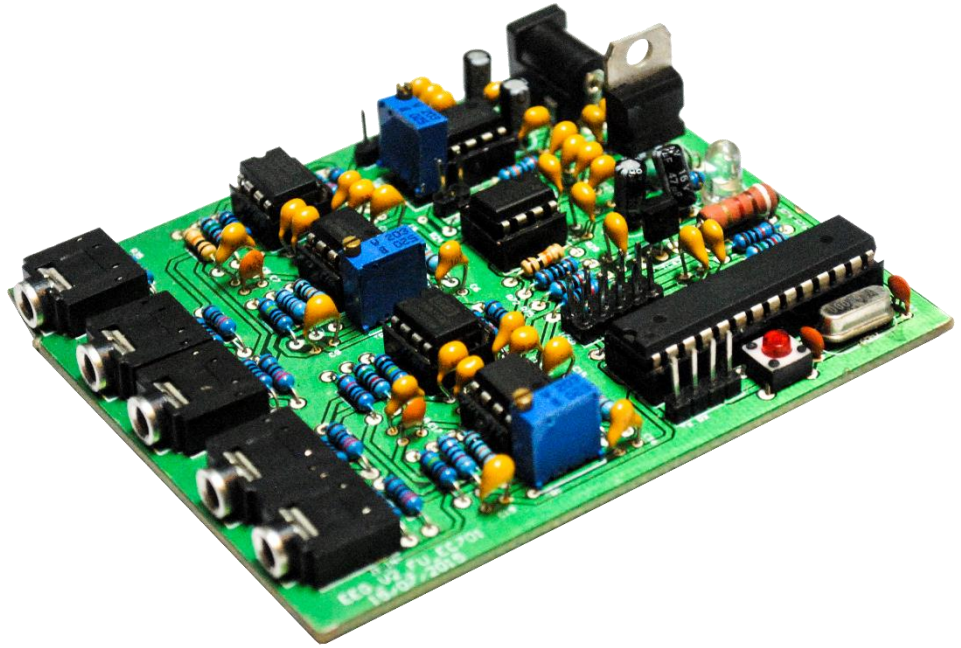
/capstone project

/ec0701/eegteam



USING EEG TO CONTROL ROBOT

/students

Hoang Van Tien	**se02728**
Vu Hoang Son	**se02514**
Trinh Thanh Tung	**se02629**
Ngo Huy Vinh	**se02698**

/supervisor

PhD. Phan Duy Hung

/table of contents

01 Introduction

Idea
What is EEG?
Existing Products
Scope

/idea

- “Mind over matter” - the power of the mind to control and influence the body and the physical world generally.
- The enormous potential of using human brain waves to support their life, especially disable people.

/what is EEG?

Basic information about EEG

- **ElectroEncephaloGraphy**
- EEG is the recording of spontaneous electrical activity of the brain over a small period of time
- EEG measures voltage fluctuations resulting from ionic current within the neurons of the brain.
- EEG signal can be recorded from multiple electrodes placed on the scalp

/what is EEG?

EEG's main attributes

EEG signals are created by the activity of neurons in the brain. There are five major brain waves, classified by their frequency range, know as Brain Rhythms.

- Delta brainwaves (0.5 to 4Hz)
- Theta brainwaves (4 to 7Hz)
- Alpha brainwaves (7 to 12 Hz)
- Beta brainwaves (12 to 38Hz)
- Gamma brainwaves (38 to 42Hz)

/existing products

Branin-controlled Armrobot
<<

Pittsburgh Univesity, USA

/existing products

Brain-controlled Wheelchair <<

University of Technology Sydney, Aus

by Prof Hung Nguyen & son

/existing products

Mindflex Toys & Game
>>

Mattel,
USA

/scope

Specifications	Description
Building a human brain wave capturing circuit	Building a circuit that can collect the mindwave and has the filters to remove the noise.
Communication with robot using a C#’s application	Using an application to make the robot go forward, backward, turn left and turn right.
Obstacles avoidance robot	Using a hardware module to detect the blockers in the fronts of robot. After detecting, the robot will automatical avoid it.
Black line following robot	The robot will moving by tracking the black line.
Using brain wave to manipulate the robot	Using the mindwave to controll the robot operates correctly as out requirement.

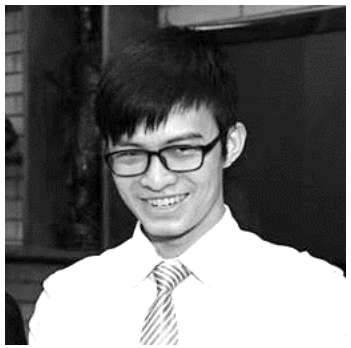
Project Management

02

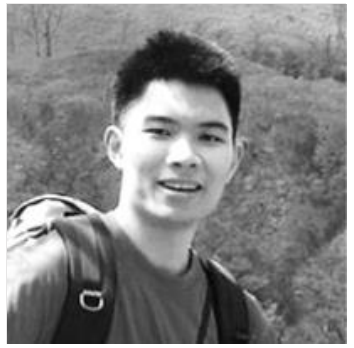
Team organization
Development model and plan
Communication Plan
Risk Management

/team organization

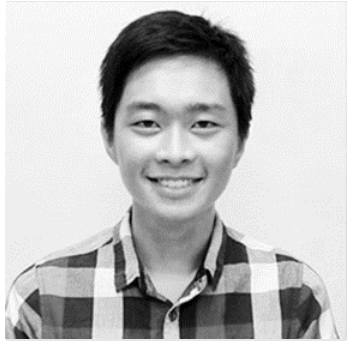
PhD. Phan Duy Hung
/supervisor



Hoang Van Tien
/team leader



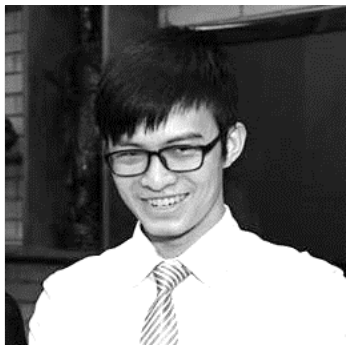
Trinh Thanh Tung
/team member



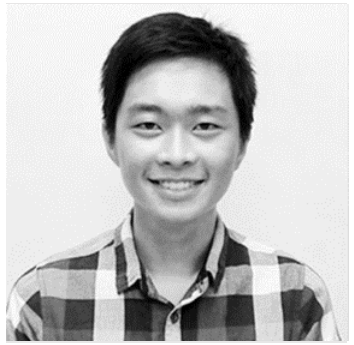
Vu Hoang Son
/team member

Ngo Huy Vinh
/team member

/responsibilities

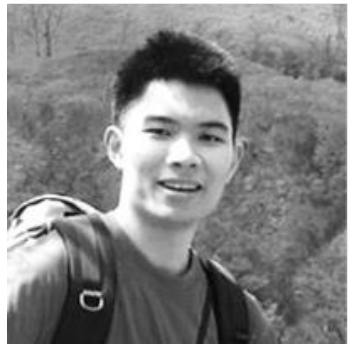


Hoang Van Tien **/team leader**



Vu Hoang Son **/team member**

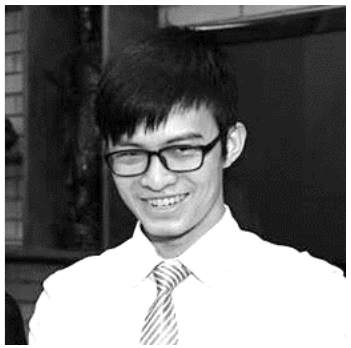
- Project Manager
- Requirement Analysis
- Hardware Research
- Hardware Developer
- Quality Assurance



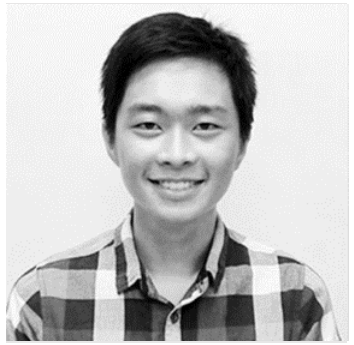
Trinh Thanh Tung **/team member**

Ngo Huy Vinh **/team member**

/responsibilities

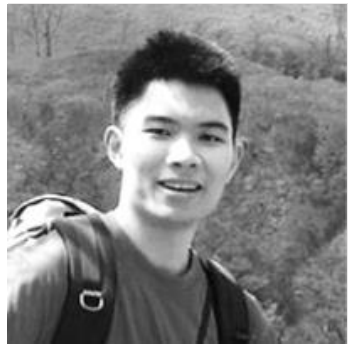


Hoang Van Tien **/team leader**



Vu Hoang Son **/team member**

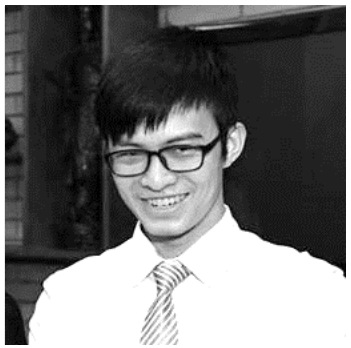
- Hardware Research
- Hardware Developer
- Software Developer
- Tester
- Reporter



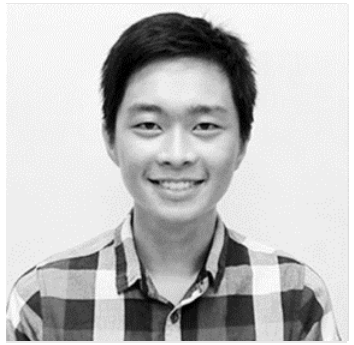
Trinh Thanh Tung **/team member**

Ngo Huy Vinh **/team member**

/responsibilities



Hoang Van Tien **/team leader**



Vu Hoang Son **/team member**

- Hardware Research
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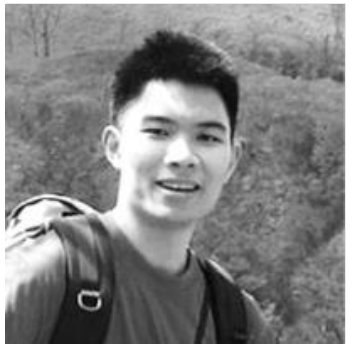
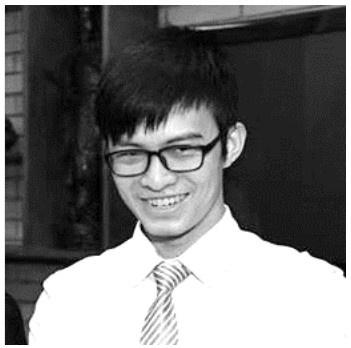
- Tester
- Reporter



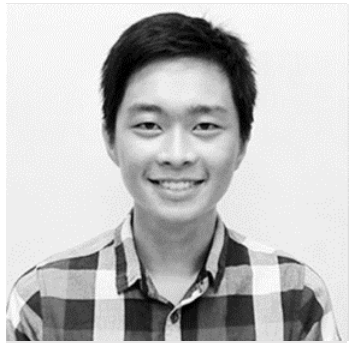
Trinh Thanh Tung **/team member**

Ngo Huy Vinh **/team member**

/responsibilities

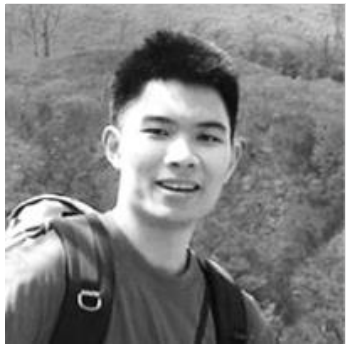


Hoang Van Tien **/team leader**



Vu Hoang Son **/team member**

- Technical Leader
- Hardware Research
- Hardware Developer
- Software Developer
- Tester

