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THE ELECTRIC DRIVE TEST STAND FOR POWER ELECTRONIC CONVERTERS TESTING

Introduction. Direct control of speed and torque in novel motor inverters requires up-to date testing methods. Quality of new electric drives isn't easy to measure, even in labour conditions ([2] and [3]). Main problem is to accurately measure the torque generated by tested drive (with natural load) and generate given torque by simulated load (if load isn't natural). One of possible methods of determining quality of inverter control is to test it on a prepared, specialized, laboratory stand. It's not an ideal method, but working conditions for tested electric drive are in this case near normal working conditions and measuring of torque (especially) and other values is easier (or possible in some cases).

Concept of test stand. Proposed idea bases on construct a simulated load with DC-machine controlled by external microprocessor circuit acts like a typical load (linear, square, etc.). Required accuracy in steady and transient conditions are possible to obtain because closed control loop with torque sensor may be used. Drive test stand was build for manual and semiautomatic testing of power inverters – control signals are generated by algorithm implemented in DSP. Described test stand with torque generator applied makes possible to use example methods of drive testing:

- continuous test in steady state (i.e. constant load torque),
- transient states (start, speed reversal, stop with/without braking – presented on Fig. 3.),
- tests with other torque characteristics (for example simple T=f(n) or complex T=f(n,time) declared by operator) – examples on Fig. 4.

Additionally stand allows:

- generate unique control signals for a DUT (start/stop, given speed etc.),
- exactly determine quality of slip compensation (for non-vector inverters or standard, non-vector mode),
- Speed error and stability of drive for sensor/sensorless vector modes,
- generate overload torque,
- make a locked-rotor tests.

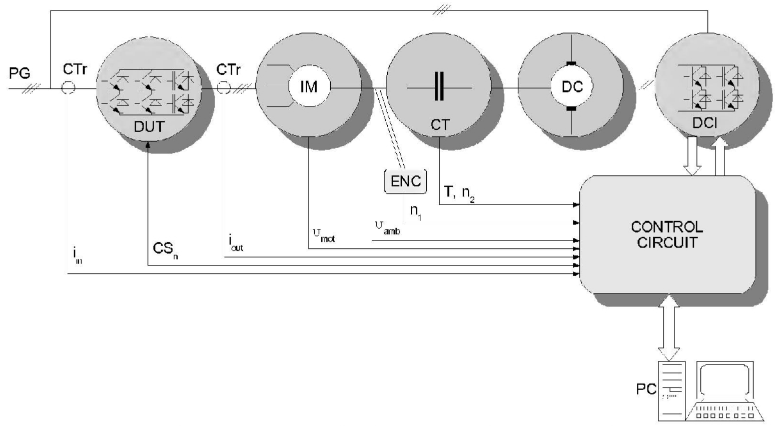

Fig. 1. Structural diagram of the test stand
PG – Power Grid, **DUT** – Device Under Test, **IM** – induction machine,
DCI – DC inverter, **ENC** – rotational encoder, **CS** – control signals,
CT – clutch with torque & speed sensor, **PC** – personal computer,
DC – Load Torque Generator, **CTr** – Current Transducers.

Hardware technology. Builded stand structural diagram is presented on Fig. 1. Main working machine (IM) is connected to a tested power inverter (called DUT – *Device Under Test*). Squirrel-cage induction machine is coupled with load by clutch equipped with tensometer sensor to exact measuring of generated torque and speed. DC-machine is connected to a DC-drive inverter controlled by a DSP. Mechanical load is simulated by this DC-machine controlled by microprocessor system. To acquire all signals personal computer (PC-2) with (with dedicated A/D card) are used. Possible to register signals are:

- drive shaft rotational speed,
- load torque (signal from clutch sensor),
- AC-drive motor currents,
- squirrel-cage motor temperature,
- ambient temperature,
- DC-drive current and voltage.

