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COMPUTER CONTROLLED EXPERIMENTAL EQUIPMENT FOR RELUCTANCE MOTORS

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Abstract: *Hardware and software structure of a computer controlled experimental equipment for reluctance motors study is presented in detail in the present paper. The realised experimental equipment contains the following elements: variable reluctance stepper motor(VRSM), PWM inverter, PC equiped with DS1104 board for acquisition and control, and a computer equiped with LAB-PC1200 board used in order to aquire current and voltage waveforms from motor phases. Experimental results are also presented in the paper.*

Key Words: ***reluctance motors, PWM inverter, DSpace DS1104 controller board, LAB-PC1200 board***

1. INTRODUCTION

The reluctance motors are widely used in digital controlled machine-tools drives, peripheral computer equipments, telecommunications through laser and satellites, nuclear techniques, industrial robots, aeronautical and military equipments etc. From stepping motors family, the variable reluctance stepper motors (VRSM) promise the low cost production and motivate the comprehensive research and design.

Despite the fact that this type of motor is very robust as actuator in special applications, it is confronted with a major problem regarding its supplying and driving system, which focuses much interest among specialists in the last decade.

Using up to date hardware and software systems, a computer controlled experimental equipment was built in order to study the behaviour of different types of reluctance motors taking into account their supplying systems.

2. EXPERIMENTAL EQUIPMENT

The proposed computer controlled experimental equipment for reluctance motors is presented in figure 1.

The most important elements of this equipment are:

- variable reluctance stepper motor (VRSM);
- PWM inverter;
- PC equipped with DSpace DS1104 controller board;
- PC equipped with LAB PC1200 board from National Instruments.

The equipment also contains a signal generator, a current feedback loop board and a module with current and voltage transducers used for galvanic separation between the power module and measure module, namely the LAB PC board.

Each of these elements will be described in detail.

2.1. Variable reluctance stepper motor(VRSM)

The VRSM used in our study is a common 8 pole, 4 phase motor with the following main characteristics:

- electromagnetic peak torque = 2Nm;

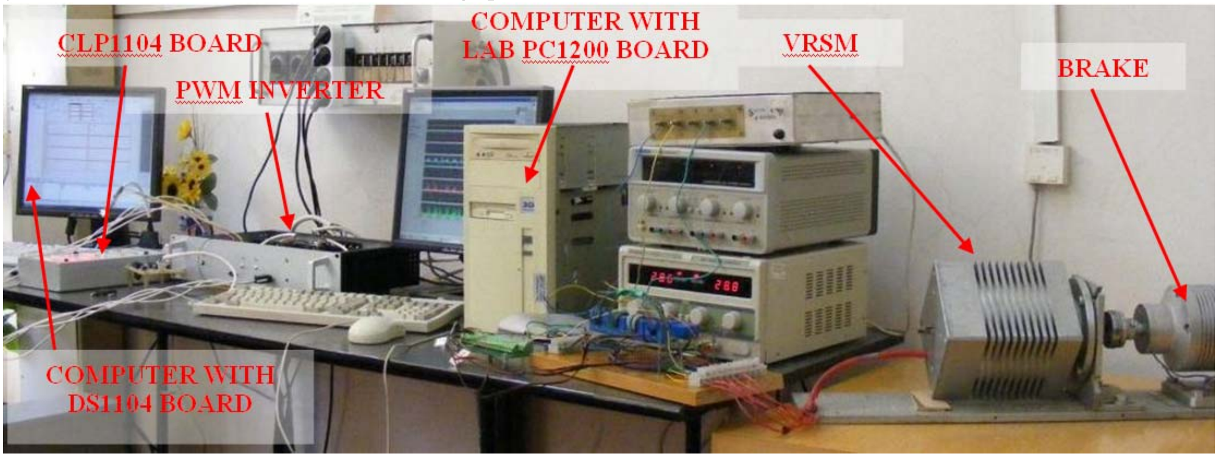

Fig. 1. *Picture of the proposed experimental test bench*

- phase current = 5 A;
- phase voltage = 60 V;
- step angle = 2.65^0 (136 steps/rot).

The motor was manufactured in author's laboratory and a picture of it is presented in figure 2.

