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EXPERIMENTAL TEST BENCH FOR RELUCTANCE MOTORS USING DS1104 CONTROLLER BOARD

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Abstract **– The paper deals with aspects regarding the implementation of an experimental test bench designed as research and development tool for reluctance motors drives. The hardware and software structure of the test bench is described in detail. The motor take into consideration is a variable reluctance stepper motor, named in the article VRSM. The PWM inverter for supplying the VRSM is simulated, realised and included into the experimental test bench. Also the DS1104 board is used as an instrument for acquisition and control. Experimental results are included in the paper.**

Keywords: *reluctance motors, PWM inverter, DS1104 controller board.*

1. INTRODUCTION

The advance of incremental motion control systems, where one usually uses stepping motors, has been enforced by the multiplicity of their utilization in digital controlled machine-tools drives, peripheral computer equipments, telecommunications through laser and satellites, nuclear techniques, industrial robots, aeronautical and military equipments etc. In this context, the reluctant motors promise the low-cost production and motivate the comprehensive research and design although they are not included in the classical treatment of the DC or AC electrical drives.

Among reluctant motors, variable reluctance stepping motors (VRSM) and switched reluctance motors (SRM) are the most popular. It serves especially in digitally controlled open-loop positioning servo-systems and is very suitable for board instrumentations.

Despite of their excellent robustness as actuators in special applications, these motors are confronted with a major problem of their supplying systems, which focused much interest among specialists in the last decade. [1]

Using up to date hardware systems, an experimental test bench was made in order to study the behaviour of different types of reluctant motors taking into account their supplying systems.

2. RELUCTANCE MOTORS

The VRSM taken for first study is a common 8 pole, 4 phase motor [2], with the following main characteristics:

Electromagnetic peak torque = 2 Nm;
Phase current = 5 A;
Phase voltage = 60V;
Step angle = 2.65^0 (136 steps/rot).
Fig. 1 shows the electromagnetic structure of its stator.

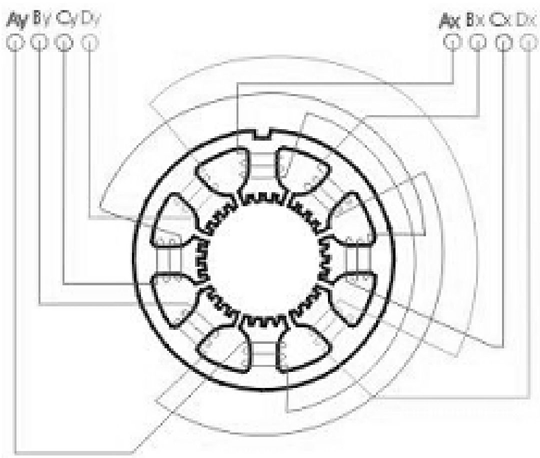

Figure 1: Structure of the VRSM stator

The motor was manufactured in authors' laboratory and the picture of it is presented in fig. 2.

3. PWM INVERTER

Usually reluctant motors are supplied by voltage source (series resistance switches or dual voltage schemes) or by current sources (PWM schemes). PWM schemes are the most popular inverters in case of reluctant motors [8] due to their adaptability to various techniques based on voltage and current processing. Fig. 3 shows the block diagram of the designed inverter [2].

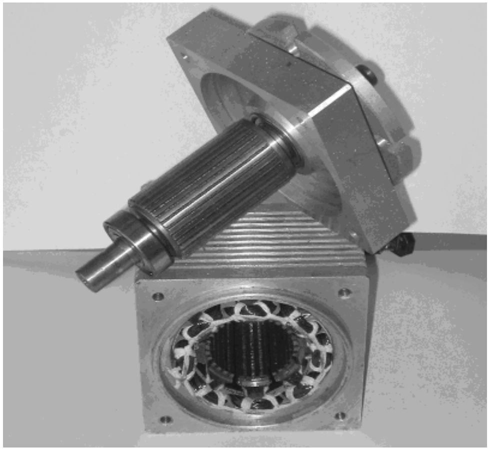

Figure 2: Picture of the VRSM

PWM inverters for motor electronic supply are dependent on the motor type. Usually, in case of PM synchronous motors and Brushless DC motors, bipolar current inverters are needed, so full-bridge inverters have to be used. In case of switched reluctance motors, unipolar inverters lead to cheaper half-bridge inverters.[2]

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.

