IET Robotics Club
Institute of Engineering and Technology, Lucknow

A proposal for

Security and Surveillance Robot

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SECURITY AND SURVEILLANCE ROBOT

1. Objective

To design and construct a remote-controlled wireless robot capable of tackling obstacles and fighting on one to one basis that can provide a safe and secure environment in domestic, industrial and military applications.

2. Description

This robot will assist in domestic, industrial and military applications by doing tasks such as monitoring, patrolling, handle risky industrial tasks like moving heavy goods. The robot will have a thermal camera in the front to monitor the situation even in dark light. The camera on the robot is further used to detect faces or objects using machine learning techniques.

The robot can be wirelessly controlled a remote. This robot is capable to carry a payload of up to 100 kg with ease at uneven terrain (rocky, the slope of up to 30 degrees).It may further assist people to carry them in case of injury. It can break through obstacles up to 50 kg as the weapon spins at 5700 rpm develops 42 kilo-joules force. The robot can easily provide its GPS location by sending a command via mobile, which is useful in case if the robot gets stolen. We have tried to keep the centre of gravity of the robot as near to the ground, to avoid flipping of the robot during impacts and inclines. Capable of moving as well as getting back to normal position even after flipping by 180 degrees. This robot is also enriched with artificial intelligence components. It is capable of detecting undesired objects and sending notifications/ alerts to the owner for the same. All the computations are done on-board using by using a raspberry pi.

Key features

- Wireless remote controlled or Autonomous
- Carry heavy payloads.
- Capable of moving in flipped position
- Manoeuvre on uneven terrain
- Break through obstacles by its weapon
- Equipped with camera for monitoring
- Can detect faces
- Provide notification of unusual activity
- Patrolling of house

3. Methodology

The weight of the robot is divided by 30-30-25-15 rule. This rule states that 30% of the total weight is devoted to the driving system (motors, transmission, and wheels) 30% for the weapon system 25% for structure and armour and 15% for the batteries and electronics. Keeping these design complications in mind the design of the robot is first made on papers and then a computer based model is made.

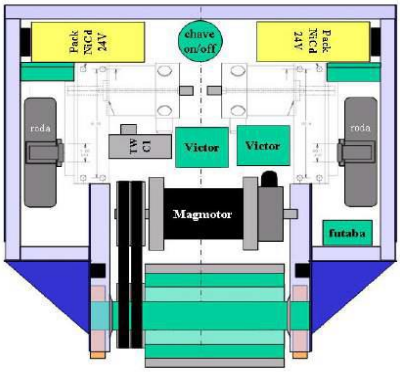


Figure 3.1 2D design for the robot

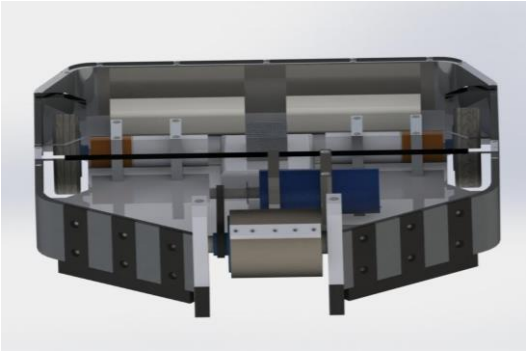


Figure 3.2 3D CAD design

The figure 3.1 shows the design of the robot in a 2D perspective and figure 3.2 shows the design in a 3D perspective.

3.1 Weight distribution

The total weight of the robot is nearly 30 kg so the weight available for various robot systems is

- Drive system (including motor, wheels) - 9.0 kg
- Weapon system - 9.0 kg
- Armour (chassis) - 7.5 kg
- Electronics components (including batteries) - 4.5 kg

3.2 Weapon Design

The Robot will be equipped with a vertical spinner which will be rotating at nearly 5700 rpm at this speed the drum will gain enough potential energy to shatter other robots. One important issue when designing spinning weapons such as disks, bars, drums, and shells is regarding the number of teeth and their height. Too many teeth on a spinning disk, for instance, will make the spinner chew out the opponent instead of grabbing it to deliver a full blow. As conclusion, one should aim for a minimum number on the tooth. The best option is to use 2 teeth so that weight is also balanced properly along the shaft as shown in the figure 3.3 and its CAD model in figure 3.4.