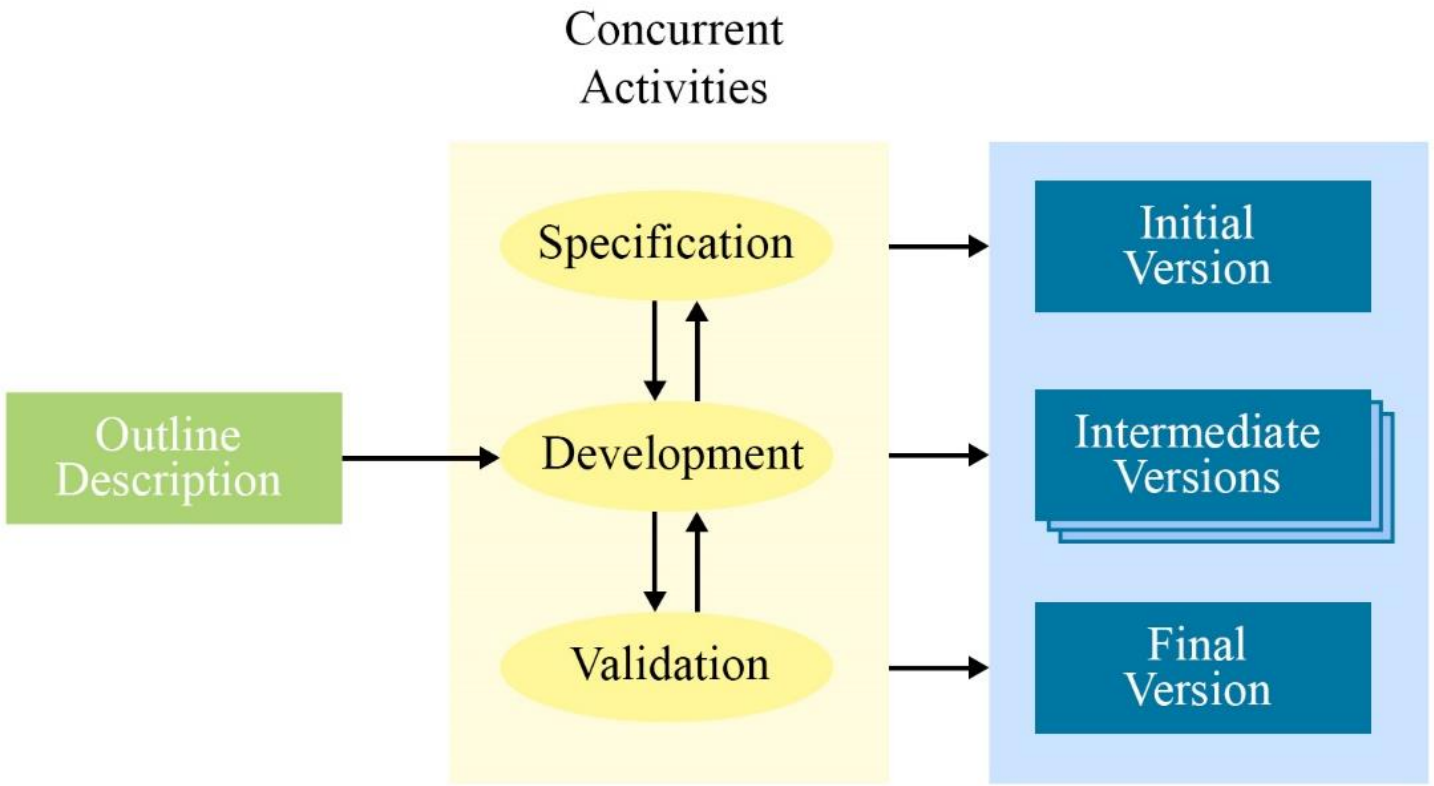


Trinh Thanh Tung **/team member**

Ngo Huy Vinh **/team member**

/development model

Incremental development is where the product is designed, implemented and tested incrementally (a little more is added each time) until the product is finished



/development model

Why incremental development?

- The cost of accommodating changing requirements is reduced.
- It is easier to get feedback on the development work that has been done.
- More rapid delivery and deployment of useful software is possible, even if all of the functionality has not been included.

/project plan

Jobs	Definition	Delivery time	Delivery location
The Robot	Design and assembly the robot's chassis	**2015/06/23**	Team leader
	Assembly and programing the Line following function for the robot	**2015/06/30**	
	Assembly and programing the Obtacles Avoidance function for the robot	**2015/07/10**	
	Programing Manual control function for the robot	**2015/07/20**	
The circuit	Drawing the circuit's schematic and PCB in Altium	**2015/07/07**	Supervisor
	Order PCB board footprint	**2015/07/18**	
	Assembly the circuit and validation	**2015/07/25**	

/communication plan

	Decription	Time
	This is the most effective way to communicate and thank to those meeting we can solve problems easily	At least three times per week
	Gmail, Skype and Facebook Group Message are used to communicate online. It helps us to keep track of team's progress	Every day
	In emergency situation, we use mobile phone to contact directly with other	In case of emergency

/risk management

Rank	Risk	Description	Solution	Status
1	**Lack of funding**	Not enough money to buy components	Funding from team members and ask for support from the university	**OK**
2	**New programming languages and tools**	Team members have never learned about C# as well as Visual Studio	Self - Study	**OK**
3	**Did not meet requirement**	Some requirements have higher level than expectation	Handled by ourselves, then ask for advises from supervisor	**OK**
4	**Miss the deadline**	Report delivery behind schedule	Try to work on schedule	**OK**
5	**Lack of soft skills**	Not good at communication skill and time management skill	Team members support each other	**OK**

/risk management (cont)

Rank	Risk	Description	Solution	Status
6	**Workspace**	Our campus is far away from downtown thus it is difficult to buy components	Unavoidable	**Failed**
7	**Team members' health**	Team members some time get sick	Try to keep healthy, in case of a member get sick, others handles that member's work	**OK**
8	**Internal Conflicts**	Having conflic during project caused by work assignment	Work assignment in a justifiable and sciential way	**OK**
9	**Lack of knowledge**	Some knowledge exceed members' experience as well as lore, specially EEG	Read more studies, researchs and documents as well as asking supervisor	**OK**

03

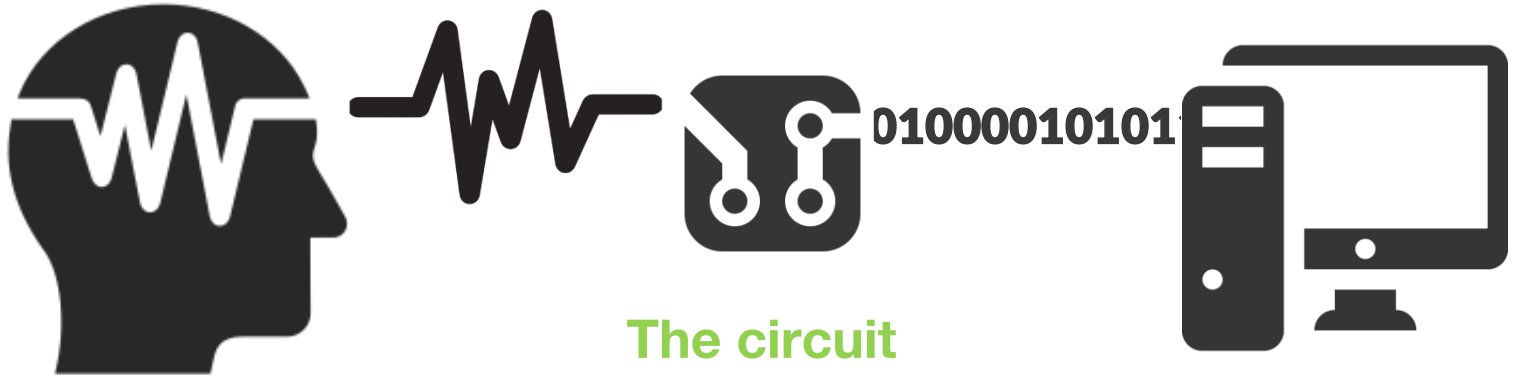
Requirement & Design

Requirement
Hardware Design

/functional requirement

The circuit

- Capture human brain waves
- Process analog into digital signal
- Transmit information to computer



The circuit

/functional requirement

The robot

auto mode:

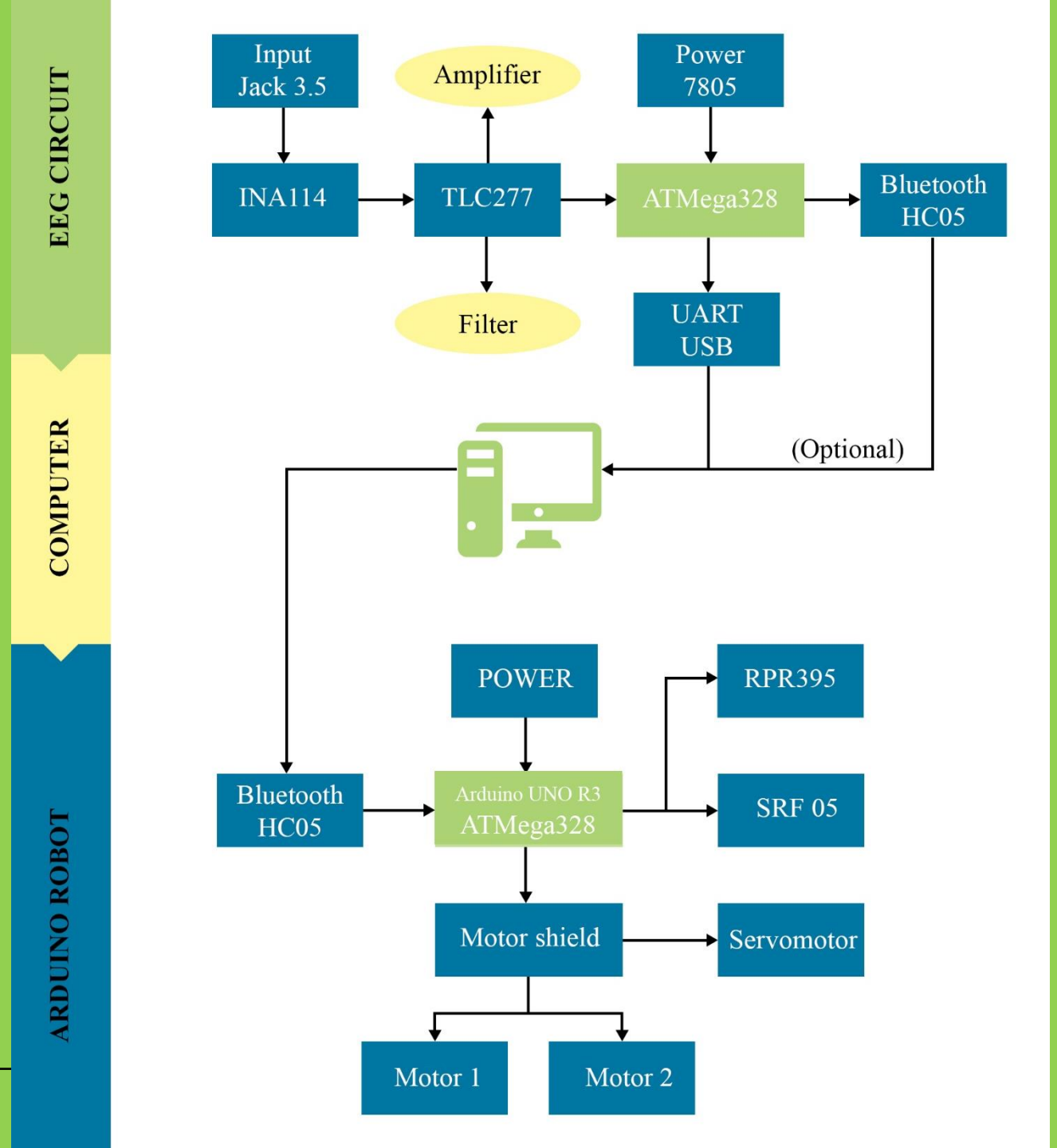
- Obstacles avoidance
- Line following

manual mode:

- Users control the robot by their brainwaves
- Users control the robot by an application via bluetooth

/non-functional requirement

/hardware design



Software Study

04

Programming Languages
Software tools

/programming languages

C#

- C# syntax is highly expressive, simplifies complexities of C++ and provides powerful features, yet it is also simple, easy to learn and can be used in many OS, have many library supported.

