

GEORGE CONSTANTINESCU' TORQUE CONVERTER ANALYSIS BY SIMULINK

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The Constantinescu Torque Converter aroused intense interest in the popular and technical press in many parts of the world. His Torque Converter was a mechanical application of his theory on the transmission of power by vibrations. Power is transmitted from the engine to the output shaft through a system of oscillating levers and inertias. In this paper, the Constantinescu Torque Converter is analyzed by Simulink. Modeling of the dynamics for an automotive application will demonstrate its high performance characteristics. In the modeling of this power transmission system, the stiffness of the shaft and various control logics are included. Using the developed simulation method, the effects of the design variables and the control conditions are evaluated.

Keywords: torque converter mechanism; Simulink; block diagram modeling environment.

1. INTRODUCTION

Simulink is a software package for modeling, simulating, and analyzing dynamic systems. It supports linear and nonlinear systems, modeled in continuous time, sampled time, or a hybrid of the two.

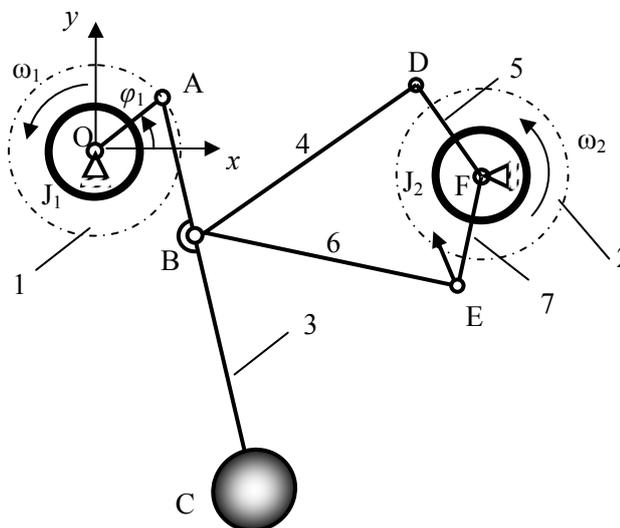


Figure 1. Typical graphical representation of G. Constantinescu torque converter mechanism

A goal of Simulink is to give you a sense of the fun of modeling and simulation, through an environment that encourages you to pose a question, model it, and see what happens.

To illustrate the basic principle of the Constantinescu torque converter, consider a typical example as shown in figure 1. The impulses are produced by a crank OA connected to a apex of a pendulum 3 (lever with a weight on the end C). A point B of the pendulum is connected with links 4 and 6 to unidirectional "mechanical valves" 5 and 7 on the secondary shaft 2.

