

DSP BASED EXCITATION CONTROL SYSTEM FOR SYNCHRONOUS GENERATOR

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Abstract. DIRES21 is a digital control system developed on the Faculty of electrical engineering and computing in Zagreb (Department of electrical machines, drives and automation). This four-processor digital system is suitable for the control and regulation of fast processes (electric motor drives, turbines, excitation of a synchronous generator, synchronization of a synchronous generator and etc.). Developed digital system is based on DSP ADMC300 processors. For implementing and testing of control algorithms it is developed software tool for algorithm modelling in graphical environment that includes more than 300 blocks implemented via ASSEMBLY programming language. It is also developed software tool for monitoring and recording of all tested algorithm variables. This software tool simplifies algorithm testing and adjustments.

Keywords. Generator excitation systems, DSP, Real time processing.

1. INTRODUCTION

Digital system *DIRES21* is developed on the faculty of electrical engineering and computing in Zagreb (Department of electrical machines, drives and automation). The main purpose of this digital system is the control and regulation of electrical machines:

- Hydro generator control [1]
- Vector control of a squirrel-cage induction motor [3]
- Excitation control of a synchronous generator (PI voltage control, fuzzy logic control, neural network control) [4]
- Self-synchronization of a synchronous generator
- Control of a diesel-electric generating set.

The algorithm modelling process is made by a graphical oriented software development tool. The software development tool consists of a finite number of graphically displayed blocks. Each block represents specific mathematical or logical function that is implemented via DSP ASSEMBLY programming language. In comparison with the higher languages programming (C, C++), this approach provides better system performances (less memory usage, shorter time of an algorithm execution). For the algorithm testing purposes specific monitoring tool is developed. It enables adjustments and monitoring (instantaneous values and/or graphical representation) of all algorithm parameters and signals.

2. HARDWARE STRUCTURE

Four-processor digital system is based on *DSP ADMC300* processors. Communication between processors is achieved via synchronized serial bus. The communication rate is 4 MHz so twenty 16-bit words can be exchanged with the

frequency of 3200 Hz. *DIRES21* hardware consists of two separate boards; processors, all the communications and power supply are arranged on the main board (Fig. 1), while the analog and digital inputs/outputs can be accessed on the other board (Fig. 2).

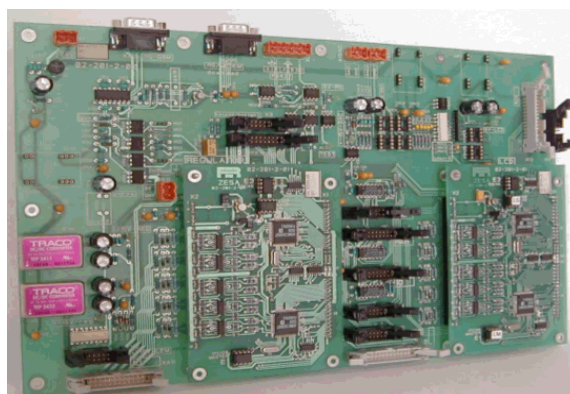


Fig.1. Main board of *DIRES21* system

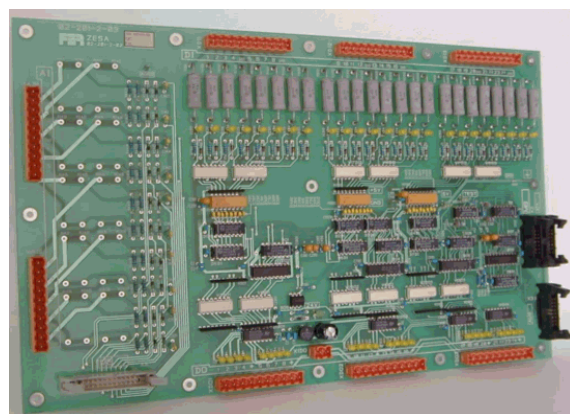


Fig. 2. Input/output board of *DIRES21* system

In Tab. 1. basic characteristics of *DIRES21* digital system are presented. There are galvanic isolation between communication channels, digital input/outputs and analog outputs. GSM communication connection is implemented via rs232 communication channel and *MODBUS* protocol, for connecting *DIRES21* to industrial systems, is implemented via rs422 communication channel. The real-time code is executed in an interrupt operating mode with the fixed frequency.

