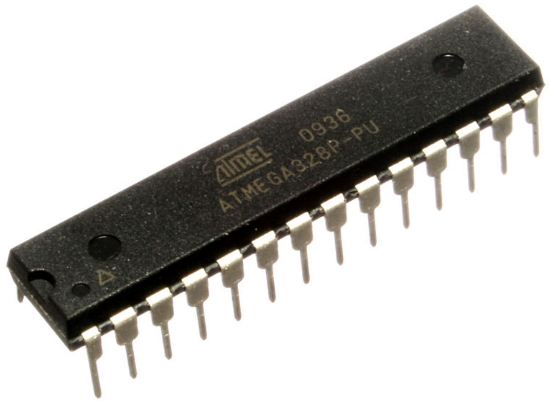
Goal: We want to build an autonomous vehicle (robot)

This means it will have to "think" for itself, its going to need a brain…



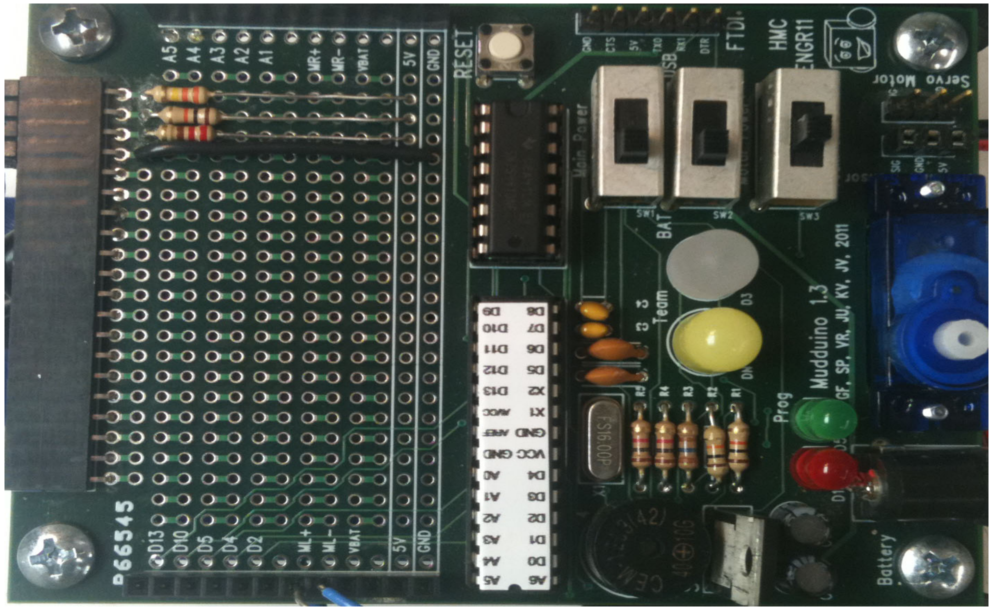
Our robot's brain will be a tiny computer called a microcontroller

Specifically an ATMEGA328

Some content by D. M. Harris

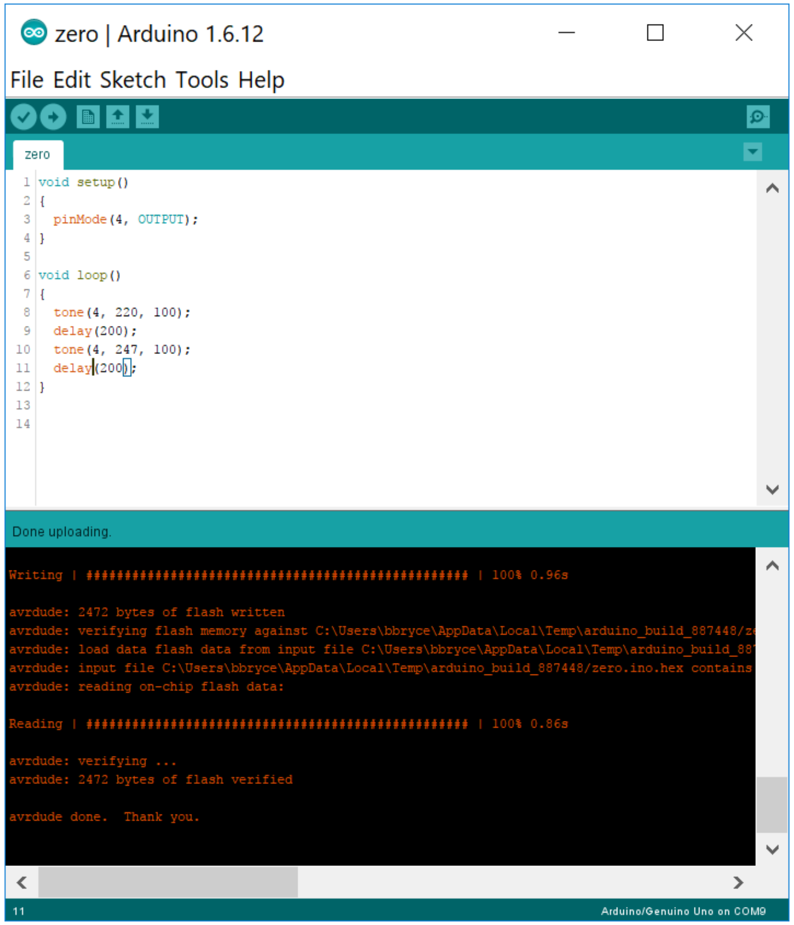
Goal: We want to build an autonomous vehicle (robot)

Just a brain will not be enough, the microcontroller needs peripherals: arms, legs, eyes… a body.



This is the PCB you will be populating in lab 1. most of the soft tissues of our robot. The bones will come in a later lab

So we have a brain and a body. But the brain does not know anything our baby robot needs to be taught what to do. That means we need to program the microcontroller... But how?



```
void setup()
{
  pinMode(4, OUTPUT);
}

void loop()
{
  tone(4, 220, 100);
  delay(200);
  tone(4, 247, 100);
  delay(200);
}
```

Done uploading.

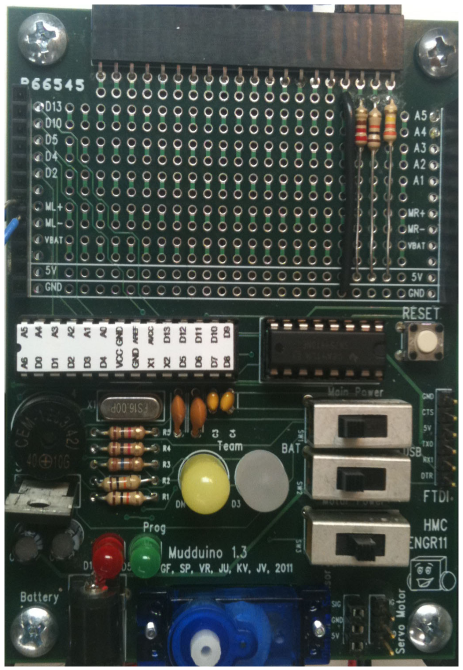
```
Writing | ################################################## | 100% 0.96s

avrdude: 2472 bytes of flash written
avrdude: verifying flash memory against C:\Users\bbryce\AppData\Local\Temp\arduino_build_887448/ze
avrdude: load data flash data from input file C:\Users\bbryce\AppData\Local\Temp\arduino_build_88
avrdude: input file C:\Users\bbryce\AppData\Local\Temp\arduino_build_887448/zero.ino.hex contains
avrdude: reading on-chip flash data:

Reading | ################################################## | 100% 0.86s

avrdude: verifying ...
avrdude: 2472 bytes of flash verified

avrdude done.  Thank you.
```

11 Arduino/Genuino Uno on COM9

We will use the Arduino IDE and middleware. Available at: https://www.arduino.cc

Mudduino – Overall Description

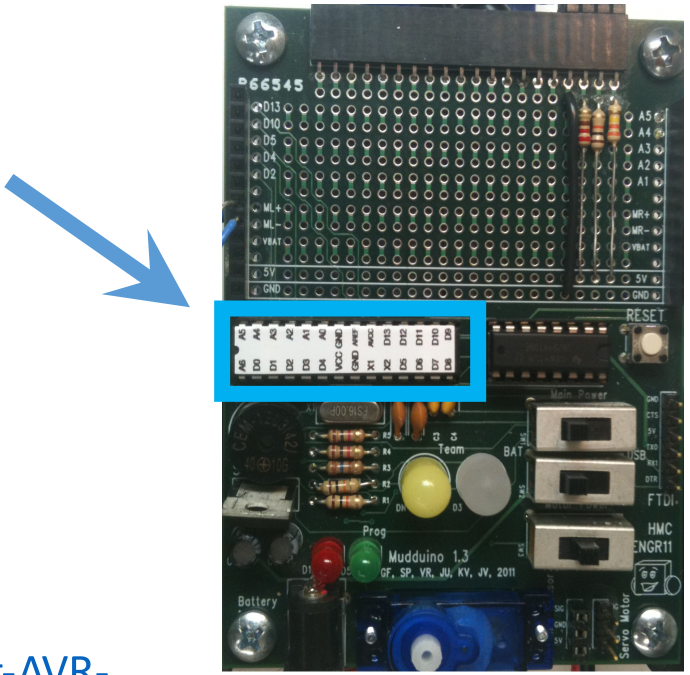
- Designed by E11 students during spring 2011 (v 1.3)
- Similar to Uno, except:
  - Uses through-hole components
    - easier to solder
    - can assemble your own board
  - Has connectors customized to robotics applications
  - Has form factor designed for your vehicle
  - Includes a blank portion -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



