How to use the POG_Modeler

- The POG_Modeler can be downloaded from the following website:

  http://www.dii.unimo.it/~zanasi/didattica/Modellistica_e_Controllo/POG_Modeler.zip

- The **Files** and **Directories** contained in the "POG_Modeler" directory are the following:

  POG_Modeler.p: Matlab coded file containing the POG_Modeler program.

  Init.m: run this Matlab file to properly set the "path" command of your Matlab in order to be able to use the POG_Modeler in any directory of your computer.

  POG_Technique_Basic_Properties.pdf: file describing the basic properties of the POG modeling technique.

  How_to_Use_POG_Modeler.pdf: this file which describes the basic information the user have to know for using the POG_Modeler program.

  SIMSCAPE_Basic_Blocks.slx: a Simulink file containing the "Simscape-like blocks" that must be used for defining the structure of the physical systems to be modeled using the POG_Modeler.

  POG_EXAMPLES. Contains many subdirectories and a pdf file:

  - **Example_ii.** each subdirectory contains an example of a physical system that has been modeled using the "Simscape-like blocks". The structure of the physical system is defined by the simulink file a "Example_ii.slx". All the other files are generated by the POG_Modeler program.

  - **SIMSCAPE_Examples.pdf:** this file shows the graphical representations of all the physical systems contained in the subdirectories.

  UTILITIES. Contains additional materials concerning the POG Modeling technique:

  - **POG_Matlab_Functions.** Contains Matlab functions useful for the POG Modeling Technique.
  - **POG_Papers.** Contains papers concerning the use of the POG Modeling Technique.
  - **POG_Videos.** Contains a few videos describing how to use the POG_Modeler.

- **How to install the POG_Modeler**:

  1) Copy all the material contained in the "POG_Modeler.zip" file in the desired user directory.
  2) Open Matlab and choose "POG_Modeler" as current directory.
  3) Run the matlab file "Init.m".

- **How to use the POG_Modeler**:

  1) Choose a "Current_Directory" where to put the files of the new physical system you want to model using the POG_Modeler program, and choose a "System_Name" for the physical system.
  2) Using Simulink, create a "System_Name.slx" file describing the structure of the physical system using only the blocks present within the "SIMSCAPE_Basic_Blocks.slx" library.
  3) Run the "POG_Modeler('System_Name')" command.
  4) Automatically the "POG_Modeler" will generate the following files:
     a) "System_Name_EQN.m": this file contain the state space differential equations of the system in symbolic and numeric form;
     b) "System_Name_SCH.eps": this figure shows the structure of the physical system;
     c) "System_Name_POG.eps": this figure shows the POG block scheme of the physical system;
     d) "System_Name_SLX.slx": this simulink file contains the POG scheme obtained using simulink blocks;

