Using PLC for Control on Asynchronous Drives – Laboratory Simulator

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Abstract – **In this paper some laboratory stands that offer opportunities for various asynchronous drives testing are described. A PLC has been involved into simulators for monitoring and control on the drive performance. A touch panel, connected to the PLC, gives a possibility of entering data of initialization and operation conditions. The simulators are useful in the students training and research.**

Keywords – **asynchronous drive, soft starter, programmable logic controller (PLC).**

I. INTRODUCTION

Programmable Logic Controllers (PLCs) are often used in the contemporary SCADA-systems and in many industrial sectors. PLCs are computer-based solid-state devices that control industrial equipment and processes. They have a user-programmable memory for storing instructions for the purpose of implementing specific functions such as I/O control, logic, timing, counting, three mode proportional-integral-derivative (PID) control, communication, arithmetic, and data and file processing. PLCs are used extensively in almost all industrial processes as the primary components in smaller control system configurations and provide operational control of discrete processes. PLCs are also used to accomplish the desired product and/or process tolerance around a specified set point. Then they can be employed in the control on localized processes and proportional, integral, and/or derivative settings on the PLC to be tuned to provide the desired tolerance as well as the rate of self-correction during process upsets (PID control). In SCADA systems, PLCs are often used at the field level as process controllers and RTUs because they are more economical, versatile, flexible, and configurable than special-purpose RTUs [1, 2, 6].

On the other hand, the fast industrial progress set up higher requirements of education quality. The training under the bachelor and master programmes in the Todor Kableshkov University of Transport prepares highly qualified experts in the fields of the Electrical Equipment of the transport, industry and power engineering. Training the skills for involving, programming, and setting-up the PLCs and human-machine interface is very important. Knowledge of the relevant software products is necessary. Evaluation of the PLC's possibilities for its using in different power drive systems for efficiency optimization is also very important.

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II. LABORATORY SIMULATORS FOR ASYNCHRONOUS DRIVES EXAMINATIONS

The fast development of electrical drives and control systems has set up higher requirements to research and education quality. Several laboratory simulators have been designed and built on contemporary devices. They offer various opportunities to examine different asynchronous drives at inconstant load torque.

A. Laboratory Simulators for testing of Frequency Controlled Asynchronous Drives

The main elements involved in the configuration of one of the simulators are developed by Siemens (Fig. 1): three phase energy-saving asynchronous motor with lightweight construction (AM – 2,2 kW, 1440 rpm); Sinamics G120 frequency converter; Simatic S7-200 Programmable Logic Controller (PLC); TP-177micro Touch Panel. A synchronous generator (SG – 30V, 60A) and variable resistor R simulate the load of the motor. Three sensors are mounted on the load system. They are connected to the PLC and form the system for assessing of the torque. The Differential Amplifier DA1 is used as voltage sensor. The current transducer HAS100S is a Hall Effect sensor measuring the generator current I_g. Its output voltage is amplified by DA2. A rotary encoder reports the generator speed n_g [2]. There is also a positioning system.

TP 177micro Touch panel connected to the PLC gives the possibility of monitoring and control on the drive system as well as of entering the initialization and parameterization data and work conditions.

A Windows-based computer system is used for configuring and data storage. The necessary commissioning software Starter is installed on this computer and is used for setting-up the Sinamics G120. A subprogram Trace is used for real-time tracing the inverter parameters. This is a great opportunity of an experimental research of transient modes of the frequency controlled asynchronous drives [3].

