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Effect of Disturbance on Closed-Loop Control System

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ABSTRACT: This paper tackles the disturbances in control operation in close-loop and its effect on the system by studding transfer function in presence and absence of disturbances. An example controlling a mechanical system is taken and the unexpected outside element effect consider here as disturbance, the close-loop feedback transfer function of the system. The model of the mechanical system is showing the effect of the disturbances obviously to the all system.

KEYWORDS: Disturbance, sensor noise (feedback), in put or set-point, output..

I. INTRODUCTION

Knowing disturbances basic systems helps control system to identify and monitor the disturbances which constitute a waste of the actual value produced from any system close- loop [1] .

so the best way to get rid of and eliminate disturbances in the systems is the use of system feedback to enable the control system to monitor the disturbances and processing system so as to reduce or minimize disturbances to reach value system
To a state of stability [2].

II. EFFECT OF DISTURBANCE

There are certain factors that affect control operation in close-loop system, some of which are disturbances as shown in (figure 1), in this system, the control unit counts error in input (set point) and variables (out-put , sensor noise and disturbance) to decrease error since that will affect active operation as time passes on the controller repeats measurement of results unit the error reaches zero level ,that is most often being result out form disturbance [3][4], the following three cases discuss the idea of Disturbance on Closed-Loop Control System.

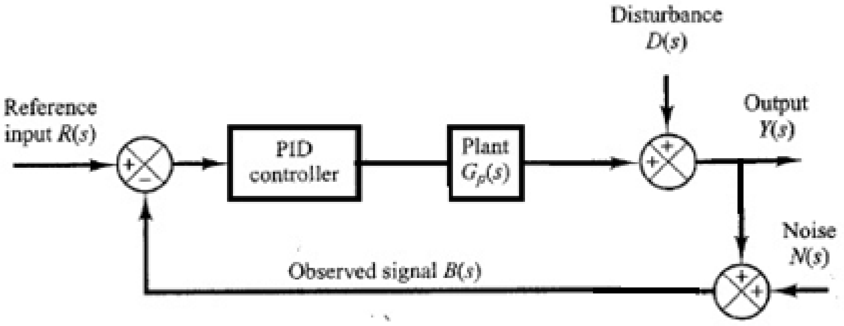

Fig. 1. Block Diagram of close loop system

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Case 1:

If disturbances value and sensor noise signal (feedback signal) being disabled to zero point and the PID controller is Gp(s) , error process variables and transfer function are given by input and output only. These changes in input cause the controller unit to perform a new successive controlling effect that in turn drive variables processes upwards or down according to physical characteristics processing in Figure (2) ,[5].

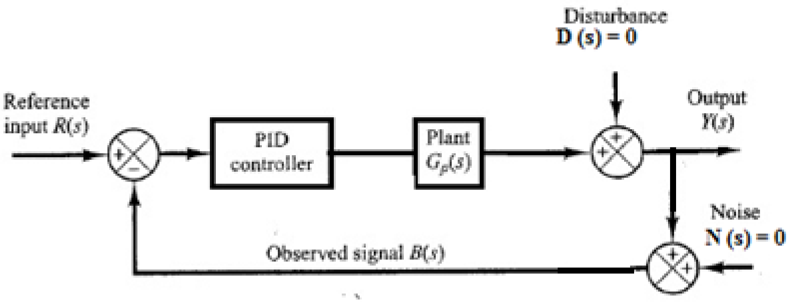

Figure (2) close loop system with no disturbance and sensor noise

$$\text{Disturbances} = 0 \qquad \ldots(1)$$

$$Noise = 0 \qquad \ldots(2)$$

$$\frac{Y(s)}{R(s)} = \frac{K_p\, G_P(s)}{(1+K_p\, G_p(s)} \qquad \ldots(3)$$

Case 2:

If sensor noise signal (feedback signal) and input are completely disabled or at least constant , the main closed-loop diagram can be counted and rearranged in order to explain the way disturbances affect in process variable " the original control loop diagram can be rearranged mathematically to show how disturbances affect the process variable. Disturbances pass through a modified process that is mathematically equivalent to the original process being driven by a feedback signal passing through the controller "[6] Figure (3) .

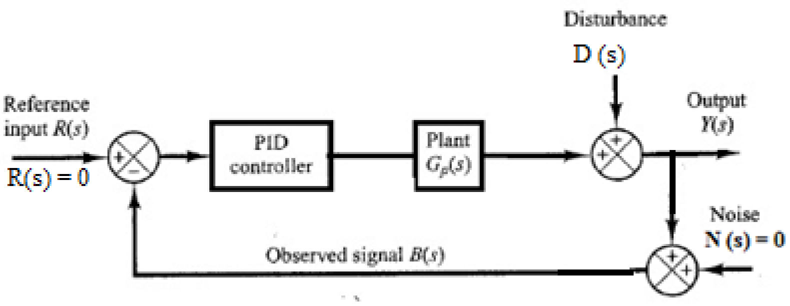

Figure (3) close loop system with no input R(s) and sensor noise

$$\mathrm{N(s)} = 0 \text{ and } R(s) = 0 \qquad \ldots(4)$$

$$\frac{Y(s)}{D(s)} = \frac{1}{1+K_p G_p\ (s)} \qquad \ldots(5)$$

$$D(s) = Y(s)\left(1 + K_p G_p(s)\right) \qquad \ldots(6)$$

Case 3:

Close loop system using feedback technique by adding the output signal to the input signal this error is having a better output response .One of the disadvantage of the open loop system its effects and sensitivity to disturbance using close loop feedback system is helpful on solving the disturbance so to compensate it by measuring the output

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compared with the input signal . Then the system responses due to that relation and act correspond , and also the closed loop system is less noise sensitivity compared with open loop system [7][8] in Figure (1).

$$Y\,(s) = \frac{K_p G_p(s)}{(1+K_p G_p(s))} R(s) - \frac{K_p G_p(s)}{(1+K_p G_p(s))} N(s) + \frac{1}{(1+K_p G_p(s))} D\,(s) \quad \ldots(7)$$

$$E(s) = R(s) - Y(s) \quad \ldots(8)$$

$$E\,(s) = \frac{1}{1+K_p G_p(s)} R(s) + \frac{K_p G_K(s)}{1+K_p G_p(s)} N(s) - \frac{1}{1+K_p G_p(s)} D(s) \quad \ldots(9)$$

III. **MODEL**

identification of subsystem parameters such as road grade (μ hill) which represent the disturbance (μ engine) and represent the vehicle engine (Vb) represent the desired velocity, In this modelled for the dynamic response of the car the noise was ignored .

Case study of disturbance for mechanical system:
Vehicle drive through hills the aim is constant velocity:

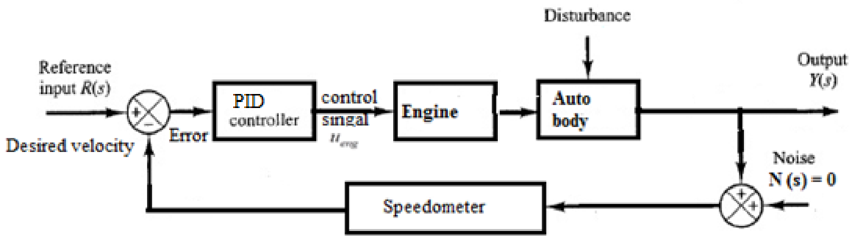

Figure (3)Vehicle drive through hills the aim is constant velocity

$$mv = -bv + \mu\ \text{engine} + \mu\text{hill} \quad \ldots(10)$$

$$\mu\ \text{engine} = k(V\text{des} - V) \quad \ldots(11)$$

$$V_{ss} = \frac{K}{b+K} V_{des} + \frac{1}{b+K} \mu_{hill} \quad \ldots(12)$$

$$V_{ss} \rightarrow V_{des} \text{ as } K \rightarrow \infty \quad \ldots(.13)$$

Steady state velocity approaches desired velocity as k → ∞. and Disturbance rejection Effect of disturbances (eg, hills) approaches zero as k → ∞. Robustness results don't depend on the specific values of b, m or k, for k sufficiently large[11].

$$\text{Let } m = 3kg \quad b = 10\,N.\frac{s}{m} \quad \mu hill = \frac{20N}{m} \quad f = 1\,N \quad \ldots(14)$$

By plugging these values in the transfer function:
The goal of this problem is to show you how each of the following contribute to obtain: fast rise time, minimum overshoot, no steady-state error.

$$K_p\ ,\quad K_i \ \text{ and } K_d$$

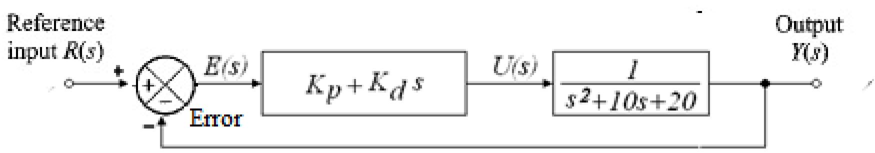

Figure (4) transfer function of velocity drive example

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The closed loop transfer function is given by:

$$\frac{Y(s)}{R(s)} = \frac{\frac{K_p + K_d s}{s^2+10s+20}}{1+\frac{K_p + K_d s}{s^2+10s+20}} \quad \ldots(15)$$

$$\frac{Y(s)}{R(s)} = \frac{K_p + K_d s}{s^2+(10+K_d)s+(20+K_p)} \quad \ldots(16)$$

let $K_p = 30$, $K_i = 70$

The proportional gain be reduced because the integral controller also reduces the rise time and increases the overshoot as the proportional controller does (double effect), figure (5) present that the integral controller eliminated the steady-state error [9][10].

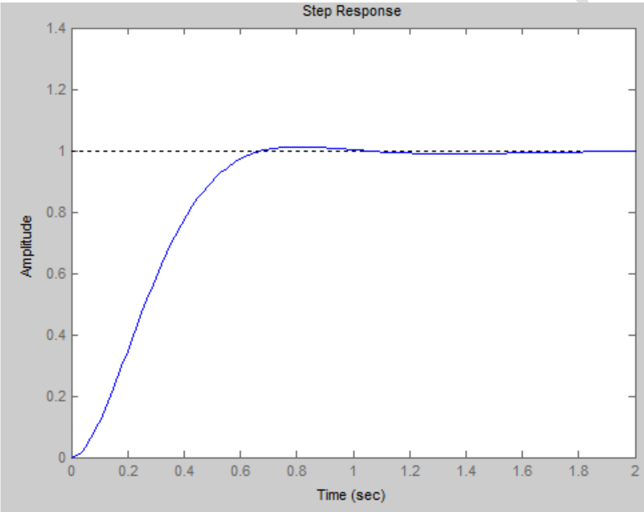

Figure (5) close – loop step kp =30 ki = 70

The algorithm automatically generates mask image without user interaction that contains only text regions to be inpainted.

IV. . RESULT

The effect of disturbance is changing the purpose or reduce the efficiency of the output, Using closed loop transfer function reduce this effect to minimize the disturbance as possible.

The disturbance reduction using PID controller participates to eliminate the disturbance effect.

V. CONCLUSION

Disturbances affect the closed-loop control systems and this is what became clear out by using a transfer function, any system that contains disturbances may be calculated or uncalculated but must disturbances account for processing system. Reduce disturbances values lead to the stability of the system and whenever a disturbances value close to zero this leads stability of system be high.

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