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CONTRIBUTION TO AUTOMATE REGULATION AFTER THE SPEED OF ACTIONS WITH ASYNCHRONIZED SYNCHRONOUS MOTOR

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ABSTRACT: The actions with asynchronous synchronous motor must assure every overload, which should not depend on the electric parameters of motor, in conditions in which the power of supply sources and mechanical robust allow this thing. At the same time the system of regulation must also assure the possibility of command the reactive power in such way as to maintain at an economical level impose. In this paper, we consider a synchronous motor with a symmetrical wind in stator, supplied from the network and a three-phase symmetrical wind of excitation, alimentated from a static converter with thyristor. The structural scheme of the motor and automate regulator for reactive moment and power; structures which have at basis the Park relations, following as on base of these structures to realize the system model.

KEYWORDS: asynchronous synchronous motor, automate regulator, structural scheme

INTRODUCTION

The utilization of electric motors by direct current in actions, assure the system a high precision and rapidity for regulation of rotation speed at a pre-establish level, but it presents and a series of disadvantages as well. Because of this cause, it has tried the passing to actions with motors of alternative current without collector synchronous and asynchronous synchronous [1, 4].

In particular, the motors synchronous asynchronous (MSA) must not be less accurate than the ones of continuous current with regard to the quality of regulation, must assure any overload necessary to action without depending on the electric parameters of motor. One of the very important conditions imposed to this type of action consists of the fact that, the system of regulation must assure the possibility of command of the reactive power in such a way to maintain it at an economical level imposed.

THE FUNCTIONAL SCHEME OF SYSTEM REGULATION

MSA we understand a synchronous motor with a symmetrical wind in the stator, alimentated from a network of alternative current and a wind bi- or tri- phased symmetrical of excitation alimentated from a static converter of frequency with thyristor (for example with direct link).

This system can be processed in the limits of a close system of automate regulation of the reactive moment and power of the motor, as in figure 1, where: 1 – MSA; 2 – transducers of rotor current; 3 – static reversible converter with thyristor; 4 – command sensor of reactive power; 5 – command sensor of rotation speed; 6 – angle transducer; 7 – transducers of stator current; 8 – tahogenerator.

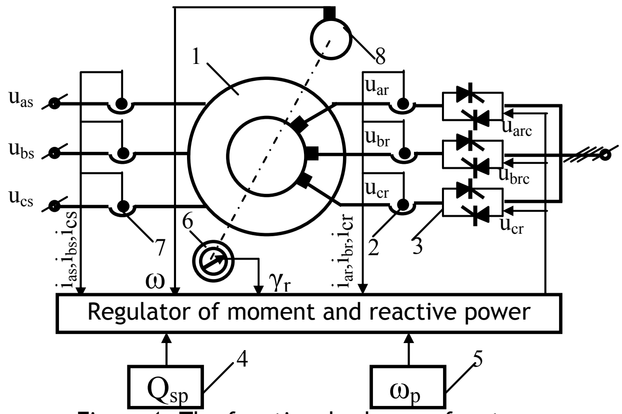

Figure 1. The functional scheme of system

Upon the regulator of reactive moment and power, activate the command signals after speed ω_p and after reactive power Q_{sp}, as well as the signals of stator currents, rotor currents, the angular position of rotors γ_r and ω. Under the action of this signals, the regulator will process the command signals u_{arm}, u_{brm}, u_{crm} which activate at the entrance of the supply sources of rotor phases.

The regulator of the reactive moment and power is synthesized in such a way that the system assures in stationary regime the maintaining of ω and Q at the given level, indifferent of the load at motor tree.

The system synthesis and analysis simplifying assumptions: at MSA with symmetrical three phases winds in stator and rotor are not be taken in consideration the iron losses and the change of saturation rank at this; the stator network supply is considered as infinite; the rotor supply sources are presumed to be electric generators without inertia, with electromotor tensions proportional with the entrance signal, that is: $U_{ar} = U_{arm}$, $U_{br} = U_{brm}$, $U_{cr} = U_{crm}$.

