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RESEARCH ARTICLE

RESEARCH TO STUDY VARIABLE FREQUENCY DRIVES AND UNIVERSAL PID CONTROLLERS

***Dhammadip Wasnik, Hari Kumar Naidu and Pratik Ghutke**

Department of Electrical Engineering, Tulsiramji Gaikwad-Patil College of Engineering & Technology, Nagpur, India

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ABSTRACT

The intent of this paper is to know the working principle of variable frequency drive and the performance of VFD. Now a days the use of VFD has been increased. Recently we found the use of VFD not only in equipment but also in HVAC system as well. This paper gives idea to understand basics terms in VFD, operation of VFD, power factor improvement and harmonic mitigation by VFD. Apart from this we will also discuss the development of new technique of tuning of PID controller particularly we will take the review of most recent technique proposed for tuning and designing of PID controllers with their performance.

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INTRODUCTION

Variable frequency drive is basically used where the variable speed is essential. It is a device in electrical system which performs the conversion of single phase or three phase supply of Fix frequency into three phase supply with variable frequency. It is used for the application of variable speed requirement. Due to smooth operation it has widely Use in the application of speeds control of motor. It can be controlled either manually or automatically. In our application it is controlled automatically by using PID Controllers. It helps the operator to vary the speed of motor automatically. The operation is carried out by using PID (Proportional integral derivative Controller). Reversing, switching and braking are additional function performed by VFD.

Block diagram: It consist of following blocks. Ac power supply, filter, dc supply, isolator, and inverter, motor. When we passes the ac suply through rectifier it convert into dc then passes through filter finally it passes through inverter which control motor. For automatic operation we are using microcontroller.

VFD Operation: To understand the operation of VFD it is understand the basic circuit of VFD which is as shown in figure below. From the circuit diagram the basic component of VFD are rectifier, filter, and inverter. During operation supply voltage first passes through rectifier (full wave bridge rectifier) which convert ac supply into pulsating dc after that this pulsating dc passes through rectifier to get pure dc finally it passes through inverter which convert it into variable frequency ac supply in our construction we are using insulated gate bipolar transistor (IGBT) and by using this variable frequency ac supply we can easily control the speed of induction motor. Because we know that synchronous speed is given by

$$\text{Speed} = \frac{(frequency)*120}{poles\ (p)}$$

So from above expression by varying frequency we can easily control speed. As the drive provide the change in frequency and output voltage to change the speed of motor this is conveniently done by pulse width modulating drive. Pulse width modulation (PWM) inverter provides varying width waveform which combined to give required waveform. In all the variable frequency drive (VFD) the output voltage to frequency ratio remain constant because the frequency, output voltage and flux realated to each other as given blow.

$$V = 4.444\ f\ N\varphi_m$$

Or we can write

$$V/f = 4.444\times N\varphi_m$$

Corresponding author:* **Dhammadip Wasnik,
Department of Electrical Engineering, Tulsiramji Gaikwad-Patil College of Engineering & Technology, Nagpur, India.

So we can conclude if we only change the frequency (if we reduce the frequency) the flux will increase and saturation of magnetic core can be occurred which can distort the waveforms. So this can be avoid by maintaining the V/F ratio constant.

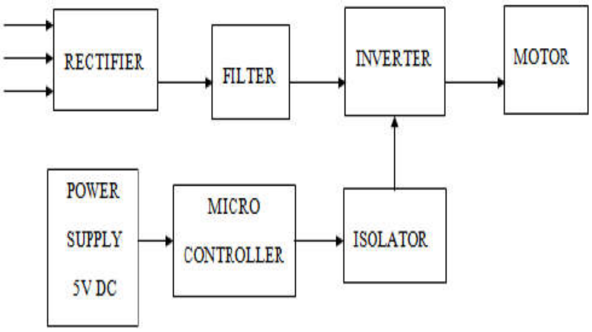

Fig. 1. VFD block diagram

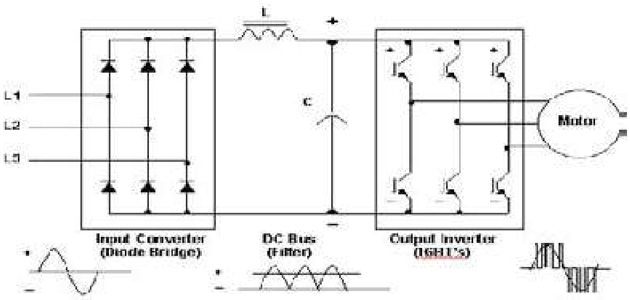

Fig. 2. circuit of VFD

Advantages of VFD

- Large energy savings at lower speed.
- 2. Increased life of rotating components due to lower operating speed.
- Reduced noise and vibration level.
- Lower KVA
- High power factor