Mudduino – Features

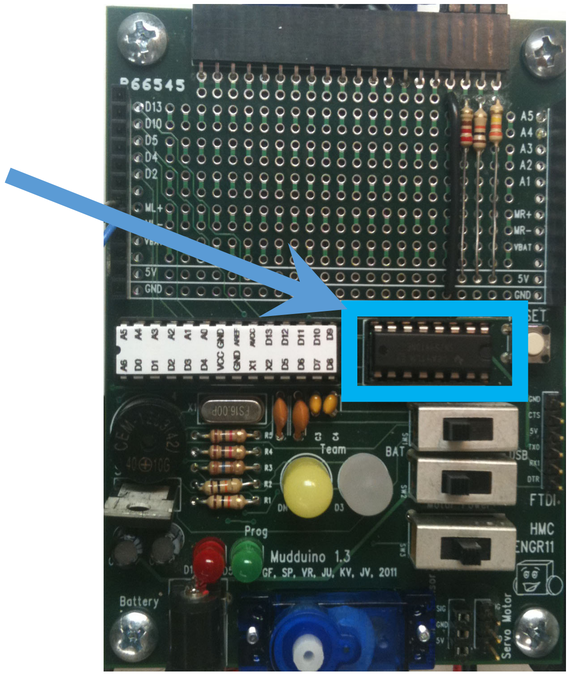
- Atmega328 microcontroller
  - 32 KB of Flash program memory, 2 KB of RAM data memory, 16 MHz
  - Runs at 16 MHz from quartz crystal
  - Has built in ADC
  - Has UART to talk serial to our computer
  - Has timers and interrupts
  - Can create pulse width modulation (PWM)
  - 8-bits
  - 1 instruction per clock AVR architecture
  - Runs at up to 5V

See the datasheet for all the goodness:
http://www.atmel.com/images/Atmel-8271-8-bit-AVR-Microcontroller-ATmega48A-48PA-88A-88PA-168A-168PA-328-328P_datasheet_Complete.pdf



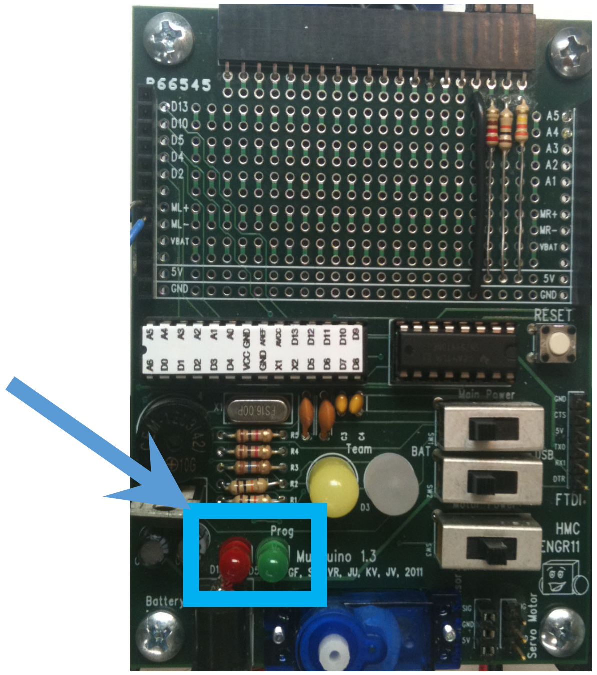
Mudduino – Features

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



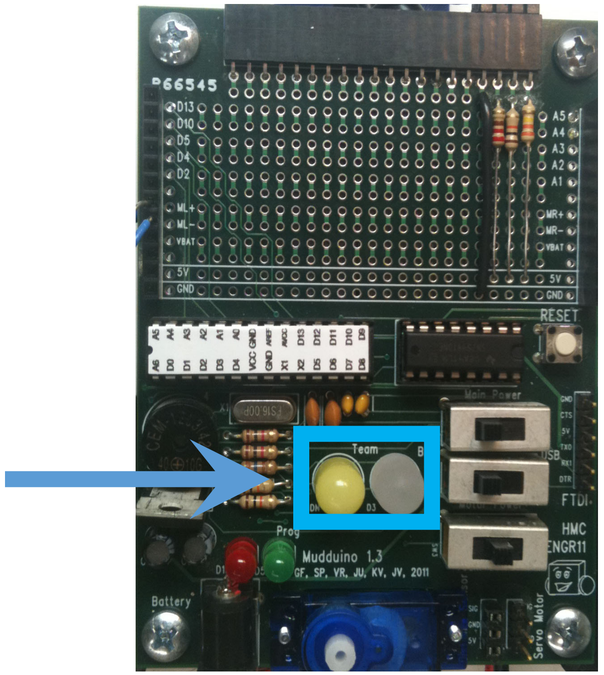
Mudduino – Features

- 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)



Mudduino – Features

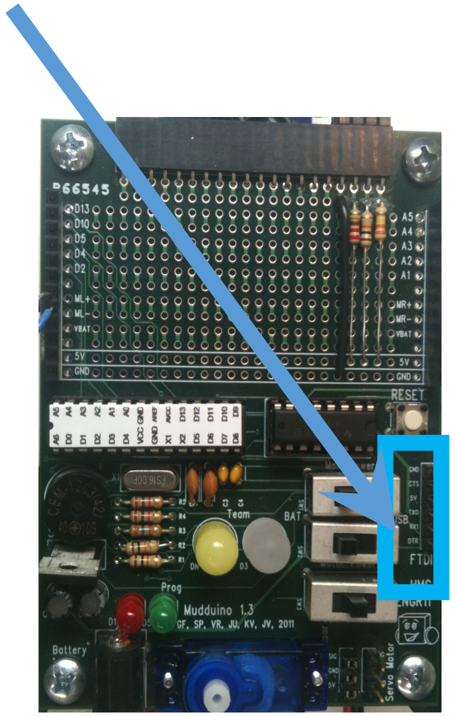
- Atmega328 microcontroller
  - 32 KB of Flash program memory, 2 KB of RAM data memory, 16 MHz
- H Bridge for driving two high-current motors
- Two indicator LEDs (red, green)
- Two team LEDs (white, green)
  - glows white (looks yellow)
  - glows green (looks white)



Mudduino – Features (cont.)

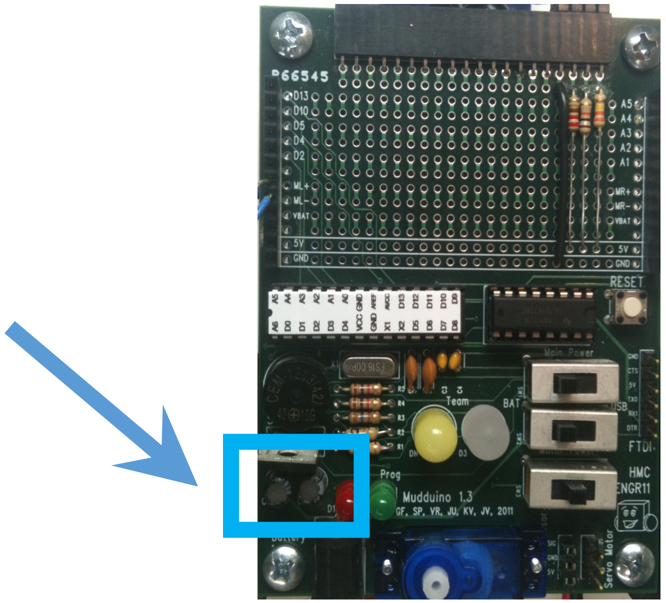
- FTDI connector to communicate with a host

(This interface talks to ATMEGA328 via the UART/serial connection and creates a USB based virtual serial port for a computer to talk to and program the microcontroller).



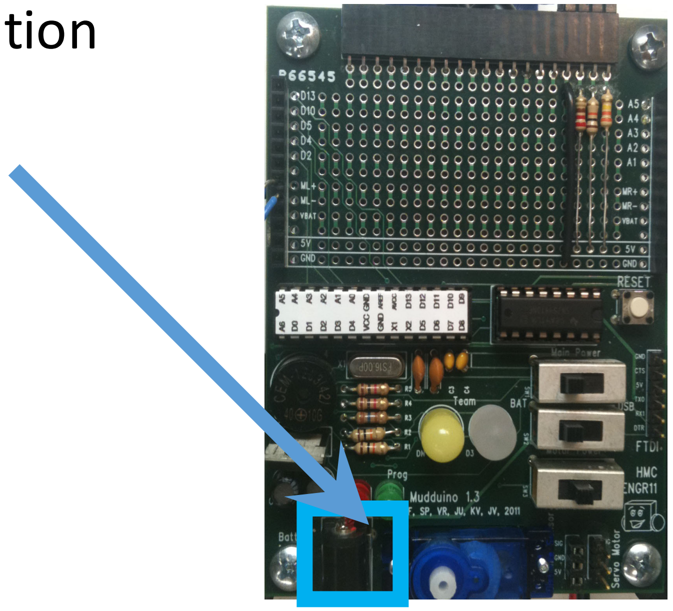
Mudduino – Features (cont.)

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



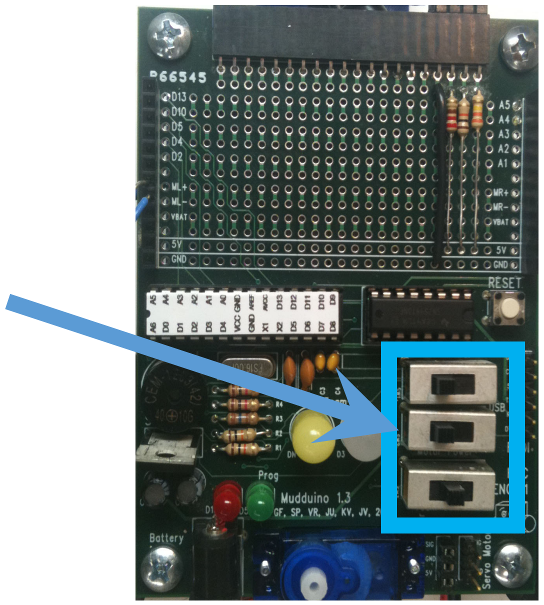
Mudduino – Features (cont.)

