Scientific Bulletin of the Petru Maior University of Tirgu Mures
Vol. 6 (XXIII), 2009
ISSN 1841-9267

Four Quadrant Chopper Drive with Specialized Integrated Circuits

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Abstract

The paper presents a high performance system for separately-excited D.C. motor control, which was designed and performed with a specialized integrated circuit (L292), made by SGS-THOMSON Microelectronics Company. With an interface and an adequate software, L292 circuit can be used as a chopper in 2 or 4 quadrant.

1. Introduction

The most remarkable effect of the integrated circuits increasing complexity and functions number is represents by, as it is widely accepted, its "intelligence" [2]. 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. Traditionally, D. C. motor drives have been used for speed and position control application. The separately-excited D. C. was and still is the most utilized motor in adjustable electrical drives, due to both its linear characteristics and relatively simple methods of speed control. The most typical application for these drives is represented by the 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 necessary that the command devices must be "intelligent". The appearance of the specialized integrated circuits in D. C. motor's command has also led to the simplification of the electrical scheme and to the improvement of the drive system's performances [3][4][5]. Taking into consideration the above mentioned aspects, the author presents in this paper the command of a separately-excited D. C. motor, with L292 specialized integrated circuit.

2 . Switch mode driver for d. c. motors

The block diagram of the L292 switch mode motor driver integrated circuits is presented in figure 1. At the input there is the levels adapter, whose aim is to transform the symmetric error signal (issued by the speed controller) in a positive signal necessary for the following blocks command.
The transformation is imposed by the fact that the L292 circuit do not have symmetric supply. Afterwards, through the error amplifier, in PI structure, the command positive signal is applied at the comparator's input while at its other input there is a triangular voltage, generated by a local oscillator. From the two voltages, at the comparator's output it is realized a PWM signal with variable duty cycle, necessary for the bridge command with
the transistors T1 – T4.

Depending on the duty cycle, in the bridge is established a current either positive, either negative, which flows through the measuring amplifier resistance's $R_{S1} = R_{S2} = R_S$ (from pin 2, 4) as well. Thus it is formed a reaction signal, which, through the filter $R_F C_F$ (from pin 5, 7) is applied at the error amplifier input [6][7].

The monolithic LSI power circuit L292 is a switch-mode driver for D.C. motors:

- Driving capability: 2A (I_{max} =2.5A), 36V, 30KHz;
- Two logic chip enable;
- External loop gain adjustment;
- Single power supply (18V to 36V);
- Input signal symmetric to ground;
- Thermal protection.

Keywords: *separately-excited D.C. motor, experimental laboratory system*

The L292 circuit it is intended for use, together with L290 and L291, as a complete "3-cip motor positioning system" for applications such as carriage / daisy-wheel position control in typewrites. The L290-L291-L292 system can be directly controlled by microprocessor [6][7]

