### Altıum.

### ALTIUMLIVE 2018: Designing for Adaptation

Hunter Scott Reach Labs, Dir. HW Engineering **San** Diego 10/4/18

### Altium

#### Who I am

- Director of Hardware Engineering at Reach Labs
- Design phased arrays, power systems
- ~10 years of HW experience

### What this is about

• How to design defensively and make it easy to modify your boards so you can skip re-spins

Altium

• "DFH" - Design for Hacking

#### What this isn't about

- How to rework
- How to debug/troubleshoot

Altium

• Design for manufacturing

### **Difficulty of rework**

Don't get intimidated. You need:

Altium

- A stereo microscope
- Good soldering iron
- No coffee

or

• A good technician

Altium

#### **Useful standards**

IPC-7711/7721 - Rework, Modification, and Repair of Electronic Assemblies
IPC-A-600 - Acceptability of Printed Circuit Boards
IPC J-STD-001-G - Requirements for Soldered Electrical and Electronic
Assemblies

**IPC-A-610E** - Acceptability of Electronic Assemblies

### Altium

### Organization

- Comment and annotate schematics
- Label testpoints
- Describe correct behavior



### Altium.

### **High level techniques**

- Isolate subcircuits 1 2
  - Give yourself options
- 3
- Make it easy to go between those options

**Altium**.

### **High level techniques**



Why it's a good idea:

- Allows you to use pieces of multiple designs together
- With multiple boards, you can do A/B testing of modifications
- Plus easier to debug, characterize, verify

Altium

#### Series resistors



Note: 0 ohm resistors can actually be as high as 50 mOhm. Pick a precision small value to get a resistor closer to 0 ohms.

### Altium

#### Load Switche<sup>-</sup>



Load switches allow digitally controlled/selective isolation, plus bonus debugging signals

Altium







486-1991-ND



Altium

#### Jumpers



From Victor Laynez, @roteno

Altium

#### Connectors



Watch out for big current loops in power lines. Will wreck EMC. Also watch out for loss in RF lines.



### Altium

#### Connectors



Example from TI Launchpad

### Altum

#### Connectors



RF jumper/isolation

**Altium**.

### **High level techniques**



Altium

### DNP is your best friend

- Costs nothing
- Easiest rework option you have
- DNP all over the place!

Altium

#### **DNP Filters**



Classic example: pi/T network

Altium

#### **DNP RF Connectors**



#### U.FL connector to measure before antenna

Altium

**DNP RF Connectors** 



Another example from the TI board with a smaller connector before PCB antennas

### Altium

#### **DNP RF Connectors**

BTW, tiny RF connectors are super confusing.

U.FL = IPEX = IPX = AMC = MHF = UMCC

If it's not one of those, it won't fit and you won't realize it until the moment you try to plug it in.

U.FL ≠ E.FL ≠ W.FL ≠ lots of other tiny, similar looking connectors

\*Don't forget, these only work up to 6 GHz. If you're higher than that, you need a different (bigger, more expensive) connector.

Altium

#### **DNP Debug Connectors**



### **DNP Entire sub-circuits**

- Use this to try different implementations of the same circuit
- Also useful if you want to make multiple versions of the same product

Altium



Altium



Altium



Altium



Altium



### **Castellated modules**

- Add and remove entire subcircuits
- Easier to redesign a risky section instead of the whole board
- Allows easy isolation for test before integration



Altium

#### **Castellated modules**

Make sure to tell your fabricator you want the board to be castellated



#### **Castellated modules**

They also allow you to use pre-made components, like power supplies.

If you want to make multiple versions of a product, but they have different power requirements, you can swap out modules.



Altium

**Castellated modules** 

Downsides:

- Takes up way more space
- If you have lots of pins, you need a larger module
- Not great for RF
- Not great for high power
- Not great for high speed

Altium



Altium



Altium



#### Altium

- This can be pretty jank
- But it can also work
- The more parts that need to be covered by the adapter, the harder it is
- Don't use the datasheet recommended pad size on the bottom of the adapter board. You need to go slightly smaller.
- XRay if you can, and use flux.

Pull up/down

Put in both pull up and pull down resistors, but only populate one.



