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Design of Robust Pi/Pid Controller for Discrete-Time Parametric Uncertain Systems

Engineering

KEYWORDS : Robust Controller, discrete- time parametric uncertain systems, Inverse Bilinear transformation, Bilinear transformation

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ABSTRACT

In this paper, we proposed a new algorithm for the design of Robust Controller for discrete-time parametric uncertain systems. This algorithm is based on the Inverse Bilinear Transformation and then robust controller is designed using the necessary and sufficient conditions of robust stability for continuous-time interval plants and Bilinear Transformation is used to obtain discrete-time controller which stabilizes the discrete-time interval plant. To show the efficacy of the proposed algorithm, this procedure is applied to a numerical example available in the literature and the results are successfully verified through MATLAB.

I.INTRODUCTION

From many years in the Industry, the process control techniques plays an important role. Today number of control methods are available such as Neuro-fuzzy control, fuzzy logic control, Genetic algorithm based control etc. Among the available techniques, the best control technique is control using the PID Controller. Though there are many control solutions using from past decades, PID controller has become the "Industry standard". This is because of the simple structure of the PID Controller and its robust performance in the wide range of operating conditions. For the design of the PID controller many methods have been proposed. Firstly, for the design of the controller the classical tuning rules developed by Ziegler&Nichols are used[1]. In many industrial plants, it became difficult to find the optimal or near optimal PID parameters on using the Ziegler&Nichols formula. After that, Tschanner developed the Jury stability conditions which are extracted from Routh&Fuller tables. And a graphical technique for selecting the PID controller parameters for the given linear system was proposed by Yeung. Also an analytical technique is proposed by Zhuang et al.for identifying the optimum PID controller settings. For the design of the controllers, a method based on complex curve fitting is proposed by Rattan et al. This method involves matching of the frequency response of the closed-loop system with reference model. The digital controller design methodology based on series expansion of pulse transfer function is proposed by Inooka et al. For the improving/increasing capabilities of traditional parameter techniques, several intelligent approaches using Genetic algorithms, & PSO came in to existence and various optimization algorithms have been proposed for tuning the PID parameters for the optimal performance. Another method is proposed for the design of discrete controller using loop-shaping technique. Here in this method the loop-shape can be obtained by means of a Glover-McFarlane H-∞ controller[2] which was developed by MacFarlane & Glover in 1989. The main advantage of this approach is that the target loop obtained is feasible, robust and acts as a input output controller with desirable properties. And also, for SISO systems the Glover-McFarlane controllers can be computed easily to achieve the given band width. Further they can produce reasonable loop shapes even though if the plant contains zeros in the right-half plane or lightly damped poles. The drawback associated with this method is it requires a state-space plant model which can be obtained by system identification step. Most of the real plant operate in a wide range of operating conditions, the robustness[3] is then an important feature of the closed loop system.When this is the case , the controller has to be able to stabilize the plant for all operating conditions. This requires design of robust controller. The problem of designing the robust controller for the parametric uncertain plants [4-5],which are having unknown but bounded parameter uncertainties attracted most of the researchers attention.Robust control is a branch of control theory that explicitly deals with uncertainty in its approach to controller design. Robust control methods aims at achieving robust stability and/or performance in the performance of uncertainties."Robust control refers to the control of unknown plants with unknown dynamics subject to unknown disturbances."Robust controller is a controller designed such that some level of performance of the controlled system is guaranteed irrespective of changes in the plant dynamics with in a pre-defined class." There are many techniques available in the literature for the design of Robust controllers. Discrete PID Controller tuning using Pole Assignment technique involves choosing desired control dynamics and computing of discrete PID controller parameters. This approach suits highly for non-linear systems control and it brings no advantages to the control of systems close to linear ones. All the available PID tuning methods have their merits & demerits with respect to the time of computation, uniqueness of solutions, simplicity in its implementation, robustness properties etc. Comparison among the existing methods and trying to find the best method will become futile[6]. Here in this paper, we proposed a new algorithm for the design of Discrete Robust Controller for discrete-time parametric uncertain system using bilinear transformation. And the proposed algorithm is verified through the numerical example and results are successfully verified.