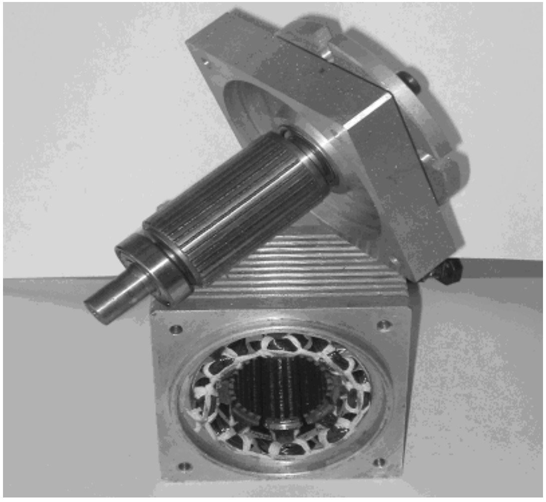

Fig. 2. *Picture of the VRSM*

2.2. PWM inverter

PWM schemes are the most popular inverters in case of reluctant motors [2] due to their adaptability to various techniques based on voltage and current processing. The block diagram of the whole PWM inverter is depicted in figure 3.

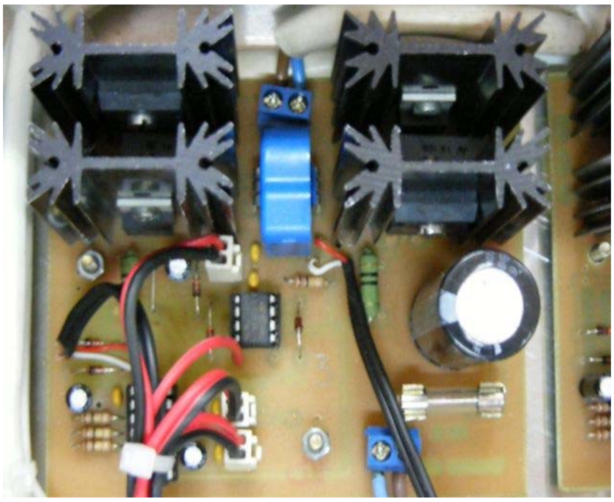

Fig. 4. *A module of the PWM inverter*

By comparing figure 3 and figure 4 one can see that shunt resistors R_{sh13} and R_{sh24} were replaced with LTSR 6-NP, closed loop (compensated) multirange current transducer using the Hall effect, produced by LEM.

The current feedback loop is based on dedicated LM555 modules, which are highly stable devices for generating accurate time delays or oscillation and incorporate Trigger Schmitt circuits.

The signals provided by the current transducers LTSR 6-NP are used by this current feedback loop board in order to perform the PWM operation.

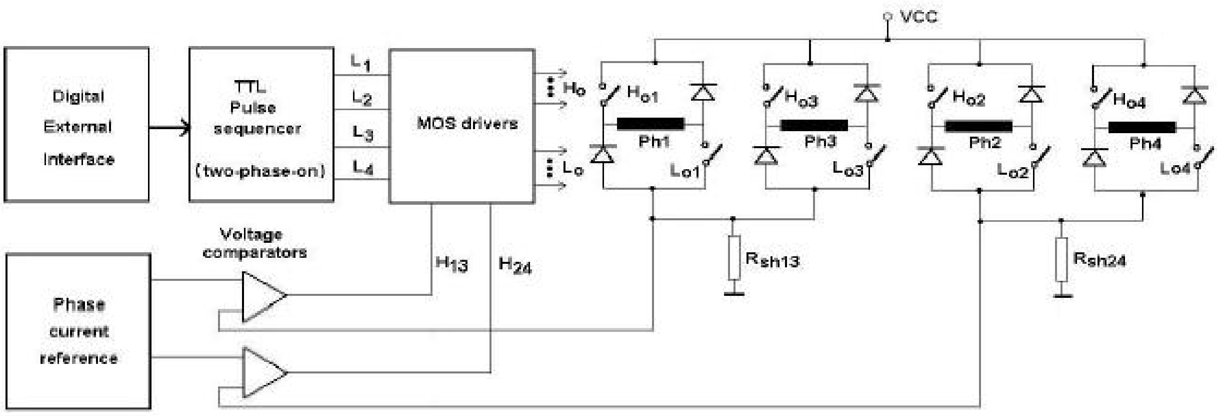

Fig.3 – *Block diagram of the inverter*

As phase currents are unipolar in case of the proposed motor, MOS half-bridge inverter schemes is chosen. Each bridge is controlled by four high/low side drivers for MOS transistors. As MOS drivers IR2110 from International Rectifier has been used.

