Microprocessor System for Control, Testing and Regulation of Transistor Converter Devices

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Abstract – **In this paper the structure and the modes of operation of a microprocessor system for control, test and regulation of a class of transistor power converters – resonant inverters is presented. The system allows to set the parameters of the output control signals at a wide frequency and duration range, to receive an information about the resonant inverter operation and to convert, save and indicate it.**

Keywords – **microprocessor system, control, test, regulation, resonant inverter**

I. INTRODUCTION

In recent years together with the quick development of the active and passive elements for the power converters, ambition to synthesize new circuits including principles and operating modes which allow higher frequencies, reducing the mass and dimensions parameters (kW/dm^3) and the price (EURO/kW) of the devices is observed. The successful realization and testing of the power circuit of such devices is determined to a great extent by the availability of a flexible control system allowing a change of control pulses parameters (frequency, amplitude, duration) and watching the output characteristics in order to define and optimize the operating mode [2].

In every separate case development of individual control systems for the transistor power converters is needed because of the various powers, frequencies, operating modes and changes of the load during the technological process. Accumulating an information about the operating modes and determining an advisable limits of change while regulating are also required.

Every time this leads to solve one and the same problem to synthesize a system for control, test, regulation and protection. On one hand the solutions are not always optimal and on the other hand redundant time is lost to develop, make experiments and debug.

II. AIM AND TASKS OF THE PROJECT

The aim of the present report is to develop a universal variant of a microprocessor control system (MCS) allowing to generate control signals at the range from 10 kHz to 1 MHz with a step of 100 Hz and duration changed with step of 50 ns. The system have to control a resonant inverter and to measure the output characteristics and parameters defining the operating modes and advisability of the project.

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The main problems to resolve are the following:

- ✓ Defining the main features of the microprocessor system to meet the requirements for universality and intended for a class of converting devices – resonant inverters;
- ✓ Synthesizing a block diagram of the control system and description of the purpose and the main features of it's blocks;
- ✓ To present the operation of the control device at different operating modes and also the ways to start and stop them.

III. FEATURES OF MICROPROCESSOR SYSTEM

The main features of the presented system are as follows:

- ✓ Setting the frequency of the control pulses equal for the two output channels at the range from 10 kHz to 1 MHz with a step of 100 Hz by a keyboard or automatically;
- ✓ Generating two-channel sequence of control signals dephased by π (rad) and separated galvanically from the powerful circuit of the inverter;
- ✓ Setting a programmable pause at switching over the channels equal for both of them at the range from 50 ns to 12,75 μs with a step of 50 ns by a keyboard or automatically;
- ✓ Control menu including commands for debugging, input parameters values, choosing a mode, measuring, saving and indicating currents, voltages, control signal parameters, time durations, etc.;
- ✓ Three operating modes of the system:

⇒ setting the parameters of the control signals, choosing the mode of operation, regulating time durations, etc.;

⇒ testing the combined operation of the resonant inverter and the control system. This is achieved by setting control signals with fixed values of the parameters, measuring, saving and indicating currents and voltages which characterizes the mode of operation of the resonant inverter;

⇒ regulating and maintaining automatically the power of the resonant inverter following a particular law of control.

- ✓ Measuring, saving and indicating on LCD the working frequency in kHz, the value of the pause in ns, the values of the high frequency current and voltages, the phase difference between the current and the voltage in the resonant circuit of the resonant inverter, time intervals, etc.;

- Blocking the output signals manually by a keyboard or automatically after definite time-out or by the differential protection.
- Indicating on LEDs the current mode of operation, the source power, the differential protection, time-out.
- Reprogramming the program memory of the microcontroller and ability to debug together the monitoring software and the hardware of the system.

IV. Block Diagram of Microprocessor System

The block diagram of the microprocessor control system is synthesizes on the base of the features mentioned above (Fig. 1). The purpose of each of the blocks is following:

CB – Control Block. It is based on an Atmel ATmega128L microcontroller [3]. It's program memory containing the monitoring program is 128kB. The internal data memory is 4 kB and the external data memory is 1 GB. CB is connected with all other blocks of the MCS.

