Department of Mechanics and Machine Design

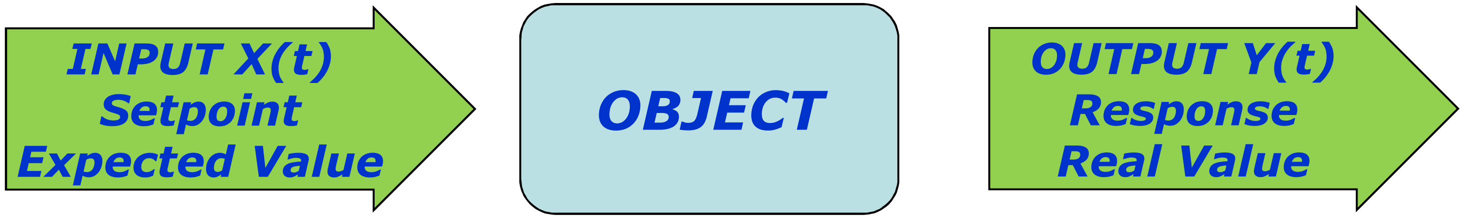
Graphical Programming

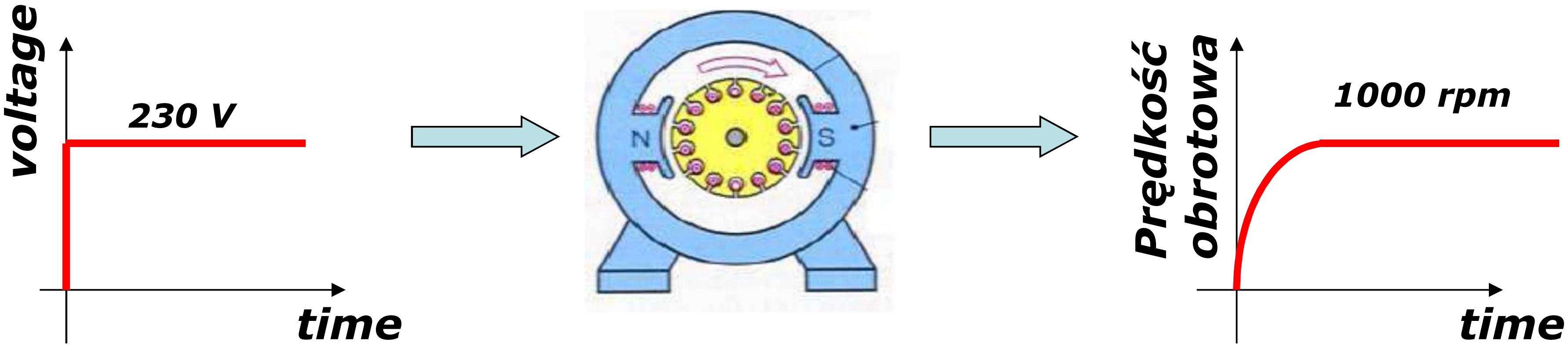
System response

Roland PAWLICZEK

Model of the system

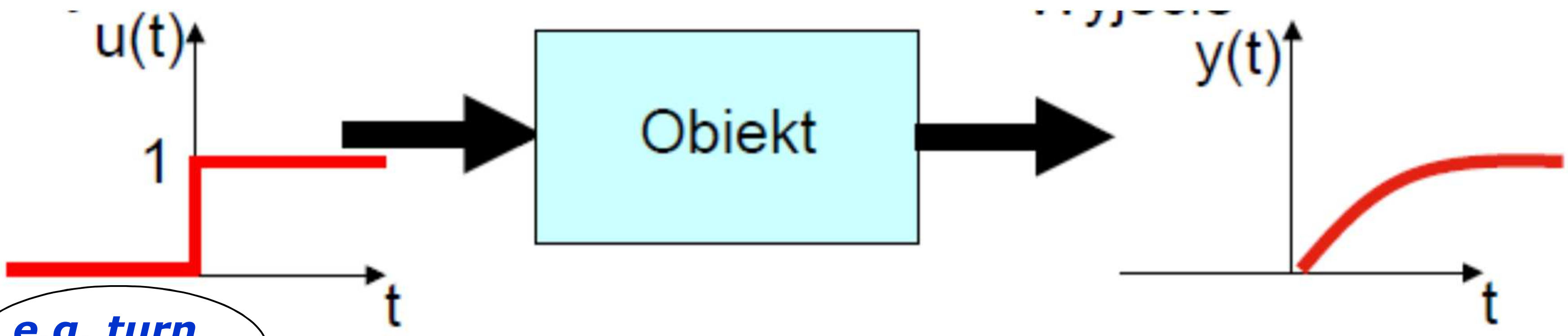
In the simplest way, a system (machines, drives) can be represent as the single-input-single-output (SISO) object, where the output signal y(t) in a reaction on the input signal u(t):



