THE ART AND SCIENCE OF PCB DESIGN

IAP 2025

Lecture 01 - SYSTEM DESIGN

How do we begin designing PCBs?

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Outline

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- Course Overview
- Introduction to System Design
- System Parameters
- Modelling the System
- Course Project
- Summary

Course Overview

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Course Numbers
- 6.S092 (U)
- 2.S975 (U); 2.S983 (G)
- EC.S03 (U)

Preregister! Ends today!

Prerequisite
6.200 or 2.678/2.679 or pre-test
Email iap-pcb-staff@mit.edu if you do not meet pre-reqs

Lectures
- MWF 10-11 @ 2-190
- Lecture recordings on pcb.mit.edu
- Lecture quiz released at 11AM and due EOD

Recitations
- MWF 11-12 @ 36-144
- Optional; provides further in-depth look and practice problems

Labs
- TTh 9-11, 11-1, 1-3 @ 38-500
- Bring laptop and computer mouse
- Lab assignments due before next lab

Fill out lab section preference form

Course Overview

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Software
- Altium Designer (Windows-only) or KiCAD
- LTspice
- Install before lab; see pcb.mit.edu

Website
- pcb.mit.edu
- Piazza

Lecturers:
- Will Vu
- Sarah Pomeranz
- Deepta Gupta

Lab Assistants:
- Marissa Liu
- Sean Boerhout
- Riya Gupta
- Noah Haefner
- Jeewoo Kang
- George Jurgiel
- Claudius Tewari

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System Design

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System Design

Introduction

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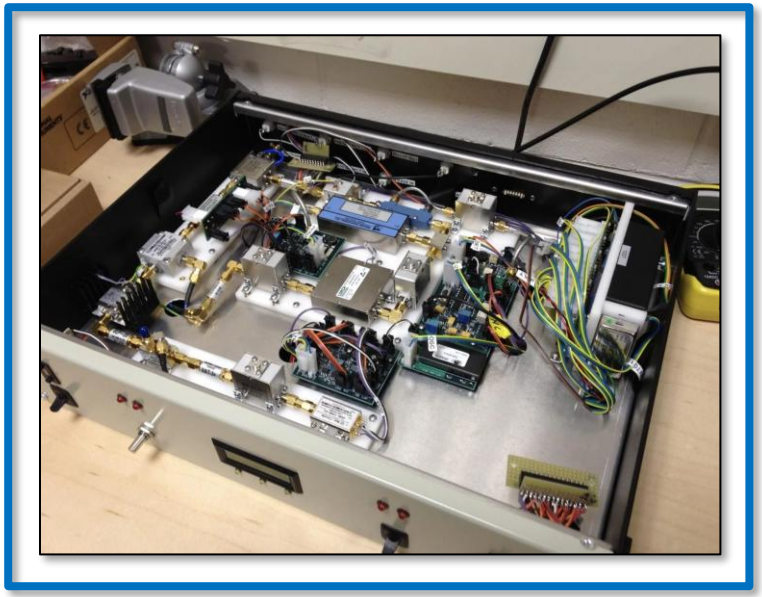
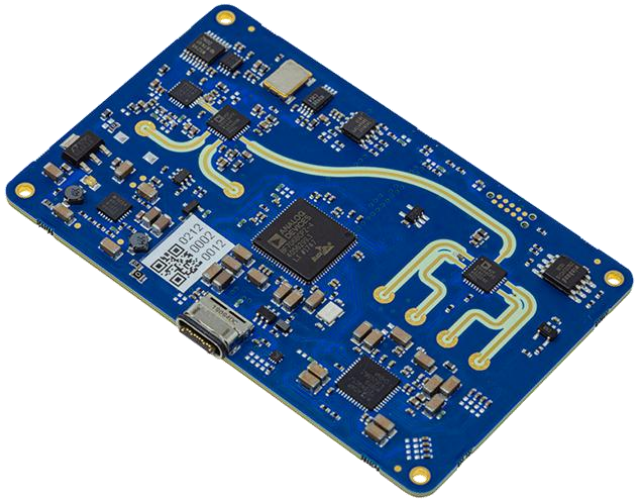
Printed Circuit Boards are medium for fabricating electronic devices



PCB Design



Before we start design PCBs, we first need to design electronic devices

System Design

Introduction

With any electronic system, we're seeking to solve a problem

Radio Astronomy

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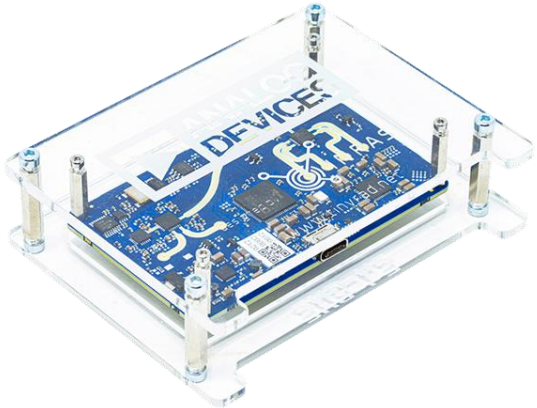
Or it could be your…

