EECS 192: Mechatronics Design Lab

Discussion 1: Introduction

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23 Jan 2019 (Week 1)

- Administrivia
- BeagleBone Blue 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
  - NATCAR

Checkoffs

- One-hour time slot on Friday 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

Get your cars!

- 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

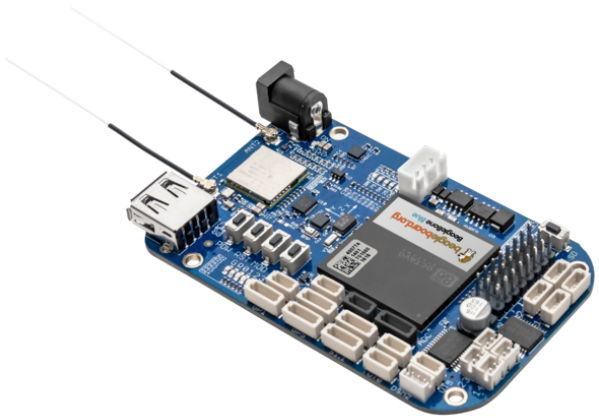
Git Refresher

- 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

Learn git here:
`try.github.io`

Hardware

- ~~FRDM-K64F Development Board~~ Beaglebone Blue (BBBL)
- Octavo Systems OSD3358 Processor
  - ~~120 MHz M4~~ 1 GHz ARM Cortex-A8
  - ~~1024 KB~~ 4 GB 8-bit eMMC flash storage
  - ~~256 KB~~ 512 MB RAM
- Program over network via USB or Wifi
- I/O connectors including
  - GPIO
  - 12-bit SAR ADC
  - USB2.0, I^2C, SPI, and UART
  - PWM, Servos, Encoders, H-bridges
- LEDs, Buttons, 9-axis IMU, Barometer

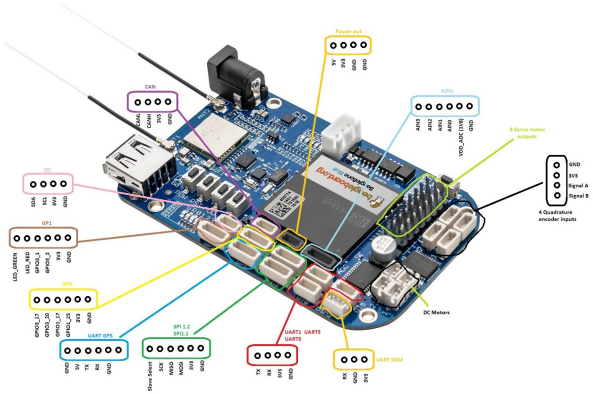


Beaglebone Blue Board

image from BeagleBoard.org

IO Refresher

- GPIO (general purpose input/output) pins (strawsondesign.com GPIO link)
  - Output: sets pin voltage from software: either GND (0) or Vdd (1)
  - Input: samples pin voltage: 0 (low) or 1 (high)
- PWM (pulse-width modulation) module (strawsondesign.com PWM link)
  - Every *period*, the pin is high based on the *duty cycle*, then low for the remainder
  - Can digitally approximate analog outputs
- Analog Inputs (ADC) (strawsondesign.com ADC link)
  - Converts a continuous analog voltage (0-1.8v) to a 12-bit (0-4095) quantity



Beaglebone Blue pinout

Robot Control Library

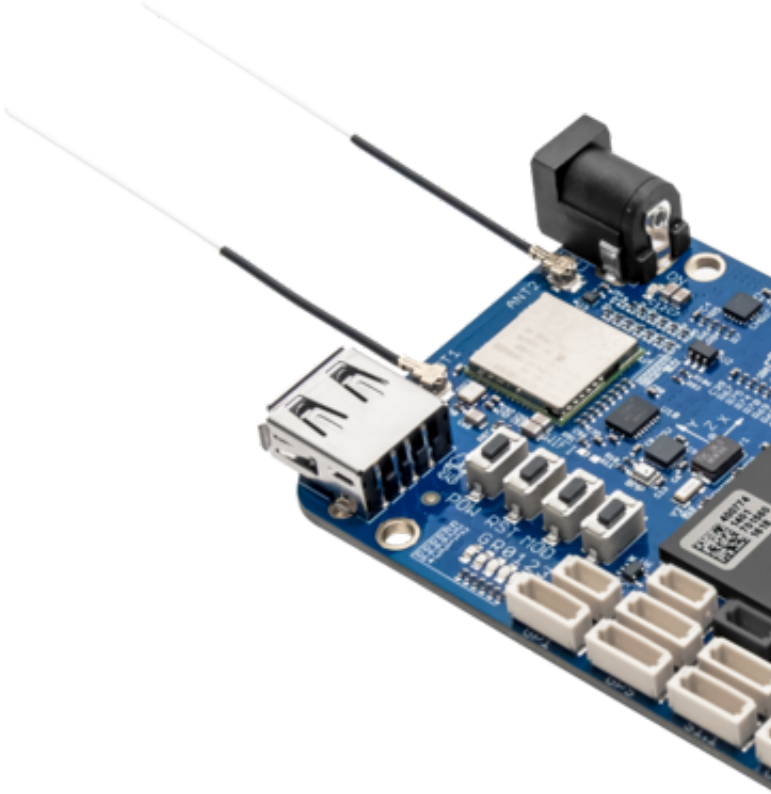
- C library hardware interface for Beaglebone Blue
- Examples and testing programs available
- Documentation: `http://strawsondesign.com/docs/librobotcontrol/index.html`