/programming languages

Arduino

Arduino Logo

- Arduino is an open-source prototyping platform based on easy-to-use hardware and software.
- Arduino Software is growing through the contributions of users worldwide by a wide range of supported libraries.
- Arduino Software makes it easy to write code and upload it to the board.

/software tools

Offices

Design

Altium Designer

Simulation

Proteus®

NI Multisim 10

Program

ARDUINO™

Visual Studio

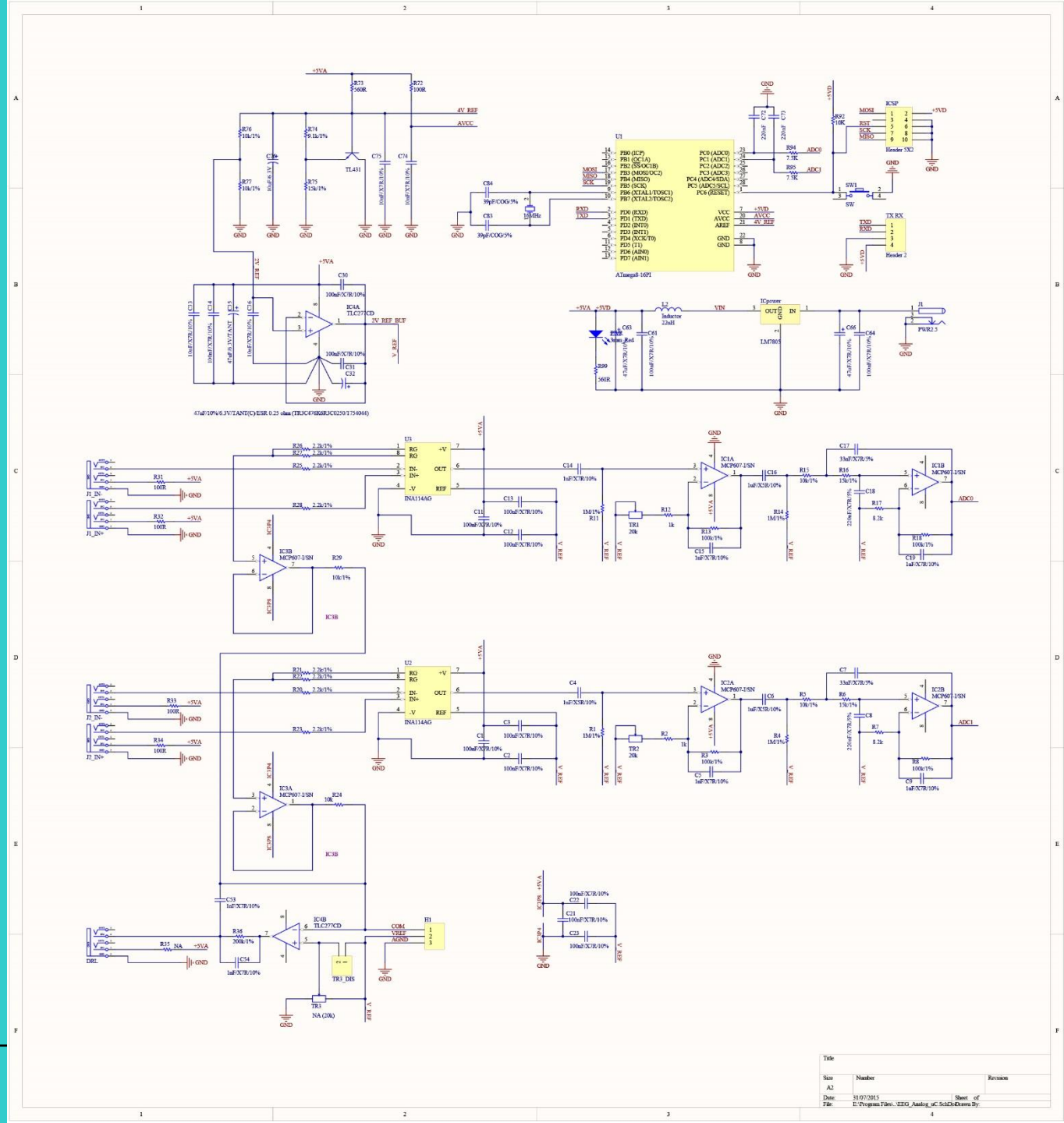
/altium designer

Why Altium Designer?

- Is an electronic design automation software package for printed circuit board, FPGA and embedded software design
- Is one of the most popular design tools that is used in circuit board design
  - *Support a wide range of footprint libraries*
  - *Have a big user community therefor we can resolve our problems easier*

