

Speed Control on a 3-Phase Induction Motor with an IFOC System Using a PI Controller: Simulation Approach

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Abstract— The three-phase induction motor remains a widely adopted solution for electric drive systems due to its low cost, high mechanical durability, and minimal maintenance requirements. However, its inherently non-linear dynamics pose substantial challenges for conventional control approaches. To overcome these limitations, advanced control strategies such as Indirect Field-Oriented Control (IFOC) have been introduced. IFOC enables decoupled control of torque and flux by transforming stator currents into a synchronously rotating d_q reference frame, allowing independent regulation of the torque-producing current (i_d) and the flux-producing current (i_q). In this study, a Proportional-Integral (PI) controller is employed as a speed regulator. The controller demonstrates effective tracking of speed commands with minimal overshoot and steady-state error, as well as fast rise and settling times. The proposed control approach incorporates real-time feedback from an incremental encoder, enabling dynamic adjustment of i_d and i_q , thus enhancing system responsiveness and stability. Implemented and simulated in the PSIM environment, the system's adaptability is evaluated through varying speed setpoints. Simulation results indicate that increasing the reference flux current (i_{ds}^*) decreases rotor speed and significantly affects dynamic performance indicators, validating the proposed method's effectiveness.

Keywords: 3-Phase Induction Motor, Electromagnetic Torque, Indirect Field Oriented Control (IFOC) method, Proportional Integral (PI), Speed Control



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INTRODUCTION

Three-phase induction motors are widely used in the industrial sector due to their simple and robust design, cost-effectiveness, and low maintenance. These advantages have led to the gradual replacement of DC motors in various applications. However, induction motors exhibit nonlinear characteristics particularly variable rotor resistance which complicate control compared to DC motors. A key limitation is their inability to maintain constant speed under varying loads; sudden load increases can reduce speed and affect system performance. To address this, a control system is required to regulate speed dynamically [1]. Such systems adjust input voltage and frequency to ensure efficient and stable operation across load

variations. Control strategies for induction motors are generally divided into scalar and vector control. While scalar control is simpler to implement, it suffers from major limitations, such as poor stability at high speeds and limited dynamic performance. One drawback is the coupling effect, where changing one control variable affects others, complicating precise control [2]. Additionally, scalar control performs poorly at low speeds due to voltage drops, resulting in significant torque reduction, known as torque degradation [3]. Thus, scalar control is generally unsuitable for applications requiring precision or high torque at low speeds. These limitations are illustrated in Figure 1, which depicts the decline in system performance under low-speed operating conditions.

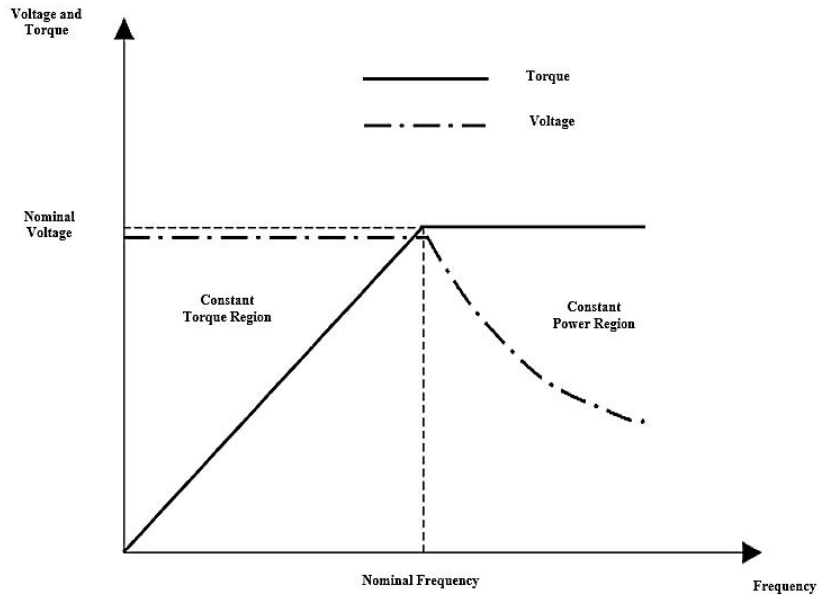


Figure 1. Scalar Control Characteristics [4]

As illustrated in Figure 1, during high-speed operation, the voltage drop across the stator resistance and inductance is relatively small and can generally be neglected. However, at low operating speeds, these voltage drops become significant and must be taken into account. This condition contributes to a considerable reduction in torque output, thereby resulting in poor torque capability under low-speed conditions. Consequently, scalar control is less suitable for low-speed applications due to its inability to maintain adequate torque in such scenarios [5]. In contrast, vector control also referred to as field-oriented control (FOC) offers a more advanced and effective approach. This method transforms the motor model from a coupled system into a decoupled form, allowing the induction motor to be controlled in a manner analogous to a separately excited direct current (DC) motor. Through this decoupling, key motor variables such as flux and torque can be independently regulated. Vector control delivers superior dynamic performance, enabling precise regulation of flux, torque, voltage, and current vectors. As a result, this control strategy is capable of maintaining high torque output even at low speeds, making it highly suitable for a wide range of industrial applications that require high-performance motor control. Vector control offers superior responsiveness to variations in both speed and load, thereby maintaining more consistent performance when compared to scalar control. As demonstrated in the study conducted by Sankeh Saha et al., which compares scalar and vector control methods in electric vehicle applications, vector control achieves faster speed tracking and lower energy consumption, ultimately resulting in higher overall efficiency [6]. The vector control method, more commonly referred to as Field-Oriented Control (FOC), is widely adopted in high-performance induction motor drive systems. By employing coordinate transformations, FOC facilitates the decoupling of electromagnetic torque control from rotor flux control, thereby enabling control of the induction motor in a manner analogous to that of a separately excited