Figure 3.3 Vertical spinner with two teeth

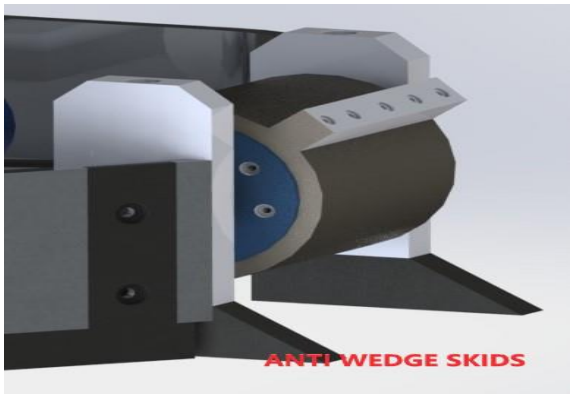


Figure 3.4 Anti wedge skidders

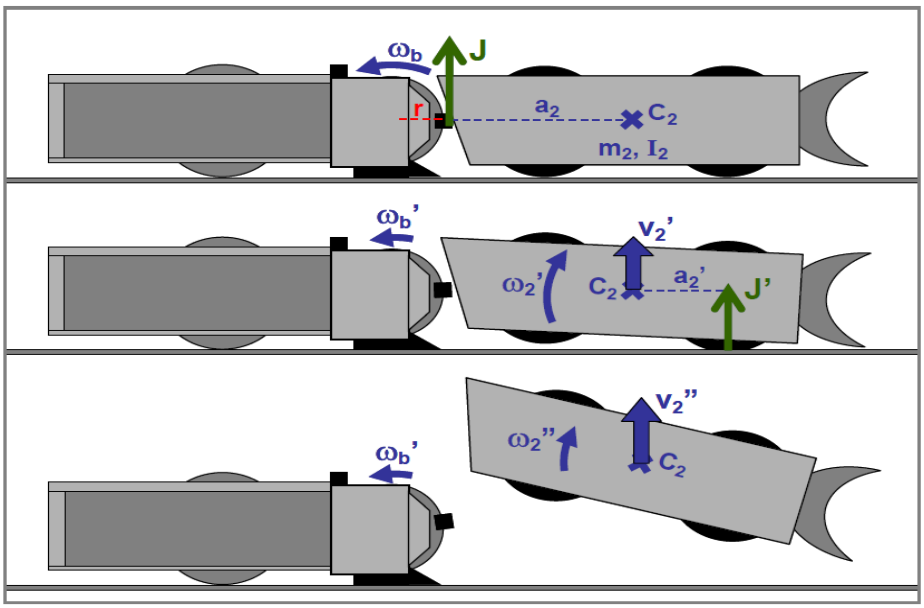


Figure3.5 the impact transfer by spinning drum to another robot

The chassis of vertical spinning robots such as drumbots or vertical spinners do not accelerate during an impact, if the impulse J is vertical in the upwards direction, as pictured in figure 3.5. As long as the spinning drum, disk or bar has solid ground supports that will transmit the entire impulse J without allowing the robot to tilt forward after the attack, the chassis vertical speed v1' and angular speed ω_1' should remain equal to zero. Obviously, the arena floor won't let the attacking robot move down.

Vertical spinners need to have a wide base so that they don't tumble when turning due to the gyroscopic effect of the weapon. The impact force is transmitted to the ground, and not sideways such as with Horizontal spinners, allowing them not to be flung to the sides due to their own impact. Their disadvantages are having their lateral and back exposed, and having a hard time making quick turns due to the gyroscopic effect.

3.3 The Gyroscopic effect:-

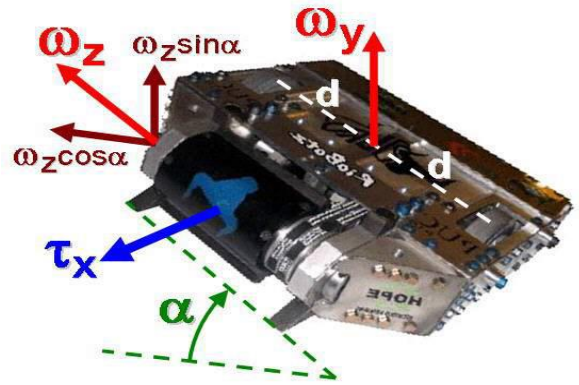


Figure 3.6 gyroscopic effect.

The gyroscopic effect comes from the fact that bodies tend to remain in their state of motion, as stated by Newton's first law. In this case, they tend to maintain their angular momentum. As the robot turns with speed ω_y and with its weapon spinning with ω_z, the robot tilts by the angle α. The projection of the vector ω_z onto the vertical, $\omega_z \cdot \sin\alpha$, doesn't change direction, but the horizontal projection $\omega_z \cdot \cos\alpha$ does, rotating around the y-axis with speed ω_y, which is responsible for the gyroscopic effect. The gravity torque T_x is equal to $m \cdot g \cdot d \cdot \cos\alpha$, where m is the mass of the entire robot, g is the acceleration due to gravity, and d is the distance between each wheel and the robot's centre of mass, as pictured in figure 3.6.

$$T_x = m \cdot g \cdot d \cdot \cos\alpha = I_{zz}.(I_z.\mathrm{Cos}\alpha)./\omega_{y,\mathrm{critical}}$$

$$\omega_{y,\ \mathrm{critical}} = (m.g.d) / (\ I_{zz}.\omega_z)$$

4. Hardware Requirements

To build such a robot, requires many hardware components. The choice of hardware required is an important step to make sure the robot performance is good.

4.1 Materials

The choice of structural materials is an important step to guarantee the robot's resistance without going over its weight limit. It is not a simple task to choose among the almost 100 thousand materials available, and for that it is necessary to know their mechanical properties. Figure 4.1 shows the two properties i.e. impact toughness and resilience of material.

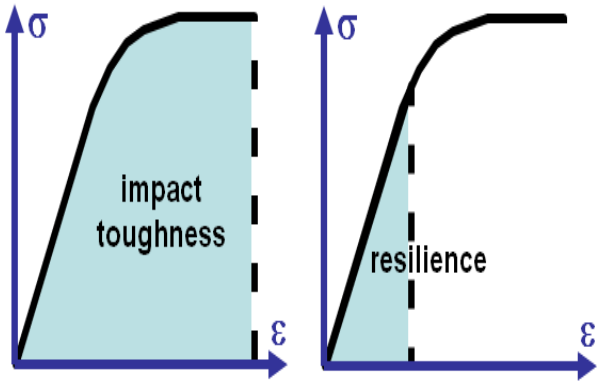


Figure 4.1 Stress-strain graph

4.1.1 Aluminium 6061T

The resistance to dynamic loads is measured by two properties of interest: **impact toughness** and **resilience**. Both measure the resistance of the material to impacts. But the impact toughness measures how much impact energy the material **absorbs before breaking**, while the resilience measures such energy before it **starts to yield** (plastically deform).

