THIN DISK STEPPER MOTOR AND ITS RESONANCES

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ABSTRACT

Stepper motors are very used in the industry. Big disadvantage of these machines is presence of resonances, which one existed beside some frequencies of power supply impulses. Disadvantage can be eliminated by mechanical structure. This article deals with measuring circuit values in resonances of thin disk stepper motor.

1 INTRODUCTION

Stepper motors can be viewed as electric machines without commutators. Typically, all windings in the motor are part of stator, and the rotor is either permanent magnet, or in case of variable reluctance motors, thoothed part of magnetically soft material. All of the commutation must be handled externally by motor controller.

2 STEPPER MOTOR WITH THIN DISK ROTOR

Stepper motor rotor is created as thin disk shaped magnet (thin is less then 1 mm). This disk is alternately axially magnetized so as so this one had the greatest pole pairs. Moment of inertia is low. Dynamic characteristics of this machines are very good. Design of this motor shows fig. 1.

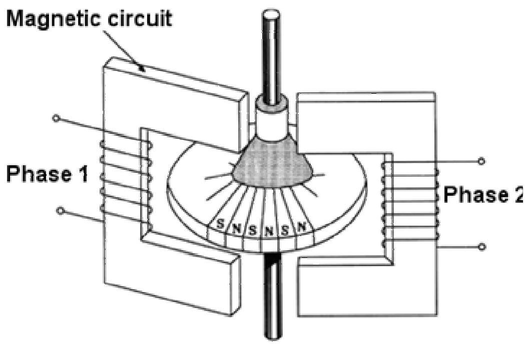

Fig. 1: *Thin disk stepper motor*

3 RESONANCE

Stepper motor base motion is turn rotor throught one step. Step is defined as mechanical response to one impulse from control unit, when rotor performed motion from initial position to new position. Static holding moment is zero in this time. In ideal case, this moment sinusoidal depended on shaft angle (1).

$$M = -M_p \sin\left(\frac{\pi}{2S}\vartheta\right) \tag{1}$$

Where:

M[Nm]	moment of motor
S[rad]	step angle
ϑ[rad]	angle of wind rotor

Intermediate damped process come into existence beside transit from first position to second position. This one can be described by equation (2)

$$\Theta(t) = Ae^{-\alpha t}\cos(\varpi_0 t) + Be^{-\beta t} \tag{2}$$

Where:

A,B	constants
α.β	dumping parameters

If stepping frequency equal or approach to frequency of characteristic vibrations, motor operated in resonance area and one lost steps. In this case, position of shaft is changed fully chaotically. Base formula for resonance frequency (3)

$$f = \frac{1}{2\pi}\sqrt{\frac{n_p M_p}{J}} \tag{3}$$

Where:

n_p	number of pole pairs
M_p[Nm]	holding torque
J[kgm^{-2}]	moment of inertia

Resonance doesn’t existed only on this base frequency. Resonances can existed on frequencies which one passed next rule (4).

$$f_i = \frac{p}{q} f \tag{4}$$

Where:

p, q	integer co-prime numbers
f[Hz]	base resonance frequency

4 MEASURING POSITION OF STEPPER MOTOR SHAFT IN RESONANCES

We measured position of motor shaft and phase currents.

Used instruments:

- Thin disk stepper motor PORTESCAP PS 530 and PORTESCAP control unit
- Digital scope Hewlett Packard with GPIB adapter
- Encoder
- Current probe
- Personal computer
- Power supply

Schematic diagram shown figure no. 2.

