Aspects Regarding Influences of Voltage and Resistant Torque on Asynchronous Motors Operation

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***Abstract* - In this paper there are analyzed a series of dynamic regimes that occur in the case when a phase of an asynchronous motor is accidentally interrupted and in the case when the resistant torque increases by step. For these situations there have been carried out, starting from the motor equations written in the two-axes theory, two Simulink programs (detailed in the paper). With their help, for a motor rated at1,2 kW, there have been obtained relevant simulations together with conclusions emerging from them. Thus, in the case when a phase was interrupted it results that: the interruption of a phase leads to a dynamic regime that is relatively quickly stabilized; this stabilized regime is characterized by high values of currents, slight decrease of the rotor speed, small oscillations of speed, important oscillations of torque. In the case when the resistant torque is modified by step there have been resulted the following conclusions: a reduced torque shock leads to increased values of the currents and to a slight decrease of the speed (after a few oscillations); an increased value of the inertia moment leads to an increased number of current oscillations in dynamic regime but also to the disappearance of the speed and torque oscillations when a torque shock occurs; for very high resistant torques the maximum torque developed by the motor becomes smaller than the resistant one which causes the decrease of the speed towards zero, finally reaching, if the protections do not cut, the short-circuit regime; the simulation program conceived here can also be used for establishing the value of the motor maximum torque; the simulations have been confirmed, as essential elements, quantitatively and qualitatively, by experiment.**

Keywords: *dynamic regimes, asynchronous motors, disturbances.*

I. INTRODUCTION

During the asynchronous motors operation it is possible to occur some particular regimes because of some external causes called disturbances.

In this category we may firstly include the supply by sources of non-sinusoidal voltage [6]-[9] etc. Beside this case, even in sinusoidal regime, there are situations which might be identified as being external disturbances.

Among them, in this paper, there will be presented a few original researches regarding:

-case when the supply of a phase is accidentally interrupted;

-case when the resistant torque increases by step.

II. PROGRAM FOR SIMULATIONS

In order to solve the problem we aimed at, there has been conceived a Simulink program [10] for each of the two cases mentioned before.

Thus, for the case when the supply was interrupted for a phase, the program depicted in figure 1 has been conceived.

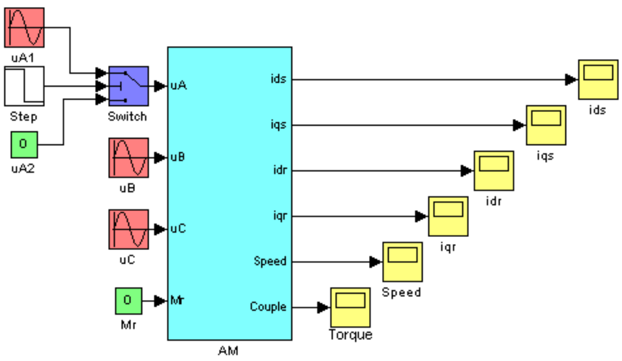


Fig. 1. Simulink scheme for the case uA=0.

For the case when the resistant torque increased by step the program depicted in figure 2 has been conceived.

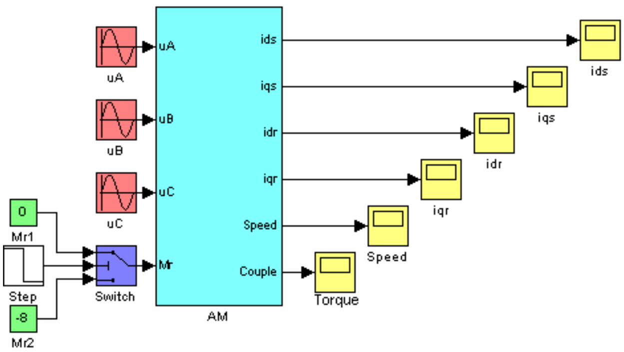


Fig. 2. Simulink scheme for the case when the resistant torque increases by step.

The AM [3] block used in the previous schemes has been achieved starting from the mathematical model of asynchronous motor written in the two-axes theory [1].