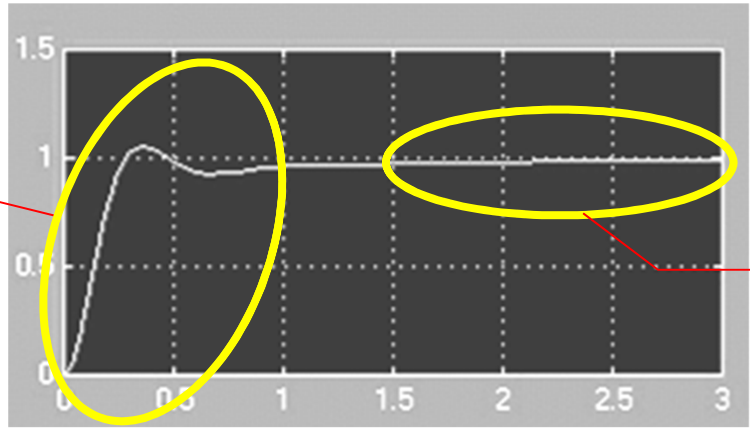


STEP response

***Step response** is the answer of the system for input signal in the form of **step signal**:*



e.g. turn on



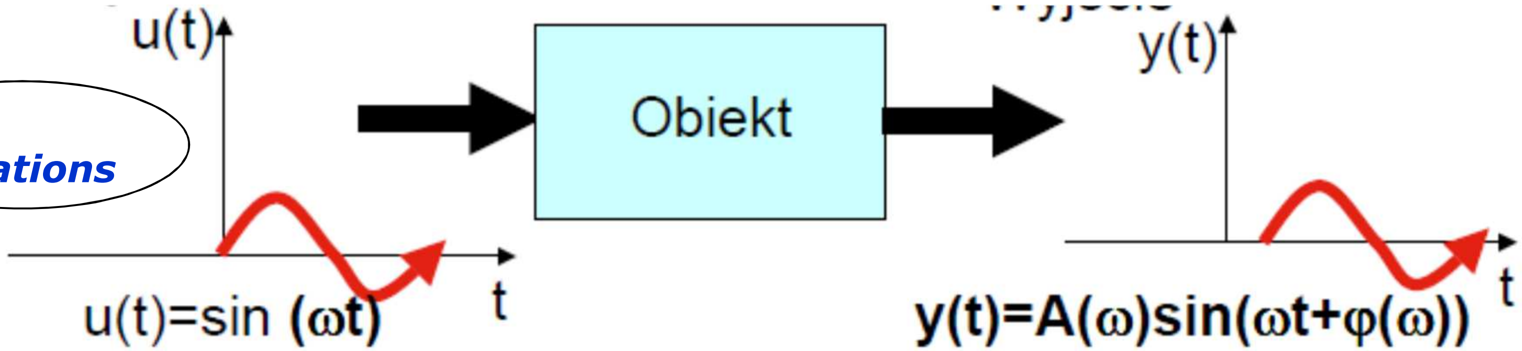
Transient period

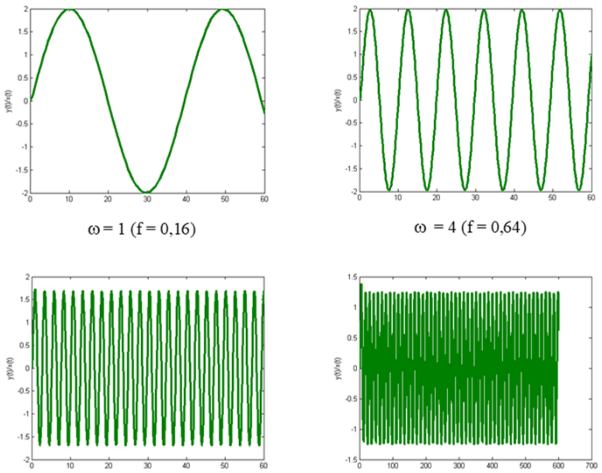
Steady state system stabilises

Frequency Response

Frequency response *is the answer of the system for input signal in the form of* ***sine wave with different frequency.***

e.g. vibrations





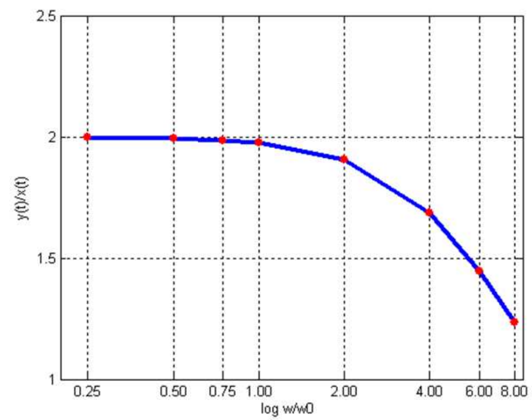
ω = 1 (f = 0,16)

ω = 4 (f = 0,64)

ω = 16 (f = 2,55)