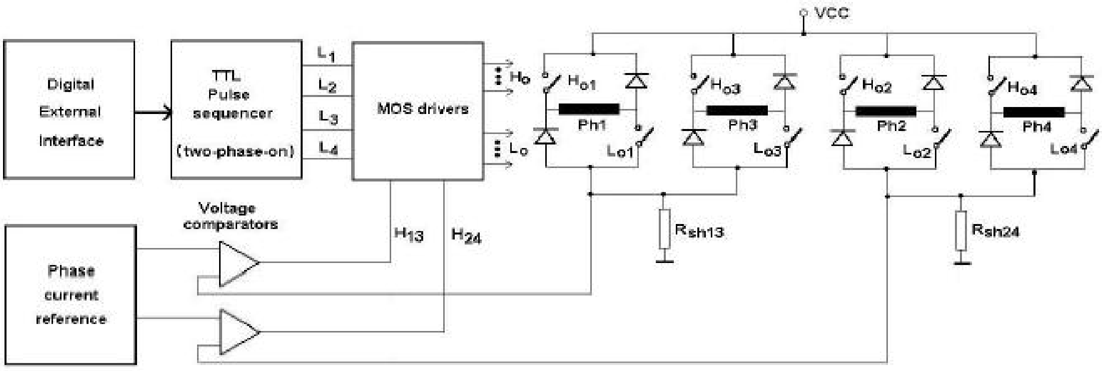

Figure 3: Block diagram of the inverter

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. [4].

Fig. 4 presents a picture of one module of the made PWM inverter which is included in the experimental test bench.

Figure 4: Picture of the made PWM inverter

By taking a look at the fig. 3 and fig. 4 one can see that the shunt resistors R_{sh13} and R_{sh24} was replaced with LTSR 6-NP, closed loop (compensated) multirange current transducer using the Hall effect, produced by LEM. The most important feature of this component is the possibility to feed the transducer reference from external supply, access to the internal voltage reference, high immunity to external interference and current overload capability.

The current feedback loop is based on LM555 which is a highly stable device for generating accurate time delays or oscillation and it have incorporated an Trigger Schmitt circuit. The signals providing by the current transducers LTSR 6-NP is used by this current feedback loop board in order to perform the PWM operation. An image of the current feedback loop board is presented in fig. 5.

4. CONTROL SYSTEM

All the subsystems of the proposed experimental test bench which is presented in fig. 6 are controlled from a PC equipped with a DS1104 controller board from DSpace. The PCI interface ensures the communication between the DS1104 board and the PC.

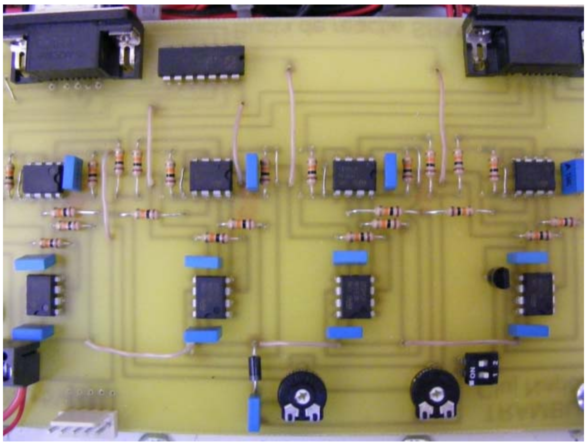

Figure 5: Current feedback loop board

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. [7]

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 to connect, disconnect and interchange different devices, simplifying system construction and testing. [7]

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. [8].

