Virtual stand for testing stepping motors used as incremental encoder

C. Donciu[1], M. Cretu[2], I. Prisecaru[3], M. Temneanu[4]

[1] *Technical University Gh. Asachi, Faculty of Electrical Engineering, Iasi, Romania, email: cdonciu@ee.tuiasi.ro*
[2] *Technical University Gh. Asachi, Faculty of Electrical Engineering, Iasi, Romania, email: mcretu@ee.tuiasi.ro*
[3] *Technical University Gh. Asachi, Faculty of Electrical Engineering, Iasi, Romania, email: ciprisecaruu@ee.tuiasi.ro*
[4] *Technical University Gh. Asachi, Faculty of Electrical Engineering, Iasi, Romania, email: mtemnean@ee.tuiasi.ro*

Abstract- In the present paper, prototype architecture for a virtual stand for stepping motors converted as rotary encoder study is illustrated.
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I. Introduction

Nowadays the stepping motors are very used in many applications as industrial equipment for flow control valves, automotive for optic axis control and home automation appliances as sewing machines.

The low cost of stepping motors offer possibility to transform it convenient in a rotary encoder. Rotary encoders are high-precision rotational position sensing devices that are widely used in mechatronics products, especially in industrial robots [1,2]. They are mounted on a rotary shaft to generate a digital signal to sense its rotational position. There are two types of encoders: absolute and incremental. The incremental encoders are simpler and cheaper compared with the absolute ones.

Our application describe how to convert a stepping motor in a incremental encoder and present a virtual stand in order to test its parameters

II. Stepping motor as incremental encoder

A KP4M4-001 stepper motor is used in order to transform it in a rotary encoder. In the KP4M4-001 stepper motor, the permanent magnet lies North - South along the shaft. It is encased in two stacks each with 25 teeth round the rim. The teeth on the South stack are out of phase with the teeth on the North stack by half the gap between teeth. This means that at the same time that the teeth on the North stack are being attracted by and thus lining up with the teeth on the currently magnetized pole of the stator, the teeth on the South stack are being repelled and thus lining up with the gaps between the teeth on

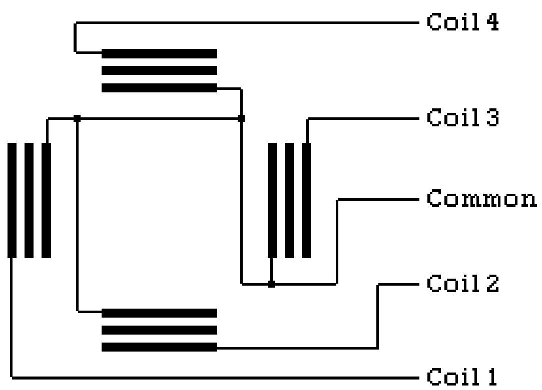

Figure 1. Coils connection

that pole. With 25 teeth round the edge of the rotor and 4 coils excited individually in turn, the KP4M4-

001 stepper motor takes 100 steps per complete revolution, that mean 3.6º resolution. The coils connection is shown in figure 1.

In order to work as incremental encoder, a sinusoidal power generator at 1KHz frequency supplies each coil of stepping motor (figure 2).

