Stability and Performance Analysis of Fractional Order Controller over Conventional Controller Design

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***Abstract*---In this paper, a new comparative approach has been proposed for reliable controller design. Scientists and engineers are often confronted with the analysis, design, and synthesis of real-life problems. The first step in such studies is the development of a 'mathematical model' which can be considered as a substitute for the real problem. The mathematical model is used here as a plant. Fractional integrals and derivatives have found wide application in the control of dynamical systems when the controlled system and the controller are described by a set of fractional order differential equations. Here the stability of fractional order system is checked at the different level and it is found that the stability region is large in the complex plane. This large stability region provides the more flexibility for system implementation in the control engineering. Generally, an analytically or experimentally approaches are used for designing the controller. If a fractional order controller design approach used for a given plant then the controlled parameter gives the better result.**

Keywords---Fractional Order Controller, Fractional Order Calculus, Stability, Performance Analysis, MATLAB, Function under Class, Ziegler-Nichols Method

I. INTRODUCTION

The technique model order reduction is used in all fields of Electrical, Chemical, Aerospace, Mechanical etc. In the large process control system and mechanical production houses, the model order reduction plays an important role to take the decision for the final product [1]-[3]. Generally, the work with large scale system is very complex and time-consuming [4]. To check the stability of the system first we make a mathematical model of the plant. If the Original system model does not match the desired performance of the implementing system, then a controller is designed to fulfill the requirement of the industry. The designed controller may be a full order or it may be fractional order. The implementation of the controller depends on the plant. If a control system satisfies their stability conditions by the Routh-Hurwitz stability criteria [5] then any analytical or experimental approaches are used. On the other hand, if control system requires the stability region beyond the Routh-Hurwitz criteria or it requires more flexibility than what an approach is useful? So to fulfill the stability condition beyond the Routh- Hurwitz criteria a fractional order approach [6] and [7] is used here to design the controller. Here the comparative analysis provides the option to opt a controller design method for the given plant.

II. PID CONTROLLER TRANSFER FUNCTION

The block diagram for a PID controller is shown in Fig. (1). The PID controller may be represented in mathematical form as,

$$u(t) = k_1[e(t) + \frac{1}{T_i}\int_0^t e(t)d + T_d \frac{de(t)}{dt}] \tag{1}$$

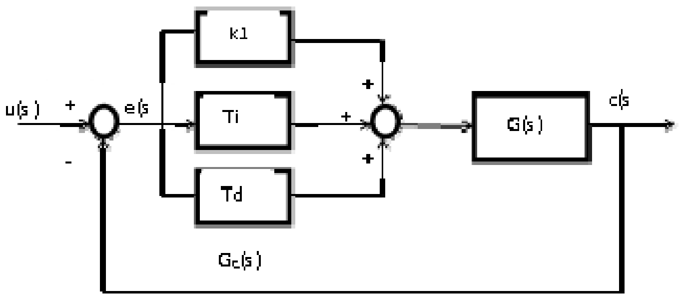

Fig. 1. PID controller block diagram

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With the given block diagram *u*(s) denote control signal and *e*(s) denotes the error signals of the system. Here k_1 represent the proportion gain and T_i , T_d used for the integral and derivative time constants respectively. The transfer function $G_c(s)$ of the corresponding PID controller is given as

$$G_c(s) = k_1[1 + \frac{1}{T_i s} + T_d s] \tag{2}$$

Equation (2) can be rewritten as

$$G_c(s) = k_1 + \frac{k_2}{s} + k_3 s \tag{3}$$

Here k_2 and k_3 used for integral gain and derivative gain values of the controller respectively.

The objective is to derive a controller such that the performance of the augmented process matches with the desired performance of the model. In the computational system, the desired performance should be satisfied by the closed loop control system. To fulfill these entire requirements a PID controller is derived in form of full order and fractional order.

