MAEG 4010 Computer-Integrated Manufacturing

Project Introduction

2024

Contact information

MAEG 4010

Computer-Integrated Manufacturing

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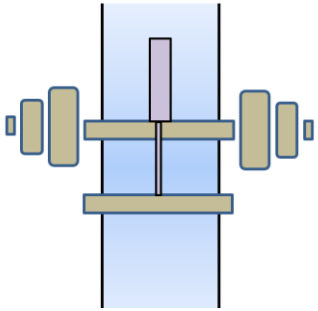
Project Topic

Pipe-climbing Robot

- Each team (3-5 students) will **design**, **build** and **demonstrate** a simple prototype of a Pipe-Climbing Robot:
  - Can either be manual/ semi-automated / fully automated
  - Need to carry min. 2.5 kg payload
  - As cost-effective as possible (need to optimise the design)
  - As light-weight as possible (need to optimise the design)



$$Score\ for\ demo = 40(e)\left(\frac{a}{1}\right) + 30\left(\frac{p}{b}\right) + 20\left(\frac{30}{c}\right) + 10\left(\frac{6}{d}\right)$$

Score for demo (21%)

$$Score\ for\ demo = 40(e)\left(\frac{a}{1}\right) + 30\left(\frac{p}{b}\right) + 20\left(\frac{30}{c}\right) + 10\left(\frac{6}{d}\right)$$

Where:

$e = 2$ (Fully automated) ; $e = 1$ (manual / semi-automated)

$a = 1$ (Compete climb 300mm up); a = 0 (Not compete climb 300mm up)