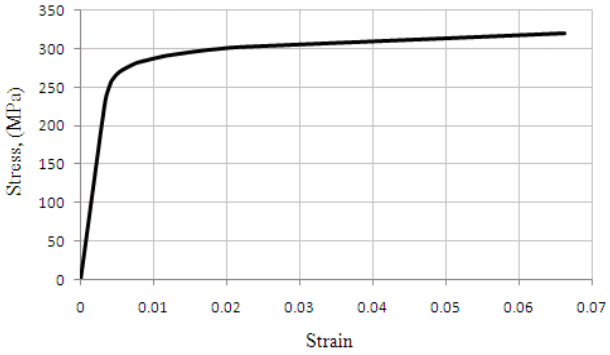


Figure 4.2 Aluminium 6061T stress-strain curve

Considering Figure 4.2, it is concluded that the **Tensile yield strength** of aluminium 6061T is nearly 276 MPa and **Ultimate tensile strength** is 310 Mpa and has a density of 2.7 g/cc. So, the chassis of the robot will be made from aluminium 6061T, because it offers high tensile strength with low density.

4.1.2 EN 24 Steel

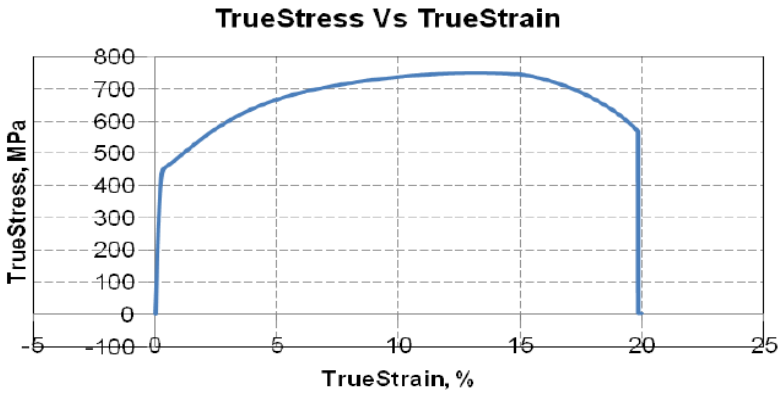


Figure 4.3 Stress-strain curve for EN24 steel

Considering the figure 4.3, it is concluded that the **Ultimate Tensile strength** of EN24 steel is about 800-1000 Mpa and **Yield tensile strength** is 680 Mpa and having a density of 7.8 g/cc. So using EN24 as a material for the weapon is a good choice. EN-24 Steel will be used to design the vertical spinner because it has very high tensile strength and is also wear resistance.

4.2 Components Required

For movement and functioning of the robot, it requires many components. There are large numbers of options available in the market to choose from, with their own pros and cons. All the components mentioned are well studied and found suitable for proper functioning of the robot.

4.2.1 Drive Motors

For the movement of such a big robot, this requires a large amount of torque from motors. This amount of torque is provided easily by an ebike motor. The figure 4.4 shows an actual view of motor whereas figure 4.5 shows its dimensions. These two motors can easily carry the robot's weight as well as a payload of up to 100 kgs. The motor runs on 24V supply voltage and consumes a current of about 19A at full load condition.

Figure 4.4 Ebike motor

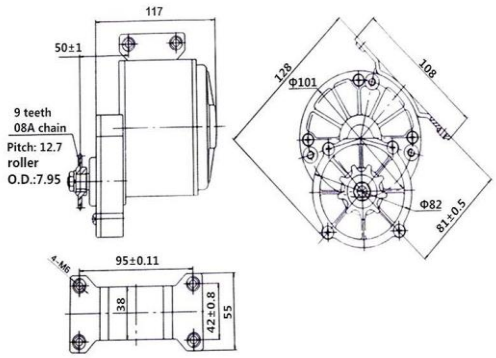


Figure 4.5 Size specifications of an Ebike

Specifications:-

- Model - MY 1016Z2
- Voltage - 24V
- Rated Amps - 19.2 A
- Current type - DC
- Power - 350 W
- Gross Weight - 3.15 kg
- Rated speed - 3000 Rpm

4.2.2 Weapon Motor

Unlike the drive motors the weapon motor does not require much torque but require a much higher speed (RPM). Using Ampflow E30-150 provides 5700 Rpm at 24 Volts at a much affordable price as compared to other available motors. Figure 4.6 shows the actual view of motor and figure 4.7 shows the size specification of the motor. The figure 4.8 shows the various parameters of motor vs torque graph. From the figure 4.8 it is concluded that in maximum load condition the motor may require up to 250A of current.