The simulator offers various possibilities of examination on a frequency controlled asynchronous drive at inconstant load torque. The influence of parameters and operating modes of the inverter on the energetic drive performance could be examined [2,3]. Using the subprogram Trace, the dynamic characteristics with starting, stopping and changing the load or the speed set point could be captured. All data are exported to Excel tables and graphs can be automatically plotted. Transient modes have a big practical importance, since the correct choice of motor power, the proper selection and sizing of the apparatus of control system, the reduction of energy consumption during starting and stopping are based on them.
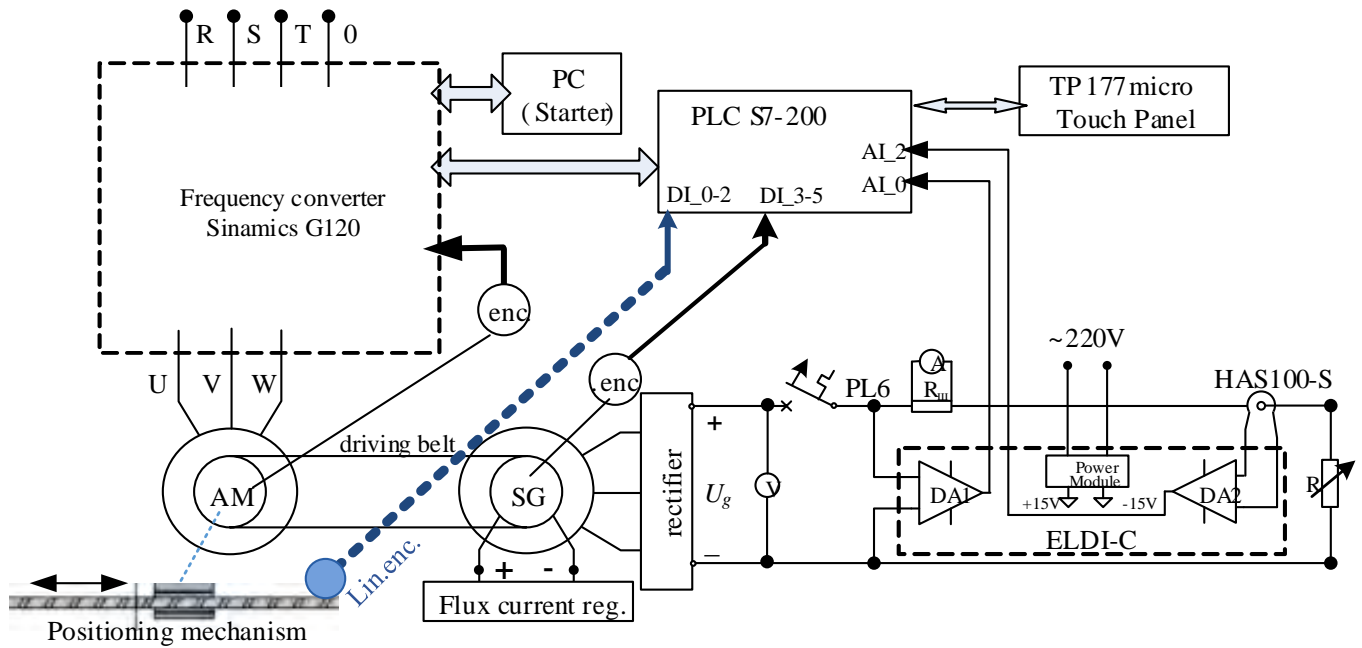
Fig. 1. Simulator for testing of an asynchronous drive with frequency converter Sinamics G120 (Siemens)

The existence of a PLC and touch panel TP177micro allows for simultaneous drive control and parameters tracing and capturing. Simatic S7-200 can be used for control and optimization tasks both for the inverter drive and the positioning system. A linear encoder reports the travelled distance of the positioning axis to the S7-200. A rotary encoder is used for closed loop speed control on the drive. A possibility of torque evaluation is created and optimal drive behaviour could be achieved. Adaptive control can be implemented. It is used when the automatic control drive system has to modify its own characteristics, depending on the operating conditions, i.e. the automatic control system adjusts (adapts) itself to variations in environment. Such control is embedded in many contemporary positioning systems. The requirements for operation with high precision, ensured and sustainable in all ranges of operating speeds, are achieved through control on the positioning, speed and torque of the motors. Adaptive control on a traction asynchronous drive could be also simulated – indirect identification of disturbances could be realized. It takes into consideration the change of controlled parameters as a result of a disturbance.

Another simulator is based on a single phase frequency converter ELDI developed by the Bulgarian company Electroinvent Ltd (Fig. 2). The load torque can be changed by

regulation of the flux of a synchronous generator. The influence of parameters and operating modes of the inverter on the energetic drive performance can be examined using the network analyzer Net Vision 2010. The true RMS values of the voltage and current are measured simultaneously. Active power, reactive power, power factor, sequence of rotation, harmonic analysis are computed and indicated. The vector diagram and the waveforms of the input signals can also be drawn on the graphic LCD display [4].

