Validation of D.C Motor Speed Control Model Using PIC 16F628A Microcontroller

Ayoade Benson OGUNDARE
Lagos State Polytechnic, Ikorodu, Lagos

Abstract

Bulk of energy used in industrial facilities is consumed by electric motors and drives. This demonstrates the reason for using energy efficient electric drives. It is imperative to investigate the effect of the voltage on the speed of these drives for industrial application. In this paper, an electric drive is designed constructed which is controlled using Programmable Integrated Controller (PIC) 16F628A and the theoretical model investigated experimentally. The results showed that a good correlation exists between the standard and well-known theoretical model presented and the experimental results. The experimental results are displayed in both tabular and graphical forms.

Keywords: D.C motor, Microcontroller, Voltage dip, electric drive, Inrush current, speed control.

"1.0 Introduction"

Full voltage applied across the terminals of motors during starting can produce objectionable voltage flicker, mechanical stress to gear boxes or belt drive systems and create pressure surges or water hammer in pumping applications if not properly monitored and controlled [1]. Even though, the motor controller can have different features and complexity depending on the task that the motor will be performing, the controller may be a relay type or contactor type, which may have several positions to select different connections of the motor, connected to some form of sensor to automatically start and stop the motor [1]. This allows a reduced-voltage at starting for the motor and hence, reversing control or selection of multiple speeds. More complex motor controllers may be used to accurately control the speed and torque of the connected motor and may be part of closed loop control systems for precise positioning of a driven machine [2]. Therefore, controlling the speed of the motor at a reduced voltage can help reduce or overcome these problems coupled with right selection of electric motors for various applications as well as selecting the appropriate starting methods and speed control for the electric motors [3]. Speed control of dc motor has been achieved through several means by different researchers and lots of works have been published in that regards [4, 5, 6-11]. In [12], Fuzzy Logic Controller model is proposed for the control of dc motor. The validity of this is tested and the simulation results presented to show the effectiveness and performance of the model.

Reference [13] showed a DC Motor using MATLAB. It presented the design, control method and simulation of PIC 16F877A microcontroller and MOSFET using Real peak and MP LAB.Application of Multilayer Neural Network and PID Controllers is demonstrated in reference [6]. The results of the work demonstrated the contribution of ANNs in controlling the DC motor in MATLAB and SIMULINK R2009b.Reference [2] considered the estimation of speed and controlling the separately excited DC motor by developing Artificial Neural Network. The validity of the new developed controllers is verified using simulation from the MATLAB/SIMULINK package

.Reference [7] presented a fuzzy neural network controller which is based on the mathematical model of brushless DC motor (BLDCM). Good robustness, excellent flexibility, adaptability as well as high Precision are obtained by the proposed model.In this paper, the speed control of the electric drives has been achieved and determined with the help of PIC 16F628A microcontroller.

"2.0 Necessity for microcontroller"

It is necessary to include microcontroller in the operation of DC motor control due to the following reasons: <u>*The motor speed is zero when stationary*.</u> This means that, the motor has no back e.m.f E_b when it is at rest. If connected directly to the supply mains, a heavy current will flow through the armature conductors because armature *High reactive power consumed by the motor.* In such a case, the rating of the upstream equipment may need to be rated higher than the steady-state condition. The reactive power during start up is closely related to the voltage dip. [14]

*Heavy inrush current. This can cause he*avy sparking at the commutator and even flashover. Damage of armature winding either by the heat develop in the armature windings, or by mechanical force set up by electromagnetic action. Damage to the rotating parts of the motor and load due to development of large starting torque and quick acceleration Large dip in the supply voltage.

The need for motor controller therefore, is not conversely enough, to provide starting but to reduce heavy starting currents and provide overload and no-voltage protection [1, 15]. The ratio of starting current or running current of an electric motor varies greatly with the size and type of motor, for any given motor the ratio depends on the kind of machinery the motor is driving. The starting current will be higher when the load is heavy. [16,17] The microcontrollers are applied to control electric motor, protect the motor against fault current and over-current so as to minimize the effect of starting current and smooth running of the electric motor.

In addition to starting, controller units can also be used for stopping the motor, by ramping the voltage down. This is particularly useful where sudden loss of driving torque would create mechanical shock on the load.

"3.0 Reduced Voltage Starter"

Application of full voltage to the terminals of a D. C motor will cause high inrush current. To reduce the inrush current in this work, variation of supplied voltage (other than the full voltage) to the motor was carried out. This was accomplished by reducing the voltage applied to the motor. This minimized voltage dips to the power supply. Electrical power is supplied to both the field and the armature windings. The field of the motor is connected permanently to a fixed exciting voltage of PIC 16F628A but the armature is supplied with variable voltages. The armature speed was found to be approximately proportional to the difference between two voltages.