Figure 4.6 Actual view of motor

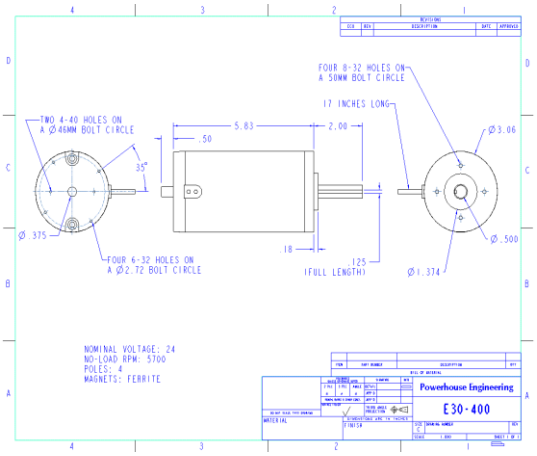


Figure 4.7 Size specification

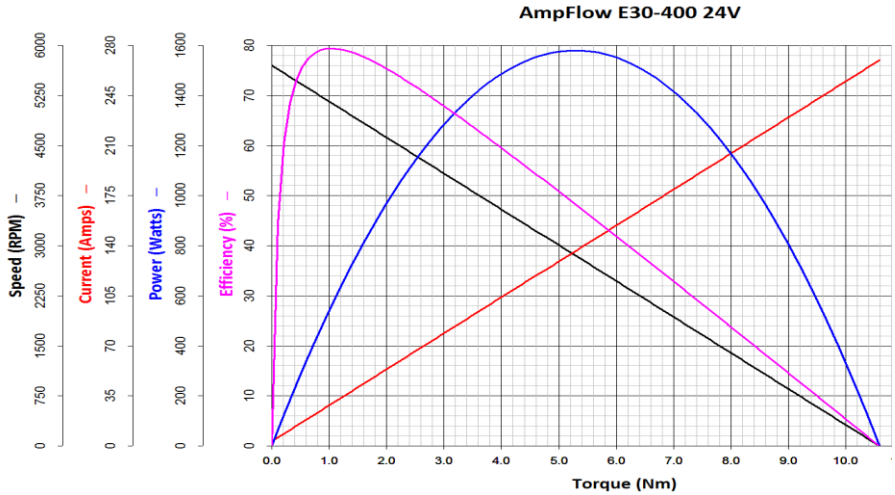


Figure 4.8 Performance chart of Ampflow E30-400

Specifications

- Model - E30 400
- Diameter(inches) - 3.1
- Length(inches) - 5.8
- Peak HP - 2.1
- Nominal Voltage - 24 V
- RPM @24V - 5700
- Weight - 2.7 kg

4.2.3 Motor Driver

A motor driver uses a larger chip or discrete FETS which are able to handle larger amounts of current and higher voltages than the standard 5V/3.3V from a microcontroller pin. They allow you to control a much larger load, from a small signal. So the motor driver suited for out need is SmartElex dual-channel motor driver as pictured in figure 4.9.

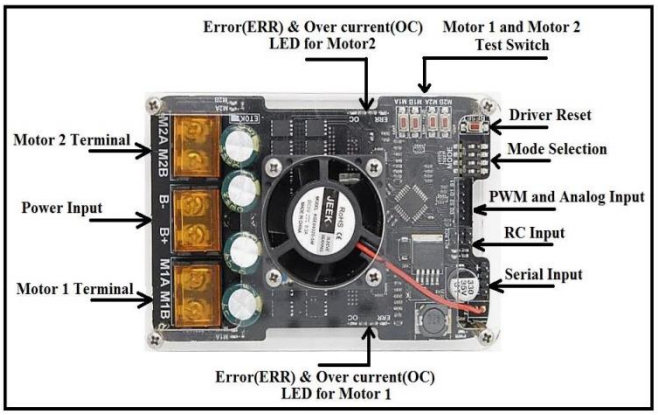


Figure 4.9 Motor driver

Specifications

- Model - SmartElex 30D
- Operating Voltage - (3 V - 30 V)
- Continuous current - 30 A
- Peak Current - 80 A (10 seconds)
- Dimensions in mm(L*B*H) - 115*76*52
- Weight (in grams) - 174
- Cooling Fan - YES

- Operating Modes - RC / PWM / SERIAL / ANALOG

4.2.4 Solenoid Relay

Solenoids are a type of relay engineered to remotely switch a heavier current. Similar to the smaller electromechanical cube relays, a coil is used to generate a magnetic field when electricity is passed through it, which effectively opens or closes the circuit. This solenoid relay will be used to trigger (ON/OFF) the weapon motor as it draws a high amount of current. Figure 4.10 shows the actual view of relay module.

Figure 4.10 Solenoid relay 500A (switch)

Specifications

- Item type - Relay
- Voltage - 24 V
- Continuous current - 300 A
- Maximum current - 500 A

4.2.5 RC Switch

The RC Relay is the radio controlled 10 A-maximum relay versions known for its comprehensive control applications for any device that can be triggered by the switch. This relay will be used to trigger (ON/OFF) the solenoid relay which further will trigger (ON/OFF) the weapon motor wirelessly via a transmitter. The figure 4.11 shows a simple circuit diagram to control a motor using a RC switch.

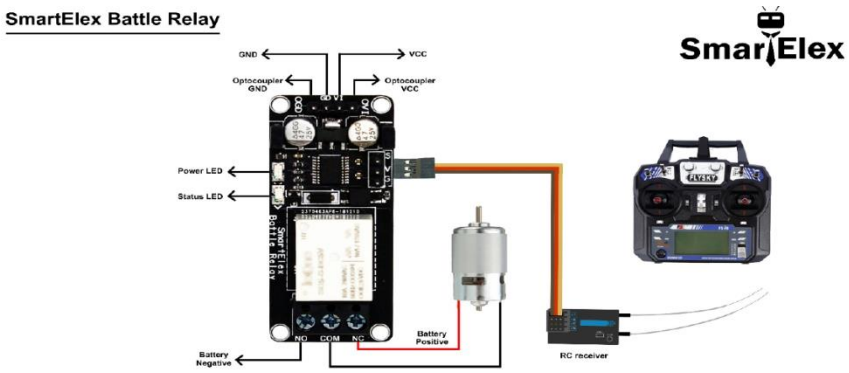


Figure 4.11 RC Switch

Specifications

- Operating voltage - 4.8 V - 5.2 V
- Maximum voltage - 240 V AC
- Maximum current - 10 A
- Weight (in grams) - 105

