The Starting Characteristics Improvement of Single-Phase Induction Motor Reducing Over Current

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Abstract - **The most common method of the single phase induction motor(SPIM) is to install a starting condenser and a centrifugal switch in series with the auxiliary winding. Even though this capacitor start method is embodied simply, it is feasible because of motor failure from malfunction of the centrifugal switch and the starting condenser. Moreover, it is hard to improve the performance characteristics of the SPIM.**

In this paper, the voltage and phase angle sequence control strategy of the auxiliary winding of the SPIM is employed to eliminate the centrifugal switch and the starting condenser. The proposed control system is superior to a conventional system in the starting performance of SPIM.

Finally, the improved starting characteristics of the SPIM is obtained with this strategy through simulation and experimental results.

I. INTRODUCTION

For the SPIM is can't generate rotating flux itself, an additional starting system should be installed on SPIM. Capacitor start method is composed of a starting condenser and centrifugal switch is widely used. But the centrifugal switch and the starting condenser have some problems of the starting failure, the breaking under the worse condition and it brings about the short life of the motor. Nowadays, users demand higher efficiency, reliability, miniaturization and noise immunity than conventional motor.[1,2] The conventional control drives using variable frequency have not been applied to SPIM because of starting problems, low speed operating characteristics, complexity, high cost, and controllability.[3]

In this paper, a voltage and phase control strategy is proposed instead of capacitor start method. In this method, the starting current and the starting time are determined by voltage and relative phase angle of the auxiliary winding. When the starting current of motor is minimized by adjusting the relative phase angle of voltage in the main and auxiliary winding and by adjusting the voltage amplitude of the auxiliary winding, the efficiency of motor is improved. Also, a good soft starting is achieved by using this phase amplitude controller which enabled to start the SPIM without the starting condenser.

II. SYSTEM CONFIGURATION

Fig.1 shows the block diagram of whole system. The main winding of motor is connected to power source through a solid state relay(SSR) and the auxiliary winding is connected to the some power source through a phase amplitude controller.[4]

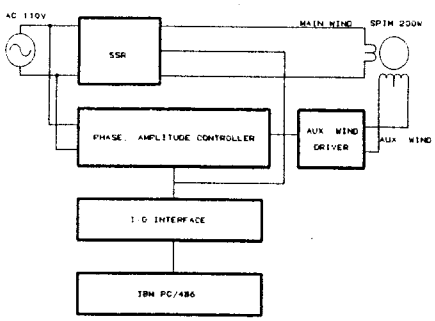


Fig. 1 Block diagram of the proposed system

The controller exchange informations with the IBM PC/486 through I/O interface. If the controller received command signals from the PC/486, this controller generates delayed and modulated signals and applies to the base of power module transistor. By the using programmed controller, the voltage level relative phase angle of the auxiliary winding voltage are freely controlled with the limits.

III. SIMULATION

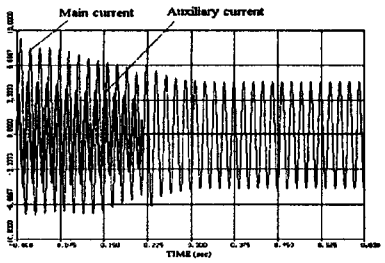
For modelling the performance of the SPIM operating in steady state, the Double Revolving Field Theory[5] and D-Q Model[6] are used. Simulations were performed to determine the starting current, the torque and the speed characteristics of the SPIM in the proposed control system. The parameters of the motor are listed in Table 1.

Fig.3 shows the current waveforms of main and auxiliary winding, with variation speed of the SPIM when it speeds up.

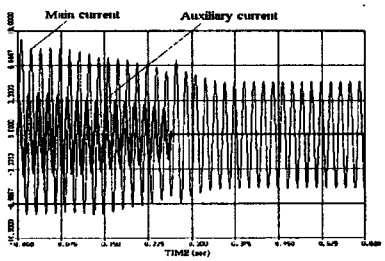
Table 1. The parameters of SPIM

Power	210[W]	Stator Resistance	3.48[Ω]
Voltage	110[V]	Stator Reactance	5.316[Ω]
Freq.	60[Hz]	Magnetizing Impedance	5.387[Ω]
Speed	1710[rpm]	Magnetizing Reactance	41.993[Ω]
Poles	4[poles]	Rotor Resistance	5.873[Ω]
		Rotor Reactance	9.215[Ω]
		Aux. W. Impedance	10.928[Ω]

These characteristics results were obtained by setting Va=100[V], 80[V], with displaced Φ by 90° . Fig.4 was obtained when Φ takes the place of 80° , 60° with Va = 100[V]. Based on these results, a sequence control starting method and its algorithm were considered to achieve the soft starting and the enhanced performance of the SPIM. To produce starting torque, Φ is kept by nearly 90° , Va is sequentially increased from low voltage to rated voltage of motor until its speed reached to about 75% of the rated speed in this algorithm.



