Fabrication of Automated Electronic Trolley

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Abstract : *Shopping trolley is a necessary tool for shopping in supermarkets or grocery stores. However, there was shopping trolley abandoned everywhere in the supermarket after being used. In addition, there were also shopping trolley safety issues such as sliding down from an escalator. On the other hand, it is inconvenient and time wasting for customers who are in rush to search for desired products in a supermarket. Therefore, an automatic human and line following shopping trolley with a smart shopping system was developed to solve the problems. The shopping trolley was equipped with ultrasonic sensor for obstacle avoidance. In conclusion, users can enjoy shopping and pay more attention on their children during shopping without the need of pushing the shopping trolley. Besides, they can track the purchased items easily.*
Keywords: *Fabrication, Automation, Shopping system, Electronic Trolley*

I. Introduction

Shopping trolleys are available in the shopping mall which are wheeled and are to be carried by the person. The shopping trolleys are available in various sizes and with baby sitters. Trolleys are fitted with the castor wheels and normal wheels for easy to move on the floor while shopping. Some people are uncomfortable to carry the trolley since it is tedious and uncomfortable to push or pull it in the crowd. We are proposing to make the automatic trolley for shopping mall which can sense us and follow us. The beauty of all this system is that it uses all of these sensors in the most effective way to help it react. Unmanned operation requires sensor system for target position, sensors for load position, and control and communication equipment on the trolley and remote consoles for control signals. To remain fully operational with the terminal at all times requires extraordinary work flows, narrow time schedules and lots of work which do considerably drive up the overall investment. Now a day, automatic trolley has become popular especially in localization scheme. It is a non-touching recognition system where it can tag and send tag data wirelessly at various distances. In order to prevent objects collision, ultrasonic sensor, light dependent resistor was used in this project. The trolley will have the drive and steering mechanism being motorized by DC batteries. The tag when shown to the trolley will get activated and the tag is sticked to the pant and the trolley will sense the tag and starts following the tag on the person. If somebody comes in between, it stops and gives buzzer sound and when the obstruction moves away, it starts moving.

II. Literature Review

Shopping trolley is also called shopping cart which is like a carriage or basket that can be used by customers to transport their purchased product inside grocery shops or supermarkets. The shopping trolley is a cart supplied by supermarkets. In united stated, supermarket workers will return the trolley to the storage area after customers leave the carts in the parking lot. In European and Canada, the supermarket performs a coin locks system on the shopping carts in order to encourage the customers to return the carts themselves after use. In addition, the design of shopping trolley was concerned. This is because poor designed shopping trolley can cause potential musculoskeletal injuries from manually pushing or pulling heavy loads. A market survey was conducted where the results shown that most of the users expected the shopping trolley to feature energy saving, pulling and pushing motion and adjustable height. Healthy and safety of users are prioritised when they are shopping in the supermarkets. Furthermore, customers especially parents cannot enjoy during shopping. This is because parents have to take care of children while shopping. In recent years, we have seen the appearance of several technological solutions for hypermarket assistance. It will be a great improvement on the existing system if the technology of IR, RFID's are implemented [1].

Shopping trolley is a convenience and necessary tool for customers who are shopping in a supermarket. They can put a lot of things inside without carrying themselves but just have to push the shopping trolley. However, there is a problem faced by retailers or manager of the supermarket nowadays. Furthermore, customers especially parents cannot enjoy during shopping. This is because parents have to take care of children while shopping. A line following trolley is a kind of cart that is designed to follow a predetermined line or path. Infra-Red (IR) line sensor equipped with IR transmitter and receiver to trace black line with white surface or

vice versa on the floor. The sensor output will be fed to the microcontroller and thus the microcontroller can give a suitable command to motor driver in order to allow motor moving according to the command given. The microcontroller will be programmed to make the robot move in any direction based on the output of line sensor [2].
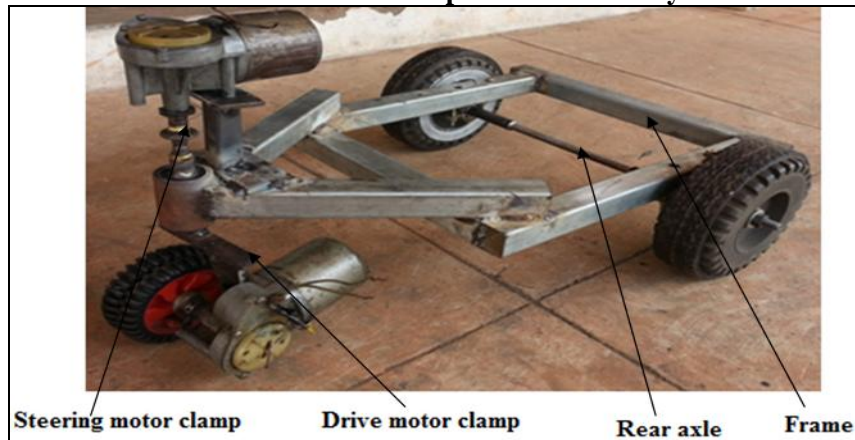
III. Mechanical Components Of Trolley

Fig 3.1: Mechanical components of trolley

1. **Rear axle**:-Round mild steel bar of diameter 20mm is taken for the length of 150mm and then it is turned on the lathe machine to reduce the diameter to 15mm and which holds the plastic wheels.
2. **Steering motor clamp**: - Mild steel flat plate is taken of size of 105*50mm weld into front frame on bottom, and then the Mild steel square tube of size 95*25mm is weld into that Mild steel plate, then another Mild steel plate of size 105*50mm is weld into square tube on top to support wiper motor (steering). Motor shaft is weld to 10mm shaft of length 50mm where the stopper is welded into it with an angle of 45degree from mean position.
3. **Drive motor clamp:** Mild steel plate of size 110*20mm is weld into motor shaft and then that plate is weld into Mild steel cylinder tube of diameter 50mm, and length 70mm which is having two ball bearings (no.6004) inside it.
4. **Frame**:-This is made out of square tube Galvanized Iron of size 400*400mm with thickness 38mm thick being but and joined as per the sketch and supports are welded as required.

