EECS 192: Mechatronics Design Lab

Discussion 1: Introduction

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20 Jan 2016 (Week 1)

- Administrivia
- FRDM Board Intro
- Soldering

Welcome

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
  - Freescale Cup
  - NATCAR

Checkoffs

- One-hour time slot on Friday 11:30am-12:30pm 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

git logo, by Jason Long, CC BY 3.0

Learn git here:

`try.github.io`

Hardware

- FRDM-KL25Z Development Board
- MKL25Z128VLK4 microcontroller
  - 48MHz ARM Cortex-M0+
  - 128KB flash
  - 16KB SRAM
- Programmable using USB
- I/O headers including
  - GPIO
  - 16-bit analog inputs (ADC)
  - 12-bit analog output (DAC)
  - PWM, I^2C, SPI, and UART modules
- On-board RGB LED and accelerometer

FRDM-KL25Z Board

image from KL25Z User's Manual

IO Refresher

- GPIO (general purpose input/output) pins

  http://developer.mbed.org/handbook/DigitalOut

  http://developer.mbed.org/handbook/DigitalIn

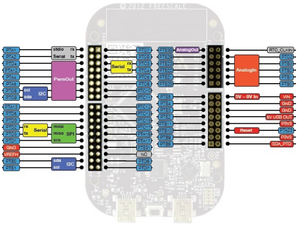
  - As an output: sets voltage on pin from software, either GND (0) or Vdd (1)
  - As an input: samples voltage on the pin, returning either 0 (low) or 1 (high)
- PWM (pulse-width modulation) module

  http://developer.mbed.org/handbook/PwmOut

  - Every *period*, the pin is high based on the *duty cycle*, then low for the remainder
  - Can digitally approximate analog outputs
- Analog Inputs (ADC)

  http://developer.mbed.org/handbook/AnalogIn

  - Converts a continuous analog voltage (0-3.3v) to a 16-bit (0-65535) quantity



FRDM-KL25Z pinout

image from ???

Concurrency Refresher

- FRDM-KL25Z's processor is single core
- Blocking Operations
  - Operations do not return until finished, blocking thread of control
  - IO operations may be lengthy!
- 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

  http://developer.mbed.org/handbook/RTOS
  - mBed has a RTOS with threading, concurrency, and synchronization
  - Beware of threading anti-patterns

"Hello, World!" Code

```
MODSERIAL serial(USBTX, USBRX);

DigitalOut led_green(LED_GREEN);
DigitalOut led_red(LED_RED);
PwmOut led_blue(LED_BLUE);

int main() {
  // Internal LED is active low.
  led_green = 0;
  wait(0.25);
  led_green = 1;
  wait(0.25);

  // Mandatory "Hello, world!".
  serial.printf("Hello,␣world!\r\n");

  // Run led_fade_thread() in own thread
  Thread ledFadeThread(led_fade_thread);

  // Periodically call led_blink_periodic()
  RtosTimer ledBlinkTimer(led_blink_periodic);
  ledBlinkTimer.start(1000);

  // Work is done in the threads,
  // so main() can sleep.
  Thread::wait(osWaitForever);
}
```

```
void led_fade_thread(
    void const *args) {
  // Note this doesn't temrinate.
  while (1) {
    // Invert duty cycle.
    led_blue.write(1-0);
    Thread::wait(250);
    led_blue.write(1-0.25);
    Thread::wait(250);
    led_blue.write(1-0.5);
    Thread::wait(250);
    led_blue.write(1-0.75);
    Thread::wait(250);
  }
}

void led_blink_periodic(
    void const *args) {
  // Toggle the red LED when called.
  led_red = !led_red;
}
```

Hello, World! Demo

Live Demo!

Note- check bootloader version:Bootloader version 1.11 and MSD firmware version 1.14.

`D:FRDM-KL25Z:SDAINFO.HTM`

This is essentially the procedure demonstrated in the checkpoint 1 page

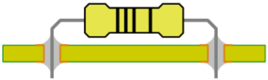
... and hopefully goes Murphy-free ...

Note: you'll have to download the Device Family Pack for the FRDM-KL25Z
`http://www.keil.com/dd2/arm/armcm0/`
(also on the checkpoint page)

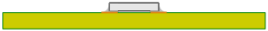
Overview

- Soldering: joining (electrically and mechanically) metals using a separate fillter 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

Example solder joints:



Through-hole



Surface-mount

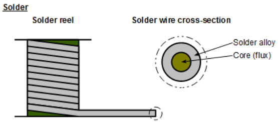
Safety Precautions

- Soldering melts metal - IT'S HOT
  - Tips typically set at $\leq$ 600°F (300°C) to avoid tip oxidation.
  - 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

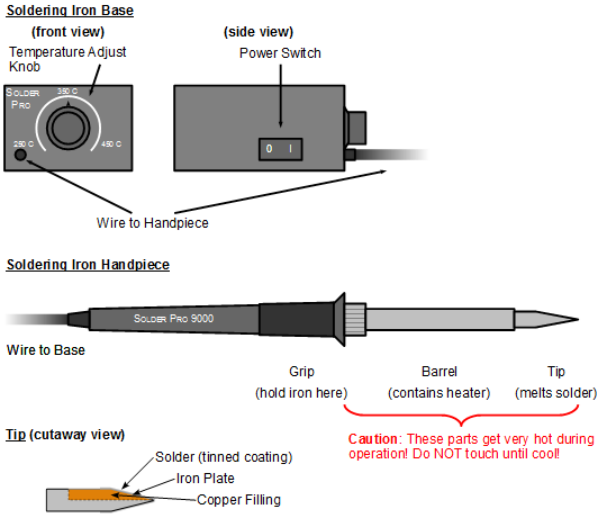
Oxidation

- 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...



Solder cross-section showing flux core

Equipment Overview

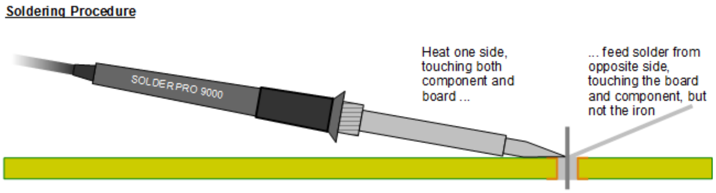


Tip Maintenence

- 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)

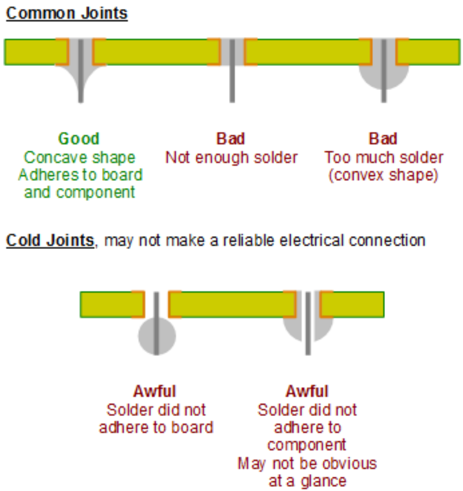
Procedure

- 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"



Through-Hole Soldering Demo

Live Demo!

... which REALLY hopefully goes Murphy-free ...

Scheduling

- 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

Fin

Get your parts and get started!

I'll be walking around helping!

For checkpoint 1, you need to solder a resistor and LED onto perfboard
Choose the resistor such that $\sim$1.6mA goes through the LED
The MCU supply voltage is 3.3v

(yes, I know those red LEDs suck)

Also, grab a computer account form!