PROGRAMMABLE DYNAMIC LOADING EQUIPMENT

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ABSTRACT

This paper provides an idea of dynamic dynamometer as a useful option to conventional static dynamometers. Also, it provides principles to design it, as a high-tech programmable dynamic loading equipment. PC, PLC and quality rectifier is to be used. It is helpful equipment for laboratory work at technical universities and design offices.

1 INTRODUCTION

In real life we can meet different types of loads of electrical drives. Equipment, which can simulate them, can be very useful by designing of an electrical drive. Especially this equipment can simulate not only continual passive load, but also non-continual dynamic or impact loads (both active and passive). With such equipment designer can verify the correctness of design of electric drive before implementation. The goal of this project is to create such an equipment.

2 OPERATING CHARACTERISTICS OF ELECTRICAL DRIVES

Characteristics $T_L= f(\omega)$, $T_L= f(\alpha)$, $T_L= f(t)$ are of the main interest by loading equipments, while by the driving machines they are $\omega= f(T)$, $T= f(I)$. The basic configuration of electrical drive is on Fig. 1.

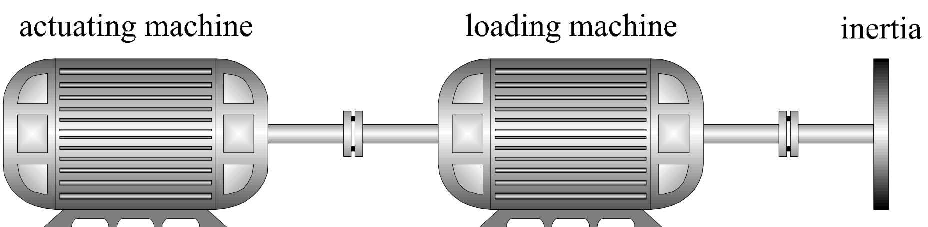

Fig. 1: *Basic Configuration of electrical drive*

The actuating machine is interconnected with the loading machine. Inertia of both (not to forget gearing) is displayed by flywheel, which influences the speed rate. Mutual torque relations are expressed by the equation (1).

$$T - T_L - T_A = 0 \tag{1}$$

2.1 LOADING MACHINES

There is a great variety of loading machines hence there is a great variety of their loading characteristics. There is empirical relation (2):

$$T_L = T_0 + \left(T_{LN} - T_0\right)\left(\frac{\omega}{\omega_N}\right)^x \tag{2}$$

where:

T_L - Loading torque of loading machine at speed ω

T_0 – Friction and ventilation torque

T_{LN} – Loading torque of loading machine at speed ω_N

x – coefficient characterizing the type of loading characteristic (x= -1,0,1,2 …)see Fig. 2.a)

Based on the above empirical relation, these kinds of loading machines can be specified:

x = -1… winding machines (paper, fiber…)

x= 0… tool machines (drillers, lathes, cutters…)

x = 1… dynamos, brakes,

x = 2… pumps, fans

any load is a combination of these typical basic kinds of loads

2.2 DRIVING MACHINES

Characteristics of basic driving machines are in Fig. 2.b) where:

1 belongs to synchronous machines

2 belongs to externally excited DC machines and asynchronous machines

3 belongs to machines with serial excitations

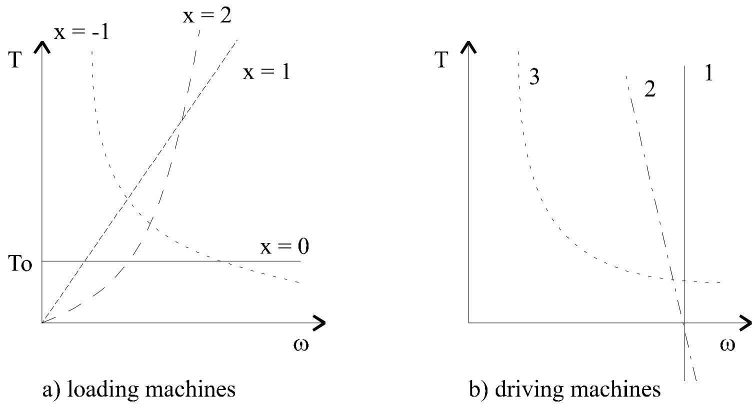

Fig. 2: *Characteristics of electrical drives*

The main goal of my work is to design an universally applicable loading equipment able to work as any loading machine, whichever is its complex loading characteristics as described above. Also, my equipment is programmable and makes use of up-to-date control technology – PC and PLC.

