Comparison of Speed Control for Separately Exacted DC Motor by using PID(Z) and PID(S) Controller

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ABSTRACT

The purpose of the paper be to optimize the precision and best system efficiency in an effective and simple way to control the speed of a DC drive using an analog and digital controller. This type is called helicopter control. The analog & digital console is a combination of a DC motor and a PID controller. The speed of the machine is controlled to increase performance. Among the various methods used to improve engine performance, the PID controller was chosen. However, the selection was not surprising, but P (relative), PD (relative - derivative), PI (relative - integrative) and PID (relative - derivative - integration); When each effect of this controller is displayed in the Rise Time reduction system, % OS (Over Shoot) and Steady State Error and Transient Time, it is confirmed that the best ones are suitable for PID configuration. The open-loop and closed-loop transfer functions are derived and their info graphics are displayed.

The speedometer recognizes the speed of the DC engine as the speediness. Each transformation of the rotor produces a beat calculated by the tachometer. A beat is moved forward into a voltage by voltage-to-frequency converters. The intensifier blunder is an operational amplifier that compares the voltage signal gotten from the tachometer utilizing the reference voltage. The coming about the error is used within the PID controller. The coordinates relative subordinate control unit (PID controller) could be a common criticism instrument (loopback) widely utilized in industrial control systems. The control unit endeavors to diminish the mistake by adjusting the method control inputs. The weighted whole of the relative, complementary, and inverse strategies are utilized to supplant the operation with a control, e.g. B. Area of a control valve or control yield. In this manner, this analog and computerized unit drives the DC engine and gives the essential input to the DC engine. The width of the field remains the same. Significant contrasts were found me. The tools used in programming, design and simulation were MATLAB SIMULINK

Keywords
Control Systems, Mathematical Modeling, DC Machine, PID, ABC, stability

1. INTRODUCTION
Independently energized DC engines have been the most carriers since of their exact, wide, basic, and nonstop control highlights, ordinarily utilized in numerous built-up applications such as electric vehicles, steel rolling plants, electric cranes, and mechanical exploiters. A common conventional strategy of controlling a moo control DC engine is to control the rheostat armature. Since of its non-line armature, the conventional control framework is awkward and wasteful to execute. The controllability, the cheapness, the troublesome great organization, and the higher current transport capacity of inactive converters driven to a huge transformation within the execution of electric drives. The favored torque-speed characteristics can be gotten utilizing customary PID (Proportional Integral Derivative) controllers [1]. The point of this proposal is to look at the execution of the DC machine in detail and in this way to adjust the speed and the physical execution of the framework with the help of the fitting control. The engine, or an electric motor, is one gadget that's one of the most prominent enhancements. Designing and innovation fields since the innovation of power. The engine is nothing more than an electromechanical gadget that changes over electrical energy into mechanical vitality. A DC engine may be a fair-mindedly straightforward electric engine that employments electrical vitality and attractive fields to produce torque and make it turn. In its least difficult frame, it wants two oppositely polar magnets and an electrical coil that acts as an electromagnet [1], [2]

The ghastly and alluring electromagnetic powers of the electromagnets make accessible the torque that causes the engine to turn. As of their tall consistency, tractability and moo taken a toll, DC engines are ordinarily utilized in fabricating applications such as electric vehicles, steel rolling plants, electric cranes, mechanical schemers and family purposes that require speed and / or station control of the engine. Subsequently, plotting the position and / or speed of a DC engine is an fundamental issue and has been considered since the starting of the final period. The DC engine is frequently organized by standard proportional-integral-derivative (PID) controllers since of their ease of development, moo fetched, moo upkeep, and productivity. In any case, the most issues with applying a conventional PID controller at a position or speed are the properties of non-linearity in a DC engine. Non-linear stuffs of a DC engine such as capacity and brushing can influence the introduction of a standard PID controller [3].