3. SOFTWARE TOOLS

For the purposes of implementing and testing of different algorithms in the field of regulation as well as control, two software tools under Windows XP Professional are developed.

Tab. 1. Basic characteristics of digital system *DIRES21*

Number of processors	4
Number of analog inputs (sampling frequency)	20 (31.25 kHz)
Number of analog outputs (sampling frequency)	2 (500 Hz)
Number of digital inputs (sampling frequency)	24 (100 Hz)
Number of digital outputs (sampling frequency)	24 (100 Hz)
Number of encoder inputs	2
Number of rs232 communication channels	2
Number of rs422 communication channels	1
Number of PWM channels	2

Graphical software development tool for algorithm modelling

Developed software tool enables in graphical environment modelling of algorithms via appropriate blocks. There are more than 300 blocks (logical, arithmetical, regulation and communication blocks) implemented manually via ASSEMBLER programming language of *DSP ADMC300* processor. Each block has an appropriate graphical display. In graphical environment modelling of control algorithms is made by connecting of these blocks in more complex control structures. The interface between this graphical software development tool and *DIRES21* hardware is implemented via *Borland C++ 3.1* programming language. On the Fig. 3 is presented part of the algorithm for the voltage and excitation current control of a synchronous generator [1]. By this software tool the reliable, simple and efficient modelling of control algorithms is achieved. Such modelled algorithms are reviewed so they can be easily analyzed.

Each block is denoted with an appropriate letter (T) and number (from 100 to 999); a letter shows the type of interrupt (in which that block is executed) and a number determines the execution order of a block (smaller number means higher priority). The execution of each block is determined by an appropriate interrupt and must be done before the next interrupt appears.

