Smart Vehicle with Counterbalance Controlling System

Submitted in partial fulfilment of the requirements
of the degree of

BACHELOR OF TECHNOLOGY
IN
MECHANICAL ENGINEERING

By
Sweekriti Shukla (16SCME101195)
Pawan Kumar Singh (16SCME101010)
Akash Singh (16SCME101099)
Kumar Mayank (16SCME101001)

Supervisor:
Dr. Shrikant Vidya

SCHOOL OF MECHANICAL ENGINEERING
GALGOTIAS UNIVERSITY
GREATER NOIDA
2020

CERTIFICATE

This is to certify that the Research work titled **Development of Smart Vehicle with Counterbalance Controlling System** that is being submitted by **–Sweekriti Shukla, Pawan Kumar Singh, Aakash Singh and Mayank Banswar** is in partial fulfilment of the requirements for the award of **Bachelor of Technology**, is a record of Bonafede work done under my guidance. The contents of this research work, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma.

Supervisor
(Dr. Shrikant Vidya)

Internal Examiner **External Examiner**
(Dr. M. Maniraj)

APPROVAL SHEET

This project report entitled **–** ***Smart Vehicle with Counterbalance Controlling System*** by **–Sweekriti Shukla, Pawan Kumar Singh, Aakash Singh** and **Mayank Banswar** is approved for the degree of Bachelor of Technology in mechanical engineering.

Examiners

_____

_____

_____

Supervisor
Dr. Shrikant Vidya

_____

Dean

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Date: _____

Place: _____

DECLARATION

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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(Enrolment No.)

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ACKNOWLEDGEMENT

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(Sweekriti Shukla)

(Pawan Kumar Singh)

(Aakash Singh)

(Mayank)

(Department of Mechanical engineering)

ABSTRACT

All vehicles are prone to rollovers to some extent. Small trucks with light weight roll at a lateral acceleration of 0.8 to 1.2g. Large and heavy trucks (for e.g. commercial trucks) roll at lateral acceleration as low as 0.2g. Trucks are more susceptible to roll as compared to the passenger cars, the reason being that they have taller bodies and larger ground clearance. Military vehicles have a wheel track that is wider than normal SUVs, so they have less tendency to rollover. The vehicles that are heavily loaded are more prone to rollover. The factors that affect the rollover conditions are high steering input, yaw rate, high speed, friction with respect to the ground, high center of mass, or structing with an external object and digging the tires into the ground. So, the objective of this experiment-based project is to design and fabricate an electromechanical counterbalance controlling system for vehicles to avoid rollover.

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1. Introduction

1.1 Project background

According to statistics from the "*National Highway Traffic Safety Administration*", about 30% of all casualties in car accidents occur due to **rollover**. Even the passengers who survive in the crash, they can have severe injuries, including some that can be worse than death. Many believe that rollover accidents occur due to excessive speed or rough driving however that's

not always the case. The driver is not always responsible for the accident. In numerous cases, faulty or **defective vehicle designs**, defective manufacturing or even defective or poorly designed roadways can be the factors that leads to rollover accidents.

Several types of actuation systems can be used for rollover prevention. Among all, the differential braking system has received the most attention from researches. It is used to prevent rollovers by reducing the yaw rate of the vehicle and the speed of the vehicle. By reducing the yaw rate and speed, the vehicle propensity to rollover is reduced. Steer by wire systems and active suspensions can also be used to prevent rollovers. Active rollover prevention systems have already been developed by several automotive manufacturers and are based on modifications of electronic stability control systems. These systems utilize lateral accelerometers to detect rollovers. But the drawback of these systems is that they can only predict and prevent Untripped rollover. There has been no assistant system developed that can predict and prevent tripped rollover. Thus, this project is specifically made considering this drawback of systems that have been developed previously for the prevention of rollover.

Tripping – According to the NHTSA report, approximately 95 percent of all rollover accidents occur when one of the vehicle's tires strikes any external object that intersperse the motion of vehicle and leads to the pitching of the vehicle forward or sideways into roll. Many objects can result in tripping, including a soft soil, a bump, a large rock, or a curb.

High Centre of Gravity – Many vehicles, especially small vans, civilian SUVs and large pickup trucks, have their center of gravity located at a higher position, which makes their designs more susceptible to rollover as compared to other vehicles, even under relatively mild conditions.

1.2 Research Purpose and Meaning

This project relates with the counterbalance controlling of vehicle. Rollovers occurs in 2 ways namely, tripped and Untripped. Tripped rollovers are caused by forces from an external object for e.g. a curb or collision with another vehicle i.e. head on collision. An example of this rollover considers a vehicle sliding sideways until both side wheels strike a solid obstacle, such as a curb. The curb provides a pinpoint for the vehicle about which it starts to rotate. The half-track 't/2' and the height 'h' of the center of gravity are shown in this diagram at the point when the vehicle strikes a curb at sideways speed *v*:

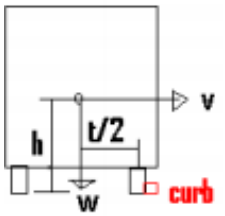


Figure 1: Vehicle rollover condition (1)

Here vehicle is at the critical point of rollover:

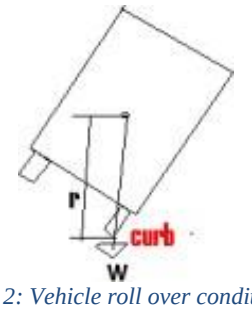


Figure 2: Vehicle roll over condition (2)

If velocity of the vehicle is greater than zero at this point, rollover will occur. If the sideways velocity just reaches to zero at this point in the rotation, the vehicle will be just on the verge of rollover (the critical point). The height of the CG at the critical point has increased to

$$r = \sqrt{\left(\frac{t}{2}\right)^2 + h^2}$$

by Pythagoras' theorem as the hypotenuse of a right triangle with sides 't/2' and 'h'.
Energy conservation requires that*:*

energy before hitting the curb = energy at the critical point, where energy = kinetic energy ($\frac{1}{2}mv^2$) *+ gravitational potential energy* (*mg* × *height above surface*):
Therefore, at the critical point where $u_p = 0$:

$\frac{1}{2}mv^2 + mgh = mgr = mg\sqrt{\left(\frac{t}{2}\right)^2 + h^2} = mgh\sqrt{s^2 + 1}$, where $s = \frac{\frac{t}{2}}{h}$

Therefore, the initial speed that just produces the critical point is given by:

$$v^2 = 2g\left(\sqrt{\left(\frac{t}{2}\right)^2 + h^2} - h\right)$$

This is the square of the initial velocity, when hitting the curb, that gives zero velocity at the critical point, the condition to just begin a rollover.
An example of Untripped rollover is when a vehicle makes a collision avoidance maneuver or a cornering maneuver with high speed. Nearly 30% of passenger accident deaths are from rollover crashes. In vehicle stability control system, the active vehicle rollover prevention is there to prevent rollovers.

2. Objective Study

India 2nd largest population in the world, unfortunately ranks at the top with highest number of road casualties (about 11% share in the world). Road accidents has always been a leading cause of death, disabilities, and hospitalization in the country. [1] The total number of road accidents related deaths in 2018 stood at 1,51,417 as per the Report on Road Accidents in India 2018. If we further categorize these road accidents according to the types of collision, we will come to know that the head on collision accidents share 18.7% which is the highest among all the type of collisions. Thus, this research paper is all about an experiment- based project that aims at reducing head on collisions with the aid of an electromechanical system for the counterbalancing of the vehicle.

2.1 Rollover accidents

A rollover is a kind of vehicle accident in which the vehicle tips over onto its roof or side. These rollover accidents are basically categorized into two categories:

1. Tripped Rollover
2. Untripped Rollover

Figure 3: : A rollover in Sydney, Australia on Christmas Day, 2001

Tripped rollovers are caused when the vehicle strikes with an external object, such as a curb or collision with another vehicle. On the contrary, Untripped crashes are caused due to factors such as steering input, speed, and friction with the ground.

Untripped rollovers occur while cornering forces make the vehicle in unstable condition. As a vehicle traverse a corner, three major forces act on it: tire forces (the centripetal force), inertial effects (the centrifugal force), and gravity force. The cornering forces from the vehicle tire pushes the vehicle towards the center of the curve. This force acts at ground level, below the center of mass. The inertia force acts horizontally through the vehicle's center of mass away from the center of the turn. These two forces lead to the roll of the vehicle towards the outside of the curve. The gravity force due to the vehicle's weight acts downward through the center of mass in the opposite direction. When the tire and inertial forces are sufficient to overcome the

force of gravity, the vehicle begins to turn over.

Generally, tripped rollovers occur when a vehicle is sliding sideways, and the tires strike a curb, digging its tires into soft soil that results in a sudden increase of lateral force. The physics are like cornering rollovers. In the 2003 report, this was the most common mechanism for about 71% of single-vehicle rollovers.

Figure 4: A rollover in southern Italy

Another type of tripped rollover occurs due to a collision with any external object like another vehicle or obstacle in the path. These occur when the collision makes the vehicle unstable, for e.g. if a narrow object in the path causes one side of the vehicle to accelerate upwards, but not the other. A side impact can also accelerate a vehicle sideways. The tires tend resist the change caused, and the coupled forces makes the vehicle to rotate. In 1983, crash tests reported that light trucks were prone to roll over after colliding with certain primitive designs of guide rail.

Rollover of a vehicle can also occur as a vehicle traverse a ditch or slope. Slopes steeper than 33% (one vertical unit rise or fall per three horizontal units) are called "critical slopes" as they can make the vehicles to overturn.

A vehicle may also roll over for other reasons, such as after hitting a large obstacle with one of its wheels or while maneuvering over rough terrain.

2.2 Vehicles

All vehicles are susceptible to rollovers to various extents. The factors affecting the tendency of rollover increases with the height of the center of mass, increased speed, steering sensitivity, and narrowness of the axle track.

SUVs are particularly prone to rollovers, especially those that are outfitted with long travel off-road suspensions. The increased height of the suspension for increased clearance raises the center of mass.

Full-size vans usually do not have off-road suspensions, but their body height makes them tend to tip. Fifteen passenger vans for e.g. the Ford E- Series, are especially popular for rollover as their height is increased by the heavy-duty suspensions necessary to carry large number of people. The tendency to rollover is increased in the vehicles that are heavily loaded. It is

recommended not to load anything on the roof of such vans, and to use experienced drivers or trained in safe operation of the vehicle.

The vehicles which have gained the publicity for tendencies to roll over are the Ford Bronco II, Mitsubishi Pajero/Montero Suzuki Samurai, Jeep CJ, and Isuzu Trooper.

Military vehicles have a wheel track that is much wider than civilian SUVs, making them difficult to roll over. However, IEDs in Afghanistan and Iraq cause roll over that is not seen by civilian vehicles.

2.3 Exit

After a rollover occurs, the vehicle may end up lying on its side or roof, often obstructing the doors, and obscuring the escape for the passengers. Large passenger vehicles such as buses, trams, and trolley buses that have doors on one side only usually have one or more methods of using windows for escape in case of a rollover. Some of the vehicles have special windows with handles to pull it out so that the windows can be used as an emergency exit. Some have tools for breaking the windows and making an improvised exit. Few have emergency exit door or hatches in their rooftops or on the opposite side of the usual door entry. Some vehicle has a combination of two or more of these escape methods.

2.4 Roll bars and cages

Rollover crashes are very dangerous for the passengers of a vehicle as compared to frontal, side, or rear crashes, because in normal passenger vehicles, the roof is more likely to collapse towards passenger and cause serious head injuries. The installation of roll cages in vehicle make them safer, but in most passenger vehicles their use would cut cargo and passenger space so much that their use is not practical.

The main reason behind the decline in the popularity of convertibles in the US was the concern about lack of protection in rollover accidents, as most of the convertibles have no protection except the windshield frame. Some Mercedes- Benz convertibles have a roll bar which is retractable and comes into action in case of an accident. Almost all race cars have roll cages, since in racing the rollover tendency is prominent. Moreover, the roll cage's chassis-stiffening effect is usually seen beneficial for the car.

2.5 Warning signs

All countries have a unique sign warning of curves and other areas of road with an increased danger of rollover for trucks and other high vehicles. These signs may include an advisory statement such as safe speed etc. to avoid a rollover.

Figure 5: Warning Signs

3. Literature review

3.1 Introduction

This chapter summarizes the lessons learned from the literature review about rollover accidents and their prevention. The literature review includes a summary of references that discuss the causes of rollover of vehicles along with the various mechanisms that have been developed to avoid these rollovers.

3.2 Crash Severity

Rollover crash has the most complex vehicle and passenger motion among the four major modes: front, side, rear, and rollover. The forces involved before and during a rollover crash are complicated as they are dynamic. These crash forces are applied to the vehicle structure in a variety of locations, and at a variety of magnitudes and directions. Crash energy is removed slowly in a rollover crash and the crash motion occurs over a much longer period.

A major difference between rollovers and planar crashes is that rollovers generally occur at higher speeds. In examining the speed distributions of planar vs. rollover crashes, one can observe that the average speed for rollovers is shifted by more than 20 mph toward higher travel speeds. The mean speeds for these distributions are: 50 mph for rollover involved cars, and 28mph for cars in all other crashes. If we talk about rollovers in which a causality is involved, the average speed is 63.4mph, compared with 45.3 mph for all other fatal crashes.

3.3 Rollover Characterization

Considerable research has been undertaken over the years to characterize rollover according to severity and to develop a standard rollover test. In most cases the studies are applicable to passenger cars. However, many of the principles are generally applicable to all vehicles. In recent years, the increase in rollover casualties from the growing population of pickups and SUVs has emphasized the need to examine these vehicles as separate classes. Some of the most relevant studies of rollover crashes will be described in the paragraphs to follow.

3.4 Reviews

3.4.1 Vehicle System Dynamics

International Journal of Vehicle Mechanics and Mobility
Volume 26, 1996-Issue 1
Active Roll Control of Articulated Vehicles

This paper illustrates an investigation into active roll control of articulated vehicles. It tells us that to avoid rollover conditions in vehicles, the lateral load transfer must be minimized. The methodology that is being used to design lateral acceleration controllers for vehicles equipped with active anti- roll bars was developed using a simplified linear

articulated vehicle model. The drawbacks of hardware and power consumption requirements of the active elements are studied. The controller is then implemented in articulated vehicle model to check the performance of an articulated lorry with active anti-roll bars. The simulation results demonstrate that the probability of a significant improvement in transient roll performance of the vehicle, having a relatively low power system (i.e.10KW) with low bandwidth actuators.

3.4.2 Google Patents

Thomas J. Wielenga US6065558A
Anti-rollover brake system

This invention provides a braking system to prevent a friction rollover of a vehicle. The brake system contains a set of brakes for applying pressure to oppose the rotation of the respective wheels of the vehicle, a sensor for generating a rollover signal in response to a predetermined force urging the vehicle to rollover, and a controller for actuating the brakes in a predetermined manner in response to the rollover signal.

In one embodiment of this invention, the controller will actuate both the front brakes to the rollover signal. In other embodiment of this invention, the controller breaks the heavily loaded front tire in response to the rollover signal.

3.4.3 Google Patents

Counterbalance system for short wheelbase vehicles
Jack B. Ottestad
US Patent 5,685,563,1997

A counterbalance system for a vehicle have an axis of forward movement, a frame, and front and rear wheels spaced by a short wheelbase dimension. A counterweight moves axially along the rail that mounted to the frame. A power link mounted to the counterweight and attached to a linkage that is pivoted both to the counterweight and to the frame moves counterweight forwardly or rearwardly to properly stabilize the vehicle at various load and slope conditions where the vehicle would be less stable.

This patent suggests us that an approach to solve the problem of rollover in vehicles is to provide an appropriate counterweight.

4. Project description

4.1 Problem description

After reading the various literature reviews, it would become obvious for one to conclude that a system should be essentially developed to prevent tripped rollover. So, this project model is constructed with the aim to reduce tripped rollover as well as Untripped rollover in small 3 wheelers or 4 wheelers that are more prone to rollover.

4.2 Technical description

Since, this is an experiment-based project, so it is implemented on a nonmoving dummy vehicle instead of a realistic vehicle. This dummy vehicle is suspend hanged on an iron frame with the help of hinges and hollow pipe frame washer. Now, a sliding mechanism is constructed over the vehicle body frame which provides "X'' and "Y'' plus and minus sliding rotation. This sliding rotation is provided by two worm gear DC motors. A heavy mass (iron cubes) is placed on the sliding mechanism. These sliding mechanisms is placed on the center of the vehicle body frame. All this mechanism is controlled by an electronic circuit so that all these movements are sensed by an accelerometer sensor. The accelerometer senses the vehicle position with respect to ground surface. When the vehicle faces any rollover condition, sensor immediately senses and sends the information to the electronic controlling unit that shifts mass to the opposite side for counter balancing.

4.3 Prototype Construction

- A 0.5-inch mild steel pipe and four plastic tires are used to construct the vehicle body frame.
- Now, the vehicle body frame is hanged to an iron frame with the help of hinges and hollow pipe.
- A rotary sliding mechanism is constructed over the model and a heavy mass is attached to it. This sliding mechanism is powered by two high speed worm gear DC motors.
- A small electronic controlling circuit control the rotary gear. This circuit is controlled by an accelerometer sensor.
- This accelerometer sensor always senses the vehicle position with respect to the ground surface. In case, the vehicle faces any rollover condition, the accelerometer informs the electronic controlling unit that controls the rpm of the worm gear motor required for the rotary sliding motion of the mechanism for counter balancing with the help of the movement of the heavy mass.

4.4 Components used

4.4.1 Mechanical components:

a) High speed worm gear DC motor

b) Pulley and sliding Mechanism:

c) Mild Steel Pipe

d) Wooden Base

e) Iron frame

f) Hinges

g) 8 Wheel rods

h) Plastic Wheels: 10-inch thick plastic

4.4.2 Electronic Components:

a) Low power (1.8V to 3.6V), ADXL335 Accelerometer

b) Controller

c) Relay

d) Transformer

e) Bridge Rectifiers

f) LCD

g) Regulator (7805IC in 5V power supply)

h) Switch

i) Jumper Wire

j) PCB

k) Capacitors, Resistors, PNP transistor & Diode

l) Choke Input Filter

m) Capacitor Input Filter.

4.5 Circuit Diagram

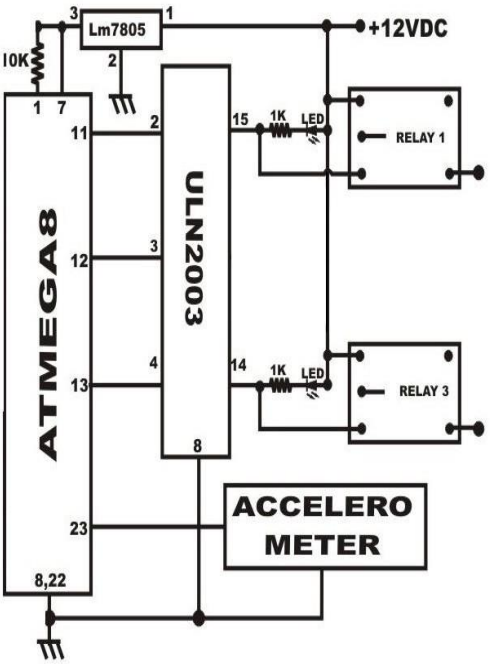


Figure 6: Complete circuit Diagram.

4.6 Component Detail

4.6.1 ATMEGA 8

Features

• High-performance, Low-power AVR®

- 8-bit Microcontroller

• Advanced RISC Architecture

– 130 Strong Instructions – Most Single-clock Cycle Execution

– 32 x 8 General Purpose Working Resistors

– 16 MIPS Throughput at 16 MHz

– On chip two cycle Multiplier

• High Endurance Non-volatile Memory segments

– 8K Bytes In-Built Self-Programmable Flash program memory

– 512 Bytes of EEPROM

– 1K Byte of Internal SRAM

– Write/Erase Cycles of 10,000 Flash/100,000 EEPROM

– Data retention of 20 years at 85°C/100 years at 25°C (1)

– Section of Additional Boot Code having Independent Lock Bits

• In-System Programming by On-chip Boot Program

– Read While Write Operation

– Programming Lock for Software Security

• Peripheral Features

– Two 8-bit Timer/Counters having Separate Presale, single comparator

•Six Channels 10-bit Accuracy

– Byte-oriented Two-wire Serial Interface

– Programmable Serial USART

– Master/Slave SPI Serial Interface

– Programmable Watchdog Timer with Separate On-chip

4.6.2 Oscillator

– On-chip Analog Comparator

•Special Microcontroller Features

– Power-on Reset and Programmable Brown-out Detection

– Internal Calibrated RC Oscillator

– External and Internal Interrupt Sources

– Five Sleep Modes: Idle, ADC Noise Reducer, Power saver

•I/O and Packages

– 23 Programmable I/O Lines

– 28-lead PDIP, 32-lead TQFP, and 32-pad QFN/MLF

•Operating Voltages

– 2.7 - 5.5V (ATmega8L)

– 4.5 - 5.5V (ATmega8)

•Power Consumption at 4 MHz, 3V, 25°C

– Active: 3.6 mA

– Idle Mode: 1.0 mA

– Power-down Mode: 0.5 µA

4.7 Pin Configurations

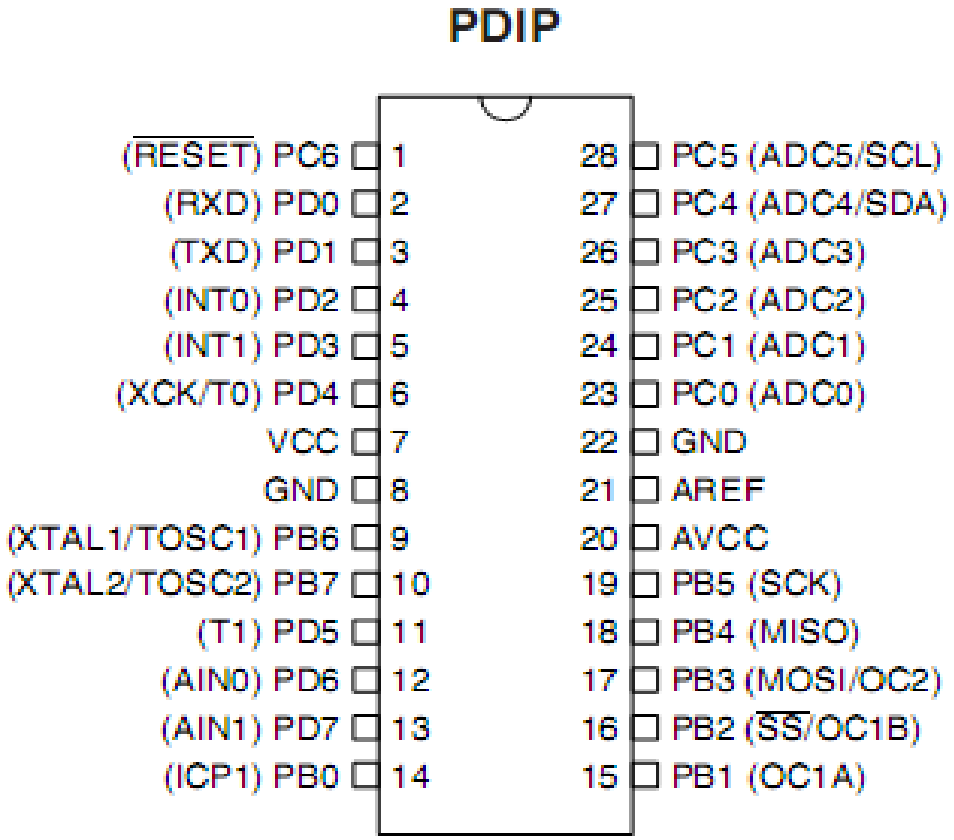


Figure 7: The ATmega8 is a low-power CMOS 8-bit microcontroller based on the AVR RISC architecture.

Programming high instruction commands in one clock cycle, the ATmega8 gains throughputs reaching 1 MIPS per MHz, permitting the system designer to optimize power consumption versus processing speed.

4.8 Block Diagram

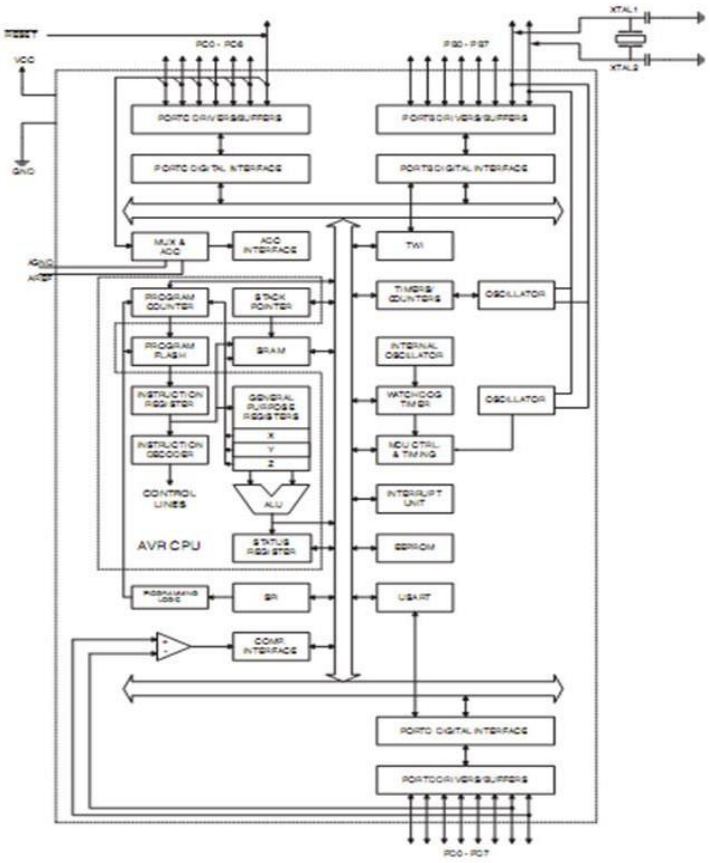


Figure 8: Block Diagram

4.9 Basic Function:

The main purpose of the CPU core is to ensure program execution correctly. Thus, the CPU must be able to access memories, perform calculations, control peripherals, and handle interrupts.

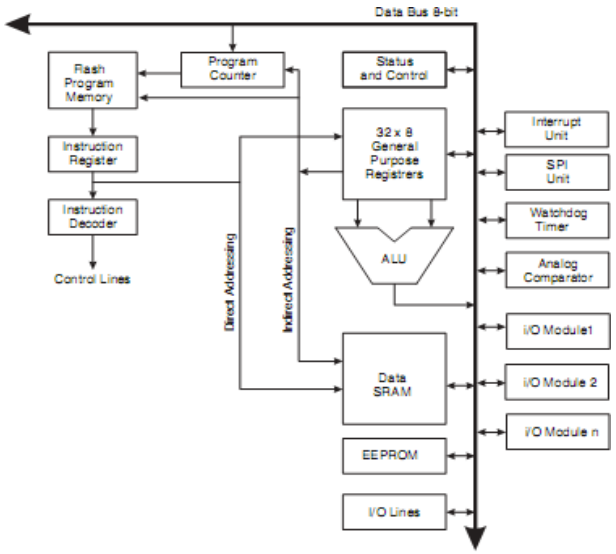


Figure 9: Interfacing of Data Bus with Different Units

To maximize the performance and parallelism of the processing, the AVR makes use of a Harvard architecture with separate memory storage and buses for programming and data.

