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# SIMULINK IMPLEMENTATION OF TWO-PHASE INDUCTION MOTOR MODEL

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***Abstract*** **– In this paper it was studied the saturation phenomenon for the main magnetic flux and its implications on the functioning characteristics of a two-phase induction motor (TPIM). Krause's model was implemented on a TPIM with known parameters and there were determined the functioning characteristics during the transient regime of the TPIM no-load start. Also it was studied as an application the functioning of converter-motor assembly and there were determined the functioning characteristics for different values of rotor resistance, through automatic rotative speed adjusting using rotor field orientation. All the applications were simulated in real time using MATLAB/Simulink environment.**

***Keywords***: *Krause's model, d-q equivalent circuit, dynamic model, TPIM, MATLAB / Simulink.*

## 1. INTRODUCTION

Single-phase and two-phase AC motors are the most-used converters in home appliances. The terms single or two-phase configuration refer to the supply voltage systems applied to the winding terminals.

A two-phase AC motor can have a configuration identical to the single-phase version of the motor, but the voltages applied to the windings terminals are independently controlled so that we have a two-phase supply voltage system. As the AC mains are available as single or three-phase systems, a two-phase voltage system is realized through the use of inverters with different control strategies.

## 2. MATHEMATICAL MODEL

Implementation of TPIM using MATLAB/Simulink environment was realized and can be found in literature [1], [2], [3] were it was used the linear model of the two-phase asynchronous motor. It was not taken into account one of the main aspects of the magnetic circuits namely its non-linearity. The complexity of this phenomenon is very great considering the layout of the field pattern and the existence of a magnetic rotating field.

Therefore in this paper a first step was made into this phenomenon direction, by considering only the saturation of the main magnetic field. The used mathematic model is Krause model [4], well known in the specialized international literature. The general equations system for the magnetic flux (1)-(4), in terms of d-q system of axes is,

$$\frac{dF_{qs}}{dt} = \omega_b\left[U_{qs} - \frac{\omega_e}{\omega_b}F_{ds} + \frac{R_s}{x_{ls}}\left(F_{mq} - F_{qs}\right)\right] \quad (1)$$

$$\frac{dF_{ds}}{dt} = \omega_b\left[U_{ds} + \frac{\omega_e}{\omega_b}F_{qs} + \frac{R_s}{x_{ls}}\left(F_{md} - F_{ds}\right)\right] \quad (2)$$

$$\frac{dF_{qr}}{dt} = \omega_b\left[U_{qr} - \frac{(\omega_e - \omega_r)}{\omega_b}F_{dr} + \frac{R_r}{x_{lr}}\left(F_{mq} - F_{qr}\right)\right] \quad (3)$$

$$\frac{dF_{dr}}{dt} = \omega_b\left[U_{dr} + \frac{(\omega_e - \omega_r)}{\omega_b}F_{qr} + \frac{R_r}{x_{lr}}\left(F_{md} - F_{dr}\right)\right] \quad (4)$$

where:

$$F_{mq} = x_{ml}^{*}\left[\frac{F_{qs}}{x_{ls}} + \frac{F_{qr}}{x_{lr}}\right], F_{md} = x_{ml}^{*}\left[\frac{F_{ds}}{x_{ls}} + \frac{F_{dr}}{x_{lr}}\right] \quad (5)$$

$$i_{qs} = \frac{1}{x_{ls}}\left(F_{qs} - F_{mq}\right), i_{ds} = \frac{1}{x_{ls}}\left(F_{ds} - F_{md}\right) \quad (6)$$

$$i_{qr} = \frac{1}{x_{lr}}\left(F_{qr} - F_{mq}\right), i_{dr} = \frac{1}{x_{lr}}\left(F_{dr} - F_{md}\right) \quad (7)$$

$$x_{ml}^{*} = \frac{1}{\frac{1}{x_m} + \frac{1}{x_{ls}} + \frac{1}{x_{lr}}} \quad (8)$$

The equivalent circuit of TPIM in d-q system of axes is presented in Figure 1.