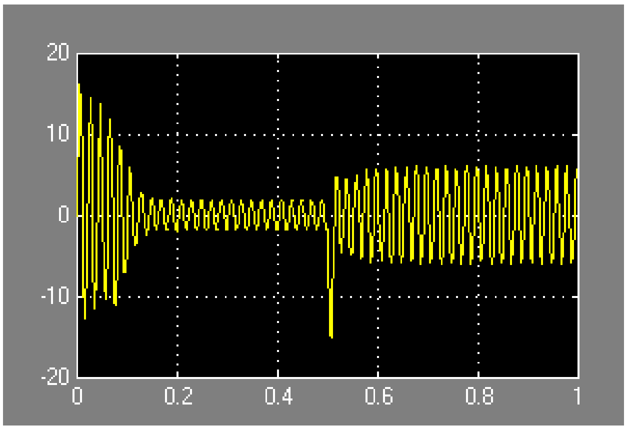
III. SIMULATIONS

The results of simulations we obtained are presented in figures 3, 4, and 5. They correspond to an asynchronous motor rated at 1,2 kW.

The parameters of this motor are, according to [2]:

R_s=7,5 Ω; R_r=5,5 Ω;
L_s=0,529 H; L_r=0,528 H;
J=0,004 kg m2; p=2.

In figure 3 there have been plotted a few quantities which are representative to the asynchronous motor operation for the cases of two successive transient regimes. The first of them was a no-load starting and the second one, after 0,5 seconds, corresponds to the case when the supply of the phase A is interrupted.



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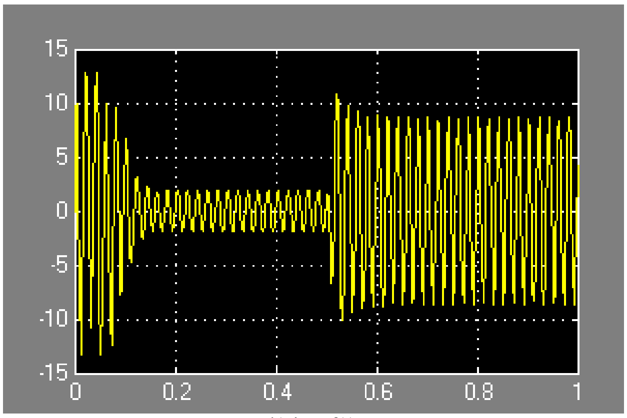

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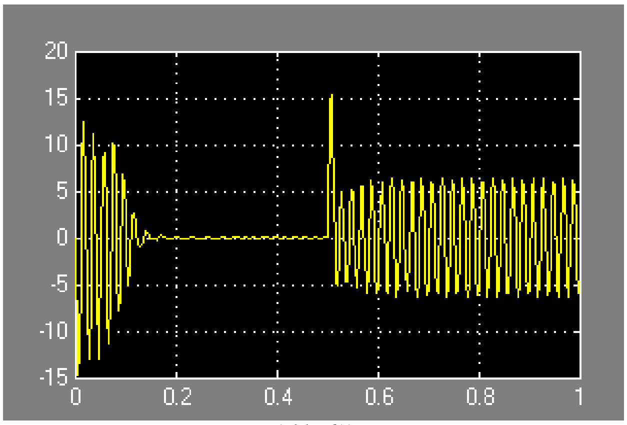

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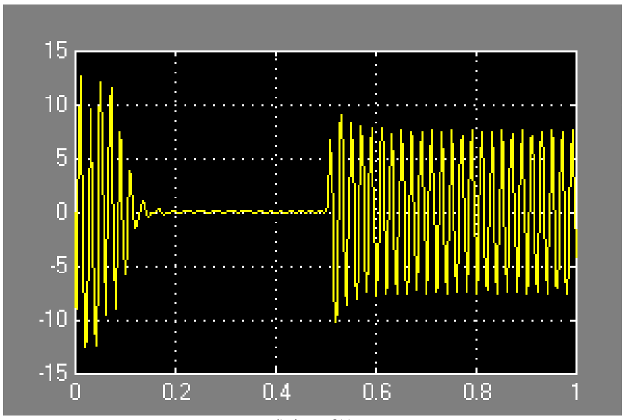

