a change of 50% of the nominal value, which affects to the dynamics (Fig. 7) and losses in the magnetizing circuit [23]. But in general, the system remains stable when a magnetic flux is reached.

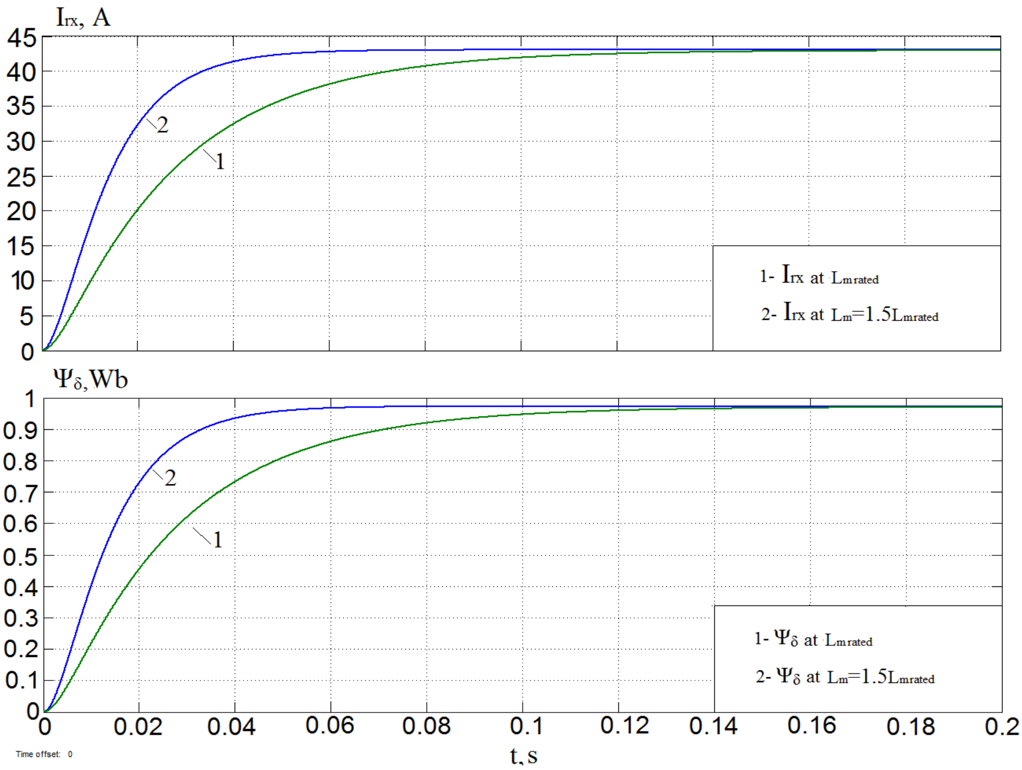

Figure 7. Simulation results of magnetic flux and currents comparison with L_m=1.5 L_m

In Fig. 8 represents the simulation model of two drive systems - with mod-els of observers and with the Machines Measurement Demux block as the flux sensor. In the latter, the motor parameters are equal to their nominal values, and in the sensorless it is changed within the limits considered above. The results of simulation of magnetic fluxes are shown in Figure 9.