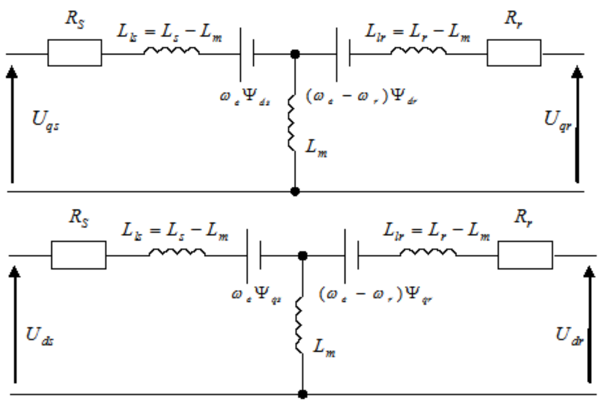


Figure 1. TPIM d-q equivalent circuit

Considering that follow-up it is intended to study the motor-converter assembly, the most adequate system of reference is the one tied to the stator because it assures the representation in natural measurements of the feeding current and voltage. Accordingly, Krause mode (1)-(4) will suffer some changes:
( $\omega_e = 0$ ; $U_{qr} = U_{dr} = 0$ - the motor has squirrel-cage rotor), to be able to be applied for a TPIM, ( $P_n = 35W, Z_S = 16, Z_R = 17, n_n = 1500 rot/\min$ ) with known parameters, Table 1.

| Parameter | Value |
|---|---|
| $P$ | 2 |
| $J$ | $3{,}3\text{x}10^{-5}$ [kgm$^2$] |
| $R_s$ | 415[ Ω ] |
| $R_r$ | 252,33[ Ω ] |
| $x_{ls}$ | 213,78[ Ω ] |
| $x_{lr}$ | 118,44[ Ω ] |
| $x_m$ | 364,73[ Ω ] |

Table 1. Motor's parameters

It has been simulated the transient regime for no-load start of TPIM that is fed with a nominal voltage of *230V*. Block diagram that is the base for this simulation is presented in Figure 2, realized in development environment MATLAB/Simulink. This way, after one period of transient regime (0,2s) in which the measurements of the characteristics values get stabilized TPIM enters into a stationary regime with constant torque and rotative speed, Figure 3.

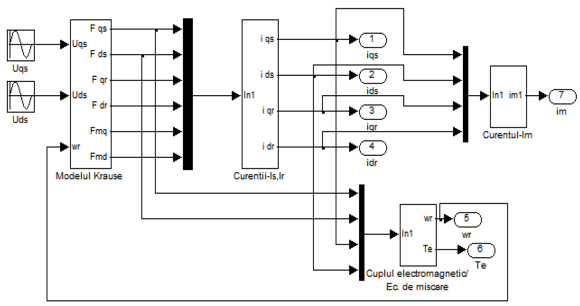
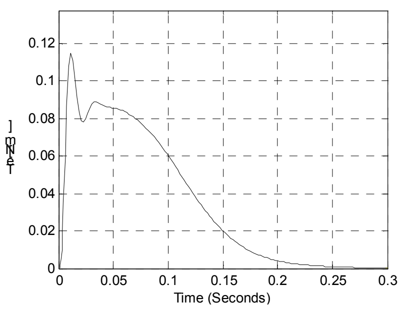



Figure 2. Implemented Simulink TPIM model



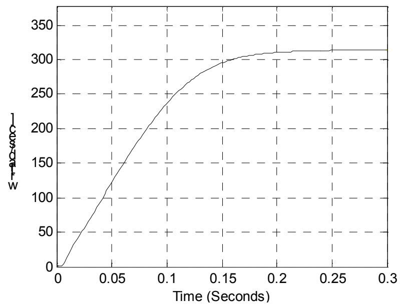




Figure 3. Electromagnetic torque / rotor rotative speed variation

Figure 4 presents "Modelul Krause" block where are implemented the equations (1)-(5), (8) written for stator reference system, and in the block "Curenții-Is Ir" there were implemented the equations (6)-(7). In Figure 5 it is implemented the electromagnetic torque and TPIM movement equation which has the form,

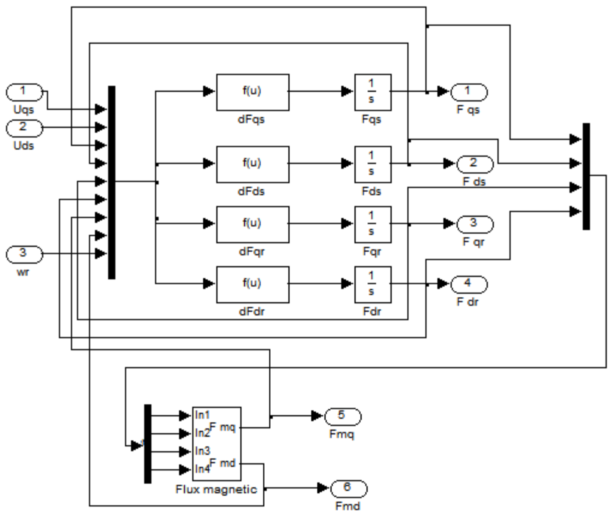



Figure 4. Krause Model

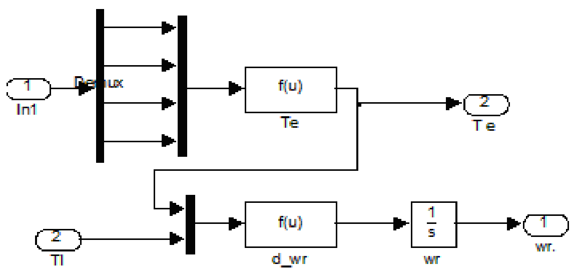



Figure 5. Electromagnetic torque/movement equation

$$T_e = \frac{p}{2\omega_b}\left(F_{ds} i_{qs} - F_{qs} i_{ds}\right) \qquad (9)$$

