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Aspects regarding Influence of Voltage Disturbances upon Reluctance Synchronous Motors Operation

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In this paper there is analyzed, by simulation, the behavior of a reluctance synchronous motor, in case of two dynamic states caused by modifying the supply voltage. The mathematical model used, the Matlab program and the simulations obtained are presented. The paper ends with conclusions resulted by analysis. There is emphasized the fact that the dynamic stability of the motor is determined by the voltage value, as well as by the machine parameters. By simulation it is possible to establish the stability range and the ways of increasing the stability can be identified. The simulations are an absolutely necessary stage in the motor dimensioning stage.

Keywords: *reluctance synchronous motor, simulations, stability.*

1. Introduction

This paper aims at studying a concrete problem of dynamic stability in the electrical machines area.

The problem of their stability is very often encountered in scientific papers presented in important international conferences and published in outstanding revues [1], [2], [3], [4], [5] etc.

The problem gets more important in case of special construction synchronous motors, as the case of reluctance synchronous motors.

This paper is a natural continuation of the paper [6].

In that paper there are presented a series of simulations which emphasize the influence of the torque shocks upon the reluctance synchronous motor operation.

In the following there will be presented similar simulations which analyze the way the supply voltage variations influence the motor stability.

2. Mathematical model of the motor

In order to carry out the analysis proposed, the two-axes mathematical model of the motor [7] has been used.

This is composed of four voltage equations and the movement equation:

$$u_d - R_s i_d + \omega L_q i_q + \omega L_{mq} i_Q = L_d \frac{di_d}{dt} + L_{md} \frac{di_D}{dt}$$

$$u_q - R_s i_q - \omega L_d i_d - \omega L_{md} i_D = L_q \frac{di_q}{dt} + L_{mq} \frac{di_Q}{dt}$$

$$-R_D i_D = L_{md} \frac{di_d}{dt} + L_D \frac{di_D}{dt} \qquad (1)$$

$$-R_Q i_Q = L_{mq} \frac{di_q}{dt} + L_Q \frac{di_Q}{dt}$$

$$\frac{3}{2} p\left(L_d i_d i_q + L_{md} i_D i_q - L_q i_q i_d - L_{mq} i_Q i_d\right) - m_r = \frac{J}{p}\frac{d\omega}{dt}.$$

The notations used have the following significances:

R_s – phase resistance the phase of stator winding;
R_D - resistance of the winding equivalent to starting cage by d-axis;
R_Q - resistance of the winding equivalent to starting cage by q-axis;
L_d - longitudinal synchronous inductance;
L_q - cross synchronous inductance;
L_{md} - d-axis magnetization inductance;
L_{md} - q-axis magnetization inductance;
L_D - leakage inductance of the winding equivalent to starting cage by d-axis;
L_Q - leakage inductance of the winding equivalent to starting cage by q-axis.

2. Simulation program

Starting from the previous equations, a Matlab program [6] has been carried out for simulating reluctance synchronous motors operation in dynamic states (Fig. 1).