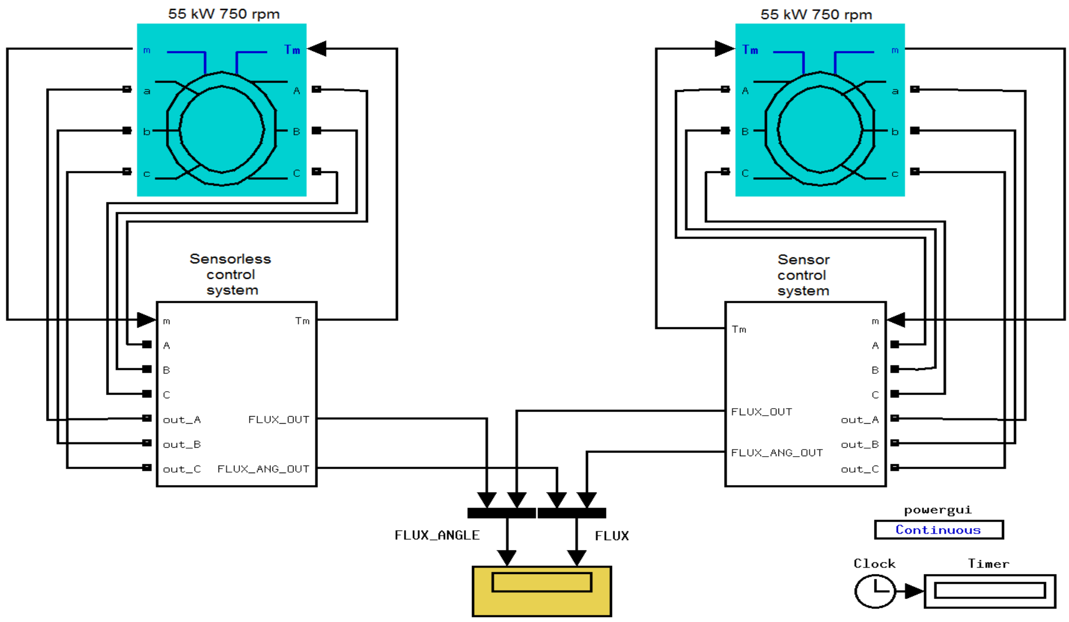

Figure 9 a) Simulation results of flux with $R_r' = 1.15 R_r'$, b) Simulation results of flux with L_m=1.5 L_m

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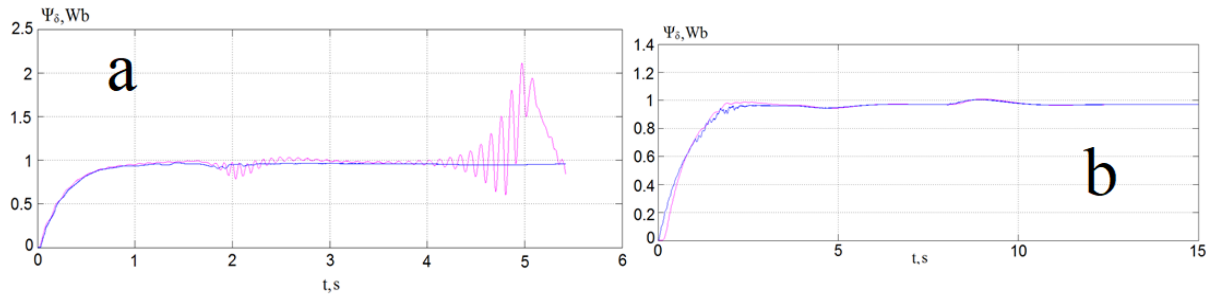

Figure 8. Simulation model of two drive systems

In this option of electric drive, a speed observer model is implemented easier than with an induction or permanent magnet synchronous motor electric drive.

III. EXPERIMENTAL RESULTS

For experimental verification the experimental setup was developed. DFIM electric drive functional scheme is shown at Fig.10. Current and voltage sensors in the rotor circuit and current sensors in the stator circuit determine the instantaneous values of rotor currents and voltages, as well as stator current, which are further used as signals for constructing coordinate observers. The blocks of coordinate transformations are implemented according to the equations of the mathematical model [19; 2] are integrated into the block of the machine flux-linkage observers. This block contains models of two flux-linkage observers, which are switched due to the logical switch by the feedback signal of the magnetization current i_{rx}.

