University of British Columbia
Electrical and Computer Engineering
ELEC291/ELEC292

Project 2: Coin Picking Robot.

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Requirements

- Two micro-controller systems: must be different 'families'!
- Programmed in C.
- Both Robot and Remote must be battery powered**.**
- Discrete MOSFET drivers.
- Metal detector.
- Remote must have display, speaker, and joystick or equivalent.
- Radio Communication using JDY-40 or

Coin Picking Robot

- Here is my robot picking coins in automatic mode. I used the EFM8 board.

  https://bit.ly/2HmJcAr

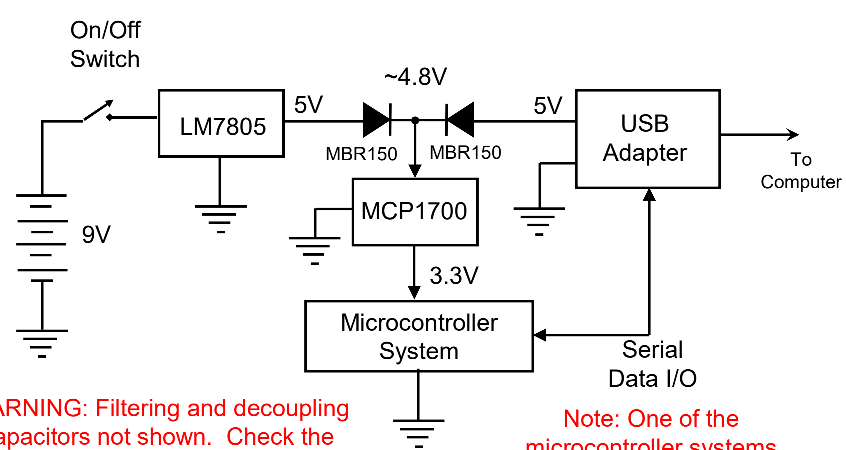
Getting Started with a New Microcontroller System

1. Obtain/assemble the hardware. Also documentation: datasheets & manuals.
2. Obtain/install the development environment. Also documentation like manuals.
3. Obtain/install a means of putting the ‘firmware’ in the hardware. May require additional hardware tools and software.
4. Settle a workflow. Also: examples, application notes, and forums.

Getting Started with a New Microcontroller System

- In this course is not too difficult. Instructions provided for:
  - STM32L051: LQFP32. 64k flash. Microchip. ARM architecture.
  - LPC824: TSOP 20. 32k flash. NXP. ARM architecture.
  - PIC32MX130: DIP-28. 64k flash. Microchip. MIPS architecture.
  - ATmega328p: DIP-28. 32k flash. Atmel/Microchip. AVR architecture.
  - MSP430G2553. DIP-20. 16k flash. Texas Instruments. MSP430 architecture.

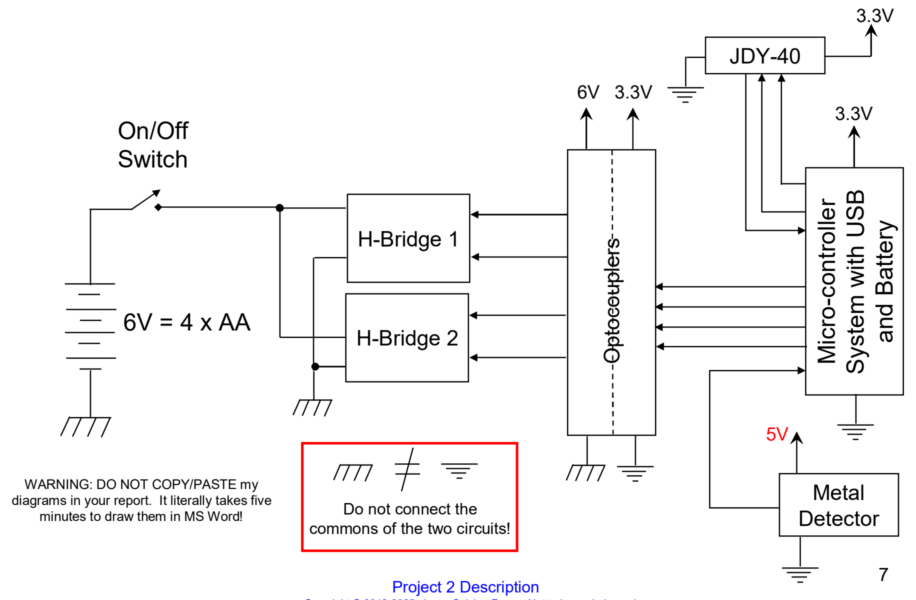
Micro-controller System with USB and 9V Battery



