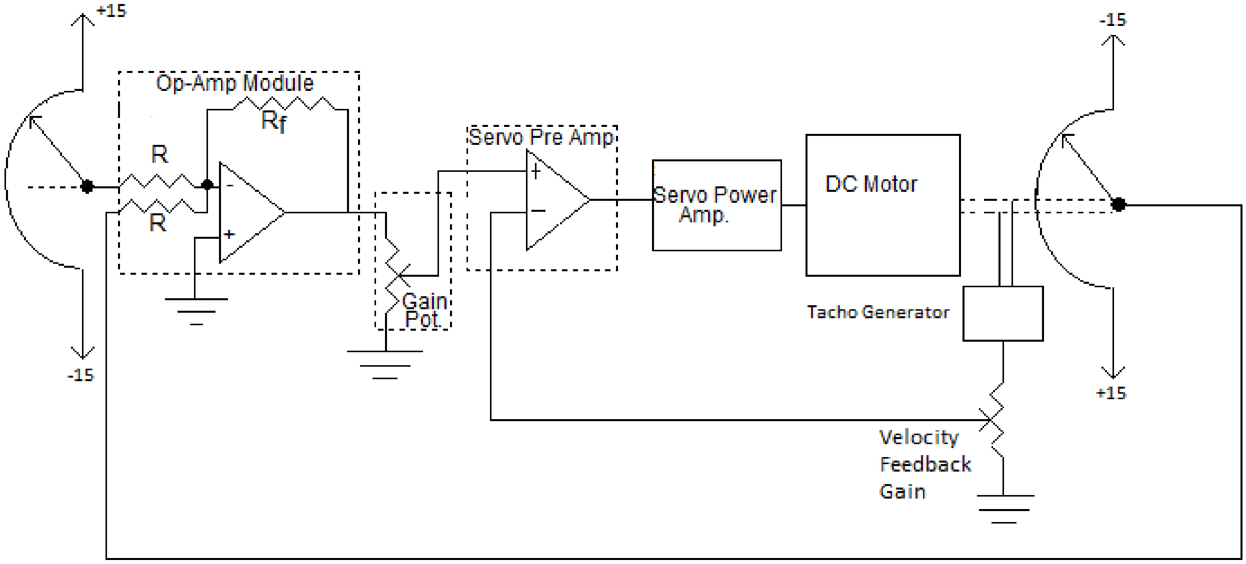
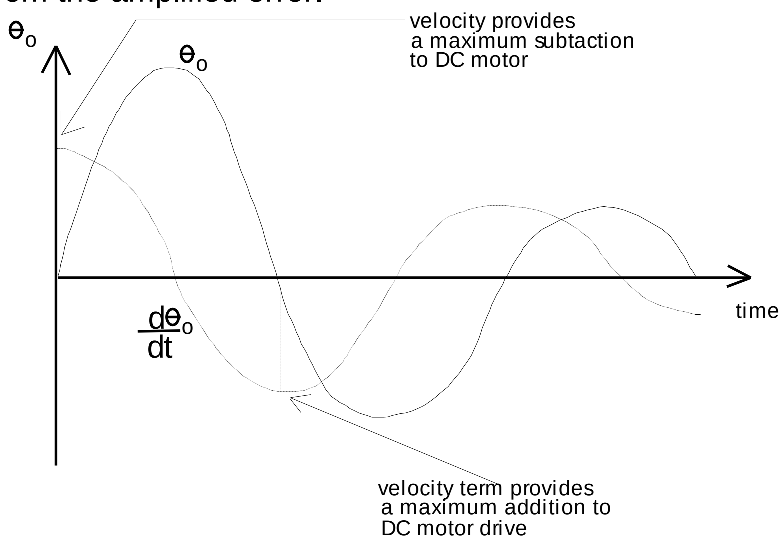
Position Control With Velocity Feedback

With a position control system, if the gain is increased , the step reponse of the output shaft tends to become more oscillatory. You may have wanted the increased gain in order to reduce the effects of **dead band** or to decrease the time to reach steady state. To help suppress the unwanted oscillations you can add what is called velocity feedback (often referred to as derivative because the derivative of position is velocity).