The IR2110 is a high voltage, high speed power MOSFET and IGBT driver with independent high and low side referenced output channels. The logic input is compatible with standard CMOS or LSTTL outputs. The output feature a high pulse current buffer stage designed for minimum driver cross-conduction. The floating channel can be used to drive an N-channel MOSFET or IGBT in the high side configuration witch operates up to 500 volts. [1]

A picture of one module of the made PWM inverter which is included in the made experimental equipment is presented in figure 4.

An image of the current feedback loop board is presented in figure 5.

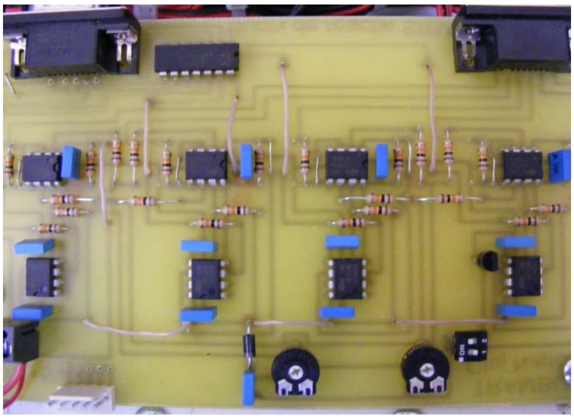

Fig. 5. *Current feedback loop board*

2.3. DSpace DS1104 board

The equipment is controlled from a PC equipped with a DS1104 controller board from DSpace.

The board is a complete real-time control system based on an MPC8240 Power PC 6003e floating-point processor and a slave DSP subsystem based on the TMS320F240 DSP for advanced I/O purposes, ensuring the computing power for real time control tasks. [5]

For rapid control prototyping, CP1104 Connector Panel provides easy-to-use connections between the DS1104 controller board and devices to be connected to it. BNC connectors and Sub-D connectors allow connecting, disconnecting and interchanging different devices, simplifying system construction and testing. [5]

The Control Desk® software package that comes with the DS1104 board is a user interface programming tool that provides all the needed functions for monitoring, control and automation of experiments. With virtual instruments provided by the software, virtual control panel can be made for real time control of the running process.

The Real-Time Interface library, as part of the Control Desk® software package, together with Real-Time Workshop from The Math Works automatically generates real-time code for Simulink models and ensures the implementation of this code on real-time hardware. [6]

The possibility to obtain real time executable code by direct compilation of the simulation file can save the user from the time consuming programming process[3] providing in this way a very useful tool for rapid prototyping.

2.4. LAB-PC1200 board

LabVIEW environment from National Instruments Co. for virtual instrumentation, as part of the experimental testing equipment has been used in order to aquire the current and voltage waveforms, and to confirm the results.

Lab-PC1200 board is a completely switchless and jumperless data aquisition board. This allows DMA intrerupts, and base I/O adresses to be assigned into system to avoid resource conflicts with other boards in the system[7].

The board was designed for high-performance data aquisition and control for applications in laboratory testing, production testing, and industrial process monitoring and control.

Lab-PC 1200 board has eight analog input channels ACH0-ACH7 that can be configure as eight single-ended or four differential inputs, a 12-bit succesive-approximation ADC, 24 lines of TTL compatible digital I/O, and three 16-bit counter/timers for timing I/O[7].

In order to have galvanic separation between the power module and measure module (the LabPC board), current transducers (LEM LA 55/P) and voltage transducers (LEM LV 25-P) have been used for each of the four phase of the motor. Both of them are closed-loop transducers using the Hall effect, and can be mounted on printed circuit board.

