

BIPOLAR HYBRID STEPPER MOTOR CONTROL AND DRIVE WITH DEDICATED ICS L297 + L298

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ABSTRACT

The paper presents some investigations and research results concerning the general purpose PWM (pulse-width modulation) with applications to stepper motor control and drive. In order to improve the dynamic performances of the motor, a PWM inverter has been realised using dedicated ICs. The bridges are capable of sustaining 46V and include internal pulse-width modulation (PWM) control of the output current to 2A. The laboratory prototype of the implemented digital control system, and experimental results are also presented in the paper.

Keywords: stepper motor, PWM control, dedicated ICS.

1. Introduction

The bipolar stepper motor is very similar to the unipolar stepper, except that the motor coils lack center taps. Because of this, the bipolar motor requires a different type of controller, one that reverses the current flow through the coils by alternating polarity of the terminals, giving us the name: bipolar. A bipolar motor is capable of higher torque since entire coil (s) may be energized, not just half-coils. Where 4-wire steppers are strictly “bipolar”, 5 and 6 wire motors with center-taps can be used with the bipolar controller. The bipolar stepper motor has 2 coils. The coils are identical and are not electrically connected. The bipolar controller must be able to reverse the polarity of the voltage across either coil, so current can flow in both direction. And, it must be able to energize these coils in sequence. This circuit is called an H-bridge. Two such circuits are needed to drive both coils of bipolar stepper motor, and is commonly called a “dual H-bridge”.

The most remarkable effect of the integrated circuits increasing complexity and functions number is represented by, as it is widely accepted, its “intelligence”. There is almost no applications domain in which the microelectronic devices “intelligence” shouldn’t have played a major role, one of the fields enjoying its advantages being the low power electric drives [1].

By introducing the “intelligence” in the drives command, this one will take over some complex

functions usually accomplished by the human factor. In the automatic regulation systems, the electric motors are utilized as execution elements. The stepper motor was and still is the most utilized motor in low power adjustable electrical drives, due to relatively simple methods of speed control. The most typical application for these drives is represented by precision positioning systems. These ones must satisfy relatively exacting dynamic conditions, generally difficult to be fulfilled, sometimes even contradictory, fact that partially explains why it is necessary that the command devices must be “intelligent”. Taking into consideration the above mentioned aspects, the author present in this paper the command and drive stepper motor with L297+L298+L6210 specialized integrated circuits .[3][4][5].

2. The L297 stepper motor controller

The L297 [4][5][7] Stepper Motor Controller integrates all the control circuitry required to control bipolar and unipolar stepper motor. Used with a dual bridge driver such as the L298 forms a complete microprocessor-to-bipolar stepper motor interface.

Unipolar stepper motor can be driven with an L297 plus a quad darlington array. It receives control signals from the system’s controller, usually a microcomputer chip, and provides all the necessary drive signals for the power stage. Additionally, it includes two PWM chopper circuits to regulate the current in the motor windings.

The heart of the L297 block diagram is a block called the translator which generates suitable phase sequences for half step, one-phase-on full step and two-phase-on full step operation.

This block is controlled by two mode inputs-direction ($\overline{CW}/\overline{CCW}$) and ($\overline{HALF}/\overline{FULL}$) – and a step clock (\overline{CLOCK}) which advances the translator from one step to the next. Four outputs are provided by the translator for subsequent processing by the output logic block which implements the inhibit and chopper functions.

Internally the translator consists of a 3-bit counter plus some combinational logic which generates a basic eight-step gray code sequence as shown in figure 1. All three drive sequences can be generated easily from this master sequence.

This state sequence corresponds directly to half step mode, selected by a high level on the $\overline{HALF}/\overline{FULL}$ input. The output waveforms for this sequence are shown in figure 2. Note that two

other signals, $\overline{INH1}$ and $\overline{INH2}$ are generated in this sequence.