$$T_e - T_l = J \frac{2}{p} \frac{d\omega_r}{dt} \qquad (10)$$

After running the simulations we get the characteristics for the stator, rotor and magnetization current, Figure 6.

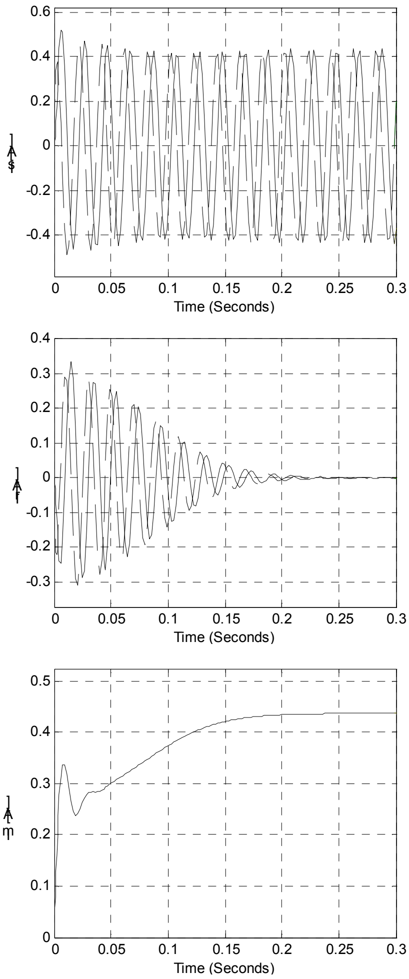



Figure 6. Time variation for TPIM currents

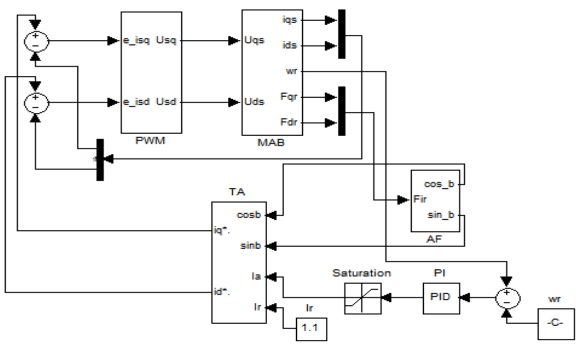
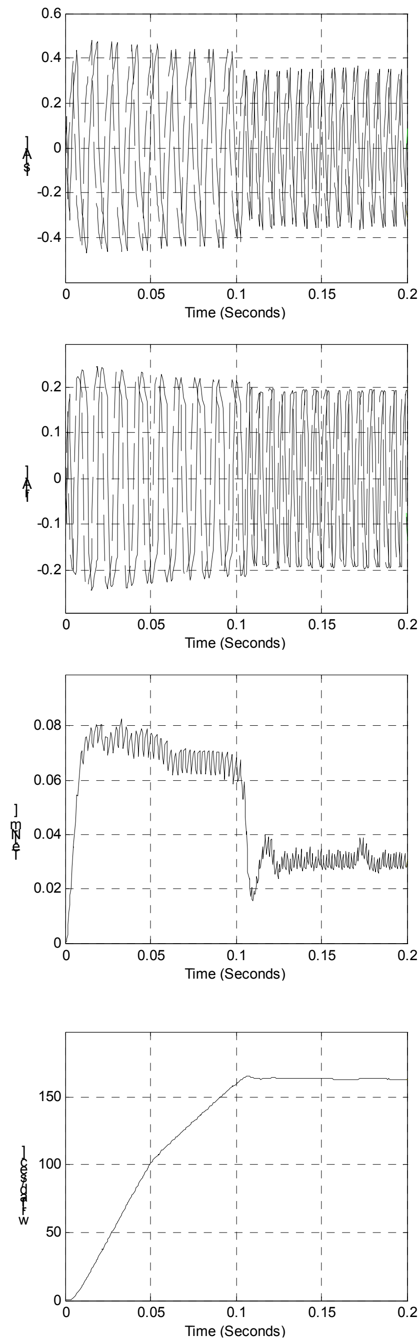