"Hello, World!" Code

```
#include <stdio.h>
#include <robotcontrol.h>

int main()
{
        if(rc_kill_existing_process(2.0)<-2)
             return -1;
        if(rc_enable_signal_handler()==-1){
                fprintf(stderr,"ERROR␣...␣\n");
                return -1;
        }
        rc_make_pid_file();

        printf("Hello␣World!\n");
        rc_set_state(RUNNING);
        rc_led_set(RC_LED_GREEN, 1);
        int toggle = 1;
        while(rc_get_state()!=EXITING){
                toggle = !toggle;
                rc_led_set(RC_LED_GREEN, toggle);
                rc_usleep(100000);
        }

        rc_led_set(RC_LED_GREEN, 0);
        rc_led_cleanup();
        rc_remove_pid_file();
        return 0;
}
```

Using the Beaglebone Blue

- Accepts power over USB or 9-18V barrel connector
- ALWAYS shut down by either:
  - sudo poweroff from SSH
  - "POW" button on board
- Beware short circuits and Electrostatic Discharge (ESD)
- We can only provide you with one replacement board if yours dies



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

Connecting to Beaglebone Blue

- Connect to USB and wait for boot
- Lab desktops with Windows:
  - Start Virtualbox
  - Pass Beaglebone USB to Ubuntu
- ssh ubuntu@192.168.7.2
- Passphrase: temppwd

Hello, World! Demo

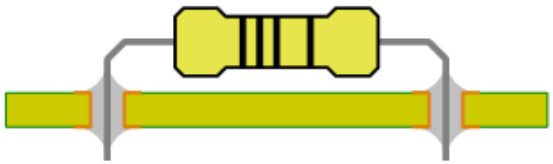
Live Demo!

Connect to Beaglebone Blue, Print "Hello World"

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

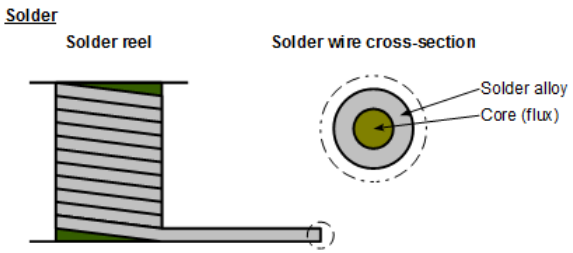
Surface-mount

Safety Precautions

- Soldering melts metal - IT'S HOT
  - Tips typically set at 700°F (371°C)
  - Irons cool slowly after turning off
  - Touching a hot tip is NOT fun
- Leaded solder contains ... 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 THIS
  - May also cause solder splatter: eyewear required (regular glasses ok)

