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DESIGN OF POWER GENERATION SYSTEM USING VEHICLE SUSPENSION

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ABSTRACT- All vehicles have suspension system. Only 26 % of the available fuel energy is used to drive the vehicle, i.e. to overcome the resistance from road friction. One important loss is the dissipation of vibration energy by shock absorbers in the vehicle suspension under the excitation of road irregularity and vehicle acceleration or deceleration. The suspension system mainly consist of a mechanical spring. The objective of this project is to design a vehicle suspension system which can harness the energy. In the present work, spring is a one type of suspension system that converts parasitic intermittent linear motion and vibration into useful energy, such as electricity. In our project, we used spring, rack & pinion arrangement and doubly fed induction generator. As shock absorber effect formed, spring is compressed and linear movement of rack is converted in rotary motion due to pinion moves as the rack is meshed with pinion. And the pinion is mounted on the shaft which is connected to shaft of doubly fed induction generator. Due to this arrangement, rotary motion of pinion is used to rotate generator. As generator rotation leads to generation of energy. And this energy is used to charge the battery and this stored energy is used for different vehicle accessories like power window, lights and air conditioner etc. And also the power generation is monitored by using PCB circuit with the help of VISUAL BASIC software.
Key words: vehicle suspension, Rack & Pinion, BESS system, Ultra capacitor, etc

1. INTRODUCTION

Fossil fuels are being consumed with very fast rate. Also the cost of fuel is increasing with a very fast rate. So somebody has to work on saving of the fuel consumption. Our aim is to demonstrate how the kinetic energy from the suspension of a vehicle can be utilized to achieve our goal of obtaining maximum energy that would otherwise have gone waste. We propose a design plan that converts the mechanical energy in vehicles to electrical energy much more efficiently than it has been done before. The electricity generated will then be used to recharge the vehicle battery for further use for functioning of the vehicle. There is a wide scope for regeneration of energy like regeneration of breaking systematic. We have decided to work on utilization of suspending mass of a vehicle through regeneration system with the help of shock absorber. Shock absorbers are having reciprocating motion in it. Although the reciprocating distance is very low the suspending mass is very high i.e. the mass of total vehicle. When vehicle is on a normal road then also shock absorbers are working due to uneven roads, sudden breaking or sudden acceleration and also a running conditions. So this reciprocating motion of shock absorbers can be converted into rotary motion and through small gearbox arrangement, i.e. rack & pinion attached to doubly fed induction generator, electricity will be generated when shock absorbers will be reciprocating.

2. LITERATURE REVIEW

The purpose of this literature review is to go through the main topics of interest. The literature review is concerned with design of spur gear, DC generator, Design of Shaft, selection of bearings & shock absorber with theoretical and experimental evaluation. The objective of this project is to design a regenerative shock absorber which can harness the energy.

A regenerative shock absorber is modeled and analyzed for emf generated using a soft Maxwell and a physical model was built to validate the model. A regenerative shock absorber model with NdFeB magnet as core and three piston stacked generated 12 volts AC operated at a speed of 1 m/s and the physical built based on this computational model developed 2 volts when operated at the same speed but with steel as core[1]. If vehicular motion can be put to generate useful power, it can be put to effective use. This idea has mothered the invention of "power generation through speed breakers", inspired by various other existing designs. In this paper an attempt has been made to generate power using speed breakers through rack and pinion mechanism by tapping the energy and utilizing it for various purposes such as lightening the street lights, etc. [2]. This paper deal with energy harvesting shock absorber is able to recover the energy otherwise dissipated in the suspension vibration while simultaneously suppress the vibration induced by road roughness. It can work as a controllable damper as well as an energy generator. The key component is a unique motion mechanism, which we called "mechanical motion rectifier (MMR)", to convert the oscillatory vibration into unidirectional rotation of the generator [3]. Electronic equipment systems are precision system. There are some vibrations and impact in moving vehicles for road environments. Therefore, shock absorber is significant in protection of electronic equipment in moving vehicles. In this paper a systematic investigation to design or evaluation of a shock absorber for protection of electronic equipment system in harsh vibration-impact environment [4]. Instead of dissipating the vibration energy into heat wastes, the damper in regenerative suspension will transform the kinetic energy into electricity or other potential energy and store it for late use. The stored energy can be used to tune the damping force of the damper to improve the suspension performance or to power vehicle electronics to increase vehicle fuel efficiency [5].