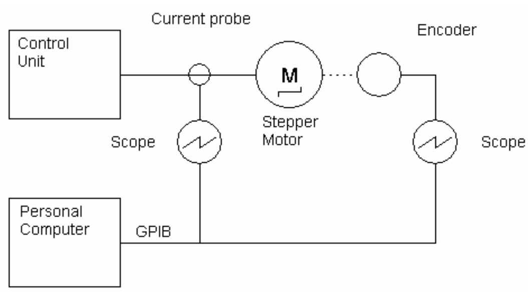

Fig. 2: *Schematic diagram*

5 RESULTS

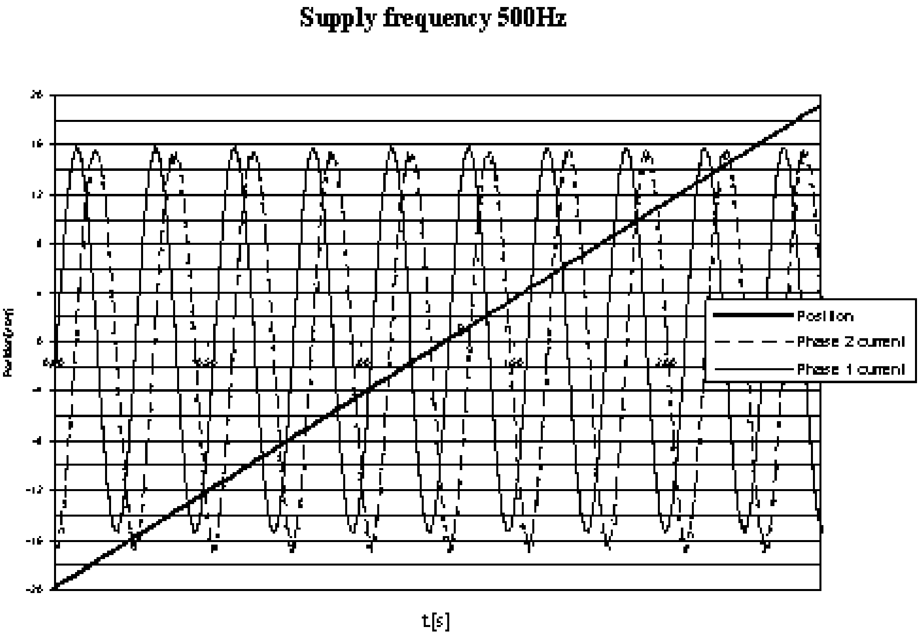

Fig. 3: *Motor supply frequency 500 Hz, free whelling*

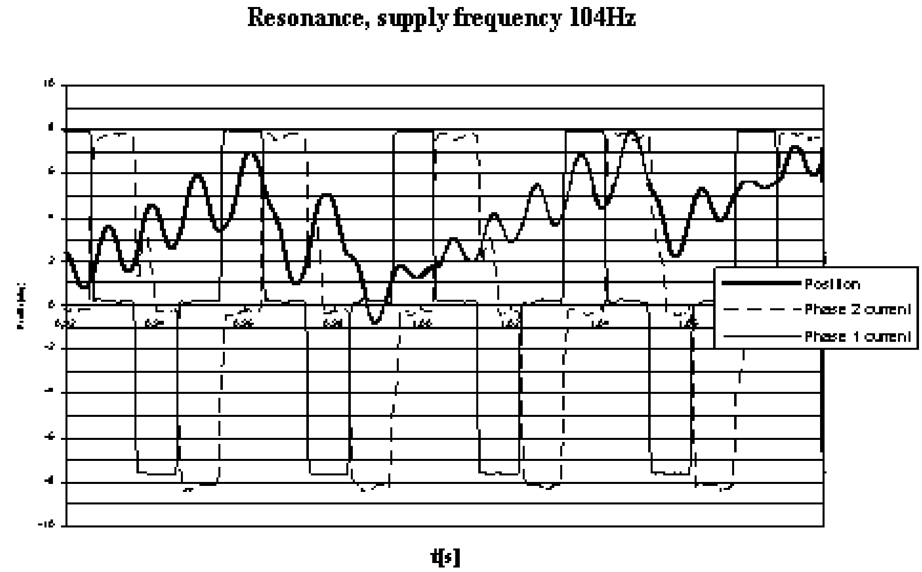

Fig. 4: *Resonances, Motor supply frequency 104 Hz, regenerative*

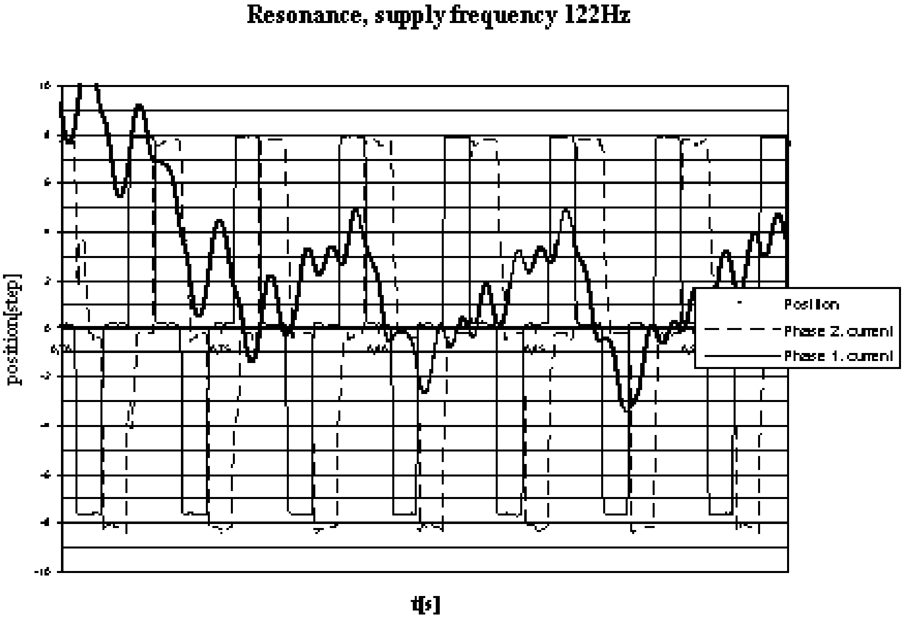

Fig. 5: *Resonance, motor supply frequency 122 Hz, regenerative*

6 CONCLUSION

Measuring verified, that while using thin disk stepper motors come in to existence resonances. All of measured dependencies show figures on the bottom. Figure no. 3 shown motor run without resonances, currents are sinusoidal. Figures no.4 and no. 5 shown motor run with resonances on different frequencies. Currents aren't sinusoidal.

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REFERENCES

[1] Pilgr, A.: Diplomová práce ÚVEE, Brno, 2003