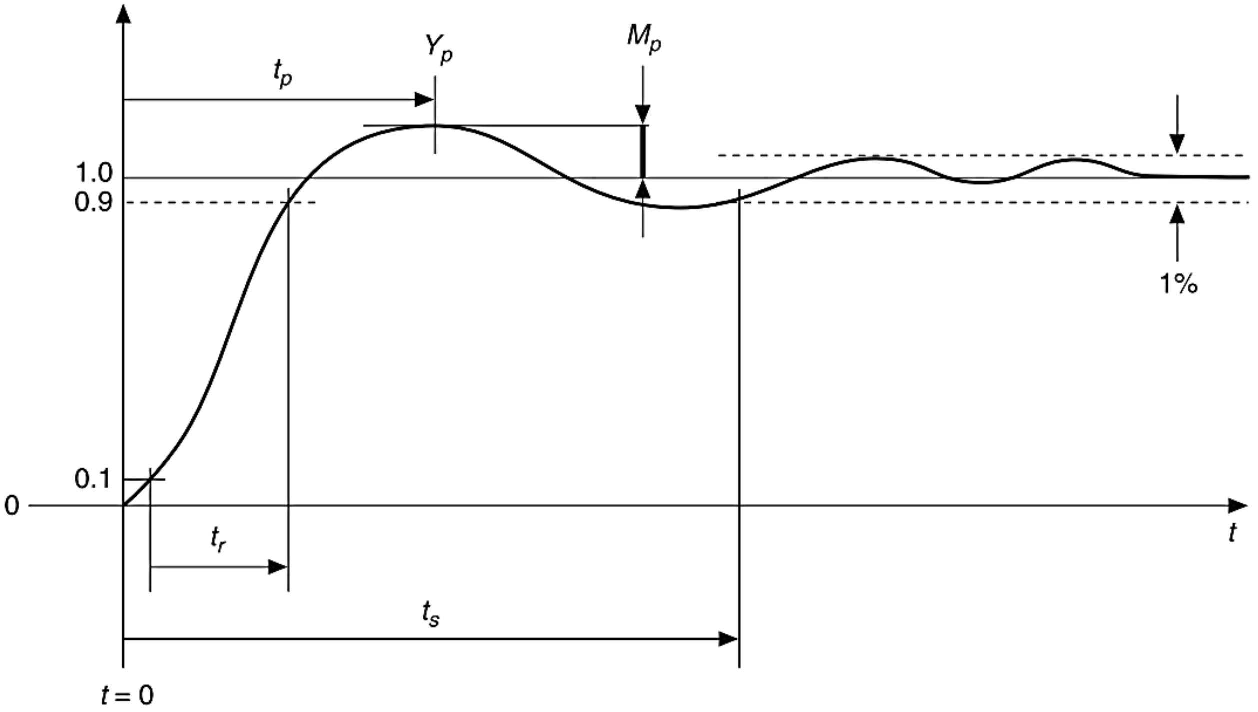
ω = 32 (f = 5,09)

f Hz	ω / ω_0	M(ω)
0,16	0,25	2
0,32	0,50	1.993
0,48	0,75	1,986
0,64	1	1,974
1,27	2	1,905
2,55	4	1,686
3,82	6	1,446
5,09	8	1,235



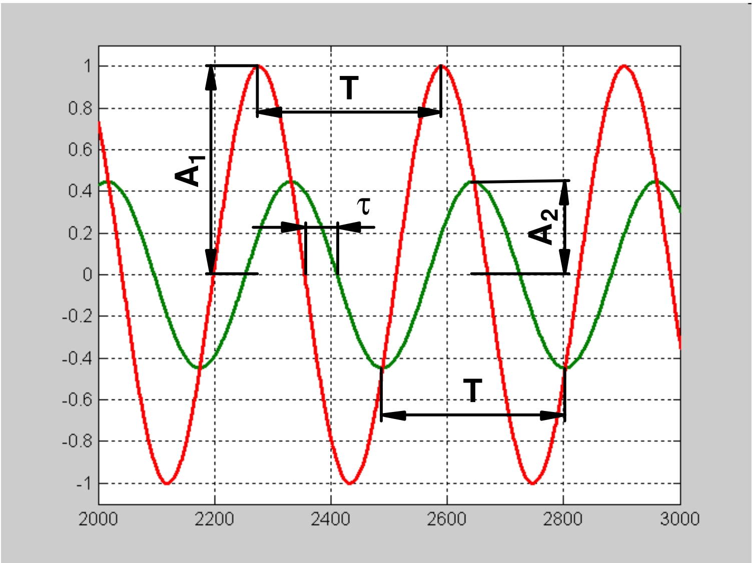
Step Response parameters

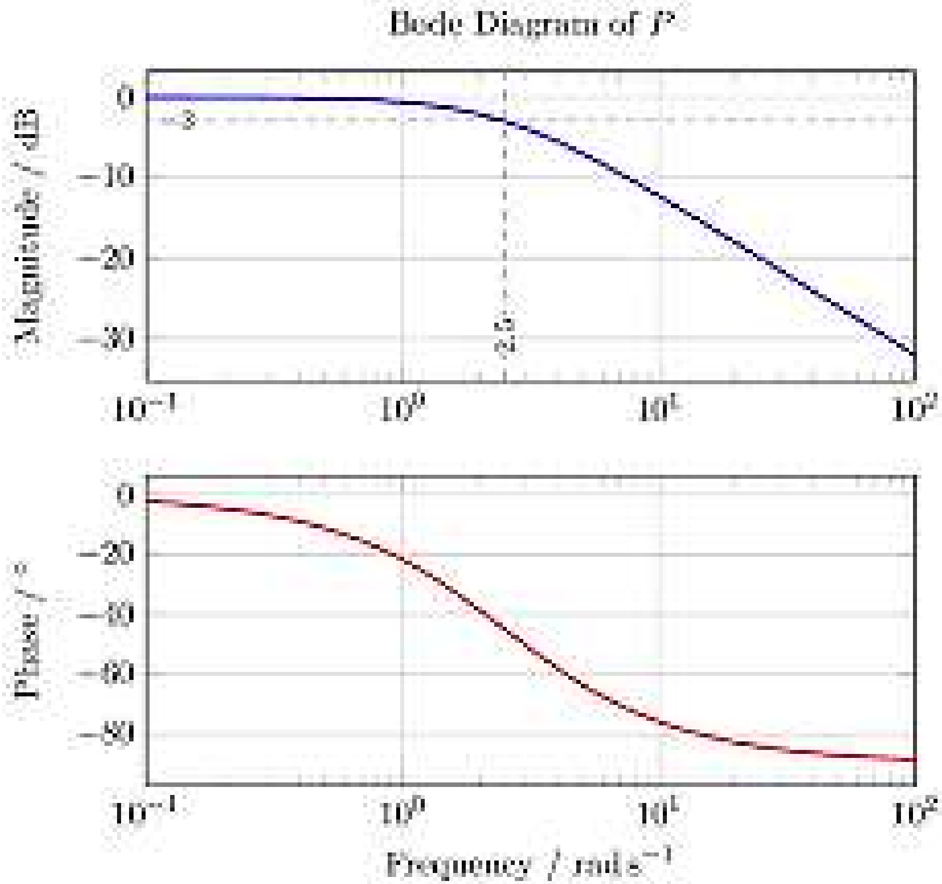
In general case it can be as follow:



- *Rise time (t_r)—The time required for the system to rise from a lower threshold to an upper threshold. The default values are 10% for the lower threshold and 90% for the upper threshold.*
- *Maximum overshoot (M_p)—The system response value that most exceeds unity, expressed as a percent.*
- *Peak time (t_p)—The time required for the system to reach the peak value of the first overshoot.*
- *Settling time (t_s)—The time required for the system to reach and stay within a threshold of the final value. The default threshold is 1%.*
- *Steady state gain—The final value around which the system response settles to a step input.*
- *Peak value (y_p)—The value at which the maximum absolute value of the time response occurs.*

Frequency response: Bode diagrams:





- *input:* $x(t) = A_1 \sin(\omega t)$
- *output:* $y(t) = A_2 \sin(\omega t + \varphi)$

magnitude: $$M(\omega) = \frac{A_2(\omega)}{A_1}$$

phase: $$\omega = 2\pi f = \frac{2\pi}{T} \quad \Rightarrow \quad \varphi = \frac{2\pi\tau}{T}$$

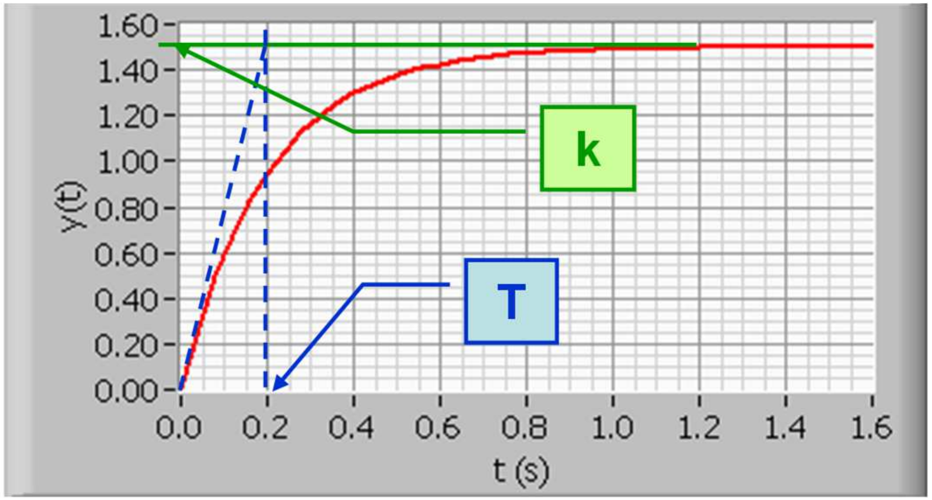
Types of object: 1st order system

Mathematical model:

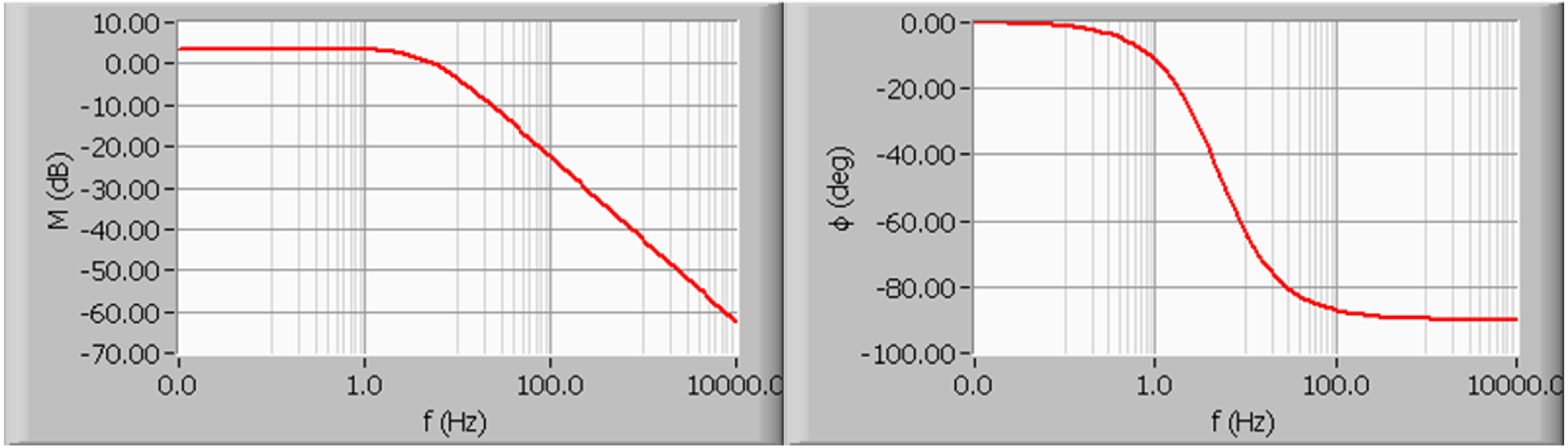
$$T\frac{dy}{dt} + y(t) = kx(t) \qquad G(s) = \frac{k}{Ts+1}$$