$p =$ Payload in g

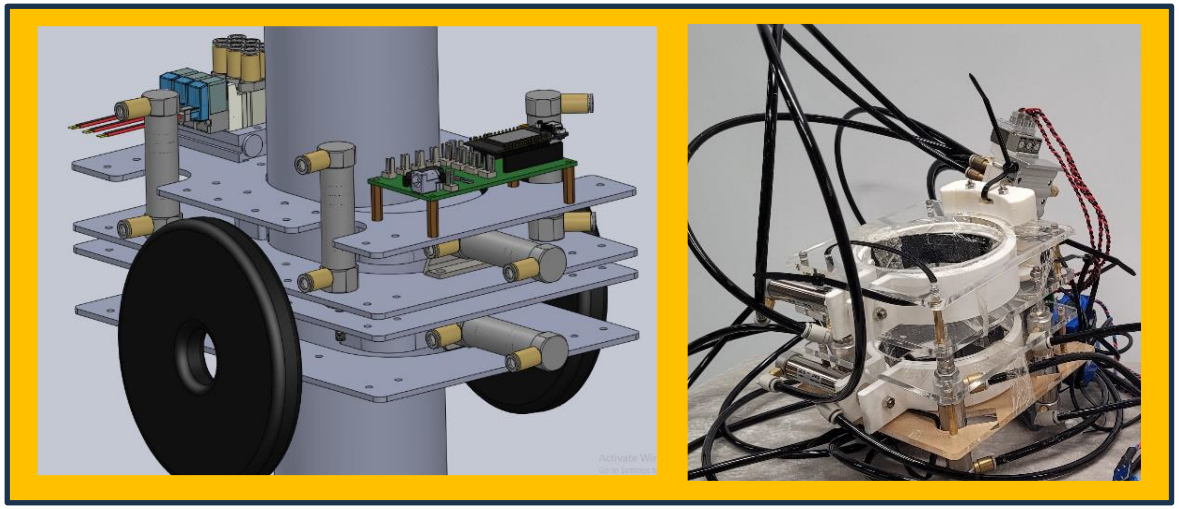
$b =$ Robot weight in g

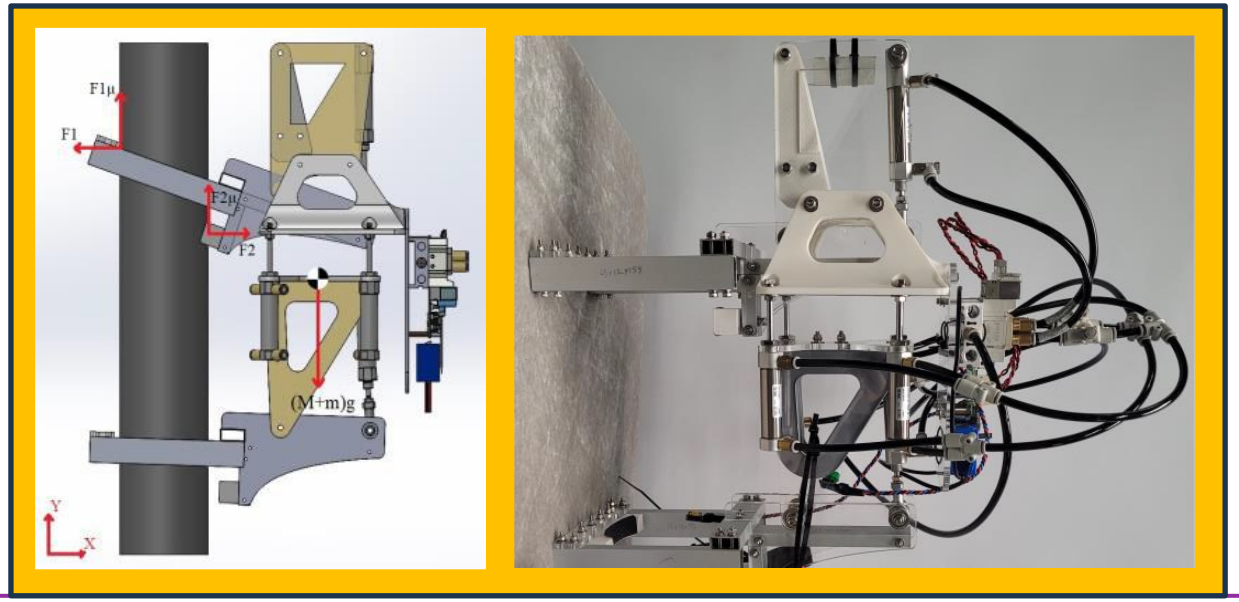
$c =$ Time in second

$d =$ No. of pneumatic cylinders

Demo twice and select the best score

Previous idea





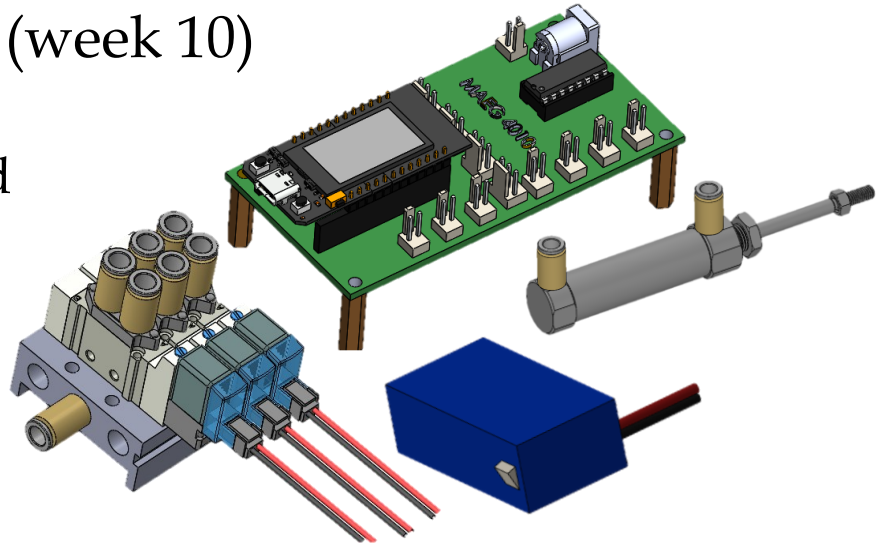
Project Topic

Pipe-climbing Robot

- For actuation - air cylinder and its pneumatic actuation peripherals - solenoid valve, compressed airline, speed controller, manual switches will be available
  - The SMC Air Cylinder: SMC CDJ2B16-30 will be available (max. of 6 cylinder per group)
  - Working pressure @ 4 bar (0.4MPa)
  - Bore size = 16mm
  - Double-acting, single rod
  - Stroke = 30mm

