# STUDY OF DC MOTOR

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**Abstract:-**Control system design and analysis technologies are widely suppress and very useful to be applied in real-time development. Some can be solved by hardware technology and by the advance used of software, control system are analyzed easily and detail.

DC Motors can be used in various applications and can be used as various sizes and rates as per our applications. In this project we have control the actual speed of dc motor as per ours requirement. This can be achieved through PIC micro controller. The microcontroller computes the actual speed of the motor by sensing the terminal voltage and displayed on LCD. In this project firstly we are giving the supply to PIC microcontroller. Then controller generates the pulse generally 5 volt DC. The generated pulse is nothing but PWM signal. Which giving to driver circuit. The function of this driver circuit to generate 12v DC pulse. This is necessary to switch/triggering on MOSFET. Thus speed of DC motor is control through duty/PWM cycle. This PWM pulse is giving to MOSFET for triggering purpose.

The modeling and simulation of this project is done through MP-LAB software. It then compares the actual speed of the motor with the reference speed and generates a suitable control signal which is fed into the triggering unit using.

**Keywords:** DC Motor, PIC Microcontroller, PWM Pulse, Duty Cycle, MOSFET, Driver Circuit, MP

## INTRODUCTION

### Background

Control system design and analysis technologies are widely suppress and very useful to be applied in real-time development. Some can be solved by hardware technology and by the advance used of software, control system are analyzed easily and detail. DC Motors can be used in various applications and can be used in various sizes and rates as per our applications .The DC-Motor is used in domestics and industrial purpose. Whenever we think about any programmable devices then the embedded technology comes into fore front. The embedded is now-a- days very much popular and most of the product are developed with Microcontroller based embedded technology. The advantages of using the microcontroller is the reduction of the cost and also the use of extra hardware such as the use of timer, RAM and ROM can be avoided. This technology is very fast so controlling of multiple parameters is possible; also the parameters are field programmable by the user. In this project we are controlling speed of DC motor. As we increase the speed of DC Motor as a result an increase in the productivity of material. The application of this is used in domestic's purpose examples are hair dryer, mixer, zero machine ,elevator and industrial purpose examples are traction and elevator. In this project we have control the actual speed of dc motor as per our requirement. This can be achieved through PIC microcontroller. The microcontroller computes the actual speed of the motor by sensing the terminal voltage and displayed on LCD. In this project firstly we are giving the supply to PIC16F8774 microcontroller. Then controller generates the pulse generally 5VDC.The generated pulse is nothing but PWM signal, which is given to the driver circuit. The function of this driver circuit is to generate12V DC pulse. This is necessary to switch/trigger the MOSFET. Thus the speed of DC motoris controlled through duty/PWM cycle. This PWM pulse is given to MOSFET for triggering purpose. The modeling and simulation of this project is done through MATLAB/PROTES software. It then compares the actual speed of the motor with the reference speed and generates a suitable control signal which is fed into the triggering unit using MATLAB. here we use PID Controller for error minimization purpose. This unit drives a Power MOSFET amplifier, which in turn supplies a PWM voltage to the dc motor.DC Motors can be used in various applications.

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**METHODOLOGY AND BLOCK DIAGRAM:-**

In the proposed design shown in DC motor of 12 Volt, 1000 rpm, Zero Crossing Detector (ZCD) for zero reference and a generator as a Speed sensor has been used. This system describes the design and implementation of the AT89c51 Microcontroller based closed loop DC Motor Speed Control System that controls the speed of a DC motor through Optically Coupled Half Controlled SCR bridge rectifier used as a Motor Driver circuit. The generator used gives a back emf in the range of 0 - 10 Volt corresponding to the speed attained by the DC Motor. This output voltage of the generator is then given as input to the signal conditioning circuit which converts the output voltage from 0-10Volt to 0 – 5 Volt. This analog value of voltage obtained after signal conditioning is fed to ADC converter which gives the corresponding digital values. The controller unit will sense this digital data of output voltage of the generator and will compare with the desired level of voltage corresponding to the set-point speed. The error obtained is reduced by Proportional (P) Control Algorithm during which the controller continuously sends triggering pulses through the opto-coupler circuit to the SCRs of the Motor.