T – time constant; k – system gain

step response



frequency response: Bode diagrams



Types of object: 2nd order oscillating system

Mathematical model:

$$\frac{d^2y}{dt^2} + 2D\omega_n \frac{dy}{dt} + \omega_n^2 y(t) = \omega_n^2 k u(t)$$

$$G(s) = \frac{k\omega_n^2}{s^2 + 2D\omega_n s + \omega_n^2}$$

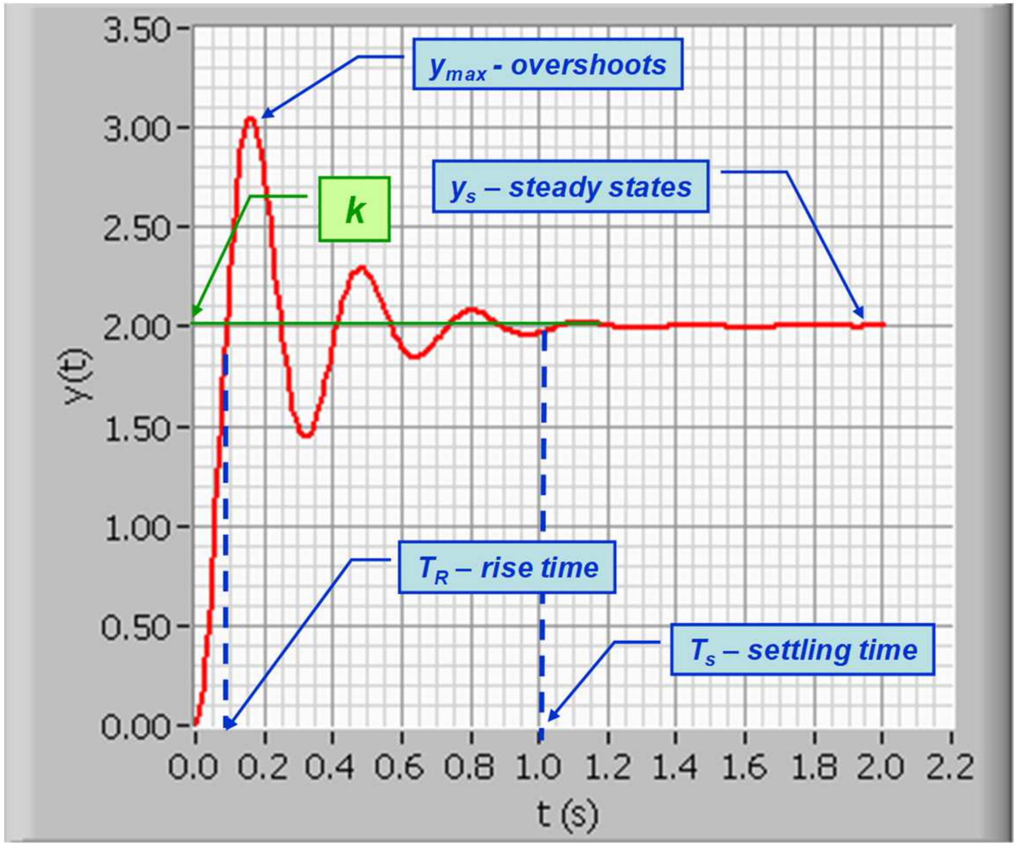
k – system gain

D – damping factor

