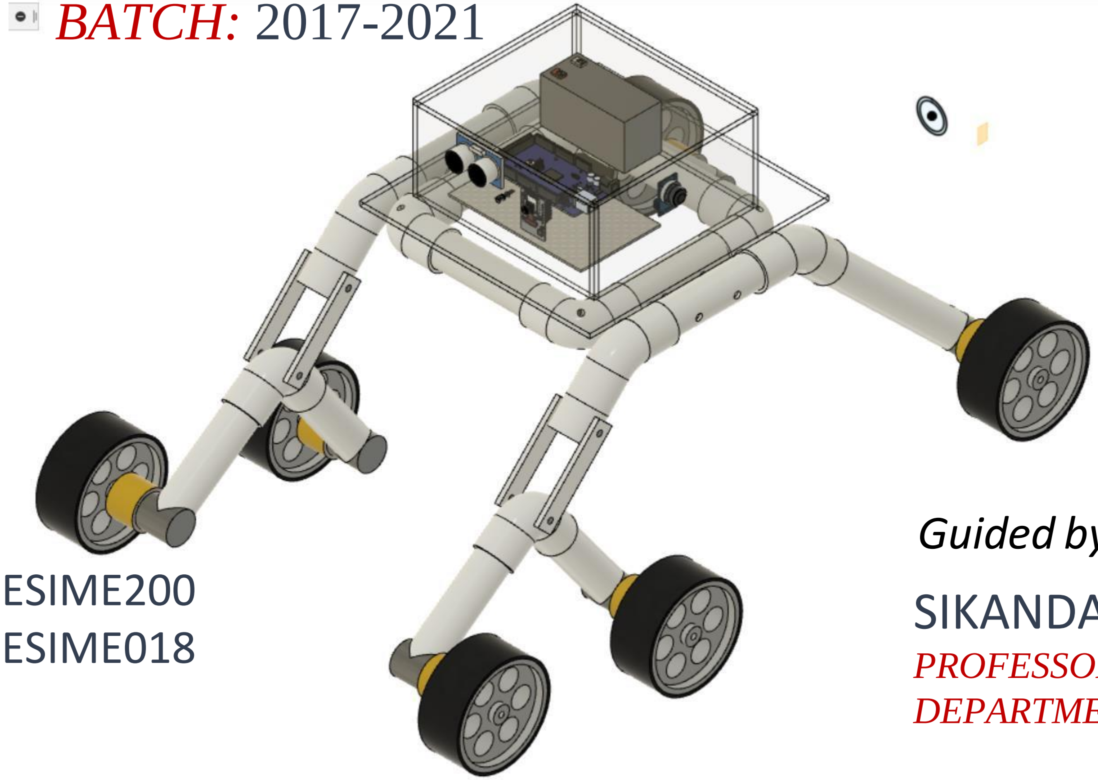
DEPARTMENT OF MECHANICAL ENGINEERING
MAJOR PROJECT 2021

S.K. CHAUDHARY EDUCATIONAL TRUST'S
SHANKARA INSTITUTE OF TECHNOLOGY
KUKAS JAIPUR [RAJASTHAN]

DESIGN AND FABRICATION OF SEARCH AND RESCUE ROGV FOR DISASTER RELIEF AND INSPECTION

BATCH: 2017-2021



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1.0 ABSTRACT

- Natural disasters in various forms like earthquakes, tsunami, cyclones, etc in common to all. The subsequent loss is great and the recovery period large.
- Considering the impact on human life, a vehicle (robot) is planned to be developed which can be used for search and rescue, and inspection operations during such events.
- The ROGV is designed implementing a rocker-boogie mechanism to ease manoeuvring over uneven ground and unpredictable environments, capable to even climb stairs.
- It is fitted with a camera to monitor the path and explore the situation/environment around the vehicle which will be giving live video feed and can be recorded
- The thermal sensor, the gas sensor and the ultrasonic sensors which can detect the temperature, concentration of LPG, propane, carbon-monoxide, smoke and obstacles.
- All telemetry data will be sent via radio to the controller which will store and display all sensor data to the remote operator. Keeping humans out of harm's way and collecting needed information can surely prove to be very useful.

2.0 LITERATURE SURVEY

Sr No.	Year of Publication	Title	Publication	Author
1.	2018	Enabling Communication Technologies for Automated Unmanned Vehicles in Industry 4.0	International Conference on Information and Communication Technology Convergence (ICTC)	Amina Fellan, Christian Schellenberger, Marc Zimmermann, And Hans D. Schotten
2.	2014	Design and development of an automated all-terrain wheeled robot	Techno-Press, Ltd.	Debesh Pradhan , Jishnu Sen And Nirmal Baran Hui
3	2015	System Modelling of Rocker-Bogie Mechanism for Disaster Relief.	IEEE International Symposium on Robotics and Intelligent Sensors (IRIS 2015)	S. F. Toha1 And Zakariya Zainol*
4	2017	Design of Rocker-Bogie Mechanism	International Journal of Innovative Science and Research Technology	Abhisek Verma, Chandrajeet Yadav, Bandana Singh , Arpit Gupta, Jaya Mishra, Abhishek Saxena
5	2018	DESIGN AND FABRICATION OF ROCKER BOGIE MECHANISM GEOSURVEY ROVER	International Journal of Scientific Development and Research (IJSDR)	B. Babu, N. Dhayanidhi, S. Dhamotharan

3.0 PROBLEM DEFINITION

Natural disasters such as earthquakes, cyclones, floods, etc. can damage buildings and may cause it to collapse.

Such environments are very risky and unpredictable for humans to operate in for search and rescue.

Some Industries that deal with harmful substances put humans at risk.

Surveying mines are usually risky job. (Develop an all purpose search and rescue system to tackle the mentioned problem.)

Fig. 3.1 Destruction caused due to earthquake

4.1 MECHANICS

4.1.1 ROCKER-BOGIE MECHANISM

- The rocker-bogie system is the suspension arrangement developed in 1988 for use in NASA's Mars rover Sojourner
- The "rocker" part of the suspension comes from the rocking aspect of the larger, body-mounted linkage on each side of the rover.
- Relative to the chassis, the rockers will rotate in opposite directions to maintain approximately equal wheel contact. The chassis maintains the average pitch angle of both rockers.
- One end of a rocker is fitted with a drive wheel, and the other end is pivoted to the bogie.
- The "bogie" part of the suspension refers to the smaller linkage that pivots to the rocker in the middle and which has a drive wheel at each end.

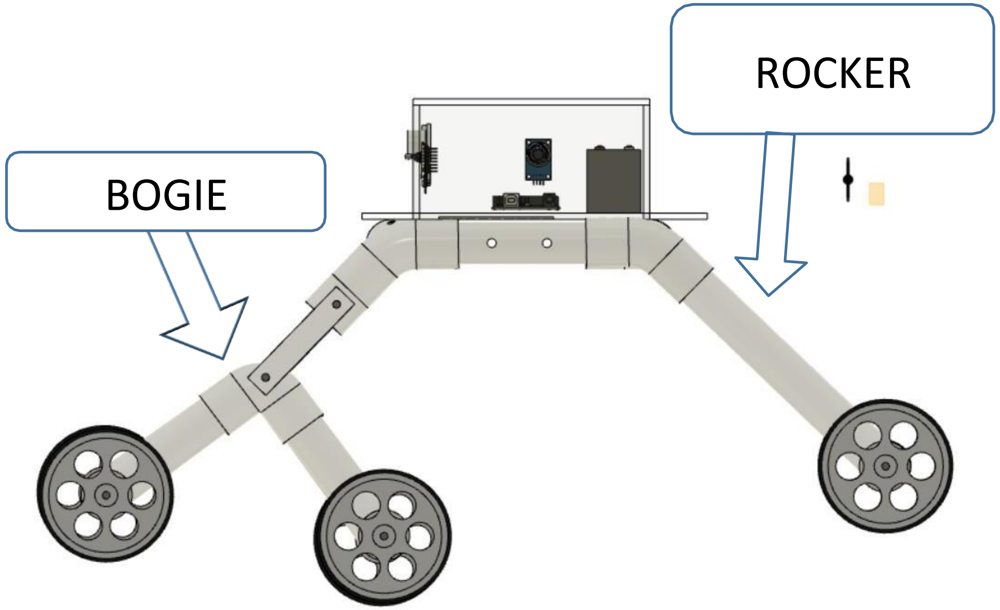


Fig. 4.1 Figure showing rocker bogie mechanism

4.1 MECHANICS

4.1.2 PVC MATERIAL

- Easily available
- Good machinability
- Light compared to metals
- Decent rigidity
- Economical
- Acrylic Sheets also allows us to see the electronics components housed inside. Identifying failures in electronic components becomes easy.