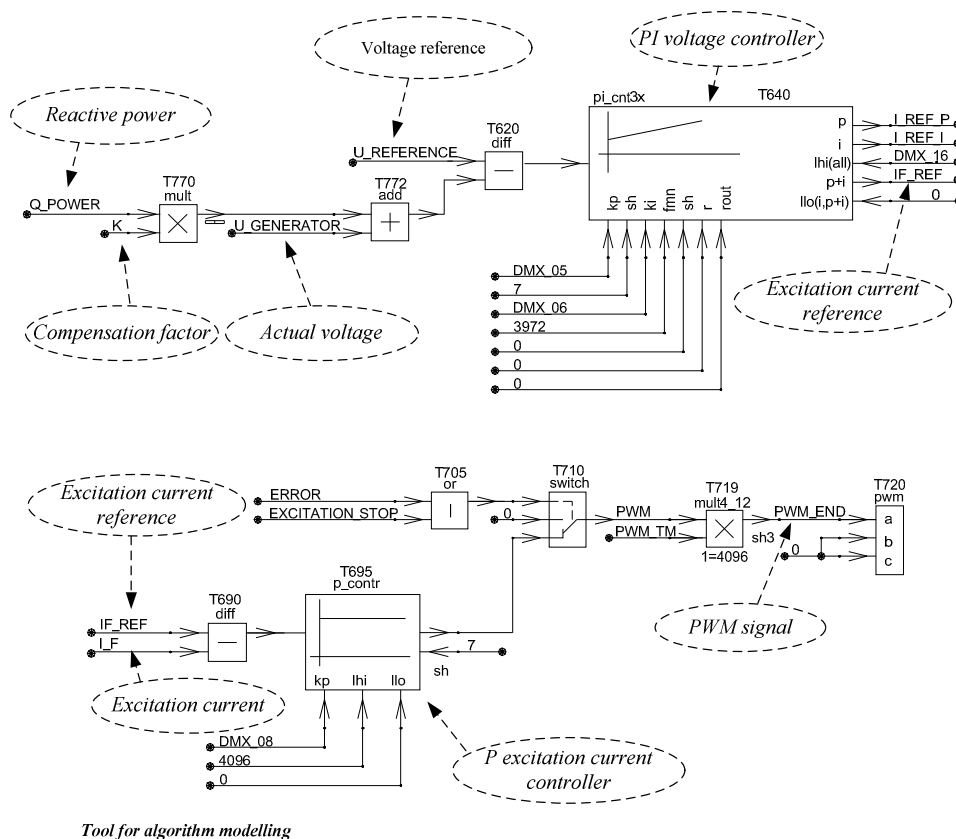


Fig. 3. Graphical environment for algorithm modelling

Software monitoring tool for the optimizing and testing of a control algorithm

This software monitoring tool is developed by *Borland C++ Builder 5*. It enables access to all important variables of control algorithms, parameters optimizing and recording of the characteristic waveforms. The main window of this software tool is showed on Fig. 4.

The testing of complex algorithms demands software tools that enable parameters optimizing, displaying and recording of characteristic waveforms. A personal computer communicates with *DIRES21* system via rs232 communication channel or via remote communication GSM.

On the main window (Fig. 4) it is possible to observe the states of the 27 variables (instantaneous, maximal, minimal, filtered, absolute filtered, difference between maximum and

minimum, the moment of maximum or minimum and the time period between maximum and minimum.) For the 9 fields of display it is possible to choose any variable from the algorithm (from 18th to 27th field). One of the 27 observed variables can be graphically displayed. In the main window are also displayed the instantaneous values of algorithm parameters. There is an access to 72 parameters of a control algorithm (parameters DMX_00 to DMX_72).

All information that are sent by the digital system to a personal computer and all operator directives can be recorded. All recorded waveforms can be later observed by this software tool (the display is the same as in the moment of recording) as well as by Microsoft Excel.