WARNING: Filtering and decoupling capacitors not shown. Check the LM7805 and MCP1700 datasheets for info about capacitors.

Note: One of the microcontroller systems can work directly with 5V.

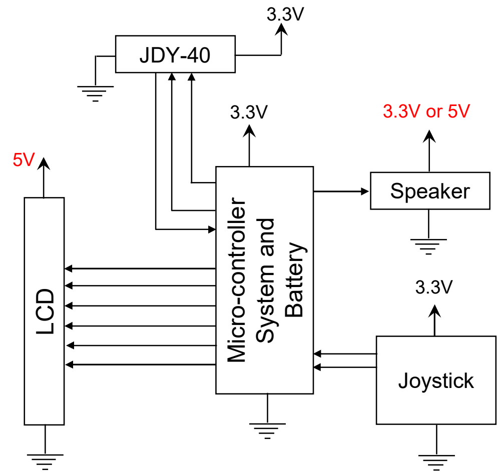
ROBOT block diagram



Considerations for the Robot Micro-controller

- Make sure you have available (at a bare minimum) and know how to use at the same time in the ROBOT micro-controller system:
  - 4 digital outputs to control the motors using PWM (4 pins)
  - Extra TXD/RXD and SET pins for JDY-40 (3 pins)
  - 1 Digital input for the metal detector (1 pin)
  - 2 Analog inputs for the perimeter detector (2 pins)
- I think all the processors provided meet the minimum requirements

Remote block diagram



WARNING: DO NOT COPY/PASTE my diagrams in your report. It literally takes five minutes to draw them in MS Word!

Considerations for the REMOTE Micro-controller.

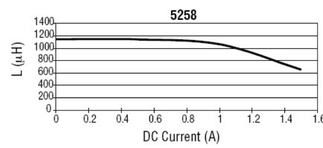
- Make sure you have available (at a bare minimum) and know how to use at the same time in the REMOTE micro-controller system:
  - 6 digital outputs for LCD (6 pins)
  - Extra TXD/RXD and SET pins for JDY-40 (3 pins)
  - 2 analog inputs for Joystick (2 pins)
  - 1 output for the speaker (1 pin)
- I think all the processors provided meet the minimum requirements

The Inductors in project Kit 2

- DigiKey part number M8275-ND

Don't drop the inductor. The ferrite core may break!

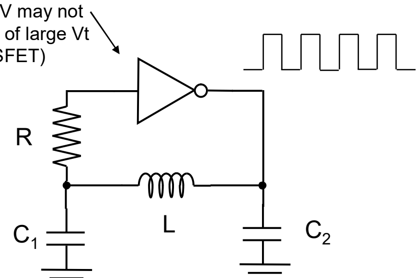
Type	Wirewound
Material - Core	Ferrite
Inductance	1mH
Tolerance	±20%
Current Rating	1A
DC Resistance	0.55 Ohms



Two used for the perimeter detector, one used in the metal detector.

Basic Metal Detector: Colpitts Oscillator.