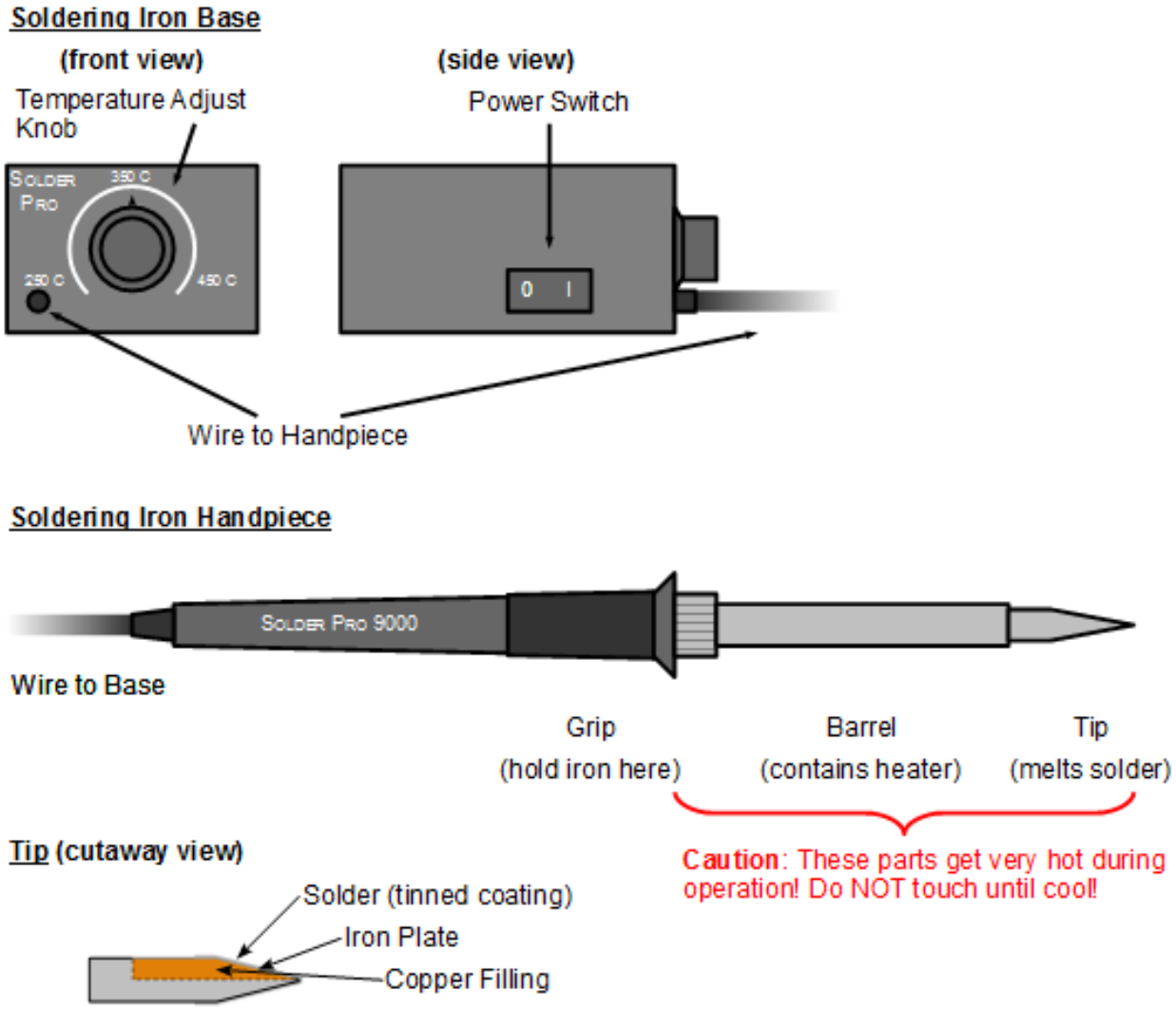
Oxidation

- 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

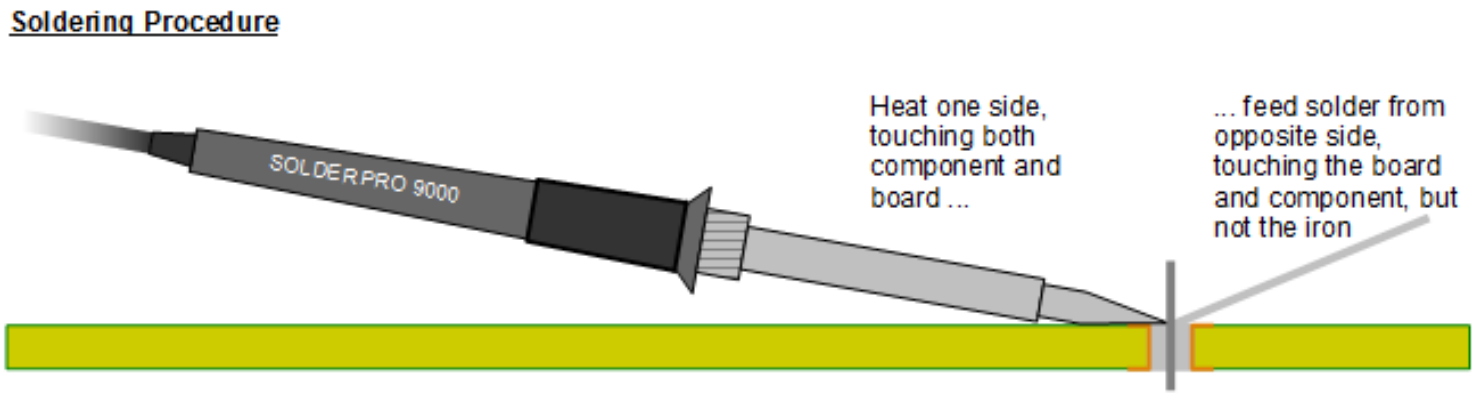


Tip Maintenence

- 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)