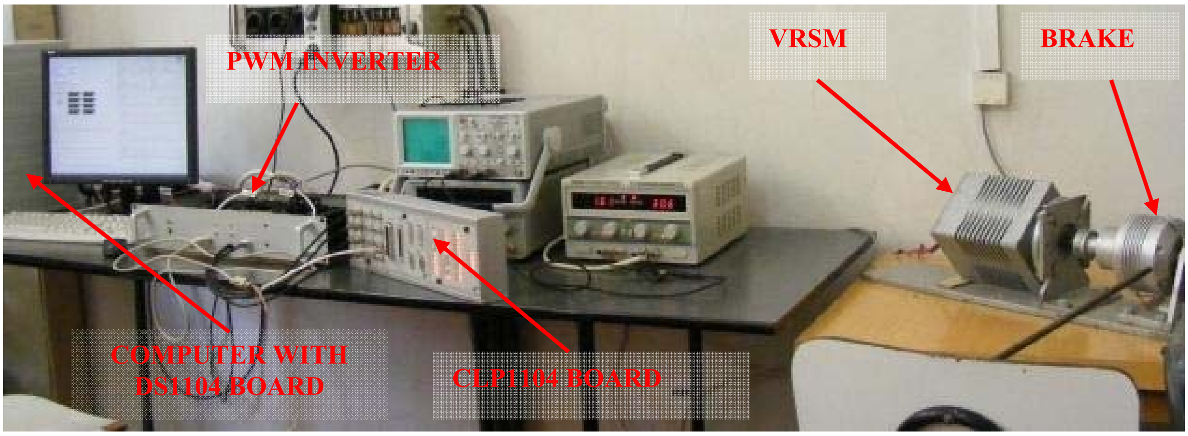

Figure 6: Picture of the proposed experimental test bench

5. EXPERIMENTAL RESULTS

The experimental test bench for reluctance motors presented in fig. 6, contain the following elements:

- PC equiped with DS1104 board for aquisition and control;
- PWM inverter;
- variable reluctance stepper motor(VRSM);
- electromagnetic brake;
- power sources;
- oscilloscope for verification.

Using this experimental test bench two experiment was 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 –see fig. 7, which contains the DS1104ADC blocks from Dspace library, corresponding to the analog inputs of the board.

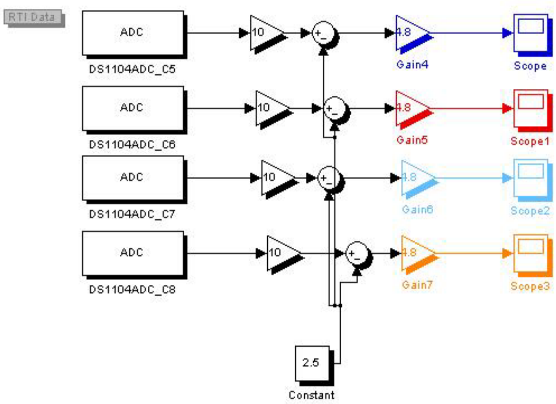

Figure 7: Simulink model for current waveform acquisition

The test bench for this case is presented in fig. 8. All the elements of the experimental test bench that was

previous presented can be seen on this picture.
The virtual control panel used for visualization of the current waveforms is presented in fig. 9.
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 Matlab Simulink model made in this case is presented in fig. 10.

