Speed Control of Induction motors

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A C K N O W L E D G E M E N T

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S U M M A R Y

The present research work deals with the theoretical and experimental investigation of the method of speed control of a 3-phase induction motor applying the thyristors as the control element.

In general different methods can be used to satisfy speed control of induction motors applying thyristors as the control element. The method described here applies thyristors in series with the stator windings in a back-to-back connection. By this method, the applied a.c. voltage to the motor terminals can be varied by adjusting the firing angle at which the current begins to flow through the motor windings. This will affect the values of the speed and torque of the motor.

In this thesis a three phase transistorized firing circuit has been used to supply the gate pulses required for firing the six back-to-back thyristors connected in the stator side of the motor. These gate pulses are always synchronized with the frequency of

the a.c. supply. The unijunction transistor is one of the main elements used in this firing circuit.

The mathematical analysis of the system was carried out aided with the two axes theory. It is important to state here that for the analysis of the three-phase induction motor controlled by back-to-back thyristors in series with the motor windings, it was found necessary to leave the stator as it is, i.e. a three phase one. Meanwhile, the rotor is transformed to an equivalent two phase one in order to simplify the differential equations of the system and to get rid of the effect of rotation. The stator is left as it is in order to consider the effect of the presence of the thyristors in each phase separately. By this method, the machine has been treated as a stationary transformer.

The differential equations of the system have been solved numerically on the digital computer (I.B.M. 1130). The transients due to starting, sudden loading and sudden variation of the firing angle are studied. The phase currents, phase voltages, electric torque as well as the mechanical speed have been calculated for different values of firing angles.

A large agreement has been observed between the theoretical and the experimental results obtained.

This research work can be applied successfully in industry to replace the d.c. motor by a three phase controllable induction motor in which the speed and torque can be controlled easily. Thus, the troubles due to commutation and brushes of the d.c. machine can be avoided.

C O N T E N T S

Page

SECTION V.

SECTION VI

A P P E N D I X

LIST OF SYMBOLS

E	:	voltage
E_1 , E_2 , E_3	:	terminal voltages of the 3-phase machine.
$\bar{E}_s$	:	The resultant stator voltage vector
$\bar{E}_r$	:	resultant rotor voltage vector
E_D , E_Q	:	the direct and quadrature components of $\bar{E}_r$ referred to stator axes
i	:	current
i_1 , i_2 , i_3	:	stator phase currents
i_1' , i_2' , i_3'	:	rotor phase currents.
$\bar{i}_s$	:	resultant stator current vector
i_{sD} , i_{sQ} ,	:	the direct and quadrature components of $\bar{i}_s$
$\bar{i}_r$, $\bar{i}_{rs}$	:	resultant rotor current vector referred to rotor and to stator axes respectively.

i_d , i_q : the rotor direct and quadrature current components referred to rotor axes.

i_D , i_Q : the rotor direct and quadrature current components referred to stator axes.

i_o , $\grave{i}_o$: zero sequence components of stator and rotor currents respectively

ψ : flux linkage

$\bar{\psi}_s$: stator flux linkage vector

$\bar{\psi}_r$: rotor flux linkage vector

ψ_1 , ψ_2 , ψ_3 total flux linking phases 1 , 2 and 3 of stator windings.

ψ_D , ψ_Q : the direct and quadrature components of the resultant flux linkage vector referred to stator system of coordinates.

R : resistance.

R_1 , R_2	:	stator and rotor winding resistance per phase respectively.
L	:	main inductance of the induction machine.
σ	:	leakage factor
t	:	time
W_m	:	rotor angular speed
[illegible]	:	electrical rotor position angle.
N_p	:	number of pairs of poles
M	:	mechanical torque
T_e	:	electromagnetic torque
	:	friction coefficient.
J	:	inertia coefficient
α	:	firing angle
β	:	extinction - angle.

SECTION I

Introduction

This can be achieved in either one of the following two methods :

In the first case, the induction motor is to be supplied from a d.c. supply through a 3-phase electronic static power inverter (2), where six thyristors are to be used for inverting the available d.c. power into a 3-phase one of controlable frequency. The frequency of the inverter output voltages follows that of the low power (few watts) triggering signals supplied to the gates of the thyristors. These triggering signals are to be obtained from an electronic circuit comprising mainly a ring-counter and supplied from a variable frequency low power oscillator.

The other method used for speed control of induction motors is realized by feeding the induction motor from a 3-phase power supply through back-to-back thyristors connected in series with the lines supplying the different phases of the motor. By controlling the firing angle of the thyristors, a control of the current flowing in the stator will be achieved, and accordingly a controllable torque-speed characteristics can be obtained.