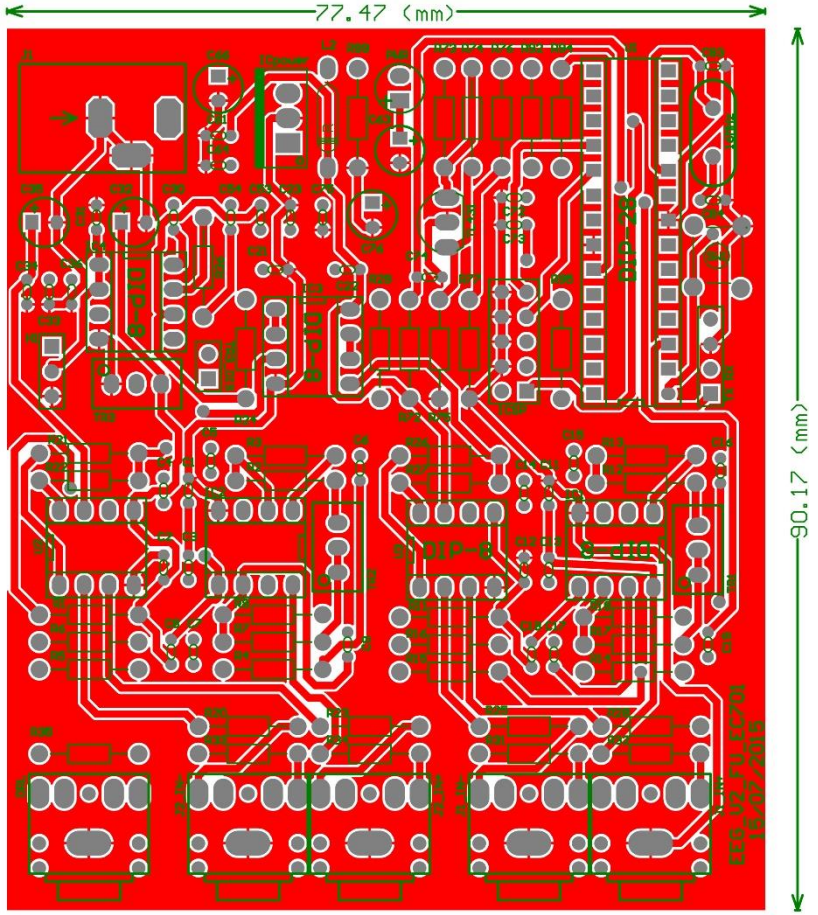
/altium designer

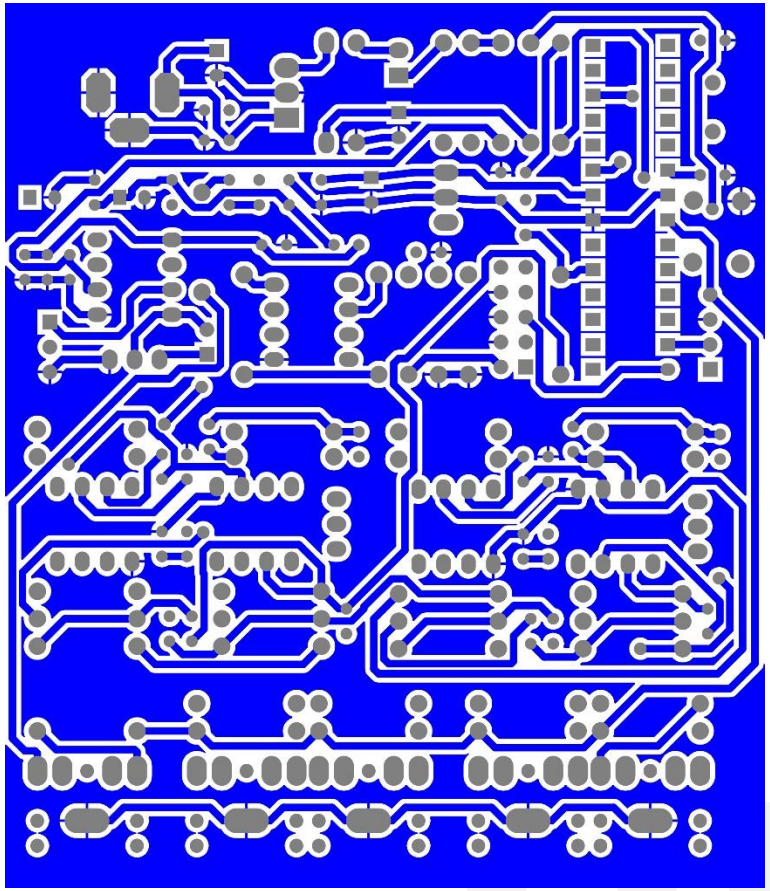
Circuit schematic design



/altium designer

Circuit pcb design



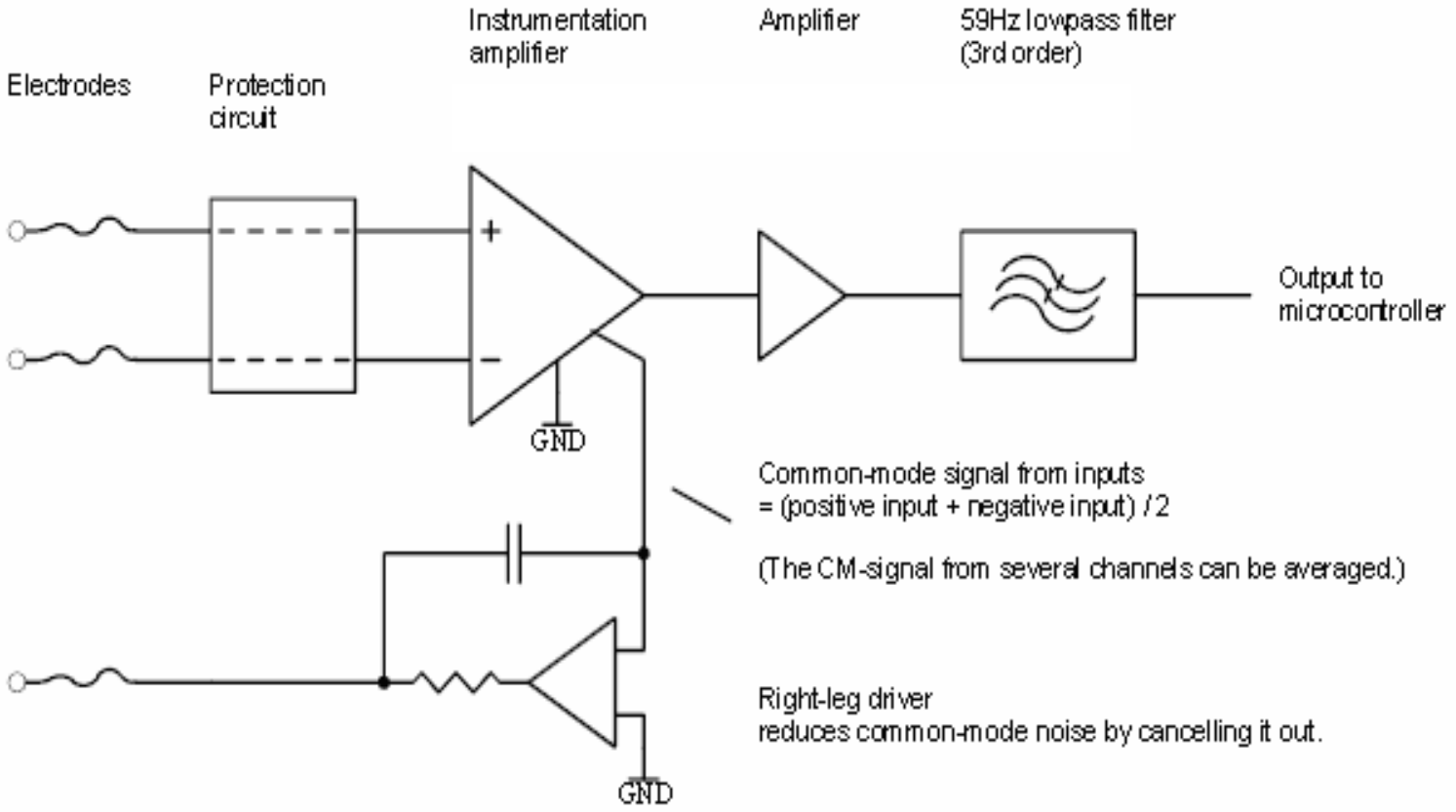


the EEG circuit

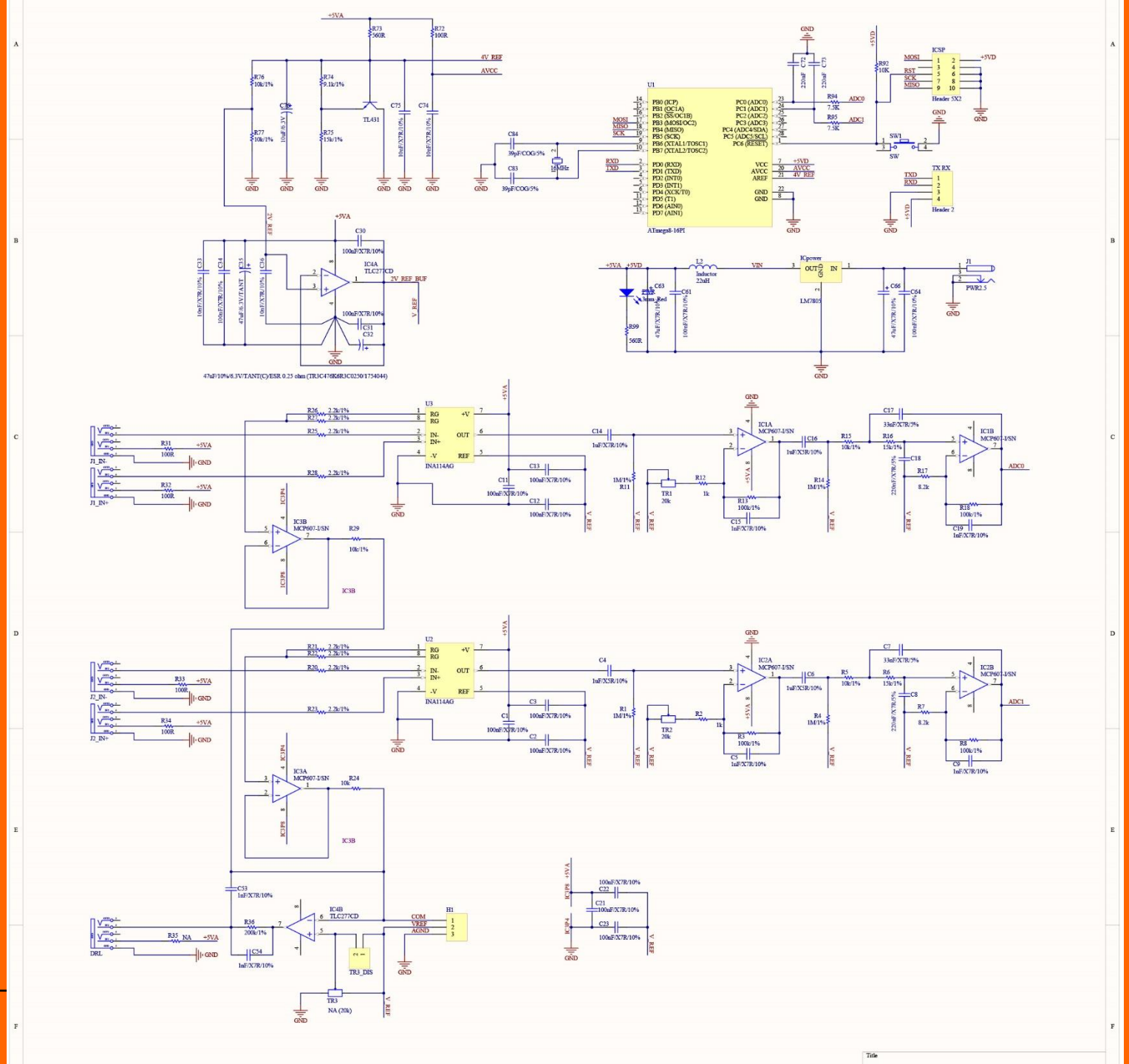
05

Analog Modules
Digital module
Validation

/eeg capturing diagram

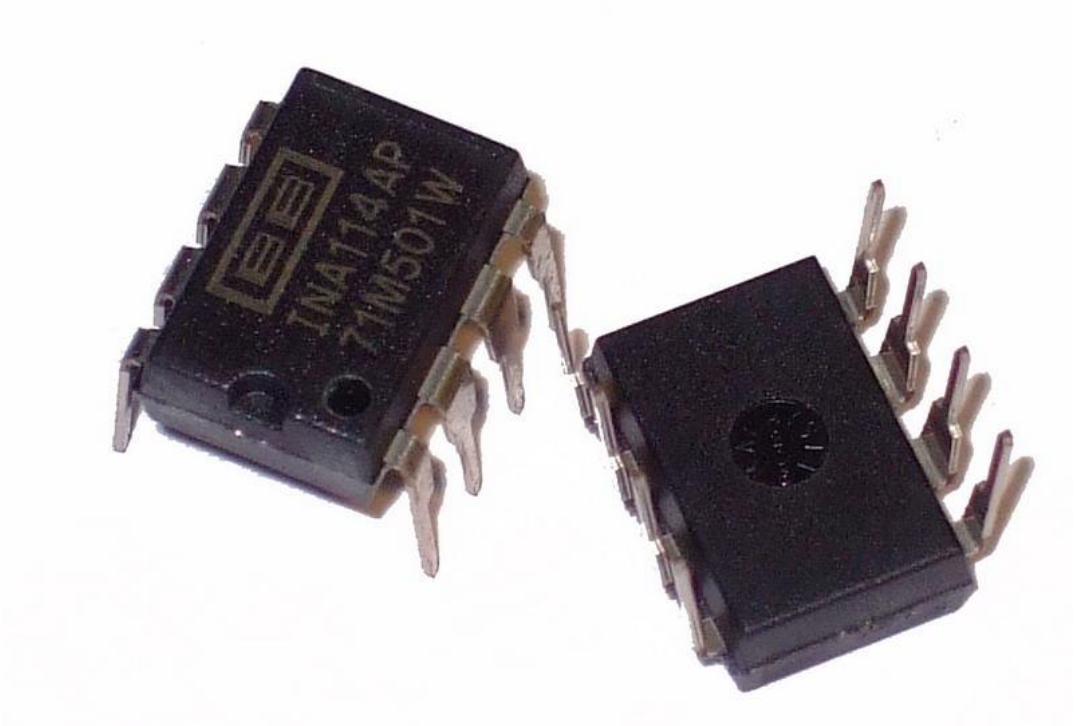


/eeg circuit's schematic



/instrumentation amplifier (INA114)

The INA114 is a low cost, general purpose instrumentation amplifier offering excellent accuracy.

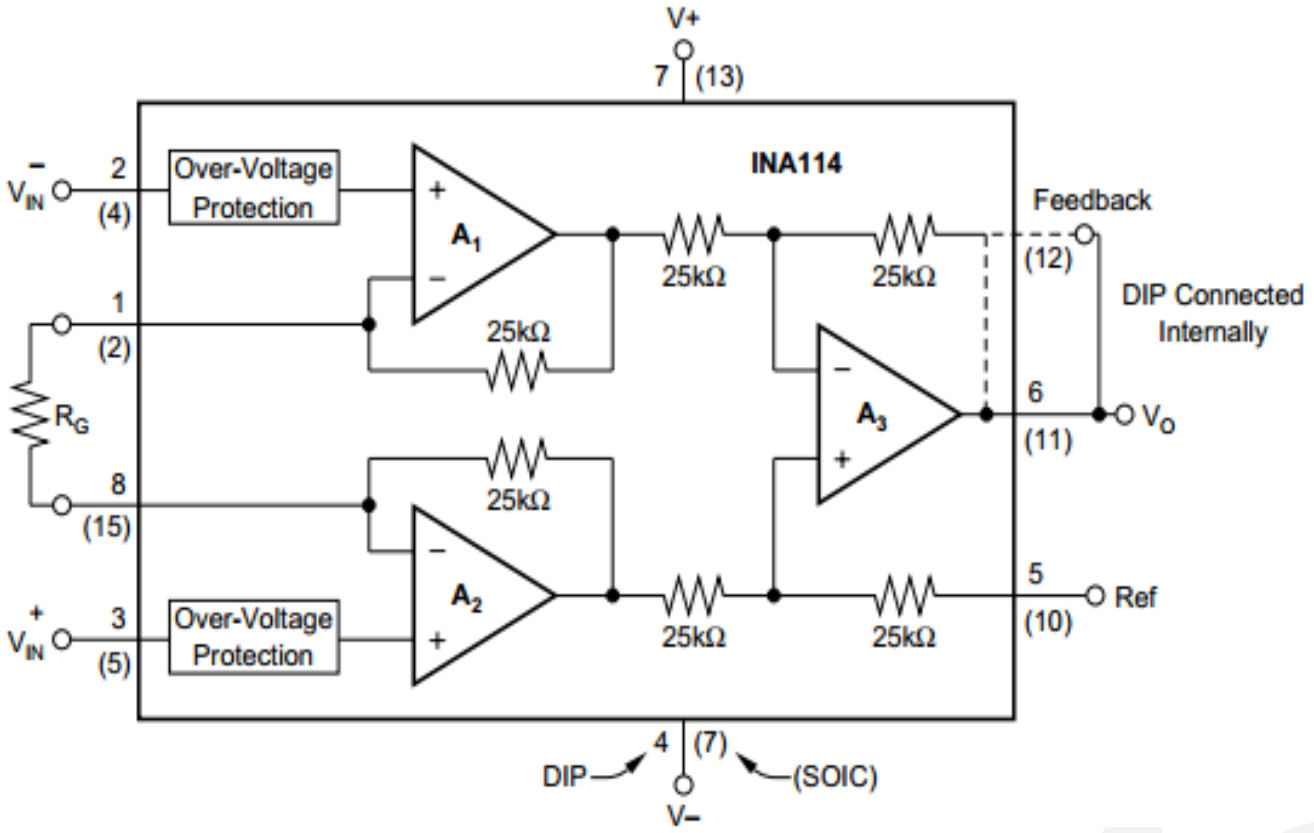


IC INA114 in reality

/instrumentation amplifier (INA114)

