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CONTRIBUTIONS CONCERNIG THE COMPUTER BASED CONTROL OF THE STEPPING MOTOR SYSTEMS

Alexandru Morar

Lect. dr. eng. at "Petru Maior" University from Târgu-Mureş
Str. Nicolae Iorga nr. 1, 4300 Târgu-Mureş, ROMANIA
e-mail: morar@upm.ro

ABSTRACT

The paper describes the command of the stepper motors using the personal computer. For this, we developed a program which main purpose is the maximum reducing of the positioning time, i.e. to obtain the optimal frequency-time characteristic. The acceleration and deceleration diagrams are linear and their slopes can be independently programmed, depending on the specific drive.

l. INTRODUCTION

The experimental study of the stepper motor (SM) command and operating mode requires the use of an electronic equipment able to command the motor according to the sequences formerly stipulated [1], [2]. In order to obtain high performances we can't separately study the motor and its electronic control. That is why a test bed possessing the versatility required by the stepper motor is necessary (e.g. different sequences and command and, algorithms). Because of the versatility of microprocessor based systems these are more and more used for the SM control, some examples being given in [3], [4]. Due to the advantages of the programmable logic versus the aired one, the author expose in this paper some contributions regarding the computer based control of an electrical drive system using stepper motors.

2.HARDWARE FACILITIES

The system above is a test bed for the SM's control, that uses an IBM-PC 486. It was achieved on a so-named "prototyping board" (for which a connector equips the computer's motherboard) and contains the necessary elements for both the open-loop control and the closed-loop one.

The system block diagram is presented in Fig.1, being designed for a four phases stepper motor command.

Excepting for the high power, all the SM's drivers are integrated nowadays. Consequently, there was also included in the system the command using the specialized circuit SAA l027, which supplementary offers increased safety and reliability (noise immunity even in a very disturbed environment, based on a voltage supply of 9,5- 15 VDC and open collector outputs) [5].

For the closed-loop control the system is equipped with an incremental optical encoder (2000 pulses/rev.). The logic circuit (SENSE DISCRIMINATOR, Fig.1) illustrated in fig.2 processes the two signals and generates the L (clockwise) and R (anticlockwise) signals. With a 4*f frequency which indicate the instantaneous direction of rotation [3].

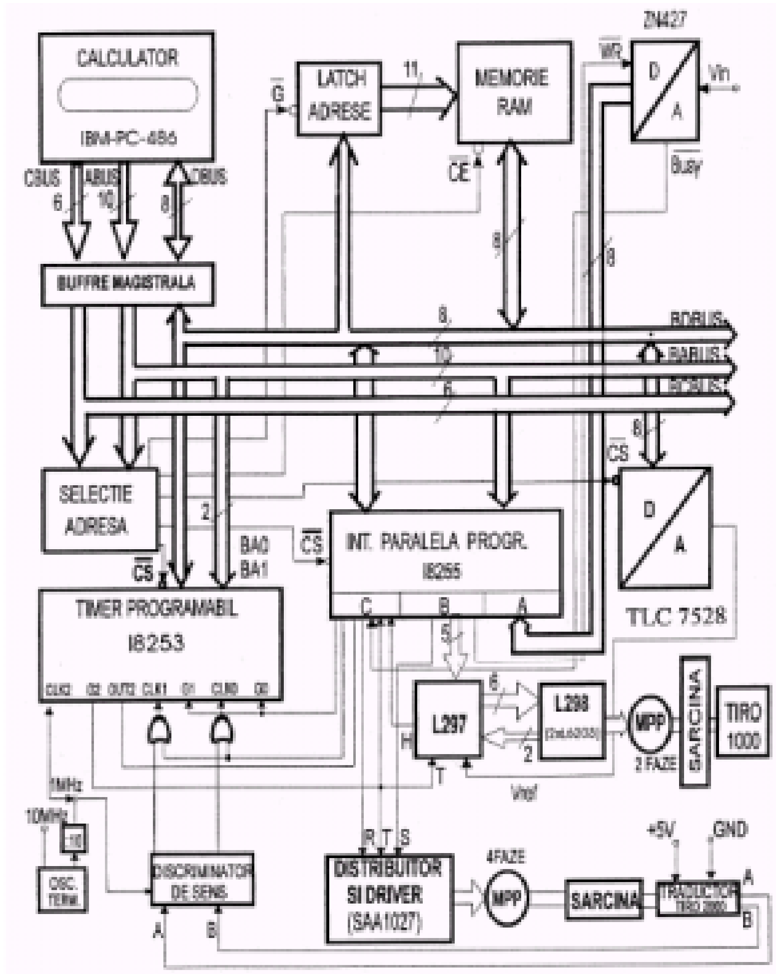


Fig.1. Computer based testing of stepper motor bloc diagram

The motor command is carried out using programmable parallel interface I8255. The control pulses are generated by programmable timer I8255 receiving the clock signal from a 1MHz quartz thermostabilized oscillator [3]. The step number prescription can be done using either the computer's keyboard, an 8-bit A/D converter (ZN427). At the same time, the system was equipped with 2KB nonvolatile RAM which can keep the application programs and a decoder to ensure the peripheral addressing space between the limits 300H-31FH (the IHM-PC allocates this space for the "prototyping boards").