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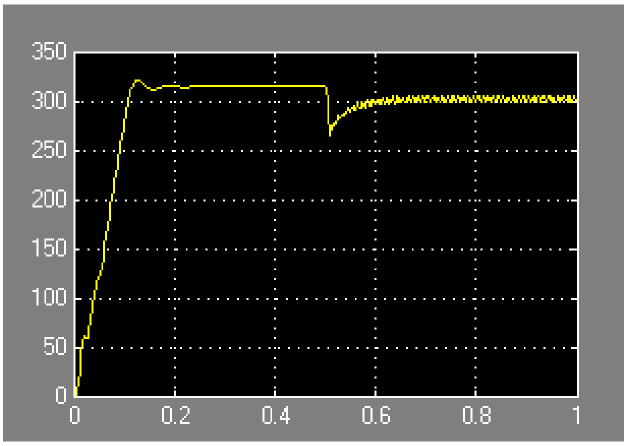
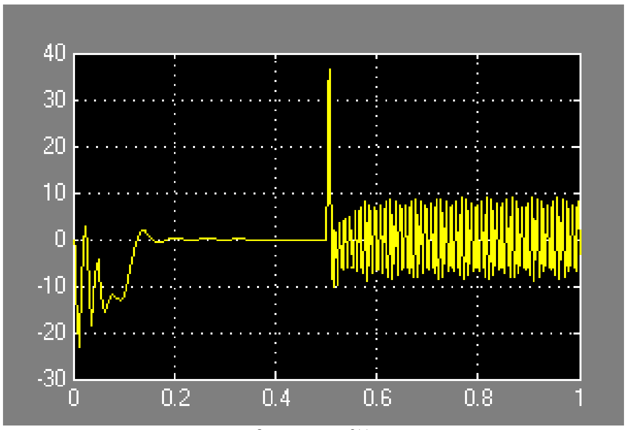


e) Speed=f(t)



f) Torque=f(t)

Fig. 3. Characteristics obtained for the case when U_A=0 V (J=0,008 kg m^2, M_r=0).

As it can be noticed, the interruption of a phase supply leads to a dynamic regime which is relatively quickly stabilized.

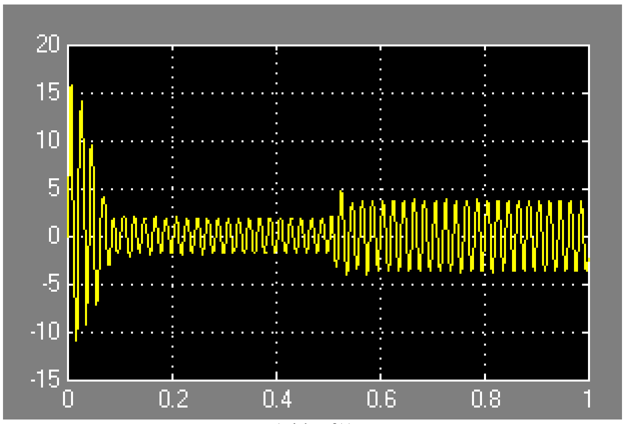
The stabilized regime resulted this way is characterized by:

- high values of currents,
- slight decrease of the rotor speed;
- small oscillations of speed;
- important oscillations of torque.

In figure 4 there are presented two successive dynamic regimes obtained for the motor having the parameters mentioned before (J=0,004 kg m^2).

The first regime is the no-load starting regime, the second one, after 0,5 seconds, is caused by the increase of the absolute value of the resistant torque (M_r=-8Nm).

The figure details the variations of six quantities considered as being representative for the transient regime we analyzed.