❖ THE STRUCTURAL SCHEME OF MSA

Take into account the simplifying assumptions taking in to consideration a system of coordinates round synchronous after axes α, β [2, 3, 5], the functional ecuations of system can be written under the forms:

$$\begin{aligned}
\frac{d\Psi_{\alpha s}}{dt} &= u_{as} + \omega_s \cdot \Psi_{\beta s} - r_s \cdot i_{\alpha s};\\
\frac{d\Psi_{\beta s}}{dt} &= u_{\beta s} - \omega_s \cdot \Psi_{\alpha s} - r_s \cdot i_{\beta s};\\
\frac{d\Psi_{\alpha r}}{dt} &= u_{\alpha r} + (\omega_s - \omega) \cdot \Psi_{\beta r} - r_r \cdot i_{\alpha r}\\
\frac{d\Psi_{\beta r}}{dt} &= u_{\beta r} - (\omega_s - \omega) \cdot \Psi_{\alpha r} - r_r \cdot i_{\beta r}\\
\frac{d\omega}{dt} &= \frac{1}{J}(M_e - M_r)
\end{aligned} \quad (1)$$

where:

$$\begin{aligned}
&\Psi_{\alpha s} = x_s \cdot i_{\alpha s} + x_m \cdot i_{\alpha r};\ \Psi_{\alpha r} = x_m \cdot i_{\alpha s} + x_r \cdot i_{\alpha r};\\
&u_{\alpha s} = U_{sm} = 1;\ u_{\beta s} = 0;\ u_{\alpha r} = u_{\alpha rc};\ u_{\beta r} = u_{\beta rc};\\
&\Psi_{\beta s} = x_s \cdot i_{\beta s} + x_m \cdot i_{\beta r};\ \Psi_{\beta r} = x_m \cdot i_{\beta s} + x_r \cdot i_{\beta r}
\end{aligned} \quad (2)$$

The reactive power of stator circuits will be:

$$Q = u_{\beta s} \cdot i_{\alpha s} - u_{\alpha s} \cdot i_{\beta s} = -U_{sm} \cdot i_{\beta s} \quad (3)$$

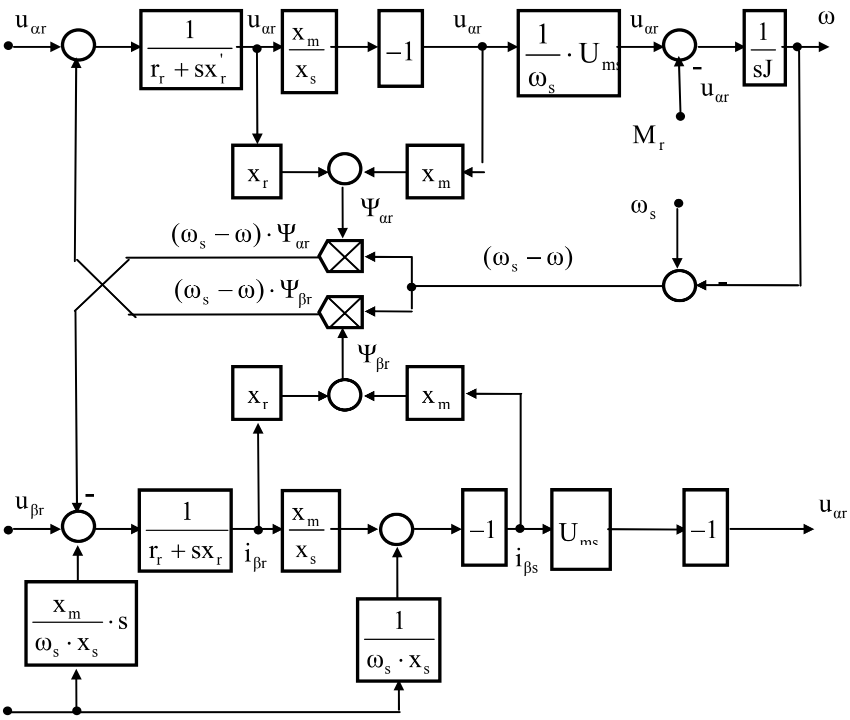

Figure 2. The structural scheme of

With the specifications that in (1) all sizes are expressed in relative units.

