

E11 Lecture 3: Welcome to the World of Mudduino

Prof. David Money Harris
Fall 2014

Outline

- Logistics
- Arduino
 - Power Supply
 - Microcontroller
 - Inputs/Outputs
 - Host Interface
- Mudduino
 - Features
 - Schematic
 - I/O Pins
- Board Assembly

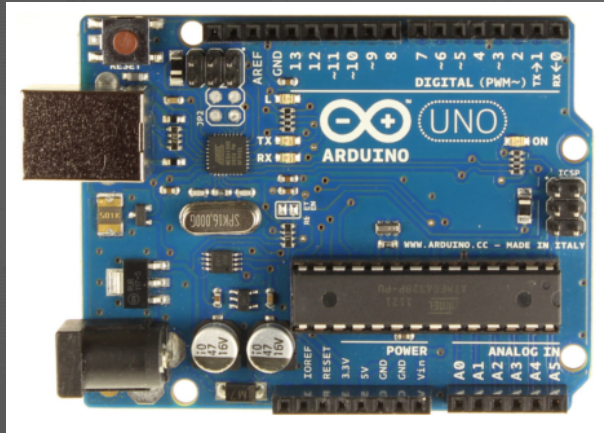
Logistics

- Problem Set 1 – due next Tuesday (9/16) before class
 - More programming in Thursday's lecture
 - Tutoring hours: LAC, Sunday, 2-5 pm
 - Bring board home with you at the end of lab!

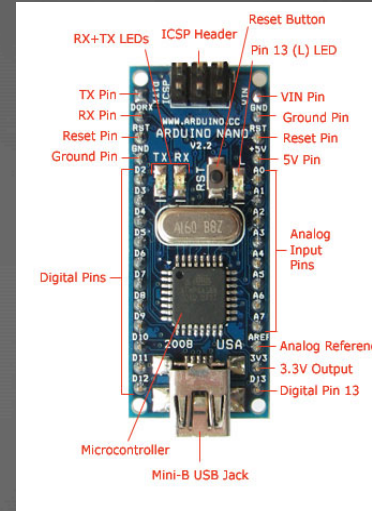
Arduino

- Open-source microcontroller platform
- Started by an Italian team in 2005, but it has spread world-wide
- Makes hardware/software solutions inexpensive & simple
- Popular with universities and hobbyists
- Mudduino is a custom version of the Arduino platform

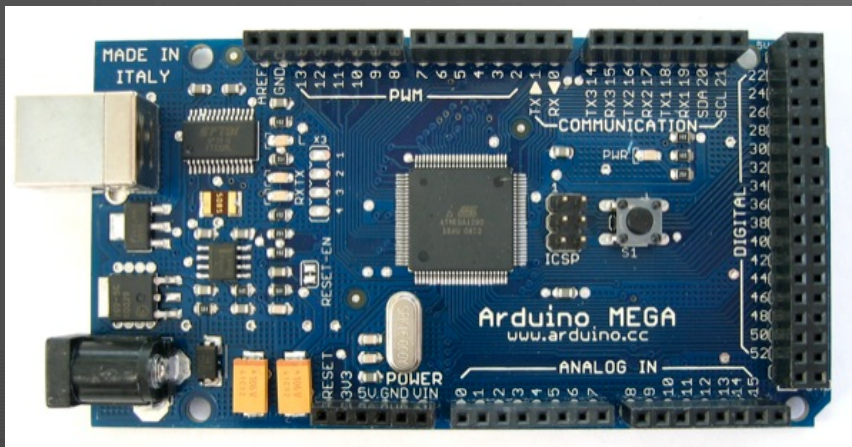
Official Arduino Boards



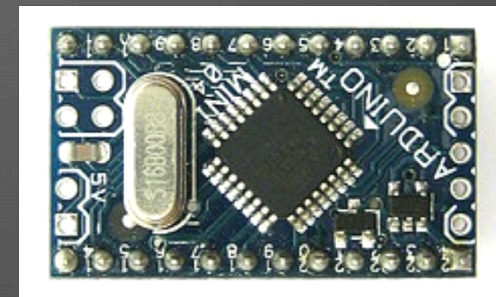
Uno



Nano



Mega



Mini

Official Arduino Boards

Version	Digital I/Os	Analog Inputs	Price	Notes
Uno	14	6	\$28	Very popular
Mega	54	16	\$65	More memory and I/Os
Nano	14	8	\$35	0.73" x 1.70", fits on a breadboard
Mini	14	8	\$25	Smallest (0.7" x 1.3"), fits on a breadboard, requires Mini USB adapter for programming

Arduino System

- The Arduino system includes:
 - Power supply
 - Microcontroller
 - Analog and digital inputs and outputs
 - Host interface: a way to interface with a host computer

Power Supply

- Two options:
 - Powered by USB port (5 V)
 - Powered by external power (DC Jack) that's connected to, either:
 - Battery (7-12 V) or
 - Wall transformer (transforms 120 VAC to 7-12 V DC)
 - On-board voltage regulator drops this to 5 V

Microcontroller

- Microprocessor with controls for outside world
- Arduino system uses Atmel Microcontrollers
 - Operate on 8-bit data
 - Operating on 32-bit data requires 4 instructions
- Mudduino uses Atmega328 Microcontroller
 - Costs \$2.32 (quantities >2000)
 - Some competing microcontrollers cost ~ \$0.50

Atmega328 Features

- 16 MHz clock
- Executes 1 instruction / clock cycle
- Analog and Digital input/output pins
- Built-in A/D converter
- On-chip memory:
 - Program memory: 32 KB of Flash Memory (retains value when powered off)
 - Data memory: 2 KB of static random access memory (SRAM) (loses value when powered off)

Atmega328 Features (cont.)

- Multiple timers/counters
 - measuring elapsed time
 - generate periodic signals
- Universal Asynchronous Receiver and Transmitter (UART) serial port controller
- Interrupts

For more information, look up the ATmega328 datasheet on the web:

http://www.atmel.com/dyn/resources/prod_documents/doc8271.pdf

Inputs and Outputs

- At least 14 digital pins
 - Configured as inputs or outputs
 - HIGH, 5 V
 - LOW, 0 V
 - Some can use PWM to simulate analog voltage
- Some pins can be configured as analog inputs
 - Connected to 10-bit A/D (analog-to-digital) converter
 - A/D converts voltage to value between 0-1023
 - Value is proportional to voltage (0 = 0 V, 1023 = 5 V)
 - 100 μ s / conversion (so at most 10,000 samples/second)

Digital Inputs and Outputs

Level	Value	Notes
V_{IL}	1.5	Maximum input voltage recognized as a 0
V_{IH}	3.5	Minimum input voltage recognized as a 1
V_{OL}	0.9	Maximum output voltage produced for a 0
V_{OH}	4.2	Minimum output voltage produced for a 1