direct current (DC) motor. This decoupling of torque and flux components significantly improves the motor's transient response, making FOC the preferred method in applications that demand high precision and dynamic performance. Field-Oriented Control (FOC) techniques are generally categorized into two main types: Direct Field-Oriented Control (DFOC) and Indirect Field-Oriented Control (IFOC). The fundamental distinction between the two lies in the method used to obtain information about the rotor flux. DFOC typically relies on a Hall-effect sensor to directly measure the air-gap flux. However, this approach presents several practical challenges, including high implementation costs, difficulties in sensor placement within the motor, and reduced measurement accuracy particularly at low operating speeds. As a result, IFOC, which estimates rotor flux through mathematical modeling rather than direct measurement, is more widely adopted in both research and industrial applications [7]. An effective speed control system should be capable of reaching steady-state conditions in the shortest possible time. This can be achieved through various strategies, such as proportionally adjusting the inverter's voltage and frequency to maintain optimal flux conditions, or fixing the voltage while significantly increasing the operating frequency beyond the fundamental level. To fulfill these performance requirements, the Indirect Field-Oriented Control (IFOC) method has been developed as a highly effective torque control strategy for three-phase induction motors. IFOC enables precise speed regulation and improved dynamic response, making it particularly suitable for applications that demand high-performance motor control. To address the complexity involved in regulating induction motors, a control method is required that enables precise speed regulation comparable to that of direct current (DC) motors. One such method is vector control, which leverages the dynamic behavior of the motor under varying operating conditions [8]. Unlike conventional control techniques, vector control not only regulates the magnitude and frequency of the angular speed but also manages the position of the voltage, current, and stator flux space vectors. This approach allows for more accurate control of both torque and speed, making it highly suitable for applications that demand high-performance motor drives. By aligning the rotor flux vector with a rotating reference frame, vector control improves both the efficiency and dynamic response of the motor. Furthermore, it achieves decoupling between the torque and flux-producing components, thereby enabling independent control similar to that of a separately excited DC motor. In this study, a Proportional-Integral (PI)-based speed controller is employed, which demonstrates the capability to rapidly track changes in the speed setpoint, thus offering high control system performance. The PI controller effectively minimizes overshoot and steady-state error, while also achieving relatively fast rise and settling times. Given the various challenges associated with the speed control of three-phase induction motors, this research focuses on modeling an Indirect Field-Oriented Control (IFOC) system for speed regulation using a PI controller. Building upon this framework, the proposed IFOC-PI approach exhibits notable advancements over conventional scalar and vector control methods. Unlike scalar strategies such as the V/f method, which lack precision in dynamic conditions, and traditional vector control systems that often rely on statically tuned PI gains, the proposed method integrates real-time feedback from an incremental encoder to dynamically regulate both torque-producing (I_q) and flux-producing (I_d) current components. This results in superior system responsiveness and stability under varying operational conditions. Moreover, a unique contribution of this research lies in the implementation of the control system within a PSIM simulation environment, enabling comprehensive modeling of encoder-based speed estimation and its integration into the control loop. Through the variation of speed setpoints (`nm_cmd`), the simulation facilitates in-depth analysis of system adaptability and robustness, effectively demonstrating the advantages of the IFOC-PI scheme in handling transient responses. This combination of dynamic feedback control, precise encoder integration, and rigorous simulation makes the proposed methodology a significant enhancement over existing control strategies for three-phase induction motor drives.

METHOD

In this study, the control system for a three-phase induction motor is developed based on the Indirect Field-Oriented Control (IFOC) method. A principal challenge in motor control is the ability to maintain constant speed despite variations in load. Typically, any change in load causes the motor speed to deviate from its reference value. Therefore, the speed control system is designed to ensure that the motor maintains the predefined reference speed even under external disturbances. The research begins with the design of the control block diagram, as illustrated in Figure 2, which depicts the overall control architecture of the IFOC-based three-phase induction motor system. The block diagram comprises several main components: the speed controller, current controller, coordinate transformation blocks (abc-to-dq and dq-to-abc), and the motor model. The speed controller, implemented using a Proportional-Integral (PI) controller, compares the reference speed with the actual rotor speed.