Unlike conventional dynamometers only allowing rather statical point-to-point measurements and fails to gain correct dynamical characteristics, my loading equipment allows to measure them. It is to stress that loading characteristics may be not only functions of speed, but also position, time, etc.

Lets concentrate now on the design of my loading equipment.

3 STRUCTURE OF THE PROGRAMMABLE DYNAMIC LOADING EQUIPMENT (PDLE)

Configuration of the PDLE consists of PC, PLC Saia Pcd4, Siemens rectifier SIMOREG and externally excited DC motor. Fig. 3. shows this loading configuration together with AC drive (asynchronous motor controlled by a Siemens frequency controller SIMOVERT). This laboratory stand is used to measure dynamic qualities of the AC drive by the PDLE. As an example, let us solve a drive task, by which the driving machine is loaded by a time ramp load torque.

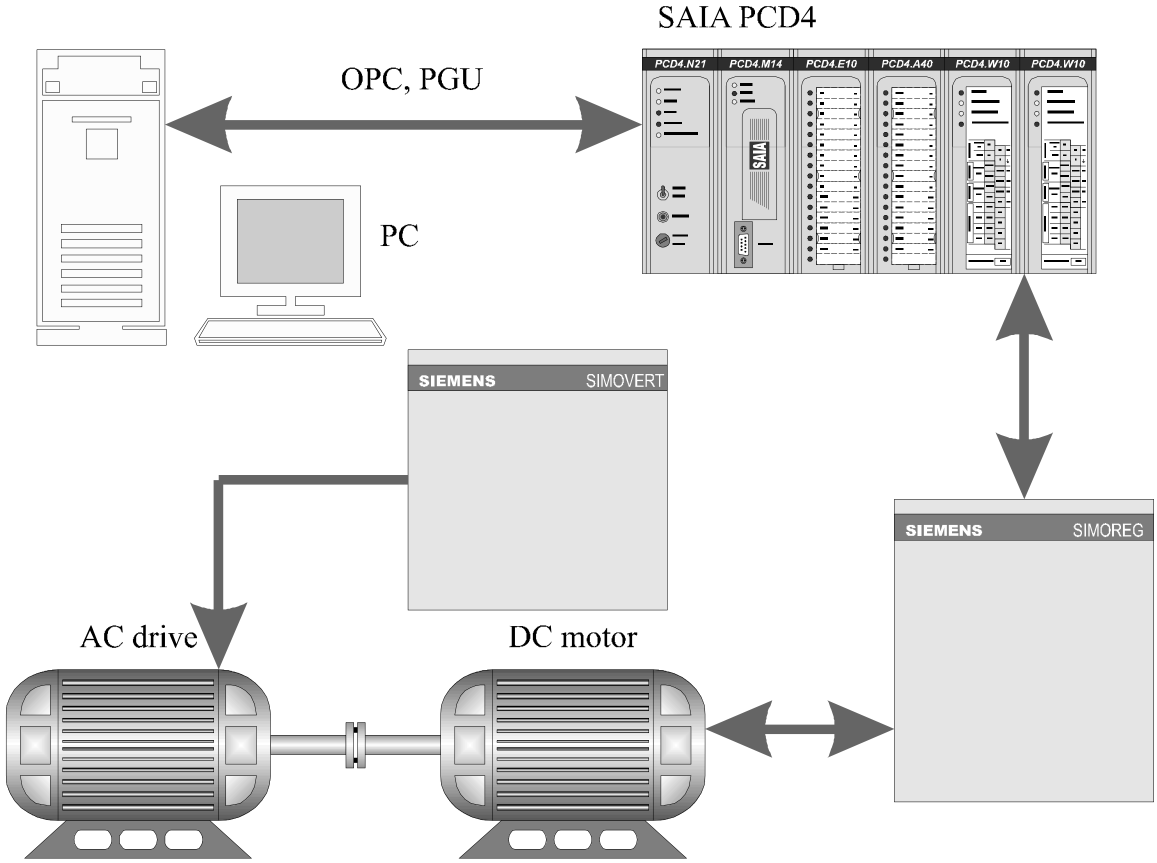

Fig. 3: *Configuration of the PDLE*

4 PROGRAMMING THE LOAD

Protocol PGU is used to load program to PLC via a serial link. PG4 is a software allowing to use tree basics programming principles:

- Ladder diagram – fupla
- Block schematics – graftec
- Assembler

Each of them has (dis)advantages of its own. Graftec is the most universal one. Inside graftec assembler or ladder diagram can by used. Assembler is the most convenient programming method for very fast control programs.

Ladder diagram is probably the most frequent method of programming . There are timers, counters and data blocks inside the ladder. E.g. see Fig. 4. to create time linear ramp. The timer (Blink) is used to increment the counter.