2. MODELING OF THE SEPARATELY EXACTED D.C MOTOR
The DC motor is basically a torque converter. The torque progressed within the engine shaft is straight corresponding to the field flux and armature current. In instruction to demonstrate a really dynamic component, the exchange work had to be resulting, which symbolizes the numerical frame of the physical component. In case the numerical show of a perfect physical framework is experienced for different input conditions and moved forward thus with the controls, the result symbolizes the energetic execution of the framework. As SEDM is as a rule utilized within the control framework, numerical models must be made to utilize the control for examination purposes.[4] From presently on, reasonable plan criteria are characterized that compare to the particular machine parameters. It is assumed that the engine has attractive linearity, hence the essential engine conditions are:

$$T = Kf\,If\,Ia = Km\,Ia \qquad (1)$$

$$ea = Kf\,If\,\omega m = Km\omega m \qquad (2)$$

Where Km = Kf If is a constant, which is also ratio $\dfrac{ea}{em}$

The Laplace transformation of Eq.(1) and Eq.(2) are:

$$T(S) = K_m I_a(S) \qquad (3)$$

$$Ea = K_m \omega_m(S) \qquad (4)$$

Within the physical framework, a switch is situated after the armature resistance (Ra) and the switch is closed at t = 0, since all introductory conditions for the exchange work must be zero. After the switch is turned off:

$$V t = e_a + I_a * R_a + L_a \frac{dla}{dt} \qquad (5)$$

From Eq.(2) and Eq.(5):

$$V t = V_m \omega_m + I_a * R_a + L_a \frac{dla}{dt} \qquad (6)$$

Since the differential condition vital to come to the exchange work of the reference framework is accomplished, the Laplace change of the conditions holder be accomplished. It is subordinate to input recreation and appears the association between framework input and yields. Laplace changes for the primary zero condition of condition (6):

$$V(S) = K_m \omega_m(S) + R_a I_a(S) + L_a(S) I_a(S) \qquad (7)$$

$$V(S) = K_m \omega_m(S) + I_a(S) R_a (1 + S\tau a) \qquad (8)$$

Where $\tau = \dfrac{La}{Ra}$ is the electrical time constant of armature. The dynamic equation for the power-driven system is:

$$T = J \frac{d\omega m}{dt} + B\omega m + Tl \qquad (9)$$

The term **B ω_m** represents the rotational loss torque of the scheme. The Laplace transform of Equality of Voltage is:

$$T(S) = J(S)\omega_m(S) + B\omega_m(S) + T_L(s) \qquad (10)$$

From Eq.(3) and Eq.(10)

$$\omega_m(S) = T(S) - \frac{T_L(S)}{B(1+S\tau_m)} = \frac{K_m I_a(S) T_L(S)}{B(1+S\tau_m)} \qquad (11)$$

Where $\tau_m = \dfrac{L}{B}$ is the mechanical time constant of the system. From Eq.(4) and Eq. (7):

$$I_a(S) = V - \frac{E_a(S)}{R_a(1+S\tau_a)} = V(S) - \frac{K_m \omega_m(S)}{R_a(1+S\tau_a)} \qquad (12)$$

Within the Laplace change, the exchange work V(S) from the input voltage to the yield precise speed ω (S) follows directly [4,5,6]: Typically the required exchange work of the SEDM, which speaks to the input proportion of the framework. within the beginning state. A piece graph representation of the condition is as takes after

$$\frac{\omega_m(S)}{V(S)} = \frac{K}{(R+LS)(JS+B)+K^2} \qquad (13)$$

This can be the specified exchange work of the SEDM that speaks to the relationship between framework input conditions and yield. Square chart representation of the condition is as takes after:
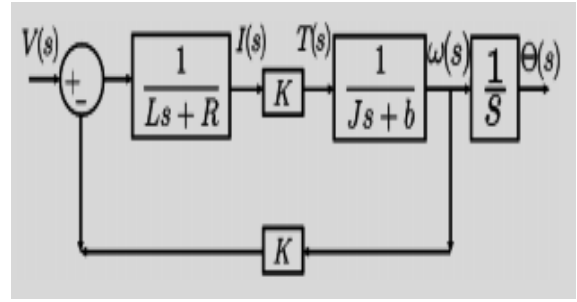