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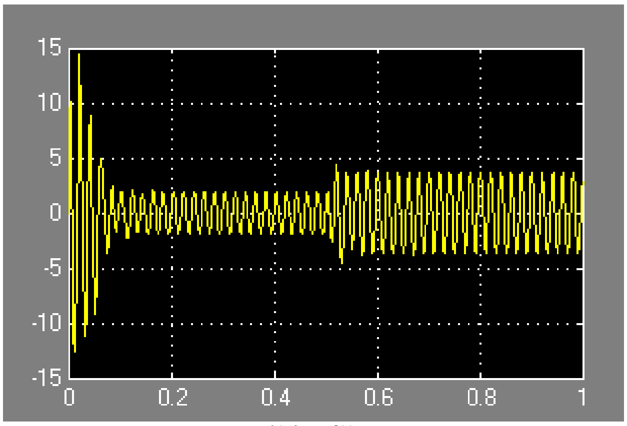

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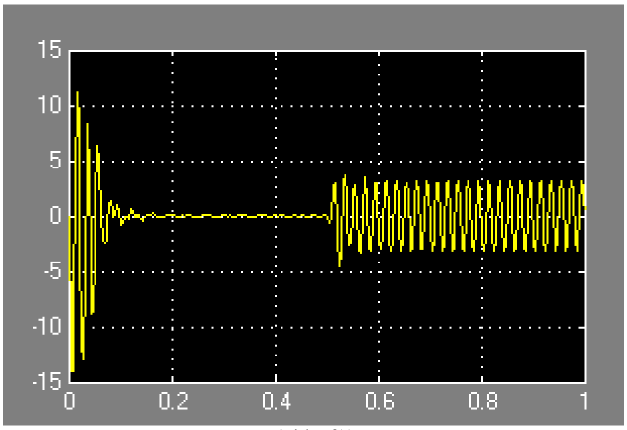

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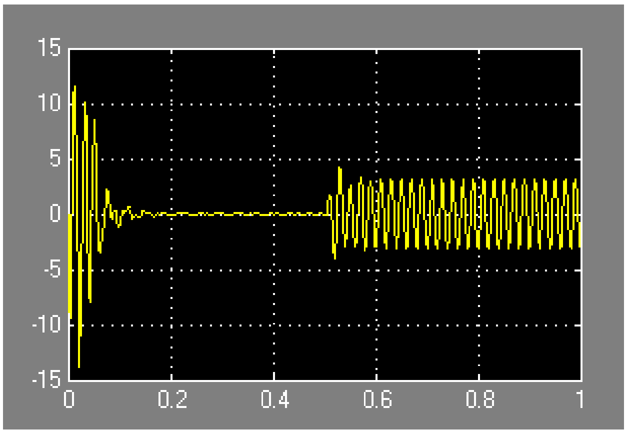

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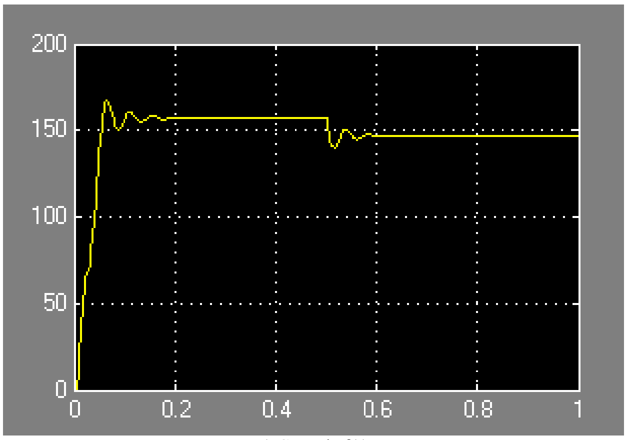
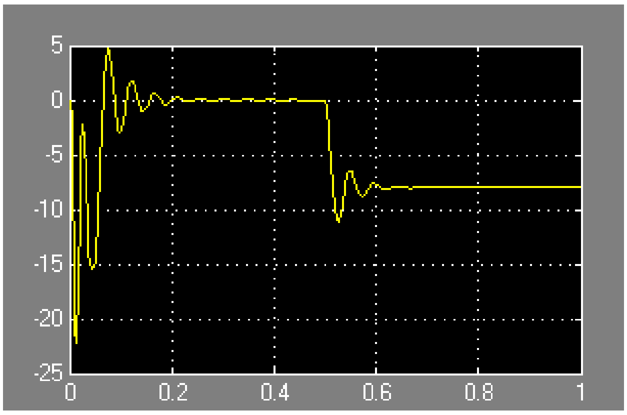


e) Speed=f(t)

