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WIRELESS CHARGING PAD FOR DRONES, E-BIKES- NEWER TREND IN EV AND AUTOMATION

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Abstract:

This Paper is Mankind has been using automotive vehicles for transportation from one place to another. These vehicles use internal combustion(IC) engines to drive it. Due to increased number of vehicles there is environmental pollution caused by IC engines and reduction in fossil fuels. The latest innovations in the Automotive Industry are helping to improve fuel efficiency and reduce emissions. One such technological advancement is Hybrid vehicles which use both IC engines and electric motors to drive the vehicles or a car in simple words, helping to reduce the amount of emissions produced maintaining the performance of the engine.

Keywords: wireless charging pad, E- bikes

1. Introduction

In This Paper the future focus is on clean and green energy producing zero emissions. Design and manufacture of electric vehicles has led to major interest in current industry Since these vehicles run on battery the main drawbacks are high cost, short distance travel and long charging time. Consumers are constantly looking for a better solution to improve the travel efficiency. Hence wired charging systems were built at every gas station. Wired charging also have some limitations like socket points, spacing occupied by the charging station, limited range of wire, vehicle has to change its orientation to connect to the charger. These can be addressed by wireless charging systems for electric vehicles. This provides flexible and hassle free charging and also systems can be built at home, parking lot, garage etc. Fig. 1 shows simplified diagram of car and wireless charging system implemented in automotive industry [2]. Many wireless power transfer techniques are used to implement this technology. These methods use coils to transmit power. Coil will produce a short range magnetic field, when a second coil is placed an electric current will flow through it. The magnetic field has transferred power from one coil to other called Induction. It is necessary to analyze these techniques based on the application to obtain optimum results for the system to function correctly. Table 1 shows different techniques with its advantages and disadvantage. This work uses resonant coupling method to achieve efficient power transmission. The system is configured at the reasonable air gap based on the ground clearance of electric vehicle. This air gap is enough to provide good amount of coupling coefficient. The design of coils plays major role, factors like geometry, frequency and coil placement to deliver the maximum power with a uniform field distribution.

2. Objectives

1. Study wireless power transfer using inductive resonance coupling.
2. Measure power, voltage, and current transfer between coils.
3. Design and build a wireless EV charging prototype.
4. EV charging is advancing fast, increasing demand for wireless systems.

3. Literature Review

1. K. Parmesh, Rashmi Prafulla kumar Neriya and M. Varun Kumar, "Wireless Charging System for Electric Vehicles"

Abstract

Wireless power transmission (WPT) is popular and gaining technology finding its application in various fields. The power is transferred from a source to an electrical load without the need of interconnections. WPT is useful to power electrical devices where physical wiring is not possible or inconvenient. The technology uses the principle of mutual inductance. One of the future applications finds in automotive sector especially in Electric Vehicles. This paper deals
with research and development of wireless charging systems for Electric vehicles using wireless transmission. The main goal is to transmit power using resonance coupling and to build the charging systems. The systems deal with an AC source, transmission coil, reception coil, converter and electric load which are battery.

Keywords: Wireless power transfer; Resonance; Inductance; Electric vehicles; High frequency converters

2. Abinand D, Deepak M, Maaz Ahmed, Phanindar Ravi Parimi, "WIRELESS CHARGING OF ELECTRIC VEHICLE: A REVIEW"

Abstract

Electric vehicles are today's zero emission vehicular technology which are considered as the future of automotive industry. The batteries of the vehicles get charged in order to drive the vehicle. The methodology of charging the electric vehicle currently is through plug-in method where the charging station charges the battery of an electric vehicle. However, an alternative method for charging the battery of an electric vehicle is through Wireless Power Transfer where it can be as a Static or Dynamic charging systems. Static Charging System can be implemented to charge the batteries of the electric vehicles when the vehicle is parked in static mode. Dynamic Charging System can be implemented to charge when the vehicle is in motion. This method of wireless charging of electric vehicle is done through inductive power transfer where wireless transmission of power is achieved by mutual induction of magnetic field between transmitter and receiver coil. The state of the battery is monitored using Battery Management system (BMS). This paper attempts to review about the difference between plug-in and wireless charging of vehicle, operational principle of wireless charging, types of charging systems, static and dynamic wireless charging, application of dynamic charging system in future and drawbacks of wireless electric vehicle charging.