Tip: To save space make your own CMOS inverter! (Use 5V. 3.3V may not work because of large Vt of PMOSFET)



$$C_T = \frac{C_1 C_2}{C_1 + C_2}$$

$$f = \frac{1}{2\pi\sqrt{LC_T}}$$

R=100Ω to 1kΩ

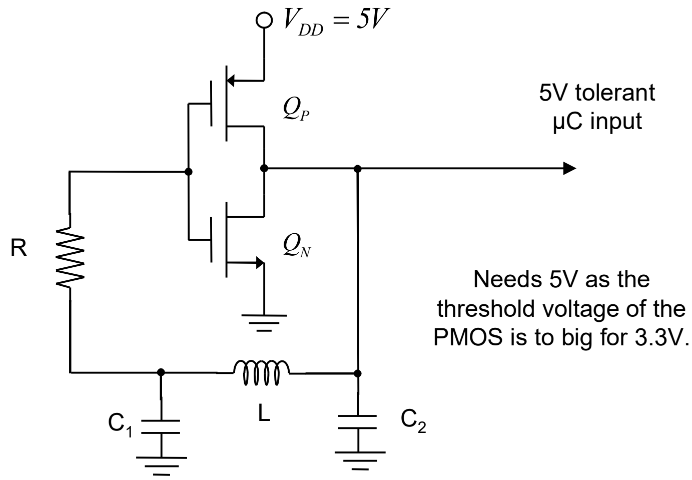
C_1=1nF to 10nF

C_2=10nF to 100nF

L=1mH

If you place metal close to the inductor, it will change the magnetic field, slightly changing the inductance which is reflected as a change in the oscillator frequency.

Colpitts Oscillator with Discrete CMOS Inverter



Project 2 Description

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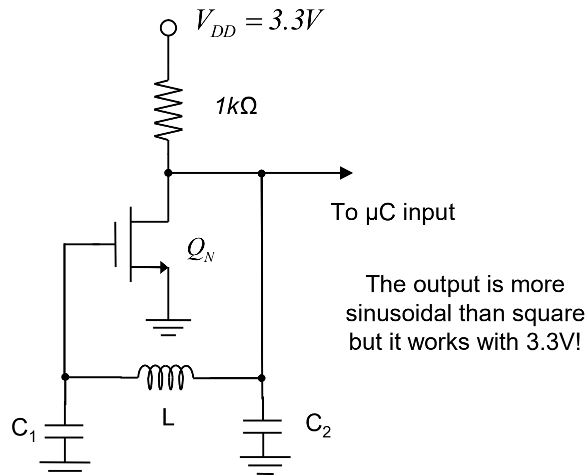
Colpitts Oscillator with Discrete CMOS Inverter



Project 2 Description

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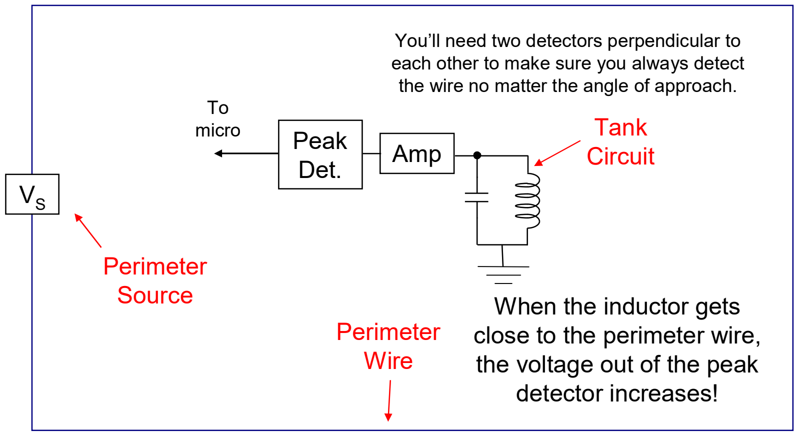
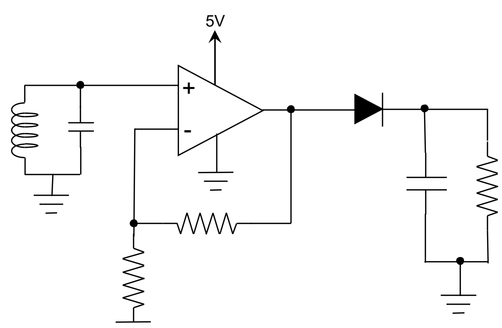
Basic Perimeter Detector