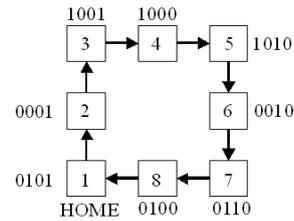


Fig.1. The basic eight – step gray code sequence

The full step modes are both obtained by skipping alternate states in the eight-step sequence. What happens is that the step clock bypasses the first stage of the 3-bit counter in the translator. The least significant bit of this counter is not affected therefore the sequence generated depends on the state of the translator when full step mode is selected (the $\overline{HALF}/\overline{FULL}$ input brought low).

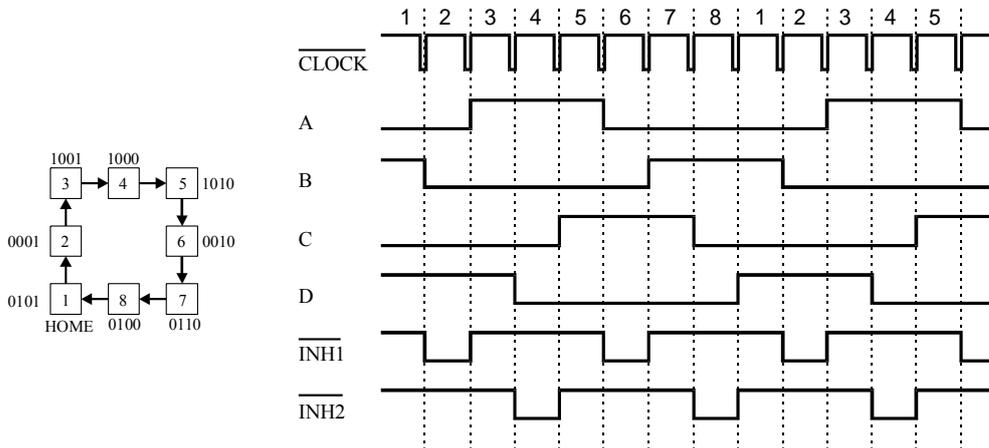


Fig.2. State sequence and output waveforms corresponding to the half step sequence.

If full step mode is selected when the translator is at any odd-numbered state we get the two-phase-on full step sequence shown in figure 3. By contrast, one-phase-on full step mode is obtained by selecting full step mode when the translator is at an even-numbered state (figure 4).

In half step and one-phase-on full step modes two other signals are generated: $\overline{INH1}$ and $\overline{INH2}$. These are inhibit signals which are coupled to the L298's enable inputs and serve to speed the current decay when a winding is switched off.

Since both windings are energized continuously in two-phase-on full step mode no winding is ever switched off and these signals are not generated.

The chopper oscillator frequency is determined by the RC network on pin 16. The frequency is roughly $1/0.7RC$ and R must be more than 10 K Ω . The L298 is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads.

Two enable inputs are provided to enable or disable the device independently of the input signals.

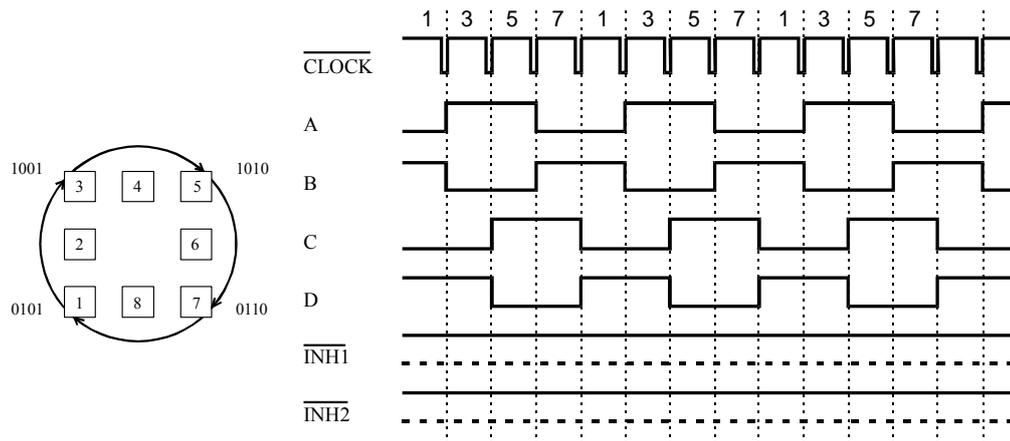


Fig.3. State sequence and output waveforms for the two phase on sequence .

