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IMC based PID Controllers Retuning and It's Performance Assessment

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Abstract

Internal Model Control (IMC) is the basis of a systematic program Q on the parameters of the concept and is based on the many modern control technology control system design. What makes IMC particularly attractive is that it presents a method to design the Q-parameterization controller has two basic demands of reality. Therefore, IMC has been a popular design process processing industry, especially as a means for adjusting the single-loop, PID controllers. In this paper, we propose an optimal filter design IMC IMC-PID controller for unstable process better set point tracking. The controller is suitable for different values of the filter tuning parameters to achieve the desired response in due IMC method is based on pole-zero offset, including IMC design principle method causes the response sets a good point. However, in a stable long lag time of load disturbances leading to undesirable process which is the result of the IMC control industry. [1]

Keywords: Internal Model Control (IMC), Proportion Integral Derivative (PID), Q-parameters

I. INTRODUCTION

Design IMC design process is quite extensive and diverse. Has developed a number of forms; These include single-input, single-output (SISO) and multiple-input, multiple-output (MIMO) formulations, continuous-time and discrete-time design process, the design process unstable open-loop system, combined with feedback - feedforward IMC design and so on. In addition to designing the controller, IMC evaluation and feedback control is related to the basic requirements, such as determining the non-minimum phase element (delay and RHP (RHP) zero) is helpful to realize the impact on control performance. Due to the complexity of the IMC controller depends on the order model and control performance requirements, IMC design also helps determine when simple feedback control structure (such as a PID controller) is sufficient.

IMC is a commonly used technique, which provides a transparent mode for various types of control design and tuning. The proportional-integral (PI), in order to meet the target of most of the control capacity and proportional - integral - derivative (PID) controllers, leading to its widespread acceptance in the control industry. Internal Model Control (IMC) based approach to the design of the controller is using the IMC, which is equivalent to the use of one of the IMC PID control in industrial applications.

Used in industrial process control applications and IMC IMC-based PID controller, there is an optimal filter structure for each specific process model to get the best performance of PID. For a given filter structure, when λ decreases, the contradiction between the ideal and the increase in PID controller, while the nominal IMC performance improvement. [2]

II. IMC Background in process control, model-based control system is mainly used to obtain the desired set point and reject small external interference. Internal Model Control (IMC) design is based on the control system contains the control, then you can achieve a perfect control process the fact that some of the statements. Therefore, if the control architecture based on an accurate model of the process has been developed and mathematically perfect control is possible.

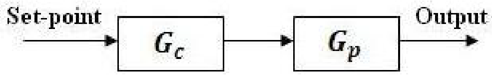


Figure 2.1 Open Loop Control Strategy [2]

Output = Qc * Gp * Set-point Qc = controller Gp = actual process Gp* = process model Qc =inverse of Gp* If Gp = Gp* (the model is the exactly same as the actual process) Output is: Y(s) = Qc * Gp * Set-point = (1/ Gp*)* Gp * Set-point = Set point

III. BASIC STRUCTURE

Special features include the IMC process model structure, which is parallel with the actual process or plant. Here, '*' has been Associated with the model for the signal representation.

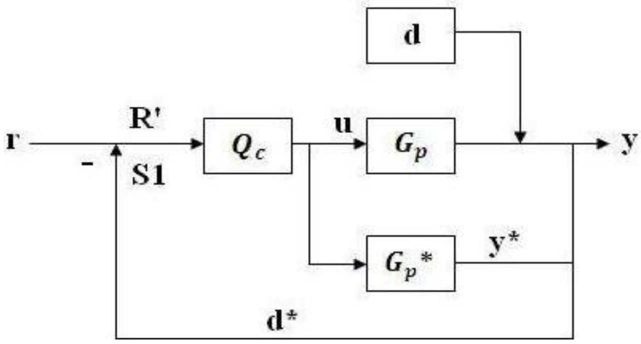
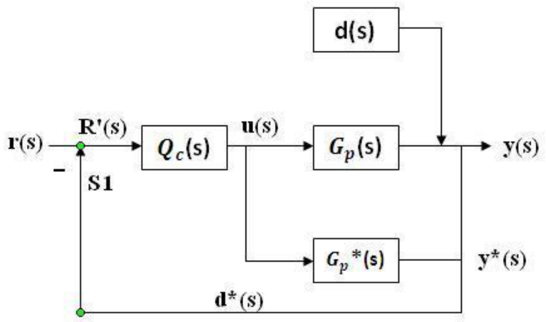