(Frontview)
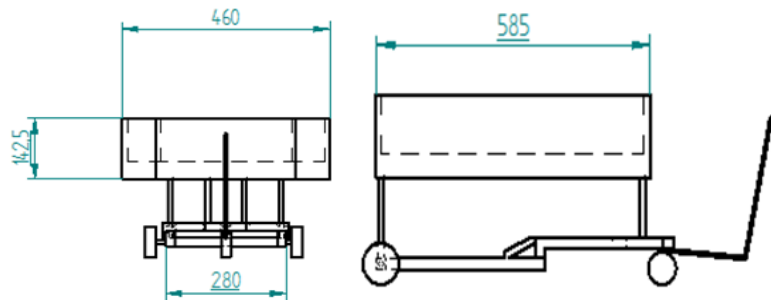
(Right side view)
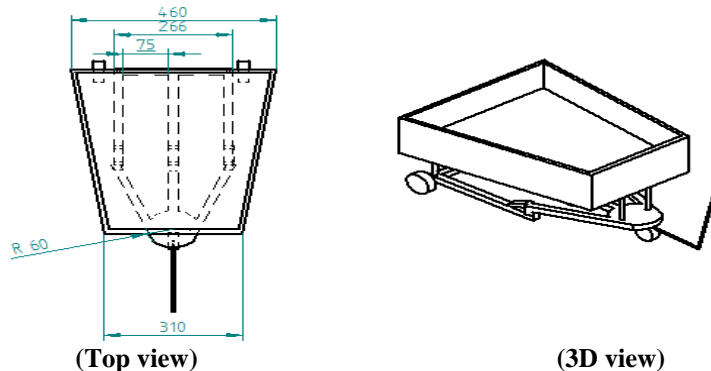
(Top view)   **(3D view)**

Fig 3.2: Frame of trolley

IV. Spur Gear Calculations

4.1 Torque calculation in DC motor

Type of gear used: Spur gear Material of spur gear: Polyamide 6 (Nylon 6)

Ratings:
System voltage: 6V DC
System current: 5Amps

Known parameters:
Allowable stress σall=82.7MPa
Number of teeths on driver gear Z1=10
Number of teeth on driven gear Z2=34
Speed of driven gear N2=15RPM
Face width b=26mm
Centre distance c=46.25mm
Diameter of driver gear D1=21mm
Diameter of driven gear D2=71.4mm

Calculations:

Gear ratio $i = \dfrac{N1}{N2} = \dfrac{Z2}{Z1}$

$i = \dfrac{34}{10} = 3.4 = \dfrac{N1}{15}$

N1=51RPM

Electrical power Pelect= V*I = 6*5 =30 W

Torque on driver gear $T1 = I * V * \dfrac{60}{RPM} * 2$

$\dfrac{30 * 60}{51 * 2\pi} = 5.61Nm$

Torque on driven gear $T2 = \dfrac{3.4}{1} * T1$
$= 3.4*5.61$
$= 19.074Nm$

Lewis form factor
$Y1 = 0.154 - \left(\dfrac{0.912}{Z1}\right)$ $Y1 = 0.154 - \left(\dfrac{0.912}{10}\right) = 0.0628$
$Y2 = 0.154 - \left(\dfrac{0.912}{Z2}\right)$ $Y2 = 0.154 - \left(\dfrac{0.912}{34}\right) = 0.1271$

σ01Y1=82.7*0.0628=5.193
σ02Y2=82.7*0.1271=10.51
As σ02Y1 > σ02Y2, Design should be based on driver.

Velocity v $= \dfrac{\Pi * D1 * N1}{60}$
$= \dfrac{\Pi * 21 * 51}{60}$
$= 56mm/sec = 0.0560m/s$

Velocity factor $Kv = \dfrac{3}{3 + Vm} = 3/(3 + 0.0560) = 0.981$

Tangential tooth load $Ft1 = σ01 * b * Y1 * p * Kv$

Where, p=circular pitch$= \Pi m = \Pi * \left(\dfrac{D1}{Z1}\right) = \Pi * \left(\dfrac{21}{10}\right) = 2.1mm$

m =module in mm

Tangential tooth load Ft1= $9550 * 1000 * P * \frac{Cs}{N1} * R1$ where R1 is radius of driver gear Cs is service factor

$$= 9550 * 1000 * 0.03 * \frac{105}{51} * 10.5$$

=802.54N

Check for stress:

Allowable stress σall= $(\sigma 01 * Kv)$ =82.7*.981=81.12MPa

Induced stress σind= $\frac{Ft1}{b*Y1*p}$ =802.54/(26*$10*-3$*2.1*10*-3)=74.5MPa

σall $>$ σin, design is safe.