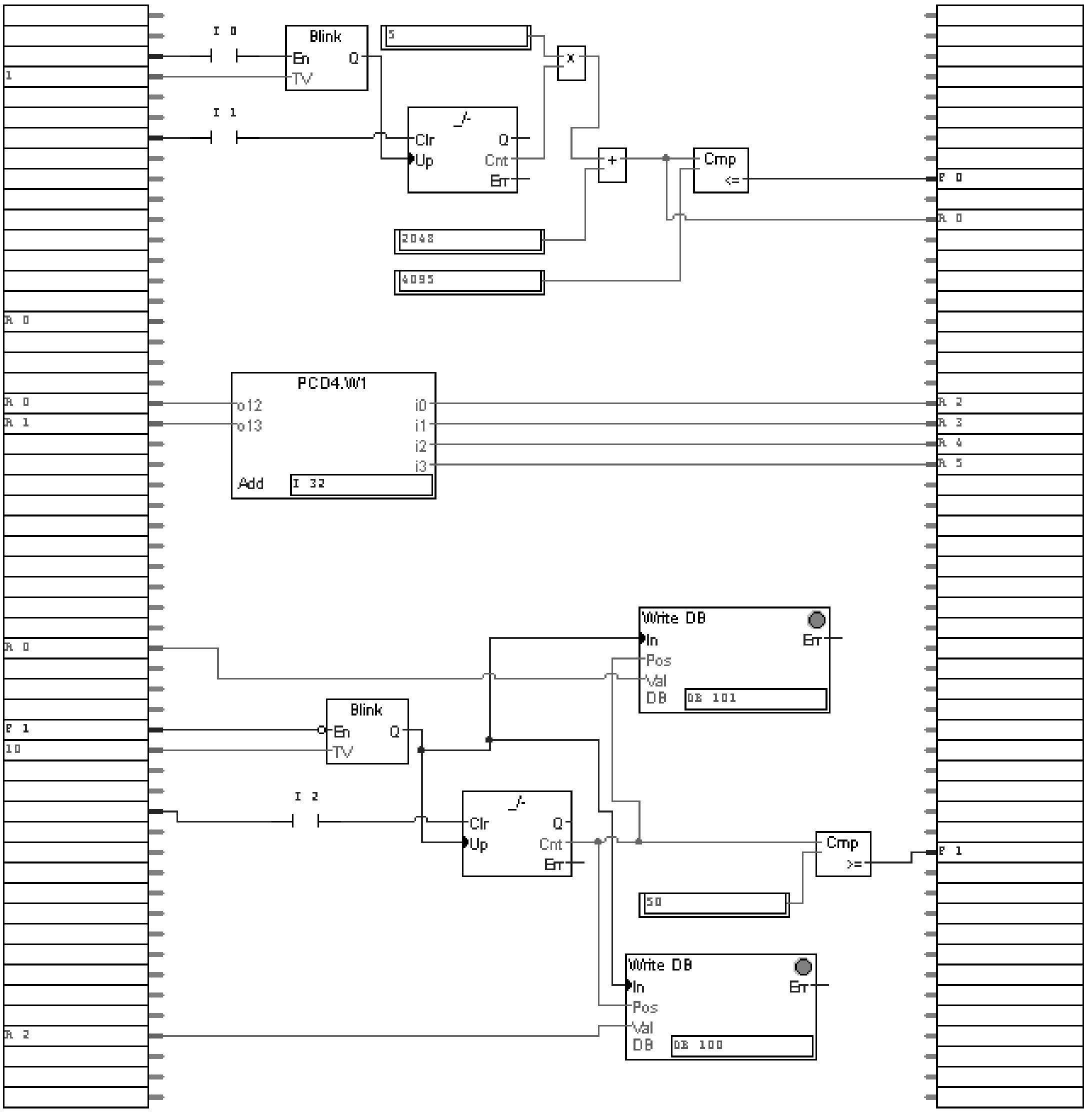

Fig. 4: *Ladder diagram*

The counter feeds its analog output. After the D/A transfer in PCD4.W1 the signal has a nature of control voltage, which for the rectifier SIMOREG means the wanted torque value. The torque is realized by both properly set rectifier and DC motor. To measure torque and speed of the DC motor (as a loading device for asynchronous motor, as „dynamic dynamometer") analog inputs of the PLC were used, by A/D transducer changed to binary form and with defined frequency written to data blocks.

5 MEASURMENT PROCEDURE AND RESULTS

After running up the frequency controlled asynchronous motor (150V, 30Hz) a switch command started the loading it for 30 s. The load ramp increased from 0 to 12 Nm, see Fig 5.

T_L = f (t)

