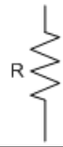
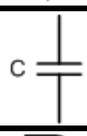
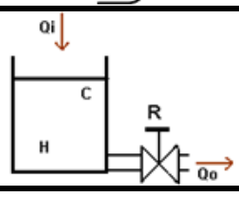
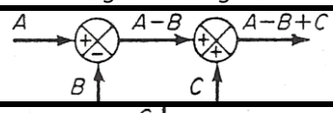
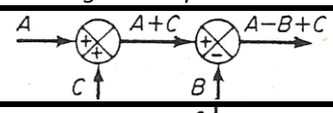
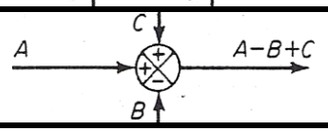
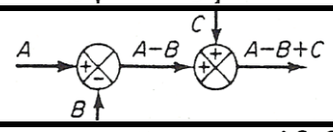
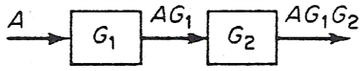
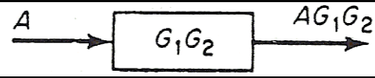
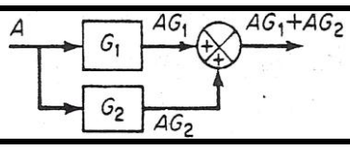
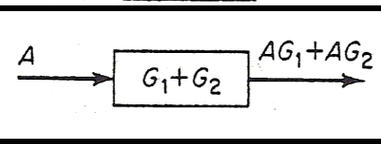
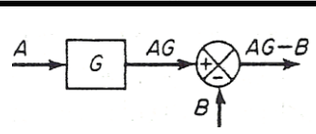
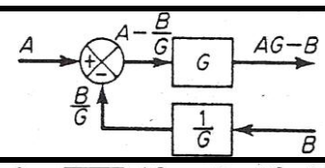
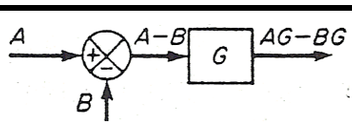
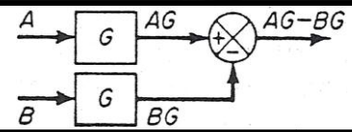
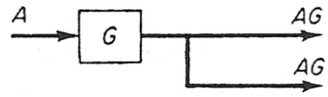
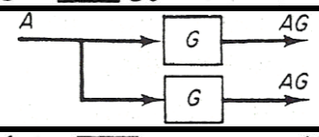
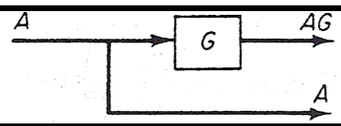
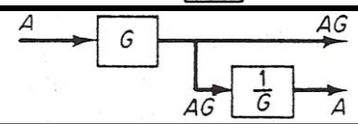
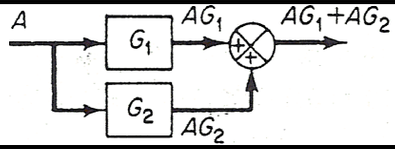
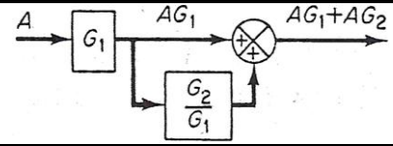
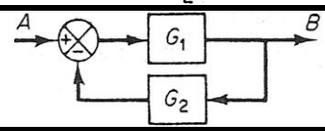
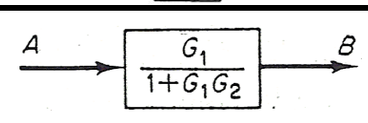
Elemento	Voltaje	Corriente
	$v(t) = R \cdot i(t)$	$i(t) = \frac{1}{R} \cdot v(t)$
	$v(t) = \frac{1}{C} \cdot \int i(t) \cdot dt$	$i(t) = C \cdot \frac{d}{dt} v(t)$
	$v(t) = L \cdot \frac{d}{dt} i(t)$	$i(t) = \frac{1}{L} \cdot \int v(t) \cdot dt$
	$q_o(t) = \frac{h(t)}{R}$	$h(t) = \frac{1}{C} \cdot \int [q_i(t) - q_o(t)] dt$