It is particularly suitable for use in measurement likes this EEG circuit whose great accuracy and stability

$$G = 1 + \frac{50k\Omega}{R_G}$$



INA114's schematic

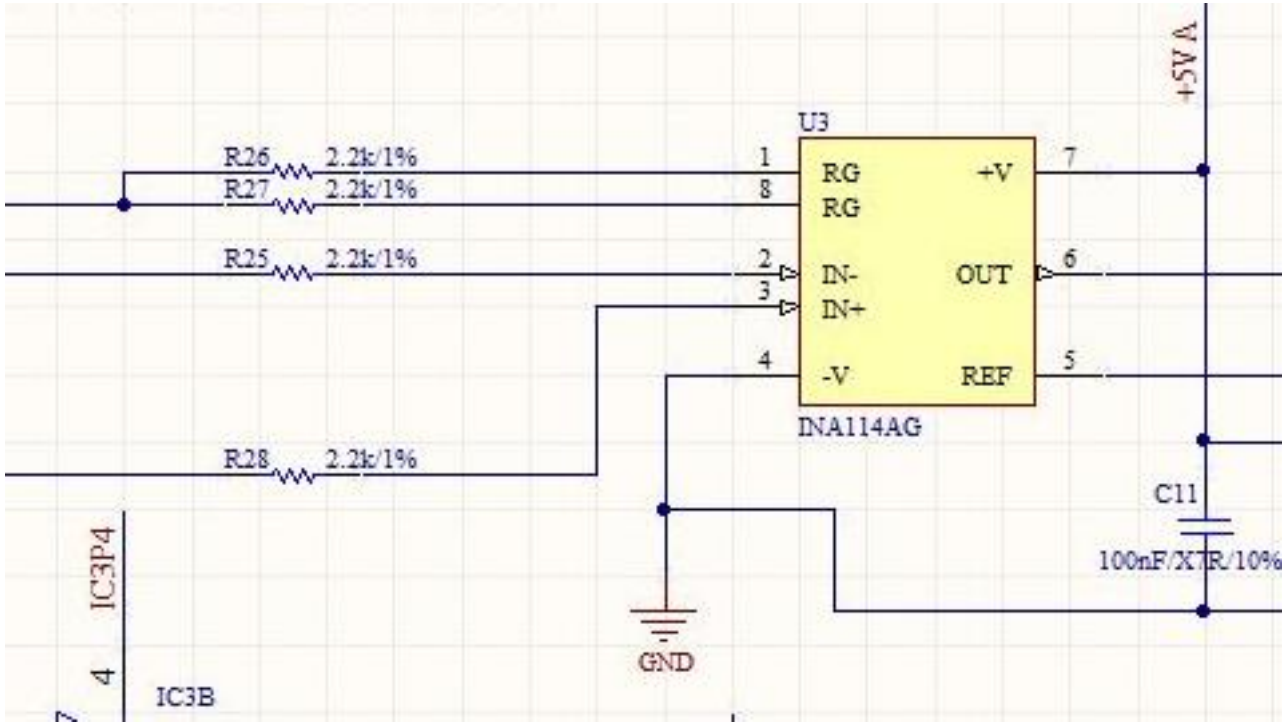
/instrumentation amplifier (INA114)

This EEG circuit requires great accuracy and stability of the circuit both short and long-term

In this circuit:

$R_G = R_{26} + R_{27} = 2{,}2\ k\Omega + 2{,}2\ k\Omega = 4{,}4\ k\Omega$,

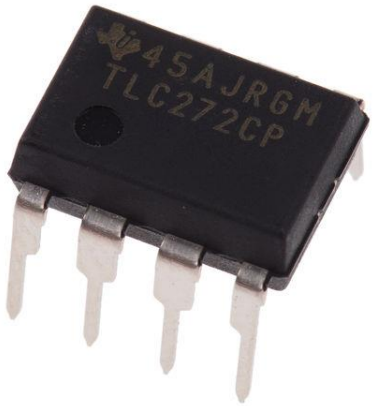
thus **G = 12,36**

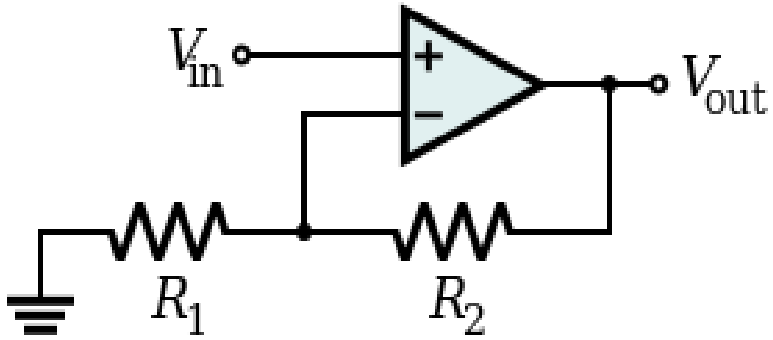


instrumention amplifier schematic

/non-inverter amplifier (TLC277)

The TLC277 precision dual operational amplifiers combine a wide range of input offset voltage grades with low offset voltage drift, high input impedance, low noise.



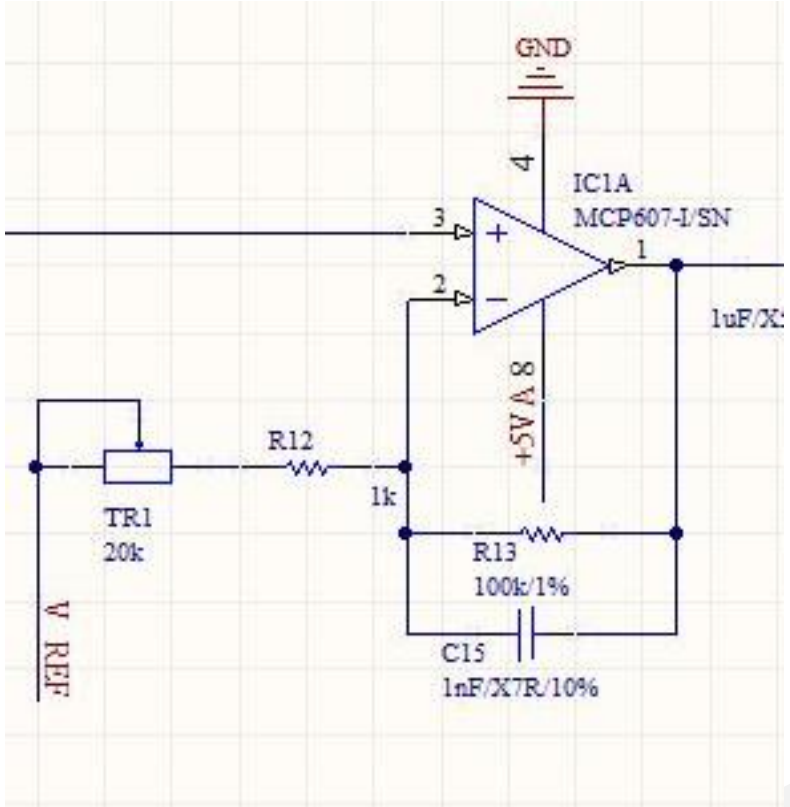


IC TLC277 in reality and its schematic

$$G = 1 + \frac{R_2}{R_1}$$

/non-inverter amplifier (TLC277)

This amplifier allows us to scale a signal to expected voltage range we wish by adjusting the gain accordingly.



non-inverter schematic

In this circuit:

R" = R13 = 100 $k\Omega$, R' = R12 + TR1, Which **R12 = 1 $k\Omega$**, TR1 changes from 20k to 1k, thus G is from 11 to 40 respectively.

Adjust TR1 to **2.77 $k\Omega$**, hence G roughly is **27.5**

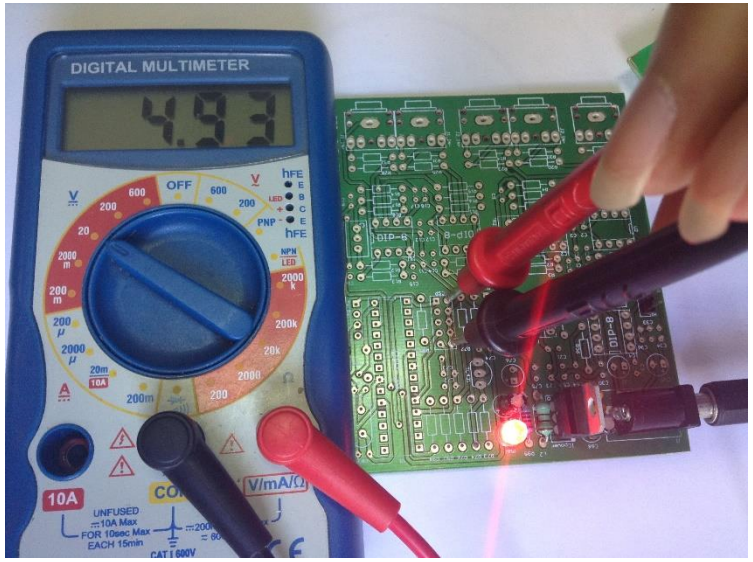
/validation

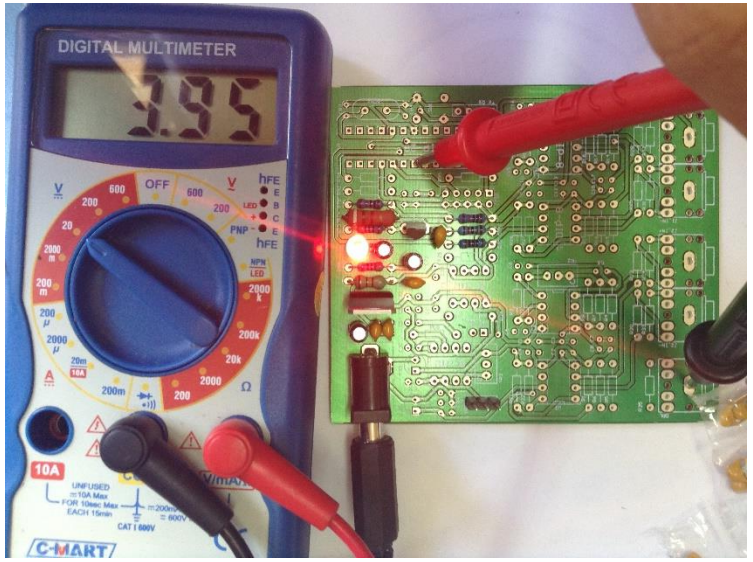
Testing source section

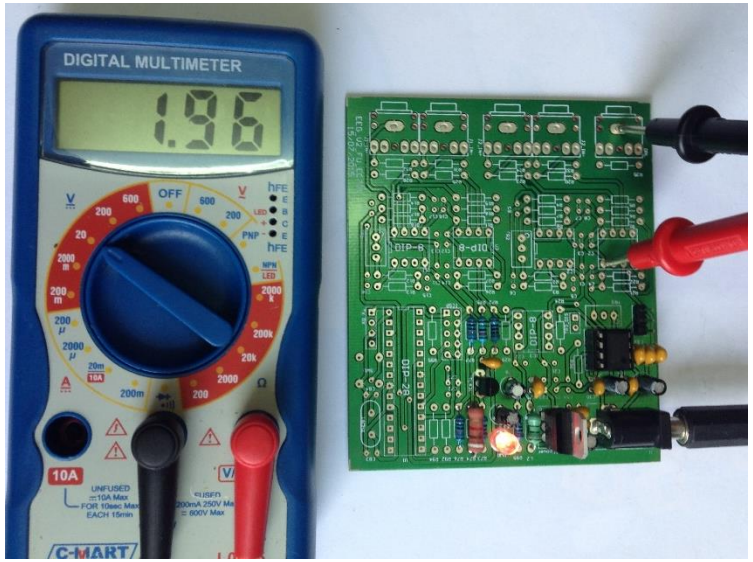
Method Desciption	Section	Expected Result	Actual Result
To validate, a Electric meter is used to check output voltage.	5V source	Signal LED turns on	Signal LED turns on
		5V	4.93V
	4V reference	4V	3.95V
	2V voltage	2V	1.96V

