AN ADAPTIVE APPROACH FOR EMBEDDED SYSTEM OF DC MOTOR CLOSED LOOP SPEED CONTROL BASED ON 8051 MICROCONTROLLER

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Abstract

The goal of the present paper is outlining 8051 Microcontroller based Embedded Closed Loop Speed Control System of DC Motor to contemplate the response of controlled variable to set-point changes. In this present plan a tachogenerator has been utilized as a speed sensor which creates a back emf relating to the speed accomplished by the DC Motor. This momentary estimation of yield voltage gave by the tachogenerator is then contrasted with the coveted voltage comparing with the coveted speed. The subsequent mistake is utilized by the microcontroller to control the terminating edge of the SCR for controlling the voltage connected to the DC Motor which thus changes straightforwardly the engine speed to accomplish the coveted esteem. In this way a ceaseless shut circle speed control framework has been accomplished. Relative (P) Control Algorithm has been utilized as a part of the present plan. Test comes about have been displayed to think about the response of process speed as for set-point changes. The framework is of minimal effort and is appropriate for various mechanical applications, for example, metro autos, trolley transports and battery worked vehicles.

Keywords—Back-emf, DC Motor, Firing angle, Microcontroller, SCR, Set-point change, Speed Control, Tachogenerator

1. INTRODUCTION

The speed of expansive electrical engines relies upon numerous elements, including supply voltage level, load, and others. A procedure control circle manages this speed through direct difference in working voltage or current for a DC Motor. The utilization of energy electronic gadgets for control of these electric machines not just offers better execution with exact control and quick reaction yet in addition gives fast support and simplicity of usage. In parallel with the headway in control hardware there has been incredible advances in microcontroller based process control frameworks too, because of its adaptability and flexibility. In this way they are broadly utilized as a part of mechanical applications since they give variable speed qualities. There are numerous techniques for speed control which has been proposed in recent years. ThadiappanKrisnan [1] has depicted and outlined SCR based speed control unit for an independently energized DC Motor. Around the same time S.A.A.Farag [2] has performed trial thinks about on factor speed DC Shunt Motor driven by a solitary stage full-wave amended power supply utilizing SCRs. S.J.Jorna and Y.T.Chan [3] planned a Microprocessor based DC Motor drive control utilizing SCRs. Numerous working methods of thyristor converter has been contemplated utilizing three stage completely controlled DC Motor engine drive framework by Ahms Ula [4].H.ChinChoi has shown trial delayed consequences of overcoming rate and position administration issues by using put in controllers. An unraveled approach of Programmable Logic Controller (PLC) based for the most part speed administration of DC Motor

has been anticipated by A.S.Z El Din [11]. HuanGuoShing has anticipated a LABVIEW helped pelvic incendiary illness arranged managementler to screen and control DC Motor Speed.

Half controlled bridge rectifier DC Motor driver circuit with a flywheel diode D3 has been used. Flywheel diode (D3) is used to eliminate negative spikes in the output voltage and prevent reversal of load voltage, improves power factor angle and better load performance. Here we have used phase controlled technique, the basic principle of which is to control the point of time at which the SCRs are allowed to conduct during eachcycle. That is at the instant SCR starts conducting, at that particular point of time control action should start. So atthe point of control SCRs are to be turned ON. This can be achieved by application of Gate signal through the Optocoupler MCT-2E with the help of the Microcontroller. For successful process control, the parameter to be controlled should be sensed by a suitable sensor, converted into a signal which will truly represent the parameter and present it to the controller for further action. Signal conditioning using passive circuits are extensively used for many years. As microcontroller cannot recognize voltage beyond 5 Volt, so it is necessary to convert the voltage signal into 0-5Volt range. In this present researchwork we have designed a Sensor analog signal conditioning. [5][6][7]

In the present examination attempts have been made to plot and make AT89c51 Microcontroller based embedded close circle speed control plan of DC Motor where Proportional (P) Control estimation has been executed to control the ending edge of the SCR for controlling the voltage associated with the DC Motor. In this diagram of Speed control structure tachogenarator has been used as a speed sensor. The tachogenerator yield voltage after change into fitting shape by the banner trim circuit formed is sustained to the microcontroller which by then using sensible control programming contrasts this ponder speed signals and the reference or needed banner given and makes a botch. This mistake is utilized by the controller to trigger the SCR at an edge estimated from the reference gave by the Zero Crossing Detector (ZCD) circuit to accomplish the required voltage over the Motor terminals which keeps up the procedure speed at wanted esteem.