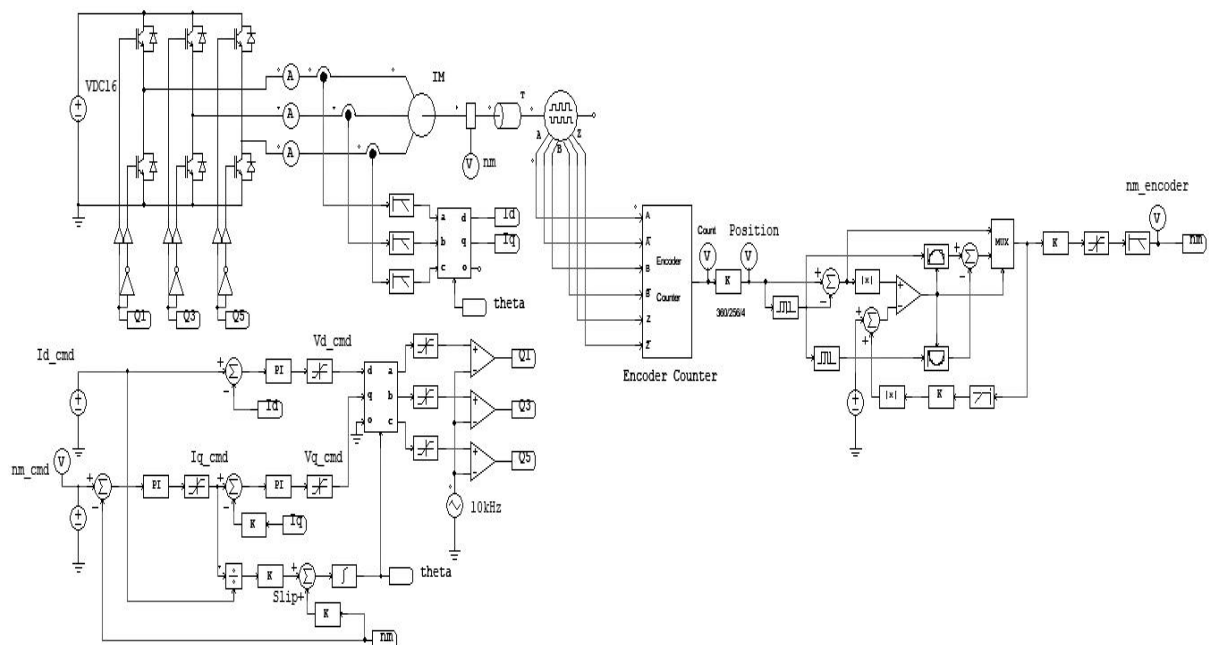


Figure 2. Block diagram of 3-phase induction motor speed control using the IFOC method using a PI controller

The resulting error signal is processed to generate the reference torque-producing current (i_{qs}^*). Simultaneously, a constant value is assigned to the magnetizing current (i_{ds}^*), which is essential for controlling the motor's magnetic flux. The reference currents (i_{ds}^* and i_{qs}^*) are subsequently transformed back through inverse coordinate transformation and fed to the current controllers. These controllers generate the control inputs for the inverter, which supplies the appropriate voltage to the induction motor. Simulation studies are conducted using Power Simulator (PSIM) to evaluate the system's performance, with particular focus on dynamic response, rise time, and overshoot under various speed setpoints and load conditions. The results provide valuable insights for optimizing controller parameters to enhance overall motor efficiency and stability. These findings highlight the importance of precise current regulation in achieving smooth torque response and minimizing mechanical stress. Furthermore, the simulation results demonstrate the effectiveness of the proposed control strategy in maintaining performance under sudden load disturbances. The system exhibits fast recovery and minimal oscillation, indicating robust control behavior. Comparative analysis with conventional methods reveals significant improvements in both transient and

steady-state performance. Overall, the proposed approach offers a reliable and efficient solution for high-performance induction motor drive applications.

A. 3-Phase Induction Motor Modelling

The dynamic model of an induction motor in a stationary reference frame can be expressed as Equations (1)-(4) [12].

Voltage Equation:

$$[V_{sabc}] = [R_s][I_{sabc}] + \frac{d}{dt}[\varphi_{sabc}] \quad (1)$$

$$[V_{rabc}] = [R_r][I_{rabc}] + \frac{d}{dt}[\varphi_{rabc}] \quad (2)$$

Flux Equation:

$$[\varphi_{sabc}] = [L_{os}][I_{sabc}] + [M_{osr}][I_{rabc}] \quad (3)$$

$$[\varphi_{rabc}] = [L_{or}][I_{rabc}] + [M_{osr}][I_{sabc}] \quad (4)$$

The explanation of the formula above can be explained in matrix form as shown in equations (5)-(7) below [13], in figure 3 is the ABC and d_{q0} transformation in the Stationary Reference Frame. This transformation is essential for simplifying the control of AC machines by converting time-varying signals into steady-state values in the rotating reference frame.

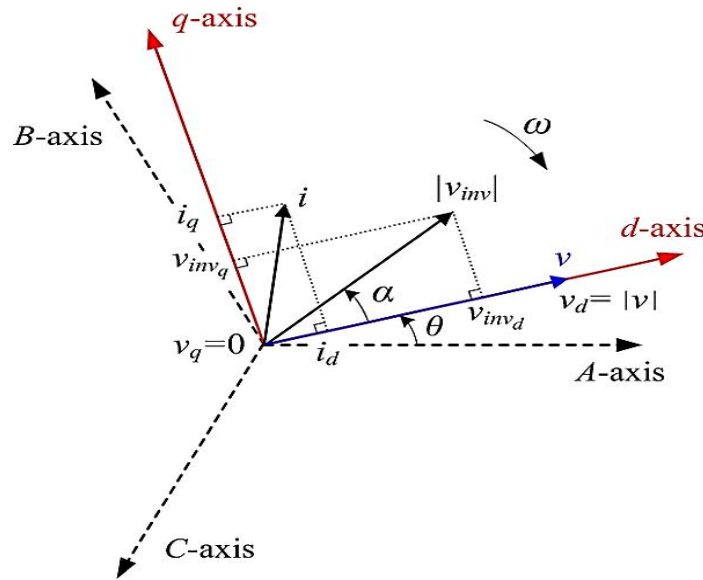


Figure 3. Transformation relations ABC and d_{q0} in the stationary reference frame

$$[V_{sabc}] = \begin{bmatrix} V_{sa} \\ V_{sb} \\ V_{sc} \end{bmatrix}; [I_{sabc}] = \begin{bmatrix} i_{sa} \\ i_{sb} \\ i_{sc} \end{bmatrix}; [\varphi_{sabc}] = \begin{bmatrix} \varphi_{sa} \\ \varphi_{sb} \\ \varphi_{sc} \end{bmatrix} \quad (5)$$

