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DESIGN OF A ROBUST ELECTRO-MECHANICAL CONTROL SYSTEM

عنوان البحث :- تصميم قانون تحكم لمنظومة كهروميكانيكية

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ملخص البحث :-

يقدم البحث طريقة مقترحه لتصميم نظام تحكم لمنظومة كهروميكانيكية ، و يحتوى البحث على النموذج الرياضى لمنظومة كهروميكانيكية مكونة من محرك تيار مستمر محكوم من دائرة العضو الدوار و مولد تيار متردد ذو وجه واحد. و هذه المنظومة لها خرجان يتم التحكم فيهما و هما التردد و القدرة الناتجتين من المولد ذو التيار المتردد و ذلك حتى يمكن ضبطهما لتغذية محرك تيار متردد للتحكم فى سرعته.

و المنظومة المذكورة منظومة غير خطية ولذلك تم استنتاج قانون التحكم لهذه المنظومة باستخدام طريقة الحذف اللاخطى.

وقد بينت المحاكاة والنتائج فعالية الطريقة المقترحة فى تصميم نظام التحكم للمنظومة الكهروميكانيكية.

ABSTRACT:

The paper introduces a suggested technique for the design of a nonlinear electromechanical control system. The suggested design technique is applied to a motor-generator set. This electromechanical system is nonlinear and at the same time multivariable. The effect of a nonlinear power amplifier included in the system is also considered. The main objective of such design is to generate electrical power with low harmonic content, which is necessary for the speed control of a.c. motors. Th
motor-generator set represents a multivariable system since, i
required to control both the frequency and amplitude of the
power. The system has also two inputs, the voltage at th
terminals and the excitation voltage of the genera
affects both outputs and hence, decoupling is requir
multivariable system. The system is nonlinear by i
hence, a nonlinear approach is used for the design
controller. Therefore, the suggested design tech
the nonlinear cancellation approach. The pe
nonlinear mathematical model of the electr
the state space form. A numerical exa
illustrate the effectiveness of the desi
suggested design technique. Simulation
of the electromechanical system u
external disturbance on the load s

INTRODUCTION:

Electromechanical systems are usually exposed to different types of nonlinearities, which affect severely the dynamic performance of such systems. The electro-mechanical system shown in fig. (1) consists of a single phase alternator, driven by an armature controlled d. c. motor. The objective of this work is to design a nonlinear compensator for controlling the frequency and the amplitude of the a.c. power at the output terminals of the single phase alternator. The shown motor-generator set has two inputs. these inputs are the motor armature voltage and the field voltage of the alternator.

MATHEMATICAL MODEL OF THE SYSTEM : the mathematical model of the system can be represented in state space (1), by the following set of differential equations:

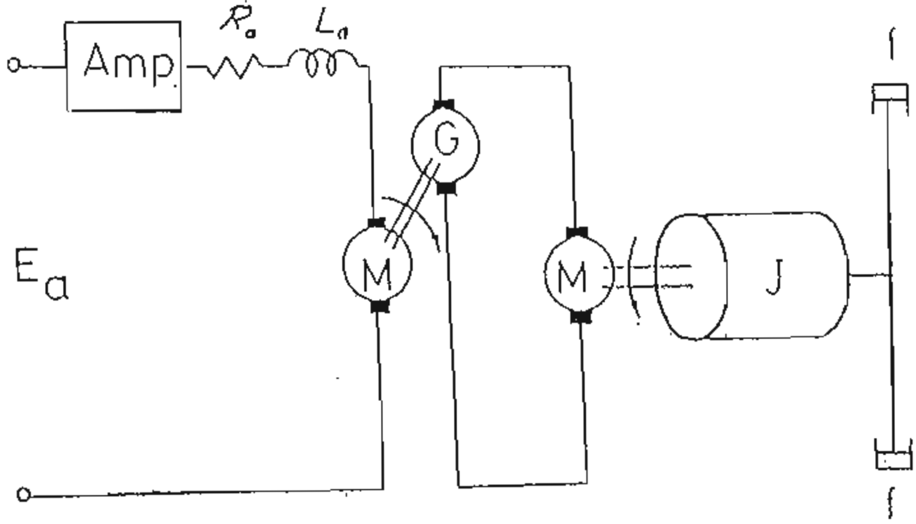

Fig. (1)

$$\dot{x}_1 = -\frac{R_L}{L} x_1 + \frac{Kg}{L} x_6 x_2 \qquad (1)$$

$$\dot{x}_2 = \frac{Fg}{J_g} x_2 + \frac{1}{J_g} x_5 - \frac{Kg}{J_g} x_6 x_1 \qquad (2)$$

$$= K_s(x_4 - x_2) \qquad (3)$$

$$\dot{x}_4 = \frac{F_m}{J_m} x_4 - \frac{1}{J_m} x_3 + \frac{K_m}{J_m} x_5 \qquad (4)$$

$$\dot{x}_5 = \frac{r_a}{L_a} x_5 - \frac{K_m}{L_a} x_4 + \frac{1}{L_a} u_1 \qquad (5)$$

$$\dot{x}_6 = - \frac{r_f}{L} x_6 + \frac{1}{L} u_2 \qquad (6)$$

$$y_1 = R_L x_1 \qquad (7)$$

$$y_2 = x_2 \qquad (8)$$

where:

x_1 = load current,

x_2 = angular velocity of the generator,

x_3 = the torque available to drive the generator,

x_4 = angular velocity of the motor,

x_5 = armature current of the motor,

x_6 = field current of the generator,

K_e = shaft stiffness,

r_a, L_a = motor armature resistance and inductance respectively,

R_L, L = local resistance and inductance respectively,

r_f, L_f = generator field resistance and inductance respectively,

F , L = viscous friction coefficient and rotor inertia respectively,

F_g, J_g = viscous friction coefficient of the generator of itsinertia,

F_m, J_m = viscous friction coefficient of the motor and load inertia,

K_g, K_m = generator and motor torque constants respectively,

u_1 = input armature voltage to the motor,

u_2 = input field voltage to the alternator,

y_1 = load voltage,

y_2 = angular velocity of the generator,

Compensator design via nonlinear cancellation:

The model represented by equations (1) → (8) can be re-written in the input/output form as follows [2,4] using equations (2), (7) & (8) we can write:

$$\dot{y}_2 = - \frac{k_m^2}{Jr_a} y_2 - \frac{1}{JR_L} \frac{y_1^2}{y_2} + \frac{k_m}{Jr_a} u_1$$

multiplying both sides by y_2 we get

$$y_2 \dot{y}_2 = - \frac{k_m^2}{Jr_a} y_2^2 - \frac{1}{JR_L} y_1^2 + \frac{k_m}{Jr_a} y_2 u_1 \qquad (9)$$

Also, from (7) we have