International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 09 | Sep 2020 www.irjet.net p-ISSN: 2395-0072

COMBINATIONAL ROVER–A MULTIPURPOSE & A ECONOMICAL ROBOTICAL VEHICLE

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ABSTRACT - Technology is being rapidly advancing over a time and there is an inflated demand for this booming technology, when it comes to technological products like Robots, designing and fabricating an advance robot with more and more features is bit difficult task and needs a lots of investment, so How to deal with it**?** Well, if you have such an issue then this paper explains you/gives you a brief idea on how to build your own advance robot in an easiest way and in most economical passion. This paper deals with work on **"**COMBINATIONAL ROVER**"** which was built in most economical passion. Combinational Rover is a multipurpose robotic vehicle designed with a combination of Rocker bogie mechanism with obstacle avoiding feature, it also has many other feature like automatic solar charger with a solar panel and a solar regulator, automatic headlights based on environmental lighting conditions, temperature and humidity analyzer, fire detector, Wi-Fi camera and mainly it has two modes of interactions, one is manual mode and the other one is automated mode. Manual is Bluetooth controlled and automated is using a loop function with ultrasonic ranging module. The peculiarity of this robot is that, it is designed and fabricated in most efficient & economical way and meets almost 60% all the feature of the robotic vehicle which are made in industries with huge investments.

Key words: **Obstacle avoidance, Ultrasonic sensor, Arduino microcontroller, Autonomous robot, Arduino software.**

1. INTRODUCTION:

Technology is getting advanced day by day in almost all the sectors, as many organizations are upgrading themselves for industry 4.o, automation is being installed and used in all the phases of industries. Automation and robotics plays a major role in this society. It makes life easier, convenient and adds classiness to the life, and it also saves major time. "Robotics" the word which means "A study of robots", Robots are nothing but a reprogrammable machine which does repetitive tasks for unlimited time. There are many types of robots available in market like welding robot, painting robot, pick and place robots, inspection robots and many such. But are they available in low cost? Definitely my answer is No, in fact Robots which are now available in market are very expensive and needs a trained professional to operate it. Well this should not become a barrier for anyone who wants to opt a new technology, as we know that nothing is impossible in this world. Here we are introducing you to a robot called "COMBINATIONAL ROVER" which is an economical and also an advanced robotic vehicle. It is a Combination of Rocker Bogie Mechanism with Ultra-Sonic Obstacle Avoiding Feature, it's an exploration robot which depicts NASA rover mechanisms. It's a robotic vehicle, with automatic solar charger (using solar panel), regulator and it do comprise of many sensors like ultrasonic sensor, DHT11, LDR, Wi-Fi camera. Some relays and a microcontroller(Arduino) with a servo motor and dc motors. This robot has two modes of interactions, one is automatic mode and other one is manual mode. It is designed with rocker bogie mechanism. This mechanism was used in NASA exploration project. The aim of this project is to build a smart and intelligent robotic vehicle which have interface to many sensors, crawl in terrain areas, to have an automatic solar charging unit peculiarly a robotic vehicle which has two modes of interaction and at last to achieve all these features in low cost. These type of automated robotic vehicles can be used in research and development fields, explorations of terrain areas, industries (for inspection).

2. LITERATURE SURVEY

ManishaB.Bansode et al.[1] in 2015 proposed a system for controlling the rover through Android application. The control of robot movement is developed in this study through the use of accelerometer. The controls are forward, backward, right and left motion. When any change occurs, the axis in the accelerometer will be sent to robot via Wi-Fi, then, the robot will move according to the changes of the value, and the axis is accepted.

Subankar Roy et al.[2] in 2016 developed a rover which can be controlled through Bluetooth. The

main aim of this paper was to provide simpler robot's hardware architecture with powerful computational platforms to enable robot designer to focus on the implementation and tests. This paper explains a very simple architecture for the robot which can further be used for various experimental courses. The advantage of low cost makes it more advantageous for students to use.

Shoeb Maroof Shaikh et al.[3] in 2015 developed a Wireless Video Surveillance Robot, to help in security purpose. This paper describes the implementation of the application for the mobile devices that run on Android operating system. It is controlled through the Bluetooth technology. This paper also discusses the use of the camera attached on the robot that transmits live video feed onto the designed android application using Wi-Fi technology. This application lets the robot control interactions with the help of GUI.