2. Methodology and Block Diagram

In the arranged design showed in Fig.1, this structure depicts the describe and utilization of the AT89c51 Microcontroller on a very basic level based close circle DC Motor Speed system that controls the speed of a DC engine through Optically Coupled 0.5 Controlled SCR interface rectifier utilized as a Motor Driver circuit. Here are numerous techniques for speed control which has been proposed in past couple of years. ThadiappanKrisnan [1] has portrayed and outlined SCR based speed control unit for an independently energized DC Motor. Around the same time S.A.A.Farag [2] has performed exploratory investigations on factor speed DC Shunt Motor driven by a solitary stage full-wave redressed control supply utilizing SCRs. S.J.Jorna and Y.T.Chan [3] composed a Microprocessor based DC Motor drive control utilizing SCRs. Numerous working methods of thyristor converter has been examined utilizing three stage completely controlled DC Motor engine drive framework by Ahms Ula [4]. A programming based bolster forward control arrangement of DC Motor has been considered to figure the heap torque by Tsuyoshi Hanamoto [5].

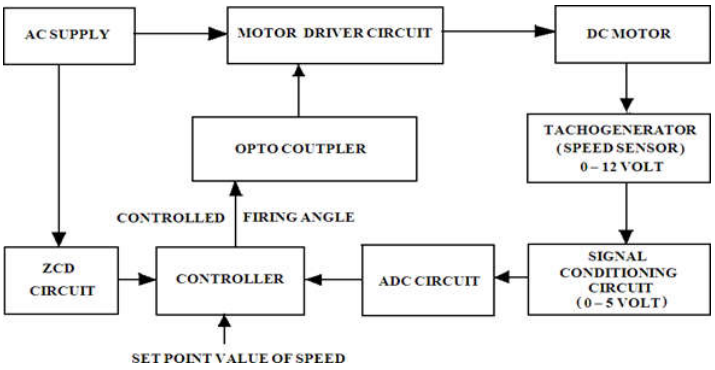

Fig.1.Block Diagram of Closed Loop DC Motor Speed Control System

The tachogenerator used offers a back electrical marvel inside the extent of zero - ten V examination to the speed accomplished by the DC Motor. This yield voltage of the tachogenerator is then given as commitment to the banner trim circuit that progressions over the yield voltage from zero-10Volt to 0 – five V. This simple estimation of voltage got when hail shaping is enlivened to ADC gadget which supplies the examination propelled regards. The controller unit can watch this handled information of yield voltage of the tachogenerator and would distinction be able to and thusly the popular level of voltage examination to the set-point speed. the blunder got is lessened by Proportional (P) administration algorithmic program in the midst of that the controller steadily sends initiating SCRs of the Motor Driver Circuit that controls the voltage associated and henceforward the speed of the DC motor.

3. Hardware Implementation and Discussions

The itemized equipment circuit of Closed Loop Speed Control framework depicted above comprises of Speed Measurement and Monitoring circuit utilizing tachogenerator as a speed sensor, Analog Signal Conditioning Circuit, Analog-to-Digital (ADC) converter, Zero Crossing Detector (ZCD) circuit, optically coupled Motor Driver circuit utilizing MCT-2E and interfacing of AT89c51 Microcontroller with the equipment circuit.[11][12]