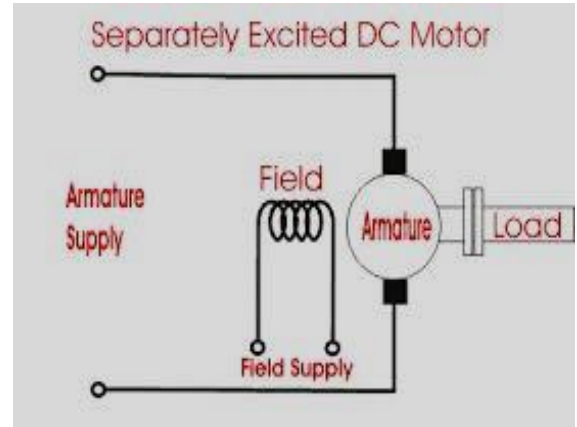**Fig (1) Block diagram representation of Transfer Function**

Fig (2) Basic block Diagram of Separately Excited DC Motor

3. PARAMETER IDENTIFICATION

Some time recently assessing the over exchange work in any way, it is vital to know the esteem of the parameters (J, B, K, R, L), which are exceptionally vital for the proper application of the DC engine. [7] There are numerous strategies of parameter definition. A few common strategies are:

1. Slope algorithm

2. Forecast of the stochastic state (utilizing the Kalman filter)

3. Slightest Square Calculation With these strategies, the Kalman channel can be utilized as an eyewitness in arrange to diminish the extent of mistakes.

With the third strategy, parameters can indeed be assessed from the open-loop exchange work. In see of the determination table of the manufacturer-supplied reference for a isolated energized DC engine, the taking after valueswere utilized for plan purposes utilizing the strategy portrayed over. These values are utilized in planning the required framework with the prescribed journey control. [8]

B : Viscous Friction Coefficent (Nms)

Vt(t) : Terminal Voltage (V)

Ia(t) : Armature current

TL(t) : Load torque (Nm)

J : Rotor Inertia (Nm^2)

Wp(t) : Rotor speed (rad/sec)

Ra : Armature and Field Resistance (Ω

KF : Torque and Back Emf Constant(NmA^-1)

Table (1): Specifications Parameters Of Sedm For The System

Parameters	Value	Unit
Wp(t) : Rotor speed	1000	rpm
Vt(t) : Terminal Voltage	220	V
Ia(t) : Armature current	15	A
TL(t) : Load torque	1	Nm
J : Rotor Inertia	5	Nm^2
KF : Torque and Back Emf Constant	1	NmA^-1
B : Viscous Friction Coefficent	0.3	Nms
Ra : Armature and Field Resistance	0.6 & 0.2	Ω

Since the foremost fundamental necessity of an motor is to be turning at the favorite speed, the steady-state blunder within the gadget speed is superior than 1%. The other introduction condition is that the engine require reach the steady-state speed when it is exchanged on. In this case, the favorite settling time, taking under consideration the complete stack speed of 1500 rpm, is 1 moment. An flood of less than 2% is required as a speed speedier than the reference might harm the gadget. In the event that the reference input (r) is recreated with a unit step input, it must yield the engine speed with a step input of 1 rad / s:

- Settling time less than 0.2 seconds
- Overshoot less than 2%
- Steady-state error less than 1%
- Rise Time less than 0.2 second

4. PID-CONTROLLER

PID-controller it's utilized to create the dynamic reaction as well as to decrease or ignore the consistent –state error. Transfer work of a PID controller is given as.[9]

$$C(c) = K_P \left(1 + \frac{1}{T_{1*S}} + T_D * S\right) \qquad (14)$$

Where :

Kp : proportional gain constant

T1 : integral reset time

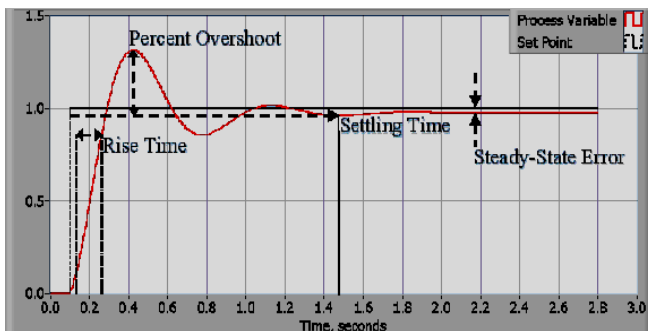TD : derivative time or rate time

Fig (3) shown rise time, steady state error.