The variables on axes α, β are connected through:

$$\begin{aligned}
i_{\alpha s} &= \tfrac{2}{3}[i_{as} \cdot \cos\omega_s t + i_{bs} \cdot \cos(\omega_s t - \tfrac{2\pi}{3}) + i_{cs} \cdot \cos(\omega_s t + \tfrac{2\pi}{3})]\\
i_{\beta s} &= \tfrac{2}{3}[i_{as} \cdot \sin\omega_s t + i_{bs} \cdot \sin(\omega_s t - \tfrac{2\pi}{3}) + i_{cs} \cdot \sin(\omega_s t + \tfrac{2\pi}{3})]\\
i_{\alpha r} &= \tfrac{2}{3}[i_{ar} \cdot \cos\nu_r + i_{br} \cdot \cos(\nu_r - \tfrac{2\pi}{3}) + i_{cr} \cdot \cos(\nu_r + \tfrac{2\pi}{3})]\\
i_{\beta r} &= \tfrac{2}{3}[i_{ar} \cdot \sin\nu_r + i_{br} \cdot \sin(\nu_r - \tfrac{2\pi}{3}) + i_{cr} \cdot \sin(\nu_r + \tfrac{2\pi}{3})]
\end{aligned} \quad (4)$$

where v_r is the electric angle between the rotor axes and the coordinate system which turns synchronously.

The reverse pass towards the command tensions of rotor phases is made through the relations:

$$u_{ar} = u_{\alpha rc} \cdot \cos v_r - u_{\beta rc} \cdot \sin v_r$$
$$u_{br} = u_{\alpha rc} \cdot \cos(v_r - 2\pi/3) - u_{\beta rc} \cdot \sin(v_r - 2\pi/3) \quad (5)$$
$$u_{cr} = u_{\alpha rc} \cdot \cos(v_r + 2\pi/3) - u_{\beta rc} \cdot \sin(v_r + 2\pi/3)$$

The system (1) gives the possibility of constructing the scheme of structure MSA, represented in figure 2, observing that the structure contains some non-linear elements as well as a cross reaction created by the presence of the electromotor force of rotation in the stator and rotor circuit, as well as of the magnetic links of these circuits.

The structural scheme can be simplified considerably if the secondary links (by ord. II) are eliminated in particular admitting the elimination of active resistor R_s and a transistor process in statoric circuit. Under these conditions from (1) the fluxes can be determinate:

$$\Psi_{\beta s} = -1/\omega_s \cdot u_{\alpha s} = -1/\omega_s \cdot U_{sm} = -1; \quad \Psi_{\alpha s} = 0 \quad (6)$$

the electromagnetic moment becoming:

$$M_e = -\Psi_{\beta s} \cdot i_{\alpha s} = 1/\omega_s \cdot U_{sm} \cdot i_{\alpha s} \quad (7)$$

❖ THE STRUCTURAL SCHEME OF THE REGULATOR

As it was mention, the actions with MSA must present the characteristics at similar performance of action case with motors of direct current, carrying out at the same time the part of synchronous compensators as well. From this point of view, we must totally take into account the dynamic proprieties of the regulate object, it is indicated that the regulator be construct not in phase coordinates, but in synchronous coordinates α, β, taking into account (4) and (5).