$$\begin{matrix} V_{ra} & i_{ra} & \varphi_{ra} \\ [V_{rabc}] = [V_{rb}] ; [I_{rabc}] = [i_{rb}] ; [\varphi_{rabc}] = [\varphi_{rb}] \\ V_{rc} & i_{rc} & \varphi_{rc} \end{matrix} \quad (6)$$

$$\begin{matrix} \cos(p\theta) & \cos(p\theta + \frac{2\pi}{3}) & \cos(p\theta + \frac{4\pi}{3}) \\ [M_{osr}] = [\cos(p\theta + \frac{4\pi}{3}) & \cos(p\theta) & \cos(p\theta + \frac{2\pi}{3})] \\ \cos(p\theta + \frac{4\pi}{3}) & \cos(p\theta + \frac{2\pi}{3}) & \cos(p\theta) \end{matrix} \quad (7)$$

Ideally, a 3-phase induction motor is assumed to be in symmetrical condition. The d_{q0} reference frame is usually placed depending on the position of compatibility with the motor analysis components used. In this research, the dynamic model of an induction motor uses a stationary reference frame as a reference d_{q0} . To transform condition abc into d_{q0} , the first thing that must be done is to determine the direction of rotation of the rotor in stationary (unchanging) conditions [14].

Table 1. 3-Phase Motor Induction Parameters [15]

Parameter	Symbol	Value	Unit
Stator Resistance	R_s	0.294	Ω (Ohms)
Rotor Resistance	R_r	0.156	Ω (Ohms)
Stator Inductance	L_s	0.00139	H (Henry)
Rotor Inductance	L_r	0.00074	H (Henry)
Poles	-	6	Unitless
Magnetization Inductance	L_m	0.041	H (Henry)
Momen of Inertia	-	0.002	Unitless

B. Indirect Field Oriented Control (IFOC)

The Indirect Field Oriented control (IFOC) system is a method that has advantages in controlling flux, voltage vector and current vector [16]. By using this method, induction motors can be regulated flux and torque separately like DC motors. The three-phase current system (abc) will be converted into an orthogonal two-phase system ($\alpha\beta$) first. Then, the system is converted into a two-phase rotational system (d_q) or commonly known as the d_q coordinate system. To convert a three-phase system into two orthogonal phases, use the Clark transformation equation.

$$I_\alpha = I_a - \frac{1}{2}I_b - \frac{1}{2}I_c \quad (8)$$

$$I_\beta = \frac{\sqrt{3}}{2}I_b - \frac{\sqrt{3}}{2}I_c \quad (9)$$

The inverse Clark transformation is used to reverse transform the α and β components into components a, b, and c using the following equation.

$$I_a = I_\alpha \quad (10)$$

$$I_b = -\frac{1}{2}I_\alpha + \frac{\sqrt{3}}{2}I_\beta \quad (11)$$

$$I_c = -\frac{1}{2}I_\alpha - \frac{\sqrt{3}}{2}I_\beta \quad (12)$$

To convert an orthogonal two-phase system into two stationary phases, use the Park transformation equation as follows.

$$I_d = I_\alpha \cos \theta + I_\beta \sin \theta \quad (13)$$

$$I_q = -I_\alpha \sin \theta + I_\beta \cos \theta \quad (14)$$

The inverse Park transformation is used to reverse transform the d and q components into α and β components using the following equation.

$$I_\alpha = I_d \cos \theta - I_q \sin \theta \quad (15)$$

$$I_\beta = I_d \sin \theta + I_q \cos \theta \quad (16)$$

From these calculations, an equation is obtained that can separate torque current and field current (decoupled). To find out the value of the angle in the Park transformation, the following equation is used.

$$\theta_t = \int_0^T \omega t \, dt + \theta_0 \quad (17)$$

In this control scheme, the motor speed is monitored using a rotary encoder as a speed sensor. The measured speed serves as system feedback, which is then compared to the reference speed. The result of this comparison is an error signal that is processed to generate a reference value for the torque-producing current (i_q^*), which becomes the input to the controller in this case, a Proportional-Integral (PI) controller. The output of the controller is then sent to the Indirect Field Oriented Control (IFOC) system and subsequently forwarded to the inverter for motor actuation [17].

C. Proportional-Integral (PI) Controller

The PI controller is a combination of a proportional controller and an integral controller. Where the characteristics of a proportional controller are reducing rise time, increasing overshoot, and reducing steady state error. Meanwhile, the integral controller has the characteristics of reducing rise time, increasing overshoot and settling time, and eliminating steady state errors. Proportional and Integral controllers have the same characteristics in terms of rise time and overshoot. In this study, a Proportional-Integral (PI) controller was implemented to regulate the speed and current of an induction motor drive system. The design and tuning of the PI controller were carried out using the trial-and-error method, which is a practical and intuitive approach often applied when an analytical model of the system is either unavailable or too complex to be accurately represented. The trial-and-error method involves iterative adjustment of the proportional gain (K_p) and integral gain (K_i) parameters based on the time-domain response of the controlled system. Initially, the integral gain was set to zero and the proportional gain was gradually increased until a satisfactory transient response (i.e., rise time, settling time, and overshoot) was observed without causing instability. Subsequently, the integral gain was introduced incrementally to eliminate steady-state error and enhance system accuracy. The final values of proportional gain (K_p) and integral gain (K_i) were selected based on a balance between dynamic performance and steady-state accuracy, ensuring system stability under various operating conditions.