The fig(3) shows that the steady state error , rice time , over shoot , and setting time that's happen when we running the separately excited D.C motor , but fig (4) that we want to reduces it after using PID-controller. so increasing K d make setting time decreases and increases damping & stability . increases K p decreases the final steady-state error and decreases the rise time but may increases the overshoot . increasing K i generally increases the overshoot and setting time

5. THE STATE SPACE MODEL AFTER LINEARIZATION

$$\begin{bmatrix} Pi_a \\ Pw_m \end{bmatrix} = \begin{bmatrix} -\frac{R}{L_a} & -K_b/L_a \\ -\frac{K_b}{J} & -B/J \end{bmatrix} \begin{bmatrix} i_a \\ w_m \end{bmatrix} + \begin{bmatrix} \frac{1}{L_a} & 0 \\ 0 & -1/J \end{bmatrix} \begin{bmatrix} V \\ T_1 \end{bmatrix}$$
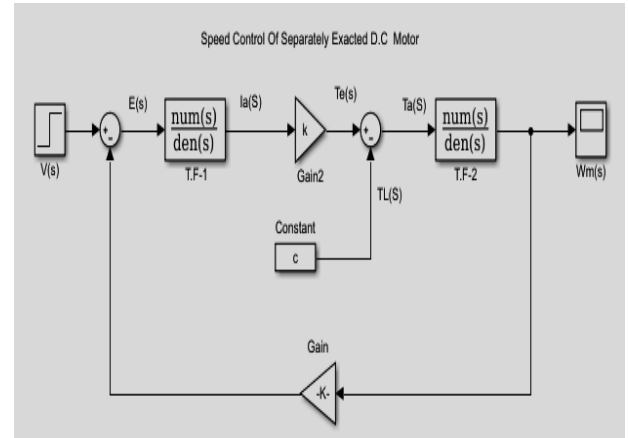

Fig (5) Simulink representation of the SEDM T.F.

With SIMULINK, a framework show with all the essential capacities of the DC engine was created. The framework is modeled utilizing the characteristic exchange work of the electrical and mechanical parameters of the engine. The electromechanical demonstrate is as it was gotten after the differential conditions of all components of the framework and the exchange work have been inferred. Figure (2) appears the input armature voltage (Vt) of the DC engine, summed by the inner emf. The result is at that point bolstered into the work square for exchanging the electrical properties in arrange to produce the armature current (Ia). It is at that point passed through a torque consistent to create torque. This is often at that point totaled with a torque load and at that point gives a yield torque that's encouraged to the useful square for the transmission of the mechanical properties. The yield is the rotor speed (Wm), which is followed back to the speed consistent and gives a consistent EMF.
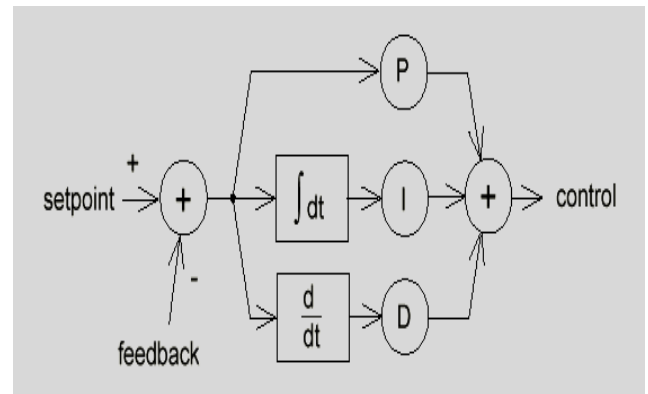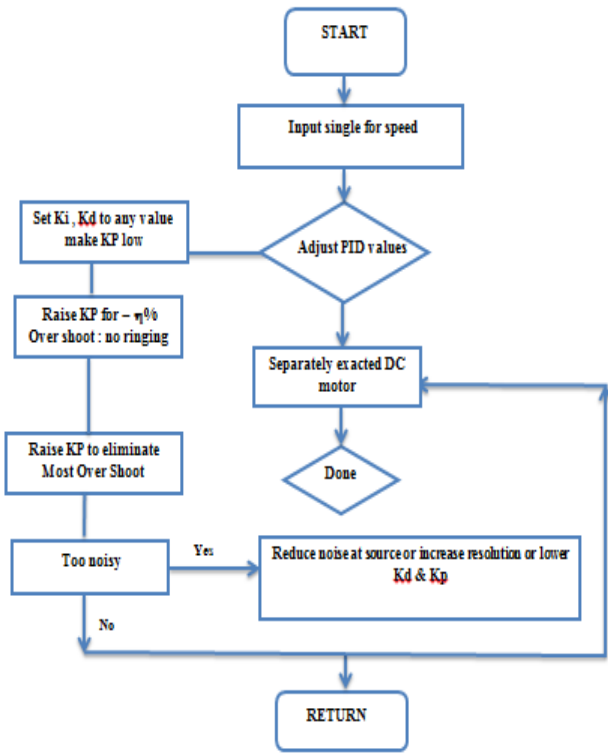
6. MODELING OF PID