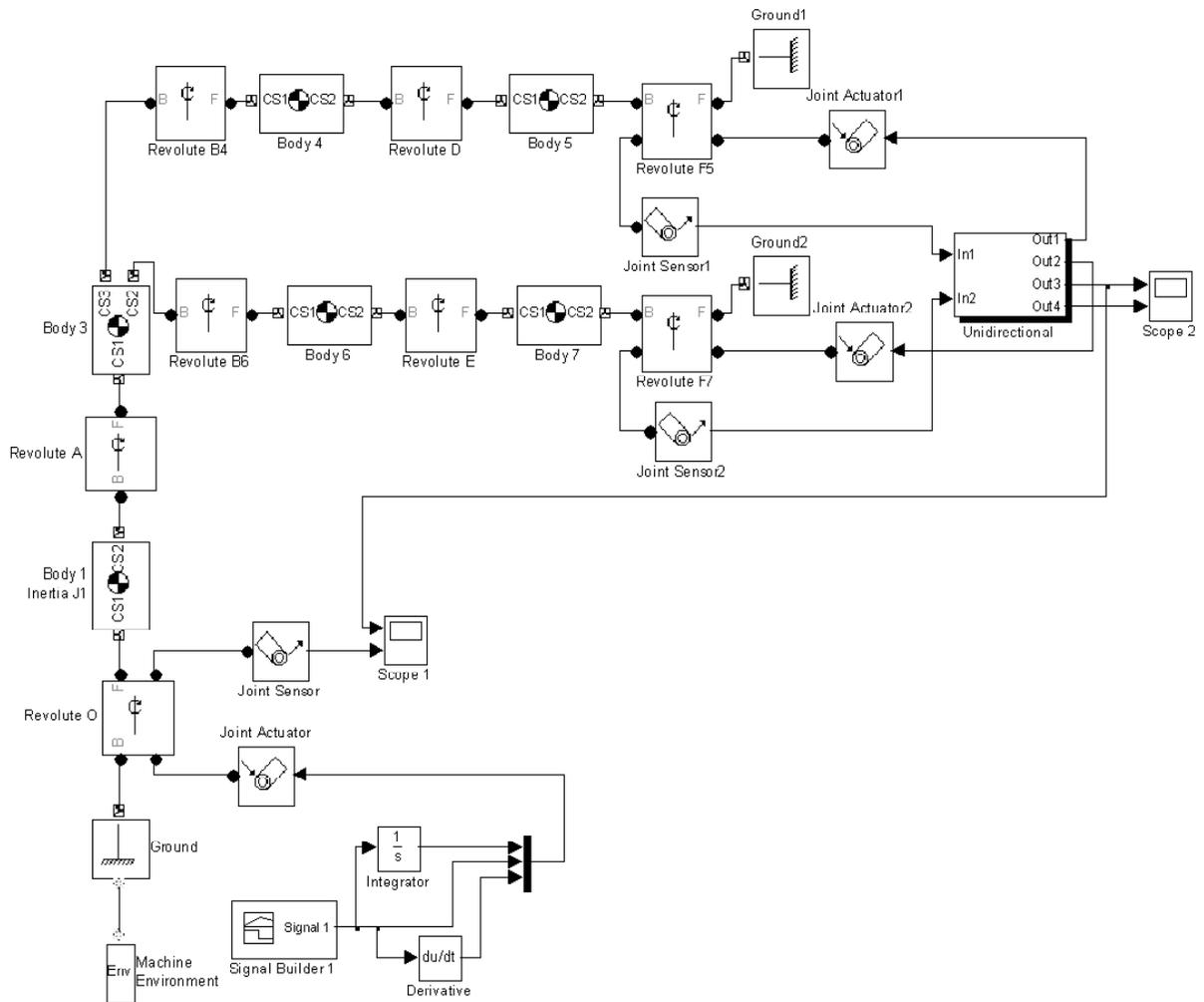


Figure 2. The Simulink model of torque converter mechanism

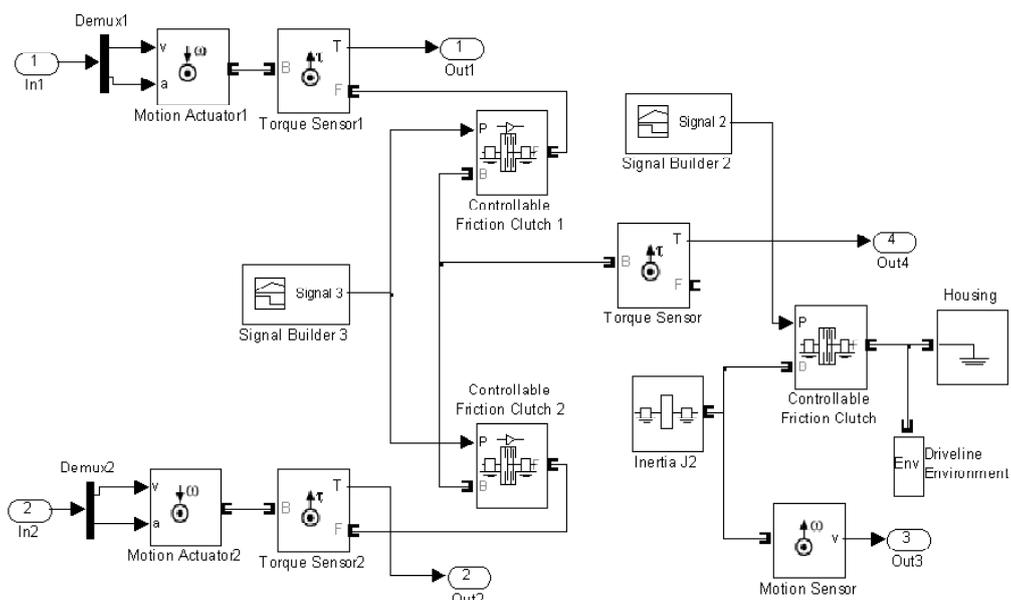


Figure 3. The Simulink model of unidirectional mechanism

2. PHYSICAL MODEL BUILDING

For torque converter analysis, in this paper are utilizing two kinds of block diagram modeling environment: SimMechanics for six bar mechanism OABDEF and SimDriveline for unidirectional mechanism and secondary shaft (see figures 2 and 3).