Key Words: Electric Vehicle, Wireless Power Transfer, Static Charging System, Dynamic Charging System, Battery Management System (BMS).

3. **Md Rakib Raihan Razu, Sultan Mahmud, Mohammad Jalal Uddin, Sikder Sunbeam Islam, "Wireless Charging of Electric Vehicle While Driving"**

Abstract

Static wireless charging is becoming popular all over the world to charge the electric vehicle (EV). But an EV cannot go too far with a full charge. It will need more batteries to increase its range. Dynamic wireless charging is introduced to EVs to capitally increase their driving range and get rid of heavy batteries. Some modern EVs are getting off this situation. But with Dynamic WPT the need of plug-in charge and static WPT will be removed gradually and the total run of an EV can be limitless. If we charge an EV while it is driven, we do not need to stop or think for charging it again. Eventually, in the future the batteries can be also removed from EVs by applying this method in everywhere. Wireless charging needs two kinds of coils named the transmitter coil and the receiver coil. The receiver coil will collect power from the transmitter coil while going over it in the means of mutual induction. But the variation of distance between two adjacent coils affects the wireless power transfer (WPT). To see the variation in WPT, a system of two Archimedean coils of copper is designed and simulated for vertical and horizontal misalignment in Ansys Maxwell simulation software. The transfer power for 150 mm air gap is 3.74 kW and transfer efficiency are gained up to 92.4%. The charging time is around 1 hour and 39 minutes to fully charge its battery from 0 state for a 150mm air gap for an EV with 6.1 kW power may take. Also, a charging lane is designed for dynamic charging. Then the power transfer is calculated from mutual inductance when the EV is driven on a charging lane. From the load power, it can be calculated how further an EV can go with this extra power.

Key Words: Electric vehicle, wireless power transfer, dynamic charging, efficiency, charging lane

4. Block diagram

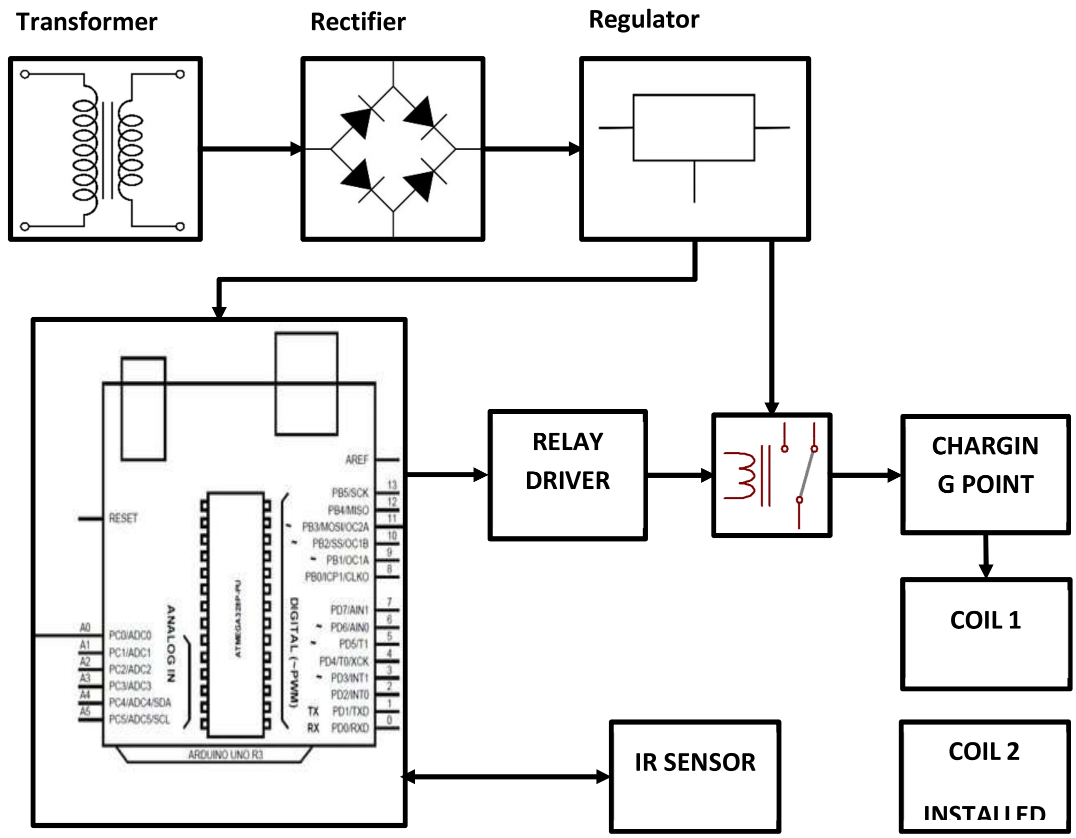


Fig. Block diagram of automatic wireless charging system

5. Circuit diagram

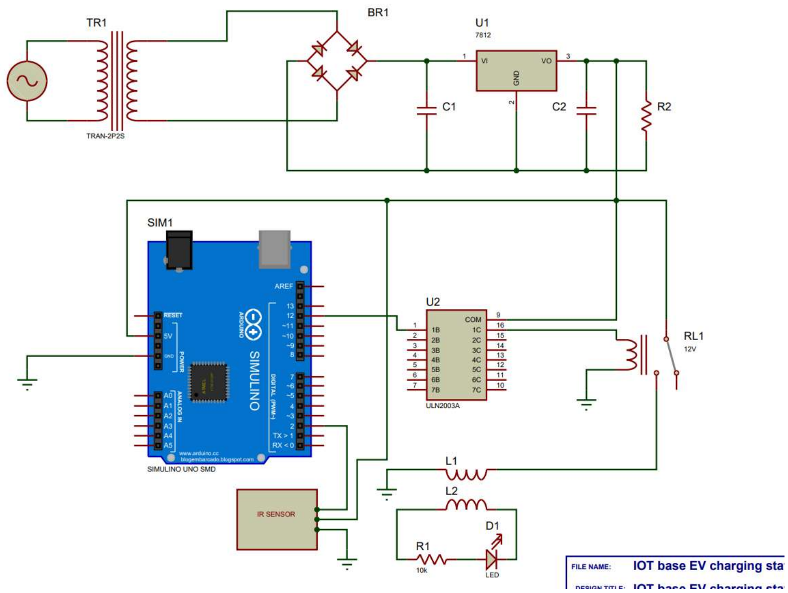


Fig. circuit diagram of automatic wireless charging system

6. Design Calculation

1. Wireless charging system architecture

The system shown in Fig. 2 gives an overview consisting of various components for charging to take place.AC supply is used as the source which is supplied to high frequency(HF) converter which converts source low frequency to high frequency. This output is fed to the transmission coil (TX). From the principle of resonant coupling the reception coil (RX) is coupled. The output is given to AC-DC converter to obtain rectified DC to charge the battery which the load. The coils in the project which is used to transmit power wirelessly are called magnetic resonators. Firstly, a rapidly oscillating current is fed to a coil at a specific resonant frequency using HF Converter. This creates magnetic field in the region around a transmission coil, tune a reception coil to the same resonant frequency as the source it will couple resonating anywhere within that region, converting oscillating magnetic field into an electrical current within the reception coil this response is called coupled magnetic response. The power can be fed to the load for charging a battery. This power can be distributed across multiple loads.

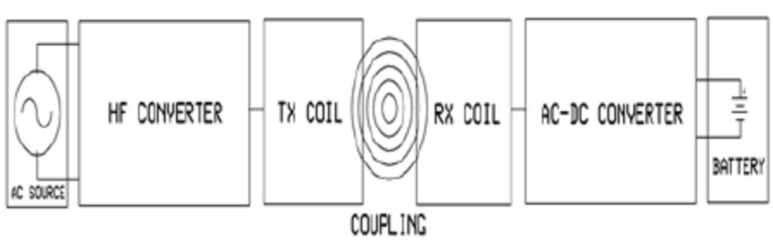


Fig. 2: Block diagram of wireless charging system The basic circuit model of the WPT system is shown in Fig. 3 connected in series to series topology [5]. Considering the complexity of the system it's easy to analyze the simplified equivalent network model. The circuit consists of primary and secondary winding L_1 and L_2 respectively. R_1, C_1 connected at primary side and R_2, C_2 at secondary side. These components are linear and passive in nature. The RLC circuit exhibits a property of resonance. The values of LC can be adjusted in such way so as to obtain a resonant frequency of 10 kHz to 30 kHz. The current through the primary coil I_1 is determined by input voltage V_1, and by the total impedance of the secondary coil as seen by the primary coil. The total impedance of the circuit is given by,

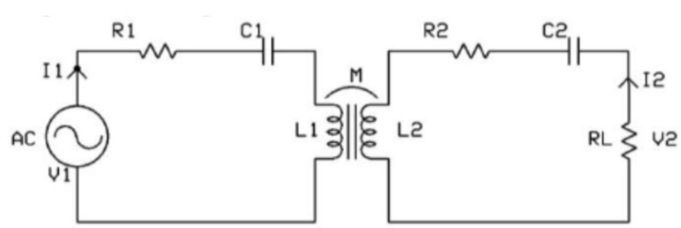
$$Z_1 = R_1 + j\left(\omega L_1 - \frac{1}{\omega C_1}\right)$$

$$Z_2 = R_2 + R_L + j\left(\omega L_2 - \frac{1}{\omega C_2}\right) \quad (1)$$

$$C_1 = \frac{1}{\omega_0^2 L_1} \text{ and } C_2 = \frac{1}{\omega_0^2 L_2} \quad (2)$$

$$0 \leq k \leq 1 \text{ and } k = \frac{M}{\sqrt{(L_1 L_2)}} \quad (3)$$

The through current can be kept constant in amplitude if input voltage is varied as a function of R1, which would result in induced voltage in secondary, which is denoted by M in Fig. 3 called mutual inductance, where $M=L_{12}=L_{21}$. The series to series topology behaves like a constant current source producing constant output current. In order to obtain the resonant frequency with a fixed inductance of coils capacitance C1 and C2 can be calculated by Eqn. (2).Mutual Inductance M is further dependent on the distance and position of the primary
and secondary coils. The ratio of the mutual inductance. M and square root of self inductances L1 and L2 is termed as coupling coefficient k, shown in Eqn. (3).



Design of transmission & reception coils Wireless power systems use magnetic cores to improve the magnetic flux density and current running through a closed loop creates agnetic flux density denoted as B. This loop encloses a surface S through this magnetic flux Φ. Eqn. (4) and Fig. 4 explain the concept [5]. Placing second closed loop within the surrounding of the first loop, due to the magnetic flux density B the second loop will have a mutual flux Φ as given by,

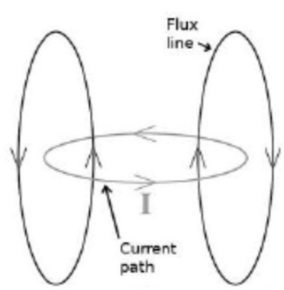
$$\Phi B = \int S B dS \quad (4)$$

Magnetic flux density B is proportional to applied current I. In order to run a current in closed loop coil is used. If the coil has N turns each turn will have magnetic flux density B i.e. B□NI. So when we consider two coils or closed loops with N1 and N2 turns magnetic flux between both the coils give mutual inductance. The inductance of the coils is determined by factors like geometry, coil alignment and permeability of the medium as follows,