3.1 Regulated Power Supply CircuitDesigned

The vast majority of the electrical local machines highlight microcontroller unit, mechanical transfer, or strong state SCR switches and a few loads, for example, single stage engines, lights, valves, and so on. They are either fueled specifically by means of a managed control supply or a switch mode control supply (SMPS). They are more effective, devour less power and are smaller and weigh less

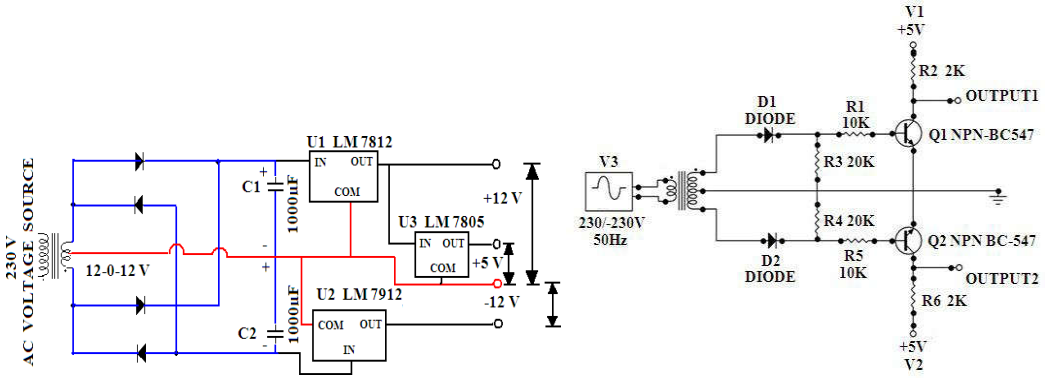

Fig.2.Circuit Diagram for Power supplydesigned

Consequently, in the present examination a managed control supply appeared in Fig.2. has been outlined utilizing full-wave focus tap rectifier circuit with 12-0-12V, 500mA focus tap advance down transformer, diodes, 1000µF, 63V electrolytic capacitor and LM 7812, LM 7805 and LM 7912 voltage controllers from where yield voltages of +12V,+5V and - 12V separately are circulated to different units of the framework parts as required for their particular operations.

3.1.1 Changed Zero Crossing Detector (ZCD) Circuit Designed

A Zero Crossing Detector (ZCD) truly distinguishes the progress of the a.c flag wave shape from positive to negative and also the different manner around, in an exceedingly excellent world giving a skinny heartbeat that concurs exactly with the zero voltage condition. this can be needed by the microcontroller to form associate SCRs with some postponement from the zero intersection of the a.c flag. during this gift work as appeared in Fig.3. a 4.5-0-4.5 Volt, 500mA focus faucet electrical device used|is employedis used} provide. Yields ar gotten from yield terminal one and yield terminal a pair of severally of the altered Zero Crossing Detector (ZCD) circuit planned.

3.1.2 DC Motor

Basically, a DC engine comprises of a stator, a rotor and commutator. The stator is the lodging of the engine and contains magnets and the rotor is the turning some portion of the engine, which is known as the armature, contains conductors put in the armature openings through which current streams. The control of speed of these DC Motors can be accomplished by variety of the connected voltage plentifulness. This can be accomplished by SCR connect circuit. By variety of the SCRs' terminating edge the sufficiency of the DC voltage and current of the armature conductors, and henceforth the speed can be differed.

3.1.3 DC Tachogenerator (Speed Sensor)

Tachogenarator is a transducer that believers speed of revolution specifically into an electrical flag. They are generally utilized for speed control of pivoting types of gear. The tachogenerator is combined with the DC engine. Tachogenerator gives a yield voltage as per the speed accomplished by the DC engine. The measure of yield voltage (e0) created by the tachogenerator is given by,

$$e0=b[npnc\varphi\omega \times 10\text{-}8/(60npp)\ ]\ \text{Volt} \quad (1)$$

Where, np= Number of poles,nc= Number of Conductors in the armature, φp=flux per shaft, npp=parallel brush amongst positive and negative brushes, ω=rpm to be estimated.

