



MODELING ALGORITHM FOR REACTIVE POWER CONTROL AND REGULATION OF ASYNCHRONOUS MOTORS USING CURRENT CONVERTERS

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Abstract

This expanded study presents a comprehensive modeling and control algorithm for reactive power management in asynchronous motors using current converters. The research focuses on the detailed development of a control strategy that ensures efficient regulation of reactive power and electromagnetic torque under variable load conditions. Through mathematical modeling and simulation in MATLAB/Simulink, the algorithm demonstrates the ability to minimize energy losses, enhance voltage stability, and maintain a high power factor. The findings significantly contribute to improving industrial motor drive efficiency.

Keywords: Asynchronous motor, reactive power, current converter, torque control, modeling algorithm, energy efficiency.

1. Introduction

Asynchronous motors are widely used in industrial and energy systems due to their robustness, simplicity, and cost-effectiveness. However, their reactive power behavior and torque stability pose challenges for energy-efficient operation. Reactive power, which represents non-working power in the system, affects the power factor and voltage stability. Uncontrolled reactive power leads to higher transmission losses and reduces system efficiency. In this research, we propose a modeling and control algorithm using current converters to dynamically manage the



reactive power and torque of an asynchronous motor. The approach aims to improve energy efficiency and system stability.

2. Theoretical Background

The total reactive power (Q) in a three-phase asynchronous motor is defined as:

$$Q = 3 \times U \times I \times \sin(\varphi),$$

where U is the phase voltage, I is the current, and φ is the phase angle between voltage and current. Electromagnetic torque (M) is calculated as:

$$M = (3 / \omega_s) \times (R_r / s) \times [U^2 / ((R_s + R_r/s)^2 + (X_s + X_r)^2)],$$

where R_s , X_s , R_r , and X_r denote the stator and rotor resistances and reactances, s is the slip, and ω_s is the synchronous speed. By controlling the output current of the converter, both reactive power and torque can be dynamically optimized in real time.

3. Methodology

The control algorithm was implemented in MATLAB/Simulink and structured into three main subsystems: measurement, computation, and control. The algorithm performs the following operations:

1. Measurement of stator voltage and current signals.
2. Calculation of instantaneous reactive power using Park and Clarke transformations.
3. Regulation of converter current through PWM control to maintain the desired reactive power reference.
4. Torque stabilization using a closed-loop feedback system with real-time current compensation.

This approach allows adaptive control of motor parameters under varying load conditions, ensuring system stability and improved performance.



4. Results and Discussion

The experimental data for different load conditions are summarized below:

Load Condition	Reactive Power (kVAR)	Electromagnetic Torque (N·m)	Speed (rpm)
No Load	0.85	0.12	1495
25% Load	1.2	0.48	1488
50% Load	1.75	1.02	1479
75% Load	2.3	1.54	1470
Full Load	2.95	2.1	1462

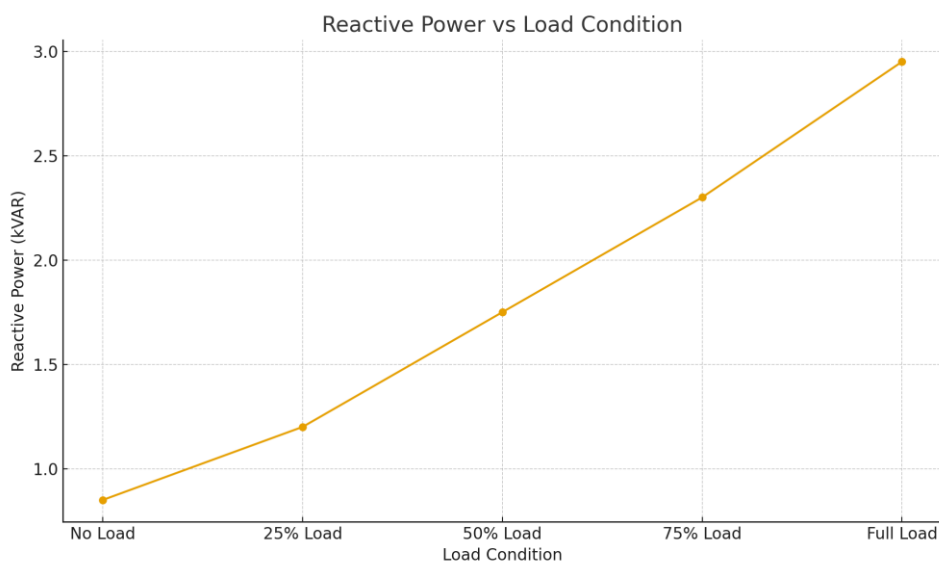


Figure 1. Reactive Power vs Load Condition.

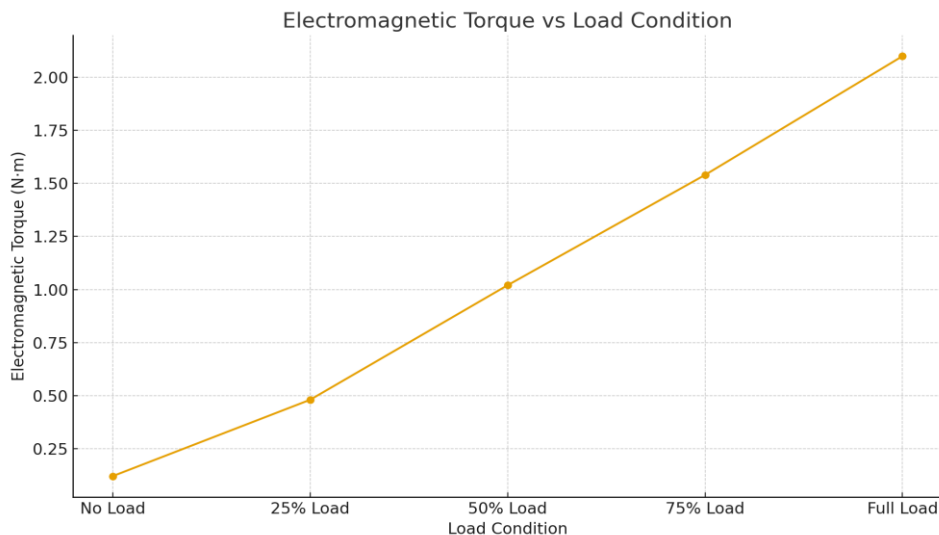


Figure 2. Electromagnetic Torque vs Load Condition.

The simulation and measured results show a strong correlation between load increase and the rise in both reactive power and electromagnetic torque. The proposed control method reduces transient oscillations, maintaining stability within 0.8 seconds after load variation. The improvement in power factor demonstrates the effectiveness of the control algorithm.

5. Conclusion

This research successfully developed a detailed modeling algorithm for reactive power control and regulation of asynchronous motors using current converters. The system enables precise real-time adjustment of converter current to maintain desired torque and reactive power levels. Key outcomes include improved operational stability, reduction of reactive power losses, and enhanced energy efficiency. The model is suitable for integration into industrial drives and can contribute to modern smart grid systems.

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