- **UROP**
- **Class project**
- **Thesis**
- **Personal pursuit**



Radar Education Platform

Driver Assistance

Terminal Missile Defense

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System Design

Introduction

The unique constraints provided by PCBs makes it a Design For Manufacturing (DFM) process

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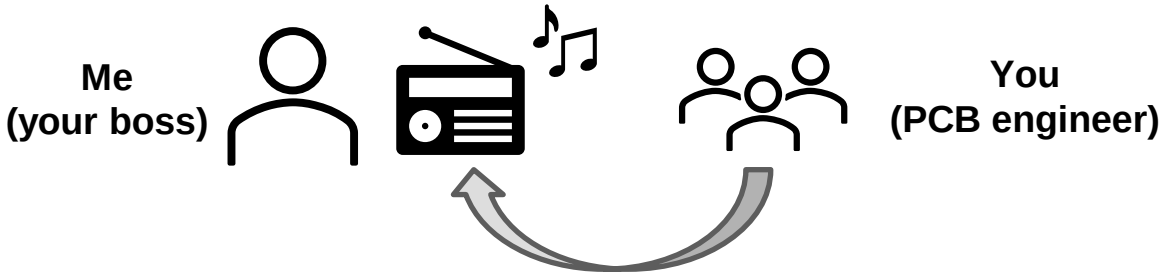
As we continue, let's use an example…



Identify Problem

Devise Solution

Identify System Parameters

Create/Model System

Design PCB! → **Fabrication** → **Test/Debug**

Repeat as needed

System Design

Defining System Parameters

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After devising a solution (our electronic system), we need metrics to design/measure it by

Electrical Performance

How well the device operates

- Speed/clock rate
- Output power
- Latency
- Resolution
- Accuracy
- Power consumption

Defined by the problem-to-be-solved

Form Factor

How the user interacts with the device

- Size
- Weight
- Control interfaces
- Training requirement

Defined by the end-user

Manufacturability

How the device is built

- Cost
- Procurement speed
- Fabrication constraints
- Assembly constraints
- COTS or custom
- Export restrictions

Defined by PCB fab/assembly capabilities

COTS – Commercial Off The Shelf

System Design

Modelling the System

[1] M. Dwye and D. S. Ricketts, "The North Carolina State University Rabbit Radar: Build a Frequency-Modulated Continuous-Wave Radar in a Day [Application Notes]," *IEEE Microwave Magazine*, vol. 21, no. 5, Institute of Electrical and Electronics Engineers Inc., pp. 136–145, May 01, 2020. doi: 10.1109/MMM.2020.2971184.

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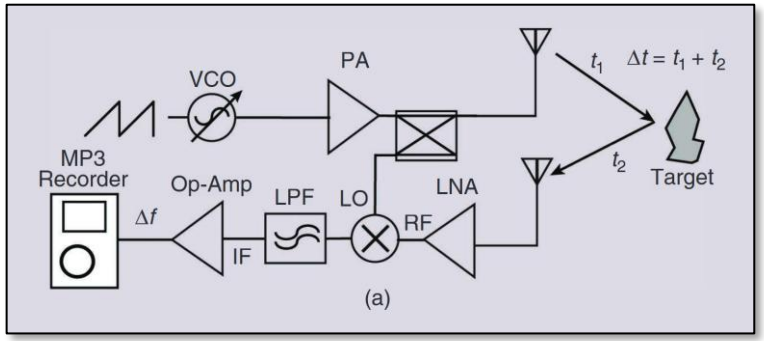
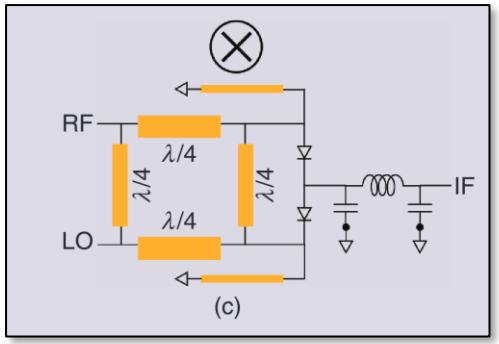
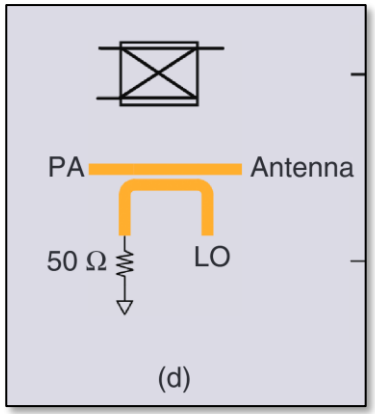
2-words, 3-syllables: ***Block Diagrams!***

Abstract the electrical system into lumped components and use circuit interconnections to show the flow of information/power/electrons

