A Microcontroller Based Fan Speed Control Using PID Controller Theory

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Abstract

PIC control application is widely used and popular in modern elections. The aim of this paper is design and construct the fan speed control system with microcontroller. PIC 16F877 and photo transistor is used for the system. User define speed can be selected by keypads for various speed. Motor is controlled by the pulse width modulation. The system can be operate with normal mode and timer mode. Delay time for timer mode is 10 seconds. The feedback signal from sensor is controlled by the proportional integral derivative equations to reproduce the desire duty cycle.

1. Introduction

Motors are widely used in many applications, such as air conditioners , slide doors, washing machines and control areas. Motors are derivate it's output performance due to the tolerances, operating conditions, process error and measurement error. Pulse Width Modulation control technique is better for control the DC motor than others techniques. PWM control the speed of motor without changing the voltage supply to motor. Series of pulse define the speed of the motor.

. Microcontroller can produce the specific pulse width modulation signal. But the ampere is not sufficient to drive DC motor directly. Therefore, MOSFET (Metal Oxide Semiconductor Field Effect Transistor) is used as the driver transistor for DC motor. User can select the desire speed by inputting the various value of duty cycle. PIC 16F877 and IRFZ44N (N channel MOSFET) is used to perform the system.

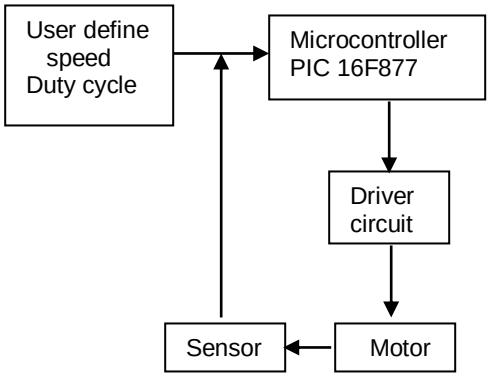

Figure 1. Block Diagram of the System

2. Background Theory

PID Controller

Proportional Integral Derivative controller is a generic control loop feedback mechanism widely used in industrial control systems. A PID controller attempts to correct the error between a measured process variable and a desired set point by calculating and then outputting a corrective action that can adjust the process accordingly and rapidly, to keep the error minimal.

PID control algorithm involves three separate parameters; the proportional, the integral and derivative values. The proportional value determines the reaction to the current error, the integral value determines the reaction based on the sum of recent errors, and the derivative value determines the reaction based on the rate at which the error has been changing. The sum of these three actions is used to

adjust the process via a control element such as the position of a control value [5].

Proportional term

$$P_{out} = K_p (et)$$

Integral term

$$I_{out} = K_i \int_0^t e(t)dt$$

Derivative Term

$$D_{out} = K_d \frac{de}{dt}$$

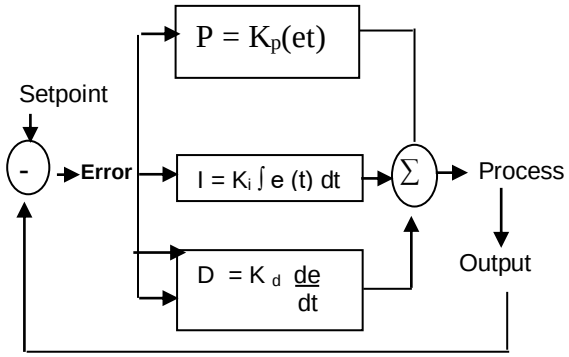

Figure 2. Block Diagram of PID Controller

3. Implementation

3.1 Software Implementation

PID control algorithm and equations are write in PIC Basic Pro language. Basic Pro assembler change the codes to Hex File. The program (Hex file) is burned into the Microcontroller. User can input the desire speed (duty cycle) by key pad to the system. System drive the DC motor with desire speed. If the system output is not equal to the desire speed, the current duty cycle is put in PID algorithm and calculated with PID equations and gains. Then the reproduce output (PID output from Microcontroller) duty cycle is drive the motor continuously. In timer mode motor drive with 100 duty cycle in 10 seconds delay time and stop automatically. Photo transistor and photodiode is use as the sensor for capture the RPM of the motor.