B. Laboratory Simulators for testing of a directly plugged in the grid Asynchronous Drive at inconstant load torque

The laboratory stand for asynchronous drive examinations is shown in Fig. 3. This motor is made in Bulgaria; its power is 3 kW. A load of the motor can be changed by an electromagnetic brake (EMC). Possibility of reverse is provided. The necessary locks and protection and control equipment are also assured. Methods for laboratory examinations and tests by instrumentation with high accuracy are developed: determination of the static mechanical and electromechanical characteristics and characteristics that show the change of energetic parameters (power factor, efficiency, THD etc.) of the drive at the load change [5].
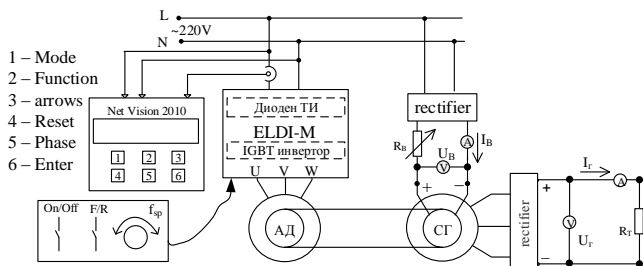
III. UPGRADING THE LABORATORY SIMULATOR

The speed regulation of the asynchronous motors in many fields of industry is not necessary. Many drives need to be started and stopped smoothly but its speed has to be constant through the operating modes. Intelligent devices called "Soft starters" can be used in those cases.

A motor soft starter is a device used with AC induction motors to temporarily reduce the torque and current surge during start-up. This reduces the mechanical stress on the motor and shaft, as well as the electrodynamic stresses on the

Fig. 2. . Simulator for testing of an asynchronous drive with frequency converter ELDI (Electroinvent)