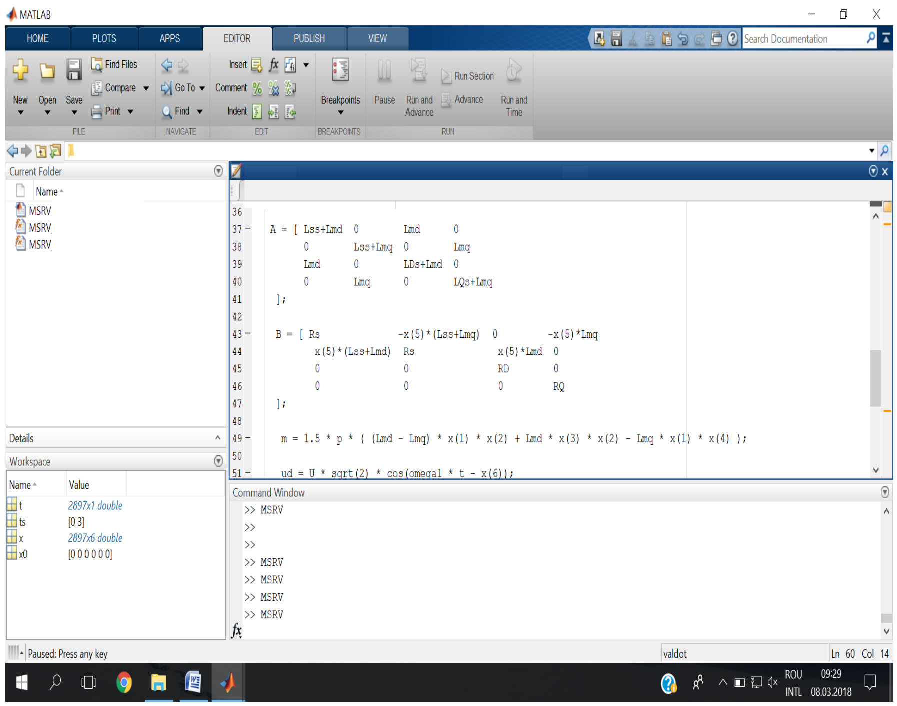


Figure 1. Sequence of the simulating program.

4. Simulations

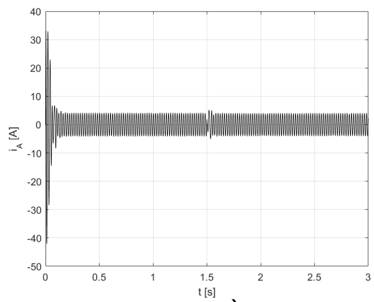
The program such carried out has been used for simulating some dynamic states occurring when the supply voltage of the motor is modified.

Thus, we assumed that after 1,5 seconds after the motor was directly-on-line started, with 220 V, the voltage decreased down to U=190 V (Fig. 2), respectively U=130 V (Fig. 3).

In order to obtain the simulations, we considered J=0,01 kgm^2, M_r=5 Nm.

The motor parameters have the following values:

$R_s=3{,}77\ \Omega$;	$R_D=1{,}5\ \Omega$;	$R_Q=4{,}5\ \Omega$;
$L_d=0{,}281$ H;	$L_q=0{,}081$ H;	$L_{md}=0{,}2729$ H;
$L_{mq}=0{,}0729$ H;	$L_D=0{,}0059$ H;	$L_Q=0{,}0067$ H;
p=2.		



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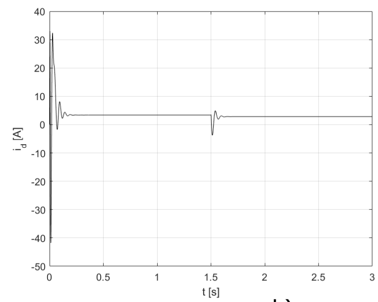

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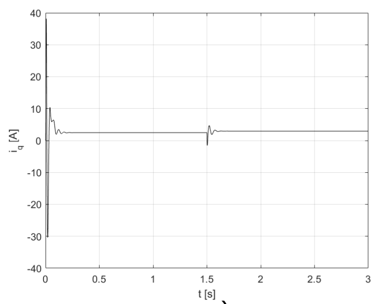

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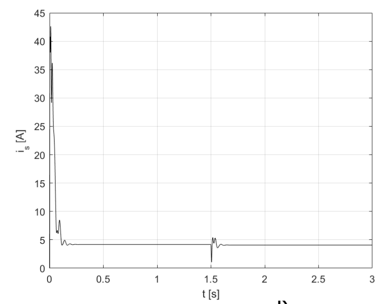

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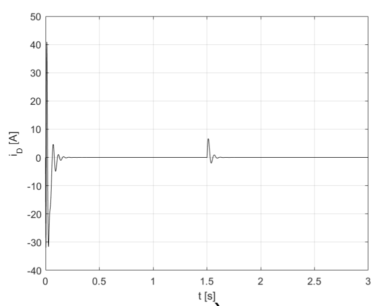

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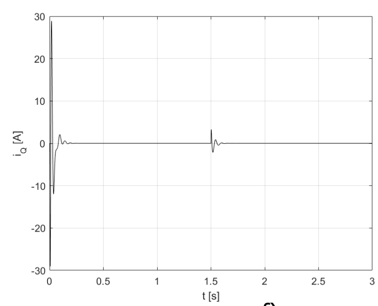

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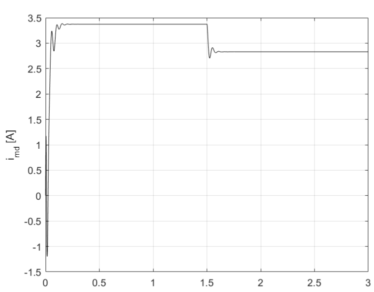

