Speed Control of Closed Loop DC Motor Using 8051 Microcontroller

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ABSTRACT: A microcontroller has all the components a microprocessor possesses and inevitably presents ROM, RAM, Serial Port, timers, input output ports interrupts, and clock circuit. The Intel invented this microcontroller, and it operates with an 8 bit family processor. The 8051 microcontroller has extensive application in various industries and also for domestic purposes when it comes to the use. The goal of this paper is to design DC Motor's 8051 Microcontroller based Embedded Closed Loop Speed Control System to research the controlled variable's reaction to set-point changes. A tachogenerator has been used in this scheme as a speed sensor producing a back emf corresponding to the speed achieved by the DC engine. This instantaneous output voltage value is then compared to the desired voltage corresponding to the desired speed given by the tachogenerator. The resulting error is used by the microcontroller to monitor the SCR's firing angle to regulate the voltage applied to the DC Motor which, in effect, directly controls the motor speed to achieve the desired value. A continuous, closed loop velocity control system was thus achieved. In the present scheme the Proportional (P) Control Algorithm was used. Experimental findings were presented to research process velocity reaction with respect to set-point adjustments. The system is low cost and is ideal for various industrial applications, such as subway trains, trolley busses and vehicles powered by batteries.

KEYWORDS: Back-emf, DC Motor, Firing angle, Microcontroller, SCR, Set-point change, Speed Control, Tachogenerator.

INTRODUCTION

In all manufacturing, commercial and residential applications such as pumps, fans, mills, conveyor belts, elevators, riders, compressors, packaging equipment and many others, electrical drives are important mechanical energy source components. These systems consume about 35 per cent of electrical power generated worldwide. Therefore demand is emerging on the market for energy efficient, less maintenance, good speed range, less noisy, high efficiency, higher torque density and cost-effective electric motor drives [1]. Thanks to its superior characteristics such as higher toque by current ratio, power density, speed range and noise less operation, the Brushless DC (BLDC) engine now has intense competition with existing engines. Over the past few years, the three phase BLDC motors have been increasingly used in many industrial applications and, more specifically, in automobiles to minimize carbon dioxide emissions, fuel consumption, and complexity control.

The BLDC motor is a combination of a synchronous motor with a permanent magnet, a solid state inverter, electronic control circuitry, and rotor location sensor [2]. Together with its BLDC motor control unit and rotor location sensor, the inverter simulates the mechanical switching of the DC motor and is called electronic switching. BLDC motor visualization practically has twocategories. Permanent magnet synchronous engine (PMSM) and BLDC motors depending on the form of their wave back-emf. The one with a six-stage trapezoidal wave form is called BLDC motors in which the stator consists of three-stage focused winding and rotor with permanent magnets and the PMSM has three-stage distributed winding and rotor with permanent magnets. The researchers focus on speed control methods, torque ripple minimization, inverter topologies and front converter design to improve drive performance.

The rapid control prototyping plays a greater role in developing the control methods and interfacing with the current electronic control unit in addition to reducing the test time. Rapid control prototyping is a process in which the mathematical models built in MATLAB / Simulink can be easily imported to the real-time machine using the RTI (Real Time Interface) blocks to bind the real-world systems. A tremendous amount of research was done on automated BLDC motor drive control. Monmasson's concept of an integrated environment for BLDC motor rapid control prototyping using Fuzzy controller, design methodology for industrial control systems using FPGA, and rapid control prototyping creation of BLDC motor using DS1103 is provided. Currently dSPACEDS1104, dSPACE DS1103 and opal-RT are the renowned hardware and real-time software tools for quick prototyping operating via the MATLAB / Simulink interface.

However, in the number of ADC and DAC ports, internal memory, input / output ports, etc. For similar facilities, the cost involved in implementing Opal-RT for fast control prototyping is slightly higher. The specifications of the DS1104 and DS1103 boards can be read for comparison. However, the comprehensive design and development methodology for implementing the Rapid Control System for speedcontrol BLDC motor drive is not accessible in the current literature to the authors' knowledge. As the real difficulty of implementing the hardware lies in choosing appropriate hardware equipment and correctly configuring the controller board equipment [3].