Algebra de Bloques	
Diagrama Original	*Diagrama Equivalente*
	
	
	
	
	
	
	
	
	
	

ENTRADA ESCALON	
SUB AMORTIGUADO $0 < \zeta < 1$	$c(t) = K_{SP}\left(1 - e^{-\sigma \cdot t} \cdot \left(\cos(\omega_d \cdot t) + \frac{\sigma}{\omega_d} \cdot sen(\omega_d \cdot t)\right)\right)$
CRÍTICAMENTE AMORTIGUADO $\zeta = 1$	$c(t) = K_{SP}\left(1 - e^{-\omega_n \cdot t} \cdot \left(1 + \omega_n \cdot t\right)\right)$
SOBRE AMORTIGUADO $1 < \zeta$	$c(t) = K_{SP}\left(1 + \frac{\omega_n}{2\sqrt{\zeta^2 - 1}} \cdot \left(\frac{e^{-s_1 \cdot t}}{s_1} - \frac{e^{-s_2 \cdot t}}{s_2}\right)\right)$
SISTEMA DE 1er ORDEN	$c(t) = K_{SP}\left(1 - e^{-\frac{t}{\tau}}\right)$
ENTRADA RAMPA	
SUB AMORTIGUADO $0 < \zeta < 1$	$c(t) = K_{SP}\left(t - \frac{2\zeta}{\omega_n} + e^{-\sigma \cdot t} \cdot \left(\frac{2\zeta}{\omega_n} \cdot \cos(\omega_d \cdot t) + \frac{2\zeta^2 - 1}{\omega_d} \cdot sen(\omega_d \cdot t)\right)\right)$
CRÍTICAMENTE AMORTIGUADO $\zeta = 1$	$c(t) = K_{SP}\left(t - \frac{2}{\omega_n} + \frac{2}{\omega_n} \cdot e^{-\omega_n \cdot t}\left(1 + \frac{\omega_n \cdot t}{2}\right)\right)$
SOBRE AMORTIGUADO $1 < \zeta$	$c(t) = K_{SP}\left(t - \frac{2 \cdot \zeta}{\omega_n} - \frac{2\zeta^2 - 1 - 2\zeta\sqrt{\zeta^2 - 1}}{2\omega_n\sqrt{\zeta^2 - 1}} \cdot e^{-\left(\zeta + \sqrt{\zeta^2 - 1}\right) \cdot \omega_n \cdot t} + \frac{2\zeta^2 - 1 + 2\zeta\sqrt{\zeta^2 - 1}}{2\omega_n\sqrt{\zeta^2 - 1}} \cdot e^{-\left(\zeta - \sqrt{\zeta^2 - 1}\right) \cdot \omega_n \cdot t}\right)$
SISTEMA DE 1er ORDEN	$c(t) = K_{SP}\left(t - T + T \cdot e^{-\frac{t}{T}}\right)$
ENTRADA IMPULSO	
SUB AMORTIGUADO $0 < \zeta < 1$	$c(t) = K_{SP}\left(\frac{\omega_n}{\sqrt{1 - \zeta^2}} \cdot e^{-\sigma \cdot t} \cdot sen(\omega_d \cdot t)\right)$
CRÍTICAMENTE AMORTIGUADO $\zeta = 1$	$c(t) = K_{SP}\left(\omega_n{}^2 \cdot t \cdot e^{-\omega_n \cdot t}\right)$
SOBRE AMORTIGUADO $1 < \zeta$	$c(t) = K_{SP}\left(\frac{\omega_n}{2\sqrt{\zeta^2 - 1}} \cdot e^{-\left(\zeta - \sqrt{\zeta^2 - 1}\right) \cdot \omega_n \cdot t} - \frac{\omega_n}{2\sqrt{\zeta^2 - 1}} \cdot e^{-\left(\zeta + \sqrt{\zeta^2 - 1}\right) \cdot \omega_n \cdot t}\right)$
SISTEMA DE 1er ORDEN	$c(t) = K_{SP}\left(\frac{1}{T} \cdot e^{-\frac{t}{T}}\right)$