Instructions in the Program memory are executed with a one level pipeline. When one instruction is executed, the next instruction is pre-fetched from the memory of Program. This concept enables instructions that is to be executed in each clock cycle.

The Program memory is In-built Reprogrammable Flash memory. The fast-access Register File contains 32 x 8-bit general purpose working resistors with one clock cycle access time. This makes the single-cycle Arithmetic Logic Unit (ALU) operation to be performed. In a general ALU operation, double operands are output from the Register File, the operation is being executed, and the result is stored back in the Register File in one clock cycle.

6 registers out of the 32 registers can be used as three 16-bit indirect address register pointers for Data Space addressing enabling efficient address calculations. One address pointer may also be used as an address pointer for look up tables in Flash Program memory. These additional functional registers are the 16-bit X, Y and Z- register. The ALU supports arithmetic and logical operations involving registers or between a constant and a register. Single register operations may also be executed in the ALU. After performing an arithmetic operation, the Status Register is updated to reflect information regarding the result of the operation. The Program flow is provided through conditional and unconditional jump and call instructions, able to address the whole address memory space. Almost all AVR instructions have a single 16-bit word format. Every Program memory address has a 16- or 32-bit instruction.

The flexible interrupt module has its own control registers in the input space with an extra global interrupt enable bit in the Status Register. Every interrupt has a separate Interrupt Vector. The interrupt has its priority according to their Interrupt Vector position. The lower Interrupt Vector address is always its priority. The input memory space includes 64 addresses for CPU peripheral functions as Control Registers, SPI, and other input functions. An input memory may be accessed directly, or as the Data Space locations following those of the Register File, 0x20 - 0x5F.

5. Accelerometer

A small low Power, 3-Axis ±3 g Accelerometer

Figure 10: Accelerometer

5.1 FEATURES

- 3-axis sensing
- Small, low profile package
- (4 × 4 × 1.45) mm^3 LFCSP
- Low power: 350 a (typical)
- Single-supply operation: 1.8 V to 3.6 V
- 10,000 g shock survival
- Excellent temperature stability
- BW adjustment having a capacitor per axis
- RoHS/WEEE lead-free compliant

5.2 Applications

- Cost sensitive, low power, motion- and tilt-sensing applications
- Mobile devices
- Gaming systems
- Disk drive protection
- Image stabilization
- Sports and health devices

5.3 General Description

The ADXL335 is a low power, small, thin, full 3-axis accelerometer having signal conditioned voltage outputs. The product measures an acceleration having a minimum full-scale range of ±3 *g*. It measures the static acceleration of gravity in tilt-sensing function, and the dynamic acceleration that results from the motion, shock, or vibration.

The user chooses the bandwidth of the accelerometer with the help of the CX, CY, and CZ capacitors at the XOUT, YOUT, and ZOUT pins. Bandwidths can be selected to be appropriate for the application, having a range of 0.5 Hz to 1600 Hz for the X and Y axes, and having a range of 0.5 Hz to 550 Hz on the Z axis. The ADXL335 is available in a low profile, 4 mm × 4 mm × 1.45 mm, 16-lead, plastic lead frame chip scale pack set.

5.4 Dc Motor

The first electromagnetic rotary motor was discovered by Michael Faraday in 1821 and contains a free-hanging wire dipping into a pool of mercury. A permanent magnet placed in the middle of the melt of mercury. If a current was passed through the wire, the wire is rotated around the magnet, showing that the current lead to the rise of a circular magnetic field around the magnet. This motor is often demonstrated in elementary physics classes, but brine (salt water) is sometimes used instead of the toxic mercury. Homopolar motor is the most basic form of the class of electric motors. A later modified form is the Barlow's Wheel.

Figure 11: DC Motor

The traditional DC motor has a rotatory armature in the form of an electromagnet. A commutator reverses the direction of the electric current twice every cycle, to flow through the armature so that the poles of the electromagnet push and pull against the permanent magnets on the outer side of the motor. As the poles of the armature electromagnet passes the poles of the permanent magnets, the commutator reverses the polarity of the armature electromagnet. At that instant of the switching polarity, inertia keeps the traditional motor in the proper direction. (See the diagrams below.)

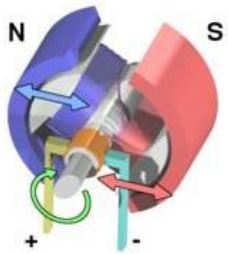


Figure 12: Armature

In a simple DC electric motor, when the coil given electric power, a magnetic field is generated around the armature. The left side of the armature is pushed away from the left magnet and drawn towards the right magnet, causing rotation.

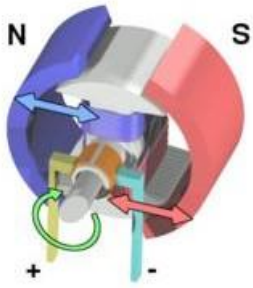


Figure 13: Armature Rotating

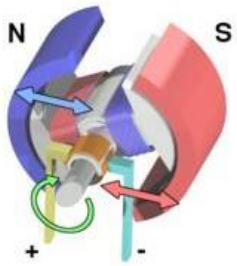


Figure 14: Continuous Rotation

When the armature becomes horizontally aligned, the commutator inverses the direction of the current through the coil, reversing the direction of the magnetic field. This phenomenon is then repeated.

5.5 Plastic wheel


Figure 15: Wheel

5.6 Relay

It is desirable or essential to isolate one circuit electrically from another, while still allowing both the circuits work in coordination.

For example, if a high-voltage circuit is to be controlled from the computer, probably it should be connected directly to the low-voltage port on the back of the computer in case something went wrong and the mains supply ended up damaging the expensive parts of the computer.


Figure 16: Relays

A general method of providing electrical isolation between two electrical circuits is to place a relay between them, as shown in the circuit diagram of figure 1. A relay has a coil that can be energized by the low-voltage circuit and a set of switch contacts that can be connected to the high-voltage circuit.

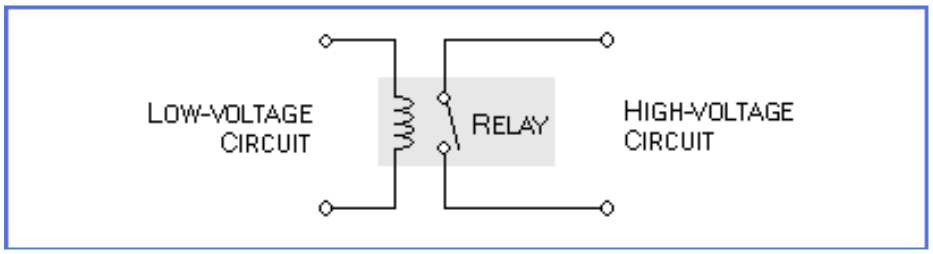


Figure 17: Relay Providing isolation Between Circuit.

5.7 TRANSFORMER

Transformers are the basic class of coils having two or more windings generally wrapped around a common core made from covered iron sheets.

It has two coils named primary winding and secondary winding. When the electric current flowing through primary winding is fluctuating, then an electric current will be induced into the secondary winding also. A steady current will not be induced from primary coil to secondary coil.

There are two kinds of Transformers:

3. Step up transformer

4. Step down transformer

In the supply of power, we use step down transformer. We supply 220V AC on the primary winding of the step-down transformer. This transformer steps down the voltage to 9V AC. We supply this 9 V AC to the rectifier circuit, which convert it into 5V DC.

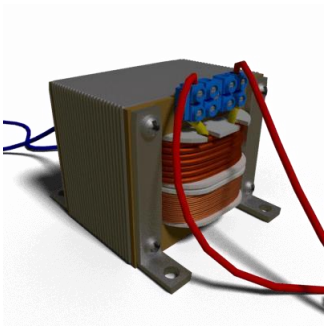


Figure 18: Transformers Coil

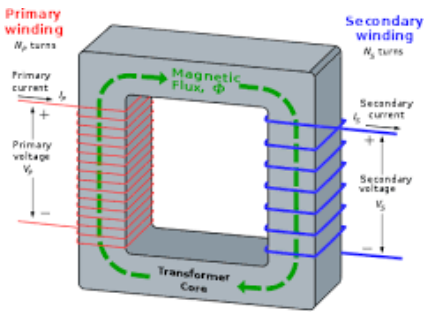


Figure 19: Transformer

5.8 REGULATOR 7805

In 5V power supply,7805 IC is used as regulator.

