Formulas in Control Engineering

Type	Step Response h(t)	Equation for Step Response	Transfer Function G(s)	Nyquist Curve G(jω)	Bode Plot $\lvert G(j\omega)\rvert_{dB}$ and φ (jω)	Poles (x) and Zeros (o)	Block Diagram
P		$h(t) = K_P\sigma(t)$	$G(s) = K_P$				
I		$h(t) = \frac{t}{T_I}$	$G(s) = \frac{1}{T_I s}$				
D		$h(t) = T_D \cdot \delta(t)$	$G(s) = T_D s$				
$P-T_1$		$h(t) = K\left[1 - e^{-\frac{t}{T_1}}\right]$	$G(s) = \frac{K}{1+T_1 s}$				
$P-T_2$		$h(t) = K\left[1 - \frac{T_1}{T_1-T_2}e^{-\frac{t}{T_1}} + \frac{T_2}{T_1-T_2}e^{-\frac{t}{T_2}}\right]$	$G(s) = \frac{K}{(1+T_1 s)(1+T_2 s)}$				
$P-T_{2S}$		$h(t) = K\left[1 \pm \frac{e^{\frac{-\vartheta t}{T_0}}}{\sqrt{1-\vartheta^2}}\sin\left(\sqrt{1-\vartheta^2}\frac{t}{T_0} + \psi\right)\right]$ $\psi = arccos\vartheta$	$G(s) = \frac{K}{(1+2\vartheta T_0 s + T_0^2 s^2)}$ $T_0 = \frac{1}{\omega_0};\ \vartheta < 1$				
$I-T_1$		$h(t) = \frac{t}{T_I} - \frac{T_1}{T_I}\left(1 - e^{-\frac{t}{T_1}}\right)$	$G(s) = \frac{1}{T_I s(1+T_1 s)}$				
$D-T_1$		$h(t) = \frac{T_D}{T_1}e^{-\frac{t}{T_1}}$	$G(s) = \frac{T_D s}{1+T_1 s}$				
PI		$h(t) = K_P\left(1 + \frac{t}{T_n}\right)$	$G(s) = K_P\frac{1+T_n s}{T_n s}$				
PD		$h(t) = K_P[1 + T_v\delta(t)]$	$G(s) = K_P(1+T_v s)$				
$PD-T_1$		$T_{vP} > T_1$ $T_v = T_{vP} - T_1 > 0$ $h(t) = K_P\left[1 + \frac{T_v}{T_1}e^{-\frac{t}{T_1}}\right]$	$G(s) = K_P\left[1 + \frac{T_v s}{1+T_1 s}\right]$ $= K_P\frac{1+T_{vP}s}{1+T_1 s}$ $T_{vP} = T_v + T_1$				
$PP-T_1$		$T_{vP} < T_1$ $T_v = T_{vP} - T_1 < 0$					
PID		$h(t) = K_P\left[1 + \frac{t}{T_n} + T_v\delta(t)\right]$	$K_P[1 + \frac{1}{T_n s} + T_v s] = K_{PP}\frac{(1+T_{nP}s)(1+T_{vP}s)}{T_{nP}s}$ $T_n = T_{nP} + T_{vP}; T_v = T_{vP}\frac{T_{nP}}{T_n}; K_P = K_{PP}\frac{T_n}{T_{nP}};\ \frac{T_n}{T_v} \geq 4$				
$PID-T_1$		$h(t) = K_P\left[1 + \frac{t}{T_n} + \frac{T_v}{T_d}e^{-\frac{t}{T_d}}\right]$	$K_P\left[1 + \frac{1}{T_n s} + \frac{T_v s}{1+T_d s}\right] = K_{PP}\frac{(1+T_{nP}s)(1+T_{vP}s)}{T_{nP}s(1+T_d s)}$ $T_n = T_{nP} + T_{vP} - T_d;\ T_v = T_{vP}\frac{T_{nP}}{T_n} - T_d;\ K_p = K_{PP}\frac{T_n}{T_{nP}}$				
T_t		$h(t) = \sigma(t - T_t)$	$G(s) = e^{-T_t s}$			No poles or zeros in a finite graph	
A_1		$h(t) = 1 - 2e^{-\frac{t}{T_1}}$	$G(s) = \frac{1 - T_1 s}{1 + T_1 s}$				

Check them out!

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