Figure 3.1 Structure of IMC [2]

IV. IMC PARAMETERS

The various parameters used in the IMC basic structure shown above are as follows: Qc= IMC Gp= actual process Gp*= process model r= set point r'= modified set point u= manipulated variable (controller output) d= disturbance d*= calculated new disturbance y= measured process output y*= process model output New calculated disturbance: d*= (Gp - Gp*)u +d Modified set-point or signal to the controller: r'= r- d*= r- (Gp - Gp*) u – d A model is perfect if process model is same as actual process, i.e. Gp=Gp* And no disturbance means d=0. Thus we get a relationship between the set point r and the output y as y = Gp.Qc .r

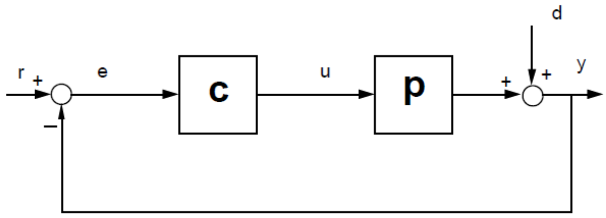
V. IMC STRATEGY



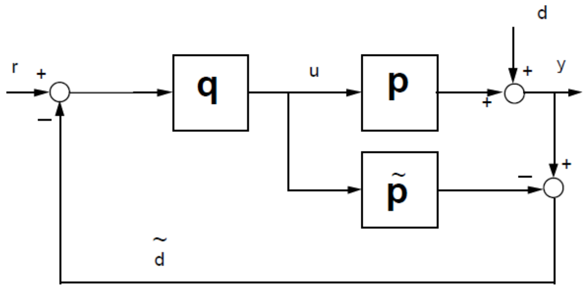
In the above figure, d(s) is the unknown disturbance affecting the system. The manipulated input u(s) is introduced to both the process and its model. The process output, y(s), is compared with the output of the model resulting in the signal d*(s). Hence the feedback signal send to the controller is d*(s) = [Gp(s) – Gp*(s)].u(s) + d(s) The error signal r'(s) comprises of the model mismatch and the disturbances which is send as modified set-point to the controller and is given by r'(s) = r(s) – d*(s) And output of the controller is the manipulated variable u(s) which is send to both the process and its model. u (s) = r'(s) *Qc(s) = [r(s) – d*(s)] Qc(s) = [r(s)–{[Gp(s)–Gp*(s)].u(s)+d(s)}] . Qc(s) u (s) = [[r(s)–d(s)]*Qc(s)] / [1+{Gp(s) – Gp*(s)} Qc(s)] But y(s) = Gp(s) * u(s) + d(s) Hence, closed loop transfer function for IMC is y(s) = {Qc(s). Gp(s). r(s) + [1 – Qc(s) . Gp* (s)] . d(s)} / { 1 + [Gp(s) – Gp* (s)] Qc(s) } Also improve the system model mismatch effects should be minimized robustness. Since mismatch between the model and the actual process usually occurs in the high frequency response of the system frequency, the low pass filter F (s) is added to prevent mismatch of. Therefore, the internal model controller is designed to process model, which in series with a low pass filter, i.e. the inverse Q(s) = Qc(s)*f(s) Order of the filter is selected to be suitable to correct or at least half (e.g., the order is equal to the molecular order of the denominator). The resulting closed loop becomes y(s) = {Q(s) . Gp(s) . r(s) + [1 – Q(s) . Gp* (s)] . d(s)} / { 1 + [Gp(s) – Gp* (s)] Q(s) }

VI. STRUCTURE - (IMC)

Internal Model Control (IMC) formed the basis for control system design approach system is the focus of this article. People need to know about IMC's first problem is that IMC structure (from the IMC design phase difference). Figure 6.1 (a) is displayed as shown in "Internal Model Control" or "Q-parameter of the" structure. Structure and classic IMC feedback Structure 6.1 (b) shows the point to its equivalent.