Effective force Feff= $\frac{Ft1}{Kv}$ =802.54/0.981=818.06N

Beam strength of weaker member Fbeam=σ01*b*Y1*p=82.7*26*0.0628*2.1=891N

Also in order to avoid breakage of gear tooth due to bending, **Fbeam>Feff**

V.   Working Principle Of Electronic Trolley

5.1 Introduction
      In this we are making a three wheel vehicle with trolley mechanism on top to hold the various types of materials being taken from the various racks in the shopping mall. The trolley will have the drive and steering mechanism being motorized and is backed by DC batteries. The IR emitter tag when shown to the trolley will get activated and the tag is sticked to the pant and the trolley will sense the tag and starts following the tag i.e., follows the person. The IR emitter is continuously emitting the signals and the receiver is on the scanner fixed to the steering mechanism which diverts the direction as per the emitter to drive the trolley in that direction controlling the direction as per the person's movement. If the person is out of the way, the scanner scans around to sense and once sensed will move towards the person. If somebody comes in between, it stops and gives the buzzer sound and when the obstruction moves away, it starts moving. If anything comes in between and the person is out of reach, the scanner scans all around and even if not sensing the person, then the buzzer sounds or the recorded sound calling the person's name will repeatedly calls, so that the person can reach back the trolley and again take the activation and makes the trolley to follow.

5.2 Circuits involved
- Tag activation to start the trolley.
- IR emitter and transmitter to control the drive and steering.
- LDR circuit for obtrusion or persons sensing maintaining the distance as preset, to stop the trolley at a particular distance from the person.
- Charging circuit to charge DC batteries.

5.3 Working of the circuit
1. **Card activation circuit**: - In this we are providing magnet at the card which closes the normally open reed relay or magnetic sensor which is connected to the pin number 7 of IC-UM-606 which gives the inverted output at pin number 6 which gives the pulse input to the decade counter CD-4017 which gives the clock output from pin number 2 which triggers the transistor to connect the relay to connect the drive motor to start.
2. **IR Transmitter** is fixed on the activation card or tag which is sticked to our pant which will be emitting signals powered by DC batteries.
3. **The IR receiver** is connected through the regulating IC to the transistor BC547 to pin number 2 of opto coupler MCT2E which gives ili6 input voltage to pin number 7 of IC-UM-606 which gives the inverted output to pin number 6 to trigger BC547 to connect the relay to rotate the steering motor in search of the IR transmitted signals and stop when received.
4. **Buzzer sound: -** The buzzer is available in ready market which we have taken and made the circuit to repeat the recorded voice. In this we have set the variable resistor to the required range and the input voltage at pin number 7 varies which gives the inverted output at pin number 6 to trigger the transistor BC547 to connect the relay to give buzzer sound.

5. **LDR Obtrusion sensor circuit**: - The light dependant resistor is fixed at the front face which senses the shade falling on it. In the absence of light falling due to the obstruction in the path, the internal resistance of the LDR changes which gives the high state input voltage at pin number 7 of IC, Um-606 which gives the inverted input to pin number 6 to trigger the transistor BC547 to connect the relay to stop the drive motor to stop the trolley till the obstruction is not cleared.
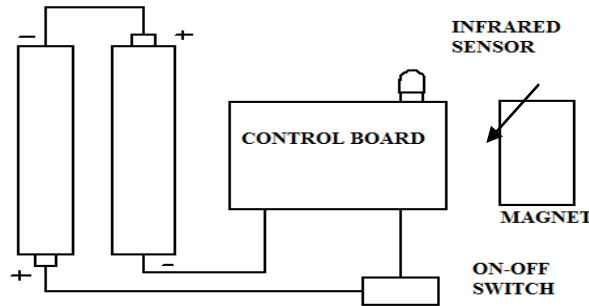
6.

Fig 5.1: Infrared Transmitter
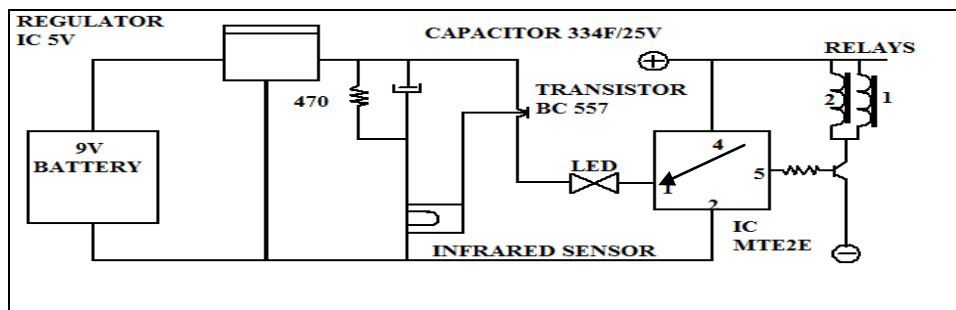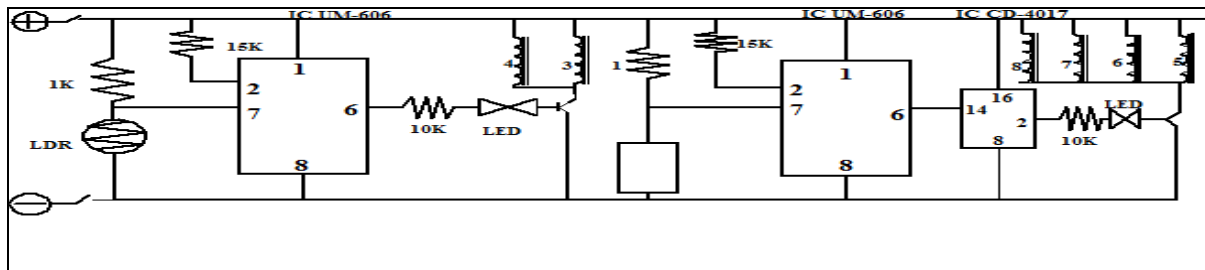