II. BRIEF REVIEW OF ROBUST STABILITY FOR CONTINUOUS-TIME PARAMETRIC UNCERTAIN SYSTEM:

A parametric uain continuous time system can be represented in transfer function form as,

$$G(s,p,q)=(p_m s^m+p_{(m-1)} s^{(m-1)}+ \text{----} +p_o)/(q_n s^n+q_{(n-1)} s^{(n-1)}+q_{(n-2)} s^{(n-2)}+ \text{----} +q_o) \quad (1)$$

Where,

$p_i \in [p_i^-, p_i^+]$, i=1,2,------m is a vector of intervals corresponding to variations in the parameters and $q_i \in [q_i^-, q_i^+]$ for i=1,2,-----n is also a vector of interval parameters.

The given parametric uncertain system is said to be stable if its characteristic polynomial $q(s)= q_0+q_1s+q_2s^2+$----------+ qnsn is robustly stable.

Consider a set of real polynomials of degree 'n' as

$$q(s)=q_0+q_1s+q_2 s^2+\text{----------}+q_n s^n \quad (2)$$

where the ranges of coefficients are

$q_0 \in [x_0,y_0], q_1 \in [x_1,y_1]$ -------,$q_n \in [x_n,y_n]$ The stability of such an interval polynomial represented in eq(2) can be determined by Kharitonov's theorem.

Kharitonov theorem: If a characteristic polynomial Δ(s,) with intervals is degree invariant,the system with the characteristic polynomial Δ(s,) is stable if and only if the systems with four kharitonov polynomials as characteristic polynomials are stable.

Let the characteristic polynomial of an uncertain system with

interval parameters be

$\Delta(s,\bar{d}) = \sum_{(i=0)}^{n} d_i s^i = \sum_{(i=0)}^{n} [x_i,y_i]s^i$;

where $d_i = [x_i,y_i]$ (3)

According to the Kharitonov's theorem[7],this interval parameter characteristic polynomial $\Delta(s,)$ can be represented as four fixed parameter polynomials called Kharitonov polynomials.

These are:

$\Delta^1(s) = x_0+x_1 s+y_2 s^2+y_3 s^3+------$
$\Delta^2(s) = y_0+y_1 s+x_2 s^2+x_3 s^3+------$
$\Delta^3(s) = y_0+x_1 s+x_2 s^2+y_3 s^3+-----$
$\Delta^4(s) = x_0+y_1 s+y_2 s^2+x_3 s^3+-------$

If each and every element of the above set is a Hurwitz polynomial then only the set of polynomial considered in eq(3) is stable.

In [8],a new stability criterion for class of fixed parameter polynomials is presented. This stability criterion is extended for the determination of robust stability of interval polynomials in [1]. According to patre[1],the robust stability of eq(2) or eq(3) can be determined by the following necessary and sufficient conditions.

Necessary conditions:
For q(s) or) to be stable the necessary conditions to be satisfied are:

$y_i \geq x_i \geq 0$,for i=0,1,2-----n
$x_i\, x_{(i+1)} > y_{(i-1)}\, y_{(i+2)}$, i=1,2,3,-------n-2 (4)

Sufficient conditions:
For q(s) or) to be stable the sufficient conditions to be satisfied are:

$y_i \geq x_i > 0$, i=0,1,2,3-----

$0.4655\, x_i\, x_{(i+1)} > y_{(i-1)}\, y_{(i+2)}$, i=1,2,3------n-2 (5)

