"Speed control of DC motor using closed loop PID controller in PLC"

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Abstract: *PLC is considered an important component in many different applications. In this paper, PID controller is designed to control motor speed based on input data and automatic maintenance. The control system uses powerful MATLAB and Simulink software for simulation. Simulation results also show that the engine has better performance; This can reduce rise time, steady-state error and overshoot, and improve safety.*

Key Words: PMDC motor, Programmable Logic Controller, PID Controller, DC drive, HMI Monitor, High Speed Counter, GMWIN Programming, MATLAB Software.

1. INTRODUCTION

Due to the high efficiency of DC motors, these motors have fast switching speed and can be used in many applications. The biggest advantage of using a DC motor in today's world is the ability to control the speed and angle of the motor. This project is about controlling the speed of a DC motor using a programmable logic controller. These controllers have advantages over traditional controllers. The advantages are obvious, such as reduced control panel size, low power consumption and durable equipment that can operate normally even in the worst case. The use of PLC in controlling operations began in 1968 and its development has been very rapid in recent years.

2. CONTROL SYSTEM DESIGN

PLC is an important part of the work. We use PLC to control motor speed. First of all, the motor speed is sent to the PLC by the shaft encoder, and then the PLC generates a control signal according to the program and PID controller to reach the desired speed. The analog signal of the D/A module is sent to the DC driver. When the control signal is received, the driver sends the required voltage to the motor. PLC receives the signal from the shaft encoder each time, PLC measures the motor speed and produces the signal to reach the highest speed in the shortest time and complete the process each time, the error is constant and low in the stable state. The HMI monitor displays the coefficients of the PID controller with the desired speed and motor power and plots the motor power against time. Additionally, using the HMI buttons, this function can change the PID coefficients and desired motor speed. The PLC used in this project is G7M-DR20U produced by LS company. One type of DC motor is the permanent magnet DC motor (PMDC). In this project, we use the MFA56VL model, which is a permanent magnet DC motor. The electrical control system is shown in Figure 1.

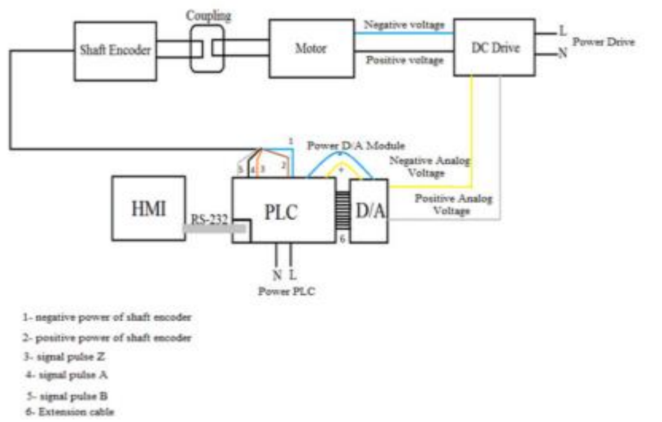


Fig 1. Wiring scheme of system

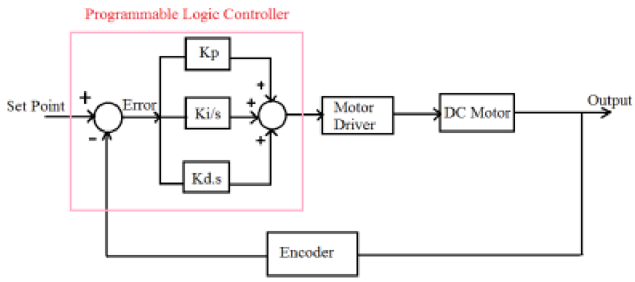


Fig 2. The PID controller diagram

The schematic of the PID controller in this circuit is shown in Figure 2. To get the best stability, overshoot and timing we need to adjust the PID parameters manually and analogy. The shaft encoder detects the speed and adjusts the speed.

2.1. Simulation

In this section, PID controller is used to control the PMDC motor. Simulation is achieved by calculating changes in the system. In order to evaluate the effectiveness of the control system, and the changes in the control coefficients in the system simulation are shown in Fig 3, 4, 5 and 6.