Faiza Tabassum et al.[4] in 2017 developed an obstacle avoiding robot to detect and avoid obstacles in its path for obstacle detection, three ultrasonic distance sensors were used that provided a wider field of detection. The robot is fully autonomous and after the initial loading of the code, it requires no user intervention during its operation. When placed in unknown environment with obstacles, it moved while avoiding all obstacles with considerable accuracy.

3. CONCEPTUALIZATION

After the launch of mars curiosity rover by NASA in the year 2011, there was a urge to many researchers, students to learn about its mechanism, features, movements etc. But due to lots of investment required to build such a robotic vehicle, many people have stopped their work including me. So I thought of building prototype of a robotic vehicle in a most simple way using commonly available sources, so that we can study its functions, capture its movements and also these type of economical multitasking vehicles can be used in Research & Development, Inspections etc.

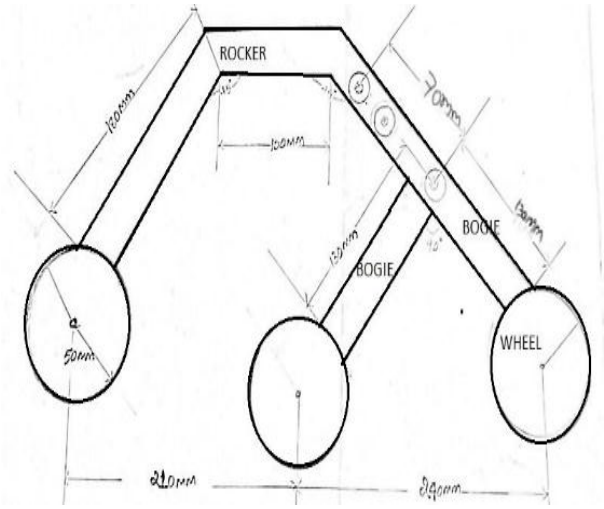
4. DESIGN

We can divide design phase in two major units, they are

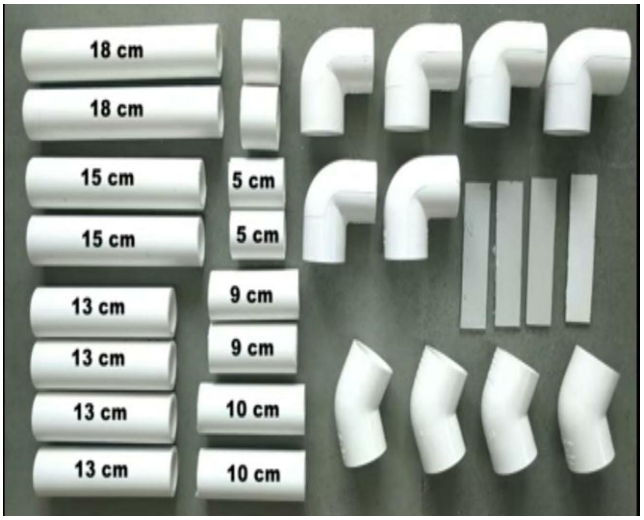
I) Rocker Bogie design
II) Circuit design

4.a) About Rocker Bogie: The rocker-bogie system is the suspension arrangement used in the Mars rovers. It was introduced for the Mars Pathfinder and also used on the Mars Exploration Rover (MER), It is currently NASA's favoured design. The term "rocker" comes from the rocking aspect of the larger links on each side of the system. These rockers are connected to every other and therefore the vehicle chassis through a differential. Relative to the chassis, when one rocker goes up, the opposite goes down. The chassis maintains the typical pitch angle of both rockers. One end of a rocker is fitted with a drive wheel and therefore the other end is pivoted to a bogie. The term "bogie" refers to the links that have a drive wheel at each end. Bogies were commonly used as load wheels within the tracks of army tanks as idlers distributing the load over the terrain. Bogies were also quite commonly used on the trailers of semi-trailer trucks. Both applications now prefer suspensions. The rocker bogie system reduces the motion by half compared to other suspension systems because each of the bogie's six wheels has an independent mechanism for motion and every wheel of this technique also has thick flutes like pattern which provides grip for climbing in soft sand and scrambling over rocks easily **picture 1(c)**. So as to beat vertical obstacle faces, the front wheels are forced against the obstacle by the centre and rear wheels which generate maximum required torque. The rotation of the front wheel over the obstacle lifts the front a part of the vehicle up and overcome the obstacle. Those wheels which remain within the centre, is then accelerated over the obstacle by the rear wheels and climbs the over the obstacle eventually, the rear wheel is pulled over the obstacle by the front and centre wheel. When each wheel overcome the obstacle, forward progress of the vehicle is slowed or completely halted which finally maintain vehicles centre of gravity.