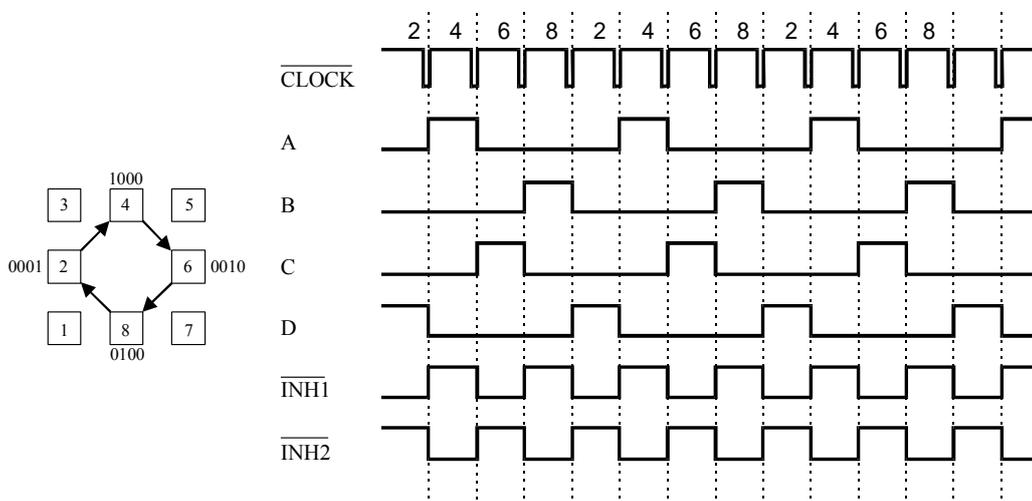


Fig.4. State sequence and output waveforms for wave drive (one phase on).

The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the connection of an external sensing resistor.

3. The experimental laboratory system

The experimental research was performed in Electrical Drives Laboratory from the Engineering Faculty, “Petru Maior “ University of Târgu-Mureş, where it was implemented an electrical drive system using stepper motor. The electrical schematic of the realized board (L 297+L298 +L6210) is shown in figure 5. In figure 6 is presented the general view of the realized board.

The general view of experimental laboratory test system is shown in figure 7.