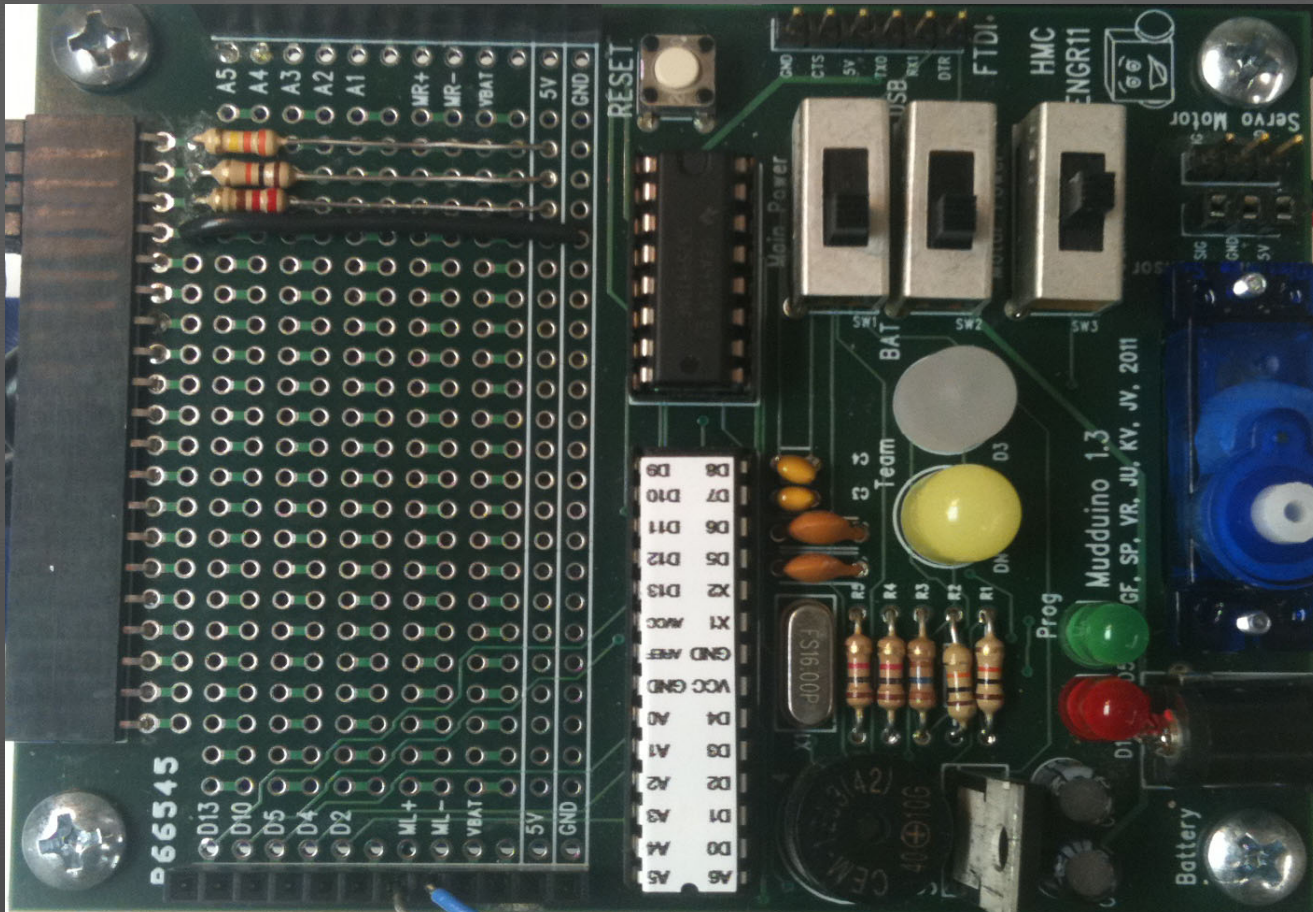
Host Interface

- Arduino communicates with host computer using USB
- Internally Arduino uses RS232 serial communication
- Converter chip converts data back and forth from USB to RS232 standards
 - Sends 8 bits of data at a time
 - Requires start and stop bit for each 8 bits of data
 - 9600 baud = 9600 bits/second = 960 bytes / second
- Host and computer must agree on data rate
 - 9600 – 115,200 baud

Outline

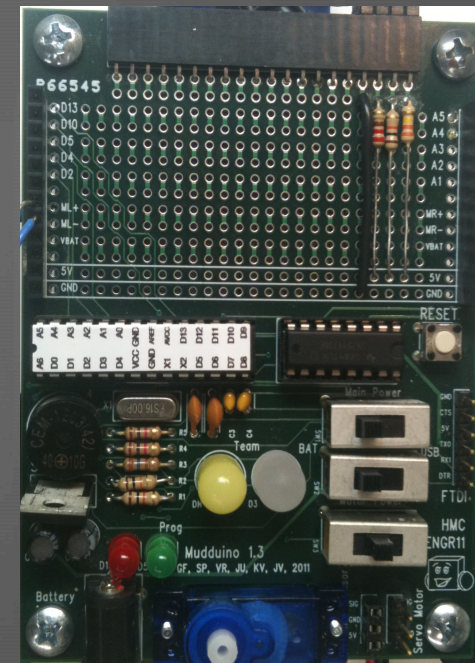
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Mudduino



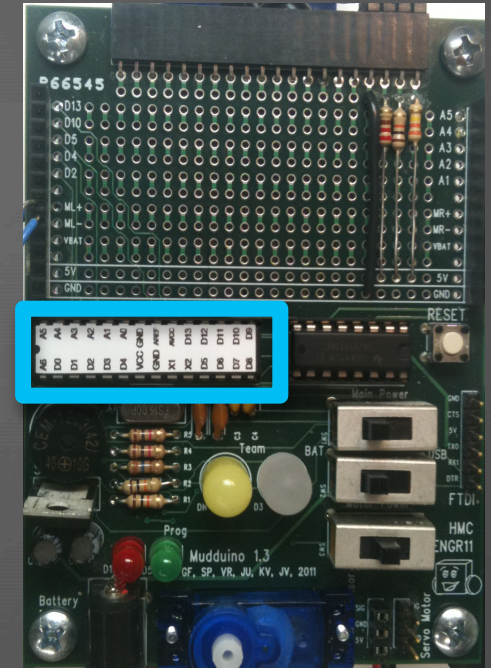
Mudduino – Overall Description

- Designed by E11 students during spring 2011 (v 1.3)
- Similar to Uno, except:
 - Uses through-hole components
 - easier to solder
 - can assemble your own board
 - Has connectors customized to robotics applications
 - Has form factor designed for your vehicle
 - Includes a blank portion - can add your own circuitry



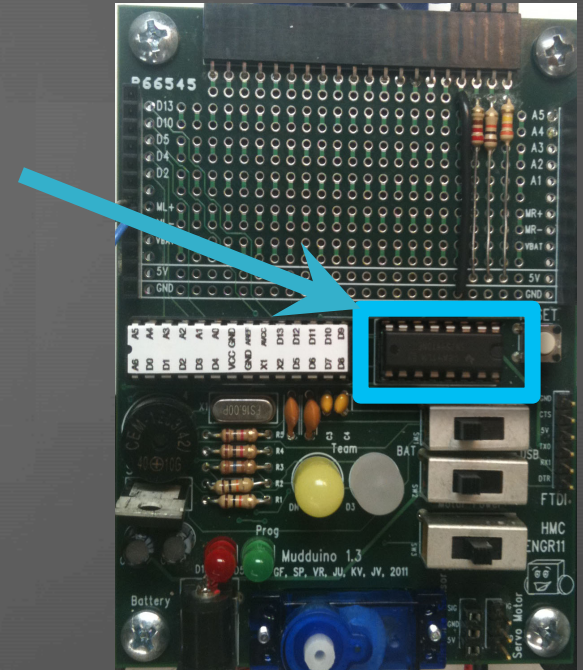
Mudduino – Features

- Atmega328 microcontroller
- 32 KB of Flash program memory, 2 KB of RAM data memory, 16 MHz



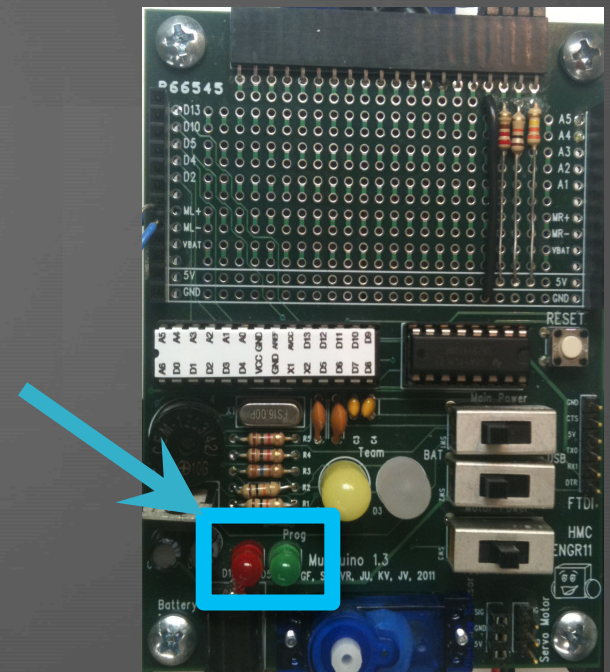
Mudduino – Features

- Atmega328 microcontroller
 - 32 KB of Flash program memory, 2 KB of RAM data memory, 16 MHz
- H Bridge for driving two high-current motors



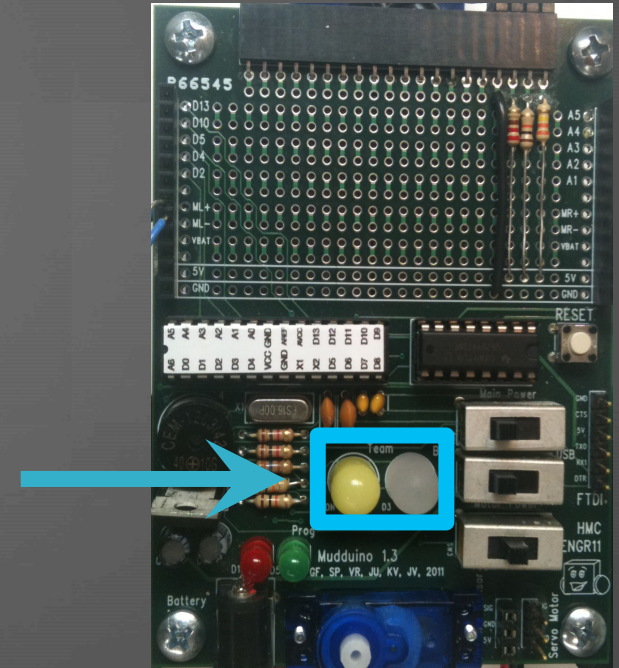
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- H Bridge for driving two high-current motors
- Two indicator LEDs (red, green)