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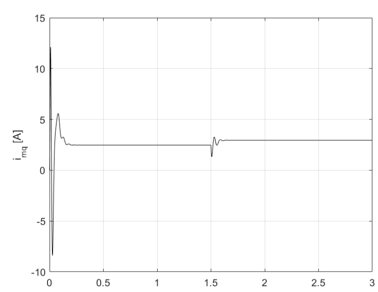

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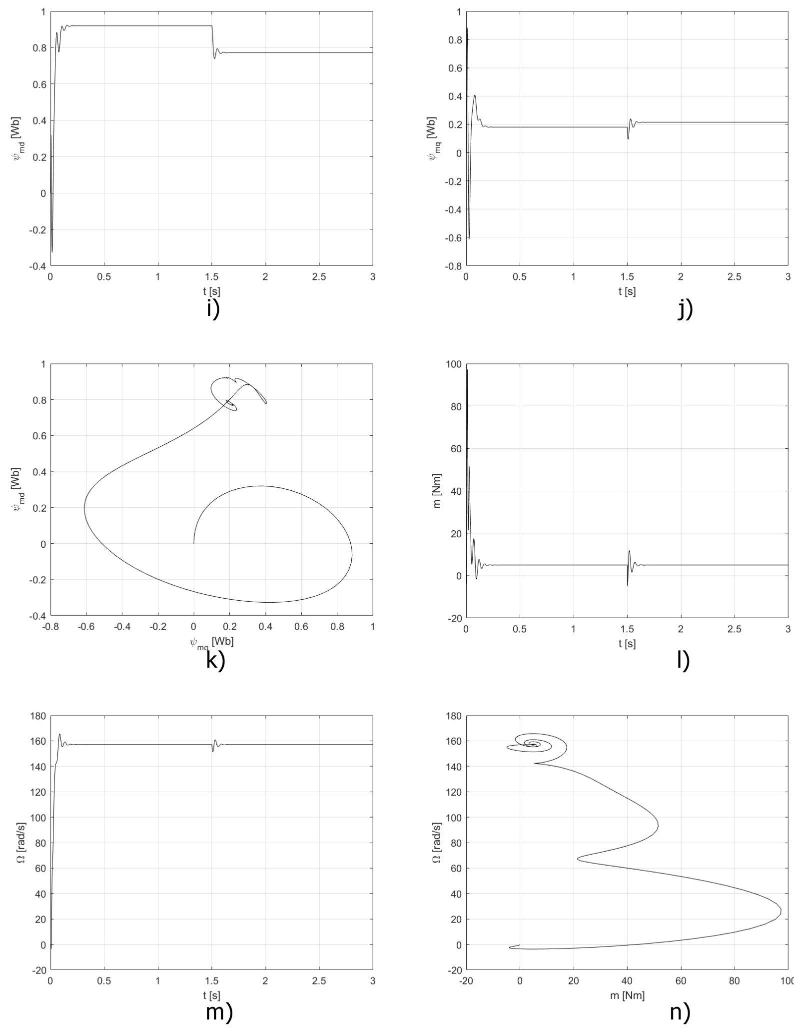
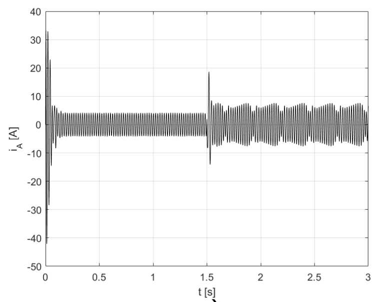


Figure 2. Characteristics obtained for: U=190 V, J=0,01 kgm^2, M_r=5 Nm.



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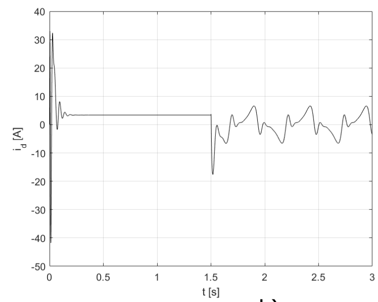

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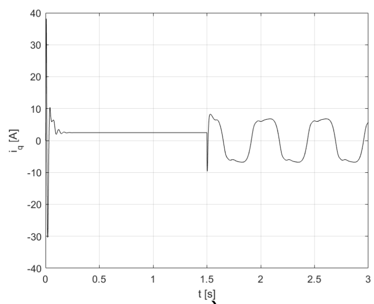

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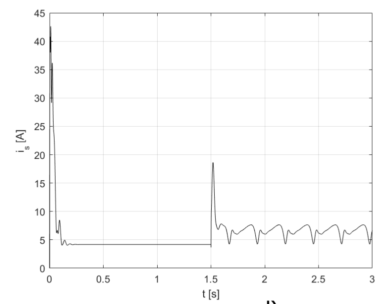