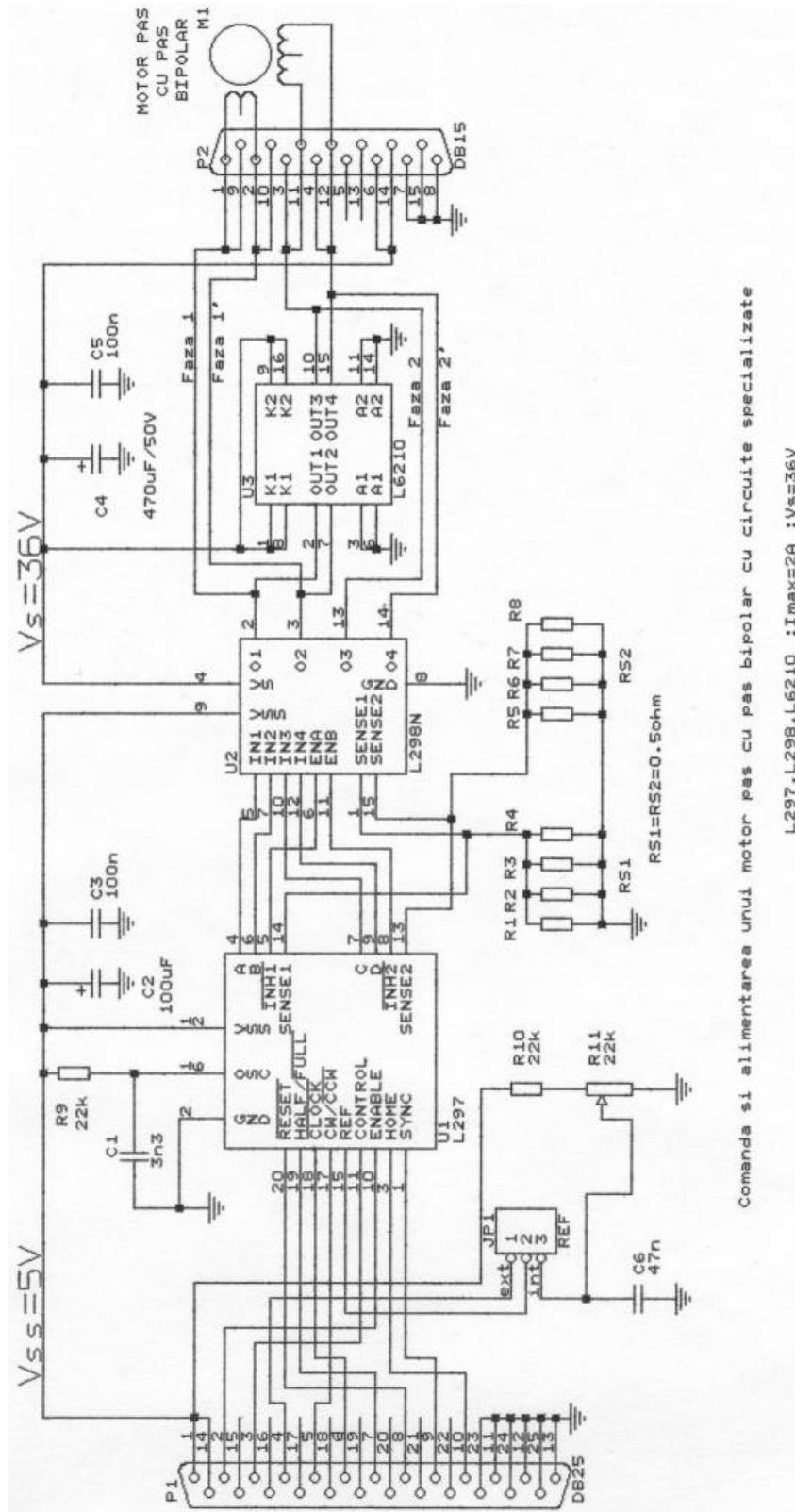
As experimental results, the phase current of a two-phase bipolar stepper motor, are shown in figure

8. These currents were measured in the following operating mode of stepper motor:

- normal drive mode (also called ”two-phase-on” drive), low frequency and high frequency;
- wave drive mode (also called ”one-phase-on” drive), low frequency and high frequency;
- half step mode, low frequency and high frequency;

In order to currents measurement, two Hall sensors (LEM modules, LA-25NP) were used, owing to their performances, such as:

- precision: $\pm 0,5 \%$;
- response time: $\leq 1\mu s$;
- bandwidth: 0÷150 kHz;
- linearity: $\leq 1\%$;
- current output (turns ratio 5/1000);



Comanda si alimentarea unui motor pas cu pas bipolar cu circuite specializate

L297, L298, L6210 ; I_{max}=2A ; V_s=36V

Fig.5. The electrical schematic of the realized board (L297+L298+L6210)