3.1.4 Sensor Analog Signal Conditioning Circuit Designed

For fruitful process control, the parameter to be controlled ought to be detected by an appropriate sensor, changed over into a flag which will really speak to the parameter and present it to the controller for additionally activity. Flag molding utilizing detached circuits are widely utilized for a long time. As microcontroller cannot perceive voltage past 5 Volt, so it is important to change over the voltage motion into 0-5Volt territory. In this present research work we have planned a Sensor simple flag molding circuit appeared in Fig.4 that proselytes 0-12Volt yield flag of the tachogenerator into 0-5Volt for every variety in the process variable (speed of the DC Motor)

3.1.5 Optically Coupled Motor Driver Circuit interfaced with 8051 Microcontroller

An opto-isolator, likewise called an opto-coupler or a photograph coupler, is an electronic gadget intended to exchange electrical flags by using light waves to furnish coupling with electrical disengagement between its info and yield. The primary reason for an opto-isolator is to forestall high voltages or quickly changing voltages on one side of the circuit from harming parts or mutilating transmissions on the opposite side or low voltage side. In this examination opto-coupler MCT-2E has been utilized which ensures the microcontroller which requires low voltage from over voltage harming and furthermore keeps the engine to keep running in the turnaround heading.

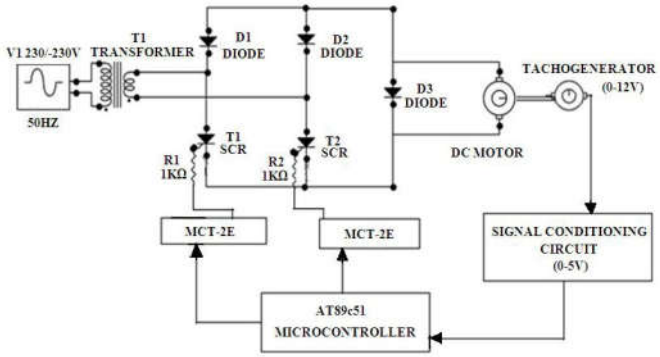

Fig.3.Interfacing between 8051 microcontroller and DC Motor Driver Circuit

As appeared in Fig.5. Half controlled extension rectifier DC Motor driver circuit with a flywheel diode D3 has been utilized. Flywheel diode (D3) is utilized to dispose of negative spikes in the yield voltage and avert inversion of load voltage, enhances control factor point and better load execution. Here we have utilized stage controlled strategy, the essential guideline of which is to control the purpose of time at which the SCRs are permitted to lead amid each cycle. That is at the moment SCR begins leading, at that specific purpose of time control activity should begin. So at the purpose of control SCRs are to be turned ON. This can be accomplished by utilization of Gate motion through the Opto-coupler MCT-2E with the assistance of the Microcontroller at any point α as for the connected voltage. This edge is known as the terminating point or postpone edge. It ought to be guaranteed however the SCR is forward one-sided it ought not be permitted to lead until the point that it is activated

3.1.6 Software Implementation of the Control Unit

Every module chip, the capacity necessity, and in addition the change of program decipherability, transferability and advantageous investigating the product configuration appeared in Fig.6 has been modularized. In this plan of shut circle speed control framework KEIL µVision 4 Software has been utilized as the C Compiler.

4. Experimental Results and Discussions

In the first step of experimentation, calibration of the DC Motor with and without speed sensor has been done by varying the voltage across the Motor terminals by varying resistance of potentiometer and recording the process speed.