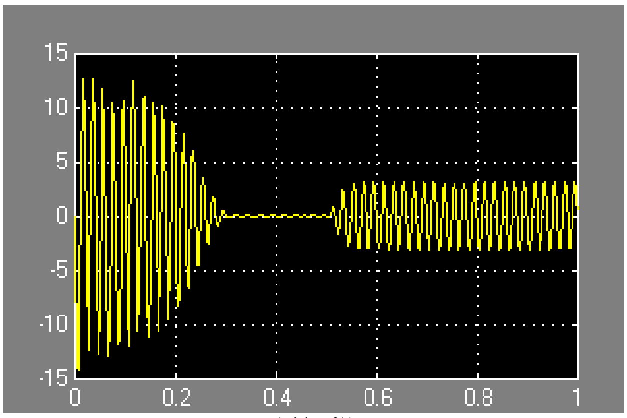


f) Torque=f(t)

Fig. 4. Characteristics obtained for the case of a torque increase to the value M_r=-8Nm (J=0,004 kg m^2).

As it can be noticed, the torque shock leads to increased values of the currents and to a slight decrease of the speed (after a few oscillations).

In figure 5 there are presented the case of the resistant torque increase by steps to a value equal to the value of the rated torque (the inertia moment being increased by 5 times).



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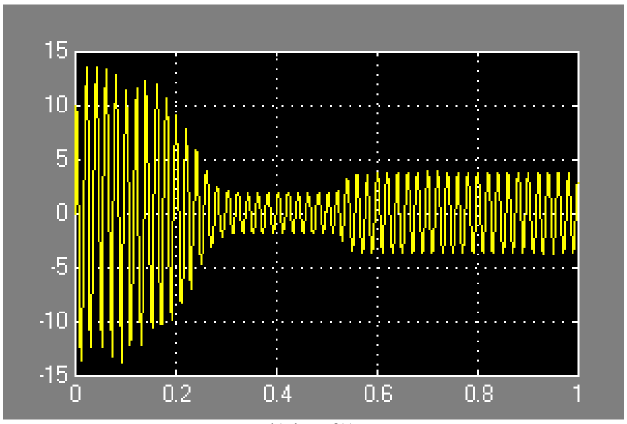

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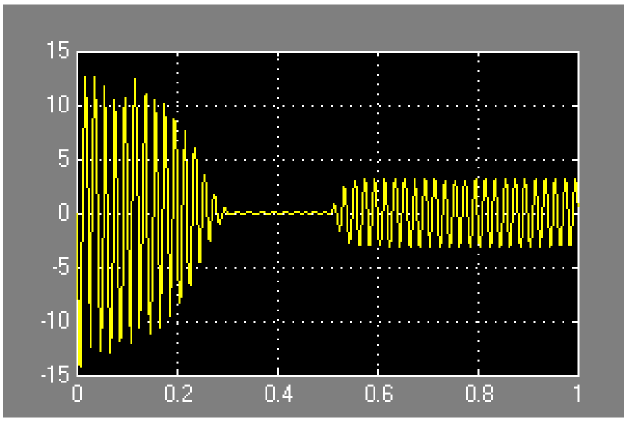

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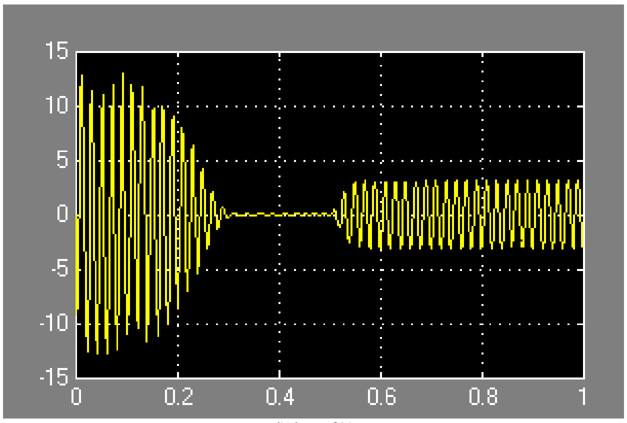