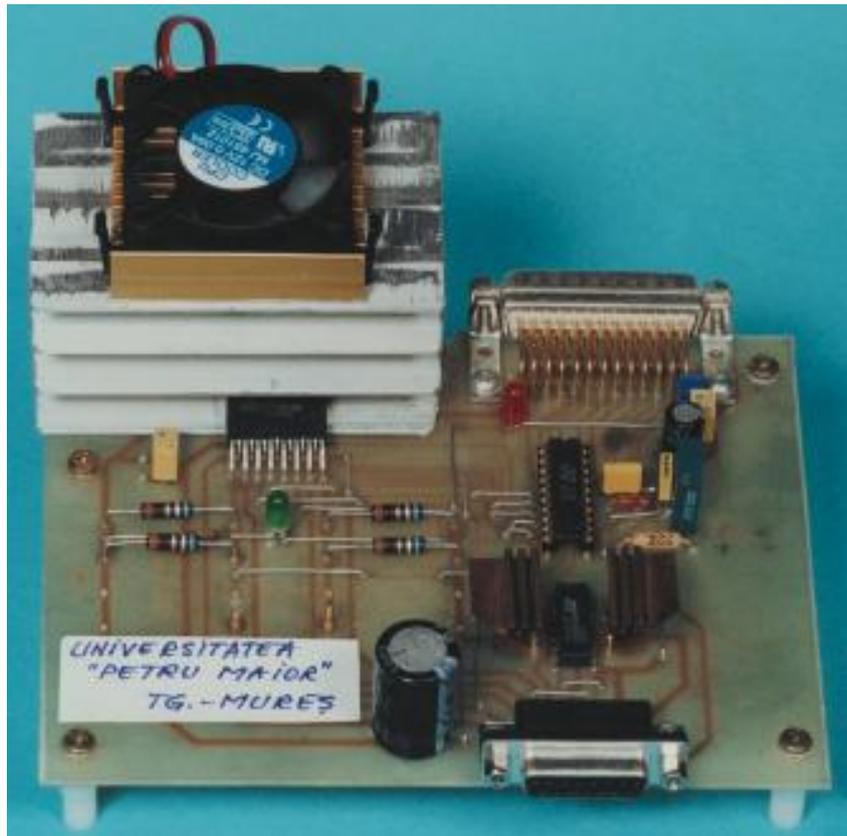


Fig.6. General view of the realized board (L297+L298+L6210)