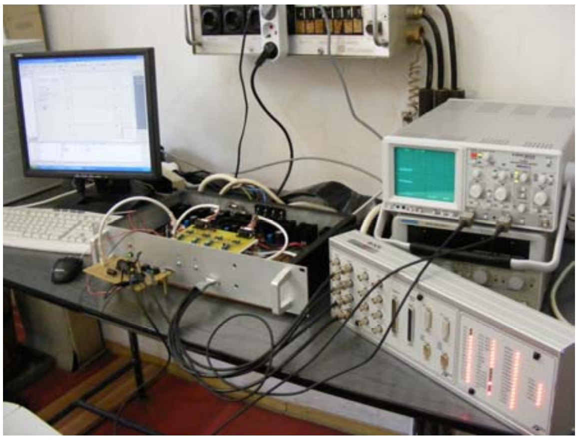

Figure 8: The test bench in case of current waveforms acquisition

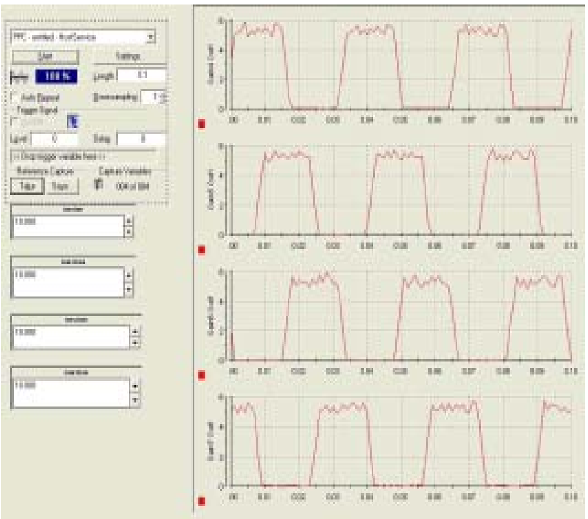

Figure 9: Virtual control panel for current acquisition

As can be seen on figure 10, the Simulink model for signal generation is present along with the DS1104ADC and DS1104BIT_OUT, blocks from Dspace library, corresponding to the analog inputs and digital output of the board.
The virtual control panel for this second experiment is presented in fig. 11.
Analysing this two experiments one can remark the elasticity and efficiency of the presented equipment that offer the possibility to conduct simple and complex experimental study related to reluctance motors.

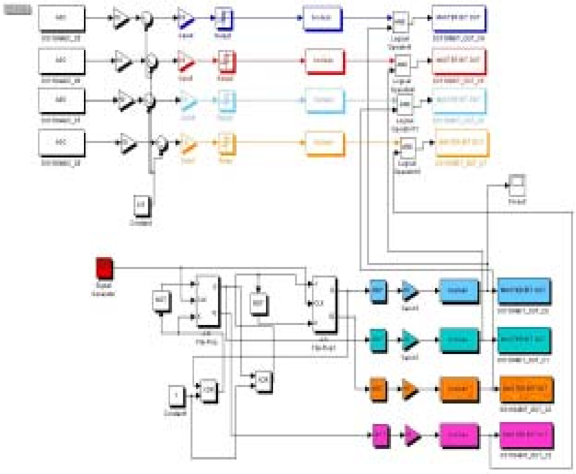

Figure 10: Simulink model for acquisition and control

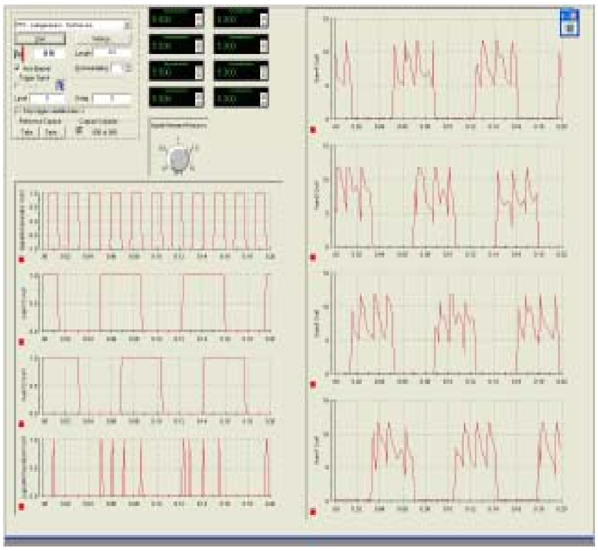

Figure 11: Virtual control panel for acquisition and control

6. CONCLUSIONS

An experimental test bench for reluctance motor was made. The variable reluctance motor taked into consideration for this first test, the PWM inverter, current feedback loop and the signal generation unit was designed and constructed in the author's laboratory.
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 posibilities to work in Matlab Simulink environment and to obtain real time executable code by direct compilation of the simulation structure.
The research will continue with the study of diferent types of reluctance motors, and more complex control models.

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