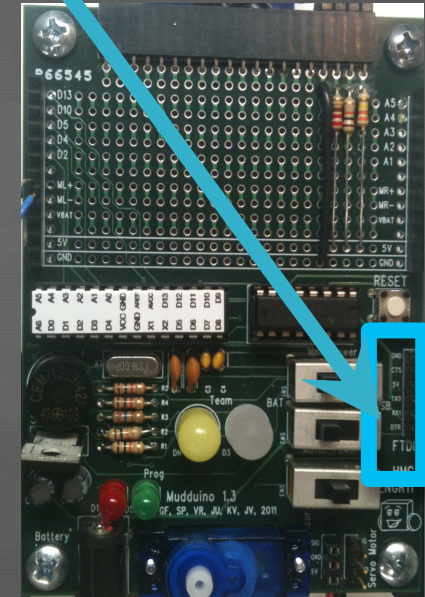
Mudduino – Features

- Atmega328 microcontroller
 - 32 KB of Flash program memory, 2 KB of RAM data memory, 16 MHz
- H Bridge for driving two high-current motors
- Two indicator LEDs (red, green)
- Two team LEDs (white, green)
 - glows white (looks yellow)
 - glows green (looks white)



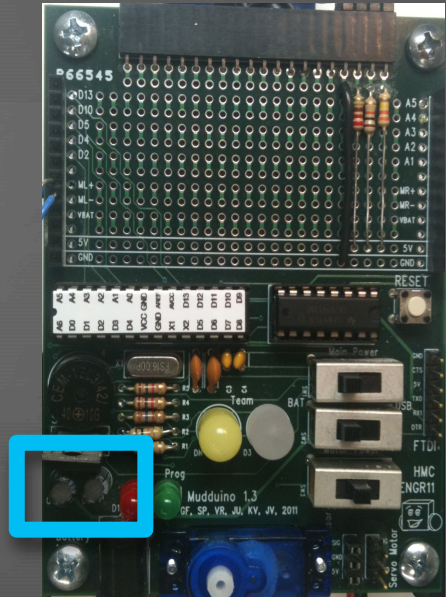
Mudduino – Features (cont.)

- FTDI connector to communicate with a host



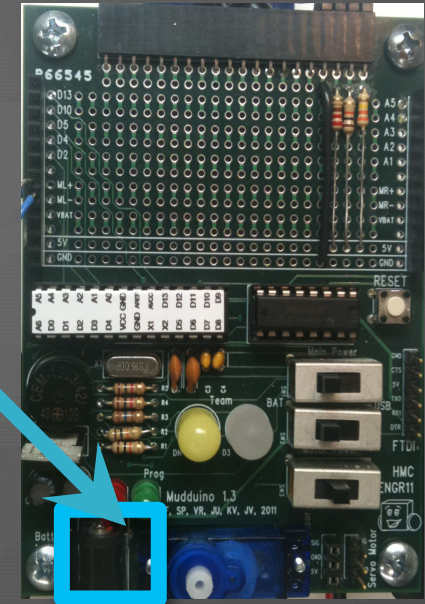
Mudduino – Features (cont.)

- FTDI connector to communicate with a host
- Power supply circuitry



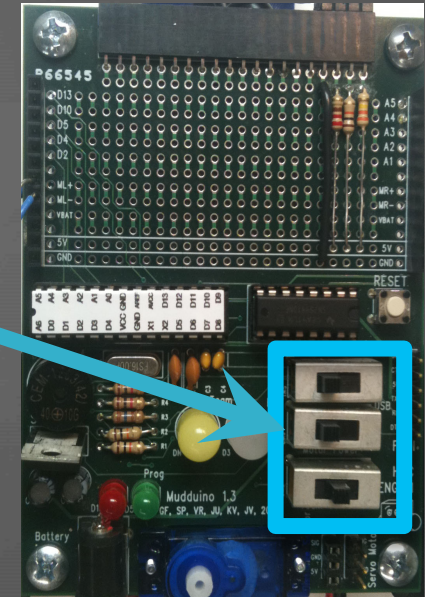
Mudduino – Features (cont.)

- FTDI connector to communicate with a host
- Power supply circuitry
- Battery connector for untethered operation



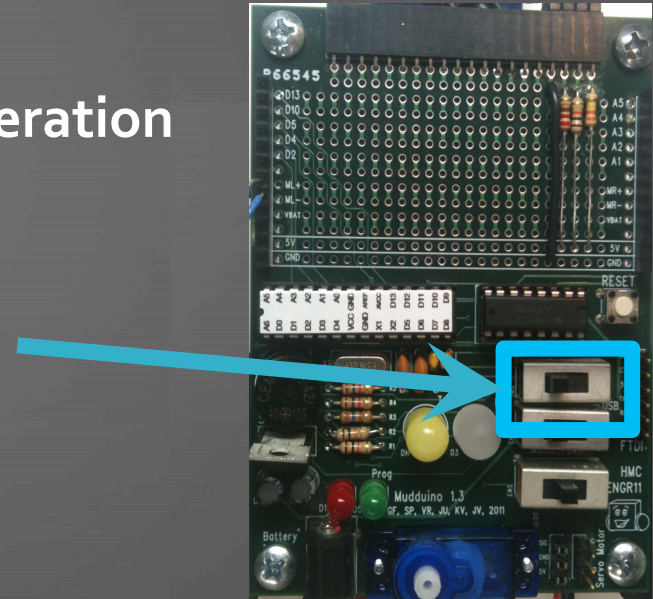
Mudduino – Features (cont.)

- FTDI connector to communicate with a host
- Power supply circuitry
- Battery connector for untethered operation
- Switches:



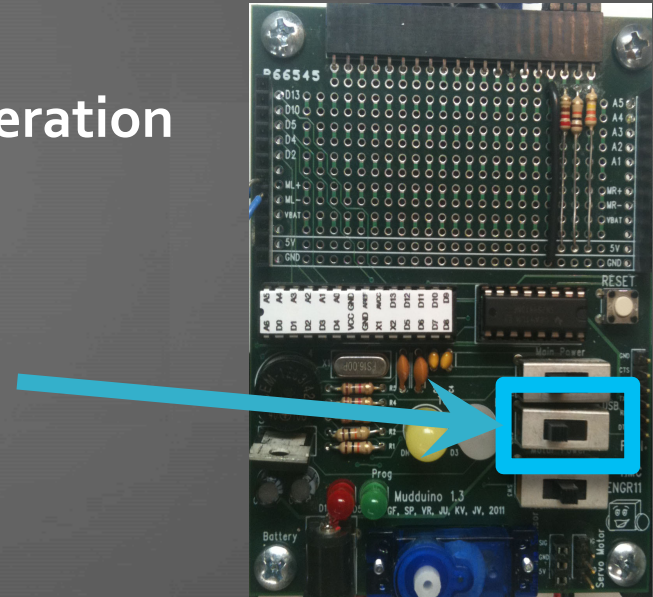
Mudduino – Features (cont.)

- FTDI connector to communicate with a host
- Power supply circuitry
- Battery connector for untethered operation
- Switches:
 - power (USB / BAT - battery)



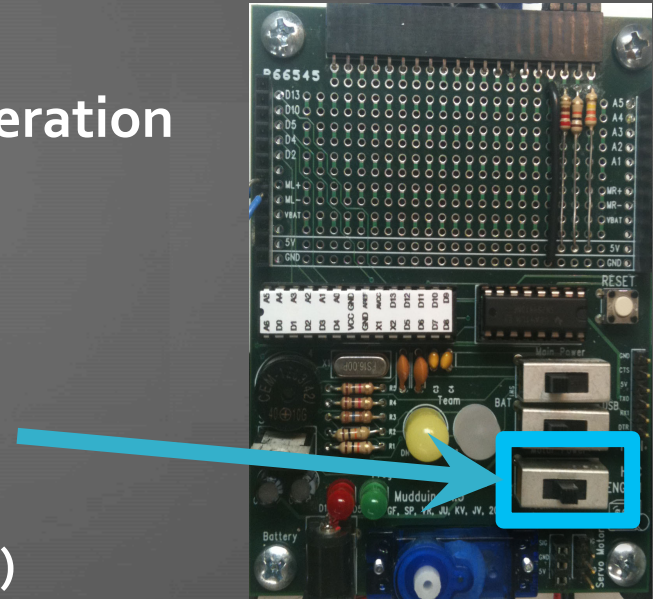
Mudduino – Features (cont.)

- FTDI connector to communicate with a host
- Power supply circuitry
- Battery connector for untethered operation
- Switches:
 - power (USB / BAT - battery)
 - motors (on/off)



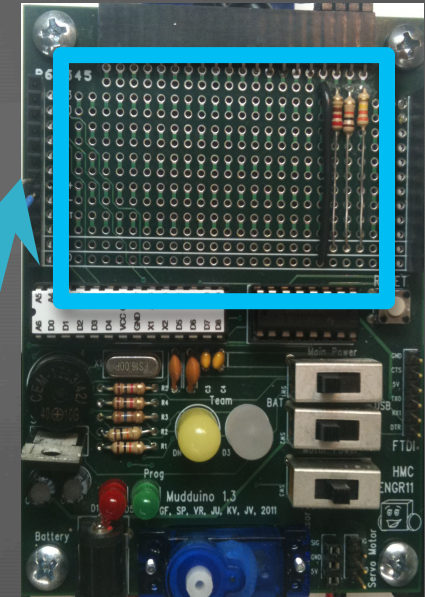
Mudduino – Features (cont.)

- FTDI connector to communicate with a host
- Power supply circuitry
- Battery connector for untethered operation
- Switches:
 - power (USB / BAT - battery)
 - motors (on/off)
 - team (white, green)
 - Center position: no selection (careful!)