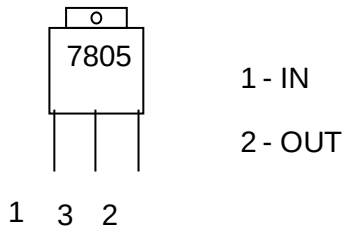


Figure 20: Regulator IC

In 7805 pin no.1 is i/o pin through which non-regulated signal is supplied. Pin no.3 is grounded & from pin no.2 the regulated output is taken.

5.8.1 Power supply

Almost all the digital circuit is operated on 5V DC supply that is produced by the following circuit. The power supply circuit contains a step-down transformer, bridge rectifier and 7805 voltage regulator IC.

5.9 BRIDGE RECTIFIERS

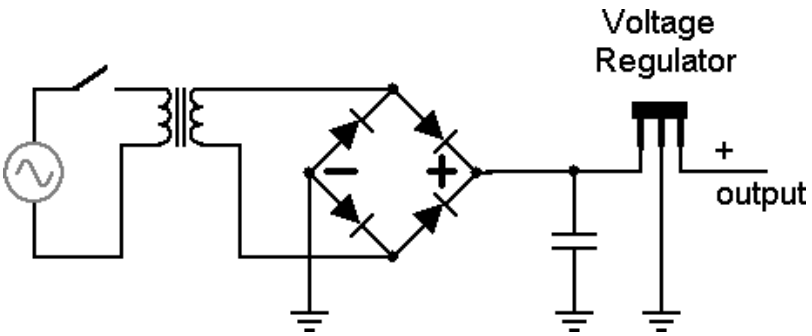


Figure 21: Bridge Rectifier

Bridge rectifier circuit includes four diodes arranged in the form of a bridge as shown in figure 23.

5.9.1 OPERATION:

In the positive half cycle of the I/O supply, the upper end A of the transformer secondary winding becomes positive wrt its lower point B. This makes point 1 of bridge positive wrt to the point 2. The diode D1 & D2 becomes forward biased & D3 & D4 become reverse biased. As a result, a current start flowing from point 1, through the diode D1 & D2 to the negative end.

In the negative half cycle of the I/O supply, the point2 becomes positive wrt the point 1. The Diodes D1 & D2 now become reverse biased. Thus, a current start flowing from point 2 to point1.

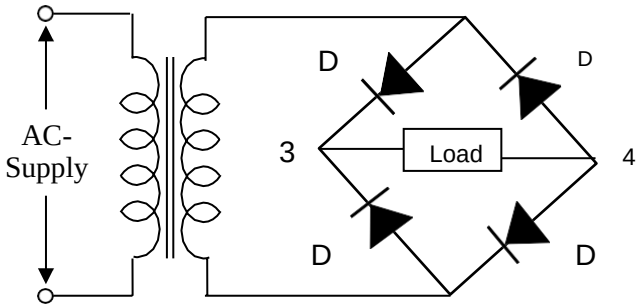


Figure 22: Rectifier

5.10 CAPACITOR

It is an electronic component whose function is to store charges and then to release it when required.

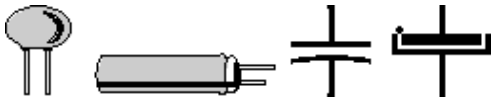


Figure 23: Capacitors

To have a better understanding of the concept of the capacitance, consider a pair of metal plates that are all placed in the vicinity of each other without any contact. If a battery is connected to these plates the positive pole to one and the negative pole to the another, the electrons from the battery will be attracted towards the plate which is connected on the positive terminal of the battery. When the battery is disconnected, one plate is left with an excess of electrons, the other with a shortage, and a potential or voltage difference exists between them. These plate acts as capacitors. Capacitors are of two types: -

(1) Fixed type capacitors like ceramic, polyester, electrolytic capacitors-these names refer to the material that are made of aluminum foil.

(2) Variable type capacitors like gang condenser in radio or trimmer. In fixed type capacitors, there are two leads and their values are written over its body and variable type capacitors has three leads. Unit of measurement of a capacitor is Faraday denoted by the symbol "F". It is a very big unit of capacitance. In case of electrolytic capacitors, its two terminals are marked as (-) and (+) so check it while using capacitors in the circuit in the right direction. Mistakes can damage the capacitor or entire circuit in operation.

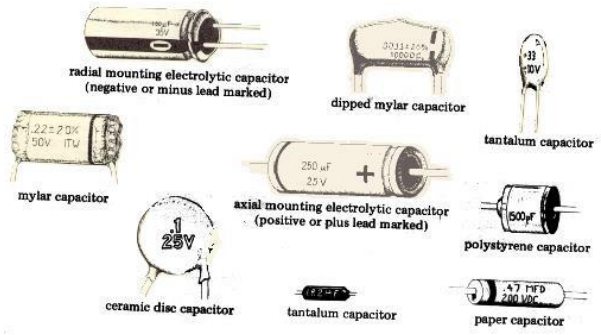


Figure 24: Capacitors

5.11 RESISTANCE

Resistance is the opposition, or the resistance offered by a material to the flow of the current. It is measured in Ohms (Ω). Every conductor represents a specific amount of resistance as no conductor is 100% efficient. Thus, to control the electron flow (current flow) in a predictable manner, we use resistors. Every electronic circuit makes use of a calibrated lumped resistors to control the flow of the current. If we broadly classify the resistors, they can be divided into two groups viz. fixed & adjustable (variable) resistors. In fixed resistors, the value of the resistance is fixed & cannot be varied. In case of variable resistors, we can vary the resistance value by an adjuster knob. It can be categorized into (a) Carbon composition (b) Wire wound (c) Special type. The most common type of resistors is being used in our project viz carbon type. The value of the resistance is generally indicated by color bands. Every resistance has a band of four colors, one of the band on either sides will be gold or silver, this is called the fourth band and shows the tolerance, other three band will give the value of resistance (see table). As for e.g. if a resistor has the following color marking on it let's say red, violet and gold. If we compare these colored rings band with the color code, its value is 27000 ohms, or 27 kilo ohms and its tolerance is ±5%. Resistors are available in various sizes (Power rating). The bigger, the size, the more power rating will be.

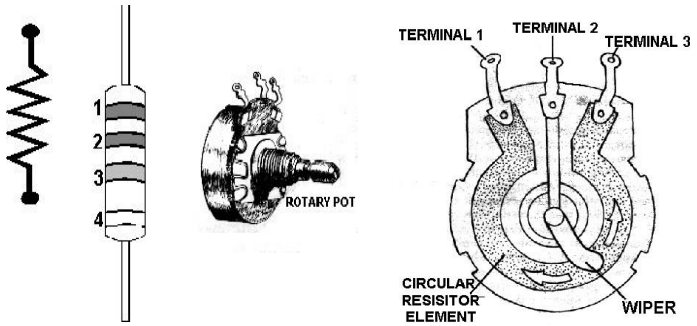


Figure 25: Resistance & POT

The first ring shows the first digit. The second ring shows the second digit. The third ring shows the number of zeroes to be placed after the digits. The fourth ring shows tolerance (gold ±5%, silver ± 10%, No color ± 20%).

In variable resistors, the dial kind of resistance boxes are there in which there is a knob with a metal pointer. This presses over brass pieces that is being placed along a circle with a gap between them. Several resistance coils of different values are connected between the gaps. If the knob is rotated, the pointer moves over the brass pieces. Whenever a gap is skipped, the resistance is included in the circuit. When two gaps are skipped, both the resistances are together included in the circuit and so on.

A dial kind of resistance box contains several dials depending upon their range, which it must cover. If a resistance box is used to read up to 10,000 of the reading, it will have three dials each having 10 gaps i.e. ten resistance coils each of them having a resistance of 10 ohms. The third dial will be having ten resistances each of 100.
The dial resistance boxes are better as the contact resistance in this case is small & constant.

5.12 TRANSISTOR

Along with conductors and insulators, there is a third class of material that exhibits proportion of both. Under some circumstances, it acts as an insulator, and under other it acts as a conductor. This phenomenon is called Semi-conduction in which a variable control over electron flow is allowed. So, the transistor is a semi-conductor device used in electronics for getting a range of amplitude. Transistor generally consists of three terminals, one is the collector, one is the base and the other is the emitter (each lead must be connected in the circuit correctly and only then the transistor will perform its function properly).The electrons are emitted through one terminal and are collected on another terminal, while the third terminal behaves as a control element. Every transistor has a number marked on its body having its own specifications. There are basically two kinds of transistors (i) NPN & (ii) PNP

5.12.1 NPN Transistors:

When a positive voltage is supplied to the base, the transistor starts to conduct by making the current to flow via the collector to the emitter circuit. The relatively small current flowing through the base circuit causes a greater amount of current to pass through the emitter / collector circuit. This process is called current gain which is measured in beta.

5.12.2 PNP Transistor:

It also performs the same thing as described above except that it has a positive voltage on its emitter and a negative voltage on its collector.

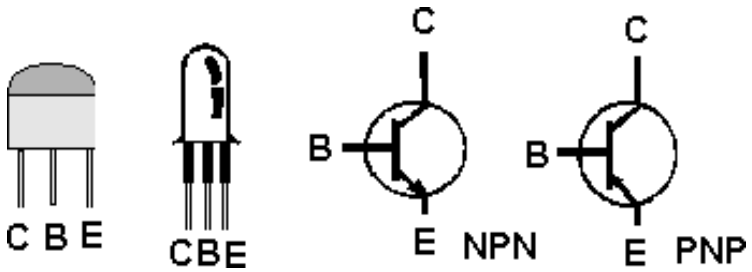


Figure 26: Transistor

5.13 DIODE

The simplest semiconductor device is consisting of a sandwich of p-type semi conducting material, having contacts to connect the p-and n-type layers to an external circuit. This is a junction diode. If the positive terminal of the battery is connected to the p-type material (cathode) and the negative terminal to the n-type material (anode), an enormous amount of current will flow which is called forward current or forward biased.

When the connections are reversed, a very little amount of current will flow. This happens because under this condition, the p-type material will gain the electrons from the negative terminal of the battery and the n-type material will donate its free electrons to the battery, giving a state of electrical equilibrium since the n-type material has no more electrons. Thus, there will be a very small amount of current that will flow, and the diode is called Reverse biased.

So, the diode allows direct current to pass in one direction while blocking it in another direction. Power diodes are basically used in converting AC into DC. In this type of diodes, current flows freely during the first half cycle (forward biased) and practically not at all during the other half cycle (reverse biased). Because of this, diode becomes an effective

rectifier, which converts AC into pulsating DC. Signal diodes are the diodes that are used in radio circuits for the detection. Zener diodes are the diodes that are used in the circuit to control the voltage.

Figure 27: Diode

Names of some common diodes are as follows:

- Zener diode.
- Photo diode.
- Light Emitting diode.

5.13.1 Zener Diode:

A Zener diode is a diode which is an especially designed junction diode, which can function continuously without being damaged in the range of reverse break down voltage. The most important applications of Zener diode are the design of the constant voltage power supply. The Zener diode is connected in reverse bias to DC through a resistance R of suitable ohm value.

5.13.2 Photo Diode:

A photo diode is a junction diode that is generally made from photo- sensitive semiconductor or material. In such type of diode, there is a proper provision to allow the light of suitable hertz to fall on the p-n junction. It is a reverse biased diode, but the voltage that is applied is less than the break down voltage. Current goes on increasing with the intensity of incident light till it becomes maximum and the maximum current is known as saturation current.

5.13.3 Light Emitting Diode (Led):

If a junction diode is forward biased, energy that is released at the junction is due to recombination of electrons and holes and it is forward biased. The energy released in case of silicon and germanium diodes is in infrared region. In the junction diode that is made of Gallium Arsenate or Indium Phosphide, the energy which is released is in visible region. Those junction diodes are called a light emitting diode or LED.

5.14 POWER SUPPLY

In case of an alternating current, the flow of the electron is alternate, i.e. the electron flow increases to maximum in positive direction and then decreases back to zero. It is then increasing in the negative direction and then decreases to zero again. On the other hand, Direct current flows in only one direction. Rectifier performs the task of converting alternating current to flow in one direction only. Whenever the anode of the diode is positive with respect to the cathode, it is called forward biased, making current to flow. But whenever the anode is negative with respect to the cathode, it is called reverse biased and does not make the current to flow.

This unidirectional property of the diode is beneficial for rectification. The diodes arranged back-to-back make the electrons to flow during positive half cycle only and suppress the negative half cycle. A couple of diodes arranged back-to-back act as full wave rectifiers as they make the electrons to flow in positive and negative half cycles both. Four diodes may be arranged to build a full wave bridge rectifier. A variety of filter circuits are being used to

smooth out the pulsations in amplitude of the output voltage from a rectifier. The property of capacitor of resisting any change in the voltage applied across them by storing energy in the form of electric field of the capacitor and of inductors to resist any alteration in the current flowing through them by storing energy in the form of magnetic field of coil can be used. Different types of combination of capacitors, inductors and resistors can also be used to increase to action of filtration to remove the pulsations of the direct current obtained from the rectifier or to smoothen the pulsations.

5.15 NEED OF POWER SUPPLY

Almost everyone is aware that a 'power supply' is a primary requisite for the 'Test Bench' of a home experimenter's mini lab. The battery eliminator is used eliminate or replace the batteries of solid-state electronic equipment. So, the equipment can be operated by 230V

A.C. mains supply instead of the batteries or dry cells. In today's era, the application of commercial battery eliminators or power supply units has become vastly popular as the power source for household appliances like trans receivers, record player, cassette players, digital clock etc.

6. THEORY

6.1 Use of Diodes in Rectifiers:

The Electrical energy available in homes and industries in India is in the form of alternating voltage. The supply is a voltage of 220V (rms) at a frequency of 50 Hz. In the USA, it is 110V at 60 Hz. For the operation of most of the electronic devices, a DC voltage is needed. As for e.g., a transistor radio needs a DC supply for its operation. Usually, this electric supply is provided by dry cells. But sometimes we use a battery eliminator instead of dry cells. The battery eliminator converts the AC voltage into DC voltage and then eliminates the need for the dry cells. Today most of the electronic equipment's consist a circuit that converts AC voltage of mains supply into DC voltage and this part of the equipment is called Power Supply. Generally, in equipment's, at the input of the power supply, there is a power transformer which is followed by a diode circuit called Rectifier. The output of the rectifier then reaches a smoothing filter, and then goes to a voltage regulator circuit. Thus, we can say that the rectifier circuit is the heart of a power supply.

6.2 Rectification

Rectification is the process of converting an alternating current or voltage into a unidirectional one. The device that is used for this process is called 'Rectifier'. A rectifier allows the current to flow during the first half positive cycles of the applied AC voltage only by eliminating the negative half cycles of the supplied AC voltage. So, as a result pulsating DC voltage is obtained. To obtain smooth DC current supply, additional filter circuits are needed.

A diode may also be used as rectifier. There are various kinds of diodes rectifiers but, semiconductor diodes are very popularly used as rectifiers. A semiconductor diode is a kind of solid-state device that consists of two elements i.e. an electron emitter / cathode and an electron collector / anode. As electrons in the semiconductor diode can flow unidirectionally only-from emitter to collector thus the diode provides the conduction in unilateral direction necessary for their citification. Copper oxide and selenium rectifier are also commonly used semiconductor diodes rectifier.

6.3 Full Wave Rectifier

The only way to rectify both alternations of the input voltage is by using two diodes in the circuit arrangement. Let's suppose 6.3 V rms (18 V p-p) is supplied to the circuit and further assume that two equal-valued series-connected resistances R are placed in parallel with the AC source. The 18 V p-p will be shown across the two resistors connected between points AC and CB, and point C is the electrical center point between A and B. Hence 9 V p-p will be shown across each resistor. At any instant during a cycle of v_{in}, when point A will be positive relative to C, point B will be negative relative to C. When A is negative related to C and point B is positive relative to C, the effective voltage in proper time phase which each diode will experience as shown in Fig. Thus, the voltage that is supplied to the anode of each diode will be equal but reversed in polarity at any point of time.

6.4 Bridge Rectifier

The bridge rectifier is a much widely used full-wave rectifier circuit. It needs 4 diodes instead of 2 but neglects the requirement for a center-tapped transformer. In the first positive half-cycle of the secondary voltage, the diodes D2 and D4 conduct electricity and the diodes D1 and D3 does not conduct electricity. Thus, current starts to flow through the secondary winding, diode D2, load resistor RL and diode D4. In the second negative half-cycles of the secondary voltage, diodes D1 and D3 are conducting, and the diodes D2 and D4 are non-conducting. Hence, the current flows through the secondary winding, diode D1, load resistor RL and diode D3. In both these two cases, the current passes via load resistor in the same direction. Thus, a fluctuating, unidirectional voltage is generated across the load.

6.5 Filtration

The rectifier circuits that we have discussed previously gives an output voltage having the same polarity, however, this output is not suitable for DC power supply for solid-state circuits. This is because of the pulsation or ripples of the O/P voltage. These ripples should be eliminated out before the output voltage would be applied to any circuit. This smoothening of the pulsating ripples is done by the networks of filters. These networks of filters contain inductors and capacitors. The inductors or choke coils are commonly connected in series with the load and the rectifier output. The inductors resist any kind of change in the magnitude of a current flowing through them by collecting up energy in a magnetic field Therefore, a series connected choke coil in a rectifier circuit is used to reduce the pulsations or ripples to a much greater extents in the output voltage.

6.6 Choke Input Filter

When a choke coil or an inductor is used as the ‘first- component’ in the filter network, the filter is called ‘choke input filter’. At first, the D.C. along with AC pulsation from the rectifier circuit goes through the choke (L). It resists the AC pulsations and allows the DC to surpass through it freely. So, the AC pulsations are reduced largely. Further ripples are by surpassed through the parallel capacitor C. However, little ripples remain unchanged, which are negligible. These little ripples can be reduced with the help of a series of choke input filters.

6.7 CAPACITOR INPUT FILTER

When the capacitor is located before the inductors in a choke-input filter network, the filter is known as capacitor input filter. The D.C. as well as the AC ripples from the rectifier circuit begins to charge the capacitor C. to the maximum value. The AC ripples are then disappeared slightly. Then capacitor C, gets discharged by the inductor or choke coil, which resists the AC ripples and allows the DC. The second capacitor C allows the further AC ripples. Small ripples will still be present in the output of DC, that can be reduced by incorporating additional filter network in series.

7. DESIGN AND ANALYSIS

Figure 28: CAD Model

7.1 Applications

This project model can be implemented in small and lighter vehicles such as three-wheeler autos or four wheelers for e.g. Tata Nano. As in these vehicles, there are no provisions for anti-roll prevention suspension because of their compact structure. However, even if an anti-roll suspension is installed in these vehicles, it would not be justified in terms of cost. So, this rotary sliding counterbalance controlling system can be implemented in these vehicles in the cockpit section of the vehicle.

7.2 Analysis

To make sure this project will fulfil all our intensions we design & analyze all the necessary components coming under continuous loads. Below are the analysis data & conclusions.

7.2.1 Pulley Analysis

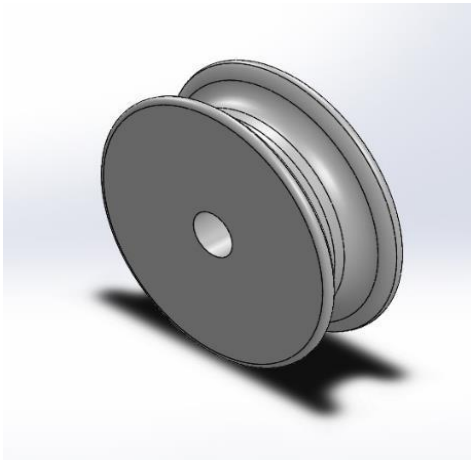


Figure 29: Pulley

7.2.1.1 Material Properties

Table 1: Material Data

Properties	
Name:	**Composite**
Model type:	**Linear Elastic Isotropic**
Default failure criterion:	**Unknown**
Tensile strength:	**3e+07 N/m^2**
Elastic modulus:	**2e+09 N/m^2**
Poisson's ratio:	**0.394**
Mass density:	**1020 kg/m^3**
Shear modulus:	**3.189e+08 N/m^2**

7.2.1.2 Load & Displacement

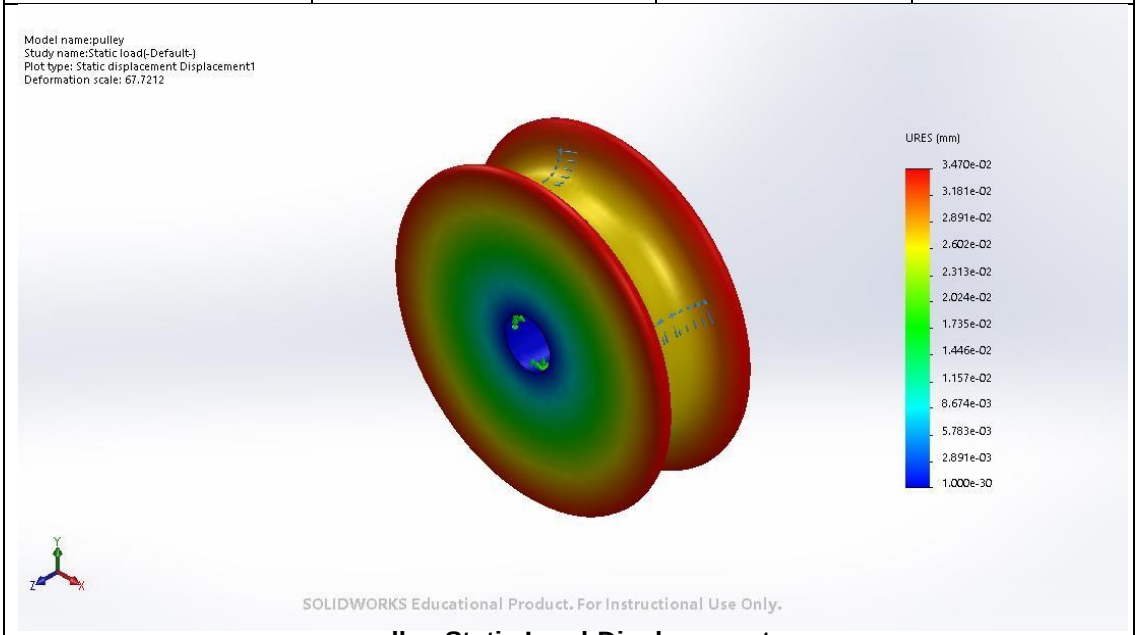
Resultant Forces

Table 2: Load Data

Components	X	Y	Z	Resultant
Reaction force(N)	**0.0012562**	**-0.00761056**	**0.00558189**	**0.00952135**
Reaction Moment (Nm.)	**0**	**0**	**0**	**0**

Table 3: Deformation

Name	Type	Min	Max
Displacement	Resultant Displacement	0.000e+00 mm Node: 541	3.470e-02 mm Node: 12630



pulley-Static Load-Displacement-Displacement1

7.2.2 Slider Analysis

7.2.2.1 Material Properties

Table 4: Material Data

Name:	**AISI 1035 Steel (SS)**
Model type:	**Linear Elastic Isotropic**
Default failure criterion:	**Max von Mises Stress**
Yield strength:	**2.82685e+08 N/m^2**
Tensile strength:	**5.85e+08 N/m^2**
Elastic modulus:	**2.05e+11 N/m^2**
Poisson's ratio:	**0.29**
Mass density:	**7850 kg/m^3**
Shear modulus:	**8e+10 N/m^2**
Thermal expansion coefficient:	**1.1e-05 /Kelvin**

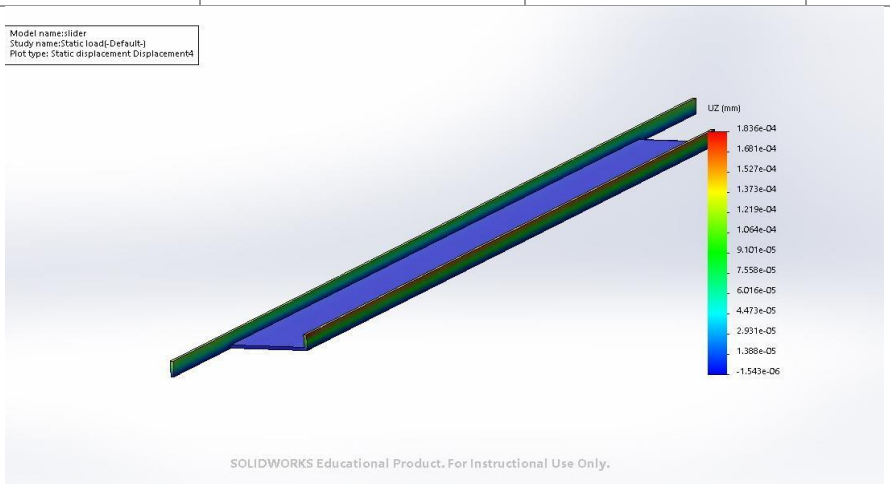
7.2.2.2 Load & Displacement

Table 5: Load Table

Components	X	Y	Z	Resultant
Reaction force(N)	**-0.00689518**	**-0.00405765**	**-5000.02**	**5000.02**
Reaction Moment (Nm.)	**0**	**0**	**0**	**0**

Table 6: Deformation Result

Name	Type	Min	Max
Displacement	Displacement	-1.071e-06mm Node: 92133	1.931e-04 mm Node: 270



slider-Static Load-Displacement-Displacement

7.2.3 Motor Holder

7.2.3.1 Material Properties

Table 7: Material Table

Name:	**AISI 1035 Steel (SS)**
Model type:	**Linear Elastic Isotropic**
Default failure criterion:	**Max von Mises Stress**
Yield strength:	**2.82685e+08 N/m^2**
Tensile strength:	**5.85e+08 N/m^2**
Elastic modulus:	**2.05e+11 N/m^2**
Poisson's ratio:	**0.29**
Mass density:	**7850 kg/m^3**
Shear modulus:	**8e+10 N/m^2**
Thermal expansion coefficient:	**1.1e-05 /Kelvin**

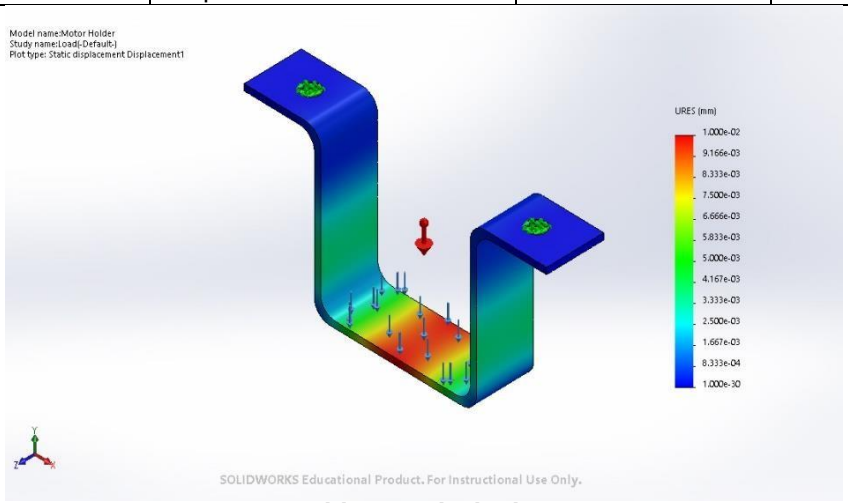
7.2.3.2 Reaction & Displacement

Table 8: Load Data

Components	X	Y	Z	Resultant
Reaction force(N)	**-0.00032568**	**30.5796**	**-0.000273526**	**30.5796**
Reaction Moment (Nm.)	**0**	**0**	**0**	**0**

Table 9: Deformation Table

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00 mm Node: 1	1.000e-02 mm Node: 12325



Motor Holder-Load-Displacement-Displacement1

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8. Publication Details

8.1 Paper 1

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8.2 Paper 2

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Publication: International Journal of Engineering Research & Technology (IJERT).
ISSN: 2278-0181
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9. Appendix (A)

9.1 Relays

9.1.1 Working of Relays

The relay is switched off in fig. 2a. The metal arm is at rest state and thus there is contact between the normally closed (N.C.) switch contact and the common switch contact.

When a current is surpassed via the coil, the net magnetic field attracts the metal arm and now there is contact between the Normally Open (N.O.) switch contact and the

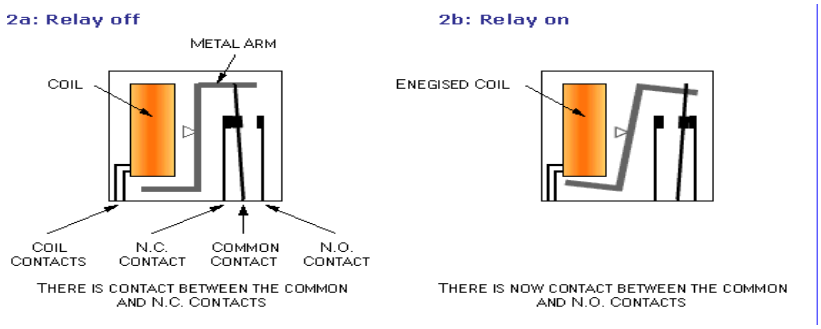

Figure 30: Mechanical Operation of Relay

common switch contact, as in figure 30.

9.1.2 Advantages of Relays

- The total isolation increases safety by ensuring that the high voltages and currents cannot be shown where they should not be.
- Relays generally come in all shapes and sizes for various applications and have various switch contact structures. Double Pole Double Throw (DPDT) relays are very common and even 4-pole relays are available. Thus, several circuits can be controlled with only one relay.
- It is convinient to tell if a relay is operating – a click can be heard as the relay switches on and off.

9.1.3 Disadvantages of Relays

- Though being mechanical, relays do have some disadvantages over other methods of electrical isolation:
- Their parts can be easily worn out as the switch contacts become filthy- sparks between the contacts occurs due to high voltages and currents.
- Their switching on and off at high speeds cannot be possible because they have a low sensitivity and the switch contacts will rapidly worn out because of the sparking.
- The coils of relays require a high current to energies, that means some micro- electronic circuits can't drive them directly without additional circuit.
- The back-emf generated when the relay coil is switched off can damage the components that are driving the coil. For neglecting this, a diode can be placed across the relay coil, that can be seen in any electronic circuit that uses relays incorporated with very sensitive components.

9.1.4 Choosing a Relay

When we need to choose a relay to use in a circuit, we need to consider over the properties of both the coil and the switch contacts. First, you are required to find a relay that has the desired number of switch poles as per the application. Then it is needed to check that the switch contacts cope with the voltage and current used - for e.g., if the relay is used to switch a 60W mains lamp on and off, the switch contacts will be required to be rated for at least 250mA at

240V AC (or the mains voltage is in your country).

Also, the material that the switch contacts are made of is of importance, for e.g.- gold is good for low- voltages whereas tungsten is suitable for switching high voltages and currents.

Eventually, it is required to choose a relay that has a coil energized by a low- voltage control circuit.

9.1.5 The Latching Relay Circuit

When a relay is as shown in figure 19, it will become 'latched'when the coil is energized by pressing the button (trigger). The method to switch the relay off is then to cut the power supply by pressing the Reset button.

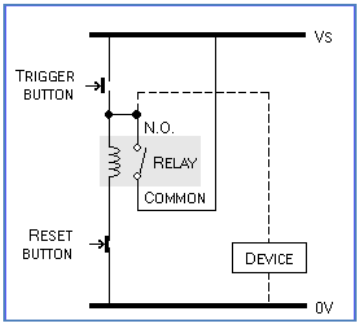

Figure 31: Latching relay Circuit

In technical language the name for this type of behavior is 'bistable' because the circuit has two stable states for its output - on and off. Biostable circuits may also be built with the aid of several components, involving the 555 timer IC and transistors.

9.1.6 Pin Descriptions

VCC: It is the notation of Digital Supply Voltage.

GND: It is the notation for Ground.

Port B(PC7.PB0): - It is an 8-bit two-directional input port having internal pull-up resistances (chosen for each bit). Like inputs, Port B pins that are externally pulled low with source current when the pull-up resistances are activated. If a reset condition becomes active even if the clock is not running, the Port B pins will be tri-stated.

Port C (PC5.PC0): - Port C is a 7-bit by two-directional input port with internal pull-up resistances (chosen for each bit). If the pull-up resistors will be activated, Port C pins i.e. externally pulled low will source current. If a reset condition becomes active, even if the clock is not running the Port C pins will be tri-stated.

Port D (PD7..PD0) :- Port D is an 8-bit two-directional input port with

internal pull-up resistances (chosen for each bit).When the pull-up resistors will be activated Port D pins i.e. externally pulled low will source current. If a reset condition becomes active, even if the clock is not running, the Port D pins will be tri-stated.

9.2 Transistors

Transistor is the combination of semi-conducting elements permitting the desired current flow. It is made up of two elements Germanium and Silicon. The two kinds of transistors are: POINT CONTACT and JUNCTION TRANSISTORS.

The two categories of transistor are:

1) **PNP TYPE:** This type is obtained by joining a layer of P type Germanium to an N-P Junction

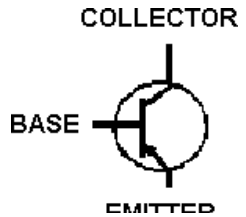

Figure 32: PNP Transistor

2) **NPN TYPE:** This type is obtained by joining a layer of N type Germanium to a P-N Junction.

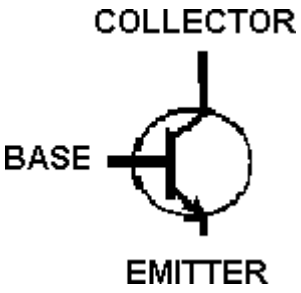

Figure 33: NPN Transistors

Both the two types are shown in figure, with their symbols of representation. The section viz in the center is called the base, the outside sections are-the emitter and the collector. The arrowhead direction denotes the direction of the conventional current with the forward bias on the emitter. The conventional flow is in a direction opposite to the electron flow.

9.2.1 Operation of PNP Transistor:

A PNP transistor is made by the process of sand witching of two PN Germanium or silicon diodes, placed back to back. The middle section containing N-type portion is extremely thin as compared to the P section. The P section of the left side is connected to the positive terminal and N-region is connected to the negative terminal that means PN is biased in the forward direction while P region of right side is connected to the negative terminal that means NP is biased in the reverse direction as shown in Fig. The P section in the

forward biased circuit is known as the emitter and P region on the right, biased negatively is known as collector. The center is called base.

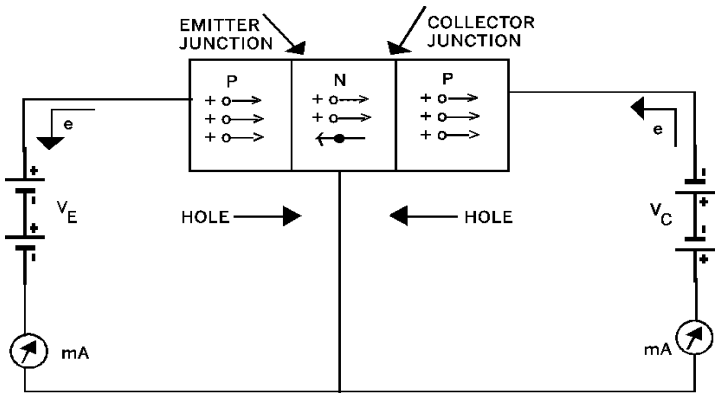

Figure 34: Working of Transistors

As the P region at the right side is biased negatively, a very small current flows but the following facts are observed: -

1. A substantial amount of current will flow through it if the emitter junction is biased in a forward direction.
2. The current that flows across the collector is slightly less than that of the emitter
3. The current in the collector is a function of emitter current that means if the emitter current decreases or increases corresponding to the change in the collector, current is observed.

Therefore, we can conclude that if the emitter is forward biased and collector is negatively biased, a substantial amount of current flows in both the circuits. Because a small emitter voltage of about 0.1 to 0.5 volts allows the flow of an appreciable emitter current and the input power is very small. The voltage of collector may be as high as 45 volts.