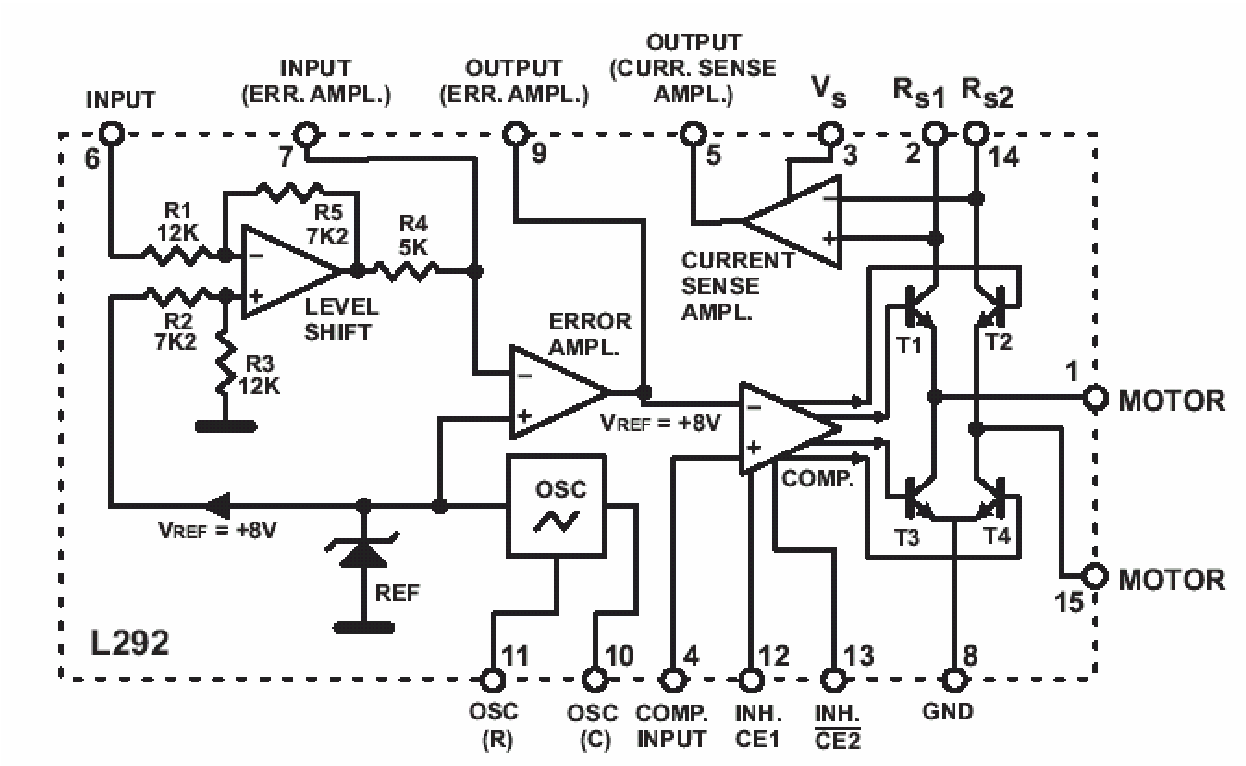

Figure 1. The block diagram of the L292 integrated circuit

3. System's description. Conclusion

The electrical block diagram of the realized system is presented in figure 2 and the electrical schematic of realized system is presented in figure 3. The main component of the command block is the specialized integrated circuit L292. There must be emphasized the following: the direct logical command (PWM signal) at the comparator's non-inverting input (pin 4) has the commutation threshold fixed (pin 9) at V_{REF} = 8V. The internal oscillator, utilized in the case of an analogue command at the input 6, has not utilized [7]. The electrical separation between the driver circuit and the digital command part is provided by a HCLP 2211 optocoupler, it can be mentioned here: TTL, LSTTL and CMOS compatibility, 300ns propagation delay time, wide supply range (4.5V to 20V), low input current (1.6mA).

The PWM signal is obtained from a specialized MICROCONTROLLER SYSTEM (80C552) dedicated to computer-based command (with IBM-PC 586) for electric drive system with separately-excited D. C. motors or stepper motors[4][5]. With this interface and an adequate software, the L292 integrated circuit can be used as a chopper in 2 or 4 quadrant.

The $\overline{\text{CE2}}$ input (pin13), which leads to the four power transistors blocking if $\overline{\text{CE2}}$ = logic "0", is utilized for the circuit protection against over-currents through the motor. The current limitation circuit is made in a differential amplifier (IC4) and two comparator's with the open-collector (IC5 and IC6). At the IC4 differential amplifier output it is obtained the voltage:

$$u(t) = U^* + R_S \bullet [i_1(t) - i_2(t)] = U^* + R_S \bullet i(t) \quad (1)$$

The two comparator's outputs become:

$$\begin{cases} \text{IC5: } [u^+(t) - u^-(t)] = u(t) - [U^* - \varepsilon(t)] = \\ \quad = R_S \bullet i(t) + \varepsilon(t) \\ \text{IC6: } [u^+(t) - u^-(t)] = [U^* + \varepsilon(t)] - u(t) = \\ \quad = -R_S \bullet i(t) + \varepsilon(t) \end{cases} \quad (2)$$

If I_M is the maximum admitted current through the motor and $R_S \bullet I_M = \varepsilon(t)$, there appear the following cases:

- If $i(t) \in (-I_M, +I_M)$ then:

$$\begin{cases} -R_S \bullet i(t) + \varepsilon(t) = R_S \bullet [-i(t) + I_M] > 0 \\ R_S \bullet i(t) + \varepsilon(t) = R_S \bullet [i(t) + I_M] > 0 \end{cases} \quad (3)$$

then $\overline{CE2}$ = logic “1” and consequently the chopper is enabled (see figure 2, 3).

- If $i(t) \in [+I_M, +\infty)$ then :

$$\begin{cases} -R_S \bullet i(t) + \varepsilon(t) = R_S \bullet [-i(t) + I_M] > 0 \\ R_S \bullet i(t) + \varepsilon(t) = R_S \bullet [i(t) + I_M] \le 0 \end{cases} \quad (4)$$

then $\overline{CE2}$ = logic “0” and consequently the chopper is blocked (see figure 2, 3).