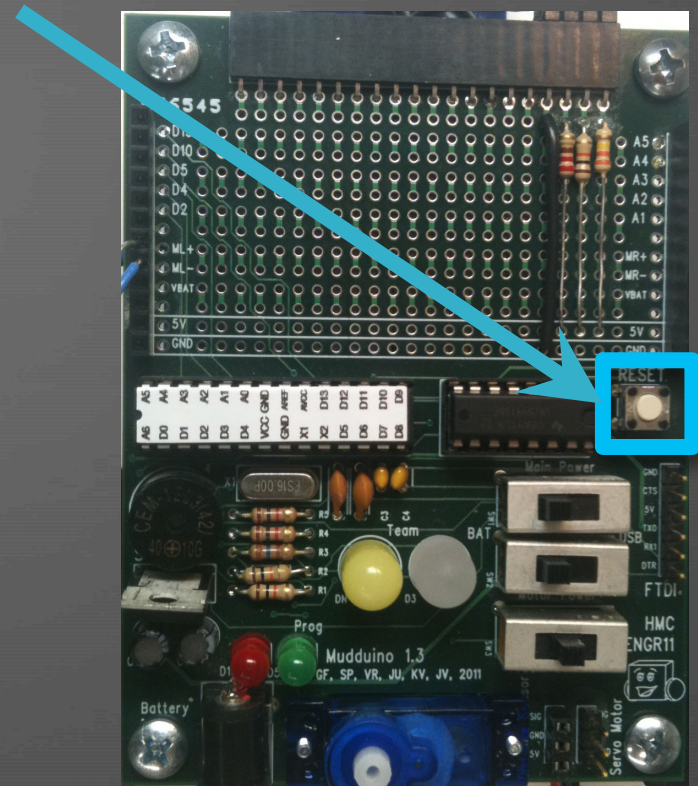
Mudduino – Features (cont.)

- FTDI connector to communicate with a host
- Power supply circuitry
- Battery connector for untethered operation
- Switches:
 - power (USB / BAT - battery)
 - motors (on/off)
 - team (white, green)
 - Center position: no selection (careful!)
- Expansion area for soldering on custom hardware



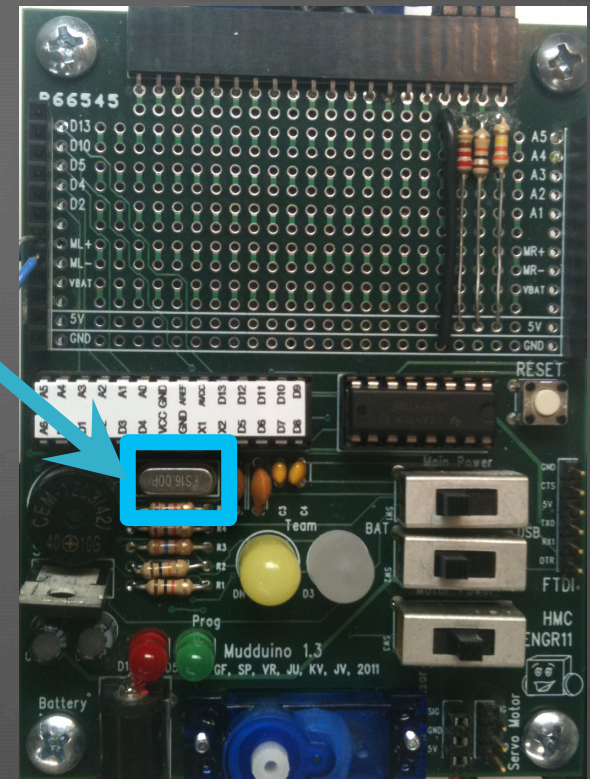
Mudduino – more parts!

- Reset button
- When push button, uploaded program restarts



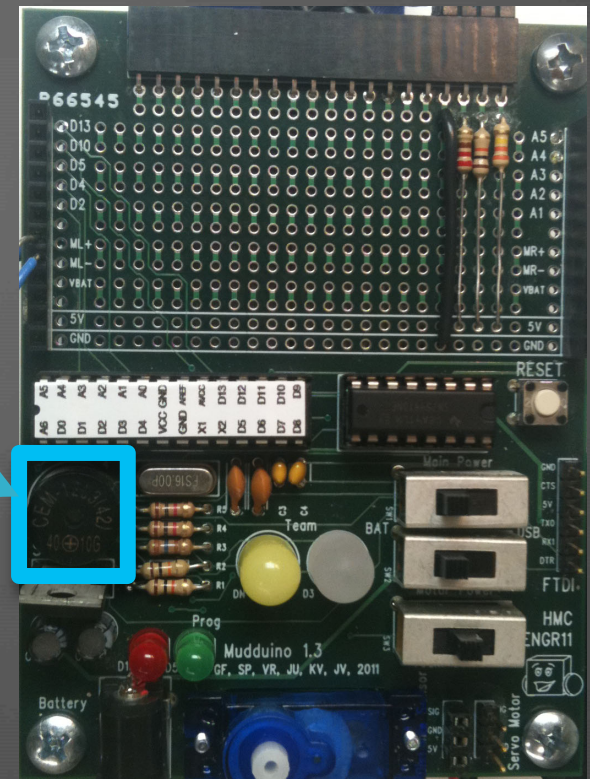
Mudduino – more parts!

- Reset button
 - When push button, uploaded program restarts
- Clock Oscillator (16 MHz)



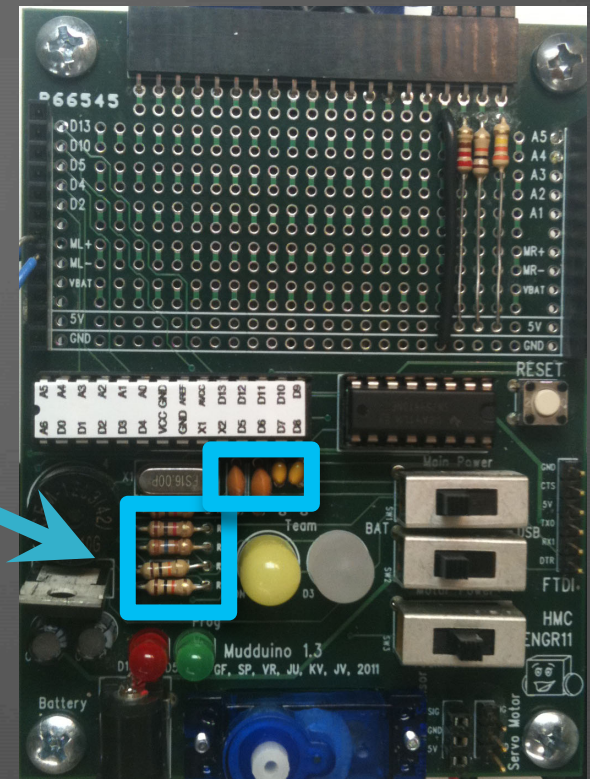
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- Reset button
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- Clock Oscillator (16 MHz)
- Speaker (Buzzer)



Mudduino – more parts!

- Reset button
 - When push button, uploaded program restarts
- Clock Oscillator (16 MHz)
- Speaker (Buzzer)
- Capacitors and resistors



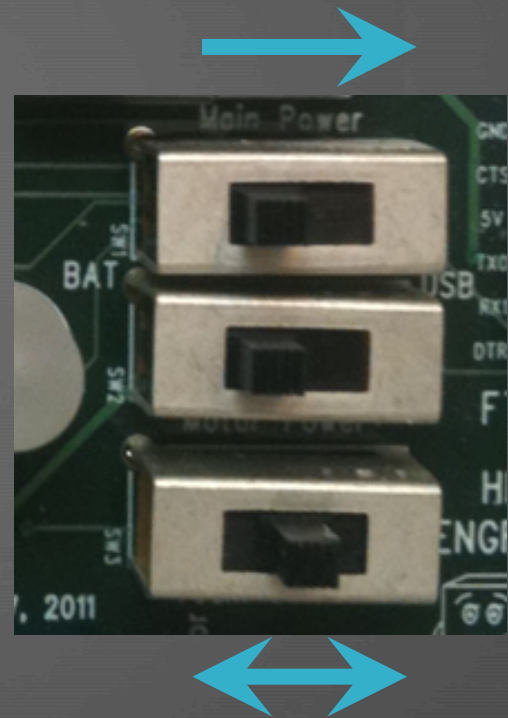
Mudduino – FTDI connector

- Important: Make sure black wire on FTDI cable is connected to pin labeled "GND" on board header



Mudduino – Settings

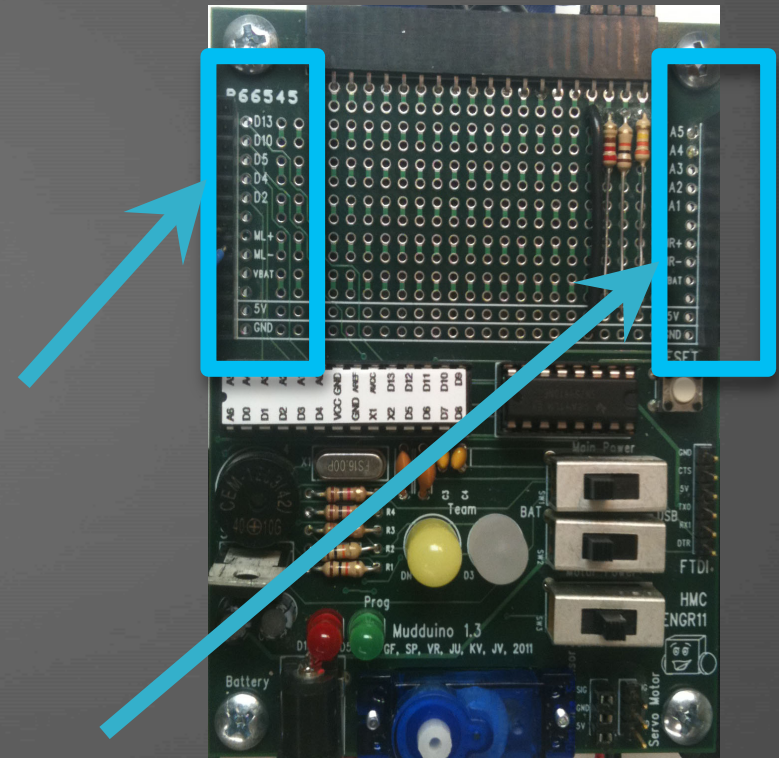
- Switches:
 - Power:
 - USB
 - to the right
 - Team:
 - white or green
 - left or right
 - but not in the middle!
 - indicates board has power



Mudduino – Pins

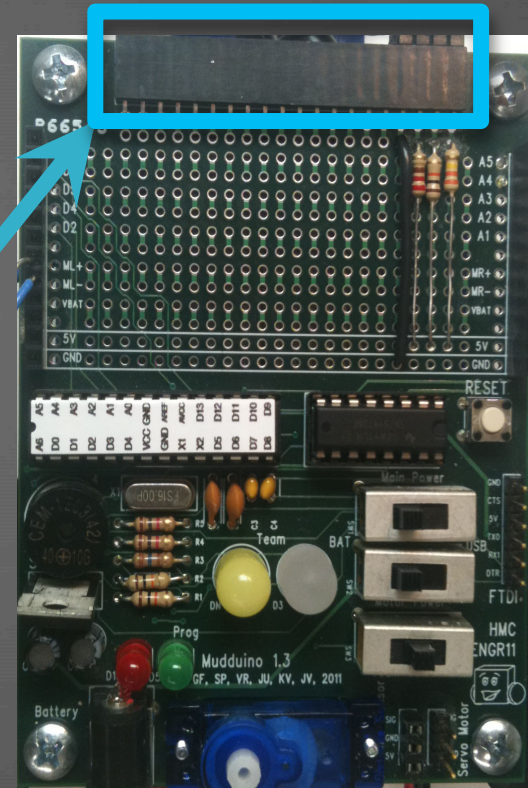
- Header pins for connecting:

- 5 digital ports
- 5 analog ports
- 2 motor ports
- Sensors:
 - Distance
 - Phototransistor
 - Reflectance
- 5V and GND
- 20 expansion pins

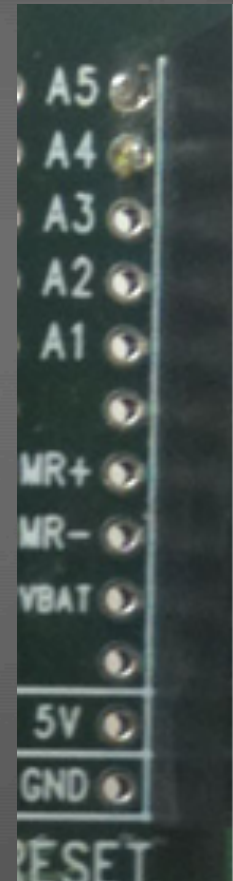


Mudduino – Pins

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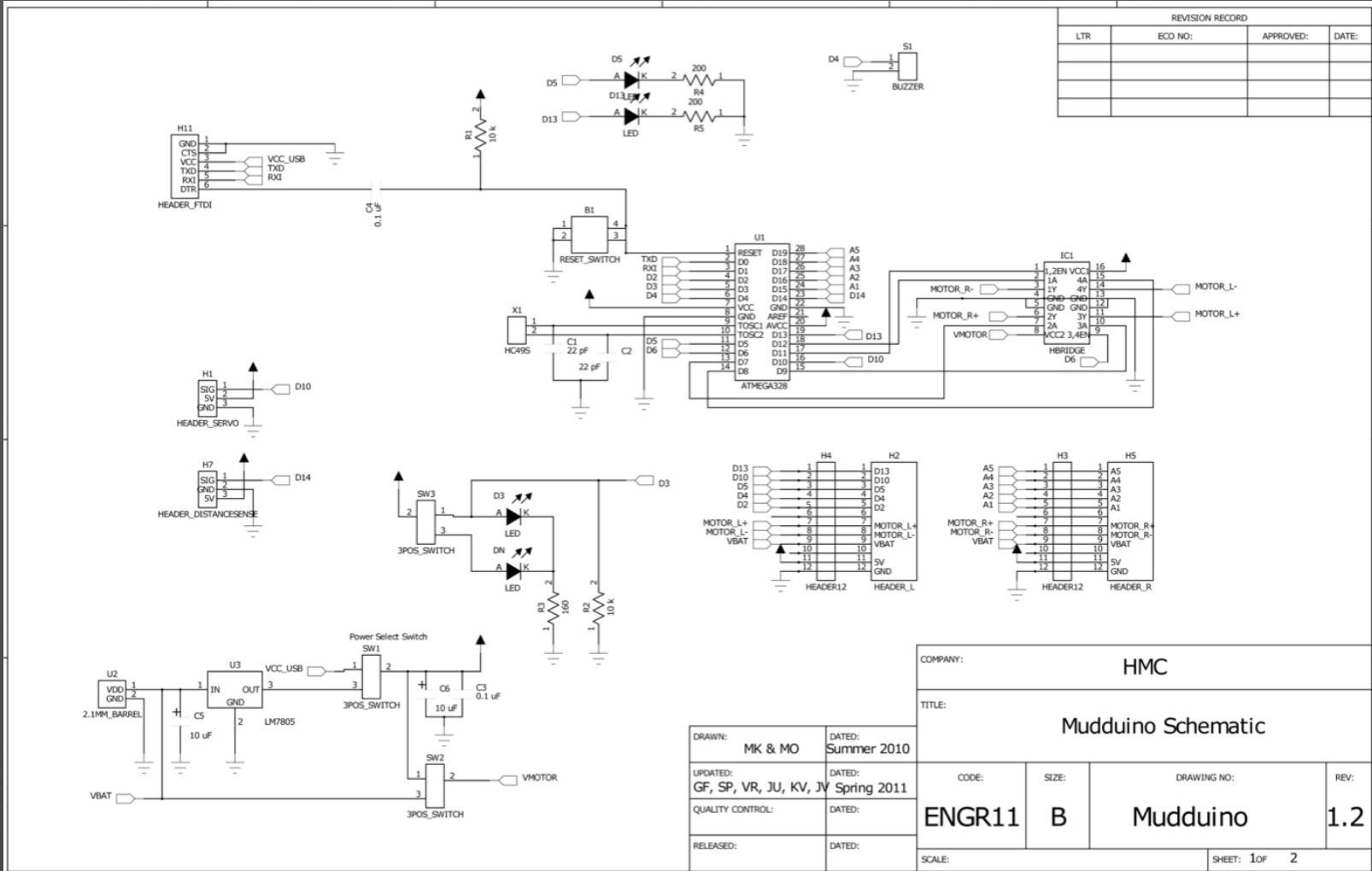
Mudduino – Pins



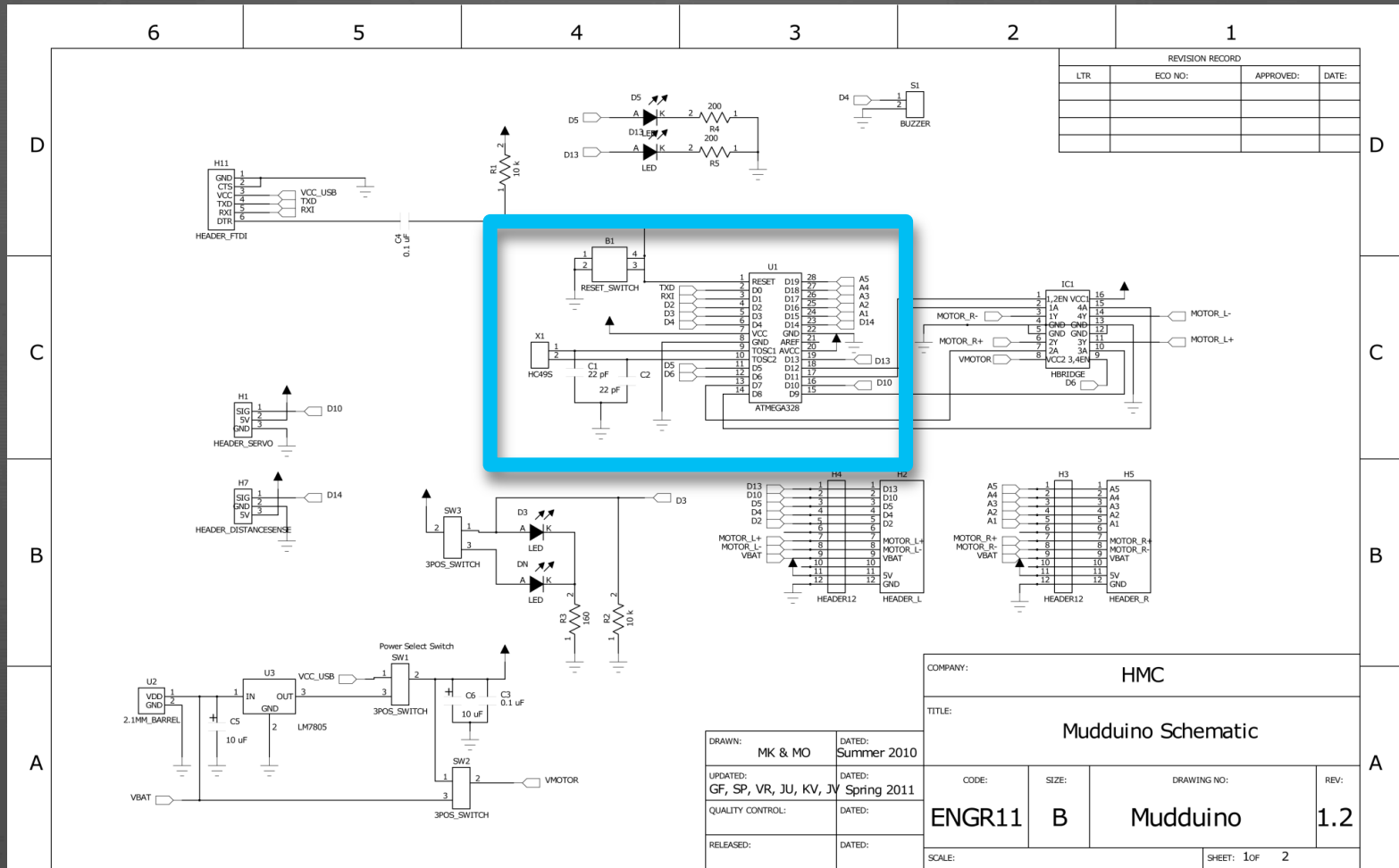
Mudduino Pinout

Digital Pin #	Analog Pin #	Notes
0		Serial TXD – don't use
1		Serial RXI – don't use
2		Header D2
3		Team (0 = green / 1 = white) read only
4		Header D4, Buzzer
5		Header D5 / green LED / programming indicator
6		Left Motor Enable
7		Right Motor +
8		Left Motor -
9		Left Motor +
10		Header D10 / Servo (use servo.write)
11		Right Motor Enable
12		Right Motor -
13		Header D13 / red LED
14	0	Distance Sensor
15	1	Header A1
16	2	Header A2
17	3	Header A3
18	4	Header A4, Reflectance Sensor
19	5	Header A5, Phototransistor

