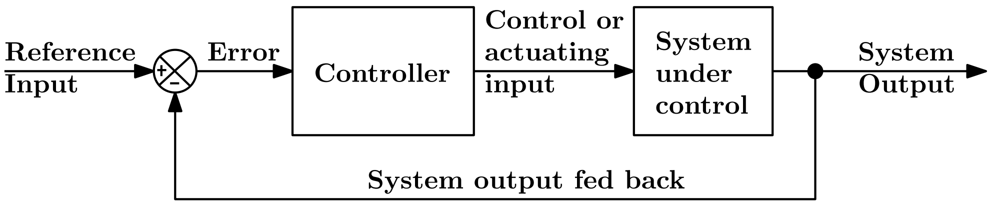
•By means of the negative feedback loop shown here (the system output is subtracted from the reference input), the accuracy of the system output in relation to a desired value can be much improved when compared to the response of an open-loop system.



This is simply because the purpose of the controller will most likely be to minimize the error between the actual system output and the desired (reference input) value.
•A disadvantage of feedback is related to where oscillations can occur in the system output, which would not occur if the system were connected in open-loop mode. The oscillations are due to the attempt to get the error signal to as low a magnitude as possible, even if this means swinging the output first one way and then the other.

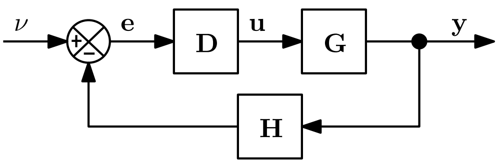
1.4.1 Effects of feedback

•Open-loop systems rely entirely on calibration in order to perform with good accuracy; any system variations or effects caused by outside influences can seriously degrade this accuracy. Although only common in relatively simple systems, an important property is found in that an increase in system gain (amplification) does not affect the stability of an open-loop system (oscillations cannot be induced in this way).
•Once feedback is applied, the system is in closed-loop. Closed-loop systems can achieve much greater accuracy than open-loop systems, although they rely entirely on the accuracy of the comparison between desired and actual output values and therefore on the accuracy of the measured output value. Effects of system variations or outside influences are much reduced, as are effects due to disturbances or nonlinear behavior. Unfortunately the advantages obtained when feedback is employed are at the expense of system stability (oscillations can often be induced by increasing system gain).

1.5 Some examples of control systems

page 8, 9, 10 in the book

1.6 Definitions of standard terminology



1. Lower case letters refer to signals, e.g. voltage, speed; are functions of time.
2. Capital letters denote signal magnitudes, as in the case of $u(t) = Ucos\omega t$, or otherwise Laplace transformed quantities, $U = U(s)$.
3. The system under control is also known as the plant or process, G.
4. The reference input ν, also known as the set-point or desired output, is an external signal applied in order to indicate a desired steady value for the plant output.
5. The system output y, also known as the controlled output, is the signal obtained from the plant which we wish to measure and control.
6. The error signal e is the difference between the desired system output and the actual system output (when $H = 1$).
7. The controller D is the element which ensures that the appropriate control signal is applied to the plant. In many cases it takes the error signal as its input and provides an actuating signal as its output.
8. The feedback element H provides a multiplying factor on the output y before a comparison is made with the reference input ν. When $H \neq 1$ the error e is the error between ν and Hy, i.e. it is no longer the error between ν and y.
9. The feedback signal is the signal produced by the operation of H on the output y.
10. The control input u, also known as the actuating signal, control action or control signal, is applied to the plant G and is provided by the controller D operating on the error e.
11. The forwardpath is the path from the error signal e to the output y, and includes D and G.
12. The feedback path is the path from the output y, through H.
13. A disturbance, or noise (not shown here), is a signal which enters the system at a point other than the reference input and has the effect of undermining the normal system operation.
14. A nonlinear system is one in which the principles of superposition do not apply, e.g. amplifier saturation at the extremes, or hysteresis effects. Almost all except the most simple systems are nonlinear in practice, to an extent at least. The vast majority of systems can however be dealt with by approximating the system with a linear model, at least over a specific range.
15. A time-invariant system is one in which the characteristics of that system do not vary with respect to time. Most systems do vary slowly with respect to time, e.g. ageing, however over a short period they can be considered to be time-invariant.
16. A continuous-time system is one in which the signals are all functions of time t, in an analog sense.
17. A discrete-time system is a system such as a digital system or a sampled data system in which the signals, which consist of pulses, only have values at distinct time instants. The operator z is used to define a discrete-time signal such that $z^3y(t) = y(t+3)$ means the value of signal $y(t)$ at a point in time three periods in the future, where a sample period T is defined separately for each system.
18. A transducer converts one form of energy (signal) into another, e.g. pressure to voltage.
19. Negative feedback is obtained when $e = \nu - Hy$.
20. Positive feedback is obtained when $e = \nu + Hy$.
21. A regulator is a control system in which the control objective is to minimize the variations in output signal, such variations being caused by disturbances, about a set-point mean value.

Note: A regulator differs from a servomechanism in which the main purpose is to track a changeable reference input.

22. A multivariable system is one which consists of several inputs and several outputs.