SimMechanics and SimDriveline are parts of Simulink Physical Modeling, encompassing the modeling and design of systems according to basic physical principles. Physical Modeling runs within the Simulink environment and interfaces seamlessly with the rest of Simulink and with MATLAB. Unlike other Simulink blocks, which represent mathematical operations or operate on signals, Physical Modeling blocks represent physical components or relationships directly.

SimMechanics is a block diagram modeling environment for the engineering design and simulation of rigid body machines and their motions, using the standard Newtonian dynamics of forces and torques.

SimDriveline is a block diagram modeling environment for the engineering design and simulation of drivelines, or idealized powertrain systems. The function of a driveline is to propel a vehicle or craft by transferring its engine torque and power into vehicle momentum and kinetic energy. Drivelines consist of bodies spinning around fixed axes and subject to Newton's laws of motion.

With SimMechanics, a researcher can model and simulate mechanical systems with a suite of tools to specify bodies and their mass properties, their possible motions, kinematic constraints, and coordinate systems, and to initiate and measure body motions.

With SimDriveline, can be represent a driveline machine. He can initiate and maintain rotational motion in a driveline with actuators while measuring, via sensors, the motions of driveline elements and the torques acting on them.

I represent a mechanical system by a connected block diagram, like other Simulink models, and I can incorporate hierarchical subsystems.

SimMechanics analysis mode for studying this machine motion is forward (direct) dynamics. This mode computes the position and velocities of a system's bodies at each time step, given the initial positions and velocities of its bodies and any forces applied to the system. SimMechanics integrates the accelerations twice to yield the velocities and positions as functions of time.

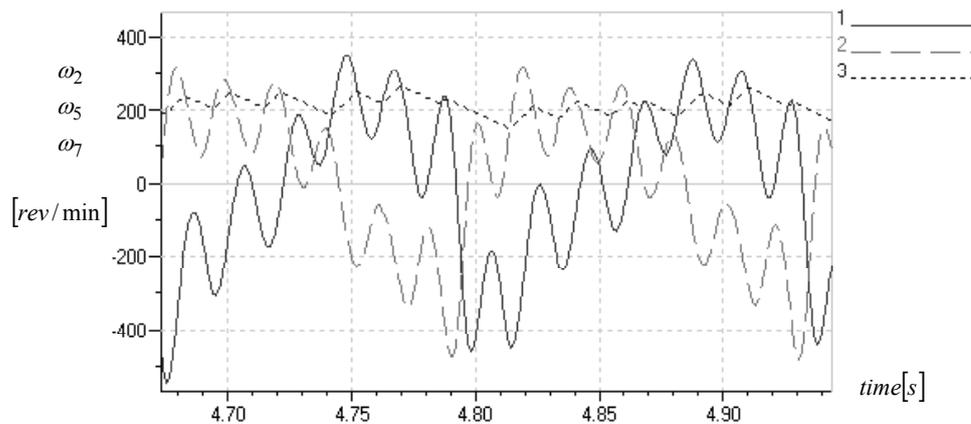


Figure 4. Angular velocity diagrams: 1- ω_5 ; 2- ω_7 ; 3- ω_2 .

The dynamic model takes the form of a system of differential equation in time, with coefficients which are configuration dependent

$$M\ddot{q} + A\dot{q}^2 + Gq = r(t) \quad (1)$$

where

- M is the inertia matrix of the system,
- $A\dot{q}^2$ represents centrifugal and Coriolis terms,
- q generalized coordinates vector of the whole mechanism,

- G represents the action of gravity on the system,
- $r(t)$ represents the external torques (generalized forces) applied on the system.

Following, the physical model shown in figure 2 is analyzed for initial dates: $J_1 = 0.5 \text{ kg} \cdot \text{m}^2$; $J_2 = 10 \text{ kg} \cdot \text{m}^2$; $m_3 = 5 \text{ kg}$; $OA = 10 \text{ mm}$; $AB = 100 \text{ mm}$; $AC = 500 \text{ mm}$ in two working condition actuation: 1 – prime mover with constant speed; 2 – prime mover with constant torque.