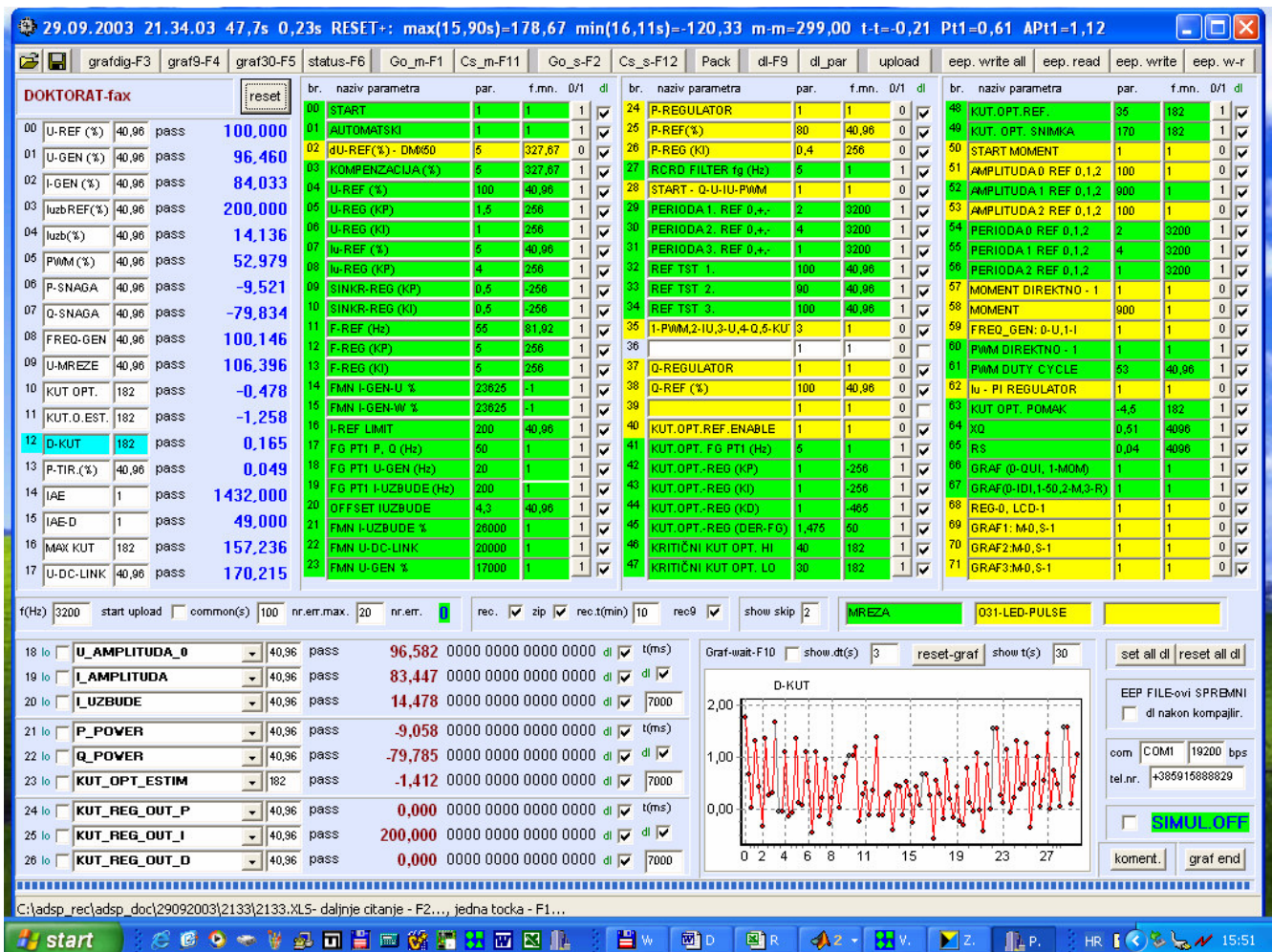


Fig.4. Main window of software monitoring tool

In the same time 30 waveforms with the sampling frequency of 0.2 s (Fig. 5) and 9 waveforms with the sampling frequency of 0.3 ms (Fig. 6) can be displayed.

From the main window other windows of this monitoring tool can be accessed. The states of 160 digital variables can be displayed. For the algorithm testing purposes the states of

96 digital variables can be simulated. Digital variables can be displayed with the minimal sample time of 0.2 s.

Experimental responses of synchronous generator for step change of active power are presented on Fig.5. and Fig.6.