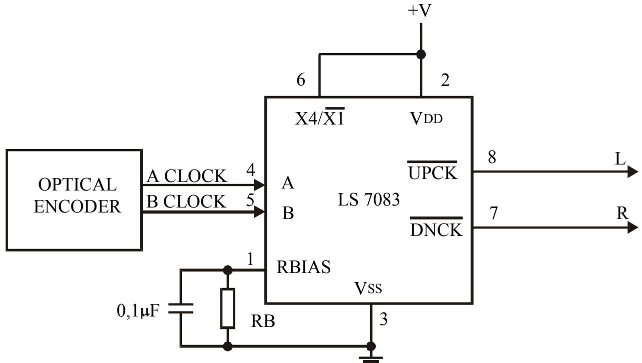


Fig.2 Sense discriminator

For the testing facility a loading system exists too, allowing the prescription of various loads on the motor shaft.

3. SOFTWARE FACILITIES

In positioning applications, stepper motors can be controlled by computer in open-loop or closed-loop configuration. This paper describes an open-loop control program for a stepper motor, The program was written in BORLAND C programming language, its corresponding flowchart being presented in Fig.3. Its subroutines are:

- Constant frequency command subroutine (CONST. FREQ.);
- Prescribed speed profile command subroutine (POSITIONING);
- Data processing and displaying subroutine (DISPLAY DATA).

The flowchart corresponding to CONST. FREQ. subroutine is shown in Fig.4. The channel A2 from I8253 generates the command pulses for thc motor and I8253 gives the SENSE signal. The channels #0 and #1 count the L and R pulses from the SENSE DISCRIMINATOR. The routine makes possible to impose the sampling frequency (20-60kHz), the command frequency and the number of steps. The data acquisition is achieved using the real-time interrupt (INT 8) handler (SAMP), which was written in the I80486 assembling language. Thus it was obtained a sampling frequency up to 60kHz. The COMM1 subroutine commands the motor and the DISPLAY DATA subroutine processes and displays the data. The flowchart corresponding to POSITIONING subroutine is shown in Fig.5. In this subroutine, a linear speed profile is prescribed. The limit characteristics of the stepper motor show the successive command frequencies for operation without loss of steps. These are the basis for the prescription of the linear speed profile. The BORLAND C program establishes at the beginning, in a conversational manner, the following parameters:

- f_{start}: the starting frequency;
- f_{max}: the constant frequency;
- t_a: acceleration time;
- t_b; constant frequency operation time;
- t_c: deceleration time.

The time constants for the achievement of the command frequencies are generated in the NS-TC subroutine. To accelerate the motor, on start from a base frequency f_{start} passing through intermediary discrete frequencies as follows:

$$m=(f_{max}-f_{start})/t_a;\ j=1;\ T_0=0;\ f_{clock}=1MHz \tag{1}$$

$$t_{j-1}=\sum_{i=0}^{j-1} T_i \tag{2}$$

$$f(t_{j-1})=m\cdot t_{j-1}+f_{start} \tag{3}$$

$$T_j=1/f(t_{j-1}) \tag{4}$$

$$TC(j)=f_{CK}\cdot T_j \tag{5}$$

The stop criterium of the algorithm is:

$$T_{j-1}>t_a \tag{6}$$

the number of the acceleration steps being Ns_a= j. The deceleration is obtained in the same way. But it is possible to prescribe other slopes. The COMM2 subroutine was designed for the implementation of the above algorithm.