The module that contains the current and voltage transducers is presented in figure 6.

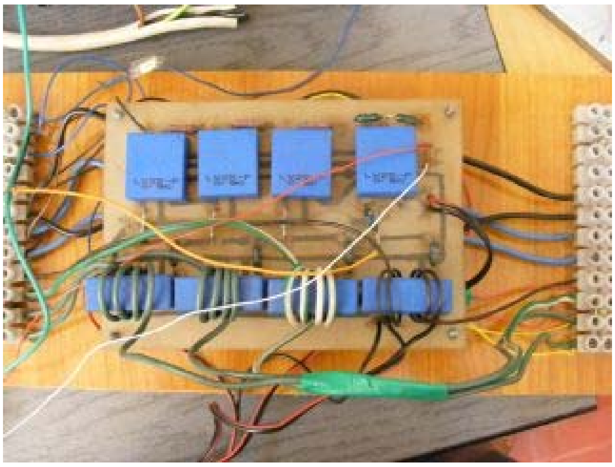

Fig. 6. *Current and voltage transducers*

3. EXPERIMENTAL RESULTS

Using this proposed experimental equipment, two experiments have been conducted. In the first experiment, the DS1104 board is used only for current waveforms acquisition. In order to acquire the current waveform from motor phases, the Matlab Simulink model was made, as seen in figure 7, which contains the DS1104ADC blocks from Dspace library, corresponding to the analog inputs of the board.

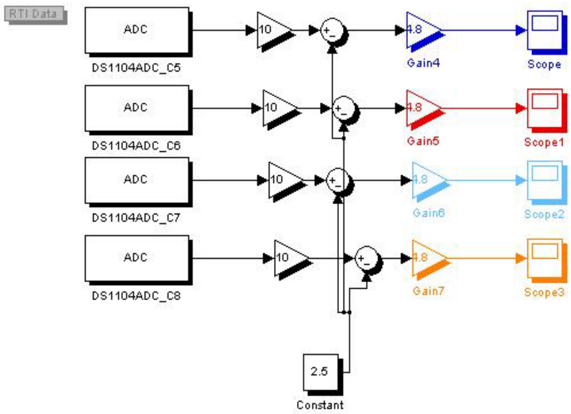

Fig. 7. *Simulink model for current waveform acquisition*

The virtual control panel used for visualization of the current waveforms is presented in figure 8.

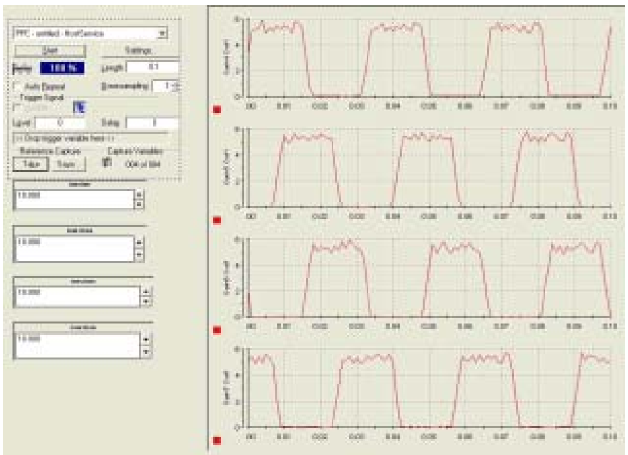

Fig. 8. *Virtual control panel for current acquisition*

In the second experiment, the DS1104 board is used for acquisition and control. The signal generator board and the current feedback loop were pulled out and the PWM operation is made only with the DS1104 board. The Simulink model for signal generation along with the DS1104ADC and DS1104BIT_OUT, as blocks from Dspace library, corresponding to the analog inputs and digital output of the board, is presented in figure 9.