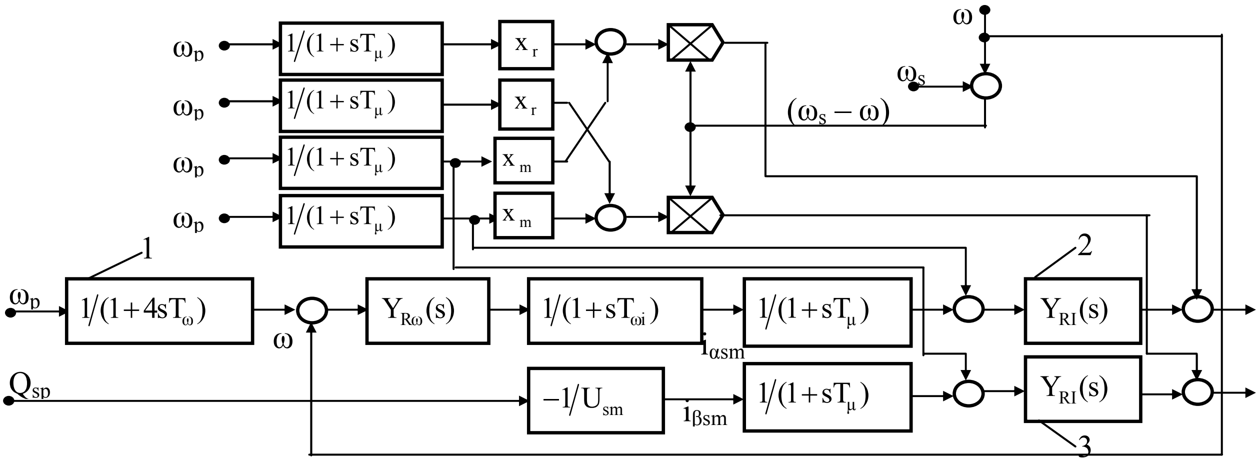

Figure 3. The structural scheme of regulator

From the structural scheme (figure 2), we can observe that, if in the regulator of reactive moment and power, the compensation condition of electromotive force of rotation at rotor is carried ut (ω_s -) and (ω_s -). Then appears the possibility of separate regulation of active current $i_{\alpha s}$ (electromotive moment and ω) and reactive current $i_{\beta s}$ (power Q_s), with the help of voltage $U_{\alpha r}$, $U_{\beta r}$. Thus, on the channel $U_{\alpha r}$ - ω, the structure analyzed is analogous with the motor structure of direct current compensated and the regulation is subordinated to the method with series correction. So, the regulator exit of speed represent the regulator entrance of current, and the motor moment is proportional with the regulator exit of speed.

On the channel $U_{\beta r}$ - Q_s, for the regulation it is enough to work only the current regulator.

Taking into account those presented based on figure 2, was obtained the structural scheme of the regulator of reactive moment and power of the MSA from figure 3, at the basis of the regulator synthesis being the general methods of synthesis subordinated to the regulation with series correction.

Through the supply of rotor winds from the static converter of frequency with thyristor, with direct link, the speed is regulated in the approximate limits $(1\pm0.3)\cdot\omega_s$. Beside, the speed regulator, in the structural scheme there appear another two regulators: 2 – regulator of active current and 3 – regulator of reactive current, at the regulator entrance 2 appears the command from the regulator exit of speed, again at the regulator entrance-3 it is applied the command of reactive power Q_{sm}.

The transfer functions of regulator are established starting from the optimum transfer functions of the regulation systems in close circuit [2, 6]. So, the transfer function of the current regulator can be give by:

$$Y_{RC}(s) = (r_{rech} + x_r^{'})/2 \cdot s \cdot T_{\mu} \qquad (8)$$

where T_{μ} - represent the time constant of measurement filters and its chosen according to the necessary action speed of the regulation circuits of current.

In some cases [4] for increasing the fiability of frequency converters it is indicated that the entries of the regulator non-inertial reverse supplementary connection be introduced after the faze currents, through this the aspect of the transfer function is not modified, only an increase of the equivalent resistance being necessary to be introduced init. The transfer function of the speed regulator can be written under the following aspect, taking into consideration a regulation law PI:

$$Y_{R\omega}(s) = J \cdot (1 + 4 \cdot s \cdot T_{\omega})/8 \cdot s \cdot T_{\omega}^{2} \qquad (9)$$

where T_{ω} - time constant which characterizes the regulation loop of speed and in general $T_{\omega} \geq 2T_{\mu}$.

In the regulation, loop of speed a supplementary tuning filter can be introduced as well, whose time constant to be $T_{\omega i} = T_{\omega} - 2T_{\mu}$.

❖ CONCLUSIONS

The establishing of structural scheme allows the model of electric actions with MSA, this model being made taking into account the machine-static converter assemble. The compensation of the electromotor tension of the rotor and the selection of the activating speeds of the regulation loop constitutes a special problem because it can lead to the worsening of the transitory processes and the apparition of oscillations. In the structural scheme, the compensation of the internal reverse reaction is presented after the rotation electromotor tension through the multiplication elements 4 and 5.

Since the results of the modelation on a red case are not finalized, then results will be presented in the future, taking into account [7] as well.

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