III. DESIGN PROCEDURE FOR THEROBUST CONTROLLER OF DISCRETE-TIME PARAMETRIC UNCERTAIN SYSTEMS
Consider a Discrete-time parametric uncertain plant represented in its transfer function as,

$$G(z,u,v) = \frac{N(z,u)}{D(z,v)} = \frac{u_0+u_1 z+u_2 z^2+----+u_m z^m}{v_0+v_1 z+v_2 z^2+----+v_n z^n} \quad (6)$$

Where $u_i \in [u_i^-, u_i^+], v_i \in [v_j^-, v_j^+]$

i = 0,1,2,--------m j = 0,1,2-------n ; mn

The stabilizing digital PI or PID controller transfer function is given by

$$C_{PI}(z,K_1,K_2) = \frac{2K_1(z-1)+K_2T(z+1)}{2(z-1)} = \frac{N_c(z)}{D_c(z)}$$

(for PI)

$$C_{PID}(z,K_1,K_2,K_3) = \frac{(2K_1+K_2+4K_3)z^2+(2K_2-8K_3)z+(-2K_1+K_2+4K_3)}{2(z^2-1)} = \frac{N_c(z)}{D_c(z)}$$

(for PID)

Convert the Discrete-time parametric uncertain transfer function in to Continuous-time parametric uncertain transfer function using Inverse-Bilinear Transformation [11] given below.

$$G(s,\bar{u},\bar{v}) = \frac{N(s,\bar{u})}{D(s,\bar{v})} = (z+1)*G(z)|_{z=\frac{1+s}{1-s}} \quad (7)$$

Let the stabilizing PI/PID controller transfer function in s-domain be defined as,

$$C_{PI}(s,\bar{K_1},\bar{K_2}) = \frac{\bar{k}_1 s+\bar{k}_2}{s} = \frac{N_c(s)}{D_c(s)}$$

(for PI)

$$C_{PID}(s,\bar{K}_1,\bar{K}_2,\bar{K}_3) = \frac{\bar{k}_1 s+\bar{k}_2+\bar{k}_3 s^2}{s} = \frac{N_c(s)}{D_c(s)}$$ (for PID)

Determine the Closed-loop transfer function T(s) with PI/PID controller using the following equation

$$T(s) = \frac{N(s,\bar{u})*N_c(s)}{N(s,\bar{u})*N_c(s)+D(s,\bar{v})*D_c(s)} \quad (8)$$

The characteristic equation of the Closed-loop transfer function T(s) is given by

$\Delta(s)=N(s,\bar{u})*(s) + D(s,)*(s)$ (9)

Where, N(s, ¯u) and D(s, ¯u) are the numerator and denominator polynomials of the plant considered respectively & $N_c(s)$ and $D_c(s)$ are the numerator and denominator polynomials of PI/PID controller transfer function respectively. Now by applying the necessary and sufficient conditions of robust stability of continuous-time system given in eq(4) & eq(5) to the closed-loop polynomial Δ(s), derive the set of inequality constraints. Then solve the obtained inequality constraints to determine the controller parameters using MATLAB-Optimization tool box[10] so as to minimize the objective function $J = \sum_{(j=1)}^{n} |\bar{k}_j|$ .Using these parameter values calculate the Closed-loop Transfer Function T(s). Then apply the bilinear transformation to the Closed-loop transfer function T(s) to obtain Closed-loop transfer function in z-domain T(z) where $T(z)=T(s)\,|_{(s=(z-1)/(z+1))}$ and then check the Necessary & Sufficient Conditions for the stability of discrete-time parametric uncertain systems.