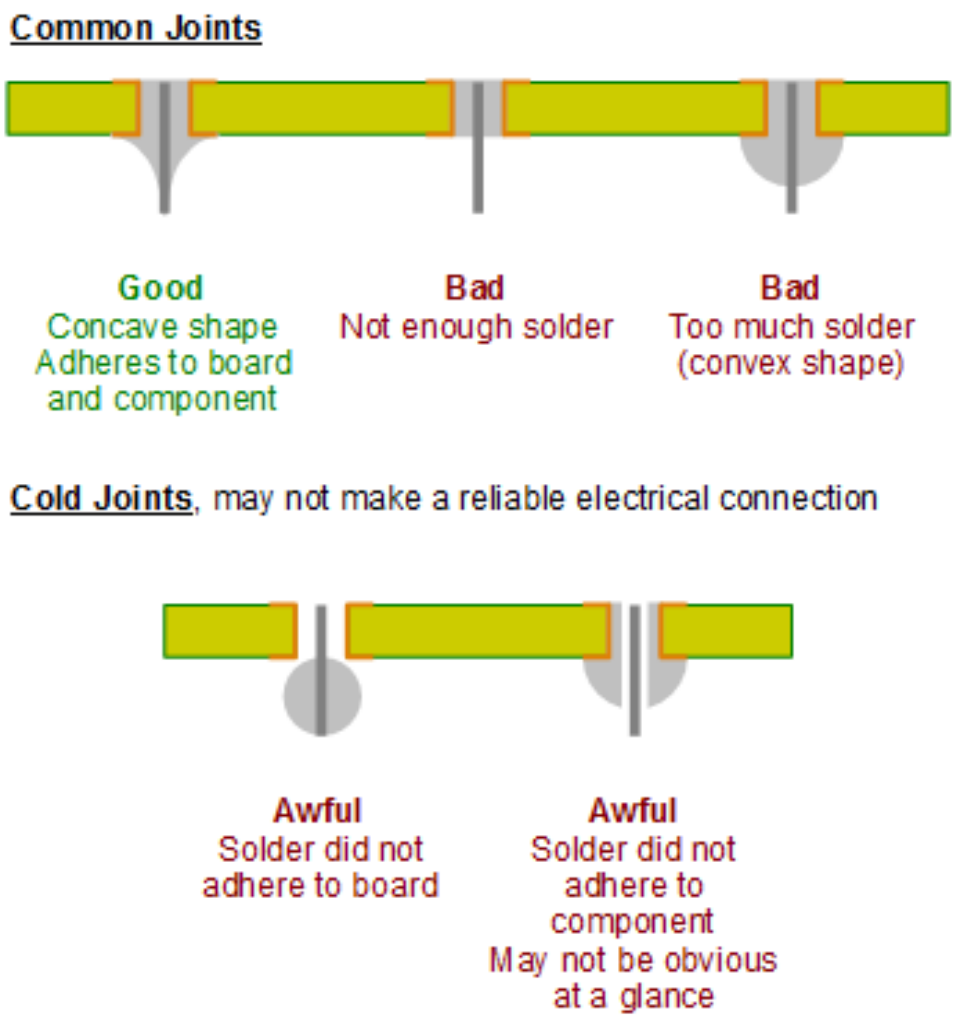
Procedure

- 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"



Fin

For checkpoints 1 and 2, you need to build 2 LED blink circuits- the first using an IC and the second using PWM from the Beaglebone Blue.
Choose the resistor such that ∼1.6mA goes through the LED
The BBBL supply voltage is 3.3v

(yes, I know those red LEDs suck)

Links

- Chassis: http://os.3racing.hk/carkits_web.php?carkits_web_key=61
- Github: https://github.com
- Beaglebone Blue: https://beagleboard.org/blue
- Robotic Control Library: http://strawsondesign.com/docs/librobotcontrol/index.html