4.2.6 Transmitter / Receiver

A radio transmitter allows the driver to send commands to a receiver inside the robot. There are several radio manufacturers, such as Futaba, Airtronics, JR, Hitec, GWS, and Spektrum. Radio systems are named for their number of channels, which is the number of outputs that a transmitter-receiver set has. Therefore using Fly-sky fs i6 is a better option, it works on 2.4 GHz frequency, 6 channels remote and can output both PWM and PPM signals. Figure 4.12 shows the meaning of various switches present in Fly Sky fs- i6 transmitter.

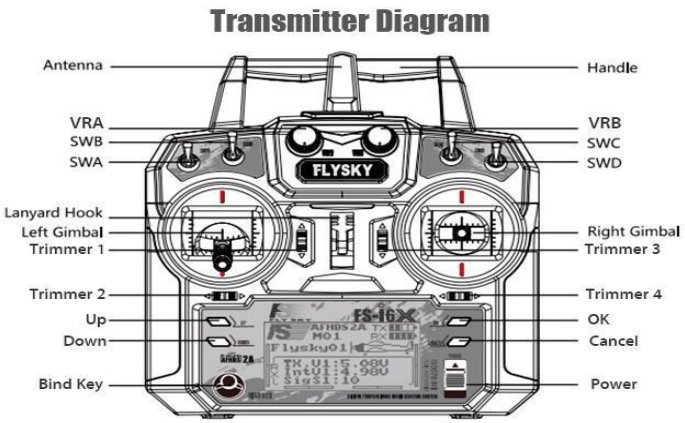


Figure4.12 Fly-Sky fs i6 Transmitter

A receiver is a component responsible to demodulate the radio-transmitted signals and direct the commands to servos and other electronic circuits. The figure 4.13 shows the actual receiver with a binding cable. The binding cable is used to bind the receiver to a specific transmitter.

Figure 4.13 Fly-Sky fs i6 Receiver

Specifications

- Model - FS-i6X RC Transmitter
- Tx channel - 6
- RF range - 2.408-2.475 GHz
- Bandwidth - 500 KHz
- Weight (in grams) - 392

4.2.7 Raspberry Pi

The Raspberry Pi is a very cheap computer that runs Linux, but it also provides a set of GPIO (general purpose input/output) pins that allow you to control electronic components for physical computing and explore the Internet of Things (IOT). Raspberry pi can be used for on-board computing hence it can perform image processing tasks easily on the go. Hence it will be used as the brain of the robot. The figure 4.14 shows various pins and components of a raspberry pi.

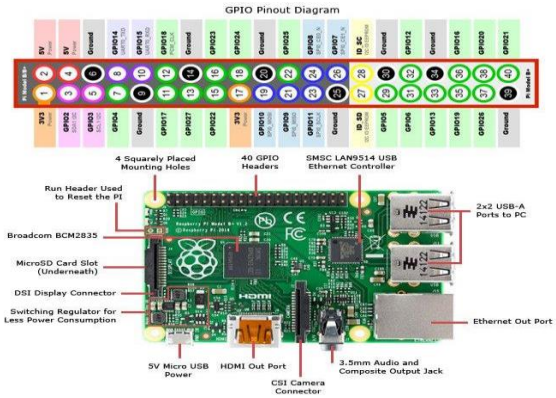


Figure 4.14 Raspberry pi pin diagram

Specifications

- Model - Raspberry pi 3 B+
- Processor - Cortex-A53 (ARMv8) 64-bit SoC @ 1.4GHz
- RAM - 1 GB SDRAM
- Connectivity - 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2
- GPIO pins - Extended 40 pin GPIO header
- USB 2.0 ports - 4
- Input Power - 5 V DC , 2.5 A
- Output Power - 15 W
- Micro-SD card slot - YES
- Weight (in grams) - 44

4.2.8 Camera

The robot will have an on-board camera that acts as the input medium for the live video feed. This raw video gets further processed in raspberry pi, which then makes the necessary decision based on the video feed and the program which is present on a raspberry pi to navigate the robot. Figure 4.15 shows the raspberry pi based camera module.

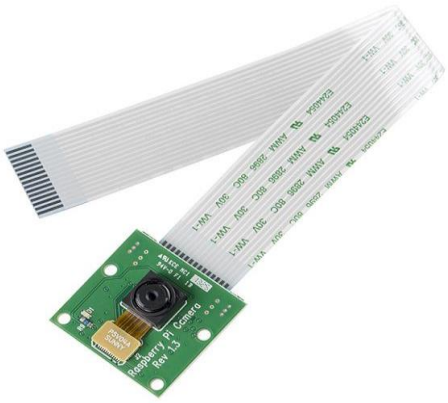


Figure 4.15 Raspberry pi camera module

Specifications

- Resolution - 5 MP
- Lens focus - Fixed
- Aperture - 2.9
- Focal length - 3.29
- Interface type - CSI (Camera Serial Interface)
- Size (L*B*H) - 25*23*8 mm

4.2.9 Batteries

The main advantages of LiPo battery cells are that they have about four times the energy density of nickel-cadmium or nickel-metal hydride batteries. LiPo batteries are very lightweight and pliable and can be made to almost any size or shape. As the components used in the robots are very power-hungry a good option will be to use Tattu 6s 22.2 V 14000 mAh 25C, this battery can provide 350 A of the current so it will be suitable for weapon motors whereas for drive motor we can use Orange 4200 mAh lipo battery. Figure 4.16 shows the actual view of one of the batteries that will be used in the robot.

Figure 4.16 - Tattu 14000mAh battery

Specifications

- Model - TA-25C-14000-6S1P
- Capacity - 14000 mAh
- Length - 23.5 cm
- Breadth - 6.8 cm
- Weight (in grams) - 1891

4.3 Joining Elements

Joining elements are used to keep the robot parts held together in a rigid and strong bond. The main types are described below.

4.3.1 Screws

Screws are joining elements, almost always cylindrical, which have helical threads around their perimeter with one or more entries. Screws are used in countless applications to apply forces, to fasten joints, to transmit power (in worm gears) or to generate linear motion. The screws used in the robot structure should have a hex (hexagonal) or Allen's head because they are the ones that allow the highest tightening torques. Figure 4.17 shows various types of screws available in the market.

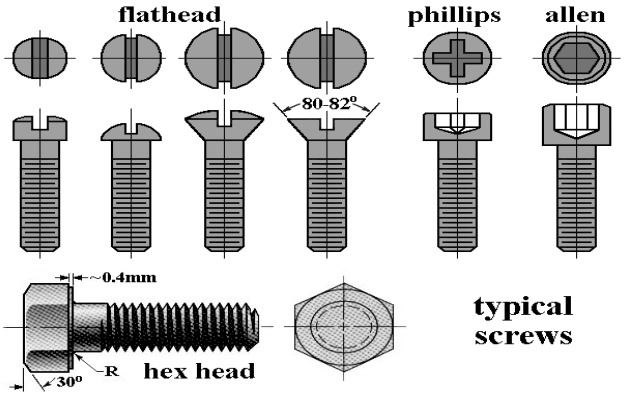


Figure 4.17 Types of screws

Allen

The highest strength screws, use 12.9 or 10.9 class types (made out of Hardened alloy steel) they have 3 times the strength of regular screws. These Allen bolts will be used in the robot for any joining purpose.

4.4 Wires

Wires must be very flexible, making it easy to route them through the robot's inside without rupturing the solders during impacts. Therefore, never use cables with a solid metallic core, use instead cables with multiple wires. Figure 4.18 shows an 8 AWG wire and figure 4.19 represents a wire gauge.

Figure 4.18 AWG wire

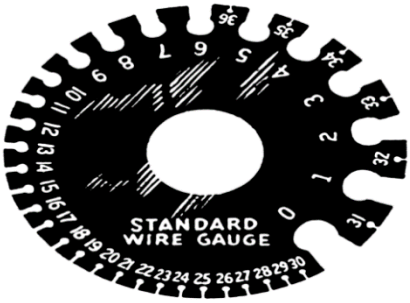


Figure 4.19 Gauge scale

It is important to keep in mind the current ratings, which depends on the wire diameter (gauge, usually measured in AWG, which stands for American Wire Gauge) and the isolation material. The higher the AWG, the smaller the wire diameter is. When it comes to isolation, there are two usual types: PVC, which withstands temperatures up to 221°F (105°C), and silicone, withstanding up to392°F (200°C). The highest current ratings for typical wire gauges are the following:

- 8 AWG: 70A to 80A continuous (PVC); 100 to 110A continuous and 500A peaks (silicone);
- 10 AWG: 50 to 60A continuous (PVC); 75 to 85A continuous and 350A peaks (silicone);
- 12 AWG: 35 to 45A continuous (PVC); 55 to 65A continuous and 200A peaks (silicone);

5. Designing

The starting point for any robot is its design and it can also be considered as most of the most complicated task of building a robot. The design of the robot is made on Dassault Solidworks which gives us the capability to design in three dimensions. With the help of this software, the team was able to make complex designs as pictured in figure 5.1 and make proper calculations. The robot is fully designed under the size complication of 65*65 cm. Figure 5.2 and 5.3 shows the CAD model of the design at different angles and figure 5.4 shows an example of real model that is to be built.

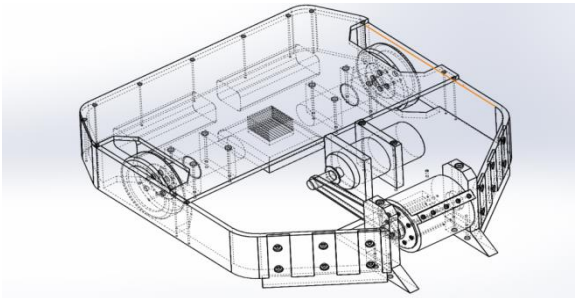
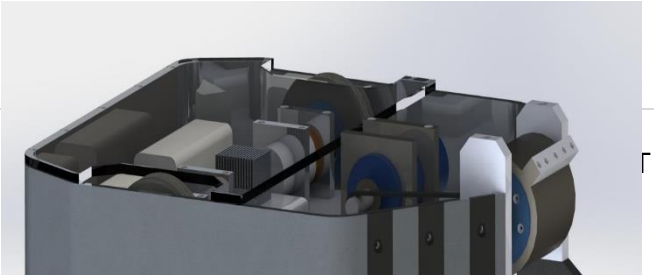


Figure 5.1 Sketch model of robot design



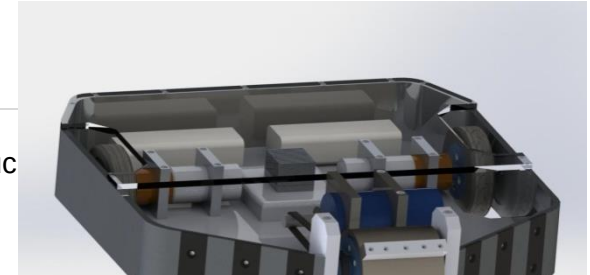


Figure 5.2 Side view of model

Figure 5.3 Front view of model

Figure5.4 An example of real model

6. Schematic

6.1 Circuit diagram for drive system

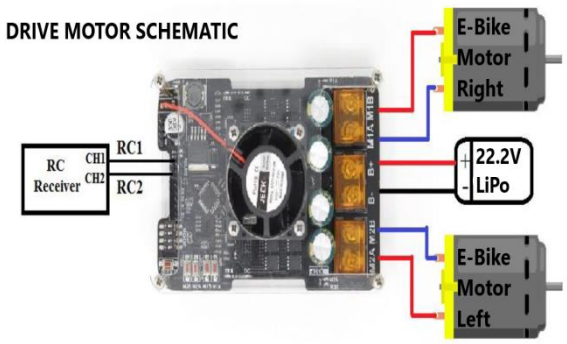


Figure 6.1 Circuit diagram of driver system

E-bike motor is used to drive the robot. For controlling its speed, SmartElex 30D motor driver module is used which is having two channels for each motor and can supply 30 A continuous current. The motor driver controls the speed of motor on the basis of width of PWM signal received by the transmitter. The figure 6.1 shows the circuit diagram of the driver motors with motor driver and receiver.

6.2 Weapon Motor Schematic

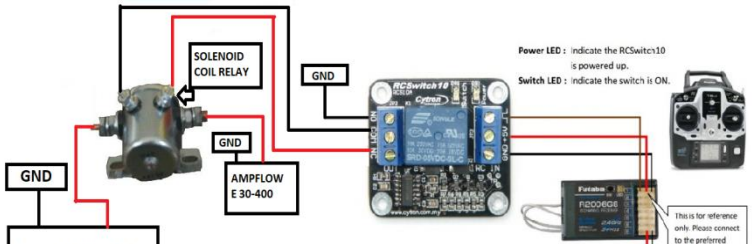


Figure 6.2 Circuit diagram for weapon system

The main problem in controlling the weapon motor is its high current requirement. The weapon motor consumes 65 Amps of continuous current, and during motor stall conditions the current may rise up to 100 - 120 Amps switching such high current is not possible by using the receiver. To handle this problem, the battle switch is used to amplify the signal of the receiver. This signal is also not capable of switching the weapon motor so this signal is used to switch the solenoid relay. The solenoid relay is capable of handling a continuous current of 300 Amps and a peak current of 500 Amps. The solenoid relay acts as a switch to start the weapon motor. Figure 6.2 shows the circuit diagram to control the weapon motor wirelessly using a RC switch and a solenoid relay.

7. Timeline

The construction of the robot is assumed to follow the below mentioned timeline for the successful completion of the project within the deadline.

- 1st - 7th Oct: - Planning, cad-designing, and compilation of the project report.
- 8th - 14th Oct:- Completion of paperwork
- 15th - 20th Oct:- Gathering of all components required
- 21st - 31st Oct:- Construction of the robot
- 1st - 7th Nov:- Testing and tuning of the robot

8. Expected Expenditure:-

S.NO	**Categories**	**Amount (In Rs.)**	
1	components	59976.00	
2	Others	3000.00	
3	Decoration and Stationary	2880.00	
4	Tools	5798.00	
5	Extra Components	7899.00	
Total Amount (In Rs.)		**79553.00**	
Total Amount(In Words)		**Seventy Nine Thousand Five Hundred Fifty Three Rupees Only**	

8.1 Components details

S.No	Name	Product name	Specification	Qty	Price (In Rs.)	Amount (In Rs.)	Reference
1	Drive Motors	E-Bike Motors	24 volt, 310 rpm, 110 kg-cm	2	3999.00	7998.00	amazon.com
2	Motor Driver	Smart flex motor driver	30 A dual channel	1	3799.00	3799.00	robu.in
3	Weapon Motor	Ampflow E30-400	5700 rpm, 51 kg-cm 24 volt	1	14190.00	14190.00	roboskull.in
4	Wheels	Colson Wheels	5 inch Diameter	2	1000.00	2000.00	robotskull.in
5	Relay	SmartElex Battle Relay	Relay switch	1	590.00	590.00	robu.in
6	Chassis Material	Aluminium 6061t (in kg)	Density- 2.7 g/cc	15	380.00	5700.00	Local Market
7	Weapon Material	EN 24 Mild steel (in kg)	Density- 7.8 g/cc	10	180.00	1800.00	Local Market
8	Battery	Tattu Lipo Battery	14000 mAh, 25C , 22.2 volt	1	15,000.00	15000.00	rcmumbai.in
9	Battery	Orange LIPO batteries	4200 mAh, 25C 22.2 volt	1	5899.00	5899.00	robu.in
10	Screws	Allen Bolts	3 inch	70	20.00	1400.00	Local Market
11	Screws	Grub Screws and Nut Bolts	5 inch, 6 inch	15	40.00	600.00	Local Market
13	Relay	Starter Relay	Solenoid Relay, 500 Amp	1	1000.00	1000.00	Local Market
		Total Amount (In Rs.)				**59976.00**	
		Total Amount (In Words)	**Fifty Nine Thousand Nine Hundred Seventy Six Rupees Only**				

8.2 Decoration and Stationary

S.No	Name	Product Name	Descriptions	Qty	Price (In Rs.)	Amount (In Rs.)	REFERENCE
1	A4 Size Paper	JK Paper	500 Paper	3	200.00	600.00	Local Market
2	Paint	Berger	1 qty= 500 ml	5	138.00	690.00	Local Market
3	Pen	Cello	Blue, Black	10	10.00	100.00	Local Market
4	Photocopy	Photocopy	Black and White	42	5.00	210.00	Local Market
5	Paint	Spray Paint	Silver , Gold(in ml)	4	300.00	1200.00	Local Market
6	Chart Paper	Chart Paper	White, Black	5	10.00	50.00	Local Market
7	Sketch	Camlin	All Color	10	15.00	150.00	Local Market
			Total Amount (In Rs.)			**3000.00**	
			Total Amount (In Words)	**Three Thousand Rupees Only**			

8.3 Tools

S.No	Name	Product name	Specification	Qty	Price (In Rs.)	Amount (In Rs.)	Reference
1	Drill machine	Bosch GSB (for assembly and maintenance of robot)	500 W , with Bits	1	3599.00	3599.00	amazon.com
2	Grinder	Bosch Professional Angle Grinder (For Maintenance)	670 W, Weight-1.9 kg	1	1899.00	1899.00	amazon.com
3	Blade	Grinder Blade	Iron Cutting Blade	20	15.00	300.00	Local Market
4	Wrench	tools 4 all	46 pieces	1	1300.00	1300.00	amazon.com
			Total Amount (In Rs.)			**5798.00**	
			Total Amount (In Words)	**Five Thousand Seven Hundred Ninety Eighty Only**			

8.4 Extra Components

S.No	Name	Product name	Specification	Qty	Price (In Rs.)	Amount (In Rs.)	Reference
1	Battery	Orange Lipo Battery (In case of Damage)	4200 mAh, 25C, 22.2 volt	1	5899.00	5899.00	robu.in
2	Wheels	Colson Wheels (In Case of Damage)	5 inch Diameter	2	1000.00	2000.00	Local Market
		Total Amount (In Rs.)				**7899.00**	
		Total Amount (In Words)	**Seven Thousand Eight Hundred Ninety Nine Only**				

8.5 Equipment Available in Robotics Club/ Institute

S.No	Name	Product name	Specification	Qty	Price (In Rs.)	Amount (In Rs.)	Reference
1	Wireless Remote	Fly Sky i6 TX/RX Remote	2.4 Ghz, 6 Channel	2	4700.00	9400.00	Amazon.com
2	Battery Charger	I Max B6AC	80 W	1	6895.00	6895.00	Amazon.com
3	Allen Key Set	Force Generic	9 pcs Allen Key	1	857.00	857.00	Amazon.com
4	Screw Driver Set	Taparia	6 pcs set	1	319.00	319.00	Amazon.com
5	Plier	PYE - 908	Pliers	1	189.00	189.00	Amazon.com
6	Raspberry pi	Raspberry Pi-3 model B+	Cortex A-53 @ 1.4 GHz 9*6*4 cm	1	2950.00	2950.00	robu.in
7	Camera	Raspberry pi Camera	5 MP Type- CSI(Camera Serial Interface)	1	2951.00	2951.00	robu.in
8	SD Card	Raspberry pi Sony Memory card	16 GB	1	525.00	525.00	Amazon.com
9	Sensor	Panasonic Passive Infrared Sensor	Long Distance(12metre) Detection Image	1	449.00	449.00	Amazon.com
10	Soldering iron	Soldron High-Quality	230 V/ 50 W	1	389.00	389.00	robu.in
11	Arduino	Arduino Uno R3	Atmega 328 , 5 Volt	1	425.00	425.00	robu.in

12	Sensor	Ultrasonic Range Finder	Sensing Range 2-400 cm	6	99.00	99.00	robu.in
		Total Amount (In Rs.)				**25448.00**	
		Total Amount (In Words)	**Twenty Five Thousand four Hundred Forty Eight Only**				

9. Outcomes

This project can be used in various applications under following domains:

a. Domestic

- It can be used as a guard by locating the intruders to attacking some extent (depending upon the accessories or weapon used in it) if required.
- It can be used as a helping hand in domestic applications in shifting heavy goods from one place to another in and outside the house.

b. Industrial

- Used for carrying loads of goods in various warehouses as it has a payload capacity of 100 kg.
- It can be used on farms for monitoring crops by sending live videos to owners which will lead to better productivity as the owner will have the exact knowledge of the problem(such as what type of insects are attacking the plants or what type of disease it might be and he can stop it from spreading).
- It may also carry pesticides at designated locations guided by RF Communication and other required things.

c. Military

- In the case of a covert military operation, the robot can face the enemy first and provide their exact location which will prevent life loss of the soldiers.
- As the robot is equipped with a thermal camera so it can also be used in the night.
- As the robot has a payload capacity of 100 kg, we can add on accessories such as guns and lethal weapons and also be used for assault purposes.
- This robot may assist in border monitoring and patrolling.

10. Future Aspects

- The robot can be further optimized by the upcoming students to such a level where it can be used as a security personal.
- It can also be made autonomous in the future so that it can detect its opponent by image processing using an on-board microcomputer such as raspberry pi
- It can be further be automated and can be used as a plant monitoring robot on farms.
- This robot is designed after considering specifications given by various competitive platforms to be organized all over India. Therefore, this robot can further be used in many other state and national level competitions.