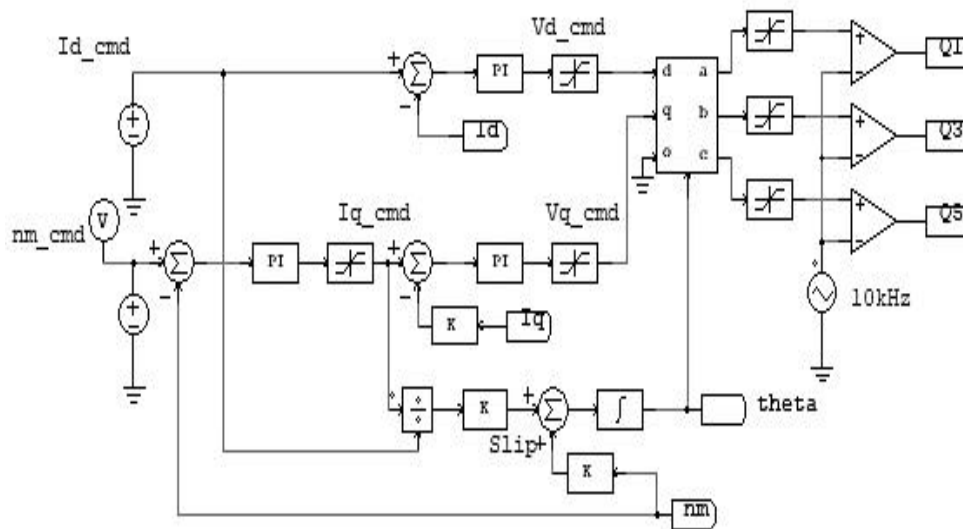


Figure 4. Block diagram of IFOC method

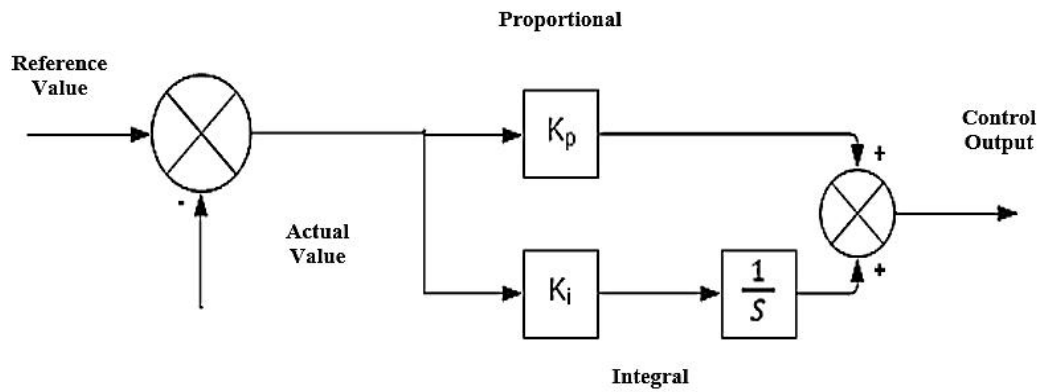


Figure 5. Block diagram of PI controller [18]

Therefore, the K_p value must be reduced to avoid excessive overshoot. The K_i value is taken to be greater than K_p , because it is desired to eliminate the steady state error. In continuous time, the PI controller output signal is formulated as follows [19].

$$co(t) = K_p \left(e(t) + \frac{1}{T_i} \int_0^t e(t) dt \right) \quad (18)$$

PI control transfer function (in domain s) can be expressed as follows:

$$co(s) = K_p \left[1 + \frac{1}{T_i s} \right] E(s) \quad (19)$$

where $CO(s)$ is the PI control output signal, K_p is the proportional constant value, K_i is the integral constant value, T_i is the time setting, and $E(s)$ is the error value of the signal. Settings using PI control are also followed by the IFOC method so that there are two control methods that work (hybrid) [20].

RESULT AND DISCUSSION

A. Result

Based on the theoretical framework and the identified problems, the system design presented in this study must undergo several stages. The objective of the proposed system is to control the speed of a three-phase induction motor by adjusting the output voltage and frequency of a three-phase inverter using the Indirect Field-Oriented Control (IFOC) method, which employs a Proportional-Integral (PI) controller. This approach aims to develop a speed control system for the three-phase induction motor that accurately follows the specified setpoint. To evaluate the system's performance, the results obtained using the PI controller are compared with those from an open-loop control method. The simulation is conducted by observing the motor speed response under no-load conditions using the PI controller, and the results are then compared with those from the open-loop condition. This comparison provides a comprehensive analysis of the effectiveness of the applied speed control method. Simulations are performed under various conditions, including constant speed settings ranging from low to medium, up to the motor's nominal maximum speed. Load testing is also conducted under both no-load and constant-load conditions. In assessing the performance of the control system under constant speed, particular attention is given to evaluating the transient response characteristics, namely: rise time, steady-state error, and maximum overshoot. These parameters are essential for evaluating the system's stability and dynamic performance. The Indirect Field Oriented Control (IFOC) method is a widely adopted control strategy for regulating the speed of three-phase induction motors. This method enables the decoupling of torque and flux components through the use of Clarke and Park transformations, allowing for independent control similar to that of DC motors. In this system, signals such as motor speed (RPM), angular velocity (ω), and rotor position (θ), obtained via a rotary encoder and processed through an inverter, are transformed into direct-axis (I_d) and quadrature-axis (I_q) current components, which serve as inputs for the IFOC scheme. As illustrated in Figure 6, the system successfully reaches a speed setpoint of 1000 RPM within 0.12 seconds, with a steady-state error of approximately 4%, utilizing a Proportional-Integral (PI) controller. When the speed setpoint is increased to 2000 RPM, the rise time slightly increases to 0.13 seconds, while at 3000 RPM, the rise time returns to 0.12 seconds, though system stability becomes more sensitive. Simulation results indicate that an increase in the speed setpoint generally leads to a greater steady-state error, suggesting a trade-off between speed and accuracy in high-speed operations of the induction motor under the IFOC method. In basic IFOC systems, the use of incremental encoders is often used to monitor rotor position and speed. They generate pulses as the rotor rotates, providing important data about position and speed. This data is then used by the controller to calculate the motor's position and speed in real-time, which is essential for precise control. The IFOC method with incremental encoders offers several advantages, this concept allows precise control of motor speed and torque, resulting in increased efficiency and dynamic response. IFOC requires only one encoder for position and velocity feedback, simplifying the system compared to other control techniques. So, it can maintain stable operation at various speeds, from low to high speeds, making it suitable for various applications.