Fig (6) PID Model

6.1 Algorithm of Speed Control of Separately Exacted D.C Motor by using PID Controller

Fig(7) Flowchart of the of speed control of separately exacted D.C motor algorithm by using PID controller

7. PROBLEM STATEMENT

When starting drive the separately excited dc motor its be under damped or over damped so it's be error and overshoot . to reduces it and make starting approaches to set point that which avoid overshoot we must using PID-controller its used to improve the dynamic response as well as to reduce or eliminate the steady –state error. As shown in figure 8.

The idea behind Under Damped / Over Damped Tuning is to start out with a nominal tuning with low gains and try to adjust the K P / K I/ K D parameters until you get an adequate damping ratio. Once you have a proper damping ratio, adjust the gains until you either get the desired performance or are limited by instability. Controllers can be programmed to avoid overshoot .

It has to slow the control effort more and more as it approaches the set point, which drags out the time required to hit the desired value.
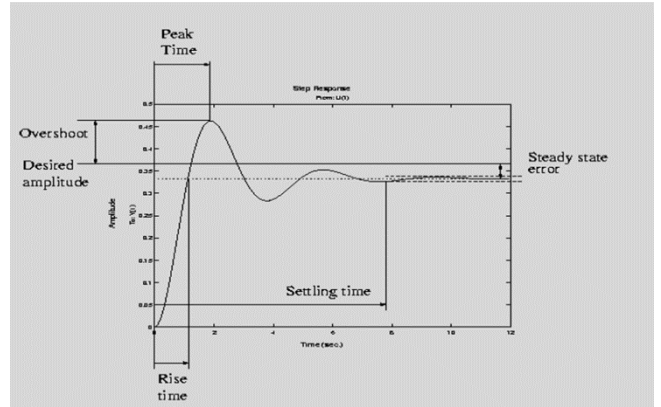

Fig (8) Over Shoot and Steady State Curve
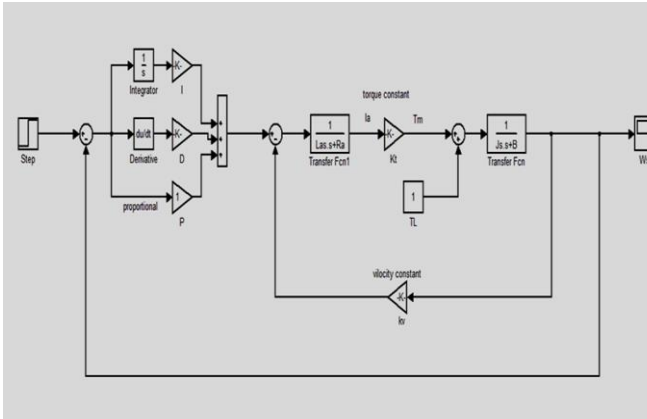
8. SIMULATION & RESULTS

