FURTHER INVESTIGATION ON TWO PHASE AND CAPACITOR SERVOMOTORS

A Thesis

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TO

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Submitted by

Lamey G. Makkar

B.Sc.(Elec. Eng. 1967) Cairo University.

Research Assistant in the Electrical & Electronic Eng. Lab.

National Research Centre, Cairo, U. A. R.

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بسم الله الرحمن الرحيم

SUMMARY

The aim of this thesis it to study the steady-state and transient performance of a capacitor servomotor both theoritically and experimentally using the Transformer Analog Network Analyser (TANA), and the digital computer.

The TANA is used to simulate the capacitor servomotor and to find out an empirical formula determining the variation of the reference voltage (after the connected condenser) as a function of the motor speed, control voltage, and the value of the connected capacitance.

A torque equation and a transfer function for the capacitor servomotor are obtained.

Several complicated digital computer programmes are written and executed to determine the torque-speed characteristics, the effects of the control voltage and the capacitance value on the gain and time constant of a capacitor servomotor and to solve the system of the nonlinear differential equations which describe the electromagnetic and electromechanical processes taking

place in the capacitor servomotor.

Experimental work is carried out to investigate both the steady-state and transient performance of the capacitor servomotor and to verify the theoritical results.

Chapter I is a general introduction and includes a comparison between the 2-phase servomotors and the d.c. servomotors, the methods of introducing the phase shift between the applied voltages on the two windings of the 2-phase servomotor. The capacitor servomotor as an unsymmetrical machine fed by a system of unbalanced two-phase voltages is also discussed in the introduction.

In chapter II, a brief survey of the available previous work concerning the study of the performance of the capacitor servomotors in the steady-state and transient conditions is presented.

The Transformer Analog Network Analyser's (TANA) theory, construction, and operation are presented in chapter III. Examples for solving simultaneous equations, power flow problems, and indudtion machine problems by the aid of the TANA are explained.

In chapter IV, the equivalent circuits of a group of thirteen capacitor servomotors of widely different parameters are simulated on the TANA to study the variation of the reference voltage (after the connected condenser), as a function of the motor speed, the applied control voltage, and different capacitance values. Torque equation is deduced by introducing the variation of the reference voltage as function of the motor speed, the control voltage, and the capacitance value in the torque equation obtained by Saleh and Yeforov [17] The motor parameters are included in the proposed torque equation in their relative values which simplifies the calculations of the torque-speed characteristics of all types of the capacitor servomotors.

The torque-speed characteristics of a drag-cup capacitor servomotor are computed on a digital computor for different values of the control voltage and different capacitance values using the proposed torque equation. Experiments are carried out on this capacitor servomotor to determine the variation of the reference voltage in magnitude and phase with the motor speed, the applied control voltage, and the capacitance value. Torque-speed characteristics are also determined experimentally for different control voltages by the aid of the torque-speedo-meter measuring instrument. For all cases, experiments confirmed the theoritical predicti s to a large extent.

In chapter V; a method has be n developed from the proposed torque equation to determine the gain and time constart of the capacitor servomotor. A digital computer programme is written and executed to determine the effects of the control voltage, as well as, the effects of the capacitance values on the gain and time constant. A new transfer function for the capacitor servomotor is also deduced taking into consideration, the nonlinearity of the capacitor servomotor.

A digital computer program is written and executed for the solution of the system of the nonlinear differential equations describing the electromagnetic and electromechanical processes in the capacitor servomotor, using Runge-Kutta-4 step method and the normalised motor parameters. The language used for the programme is the FORTRUN language. The transient torque-time, speed-time, and torque-speed curves are recorded for different control voltages.

The transient speed of the drag-cup capacitor servomotor under investigation is recorded experimentally using a light beam recording oscillograph (lumiscript).

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LIST OF MAIN SYMBOLS

V_c the applied voltage to the control winding,

V_s the applied voltage to the reference winding,

V_r the voltage at the reference winding terminals after the connected condenser in series with the reference winidng,

k the ratio of the effective number of turns of the rerference winding to that of the control winding,

$$\nu = \frac{n}{n_s} = \frac{\text{rotor speed}}{\text{motor synchronous speed}} ,$$

n_{NL} the no load speed,

r_R effective rotor resistance,

r_{S1} effective resistance of the control winding,

r_{S2} effective resistance of the reference winding ,

X_M the mutual reactance,

$X_{s\ell_1}$ the equivalent leakage reactance of the control winding,

$X_{s\ell_2}$ the equivalent leakage reactance of reference winding,

$X_{\ell R}$ the equivalent leakage reactance of the rotor winding ,

X_c the equivalent reactance of the condenser connected in series with the reference winding,

J Moment of inertia of rotating parts,

F frictional force per unit angular speed,

CHAPTER I

INTRODUCTION

The servomotors are considered of the most important elements of control systems. They are classified into two main types; nonelectric servomotors and electric servomotors. Nonelectric servomotors, such as hydraulic and pneumatic motors, are particularly required for very wide speed ranges. The electric servomotors are classified into direct current servomotors and alternating current servomotors. The direct current servomotors have been particularly used in air-craft control system, where weight and space limitations require motors having minimum weight to power ratio.

In modern precise servomechanisms, d.c. servomotors have been replaced by the two-phase a.c. servomotors. The most significant properties of these servomotors compared with d.c. servomotors are:

I) Their reliability based on the absence of any sliding contacts.

II) The absence of radio interference.

III) The absence of commutator that requires periodic maintainance and occupies a large percentage of