Project Material

- 1st Material pick up and Demo (week 10)
  1. PCB Board
  2. 3 Solenoid valves with Manifold
  3. 2 Buttons
  4. 12 V Battery
  5. 3 Pneumatic actuators
  6. 6mm Tube
  7. Flow controller

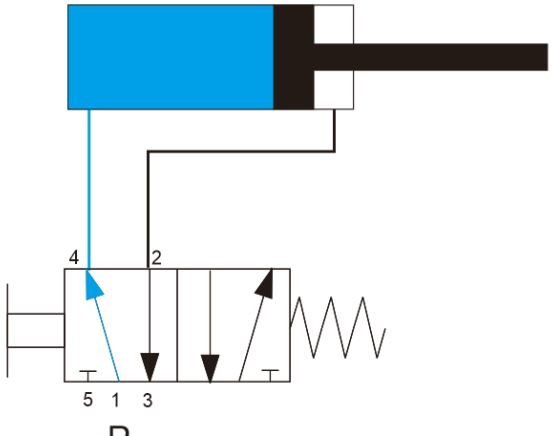


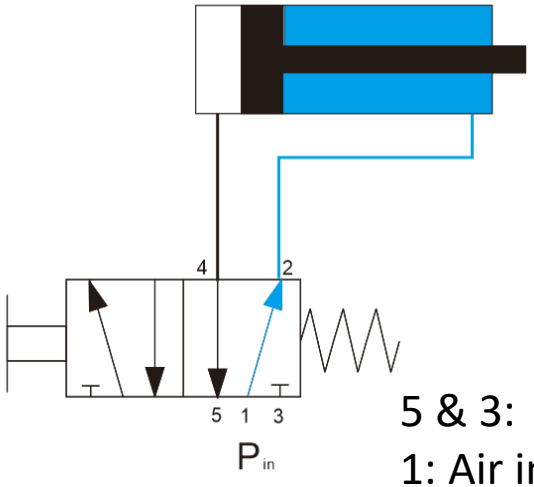
- 2nd Material pick up and Build (After submit drawing file)
  1. Laser cutting (3/5mm Acrylic sheet), 3D Printing (PLA), Waterjet (2/3mm Aluminium, Stainless steel, Carbon fiber, etc.) **Please preparing the suitable drawing file.**
  2. More Pneumatic actuators, connectors, flow control, 6mm tube etc.
  3. Fastener (M3,M4,M5 screws and nuts), Bearings

Pneumatics Actuator

- Double Acting actuator and Solenoid Valve

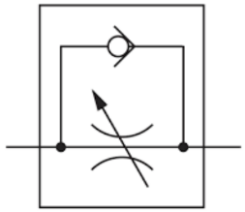
Example : 5/2 directional control valve with double acting