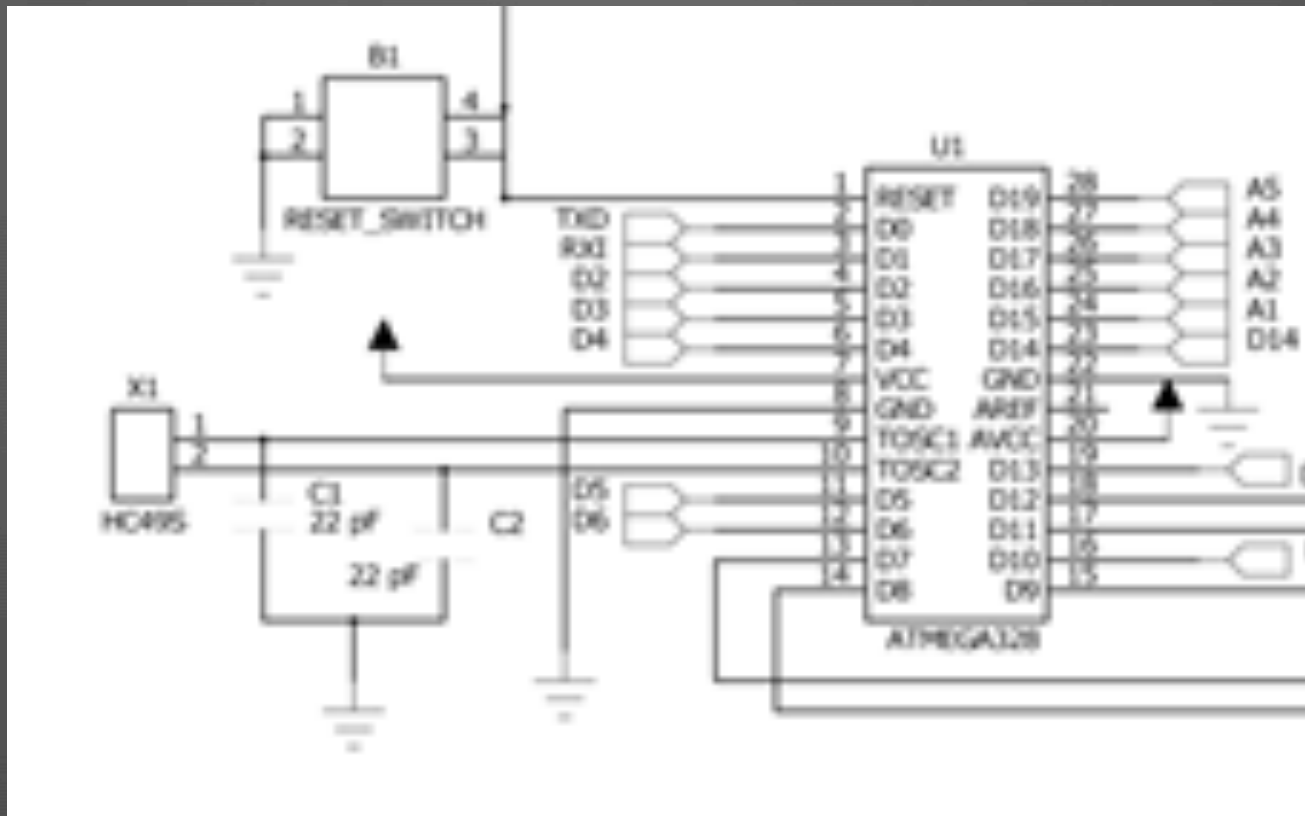
Mudduino Schematic



Mudduino Schematic



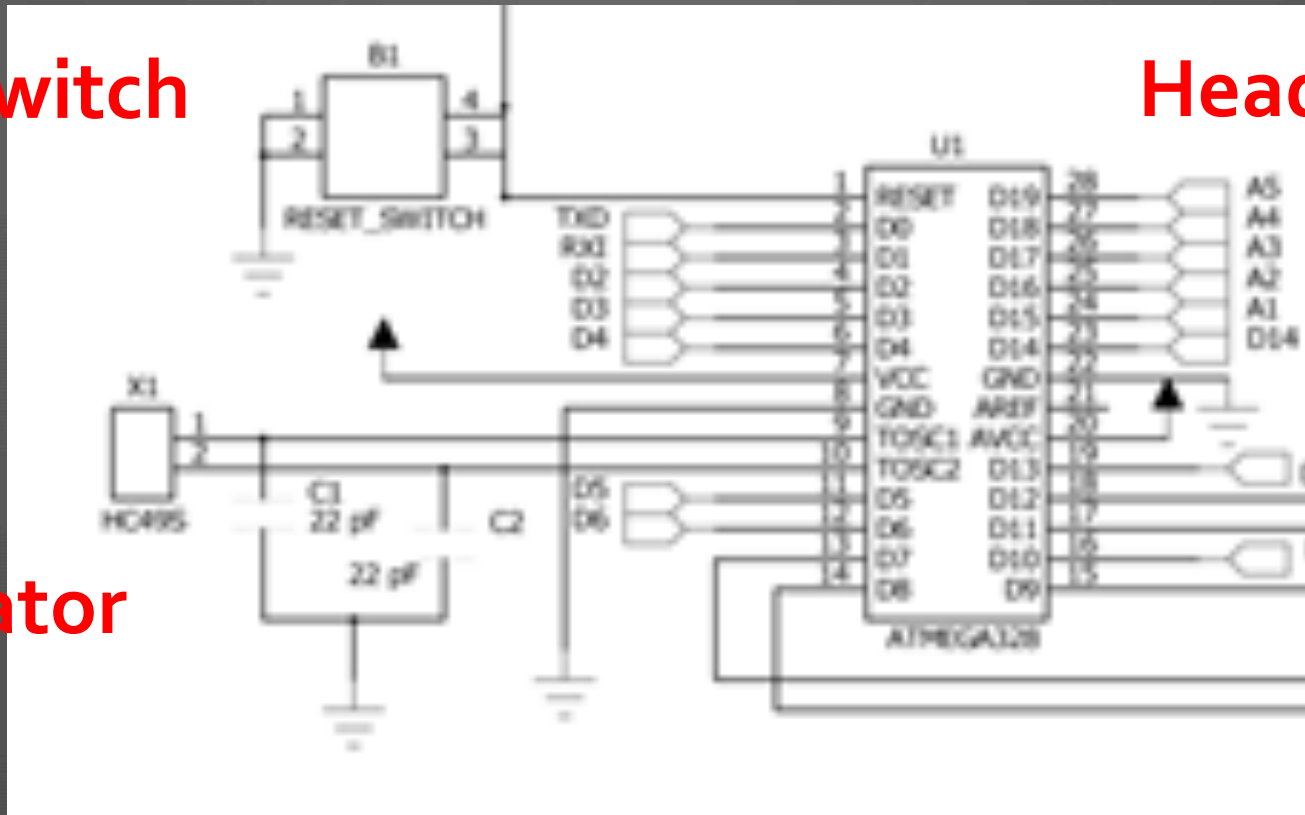
Mudduino Schematic



Mudduino Schematic

Reset switch

Header pins



Oscillator

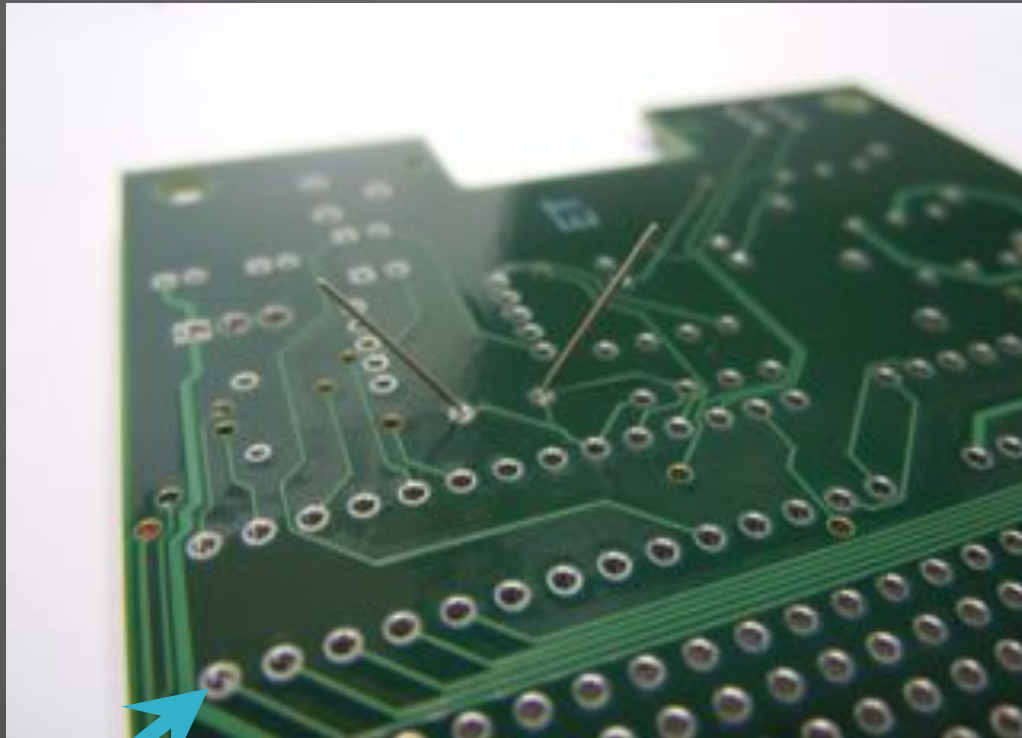
Arduino Bootloader

- Your Atmega328 preprogrammed with Arduino bootloader
 - Occupies part of flash memory
 - Initializes chip at powerup or reset
 - Monitors serial port (USB port), waiting for program to be uploaded

Mudduino Assembly

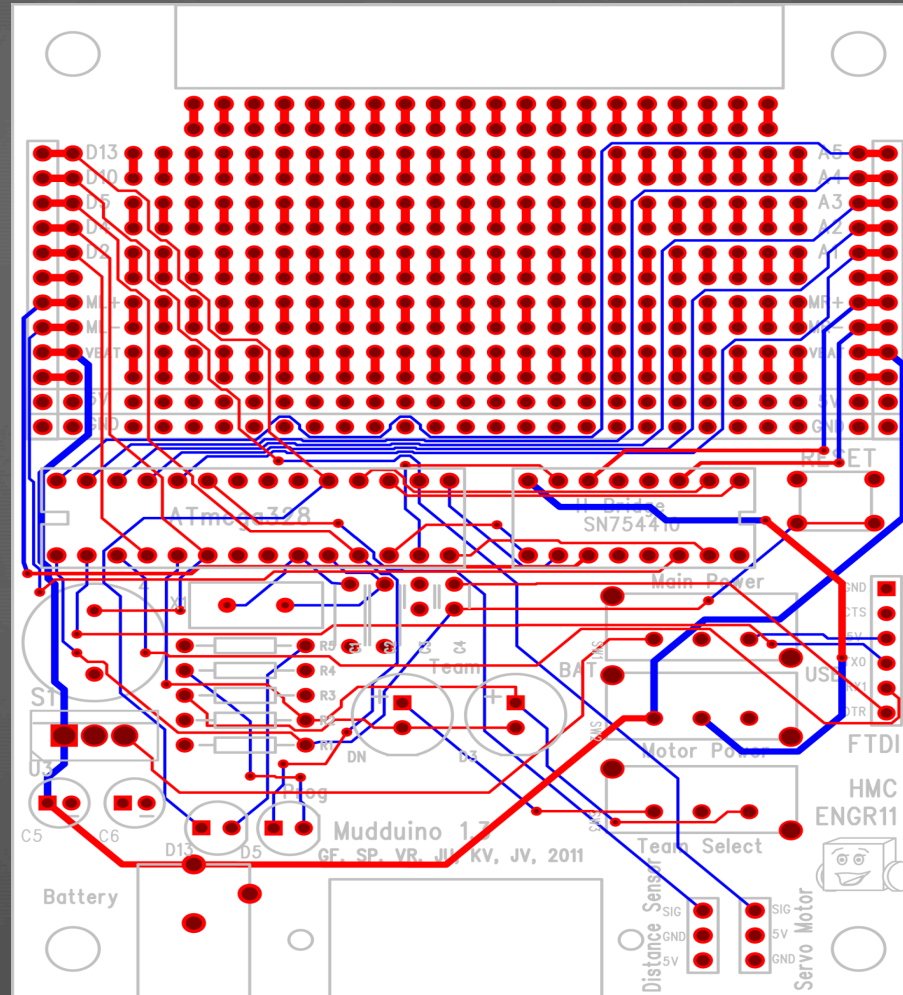
- You will all assemble (build) your own Mudduino in lab this week
- Start with a bare printed circuit board (PCB)
 - PCB has 4 conducting layers (sandwiched between insulator – called FR4):
 - Two inner layers for power and ground
 - Two outer layers for carrying signals
- Solder parts using a soldering iron and solder
 - Parts must have good electrical and mechanical connection to board!

Bare PCB



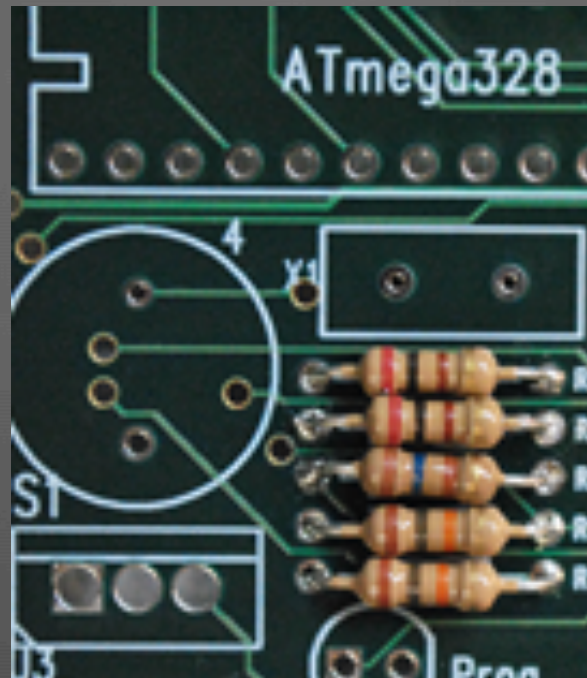
Holes through which parts are placed

PCB Drawing - Traces



Through-hole Assembly

- Place pins of part through the hole
- Solder on opposite side of board



Place parts



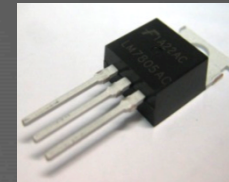
Oscillator



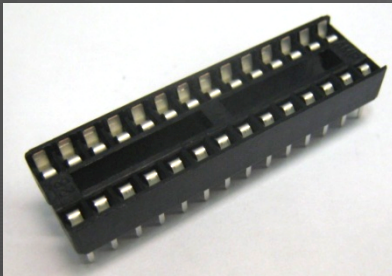
Reset
Pushbutton



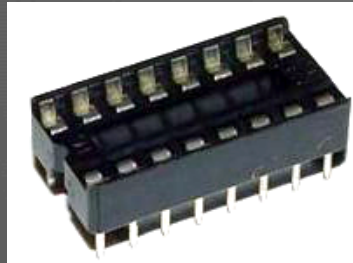
Speaker



Voltage regulator



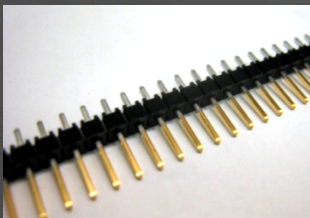
Sockets



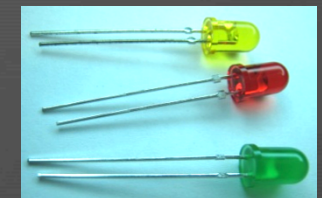
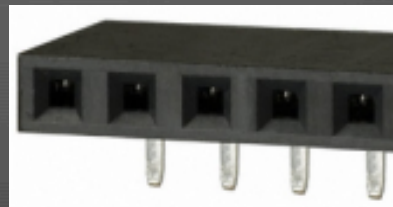
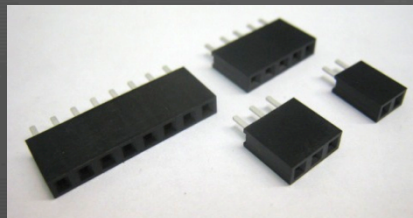
Capacitors