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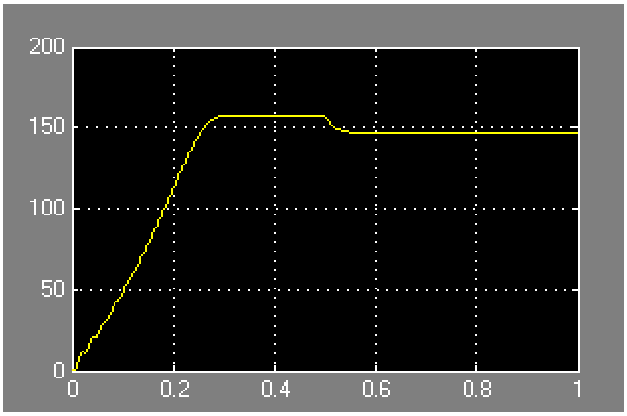
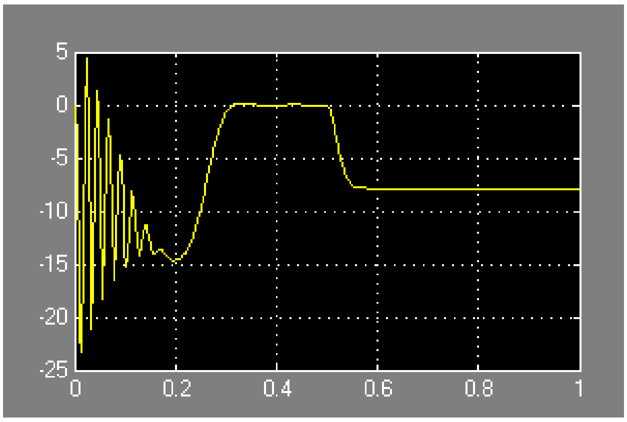


e) Speed=f(t)



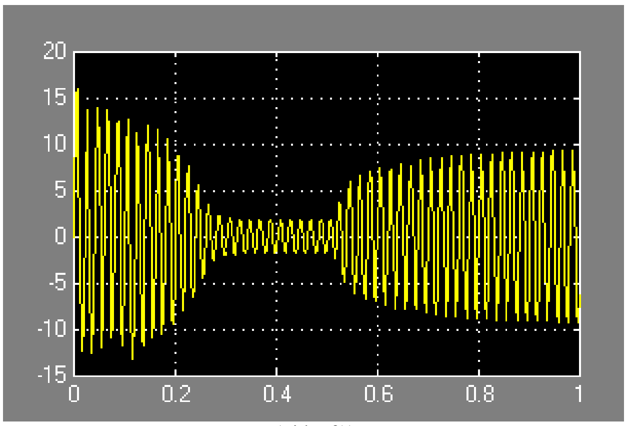
f) Torque=f(t)

Fig. 5. Characteristics obtained for the case of a torque increase to the value M_r =-8Nm (J=0,02 kg m^2).

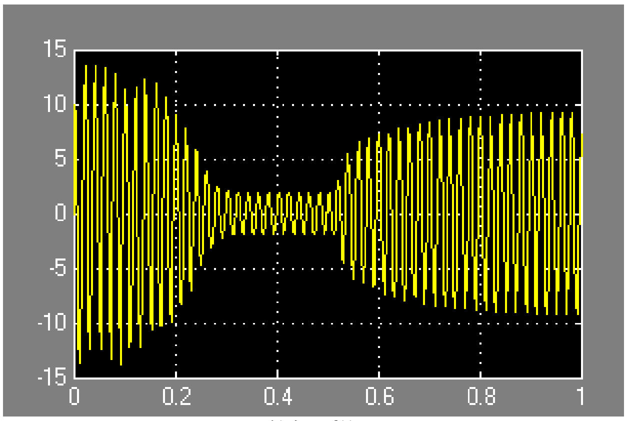
The analysis of these graphics shows that an increased value of the inertia moment leads to an increased number of current oscillations in dynamic regime, but also to the disappearance of the speed and torque oscillations when the torque shock occurs.