SPI - Serial Programming Input. It is intended for connecting the programmer Atmel STK500 to program and correct the monitor program.

JTAG – input intended for connecting Atmel JTAG ICE to debug the monitor program and the hardware of the MCS.

LED, LCD – Indicator blocks (LEDs and LCD) showing the values of the parameters or the current mode of operation.

K – Keyboard for setting the input parameter values in the first mode and to choose and start a command from the menu.

PTI - Programmable Time Intervals block generating digitally two-channel control signals with programmable duration set manually by the operator or automatically by the regulating algorithm.

TGB – Timing Generation Block setting the step of the change for the programmable interval generated by PTI.

PFB - Programmable Frequencies Block implementing various frequencies of the control signals at the range from 10 kHz to 1 MHz, set manually by the operator or automatically by the regulating algorithm.

GSB - Galvanic Separation Block isolating galvanically the programmable duration control signals from the signals Y1÷Y4 driving the gates of the transistors T1÷T4.

DB – Drivers Block generating and regulating the level of the control signals Y1÷Y4 grouped in couples: Y1 and Y3 sourced by the first channel and Y2 and Y4 sourced by the second channel of the output signal from GSB.

FLS – Block Forming the Levels of the Signals from the voltage transformer (HT) and the current transformers TT1÷TT5 at the range of 0÷3 V and also to generate the phase difference between the current and voltage in the resonant circuit.

DPB – Differential Protection Block applying a control signal for switching off the resonant inverter by stopping the control pulses in an emergency mode – simultaneous operating of the transistors in one and the same side [1].

PS1,2 – Power Sources 1 and 2.

RI – Resonant Inverter

V. Operation Modes of the Control System

Three modes of operation exist:

- "Setting the system" mode

The purpose of the mode is to set the parameters of the signals supplying the operation of the system in the other two modes.

In that mode the system is prepared for the two other modes without starting the operation of the inverter. The system is getting into this mode automatically by default at switching on the power supply.

In this mode possibilities are provided for inputting the parameters of the control signals – operation frequency and duration, the power of the resonant inverter, operating time, time durations for maintenance various values of the output power, etc.

- "Testing, measuring and indicating" mode

The main task of this mode is to control the operation of the resonant inverter at fixed values of the control signals parameters, to measure, save and indicate the values of the characteristics of the resonant inverter. In this way it is possible to accumulate digital information at the various operation modes of the transistors at various fixed values of the frequency and various durations of the control signals.

The starting of this mode is possible from the first mode by the command "Start/Test" from the main menu. The results of the measuring may be saved in the memory of the CB, and also may be indicated on the LCD.

Quitting the mode is possible by two ways:

⇒ Manually, by a command "Stop" input by the operator. The resonant inverter operation is stopped by blocking the control signals;

⇒ Automatically, after a definite time period while the device is operating or switching on the differential protection.

- "Regulating and maintenance the power" mode

The main task of the mode is to monitor the changes of the operation mode according to prior defined control law of the resonant inverter defined by the particular technological process and to maintain it in advisable limits.

This leads to possibilities for realization of the particular technological process maintaining an optimal mode of operation.

The start of the mode is implemented from the first mode by a command "Start regulation". In this mode the parameters values of the RI are monitored automatically and the control signal parameters are changed automatically with a defined step at advisable limits.

Quitting the mode is as at the previous one – manually or automatically.

VI. Conclusion

The suggested analysis approach is characterized with flexible development of the monitor program and leads to reducing the time of development of optimal control system circuits.

The presented microprocessor system is suitable for implementing in development of wide range of transistor resonant inverters, as it allows an easy setting in a wide range the parameters of the transistor control signals. On the other hand it allows measuring the output characteristics and parameters and precise defining of the modes of operation.

The measuring and saving the values of the main characteristics and parameters of the resonant inverters allows to determine their static and dynamic parameters by the means of analysis.