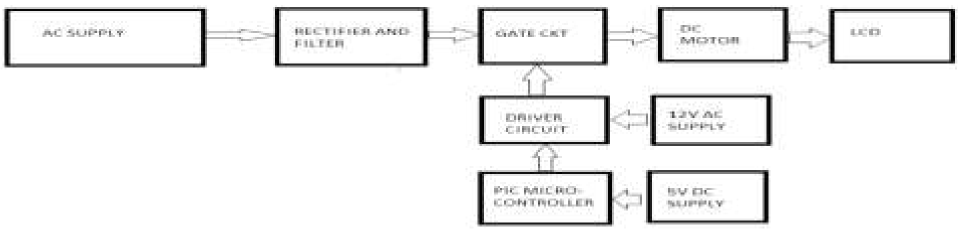


**Figure 1: Block Diagram**

**HARDWARE IMPLEMENTATION AND DISCUSSIONS**

The detailed hardware circuit of Closed Loop Speed Control system described above consists of Speed Measurement and Monitoring circuit using tacho generator as a speed sensor, Analog Signal Conditioning Circuit, Analog-to-Digital (ADC) converter, Zero Crossing Detector (ZCD) circuit, optically coupled Motor Driver circuit using MCT-2E and interfacing of AT89c51 Microcontroller with the hardware circuit.

**Regulated Power Supply Circuit Designed** Most of the electrical domestic appliances feature microcontroller unit, mechanical relay, or solid state SCR switches and several loads such as single phase motors, lamps, valves, etc. They are either powered directly via are regulated power supply or a switch mode power supply (SMPS). A regulated power supply is one that controls the output voltage or current to a specific value. The controlled value of voltage is held nearly constant despite variations in either load current or the voltage supplied by the power supply's energy source. They are more efficient, consume less power and are more compact and weigh less.

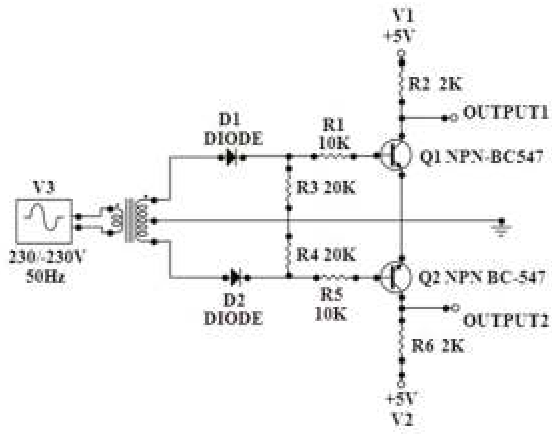


**Fig.2**

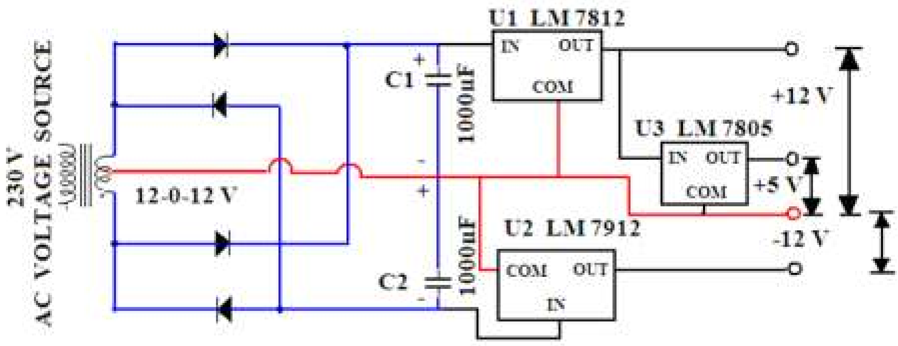


**Figure.3**

**OBJECTIVE :-**

The project is an endeavor towards an effective design and development of microcontroller based electronic speed governor for genset automotive engine.

**The following are the main objective**

1. To design drivers for both throttle actuator and magnetic pickup sensor.
2. To design hardware for the system using PIC16F877A microcontroller.
3. To develop an experimental setup for mounting of throttle actuator and magnetic pickup sensor.
4. Implement the PID algorithm in embedded C code.
5. Application of the designed algorithm in an embedded controller to verify on actual engine operation.

**SYSTEM DESCRIPTION:-**

The following Figure 2 shows block diagram of working of electronic speed governor system. The magnetic pickup sensor is mounted on engine flywheel. The engine rpm is measured in capture compare module of the PIC microcontroller. The throttle actuator's lever is directly connected to the engine fuel pump. The throttle actuator is controlled from the pulse width modulation signal so it is directly connected to the RC2 pin of the PIC microcontroller. The engine rpm is continuously measured and compared with the required set point and when the error signal is generated it is directly processed in the PID algorithm. The PIC micro controller generates the required pulse width modulation duty cycle from the PID algorithm based on which diesel engine gets stabilized at required set point. The working pulse width modulation period is calculated from initial trails on the throttle actuator.

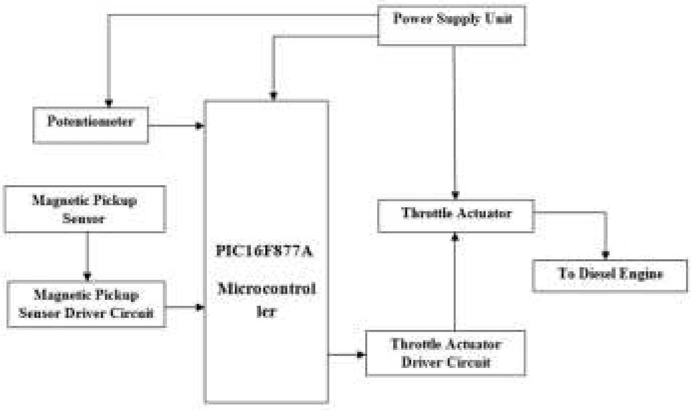


**Figure 4: Block diagram of Electronic Speed Governor System**

In this project CCP1 (PWM) is used to control the position of throttle actuator. PWM stands for the Pulse Width Modulation where the width of a digital waveform is varied to control the power delivered to a load. The underlying principle in the whole process is that the average power delivered is directly proportional to the modulation duty cycle as shown in Figure 3. The pulse width modulation is required to switching the load devices through MOSFET based power stage or from any other components. The pulse width modulation has ON time and OFF time and addition of both is period. The average voltage applied to the load is varied from the pulse width modulation which directly depends upon the duty cycle. The time is inversely proportional to the frequency because of which the required period given to the load is in the form of frequency Design and Development of Microcontroller Based Electronic Speed Governor for Genset/ AutomotiveEngine

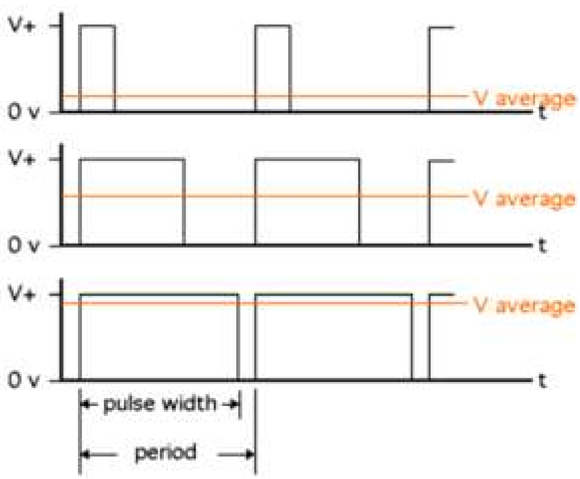


**Figure 5: Pulse width modulation with different duty cycle.**

## DESIGN OF CONTROLLER:-

The improved electronic speed governor system includes digital controller, drive circuit ,electromagnetic throttle actuator and the engine speed sensor. The system to be controlled (plant) is the diesel engine. The electronic speed governor is a closed loop system in which feedback is taken from engine rpm. The controller output is in the form of pulse width modulation duty cycle. When the rpm error is generated the required pulse width modulation duty cycle is calculated from PID algorithm. The capture compare module inPIC16F877A is used to calculate engine rpm. The PID update time is kept in proportion with the throttle actuator response time. The key step of the electronic governor design is to choose the suitable actuator coupled suitably with fuel pump rack. The requirements to actuator of diesel engine governor system are fast response, high accuracy and reliability. Under diesel engine operating principle, the engine speed regulation is achieved by regulating the movement of the pump rack. With electronic speed controller, the movement of pump rack is mainly affected by the diesel engine speed change.

### A. System to be controlled

The system to be controlled is a diesel engine, speed-torque characteristics of which are mentioned in below Figure 4. The PID algorithm is implemented on diesel engine to achieve required set point rpm. The controlled parameter is engine rpm and controlled variable is engine throttle angle

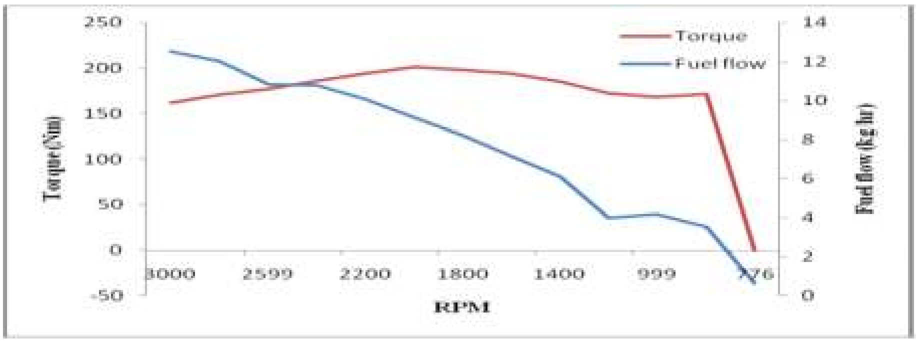


**Figure 4: Base diesel engine speed torque characteristics.**

The diesel engine having idle rpm is 780 with 0.58 kg/hr fuel flow. The diesel engine produces power up to 52 kW and generates 223 Nm torque at rated engine rpm. The diesel engine works on mechanical governor and having distributor type fuel pump. The above Figure 4 shows the behavior of diesel engine at various loads, the red line shows the engine Torque in Nm. The engine load is directly proportional to the fuel flow. The blue line in Figure 4 shows the fuel flow in kg/hr, which directly increases as engine torque increases. Design and Development of Microcontroller Based Electronic Speed Governor for Genset/AutomotiveEngine

### B. Controller: Throttle Actuator

The Figure 5 shows the throttle actuator. As the actuator has two way connections it can controlled by lever from both sides, accordingly fuel pump lever can be adjusted with appropriate torque. The actuator is an electro magnetic servo device which can be integrated into a closed loop control system. An engine control system can be described as follows; an electrical signal is generated by a magnetic speed sensor which is proportional to the engine speed. The signal is sent into the electronic speed control unit which compares it to the preset engine speed setting. When the magnetic speed sensor signal and the preset engine speed setting are not equal, a change in current from the speed control unit to the actuator will change the magnetic force in the actuator. The throttle actuator is prewired for 12 volt or 24 volt. The harness included with the actuator can be used to connect the actuator to the speed control. For 12 volt operation it is preferable to connect four cables, one to each of the coil wires with maximum current is 8 Amps. A. Pump rack B. Return spring C. Rack displacement sensor D. Electromagnetic actuator E. Engine speed sensor.

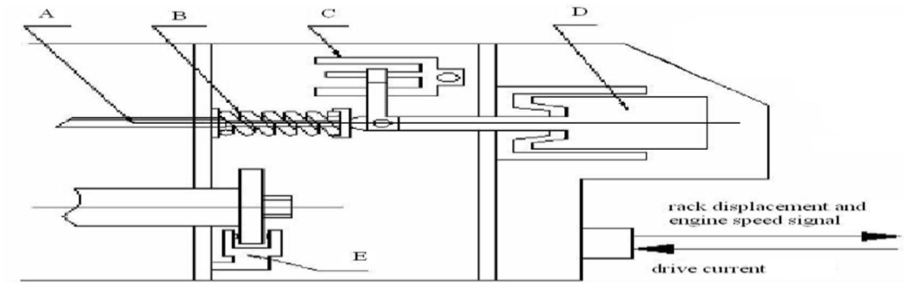


**Figure 5: Throttle Actuator [1].**

Available maximum torque 2.7 Nm Angular Travel 25 cw /ccw Operating Voltage 12 Volt Normal operating Current 0.9 Ampere at 12 Volt Maximum Current 6 Ampere at 12 Volt The Table 1 shows the throttle actuator specifications. The arrangement of the linkage for actuation of engine fuel control is an important application consideration. For proportional actuators to operate with linear control systems, it is important to obtain a linear relationship between actuator strokes and fuel delivery. The linkage configuration for diesel fuel systems is typically as illustrated in Figure 5. According to the current speed and the preset value the rotation of the actuator shaft will then adjust the fuel to the engine and cause the engine speed to be equal to the preset engine speed setting. Shaft rotation is proportional to the amount of actuator current and counterbalanced by the internal spring. Since the design has non sliding parts and is totallysealed, outstanding reliability results, a single compression spring is used to improve reliability. No maintenance is necessary.

**C. Controller: PIC16F877A Microcontroller**

The nominal output in Eqn. (1) is taken from the potentiometer at no load condition. The analog to digital conversion module of PIC16F877A is used to measure voltage from potentiometer. The pulse width modulation duty cycle is calculated as per the voltage from the potentiometer. The engine rpm is measured in capture compare module of PIC16F877A microcontroller. The updated values of engine rpm and the pulse width modulation duty cycle are displayed on LCD. The engine rpm is continuously compared with the set point and when error signal generates it directly processed into the PID algorithm. The pulse width modulation duty cycle is calculated from the PID algorithm and from which PIC16F877A microcontroller moves the throttle actuator lever in such a position where engine gets stable at the required set point.

**CONCLUSION:-**

The electronic speed governor gives satisfactory results for the tested set points at 1500 rpm and 1000rpm. The diesel engine runs very stable at different loading conditions. Overshooting and undershooting of set point was minimized because of PID algorithm. The diesel engine runs very stable at set point in both loading and unloading conditions. On the microcontroller side both the actuator and sensor calibration is quite critical and their control is very important in further development in this project.

- The electronic speed controller designed for Genset/Automotive engines is practically implemented on diesel engine to stabilize the engine for required set point at various loading conditions.
- The driver was designed such that the output peak to peak voltage of magnetic pick up sensor was reduced from 10 to 5 peak to peak voltages which are acceptable by controller.
- The driver was designed to meet the requirements of throttle actuator that is 12 Volt and 6.5 Ampere.

• The PID algorithm works very successfully and calculated pulse width modulation duty cycle as per the need of diesel engine to run at set point with no load and partial load.
• The Engine was stabilized by proper functioning of calculated gains and update time for PID.

**ACKNOWLEDGMENTS**

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