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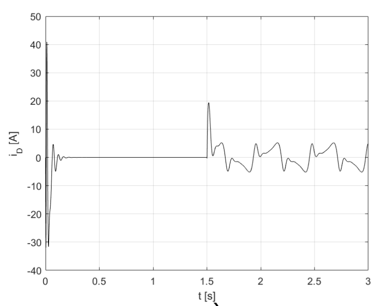

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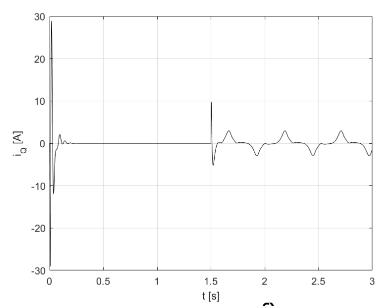

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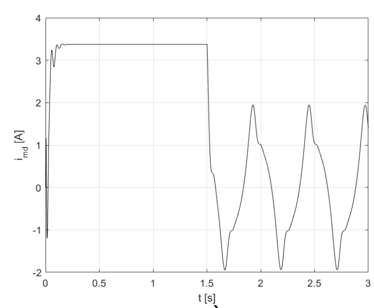

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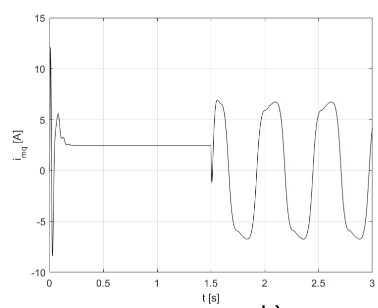

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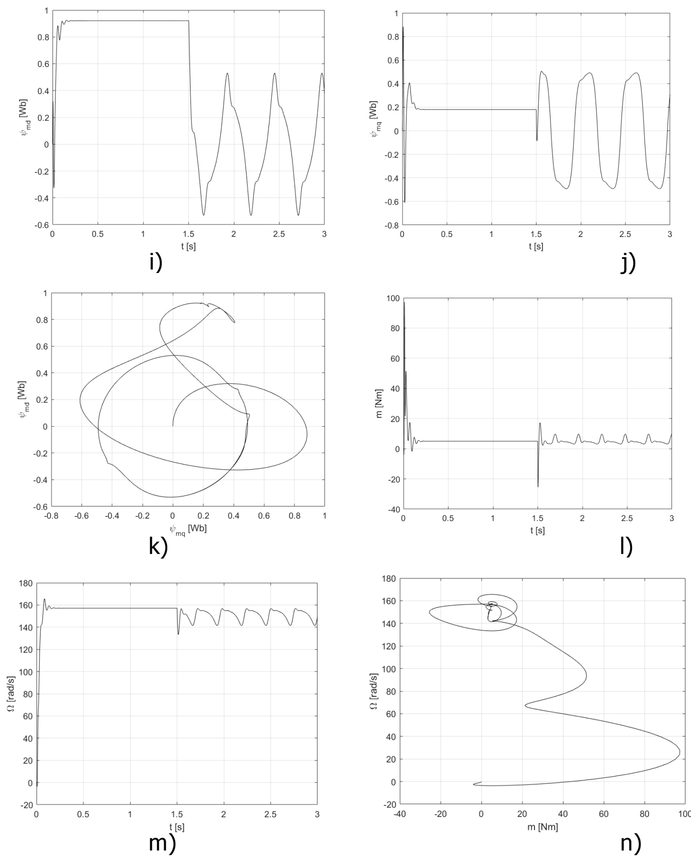

Figure 3. Characteristics obtained for: U=130 V, J=0,01 kgm^2, M_r=5 Nm.

5. Conclusion

As noticed in the figures 2 and 3, the motor behavior after the supply voltage was modified, is conditioned by its value. According to the figure 2, for a low decrease of the voltage value, the motor does not lose its stability. It enters another steady state. But if the voltage decrease is important, the motor loses its stability (Fig. 3).

Once entered oscillations, the rotor cannot reach the synchronism speed. Moreover, large variations of the torque occur. Finally, the operation point, in Ω=f(m) coordinates, moves on a limit cycle.

In conclusions, the value of the voltage which makes the motor unstable can be established by simulations. The fact that the stability range also depends, for the same values of the voltage disturbances, upon the motor parameters, must be also mentioned.

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