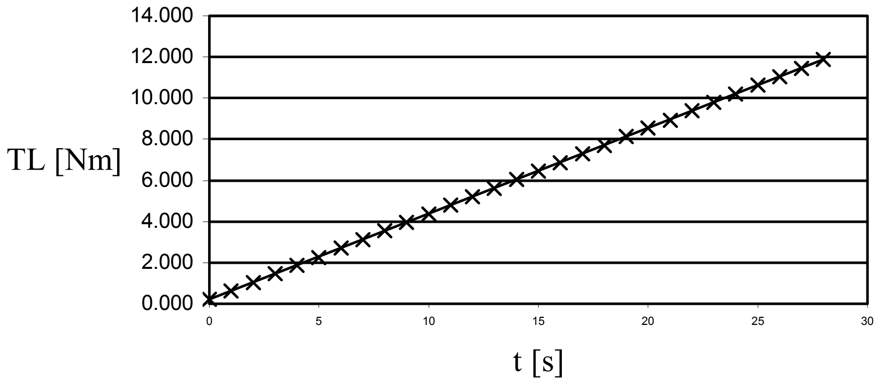

Fig. 5: *Load ramp*

A designer may want to see the speed-torque curve displayed on Fig 6. of the drive generated by the DC motor and analyze how convenient the drive is for the given purpose (the drive may be equipped with speed controller, unlike in our example).

n = f (T_L)

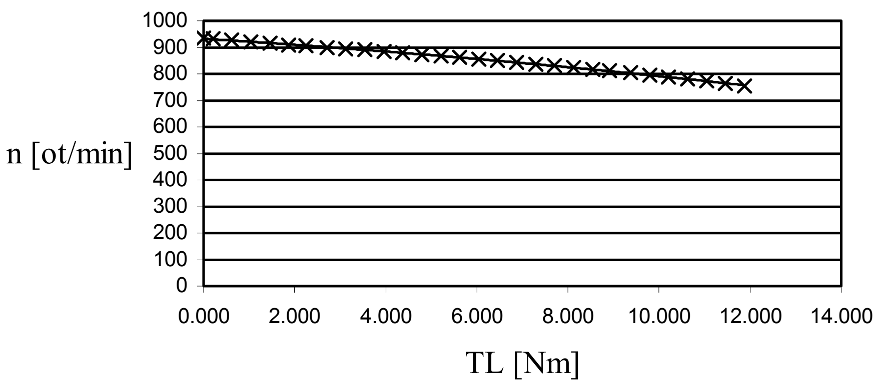

Fig. 6: *Speed-torque curve*

6 COMPUTER AIDED MODELLING AND SIMULATION

CAMS is an obvious final stage of every design. MATLAB is the very frequent program for this purpose. I used it to obtain additional results, (given below) to run some simulation experiments on the model of my PDLE. After running up the motor in no load it was loaded by 6 Nm in time 0,6 s. Current and speed time responses see Fig. 7.