In its application, the phase current signal of a 3-phase motor is represented in d_q space (coordinates $\sin$ and $\cos$) using the Clarke transformation. It converts three phase current signals into two signals in one coordinate system. After that, the current signal in d_q space is adjusted to the rotational speed of the motor rotor using the Park transformation. This causes one signal to be related to the magnetic field (d) and the other to be related to the torque (q). The current signal resulting from the Park transformation is then regulated using a Proportional-Integral (PI) controller to produce the desired reference current. The PI value is adjusted to ensure that the current meets system requirements and to compensate for interference. The resulting reference current is then used to control the inverter which

converts direct current to alternating current according to the needs of the induction motor. The system continuously takes feedback from the motor and dynamically adjusts current according to changing operating conditions.

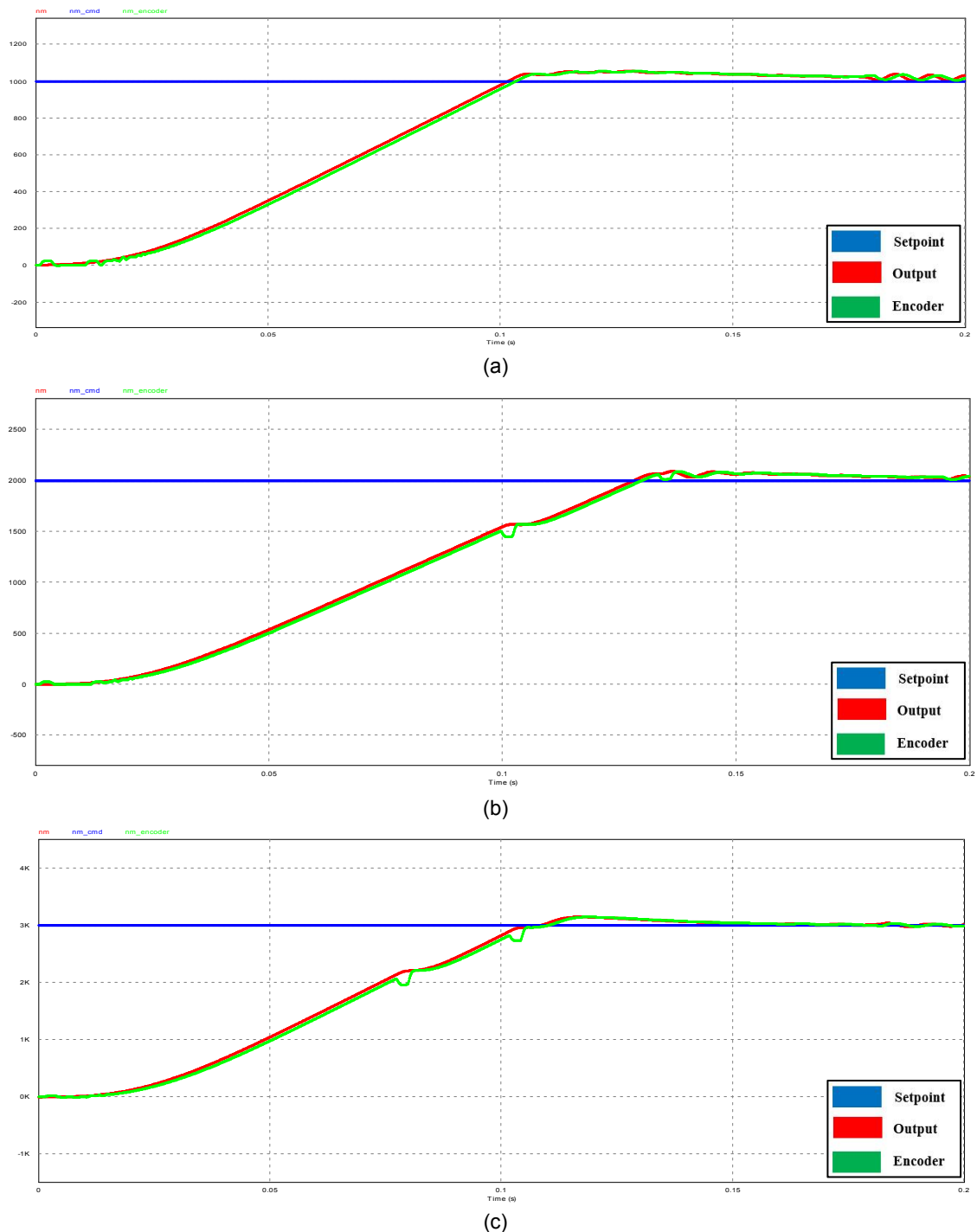


Figure 6. Speed response of an induction motor: (a) 1000 rpm; (b) 2000 rpm; (c) 3000 rpm