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



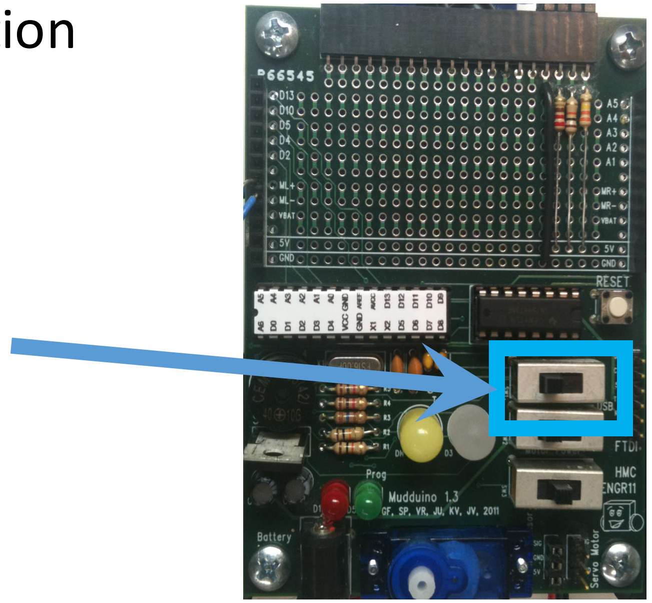
Mudduino – Features (cont.)

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



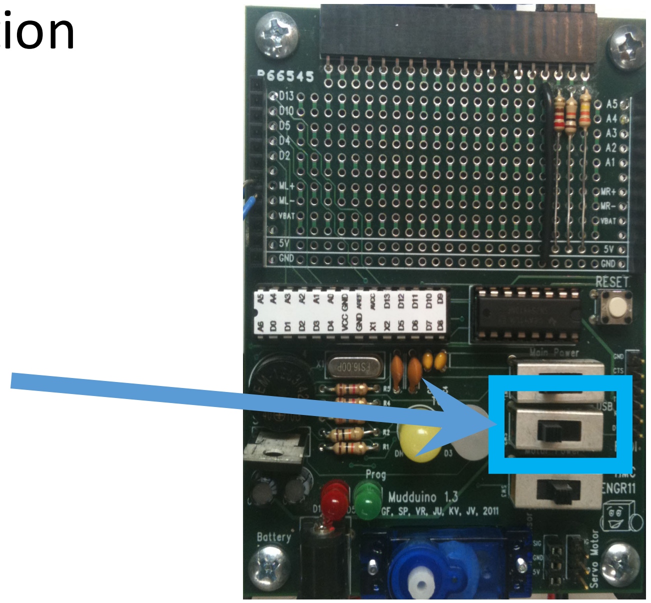
Mudduino – Features (cont.)

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



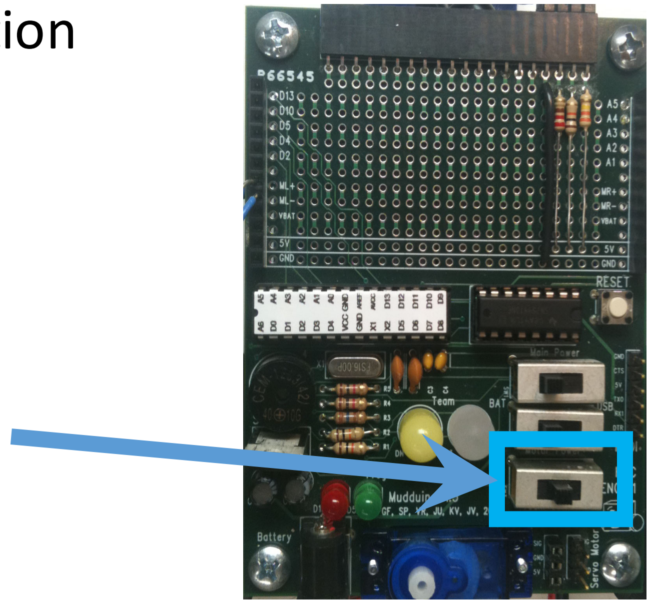
Mudduino – Features (cont.)

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



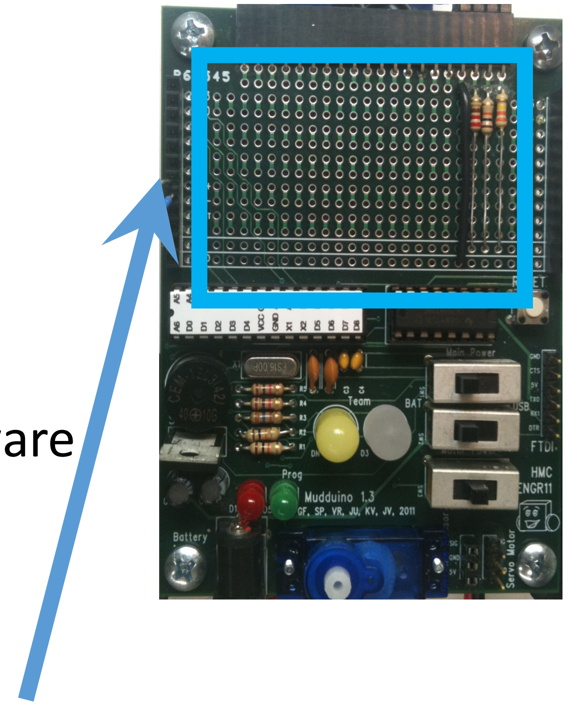
Mudduino – Features (cont.)

- 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!)



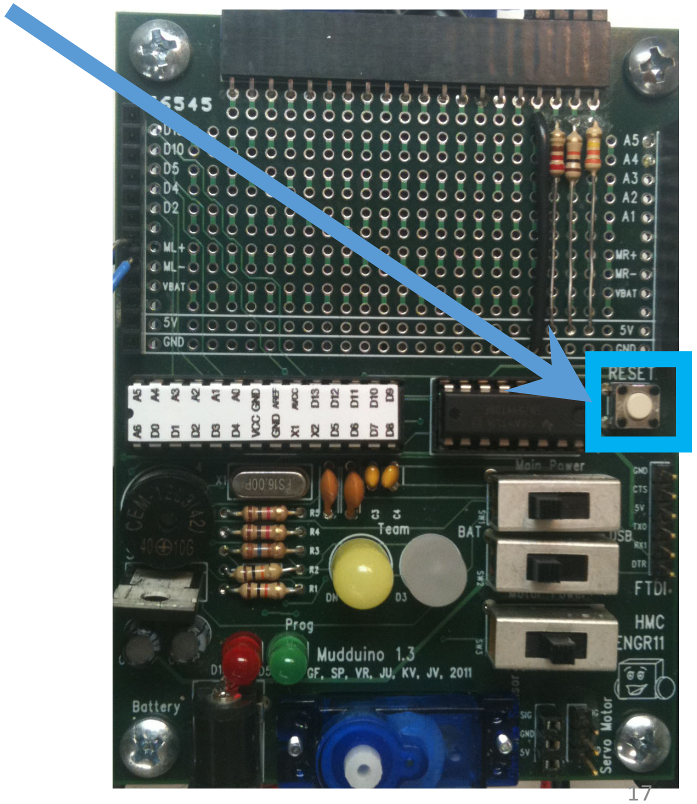
Mudduino – Features (cont.)

- 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



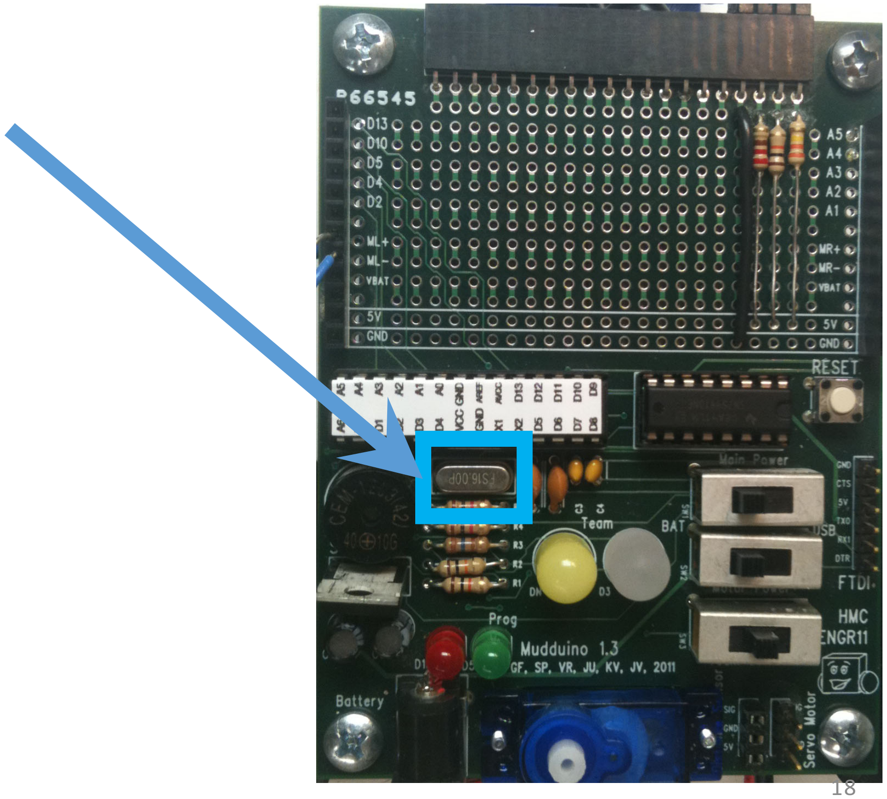
Mudduino – more parts!

