# Practical Realization Digital PID Controller for Speed Control of DC Motor Using Back-EMF Feedback Method

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***Abstract*— This paper describes the speed control of dc motor using back emf method. Among the various techniques for controlling the speed control of dc motor, this method offers relatively simple and cost effective solution. In this method no feedback sensor or extra feedback signal processing circuitry is required. The speed control of dc motor has been achieved using pid controller which is implemented on PIC microcontroller and one method is also proposed to achieve better speed control of dc motor.**

***Keywords*— PID, dc motor, back emf, PIC microcontroller**

## I. INTRODUCTION

For the speed control of dc motor various algorithms have been proposed and verified[1]-[2]. The simulation study is also been carried out by various researchers for the speed control of dc motor using advanced algorithms like MPC or Neuro-fuzzy. Our task is to control the dc motor using simple algorithm and without the feedback circuit.

## II. HOW BACK EMF IS MEASURED

Back-EMF refers to using the voltage generated by a dc motor during the speed of the motor's rotation. This can be used in motion control algorithms to modulate the velocity or to compute the angular distance the motor has travelled over time.

Typically a motor takes power in the form of voltage and current and converts the energy into mechanical energy in the form of rotation. With a generator, this process is simply reversed. A generator takes mechanical energy and converts it into both electrical energy with a voltage and current. Most motors can be generators by just spinning the motor and looking for a voltage/current on the motor windings.

When doing Back-EMF measurements for motion control, this fact has been used. The motor is run almost continually as a motor with current being supplied to turn the windings. Occasionally, and for a very short period of time, the process is reversed. The windings are allowed to float and the inertia in the motor keeps it spinning while a measurement of the voltage from the rotation of motor/generator is taken.

The voltage observed when the motor is in rotation is directly proportional to the speed the motor is running. This fact can be used to measure the motor's speed with no optical encoders or other forms of active feedback.

### A. Complete process for back emf measurement

Measuring the velocity from a motor using Back-EMF requires two alternating steps. First, the motor is run for some period of time by providing current to the windings. This current can be supplied as a constant voltage or a PWM motor input to vary the speed. The second step is to remove the current from the windings and "float" them. This means that there is no active circuit between the windings and any other source/sink. This allows the inertia in the motor and mechanical system to spin the motor long enough to measure the voltage produced by the motor. Typically these two steps are alternated roughly 50Hz (times per second).

The time required for the motor to change from a motor to a generator depends on the internal capacitance or stored charge in the induction of the motor windings. This time is typically in the order of a millisecond , depending on the conditions. One can observe the output on the scope.

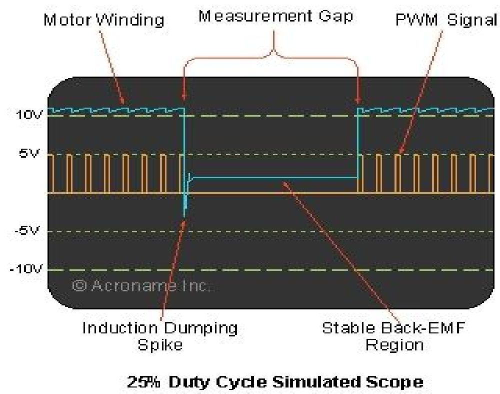


Fig.1 Backemf method example for 25% duty cycle

Above we see how a scope might look when running a motor at 1/4 speed. Notice how the Back-EMF rises up to roughly 1/4 of the PWM maximum voltage and stabilizes. If the Back-EMF measurement gap is too long, the motor will begin to slow down and the feedback will drop accordingly.

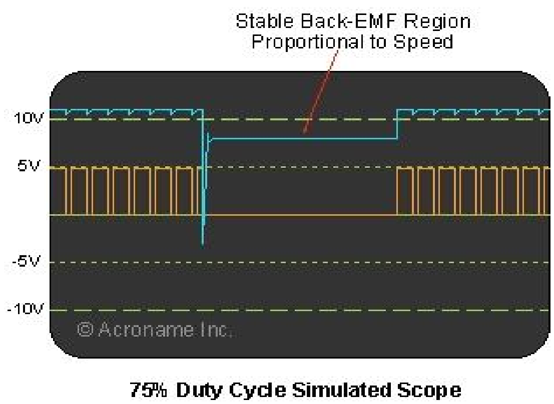


Fig.2 Backemf method example for 75% duty cycle

Next, we see what the scope might look like when running the motor at 3/4 speed. Notice how most everything remains the same but now the stable Back-EMF signal is roughly 3/4 of the maximum motor winding voltage.

