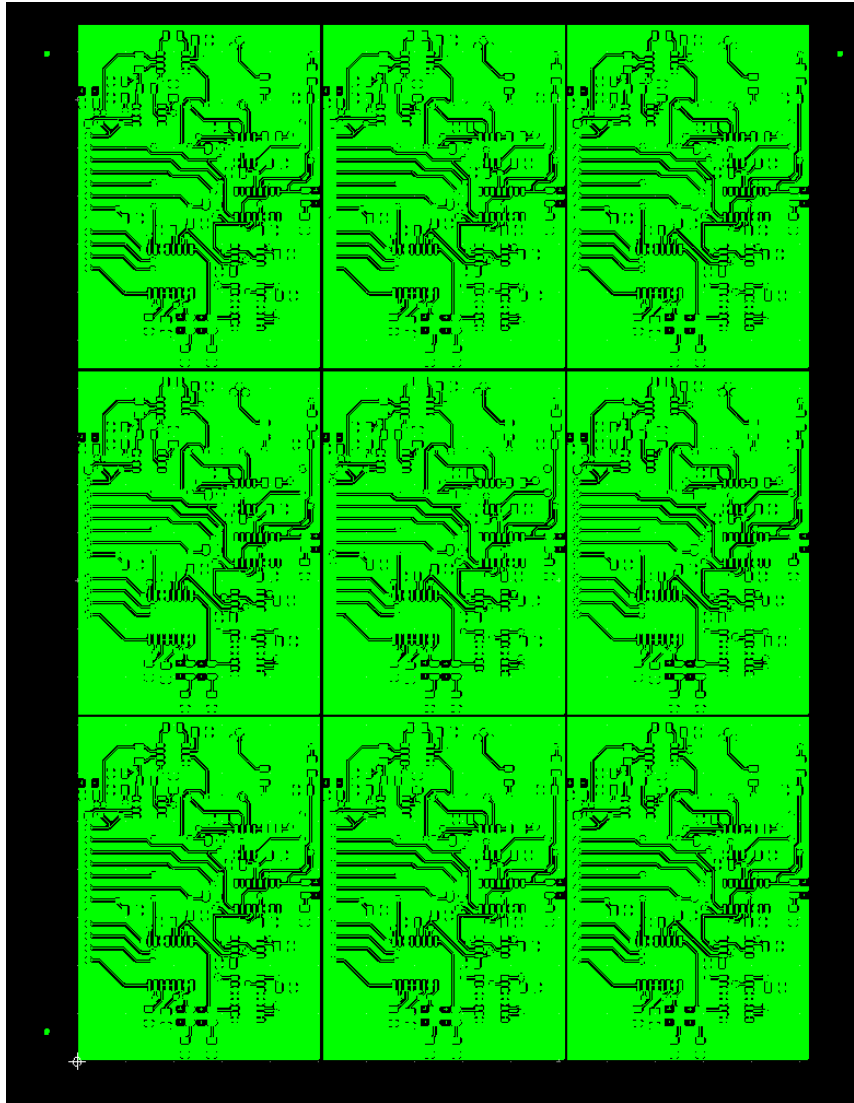# ALWAYS clean your PCB with Alcohol First