- If $i(t) \in (-\infty, +I_M]$ then :

$$\begin{cases} -R_S \bullet i(t) + \varepsilon(t) = R_S \bullet [-i(t) + I_M] \le 0 \\ R_S \bullet i(t) + \varepsilon(t) = R_S \bullet [i(t) + I_M] > 0 \end{cases} \quad (5)$$

then $\overline{CE2}$ = logic “0” and consequently the chopper is blocked (see figure 2, 3).

The electro-lighting diode D5, commanded by the monostable circuit IC7, visually signalizes the presence of an over-current.

The experimental research was performed in the Electrical Drives Laboratory of the Engineering Faculty, “Petru Maior” University of Tâtrgu-Mureş, where it has been realized an electrical driving system using separately - excited D. C. motor. The general view of developed system is presented in figure 4.

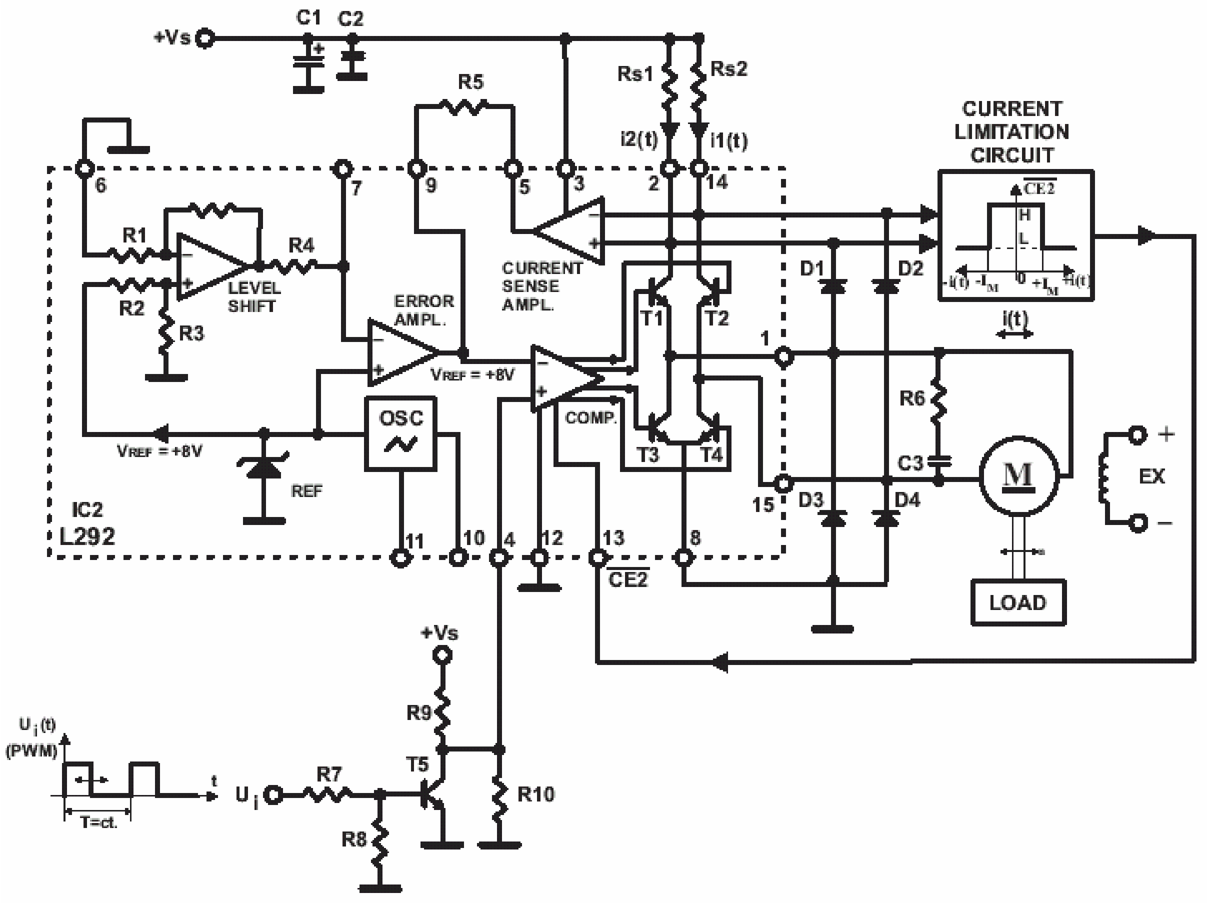

Figure 2. The electrical block diagram of the realized system

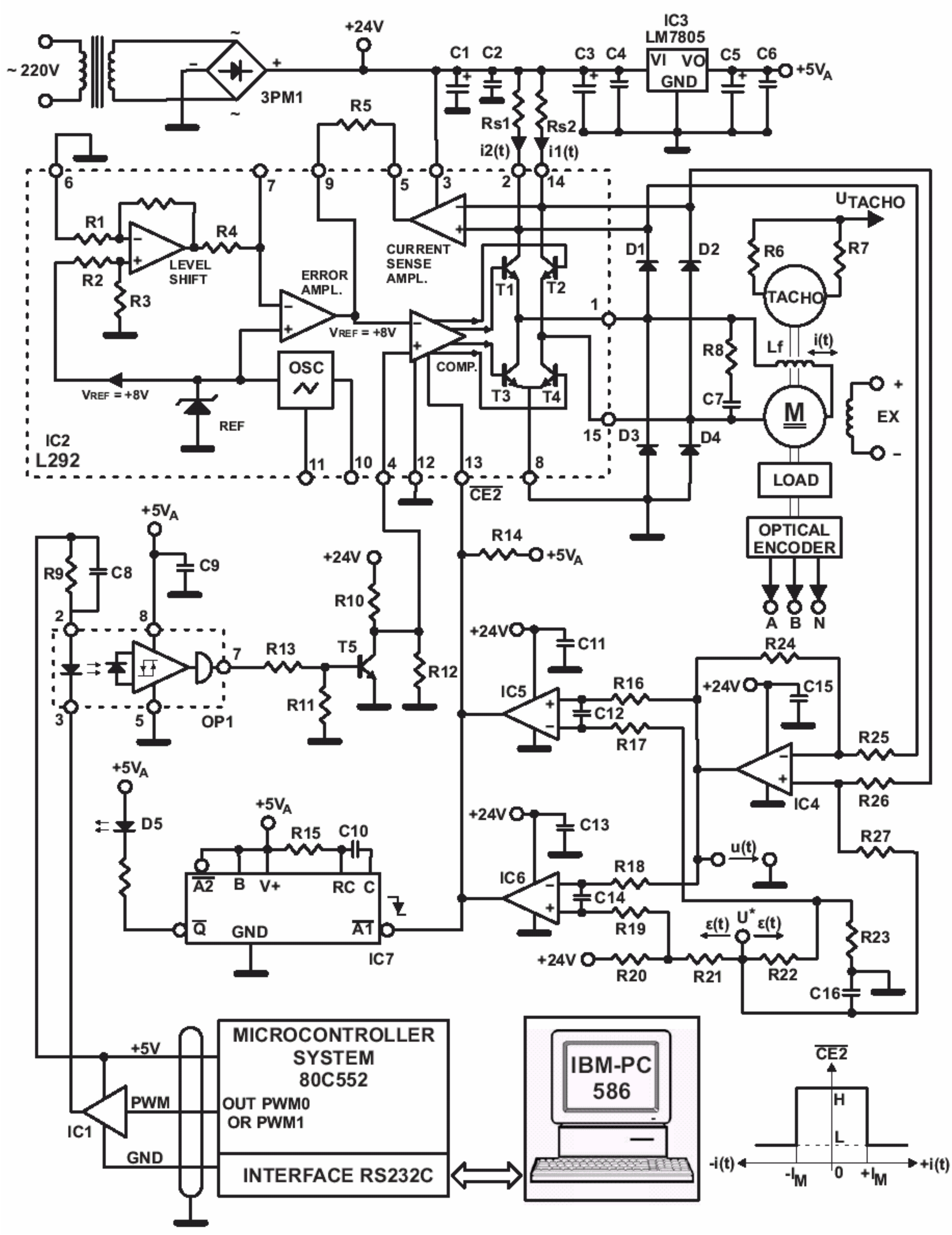

Figure 3. The electrical schematic of realized system

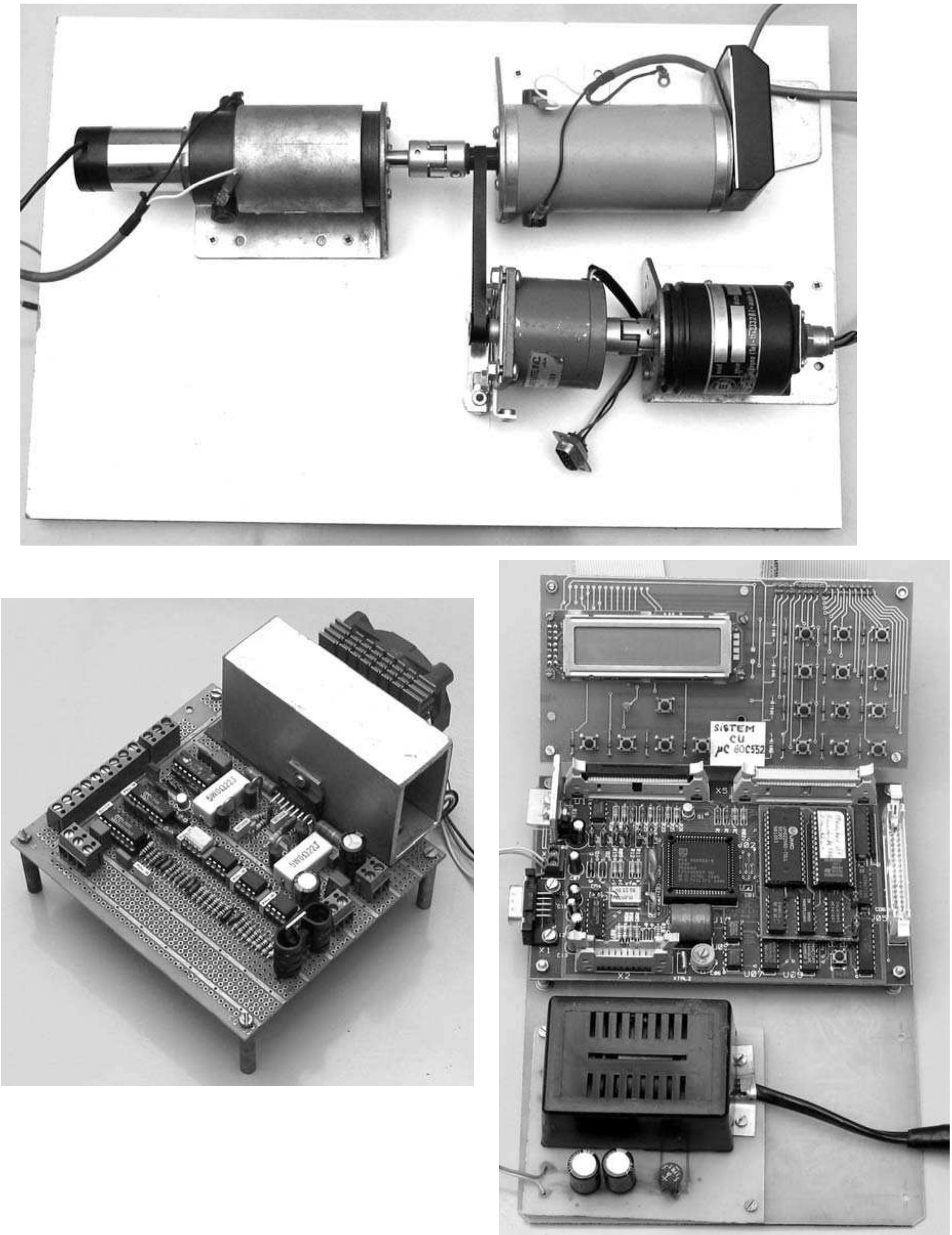

Figure 4. The general view of experimental laboratory system

4. References

[1] Mohan, N., Undeland, T.M., Robbinson, W.P., “Power Electronics: Converters, Application and Design”*, John Wiley & Sons*, New York, 1989.
[2] Teodorescu, D., “Automatizări microelectronice”, *Editura Tehnică*, Bucureşti, 1988.
[3] Morar, A., “Sisteme electronice de comandă şi alimentare a motoarelor pas cu pas implementate pe calculatoare pesonale (Electronic systems for stepping motor control implemented on personal computers)”.*Teză de doctorat, Universitatea Tehnică din Cluj-Napoca*, 2001.
[4] Morar, A., “Echipamente de comandă a motoarelor pas cu pas implementate pe calculatoare personale”. *Editura Universităţii “ Petru Maior ” din Tg.-Mureş, ISBN: 973-8084-47-4* , Tg.-Mureş, 2002.
[5] Morar ,A., “Interfeţe avansate de comandă şi control. Curs”. *Lito Universitatea “ Petru Maior “ din Tg.-Mureş*, 2002.
[6] Băluţă, Gh., “Acţionări electrice de mică putere. Aplicaţii”, *Editura “POLITEHNIUM”, ISBN 973-621-072-3*, Iaşi, 2004.
[7] *** SGS-THOMSON, “Microelectronics”, *Data on disc*, 1996.
[8] *** “LEM Module”, *Data Book*, Geneva, Switzerland, 1992.