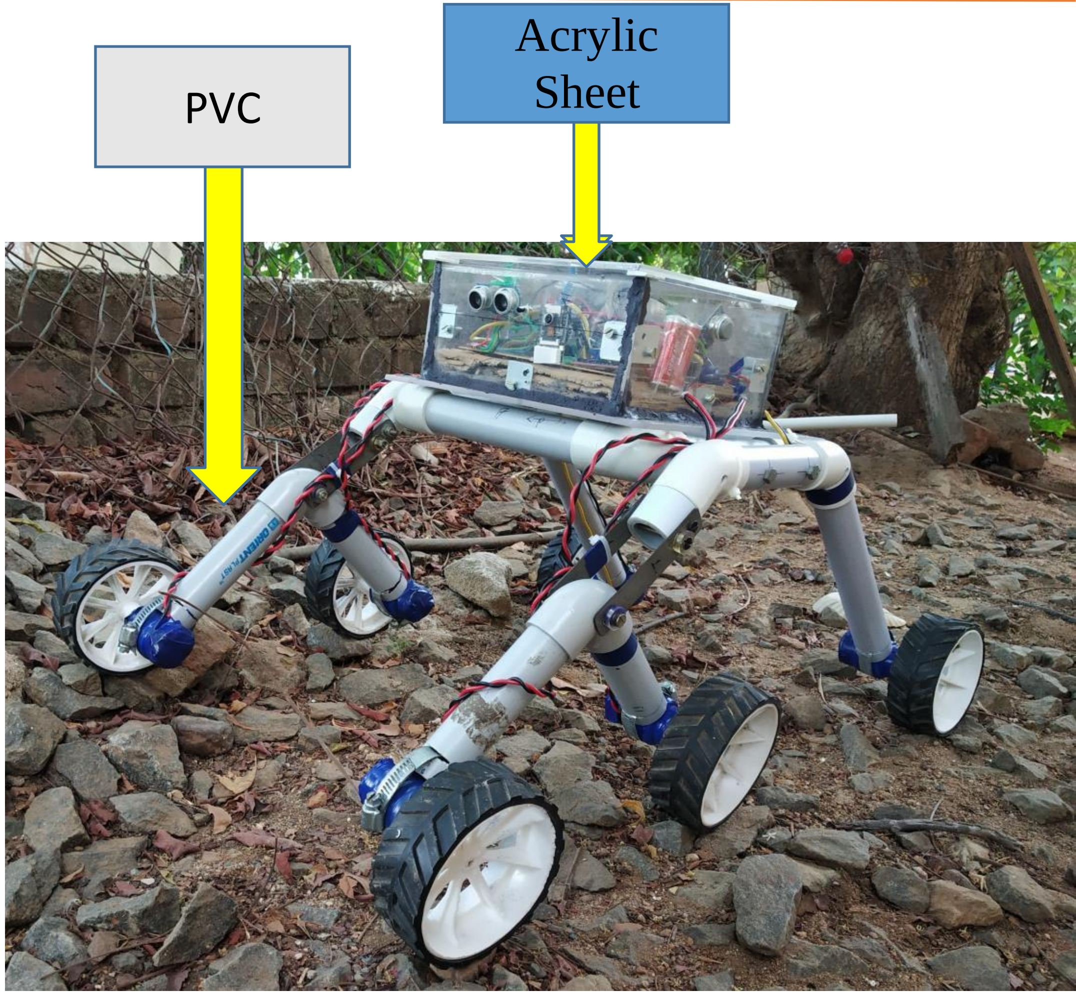


Fig. 4.2 Figure showing Model and materials used

4.1 MECHANICS

4.1.3 AMPHIBIOUS PROPERTIES

- Majority of the electronic components housed in a single waterproof compartment.
- The motors are made waterproof using wax, plastic, and insulation tape.
- All the exposed sensors are protected from water by the top cover which is extended forward.
- The electronics compartment is mounted high so that it dosen’t come in contact with water easily.
- Float used will prevent the ROGV from sinking.
- The ROGV is partly amphibious in nature and can be operated both on land and small puddles of water.
- Epoxy putty is use to secure the necessary parts from water.

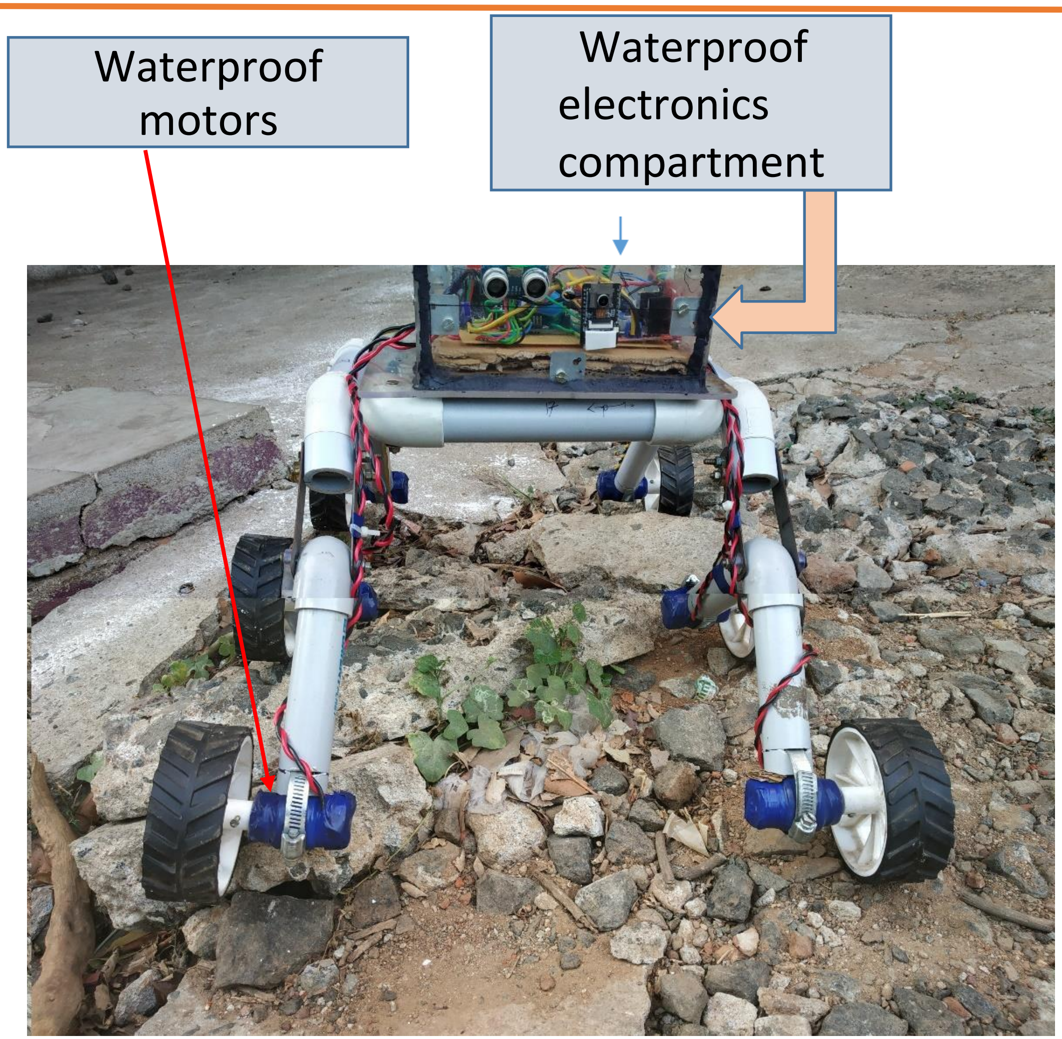


Fig. 4.3 Figure showing waterproof components

4.2 CONTROL AND SENSOR SYSTEMS

4.2.1 COMMUNICATION

RADIO COMMUNICATION:

- Communication between two microcontrollers using radio technology.
- NRF24L01+ (PA/LNA) Module is full duplex, radio transceiver module operating at 2.4GHz band. Fig 4.2.1b
- With the external antenna, PA and LNA, it has a range of upto 1km.
- Interacts with the microcontroller through SPI interface.
- Radio communication is known to be reliable and of longer range.
- Other radio modules like cheaper RF modules and LoRa operate in the 433MHz band and are usually half duplex. Fig 4.2.1a & Fig 4.2.1c

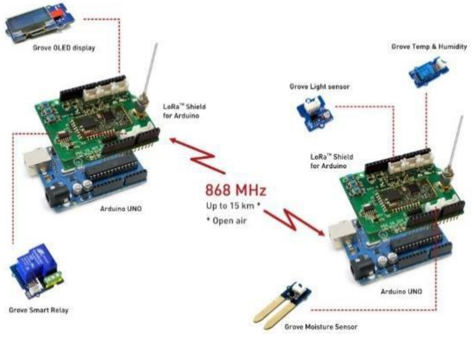


Fig 4.2.1a: LoRa Module

Fig 4.2.1b: NRF24L01+PA+LNA RADIO TRANSCEVIER MODULE

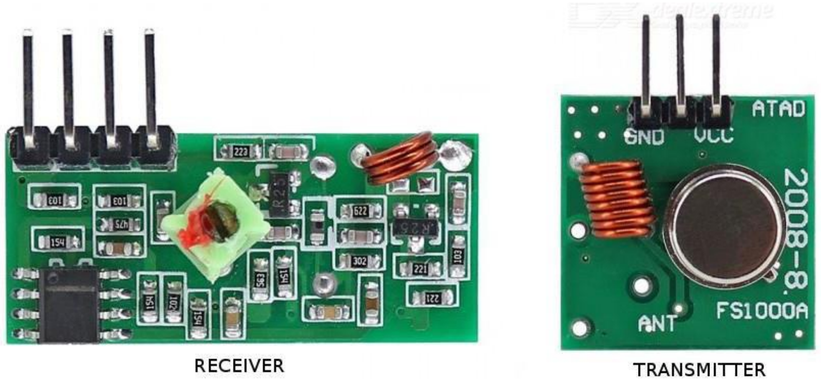


Fig 4.2.1c: 433MHz RADIO MODULES

4.2 CONTROL AND SENSOR SYSTEMS

4.2.2 SENSORS

Fig 4.2.2a: ESP32 CAM

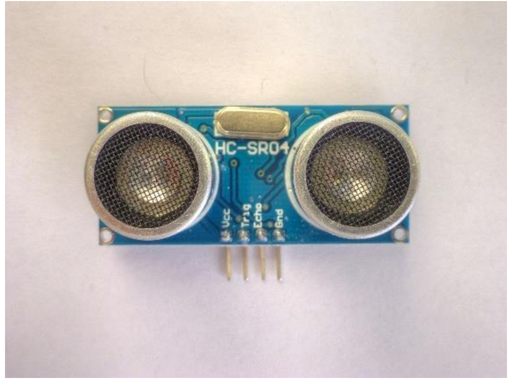


Fig 4.2.2b: HC-SR04

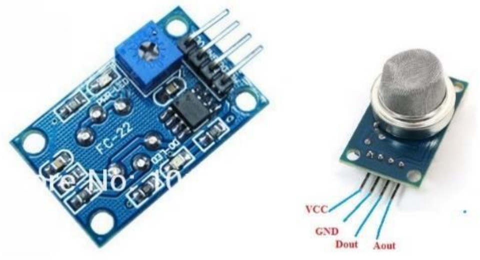


Fig 4.2.2c: MQ-2 Gas Sensor

Fig 4.2.2d: LM35

- ESP32CAM - 2MP Camera to stream live video data for assessing the surrounding environment.
- Fig 4.2.2a

- HC-SR04 Proximity Sensor to detect any sudden change in the height of the ground in front of the rover.
- Fig 4.2.2b

- LM-35 Temperature sensor to measure environment temperature.
- Fig 4.2.2c

- MQ-2 Gas sensor to detect the presence of flammable gases.
- Fig 4.2.2d

4.2 CONTROL AND SENSOR SYSTEMS

4.2.3 CONTROLLER

MICROCONTROLLER: RASPBERRY PI PICO Fig 4.2.3a

- RP2040 microcontroller chip designed by Raspberry Pi in the UK.
- Dual-core Arm Cortex-M0+ processor, flexible clock running up to 133 MHz.
- 264KB on-chip SRAM.
- 2MB on-board QSPI Flash.
- 26 multifunction GPIO pins, including 3 analogue inputs.
- 2 × UART, 2 × SPI controllers, 2 × I2C controllers, 16 × PWM channels.
- 1 × USB 1.1 controller and PHY, with host and device support.
- 8 × Programmable I/O (PIO) state machines for custom peripheral support.
- Supported input power 1.8–5.5V DC.
- Operating temperature -20°C to +85°C.
- Low-power sleep and dormant modes.
- Accurate on-chip clock.
- Temperature sensor.

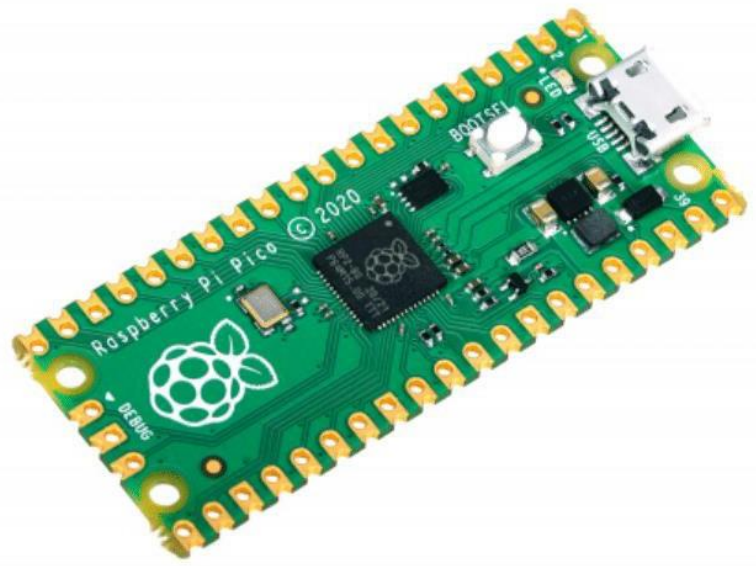


Fig 4.2.3a: RASPBERRY PI PICO MICROCONTROLLER

4.2 CONTROL AND SENSOR SYSTEMS

4.2.3 CONTROLLERS

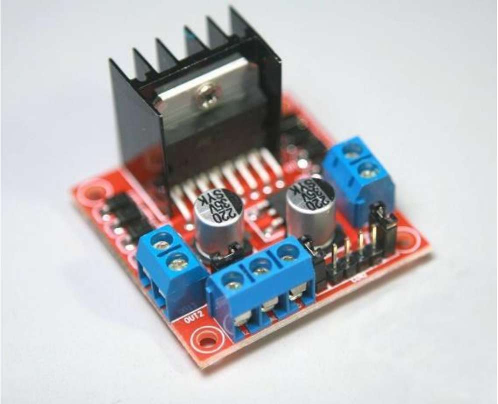


Fig 4.2.3b: L298N MOTOR DRIVER

Fig 4.2.3c: HW-131 POWER SUPPLY

- L298N MOTOR DRIVER: Takes 5V – 35V DC input and supplies current to four connections for motors. Motor control is done is done by H-bridge, and six input pins, two of which take in digitial or PWM signals for motor control.
- Fig 4.2.3b

- HW-131 POWER DISTRIBUTER: Takes 6V – 12VDC input and supplies out 5V and 3.3V
- Fig 4.2.3c

4.2 CONTROL AND SENSOR SYSTEMS

4.2.4 CODE STRUCTURE

- Code for the pi pico microcontroller can be written in micro-python or C++.
- Dual core multithreaded programming is used to distribute sensor computing load and peripheral control load.
- On the rover, the first core is used for communication, i.e., receiving motor control data and sending sensor data.
- The first core also sends control signals to the motor driver.
- The second core is used for receiving sensor data and computing the data into a readable format and then updating the global variables holding the sensor data.
- See Fig 4.2.4