The Paper system be realized MATLAB R2017a Platform in adding to the results are discussed in this division. The total working Simulink Circuit Diagram .The simulation model of control of separately exacted dc motor contains , power circuits, which include the unit step, PID-Controller and system for DC motor with control as shown in fig (8)
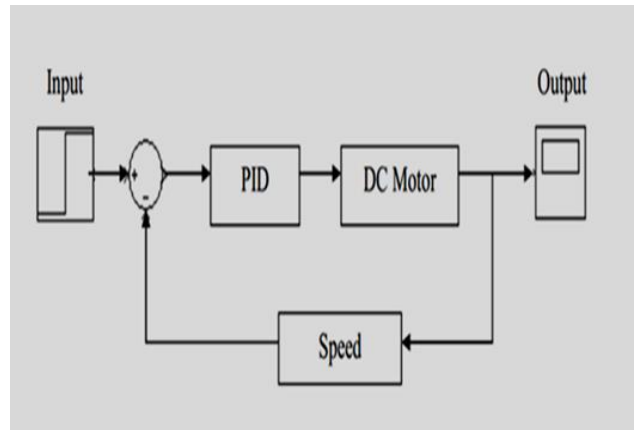
(a)
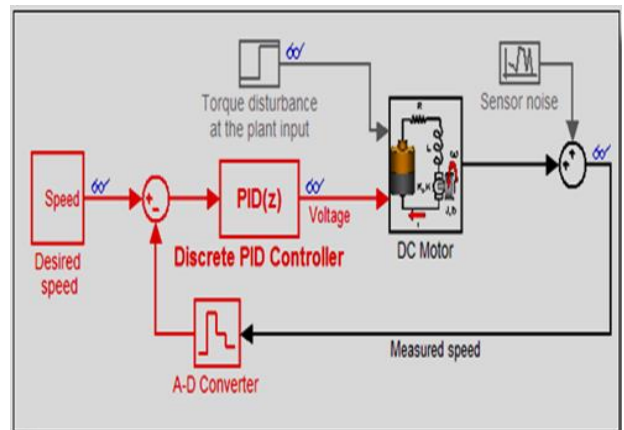
(b)

(C)

Fig (9) Block diagram of control of separately exacted dc motor by using PID-Controller (a,b,c)

8.1 The State space model for DC motor after linearization

$$\begin{bmatrix} Pia \\ Pwm \end{bmatrix} = \begin{bmatrix} -\frac{R}{La} & -Kb/La \\ -\frac{Kb}{J} & -\frac{B}{J} \end{bmatrix} \begin{bmatrix} ia \\ wm \end{bmatrix} +$$

$$\begin{bmatrix} \frac{1}{La} & 0 \\ 0 & -\frac{1}{J} \end{bmatrix} \begin{bmatrix} V \\ T1 \end{bmatrix}$$

▶ $X^. = AX + BU$

▶ $A = \begin{bmatrix} -3 & -4 \\ 0.16 & -1.5 \end{bmatrix}$
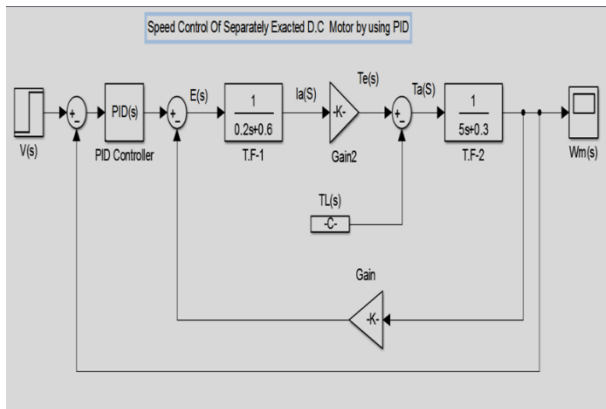
▶ $B = \begin{bmatrix} 5 & 0 \\ 0 & -0.2 \end{bmatrix}$

Fig (10) Block diagram of control of separately exacted dc motor by using PID-Controller

8.2 Controllers Design [PID(S)]

In this study the PID gains are obtained through Matlab auto tuning process. Methods as Ziegler-Nichols or Cohen Coon haven't used due to very oscillatory open loop response as shown in the fig for Rotor Speed angular Response.

We make beyond any doubt connected a PID controller to control the engine speed. The botch between the reference speed and the real speed be found known as input to a PID controller. The PID controller subordinate on the blunder adjustments its yield, to control the vegetal input such that the botch is diminished. A thorough fabric almost the hypothesis and tuning of PID controllers is given in[2] From the plot we see 220 v is

applied to the system , the motor can only achieve a maximum speed of 1000 rpm , by using PID controller and separately exacted dc motor with close loop . That we are required for the our design ,Setting without PID controller