Figure 7 explains the current in each phase. If observed at the initial time up to 0.2 seconds with a speed of 1000 RPM, the condition of the motor is experiencing inrush current, but after passing 0.2 seconds the motor enters its nominal current condition. Meanwhile, when the speed is increased to 3000 RPM, the time when the inrush current occurs becomes shorter. When compared to 1000 RPM using the IFOC method with a PI controller, this can reduce

the nominal current value to 15 A from the previous 20 A. This explains that the control concept applied can increase the efficiency value of an induction motor. Figure 8 shows the electromagnetic torque produced by a 3-phase induction motor. These torque fluctuations show the motor's response to changing load conditions, highlighting the importance of effective IFOC controller tuning. If the torque oscillations are too pronounced, it could indicate a problem with the controller tuning or interference caused by encoder noise, which affects the accuracy of rotor position and speed measurements. Overall, the waveforms provide important insights into the motor's operational performance and ability to produce the desired torque under various conditions.

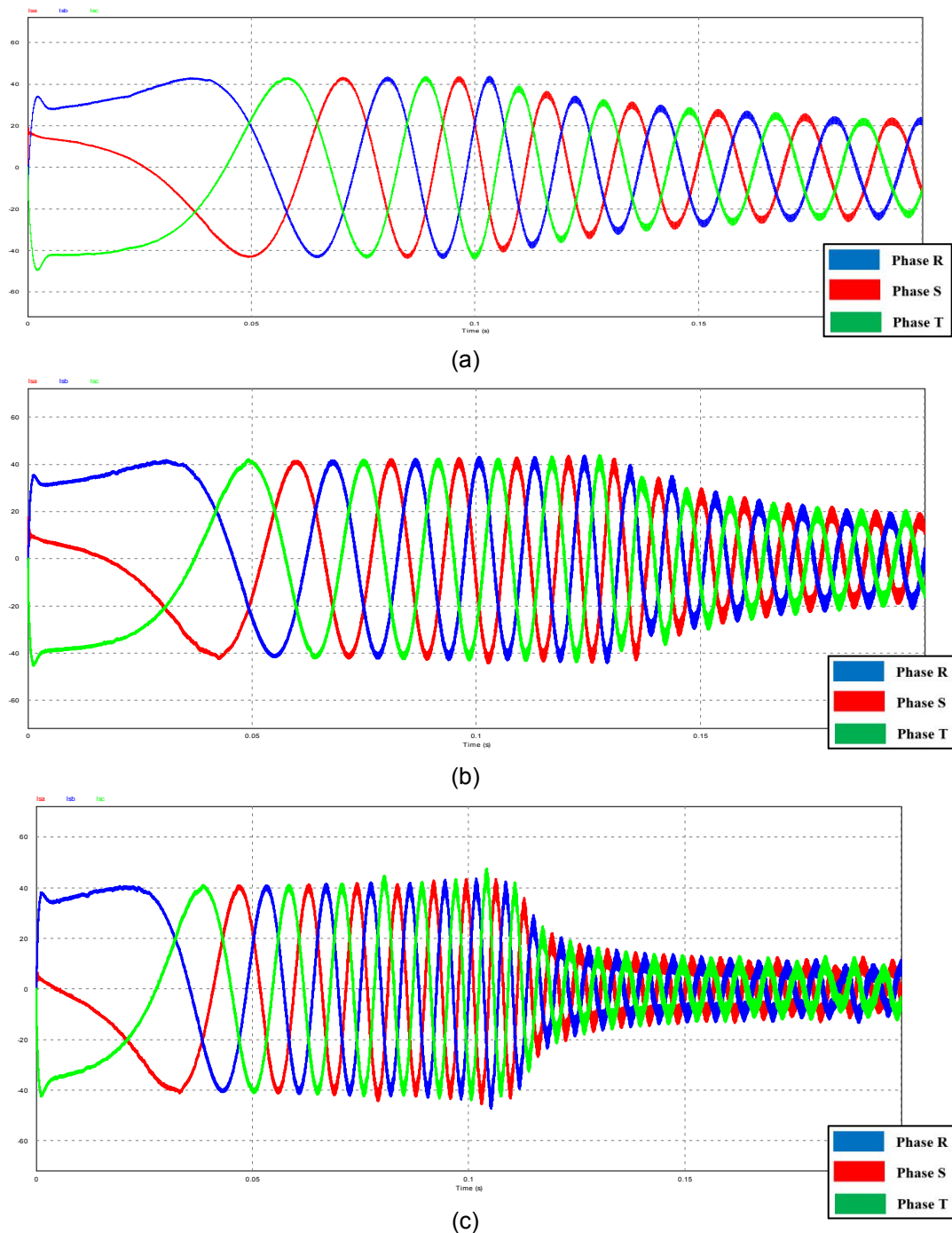


Figure 7. The current of each phase when set at speed: (a) 1000 rpm; (b) 2000 rpm; (c) 3000 rpm

Table 2. Simulation Result

Setpoint (RPM)	Rise Time (s)	Steady State Error (%)	Maximum Overshoot (%)
1000	0.105	4	0
2000	0.13	3	0
3000	0.12	0	0

