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A Review on Speed Control of VSI-FED Induction Motor by P, PI and PID Controller

KakadeNisha Sudhakar[1], Vivek Kumar Yadav[2]
[1]M.Tech Scholar, [2]Assistant Professor
SRK University, Bhopal, Madhya Pradesh, India
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Abstract: This research paper has been making an effort to current study of P (Proportional), PI (Proportional Integral), and PID (Proportional Integral Derivative) controller for speed control of IM (Induction Motor). Generally, the principle of operating a 3-phase IM (Induction Motor)specifies that motor speed is directly linked to frequency of supply. This detail has made inverter fed IM (Induction Motor) having a very common configuration in majority of industrial applications. The VSI-fed IM (Induction Motor) drives are progressively applied in several recent industrial applications that needtremendous transient performance of drives. Improved performance of P, PI and PID controller is deliberate and compared.

Keywords: Proportional (P), Proportional-Integral (PI), and Proportional-Integral-Derivative (PID), VSI-Fed IM

I. INTRODUCTION

One and allrecognizevigorous role played by electrical motors inimprovement of industrial schemes. IM (Induction motors) are currently a standard for industrial electrical drives and greatrecitalcapricious speed drive applications have a series of benefits. There are numerous ways for speed control of IMs (Induction motors) fed through VSIs using diverse modulation methods. Investigators, expert and researchers are unceasingly inventingnovelmethods and approaches that cover speed control necessities of drive. Progressive control methodsfor instance fuzzy, genetic algorithm,neuro-fuzzy, sliding mode control, etc. have as well been comprehensively used in motion control applications. Intrinsicallyforthrightworking characteristics, flexible recital and efficacyinvigorated use of VSI-fed IM (Induction Motors) in numerouskinds of industrial drive application. Utmost multiuse production machines profit from modifiable speed control, meanwhile frequently their speeds need change to augment the machine procedure or adapt it to numerous tasks for enhanced product feature, production speed.

VSIs are used to control speed of 3-phase SCIM (Squirrel Cage IM) by varying frequency and potential and entail of input rectifier, DC-link and output converter. They are obtainable for low potential range and medium potential range. The fundamental action involved in modifiable speed control of IM (Induction Motors) in is to apply anadjustablepotential magnitude, and adjustable frequency to motor in order toattainadjustable speed operation. BothCurrent Source Inverter (CSI) and Voltage Source Inverter (VSI)are used in modifiable speed AC-drives.

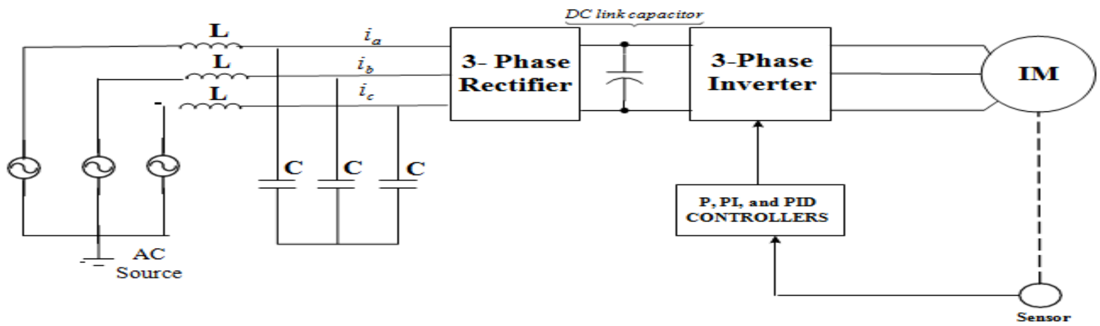

Fig.1 Block Diagram of VSI-Fed Induction Motor Drive using P, PI and PID Controller

II. FUNDAMENTALS OF CONVENTIONALCOTROLLERS

P-I-D controllers use three basic mannerskinds of modes: P (Proportional), I(Integral) and D(Derivative). Even thoughP (Proportional) and I (Integral) modes are as well used as single control modes a D (Derivative) mode is seldom used on its own in control schemes. Such amalgamationsfor instance PI

(Proportional-Integral) and PID ((Proportional-Integral-Derivative) controller are very regularly in practical schemes.

(A) P (PROPORTIONAL) CONTROLLER

A P (Proportional) controller scheme is a kind of linear feedback control scheme. The P (Proportional) controller scheme is more difficult than on-off control schemessimilar a bi-metallic domestic thermostat, but modest than a P-I-D control scheme used in somewhat like an automobile cruise control.Generally it can be said that P (Proportional) controller can't stabilize upper order processes.

For 1^{st} order processes, connotationprocedures with one energystowage, a large intensification in gain can be tolerated.

P (Proportional) controller can stabilize only 1^{st} order unstable procedure. Varying controller gain K can change closed-loop dynamics. A great controller gain will consequence in control scheme with:

a) Better reference following i.e. lesser steady state error.
b) Broader signal frequency band of closed-loop scheme and higher sensitivity w.r.t. measuring noise i.e. Faster dynamics
c) Lesser amplitude and phase margin

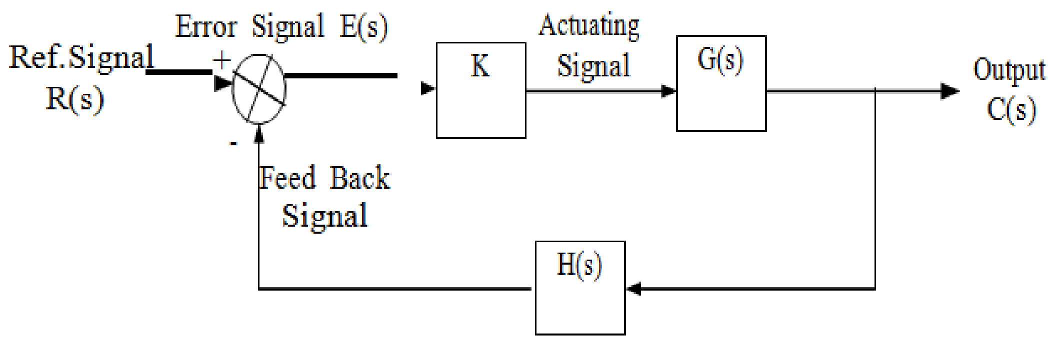

Fig.2. Block Diagram of P(Proportional) Controller

InP (Proportional) controller procedure, controller output is comparative to error signal, which is difference amid set point andprocedureadjustable. In P (Proportional) controller actuating signal for control act in a control scheme is proportional to error signal. The error signal being difference amid reference input signal and feed-back signal attained from output.

The actuating signal is relative to error signal consequently;scheme is so-calledP (Proportional) controller scheme.

The error of signal assumed as follows:

e(t) = k[r(t) - h(t)]

It is anticipated that control scheme be under-damped forperspective of quick reply. An under-damped control schemedisplays exponentially crumbling in output time response all through transient period.

(B) PI (PROPORTIONAL INTEGRAL) CONTROLLER

At present-day, P-I (Proportional-Integral) controller is mostbroadlyaccepted in industrial application because of its simple structure, simple to design and low price. In spite of these benefits, the P-I (Proportional-Integral) controller fails when controlled entity is very much nonlinear and undefined. P-I (Proportional-Integral) controller will eradicate forced oscillations and steady-state error ensuing in action of on-off controller and P (Proportional) controller correspondingly. Though, introducing I (Integral) mode has a negative (-ive) effect on speed of response and whole stability of scheme. Consequently, P-I (Proportional-Integral) controller will not escalation speed of response. It can be anticipated since P-I (Proportional-Integral) controller doesn't have means to foresee what will occur with error in nearby future. This problematic can be resolved by presentingD (Derivative) mode which has capability to foresee what will happen with error in nearby future and consequently to diminution a reaction time of controller. P-I (Proportional-Integral) controllers are very regularly used in industry, particularly when response speed is not amatter. A control deprived ofD (Derivative) mode is used when:

1. Fast response ofscheme is not essential.
2. Enormous disturbances and noise are present all throughthe operation ofprocedure.
3. There is merelyone energystowage in procedure (capacitive or inductive).
4. There are enormous transport delays inscheme.

Consequently, keepbenefits ofP-I (Proportional-Integral) controller. This indication to suggest a P-I (Proportional-Integral)controller shown in Figure.This controller uses ofP (Proportional) term even though I(Integral) term is kept, unaffected.

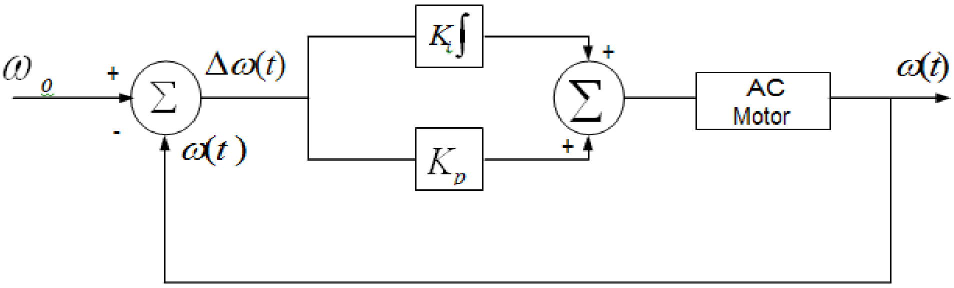

Fig.3. Block Diagram of P-I (Proportional-Integral)Controller

The controller output in this circumstance is
u (t) = K p . e (t) + K i∫ e (t) dt
Fig. 3.Block diagram P-I (Proportional-Integral) controller an integral error compensation system, output response be subject to in some way upon integral of actuating signal. This kind of compensation is presentedby means of a controller which produces an output signal entailing of 2-terms, one proportional to actuating signal & other proportional to its integral. Such a controller is so-calledPI controller or proportional plus integral controller.

(C) PID (PROPORTIONAL-INTEGRAL-DERIVATIVE) CONTROLLER

Numerous industrial controllers employ a P (Proportional), I (Integral) plus D (Differential) i.e. PID regulator making ready that can be tailored to enhance a specific control scheme. PID (Proportional-Integral-Derivative) controller is utmostgenerally used algorithm for controller design and it is utmostbroadly used controller in industry. The controllers used in industry are either one PID controller or its enhanced version. The basic kinds of PID (Proportional-Integral-Derivative) controller are parallel, serial and mixed controller. The PID (Proportional-Integral-Derivative) controller algorithm exploited for is design velocity algorithm; it is furthermoreso-called incremental algorithm. In industry, PID (Proportional-Integral-Derivative) controllers areutmost common control approach to use in real applications.

PID (Proportional-Integral-Derivative) controller has allessential dynamics: fast reaction on variation of controller input (Derivative mode), rise in control signal to lead error towards zero (Integral mode) and appropriateact inside control error area to eradicate oscillations (Proportional mode). Derivative (D) mode mends stability ofscheme and permitsescalation in gain K and diminution in integral time constant T_i, which escalations speed of controller response. PID (Proportional-Integral-Derivative) controllers areutmostregularly used controllers in process industry. The majority of control schemes in world are operated PID (Proportional-Integral-Derivative) controllers. It has been described that 98 percent of control loops in pulp industries and paper industries are controlled by single-input single-output (SISO)PI (Proportional-Integral) controllers and that in process control applications, more than 95 percent of controllers are ofPID (Proportional-Integral-Derivative)kind controller. PID (Proportional-Integral-Derivative) controller associationsbenefit of P (Proportional), D (Derivative) and I (Integral) control action.

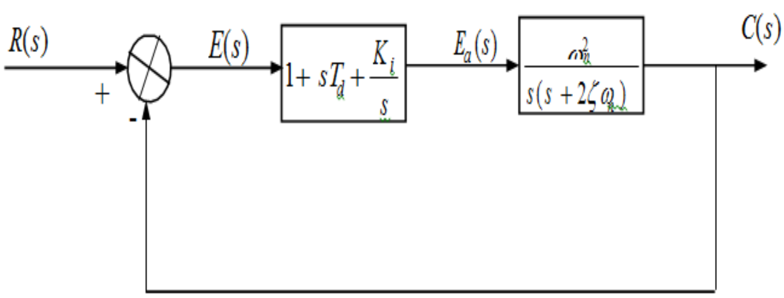

Fig.4. Block Diagram of PID (Proportional-Integral-Derivative)Controller

$$u(t) = K_P e(t) + K_i \int e(t).dt + K_d \frac{d\,e(t)}{dt}$$

The control-signal is proportional to error signal andK_p (Proportional gain). A P (Proportional) controller will have effect of decreasing rise time and will diminish, but never eradicate. If an integrator is added, control signal is proportional to integral of error andKi (Integral gain). I (Integral) control will have effect of diminished error, in standard, to zero value. The in standard must be added, since there are continually limits on correctness in any scheme. D (Derivative) control is used to antedate future conduct of error signal by means ofremedial actions based on rate of change in error signal. The control signal is proportional toD (derivative) of error and K_d is derivative gain.

D (Derivative) control will have effect of growing stability ofscheme, diminishingoverreach, and refining the transient response. D (Derivative) control action can by no means be used alone since this control action is in effect only during transient eras. The PID (Proportional-Integral-Derivative) controller makes a control loop retort faster with fewer overshoot and greatest popular technique of control by aexcessive margin. The collective action hasbenefits of each of 3-individual control activities.

Table 1:Assessment of Gain Response of P, PI and PID Controllers.

Parameter	Speed of Response	Stability	Accuracy
Increasing k	Rise	Depreciates	Improves
Increasing k_i	Diminution	Depreciates	Improves
Increasing k_d	Rise	Improves	No impact

Table 2: Effects on Numerous O/P Parameters of P, PI and PID Controller w.r.t. Variation in Rise Time.

Parameter	P Controller	PI Controller	PID Controller
Rise time	Diminution	Diminution	Minor Diminution
Overshoot	Rise	Rise	Minor Diminution
Settling time	Small change	Increase	Minor Diminution
Steady state error	Decrease	Important change	No change
Stability	Worse	Worse	If K_d Small Better

Table 1 and table 2 displays effects of factors and effects of varying control parameters correspondingly. As we can there see is a diminution in rise time, overshoot and settling time and there is no-change in steady-state error PID (Proportional-Integral-Derivative) Controller is improved than P (Proportional) and PI (Proportional-Integral) controller.

III. RECITALASSESSMENT OF P, PI, AND PID CONTROLLERS

It is to be illustrious that, when gain is growingresponse speed is growing in case of P (Proportional) and PID (Proportional-Integral-Derivative) controller but in PI (Proportional-Integral) controller gain of response is diminishing. In PID (Proportional-Integral-Derivative) controller there is a minor diminution or no-changes are revealed in numerousparameters which can see from table 1 and table 2.In future there is no-change in steady-state error so PID (Proportional-Integral-Derivative) controller is enhanced than P (Proportional) and PID (Proportional-Integral-Derivative) controller.

IV. CONCLUSION AND FUTURE POSSIBILITY

P (Proportional) controller can stabilize only 1^{st} order unstable procedure. PI (Proportional-Integral) controller can be used to evade large turbulences and noise presents all through operation procedure. HoweverPID (Proportional-Integral-Derivative) controller can be used when dealing with upper order capacitive procedures. The study of P (Proportional), PI (Proportional-Integral) and PID (Proportional-Integral-Derivative) Controller is carried-out, in which PID (Proportional-Integral-Derivative) controller gives decent response than a few other controller. Additional output response of VSI-Fed IM (Induction Motor) drive will be estimated by using dissimilar controller i.e.P (Proportional), PI (Proportional-Integral)and PID (Proportional-Integral-Derivative) controller. Based on dissimilar industrial application of IM (Induction Motor), ansuitable controller can be preferred.

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