/validation

Testing source section







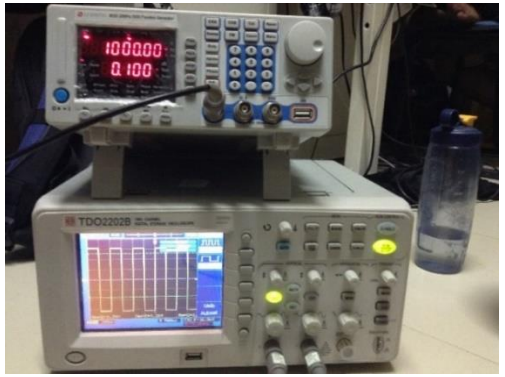
/validation

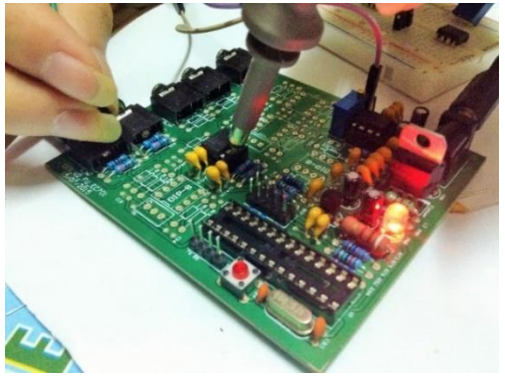
Testing instrumentation amplifier (INA114)

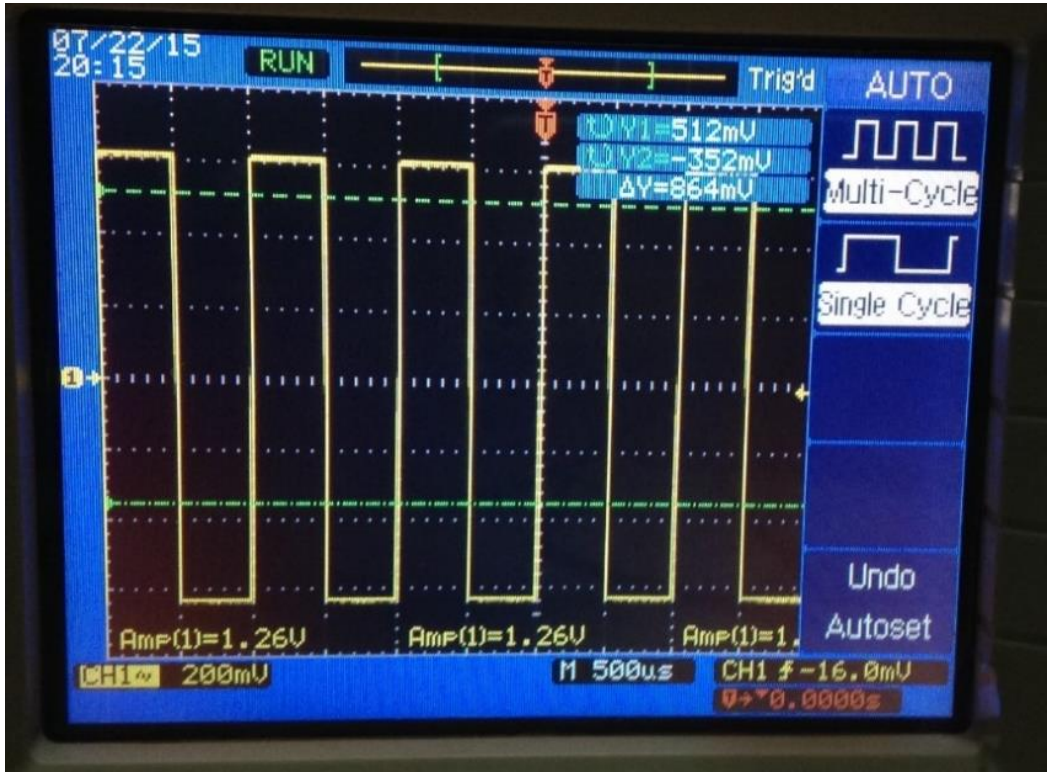
Method Desciption	Expected Result	Actual Result
Using a pulse generator to produce a rectangle pulse with amplitude at 0.1 V and observe the result on oscilloscope.The pulse which is displayed in oscilloscope is the output of INA114 at pin 8.	The pulse's shape is unchanged	The pulse's shape is unchanged
	1.236V	1.26V

/validation

Testing instrumentation amplifier (INA114)







Pulse generator, test manipulation and result displayed on oscilloscope

/validation

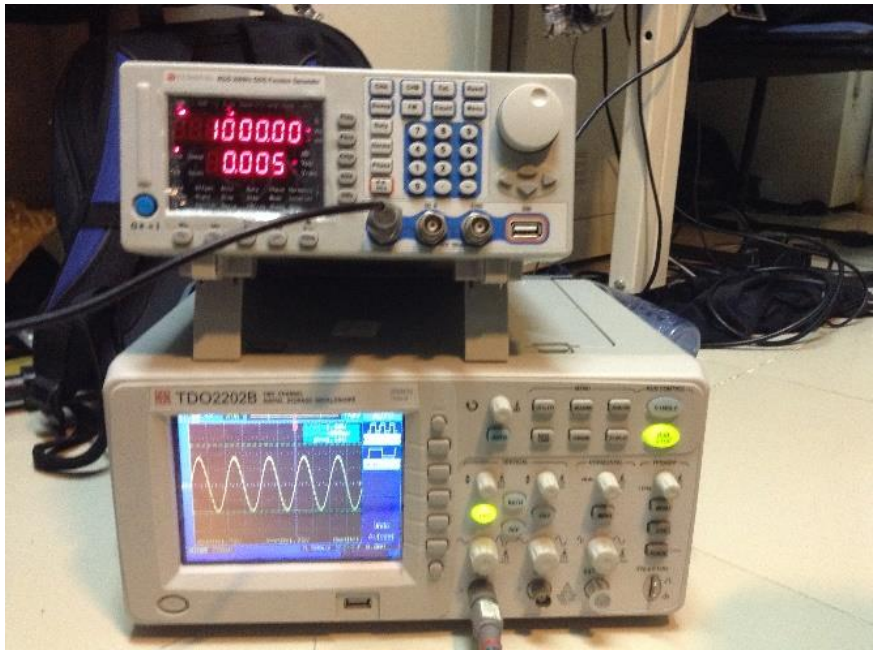
Testing TLC277

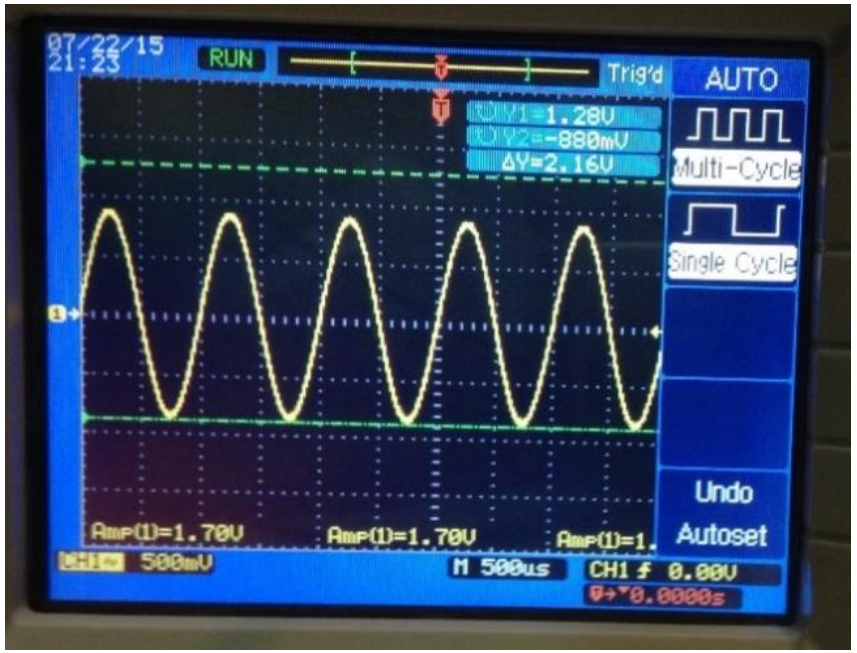
Method Desciption	Expected Result	Actual Result
Using a pulse generator to produce a rectangle pulse with amplitude at 0.005 V, the pulse which is displayed in oscilloscope is the output pin 1 of IC1	1.6995V	1.7V

Input for this amplifier is output of previous section which is ***0.005V x 12.36 = 0.0618 V***
According to the above formula, expected output is ***0.0618 V x 27.5 = 1.6995V***

/validation

Testing TLC277



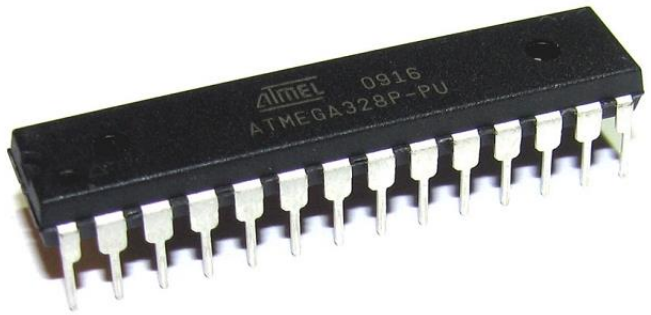


Pulse generator and result displayed on oscilloscope

/digital module

ATmega328 Microcontroller

- A low-power CMOS 8-bit microcontroller,
- Execute powerful instructions in a single clock cycle,
- Optimize power consumption versus processing speed



/ADC programming

Why we need an ADC?

- Brain wave is a kind of analog signal.
- The storage and direct processing of analog signals is extremely difficult.
- Digitalization makes things be handled and stored easily
- In arduino, ADC is executed by

```
analogRead(A0);
//A0 is analog input
```

/ADC programming

ADC programming

- With arduino, ADC is done by 3 main commands:

```
analogReference(EXTERNAL);
//use external Vref
analogRead(A0);
//adc executing
if(millis()%4==0){ }
//sampling
```

/packet transfer

Packet structure

- The circuit communicate with computer by sending packages with structure is as below

Sync0	Sync1	Version	Count	Data	Switches	Time

- With arduino, data (8bits) is send by following command

```
Serial.write(data);
```

