Simulation Analysis on Permanent Split Capacitor (PSC) Motor Based on the MATLAB/SIMULINK

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Abstract: - A Matlab/Simulink analysis is performed for the speed control of single phased permanent split capacitor (PSC) motors used in the application of air curtains. The Matlab/Simulink model is established for the PSC motor and the parameters are investigated according to the current, voltage, power and speed values. An Isolated Gate Bipolar Transistor (IGBT) is used for the driver circuit. The signal applied on the motor is Pulse Width Modulation (PWM) inverter. The speed tuning is obtained by changing pulse width using the PWM. The driver efficiency is an important factor especially for the motors that need to be active consistently. In this study, the efficiency of the driver circuit is calculated and suggested to be relatively better when compared to the conventional techniques.

Key-Words: Matlab/Simulink, PSC Motor, PWM, IGBT

1. Introduction

Asynchronous motors are frequently used in industrial applications and residences due to their user friendliness, simple design and ability to be maintenance free and cheap [1]. In industrial applications, three phased asynchronous motors are used while single phased motors are preferred in household appliances because of their easiness in power access [2].

Single phased asynchronous such as permanent split capacitor (PSC) motors, divided phase motors, fixed magnet synchronous motors and shaded pole motors are especially used in household appliances. There are many studies in the literature that investigate the control and analysis of those motors. Different types of PWM is used as the control signal in those studies [2-24].

In this study, the performance analysis of a single phased fixed magnet asynchronous motor consisting of a main and a minor coil is evaluated by establishing the Matlab/Simulink model of a PWM controlled driver using IGBT. The performance analysis is evaluated according to the motor stage. The results and analysis are performed according to the fact that the study is designed as having six stages.

2. Parameter Determination

The minor coil and the capacitor which is connected to it in series are active during all the work stage of PSC motors. The capacitor is an oil paper capacitor which can be active continuously. Those kinds of motors are often preferred in household appliances such as aspirator and fan because of their silence in operation. The equivalent circuit that belong to those motors are given in Fig. 1.

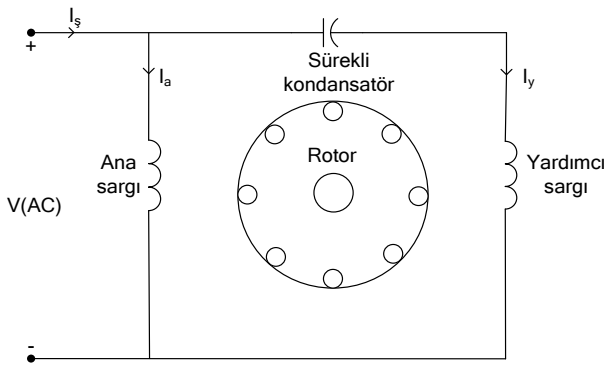

Figure 1. The equivalent circuit of a single phased asynchronous motor having a continuous capacitor

Several experiments are required in asynchronous motors in order to determine the motor parameters. In this study, DC test,

locked rotor and idle running experiments are performed. The test results are presented in Tables 1, 2 and 3.

Table 1. DC experiment results

DC experiment		
	Major Coil	Minor Coil
R_{DC}	58 Ω	85 Ω

Table 2. Locked rotor experiment results

Locked Rotor Experiment		
	Major Coil	Minor Coil
R_{DC}	58 Ω	85 Ω
U_{BL}	235 V	74 V
I_{BL}	1,4 A	0,510 A
θ	28^0	27^0

Table 3. Idle running experiment results

Idle Running Experiment		
θ_{NL}	58^0	58^0
V_{NL}	235V	235V
I_{NL}	920mA	920mA

Where R_{DC} is the coil resistance, U_{BL} and V_{NL} are voltages, I_{BL} and I_{NL} are currents, θ and θ_{NL} are angles in the tables.

3. Matlab/Simulink Model

The current, the rpm, the voltage and the power values of the motor are obtained by using the determined parameters and the Matlab/Simulink model according to the stages of the motor. The parameter input screen view is given in Fig. 2.

