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START-UP OF INDUCTION MOTOR WITH LIMITATION OF STARTING ELECTROMAGNETIC TORQUE OSCILLATION – LABORATORY RESEARCH

Introduction. The procedure of start-up of induction motor with limitation of starting electromagnetic torque oscillation was presented in [1] and practical realization in [2]. The mathematical model of electromechanical system with squirrel-cage induction motor switched on according this procedure, the computer program for simulation analysis of this system and simulation results ware presented in [3]. Practical advantages of the procedure ware showed among other things in [4] and [5]. The results of laboratory research of start-up induction motor with electromechanical contactors (with the procedure use) are presented in this paper.

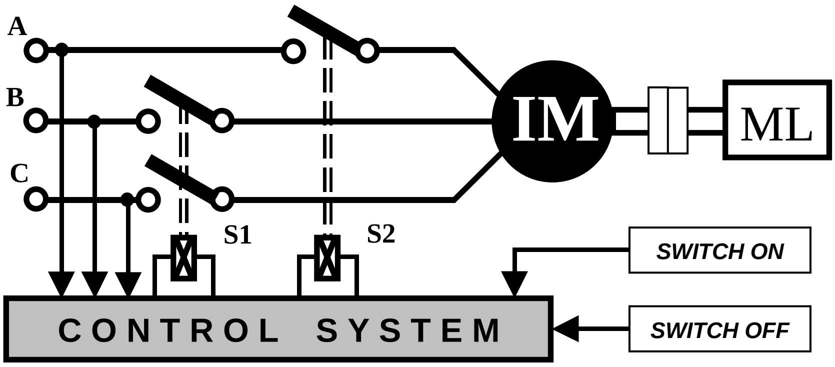

Fig. 1. Graphical representation of start-up system

Analysed system operation. The rotor shaft of induction motor (IM) is coupled by means of a rigid coupling with a working machine (ML). The essence of the proposed procedure is a controlled delay of switching of winding of one phase (here the phase A) of the stator in relation to switching time of windings of the two remaining phases (here phases B and C). For this purpose it is necessary to observe course of voltage which is to be supplied to respective windings with delay (here phase A voltage), and when this voltage passes over zero switching of winding of two phases should take place. After a lapse of set time winding of the phase where voltage was observed is switched on. The optimal value of delay was given, among other things, in [5]. For practical realization of the start-up procedure, authors used two electromechanical contactors S1 and S2 (see in fig. 1). Contactor coils are supplied with control system. Supply line voltages are input signals for the control system. The practical problem is taking the self-time of an electromechanical contactor into consideration. Figure 2 shows the algorithm implemented in the control system. The switch on point may be present in any time t_{ON} in figure 2. The system waits for zero voltage point in phase A to be detected (time t_0). In this time, a time counter starts and control system is taking the self-time of contactors t_{stS1} and t_{stS2} into consideration. The coil of the contactor S1 is supplied in the time t_1, but contacts of this contactor will be closed in time t_{S1}. Likewise the coil of the contactor S2 will be supplied in the time t_2, but contacts of this contactor will be closed in time t_{S2}.

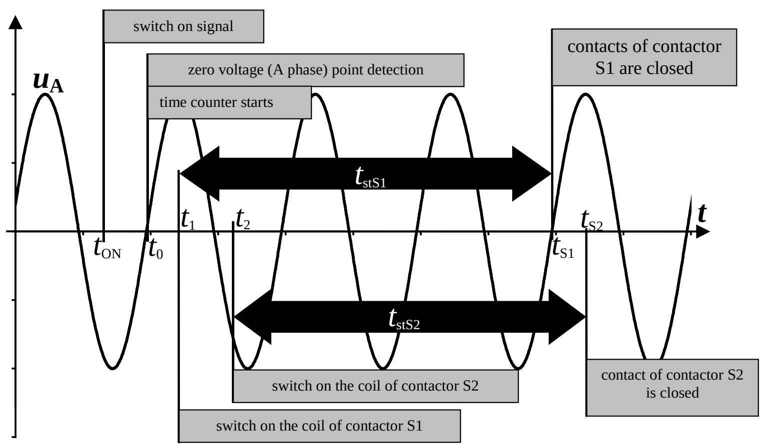

Fig. 2. Algorithm of switch on the induction motor by electromechanical contactors

Results of laboratory research. In figure 3 showed results of laboratory tests with induction motor, which nominal parameters are given by: P_N=2,2 kW; U_N=380 V; n_N=1420 rpm.; f_N= 50 Hz and $\cos\Phi_N$=0,82. Transient during the classical (not controlled) induction motor start-up is showed in figures 3a, 3c and 3e. Transient during the start-up with the proposed procedure is showed in figure 3b, 3d and 3f. Currents of stator windings and the speed of motor rotor are presented in figures 3a-3d. The voltage (CH2) of phase A winding of motor stator, the phase B current (CH3) and rotor speed (CH1) are presented in figures 3e and 3f.

Conclusion. Laboratory tests of the starting system of the induction motor with use of electromechanical contactors confirmed possibility practical realisation of the proposed procedure. Although in the results currents, voltages and rotor speed were presented, conclusion about electromagnetic torque oscillation was based on the simulation researches. Electromagnetic torque oscillation will be limited, what can be seen based on effects of acceleration of the motor rotor – in practice the negative accelerations are not present.