- Reset button
  - When push button, uploaded program restarts



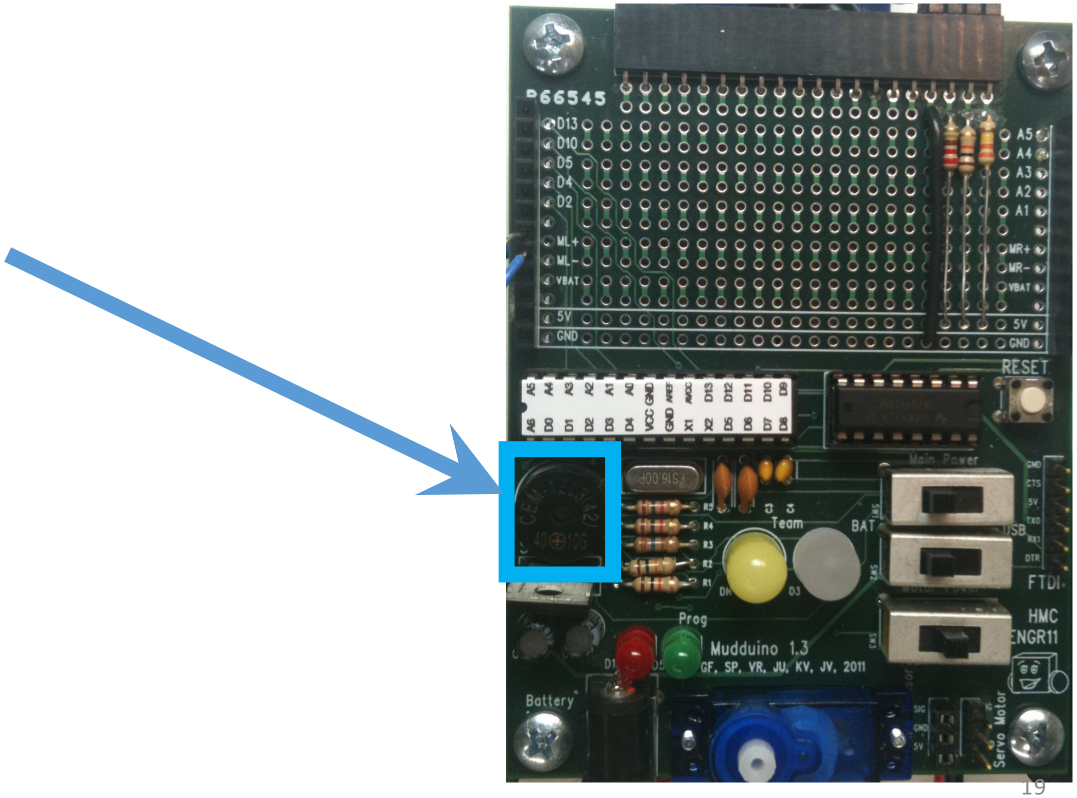
Mudduino – more parts!

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



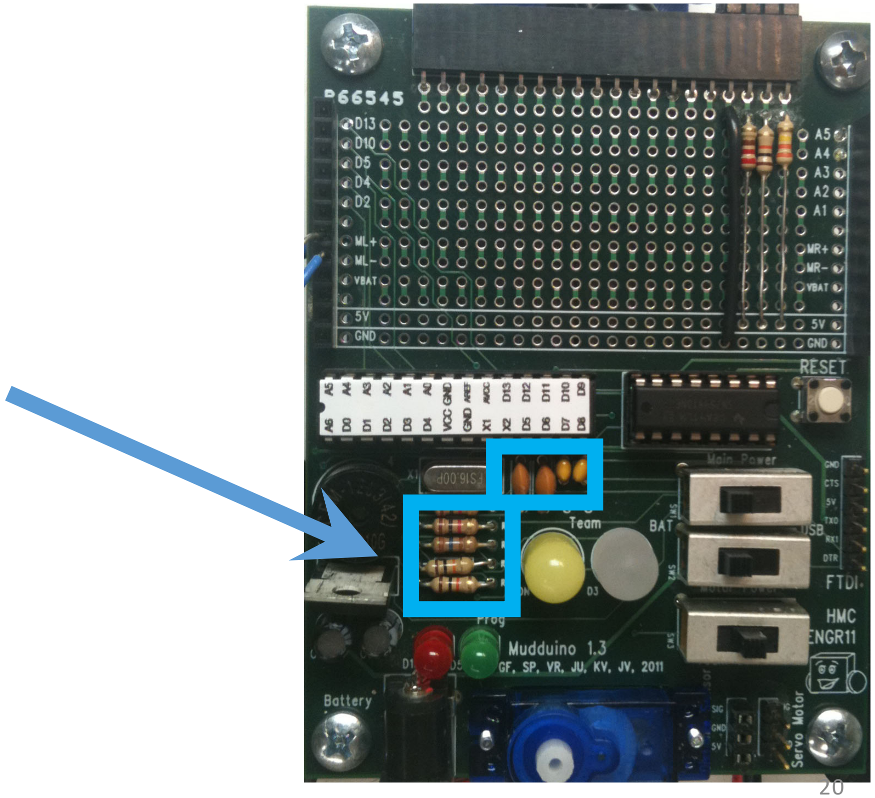
Mudduino – more parts!

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



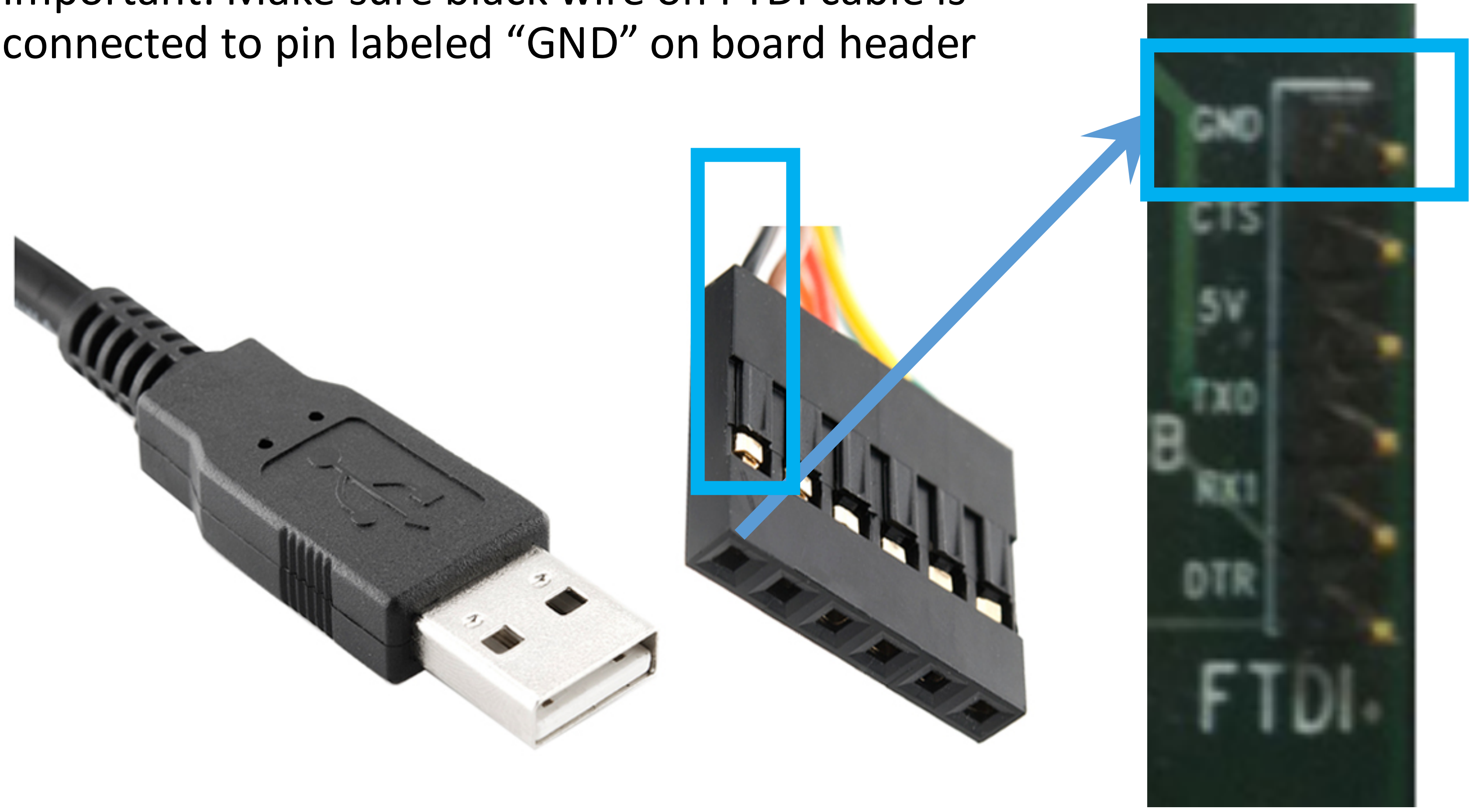
Mudduino – more parts!

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



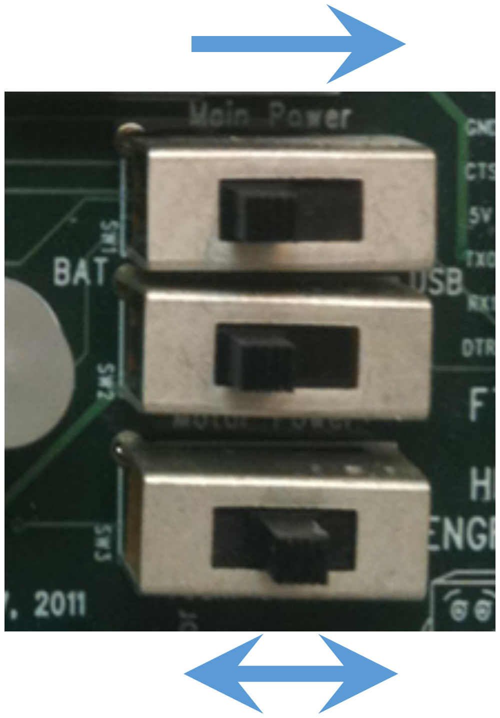
Mudduino – FTDI connector

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



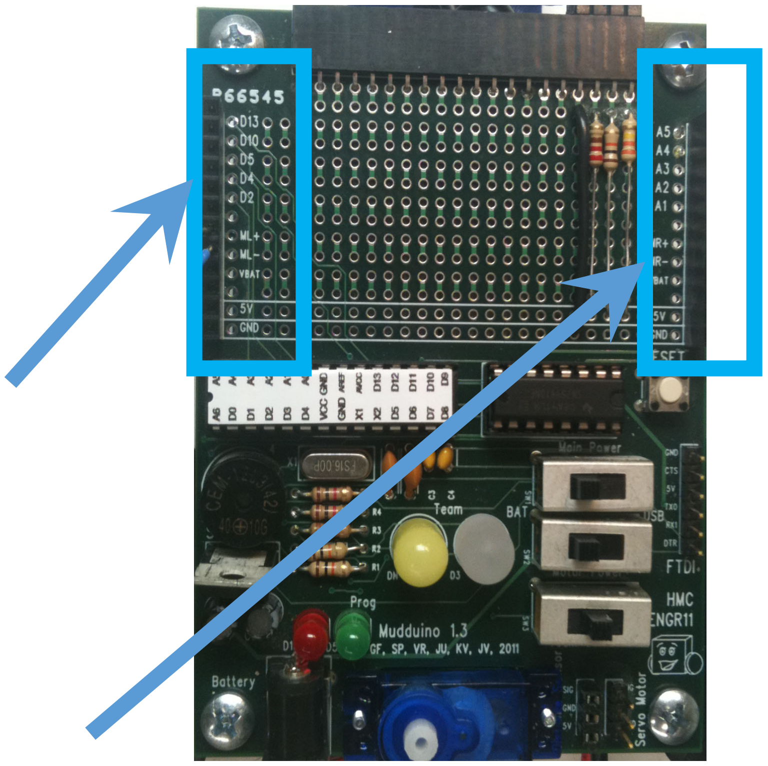
Mudduino – Settings

- 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
  - 5 V and GND
  - 20 expansion pins