frequency response: Bode diagrams

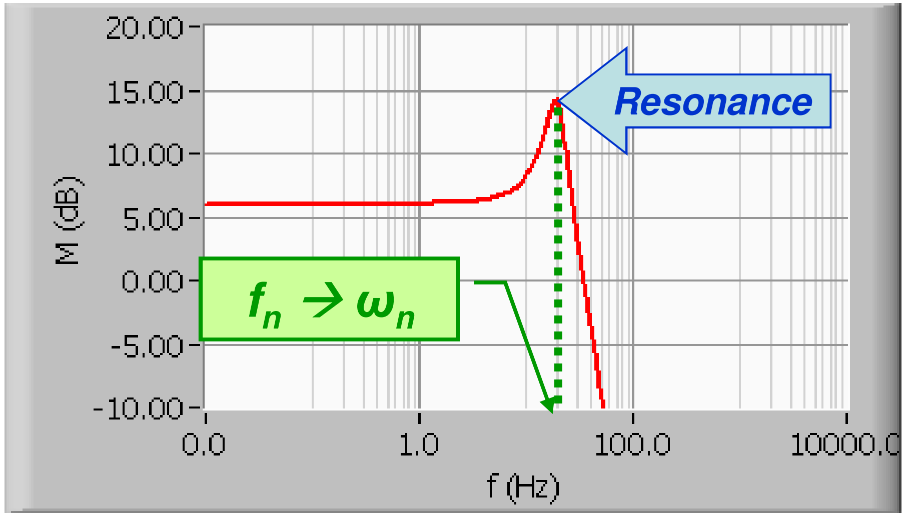
ω_n – natural frequecy

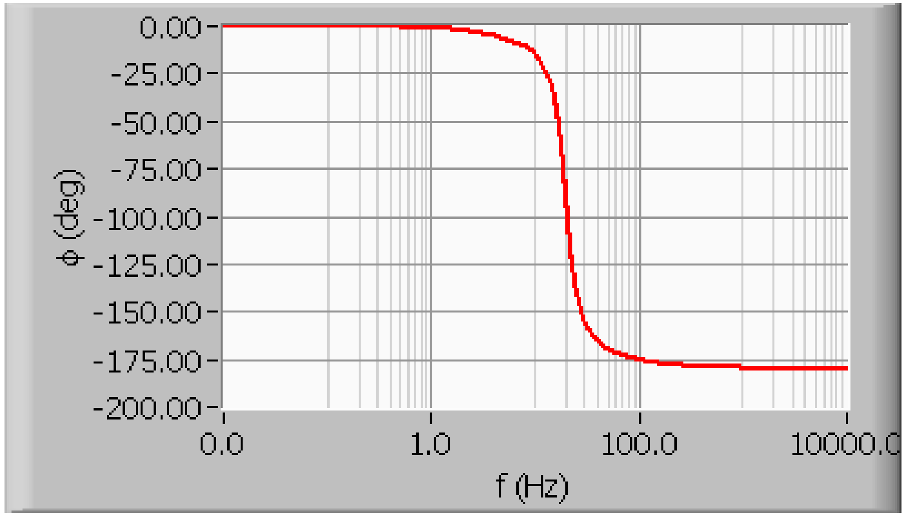
step response



Types of object: 2nd order oscillating system

frequency response: Bode diagrams

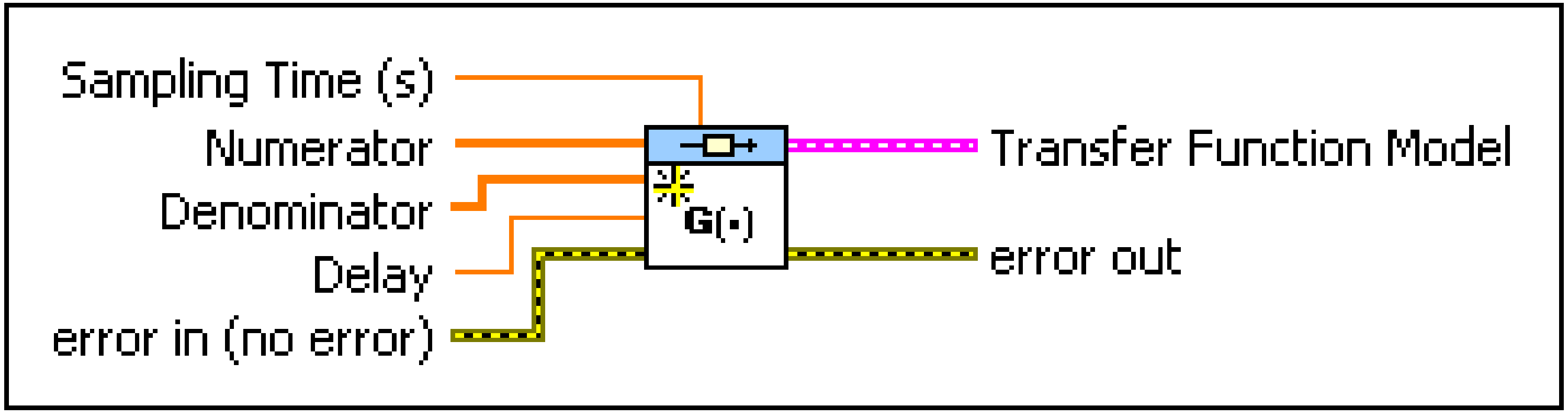




Create Transfer Function Model:

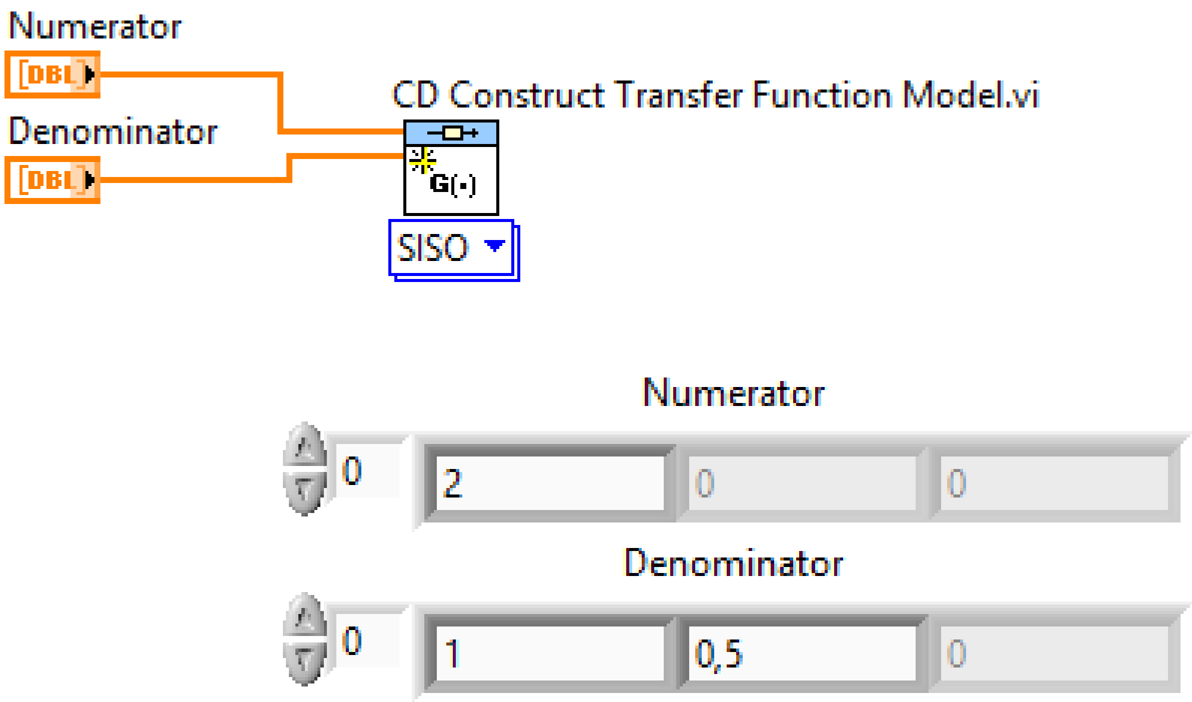
On Block Diagram Window:

1. Open ***Function Palette / Control & Simulation / Control Design / Model Construction / CD Construct Transfer Function Model***



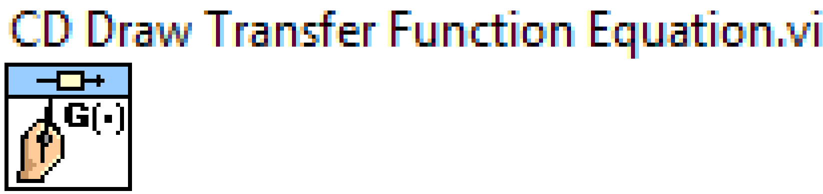
LabVIEW Control Design Module

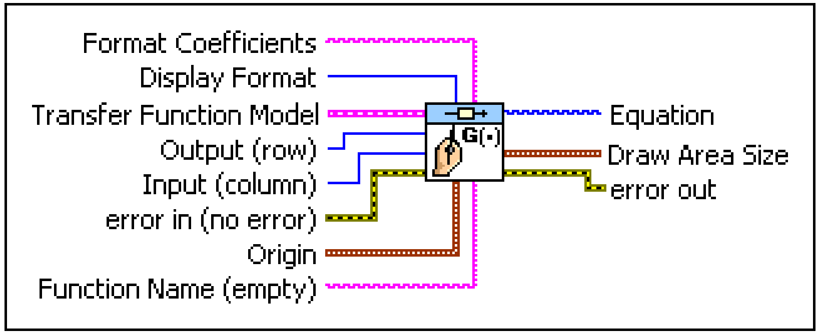
2. *Place the cursor on terminal **Numerator**, click Rigth Mouse Button (RMB) and **Create/Control***
3. *Repeat operation for terminal **Denominator***



LabVIEW Control Design Module

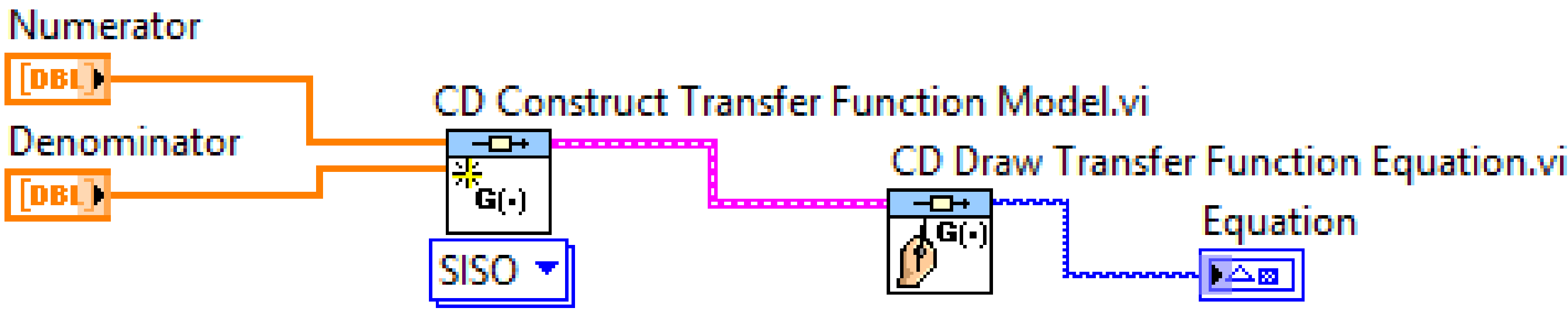
4. *Open* ***Function Palette / Control & Simulation / Control Design / Model Construction / CD Draw Transfer Function Model***





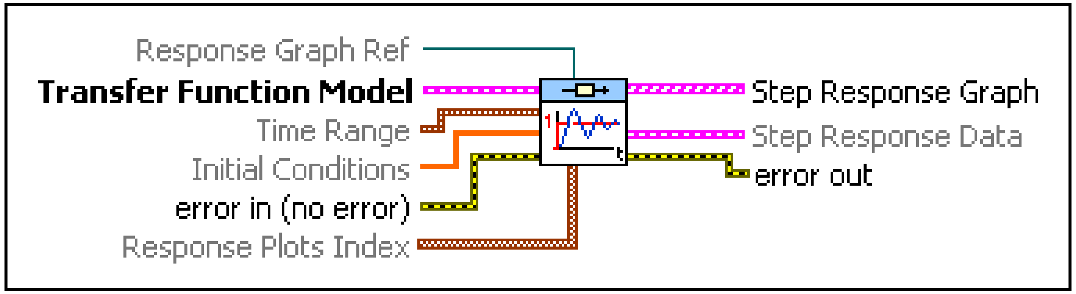
5. *Click RMB on terminal* ***Eqiation*** *and create* ***Indicator.*** *Connect terminals* ***Transfer Funtion Model****.*

   Run the program.