Project 2 Description

Very Simple Perimeter Detector

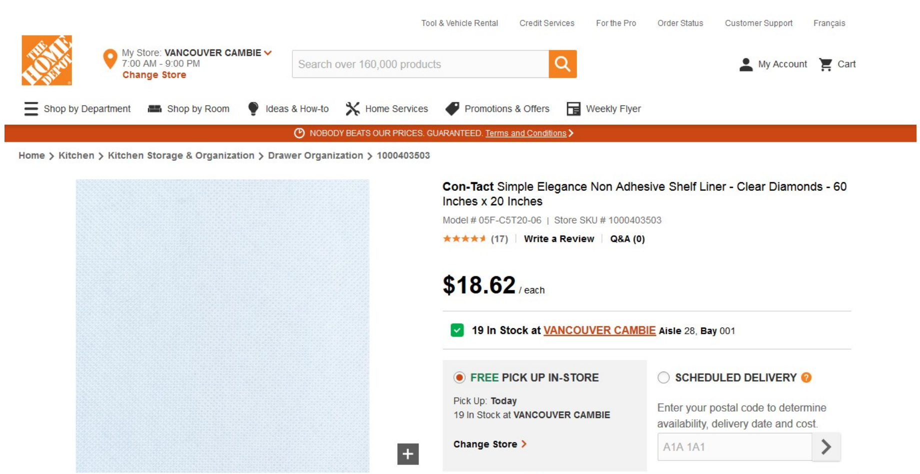


Project 2 Description

Coin Picking Area

- At least 0.5 m^2.
- I used a "Con-Tact Simple Elegance Non Adhesive Shelf Liner - Clear Diamonds - 60 Inches x 20 Inches" from Home Depot ($16.85). It has several advantages:
  - Good grip.
  - Easy to roll and transport.
  - Fits perfectly in the lab benches.
  - Easy to clean.

Coin Picking Area Surface



Perimeter Signal Source

- Either use:
  - Function generator in the lab.
  - 555 Timer in A-stable configuration. I like this option better because allows you to setup your perimeter anywhere you want. I connected the output of the 555 timer in series to the perimeter wire using a 47Ω resistor. Used 9V battery to power the 555 timer.

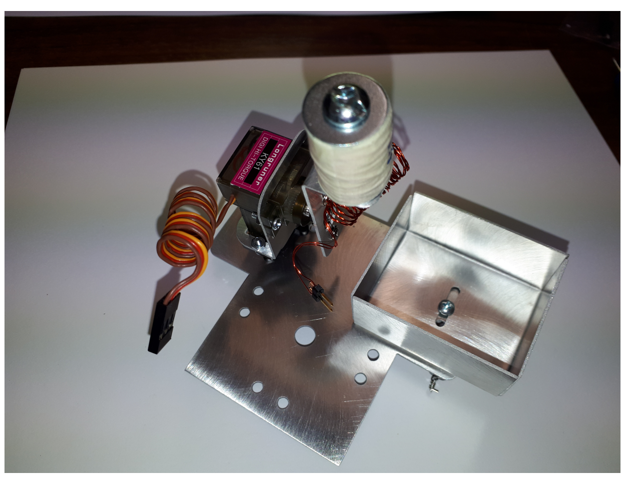
Robot Construction

Part #	Description
Solarbotics GM4	Gear Motor 4 - Clear Servo
	3D printed wheels (two)
Tamiya 70144	Ball Caster
4 x AA	Battery holder
1 x 9V cable	9V battery clip
	Aluminum chassis made using the water jet cutter.

Robot Construction

- Instruction posted in Canvas:
  – How to assemble the complete robot.
  – How to make the metal detector inductor.
  – How to make the electromagnet.
- You’ll need to figure out the electronics and software yourself (as a team!).

Coin Picking Mechanism



Robot (without electronics)

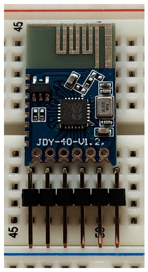
JDY-40 Radio

- Needs three pins: TXD, RXD, and SET.
- Use at low baud rates. 9600 baud top.
- Power ONLY with 3.3V. Be super careful with voltage polarity.
- Set an unique device ID to your JDY-40 pair using this 'AT' command:

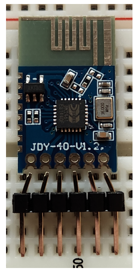
  `SendATCommand("AT+DVIDxxxx\r\n");`

  Where xxxx is 0000 to FFFF (in hex)
- Example for the EFM8 provided on Canvas.