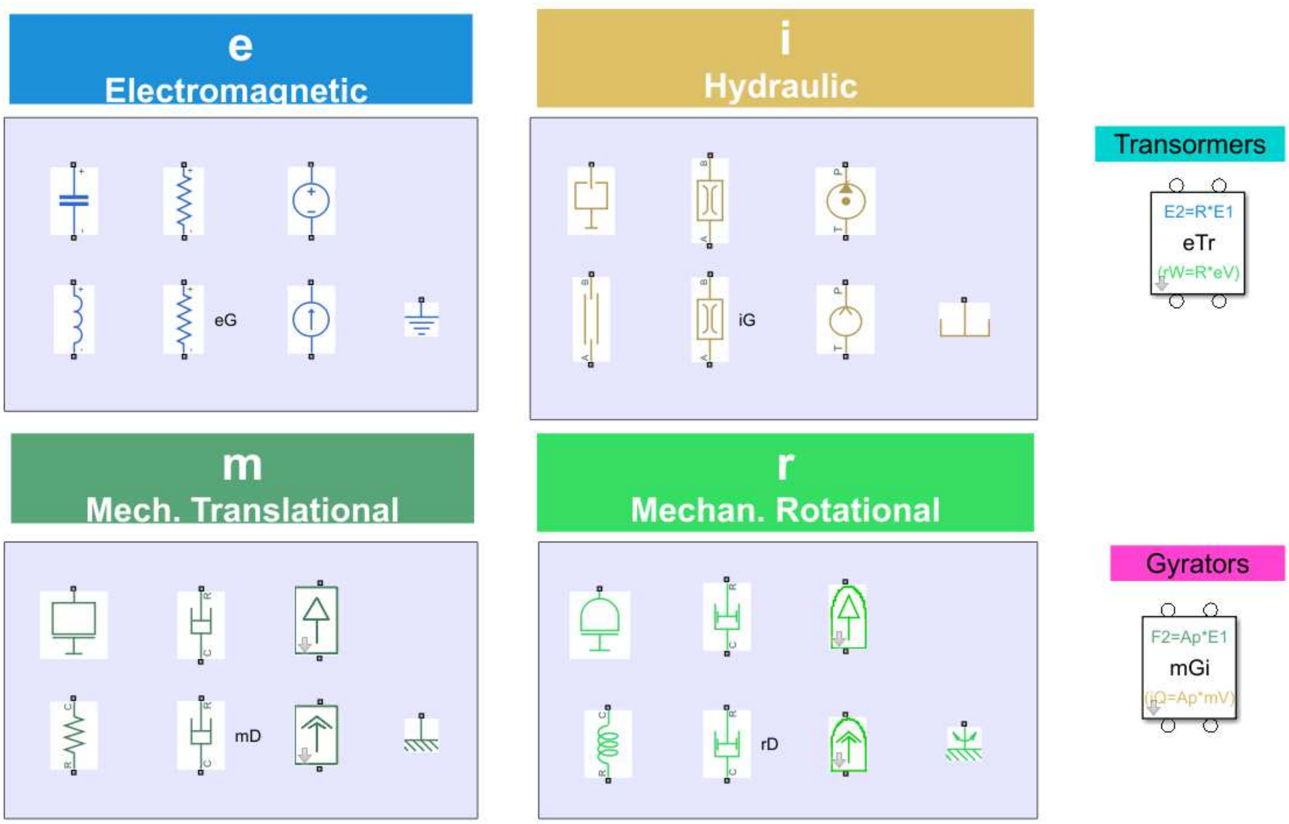
e) "System_Name_SLX_m.m": this matlab file defines all the variables of the system, run the simulink file and plot the simulation results;

f) "System_Name.tex": this latex file is a relation on how to model the considered physical system. In particular, the relations shows: the physical scheme of the system, the POG block scheme, the POG state space equations in symbolic form, the default names and values of all the systems parameters, the default transfer function $H(s)$, the poles of the system and the simulation results obtained running the simulink file.

g) "System_Name.pdf": this is the compiled pdf file obtained from the latex file. This file will be generated only if the "latex" program is installed in the PC.

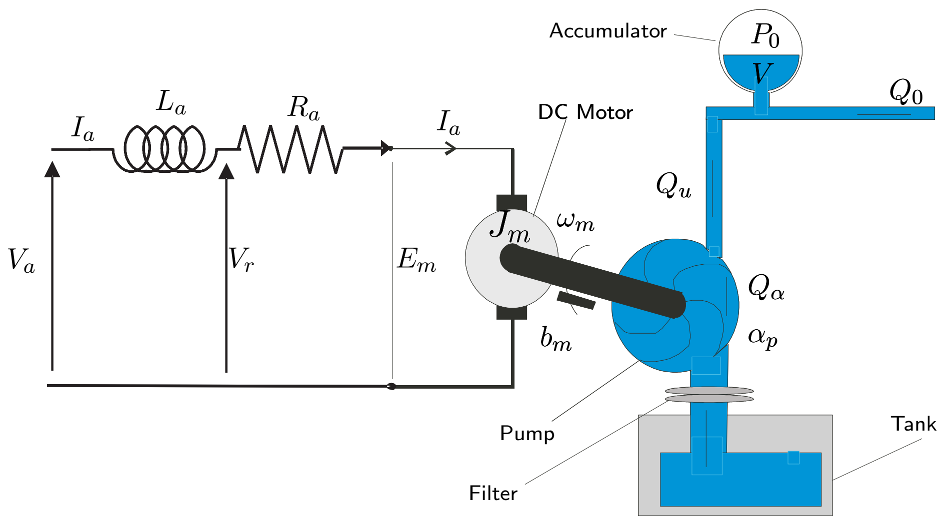
h) "System_Name_*_***_SIM.eps": these figures show the simulation results obtained using the simulink file.

The Simscape blocks present within the "SIMSCAPE_Basic_Blocks.slx" file.



