Some remarks on the stability of feeddrives with DC-motors

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Note for STC "MACHINE TOOLS"
PARIS, January 1978
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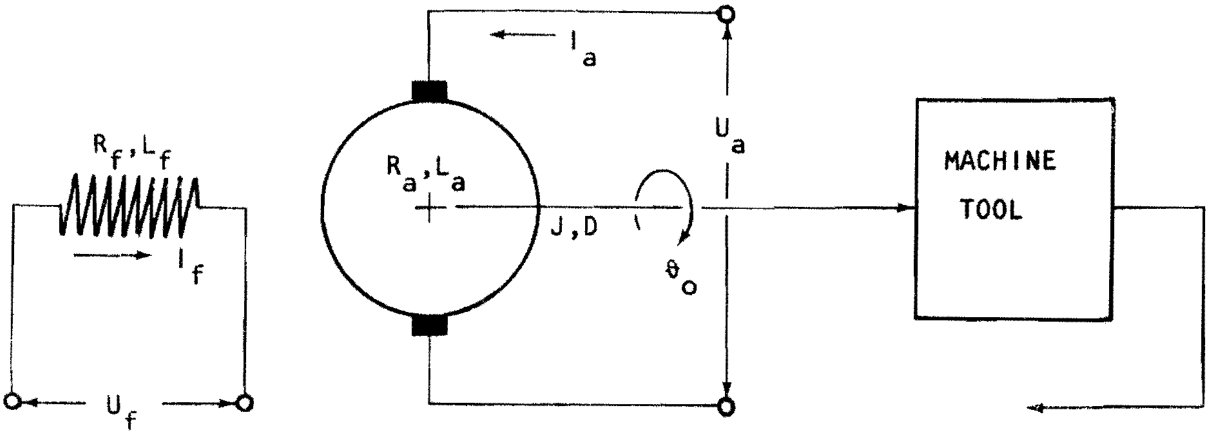


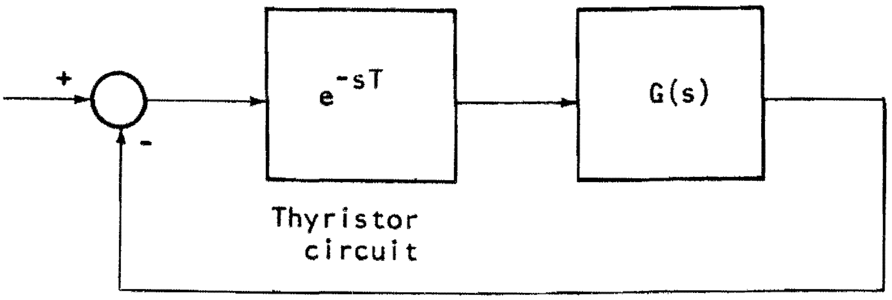
Conventionally, there are two possibilities for the control of the DC-motor:

1. *Control of the armature current I_a, while the field current I_f is kept constant.*

   The input signal ϑ_i is proportional with U_a. Basicly, the system is of third order. However, assuming the self-induction L_a to be small (which is very realistic), the system becomes of second order with a transfer function:

$$\frac{\vartheta_o(s)}{\vartheta_i(s)} = \frac{K'}{s(1+\tau s)} = G(s)$$

   Although, this transfer function on itself can not cause instability, the system is often used in combination with a thyristor ignition circuit that causes the trouble. This circuit couples a time delay e^{-sT} with the transfer function G(s) as follows:



In order to give an idea of the stability situation of this feedback system, let us assume that the function G(s) has a phase angle of -135 degrees (in the middle of the second quadrant in the Nyquist diagram). So, only -45 degrees is necessary for instability as far as phase is concerned. This can be achieved at very low frequencies in the thyristor circuit. For example with a 50 Hz mains voltage:

single-acting thyristor circuit $\frac{\pi}{4} = 2\pi f * 2.10^{-2}$

T = 20 ms $\underline{f = 6.25\ \text{Hz}}$

double-acting thyristor circuit $\frac{\pi}{4} = 2\pi f * 10^{-2}$

T = 10 ms $\underline{f = 12.5\ \text{Hz}}$

2. *Control of the field current I_f, while the armature current I_a is kept constant.*
   The input signal ϑ_i is proportional with U_f. The transfer function can be written as:

$$\frac{\vartheta_o(s)}{\vartheta_i(s)} = \frac{K}{s(1+\tau_1 s)(1+\tau_2 s)}$$

τ_1 = electrical time constant,
τ_2 = mechanical time constant.

Although, it is attractive to use the field current for controlling the DC-motor because this current is smaller than the armature current, the system opens immediately possibilities for instability since the transfer function is of third order.

Conclusions:

In using DC-motors for feeddrives, there are several possibilities for instabilities. One of the topics for cooperative research in this field can be an investigation of these instabilities, how to avoid them and, perhaps, looking for new ways of control for the DC-motor. In doing this, it is of importance to look not only into the DC-motor on itself, but to consider the complete feeddrive system.