5 & 3: Air out

1: Air in



Flow control valve

- $P = \frac{F}{A}$

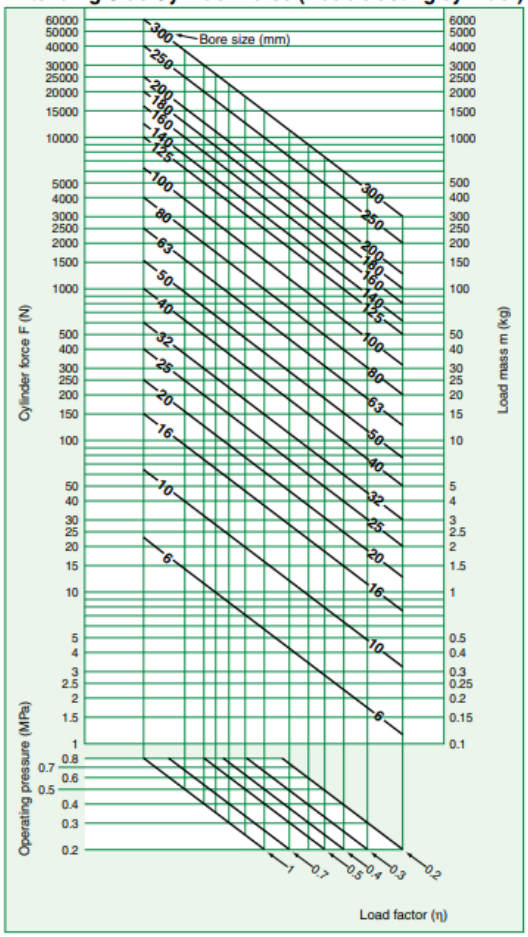
Where P is Pressure, F is normal force, A is contact area

Extend or Retract has larger force?

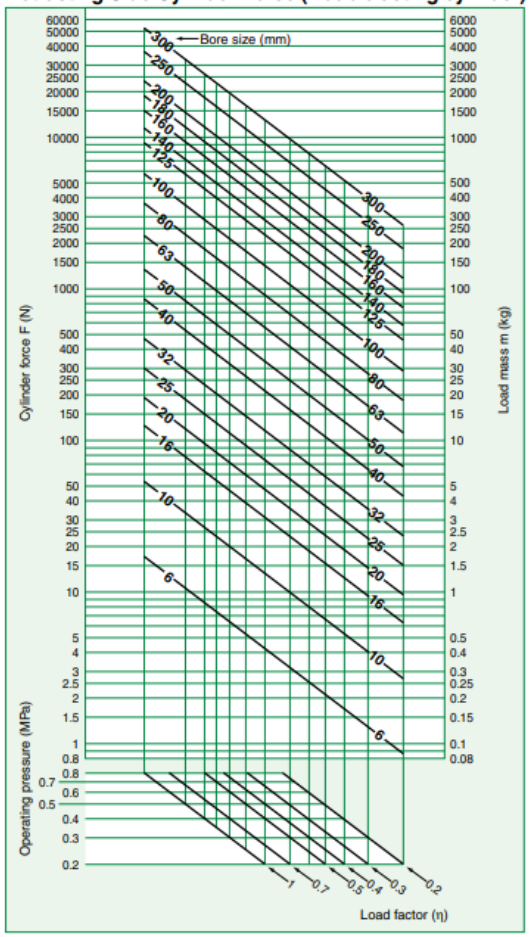
Flow control valve connect direction?

Double Acting Pneumatics Actuator

Graph (1)
Extending Side Cylinder Force (Double acting cylinder)

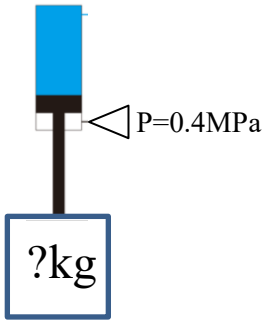


Graph (2)
Retracting Side Cylinder Force (Double acting cylinder)



Example:

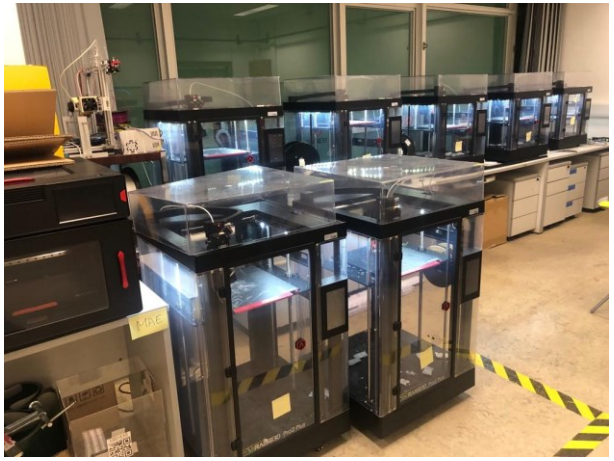
The bore size of cylinder is 16mm, operating pressure is 0.4MPa as shown below. Determine the max. payload?