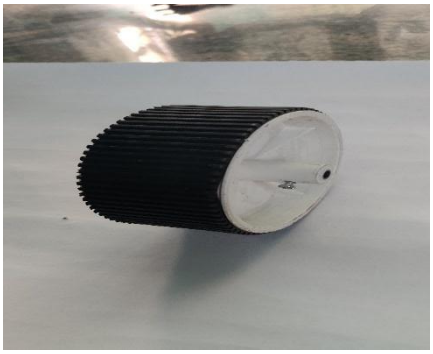
[I] Design: For our project I have used PVC as a material because of its high strength, durability although and easily available. We can use many other materials like aluminium, high carbon and also composites material like plastic fibre reinforced with aluminium etc. But these materials are bit costlier. Following **picture 1(a**) shows the design of rocker bogie system with measurements. And **picture (b)** shows the detail of joints, bends and links used in this project .and every joint is connected using strong and durable steel nuts and bolts. Six individual link has its own independent motor connected at the end. shown in figure 1(d)



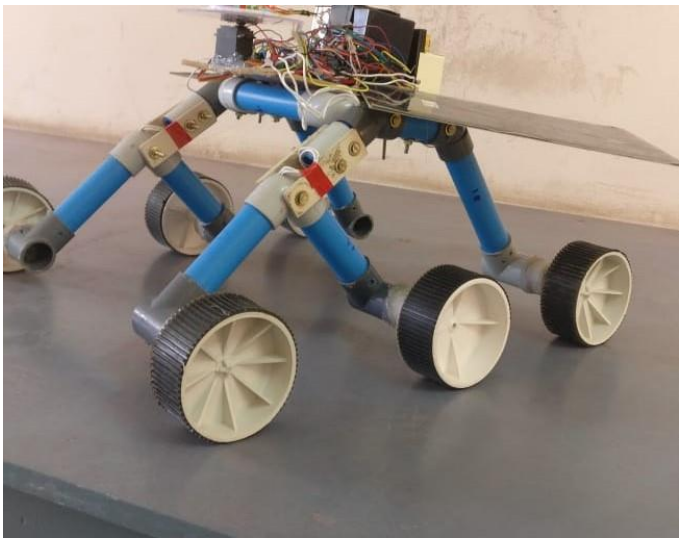
Practical Fig-1(a)



Practical Fig-1(b)



Practical Fig-1(c)



Practical Fig-1(d)

[II] Circuit design: Circuits design is not done to complicated. I have designed circuit in an easy way so that everyone can understand it.

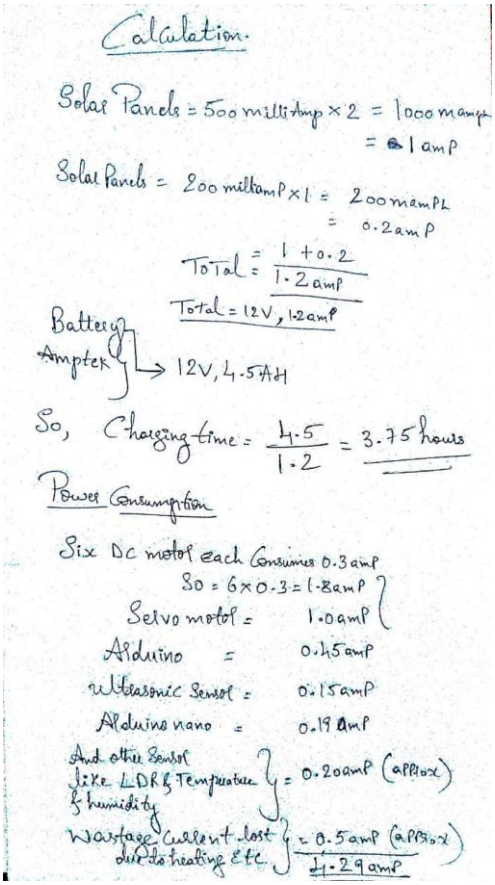
Components used here for circuit are :

1) Arduino Uno
2) Motor driver –L298 2a
3) Dc motor -100 rpm
4) Ultrasonic sensor-HC-SR04
5) Relays
6) Servo motor –MG995
7) Dc battery -12 v, 4.5 AH
8) Solar panel of 12v 500 milli amp x 2
9) Solar panel of 12v 200 milli amp x 1
10) Solar charge regulator
11) Light-dependent resistor
12) Temperature and humidity sensor
13) Bluetooth receiver /transmitter –HC05
14) Wires

As heart of this circuit we have microcontroller known as Arduino Uno which is connected to an ultrasonic sensor and HC-05 for its communication as input. Arduino is further connected to motor driver L298 2a, and later from motor driver its ben connected to six dc motors. And another output from Arduino is connected to MG995 servo motor for sensor movement. Another part of circuits contains an Arduino mini with light dependent resistor, temperature and humidity sensor as input and with an another Bluetooth transmitter to transmit the data collected via sensors (temperature, humidity, light condition). And a relay is also connected to it as output which activates a bright led when LDR shows bad lighting condition for its movement.

Now coming to power it is being powered by 12 v 4.5 ah lead acid battery. For its automatic charge control unit, we have three solar panels connected to it. in which two are of 12v, 500 milli amp and another one is of 12v 200 milli amp. All three solar panel are connected in parallel connection and are connected to a battery via a solar charge regulator. And all the ground connection is made common to make it work in a clockwise as one unit.

Calculation:



Practical image 1

The above calculation is a completely theoretical.

Brief explanation on calculation show in image 2:

As we know that there are three solar panels in which two are of 12v, 0.5 amp each and other one is 12v, 0.2 amp, so overall when all the solar panel is connected din parallel way voltage remains constant but current of all the three panels adds up. So the total current which we get for charging through solar panel to the battery via solar charge regulator is 12v, 1.2 amp. Battery is of 12v, 4.5 amp, therefore charging time is 4.5/1.2=3.75 hours. And overall power consumption is 4.29 amp which is nearly equal to power supplied.

5. Main components used here with its specification:

a) Arduino Uno:

Practical image 2(a)

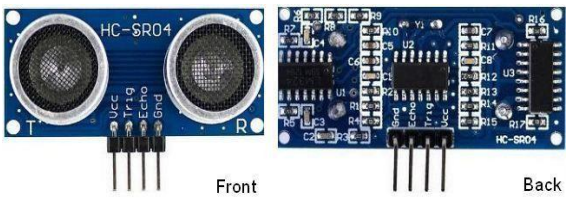
- Microcontroller: ATmega328P
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Input Voltage (limit): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- PWM Digital I/O Pins: 6
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- DC current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB (ATmega328P) of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328P)
- EEPROM: 1 KB (ATmega328P)
- Clock Speed: 16 MHz
- LED_BUILTIN: 13
- Length: 68.6 mm
- Width: 58.4 mm
- Weight: 25 g

b) L298 2a - MOTOR DRIVER:

Practical image 3(b)

- Driver Model: L298N 2a
- Driver Chip: Double H Bridge L298N
- Motor Supply Voltage (Maximum): 46V
- Motor Supply Current (Maximum): 2A
- Logic Voltage: 5V
- Driver Voltage: 5-35V
- Driver Current:2A
- Logical Current:0-36mA
- Maximum Power (W): 25W
- Current Sense for each motor
- Heatsink for better performance
- Power-On LED indicator

c) HS-SR04 ULTRASONIC SENSOR:



HC-SR04

Fig Practical image 3(c)

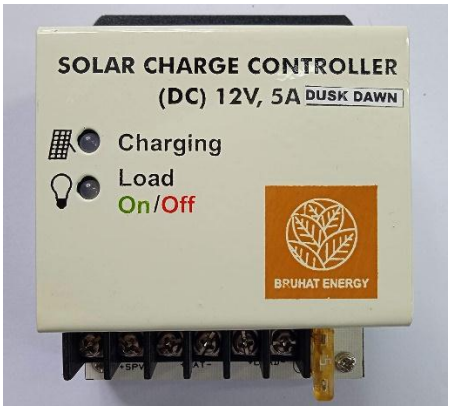
- Operating voltage: +5V
- Theoretical Measuring Distance: 2cm to 450cm
- Practical Measuring Distance: 2cm to 80cm
- Accuracy: 3mm
- Measuring angle covered: <15°
- Operating Current: <15mA
- Operating Frequency: 40Hz

d) Bluetooth receiver /transmitter:

Practical image 3(d)

- Serial Bluetooth module for Arduino and other microcontrollers
- Operating Voltage: 4V to 6V (Typically +5V)
- Operating Current: 30mA
- Range: <100m
- Works with Serial communication (USART) and TTL compatible
- Follows IEEE 802.15.1 standardized protocol
- Uses Frequency-Hopping Spread spectrum (FHSS)
- Can operate in Master, Slave or Master/Slave mode
- Can be easily interfaced with Laptop or Mobile phones with Bluetooth
- Supported baud rate: 9600,19200,38400,57600,115200,230400,460800.

e) Solar charge controller:



Practical image 3(e)

This is a 12V, 5A Solar Charge Controller, which uses relay and operates on Direct Current. The following are the parameters that need to be maintained before proceeding with the connection: Max. PV Voltage: 25V Max. Charging Current: 5A Max. Discharge Current: 5AProcedure for connection Kindly ensure that polarity is maintained during the connection.

1) Firstly, connect the Battery terminals to the charge controller

2) Next, connect the Solar panel

3) Lastly, connect the Load operating on 'Direct Current

Indications on Charge Controller

1)Charging: Green LED is continuously on until Battery reaches 14.7V. After which it toggles between Yellow and Green colours respectively, due to Battery self-discharge. If no solar voltage i.e. during night time or highly overcast condition (<6V) then this stops glowing.

2) Load Off- Red LED glows indicating that 'Battery Low' has reached i.e. 11 V or Solar module voltage is 6V & below. During this condition. Load cannot be operated or switched on.

3) Load On - Green LED glows indicating the Battery is at 12.5V or higher and Load can be operated.

f) MG995 SERVO MOTOR:

Practical image 3(f)

- Metal geared servo for more life
- Stable and shock proof double ball bearing design
-
- High speed rotation for quick response
- Fast control response
- Constant torque throughout the servo travel range
- Excellent holding power
- Weight: 55 g
- Dimension: 40.7×19.7×42.9mm
- Operating voltage range: 4.8 V to 7.2 V
- Stall torque: 9.4kg/cm (4.8v); 11kg/cm (6v)
- Operating speed: 0.2 s/60º (4.8 V), 0.16 s/60º (6 V)
- Rotational degree: 180º
- Dead band width: 5 µs
- Operating temperature range: 0ºC to +55ºC
- Current draw at idle: 10mA
- No load operating current draw: 170mA
- Current at maximum load: 1200mA

g) DC MOTOR (12VOLTS, 100 RPM):

Practical image 3(g)

- **100RPM 12V DC motors with Gearbox**
- **3000RPM base motor**
- **6mm shaft diameter with internal hole**
- **125gm weight**
- **Same size motor available in various rpm**
- **1.2kgcm torque**
- **No-load current = 60 mA(Max), Load current = 300 mA(Max)**

h) LDR light sensor:

Practical image 3(h)

Sensor Model	LDR
Voltage	+3.3V
Input	Light
Output	Analog Signal
Units	LUX

i) Battery:

Lead acid battery of 12v, 4.5 Ah

Practical image 3(i)

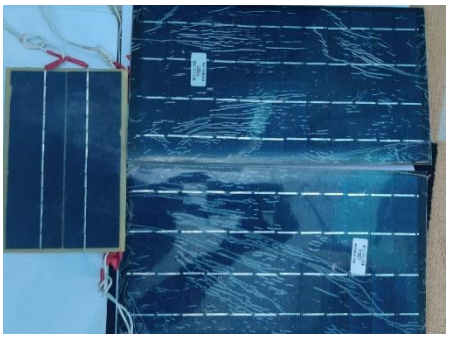
j) Solar panel:

Practical image 3(j)

Volt: 12v

Current: o.5amp and o.2 amp

k) wheels:



Practical image 3(k)

Wheel diameter: 10 cm

Shaft diameter :6mm

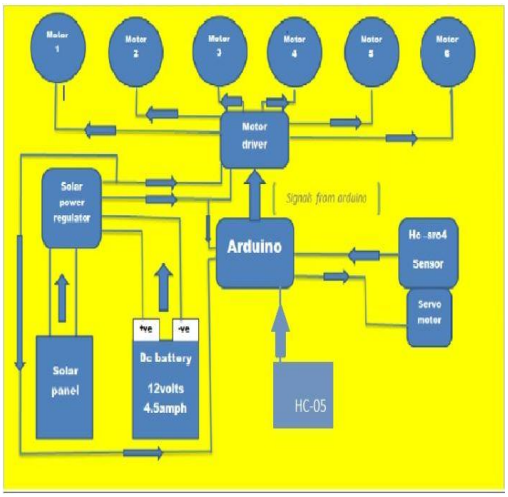
6. Working

This robot has two modes of interaction one is automated mode and another one is manual mode. Logic for this robots is as follows at the start when the robot power is on, initially it waits for 1 min for manual signal via Bluetooth if signals are not transmitted by us or if the signals are not received by robot then automatically it goes for autonomous mode where it takes continuous analog signals from ultrasonic sensor as input to Arduino which reads the data and sends further signals to motor driver accordingly and motor driver sends further signals to motor to rotate accordingly.

(Question: you may have doubt why to use motor driver as intermediate between Arduino and motor driver …?)

The answer is that Arduino understands high level language but motors won't understand high level language as they understand low level language/machine language i.e. binary numbers. So to convert the high level language into a low level machine readable language we use motor driver as intermediate between Arduino a motor.)

If signals are transmitted via Bluetooth using a Bluetooth mobile application in mobile phones within 1 min then it shifts to manual mode where one can operate it as required. After it enters any of the mode neither automated mode nor manual mode it can be changed via reset button only. This might be disadvantage of this robot. But having two modes of interaction in one robot is advantageous.



Block diagram - Practical image 4(a)

Prototype picture: Practical image 4(b)

7. Advantages

- On the top it has two modes of interaction which makes it more advantageous
- It doesn't require manual operator to operate it or control it, as it is automated so it eliminates human operator.
- It has an equal distribution of load on all six wheels.
- It can be driven even on uneven terrain.
- Whenever robot senses any obstacle automatically diverts its position to left or right and follows the path without human guidance.
- Can be left in larger areas for more time for inspection as it carries its self- charging solar circuit and solar panel with it to charge battery continuously.
- Low cost, effective and efficient robot.
- Can be used where human interruption is dangerous.
- It senses the temperature and humidity.
- It has automatic led (off/on) according to environmental lightning conditions

8. Disadvantages

- The system is designed to be used at slow speed of around 10 cm per second (3.9 in/s) so as to minimize dynamic shocks and consequential damage to the vehicle when surmounting sizable obstacles
- Since it moves very slow, work done by it is more time consuming

- It is not water proof, so must be protected/kept far from rain /water.

- After it enters any of the mode neither automated mode nor manual mode it can be changed via reset button only.

9. Conclusion

This is a wide field of study and is very less explored. So this gave me the motivation for the development of this Combi Rover model in a cost effective manner. My concern during the development of rover is to optimize the speed such that the rover does not flip and may travel a little faster. Mainly to have a multipurpose robotic vehicle with two modes of interaction one is manual and another one is autonomous mode also to make it cost effective with maximum possible results.

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