Figure 7. Automatic rotative speed adjusting system

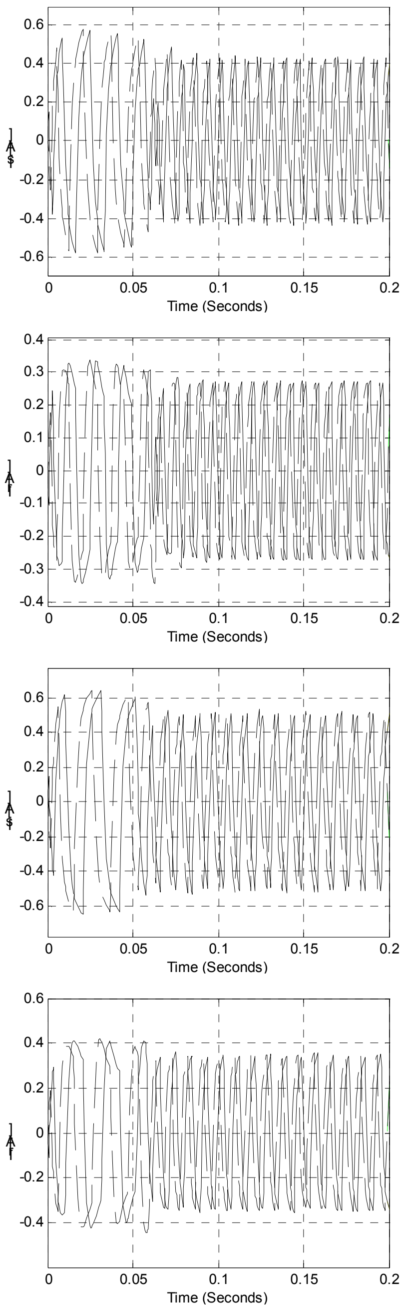
After implementing Krause model, [4] and implementing it for a TPIM with known parameters we will continue with the study the motor-converter assembly, very often used in electric drive application. It will be simulated the operation of a converter-motor assembly with automatic rotative speed adjusting using rotor field orientation. The structure of the automatic rotative speed adjusting system, implemented using MATLAB/Simulink, is presented in Figure 7.

The simulations performed for different values of the rotor resistance have shown the changes of the characteristics with the variation of this parameter, Figure 8. It was simulated TPIM transient regime at no-load start for the first 0,05s, then it was applied a load torque $T_{rez} = 0{,}03 Nm$. For the rotative speed control system it was used a prescribed value corresponding to the nominal rotativ speed, 157,07 rad/s.

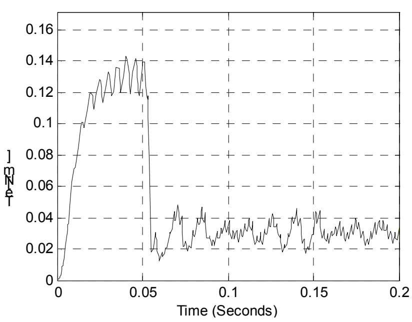
a) $R_R = 500\Omega$



b) $R_R = 252,33\Omega$




c) $R_R = 126\Omega$



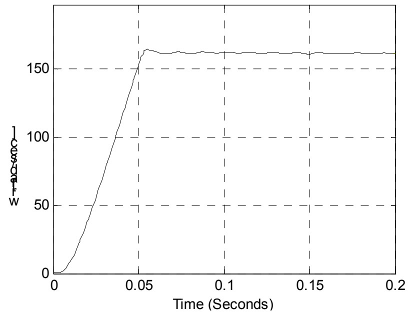




Figure 8. Characteristics for TPIM with automatic rotative speed adjusting

## 3. CONCLUSIONS

In this paper it was studied the saturation phenomenon for the main magnetic flux and its implications on the functioning characteristics of a two-phase induction motor. Krause's Model [4] was implemented on a TPIM with known parameters and there were determined the functioning characteristics during the transient regime of the TPIM no-load start. It can be observed that TPIM enters into a stationary regime with constant torque and rotative speed, where the characteristic measurements get stabilized.
Also the functioning of the converter-motor system was studied and there were determined the functioning characteristics for different values of rotor resistance, through automatic rotative speed adjusting using rotor field orientation. After implementing the model using MATLAB/Simulink development environment and running the simulations it was observed that for rotor resistance values less than the prescribed ones, the motor mechanical and electromagnetic processes take place much faster compared with the ones which you can get for rotor resistance values greater than the prescribed ones.

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