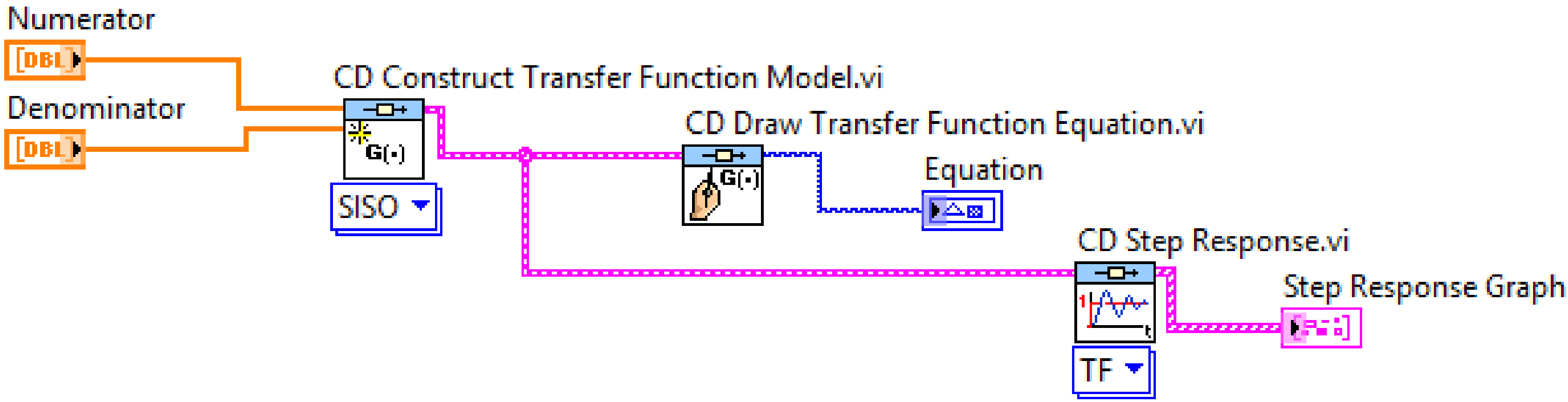


See Step Response:

*1. Open **Function Palette / Control & Simulation / Control Design / Time Response / CD Step Response***

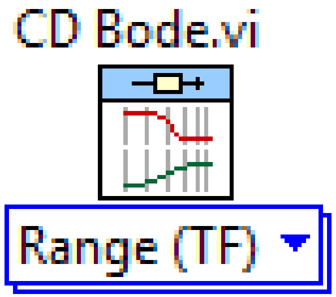


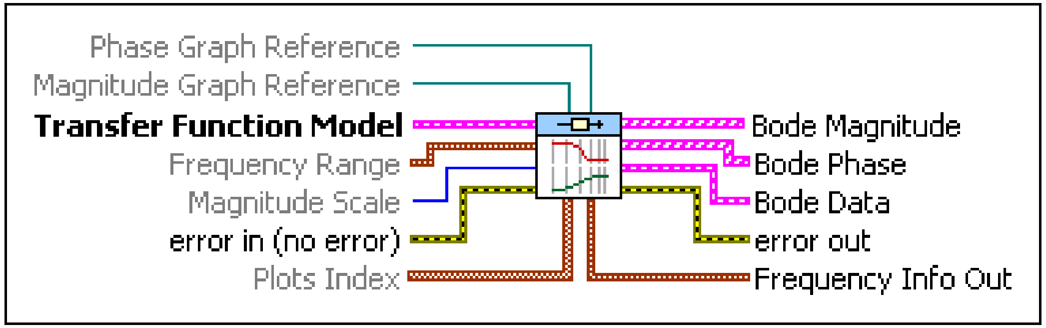
*2. Connect terminals **Transfer Function Models** and generate **Indicator** for terminal **Step Response Graph**.*



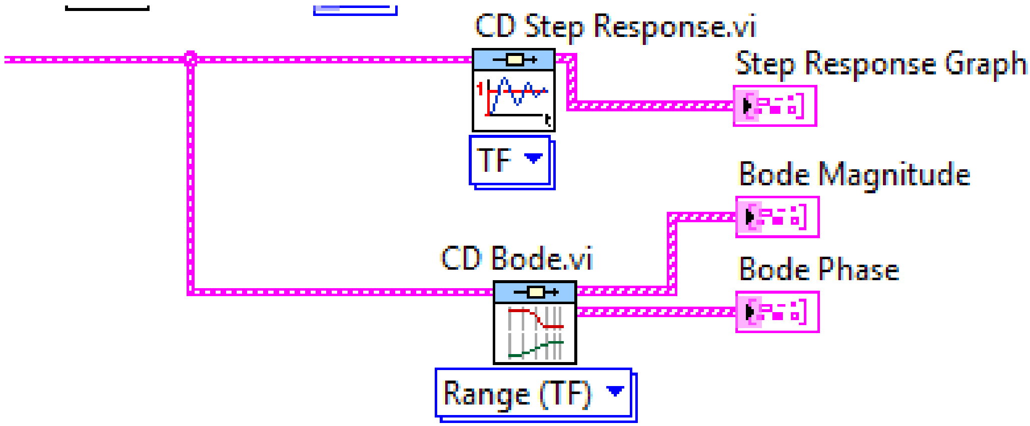
See Frequecny Response:

1. *Open **Function Palette / Control & Simulation / Control Design / Frequency Response / CD Bode***





2. *Connect terminals **Transfer Function Models** and generate **Indicator** for terminals **Bode Magnitude** and **Bode Phase**.*



LabVIEW Control Design Module