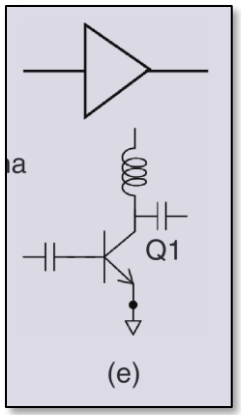
NC State Rabbit Radar [1]

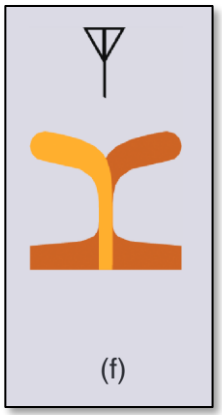






Breakdown the system into individual components





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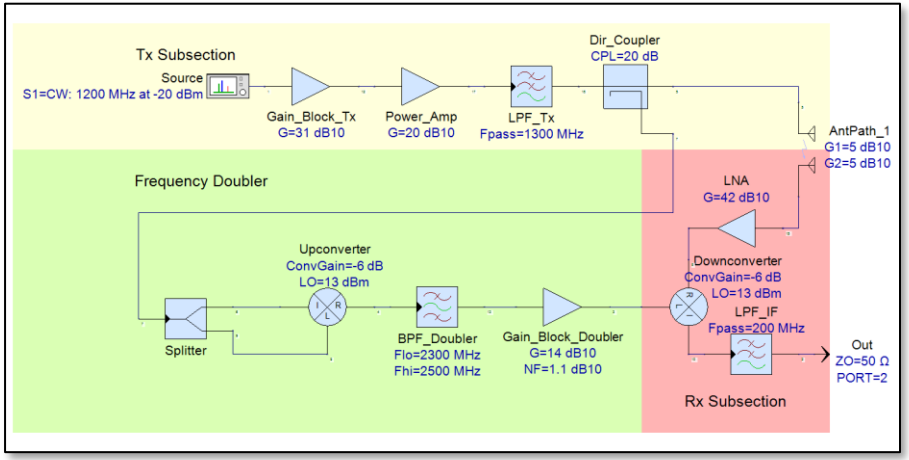
System Design

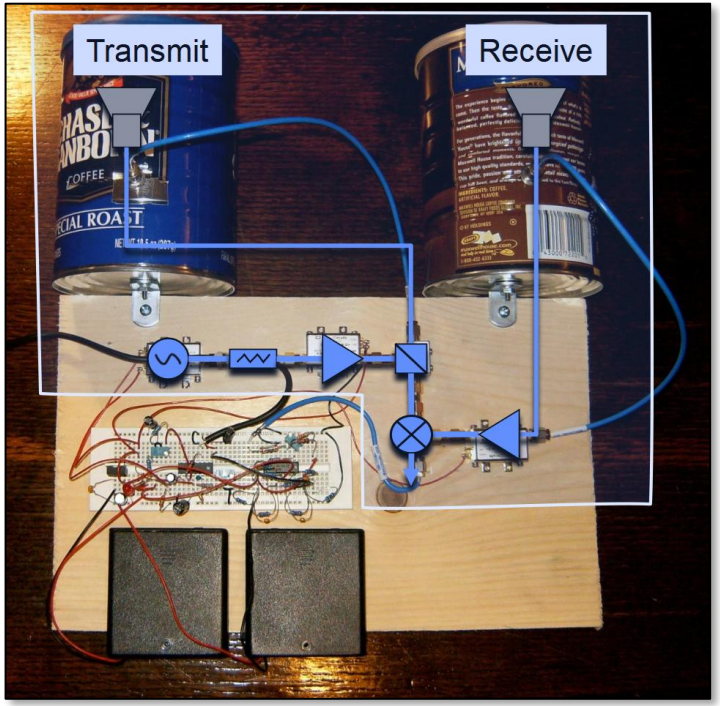
Modelling the System



Using our block diagrams we can perform simulations at various levels:

1. **System level**
2. **Circuit level**
3. **Component level**

Block diagrams help explain system functionality at a high level



System Design

Course Project

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Recall our example…?

- Identify Problem ✓
- Devise Solution ✓
- Identify System Parameters ✓
- Create/Model System ✓

FM radio receiver

Course Project!

Throughout IAP you'll be guided through the

1. **System design,**
2. **Circuit design,**
3. **PCB design, and**
4. **Fabrication/assembly**

of the course project!

Later topics

Design PCB! → Fabrication → Test/Debug

Summary

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- System design consists of crucial steps we must take before designing any PCB
- After determining a problem, we can devise an electronic system to solve it
- We must define system parameters by which to quantify our device/system's performance
- We must model our system using block diagrams to create abstractions to aide with design, simulation, and documentation
- Course project will be designing an FM radio receiver

Questions?

- ❑ Make sure you are pre-registered for the course
- ❑ Fill out lab preferences form ASAP (lab sections released tonight)
- ❑ Complete Lecture Quiz 01 (pcb.mit.edu/schedule), due midnight today
- ❑ Complete required software setup (pcb.mit.edu/schedule) before lab tomorrow
- ❑ Optional recitation following lecture in 36-144