Advantages of PID algorithm are can be initialize the controller integral to a desired value, commonly the process present value for startup problems, can be disable the integral function until the process variable has entered the controllable region, limiting the time of integral error calculation and preventing the integral term from accumulating above or below predetermined bounds.First, design the circuit diagram for the system. Assign the input ports and output ports for keypads and PWM generator PORTB is input and PORTD is output. PORTC.2(CCP1) channel is pulse width modulation generator. After that, the application is run and test with simulation mode. Adjust the crystal value for operation.

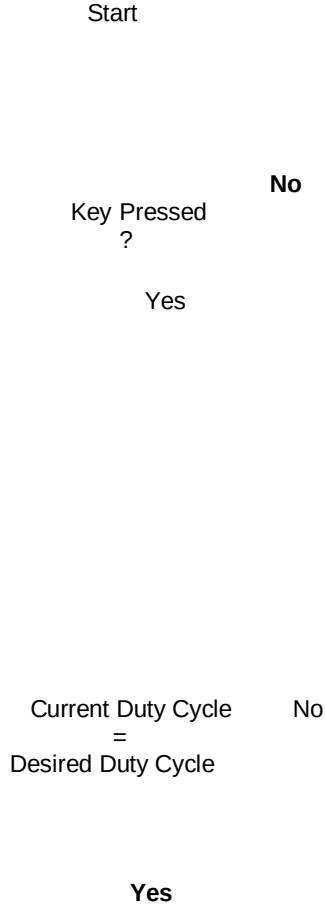

Figure 3. Flowchart of the System

The require application source code is write in Microcode Studio Integrated Development Environment(IDE) software. The source code

language is write in PIC Basic Pro language. Install the PIC Basic Pro compiler for compiling the program. The source code in IDE software is compile with the PIC Basic PRO compiler and assembling that code into hexa codes. (hex. File). EPICWIN programmer software is install for download. Hexa codes are downloading into the Microcontroller by programmer software and programmer. After download , check with verify tool in EPICWIN software. If there is no error, shows verify complete. User can use the Microcontroller in specific application.

3.2 Hardware Implementation

PIC 16F877 is the 40 pin microcontroller has 2 channel PWM generator (CCP1 and CCP2) or PORTC.1 and PORTC.2.

The phototransistor sensor is connected to the PORTA0 of the microcontroller PORTB of the PIC is input and PORTD is output.

In usual, the ampere of the microcontroller has not sufficient to directly drive the DC motor. Therefore MOSFET IRFZ44N is used as the driver circuit, keypads are use for select the desire speed(duty cycle). In timer mode PORTS.6 or RB6 is use to start the timer. C1815 transistor is use as the driver for 5v relay.

If RB6 (button6) is press the DC motor start automatically for 10 seconds delay time and stop.

3.2.1 Design Calculation for Instruction Cycles In PIC 16F877

PIC 16F877 can be use between minimum 4MHZ and maximum 20MHZ for operating speed. 4MHZ (frequency) crystal is chosen for the operation.