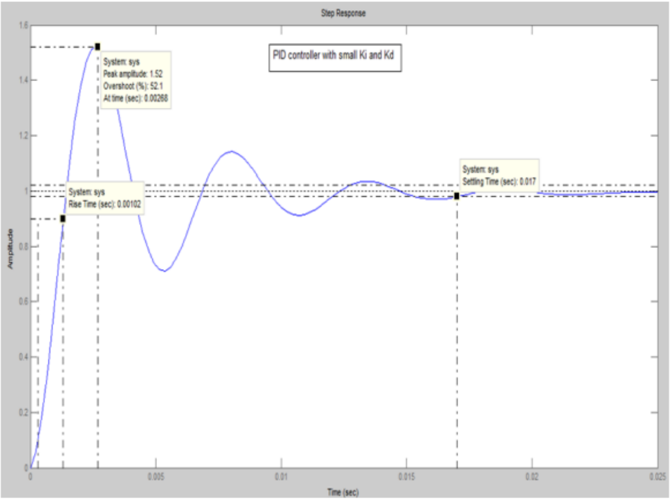


Fig 3. The step response with ki and kd small

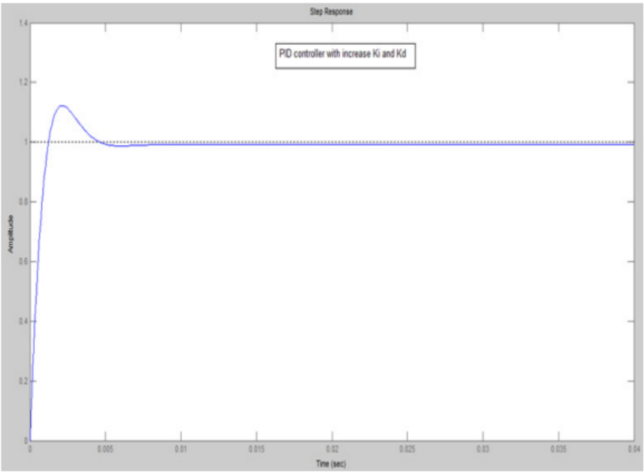


Fig 4. The step response with increasing ki and kd

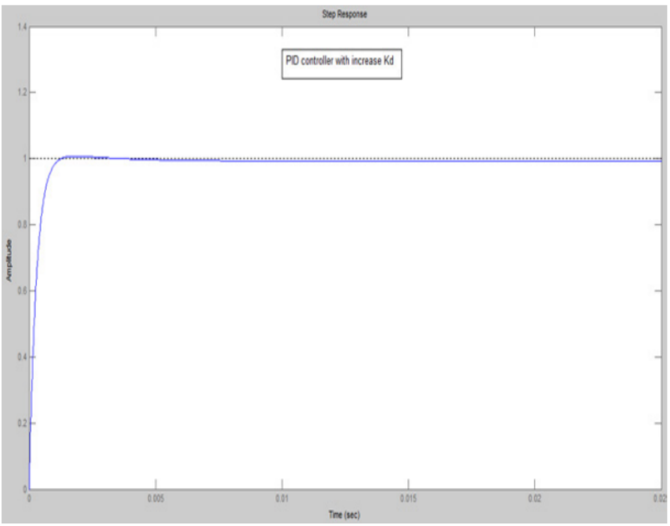


Fig 5. The step response with increasing kd

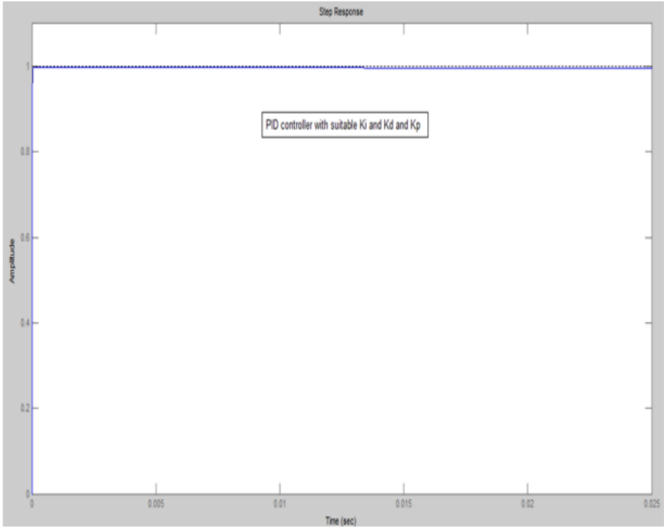


Fig 6. The step response with final obtained kd, ki, kp

In Fig 3, Fig 4, Fig 5 and Fig 6, the improvement in performance is clear and significant. By means of appropriate tuning coefficients ki, kd and kp, tuning time, steady-state error and overshoot can be reduced. The step response of the control system is about 52.1% overshoot as shown in Fig. 3, which is transferred to Fig. 6, which shows the control quality. If the balance of the DC motor is as follows:

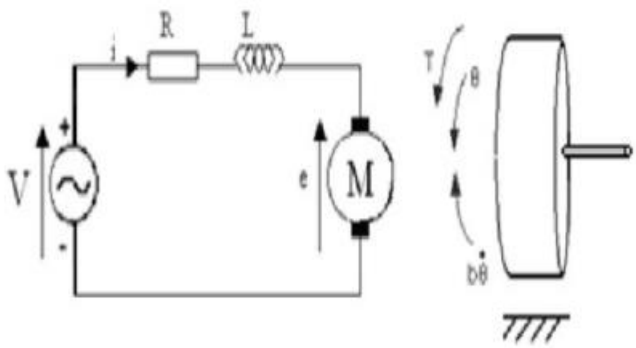


Fig 7. Circuit of DC motor

Relations between the torque and the returned magnetic field is as follow:

Ti =K (1)

e=Ke dθ / dt (2)

Ke and Kt are equal amount in SI. According to fig.7 & relationship based on Newton's law and Kirchhoff law have:

$$J\frac{d^2\theta(t)}{dt^2}+b\frac{d\theta(t)}{dt}=k_e i(t) \quad (3)$$

$$L\frac{di(t)}{dt}+R.i(t)=V(t)-k\frac{d\theta}{dt} \quad (4)$$

By taking the Laplace from the parties of relations (3) , (4) have:

$$s(Js+b)\theta(s)=K.I(s) \quad (5)$$

$$(Ls+R)I(s)=V(s)-Ks\theta(s) \quad (6)$$

According to the (5), the current is:

$$I(s)=\frac{s(Js+b)\theta(s)}{K} \quad (7)$$

According to the (6) , (7):

$$\frac{s(Ls+R)(Js+b)\theta(s)}{K}=V(s)-Ks\theta(s) \quad (8)$$

According to (8), Voltage input to output speed ratio is as follow:

$$\frac{\dot{\theta}(s)}{V(s)}=\frac{K}{(Ls+R)(Js+b)+k^2} \quad [\frac{rad/sec}{V}] \quad (9)$$

As a result, we have:

$$\frac{\dot{\theta}(s)}{V(s)}=\frac{0.6}{0.000042S^2+0.01443S+0.666} \quad (10)$$

DC motors are not listed in Table 1. These dimensions and quantities are determined. Ziegler and Nichols proposed rules for determining the values of the gain Kp, integration time Ti, and derivative time Td based on the dynamic response of the given product. For the Ziegler-Nichols frequency response method, the critical gain Kcr and the critical time Pcr must first be determined by setting Ti = and Td = 0. Increase the value Kp from 0 to the critical value Kcr, the output first exhibits continuous oscillations.

Table 1. DC motor Parameters

parameters	value
R	15.31 Ω
L	48 mH
J	0.00088 $Kg.m2$
B	0.02 $N.m.sec/rad.s{-}1$
K	0.6 $N.m.A{-}1$

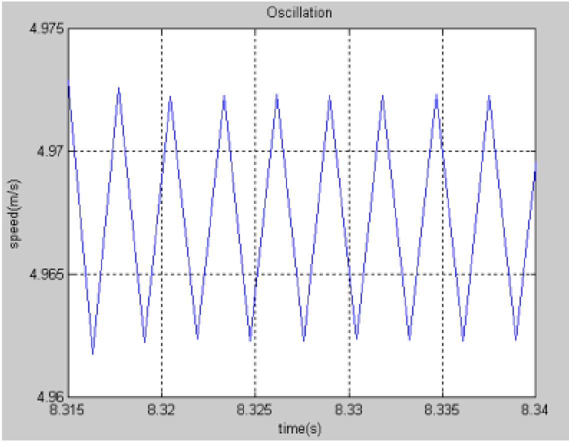


Fig 8. speed Vs time graph

2.2. Hardware Implementation:

In this paper, speed control of DC electric motor designed and simulated and made. The main Required components to make are shown in fig.9.

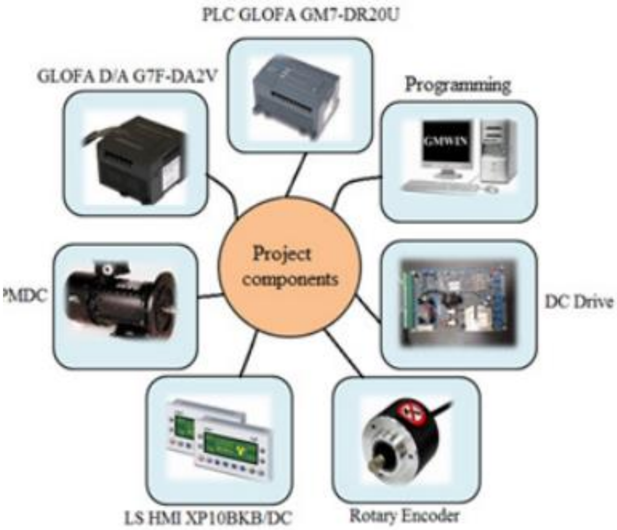
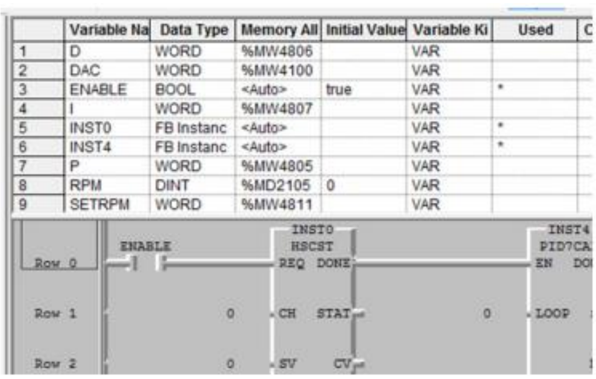


Fig 9. Setup of speed controlling DC motor



	Variable Na	Data Type	Memory All	Initial Value	Variable Ki	Used
1	D	WORD	%MW4806		VAR	
2	DAC	WORD	%MW4100		VAR	
3	ENABLE	BOOL	<Auto>	true	VAR	*
4	I	WORD	%MW4807		VAR	
5	INST0	FB Instanc	<Auto>		VAR	*
6	INST4	FB Instanc	<Auto>		VAR	*
7	P	WORD	%MW4805		VAR	
8	RPM	DINT	%MD2105	0	VAR	
9	SETRPM	WORD	%MW4811		VAR	

Fig 10. Part of GMWIN program

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First, PLC and HMI must be programmed. We use GMWIN to make PLC. We use high speed and automatic tuning to program PLCs. Some programs in GMWIN are shown in figure 10. To connect the PLC to the PC, we use a USB to RS-232 converter as shown in fig 11.

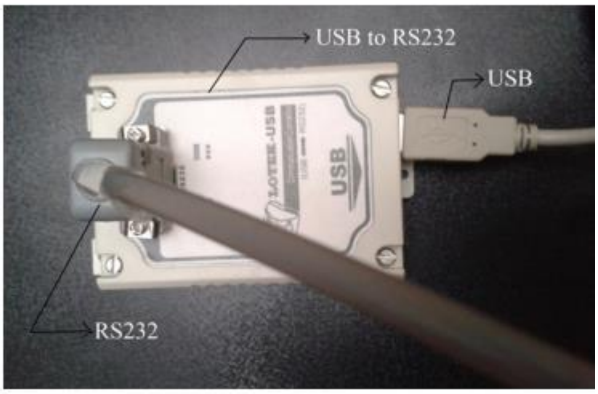

Fig 11. USB to RS232 Converter

We use Panel Editor software to program the HMI. HMI allows us to instantly display system faults and critical signals and view errors online. Generally speaking, please follow the steps below (shown in Figure 12) to create and use the program to set up the HMI and PLC. Shaft encoders are used to receive and transmit motor speed. Another component used here is called connection. There needs to be a connection for transmission speed between coaxial and shaft encoders due to the difference between the two shafts. It is designed with 12mm input ID and 6mm output ID.

The two screws in the connection between the two axles are to prevent collision. The basis for using frame encoders. Due to the low height of the encoder shaft, we need a solid base and vibration resistance. Also consider using boards made of MDF to fix everything until everything is stable and not moving. Figure 13 shows the connection between the motor and the encoder shaft. A, B and Z outputs of the shaft encoder are connected to the PLC, and the 24VDC PLC power supply is connected to the shaft encoder. All details regarding the construction of this project are shown in Figure 14.