https://ca01.smcworld.com/catalog/BEST-technical-data-en/pdf/6-2-1-m21-43-tech_en.pdf

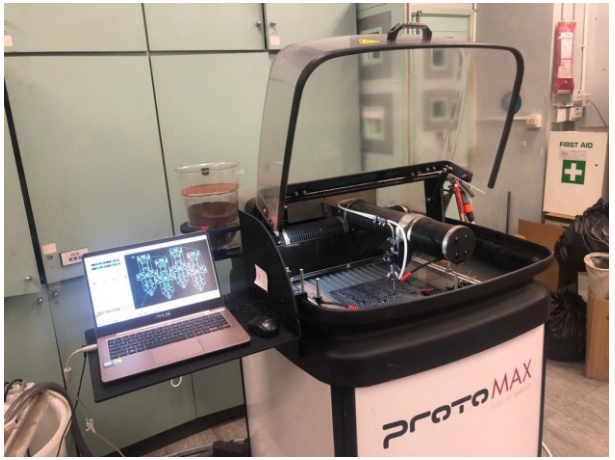
Machine Support

Laser Cutter



3D Printer

Hand Tools



Waterjet cutter

CNC Machine

Fabrication process

- Common material used:

Material / Property	Acrylic Sheet	PLA	Aluminum Tube	Aluminum/ Stainless steel/ Carbon Fibre Sheet	Aluminum
Method	Laser cutter	3D Printer	Mill/Drill	Water Jet	CNC
Strength	Strong in 2D Plane	Low	Strong	AL: Strong SS 304 & CF: Very strong	Strong
Time	Minutes	Hours/Day	Hours	Minutes/Hour	Weeks
Shape	Custom 2D	Any Shape	Standardized	Custom 2D	Any Shape
Cost	*	**	**	Al, SS 304: ** CF: ****	*****
	Highly Recommend			Recommend	