PID (Proportional integral derivative controller)

The PID controllers (proportional integral derivative controller) are widely used in industries for the speed control purpose. A PID controller calculates an "error" value as the difference between the measured process value and the desired set point. The PID controller calculation involves three separate constants and is accordingly sometimes called three-term control i.e. the proportional, the integral and derivative value which is denoted by P, I and D. A proportional controller may not give steady state error performance which is needed in the system.

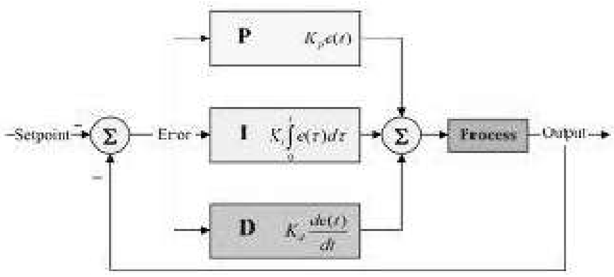

Fig. 3. PID block diagram

An integral controller may give steady state error performance but it slows a system down. So the addition of a derivative term helps to cure both of these problem. The final form of PID algorithm is

$$U(t) = MV(t) = K_p U(t) + K_i \int_0^t e(t)dt + K_d \frac{d}{dt} e(t)$$

Proportional term

Process variables for different K_p values (Ki and Kd held constant) are shown in Figure below. The proportional term makes a change to the output that is proportional to the current error value. The proportional response can be adjusted by multiplying the error by a constant Kp called the proportional gain. Process variables for different Kp values (Ki and Kdheld constant) are shown in Figure 4.5. The proportional term makes a change to the output that is proportional to the current error value. The proportional response can be adjusted by multiplying the error by a constant Kp, called the proportional gain. A high proportional gain results in a large change in the output for a given change in the error. If the proportional gain is too high, the system can become unstable (see the section on loop tuning). In contrast, a small gain results in a small output response to a large input error, and a less responsive or less sensitive controller. If the proportional gain is too low, the control action may be too small when responding to system disturbances. Tuning Theory and industrial practice indicate that the proportional term should contribute the bulk of the output change. A pure proportional controller will not always settle at its target value, but may retain a steady-state error. Specifically, drift in the absence of control, such as cooling of a furnace towards room temperature, biases a pure proportional controller. If the drift is downwards, as in cooling, then the bias will be below the set point, hence the term "droop. Droop is proportional to the process gain and inversely proportional to proportional gain. Specifically the steady-state error is given by

$$e = G / Kp$$

Droop is an inherent defect of purely proportional control. Droop may be mitigated by adding a compensating bias term (setting the set point above the true desired value), or corrected by adding an integral term.

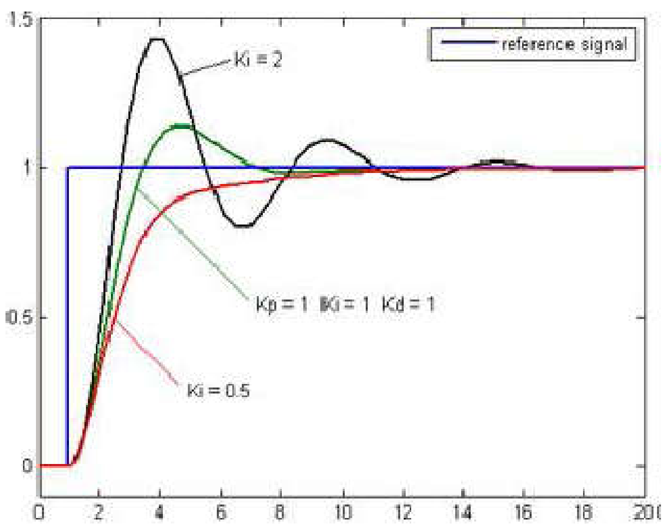

Fig.5. Process variable for different Ki

Integral Term

Process variables for different Ki values (Kp and Kd held constant) are shown in figure above The contribution of the integral term is proportional to both the magnitude of the error and the duration of the error. The integral in a PID controller is the sum of the instantaneous error over time and gives the Accumulated offset that should have been corrected previously. The accumulated error is then multiplied by the integral gain (Ki) and added to the controller output.
The integral term is given by the Equation