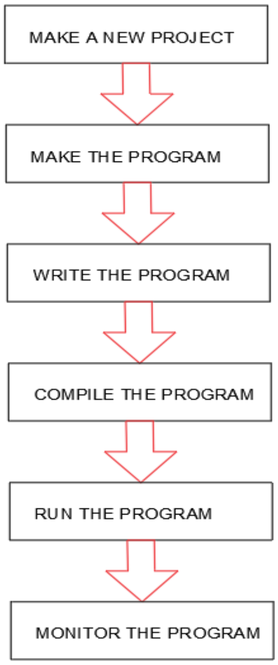

Fig 12. The general trend of setting up

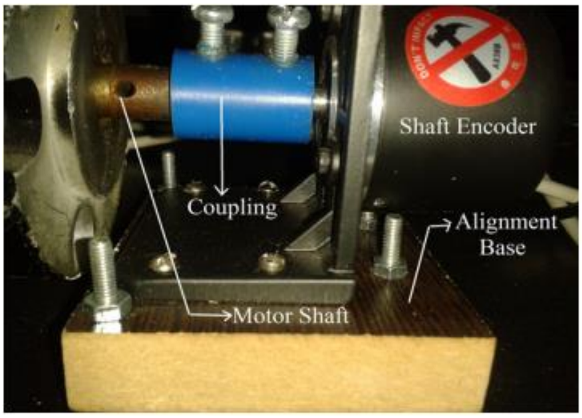

Fig 13. Shaft encoder connected to motor shaft

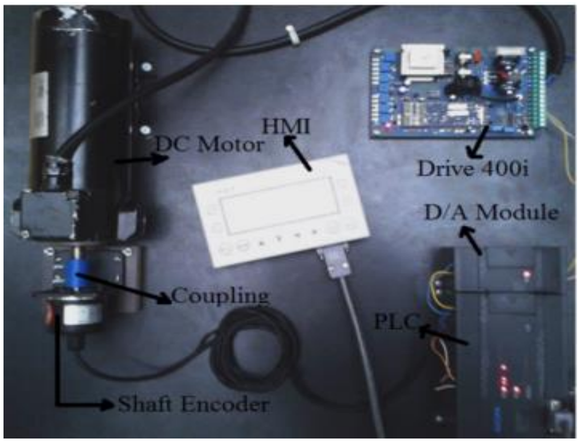

Fig 14. hardware implementation

When GMWIN software is connected to the PLC, it can monitor the operation and performance of the system. Figure 15 shows the graph from GMWIN software for the 60 rpm setting; It shows that the system reaches the problem quickly with fewer errors and overshoots.

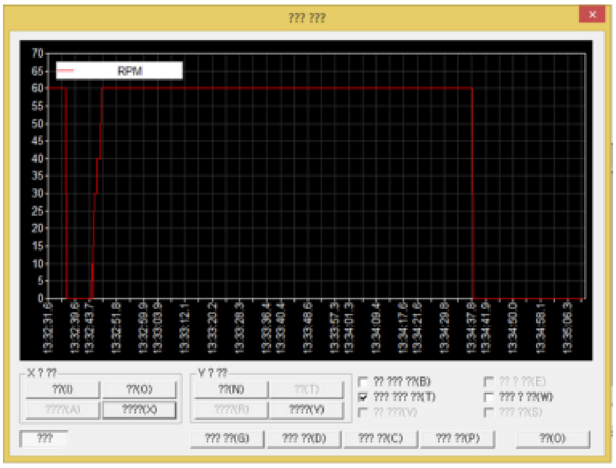

Fig 15. Velocity Vs time graph for 60r.p.m

In addition, the speed can be adjusted by comparing the measured time with the P, I, D coefficients, and the set value and the current value are displayed on the HMI for monitoring purposes. For example, the engine speed for a 260-rpm setting is shown in figure 16. HMI function buttons are defined. If this function is not defined, this button will not work. F1, F2, F3, F4 key positions are used for the defined functions. The F1 key is set to increase the Kp value in steps of 10. The F2 key is set to increase the current value in 10 steps