R S T N

ACB

1 – Mode
2 – Function
3 – arrows
4 – Reset
5 – Phase
6 – Enter

S F K2.2
K1.1
K1
K1
K2
K2
R K1.2
K2.1
K2

Net Vision 2010

PC

U V W

АД

1 2 3
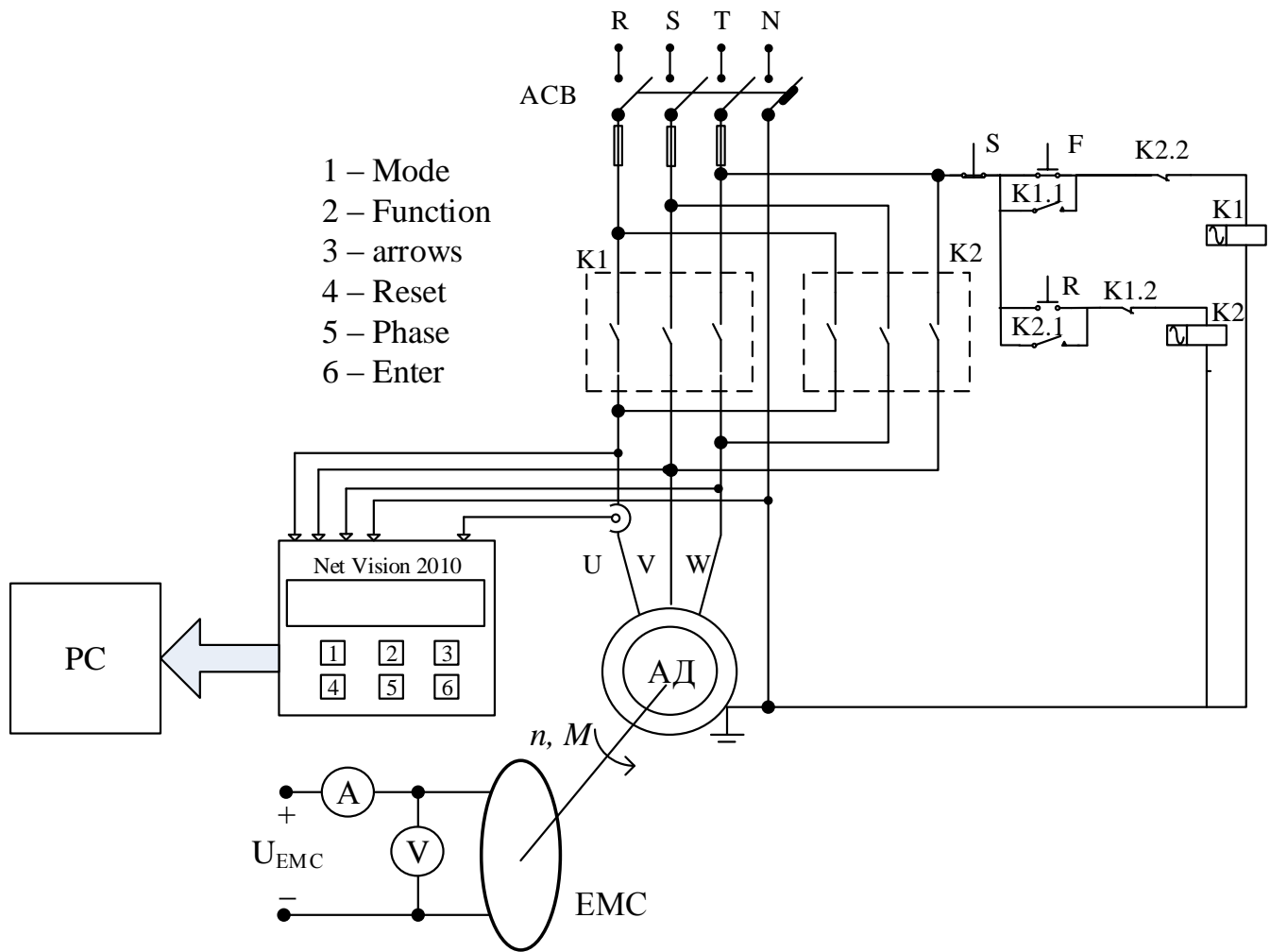4 5 6

n, M

A
+
U_EMC
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Fig. 3. Simulator for testing of a directly plugged in the grid asynchronous drive

electrical distribution network, extending the lifespan of the system [7]. Electrical soft starters reduce the torque by temporal reduction of the voltage or current input. Typically, the voltage is controlled by reverse-parallel-connected thyristors. The soft starter continuously controls the three-phase motor's voltage supply during the start-up phase. This way, the motor is adjusted to the machine's load behavior. Mechanical operating equipment is accelerated smoothly. Service life, operating behavior and work flows are positively influenced. The thyristors can be bypassed by a relay or a contactor in steady-state operation. Electrical soft starters can use solid state devices to control the current flow and therefore the voltage applied to the motor. They can be connected in series with the line voltage applied to the motor, or can be connected inside the delta (Δ) loop of a delta-connected motor, controlling the voltage applied to each winding. Solid state soft starters can control one or more phases of the voltage applied to the induction motor with the best results achieved by three-phase control.

Soft starters can be set up to the requirements of the individual application. In pump applications, a soft start can avoid pressure surges. Conveyor belt systems can be smoothly started, avoiding jerk and stress on drive components. Fans or other systems with belt drives can be started slowly to avoid belt slipping. Soft starts are seen in electrical R/C helicopters, and allow the rotor blades to spool-up in a smooth, controlled manner rather than a sudden surge. In all systems, a soft start limits the inrush current and so improves stability of the power supply and reduces transient voltage drops that may affect other loads.

Therefore, the study and examination of the soft starters is very important. The laboratory stand shown in Fig. 3 can be upgraded with an appropriate soft starter. Altistart 01 soft start/soft stop units ATS01N2 developed by Schneider Electric Company could be used [7].

The Altistart 01 starters enhance the starting performance of asynchronous motors by allowing them to start gradually, smoothly, and in a controlled manner. It helps to prevent mechanical shocks, which cause wear and tear, and subsequent maintenance work and production downtime. The series includes several devices offering various features. Some of them operate only as a torque limiter on starting, but others can be used as a soft start/soft stop unit for asynchronous motors.