$$M = \frac{\mu_0 \mu_r N_1 N_2}{l} \quad (5)$$

$$L = \frac{d^2 * N^2}{18d + 40l} \quad (6)$$

Where μ_0 defines permeability constant measures amount of resistance exhibited to form magnetic field in vacuum $\mu_0 = 4\pi \times 10^{-7}$ H·m^{-1}. μ_r relative permeability defines ability of conductor in magnetic field. A is the area of cross-section the conductor. l is the length of the conductor or coil. Similarly, the values of the self inductance L of the coils can be calculated using the Eqn. (6). Where d is the diameter of cross-section [5]. All the above can be implemented in simulation tools to analyze the working of the coils in 2D and 3D space.



2. POWER SUPPLY DESIGN

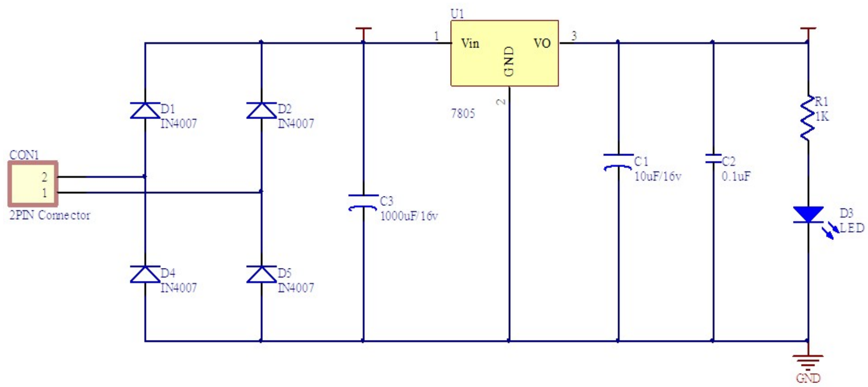


Fig 4.1.1 Power Supply

The LM78XX series of three-terminal positive regulators is available in the TO-220 package and with several fixed output voltages, making them useful in a wide range of applications. Each type employs internal current limiting, thermal shut-down, and safe operating area protection. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components for adjustable voltages and currents.

Features

• Output Current up to 1 A

• Output Voltages: 5, 6, 8, 9, 10, 12, 15, 18, 24 V

• Thermal Overload Protection

• Short-Circuit Protection

• Output Transistor Safe Operating Area Protection

3. DESIGNING OF POWER SUPPLY:

A) The following information must be available to the designer of the trans-former.

1) power output.
2) operating voltage.
3) Frequency range.
4) Efficiency and regulation.

Size of core is one of the first consideration in regard of weight and volume of a transformer. This depends on type of core and winding configuration used. Generally following formula is used to find Area or Size of the Core.

$$Ai = \sqrt{Wp} / 0.87$$

Where Ai = Area of cross section in square cm.

Wp = Primary Wattage.

For our project we require +5V output, so transformer secondary winding rating is 9V, 500mA.

So secondary power wattage is,

$$P2 = 9 * 500mA$$

$$= 4.5Watt$$

So,

$$Ai = \sqrt{4.5} / 0.87$$

$$= 2.43$$

Generally 10% of area should be added to the core.

So,

$$Ai = 2.673$$

a) Turns per volt:- Turns per volt of transformer are given by relation.

$$\text{Turns per volt} = 100000 / 4.44\ f * Bm * Ai$$

Where,

F = Frequency in Hz.

Bm = Density in Wb / Square meter.

Ai = Net area of the cross section

Following table gives the value of turns per volt for 50 Hz frequency.

Flux density 0.76 Wb /sq m	1.14	1.01	0.91	0.83
Turns per Volt 45 / Ai	40 / Ai	45 / Ai	50 / Ai	55 / Ai

Generally lower the flux density better the quality of transformer. For our project we have taken the turns per volt is 0.91 Wb / sq.m from above table.

Turns per volt = 50 / Ai

= 50 / 2.673

= 18.7055

Thus the turns for the primary winding is,

230 * 18.7055 = 4302.265

And for secondary winding,

9 * 18.7055 =168.3495

b) wire size :- As stated above the size is depends upon the current to be carried out by winding which depends upon current density. For our transformer one tie can safely use current density of 3.1 Amp / sq.mm.

for less copper loss 1.6Amp/sq.mm or 2.4sq.mm may be used generally even size gauge of wire are used.

R.M.S secondary voltage at secondary to transformer is 9V. so maximum voltage Vm across secondary is

Vm= Vrms x√2

Vrms=Vm / √2

= 9 * 1.141

= 12.727v

D.C output voltage Vm across secondary is,

Vdc = 2 * Vrms/pi

= 2 * 12.727/3.14

= 8.08 V

P.I.V rating of each diode is

PIV = 2Vdc

= 2 * 8.08

= 16.16 V

Maximum forward current, which flow from each diode is 500 mA. So from above parameter, we select diode 1N4007 from the diode selection manual.

B) Design of filter capacitor:-

Formula for calculating filter capacitor is

C = ¼ √ 3 r * F * R1

Where,

r = ripple present at output of rectifier, which is maximum 0.1 for full wave rectifier.

F = frequency of AC main.

R1 = input impedance of voltage regulator IC

C = 1/(4 *(√ 3 * 0.1 * 50 * 28))

= 1030 µf

= 1000 uF

Voltage rating of filter capacitor should be greater than the i/p Vdc i.e. rectifier output which is 8.08 V so we choose 1000µf / 25V filter capacitor

7805 IC Rating

- Input voltage range 7V- 35V

- Current rating $I_{c} = 1A$
- Output voltage range $V_{Max} = 5.2V$, $V_{Min} = 4.8V$

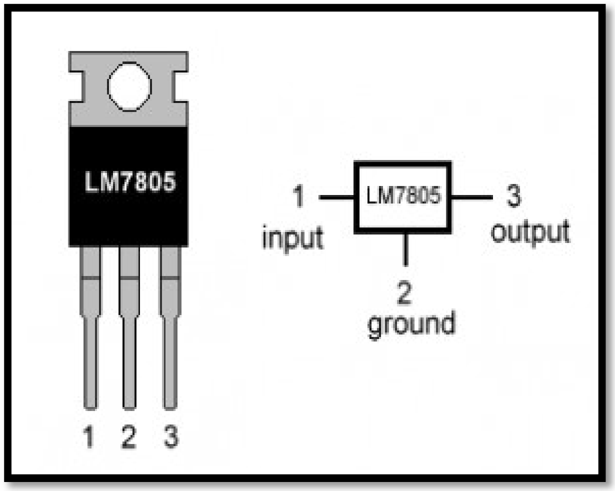


Fig. viii pin out diagram of LM7805

PIN NO	PIN	Function	DESCRIPTION
1	INPUT	Input voltage (7V-35V)	In this pin of the IC positive unregulated voltage is given in regulation.
2	GROUND	Ground (0V)	In this pin where the ground is given. This pin is neutral for equally the input and output.
3	OUTPUT	Regulated output; 5V (4.8V-5.2V)	The output of the regulated 5V volt is taken out at this pin of the IC regulator.

Table: 6 Pin Details of 7805 IC

The difference between the input and output voltage appears as heat. The greater the difference between the input and output voltage, the more heat is generated. If too much heat is generated, through high input voltage, the regulator can overheat. If the regulator does not have a heat sink to dissipate this heat, it can be destroyed and malfunction. Hence, it is advisable to limit the voltage to a maximum of 2-3 volts higher than the output voltage. So the two options are, design your circuit so that the input voltage going into the regulator is limited to 2-3 volts above the output regulated voltage or place an appropriate heat sink that can efficiently dissipate heat.