Rover_main.py *

```
#Run second core for sensor data and calculations
def sensor_data_thread():
    #Call global variables inside thread to be able to modify it
    global rover_sys_temp, environment_temp, distance, lpg_level
    #Thread progam
    while True:
        #system and external environment temperature
        sys_voltage = sys_temp.read_u16() * conversion_factor
        rover_sys_temp = int(27 - (sys_voltage/1000 - 0.706) / 0.001721)
        ext_voltage = int(ext_temp.read_u16() * 1750/65535)
        environment_temperature = int((ext_voltage) / 10)
        #ultrsonic sensor data
        distance = int(get_distance())
        #gas sensor data
        LPG_levels = getLPGData()
        CO_levels = getCOData()
        SMOKE_levels = getSmokeData()
        utime.sleep(0.5)
#Starting thread to run on core 2
_thread.start_new_thread(sensor_data_thread, ())

#Ultrasonic sensor distance calculator
def get_distance(timer):
    trigger.high()
    utime.sleep_us(10)
    trigger.low()
    while echo.value() == 0:
        start = utime.ticks_us()
    while echo.value() == 1:
        stop = utime.ticks_us()
    duration  = stop - start
    distance = (duration * 0.0343)/2
    #print("Distance", distance, "cm")
    return distance
timer.init(freq = 2, mode = Timer.PERIODIC, callback = get_distance)
```

Fig 4.2.4: MICROPYTHON CODE SHOWING MULTITHREADING

5.0 DESIGN AND CALCULATIONS

5.1 ROCKER-BOOGIE DESIGN

5.1.1 CADD DRAWING

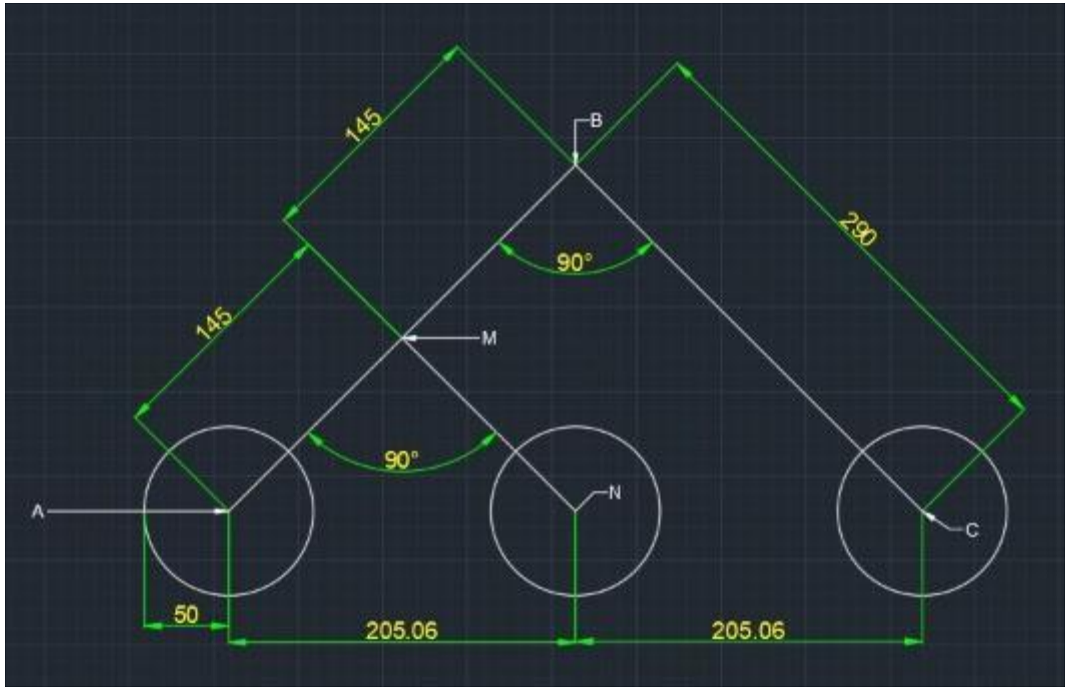


Fig. 5.1 Figure showing rocker bogie mechanism Calculations

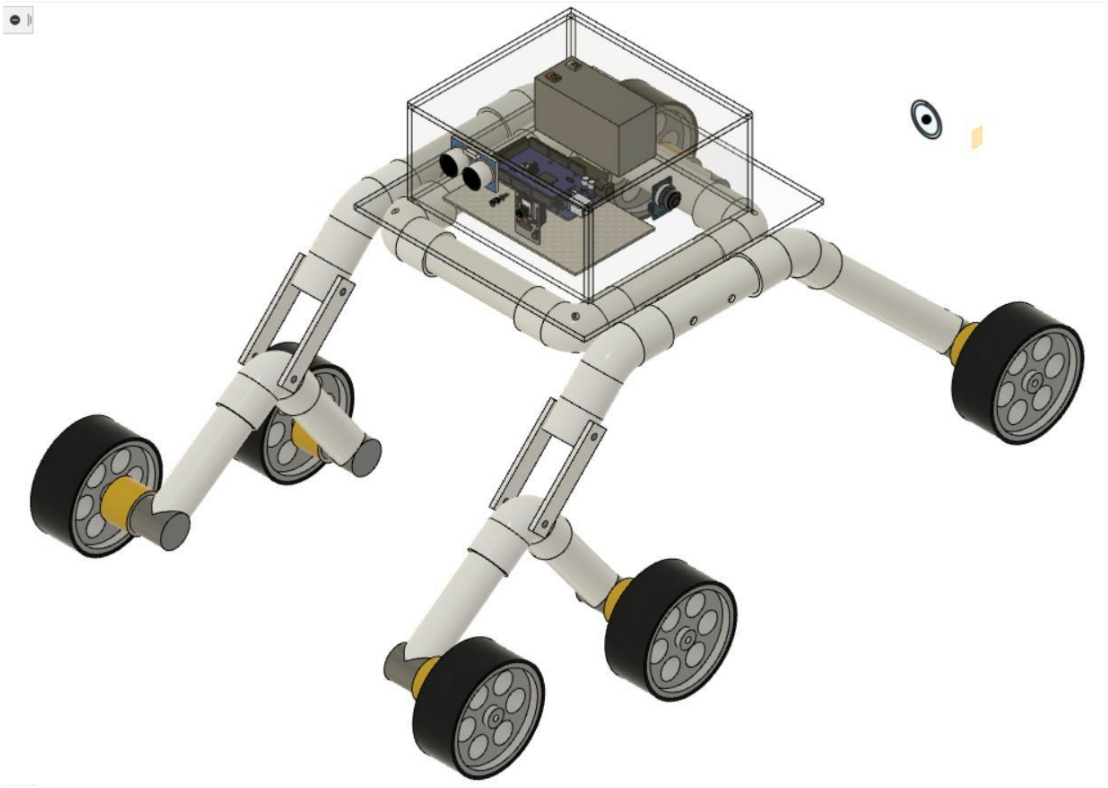


Fig. 5.2 3D CAD Model

5.1 ROCKER-BOOGIE DESIGN

5.1.2 DESIGN CALCULATIONS

- If horizontal length of stairs is 280 mm
- Then wheel base = horizontal length of stairs – (Rf + Rr)
- Rf = radius of front wheel
- If horizontal length of stairs is 280 mm
- Then wheel base = horizontal length of stairs – (Rf + Rr)
- Rr = radius of rear wheel
- So wheel base = 280 – (50+50)
- Wheel base = 180 mm
- Let $\theta = 45^0$
- In Triangle BNC, Angle BNC = 90^0
- Angle NBC = Angle NCB = 45°
- Therefore, NC = NB
- $NC^2 + NB^2 = BC^2$ (from Pythagoras theorem)

- $BC^2 = 2(NC^2)$ ……. (1)
- $= 2(205^2)$
- BC = 205.5 mm
- Rounding off to 206 mm
- Substituting in eqn (1) we get,
- $390^2 = 2(NC^2)$
- NC = 205.5 mm
- Also,
- NC = AN = 205.5 mm
- In Triangle AMN, angle AMN = 90^O
- $AM^2 + MN^2 = AN^2$
- $2(AM^2) = AN^2$
- AM = 145 mm