4.EXPERIMENTAL RESULTS

Figure 6 exposes the computer based testing bed of SM which was achieved by

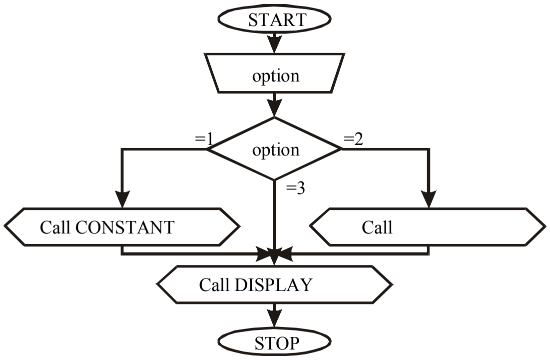
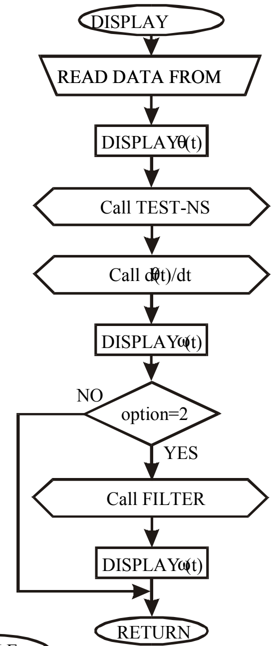