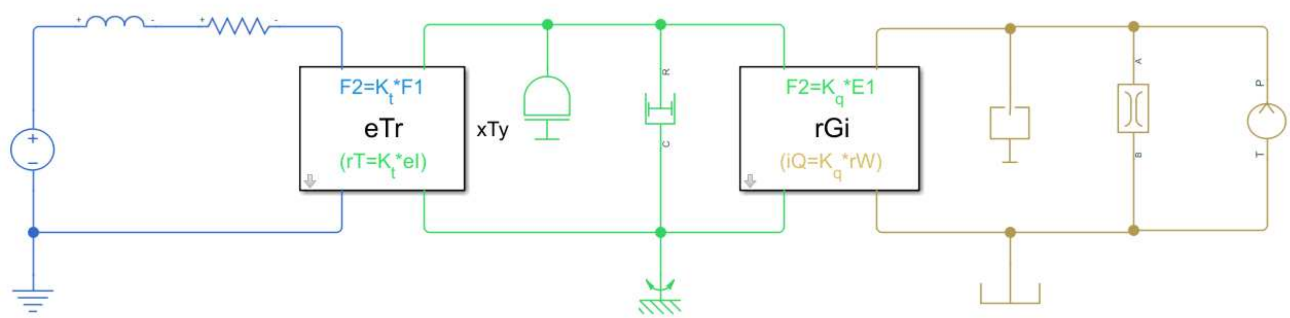
Example: a DC electric motor with an hydraulic pump.

The physical system:



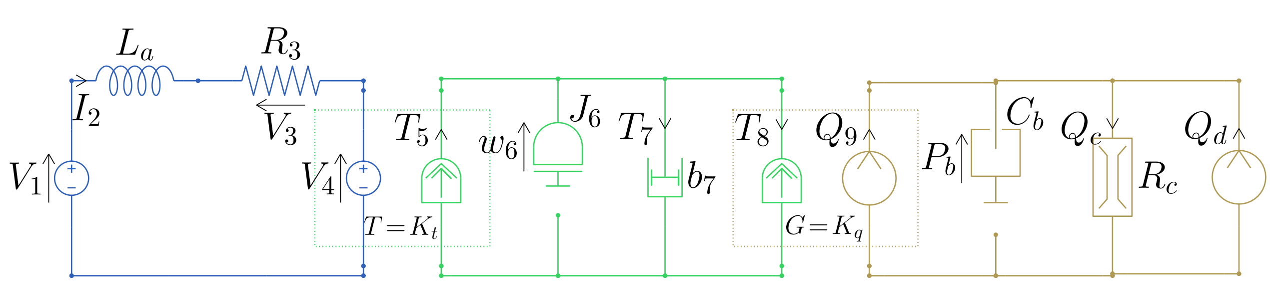
The simulink/simscape file:

This simulink/simscape file "System_Name.slx" describes the structure of the physical system using only the blocks present within the "SIMSCAPE_Basic_Blocks.slx" library.

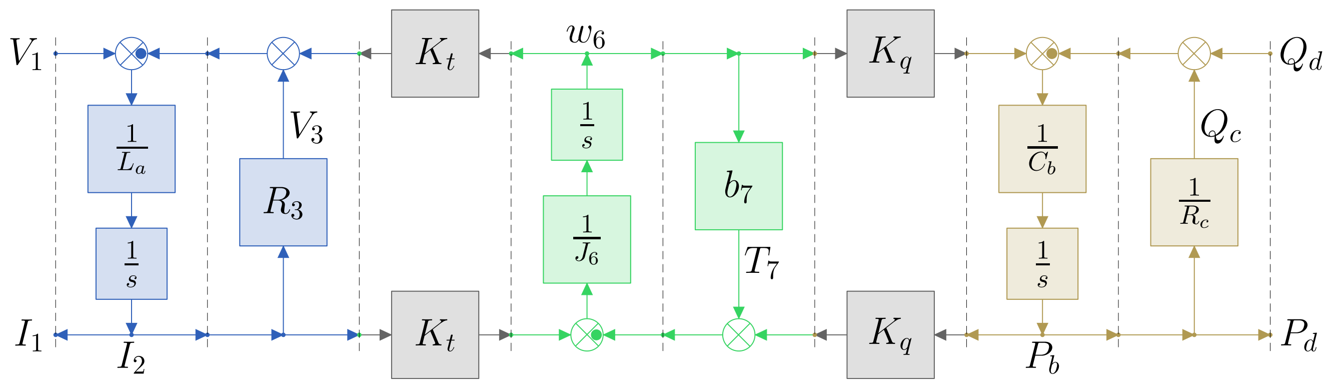


The latex relation generated by the POG_Modeler

Consider the following physical physical system:



The corresponding POG block scheme is:



The POG state space equations

The state space equations of the considered system are the following:

$$\begin{bmatrix} L_a & 0 & 0 \\ 0 & J_6 & 0 \\ 0 & 0 & C_b \end{bmatrix} \dot{\mathbf{x}} = \begin{bmatrix} -R_3 & -K_t & 0 \\ K_t & -b_7 & -K_q \\ 0 & K_q & -\frac{1}{R_c} \end{bmatrix} \begin{bmatrix} I_2 \\ w_6 \\ P_b \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} V_1 \\ Q_d \end{bmatrix}$$

$$\begin{bmatrix} I_1 \\ P_d \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \mathbf{x} + \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \mathbf{u}$$

The transfer function $\mathbf{H}(s)$ which links the input vector $\mathbf{u}(s)$ to the output vector $\mathbf{y}(s)$, $\mathbf{y}(s) = \mathbf{H}(s)\,\mathbf{u}(s)$, is the following:

$$H(s) = \frac{K_q K_t R_c}{R_3 b_7 + K_t{}^2 + J_6 R_3 s + L_a b_7 s + K_q{}^2 R_3 R_c + J_6 L_a s^2 + C_b K_t{}^2 R_c s + K_q{}^2 L_a R_c s + C_b R_3 R_c b_7 s + C_b J_6 L_a R_c s^3 + C_b J_6 R_3 R_c s^2 + C_b L_a R_c b_7 s^2}$$

Numerical and simulation results

System parameters, input values and initial conditions:

```
%%%%%%%%%%%%    SYSTEM PARAMETERS   %%%%%%%%%%%%%%%%%%%%%%%%%%
L_a = 0.02*H;             % 2. Inductance L_a . Internal parameter.
R_3 = 100*Ohm;            % 3. Resistance R_3 . Internal parameter.
K_t = 1;                  % 5. Parameter. Transformer/Gyrator.
J_6 = 0.01*kg*m^2;        % 6. Inertia J_6 . Internal parameter.
b_7 = 0.1*Nm/(rad/sec);   % 7. Angular Friction b_7 . Internal parameter.
K_q = 1;                  % 9. Parameter. Transformer/Gyrator.
C_b = 0.001*m^3/Pa;       % 10. Hyd. Capacitance C_b . Internal parameter.
R_c = 10000*Pa/(m^3/sec);% 11. Hyd. Resistance R_c . Internal parameter.
%%%%%%%%%%%%    INPUT VALUES   %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
V_1_0 = 10*V;             % 1. Voltage V_1_0. Input value.
Q_d_0 = 0*m^3/sec;        % 12. Volume Flow rate Q_d_0. Input value.
%%%%%%%%%%%%    INITIAL CONDITIONS X0 %%%%%%%%%%%%%%%%%%%%%%%%%
I_2_0 = 0*A;              % 2. Current I_2_0. Initial condition.
w_6_0 = 0*rad/sec;        % 6. Angular Velocity w_6_0. Initial condition.
P_b_0 = 0*Pa;             % 10. Pressure P_b_0. Initial condition.
```

The numerical value of the transfer function $H(s)$ which links the input $V_1(s)$ to the output $P_d(s)$ is:

$$H(s) = \frac{P_d(s)}{V_1(s)} = \frac{10000}{0.002s^3 + 10.02s^2 + 311.0s + 1.0e^{+6}}.$$

The poles of the system are the following:

$$\text{Poles} = \begin{bmatrix} -5.5492 - 316.21i \\ -5.5493 + 316.21i \\ -4999.0 \end{bmatrix}.$$

The settling time T_s and the oscillation period T_ω of the system is:

$$T_s = \frac{-3}{-5.5492} = 0.54061s, \qquad T_s = \frac{2\pi}{316.21} = 0.01987s$$

The time behavior of the components of the state vector $\mathbf{x}$ obtained in simulation are the following: