EECS 192: Mechatronics Design Lab

Discussion 1: Introduction

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- Administrivia
- FRDM Board Intro
- Soldering
Welcome to EE192!
Project

- Project: build an autonomous track-following racecar given a stock chassis and microcontroller dev kit
- Teams should be 3 students
  - Combined skillset should include mechanical design / fabrication, electronics, programming
  - Controls experience helpful
- Teams formed by checkoff Friday
- Read the competition rules
  - NATCAR
Checkoffs

- One-hour time slot on Friday 3:00-4:00 pm (TBD?) to demonstrate that your project is where it should be
- At least one team member needs to show up to run your hardware
- These are graded, half credit if late

- First checkoff this Friday
  - Form project teams and check out cars
  - Checks4Cars program: trade a $300 deposit check for a car
  - Get private course GitHub repository
  - Details on website

Get your cars!
Git Refresher

- **Git**: distributed version control software
  - Each commit: like complete snapshot
  - Branches: separate chains of commits
    - eventually merged back to its parent
  - Distributed: everyone has compete copy
    - Most operations local, periodically sync

- **Best Practices**
  - Small, logical, often commits
  - Write good commit messages
  - Develop in branches: keep master clean
Hardware

- FRDM-K64F Development Board
- MK64FN1M0VLL12 microcontroller
  - 120 MHz ARM Cortex-M4
  - 1024 KB flash memory
  - 256 KB RAM
- Programmable using USB
- I/O headers including
  - GPIO
  - 16-bit analog inputs (ADC)
  - 12-bit analog output (DAC)
  - PWM, I$^2$C, SPI, and UART modules
- On-board RGB LED, Accelerometer, Magnetometer
IO Refresher

- **GPIO (general purpose input/output) pins**
  - As an output: sets voltage on pin from software, either GND (0) or Vdd (1)
  - As an input: samples voltage on the pin, returning either 0 (low) or 1 (high)

- **PWM (pulse-width modulation) module**
  - Every *period*, the pin is high based on the *duty cycle*, then low for the remainder
  - Can digitally approximate analog outputs

- **Analog Inputs (ADC)**
  - Converts a continuous analog voltage (0-3.3v) to a 16-bit (0-65535) quantity
Concurrency Refresher

- FRDM-KL64F’s processor is single core
- Blocking Operations
  - Operations do not return until finished, blocking thread of control
  - IO operations may be lengthy!
  - `printf`
- Nonblocking Operations
  - Operations return immediately, activity continues in the “background”
  - IO operations can buffer data and use interrupts to send/receive data
- Threading and RTOS
  - [https://www.freertos.org/](https://www.freertos.org/)
  - `freeRTOS` includes threading, concurrency, and synchronization
MCUExpresso

- An IDE with a **debugger**!
- Develop code in C for K64F
```
#include "fsl_device_registers.h"
#include "fsl_debug_console.h"
#include "board.h"
#include "pin_mux.h"
#include "clock_config.h"

int main(void)
{
    // cause linker to include floating point
    asm (".global_printf_float");

    // Init board hardware
    BOARD_InitPins();
    BOARD_BootClockRUN();
    BOARD_InitDebugConsole();

    // print and return
    printf("Hello, World.\r\n");
    while (1) {
        // do something;
    }
    return 0;
}
```
Live Demo!

Print "Hello World", Demonstrate Breakpoints, etc.
Soldering: joining (electrically and mechanically) metals using a separate filler metal “solder”

Electronics: bonding component pins/leads to circuit board through-holes or pads
  - Solder is usually a tin/lead alloy (e.g. 63/37) or lead-free tin-silver-copper alloy (e.g. SAC305)

This tutorial focuses on introductory through-hole soldering
  - Note: most production boards today are surface-mount to save space
Safety Precautions

- Soldering melts metal - IT’S HOT
  - Tips typically set at 700°F (371°C)
  - Irons can stay hot after turning off
  - Touching a hot tip is NOT fun
- Leaded solder contains, well, lead...
  - ... which is known to the state of California to cause cancer and reproductive harm ...
  - WASH YOUR HANDS AFTERWARDS
- Solder vaporizes flux, producing fumes
  - Regular exposure linked to asthma
  - DON’T BREATHE THEM IN
  - May also cause solder splatter: safety goggles recommended

Lead poisoning: not as fun in real life

©Fox
Soldering depends on good thermal transfer from tip to solder / component / board

- Metals oxidize, forming an oxide layer
  - Oxides impede thermal transfer
  - Reactions faster at higher temperatures

- Flux provides chemical cleaning
  - Rosin flux is corrosive when heated
  - ... and is present in solder wire spools
  - ... but is “burned” upon use

- Just keep this in mind...
Equipment Overview

Soldering Iron Base
(front view)
- Temperature Adjust Knob
- Wire to Handpiece

(side view)
- Power Switch

Soldering Iron Handpiece
- Wire to Base
- Grip (hold iron here)
- Barrel (contains heater)
- Tip (melts solder)

Tip (cutaway view)
- Solder (tinned coating)
- Iron Plate
- Copper Filling

Caution: These parts get very hot during operation! Do NOT touch until cool!
Tip Maintenance

- The tip is what heats things up
  - Want to maximize thermal transfer!
- Keep the tip “tinned” with solder
  - Provides better thermal transfer
  - Sacrificial layer preventing tip oxidation, which destroys the tip
- Must be occasionally refreshed
  - The solder oxidizes, accelerated by heat
  - Cleaning: wipe on brass or wet sponge
  - Immediately re-tin (apply solder layer)
Procedure

- Beginner’s tip: use iron to heat up component and board, not solder
  - Feed solder in through the other side
  - Solder only melts when component and board sufficiently hot
- Maximizing heat transfer
  - Point tips: solder using “side” of tip, not point
  - Chisel tips: use the broad flat end
Joint Inspection

Optimal joint shape is a “solder volcano”
Quick poll: best time for GSI office hours? (about 2 per week)
- Thursday, for the pre-checkoff scramble?
- Other times?

Thursday section only: has schedules cleared up enough to move discussion to Wednesday?
- Otherwise, future discussion sections (starting Thu, 29 Jan) will be 9:30am-10:30am
Electrostatic Discharge

- You build up static charge on your body
  - ... just by walking, especially when it’s dry
  - ... and up to several kV
  - but under ~2kV is imperceptible
- Chips are sensitive to high voltages:
  may cause permanent damage
  - read: board stops working “for no reason”
- Remember to ground (discharge) yourself before handling sensitive electronics
  - Touch the grounded lab bench surface
  - Use a ESD wriststrap
  - Avoid touching traces on boards

Don’t let this happen to you
Get your parts and get started!

I'll be walking around helping!

For checkpoint 1, you need to build 2 LED blink circuits - the first using an IC and the second using PWM from the K64F. Choose the resistor such that \(~1.6\text{mA}\) goes through the LED. The MCU supply voltage is 3.3v.

(yes, I know those red LEDs suck)

Also, grab a computer account form!
Links

- Chassis: 
- Github: https://github.com
- K64F: https://os.mbed.com/platforms/FRDM-K64F/
- MCUExpresso: https://mcuxpresso.nxp.com/en/welcome