Mudduino – Pins

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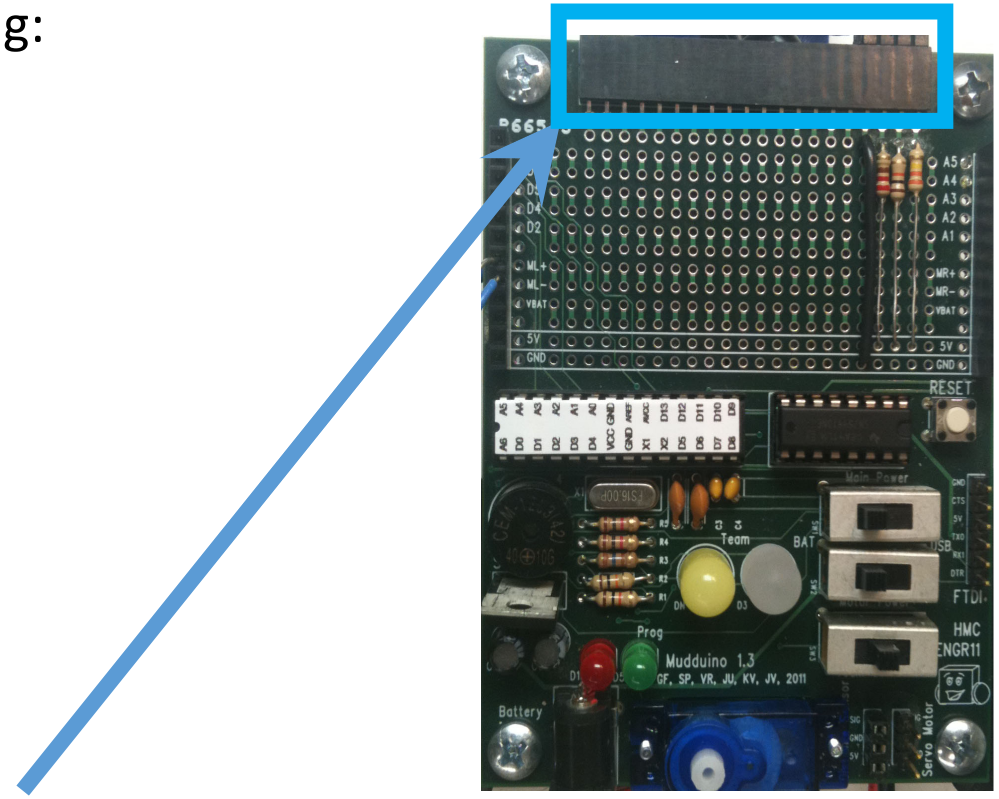
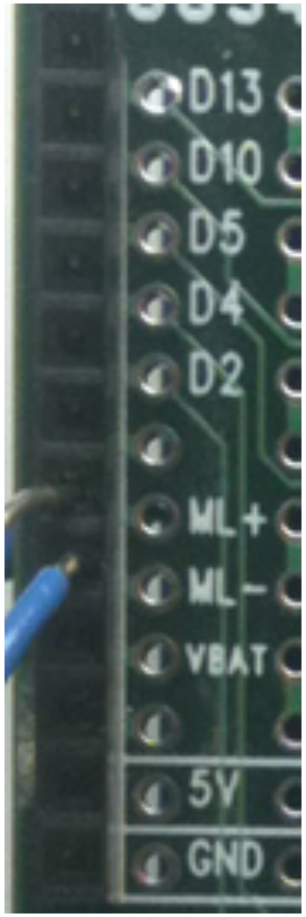
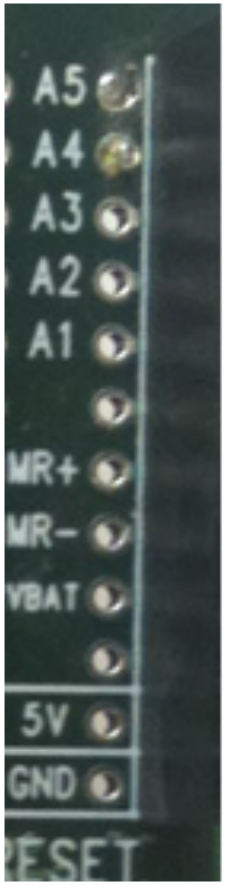
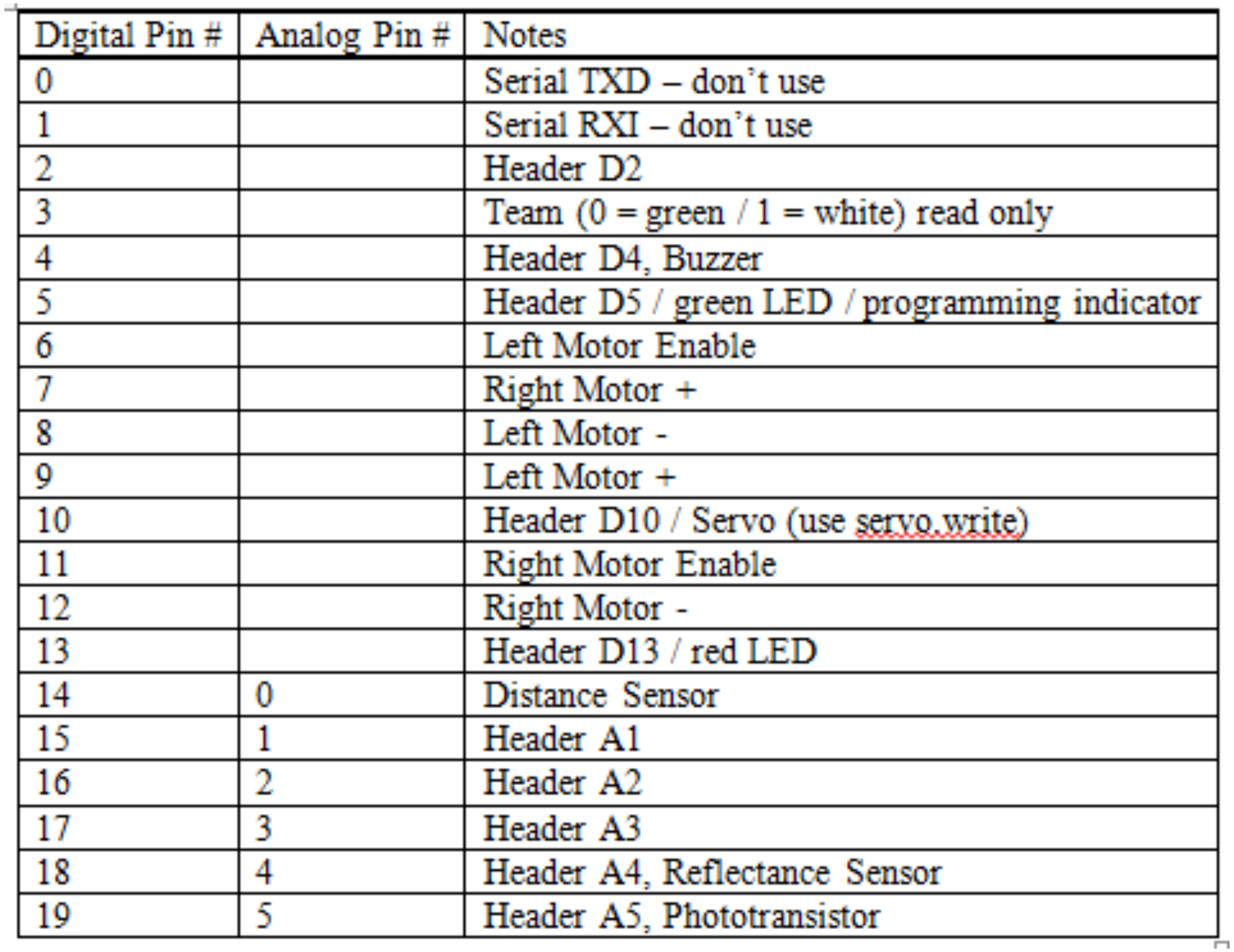