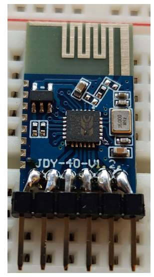
JDY-40 Radio Pins



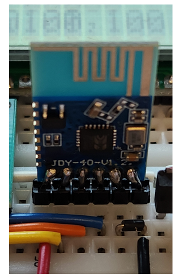
PROBLEM: JDY-40 pins are 2mm apart.
Bread board holes are 2.54mm apart.



Solution step 1: bend the header pins so that they match the JDY-40 holes spacing.

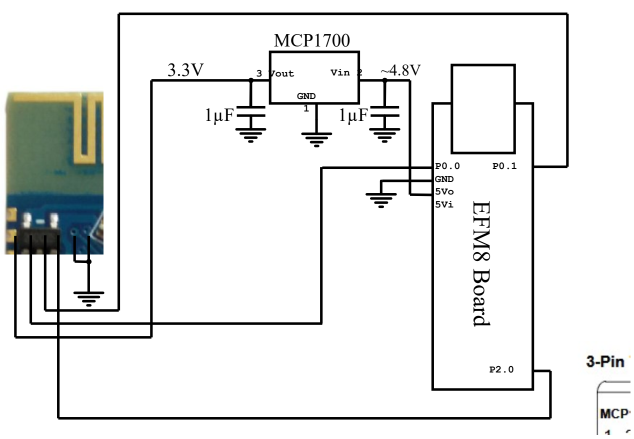


Solution step 2: Solder header on top.