Attempts were made in the present investigation to design and improve DC Motor's embedded closed loop speed control system based on AT89c51 Microcontroller where Proportional (P) Control Algorithm was implemented to control the SCR firing angle for controlling the voltage applied to the DC Motor. Tachogenarator was used as a velocity sensor in this design of Speed control device. After conversion, the tachogenerator output voltage is fed to the microcontroller by the built signal conditioning circuit, which then compares these calculated velocity signals with the reference or desired signal provided and generates an error using the correct control software. This error is used by the controller to activate the SCR at an angle determined from the Zero Crossing Detector (ZCD) circuit reference to achieve the appropriate voltage across the engine terminals to maintain the process speed at the desired value.

LITERATURE REVIEW

This paper presents the design and implementation of the DC motor speed control system based on Arduino Uno, using Multilayer Neural Network controller and PID controller. A model reference structure is built using PID control to get the neural controller. Levenberg-Marquardt back propagation algorithm trains the artificial neural network. It uses neural feed forward network with two secret neurons and one output neuron. DC motor speed is controlled by varying the pwm signal duty cycle which is fed to the mosfet irf 640 doors [1]. The main function of the speed controller is to take a suitable signal speed sample and carry the engine to the speed desired. The dc drive's benchmark goal is to maintain a device with stable velocity regardless of the load situation. In this project, PWM is produced using P89V51RD2 microcontroller which can be used for speed control of a DC motor. A driver IC L293D feeds DC motor. The L293D is powered by the microcontroller-generated PWM signal [2]. This paper presents the possibility of using cheap credit card sized computers such as the Beaglebone board for real-time motor control, namely the PI-controller-based DC motor speed control. It defines the program design and implementation for evaluating engine speed and control feedback.

The software design incorporates three modules that were built as kernel and user space applications [3]. The inspiration behind this paper is to formulate a model for learning microcontroller by designing a simple closed loop DC motor speed control system based on 8051 microcontroller as a Lab project. The basic components of the control system are developed using the 8051 hardware and software tools, i.e. setting the desired motor speed, sampling the speed input, speed error measurement, and correction. Thus through this project students study the design environment of the process of production of the

8051 microcontroller, hardware and software systems [4]. The present study discusses the design, development, fabrication and analysis of the PID logic controller for DC motor speed control systems based on cygnal microcontrollers.

In 'C' language, the program is developed using the Si-Lab IDE C-cross compiler. The paper deals with specifics about the hardware and software [5]. This project is primarily concerned with designing and implementing bidirectional dc motor speed and position control system using the ATMEGA32 and Lab VIEW microcontroller software. It is a closed-loop real time control system, where the optical encoder is coupled to the motor shaft to provide the microcontroller with the input velocity signal and angular shaft position. Pulse Width Modulation (PWM) technique is used which is developed using Atmega32 to drive the motor driver circuit via the developed PWM signal. The voltage around the motor is variable by changing the service cycle. The Lab VIEW program offers a graphical user interface (GUI) that allows the user to reach the desired speed or angle [6]. This paper suggested a DC motor, an infrared sensor and a microcontroller based Embedded device. Here in this paper author used pulse width modulation (PWM) or duty-cycle variation system, widely used in DC motor speed control. The PWM makes it possible to drive the motor using a microcontroller, which gives tremendous flexibility. This paper offers a forum for further development in the industrial use of DC motors. DC motors have speed control capabilities which means it is possible to adjust speed, torque and even direction of rotation at any time to meet a new condition [7]. This paper deals with Brushless DC motor (BLDC) open loop speed control using Arduino UNO processor.