Now due to symmetry

- AM = MN =115 mm
  BM = AB – AM
  = 290-145 mm
  BM = 145 mm
- **Height of RBM**
- $Height^2 = BC^2 – NC^2$
- $Height^2 = 290^2 – 205.5^2$
- Height = 205.5 mm
- Net Height = Height + radius of wheel
  = 206 + 50= 256 mm
- BM = 145 mm

5.1 ROCKER-BOOGIE DESIGN

5.1.3 3D MODEL

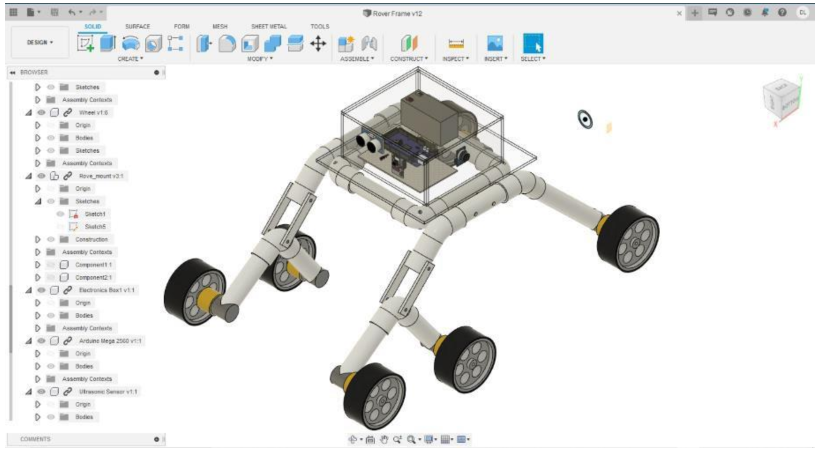


Fig 5.1.3a: ROVER 3D MODEL

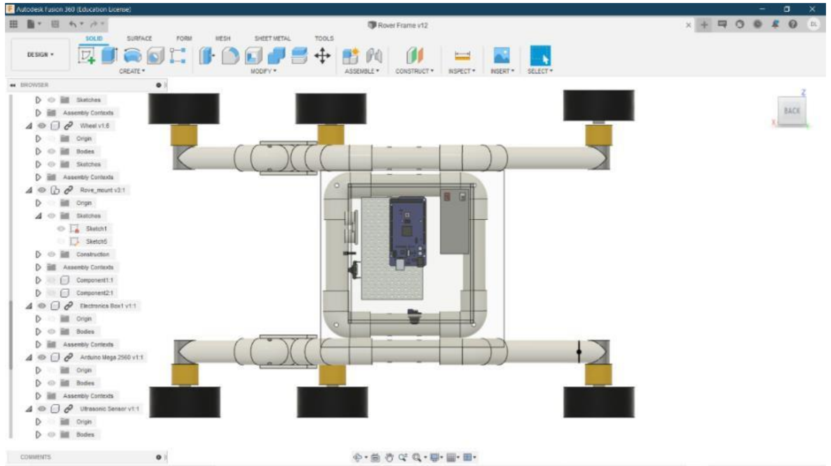


Fig 5.1.3a: ROVER 3D MODEL TOP VIEW

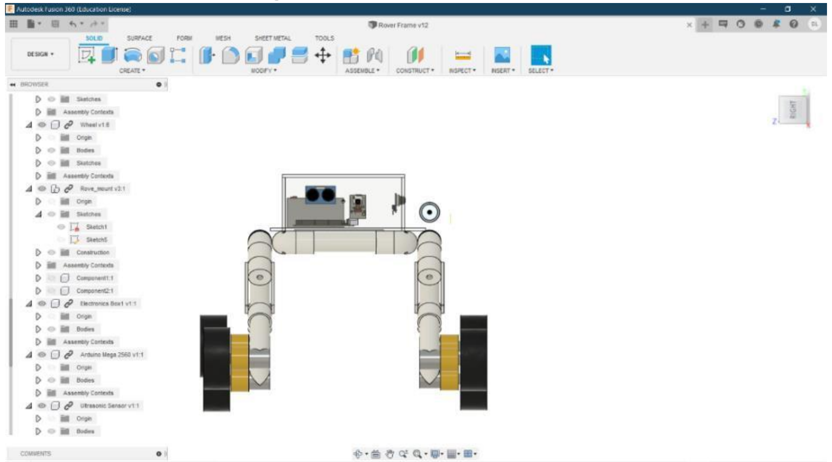


Fig 5.1.3a: ROVER 3D MODEL FRONT VIEW

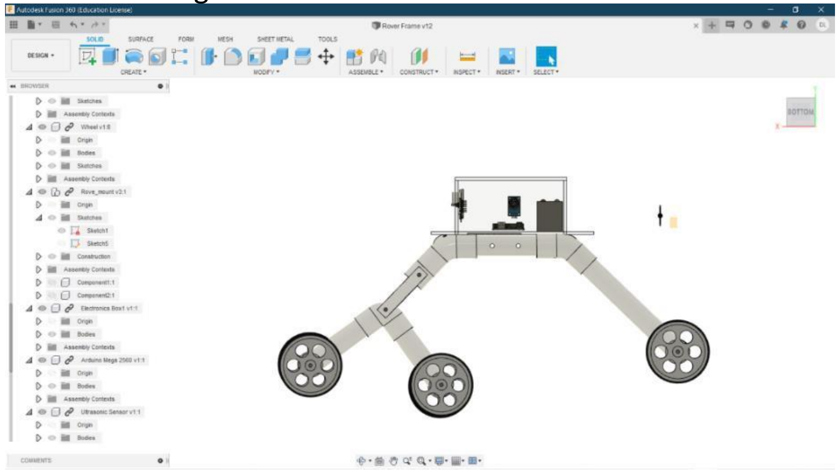
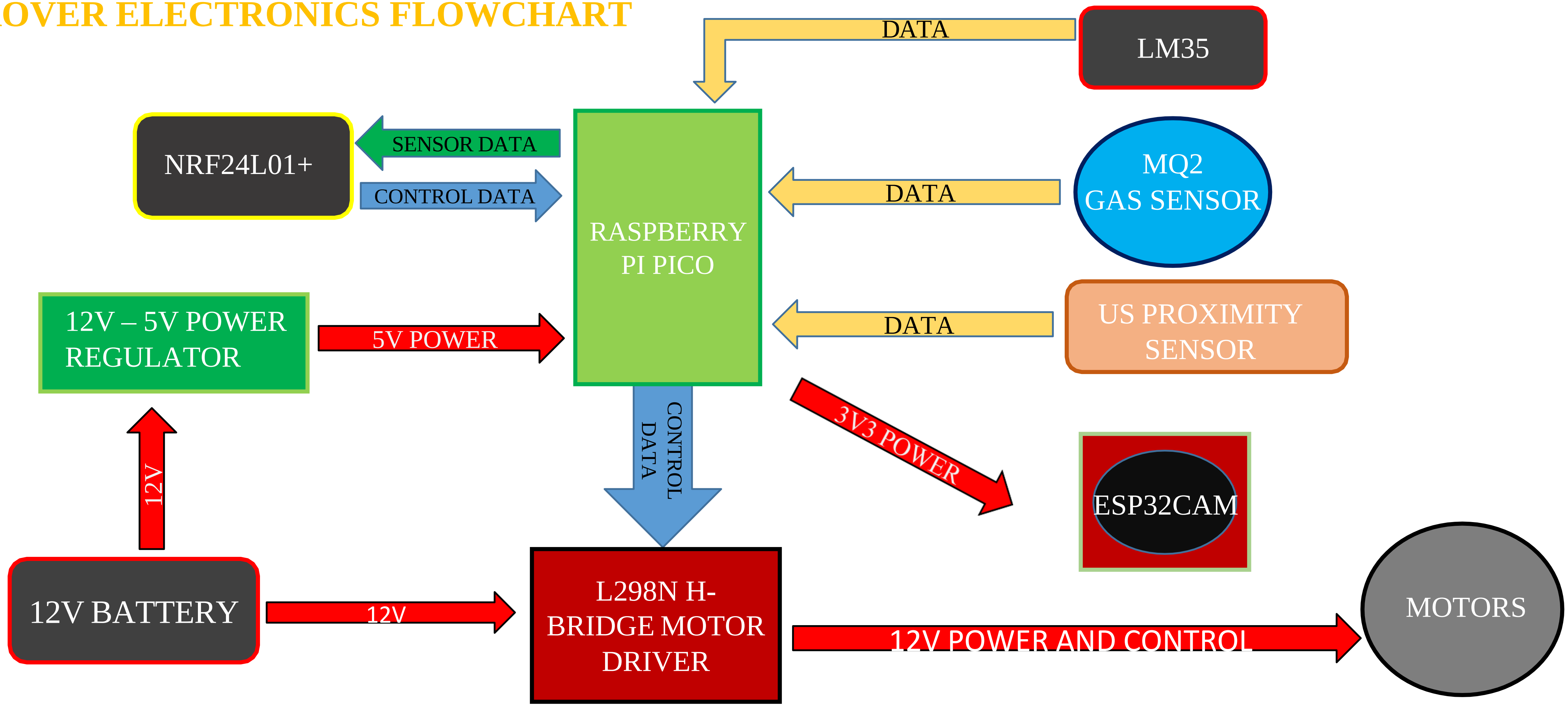