Fig 5.2: Infrared Circuit

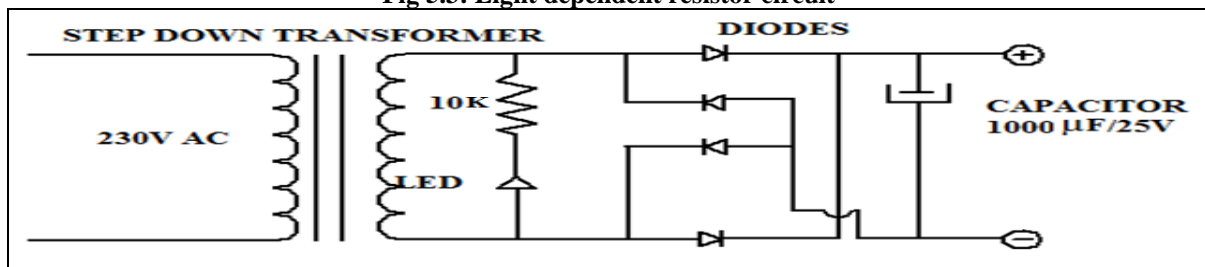**Fig 5.3: Light dependent resistor circuit**

Fig 5.4: Charging of 6V battery

Battery charging:
There are two types of charging namely, conductive and inductive. In conductive type of charging process, direct wires are connected between the electrical supply source, the charger and the battery. In the inductive charging, there is no direct wire connection between the source of electricity and the battery. In the inductive type charging, an AC supply activates the primary coil of transformer. Whereas, the secondary forms part of the system in which battery is to be charged. For inductive charger, an on-board rectifier is required to convert the AC into DC for battery. Pulse technique is another efficient method to reduce the time taken for recharging.
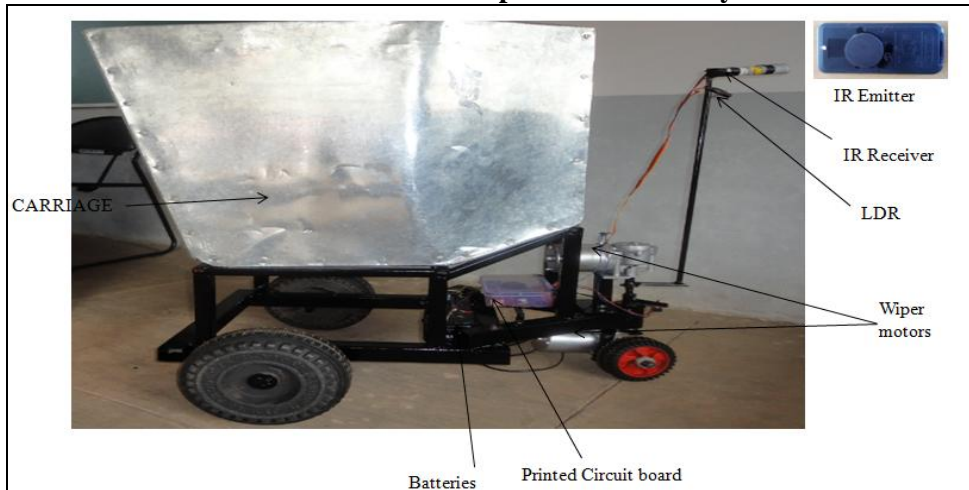
VI. Electroncs Components Of Trolley

Fig 6.1: Electronic components of trolley
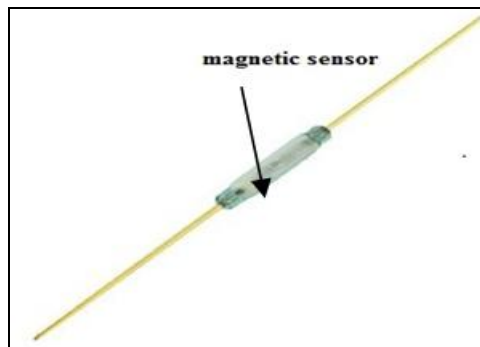
6.1 Magnetic Sensor:-

Fig6.2: Magnetic sensor

The reed switch is an electrical switch operated by an applied magnetic field. It consists of a pair of contacts on ferrous metal reeds in a hermetically sealed glass envelope. The contacts may be normally open, closing when a magnetic field is present, or normally closed and opening when a magnetic field is applied. The reed relay is a type of relay, in which a reed switch is mounted inside a coil. One important quality of the switch is its sensitivity, the amount of magnetic energy necessary to actuate it. Sensitivity is measured in units of Ampere-turns, corresponding to the current in a coil multiplied by number of turns. Typical pull-in sensitivities for commercial devices are in the 10 to 60 AT range [3].
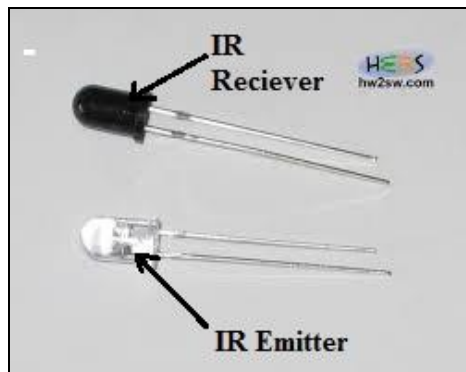
6.2 Infrared sensor:-
6.3

Fig6.3: Infrared sensor

Passive infrared sensors (PIR sensors) are electronic devise which measure infrared light radiating from objects in the field of view.All objects emit infrared radiation. This radiation is invisible to the human eye but can be detected by electronic devices designed for such a purpose. The term passive in this instance means the PIR does not emit any energy if any type but merely sits 'passive' accepting infrared energy through the front of the sensor, known as the sensor face. At the core of a PIR is a solid state sensor or set of sensors, with approximately 1/4 inch square area. The sensor areas are made from a pyro electric material.
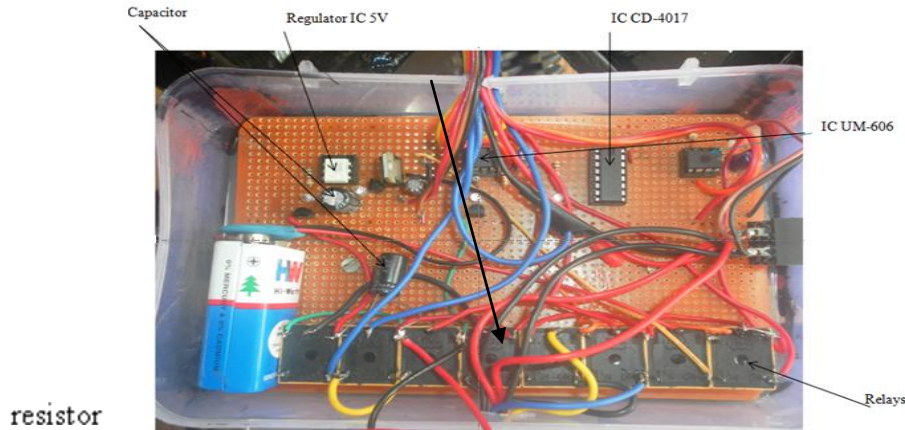
Printed circuit board

Fig 6.4: Printed circuit board

A printed circuit board mechanically supports and electrically connects electronic components using conductive tracks and other features etched from copper sheets laminated on to a non conductive substrate. It can be single sided, double sided or multi layer. Multi-layer printed circuit board allow for much higher component density. Advanced printed circuit board may contain components- capacitors, resistors or active devices embedded in the substrate [4].
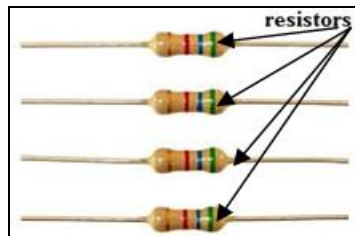
6.4 Resistors:-

Fig 6.5: Resistors

6.5 Transformer:-
According to ohms law: "Electrical resistance of a conductor is the effective opposition offered by the conductor to the now of charges through it and is defined as the rate of potential difference between the ends of the conductor to the current flowing through the conductor". The SI unit of resistance is the Ohm.
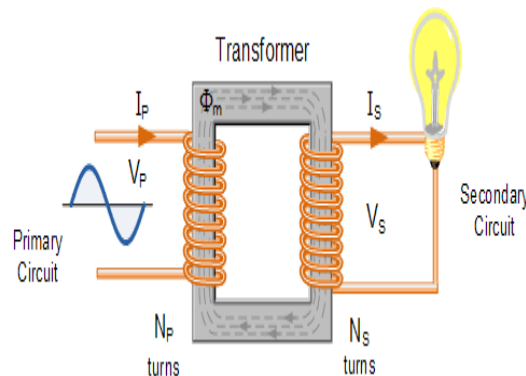

Fig 6.6: Transformer

A transformer is a static electrical device, which transfer electrical power from one electrical circuit to the other which are magnetically coupled together with or without change of voltage and without any change in power and frequency. The basic use of transformer is to increase or decrease ac. voltage. If it is used to increase the voltage, it is called a step-up transformer, if it is used to decrease the voltage; it is called a step down transfer. If the voltage is not changed, it is called one to one transformer. As the transformer is a static apparatus, there are no moving parts. Hence, there are no mechanical losses in a transformer. It works on the principle of mutual induction between two magnetically coupled coils. For a transformer there is no direct electrical connection between the two coil windings, thereby giving it the name also of an **Isolation**

Transformer: Generally, the primary winding of a transformer is connected to the input voltage supply and converts or transforms the electrical power into a magnetic field. While the job of the secondary winding is to convert this alternating magnetic field into electrical power producing the required output voltage as shown. Mutual induction is defined as "the production of an electromotive force in a circuit by a change in the current in an adjacent circuit which is linked to the first by the flux lines of a magnetic field"[5].

6.6 Integrated Circuits:-

An integrated circuit (abbreviated as IC) is a small Silicon semiconductor crystal, called a Chip, containing electrical components such as transistors, diodes, resistors and capacitors[6]. The various components are interconnected inside the/chip to form a electric circuit. The chip is mounted on a metal or plastic package, and connections are welded to external pins to form the IC. ICs are classified in two general categories, linear and digital. Linear ICs operate with continuous signals to provide electron functions such as amplifiers and voltage comparators. Digital ICs operate with binary signals and are made up of interconnected digital gates. IC 7400 :- (7400 Quad NAND)[7].