$$t_r = \frac{\pi - \beta}{\omega_d} \qquad \beta = \tan^{-1}\left(\frac{\omega_d}{\sigma}\right) \qquad t_p = \frac{\pi}{\omega_d} \qquad Mp_{\%} = e^{\frac{-\zeta \cdot \pi}{\sqrt{1-\zeta^2}}} \times 100\% = \frac{c(t_p) - c(\infty)}{c(\infty)} \times 100\%$$

$$\sigma = \zeta \cdot \omega_n \qquad \omega_d = \omega_n \cdot \sqrt{1 - \zeta^2} \qquad \tau = \frac{1}{\sigma}$$

$$K_{SP} = K_R \cdot K_{FdT} = c(\infty)$$

$$c(t_p) = K_{SP}\left(1 + e^{\frac{-\zeta \cdot \pi}{\sqrt{1-\zeta^2}}}\right) \qquad \zeta = \sqrt{\frac{\left(\ln Mp_{o/1}\right)^2}{\pi^2 + \left(\ln Mp_{o/1}\right)^2}}$$

$$FdT_{1^{er}\ orden} = K_{FdT}\left(\frac{1}{\tau\, s+1}\right)e^{-\theta s}$$

$$FdT_{2^{do}\ orden} = K_{FdT}\left(\frac{\omega_n^{\,2}}{s^2+2\,\zeta\,\omega_n\, s+\omega_n^{\,2}}\right)e^{-\theta s} = K_{FdT}\left(\frac{\omega_n^{\,2}}{s^2+2\,\sigma\, s+\omega_n^{\,2}}\right)e^{-\theta s}$$

e_{ss}	36,8%	13,5%	5%	2%	1%
t_s	τ	2 τ	3 τ	4 τ	5 τ

ζ	Razón (relación) de amortiguamiento
τ	Constante de tiempo (63.2% del valor final, sistemas de 1er orden)
ϑ	Tiempo de retardo (comienzo de la señal)
σ	Constante de atenuación
ω_n	Frecuencia natural no amortiguada
ω_d	Frecuencia natural amortiguada
t_d	Tiempo de retardo (50% del valor final, sistemas de 2do orden)
t_s	Tiempo de establecimiento
t_r	Tiempo de levantamiento
t_p	Tiempo de máximo impulso
Mp	Sobreimpulso (sobrepaso)
e_{ss}	Error de estado estacionario
K_{FdT}	Ganancia de FdT normalizada
K_{SP}	Punto de establecimiento
K_R	Ganancia de la señal de entrada normalizada

LÓPEZ

CRITERIOS DE COMPORTAMIENTO							
Controlador	Criterio	A	B	C	D	E	F
P	ISE	0,6659	-1,027				
	IAE	0,4373	-1,098				
	ITAE	0,3620	-1,119				
PI	ISE	1,305	-0,960	0,492	-0,739		
	IAE	0,984	-0,986	0,608	-0,707		
	ITAE	0,859	-0,977	0,674	-0,680		
PID	ISE	1,495	-0,945	1,101	-0,771	0,560	1,006
	IAE	1,435	-0,921	0,878	-0,749	0,482	1,137
	ITAE	1,367	-0,947	0,842	-0,738	0,381	0,995

ZIEGLER-NICHOLS

Tipo de controlador	K_C	Ti	Td
P	T / θ	∝	0
PI	0,9 T / θ	θ / 0,3	0
PID	1,2 T / θ	2 θ	0,5 θ

Tipo de controlador	K_C	Ti	Td
P	0,5 Kcr	∝	0
PI	0,45 Kcr	Tcr / 1,2	0
PID	0,6 Kcr	0,5 Tcr	0,125 Tcr

$$Gp(s) = \frac{K\cdot e^{-\theta\cdot s}}{T\cdot s+1} \qquad \alpha = \frac{\theta}{T}$$

$$K_C = \frac{A\cdot \alpha^{B}}{K} \qquad Ti = \frac{\mathrm{T}}{C\cdot \alpha^{D}} \qquad Td = \mathrm{T}\cdot E\cdot \alpha^{F}$$