Fig 5.1.3a: ROVER 3D MODEL SIDE VIEW

5.2 ELECTRONICS

5.2.1 ROVER ELECTRONICS FLOWCHART



5.2 ELECTRONICS

5.2.2 REMOTE CONTROLLER

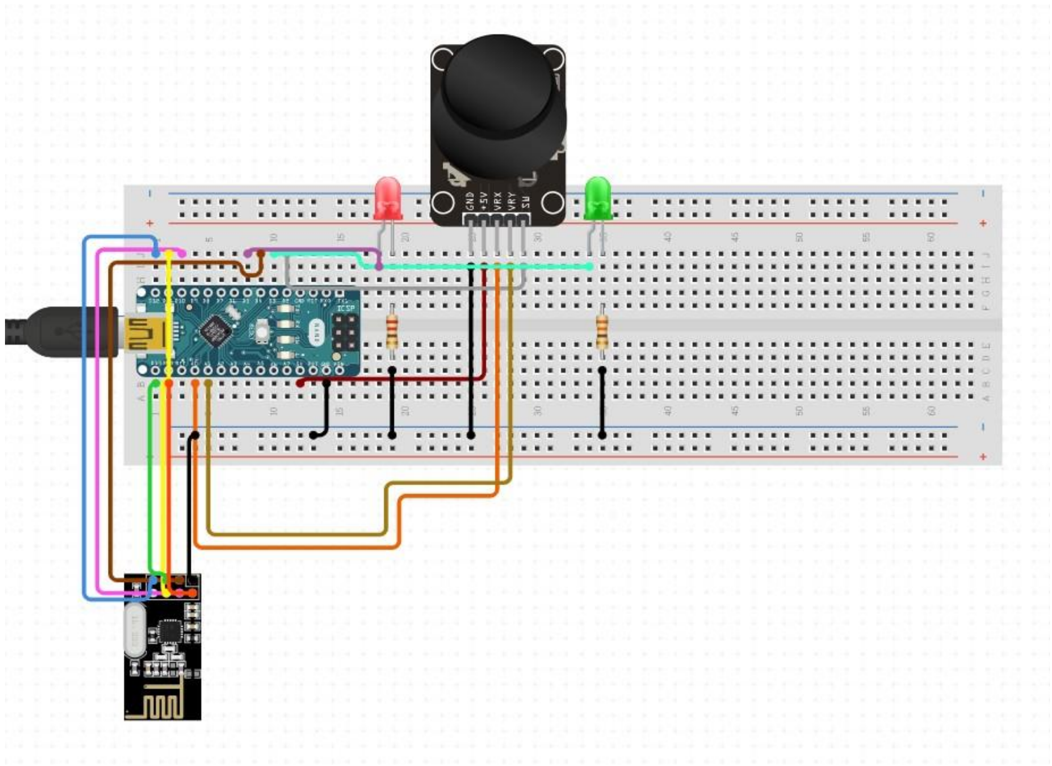


Fig 5.2.2a: Remote controller circuit

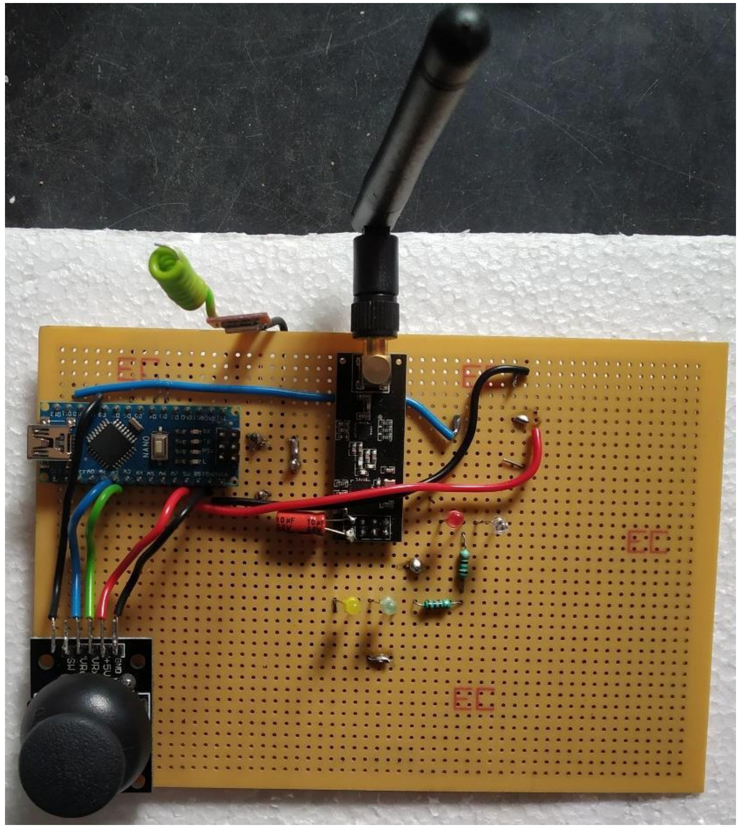


Fig 5.2.2a: Remote controller

6.0 BUDGET DETAILS

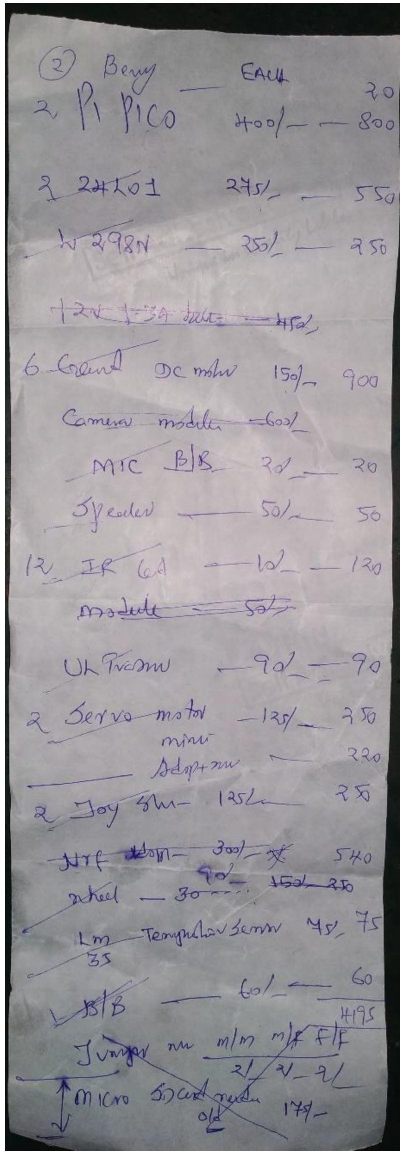
6.1 ELECTRONIC COMPONENTS

Se. no	Item	Price per Item	Quantity	Total item price
	ELECTRONICS			
1	Raspberry Pi Picco	400	2	800
2	Male Header Pins x40	10	2	20
3	nRF24L01 (PA/LNA)	275	2	550
4	LM1117 3V3 SMD	20	2	40
5	L298N Motor Driver	250	1	250
6	Geared DC motor	150	6	900
7	IR LED	10	11	110
8	3.3V Cell Battery	10	1	10
9	Ultrasonic PS	90	1	90
10	Servo Motor	125	2	250
11	JoyStick Module	125	2	250
12	120mm x 40mm Wheels	90	6	540
13	LM35 Temperature Sensor	75	1	75
14	12V Adapter/Charger	110	1	110
15	Bread Board	60	1	60
16	USB-UART Adapter	161	1	161
17	12V Battery	475	1	475
18	12V to 5V/3V power supply module	150	1	150
19	Prototyping PCB	50	3	150
20	Hook-up wire (1pck)	45	1	45
21	Female header pins x40	10	2	20
22	MQ-2 gas sensor	220	1	220
23	ESP32 CAM	650	1	650
	Total			***5962***