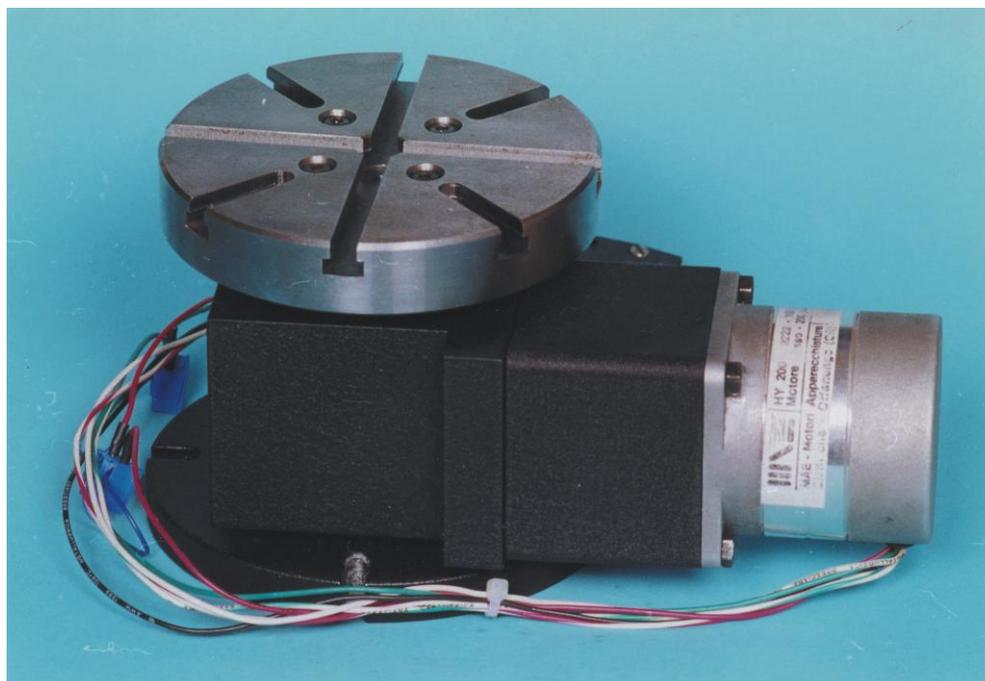


Fig.7. General view of experimental laboratory test system

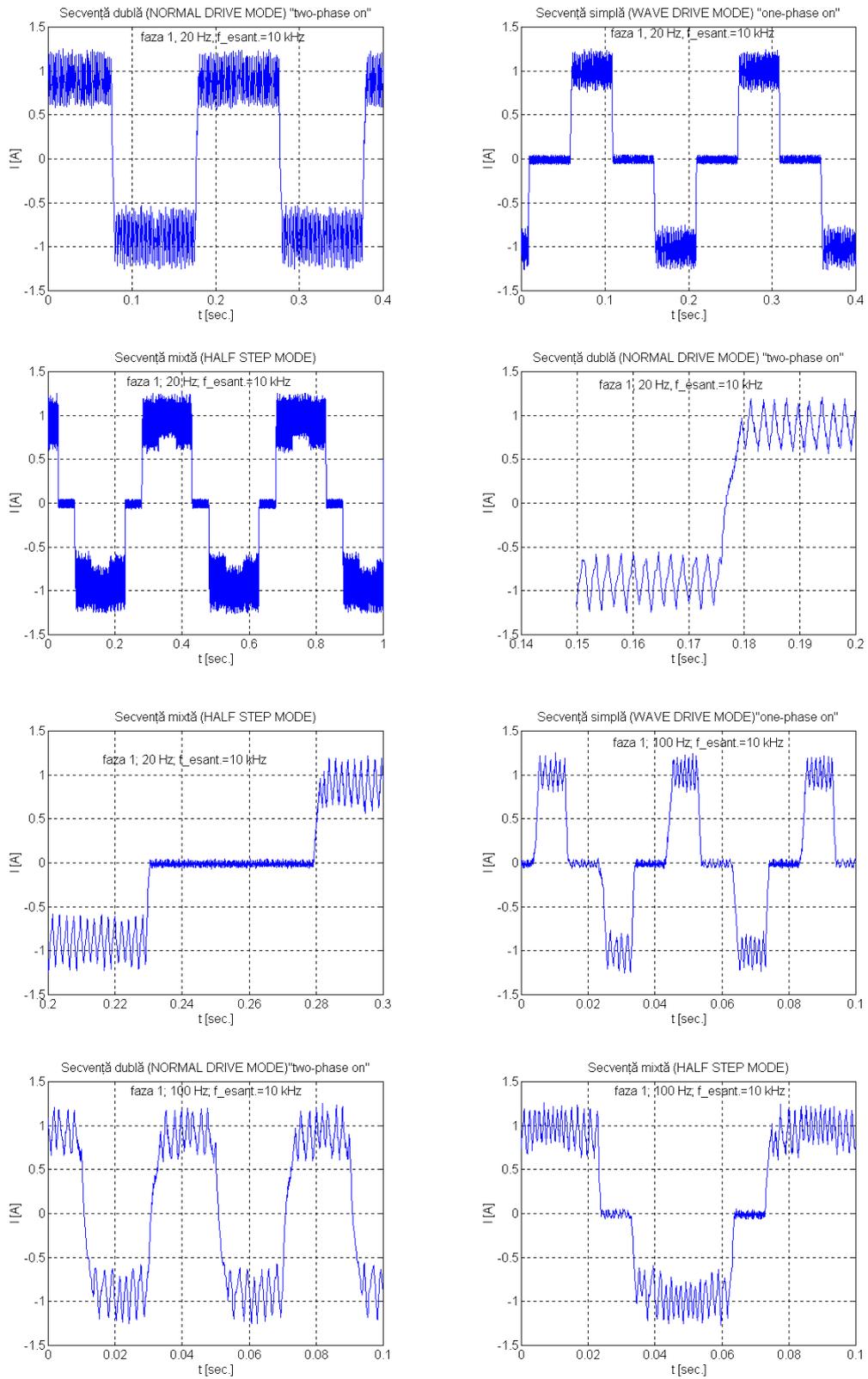


Fig.8. Experimental results, the phase currents of a two-phase bipolar stepper motor.

4. Conclusion

The modern solution involve new power semiconductor devices with high performances, dedicated command circuits with multiple specific function and new control techniques. The test stand dedicated to the stepper motor command presented in this paper has the following advantages:

- dramatically simplified stepper motor driving small-and medium-sized motors;
- complete microprocesor (microcontroller, PC) – to - bipolar stepper motor;
- low cost assembly;
- very few components are required;
- software development is simplified;
- flexibility in selecting constant-speed running frequencies;

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