In figure 6 the resistant torque is two times the rated torque value and the inertia moment is increased by 5 times [5].

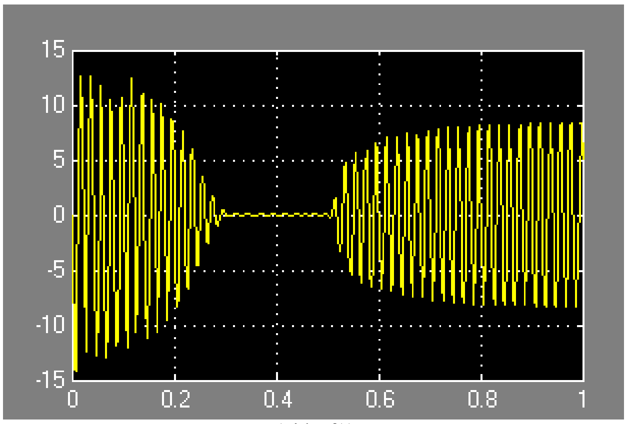
In order to compare the simulations we have obtained with the simulations obtained in the previous cases, the same characteristic quantities have been plotted.



a) ids=f(t)



b) iqs=f(t)



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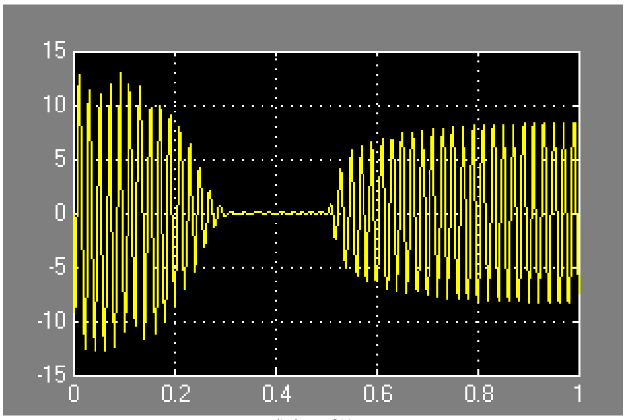
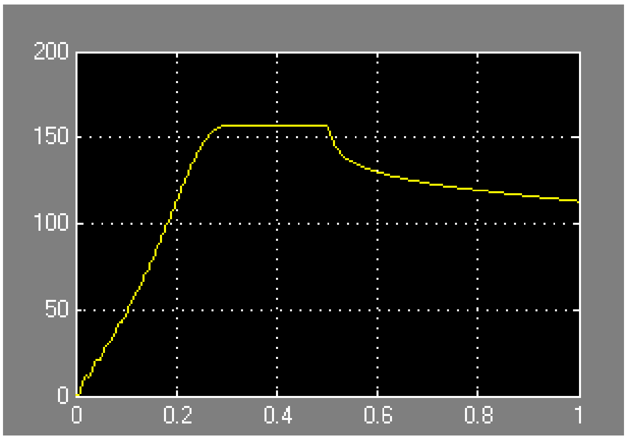
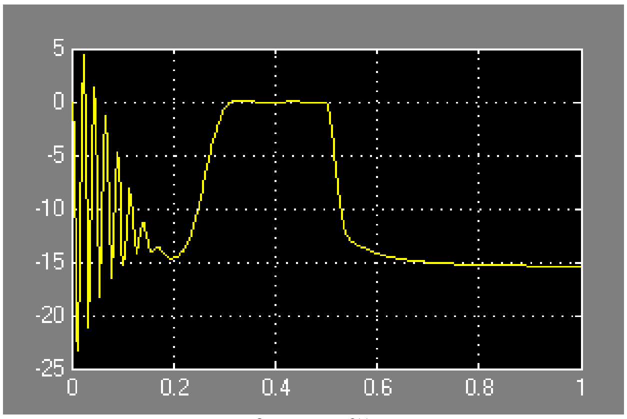


d) iqr=f(t)



e) Speed=f(t)



f) Torque=f(t)

Fig. 6. Characteristics obtained for the case of a torque increase to the value M_r=-16 Nm (J=0,02 kg m^2).

