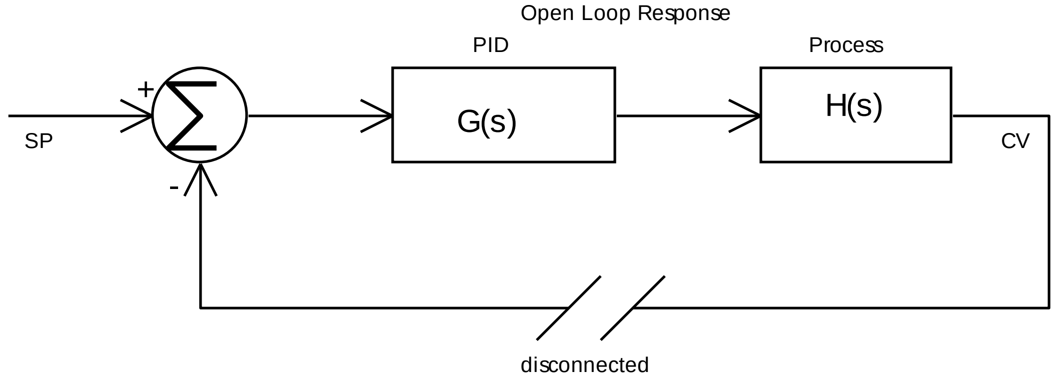
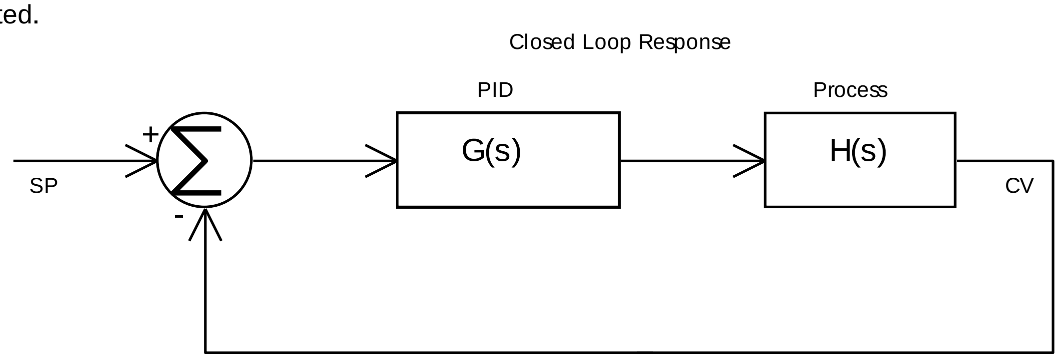
Open Loop, Closed Loop Response and Stability

Open Loop frequency response measures the response of the loop with the controlled variable disconnected.



For the open loop response, transfer function is $\frac{C_v}{SP} = G(s)H(s)$

Closed Loop frequency response measures the response of the loop with the controlled variable connected.

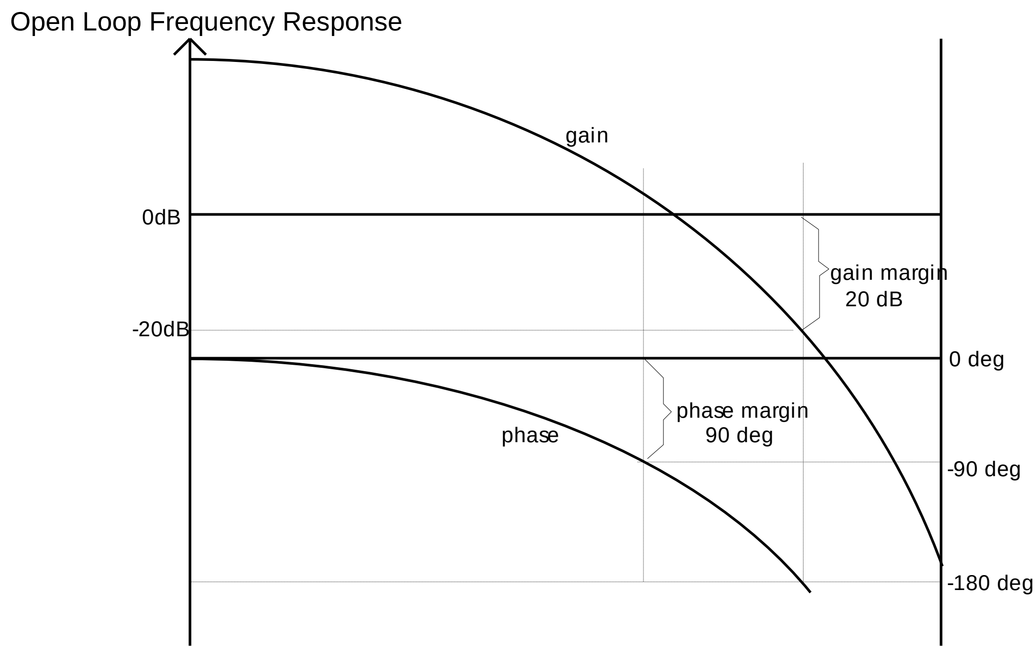


For the closed loop response, the transfer function is $\frac{C_v}{SP} = \frac{G(s)H(s)}{1 + G(s)H(s)}$

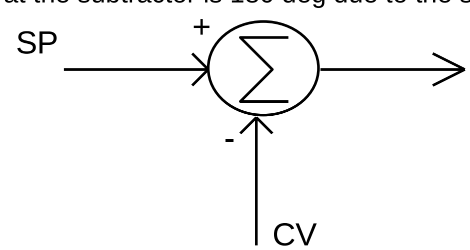
Frequency Response Method For Ensuring Controller Stability

Control System is stable only if:

- open loop gain G(s)H(s) is less than 1 at a frequency for which the phase angle is less than -180 deg.
- phase shift is less than 180 deg (>-180 deg) at the frequency for which open loop gain G(s) H(s) is 1 (0 dB)



The Phase shift that takes place at the subtractor is 180 deg due to the subtraction. That is:



For example, suppose the set point is 50%, and CV=40%. Then the output from the summer is 10%. If CV rises to 45%, then the output falls to 5%. The phase relationship between the output and CV is 180 deg.

Now if the loop contributes 180 deg of phase shift at a given frequency, then the total phase shift would be 360 deg at the frequency. If the loop gain were 1 or greater the control system would become unstable.

When the phase shift of the loop G(s)H(s) is -180 deg.

Often a gain margin of 6 dB is used to ensure loop stability.