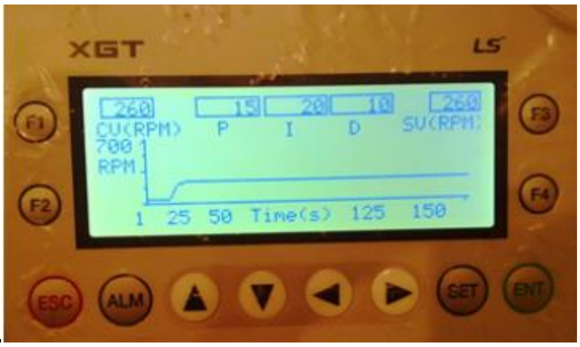

Fig 16. HMI monitor

To prevent noise from the AC source from being transmitted to the control unit and its equipment and accessories, we use appropriate electrical equipment with filters and insulation, and use cable shielding with one side connected to ground. We create legal lines. We are considering two soils, one for PE and the other for CE. There are two different paths, although both are connected to ground. The controller is connected to CE ground.

When determining the allowable rise of the engine, 130 ° C should be subtracted from the temperature. It is a class F electrical insulation type. Ambient temperature can be measured using information such as load performance, engine performance and temperature rise coefficient. The ramp function acts as a control to prevent the engine from starting at low temperatures.

It is a negative value that describes the deflection as a function of increasing torsional load. Looking at the engine chart, the idle speed of the engine at 200 volts is 2000 rpm. If the torque load is not connected to the motor shaft, the motor will run at this speed. Engine speed under load is the no-load speed minus the speed reduced by the load. The proportionality constant for the relationship between engine speed and engine torque is the slope of the torque-speed curve calculated by dividing the engine's no-load speed by the standing torque.

Motor load current is the sum of no-load current and load current. For a DC motor, the output torque is directly proportional to the current entering the motor, regardless of motor speed. The straight line between torque and current is the torque-current curve, as shown in figure 17. This figure has been drawn to match figure 18.

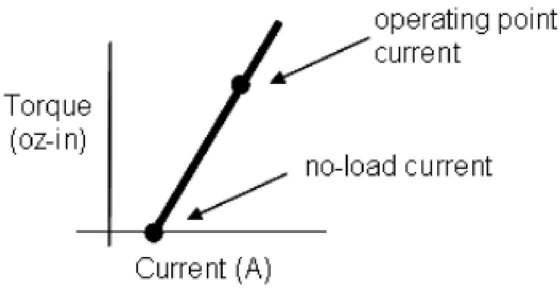

Fig 17. Torque versus Current graph

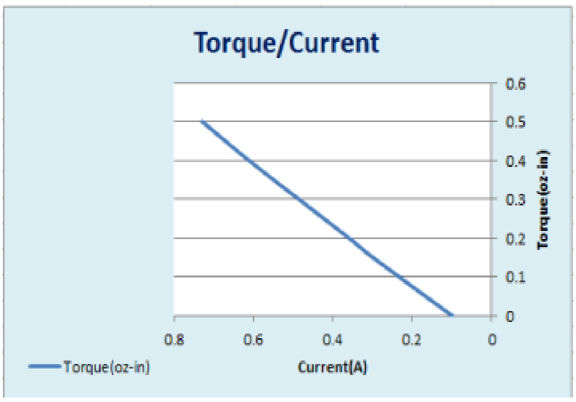

Fig 18. Torque Vs Current graph for proposed circuit

3. CONCLUSIONS

The control system is designed to control the engine very quickly. The engine speed (current value) reaches the set value in a short time with very little overshoot, which is very useful in preventing floor damage in speed control in industry. By comparing the simulation results before and after the check, we can conclude that many requirements such as rise time and overshoot have been improved. Simulation and hardware implementation show improved performance

REFERENCES

[1] P. C. Sen, "Electric motor drives and control: past, present and future ", IEEE Transactions on Industrial Electronics, Vol. IE37, NO. 6, 1990, pp. 562-575.

[2] M. Rashid, "POWER ELECTRONICS Circuits, Devices, and Applications", Prentice- Hall-2th ed, 1993.

[3] J. Ziegler, N. Nichols, "Optimum Settings for Automatic Controllers,"ASME Trans. 64 (1942), pp. 759-68

[4] K.ogata, "Modern control Engineering", 5th ed , 2010.

[5] T. Krishnan, B. Ramaswamy, "A fast response dc motor speed control system", IEEE Transactions on Industrial App, vol., IA-10, No. 5, Sept./Oct. 1974, pp. 643-651.

[6] Z. Wan-zhen, "PLC analysis and design applications", Electronic Industry Press, 2004.

[7] X. XingMing, "PLC control system reliability design", Automation and Instrumentation, 200