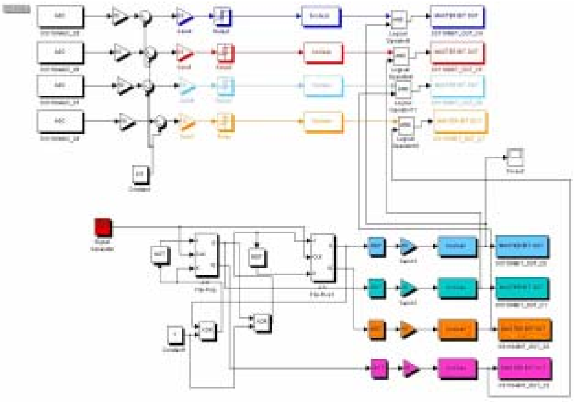

Fig. 9. *Simulink model for acquisition and control*

The virtual control panel used for aquisition and control is presented in figure 10.

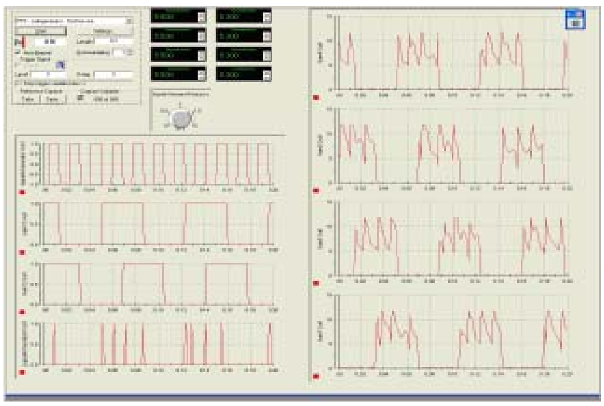

Fig. 10. *Virtual control panel for acquisition and control*

In order to confirm the results, LabVIEW environment have been used, along with the mentioned LAB- PC1200 board.

Using a simple virtual instrument - having the schematic diagram represented in figure 11 - the current and voltage waveform was aquired for all the four phases.

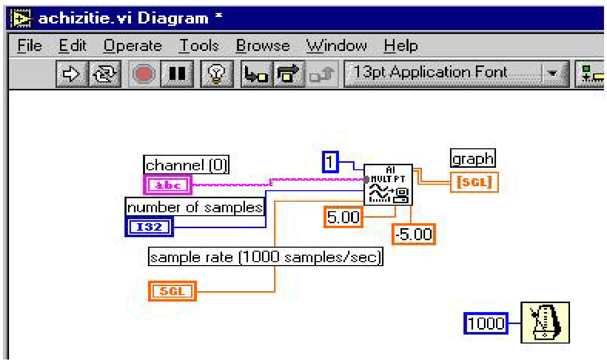

Fig. 11. *Schematic diagram of the used .VI*

The results are presented in figure 12.

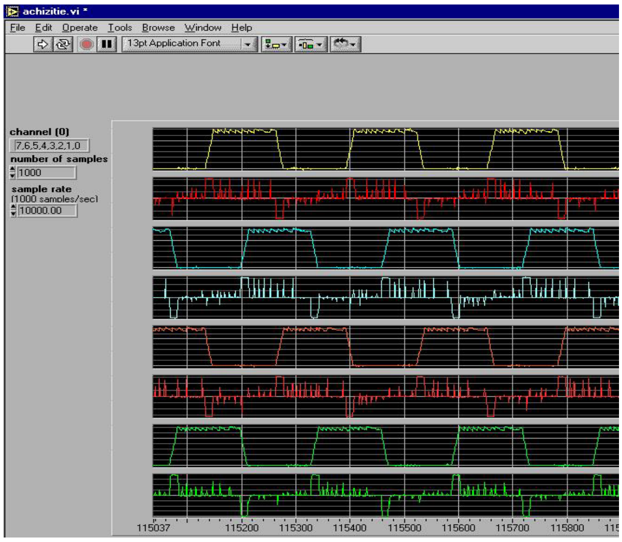

Fig. 12. *Current and voltage waveforms acquired in LabVIEW*

4. CONCLUSIONS

Computer controlled experimental equipment for reluctant motors was built by combining two boards dedicated for signal acquisition and control, and three software environments – Matlab Simulink from Math Works, Control Desk from Dspace and LabPC1200 from National Instruments.

The DS1104 controller board has proved to be a very useful tool for research and development in case of reluctance motor drives. The main advantage of this card results from the possibilities to work in Matlab Simulink environment and to obtain real time executable code by direct compilation.

5. REFERENCES

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