6.2 MECHANICAL COMPONENTS

Se. no	Item	Price per Item	Quantity	Total item price
		HARDWARE		
1	PVC Pipe	24.5/feet	10	240
2	Nuts/Bolts	5	100	190
3	Solder Wire	10	2	20
4	PVC Dendrite Solution	60	1	60
5	PVC Joint 120	25	2	50
6	PVC Joint 90	15	6	90
7	Pipe Fasteners	6	10	60
8	Heat Shrinking Plastic	0	0	0
9	Waterproofing Wax	82	1	80
10	Acrylic sheet	0	0	0
11	L-joints	45	10	45
12	Glue-gun stick	10	2	20
13	Double-sided tape	8	2	16
14	1.5V Battery	14	4	56
15	Acrylic sheet cutter	30	1	30
16	Hacksaw Blade	10	1	10
	Total			***967***

6.3 BILLS OF COMPONENTS AND MATERIALS PURCHASED



4/29/2021 Invoice

ELECTRONICSCOMP.COM

Invoice #2370296

Order Details	
ElectronicsComp.com Constflick Technologies Private Limited Building No 13 and 14, 3rd Floor, 2nd Main, Siddaiah Road Near Passport Office Sudhama Nagar, Bangalore, Karnataka - 560027 India. Customer Support - care@electronicscomp.com **Mobile** +91-9008032648 **E-Mail** care@electronicscomp.com **Web Site:** https://www.electronicscomp.com (https://www.electronicscomp.com)	**Date Added:** 20/04/2021 **Invoice No.:** INV/21-22/5441 **Invoice Date :** 22/04/2021 **Order ID:** 2370296 **Payment Method:** Debit Card, Credit Card, NetBanking, UPI and Wallet **Shipping Method:** Flat Shipping Rate **GSTIN No.:** 29AAGCC1645N1ZA

Billing Address	Shipping Address
Arun Prasad B-3 Complex, Vel Tech University, Avadi, Chenai - 600062 Chennai 600062 Tamil Nadu India Contact No. - 7029857771 Email. - dslowden19@gmail.com	Arun Prasad B-3 Complex, Vel Tech University, Avadi, Chenai - 600062 Chennai 600062 Tamil Nadu India

No. of Products	Model	HSN Code	Quantity	Price	Tax	Total
MB102 Breadboard Power Supply Module 3.3V/5V	EC-0467	8504	1	Rs.59.00	IGST (18%)	Rs.59.00
40x2 Pin Female Berg Strip - Break Away Header Straight	EC-0654	8536	1	Rs.13.50	IGST (18%)	Rs.13.50
12V 1.2Ah Rechargeable Sealed Lead Acid Battery	EC-0963	8507	1	Rs.550.00	IGST (28%)	Rs.550.00
Single Strand Hookup Wire - 22AWG (Gauge) - Yellow - 5 metre	EC-2737	8544	1	Rs.35.00	IGST (18%)	Rs.35.00
9x15 cm Double Sided Universal PCB Prototype Board	EC-2798	8534	2	Rs.101.00	IGST (18%)	Rs.202.00
MT76813DBI ESP8266 Serial WiFi Wireless Gain Antenna	EC-4971	8517	1	Rs.99.00	IGST (18%)	Rs.99.00
					Sub-Total	Rs.958.50
					Flat Shipping Rate	Rs.49.00

https://www.electronicscomp.com/index.php?route=account/order/invoice&order_id=2370296 1/2

4/29/2021 Invoice

No. of Products	Model	HSN Code	Quantity	Price	Tax	Total
					IGST (18%)	Rs.82.35
					IGST (28%)	Rs.154.00
					Total	Rs.1,243.85

CONSTFLICK TECHNOLOGIES (OPC) PRIVATE LIMITED BANGALORE

ElectronicsComp.com - Order 2356217

1 message

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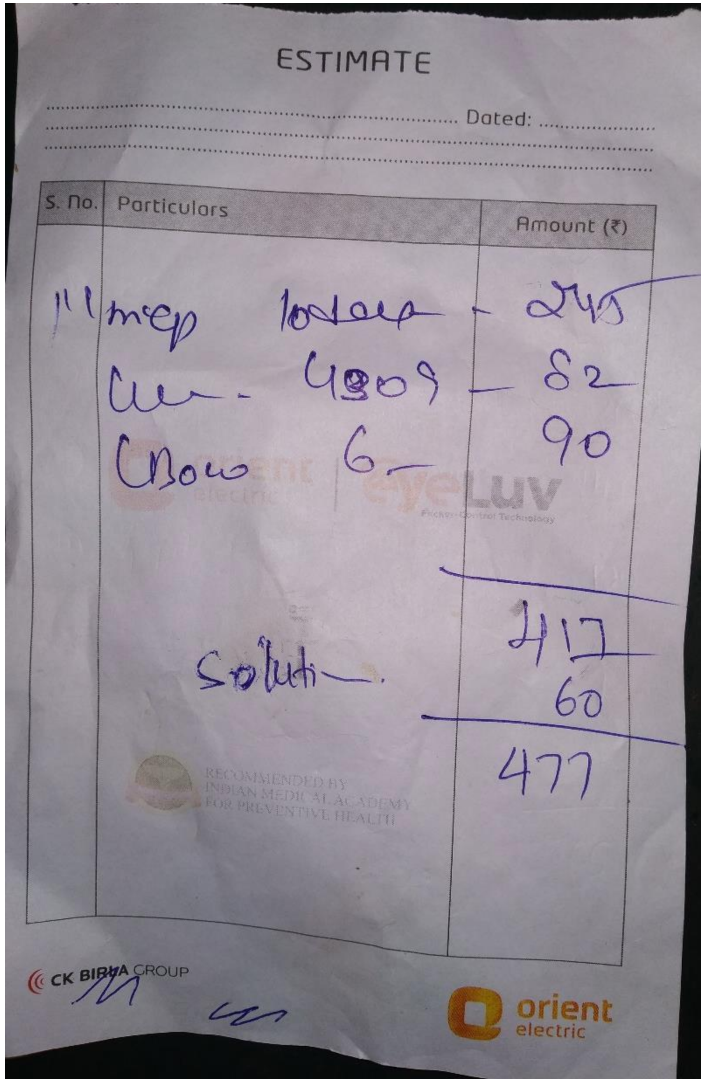
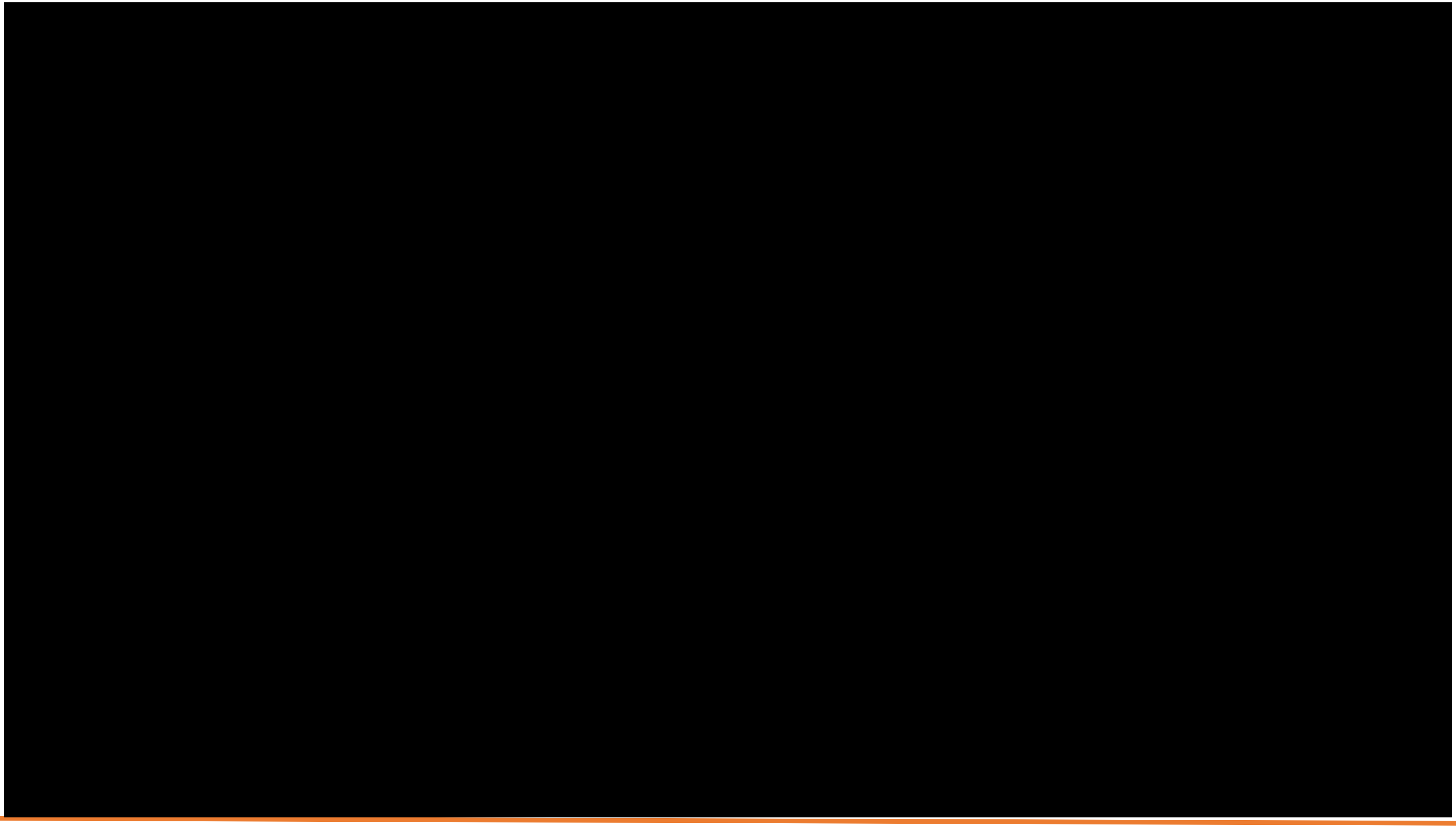
Order Details	
Order ID: 2356217 **Date Added:** 02/04/2021 **Payment Method:** Debit Card, Credit Card, NetBanking, UPI and Wallet **Shipping Method:** Flat Shipping Rate	**E-mail:** praun09@gmail.com **Telephone:** 7029857771 **IP Address:** 115.240.192.149 **Order Status:** Confirmed