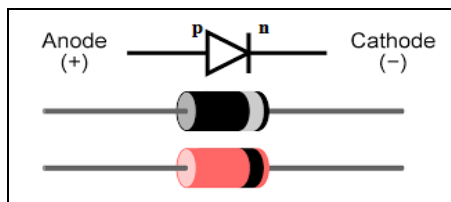**Fig 6.7: IC 7400**

6.7 Diode:-

Fig 6.8: semiconductor diode

It is a combination of P-type and n-type semiconductors. Or a P-n junction is called a crystal diode or a semiconductor diode. In p type semiconductor Holes are the majority charge carriers and electrons minority carriers. In n-type semiconductor electrons are the majority charge carriers and holes are the applied voltage opposes the junction potential difference and for values of the applied voltage greater than the junction potential difference the charge carries easily cross the junction from either side.
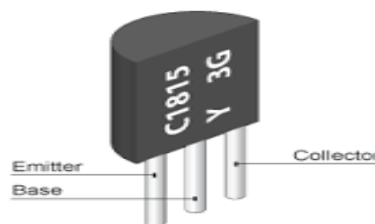
6.8 Transistor:-

Fig 6.9: transistor

A transistor is a 3 terminal two junction semi-conducting device whose basic action is amplification. There are two types of transistors (i) npn transistor. (ii) pnp transistor. In our circuit we have use npn transistor. Symbolically it can be represented as below
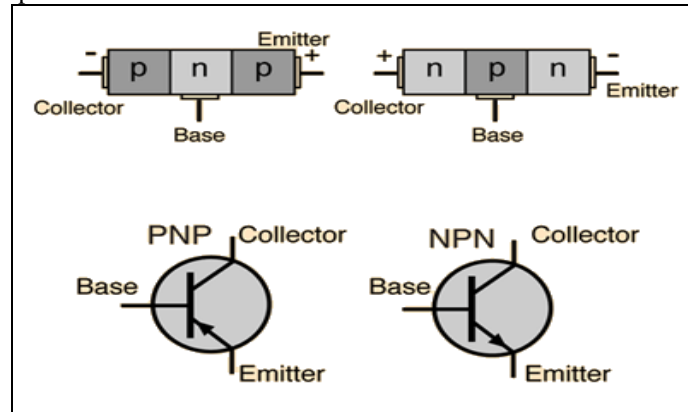

Fig 6.10: pnp and npn transistors

In npn transistor a very narrow p-region is sandwiched between two n-regions and in pnp transistor a very narrow n-region is sandwiched between two p-regions. It is represented as above. Here note that emitter is heavily doped than collector.

6.9 Relay: A relay is a simple electromechanical switch made up of an electromagnet and a set of contacts. Relays are found hidden in all sorts of devices.
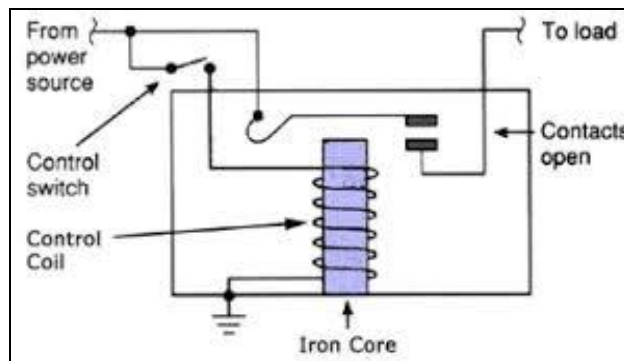

Fig 6.11: Relay

Relay is used for many control functions and is essentially an electromechanical switch. The construction of a typical relay is shown in fig above. A relay essentially contains a coil of wire wound around an iron core. The relay has set of two contacts, one of which is spring loaded and movable and other is fixed. These contacts are electrically isolated from the coil and are used to make or break another circuit.
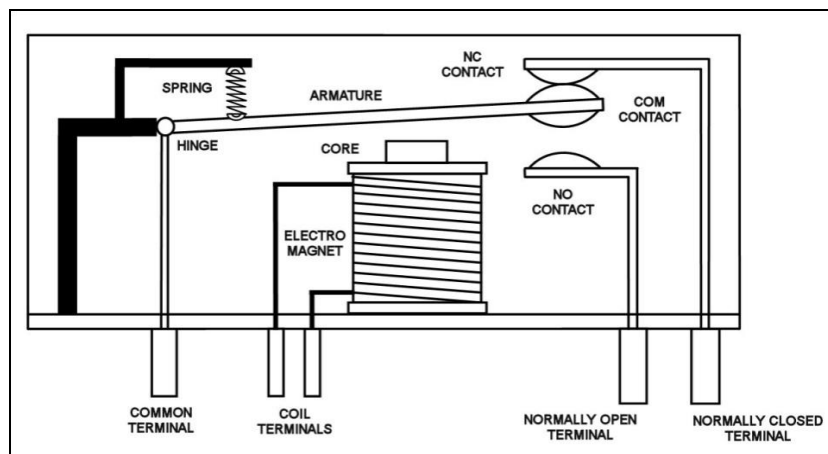

Fig 6.12: Working principle of relay

Fig: shows the working principle involved in moving from the energized state to the de-energized state. When the relay is energized, a magnetic field is created around the coil. Therefore, the magnetic field attracts the Armature (movable contact). Due to attraction, the contact moves to close the circuit i.e. COM contact move to NO contact. When the current supply is stopped, the spring causes the Armature to move to its original position i.e. COM contact move to NC contact.

