Some remarks on the stability of feeddrives with DC-motors

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Some remarks on the stability of feeddrives with DC-motors.

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 $\theta_i$ is proportional with $U_a$. Basically, 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:

$$\frac{\theta_o(s)}{\theta_i(s)} = \frac{K_i}{s(1+Ts)} = G(s)$$

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:

<table>
<thead>
<tr>
<th>Circuit Type</th>
<th>$\frac{\pi}{4}$</th>
<th>$f$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-acting thyristor</td>
<td>$2\pi f \times 2.10^{-2}$</td>
<td>6.25 Hz</td>
</tr>
<tr>
<td>Double-acting thyristor</td>
<td>$2\pi f \times 10^{-2}$</td>
<td>12.5 Hz</td>
</tr>
</tbody>
</table>

2. Control of the field current $I_f$, while the armature current $I_a$ is kept constant.

The input signal $\theta_i$ is proportional with $U_f$. The transfer function can be written as:

$$\frac{\theta_o(s)}{\theta_i(s)} = \frac{K}{s(1+\tau_1 s)(1+\tau_2 s)}$$

$\tau_1$ = electrical time constant,
$\tau_2$ = 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.