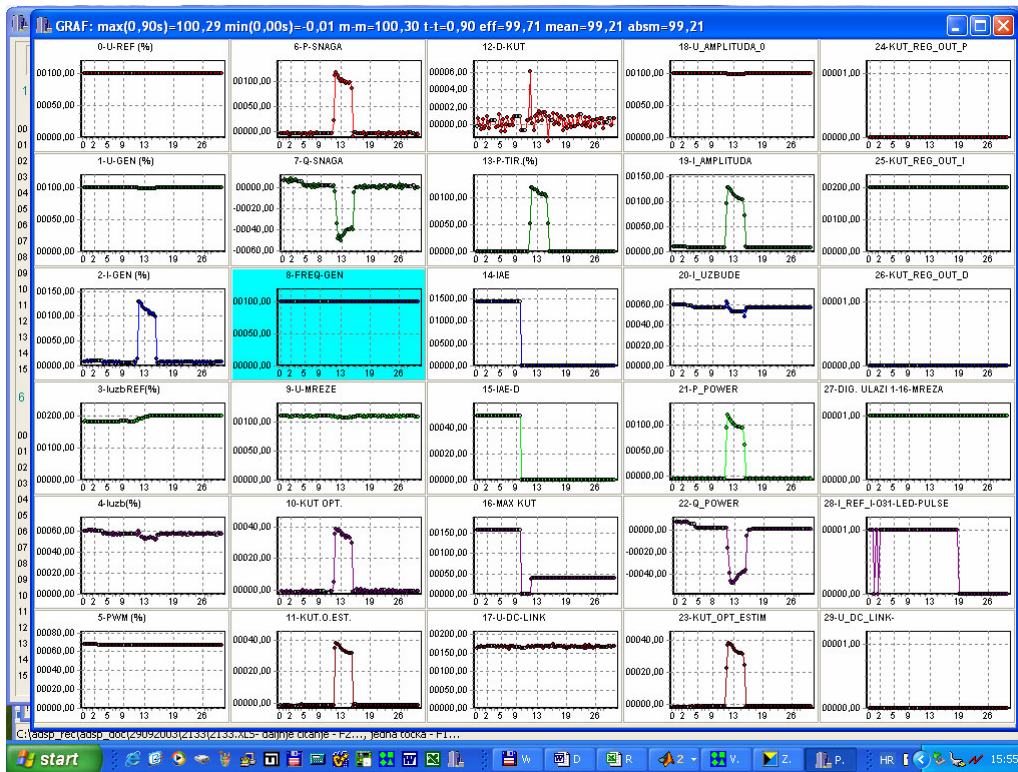


Fig. 5. Display of 30 waveforms with the sampling frequency of 0.2 s

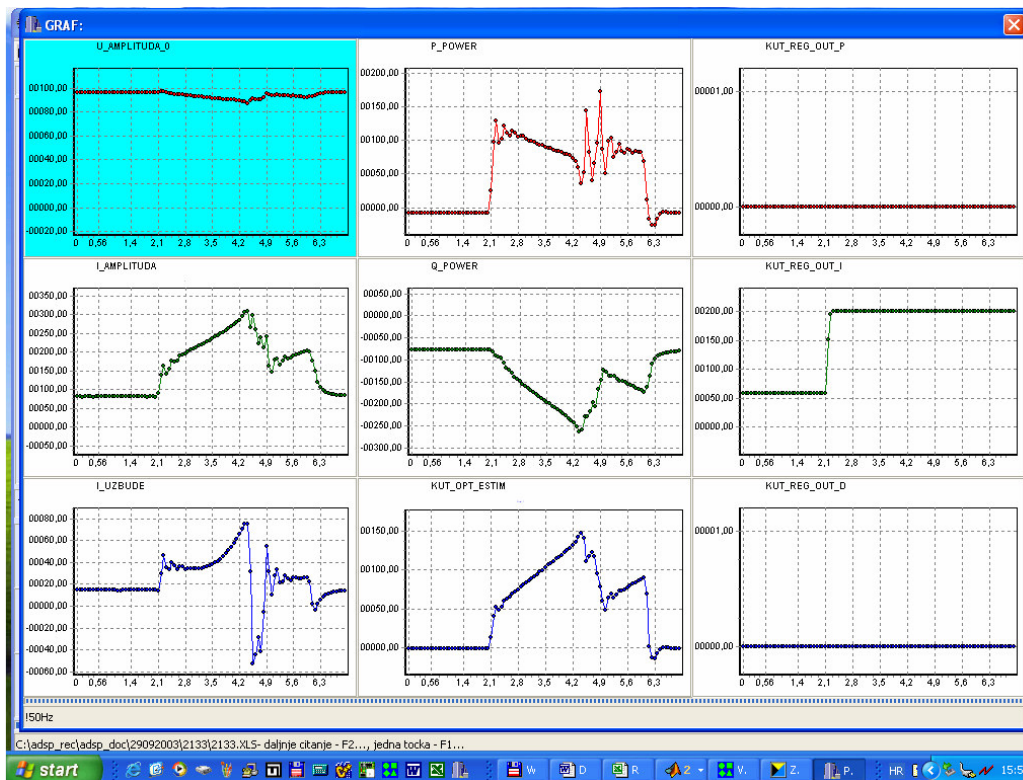


Fig. 6. Display of 9 waveforms with the sampling frequency of 0.3 ms

4. SYNCHRONOUS GENERATOR EXCITATION CONTROL

Laboratory use of digital control system in synchronous generator excitation system is presented on the Fig 7.