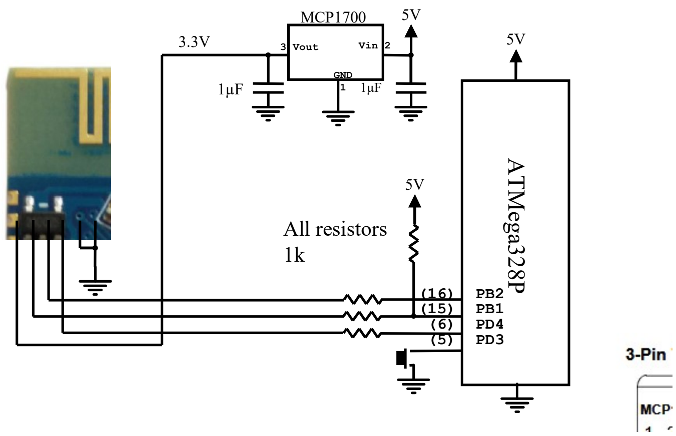


Solution step 3: Plug board into bread board

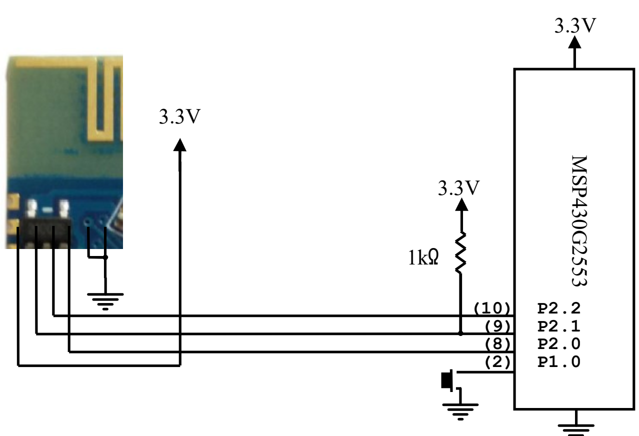
JDY-40 Radio Wiring: EFM8



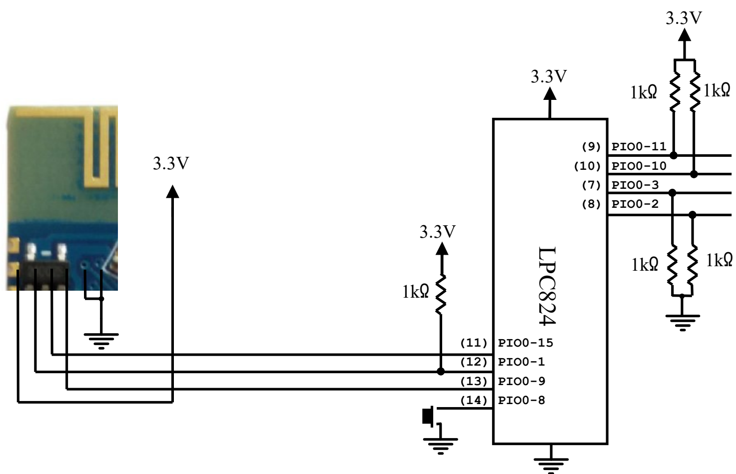
JDY-40 Radio Wiring: ATMega328P



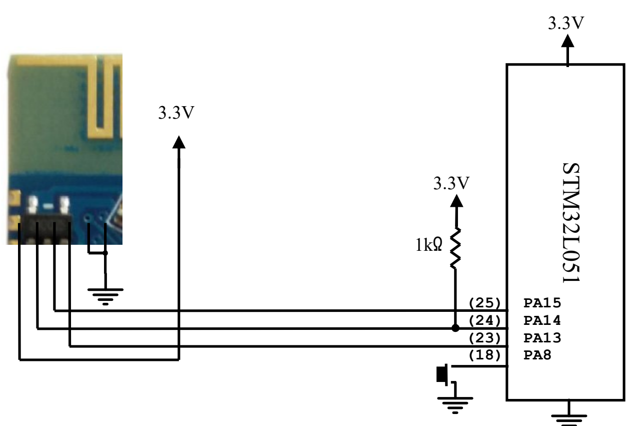
JDY-40 Radio Wiring: MSP430G2553/MSP430G2253