Mudduino – Pins



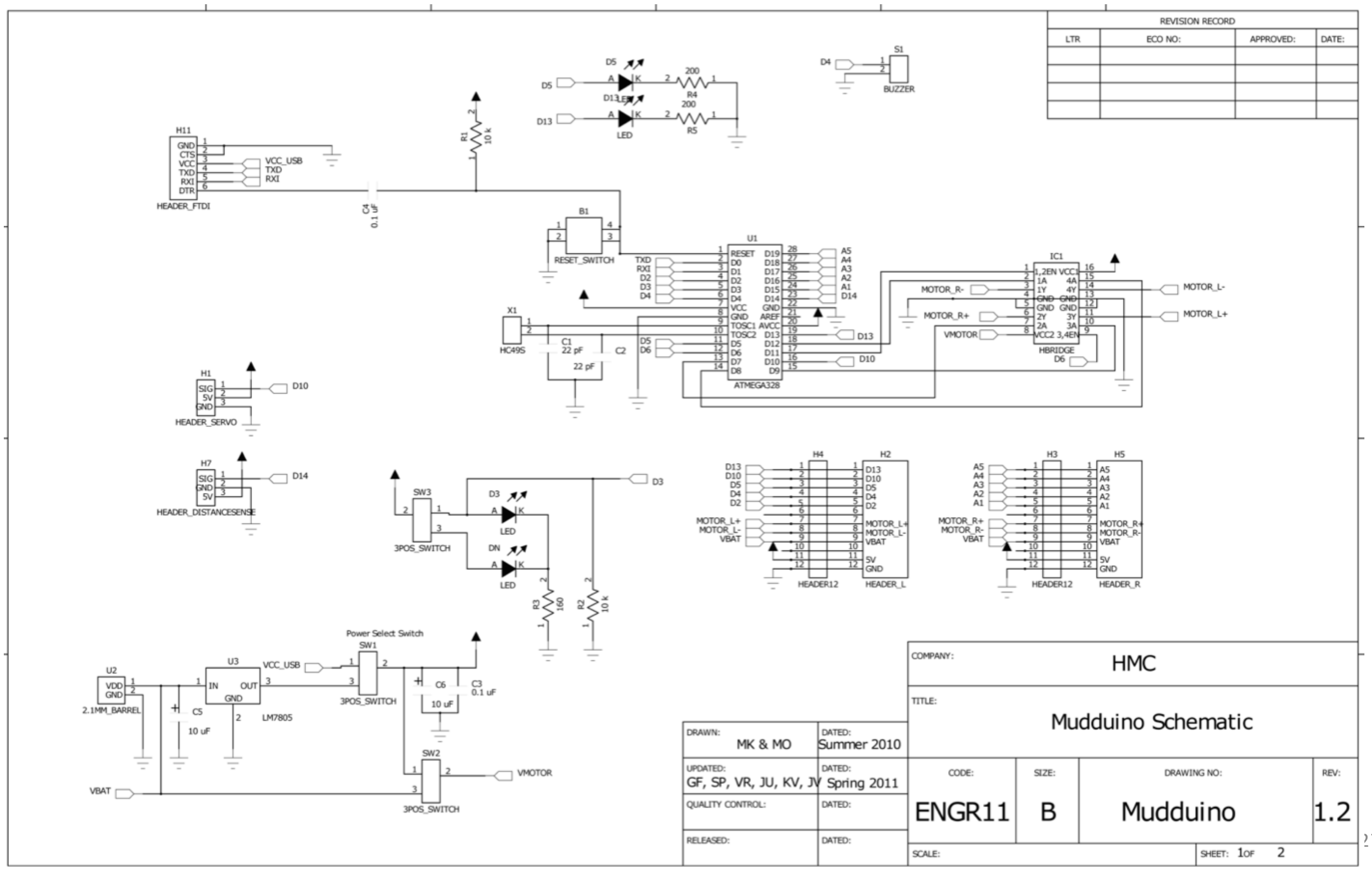


Mudduino Pinout

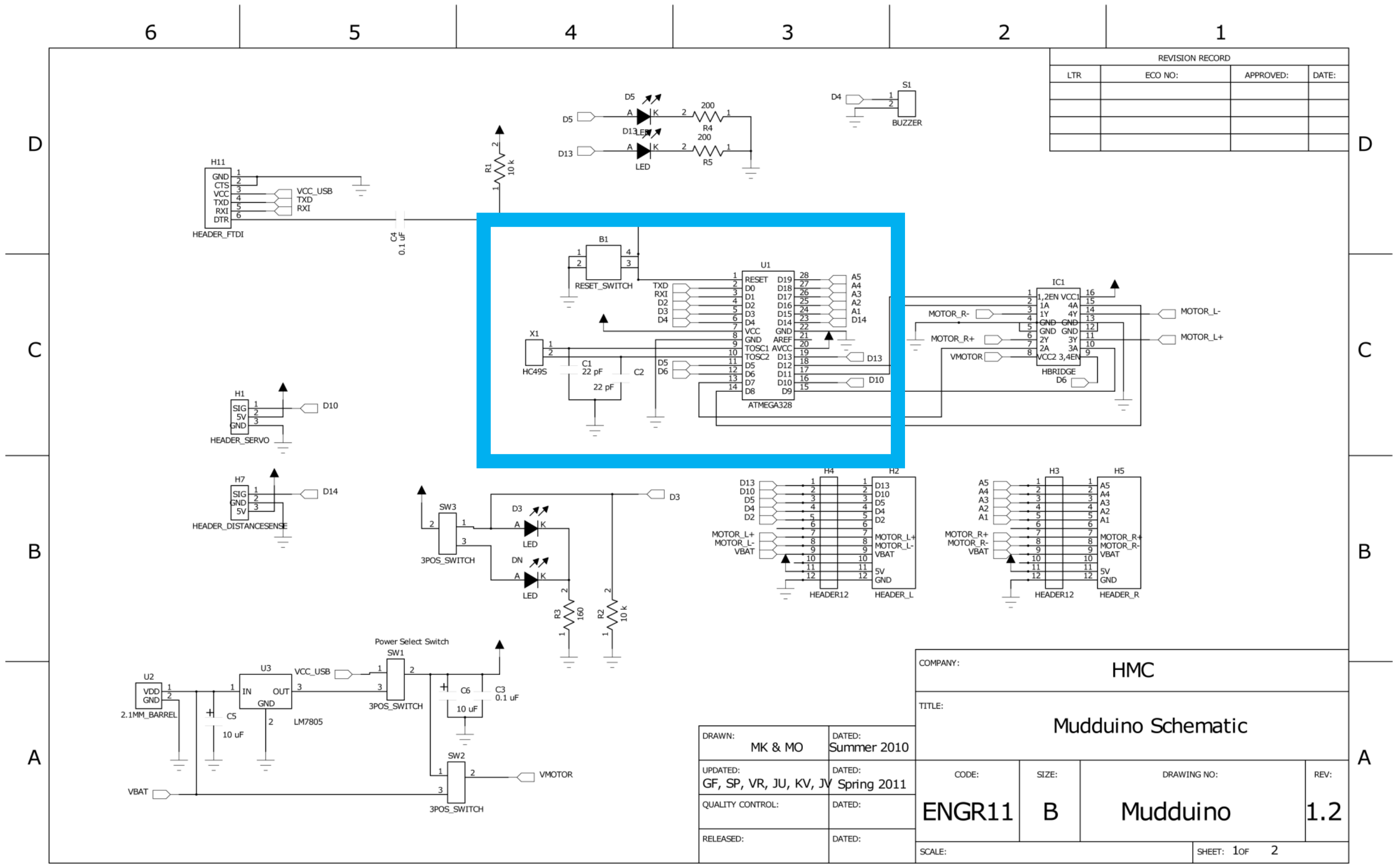


Digital Pin #	Analog Pin #	Notes
0		Serial TXD – don't use
1		Serial RXI – don't use
2		Header D2
3		Team (0 = green / 1 = white) read only
4		Header D4, Buzzer
5		Header D5 / green LED / programming indicator
6		Left Motor Enable
7		Right Motor +
8		Left Motor -
9		Left Motor +
10		Header D10 / Servo (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