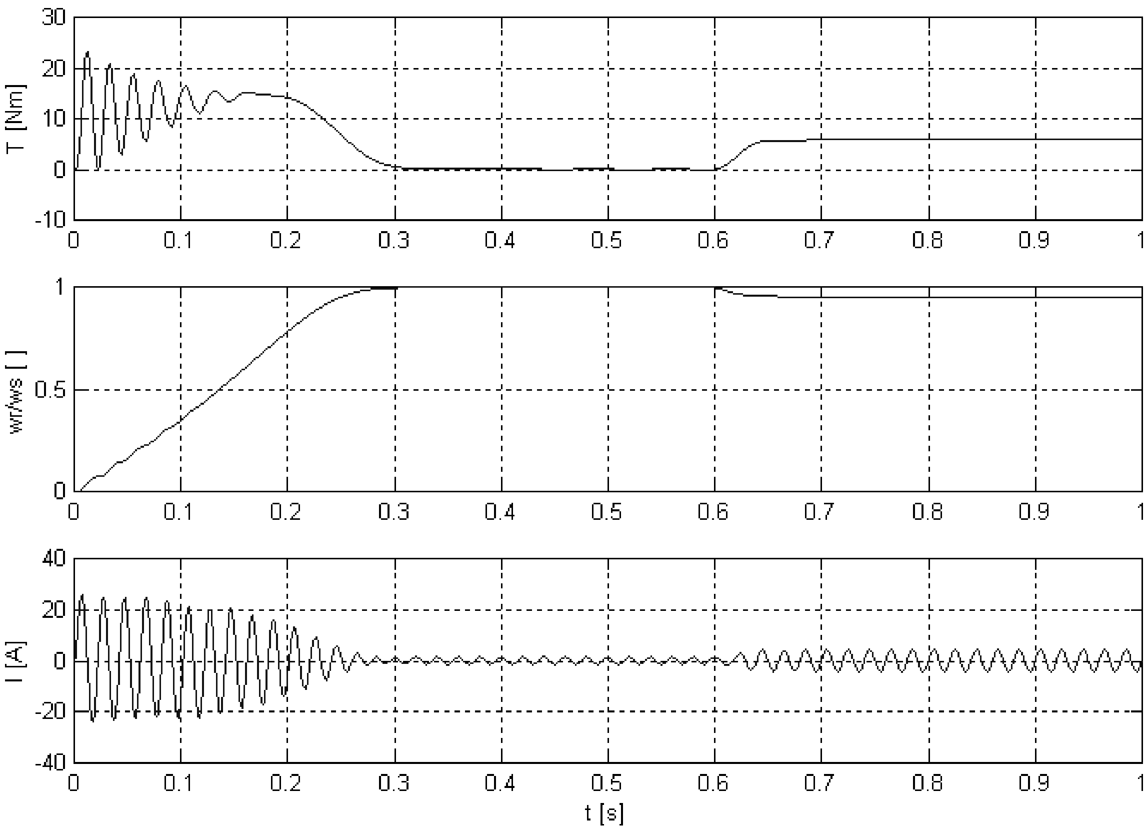

Fig. 7: *Simulation of loading an asynchronous motor by a constant load*

REFERENCES

[1] Hruškovič, L.: Elektrické stroje, Bratislava, STU 1999, ISBN 80-227-1249-3

[2] Chee-Mun, O.: Dynamic Simulation of electric machinery, New Jersey, 1997, ISBN 0-13-723785-5

[3] Tassin, A.: SAIA Reference Guide, SAIA AG 1992