3. COMPONENTS USED

3.1. MECHANICAL COMPONENTS

3.1.1. SHOCK ABSORBER

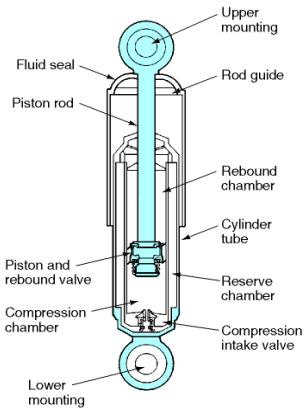


Figure: 1.Shock absorber

3.1.2. SPRING

Figure: 1.Spring

A spring is an elastic object used to store mechanical energy. Springs are usually made out of spring steel. There are a large number of spring designs; in everyday usage the term often refers to coil springs. Small springs can be wound from pre-hardened stock, while larger ones are made from annealed steel and hardened after fabrication. Some non-ferrous metals are also used including phosphor bronze and titanium for parts requiring corrosion resistance and beryllium copper for springs carrying electrical current (because of its low electrical resistance). When a coil spring is compressed or stretched slightly from rest, the force it exerts is approximately proportional to its change in length (this approximation breaks down for larger deflections).

3.1.2. RACK &PINION

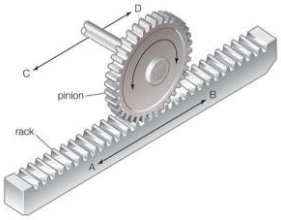


Figure: 2. Rack & Pinion

A **rack and pinion** is a type of linear actuator that comprises a pair of gears which convert linear motion into rotational motion. A circular gear called "the pinion" engages teeth on a linear "gear" bar called "the rack"; linear motion applied to the rack causes the pinion to move relative to the gear, thereby translating the linear motion of the rack into rotational motion.

3.1.3. DOUBLY FED INDUCTION GENERATOR

Figure: 3.Doubly Fed Induction Generator

The doubly fed induction machine is a useful motor for industrial application and a largely adopted generator. Its speed and torque can be controlled by rheostats or frequency converter connected to the rotor winding, what allows the reduction of converter power just to a fraction of induction machine mechanical power, saving installation costs. The benefits of the use of doubly fed induction machines are undeniable; nevertheless, to take advantages of them it is mandatory to provide electrical connection between the rotor winding and the rheostat or the frequency converter. The most common way to access the rotor winding is by brushes and slip-rings. However, the mechanical contact between moving slip-rings and static brushes wears these components and involves high rate of maintenance. Powder generated by brushes wearing can be also prejudicial for motor insulation. Additionally, any fault on electrical contact can generate sparks, limiting this machine installation only to non-explosive environment. It is mainly used to produce alternating current (AC) in both positive and negative cycles.

