# Printed Circuit Board (PCB) Design

Lecture 17 Microprocessor-based Systems (E155) Prof. Josh Brake



### Survey Feedback

- Most important things you've learned
  - Datasheets!
  - Understanding the "plumbing"
- Things still unclear
  - Interrupts
  - Redundancy/error checking
  - CMSIS
- Things to change
  - Start earlier
  - Refreshers

# TBD lectures no longer TBD

- Direct Memory Access (DMA)
  - Load from or store to memory without using CPU
- Real-time operating systems
  - Why?
    - Multi-tasking
    - Scheduling

# Outline

- What is a PCB?
  - History
  - Components
- PCB Design process
- Layout considerations
- KiCad Demo
- Further resources



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### Why PCBs?



<u>AP Physics B Final Project: Wire Wrapping</u> by Andrew Adams under <u>CC BY-SA 2.0</u>

### Components

- Two main types
  - Through-hole
  - Surface mount technology (SMT)



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# Helpful Terms

- Trace copper "wire" on board
- Via hole through the board
- Pad exposed copper area where part is soldered
- Package physical size of part and pins
- Surface mount part which is attached to one side of PCB
- Through-hole part which is inserted through PCB

# PCB vs. Breadboard

- Pros for PCB
  - Stability and reliability
  - More space efficient
  - Better grounding
  - Physical mounting is more stable
- Pros for breadboard
  - Flexible
  - Ease of debugging and isolating problems
  - Fast!

### Ways to manufacture

- Etching
- Milling
- Printing



http://www.webshop.mipec.eu/fotky6870/fotos/\_vyrp14\_71DSC\_7924.jpg



#### **Design Process**



Budget around 6-8 weeks per iteration if you are new at it.

Step	KiCad Tool Name	
Design circuit		
Create symbols	library editor	
Schematic capture	eeschema	
Create footprints	footprint editor	
Generate netlist	cvpcb	
Board layout	pcbnew	
Production	GerbView	
Generate BOM	Digi-Key	

# Create/Import Symbols

- Open eeschema
- Add/create libraries
- Select or import symbol
- Symbols for many common parts already exist







# Schematic Capture

- Layout components
- Then go and connect with wires or labels



#### Create/Import Footprints

• Connect schematic symbols to their physical shape

			Assign Footp	rints	
🔅   🛅 🔷 🔿   🚧	<b>\$</b> ₩ <mark>0</mark>   F	Footprint Filters: 🚏			
Footprint Libraries	Symbol : Fo	otprint Assignments			Filtered Footprints
Battery	1	C1 -	С:		1 Battery:BatteryHolder_Bulgin_BX0036_1:
Button_Switch_Keyboard	2	C2 -	с:		2 Battery:BatteryHolder_ComfortableElect
Button_Switch_SMD	3 I	.S1 - Speake	r :		3 Battery:BatteryHolder_Eagle_12BH611-GH
Button_Switch_THT	4	R1 -	R :		4 Battery:BatteryHolder_Keystone_103_1x:
Buzzer_Beeper	5 F	RV1 - R_PC	т:		5 Battery:BatteryHolder_Keystone_104_1x:
Calibration_Scale	6	U1 - STM32F401RET	x : Package_QFP:I	QFP-64_10x10mm_P0.5mm	6 Battery:BatteryHolder_Keystone_105_1x;
Capacitor_SMD	7	U2 - LM38	6:		7 Battery:BatteryHolder_Keystone_106_1x;
Capacitor_Tantalum_SMD					8 Battery:BatteryHolder_Keystone_107_1x;
Capacitor_THT					9 Battery:BatteryHolder_Keystone_500
Connector					10 Battery:BatteryHolder_Keystone_1042_1:
Connector_AMASS					11 Battery:BatteryHolder_Keystone_1058_1:
Connector_Amphenol					12 Battery:BatteryHolder_Keystone_1060_1:
Connector Audio					13 Battery:BatteryHolder_Keystone_2460_1:
Connector_BarrelJack					14 Battery:BatteryHolder_Keystone_2462_2:
Connector_Card					15 Battery:BatteryHolder_Keystone_2466_1;
Connector_Coaxial					16 Battery:BatteryHolder_Keystone_2468_2:
Connector_DIN					17 Battery:BatteryHolder_Keystone_2479_3:
Connector_Dsub					18 Battery:BatteryHolder_Keystone_2993
Connector_FFC-FPC					19 Battery:BatteryHolder_Keystone_2998_1;
Connector_Harwin					20 Battery:BatteryHolder_Keystone_3000_1;
Connector_HDMI					21 Battery:BatteryHolder_Keystone_3001_1:
Connector_Hirose					22 Battery:BatteryHolder_Keystone_3002_1:
Connector_IDC					23 Battery:BatteryHolder_Keystone_3008_1:
Connector_JAE					24 Battery:BatteryHolder_Keystone_3009_1:
Connector_JST					25 Battery:BatteryHolder_Keystone_3034_1:
Connector_Molex					26 Battery:BatteryHolder_LINX_BAT-HLD-01:
Connector_Multicomp					27 Battery:BatteryHolder_MPD_BA9VPC_1xPP:
Connector_PCBEdge					28 Battery:BatteryHolder_MPD_BC2AAPC_2xA2
Connector_Phoenix_GMSTB					29 Battery:BatteryHolder_MPD_BC12AAPC_2xi
Connector_Phoenix_MC					30 Battery:BatteryHolder_MPD_BC2003_1x200
Connector_Phoenix_MC_HighVo					31 Battery:BatteryHolder_MPD_BH-18650-PC2
Connector_Phoenix_MSTB					32 Battery:BatteryHolder_Seiko_MS621F
No filtering: 11720					
				Apply, Save Schemati	c & Continue Cancel OK

#### **Generate Netlist**

Gives list of network connections between components



# **Board Layout**

• Open PCB new and import schematic





#### Production

- Check out the Gerber with an online viewer
- Gerber file is industry standard file for machines with manufacture PCBs

# Layout Considerations

- Trace Widths
- Decoupling capacitors: Rules of thumb
  - ~10  $\mu F$  for next to power inputs
  - 10-100 nF next to ICs



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#### KiCad Demo



#### References

- <u>https://cei-lab.github.io/ece3400-2018/lectures/Lecture15-</u> <u>PCB\_Design.pdf</u>
- <u>https://ocw.mit.edu/courses/mechanical-engineering/2-996-biomedical-devices-design-laboratory-fall-2007/lecture-notes/lecture02.pdf</u>
- <u>https://www.protoexpress.com/blog/7-pcb-design-tips-solve-emi-emc-issues/</u>

#### **Further Resources**

- Shawn Hymel YouTube series <u>KiCad Digi-Key Tutorial</u>
- Chris Gammel Video series <u>Getting to Blinky 4.0</u>
- Prof. Spencer PDF <u>How to make a PCB for me</u>
- Clinic Tutorial

# Up Next

- Wednesday: Motors and Speakers
- Lab 7: The Internet of Things
  - Final project proposal due today