4.1 Open Loop Speed Variation of DC Motor with input Voltage (without SpeedSensor)

The information voltage of the DC Motor was shifted from 0 – 12 Volt by utilizing a 10KΩ multi-turn Potentiometer(POT) for which an open circle speed variety from 150 rpm to 800rpm has been gotten. The open circle variety of Speed with connected voltage without speed sensor has been appeared in Fig 4. This variety of Speed with the connected voltage will be required later to fire of the SCRs with the microcontroller. The SCRs will be terminated at this voltage levels as opposed to utilizing a potentiometer to get the required Speed

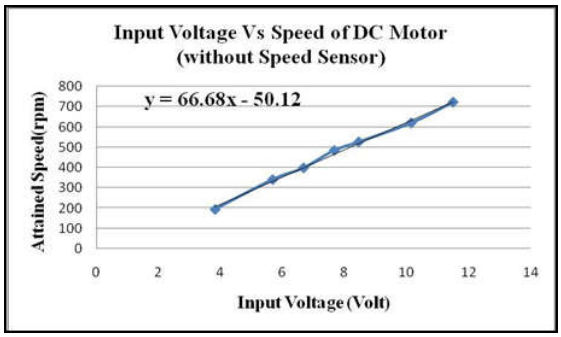

Fig.4. Open Loop Speed Variation withappliedvoltage without SpeedSensor

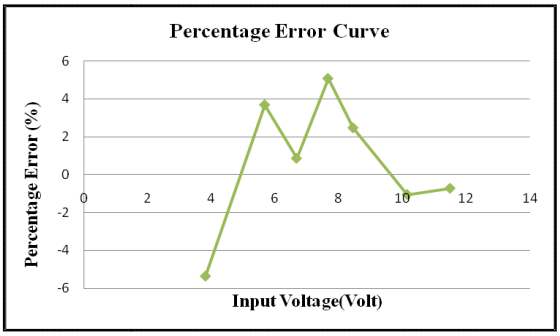

Fig.5. Percentage Error Curve

By looking at the bend of Fig.4. it is watched that it is relatively straight. This prompts the improvement of direct guess of speed accomplished with connected info voltage by plotting a straight pattern line condition and contrasting it and the bend acquired. In this way direct figured esteems or genuine estimations of engine speed are acquired. The blunder rate is computed from the deliberate esteem and the genuine estimations of speed. From the rate blunder bend in Fig.8 it is watched that the rate blunder lies between ±6%.

4.2. Open Loop Speed Variation of DC Motor with input Voltage (with SpeedSensor)

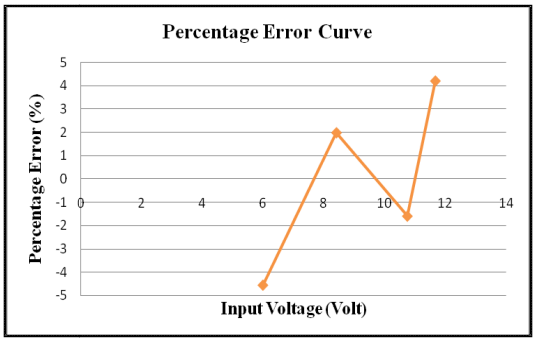

Fig.6. Percentage Error Curve

Fig.6. speaks to variety of DC Motor Speed with connected voltage with speed sensor. Here the tachogenerator utilized as a Speed Sensor is coupled as a heap with the pole of the DC Motor whose speed is to be controlled. While playing out the past experimentation of open circle speed variety without speed sensor, we have watched that there were vast vacillations of Speed with the variety of connected voltage without the heap. Yet, here the deviation of the bend from the trendline condition is little which implies variety of estimated estimation of engine speed contrasted and the ascertained genuine esteem is likewise relatively direct. The blunder rate is ascertained from the deliberate esteem and genuine estimation of accomplished Speed. From the rate blunder bend in Fig.10. it is watched that the rate blunder lies between ±5%

4.2.1 Variation of Tachogenerator (Speed Sensor) Output Voltage with Speed accomplished by DC Motor

Fig.6. speaks to variety of DC Motor Speed with the tachogenerator (Speed Sensor) yield voltage. The speed variety was acquired from 200 rpm to 600 rpm. The tachogenerator makes a back emf in the extent of 0-10 volt identifying with each speed achieved by the DC Motor. This straightforward estimation of voltage is fed to the banner trim circuit which changes over it in the extent of 0-5 Volt to be reinforced to the Microcontroller unit.