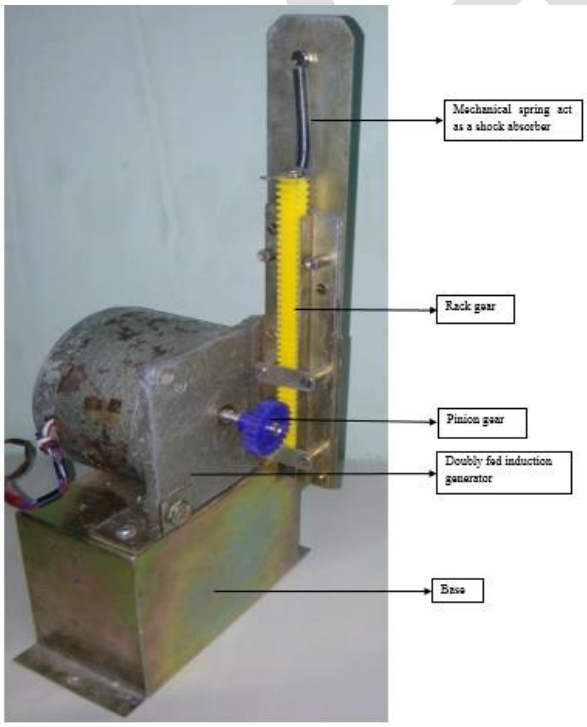


Figure: 4. Mechanical components arrangement

3.2. ELECTRICAL AND ELECTRONICS COMPONENTS

Electrical power transformer is a static device which transforms electrical energy from one circuit to another without any direct electrical connection and with the help of mutual induction between two windings. It transforms power from one circuit to another without changing its frequency but may be in different voltage level. A capacitor (originally known as a condenser) is a passive two -terminal electrical component used to store electrical energy temporarily in an electric field. The SI unit of capacitance is the farad (F), which is equal to one coulomb per volt (1 C/V). A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. Resistors act to reduce current flow, and, at the same time, act to lower voltage levels within circuits. The SI unit of resistance is Ohm (Ω).A bridge rectifier is an arrangement of four or more diodes in a bridge circuit configuration which provides the same output polarity for either input polarity. It is used for converting an alternating current (AC) input into a direct current (DC) output. 7805 is a voltage regulator integrated circuit. It is a member of 78xx series of fixed linear voltage regulator ICs. . 7805 provides +5V regulated power supply. A crystal oscillator is an electronic oscillator circuit that uses the

mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a precise frequency. A light-emitting diode (LED) is a two- lead semiconductor light source. It is a p–n junction diode, which emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called **electroluminescence**, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor.

3.2.1. ULTRA CAPACITOR BATTERY

Ultra capacitors can be defined as an energy storage device that stores energy electrostatically by polarizing an electrolytic solution. Unlike batteries no chemical reaction takes place when energy is being stored or discharged and so ultra-capacitors can go through hundreds of thousands of charging cycles with no degradation. Ultra capacitors are also known as **double-layer capacitors** or **super capacitors.**

Figure: 5.Ultra capacitor battery

3.2.2. 40 PIN PIC IC BASE

The name PIC initially referred to **"Peripheral Interface Controller"**. PIC microcontroller is the first RISC based microcontroller fabricated in CMOS (complementary metal oxide semiconductor) that uses separate bus for instruction and data allowing simultaneous access of program and data memory.

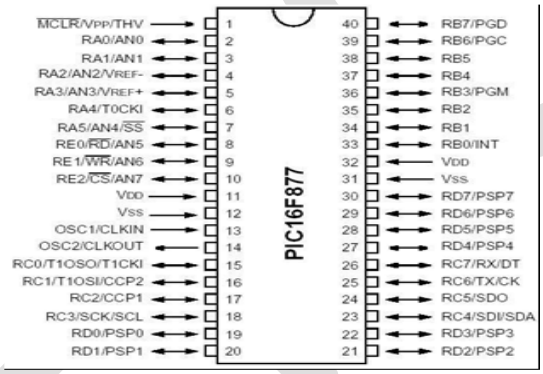


Figure: 6.PIC 16F877

3.2.3. PERSONEL COMPUTER:

In personal computer, data transfer takes place serially. RS-232standard is used for serial communication .PIC Micro controller is linked to PC through the RS-232 port. The PC displays the menu for selecting the calibrating equipment and all the calibration results graphically and in tabular form. The user can access the calibration data to get calibration reports, comparison graphs etc. at any time using the menu offered in the PC.

3.2.4. RS 232 CONNECTOR

The most common communication interface for short distance is RS-232. RS-232 defines a serial communication for one device to one computer communication port, with speeds up to 19,200 baud. Typically 7 or 8 bit (on/off) signal is transmitted to represent a character or digit. The 9-pin connector is used. The pin detail is given below.