Fig.3. Flowchart of the main



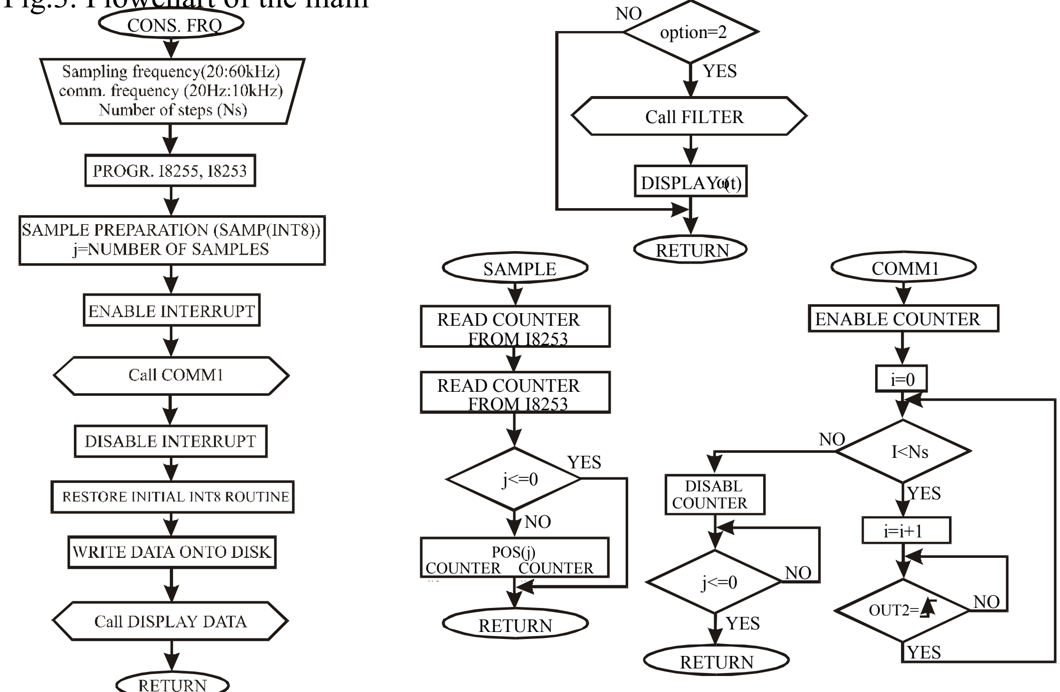


Fig.4. Flowchart of the constant frequency command routine

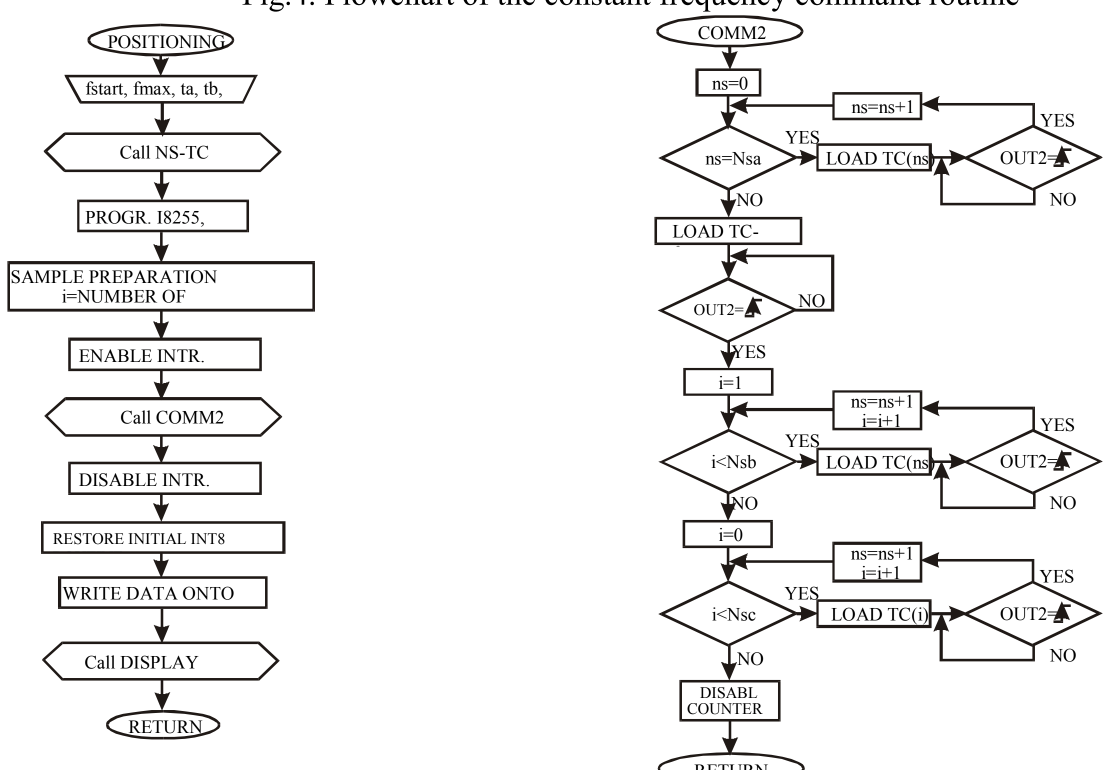
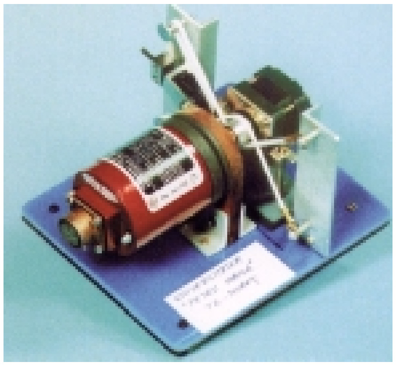
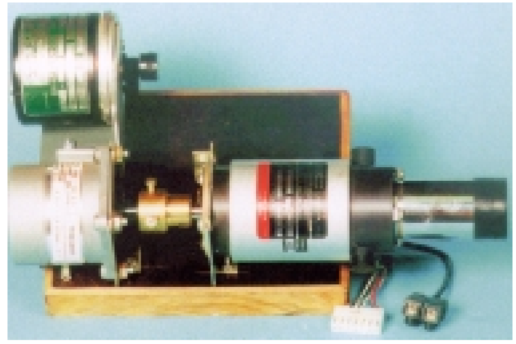
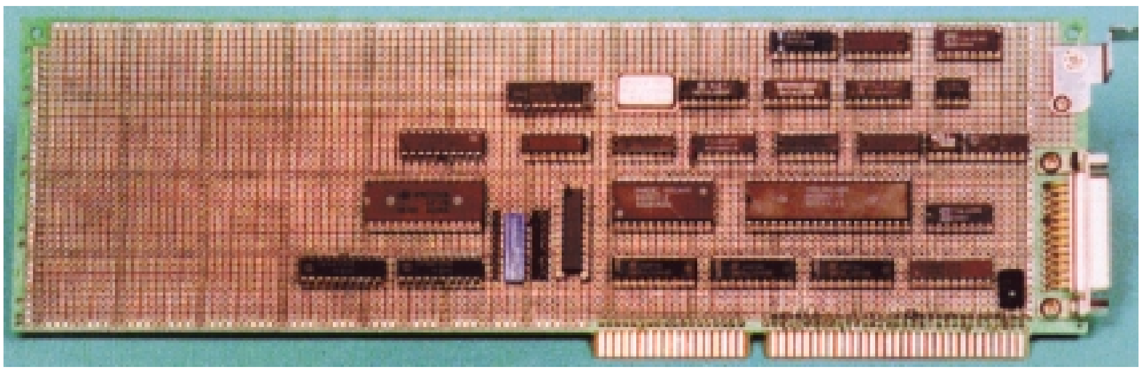