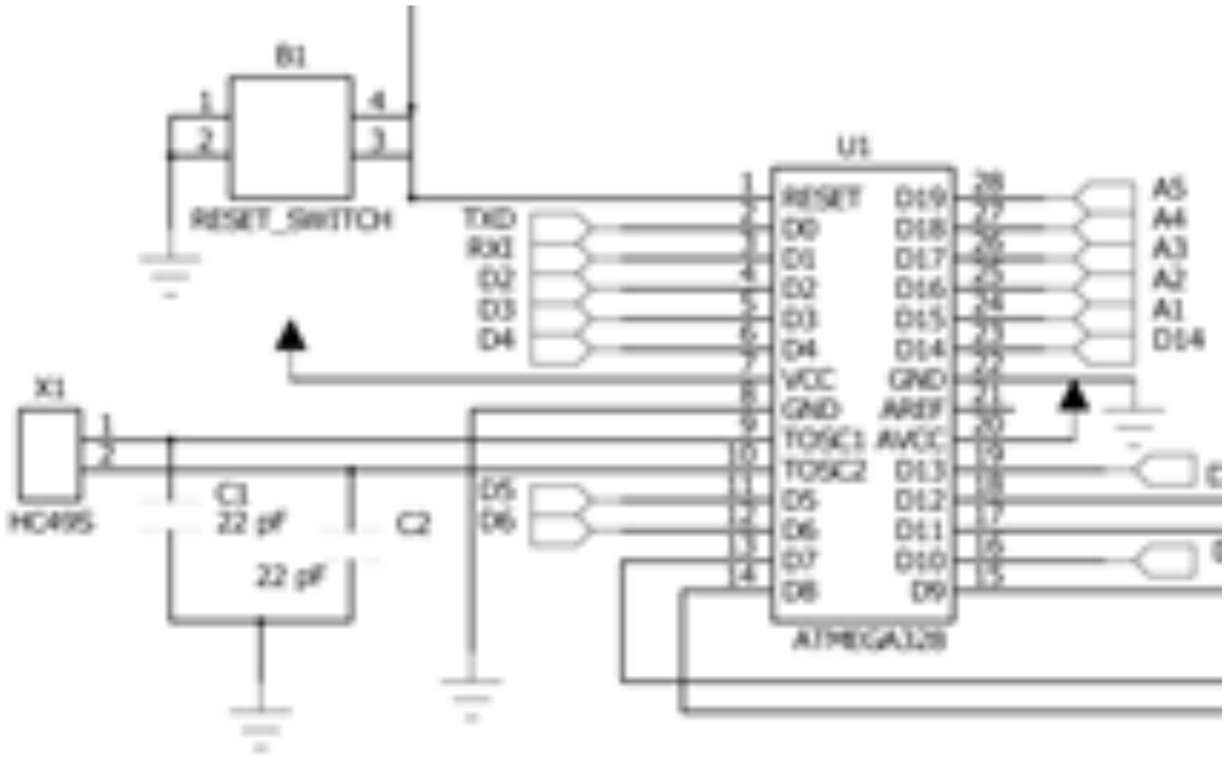
Mudduino Schematic



Mudduino Schematic



Mudduino Schematic

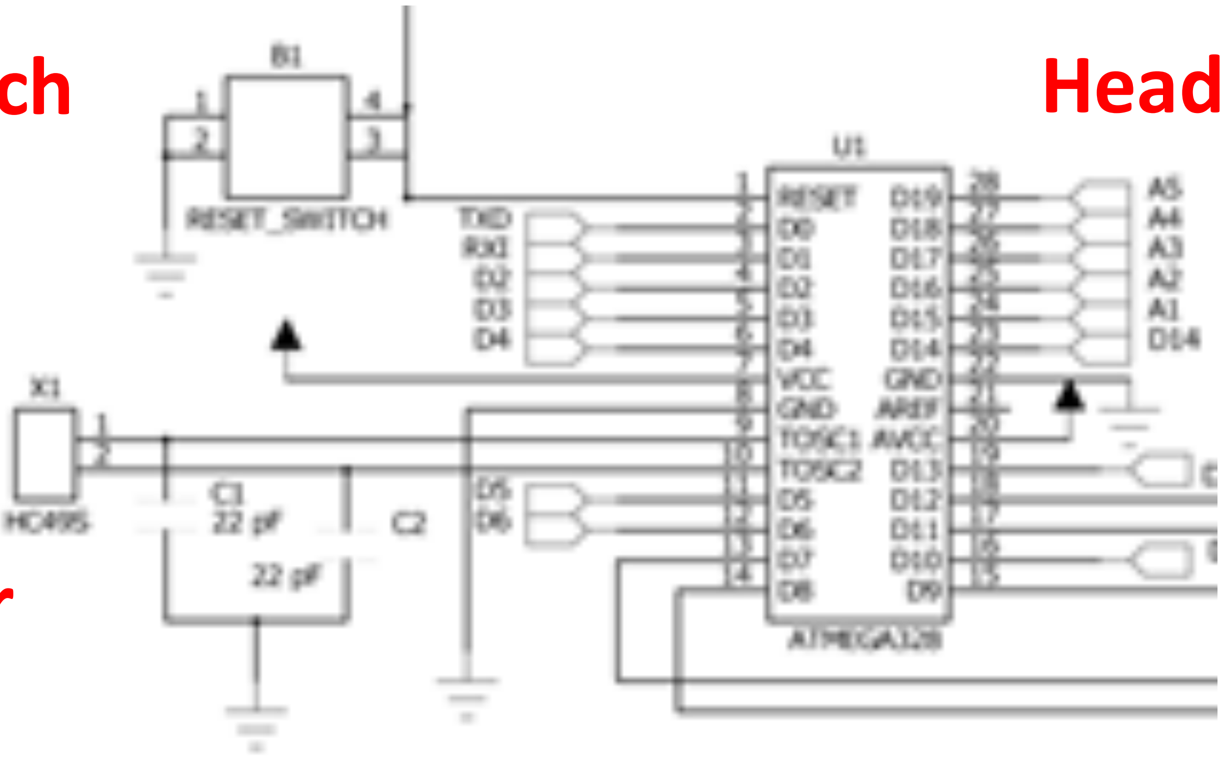


Mudduino Schematic

Reset switch

Header pins

Oscillator



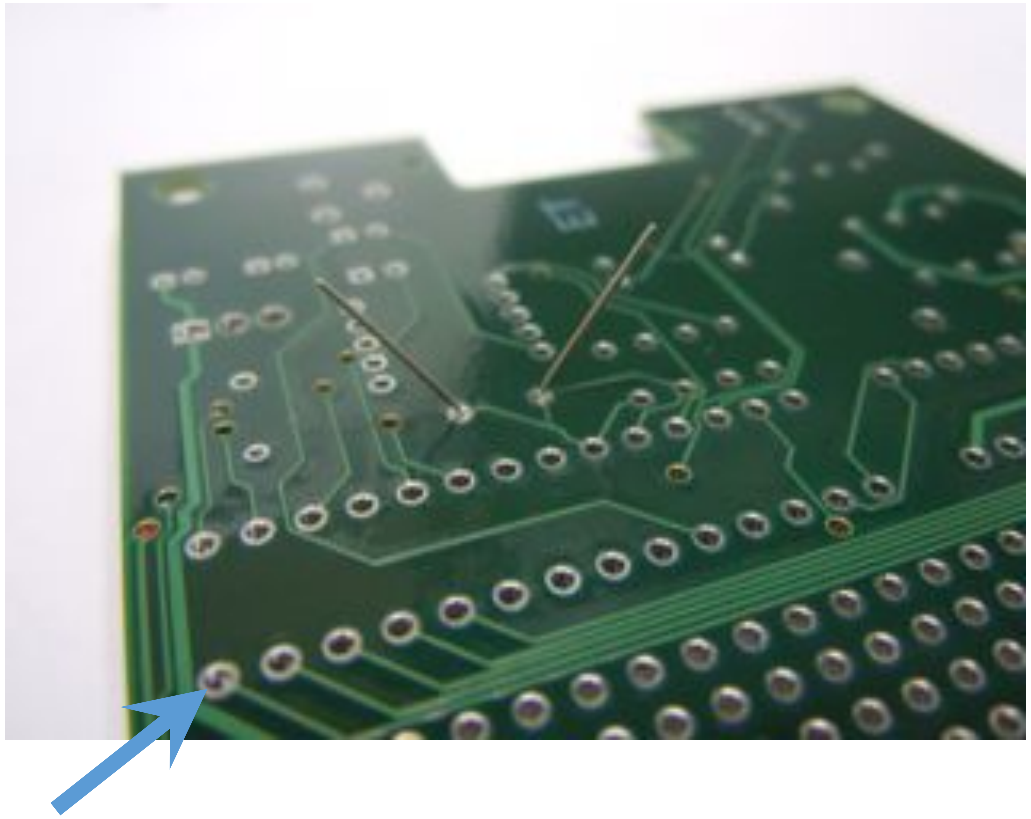
Arduino Bootloader

- 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

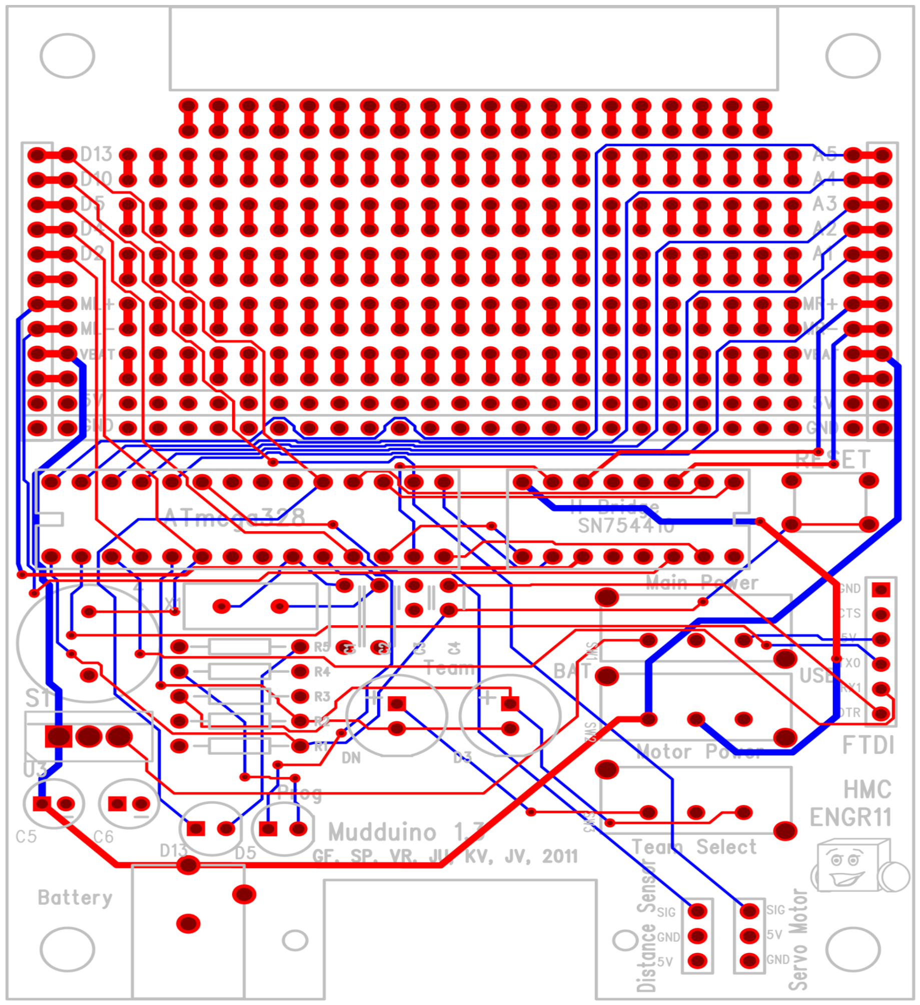
- You will all assemble (build) your own Mudduino in lab 1
- Start with a bare printed circuit board (PCB)
- Solder parts using a soldering iron and solder
  - Parts must have good electrical and mechanical connection to board!