III. FRACTIONAL ORDER SYSTEM FUNDAMENTALS

A. The introduction to fractional calculus.

The term "fractional-order calculus" is by no means new. It is a generalization of ordinary differentiation by non-integer derivatives. The theory of fractional-order derivatives was developed mainly in the 19th century [8-11]. In the development of fractional order calculus, there appeared different definitions of fractional-order differentiation and integration. To reduce to a general form fractional calculus from integration and differentiation to the fractional order fundamental operator $\alpha D_t^{\beta} f(t)$, where α and t are the limit and $\beta \in R$ is the directive of operation. The continuous integration differential operator is [12]

$$\alpha D_t^{\beta} f(t) = \begin{cases} \dfrac{d^{\beta}}{dt} \cdots \beta > 0 \\ 1 \cdots \beta = 0 \\ \displaystyle\int_{\alpha}^{t} (d\tau)^{-\beta} \cdots \beta < 0 \end{cases} \tag{4}$$

There are various definitions for fractional integration and differentiation. Some of the definitions spread out directly as of integer-order calculus. The deep-rooted descriptions include the Cauchy integral formula, the Grunwald–Letnikov (GL) definition and Riemann–Liouville (RL) definitions are given [12] as

Definition 1: - Cauchy integral formula

$$D^{\gamma} f(t) = \frac{\Gamma(\gamma - 1)}{2\pi j} \int_{c} \frac{f(\tau)}{(\tau - t)^{\gamma + 1}} d\tau \tag{5}$$

Where c is the smooth curve encircling the single value function f (t)

Definition 2: - Grunwald–Letnikov (GL) definition

$$\alpha D_t^{\beta} f(t) = \begin{matrix} Lim \\ h \to 0 \end{matrix} h^{-\beta} \sum_{j=0}^{\left[\frac{t-\alpha}{h}\right]} (-1)^j \binom{\beta}{j} f(t - jh) \tag{6}$$

Here [.] represent the integer part.

Definition 3: - Riemann-Liouville (RL) definition

$$\alpha D_t^{\beta} f(t) = \frac{1}{\Gamma(n - \beta)} \frac{d^n}{dt^n} \int_{\alpha}^{t} \frac{f(\tau)}{(t - \tau)^{\beta - n + 1}} d\tau \tag{7}$$

The following function given below is obtained by Laplace Transform of the GL and RL fractional differential-integral. The zero initial conditions and order β gives the following result

$$\ell[\alpha D_t^{\pm\beta} f(t); s] = s^{\pm\beta} F(s) \tag{8}$$

B. Fractional order system

The fractional-order system is the extension form of the traditional integer order systems. Fractional order system is gained from the fractional-order differential equations. A classic n-term linear fractional order differential equation (FODE) is assumed by

$$\alpha_n D_t^{\beta_n} y(t) + \ldots + \alpha_1 D_t^{\beta_1} y(t) + \alpha_0 D_t^{\beta_0} y(t) = 0 \tag{9}$$

Let considering the control function on which input signal is applied to FODE system Eq. (9) as follows:

$$\alpha_n D_t^{\beta_n} y(t) + \ldots + \alpha_1 D_t^{\beta_1} y(t) + \alpha_0 D_t^{\beta_0} y(t) = u(t) \tag{10}$$

After Laplace transform of Eq. (10), we get

$$\alpha_n s_t^{\beta_n} Y(t) + \ldots + \alpha_1 s_t^{\beta_1} Y(t) + \alpha_0 s_t^{\beta_0} Y(t) = U(t) \tag{11}$$

From Eq. (11), we can obtain a fractional-order transfer function as

$$G(s) = \frac{Y(s)}{U(s)} = \frac{1}{\alpha_0 s^{\beta_0} + \alpha_1 s^{\beta_1} + .. + \alpha_n s^{\beta_n}} \tag{12}$$