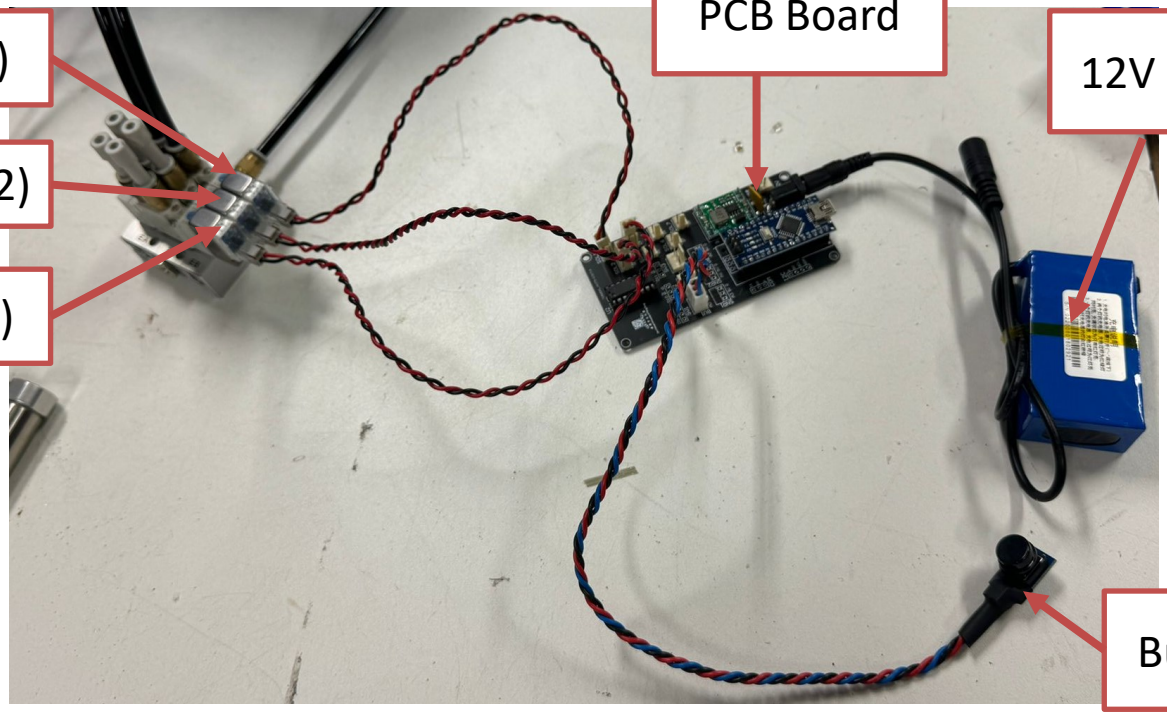
Reminder

- Time management
  - Design process?

  Design→ Manufacture → Assembly → Test → improvement
- Procedure
  1. Send an e-mail to Tutor and Billy to request their comments.
  2. Send the improved SOLIDWORKS files, including the drawing and STL file
  3. Collect the 3D printing/ Laser cutting/Waterjet cutting parts (It needs around **3 Days** to fabricate all parts, we will notify you via email once they are finished.)
  4. Book the time slot for assembly in ERB 104

Electronics Connection

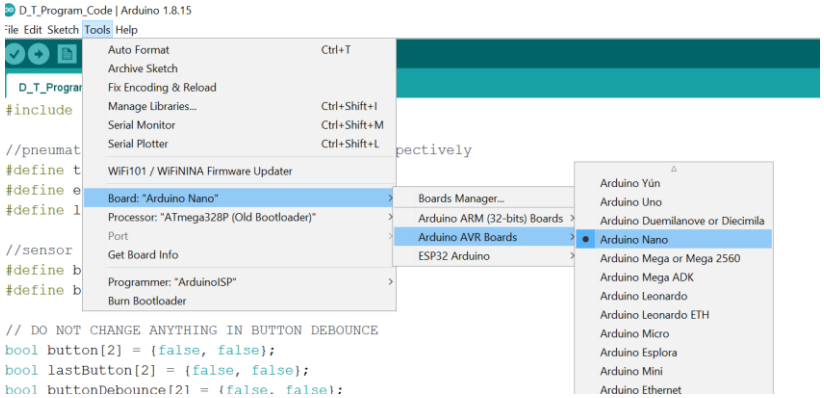
Connect the wires as following:

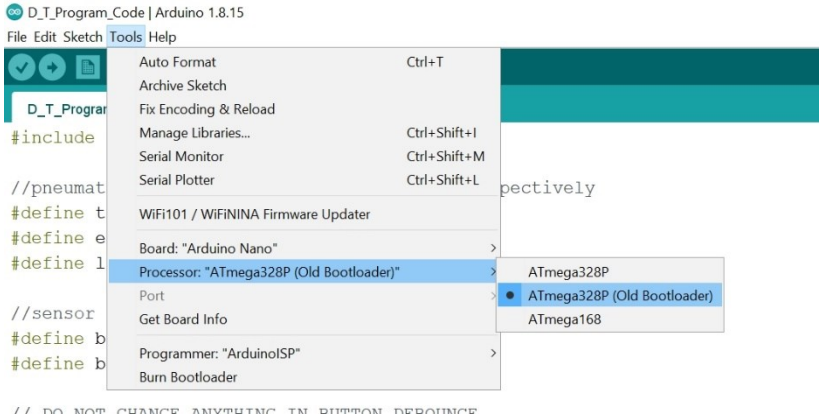


- Pneumatic output 1 - 7 = pin 2, 3, 4, 5, 6, 7, 8
- Sensor input 1 - 4 = pin A0, A1, A2

Arduino IDE

- Download the Arduino IDE at this website, https://www.arduino.cc/en/software
- Open the sample code afterwards. In "Tools", select "Board Arduino Nano"
- Select "Processors: ATmega328p(Old Bootloader)"
- Plug in the Nano to your computer then select the corresponding USB port in "Port". Upload the code to your board afterwards and test it out with the button.