Finally, we see what the 3/4 speed case might look like when the motor is under load. Since the motor has a great deal of current developing a large induction in the windings when it is under load, the inductive spike is bigger and the stable Back-EMF region takes longer to achieve as this larger induction must be dumped from the windings first before the Back-EMF region stabilizes. Proper tuning of the latency before taking the measurement is important to minimize the measurement gap while allowing enough time for stable Back-EMF measurement.

There are probably as many ways to measure the voltage in a Back-EMF circuit as there are potential motor, direction, and voltage combinations. The key is to ensure that the measurement is passive so it doesn't affect the motor and that it is fast so that the motor can spend most of the time running.

## III. Practical Setup for Backemf Measurement

For sensing the motor speed and feeding it back to controller, usually, some transducer (sensor) is used such as[3]: -

1.Tachogenerator (analog output).

2.Encoder (pulse output).

3. Resolver (Not used unless it is flight control or defense application).

4. Photo interrupter (common one, can be found in older ball type mouse).

These sensors are accurate, but cost money. Here we use the back emf of motor to sense the speed of motor. Please refer to the figure 3. A DC motor when driven by external means, will generate a voltage. This voltage is also generated by the motor, when it is supplied by a DC source. This voltage is proportional to the speed of motor and is called the back emf. The back emf is linearly proportional to the speed. To measure the back emf of motor, the PWM driver has to be stoped for a brief period. During this brief period, the motor coasts for some time when the current flows through the freewheeling diode. Once the energy stored in motor inductance is exhausted, the back emf build up. This back emf is scaled to suitable voltage using the potential divider. The back emf signal is then fed into the ADC input of controller. Here the ADC channel no 0 is used. The reading of the ADC data has been done using ADC_read(0) command. Also the resistive divider step down the step voltage to 0-5 voltage. The microchip device PIC16F877A[4] has been used for the experiment purpose.

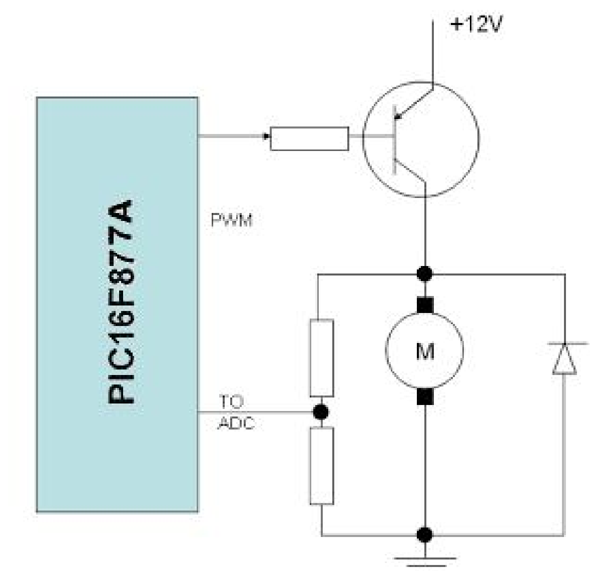


Fig. 1 Example of an image with acceptable resolution

## IV. Results and Conclusion

The output of the dc motor has been measured and it has been calibrated in scale of 0-255 integer value , where the constant 255 represents the 1000 rpm. As shown in the Figure 4 the setpoint is approximately equal to 250rpm which motor attained initially. When the load change is applied the motor speed is suddenly increase and again it stabilized and runs at setpoint value. The PID algorithm is also implemented in novel manner so that initially it is only a proportional action but when the load change occurs it is sensed by the back emf and integral action takes place. This manner one can speed up the response and carry out the speed control in smooth and effective manner.

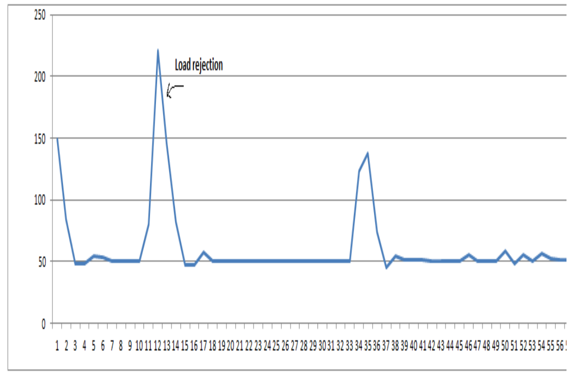


Figure.4 Motor output

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