/result

The eeg circuit

The EEG circuit and package

06

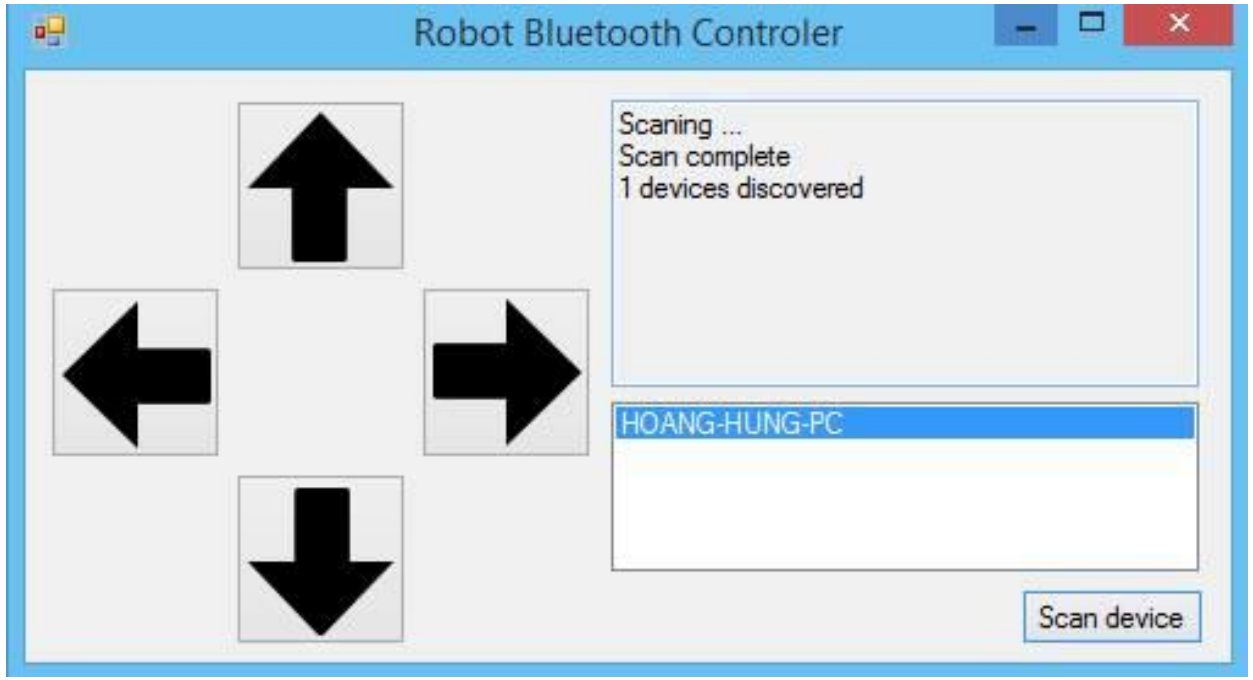
the Robot

Manual Control Application
Robot's Modules
Robot Programming

/manual control application

The applicaiton was designed to navigate the robot to go straight forward, go backward, turn right and turn left via Bluetooth. Its function:

- *Scanning for bluetooth devices*
- *Connecting with a device*
- *Navigating robot*



/manual control application

Scan thread

- The software generate a thread to scan surround bluetooth devices.
- If it can not make a thread, it would notice user turn computer's bluetooth on.
- The application will display list of around bluetooth devices.

/manual control application

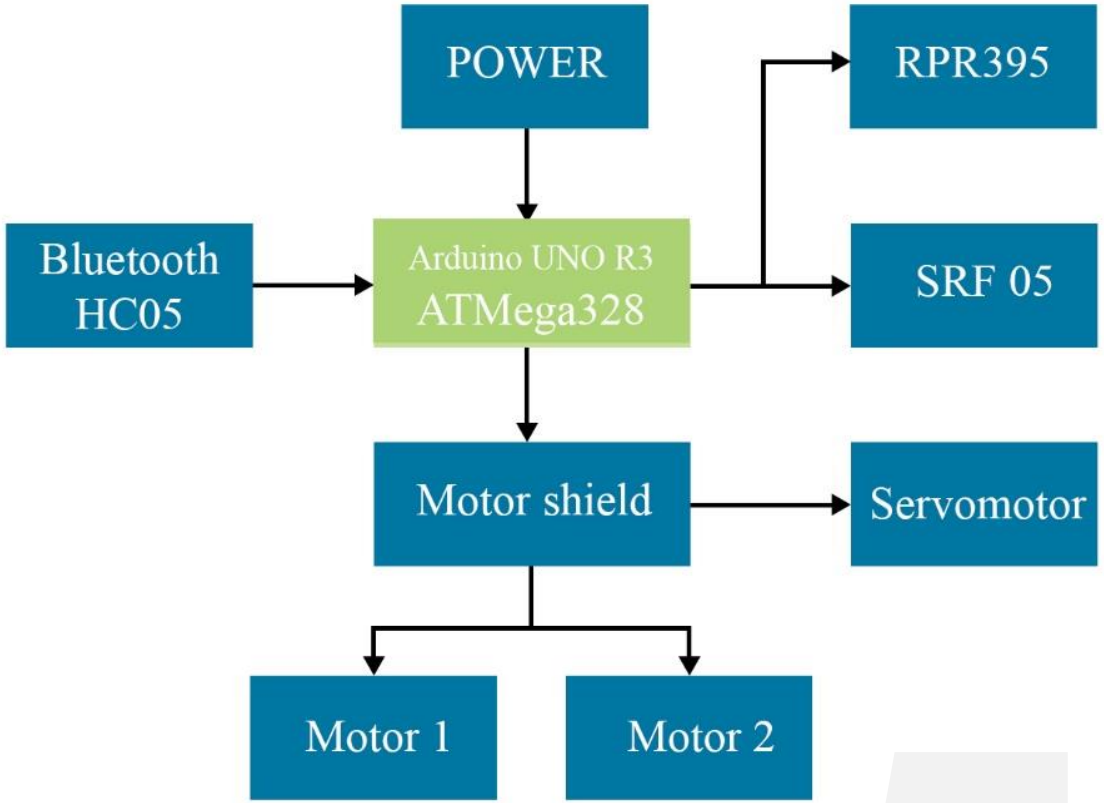
Connect thread

- The software makes an other thread to connect with chosen device with a predetermined password.
- It periodically sends packets to the device.

/arduino modules

The robot was built from arduino boards, shields, accessories

- **Board:** Arduino UNO R3
- **Shield:** Adafruit Motor Shield
- **Accessories:** HC05, Motors, Servo motor, SRF 05, RPR395

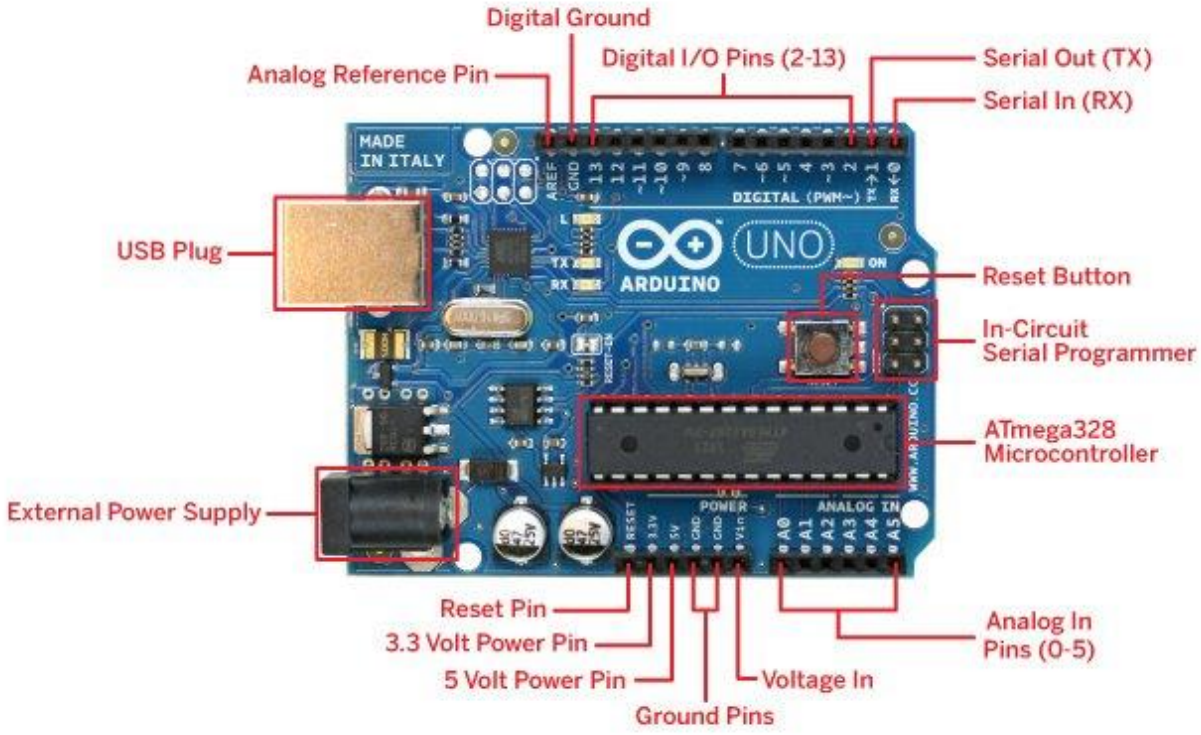


/arduino uno r3

- The Arduino Uno is a microcontroller board based on the **ATmega328** with full of components can adapt to particular needs

/arduino uno r3

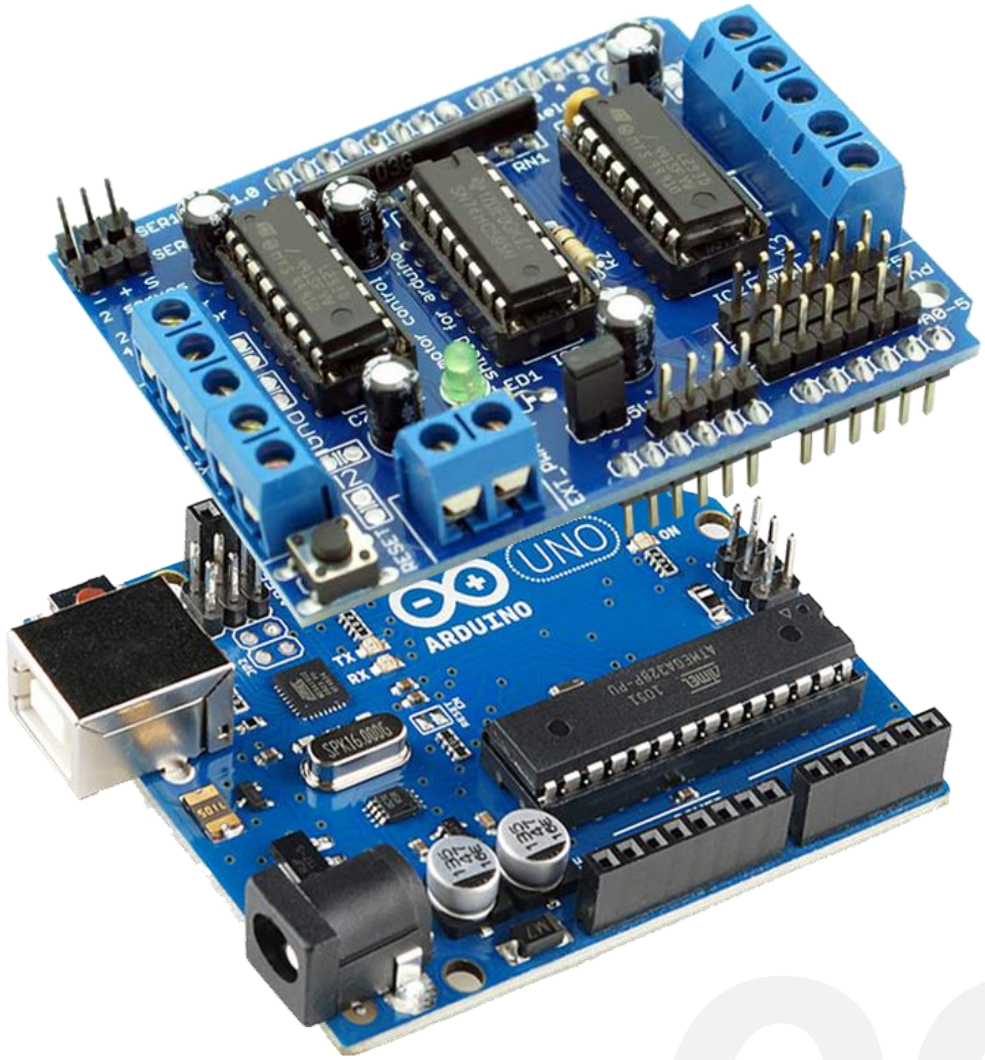
- The Arduino Uno is a microcontroller board based on the **ATmega328** with full of components can adapt to particular needs
  - *14 digital I/O pins, 6 analog input*
  - *16MHz ceramic resonator*
  - *USB connection,*
  - *Power jack 3.5*
  - *ICSP header*