Figure: 7.RS 232 Connector

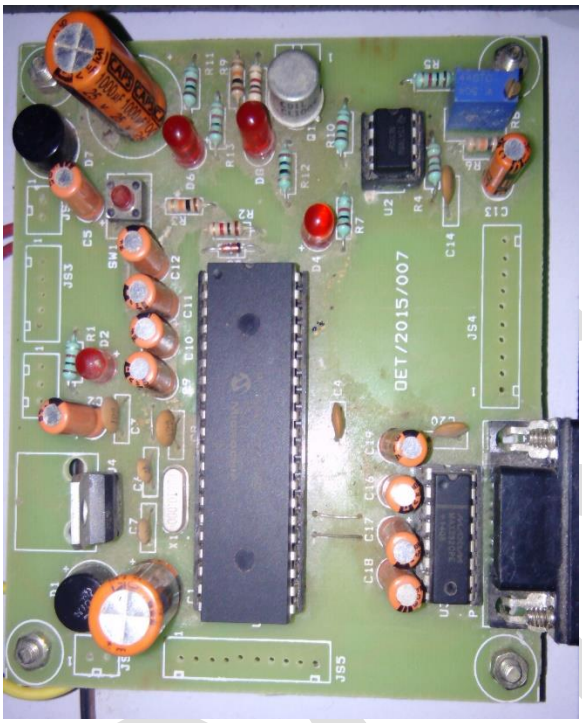


Figure: 8. Electronics components arrangement in PCB

4. SOFTWARE USED

4.1. VISUAL BASIC 6.0

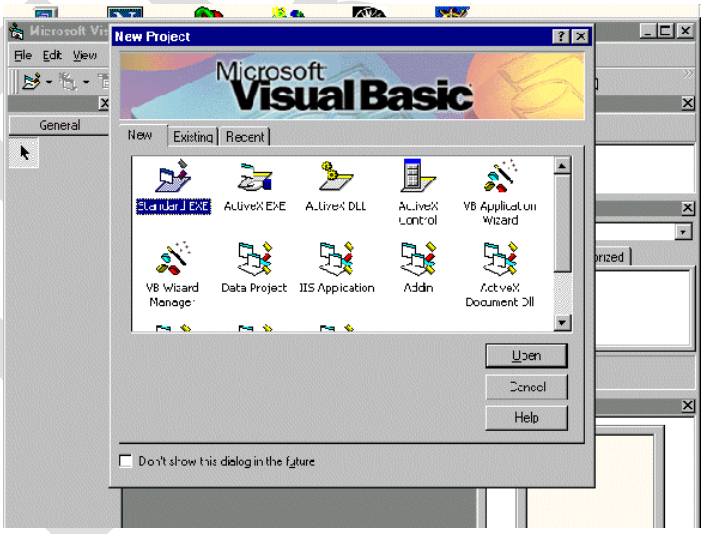


Figure: 9 .Visual Basic

Visual Basic is a third-generation eve-driven programming language and integrated development environment (IDE) from Microsoft for its COM programming model first released in 1991 and declared legacy in 2008. Microsoft Intended Visual Basic to be relatively easy to learn and use. Visual Basic was derived from BASIC and enables the rapid application development (RAD) of graphical user interface (GUI) applications, access to databases using Data Access Objects, Remote Data Objects, or ActiveX Data Objects, and creation of ActiveX controls and objects.

Paradigm : Object-based and Eve driven
Developer : Microsoft
First appeared : 1991; 25 years ago
Stable release : 6.0 / 1998; 18 years
Typing discipline : Static, strong
OS : Microsoft Windows and MS-DOS

Major implementation: Microsoft Visual Studio

5. MECHANISM USED

5.1. RACK &PINION MECHANISM

A **rack and pinion** is a type of linear actuator that comprises a pair of gears which convert linear motion into rotational motion. A circular gear called "the pinion" engages teeth on a linear "gear" bar called "the rack"; linear motion applied to the rack causes the pinion to move relative to the gear, thereby translating the linear motion of the rack into rotational motion.

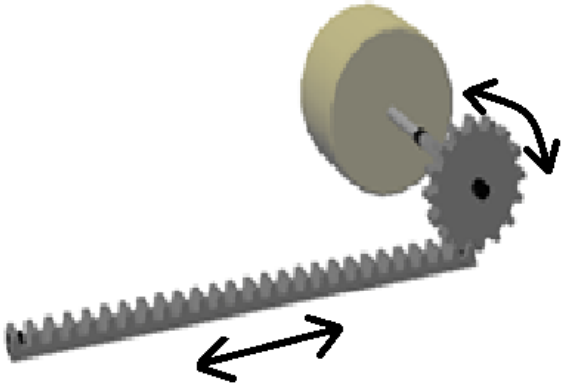


Figure: 10.Rack & Pinion Arrangement

6. CONSTRUCTION

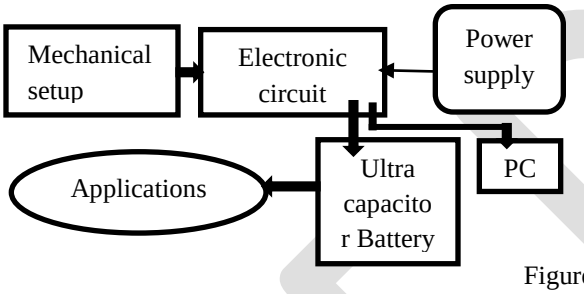
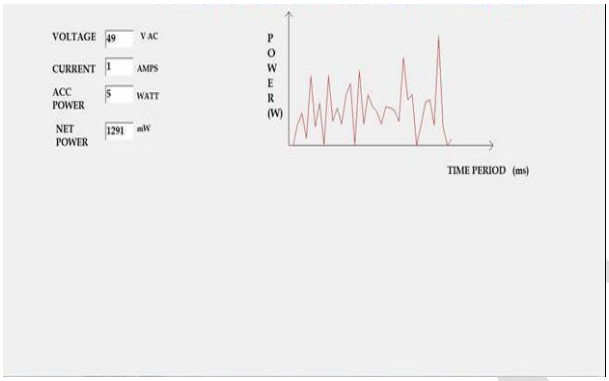