4. RELAY

Electromagnetic relays are those relay which operates on the principle of electromagnetic attraction. It is a type of a magnetic switch which uses the magnet for creating a magnetic field. The magnetic field then uses for opening and closing the switch and for performing the mechanical operation.

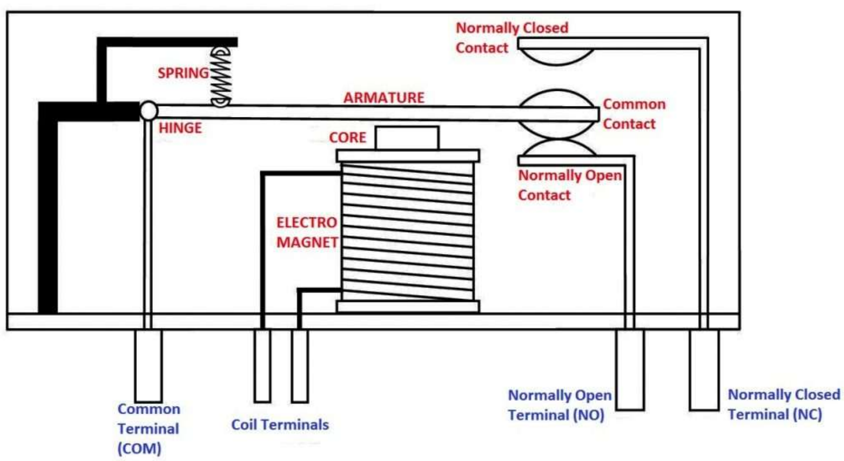


Fig.4.4(a): Electromagnetic relay

The construction and working of a relay can be understood from the above diagram. The main part of a relay is the electromagnet. The electromagnet is made by a coil of wire wrapped around a soft iron core which provides low reluctance path for magnetic flux. It also consists of a movable iron armature and one or more set of contacts. These are held in a position by a spring as shown in the above diagram. Normally a SPDT relay has 5 terminals. Two them are used to energies the electromagnet and other three are COM, NO, NC. COM stands for Common, NO stands for Normally Open and NC stands for Normally Closed. When the electromagnet is not energized, the armature will be connected to NC contact. Thus COM and NC will be connected. When the electromagnet is energized, the electromagnet attracts the iron armature and it will be connected to NO contact. Thus COM and NO will be connected.

- **<u>Specifications of Relay</u>**
    - Coil Ratings

- Contact Ratings
- Change Over Time
- Enclosure and Mounting

- **Coil Ratings**

For DC operated relays electromagnet excitation voltage and coil resistance are specified while for AC operated relays AC Voltage and VA ratings are specified.

- **Contact Ratings**

The commonly used contact ratings are the maximum voltage and current it can handle continuously.

- **Change Over Time**

It is also known as Operation Time. Turn – ON (Switch – ON) time is the time required for the relay to make ON contact after energizing the electromagnet and Turn – OFF (Switch – OFF) time is the time required to make OFF contact after de-energizing the relay. In some applications such as UPS these times are critical.

- **Enclosure and Mounting**

Relays are available in enclosure and in open execution. If the relays are used in cabinet of a device, then you may use open execution type. However if there is a possibility of dust gathering in to electrical contacts, it is better to use enclosed type relays. There is also a possibility of sparks in contacts, thus in hazardous environments properly enclosed relay must be selected.

Fig 4.4(b): Relay

A relay can be defined as a switch. Switches are generally used to close or open the circuit manually .Relay is also a switch that connects or disconnects two circuits. But instead of manual operation a relay is applied with electrical signal, which in turn connects or disconnects another circuit. Every electromechanical relay consists of an consists of an

1. Electromagnet

2. Mechanically movable contact

3. Switching points and

4. Spring

Electromagnet is constructed by wounding a copper coil on a metal core. The two ends of the coil are connected to two pins of the relay as shown. These two are used as DC supply pins. Generally, two more contacts will be present, called as switching points to connect high ampere load. Another contact called common contact is present in order to connect the switching points. These contacts are named as normally open (NO), normally closed(NC) and common(COM) contacts. Relay can be operated using either AC or DC. In case of AC relays, for every current zero position, the relay coil gets demagnetized and hence there would be a chance of continues breaking of the circuit. So, AC relays are constructed with special mechanism such that continues magnetism is provided in order to avoid above problem. Such mechanisms include electronic circuit arrangement or shaded coil mechanism.

7. Working

- Relay works on the principle of electromagnetic induction.
- When the electromagnet is applied with some current it induces a magnetic field around it.
- Above image shows working of the relay. A switch is used to apply DC current to the load.
- In the relay Copper coil and the iron core acts as electromagnet.
- When the coil is applied with DC current it starts attracting the contact as shown. This is called energizing of relay.
- When the supply is removed it retrieves back to the original position. This is called De energizing of relay.

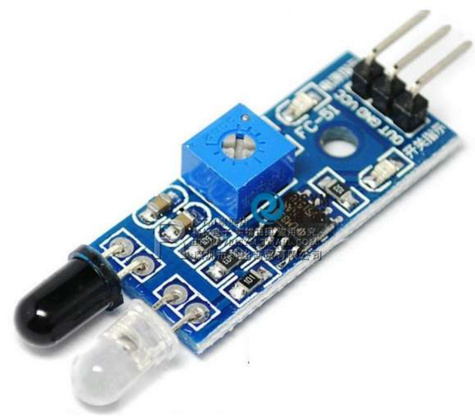
There are also such relays, whose contacts are initially closed and opened when there is supply i.e. exactly to opposite to the above shown relay. Solid state relays will have sensing element to sense the input voltage and switches the output using Opto-coupling.

IR SENSOR

A **passive infrared sensor** (**PIR sensor**) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. They are most often used in PIR-based motion detectors. PIR sensors are commonly used in security alarms and automatic lighting applications.

PIR sensors detect general movement, but do not give information on who or what moved. For that purpose, an imaging IR sensor is required.

PIR sensors are commonly called simply "PIR", or sometimes "PID", for "passive infrared detector". The term *passive* refers to the fact that PIR devices do not radiate energy for detection purposes. They work entirely by detecting infrared radiation(radiant heat) emitted by or reflected from objects.



Operation

All objects with a temperature above absolute zero emit heat energy in the form of electromagnetic radiation. Usually this radiation isn't visible to the human eye because it radiates at infrared wavelengths, but it can be detected by electronic devices designed for such a purpose.

A PIR sensor can detect changes in the amount of infrared radiation impinging upon it, which varies depending on the temperature and surface characteristics of the objects in front of the sensor.[2] When an object, such as a person, passes in front of the background, such as a wall, the temperature at that point in the sensor's field of view will rise from room temperature to body temperature, and then back again. The sensor converts the resulting change in the incoming infrared radiation into a change in the output voltage, and this triggers the detection. Objects of similar temperature but different surface characteristics may also have a different infrared emission pattern, and thus moving them with respect to the background may trigger the detector as well.[3]

PIRs come in many configurations for a wide variety of applications. The most common models have numerous Fresnel lenses or mirror segments, an effective range of about 10 meters (30 feet), and a field of view less than 180°. Models with wider fields of view, including 360°, are available, typically designed to mount on a ceiling. Some larger PIRs are made with single segment mirrors and can sense changes in infrared energy over 30 meters (100 feet) from the PIR. There are also PIRs designed with reversible orientation mirrors which allow either broad coverage (110° wide) or very narrow "curtain" coverage, or with individually selectable segments to "shape" the coverage.

8. Advantages

1. Charging process is simple and automatic.
2. It doesn't require any human input.
3. It is small in size and compact compared to a wired system.
4. As it does not have any contact, there are no exposed electric connections.

9. Disadvantages

1. Standardization of charging system.
2. The difficulty of installation of a wireless charging system.
3. The vehicle has to park on the exact location where charger coils installed to charge the battery.
4. Electric cars are more expensive, and battery packs may need to be replaced

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