Fig5. Flowchart of positioning routine







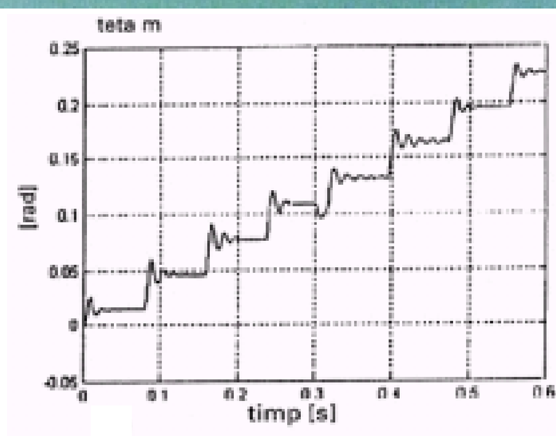


Fig.7. Angular position: low frequency, without loading

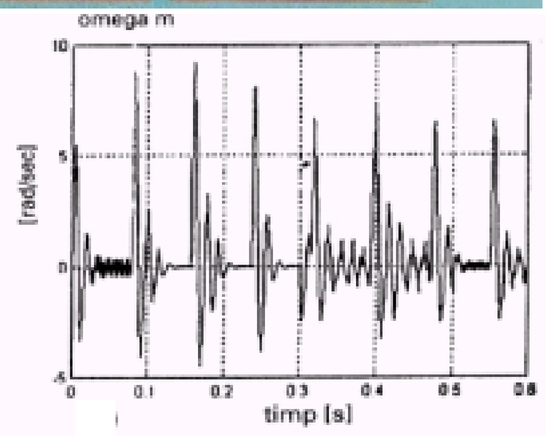


Fig.8 Angular speed: low frequency, without loading

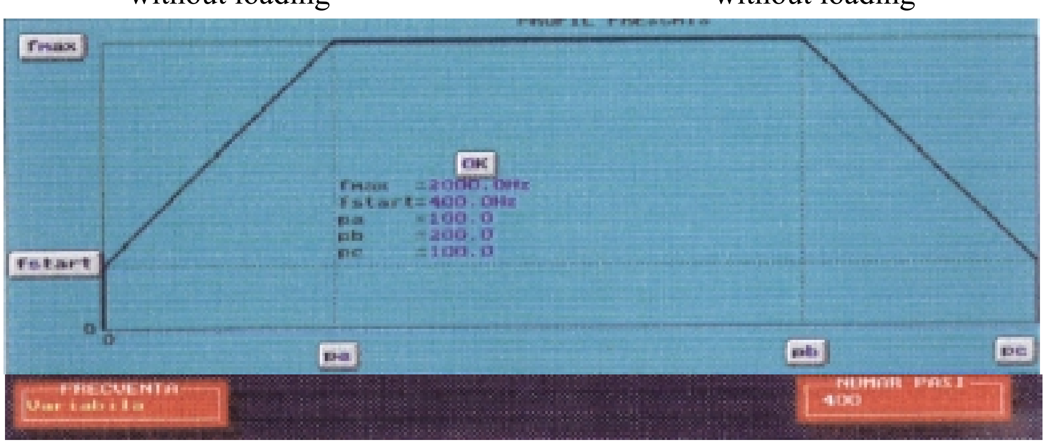


Fig.9. Prescribed speed profile

the Electrical Drive Laboratory from the "Petru Maior" University of Târgu-Mureş. Experimentally thee tests were done using, a japanese motor with 1.8 degrees/step and 160 mA current/phase. In Fig. 7 and 8 are shown the position, respectively the angular speed at 20 Hz, without loading.

Fig. 9 presents a complete positioning cycle. The real speed profile obtained by the filtration of the instantaneous angular speed. For the achievement of the real speed profile the FILTER subroutine was added to the program. The subroutine implements a second order low pass filler; the filter's coefficients were designed for sampling frequencies between 20-50 kHz, using the MATLAB software. At the same time the REMEZ function from MATLAB was used in order to obtain the coefficients of the derivative filter on purpose to achieve the angular speed. The FREQ, CONST. routine and the POSITIONING routine also confirm the number of steps made by the motor, the TEST-NS subroutine being designed on this purpose.

5. CONCLUSIONS

The last progresses both in control and in motor drive domain impose on the researchers a continuous reorientation in order to solve the design problems with the newest technica1 means. In this sense the author have developed a versatile program for the open-loop control of stepper motor.

Among the facilities offered by this program we mention:

- high sampling frequency;
- large memory area used to store the aquisited data (about 300 kB - maximum memory space available from MS-DOS system);
- the possibility to prescribe linear acceleration/deceleration profiles: their slopes can be independently programmed, according with the specific drive;
- the confirmation of the steps made by the motor;
- the aim of this program is the maximum reducing of the positioning time, i.e. to obtain the optimal frequency/time characteristic.

The program presented in this paper is a beginning for the closed-loop control of the stepper motors.

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