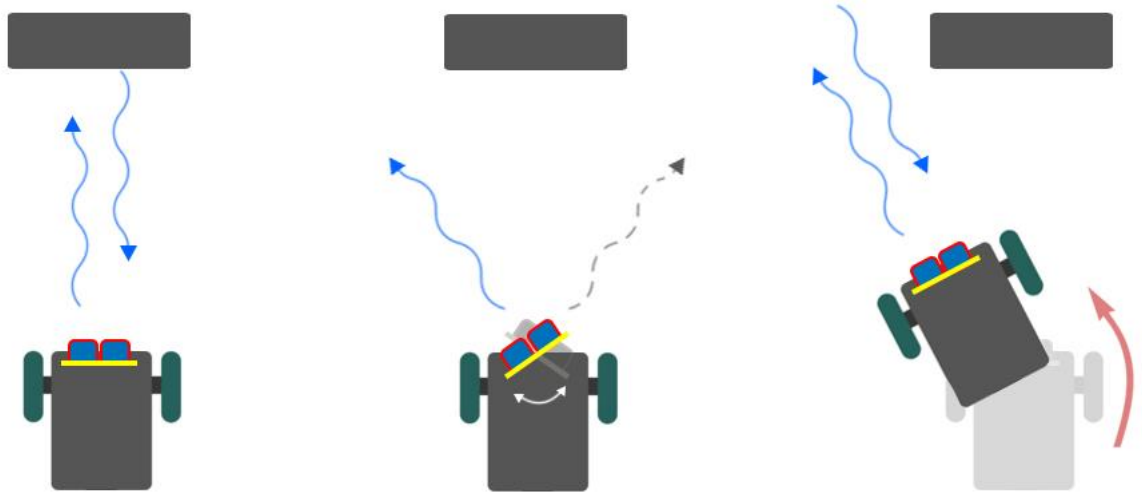


Arduino UNO R3

/adafruit motor shield

- Arduino is a great starting point for electronics
- With a motor shield, it will be nice tidy platform for robotics and mechatronics
- Can drive 4 DC motors or 2 stepper motors or 2 Servo





How can the robot recognize obstacles?

- The robot 'sees' these obstacles using its ultrasonic sensor, doing some basic math to determine how far away these objects are
- The robot finds an alter route if the distance to front object is smaller than a fixed distance

/obstacle avoidance function

/obstacle avoidance function

How can the robot recognize obstacles?

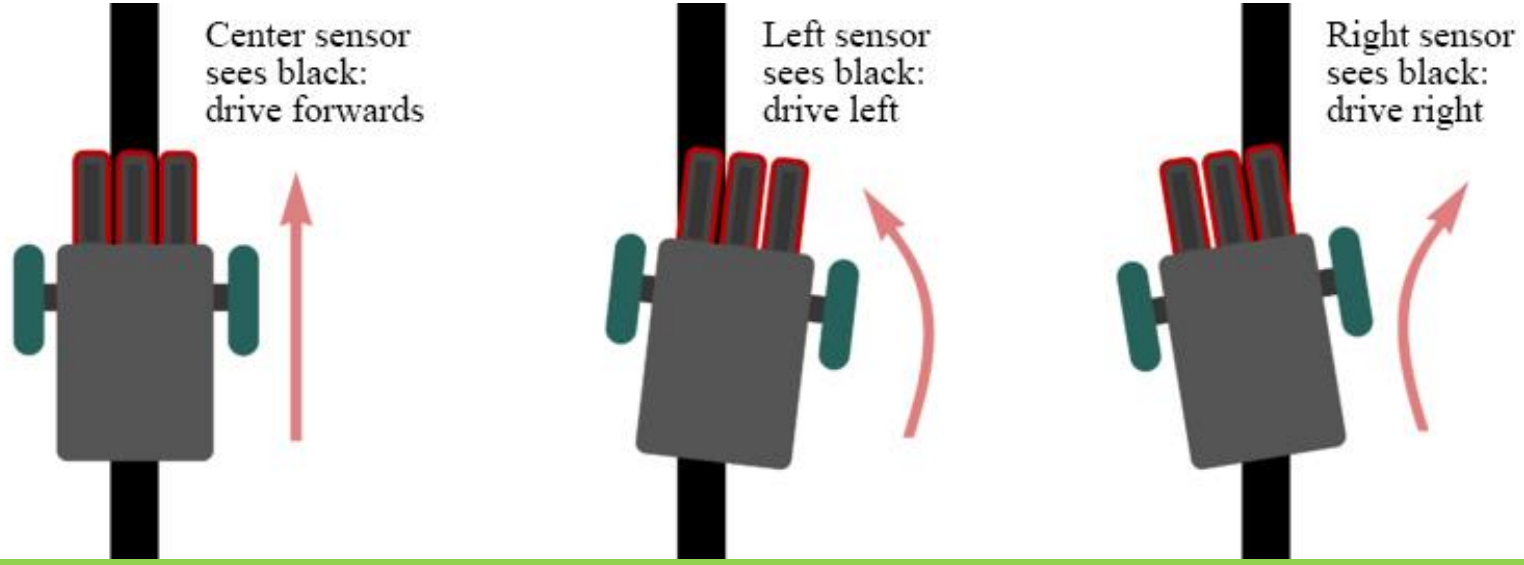
A servomotor is a rotary actuator that allows for precise control of angular position, velocity and acceleration

- *Resonable price*
- *High accuracy*
- *Availability*
- *Arduino libraries supported*

/obstacle avoidance function

How can the robot recognize obstacles?

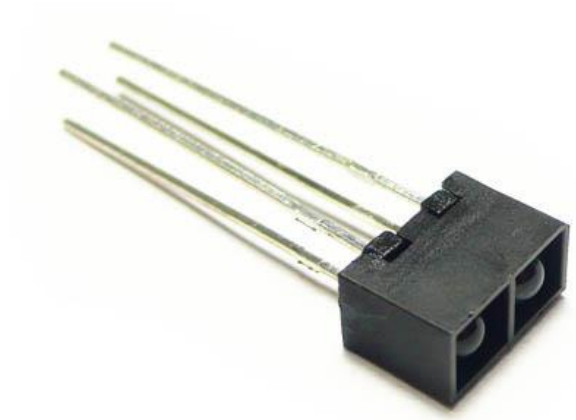
- SRF05 - Ultrasonic sensor module is used to measure the distance to the barrier
- The distance is determined by the time ultrasonic waves are emitted from the transmitter module to the barrier and feedback

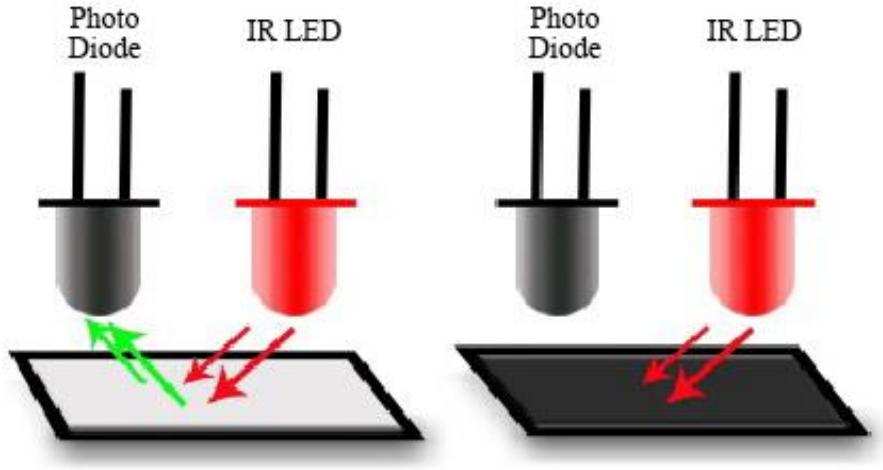


How can the robot track a black line?

- Use our three sensors to our advantage
- There are three possible states:
  - *The center sensor seeing the line*
  - *The left sensor seeing the line*
  - *The right sensor seeing the line.*

/line following function





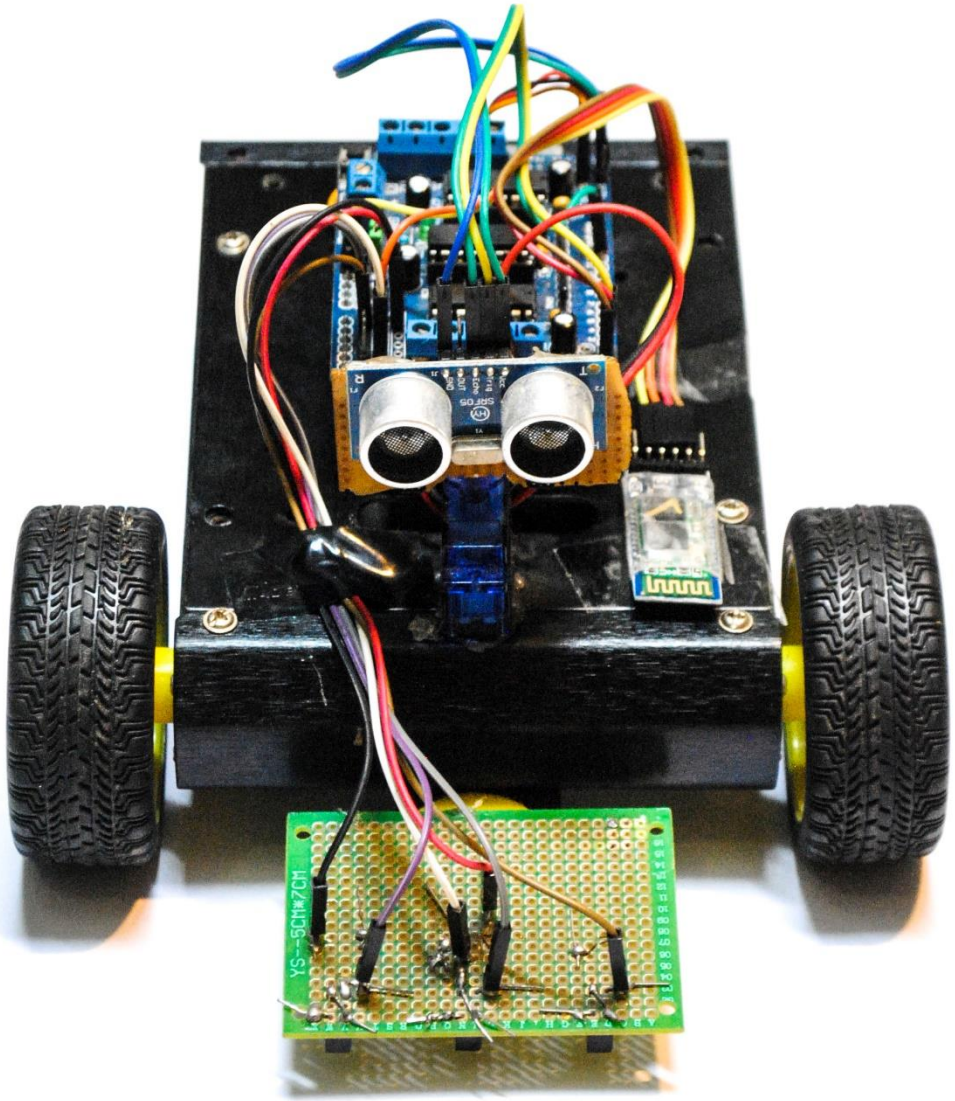
How can the robot track a black line?

- Using the RPR-359F photo reflective sensor to act like robot's eyes
- The sensor works by detecting reflected light coming from its own infrared LED

/line following function

/result

The robot



Q&A

07

finally,

/thankyou