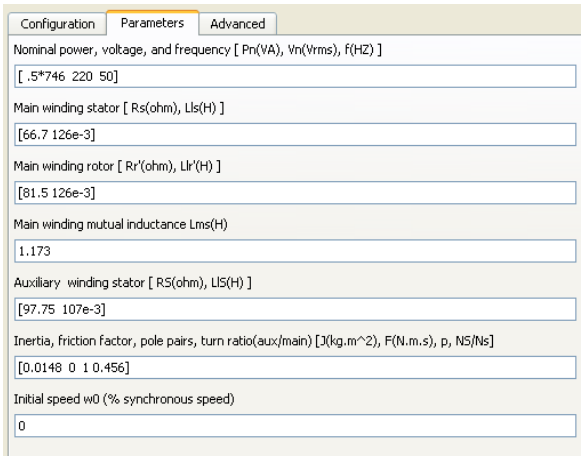

Figure 2. The motor parameters for Matlab

The Matlab/ Simulink model is shown in Fig. 3.

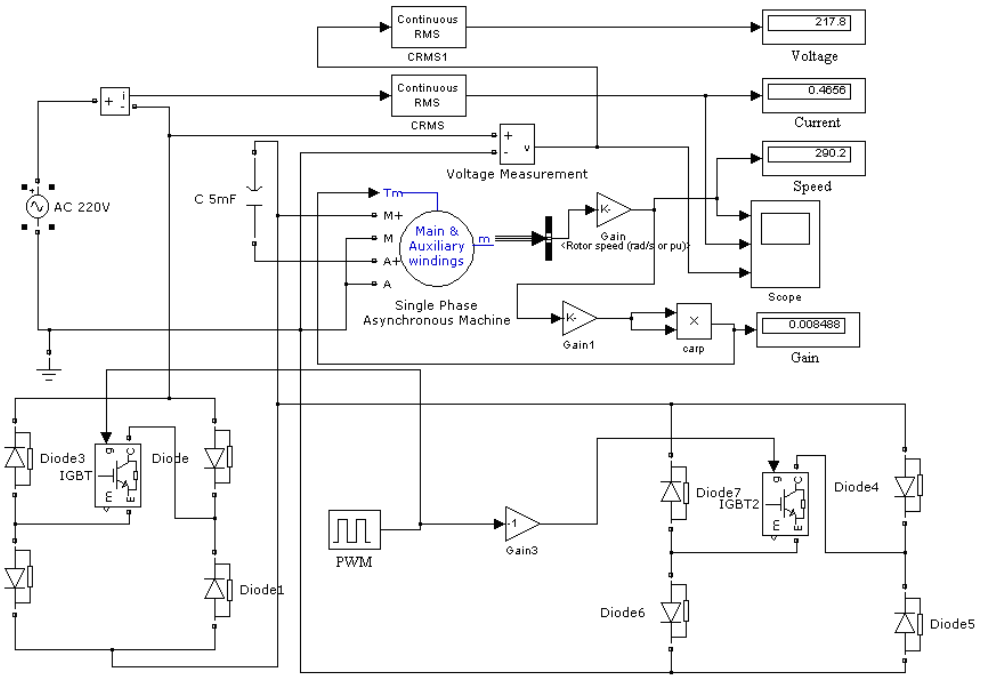

Figure 3. Matlab/Simulink model

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4. Simulation Results

PWM is used as the control signal of PWM motor. The control signal is generated according to the pulse width percentage. Fig. 4 shows PWM percentage with the motor stage. As it can be seen from the graph, the PWM percentage is increased as the stage increased. At the last stage, the PWM percentage is 99.9 %.

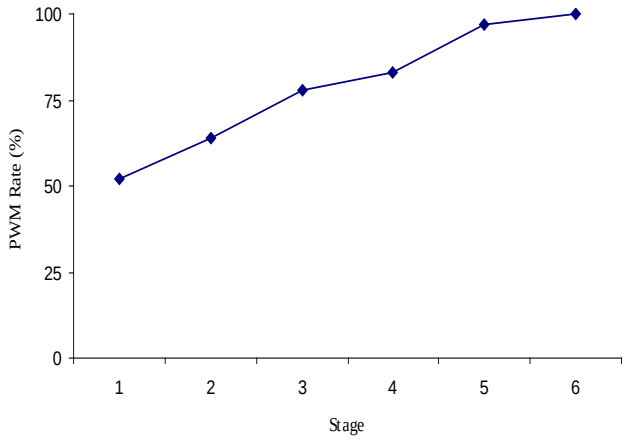

Figure 4. PWM rate according to the stage

The stage-speed graph is given in Fig. 5. As expected, the motor speed increases as the stage increases.