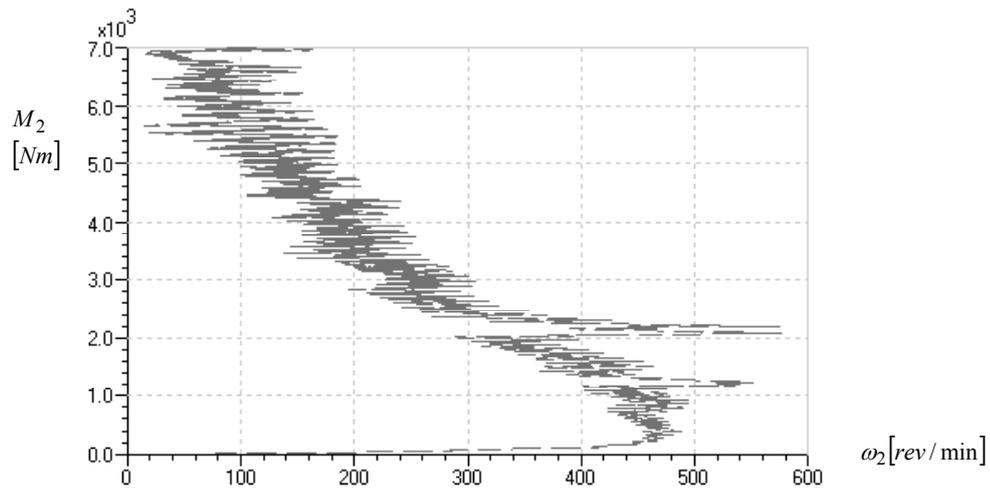


Figure 5. Output torque diagram $M_2(\omega_2)$

3. PRIME MOVER WITH CONSTANT SPEED ACTUATION MECHANISM

For prime mover with constant angular velocity $n_1 = 3000 \text{ rev/min}$ (par example electromotor) and load torque $M_2 = 0 \dots 7000 \text{ Nm}$, linear varying with respect to time (t), the angular velocity diagrams for levers 5, 7 and unidirectional mechanism 2 are depicted in figure 4.

The output torque diagram M_2 with respect to output angular speed ω_2 is depicted in figure 5. The input torque diagram M_1 with respect with to output angular speed ω_2 is depicted in figure 6.