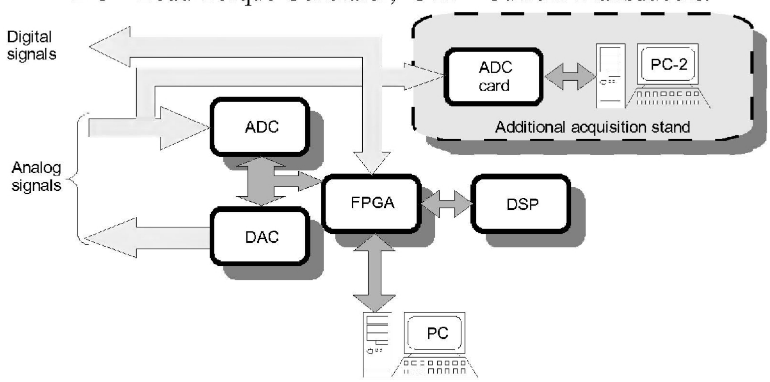

Fig. 2. Structural scheme of the control circuit
ADC – analog to digital converter
DAC – digital to analog converter
FPGA – programmable logic IC
DSP – main control processor
PC-2 – verifying acquisition PC

Used machines parameters. Used in torque generator DC machine is PKMPa44a/109 type, separately excited, of 5kW rated power, 26.1A rated current, 220V rated voltage and rated speed 1450min^{-1}. Used AC machine is squirrel-cage induction motor 1AP100L-4 type, rated power 3kW, rated current 6.8A, rated voltage 380V and speed 1420min^{-1}. Used tensometer coupling is Beta2002-M type, with torque and speed analogue outputs, and Modbus (RS-485) interface (not used in this project).

Control system consists of FPGA-IC and signal processor. Control system is interfaced with personal computer, which perform following main tasks:

- acquires measured data,
- makes possible to edit and load processor program.

Use of signal processor makes possible modeling characteristics of load torque as function of speed, time or other variables. Some implemented characteristics showed on Fig. 4. Programmed tests are then simple to make and use. Data acquisition system is integrated with control system of DC-drive, and consists of main signal processor (ADSP-21065) supported by FPGA circuit and fast A/D & D/A interface board .Used FPGA integrates a DC-drive (load) modulator, AD/DA control circuit with interrupt generation system for signal processor, rotary encoder signal decoder (to obtain exact shaft speed) and communication system with ADSP and host PC.

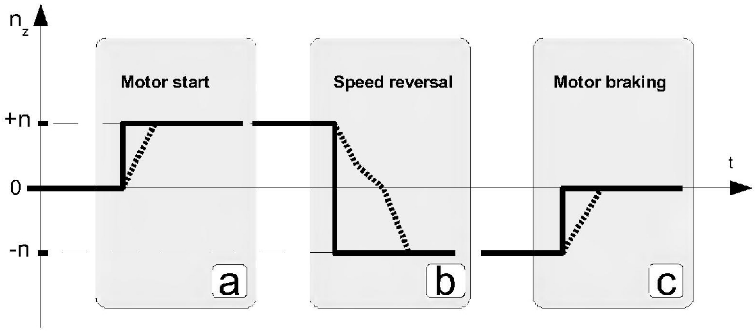

Fig. 3. Example of possible time-based speed test schemes
a) - motor start, b)- speed reversal, c)- braking to stop

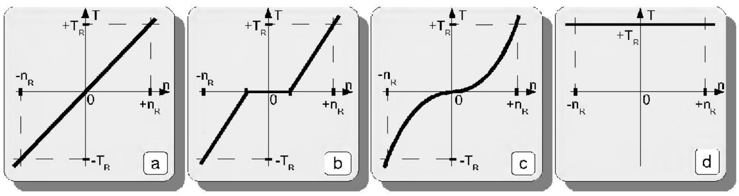

Fig. 4. Used classical load characteristics
a) linear, b) linear with nonsensivity zone (without hysteresis),
c) nonlinear (square), d) active (constant torque).

DSP integrates an overall control algorithm (torque generation, DC-inverter control by FPGA modulator, generation of discrete signals for tested inverter generator etc.).

Software. Software for DSP was made in Analog Devices VisualDSP IDE, in C++ language. Software on PC-computer uses MS-DOS and was made in Borland C++ IDE. Modular construct of DSP program allows to easy change of possible testing configurations.

In future versions use of multi-threaded windowed OS is planned (Windows or Linux X-Window) with dedicated operator panel, also autonomous mode ([4]) of work with registering all data on flash-disk (SD or CF-card) will be added.

Conclusions. Stand makes possible doing of semi-automatic drive testing with squirrel-cage induction motor and many types of programmed loads and states, both steady and transient. Many of signals are possible to register (torque, speed, input and output currents, ambient and motor temperature). Described test stand is used in Laboratories of UTP to verify realized squirrel-cage motor drive models in real-time simulators ([1]). The test stand is still in development state.

References

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