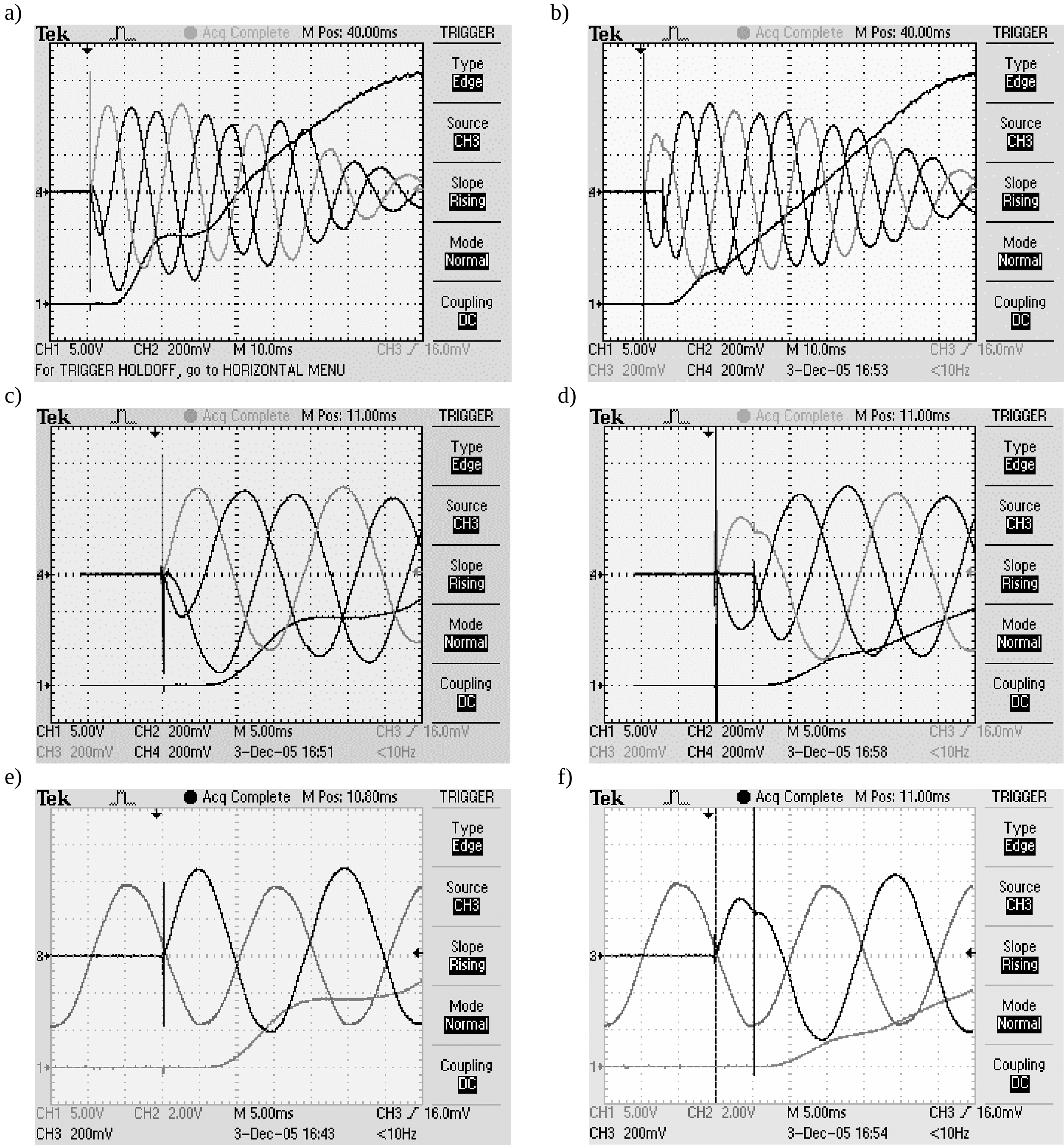

Fig. 3. Experiment results for start-up of induction motor (nominal power 2,2 kW)

Results of laboratory tests presented in this paper confirm the practical effects, which ware expressed in earlier theoretical and simulation research. The paper covers work we have carried out at the Faculty of Telecommunications and Electrical Engineering (University of Technology and Life Sciences in Bydgoszcz). Presented results are part of Zbigniew Ludwikowski's doctoral thesis.

References. 1). Ludwikowski Z., Borowski R.: Nowa koncepcja sterowania rozruchem silnika indukcyjnego klatkowego z minimalizacja udarow momentu obrotowego. Proceedings of Conference „Modelling and Simulation", Zakopane (Poland) 2000, (in Polish). 2). Cieslik S., Ludwikowski Z.: The manner and system to start-up of three-phase induction motors with minimising oscillation of electromechanical torque. PL patent application. 3). Cieslik S., Ludwikowski Z.: Oscillation limitation of electromagnetic torque of squirrel-cage motor on starting. Computer Application in Electrical Engineering, Published by Institute of Industrial Electrical Engineering, Poznan University of Technology, Poznan 2004, pp. 557-587. 4). Ludwikowski Z., Cieslik S.: Limitation of mechanical vibration during start-up of induction squirrel-cage motors. Problems of Automated Electrodrives – theory and practice, Charkov 2003, pp. 189-190. 5). Ludwikowski Z., Cieslik S., Plakhtyna O.: Dynamic properties of the electric drive with an induction motor using start-up with limited oscillation of the electromagnetic torque. Techniczna Elektrodinamika (Ukraine), Kiev 2004, pp. 38-40.