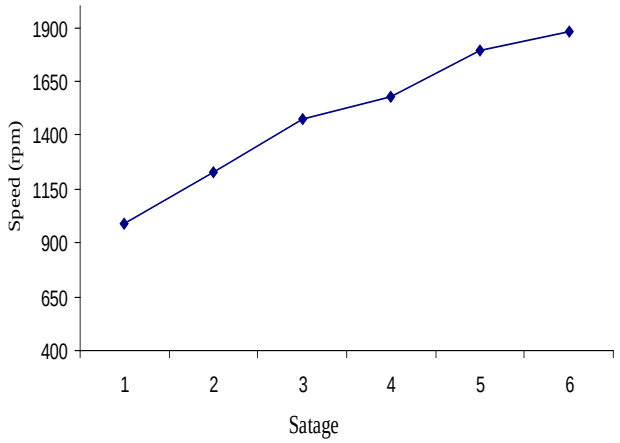

Figure 5. The motor speed according to the stage

The stage-current relationship is presented in Fig. 6. The current also increases with the increasing stage.

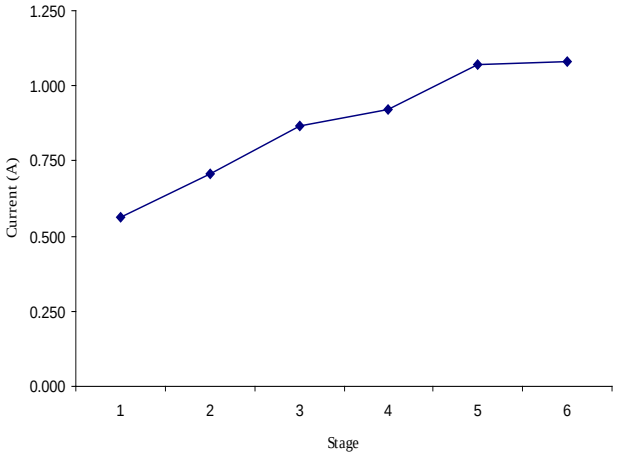

Figure 6. Motor current according to the stage

Lastly, the stage-power relationship is given in Fig. 7. The increase in stage also increases the power.

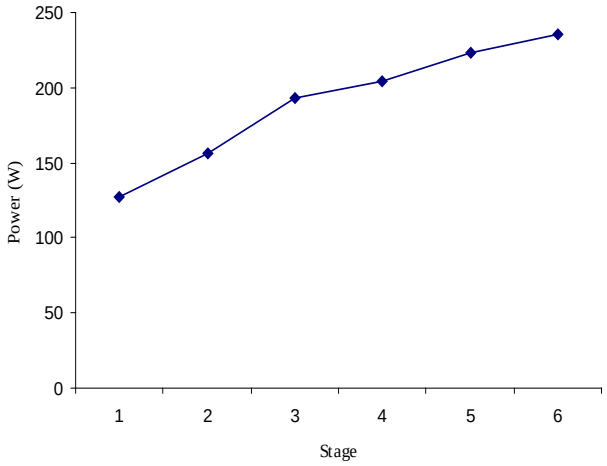

Figure 7. The motor power according to the stage

The efficiency of the driver circuit is measured at the 6th stage which is the last one. The efficiency of the driver is calculated as the ratio of the input and the output powers. As a result, the driver efficiency is obtained as 94.29 %.

$$\eta = \frac{P\varsigma}{Pg} \times 100 = \frac{220.45}{233.784} \times 100 = 94.29 \ \% \qquad (1)$$

5. Conclusion

In this study, a Matlab/Simulink based analysis according to the motor stage is performed for PSC (permanent split capacitor) motors that are used in small machine tools, boilers, cooling fans and household appliances such as washing machines, dishwashers, hair dryers and aspirators.

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As a result of the analyses of the parameters obtained according to the motor stages, it is suggested that the driver circuit for IGBT transistors and PWM application are significant. Especially for the air curtains in aspirators, the speed control of the motor strongly depend on the driver capabilities.

The simulation results show that the efficiency of the driver at the 6^{th} stage of the motor is about 95 %. This percentage matches up with the desired efficiency for the driver.

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