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

The integral term accelerates the movement of the process towards set point and eliminates the residual steady-state error that occurs with a pure proportional controller. However, since the integral term responds to accumulated errors from the past, it can cause the present value to overshoot the set point.

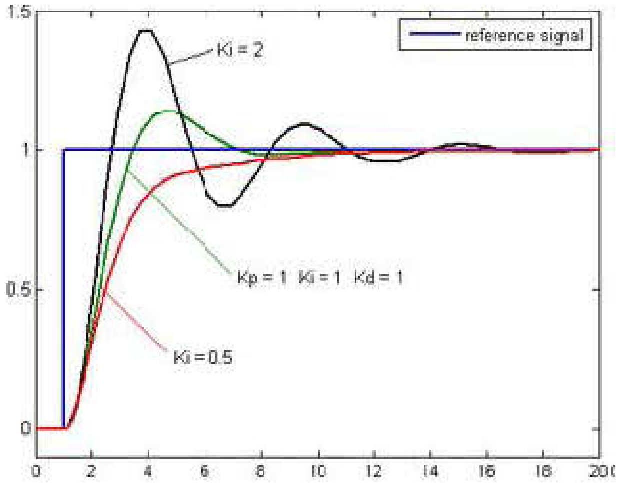

Fig.5. Process variable for different Ki

Derivative term

The derivative term is given by the Equation

$$D_{out} = K_d \frac{d}{dt} c\ (t)$$

The derivative term slows the rate of change of the controller output.

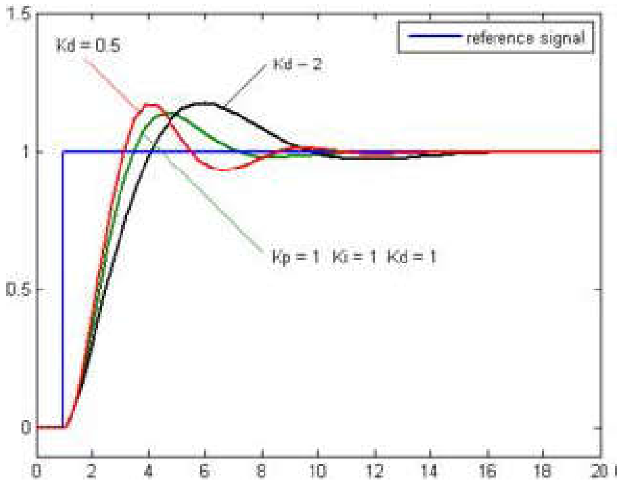

Fig. 6. Process variable for different Kd

Derivative control is used to reduce the magnitude of the overshoot produced by the integral component and improve the combined controller process stability. However, the derivative term slows the transient response of the controller. Also, the differentiation of a signal, amplifies noise and thus this term in the controller is highly sensitive to noise in the error term, and can Cause a process to become unstable if the noise and the derivative gain are sufficiently large. Hence an approximation to a differentiator with a limited bandwidth is more commonly used. Such a circuit is known as a phase-lead compensator.

Advantages of PID controller include the following

- Very less oscillation.
- Low overshoot.
- Faster and no offset.
- An integral term gives zero steady state error for step input.
- An derivative term often produce faster response.

Conclusion

The conclusions of this study is that we can easily control the speed of the motor with efficient control and minimum losses as we are using inverter circuit which consist of IGBT (insulated gate bipolar transistor) also to controller VFD we are using PID controller which is universal PID controller means which can takes multiple input and multiple output. Despite the long history of PID controller and application still there are many issue and challenges in overall control system design. So there is requirement of such a investigation which satisfy the requirements of newly-devised methodology.

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