(A)



(B)

Figure 5.1 (C) shows the evolution of IMC structure. We will prove, Q (S) design is more simple than C (S) designs. Its design Q (S), which is equivalent classic feedback controller C (s) can be easily obtained by the algebraic transformation, and vice versa. [3] *c=q1−qp* q=c1+cp For linear, in the absence of constraints on the stability of U plants, it makes no difference whether it is achieved by c or q controller.

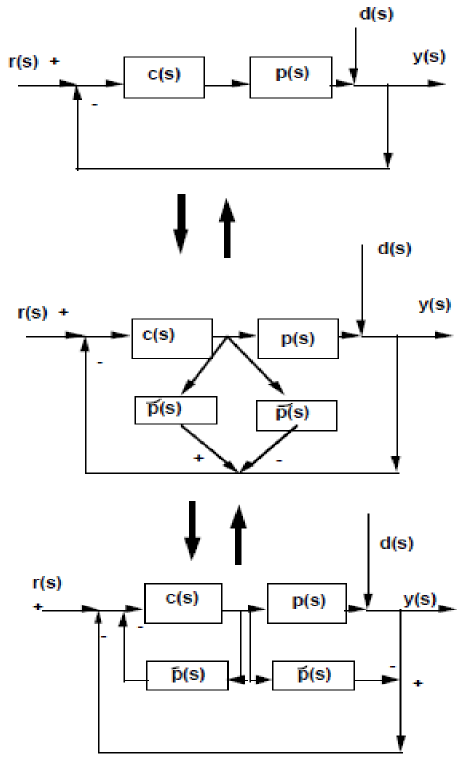


Figure 6.1(c) [3] However, there is no actuator constraints IMC structure can be used to avoid input saturation, without the need for special measures to produce anti-saturation stability problems.

VII. CLOSED-LOOP TRANSFER FUNCTIONS FOR IMC

Sensitivity and complementary sensitivity η & ε operators are used to define a classical linear behavior of the closed-loop feedback control system. y=ŕ + d' u=p−1η(r−d) $\boldsymbol{e}$c=Ɛ(r−d) We also know η=pc(1+pc)−1 for classical feedback control system. A statement of the sensitivity and complementary sensitivity operators in terms of the internal model pˆand the IMC controller q(s) corresponds to: η s =pq1+(p−p) Ɛ s =1−p̂q1+q(p−p)

In the absence of model mismatch (p= p), these functions simplify to $\hat{s}$ =$p\hat{q}$ $\hat{s}$ =1− $\hat{s}$ =1−$p\hat{q}$ $p\hat{}$−1=q which lead to the following expressions for the input/output relationships between y, u, ec, r and d: y=$p\hat{q}r$− 1−$p\hat{q}$ d u=(r−d) ec= 1−$p\hat{q}$ (r−d) From the above equation, we can recognize that the benefits of the IMC parameter. Closed-loop set point r and the reaction between the output y can be determined easily from the product pq of a simple nature. Furthermore, in response to the manipulated variable q is determined by design. As a result, both the control system simplifies the task of analysis and synthesis. [4] **VIII. Internal Stability** Internal Stabilizer (IS) is a key requirement of any control system theory. In a stable system of internal controls, bounded presented the results of the control system in a bounded output signal everywhere from anywhere in the control system of the input signal. For IMC structure, we have important results of the internal stability of the following:

1. Assuming a perfect internal model (P=Pˆ). IMC control system is internally stable if and only if p and q are stable.
2. Assuming a stable and p is p = pˆ, then the feedback system is in the classic stable if and only if q is stable.

These results apply to IMC structure, even if pˆ and q are non-linear operator. According to fabless does not match the open-loop, linear systems under stable conditions, IMC structure, thus providing feedback relative to traditional following benefits:

- It eliminates the need to address the roots of the characteristic polynomial 1 + PC's; stability can only be determined by examining polesof q also.
- You can search for Q instead of C without any loss of generality.