Digikey PN
473-1150-ND

Don't Touch it After You Clean It. Handle Like a Record

For Multiple Boards Consider Panelizing

These are Some Good Solder Choices

- 63/37 RA/RMA for hand soldering
- 42/57.6/0.4 for Reflow Soldering

Item	Digikey PN
63/37 Solder Wire	KE1400-ND
42/57.6/0.4 Solder Paste	SMDLTLFP-ND

Weld	T (deg C)	Minutes
Pre-heat	100	1
Heat	150	1
Melt	170	0.5
Cool	170	-

This Profile Works Well for 42/57.6/0.4 with Single Chamber Reflow Ovens

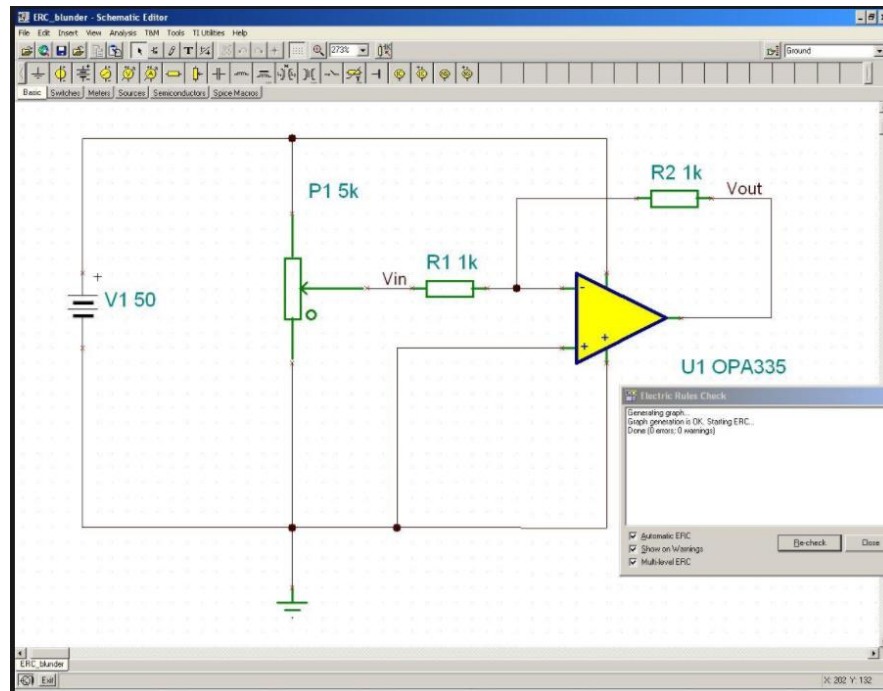**Always Store Solder Paste in the Fridge, Remove 24 Hours Before Use**

Some Final Comments on ASSM

- You can use conformal coating to "seal" your board after it has been soldered. Protects agains condutction and moisture
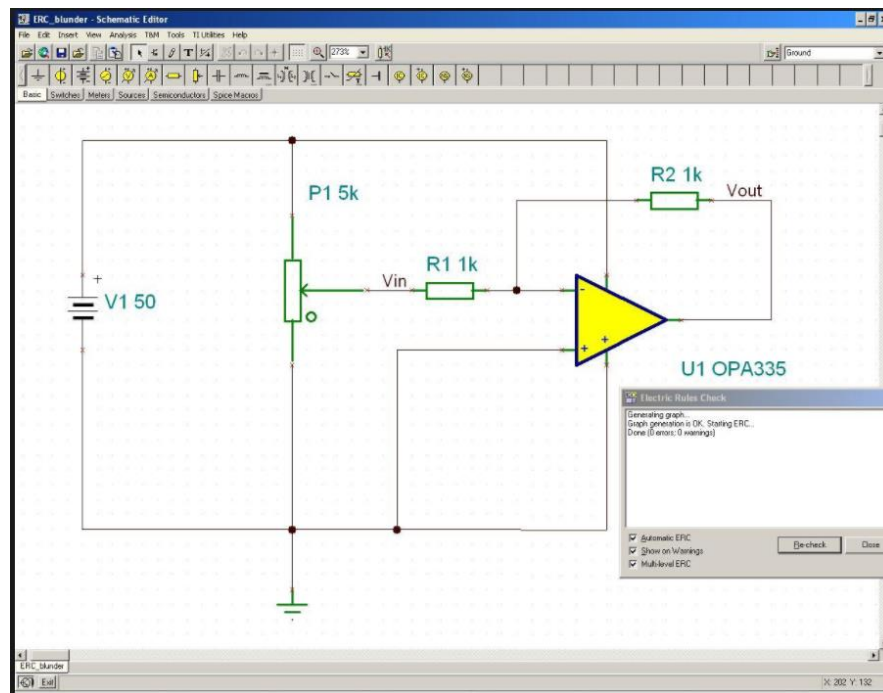- Watch your packaging when ordering – reals are a pain if not using P and P
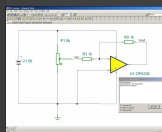
Free Tools