The Altistart U01 limits the starting torque and current peaks on starting on machines that do not require a high starting torque. It is designed for the following simple applications: conveyors, compressors, conveyor belts, pumps,

fans, automatic doors and gates, small cranes, belt-driven machinery, etc.

The Altistart 01 ATS01N1 soft starters control one phase of the motor power supply (single-phase or three-phase) to limit the starting torque. They feature an internal bypass relay. An external power supply is required for controlling the starter. A contactor is always required to shut off power to the motor.

The Altistart 01 ATS01N2 soft start/soft stop units control two phases of the motor power supply to limit the starting current and for deceleration. They also feature an internal bypass relay. The use of a line contactor is not necessary on machines where electrical isolation is not required. These devices are equipped with 3 potentiometers for setting the starting and deceleration time and for adjusting the starting voltage threshold according to the motor load. 2 logic inputs provide Run/Stop commands and 1 logic input can be used for the Boost function. 1 logic output indicates the end of starting and 1 relay output indicates that the motor has reached a standstill at the end of the deceleration stage. These inputs and outputs can be connected to the PLC Simatic S7-200. The scheme of the upgraded simulator is shown in Fig. 4. The line circuit breaker is mounted between the grid and soft starter, but is not shown in scheme. TP177micro Touch Panel can be configured for Start / Stop and Boost commands, which can be transmitted through the PLC to the soft starter. Digital inputs of the PLC can be used for receiving the information about drive condition.
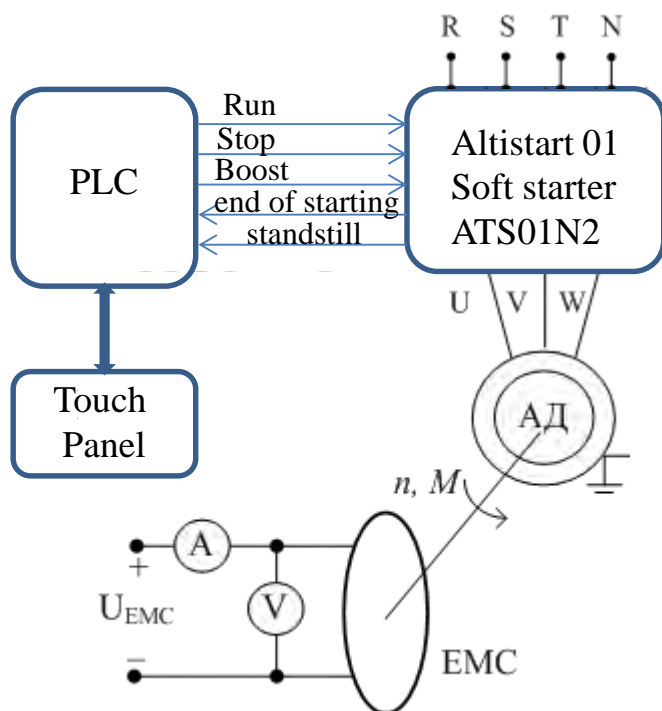

Fig. 4. Simulator for testing of an asynchronous drive with soft starter

IV. CONCLUSION

Soft starters are widely used in industry for control on asynchronous drives when the speed regulation is not a mandatory requirement. They are cheaper than inverters and frequency converters and allow temporal reduction of the torque and current surge during start-up, as well as smooth deceleration.

PLCs are often implemented as primary components in small and medium control system configurations. The PLC Simatic S7-200 offers maximum automation at minimum cost. It is compact, fast and highly powerful, feature great communications capabilities and it is based on very user-friendly software and hardware. It can be used for complex automation tasks and finds application in many branches of industry, power engineering and transport.

These advantages cause to teaching the students how to use and program soft starters and PLCs. The upgraded simulator offers various possibilities of implementation into practice many laboratory exercises, for example:

- Examination of an asynchronous motor at a constant speed and variable load;
- Study of the influence of the start-up and ramp-down time on the drive performance.

The laboratory simulator gives possibilities of student's practical training in many terms of reference, for example:

- Training the programming skills for setting-up the soft starters, PLCs and touch screens – a knowledge of the relevant software products is necessary;
- Synthesis of algorithms for optimal control on the drive systems;
- Evaluation of the PLC's possibilities of its using in the drive systems for the efficiency optimization.

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