Real-time implementation of the drive in open loop speed control was performed in which the motor speed depends on the input voltage provided to the stator winding and is nothing but duty cycle setting. The open loop speed control is also useful in many practical applications but the present work mainly deals with observing the drive's running output without any speed feedback system being used. That is, the speed of the motor can differ if it is subject to variations in load and/or voltage supply [8]. The main function of the speed controller is to take a suitable signal speed sample and carry the engine to the speed desired. The dc drive's benchmark goal is to maintain a device with stable velocity regardless of the load situation. In this project, PWM is produced using P89V51RD2 microcontroller which can be used for speed control of a DC motor. A driver IC L293D feeds DC motor. The L293D is powered by the microcontroller-generated PWM signal. This work is realistic, and highly feasible from an economic point of view and precision[9]. This paper uses Artificial Neural Networks (ANNs) to estimate speed and control it for a separately excited DC motor, one of the most important modern techniques used in control applications and to increase the performance of separately excited DC motor (SEDM) speed controls. The DC motor rotor speed can be set to follow an arbitrarily chosen trajectory. The goal is to accurately control the speed of the trajectory, particularly when the parameters of the motor and load are unknown. There are two pieces of such a neural control scheme. One is the neural identifier used to measure engine velocity [10].

METHODOLOGY

In the concept suggested, shown in Fig.1. A 12 Volt, 1000 rpm DC motor, Zero Crossing Detector (ZCD) for zero reference, and a Speed Sensor Tachogenerator were used. This system describes the design and implementation of the closed loop DC Motor Speed Control System based on the AT89c51 Microcontroller, which controls the speed of a DC motor by means of the Optically Coupled Half Controlled SCR bridge rectifier used as a motor driver circuit. The tachogenerator used gives a back emf in the range of 0-10 Volt, which corresponds to the speed achieved by the DC engine. The tachogenerator output voltage is then supplied to the signal conditioning circuit as input, which converts the output voltage from 0-10Volt to 0-5 Volt. This analog voltage value is fed to the ADC converter which gives the corresponding digital values after the signal conditioning.

The controller device can sense this tachogenerator's digital output voltage data and compare it with the desired voltage level corresponding to the set-point speed. The error obtained is minimized by the Proportional (P) Control Algorithm, during which the controller continually sends triggering pulses to the motor's SCRs through the opto-coupler circuit. Driver circuit which controls the applied voltage, and hence the DC motor speed. Then the signal for error is modified and hence the loop is repeated. That way the desired velocity is achieved.