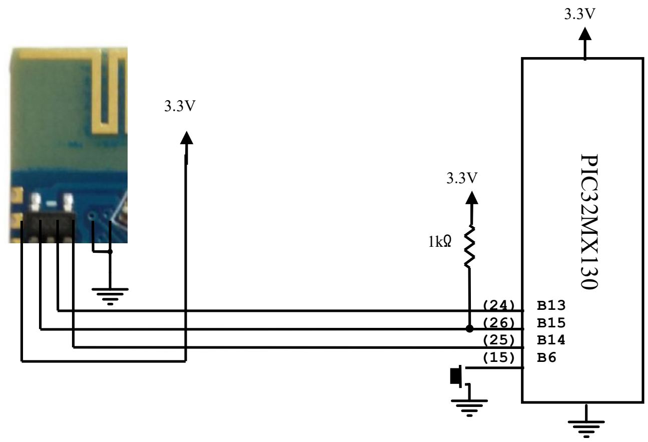
JDY-40 Radio Wiring: LPC824



JDY-40 Radio Wiring: STM32L051



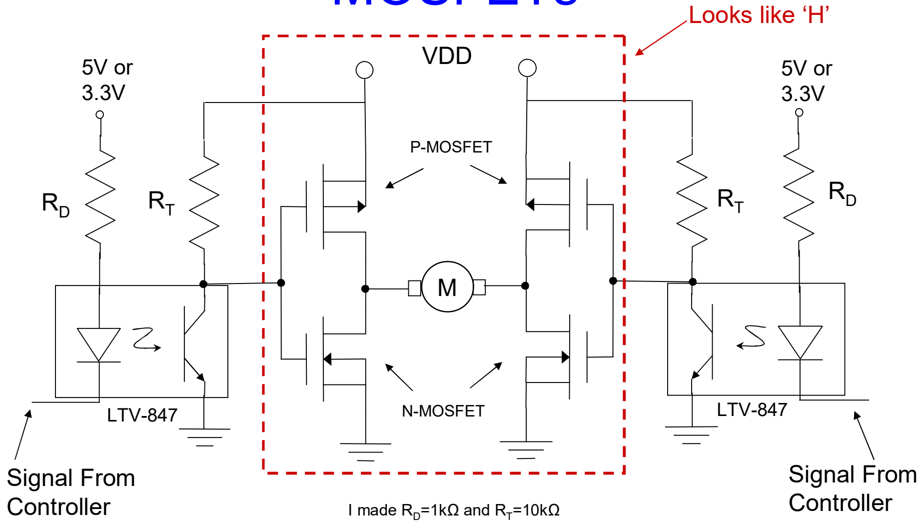
JDY-40 Radio Wiring: PIC32MX130



Communicating with the JDY-40

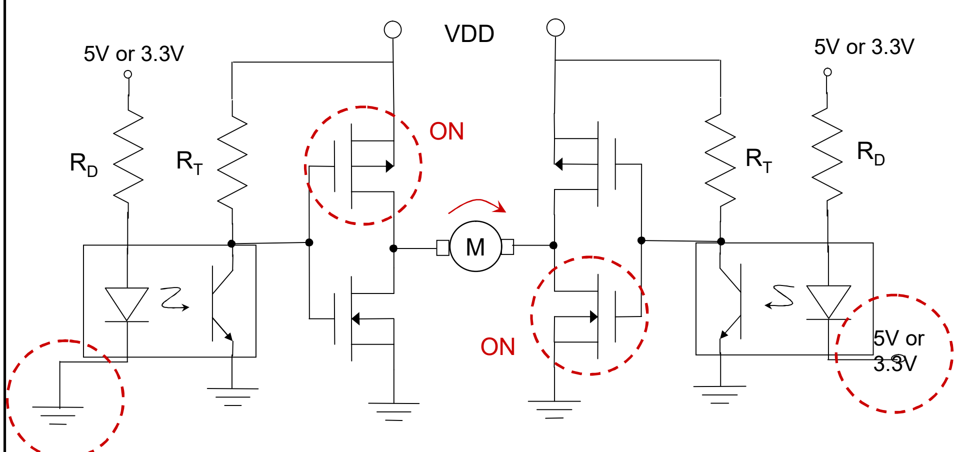
- Ideally the micro-controller connected to the JDY should have a dedicated <u>HARDWARE</u> UART (serial port).
- The only two micro-controllers that don't have an extra UART are the ATMega328p and the MSP430G2553. One excellent solution: timer ISR UART (used in the examples provided).
- Examples posted on Canvas.

H-Bridge with Optocouplers and MOSFETs

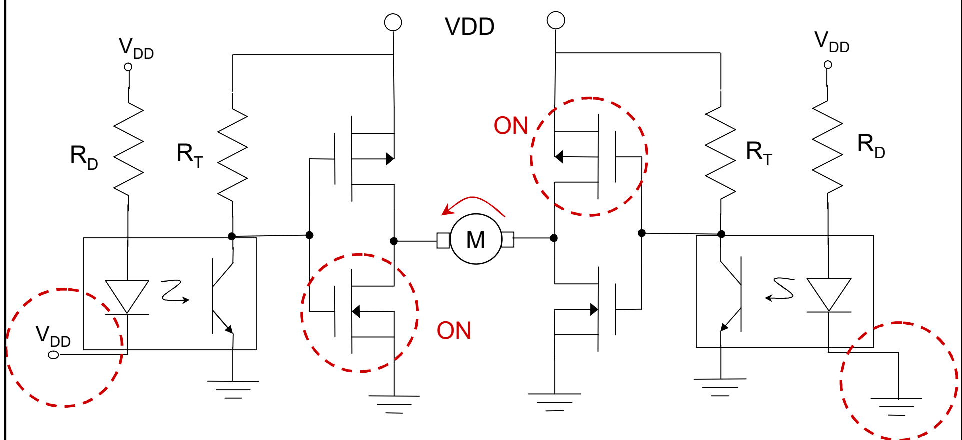


I made R_D=1kΩ and R_T=10kΩ

H-Bridge with Optocouplers and MOSFETs CW Rotation



H-Bridge with Optocouplers and MOSFETs CCW Rotation



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Optocouplers

- An optocoupler is a combination of a light source and a photosensitive element
- You can use an optocoupler when you want to isolate high or very high voltages, inductive circuits, or "noisy" circuits from the microcomputer system.
- The typical optocoupler consists of an infrared LED and a NPN BJT.
- The BJT usually doesn't have a base pin! Instead it is the light from the LED what is used to saturate the transistor.