Advantages of Relays: The advantages of using a relay is that a small current (circuit 1) can be used to switch ON and OFF a circuit with large currents (circuit 2).
This is useful for two reasons.
1. The low current circuit (circuit 1) may contain a component such as LDR (Light Dependent Resistor), which uses only small currents.
2. Only the high current circuit (circuit 2) needs to be made from thick wire.
The relay is used to operate starter motors in cars and the heating circuit in diesel engines [8].

6.10 IC UM-606 Pin connections
The **555 timer IC** is an integrated circuit (chip) used in a variety of timer, pulse generation, and oscillator applications. The 555 can be used to provide time delays, as an oscillator, and as a flip-flop element [9].
A timer Um606 is available in market in following package:
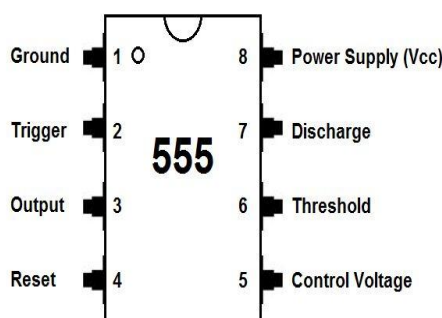1.8 pin DIP package
2. 8 Pin metal 555 timer IC

Fig 6.13: IC UM-606 pin connection

Details of Pins of IC UM-606:
Pin No.1: This is the common or ground terminal. Negative terminal of power supply is connected at this pin.

Pin No.2: The trigger voltage of lower comparator is applied at this pin. Normally, the voltage at this pin is at least two-third of the supply voltage (+Vcc). The output remains low in this condition. When a negative going pulse, which is more than one-third of + Vcc, is applied at pin no.2, then the circuit is triggered. The flip-flop changes its state and the output becomes high. Thus, when the voltage at pin no. 2 is more than one-third of +Vcc then the output remains low and when the voltage at the pin no.2 is less than the one-third of +Vcc, then the output goes high.

Pin No.3: This is the output pin. This output has 2 logic states. The output in its low state is almost equal to the ground, and in the high state this output is almost equal to +Vcc.

Pin No.4: This is the reset input pin which controls flip flop directly. As its name suggest, the signal at this pin returns the device to its original state. When the reset terminal is connected to the ground then the pin no.3 (output) and pin no.2 (trigger voltage) becomes low that is the voltage at these pins becomes almost zero volt. When the reset terminal is not used then pin no.4 should be kept connected to +Vcc.

Pin No.5: This is the control voltage input pin. Generally this pin is not used and is kept connected to the ground through a 0.01µF capacitor. Any external voltage at pin no.5 will change both the threshold and the trigger voltage reference levels.

Pin No.6: This is the input pin for threshold voltage of the upper comparator. A timing resistance is connected to Vcc from pin no.6. This pin no.6 is also connected to the ground by an external capacitor begins to charge through the timing resistance. When the voltage across the capacitor reached the threshold level then the output becomes low.

Pin No.7: It is the discharging the external capacitor by internal discharge transistor. Usually, pin no.7 is kept connected with the pin no. 6 directly or through a resistance. When the output becomes low at the pin no.7 then the external capacitor is discharge by the internal discharge transistor. When the output at pin no.7 goes high, then the internal discharge transistor remains cut-off and the external capacitor charges towards Vcc.

Pin No.8: This is the positive voltage supply terminal and is connected to +Vcc. The voltage at this pin should be between +5V to +15V.

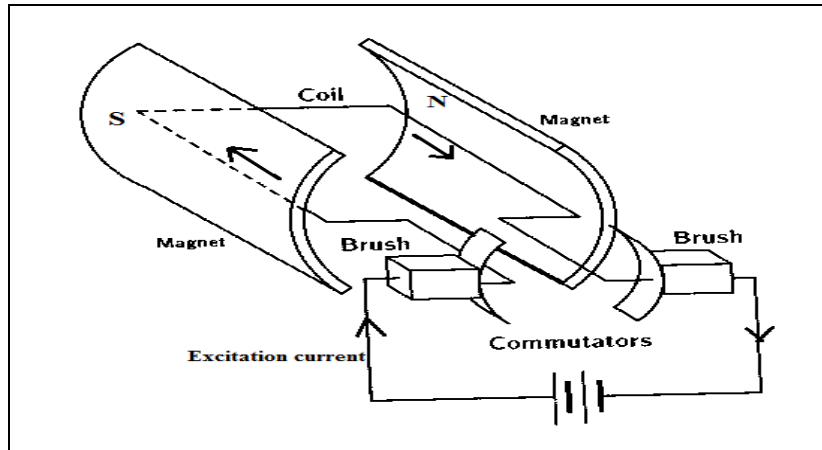### 6.11 Drive system: DC Motors

Fig 6.14: DC motor

There are varieties of types of motors used in automated vehicles, they include DC motors, Stepper motors and AC motors, and among these motors we have used DC motors. The main components of DC motors are rotor and stator. Usually, the rotor includes the armature and the commutator assembly and the stator includes the permanent magnet and brush assembly. When the current flows through the winding of the armature, it sets up a magnetic field opposing the field set up by the magnets. This produces a torque on the rotor. This system is shown schematically in fig: . The current in coil will produce a magnetic field with a north/south orientation causing the repulsion of the PM in the south pole (or north pole) and the coil in south pole (or north pole) resulting a torque that will rotate the coil.

According to law of magnetism, when a current carrying conductor is placed in a magnetic field, it will experience a force at right angles to the field. The lines of forces due to the magnetic field are acts perpendicular to both wire and magnetic field. The force produced is oscillatory in nature unless current direction is changed every time, the coil changes from one set of pole faces to the next pole faces. This is achieved using commutators.

