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DRIVING SYSTEM FOR A SIMULATION PLATFORM USED FOR A TRANSPORT VEHICLE

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Abstract:

The paper presents a platform for simulation of movement of a transport vehicle. The simulator can be used for training of military tank drivers, automobile drivers and for other transport or battle vehicles. The platform can be designed to carry a real vehicle and to simulate its movement in different conditions.

The platform structure is based on a hexapod robot, which assures high stiffness and good mobility. The novelty of the solution consists in the electro-mechanical drive system with six kinematic axes coupled to the same drive source. The tuning of kinematic and dynamic parameters of each axes is made by means of electro-mechanical variators.

The main advantage of the solution presented in this work is that the energy used for brake operation on some axes is used by the other axes for acceleration. The system can also be equipped with flywheels for balance of energy use.

1. The actuating system

The structural kinematic diagram of the simulation platform was developed on a hexapod robot (figure 1). The platform (p1) has six degrees of freedom given by the three translation movements X, Y, Z and by the three orientation movements A, B, C.

Using an adequate command of the platform we can simulate the displacement of a tank (or other mean of transportation) mounted on the platform. The spatial movement of the platform, following the movement rules imposed by the geometry of the ground and by the parameters of the mean of transport, results by displacing the axes 1, 2, 3, …, 6.

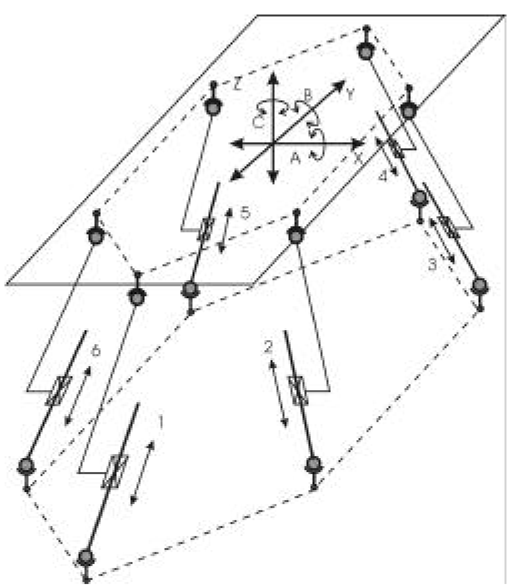


Figure 1. Structural diagram of the platform

Analysing the movements presented in figure 1 we observe that a part of the axes 1-6 lift up the platform, while other part it moves them down. Taking into account the great weight of masses in motion, the recovery of the energy of the axes which move down the platform and its application/usage by the axes that lift the platform will considerably reduce energy consume.

Designing a driving system which use a single driving motor and electro-mechanic adjustment systems on each axis (each movement) will correspond to recovery of the masses being in motion.

The command of the axes is realised with a command device.

This generates command parameters c1, c2,…, c6.

The independent adjustment of the six movements, derive from the same motion source, admit generating some consumed power optimizing programmes, such as, for example, overlapping of accelerating mode of some axes with the brake mode of others.

The driving of the six axes from the same motor doesn't lead to the simplification of the command equipment, the number of the commanded axes remaining the same.

The kinematic scheme at the base of designing each axis is illustrated in figure 2.

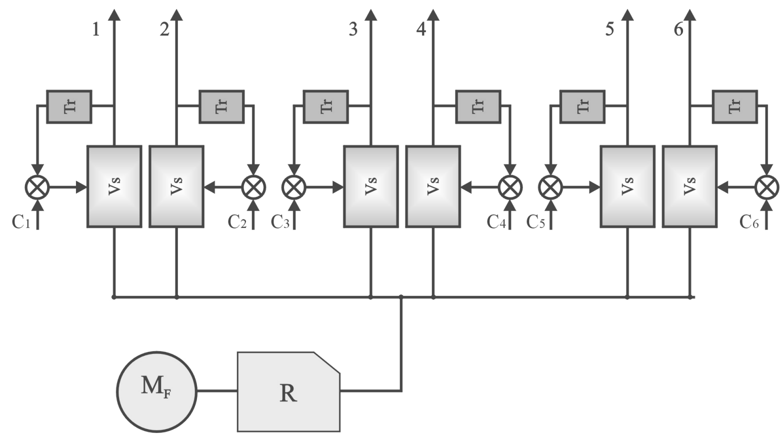


Figure 2. Block diagram for driving the platform

The kinematic scheme of the axis in figure 2 contains servo-controlled variable controller Vs, conceived by associating a kop friction variable controller (figure 3), with adjustable transfer ratio (i_V) with a bevel gear with cylindrical pinion (z_1, z_2, z_3, s). The inputs for the bevel are a movement of constant value $?_i$ and an adjustable movement $?_s$, by the friction variable controller. The total of the two movements lead to an adjustable angular velocity $?_e$, at the output shaft. The transformation function of the servo-controlled variable controller is:

$$?_e ? ?_i ?i_C i_V ?i ? 1?? 1? \quad (1)$$

where:

$$i_V ? \frac{\cos(? ? ?)}{\cos(? ? ?)}; \quad i_C ? i_{C1} i_{C2} ? \frac{Z_a}{Z_b}\frac{Z_c}{Z_d} \quad (2)$$

For a proper fraction i_V, well established, it will be realised a positioning of the output shaft without being necessary to stop the driving motor.

The adjustment of the transformation ratio of the friction variable controller is made using the command motor mc of each axis.

2. Differential equation of the movement for a kinematic axis

In order to establish the dynamic equation of the ideal/optimal variable controller there are made the following simplifying hypothesis:

1. The friction variable controller can transmit any couple (which doesn't slide);
2. The inertial moment of the friction variable controller is constant;
3. The efficiency of the transmission is not taken into account.