Frequency (F) 4MHZ

Period (one clock cycle) $T = \frac{1}{F}$

T = 0.25 microsecond

Instruction cycle = 4clock cycle

One instruction = 0.25 * 4

= 1 microsecond

3.2.2 Fan Speed Control Circuit Diagram

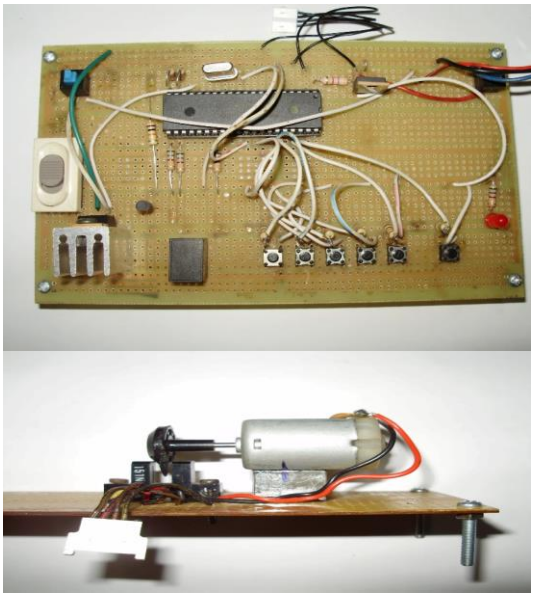

Figure 4. Sensor and DC Motor

4.Experimental Result

Experimental result of revolutions per minute and duty cycles are on the table 1.

The revolution of the DC motor is captured by counter machine. In each specific duty cycle, tested for (5) times. If RB6 (button) is press the DC motor start automatically for 10 seconds delay time with 100 duty cycle and stop. Therefore, the average RPM is calculated as follow.

$$\text{Average (RPM)} = \frac{\text{Total RPM (5 times)}}{5}$$

Table 1. Duty Cycles and RPM

Button	Duty Cycles	RPM
0	100	37.78
1	135	39.04
2	190	42.94
3	220	68.96
4	245	78.15
5 TimerMode Delay Time (10 seconds)	100	37.74

5. Conclusion

In this system, control action is only for speed and timer. Phototransistor is use as the sensor to capture the RPM of the motor. Counting results from sensor is store in a variable in microcontroller. PID control algorithm manipulate that variable and reproduce the desire duty cycle. For more reliable system other sensors can be use, such as current sensor and voltage sensor. To set more reliable controller, TC 4424 MOSFET driver IC for specific speed and direction of the motor. Desired speed (duty cycle) is determine by the PID control program. PID tunning techniques and equations can be use as further extension to achieve the good performance PID controller

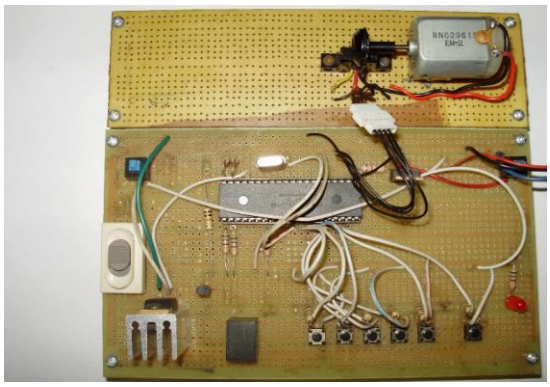

Figure 5. Fan Speed Control Circuit

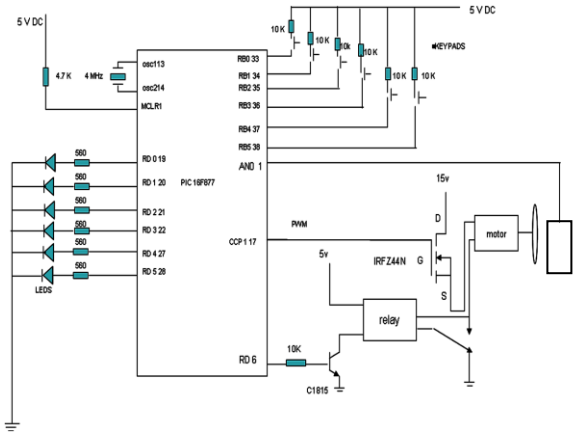

Figure 6. Overall Circuit Diagram

6. References

[1] "DC Motor Model" http://www.circuitcenter.com/circuits/dc motor/ dc motor model. CIR

[2] "DC Motor Theory" http://www.zone.ni.com/devzone/devzoneweb.nsf/opendoc

[3] "DC Motor Speed Modelling" http://www.engin.umich.edu/group/ctm/example/motor/motor.html

[4] D.oh, 2005, "Tutorial; Microchip PIC 16F877 Microcontroller"

[5] "Introduction to closed-loop control, proportional integral Derivative, PID" http://www.omega.com

[6] "Microcontroller in control Applications PIC16F877" http://www.eng.auburn.edu