Necessary & Sufficient Conditions for Discrete-time Parametric Uncertain Plant:
Consider a discrete-time parametric uncertain polynomial,

$$p(z) = \bar{d_o}z^n + \bar{d_1}z^{n-1} + ----+\bar{d_n}\ ;\ \bar{d_i} \in [\underline{\Delta_i}, \overline{\Delta_i}]$$, i=0,1,2,------n (10)

Where, $\underline{\Delta_i} = min(\bar{d_i})$; $\overline{\Delta_i} = \max(\bar{d_i})$

The polynomial represented in eq(10) is robustly stable if and only if the necessary and sufficient conditions satisfy[9].

$$p_o(z) = \underline{\Delta_0} + \underline{\Delta_1}z + \underline{\Delta_2}z^2 + ---+\underline{\Delta_n}z^n$$
$$p_1(z) = \overline{\Delta_0} + \overline{\Delta_1}z + \overline{\Delta_2}z^2 + ---+\overline{\Delta_n}z^n \quad (11)$$

Where, k=(n+1)/2.

$$p_2(z) = \underline{\Delta_0} + \underline{\Delta_1}z + \overline{\Delta_2}z^2 + ---+\underline{\Delta_n}z^n$$
$$p_3(z) = \overline{\Delta_0} + \overline{\Delta_1}z + \underline{\Delta_2}z^2 + ---+\overline{\Delta_n}z^n$$
$$p_4(z) = \overline{\Delta_0} + \underline{\Delta_1}z + \underline{\Delta_2}z^2 + ---+ \quad (12)$$
$$p_5(z) = \Delta_0 + \overline{\Delta_1}z + \overline{\Delta_2}z^2 + ---+$$

If the zeros of the polynomials (z) to lie inside the unit circle, then the polynomial p(z) robustly stable.Then obtain the closed-loop step response of the system.

IV.NUMERICAL EXAMPLE
Design of Discrete Robust PI Controller:
Consider the discrete parametric uncertain system transfer function

$$G(z) = \frac{[1,2]z^2 + [3,4]z + [8,10]}{[6,6]z^3 + [9,9.5]z^2 + [4.9,5]z + [0.8,0.85]}$$

Obtain G(s) using Inverse Bilinear transformation eq(7) to G(z)

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then discrete system can be changed as,

$$G(s) = \frac{[10,18]s^2 + [-36,-24]s + [24,32]}{[0.55,1.2]s^3 + [5.9,6.65]s^2[19.45,20.2]s + [20.7,21.35]}$$

The transfer function of the PI controller can be defined as

$$C_{PI}(s) = \frac{\overline{K}_1 s + \overline{K}_2}{s}$$

Obtain Closed-loop transfer function T(s) with PI Controller using eq(8).

Then,

$$T(s) = \frac{\begin{matrix}[10\overline{K_1}, 18\overline{K_1}]s^3 + [10\overline{K_2} - 36\overline{K_1}, 18\overline{K_2} - 24\overline{K_1}]s^2 \\ +[24\overline{K_1} - 36\overline{K_2}, 32\overline{K_1} - 24\overline{K_2}]s \\ +[24\overline{K_2}, 32\overline{K_2}]\end{matrix}}{\begin{matrix}[0.55,1.2]s^4 + [10\overline{K_1} + 5.9, 18\overline{K_1} + 6.65]s^3 + \\ [10\overline{K_2} - 36\overline{K_1} + 19.45, 18\overline{K_2} - 24\overline{K_1} + 20.2]s^2 \\ +[24\overline{K_1} - 36\overline{K_2} + 20.7, 32\overline{K_1} - 24\overline{K_2} + 21.35]s \\ +[24\overline{K_2}, 32\overline{K_2}]\end{matrix}}$$

For the above system the closed –loop polynomial will be

$$\Delta(s, \overline{K_1}, \overline{K_2}) = \begin{matrix}[0.55,1.2]s^4 + [10\overline{K_1} + 5.9, 18\overline{K_1} + 6.65]s^3 + \\ [10\overline{K_2} - 36\overline{K_1} + 19.45, 18\overline{K_2} - 24\overline{K_1} + 20.2]s^2 \\ +[24\overline{K_1} - 36\overline{K_2} + 20.7, 32\overline{K_1} - 24\overline{K_2} + 21.35]s \\ +[24\overline{K_2}, 32\overline{K_2}]\end{matrix}$$

Up on applying the necessary and sufficient conditions of eq(4) & eq(5) to the above closed- loop polynomial, the following inequality constraints are obtained. So as to make these set of constraints in to feasible closed set, a small positive number'' is introduced in the constraints. The value of will affect feasible parameter region.

$$-8\overline{K}_2 + \varepsilon < 0$$

$$-8\overline{K}_1 - 12\overline{K}_2 - 0.65 + \varepsilon < 0$$

$$-8\overline{K}_2 - 12\overline{K}_1 - 0.75 + \varepsilon < 0$$

$$-8\overline{K}_1 - 0.75 + \varepsilon < 0$$

$$864\overline{K}_1^2 + 360\overline{K}_2^2 - 960\overline{K}_1\overline{K}_2 + 278.4\overline{K}_1 + 1120\overline{K}_2 - 402.615 + \varepsilon < 0$$

$$402.192\overline{K}_1^2 + 167.58\overline{K}_2^2 - 446.88\overline{K}_1\overline{K}_2 + 129.5952\overline{K}_1 + 521.36\overline{K}_2 - 187.417 + \varepsilon < 0$$

$$360\overline{K}_1^2 - 100\overline{K}_1\overline{K}_2 + 56.3\overline{K}_1 - 87.8\overline{K}_2 - 89.135 + \varepsilon < 0$$

$$167.58\overline{K}_1^2 - 46.55\overline{K}_1\overline{K}_2 + 26.2077\overline{K}_1 - 40.8709\overline{K}_2 - 41.4923 + \varepsilon < 0$$

Up on solving these above constraints using MATLAB-Optimization tool box which minimizes the objective function J=, we get the controller parameter values for different '' values.

For the controller parameters obtained are:

$$\overline{K_1} = 0.0313, \overline{K}_2 = 0.1250$$

For these parameter values the closed-loop transfer function will be,

$$T(s) = \frac{[0.313,0.5634]s^3 + [0.1232,1.4988]s^2 + [-3.7488,-1.9984]s + [3,4]}{[0.55,1.2]s^4 + [6.213,7.2134]s^3 + [19.5732,21.6988]s^2 + [16.9512,19.3516]s + [3,4]}$$

By converting the above Closed-loop transfer function in s-domain into discrete-time system using the Bilinear transformation then the discrete system will be

$$T(z) = \frac{[-0.3126,4.0638]z^3 + [2.0622,8.9394]z^2 + [10.4386,17.3158]z + [4.5582,8.9346]}{[46.2874,53.4638]z^4 + [26.6756,40.0772]z^3 + [-22.0976,-7.9464]z^2 + [-19.0772,-5.6756]z + [-3.4418,3.7346]}$$

The necessary and sufficient conditions for robust stability of T(z) are derived using eq(11) & eq(12) are,

Necessary conditions:

$$\Delta^0(z) = 46.2874z^4 + 26.6756z^3 - 22.0976z^2 - 19.0772z - 3.4418$$

$$\Delta^1(z) = 53.4638z^4 + 40.0772z^3 - 7.9464z^2 - 5.6756z + 3.7346$$

(13)

Sufficient conditions:

$$\Delta^2(z) = 46.2874z^4 + 40.0772z^3 - 7.9464z^2 - 19.0772z - 3.4418$$

$$\Delta^3(z) = 53.4638z^4 + 26.6756z^3 - 22.0976z^2 - 5.6756z + 3.7346$$

$$\Delta^4(z) = 53.4638z^4 + 40.0772z^3 - 22.0976z^2 - 19.0772z + 3.7346$$

$$\Delta^5(z) = 46.2874z^4 + 26.6756z^3 - 7.9464z^2 - 5.6756z - 3.4418$$

(14)

It is observed that the roots of eq(13) & eq(14) lie inside the unit circle. Therefore the Closed-loop transfer function T(z) is robustly stable. Hence the designed PI Controller stabilizes the considered system. The closed-loop step response of the system with the PI Controller for andisshowninFig1.

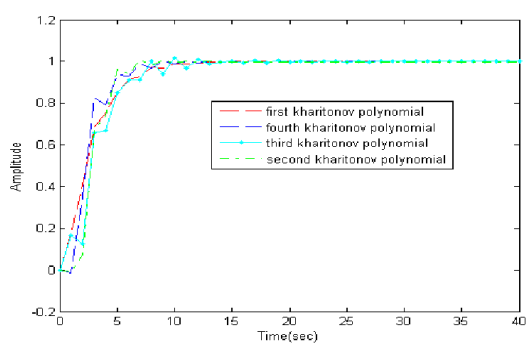

Figure1.Discrete step response of the system with PI Controller

The controller transfer function $C_{PI}(z)$ is given by

$$C_{PI}(z, K_1, K_2) = \frac{0.0626(z-1) + 0.25T(z+1)}{2(z-1)}$$

Design of Discrete Robust PID Controller:

Now we consider the PID controller transfer function (s) as

$$C_{PID}(s) = \overline{K}_1 + \frac{\overline{K}_2}{s} + \overline{K}_3 s$$

The closed-loop polynomial obtained after calculation will be

$$\Delta(s,\overline{K}_1,\overline{K}_2,\overline{K}_3) = \begin{matrix}[10\overline{K}_3 + 0.55, 18\overline{K}_3 + 1.2]s^4 \\ +[10\overline{K}_1 - 36\overline{K}_3 + 5.9, 18\overline{K}_1 - 24\overline{K}_3 + 6.65]s^3 \\ +[10\overline{K}_2 - 36\overline{K}_1 + 24\overline{K}_3 + 19.45, 18\overline{K}_2 - 24\overline{K}_1 + 32\overline{K}_3 + 20.2]s^2 \\ [24\overline{K}_1 - 36\overline{K}_2 + 20.7, 32\overline{K}_1 - 24\overline{K}_2 + 21.35]s \\ +[24\overline{K}_2, 32\overline{K}_2]\end{matrix}$$

On applying the necessary and sufficient conditions to the above closed-loop polynomial, the inequality constraints obtained are:

$$-8K_2 + \varepsilon < 0$$

$$-8K_1 - 12K_2 - 0.65 + \varepsilon < 0$$

$$-8K_2 - 12K_1 - 8K_3 - 0.75 + \varepsilon < 0$$

$$-8K_1 - 12K_3 - 0.75 + \varepsilon < 0$$

$$-8K_3 - 0.65 + \varepsilon < 0$$

$$-960K_1K_2 + 864K_1^2 - 576K_1K_3 + 278.4K_1 + 360K_2^2 + 96K_2K_3 + 706K_2 - 496.8K_3 - 402.615 + \varepsilon < 0$$

$$-446.88K_1K_2 + 402.192K_1^2 - 268.128K_1K_3 + 129.5952K_1 + 167.58K_2^2 + 44.688K_2K_3 + 328.643K_2 - 231.2604K_3 - 187.417 + \varepsilon < 0$$

$$-100K_1K_2 - 72K_2K_3 - 87.8K_2 + 360K_1^2 - 960K_1K_3 + 56.3K_1 + 864K_3^2 + 942.9K_3 - 89.135 + \varepsilon < 0$$

$$-46.55K_1K_2 - 33.516K_2K_3 - 40.8709K_2 + 167.58K_1^2 - 446.88K_1K_3 + 26.2076K_1 + 402.192K_3^2 + 438.91995K_3 - 41.4923 + \varepsilon < 0$$

$$-100K_1K_3 + 360K_3^2 - 5.5K_1 - 39.2K_3 - 3.245 + \varepsilon < 0$$

$$-46.55K_1K_3 + 167.58K_3^2 - 2.56025K_1 - 18.2476K_3 - 1.5105 + \varepsilon < 0$$

Up on solving these above constraints using MATLAB-Optimization tool box which minmizes the objective function J = ,we get the controller parameter values for different '' values.

For , the values of the controller parameters obtained are:

$$\overline{K}_1 = 0\ ,\ \overline{K}_2 = 0.125\ ,\ \overline{K}_3 = 0.0438$$

For the obtained parameter values the closed-loop transfer function will be

$$T(s) = \frac{\begin{matrix}[0.438, 0.7884]s^4 + [-1.5768, -1.0512]s^3 \\ +[2.3012, 3.6515]s^2 + [-4.5, -3]s + [3,4]\end{matrix}}{\begin{matrix}[0.988, 1.9884]s^4 + [4.3232, 5.5988]s^3 \\ +[21.7512, 23.8516]s^2 \\ +[16.2, 18.35]s + [3,4]\end{matrix}}$$

After converting the above system in to discrete using Bilinear transformation the discrete plant obtained will be, T(z)=T(s) $|_{(s=(z-1)/(z+1))}$

$$G(z) = \frac{\begin{matrix}[-0.3376, 4.3888]z^4 + [1.9488, 11.4016]z^3 \\ +[13.3248, 24.128]z^2 \\ +[6, 21.1456]z + [9.7904, 14.5168]\end{matrix}}{\begin{matrix}[46.2624, 53.7888]z^4 + [25.2488, 40.1016]z^3 \\ +[-23.7752, -7.572]z^2 \\ +[-24.0072, -9.1544]z + [1.7904, 9.3168]\end{matrix}}$$

The necessary and sufficient conditions for robust stability of G(z) are derived using eq(11) & eq(12) are,

Necessary conditions:

$$\Delta^0(z) = 46.2624z^4 + 25.2488z^3 - 23.7752z^2 - 24.0072z + 1.7904$$

$$\Delta^1(z) = 53.7888z^4 + 40.1016z^3 - 7.572z^2 - 9.1544z + 9.3168$$

Sufficient conditions:

$$\Delta^2(z) = 46.2624z^4 + 40.1016z^3 - 7.572z^2 - 24.0072z + 1.7904$$

$$\Delta^3(z) = 53.7888z^4 + 25.2488z^3 - 23.7752z^2 - 9.1544z + 9.3168$$

$$\Delta^4(z) = 53.7888z^4 + 40.1016z^3 - 23.7752z^2 - 24.0072z + 9.3168$$

$$\Delta^5(z) = 46.2624z^4 + 25.2488z^3 - 7.572z^2 - 9.1544z + 1.7904$$

It is observed that the roots of the necessary and sufficient conditions lie inside the Unit circle. Therefore the closed-loop transfer function T(z) is robustly stable. Hence the designed PID Controller stabilizes the considered system. The closed-loop step response of the system with PID Controller for ε=1 and K_1=0, K_2=0.125, K_3=0.0438 , & is shown in Fig2.

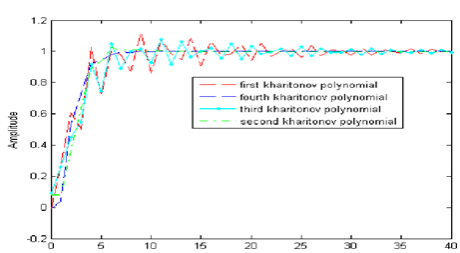

Figure2.Discrete step response of the system with PID Controller

The controller transfer function CPID(z) is given by

$$C_{PID}(z,K_1,K_2,K_3) = \frac{(0.3002)z^2 + (-0.0956)z + (0.3002)}{2(z^2-1)}$$

V.CONCLUSION

In this paper, a robust PI and PID controller algorithm is proposed for Discrete-time parametric uncertain system is proposed. To show the efficacy of the proposed algorithm , a typical example available in the literature is considered. This example is simulated through MATLAB-Optimization tool box and convincing results are obtained. It has been observed from the simulation results that the designed PI/PID controller stabilizes the plant.

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