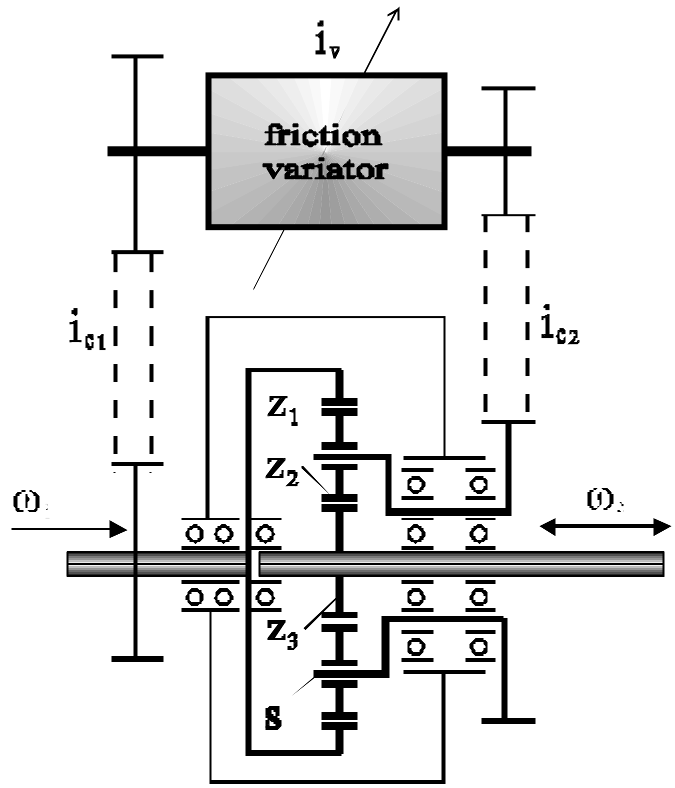


Figure 3. Electromechanical variator

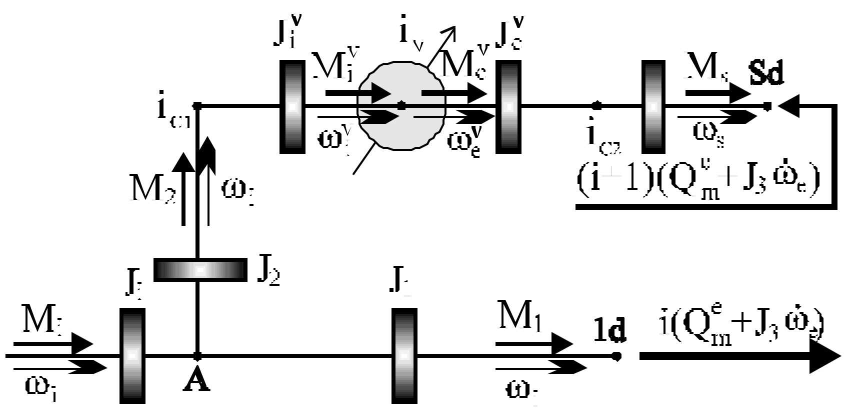


Figure 4. The axis applying stresses scheme

The scheme from figure 4 was adopted by applying some mechanical knowledge on the base of which was determined the movement dynamic equation:

? ?i_v m_2 ? i_v J_i^r ? J_V^r ? i_v ?c i_v ? i ?^2 J_V^r ? ? ?_i ?

? ?i_v m_1 ? i_v ?c i_v ? i ?^2 f ? c i_v ?c i_v ? i ?i_V^* J_e^r ? ?_i ? (3)

? i_v m_0 ? i_v ?c i_v ? i ?M_e ? 0

Relation (3) is a differential equation, linear and heterogeneous, with variable coefficients which can be written as:

$$\left[a_1 i_v^3 ? a_2 i_v^2 ? a_3 i_v\right] ?_i ? \left[a_4 i_v^3 ? a_5 i_v^2 ? a_6 i_v ? a_7 i_v^2 i_v^* ? a_8 i_v i_v^* ? a_9\right] ?_i ? \quad ? a_{10} i_v^2 M_e ? a_{11} i_v M_e ? a_{12} i_v ? 0 \tag{4}$$

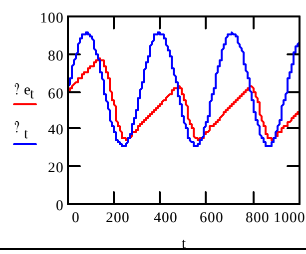
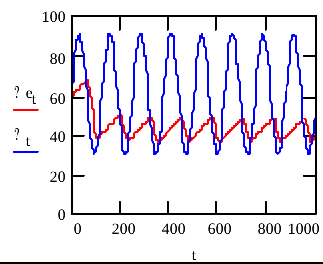
The constant coefficients a_i are determined by identifying relations (3) and (4). In the differential equation (4) are known: constant coefficients of the equation, the variation function of the of the “static” moment $m_e = m_e(t)$; command function $i_v = i_v(t)$.

The numerical equation was solved using numerical methods. With the control function:

$$i_v(t) ? i(0) ? A \sin(at ? b), \tag{5}$$

the model of the system gives the results presented in the table 1.

Table 1.

MMAX=25[NM] ME=0 IV_0=1.2 A=0.1 A=20 B=0 T[MS]		MMAX=25[NM] ME=0 IV_0=1.2 A=0.1 A=50 B=0 T[MS]	

3. Conclusions

The use of the proposed solution has the following advantages:
- the possibility of using some beaters for balancing energy supply;
- reducing of the installed power and of the energy supply.

The main disadvantage of these solutions is in the complexity of the mechanical structures, with direct effects on the price.

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