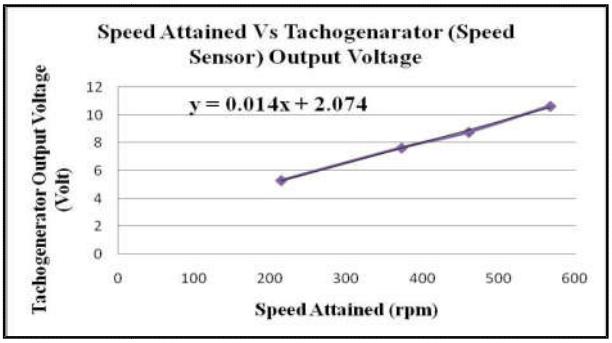

Fig.7.VariationTachogenerator Output Voltage with Speed Attained by DC Motor

It is seen from Fig.7 that the variety of the tachogenerator (Speed Sensor) yield voltage with the Speed of the DC Motor contrasted and the straight trend line condition is relatively director.

4.2.2 Variation of Signal Conditioning Output with Tachogenerator (Speed Sensor) OutputVoltage

The information given to the 8051 Microcontroller ought to change within 0 to 5 volts. The AT89c51 Microcontroller utilized can't perceive simple voltage past 5Volt. Hence, the tachogenerator yield voltage is given as contribution to the Signal Conditioning circuit outlined as appeared in Fig.4 which changes over the yield voltage of the tachogenerator from 0-10Volt to 0-5 Volt

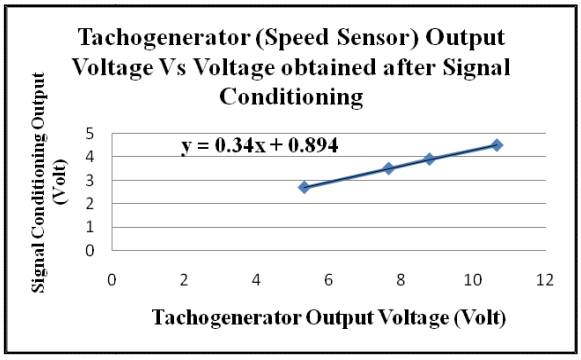

Fig.8. Variation of Signal conditioningoutputwith TachogeneratorOutputVoltage

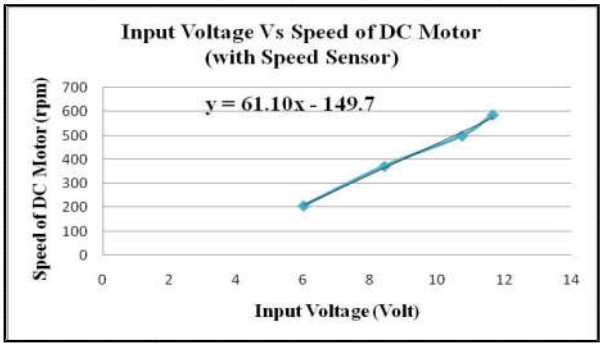

Fig 9: Set point speed vs speed attained

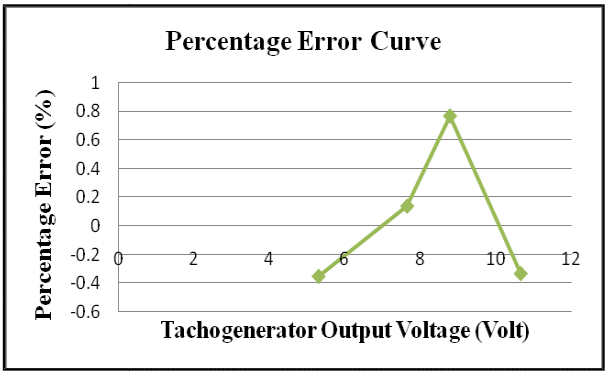

Fig 10: Percentage Error Curve

The variety of the yield voltage after flag molding concerning the change in tachogenerator yield voltage is appeared in Fig 9. The rate blunder bends in Fig.9. Demonstrates that the rate mistake ascertained in the wake of contrasting the deliberate esteems and the genuine esteems acquired from straight trend line condition, lies between - 0.4% to - 0.8%.