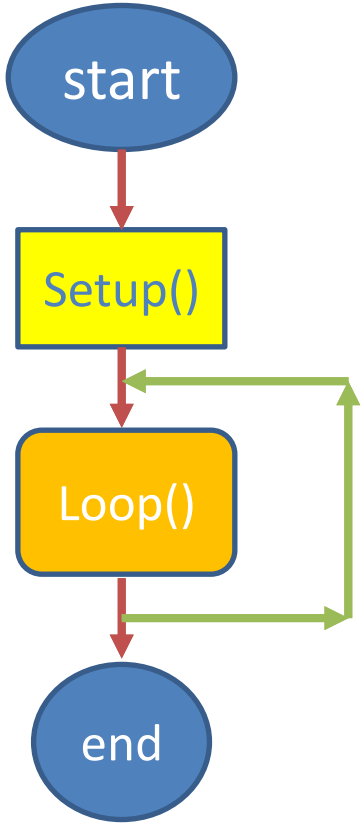
Ref.: you can also follow this tutorial, https://youtu.be/R102xfcx75I?t=665 , to upload your program.

Arduino Program Structure

The program will be included:

void setup() {}
All the initial setup will be done in the routine

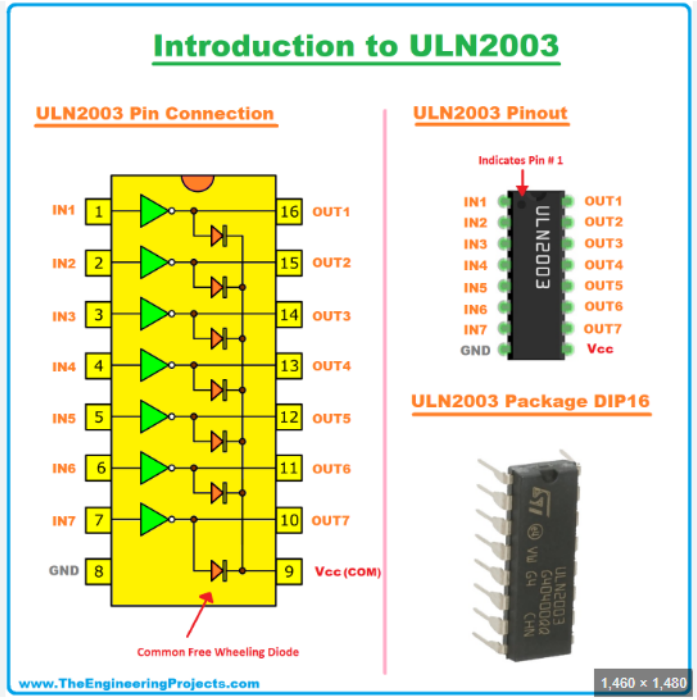
void loop(){}
It will be looped endlessly for executing all the processes (sensor checking , decision making, and ……)



https://www.youtube.com/watch?v=fJWR7dBuc18
https://www.youtube.com/watch?v=nL34zDTPkcs

ULN2003 Features

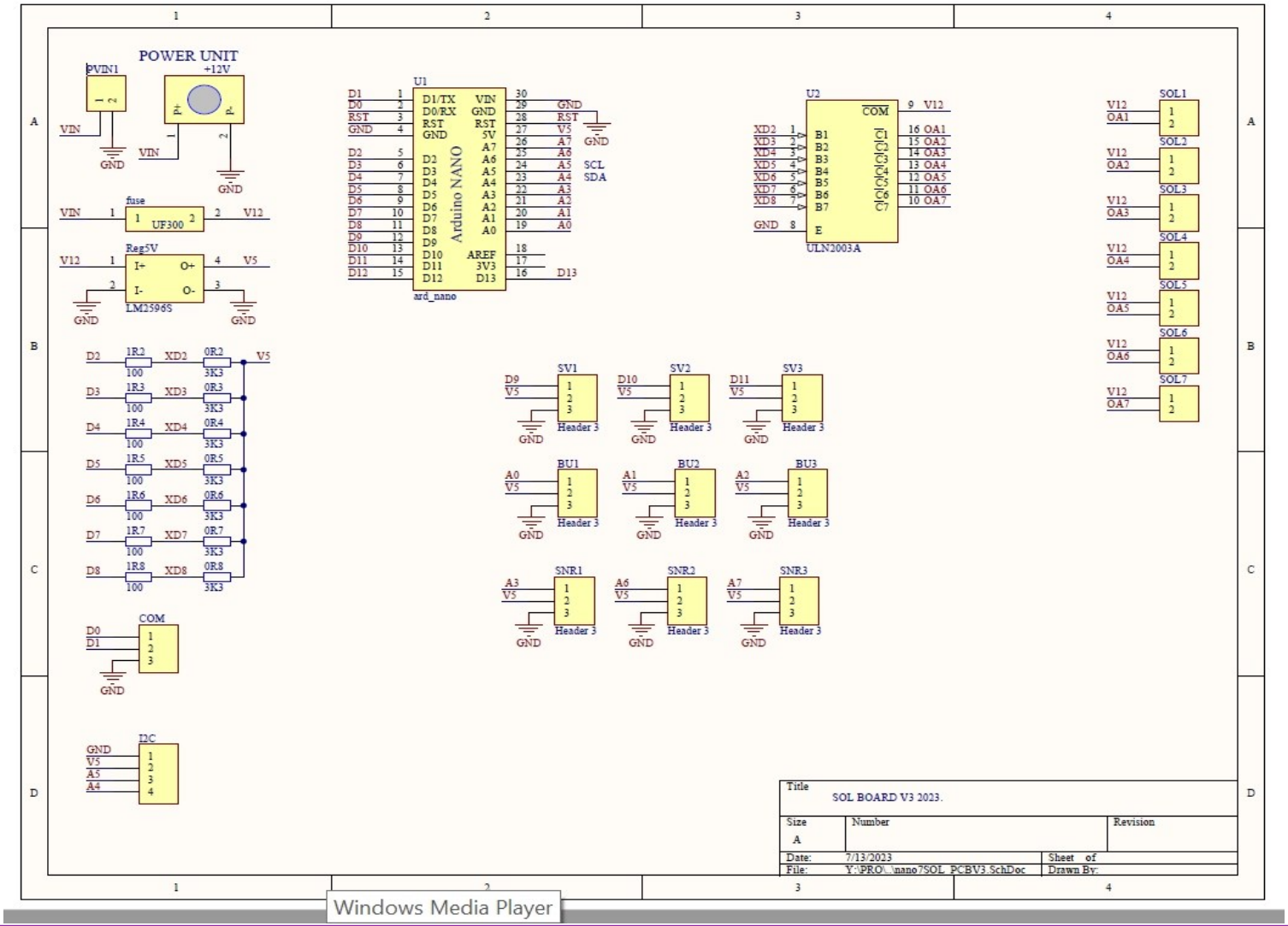
ULN2003AN



ULN2003 Features

- Contains 7 high-voltage and high current Darlington pairs
- Each pair is rated for 50V and 500mA
- Input pins can be triggered by 3V (TTL)
- All seven Output pins can be connected to gather to drive loads up to (7×500mA) ~3.5A.
- Can be directly controlled by logic devices like Digital Gates, Arduino, ESP32 etc
- Available in 16-pin DIP, TSSOP, SOIC packages

Schematic Diagram



Windows Media Player

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