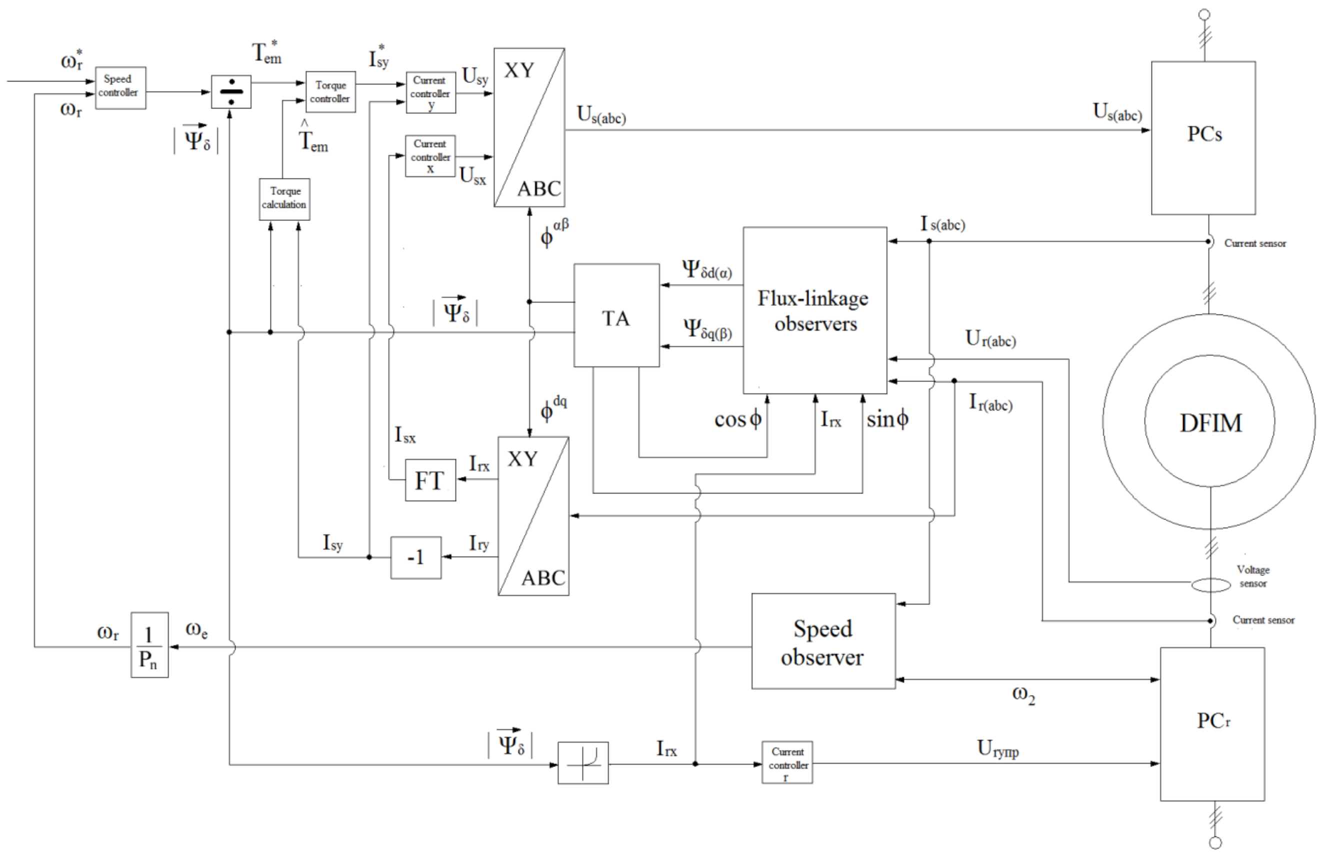

Figure 10. DFIM electric drive functional scheme

The experimental setup consists of DFIM, two power converters in stator and rotor circuits, DC motor in load operation mode, encoder on the shaft, measure-ment equipment and PC with Matlab and LabView software.

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The results of the estimated and experimental flux-linkage value by two models of observers are shown in Fig. 11. For current model of flux-linkage observer at the linear section of the magnetization curve the error between the estimated data and the obtained ones was experimentally $\Delta_{\Psi\pi uн}$ = 13.6%, and for the saturation section - $\Delta_{\Psi\pi uн}$ = 4.81%.

For voltage model of flux-linkage observer at the linear section of the magnetization curve the error between the estimated data and the obtained ones was experimentally $\Delta_{\Psi\pi uн}$ = 9.4%, and for the saturation section - $\Delta_{\Psi\pi uн}$ = 14.89%.

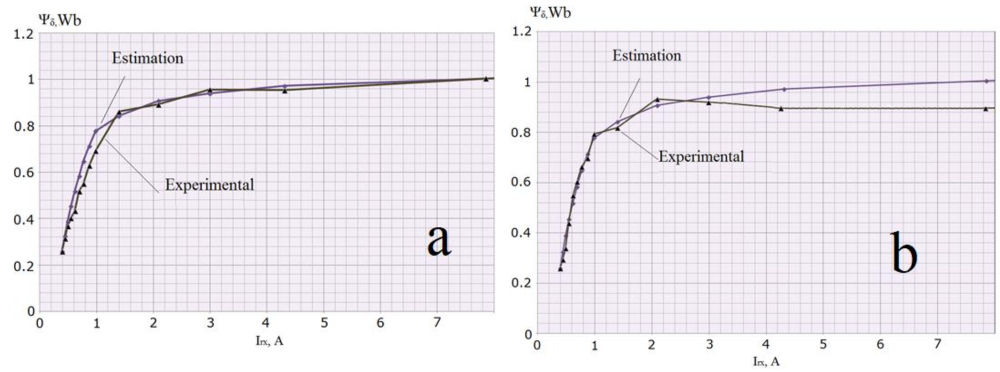

Figure 11. a) Dependences of Ψδ=f (Im) for flux-linkage observer using current value for estimation, b) Dependences of Ψδ=f (Im) for flux-linkage observer using voltage value for estimation

Speed estimation strategy does not contain in the algorithm of the rotor speed estimation trigonometric functions, parameters of the base machine, does not depend on the operating mode of the ED, allow estimating the speed of the rotor with an error of no more than 5% at a rotor speed of 10-30% of the nomi-nal values (Fig.12).

