# Tutorial 2 – Dynamic system Analysis

# Modeling and simulation (no report)

---

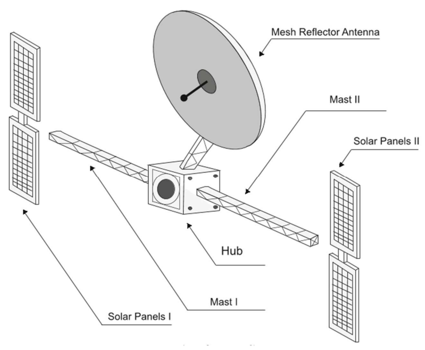
## ***Satellite antenna with flexible solar panels***

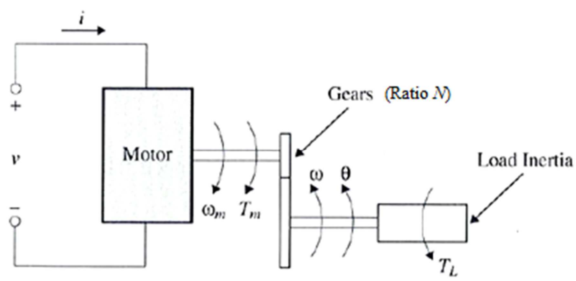
*Skills to develop:*
- modeling of systems for linear and rotational motions
- modeling of systems using Newton's laws
- modeling of systems using conservation laws
- simulation with block diagram
- observability and governability

*Objectives of the exercise:*
- establish the motion equations of an electromechanical system with a flexible load
- compute transfer functions and state-space representations
- analyze transfer functions and state-space representations

***Description of the context***

A gearmotor ensures the positioning of satellite solar panels.




data for the gear motor

$N = 300$ ratio of reduction

$J_m = 0.001$ $m^2kg$ DC motor inertia

$k_e = k_\Gamma = 0.2$ en V/rad/s ou en Nm/A torque constant

$R_e = 2\ \Omega$

$L_e = 2$ mH

data for the load

$J_l = 100$ $m^2kg$ load inertia

$K_l = 1e4$ N/m load stiffness N/m

$b = 10$ Viscous coefficient

***Questions***

1. Write the electrical equation of the motor and the mechanical equation of the gear motor connected to the load.

2. *Case* $T_L = 0$ *.*

2.1 - Compute the transfer function $\frac{\theta}{v}$

2.2 - With Matlab, compute the poles of the transfer function:
- method 1: define the numerator and denominator and use the function *roots*
- method 2: define a system (function *tf*) and use the function *zpkdata*

With Matlab, plot the Bode diagrams (function *bode*), the Nichols diagram (function *nichols*), and the root locus (function *rlocus).* Try also the LTIview Graphical Interface (function *ltiview*)

2.3 – With Simulink, make the bock diagram of the system (use inport and outport blocks to define input and output) and, with Matlab, compute the state-space representation with $\theta$ as output using the function *linmod.* Then plot the Bode diagrams (you must of course find the same Bode diagrams as in question 2.1 (hint: to plot two curves on the same diagram, use the function *hold on*).
Compute the eigenvalues of the matrix A (function *eig*), the natural frequencies and damping ratios of the system.
Compare the eigenvalues with the poles of the transfer function.

2.4 – Observe the step response (function *step* or ltiview)

3. *Case* $T_L = b\dot{\theta} + K_l\theta$

3.1 - Compute the transfer function $\frac{\theta}{v}$

3.2 - With Matlab, compute the poles of the transfer function and plot the Bode diagrams, the Nichols diagram, and the root locus.
Analyze the effect of the load.

3.3 – With Simulink, make the bock diagram of the system. With Matlab, compute the state-space representation with $\theta$ as output using the function *linmod*, the eigenvalues of the matrix A, the natural frequencies and damping ratios of the system. Plot the Bode diagrams.

3.4 – Observe the step response and the effect of the load.

3.5 – Use the equations to write a state-space representation with $\theta$ as output. Compare with the state-space representation obtained in 3.2. Is the state-space representation unique?

3.6 - Study the observability (functions *obssv* and *rank*) and the controllability of the system (functions *ctrb* and *rank*)