In broad, for a dynamic system with single variable and fractional order transfer function of a system can be defined as

$$G(s) = \frac{b_0 s^{\gamma_0} + b_1 s^{\gamma_1} + \ldots + b_m s^{y_m}}{a_0 s^{\beta_0} + a_1 s^{\beta_1} + \ldots + a_n s^{\beta_n}} \tag{13}$$

Here $b_i (i = 0,1 \ldots m), a_i (i = 0,1 \ldots n)$ are constant and $\gamma_i (i = 0,1 \ldots m), \beta i (i = 0,1 \ldots n)$ are random real or rational number and without lacking generality, can be prescribed as $\gamma_m > \gamma_{m-1} > \ldots \gamma_0$ and $\beta_m > \beta_{m-1} > \ldots \beta_0$

The incommensurable fractional order system Eq. (13) can also be expressed incommensurable form by the multi-valued transfer function

$$H(s) = \frac{b_0 s + b_1 s^{\frac{1}{v}} + \ldots + b_m s^{\frac{m}{v}}}{a_0 s + a_1 s^{\frac{1}{v}} + \ldots + a_n s^{\frac{n}{v}}}, (v > 1). \tag{14}$$

Note that every fractional order system may be represented in the form of Eq. (14) and domain of H(s) meaning is a Riemann sheets.

IV. STABILITY OF FRACTIONAL ORDER SYSTEM

Stability is one of the most frequent terms used in literature when we deal with the dynamical systems and their behaviors. In mathematical vocabulary, stability theory addresses the convergence clarifications of differential or difference equations. A system (LTI) is said to be stable if the roots of characteristics polynomial are had negative real part. In the case of fractional order system (LTI), the stability is not same as of integer one. Important point is that, for a fractional order system, the roots may lie on the right half of complex plane Fig. (2).

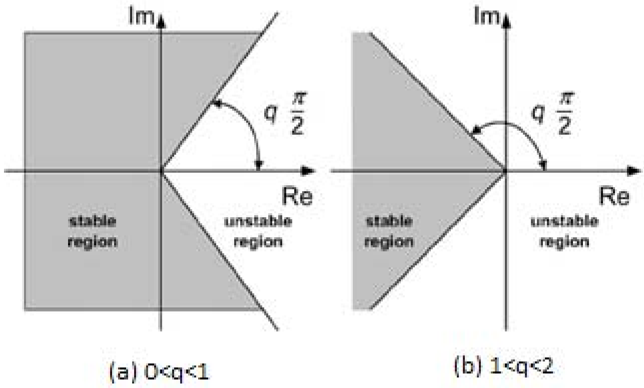

Fig. 2. Stable and unstable region of LTI fractional order system

Theorem: - According to Matignon's stability theorem the fractional order transfer function $G(s) = \frac{N(s)}{D(s)}$ is stable if and only if $|\arg(\sigma_i)| = q\frac{\pi}{2}$, where $\sigma = s^q$, $(0 < q < 2)$ with $\forall \sigma_i \in C$, i^{th} root of $D(\sigma) = 0$.

If $s = 0$, is a single root of D(s), the system cannot be stable.

Above theorem stability region is shown in Fig. (2), Indicate the wholes s plane where $q = 0$. It shows the Routh-Hurwitz stability and $q = 1$ tends to the negative real axis for $q = 2$.

As we know that only the poles play an important role in the stability of a system. So the stability assessment is done by denominator only and numerator does not affect the stability of an FOTF. The stability of fractional order system can be analyzed in another way also. Let considering here, the characteristic equation of a general fractional order system as:

$$\alpha_0 s^{\beta_0} + \alpha_1 s^{\beta_1} + \ldots + \alpha_n s^{\beta n} = \sum_{i=0}^{n} \alpha_i s^{\beta_i} = 0 \tag{15}$$

For $\beta_i = \frac{v_i}{v}$, we can transform the Eq. (15) into the σ-plane.

$$\sum_{i=0}^{n} \alpha_i s^{\frac{v_i}{v}} = \sum_{i=o}^{n} \alpha_i \sigma^{v_i} = 0 \tag{16}$$

Here $\sigma = s^{\frac{k}{m}}$ and m is the least common multiple of ν.

For a given αi, if the absolute phase of all roots of transform Eq. (16) is $|\phi_\sigma| = |\arg(\sigma)|$, we can close the following points for the stability of fractional order systems.

1. The stability condition is as $\frac{\pi}{2m} < |\arg(\sigma)| < \frac{\pi}{m}$.

2. The oscillation condition is as $|\arg(\sigma)| = \frac{\pi}{2m}$.

If any linear time invariant (LTI) fractional order system satisfy the above two points then the system is stable otherwise unstable.

V. FRACTIONAL ORDER CONTROLLER DESIGN

Maximum of the works in fractional order control systems are in hypothetical nature. Controller design and application in run-through is very small. In this paper, the core objective is to spread on the fractional order control (FOC) to examine the system control performance. The fractional-order $PI^{\lambda} D^{\mu}$ controller was proposed as a broad view of the PID controller with integrator of real order λ and differentiator of real order μ. The transfer function of such kind the controller in Laplace domain has form

$$C(s) = K_P + \frac{K_I}{s^{\lambda}} + K_D s^{\mu}, (\lambda, \mu > 0) \tag{17}$$

Here K_P is the proportional gain constant K_I is the integral gain constant and K_D is the derivative gain constant. If λ=1and μ=1, we obtained a classical PID controller. If λ=0 and μ=0, we obtained a PD^{μ} and PI^{λ} controller respectively. These entire controllers are the case of $PI^{\lambda}D^{\mu}$ controller, which provides flexibility with an opportunity to adjust the dynamic property of fractional order control system. Two steps are used here to design such controllers.

Step 1: - Design of K_P

Overshoot in percentage [Pr], settling time in second [Ts] and static error in percentage [Et] belongs to Proportional gain K_P. In general, K_P can be obtained by

$$K_P \geq \left(\frac{100}{E_t} \right) \tag{18}$$

Here Proportional gain K_P is selected for minimum static error.

Step 2: - Design of K_D, μ, K_I and λ

To determine these values for Fractional-Order controller design, the following synthesis scheme is used here.

Let the controller transfer function is C(s), Plant transfer function is G(s) and a unity feedback is applied to the system. Phase margin of controlled system [13 and 14] is

$$\Phi_m = \arg[C(j\omega_g)G(j\omega_g)] + \pi \tag{19}$$

Here $j_{\omega g}$ is the crossover frequency. Phase margin is an independent or constant phase. This can be accomplished by controller of the form

$$C(s) = k_1 \frac{k_2 s + 1}{s^v}, k_1 = \frac{1}{K_{plant}}, k_2 = \tau \tag{20}$$

Here K_{plant} is the gain of plant and τ is the time constant for the plant.

Now from the Eq. (19) and Eq. (20)

$$\begin{cases} \phi_m = \arg[C(j\omega_g)G(j\omega_g)] + \pi \\ \quad = \arg\left[\frac{k_1 k_{plant}}{j\omega^{(1+v)}} \right] + \pi \\ \quad = \arg\left[(j\omega)^{-(1+v)} \right] + \pi \\ \quad = \pi - (1+v)\frac{\pi}{2} \end{cases} \tag{21}$$

Here for a given plant, we fix the gain margin. Put the gain value in Eq. (21) one can find out the value of v. the other desired values k_1 and k_2 are obtained from Eq. (20). Now using these constant in Eq. (20), we can obtain a fractional I^{λ} D^{μ} controller, which is a particular case of $PI^{\lambda}D^{\mu}$ controller has the form

$$C(s) = k_1 k_2 s^{(1-v)} + k_1 s^{-v}; K_D = k_1 k_2 and K_I = k_1 \tag{22}$$

If the value of K_P is given then the full transfer function of fractional order controller is

$$C(s) = K_P + K_D s^{(1-v)} + K_I s^{-v} \tag{23}$$

If do a comparison with Eq. (17), we can say

$$\mu = (1-v) and \lambda = v.$$

VI. CONTROLLER DESIGN USING ZIEGLER-NICHOLS SECOND METHOD

In this method, we first set T = ∞ and T_d = 0. By use the proportional control action increase K from 0 to a critical value K_{cr} at which the output exhibits sustained oscillations in the system Fig (3).

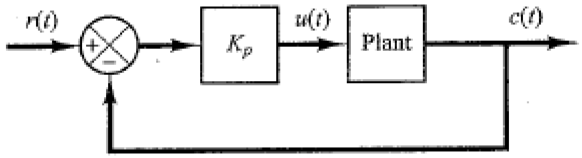

Fig. 3. Closed loop system for proportional controller

Thus, the critical gain K_c and the corresponding period P_{cr} are determined by experiment. According to Ziegler-Nichols method the values of the parameters K_p , T_i and T_d can be obtained by the formulas shown in Table 1.

TABLE I

For Critical Gain and Critical Period

Type of controller	K_p	T_i	T_d
P	0.5 K_{cr}	∞	0
PI	0.45 K_{cr}	1/1.2 P_{cr}	0
PID	0.6 K_{cr}	0.5 P_{cr}	0.125 P_{cr}

The PID controllers tuned by the second method of Ziegler-Nichols rules give [15].

$$Gc(s) = K_p(1+\frac{1}{T_i s}+T_d s) \tag{24}$$

$$= 0.6K_{cr}(1+\frac{1}{0.5P_{cr}s}+0.125P_{cr}s)$$

$$= 0.075K_{cr}P_{cr}\frac{(s+\frac{4}{P_{cr}})^2}{s} \tag{25}$$

Equation (25) shows that the PID controller has a pole at the origin and double zeros at $s=\frac{-4}{P_{cr}}$.

VII. EXAMPLES

Consider the control system [16] given in below figure, in which a PID controller is used to control the system Fig. (4). Here the objective is to analysis the stability of the system and designs the controller by proposed approach.

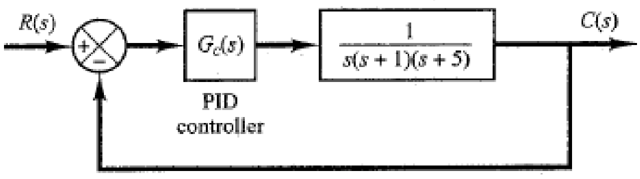

Fig. 4. PID control and two degrees of freedom control

A. Stability Check and Controller Design by Ziegler-Nichols Method

The first requirement is to find out the starting point for K_p and double zeros. Let start the tuning with considering the K_p only. Here the closed loop response is

$$Gcl_{ZN} = \frac{C(s)}{R(s)} = \frac{K_P}{s(s+1)(s+5)+K_P} \tag{26}$$

By the help of Routh-Hurwitz criteria, the value of K_{cr} for sustained oscillations is K_{cr} = 30. So after putting this value in characteristic equation the value of critical frequency is $\omega = \sqrt{5}$. Now with the help of table 1other values are

$$P_{cr} = \frac{2\pi}{\sqrt{5}} = 2.8099$$

$$K_P = 0.6K_{cr} = 18$$

$$T_i = 0.5P_{cr} = 1.405$$

$$T_d = 0.125P_{cr} = 0.35124$$

After putting the values in $Gc_{ZN}(s) = K_p(1+\frac{1}{T_i s}+T_d s)$ we find out the controller transfer function $Gc_{ZN}(s) = \frac{6.3223(s+1.4235)^2}{s}$, here the double zeros exists on s = -1.4235.

So here the initial values are obtained. As the requirement of industry, we can set the value of maximum overshoot in programming. Generally, according to the better establishment of the system, the overshoot should be between10% to 40%. Using the MATLAB program, we vary the gain 90 to 3.5 with step size -0.2 and zeros as 7 to 0.3 with step size -0.2. Fine tuning gives the following results Fig. (5) and Fig. (6).

Gain (K) = 21and Zeros (a) = 0.4

Maximum overshoot (m) =1.0995

The final close-loop transfer function of the system is

$$Gcl_{ZN}(s) = \frac{6.3223s^2+18s+12.8111}{s^4+6s^3+11.3223s^2+18s+12.811} \tag{27}$$

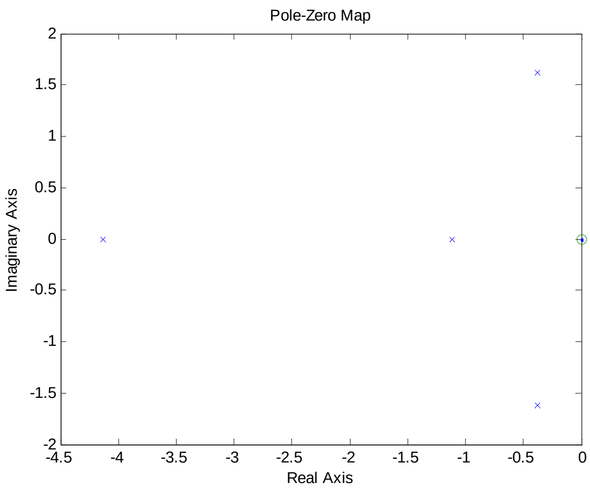

Fig. 5. Pole location on Pole-Zero Map

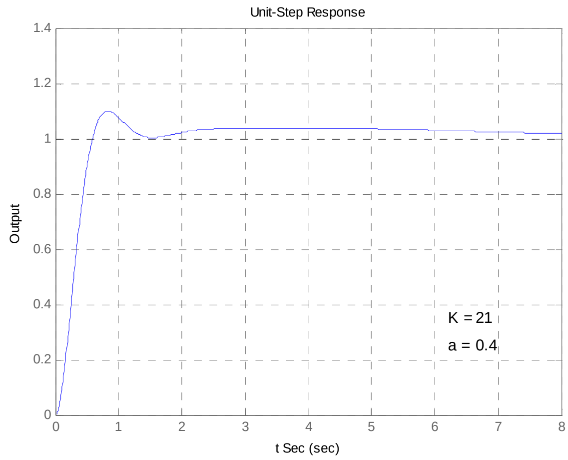

Fig. 6. Unit step response of the closed loop system

B. Stability Check and Controller Design by Fractional-Order Method

Consider the transfer function model of plant in given example is

$$G_{Plant} = \frac{1}{s(s+1)(s+5)} \tag{28}$$

Here s = -5 is non-dominant pole and it does not affect the plant stability so we can eliminate it. After removing the dominant pole the transfer function of the plant is

$$G_{Plant} = \frac{0.2}{s(s+1)} \tag{29}$$

We are using here the technique proposed in section 4 for fraction order controller design. According to this

Step 1: - To design the K_P

For minimum static error the value of proportional gain K_P=10, from Eq. (29)

Step 2: - Design of K_D, μ, K_I and λ

The value of a time constant $\tau = 1$ and gain of Plant $K_{Plant} = 0.2$ respectively Eq. (29).

If we fix to gain margin $\phi m >= 60^0$ for the given control system. Then we find out the value of v = 0.3 by Eq. (21). The other desired value $k_1 = 5$ and $k_2 = 1$ obtained from Eq. (20). Now putting these values in Eq. (22), we got

$$C_{FO}(s) = 5s^{0.7} + \frac{5}{s^{0.3}} \tag{30}$$

Now adding the value of K_P = 10 from step 1into Eq. (30), we got final transfer function of fractional order controller as

$$C_{FO}(s) = 10 + 5s^{0.7} + \frac{5}{s^{0.3}} \tag{31}$$

The open loop control system for controller and plant is

$$G_{ol}(s) = \frac{5s + 10s^{0.3} + 5}{s^{2.3} + s^{1.3}} \tag{32}$$

The close-loop transfer function of given control system with unity feedback is obtained as

$$G_{cl}(s) = \frac{C(s)G_{Plant}(s)}{1 + C(s)G_{Plant}(s)}$$

Or

$$G_{cl}(s) = \frac{5s + 0.8s^{0.3} + 5}{s^{2.3} + s^{1.3} + 5s + 10s^{0.3} + 5} \quad (33)$$

The function *isstable* checked the denominator of Gcl(s), $s^{2.3}+s^{1.3}+5s+10s^{0.3}+5$ and it is found that K=1, indicate the system is stable. Here Fig. (7) Shows that system controlled by fractional order controller has more stability region and Fig. (8) Indicate that the complete designed system is stable. Figure (9) represents the comparison between both type controller designs.

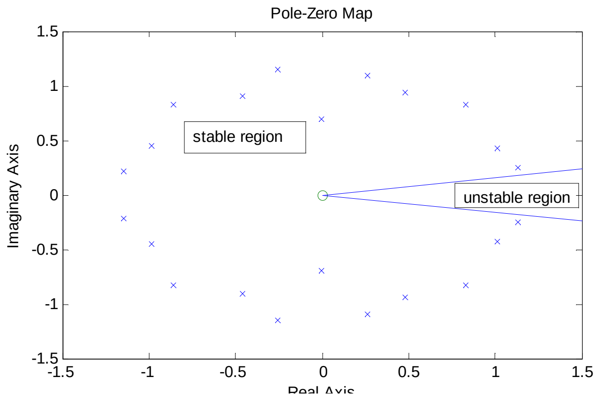

Fig. 7. Pole position of a closed loop system

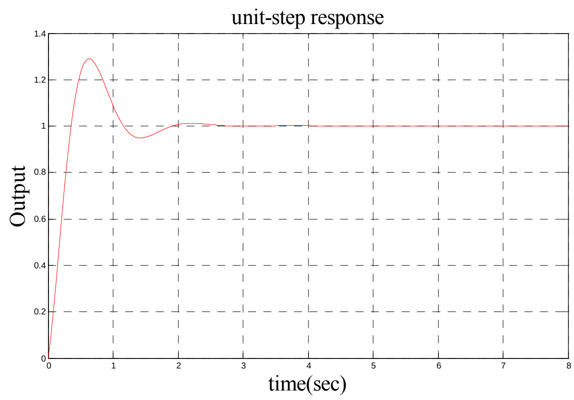

Fig. 8. Step response of closed loop system

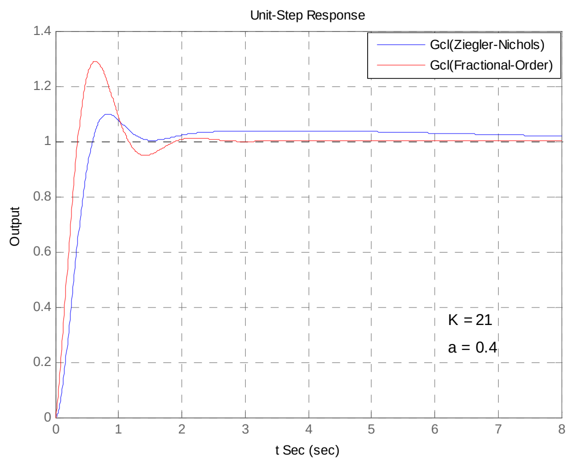

Fig. 9. Simultaneously unit step response of both systems

TABLE II

Comparison for Performance Specification of Designed Controller

Controller design	Ziegler-Nichols Method	Fractional-Order Method
Models	**Full Model**	**Full Model**
Specifications	G (s)	G (s)
Rise time (sec)	0.394	0.25
Settling time (sec)	7.74	2.6
Peak amplitude	1.1	1.291
Overshoot (%)	9.95	29.1
At time (sec)	0.83	0.62