Resistors

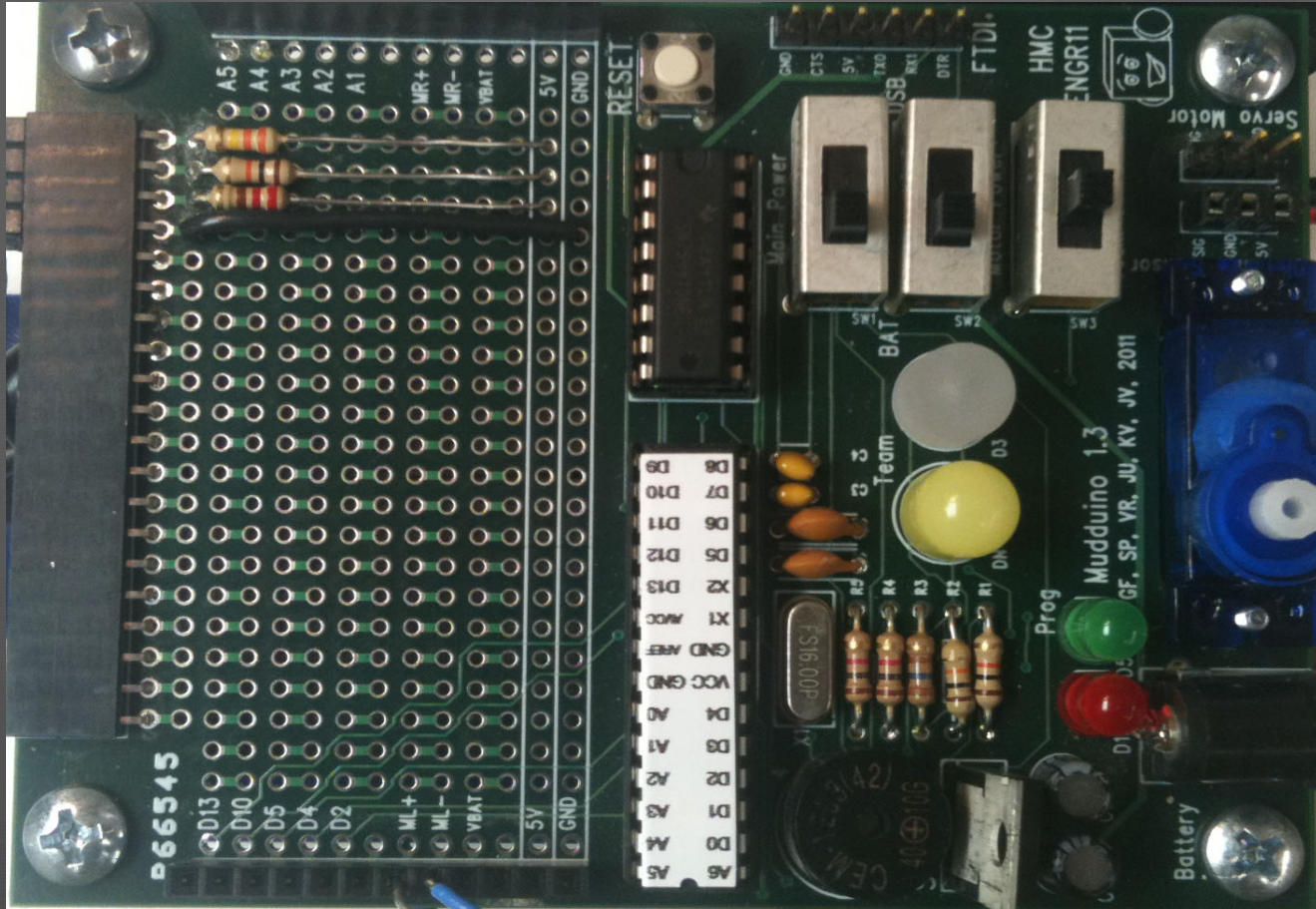


Header pins

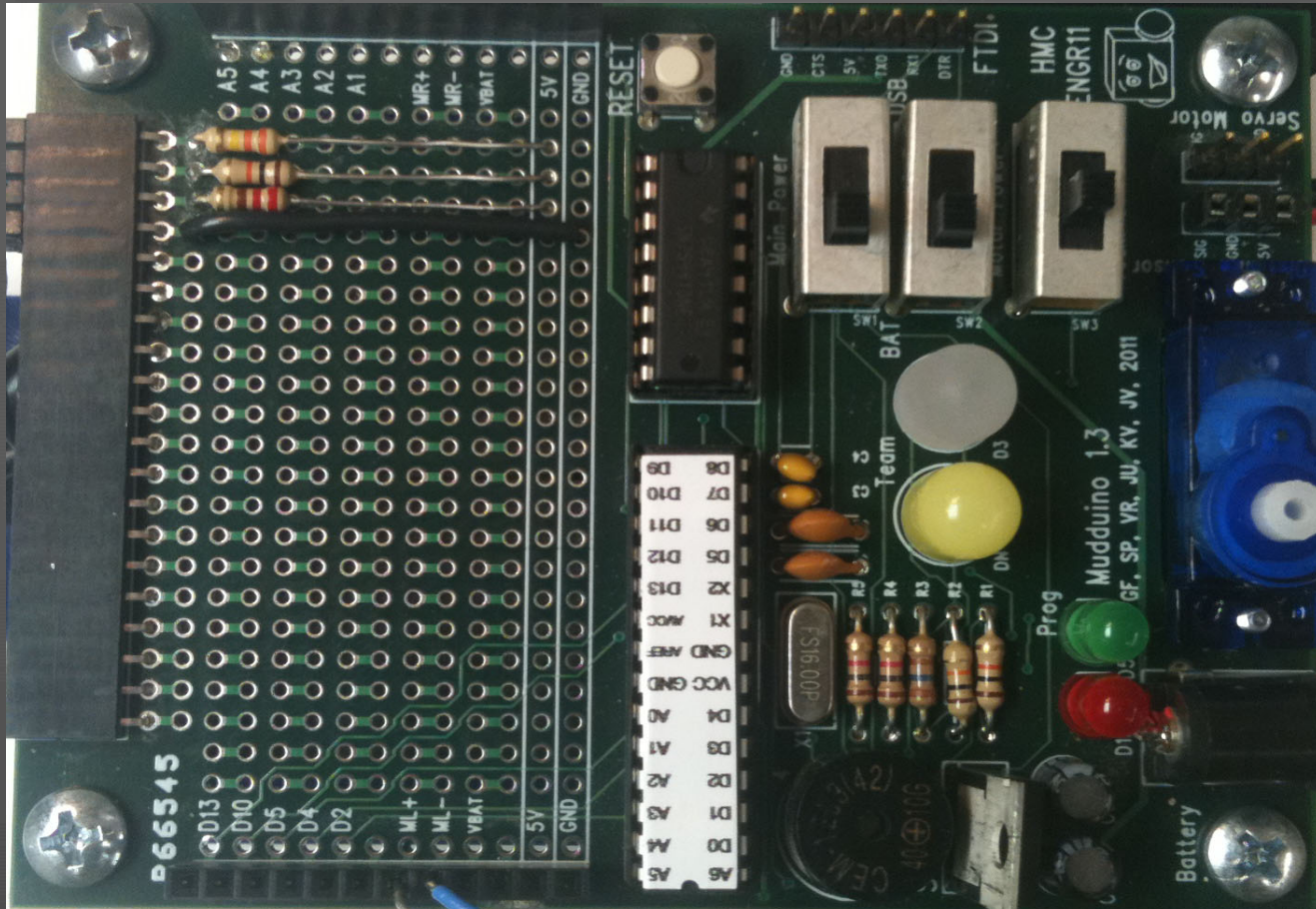


LEDs

Voila! – your very own Mudduino



Voila! – your very own Mudduino



Test & Debug!