For the case analyzed in the previous figure the maximum torque developed by the motor becomes smaller than the resistant one. Consequently the motor slows down to zero speed, finally reaching, if protections do not cut, the short-circuit regime.

As a consequence, the simulation program conceived here can also be used for establishing the maximum torque of the motor.

IV. Experimental Verifications

For verifying experimentally, partially, the graphics detailed before, a data acquisition system detailed in [4] has been used (fig. 7).

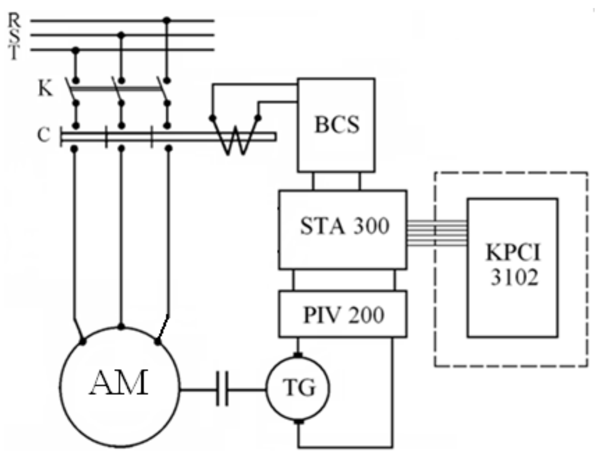


Fig. 7. Experimental circuit.

The significances of the notations used in this figure are:

AM – asynchronous motor;
KPCI 3102 – data acquisition board;
TG – direct current tacho-generator;
PIV 200 – block of voltage adapting;
STA 300 – block of connections;
BCS – block of command and synchronization;
C – contactor.

With its help, there has been monitored the evolution of the rotor speed during the starting for a motor rated at 1,2 kW (fig. 8).

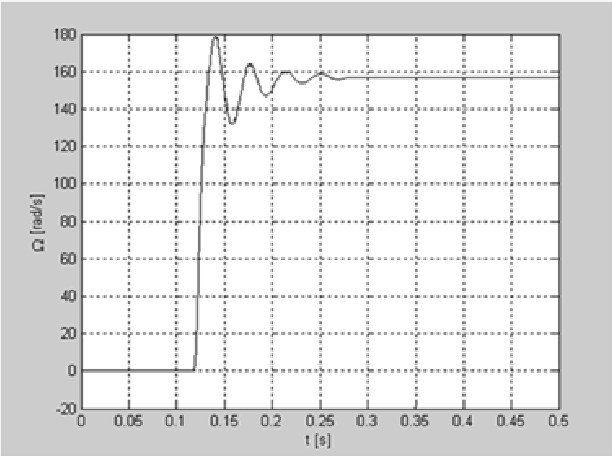


Fig. 8. Mechanic angular speed experimentally obtained.

Comparing this characteristic with that from figure 4e it is noticed that the experiment validates the simulations quantitatively and qualitatively.

V. CONCLUSIONS

Starting from an original simulation program for the asynchronous motors operation in dynamic regime, there have been obtained some representative simulations for the two cases:

- case when the supply is accidentally interrupted for a phase;

- case when the resistant torque increases by step.

For the first case, the following conclusions have resulted:

- the supply interruption for a phase leads to a dynamic regime which is relatively quickly stabilized;

- the stabilized regime resulted this way is characterized by high values of currents, a slight decrease of the rotor speed, small oscillations of speed, important oscillations of torque.

For the case when the resistant torque increases by step, the following conclusions have been obtained:

- a reduced torque shock leads to increased values of the currents and to a slight decrease of the speed (after a few oscillations);

- an increased value of the inertia moment leads to an increased number of current oscillations in dynamic regime but also to the disappearance of the speed and torque oscillations when a torque shock occurs;

- for very high resistant torques the maximum torque developed by the motor becomes smaller than the resistant one which causes the decrease of the speed towards zero, finally reaching, if the protections do not cut, the short-circuit regime;

- the simulation program conceived here can also be used for establishing the value of the motor maximum torque;

- the simulations have been confirmed, as essential elements, quantitatively and qualitatively, by experiment.

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