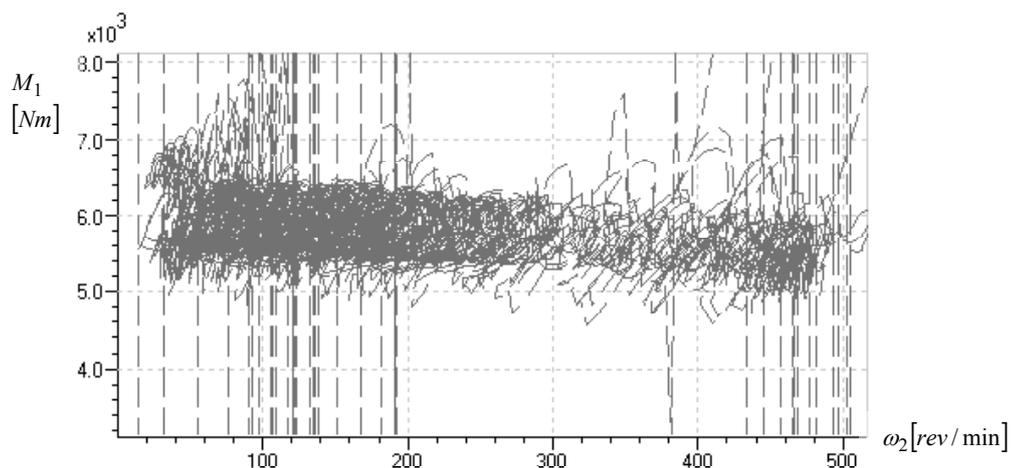
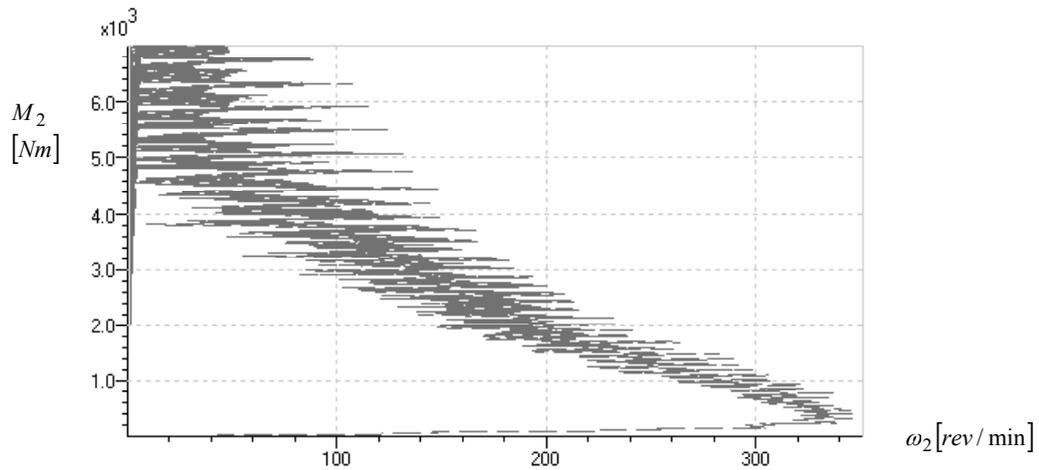
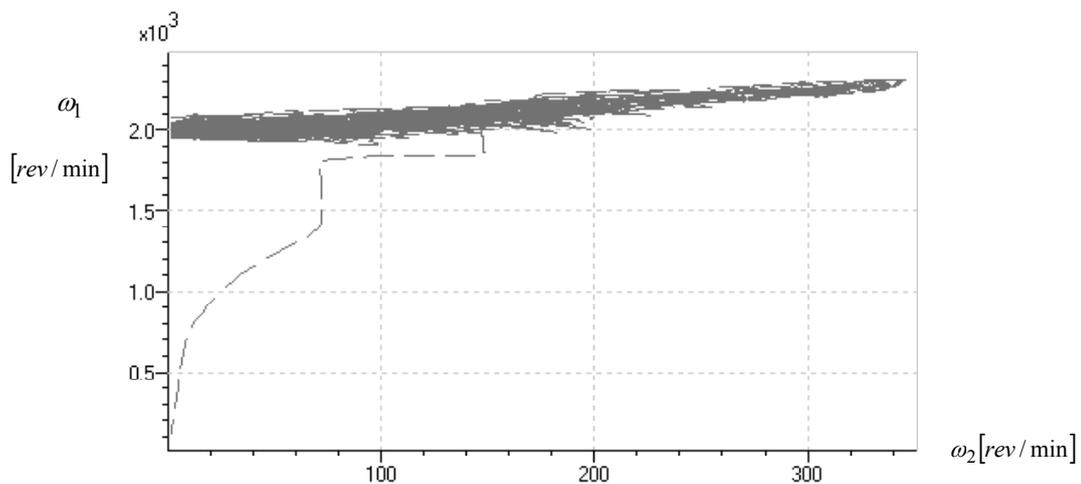


Figure 6. Input torque diagram $M_1(\omega_2)$

Figure 7. Output torque diagram $M_2(\omega_2)$ Figure 8. Input angular velocity diagram $\omega_1(\omega_2)$

4. PRIME MOVER WITH CONSTANT TORQUE ACTUATION MECHANISM

For prime mover with constant torque $M_1 = 4000Nm$ actuation (par example internal-combustion engine), the output torque diagram M_2 and input angular velocity ω_1 (with respect to output angular velocity ω_2) are drawn in figures 7 and 8.

5. CONCLUSIONS

The inertia reaction loads applied from the pendulum 3 to the drive rods 4 and 5 as shown in figure 1, provides the variable transmission of power in the Constantinescu torque converter. The Constantinescu converter apply a ratcheting or one-way cluching device to convert an oscillating torque into a unidirectional torque. It utilize an inertial reaction force to achieve variable control. The output torque M_2 is the product of the input torque M_1 and the speed ratio. For the both case (prime mover with constant speed actuation constant or prime mover with constant torque actuation constant), it controls the magnitude of the output torque via the speed ratio.

This modeling of the dynamics for an automotive application is demonstrate its high performance characteristics. Analysis indicates that the upper design load limit is nearly unlimited (see figures 5 and 7) in high mechanical efficiency for most operational conditions, due to pure dynamic coupling and the small number of energy-dissipating components.

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