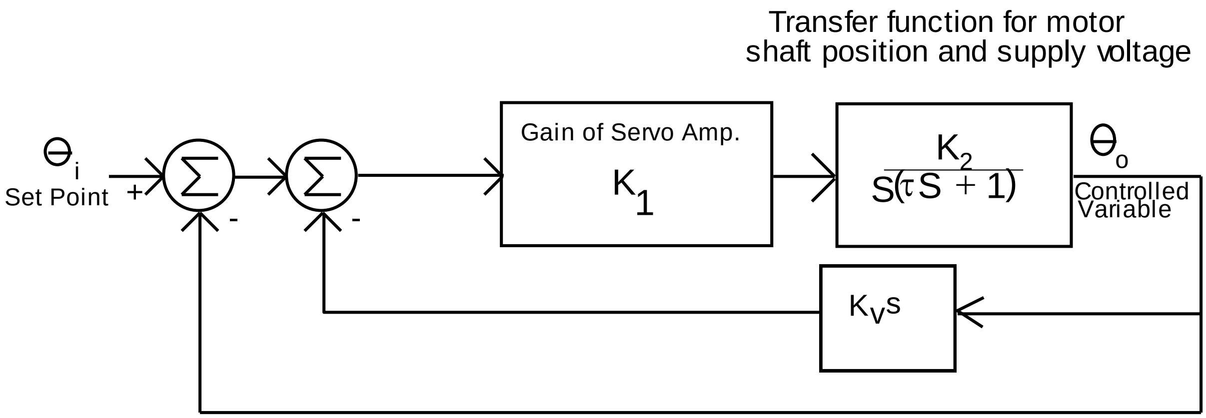


The output of the tachometer is a DC voltage that is proportional to the angular velocity of the DC motor. That is the faster the motor rotates, the greater the output from the tachometer.

The Servo pre amp above has an additional input used for subtracting the velocity feedback term from the amplified error.



This velocity feedback term acts to "put on the breaks" or dampen the reponse very much like a shock absorber does for an automobile spring. That is, if the output position is rising rapidly, the velocity term is large and tends to subtract from the signal going to the motor. However, if the output position is at its peak, then the velocity feedback term stops subtracting from the signal going to the motor. When the output position begins to fall, the velocity feedback term begins to add to the motor drive.



Find the transfer function of the position control system with velocity feedback.

$$\theta_o = (\theta_i - \theta_o - \theta_o K_v S)\frac{K_1 K_2}{S(\tau S+1)}$$

$$\theta_o = \frac{K_1 K_2}{S(\tau S+1)}\theta_i - \frac{K_1 K_2}{S(\tau S+1)}\theta_o - \frac{K_1 K_2 K_v S}{S(\tau S+1)}\theta_o$$

$$\theta_o + \frac{K_1 K_2}{S(\tau S+1)}\theta_o + \frac{K_1 K_2 K_v S}{S(\tau S+1)}\theta_o = \frac{K_1 K_2}{S(\tau S+1)}\theta_i$$

$$\theta_o(1 + \frac{K_1 K_2}{S(\tau S+1)} + \frac{K_1 K_2 K_v S}{S(\tau S+1)}) = \frac{K_1 K_2}{S(\tau S+1)}\theta_i$$

$$\frac{\theta_o}{\theta_i} = \frac{\dfrac{K_1 K_2}{S(\tau S+1)}}{(1 + \dfrac{K_1 K_2}{S(\tau S+1)} + \dfrac{K_1 K_2 K_v S}{S(\tau S+1)})}$$

$$\frac{\theta_o}{\theta_i} = \frac{K_1 K_2}{S(\tau S+1) + K_1 K_2 + K_1 K_2 K_v S}$$

$$\frac{\theta_o}{\theta_i} = \frac{1}{\dfrac{S(\tau S+1) + K_1 K_2 + K_1 K_2 K_v S}{K_1 K_2}}$$

$$\frac{\theta_o}{\theta_i} = \frac{1}{\dfrac{\tau}{K_1 K_2}S^2 + \dfrac{(1 + K_1 K_2 K_v)}{K_1 K_2}S + 1}$$

As K_V rises, the overall coefficient of the S term $\frac{(1+K_1K_2K_v)}{K_1K_2}$ rises. Since the coefficient of the S term corresponds to $\frac{2\rho}{\omega_n}$ then as K_V rises the damping factor ρ rises. Note that because the natural frequency is $\omega_n = \sqrt{\frac{K_1K_2}{\tau}}$,then increasing K_V will not affect the natural frequency.

That is, increasing the velocity feedback term increases the damping without changing the natural frequency. The damped frequency $\omega_n\sqrt{1-\rho^2}$ however will decrease (the period of the damped oscillation will increase.