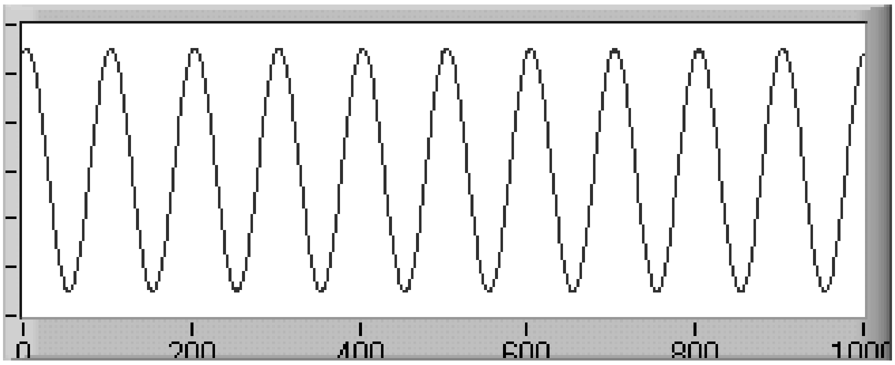

Figure 2. 1KHz sinusoidal power supplies

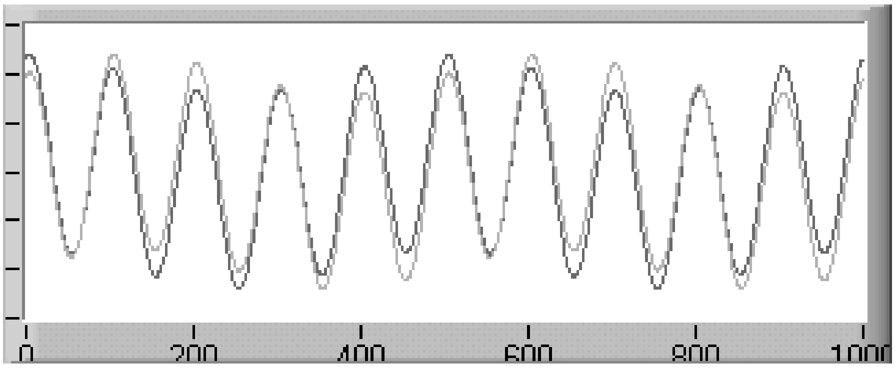

Figure 3. Modulated signals

Due to rotary motion of stepping rotor current outputs of two coils (coil1 and coil2) results as two modulated signals as shown in figure 3.

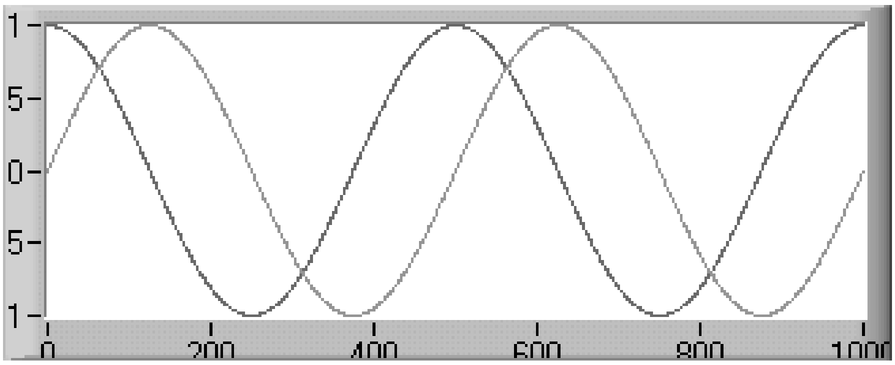

Figure 4. Quadrate signals

The signals are soft filtrated and after that are obtained two signals that are electrically 90° out of phase with each other, as shown in figure 4. The term quadrature refers to this 90° phase relationship.

A digital Butterworth Filters is used in order to cut high signal frequency. A smooth response at all frequencies and a monotonic decrease from the specified cutoff frequencies characterizes the frequency response of Butterworth filters. Butterworth filters are maximally flat (the ideal response of unity in the passband and zero in the stopband. The half power frequency or the 3-dB down frequency corresponds to the specified cutoff frequencies [3,5].

The advantage of Butterworth filters is a smooth, monotonically decreasing frequency response. After you set the cutoff frequency, LabVIEW sets the steepness of the transition proportional to the filter order. Higher order Butterworth filters approach the ideal lowpass filter response.

This technique, using two signals electrically 90° out of phase, allows the software decoding to determine which channel is leading the other and hence ascertain the direction of rotation, with the added benefit of increased resolution

The system architecture for testing stepping motor converted, as incremental encoder, is composed from following mains parts:

- SM stepping motor which perform rotary motion;
- IESM incremental encoder tested;
- OIE high-resolution optical encoder;
- Sinusoidal power generator.

All devices are connected via drivers card to computer, where are executed by software the signals filtration, rotary motion interpretation and results evaluation (figure 5).