VIII. CONCLUSIONS

On behalf of the result shown in the table 2, some important point may be described for tuning of the controller. All basic ideas of fractional calculus, the stability of fractional order system and MATLAB function are presented here. The main purpose of the paper is to draw attention to fractional order system stability and analysis over a conventional way. Here an integer order plant is controlled by full order controller and fractional order controller. It concludes here that the fractional order system has a large region for stability which improves the performance of the system. Here all transient parameter of fractional order controller design system has better performance over conventional controller design except overshoot. Here the maximum overshoot is 29.1 % in comparison to 9.95%, but it's not a problem because due to this, the response is fast and till 40 % the overshoot is accepted in the general system design. We believe that the comparative approach used in this paper is useful for selecting the method of controller design.

REFERENCES

[1] Per-Olof, G. Carl Fredrik, Mannerfel and P. Molander, "Contributions to the model reduction problem," IEEE Transactions on Automatic Control, Vol. AC-27, No. 2, April 1982, pp. 454-455.
[2] B. Bandyopadhyay, A. Rao and H. Singh, "On Pade approximation for multivariable systems," IEEE Trans. Circuits and Systems, Vol. 36, No. 4, pp. 638-639, 1989.
[3] Y. Smamash "Truncation method of reduction," A viable alternative electronic letters' 22nd January, 1981, Vol. 17, No. 2, pp. 97-98.
[4] M. Jamshidi, "An overview on the aggregation of large scale systems," 1981, pp. 9-92.
[5] Y. Shamash, "Model reduction using the Routh stability criterion and the Pade approximation technique," Int. J. Control, Vol. 21, No. 3, pp.475-484, 1975.
[6] Axtell M., Bise E. M., "Fractional calculus applications in control systems," In Proceeding of the IEEE 1990 National Aerospace and Electronics Conference, New York, 1990, pp. 563–566.
[7] Dorcak L., "Numerical models for simulation the fractional-order control systems," UEF SAV, The Academy of Sciences Institute of Experimental Physics, Kosice, Slovak Republic, 1994, pp. 62–68
[8] Oldham K. B. and Spanier J., "The Fractional Calculus," New York, Academic Press, 1974
[9] Podlubny I., "Fractional Differential Equations," San Diego, Academic Press, 1999
[10] Miller K. S., Ross B., "An Introduction to the Fractional Calculus and Fractional Differential Equations," New York, Wiley, 1993
[11] Samko S. G., Kilbas A. A. and Marichev O. I., "Fractional Integrals and Derivatives and Some of Their Applications," Minsk: Nauka i Technika, 1987
[12] Y. Q. Chen, Ivo Petras and Dingyu Xue, "Fractional Order Control," A Tutorial, American Control conference, June 10-12, 2009
[13] Bidan P., "commande diffusive dune machine electric introduction," ESAIM proceeding, vol. 5, France, 1998, pp. 55-68
[14] VINAGRE, B. M. Podlubny, I. Dorcak, L. Feliu, V., "On Fractional PID Controllers: A Frequency Domain Approach," Proceeding of the IFAC Workshop on Digital Control PID'00, Terrassa, Spain, 2000, pp. 53-55.
[15] C.C. Hang, K. J. Astrom and W. K. Ho, "Refinement of the Ziegler-Nichols tuning formula," IEEE Proceeding a Control Theory and Application, Vol. 138, No. 2, pp. 111-118, 1991.
[16] K. Ogata, Modern Control Engineering, 4th ed., Englewood Cliffs, NJ: Prentice Hall, 2001."

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