▶ **The values of PID gains are**
▶ **K p = 4**
▶ **K d = 5**
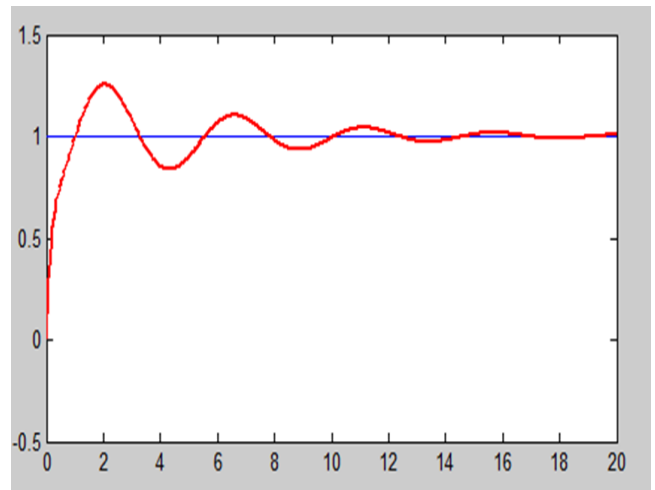▶ **K i = 15**
▶ **Settling time 7.5 sec**
Over shoot 1.4%

Fig (11) Rotor Speed angular without PID control

with PID controller

- K p = 6
- K i = 2
- K d = 2
- Over shoot 1.1 %
- Steady state error 1%
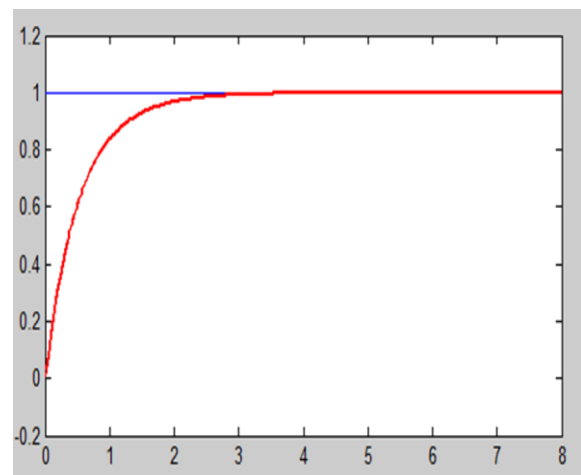- Settling time 1.74 sec

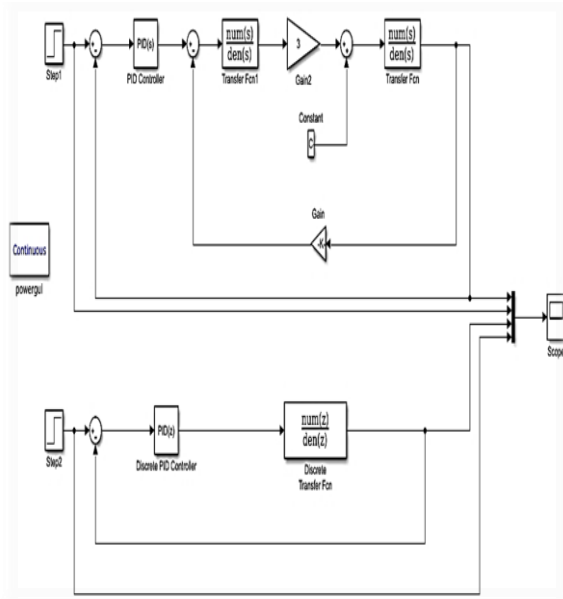**Fig (12) Speed with Time Response using PID- Controller**

Fig (13) Simulink representation of the SEDM T.F continues and T.F digital controller by using Matlab.

8.3 Controllers Design Digital (PID(Z))

Code Mat lap program convert T.F(S) Continues to T.F(Z) Digital

T1= tf ([-0.1 0.2],[1 3.06 0.67])
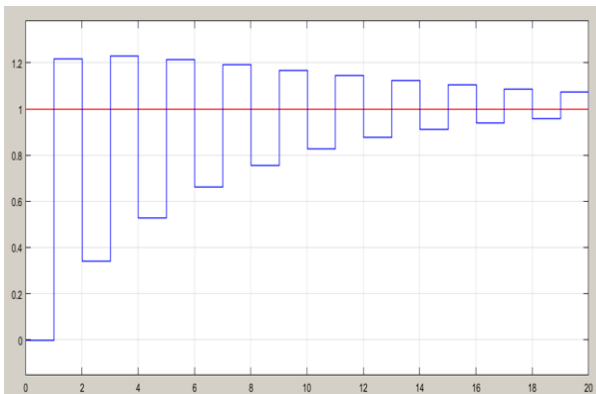
G=tf(T1)