Altium

#### Extra IO

# Break out spare IO and status/settings pins



### Altium

#### **PCB notes**

Put a rectangle of white silkscreen in a corner and you can use it to label boards with specific changes or other notes.



Altium

#### Chokes

Add a series choke that you can replace with a OR if you need to. Very helpful for EMC testing.



### Altium

### Shielding

- Put down pads for a removable shield just in case
- Use removable can shields instead of solder down shields



Altium

**High level techniques** 



Make it easy to go between those options

Vias in pads



Vias in pads



Altium

Vias in pads



Altium

### **Tenting vias**

Look at all those test points!



Altium

**Tenting vias** 



### **Test points**

Put test points everywhere.

- Copper test point for small spaces
- Solderable testpoints for bigger stuff (like power)
- These big ones won't break off after hours of abuse



36-5018CT-ND



### **Test points**

Putting test points on communication lines helps with probing and moving/adding things to the bus.

Label them in silkscreen! Make sure they're not obscured by other footprints.



Altium

### **Resistor dividers**

If you're controlling settings using a resistor divider, use a pot instead. Makes it easier to adjust and tune rather than swap out resistors over and over.



#### **Power**

Pick LDOs that have a high input voltage rating so you can change power sources

Voltage - Input (Max)	6V
Voltage - Output (Min/Fixed)	0.8V
Voltage - Output (Max)	5.5V

Voltage - Input (Max)	20V
Voltage - Output (Min/Fixed)	3.3V

#### **Footprints**

If you can help it:

- Don't use QFN. External pins are easier to deal with.
- Don't pick very small parts (0201, even 0402).
- Draw footprints slightly larger or longer than in the datasheet

### Stackup

Keep all parts on the same side if possible. Way easier to reflow and rework. Big boards (large thermal mass) or parts that need to be reflowed can be done in a reflow oven.

Altium

Use leaded solder. It's easier to work with. Change to lead free during production.

Have a ground plane and power plane.

### Soldering

- Leave space for a soldering iron tip
- Think about things that can melt (like plastic connectors)



**Other materials** 

• If you need to use underfill, consider something like Loctite UF 3810. It can be removed with hot air.

Altium

• Avoid potting, RTV, or conformal coating until you're happy with the electrical performance

### Silkscreen

- Mark pin numbers periodically
- Make sure designator is visible when part is populated



Altium

### Circuit tape

- From CircuitMedic.com
- Holds wires to PCB, cures fully in 72 hours. Leaves no residue.



What about RF?

"RF is scary and fragile and I'm afraid I'll mess it up" - almost everyone

What about RF?

We already saw how to jumper RF



### What about RF?

You can also buy really thin gauge coax cable (micro coax)

Product Attributes				
	Categories	Cables, Wires		
		Coaxial Cables (RF)		
	Manufacturer	Molex - Temp Flex		
	Series	Temp-Flex 100066		
Part Status		Active		
	Cable Type	Coaxial		
	Cable Group	-		
	Wire Gauge	30 AWG		
(	Conductor Strand	7 Strands / 38 AV	VG	
Jacket (Insulation) Material		Fluorinated Ethylene-Propylene (FEP)		
Jacket (Insulation) Diameter		0.071" (1.80mm)		
Shield Type		Braid		
Impedance		50 Ohms		

,

What about RF?

Part	Status	Active	
Cable	e Type	Micro Coaxial	
Cable	Group	-	
Wire	Gauge	50 AWG	
Conductor Strand		7 Strands / 58 AWG	
Jacket (Insulation) M	aterial	Perfluoroalko	ky (PFA)
Jacket (Insulation) Dia	ameter	0.006" (0.16m	ım)
Shield	d Type	Spiral	
Impe	dance	50 Ohms	

Altium

A9450W-328-ND \$5.50 a foot

### **Pigtails**

# Semi-rigid pigtails are better than floppy ones









### Altium

### **Pigtails**

Give yourself a low inductance ground pad for your pigtails



### **Coplanar waveguide**

- Easier to pigtail
- Possible to probe without soldering



#### Antennas

If your design allows it, picking an antenna structure that is easy to modify can be helpful.



### Altium.

### **High level techniques**

- Isolate subcircuits 1 2
  - Give yourself options
- 3
- Make it easy to go between those options



## Thank you!

Slides: hscott.net/adaptation @hunterscott