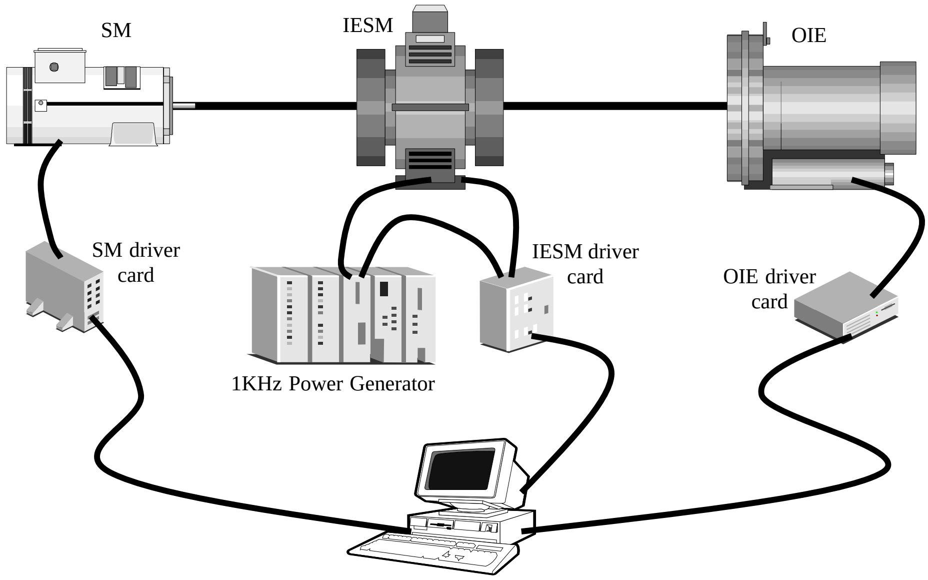

Figure 5. Virtual stand architecture

In figure 6 stepping motor board, composed from SM stepping motor that perform rotary motion, OIE high-resolution optical encoder and IESM incremental encoder tested is showed.

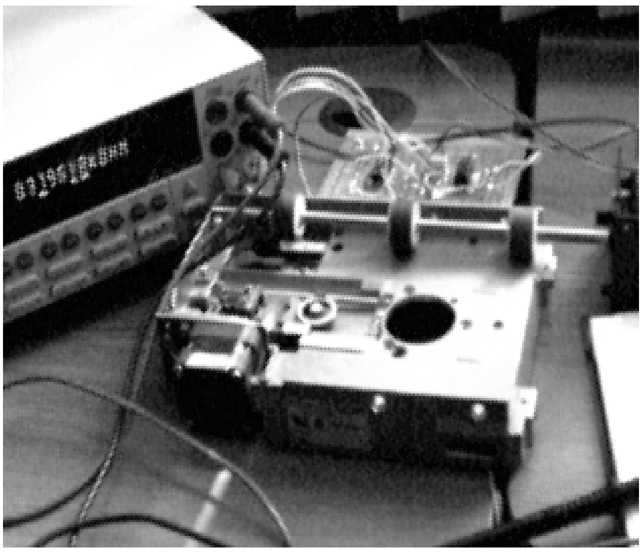

Figure 6. Stepping motor board

The stepping motor (SM) used is a SST39D type with 1.8º resolution, controlled by a UDN2540B quad Darlington power driver made by Allegro Company. Combining AND logic gates and inverting high-current bipolar outputs, the UDN2540B quad Darlington power drivers provide interface between low-level signal-processing circuits and power loads totalling 360 W. Each of the four independent outputs can sink up to 1.8 A in the on state with peak inrush currents to 2.5 A. In order to control the input of driver is used four pins of parallel port (Data1, Data2, Data3 and Data4).

Optical incremental encoder is a high-resolution encoder, with 0.05º resolutions, used for accuracy determination.

Tested accuracy for KP4M4-001 stepper motor as incremental encoder was 1% with a 360º / 100 steps = 3.6º resolution.

III. Conclusions

The low cost of stepping motors offer possibility to transform it convenient in an incremental encoder using a minimum number of devices.

A virtual stand for encoder study was presented which let the possibility to extend actual stage to a distributed interactive measurement system.

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