# Analog Implementation of PID Position

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## Objective

The aim of this project is to demonstrate the effect of a PID controller on the response of a DC motor trying to reach a specific position.

## Introduction

A control system is an interconnection of components forming a system configuration that will provide a desired system response. Modern control theory is concerned with systems that have self-organizing, adaptive, robust, learning, and optimum qualities.

The control of an industrial process by automatic rather than manual means is often called automation. Automation is prevalent in the chemical, electric power, paper, automobile, and steel industries, among others. Automatic machines increase productivity in industries.

Among the most popular control systems are PID controllers. PID controllers are found in a wide range of applications for industrial process control. Approximately 95 percent of the closed loop operations of industrial automation sector use PID controllers.

The PID controllers have excellent property of making the system response faster and at the same time reduce the steady state error to zero or at least to a very small tolerance limit.


*"We put all this high-tech control equipment in 30 years ago. I still don't understand why we can't get the information we need out of the system."*

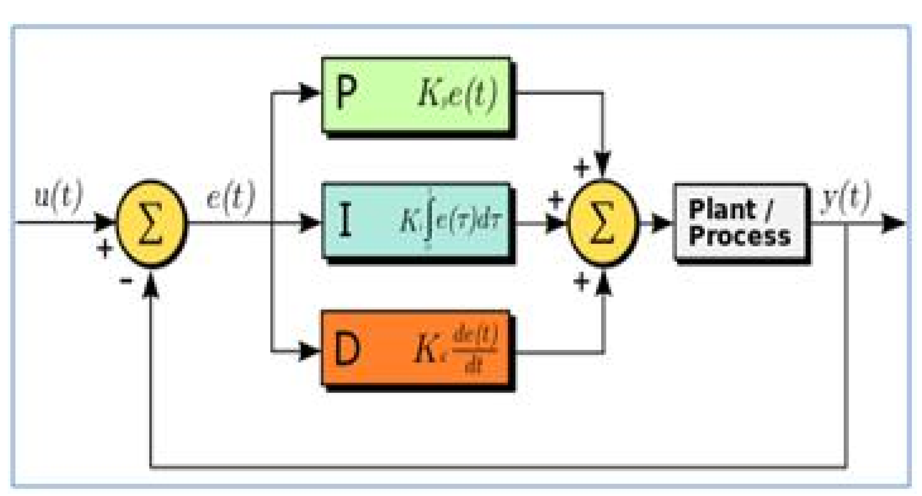
## What is a PID Controller?

The term PID stands for Proportional Integral Derivative. A PID controller is a part of a feedback system that uses Proportional, Integral and Derivative drive elements to control a process. PID control is needed because some processes are harder to control using other standard methods. The PID controller can provide a controlled, almost-intelligent drive for systems.

**P- Controller:** Proportional controller gives output which is proportional to current error e(t). Its gain is called Kp.

**I- Controller:** Integral controller provides necessary action to eliminate the steady state error. It integrates the error over a period of time until error value reaches to zero. It holds the value to final control device at which error becomes zero. Its gain is called Ki.

**D- Controller:** D-controller anticipates future behavior of the error. Its output depends on rate of change of error with respect to time, multiplied by derivative constant. It gives the kick start for the output thereby increasing system response. Its gain is called Kd.




The output of the PID controller circuit goe to an absolute-value output circuit, which is used as a full-wave rectifier. This circuit produces an output signal that swings positively only, regardless of the polarity of the input signal. This is done to provide a positive input to the Arduino.

## How does the entire system work ?

The system is composed of many sub parts as seen in the figure.

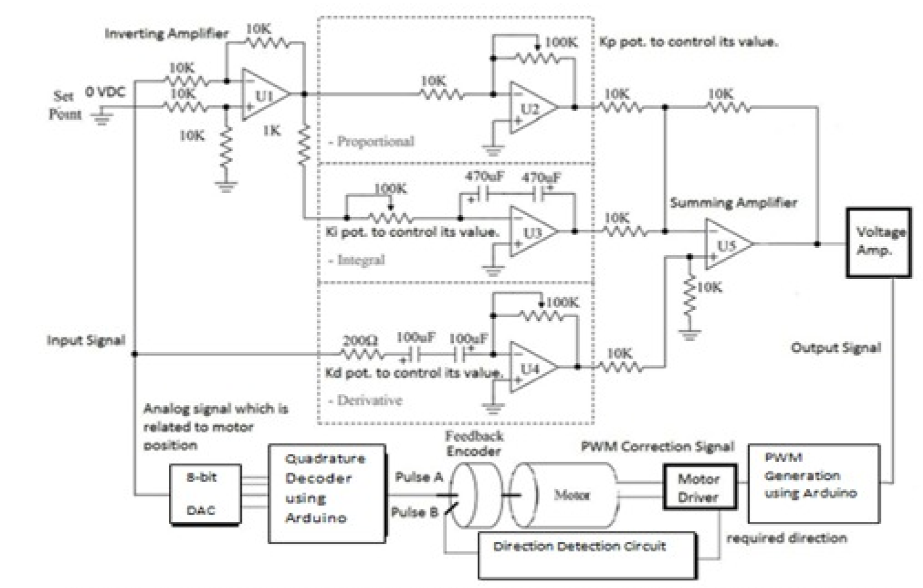


Figure 12: Schematic of Analog PID Controller Circuit along with the Other Blocks of the System

1. The motor is connected to a rotary encoder, which relays the position of the DC motor shaft in the form of two pulse signals.
2. A quadrature decoder is implemented using Arduino to read this information. It counts the number of slots covered by the disk in clockwise or anticlockwise direction.
3. A DAC module is used with the Arduino to generate a PWM (Pulse Width Modulation) signal to be fed to the PID circuit.
4. The Arduino is also used to detect the direction of the motor using the pulse signals from the encoder.
5. An analog PID controller has 3 potentiometers to control PID parameters. This takes an analog signal given from a point and sets the point as the zero position. This part then outputs an analog signal which controls the speed of the motor.
6. The analog signal that controls the speed of the motor is fed back to the Arduino. It converts it into a PWM signal and then feeds the PWM block output to the motor driver to adjust the motor shaft to the desired position.

## Tuning methods

Before the working of PID controller takes place, it must be tuned to suit with dynamics of the process to be controlled. It can be done by methods like the Trial and Error Method, Process reaction curve technique and Zeigler-Nichols method.

**Trial and Error Method:** It is a simple method of PID controller tuning. While system or controller is working, we can tune the controller. In this method, first we have to set Ki and Kd values to zero and increase proportional term (Kp) until system reaches to oscillating behavior. Once it is oscillating, adjust Ki (Integral term) so that oscillations stops and finally adjust D to get fast response.

## Why Analog over Digital ?

1. Analog signals have high resolution compared to digital sugnals due to finite word length of the digital processor.
2. Another con of Digital control is the imit cycles due to the finite word length of the digital processor or analog-to-digital (A/D) and digital-to analog (D/A) converters.
3. Analog response is faster than digital as there are time delays in control loop due to the computation of control algorithm by the processor.

## References

1. 'Op-Amps and Linear Integrated Circuits', Ramakant A. Gayakwad
2. 'Position and Speed Control of a DC Motor using Analog PID Controller', Dialog Semiconductors
3. 'Study of Digital Vs Analog Control', P. Murphy, M. Xie*, Y. Li*, M. Ferdowsi, N. Patel, F. Fatehi, A. Homaifar, F. Lee*