"4.0 Empirical Model"

The generated e.m.f E, in armature is smaller than the terminal voltage V, for a motor and it is given by

$V = E + I_a R_a$ ------------------------ (i) where Ra is the armature resistance and Ia is the armature current.

resistance is very small [1,12,13] . The generated e.m.f, E, is proportional to the speed N of the motor according to the expression given by

$$E = kN\Phi \text{ ---------------------------- (2)}$$

Where k is the machine constant, N is the speed and Φ is the flux.

Substituting equation (2) in equation (1), we have $V = kN\Phi + I_a R_a$

$$N = V - (I_a R_a)/k\Phi \text{ ....(3)}$$

Since $I_a R_a$ is far less than V

equation (3) can be written as)

$$N = V/k\Phi \text{ ....(4)}$$

Equation (4) Shows that the speed of an electric motor is approximately proportional to the applied voltage. This equation is known as the empirical model for d.c motors. Therefore, variation of supplied voltage to the motor is for manual or automatic control of speed over a wide range and in both direction of rotation.

"5.0 Construction and Simulation"

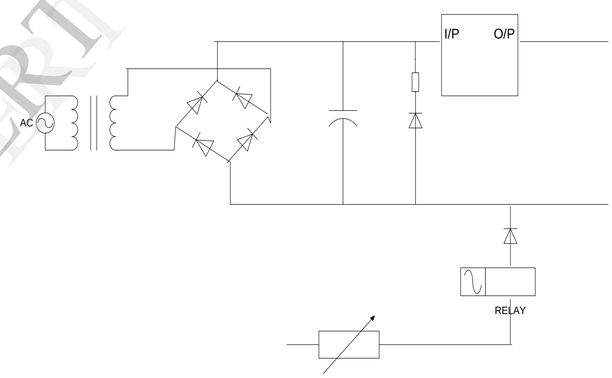
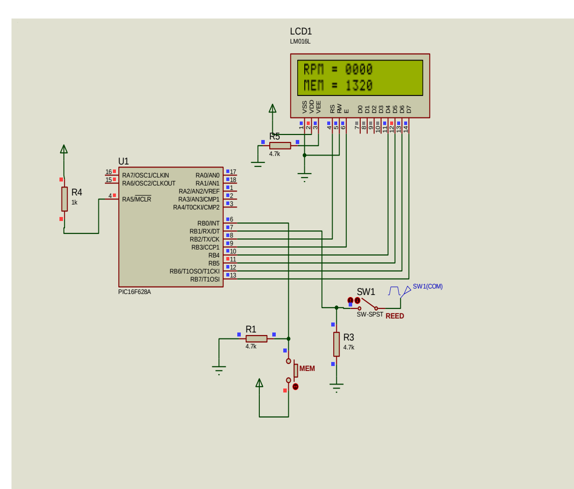


Figure 1.0 Experimental circuit diagram



"Figure 2.0 Simulation circuit of Programmable Integrated Controller 16F628A"

igure 3.0 Experimental Set-up" (Front view)

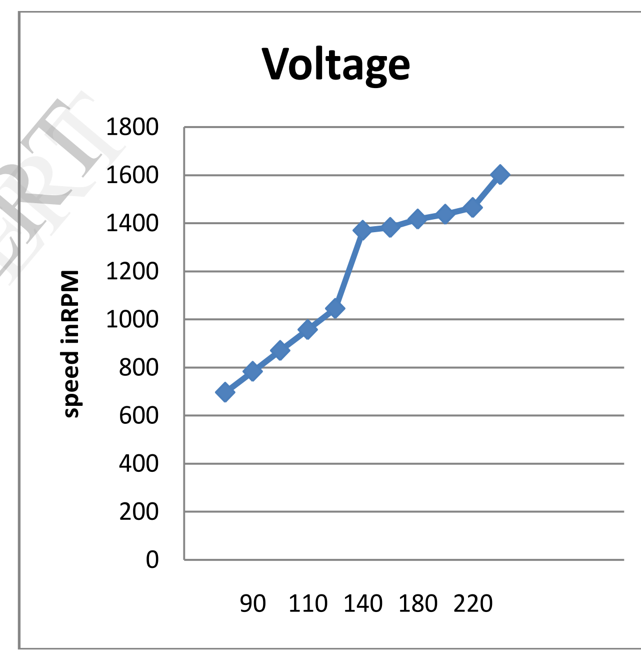
"6.0 Experimental Procedure".

Figure 1.0 shows the circuit diagram used for the experiment in this work. The experimental set-up is shown in figure 3.0. The motor was made to rotate by varying the voltage supply to the circuit. The input voltage was rectified and its variable output voltage was applied to the electric motor. The speed of the motor was determined by using a PIC 16F628A micro controller figure 1. A magnetic metal was attached to the pulley and an electronics card was placed at a distance of 2cm away from the rotating pulley that carried the magnet figure 2. The card is made of bi-metallic strip separated from each other, whenever a revolution is made, the magnetic spot on the rotating pulley focuses on the card and a pulse is generated in the circuit which gives a count of one revolution based on the program that has been added to the micro-controller. The two separate metals on the card are brought together by the magnetic force of attraction from the rotating pulley per revolution

"7.0 Results and Discussion"

"Table 1.0. Input voltage/ Operating speed".