Payment Address	Shipping Address
Arun prasad heroes hostel, B 3 Complex , Veltech University, Avadi, Chennai 600062 Tamil Nadu India	Arun prasad heroes hostel, B 3 Complex , Veltech University, Avadi, Chennai 600062 Tamil Nadu India

Product	Model	HSN Code	Quantity	Price	Total
CP2102 USB 2.0 to TTL UART Serial convertor Module	EC-1180	8538	1	Rs.98.00	Rs.98.00
ESP32 CAM WiFi Module Bluetooth with OV2640 Camera Module 2MP For Face Recognization	EC-4974	8517	1	Rs.540.00	Rs.540.00
				Sub-Total:	Rs.638.00
				Flat Shipping Rate:	Rs.49.00
				IGST (18%):	Rs.123.66
				Total:	Rs.810.66



7.0 DEMONSTRATION OF OUR ROGV



8.0 RESULTS

- The following data were obtained from the rover over radio communication. Fig.10a

- Rover's 12V 1.3 Ah battery lasts for about 20mins.

```
Shell ×
                REMOTE DATA...
SYSTEM TEMPERATURE:          32.19398 *C
SELECTED SPEED:              1
                ROVER DATA...
ENVIRONMENT TEMPERATURE:     28.15645 *C
OBSTACLE DISTANCE:           42.545 cm ,     DROP ALERT:   False
LPG LEVELS:                  246 ppm
CO LEVELS:                   45 ppm
SMOKE LEVELS:                82 ppm
```

Fig.10a: ROVER DATA DISPLAYED ON THE MICROPYTHON SHELL

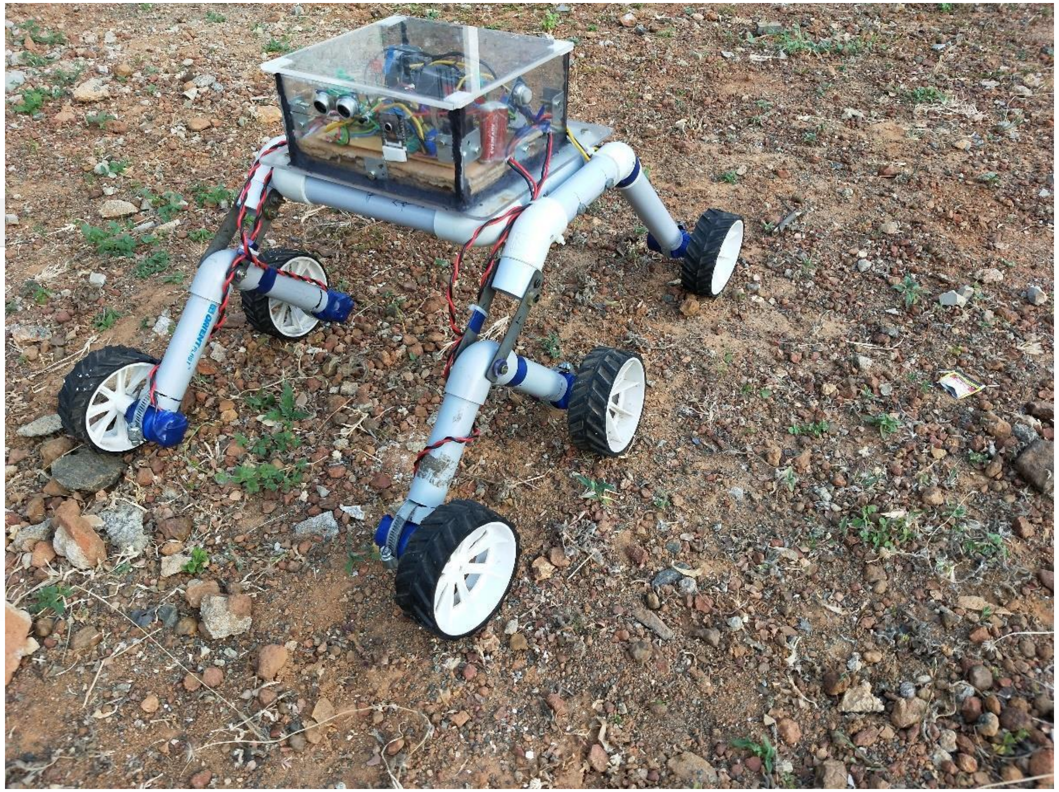


Fig.8.1: FABRICATED ROVER MODEL

9.0 CONCLUSION

- The model built will serve the purpose of the defined problem.
- The design is comparatively economical.
- The ROGV is designed for unpredictable terrain and it’s aided by the implementation of the rocker-bogie mechanism.
- Camera is functional and we can get live camera stream to examine the environment.

9.1 FUTURE SCOPE

- The camera can be made movable.
- Changes in the current model can be made for better functionality, range and performance.
- LoRa (Long range radio module) can be used to increase the operating range of the ROGV.
- Path tracking of the rover and automatic return of the rover could possibly be implemented in the future.
- The ROGV can be made more maneuverable in water.

THANK YOU