PID Transfer Function for 505/505E

Assuming:
Feedback dominant control (Sdr>1)

Where:
P is the Proportional Gain
I is the Integral Gain in repeats/sec
Sdr is the Ratio of the lead breakpoint to the reset (I) breakpoint

Output Calculation:

Y=Feedback + P * Lead/Lag * (InputError - Droopfeedbackterm)

$$Y=\frac{Y}{\frac{S}{I}+1}+P\cdot\frac{\frac{S}{I\cdot Sdr}+1}{S\cdot Tf+1}\cdot\left(U-\frac{Y\cdot Droop}{\frac{S}{I}+1}\right)$$

$$Y=\frac{-\left[\frac{-P}{(S\cdot Tf+1)}\cdot\frac{S}{(I\cdot Sdr)}\cdot U-\frac{P}{(S\cdot Tf+1)}\cdot U\right]}{\left[1-\frac{1}{\left(\frac{S}{I}+1\right)}+\frac{P}{(S\cdot Tf+1)}\cdot\frac{S}{(I\cdot Sdr)}\cdot\frac{Droop}{\left(\frac{S}{I}+1\right)}+\frac{P}{(S\cdot Tf+1)}\cdot\frac{Droop}{\left(\frac{S}{I}+1\right)}\right]}$$

$$Y=\frac{(S+I)}{I}\cdot P\cdot U\cdot\frac{(S+I\cdot Sdr)}{\left(Sdr\cdot S^{2}\cdot Tf+Sdr\cdot S+P\cdot S\cdot Droop+P\cdot Droop\cdot I\cdot Sdr\right)}$$

$$Gpc=\frac{(S+I)}{I}\cdot P\cdot\frac{(S+I\cdot Sdr)}{\left(Sdr\cdot S^{2}\cdot Tf+Sdr\cdot S+P\cdot S\cdot Droop+P\cdot Droop\cdot I\cdot Sdr\right)}$$

The ‘Sdr’ term is referred to as the ‘Derivative Ratio’ in the 505 / 505E.

PID Transfer Function for 505/505E

Assuming:
Input dominant control (Sdr<1)

Where:
P is the Proportional Gain
I is the Integral Gain in repeats/sec
Sdr is the Ratio of the lead breakpoint to the reset (I) breakpoint

Output Calculation:

Y=Feedback + P * Lead/Lag * (InputError - Droopfeedbackterm)

$$Y = \frac{Y}{\frac{S \cdot Sdr}{I} + 1} + P \cdot Sdr \cdot \frac{\frac{S}{I} + 1}{S \cdot Tf + 1} \cdot \left(U - \frac{Y \cdot Droop}{\frac{S}{I} + 1} \right)$$

$$Y = \frac{-\left[-P \cdot \frac{Sdr}{(S \cdot Tf + 1)} \cdot \frac{S}{I} \cdot U - P \cdot \frac{Sdr}{(S \cdot Tf + 1)} \cdot U \right]}{1 - \frac{1}{\left(S \cdot \frac{Sdr}{I} + 1 \right)} + P \cdot \frac{Sdr}{(S \cdot Tf + 1)} \cdot \frac{S}{I} \cdot \frac{Droop}{\left(\frac{S}{I} + 1 \right)} + P \cdot \frac{Sdr}{(S \cdot Tf + 1)} \cdot \frac{Droop}{\left(\frac{S}{I} + 1 \right)}}$$

$$Y = U \cdot P \cdot (S + I) \cdot \frac{(S \cdot Sdr + I)}{\left[I \cdot \left(P \cdot Droop \cdot I + S^2 \cdot Tf + S + P \cdot Sdr \cdot S \cdot Droop \right) \right]}$$

$$I = \frac{1}{Tf}$$

$$Y = U \cdot P \cdot \left(S + \frac{1}{Tf} \right) \cdot \frac{\left(S \cdot Sdr + \frac{1}{Tf} \right)}{\left[\frac{1}{Tf} \cdot \left(P \cdot Droop \cdot \frac{1}{Tf} + S^2 \cdot Tf + S + P \cdot Sdr \cdot S \cdot Droop \right) \right]}$$

$$Y = U \cdot P \cdot (S \cdot Tf + 1) \cdot \frac{(S \cdot Sdr \cdot Tf + 1)}{\left(P \cdot Droop + S^2 \cdot Tf^2 + S \cdot Tf + P \cdot Sdr \cdot S \cdot Droop \cdot Tf \right)}$$

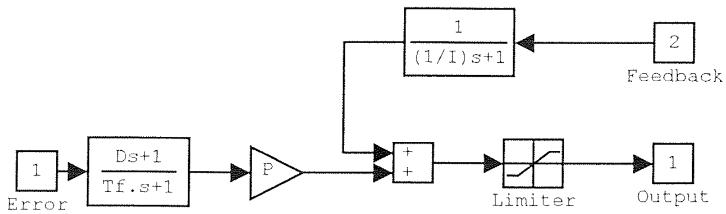
The overall trasfer function gain (Y/U) is:

$$Gpc = P \cdot (S \cdot Tf + 1) \cdot \frac{(S \cdot Sdr \cdot Tf + 1)}{\left(P \cdot Droop + S^2 \cdot Tf^2 + S \cdot Tf + P \cdot Sdr \cdot S \cdot Droop \cdot Tf \right)}$$

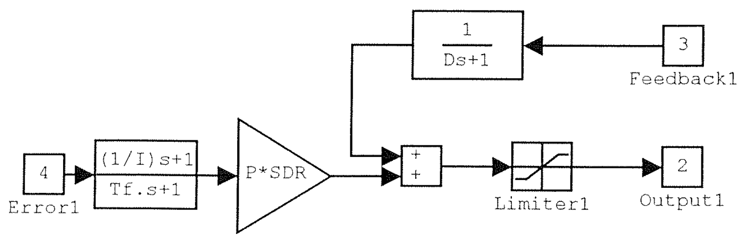
The ‘Sdr’ term is referred to as the ‘Derivative Ratio’ in the 505 / 505E.

Transfer Function of the PID

This is the S plane equivalent to the PID.



SDR >1 (Feedback Dominant)
D=1/(SDR*I)



SDR <= 1 (Input Dominant)
D=SDR/I

If SDR >= 100 then D and Tf are eliminated. For SDR <= .01 D and Tf are set to the same value and cancel each other out when the control is in use.

The feed back is connected to the output of the PID when the PID is being used. The use of the feedback prevents reset windup when another controller is being used.