4.2.3 Digital Signal Conditioning using Analog to Digital Converter(ADC)

The flag molding circuit yield which is a simple voltage is currently changed over to its identical advanced shape utilizing ADC as appeared in Table.1. This advanced yield is given as contribution to the microcontroller unit utilized

4.2.4 Variation of Open Loop Voltage with FiringAngle

Table.1. speaks to the Open Loop Voltage and Speed Variation with change in terminating point of the SCRs from 40.75º to 174.90°. This variety has been accomplished through C program utilizing AT89C51 Microcontroller. For various twofold mixes of info given to the Microcontroller, the Microcontroller triggers the SCRs with various postpones surrendered in the look table written in the C program. It is watched that with the reduction in the terminating edge, the open circle voltage over the heap in the driver circuit increments and the other way around. In this way, Speed of the DC Motor likewise increments.

4.2.5 Closed Loop Speed Control of DCMotor

The set point and the Speed achieved, with a corresponding consistent over and again until the point that the mistake is diminished to zero. Consequently, Proportional(P) Control of Speed is acquired with some counterbalance mistake.

Table 1 :Speed attained for a given Set-point Speed

Set-point speed (RPM)	Speed attained (RPM)	Percentage Error (%)
372	390	1.980902
460	484	-2.71335
567	603	1.071955

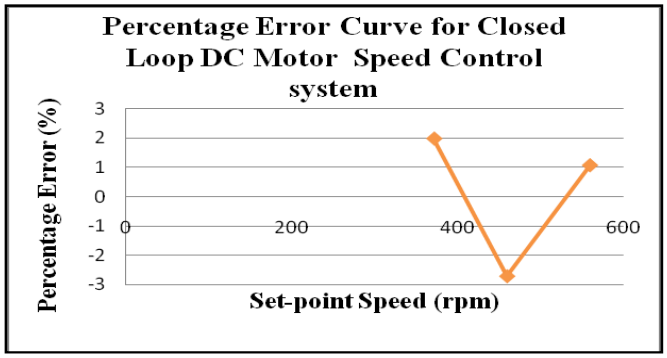

Fig 11: Percentage Error curve for closed loop

5. Conclusion

A technique for planning a Single stage half-controlled SCR based scaffold rectifier circuit utilized as a DC Motor driver has been given which the speed of DC engine has been effectively controlled by utilizing 8051 microcontroller. Different processors, for example, 8085 and 8086 Microprocessors could likewise be utilized however the framework fashioner needs to include peripherals, for example, Memory, I/O ports and clocks remotely to make them useful contrasted with 8051 Microcontrollers. In this manner 8051 Microcontrollers are perfect for these inserted control applications in which cost and space are basic. Speed of high appraising 220V,8A,1400 rpm DC Motors can likewise be controlled utilizing rheostats of 500Ω,2A as opposed to utilizing potentiometer (POT) by shifting the armature voltage as it has been done here for 12 Volt,1000 rpm DC Motor. In any case, it is watched that speed control utilizing Microcontrollers as computerized controller is more precise and flexible than some other simple controllers. Both the circuit outline and the control calculation of the consistent advanced controller have been examined. The adequacy of the outline technique has been very much confirmed by exploratory outcomes. The rate blunder of shut circle speed control framework lies roughly between ± 2% which has been diminished from ± 6% acquired in open circle speed control framework. Along these lines, the outcome demonstrates that the Microcontroller is a solid and exceptionally adaptable instrument to control the DC Motor with more exactness and accuracy. A balance blunder has been acquired in the present work which can be killed by utilizing PI control calculation which gives the future extent of work. The controller actualized has lessened the aggregate equipment many-sided quality and along these lines is more advantageous and simple to execute.

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