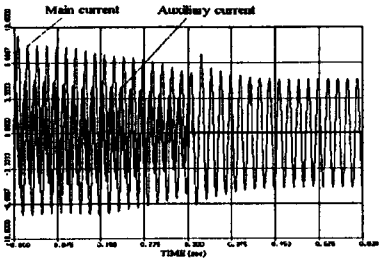
(a) Va = 100V



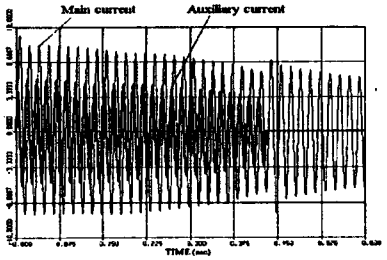
(b) Va = 80V

Fig. 3 Current waveform by variable auxiliary winding voltage

Fig.5(a) shows the curves of speed and currents of the capacitor start SPIM when its windings are applied to the rated voltage. Comparing in Fig.5(a), when Va was increased sequentially from 10V to 100V, according to the voltage and phase control strategy, the more soft starting characteristics of motor was obtained with Fig.5(b).

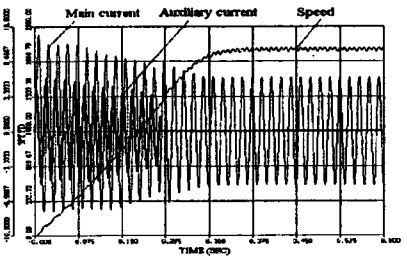


(a) Φ = 80°

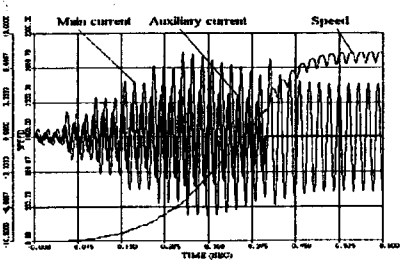


(b) Φ = 60°

Fig. 4 The starting characteristics by variable phase angle (Va = 100V)



(a) Capacitor starting

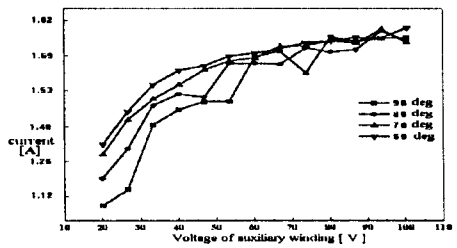


(b) Sequency starting

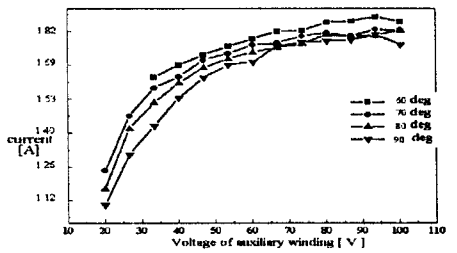
Fig. 5 Current waveform and speed curve

Ⅳ. EXPERIMENTAL RESULTS

Fig. 6 shows the starting current with respect to sequentially increased Va within the range of 20V ~100V and set Φ=90° , 80° ,70° and 60° with no load(a) and with load(b). In these figures, the starting current of auxiliary winding is in proportion to Va and in reversely proportion to Φ. Under the load test, its results show that when Φ=90° , or 80° , the starting times are short enough in each case and the current of main winding is small enough with Va=54V, 60V, 80V and 87V. Fig.7 shows the current waveform of the capacitor start and the proposed sequence control of SPIM. In comparison with the capacitor start system of motor, the proposed control system shows that it does contribute to save the starting current of motor about 40%.



(a) no load

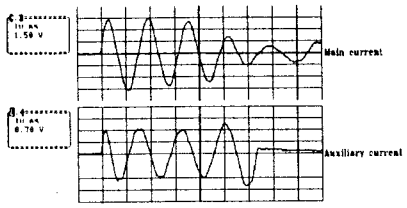


(b) load

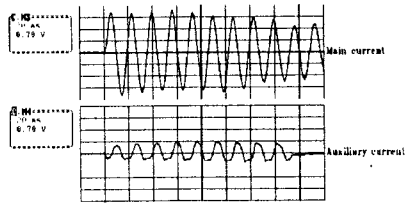
Fig. 6 The starting current by variable auxiliary winding voltage and phase angle

Ⅴ. CONCLUSIONS

The voltage and phase control strategy to enhance the starting characteristics of the capacitor start SPIM is presented in this paper. This strategy embodied by a starting controller based on the IBM PC/486. With increasing the voltage amplitude sequentially and adjusting the voltage phase angle of the auxiliary winding of single phase induction motor, the efficiency and the starting characteristics of SPIM can be improved. This controller enables to adjust the starting torque, current and time for soft starting of noise immunity. The system could be contributed to improvement efficiency of the SPIM. From now on, the study makes further progress to use the sequence controller on the various types of single phase induction motors running under the worse condition.



(a) Capacitor starting



(b) Sequency starting

Fig. 7 Current waveform

Ⅵ. ACKNOWLEDGEMENTS

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