BLOCK DIAGRAM OF CONTROL SYSTEM

Block Diagram:

A control system may consist of a number of components. In order to show the functions performed by each component in control engineering, we commonly use a diagram called the "Block Diagram".

A block diagram of a system is a pictorial representation of the function performed by each component and of the flow of signals. Such a diagram depicts the inter-relationships which exists between the various components. A block diagram has the advantage of indicating more realistically the signal flows of the actual system.

In a block diagram all system variables are linked to each other through functional blocks. The "Functional Block" or simply "Block" is a symbol for the mathematical operation on the input signal to the block which produces the output. The transfer functions of the components are usually entered in the corresponding blocks, which are connected by arrows to indicate the direction of flow of signals. Note that signal can pass only in the direction of arrows. Thus a block diagram of a control system explicitly shows a unilateral property.

Fig 2.1 shows an element of the block diagram. The arrow head pointing towards the block indicates the input and the arrow head away from the block represents the output. Such arrows are entered as signals.

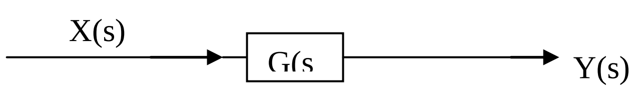

Fig 2.1

The advantages of the block diagram representation of a system lie in the fact that it is easy to form the over all block diagram for the entire system by merely connecting the blocks of the components according to the signal flow and thus it is possible to evaluate the contribution of each component to the overall performance of the system. A block diagram contains information concerning dynamic behavior but does not contain any information concerning the physical construction of the system. Thus many dissimilar and unrelated system can be represented by the same block diagram.

It should be noted that in a block diagram the main source of energy is not explicitly shown and also that a block diagram of a given system is not unique. A number of a different block diagram may be drawn for a system depending upon the view point of analysis.

Error detector : The error detector produces a signal which is the difference between the reference input and the feed back signal of the control system. Choice of the error detector is quite important and must be carefully decided. This is because any imperfections in the error detector will affect the performance of the entire system. The block diagram representation of the error detector is shown in fig2.2

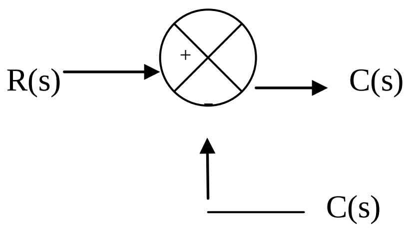

Fig2.2

Note that a circle with a cross is the symbol which indicates a summing operation. The plus or minus sign at each arrow head indicates whether the signal is to be added or subtracted. Note that the quantities to be added or subtracted should have the same dimensions and the same units.

Block diagram of a closed loop system .

Fig2.3 shows an example of a block diagram of a closed system

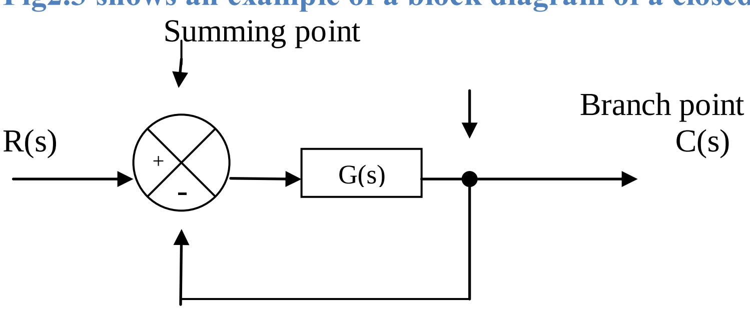

Fig. 2.3

The output C(s) is fed back to the summing point, where it is compared with reference input R(s). The closed loop nature is indicated in fig1.3. Any linear system may be represented by a block diagram consisting of blocks, summing points and branch points. A branch is the point from which the output signal from a block diagram goes concurrently to other blocks or summing points.

When the output is fed back to the summing point for comparison with the input, it is necessary to convert the form of output signal to that of he input signal. This conversion is followed by the feed back element whose transfer function is H(s) as shown in fig 1.4. Another important role of the feed back element is to modify the output before it is compared with the input.

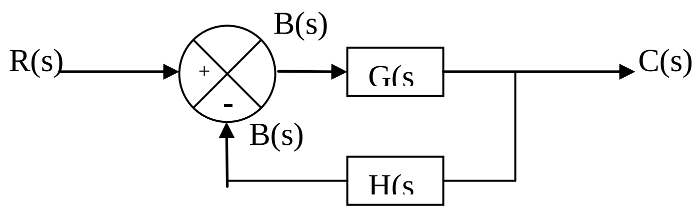

Fig 2.4

The ratio of the feed back signal B(s) to the actuating error signal E(s) is called the open loop transfer function.

open loop transfer function = B(s)/E(s) = G(s)H(s)

The ratio of the output C(s) to the actuating error signal E(s) is called the feed forward transfer function .

Feed forward transfer function = C(s)/E(s) = G(s)

If the feed back transfer function is unity, then the open loop and feed forward transfer function are the same. For the system shown in Fig1.4, the output C(s) and input R(s) are related as follows.

$$C(s) = G(s)\,E(s)$$

$$E(s) = R(s) - B(s)$$

$$= R(s) - H(s)C(s) \qquad \text{but } B(s) = H(s)C(s)$$

Eliminating E(s) from these equations

$$C(s) = G(s)[R(s) - H(s)C(s)]$$

$$C(s) + G(s)[H(s)C(s)] = G(s)R(s)$$

$$C(s)[1 + G(s)H(s)] = G(s)R(s)$$

$$\frac{C(s)}{R(s)} = \frac{G(s)}{1 + G(s)H(s)}$$

C(s)/R(s) is called the closed loop transfer function.

The output of the closed loop system clearly depends on both the closed loop transfer function and the nature of the input. If the feed back signal is positive, then

$$\frac{C(s)}{R(s)} = \frac{G(s)}{1 - G(s)H(s)}$$