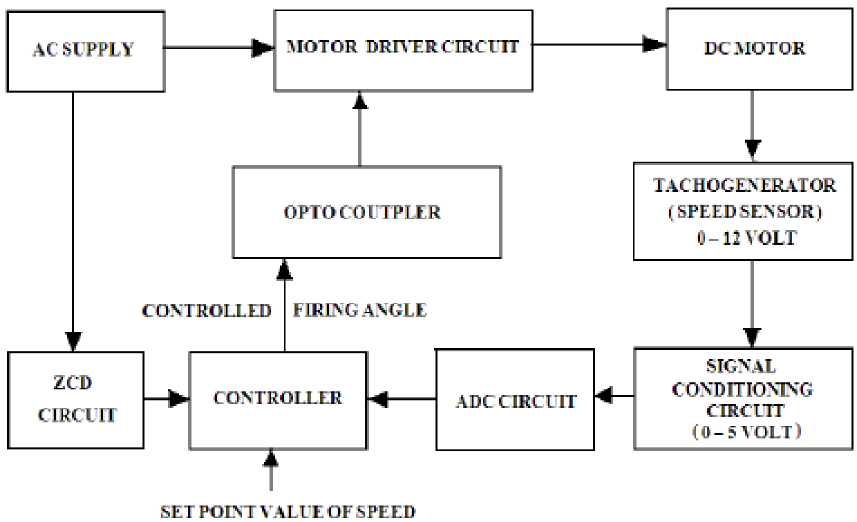

FIGURE.1.Block Diagram of Closed Loop DC Motor Speed Control System

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

Regulated Power Supply Circuit Designed

In the concept suggested, shown in Fig.1. A 12 Volt, 1000 rpm DC motor, Zero Crossing Detector (ZCD) for zero reference, and a Speed Sensor Tacho generator were used. This system describes the design and implementation of the closed loop DC Motor Speed Control System based on the AT89c51 Microcontroller, which controls the speed of a DC motor by means of the Optically Coupled Half Controlled SCR bridge rectifier used as a motor driver circuit. The tacho generator used gives a back emf in the range of 0-10 Volt, which corresponds to the speed achieved by the DC engine. Most domestic electrical appliances are fitted with microcontroller unit, mechanical relay or solid state SCR switches and multiple loads such as single phase motors, lamps, valves etc. They are operated either directly through a controlled power supply, or through a switch mode power supply (SMPS). A controlled power supply is one that regulates the voltage or current output to a specific value. With fluctuations in either load current or voltage supplied by the energy source of the power supply, the voltage regulated value of the voltage is kept almost constant. They are more powerful, have lower power consumption, are more compact and weigh less.

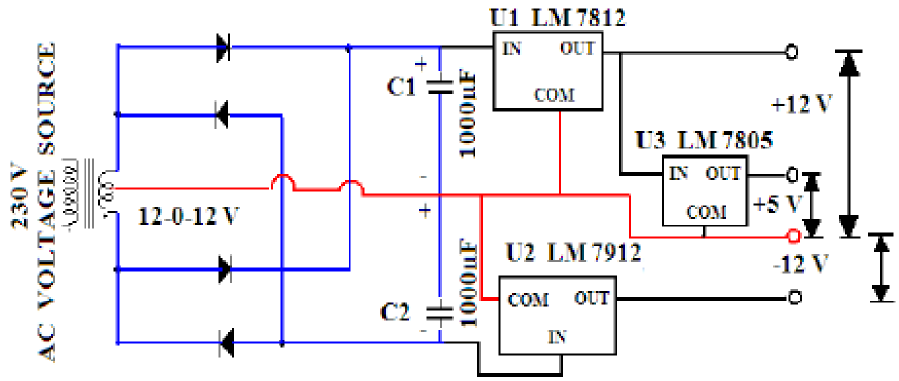

FIGURE.2.Circuit Diagram for Power supply designed Using voltage regulators.

Therefore a controlled power supply shown in Fig.2 is present in the present investigation. Designed using full-wave center tap rectifier circuit with 12-0-12V, 500mA center tap step-down transformer, diodes, 1000µF, 63V electrolyte condenser and LM 7812, LM 7805 and LM 7912 voltage regulators from which output voltages of + 12V, + 5V and -12V are distributed to various system component units as required for their respective operation.

Modified Zero Crossing Detector (ZCD) Circuit Designed

A Zero Crossing Detector (ZCD) simply measures the transition from positive to negative of the a.c signal waveform and vice versa, preferably supplying a small pulse that exactly corresponds with the zero voltage state. The microcontroller will need this to produce a triggering pulse to the SCRs with some delay from the zero crossing of the ac signal. In this work now as shown in Fig.3. The 4.5-0-4.5 Volt, 500mA center-tap transformer is used with two diodes, and two n-p-n transistors with appropriate resistors are used to obtain the ZCD circuit outputs from the collector terminals connected to + 5V.

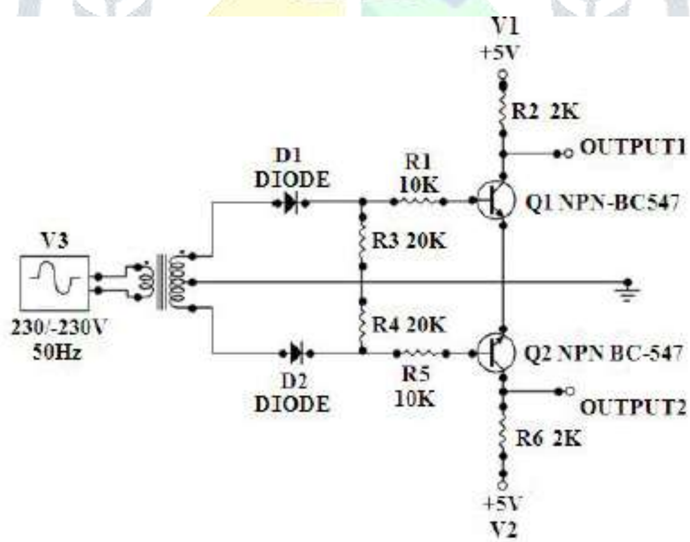

FIGURE.3. Modified 50/60 Hz Zero Crossing detector Circuit Designed

DC Motor

A DC motor consists basically of a stator, a rotor, and a commutator. The stator is the motor's housing and contains magnets, and the rotor is the rotating part of the motor, called the armature, that contains conductors placed in the slots of the armature through which current flows. The speed regulation of these DC Motors can be accomplished by adjusting the amplitude of the applied voltage. This can be done by circuiting the SCR bridge. The amplitude of the DC voltage and current of the armature conductors can be varied by variation of the firing angle of the SCRs, and therefore the speed can be varied.

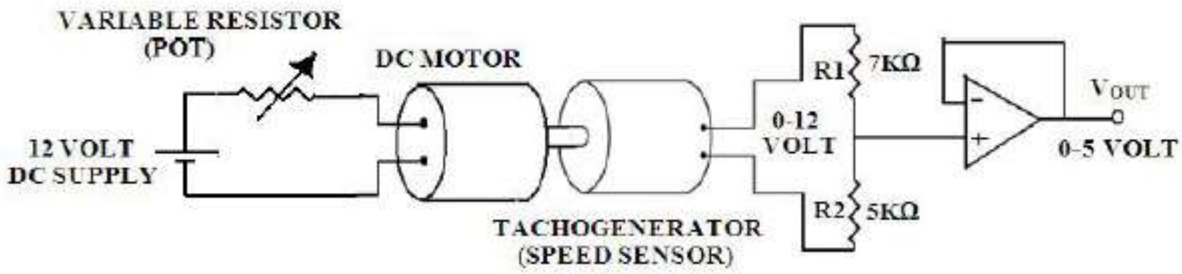

FIGURE.4. Sensor Signal Conditioning Circuit Designed.

Sensor Analog Signal Conditioning Circuit Designed

The parameter to be monitored should be sensed by an appropriate sensor, transformed into a signal that will accurately reflect the parameter and present it to the controller for further action for effective process control. Signal conditioning is widely used for many years using passive circuits. As microcontroller cannot understand voltage beyond 5 Volt, the voltage signal must be converted to a range of 0-5Volt. We constructed a Sensor analog signal conditioning circuit in this present research work as shown in Fig.4. That converts 0-12Volt tacho generator output signal to 0-5Volt for each process variable variation (DC Engine speed).

CONCLUSION

A method for designing a single step, half-driven SCR-based bridge rectifier circuit used as a DC Motor driver was presented with which the DC motor speed was successfully driven using 8051 microcontroller. Many processors such as 8085 and 8086 Microprocessors may also be used but the device designer must add additional peripherals such as memory, I/O ports and timers to make them usable compared to 8051 Microcontrollers. For such embedded control applications, 8051 microcontrollers are therefore suitable in which cost and space are important. Speed of 220V,8A,1400 rpm DC Motors can also be controlled by using 500,2A rheostats instead of using a potentiometer (POT) by varying the voltage of the armature as it was done for 12 Volt,1000 rpm DC Motor. But speed control with Microcontrollers as digital controller is found to be more precise and flexible than any other analog controller. The circuit architecture and the continuous automated controller control algorithm were both studied. Experimental tests have very well checked the validity of the design process. A method for designing a single step, half-driven SCR-based bridge rectifier circuit used as a DC Motor driver was presented with which the DC motor speed was successfully driven using 8051 microcontroller. Many processors such as 8085 and 8086 Microprocessors may also be used but the device designer must add additional peripherals such as memory, I/O ports and timers to make them usable compared to 8051 Microcontrollers. For such embedded control applications, 8051 microcontrollers are therefore suitable in which cost and space are important.

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