Bare PCB



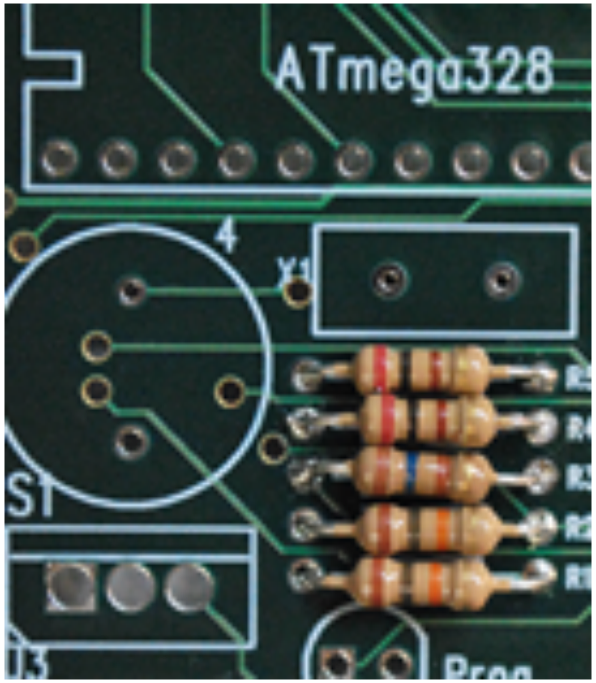
Holes through which parts are placed

PCB Drawing - Traces

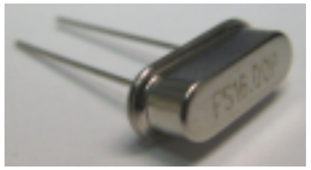


Through-hole Assembly

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

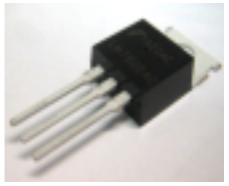


Place parts

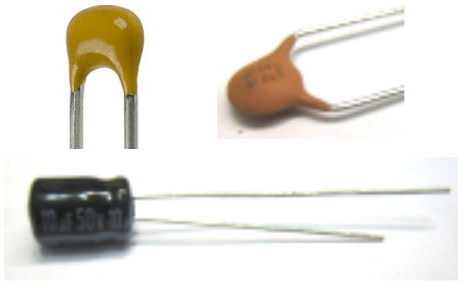

Oscillator

Reset Pushbutton

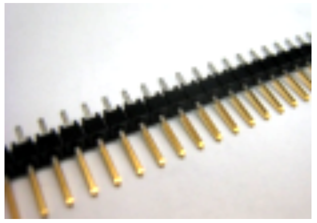
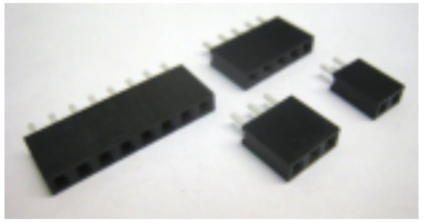
Speaker


Voltage regulator

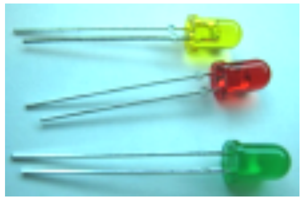
Sockets


Capacitors

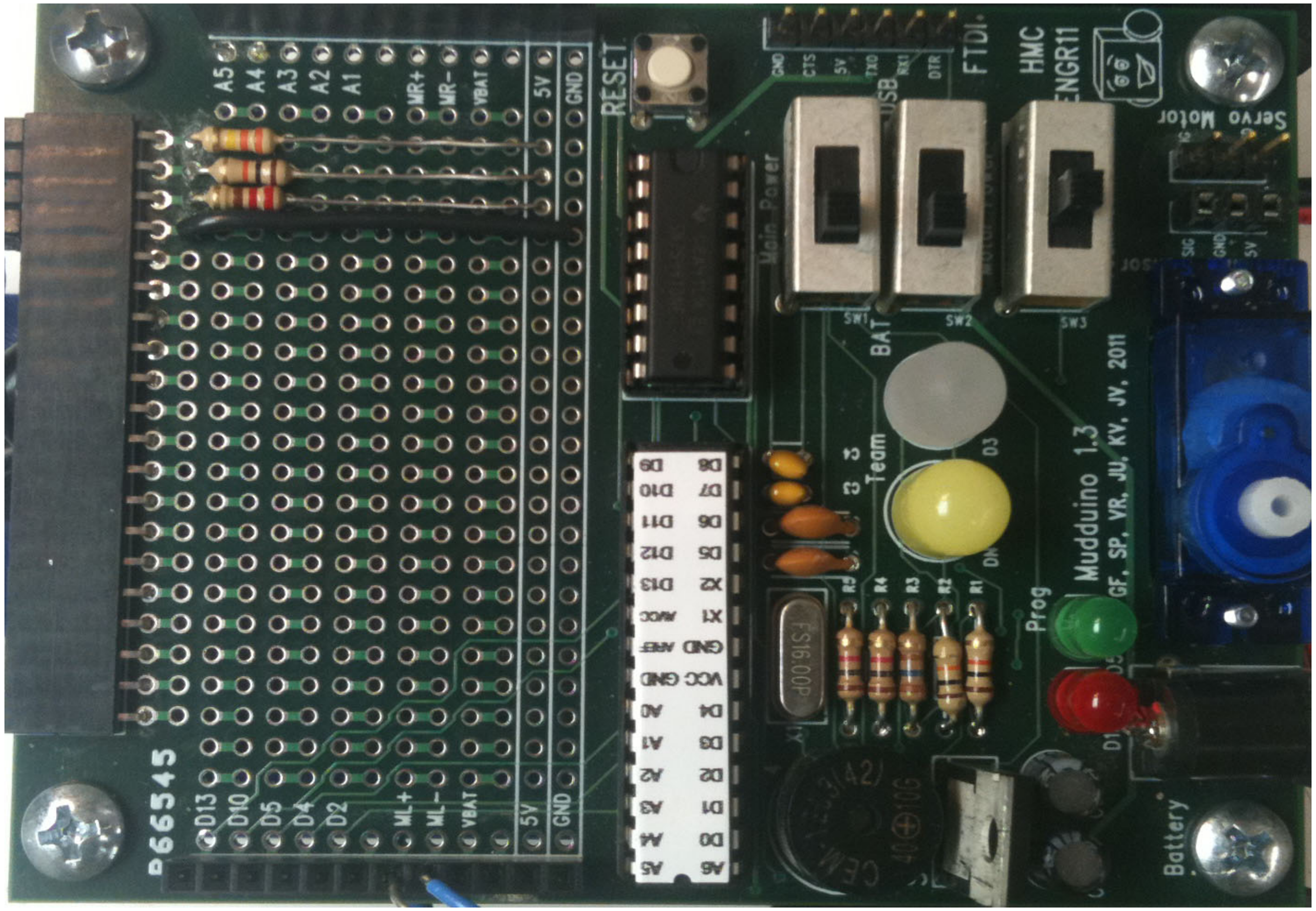
Resistors

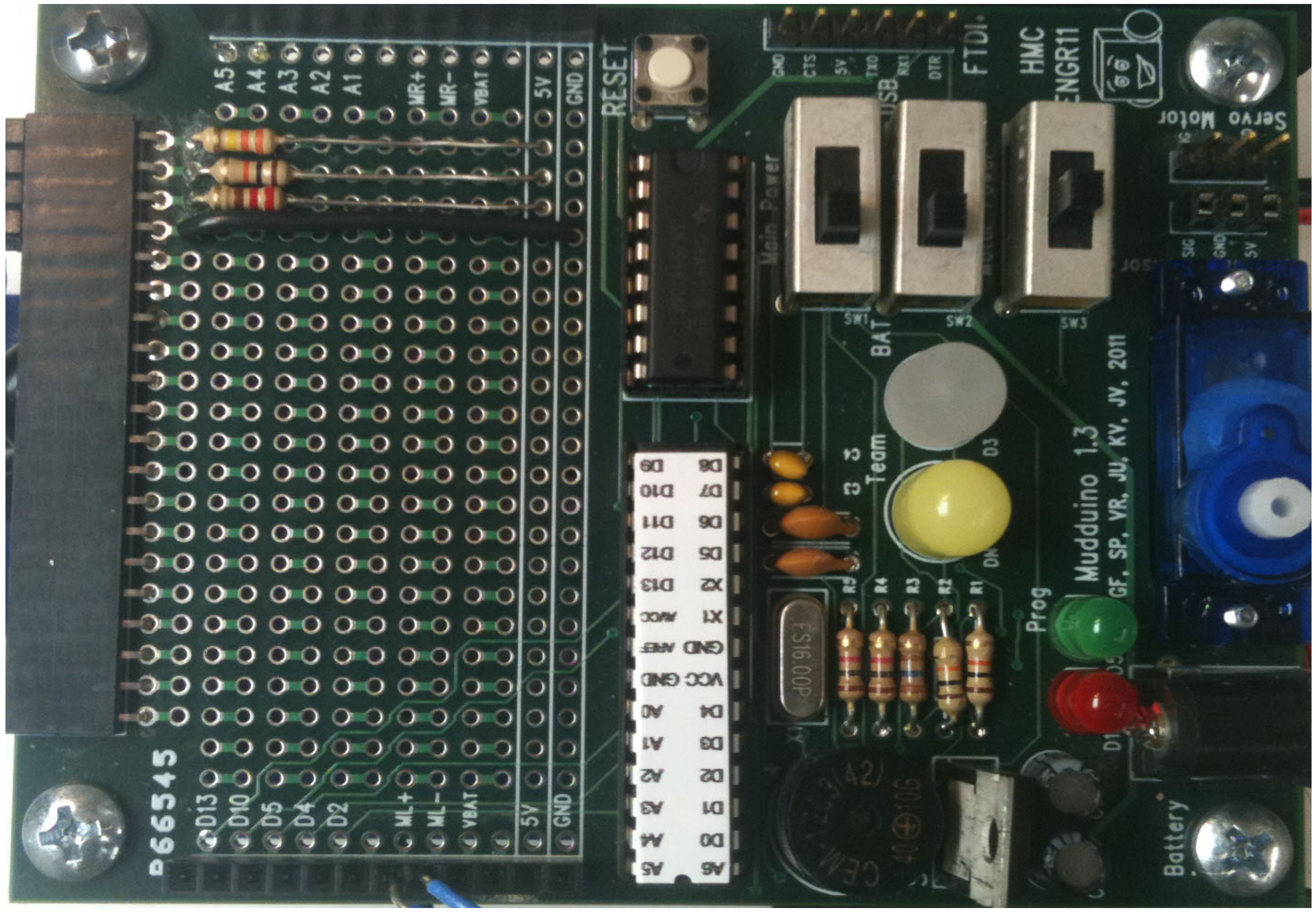
Header pins


LEDs

Voila! – your very own Mudduino



Voila! – your very own Mudduino



Test & Debug!