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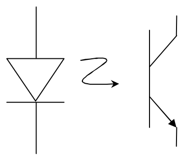
Designing with Optocouplers



Some optocouplers include a base pin!

- When designing with optocouplers you take into consideration the following parameters:
  - The current transfer ratio (CTR) is a parameter similar to the DC current amplification ratio of a transistor (β) and is expressed as a percentage indicating the ratio of the output current (I_C) to the input current (I_F).
    $CTR(\%)=(I_C/I_F) \times 100$
  - The Diode forward voltage (1.2 to 1.4V).
  - The maximum diode forward current (around 50mA max).
  - The BJT saturation voltage (0.1 to 0.4V).
  - The voltage isolation between the diode and the transistors (a few hundred volts to thousands of volts)

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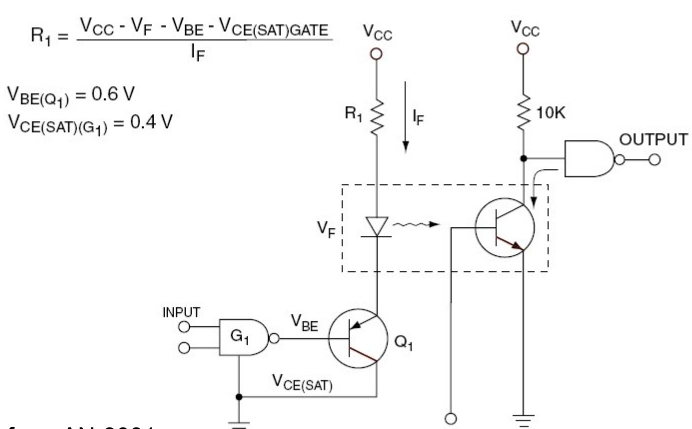
Optocouplers circuits



This is from AN-3001, Fairchild Semiconductors

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LTV-846/LTV-847 Optocoupler

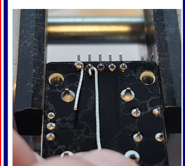
- CTR=50%
- Diode forward voltage=1.4 max.
- Maximum diode forward current is 50mA
- The BJT saturation voltage is less than 0.12V!
- Voltage isolation 5000V_{RMS}

Why you may need Optocouplers?

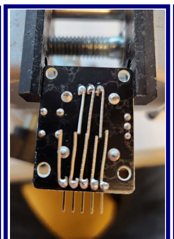
- To interface the low voltage of the microcontroller to the high voltage of the motors.
- To keep the 'noise' from the motors away from the microcontroller and the metal detector circuit.
- It could be possible to not use optocouplers this year... I hadn't tested that yet.

Joystick

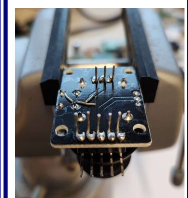
PROBLEM: The joystick can not be plugged in the breadboard.



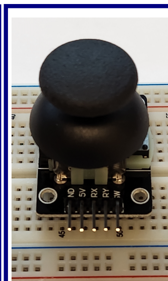
Solution step 1: Make a little loop with hook-up wire and solder around the back of the connector pins.



Solution step 2: Add wires to the pins of the connector and the pins of one of the potentiometers as shown.



Solution step 3: Bend the wires perpendicular to the board. Cut so they are about 1cm long.



Solution step 4: Plug the joystick into the breadboard!

Battery powered.

- Both the robot and the remote must be battery powered.
- Both a couple of 9 volt battery straps and a 4 x AA battery holder are included in the parts kit for this project.
- You can use any kind of batteries you want, provided that you acquire the batteries and the holders yourself.
- WARNING: batteries are neither included in the parts kits nor they will be provided in the lab. You must buy your own batteries.
- Brand name batteries have lower internal resistance, but they are more expensive.