VOLTAGE	SPEED IN RPM
80	696
90	783
100	870
110	957
120	1045
140	1370
160	1382.5
180	1417.5
200	1437.5
220	1465
240	1602.5



"Figure 4.0 Plot of Voltage against speed"

Figure 4.0 shows that as the applied voltage to the motor is increasing, the speed is also gradually increasing. From 80V to 140V the rate at which the speed is increasing is linearly constant. Between 140v to 200V the speed is almost constant. At 140V the speed is 1370rpm which represent 80% of full load speed. Therefore, at 140V of the supply voltage the starting equipment can be disconnected since it has already achieved 75% and above of the rated speed.

"8.0 Conclusion"

Validation of DC Motor speed control using PIC 16F628A Microcontroller is presented in this paper. The theoretical background model to show the direct relationship of voltage on the speed of dc drives in order to control the speed of a DC machine is discussed and presented. A DC machine is designed and constructed in this work. Speed measurements of the constructed DC machine were obtained. The results were presented in both tabular and graphical forms. It is shown that as the terminal voltage is increasing, the speed gradually increases.

Results of the constructed DC machine presented validate the theoretical model.

"9.0 References":

[1] Okoro, O.I., M.U. Agu, and E. Chinkuni, "Basic principles and functions of electrical machines", *Pacific journal of science and technology*, 2006, pp. 45-52.

[2] Amit Kumar Singh, Dr. A.K. Pandey, "Intelligent PI Controller for Speed Control of SEDM using MATLAB", *International Journal of Engineering Science and Innovative Technology (IJESIT),* January 2013, Volume 2, Issue 1.

[3] Fehr, Ralph E., *Industrial Power Distribution*, Prentice-Hall, 2002.

[4] G. Madhusudhana Rao, B. V. Sanker Ram, "A Neutral Network Based Speed Control for D.C Motor", *International Journal of Recent Trends in Engineering*, November 2009, Volume 2, No 6, pp. 121-124.

[5] Boumeddiene Alloua, Abdellah Laoufi, Brahim Gasbaoui, and Abdessalam Abderrahmani, "Setting Up PID DC Motor Speed Control Alteration Parameters Using Particle Swarm Optimization Strategy", *Leonardo Electronic Journal of Particles and Technologies*, January-June 2009, Issue 14, pp 19-32.

[6] Neerparaj Rai, Bijay Rai, "Neural Network based Closed loop Speed Control of DC Motor using Arduino Uno", *International Journal of Engineering Trends and Technology*, 2013, Volume 4, Issue 2.

[7] L. Yongjian, Hu Fan, Qiang Zou, Jing Wan, "Brushless DC Motor Speed Control System Based on Fuzzy Neural Network Control", *Proceedings of the 2009 International Workshop on Information Security and Application (IWISA 2009)*, Qingdao, China, November 21-22, 2009.

[8] José Carlos Gamazo-Real, Ernesto Vázquez-Sánchez, and Jaime Gómez-Gil, Review "Position and Speed Control of Brushless DC Motors Using Sensorless Techniques and Application Trends" *Sensors 2010*, pp 6901-6947, doi:10.3390/s100706901 sensors, ISSN 1424-8220.

[9] Suroor Moaid Dawood, Dr.Rabee' Hashim Thejeel, "PIC 16F877A Microcontroller Based Multiple DC Motors Controller", *Asian Transactions on Engineering* (ATE ISSN: 2221-4267) Volume 03, Issue 02.

[10] Aamir Hashim, Obeid Ahmed, "High Performance Speed Control of Direct Current Motors Using Adaptive Inverse Control" *WSEAS transactions on systems and control*.

[11] B Sharmila, and N devarajan, "Perfomance Networked DC Motor with Fuzzy Logic Controller", *IJCSI International Journal of Computer Science*, July 2010, Issues. Vol. 7, Issue 4, No 9,.

[12] P. Prayal Raval, Prof. C. R. Mehta, "Modeling, Simulation and Implementation of Speed Control of DC Motor Using PIC 16F877A", *International Journal of Emerging Technology and Advanced Engineering*. March 2012, ISSN 2250-2459, Volume 2, Issue 3.

[13] Aamir Hashim Obeid Ahmed (2006) "High Performance Speed Control of Direct Motors Using Adaptive Inverse Control", *International journal of science and & research publications.*
B.L. Theraja, *Electrical/Electronic Technology*, S Chand and Company Ltd, New Delhi India.

[14] Yarborough, B. Raymond, *Electrical Engineering Reference Manual*, Professional Publications, Inc, Fifth Edition, 1990.

[15] Rohit Gupta, Ruchika Lamba, Subhransu Pahdee, "Thyrisor based speed control techniques for DC

[16] motor- A comparative analysis", *International journal of science and research publications*, 2012.

[17] Mohamad Shukri Bin Abdulmanaf, "DC Motor Speed Control Using Microcontroller PIC 16F877A", *International publication*, 2006