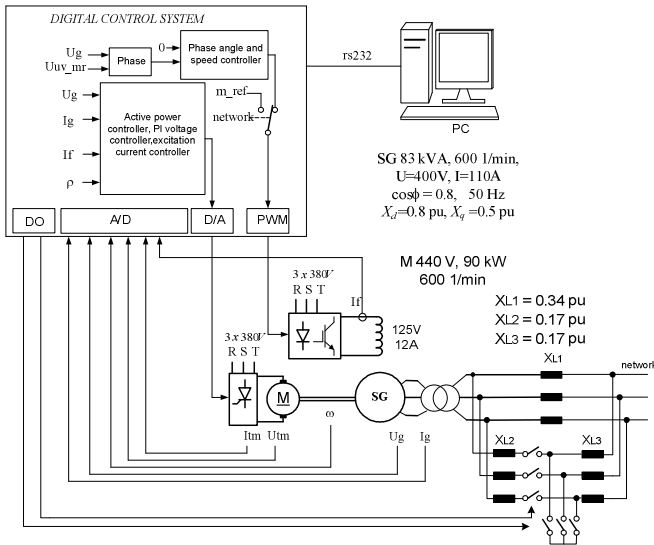


Fig.7. Laboratory model of digital control system *Dires21* in excitation control of synchronous generator

In *Dires21* are implemented active and reactive power controller, voltage and excitation current controller, load angle controller, phase angle and speed controller [2] and self synchronization unit.

Fig. 8. shows experimental responses on the step changes of voltage reference (from 100% to 90% and then back to 100%) in generator operating point $P=50\%$, $Q=0\%$ with included voltage PI controller and excitation current P controller.

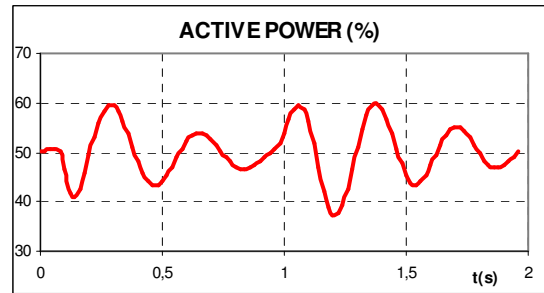
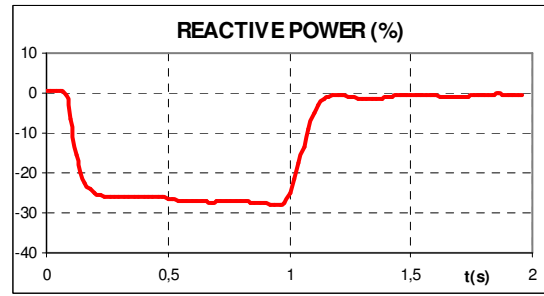
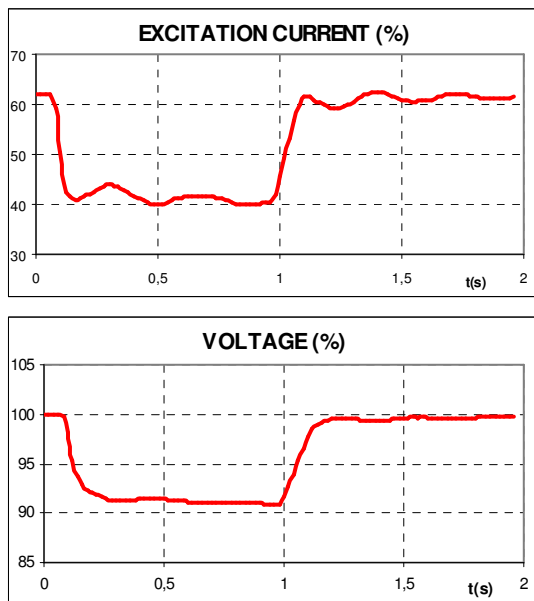


Fig. 8. Experimental responses on the step change of voltage reference in generator operating point $P=50\%$, $Q=0\%$

5. CONCLUSION

Dires21 is a well proven industrial digital control system. It showed good characteristics and reliability (electromagnetic interference resistance) in different control application (regulation of a hydro generator, excitation control of a synchronous generator, self-synchronization of a generator, rectifier current regulation). *Dires21* graphical software development tool reduces the complexity of algorithms modelling. Developed software tools simplify algorithm testing and final system adjustments by allowing access to all algorithm signals and parameters. There is no need for additional measurement equipment because *Dires21* software tool enables the recording of all algorithm signals. This digital system can be connected with the higher control level by GSM or MODBUS communication protocol.

6. REFERENCES

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