The system is implemented and tested in laboratory conditions to control the operation of resonant inverters with operation frequency by 500 kHz and power by 3 kW.

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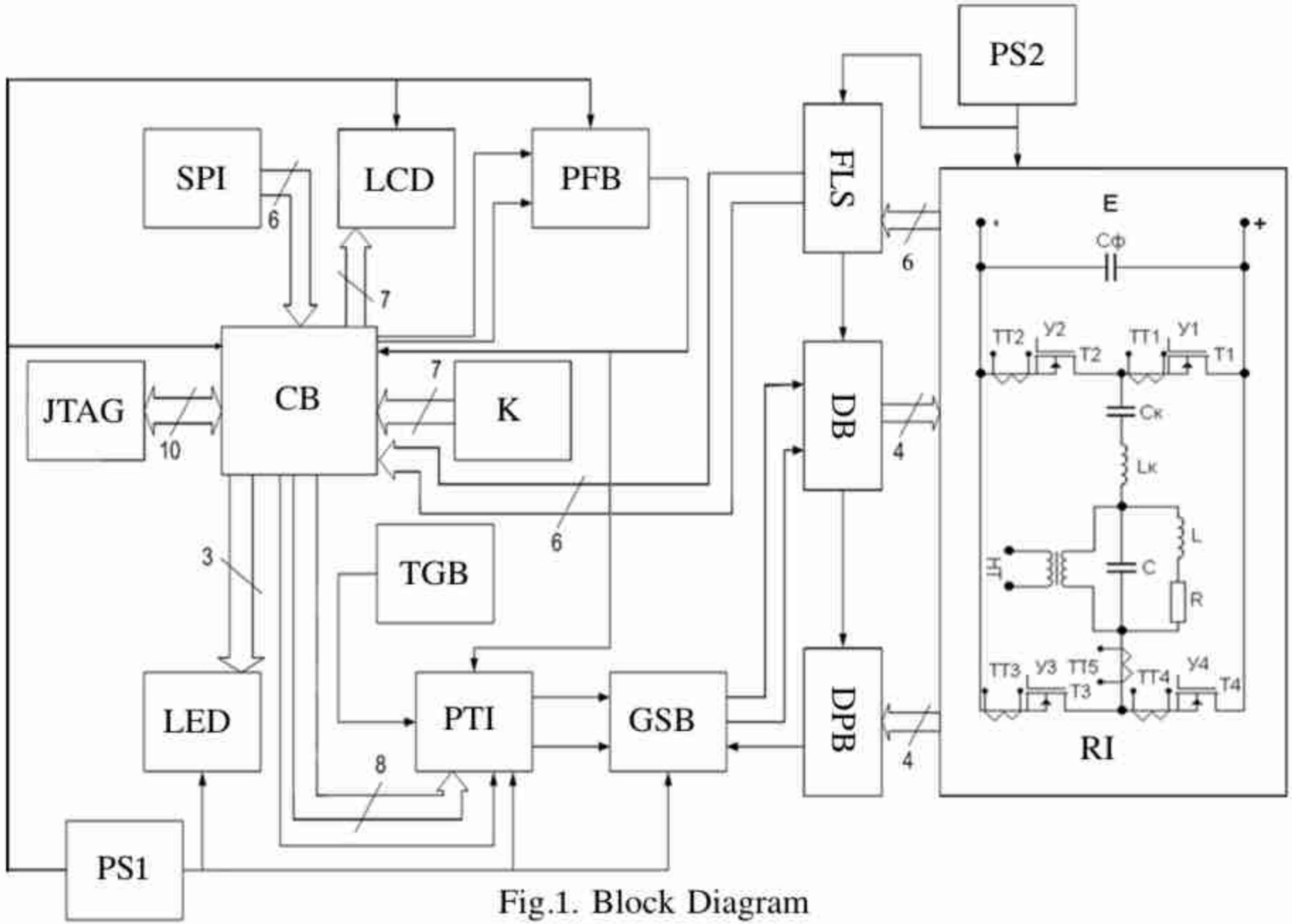

Fig.1. Block Diagram