VIII. IMC BASED PID STRUCTURE

In the IMC structure the point of comparison between the process and the model output can be moved as shown in the figure below to form a standard feedback structure which is nothing but another equivalent feedback form of IMC structure know n as IMC based PID structure. [5,6]

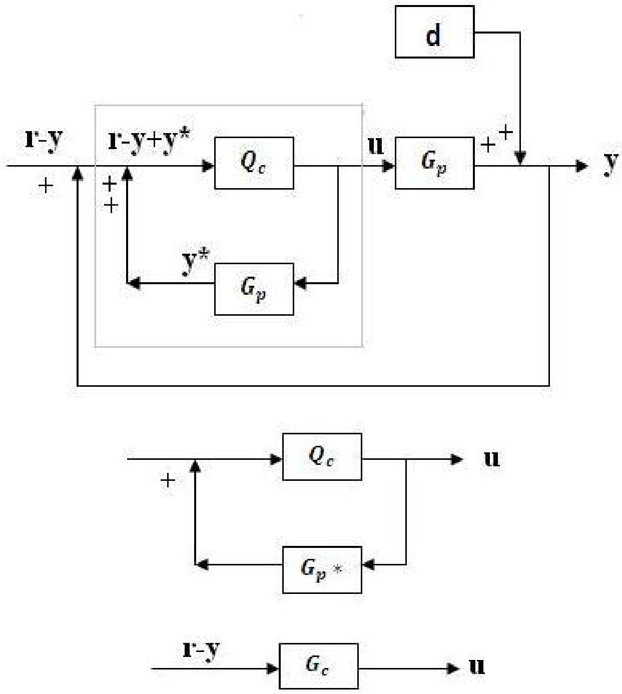


Figure 9.1 IMC and IMC based PID structure

8.1. For first order:

Gc(s) = [Kc . (Ti .s + 1)]/ (Ti. s) And we find that Kc and Ti (PI tuning parameters) Kc=Tp/(lem*Kp); Ti= Tp Similarly for 2nd order we compare with the standard PID controller transfer function given by:[7,8] Gc(s) = Kc.[(Ti . Td . s^2+Ti . s+1)/Ti . s]. [1/ Tf . s+1] Where, T = Tau (constant); Ti = integral time constant; Td = derivative time constant; Tf = filter tuning factor Kc = controller gain

IX. IMC BASED PID FOR 2ND ORDER SYSTEM

Now we apply the above IMC based PID design procedure for a second order system with a given process model.

9.1 Given process model:

Gp*(s) = Kp*/[(Tp1*(s)+1).(Tp2*(s)+1)] Gp*(s) =Gp*(+)(s).Gp*(-)(s) = 1.Kp*/ [Tp*(s)+1] Qc*(s) = inv[Gp*(-) (s)] = [Tp*(s)+1] / Kp* Qc(s) = Qc*(s). f(s) = [Tp*(s)+1] / [Kp*.(lem(s) + 1)] f(s) = 1 / (lem. s + 1) [9]

9.2. Equivalent feedback controller using transformation: Gc(s) = Qc (s)/(1-Qc(s) Gp*(s)) =[Tp1 .Tp2 s^2 +(Tp1 +Tp2)s+1] / [Kp . lem . s] (It is the transfer function for the equivalent standard feedback controller) Gc(s) =[Kc.(Ti .Td.s^2 + Ti.s+1)]/ [Ti. s] (transfer function for ideal PID controller for second order)[10] **12.3 PID tuning parameters (on comparison)** Kc = (Tp1 + Tp2) / (Kp. lem) Ti = Tp1 + Tp2 Td= Tp1.Tp2/ (Tp1 + Tp2)

X. CONCLUSION

The IMC and IMC-based PID controller can successfully achieve any industrial process because it is present in the plant uncertainty parameters sufficiently strong. IMC-based PID controller algorithm is robust and simple processing model uncertainty, therefore, IMC-PID tuning method seems to be a useful tradeoff between performance closed-loop systems, we achieved robust build inaccurate single-mode tuning parameters. It also provides a good solution in the process of a significant time delay is actually working in the real-time situation. IMC has to compensate the model uncertainty and disturbance open-loop control does not have the ability to attach advantage.

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