TINA is a Free SPICE-based Analog Simulation Program

- DC, Transient & Frequency Analysis
- Virtual Tools Including Oscope and Probes

http://www.ti.com/tool/tina-ti

Webench is an Online Design Tool
Power, Lighting, Filtering, Clocking and Sensing Circuits
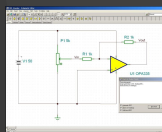
Express PCB is A PCB MFG That Makes Cheap Boards, Provided They're Designed with Their Tool
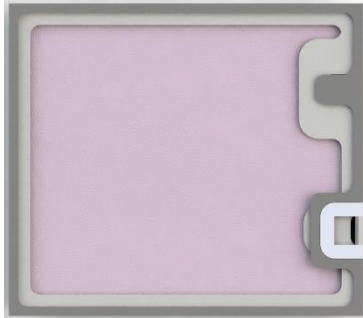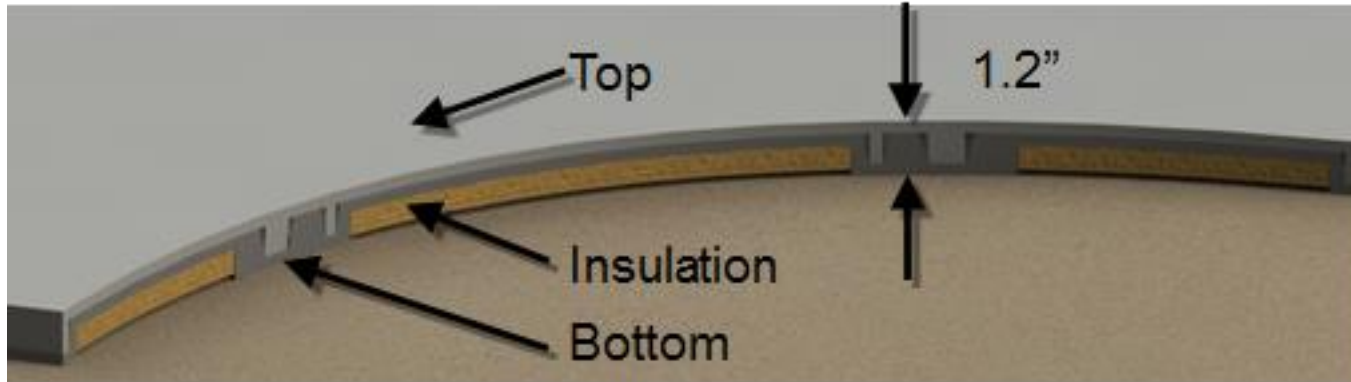

https://www.expresspcb.com/free-cad-software/
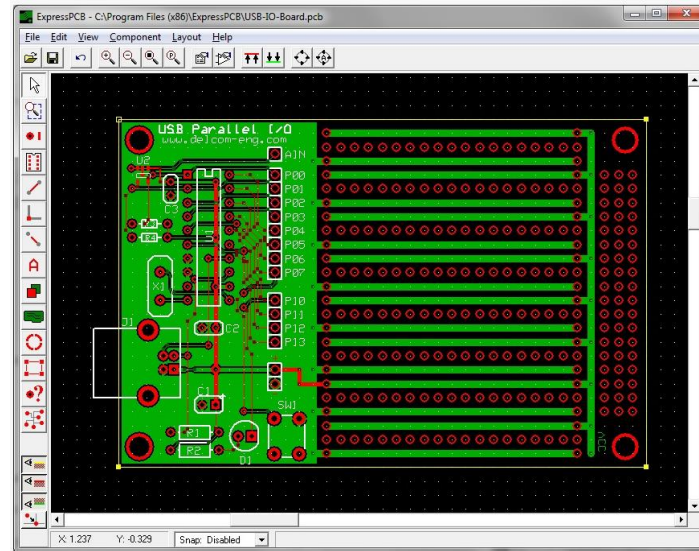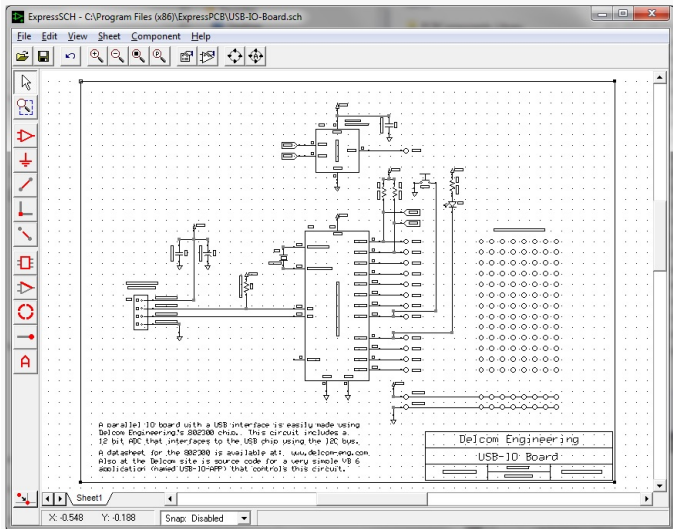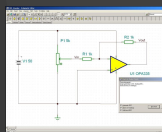
Design For Manufacture

Make sure you have fillets, drafts, clearances, tolerances

Gemini Plastics, Inc. is a great plastic manufacturer
http://www.gplastics.com/index.html
Jeremy O'Connell 920-336-2525
joconnell@gplastics.com

Communicate with your potential manufacturer ahead of time to get a sense of what their tools can and cannot do

These are My Best Practices

Your best practices depend on what you do, in your work there are elements just like this.

Think through your work process to save yourself time and money

Questions?