Figure: 11. System Block Diagram

The system consists of following components such as suspension system, rack and pinion, doubly fed generator and embedded system. The suspension system absorbs the small vibration that is produce in the vehicle. Rack and pinion converts linear vibration motion into rotary motion. Generator is used to produce continuous alternating current (AC). The embedded system controls the whole process. Connections are made for the designed working condition. Initially high frequency charge controller is wired with doubly fed induction generator for power generation. Input power is given by rack and pinion due to small vibration of vehicle suspension. Suspension is the system used to allow relative motion between road and vehicle tires. And act as a weight transfer. This suspension gets small range of deflection rate from moving vehicle vibration. And this vibration makes spring system to gradual movement dependently with rack and pinion movement. Total jacking force of suspension system is converted to rack and pinion movement. This linear force is converted into rotary movement because of pinion mechanism. After this undamming rotary force directly applied to generator through pinion movement. Generator gets powered then it rotates mechanically to produce power. Power producing is concerned only with rack and pinion not with vehicle movement. Leveling suspension is continuously working among with deflection of vehicle movement.so the power output is very precious with small input. Fortunately we can furnish our power output exactly with VISUAL BASIC software. It is used to acute graph calculation for future assumption of enormous power. Produced level of power again transferred cyclically for vehicle movement. So it is called as heterogeneous power generation. This type of active power can be used in many industrial applications and home appliances.

7. GRAPH



Graph 1: At maximum energy level

Graph plotted for the maximum value of energy at peak condition of vehicle movement. At this condition, rack and pinion movement is slightly increased for maximal. So energy value is high.

8. DESIGN CALCULATION

8.1. DESIGN OF SPRING

For suspension system we are selected the helical spring.

Kw = (4C-1/4C-4) + (0.615/C)

τ = (8FDm/πd3)× kw

But C = Dm/d

Dm = C×d

τ =8FC/πd2 kw

d2=8FC/ $\tau\pi$

Where, F=Load on the System

C=spring index

G= Modulus of rigidity

τ = Permissible shear stress

Wire Diameter = d

Mean diameter =Dm

Outer diameter = D0=Dm+d

Inner diameter = Di=Dm-d

Spring is plain grounded , N=Nt

Solid Length = Nt× d

Total gap= (Nt – 1) ×gap between two adjacent coil

Free Length (Lf) = Solid length + Total gap length +δ

Pitch of Coil = Free Length/(Nt-1)

8.2. DESIGN OF RACK & PINION

Lewis form factor is

Y = 0.289 for 24 teeth

Cs = service factor

Cv= 3/ (3+v)

And v =πdn / (60×1000)

Pt = 2Mt/dp, Peff = (Cs*Pt) / Cv

Wear Strength, Sw = bQdpK

Q =2ZG/(ZG+ZP)

K = 0.16((BHN)/100)2

BHN= 270 for cast iron material, K = 1.17

Factor of Safety f'(s) = Sw/Peff

= 298.77 / 575

= 0.51

RESULT AND CONCLUSION

Vehicle Suspension Energy Generation is very efficient and useful in converting the Kinetic Energy from the movement of the vehicle, especially the suspension, which usually goes waste, to electric energy that can be used to fulfill needs of the auxiliaries in the vehicle. Currently the batteries of automobiles are charged by specific alternator which is attached to IC engine shaft. So that the fuel used in automobiles is also consumed for rotating the alternator to charge the battery, this consumption is found to be 4% of total consumption. By newly designed suspension, regeneration system presently using alternator is detached from the engine and attached to the suspension system. The advantage of this concept is energy storage system is possible using "BESS system" and even fully drained battery is charged by ultra capacitor using high frequency charge controller system.

If we install this regeneration system for all 4 wheels then we can generate high amount of electric power. This high amount of electric power can be used for the working of vehicle air conditioner or refrigeration system of vehicles. This suspension system will be mostly useful for heavy compressed vehicles, milk trucks, fire brigade trucks and also those having high requirement of electricity inside it. From result graph we are observed that for a small amount of vibration of vehicle, we get the maximum voltage and current.

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