hd=c2d(G,0.5)

without PID(Z) controller

Fig (14) Speed With Time Response without Using digital PID – Controller
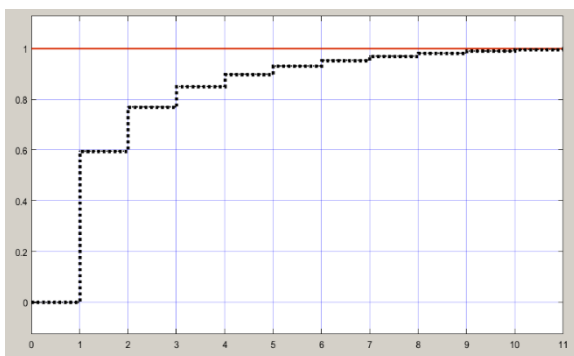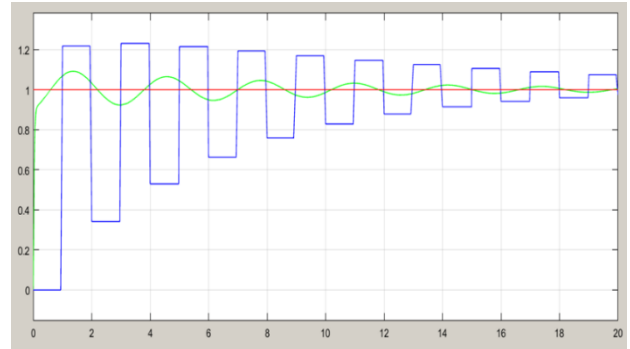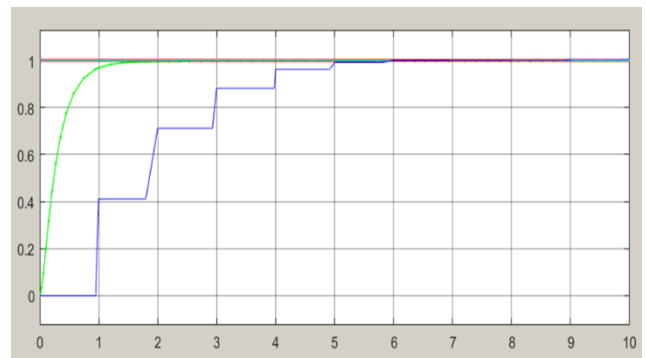

Fig (15) Speed With Time Response by Using digital PID – Controller

Show in figure (16) (a) comparison of Speed With Time Response between of digital & continuous system without Using PID – Controller. (b) comparison of Speed With Time Response between of digital & continuous system by Using PID – Controller.

(a)

(b)

Fig (16) comparison of Speed With Time Response between of digital & continuous system(a,b)

Table (2): Comparison of Speed With Time Response by using PID(Z) & PID(S) Controller

Parameters	Without PID controller	With PID(s) controller	With PID(z) controller
Over shoot	1.4 %	1.1 %	1 %
Steady state error	1.18%	1 %	0.985 %
Settling time	7.5 sec	1.74 sec	1.6 sec

9. CONCLUSION

The DC motor speed control comparison was designed separately using a PID (Z) and PID (S) controller in a Matlab / Simulink environment. Simulation result shows that this was accomplished at adaptable speed by trading the voltage valuable to the non-inverting station of the blunder intensifier which gives the blunder completed zero by the PID controller. The speed of the DC engine through trading the voltage be total from

the DC engine to the armature yield member. The speed of the DC engine holder is different by trading the input reference voltage. The reference voltages, reference, and flag voltage are always equaled and the alter in these voltages is give for the PID controller which is zero, and the engine supply is distinctive from the DC engine. In the event that the reference voltage is greater than the criticism voltage, at that time the input voltage to the engine soul be made strides until the voltages rise to. On the off chance that the reference voltage is less than the motor's input voltage, at that point the input voltage to the DC engine will be decreased to partner the reference voltage. In this strategy, the speed of the DC engine can be organized made on the input voltage, but PID(Z) is more difficult than PID(S) controller.

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