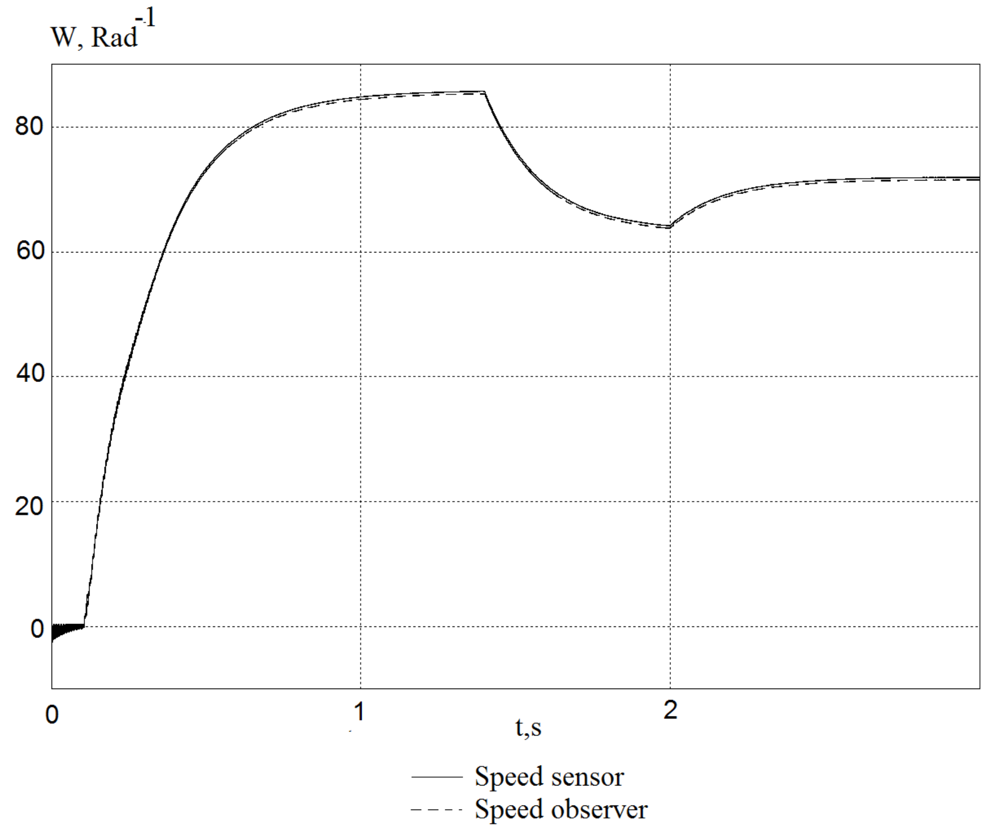

Figure 12. Dependences of ω=f (t) at Tem = Temrated and changing ω

In this electric drive system identification of flux-linkage at zero angular ve-locity of the rotor is possible. This is laid down in the principle of the operation of a DFIM, controlled by two circuits, when the magnetization of the machine is carried out before the stator PC is turned on. In this case, and flux-linkage is pro-duced only by the excitation current in rotor circuits.

IV. CONCLUSION

The proposed algorithms for estimation of air gap magnetic flux-linkage make it possible to exclude a flux sensor from the control system of the electric drive and use a serial motor with a wound rotor as the base machine. The ob-server for the voltage of the rotor is sensitive to the change in resistance and if it deviates by 5-10% of the nominal value causes the FOC system is become unsta-ble.

Great influence on the evaluation of flux is due to the presence of a DC component in the rotor voltage. To compensate for the integration error, it is nec-essary to introduce feedback into the integrator structure.

The application of the current model leads to errors of at least 15% in the estimation of the magnetic flux in the low-load region, which affects the dynamics and losses in the magnetizing circuit. But in general, the system remains stable when a specified magnetic flux is reached. Both proposed models of observers allow estimating the value of the flux when the rotor is stationary.

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