The greatest advantage of DC motors may be speed control. Since speed is directly proportional to armature voltage and inversely proportional to the magnetic flux produced by the poles, adjusting the armature voltage and/or the field current will change the rotor speed. In fact, fine speed control is one of the reasons for the strong competitive position of DC motors in the modem industrial applications [10].

6.12 Steady-state characteristics of DC motor
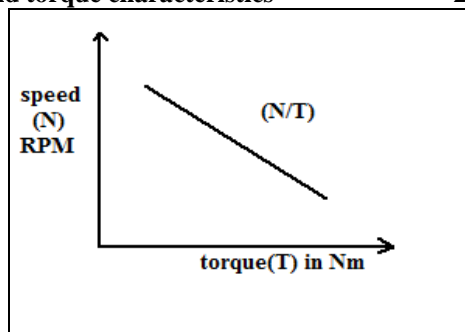**1. Speed and torque characteristics**   **2. Voltage and speed characteristics**

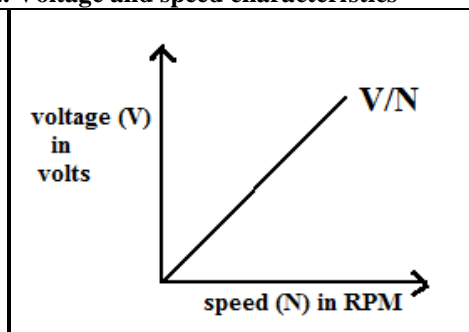**Fig 6.15: Speed and torque characteristics**   **Fig 6.16: Voltage and speed characteristics**

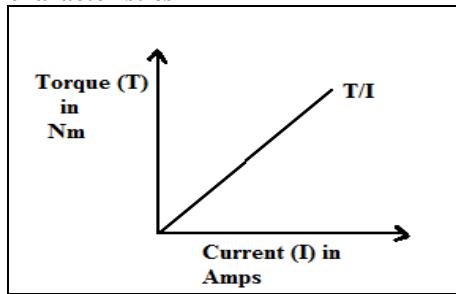**3. Torque and armature current characteristics**

Fig 6.17: Torque and armature current characteristics

VII.   Result And Performance Analysis

By plotting Load vs. Time, tabulations were made for different loads keeping the Distance constant. The following observations were made and graph of Load (W) vs. Time (t) was plotted.

Table 7.1: Load vs. Time characteristics

Trial no.	Distance in meter	Load in Kg	Time in second
1	10	0	40
2	10	2	40
3	10	4	40
4	10	6	40
5	10	8	40
6	10	10	40
7	10	12	40
8	10	14	40
9	10	16	40
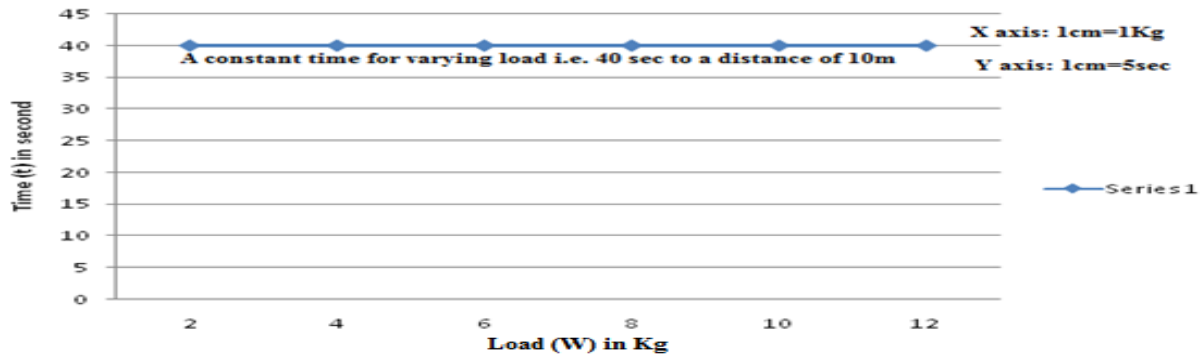
Fig 7.1: Load vs. Time characteristics

VIII.   Cost Estimation

Table8.1: Cost estimation

	Parts	Material	Quantity	Cost
1	Drive motor	12V DC,2AMP	1nos	Rs 1000
2	Steering motor	12V DC,2AMP	1nos	Rs 1000
3	Frame	Galvanized iron	1set	Rs 300
4	Control circuit	Standard	1set	Rs 2000
5	Carriage	Galvanized iron	1set	Rs 450
6	Batteries	6V DC,5AMP	4nos	Rs 1000
7	Wheels	Plastic	4nos	Rs 300
8	Bearings	Standard	2nos	Rs 180
9	Nut, Bolts, Washers and other expenses	Standard	-	Rs 600
10	Charger	Standard	1set	Rs 150
			Total cost	Rs 6880/-

The cost is round off to Rs.7000/-

IX. Conclusion And Future Improvements

With the aid of automatic line following and human leading functions, supermarket owners need only to purchase and can easily install it under shopping trolley. Users can enjoy shopping without pushing shopping trolleys themselves. The location of shopping trolley can always be tracked easily by using Infrared technology. Users can control the movement of shopping trolley by using their Infrared sensors.

Improve the movements of trolley by adding **RFID (Radio Frequency Identification)** to the tag which is sticked to our pant and software development. Both client and server are developed by using Java programming language in eclipse software. Android application is developed as client on Android phone; meanwhile server will act as database system to store the items' information.

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