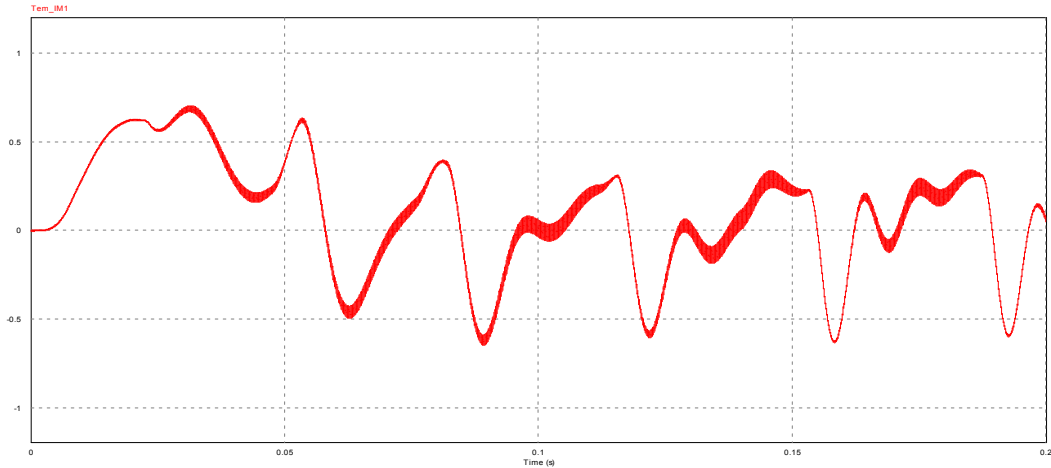


Figure 8. Electromagnetic torque on 3-phase induction motor

The PI controller faces several limitations in regulating the speed of induction motors. One major challenge is that the proportional (K_p) and integral (K_i) constants need to be retuned whenever the system experiences changes in load or motor parameters. Additionally, the PI controller struggles with accurately setting the initial speed and rotational size, which can lead to instability during startup or under load variations. To overcome these challenges and enhance the performance of the induction motor speed regulation system, the Indirect Field-Oriented Control (IFOC) method can be employed. IFOC provides more precise control and improves the dynamic response across a wide range of operating conditions. By decoupling the control of torque and flux, IFOC not only ensures smoother and more stable motor operation but also enhances motor efficiency. Moreover, this method is well-suited to adapt to load fluctuations, ensuring optimal performance even under varying environmental conditions.

B. Discussion

In the Indirect Field Oriented Control (IFOC) method applied to a three-phase Induction Motor, the stator current component i_d is responsible for generating the necessary magnetic flux, while i_q is responsible for producing torque [21]-[23]. The decoupling of flux and torque in this method allows the stator currents to be controlled independently, enabling the induction motor to exhibit a dynamic response similar to that of a separately excited DC motor. Field Oriented Control (FOC) can be implemented using two fundamental approaches: direct and indirect [24]-[26]. The direct method involves the direct measurement of flux in the air gap between the stator and rotor, which typically requires sophisticated sensors and additional hardware. In contrast, the indirect method estimates the magnetic flux by utilizing the motor's electrical parameters, such as applied voltages and resulting currents. While the indirect method is more cost-effective and easier to implement, its accuracy is highly dependent on the machine parameters, making it more susceptible to variations such as temperature changes or the effects of aging [27]. In this study, the Indirect Field Oriented Control (IFOC) method is employed due to its excellent performance in achieving high dynamic response and steady-state precision, as illustrated in the figure. Unlike the scalar

control method (V/f), which lacks dynamic torque regulation, IFOC maintains independent control of the torque and flux components of the induction motor (IM), thereby enhancing efficiency and accuracy [28] – [30].

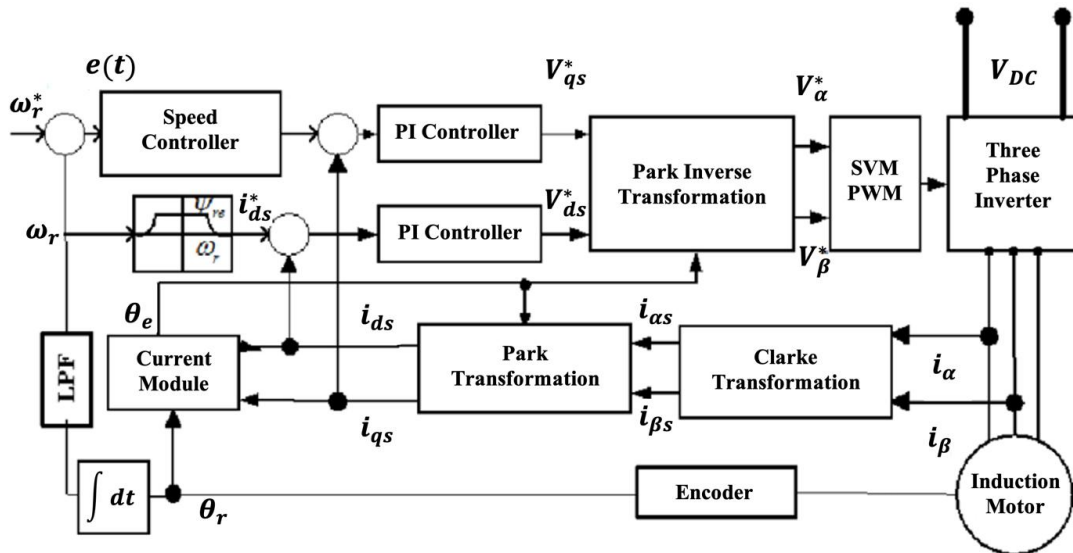


Figure 9. IFOC control method of the Induction Motor

The actual rotor speed (ω_r) is measured by an encoder and compared to the reference speed (ω_r^*) to generate a speed error signal $e(t)$, which is processed by the speed controller. The output of the speed controller is the reference torque current i_{qs}^* , which is compared with the actual i_{qs} and passed through a PI controller to generate the voltage reference V_{qs}^* . Similarly, the flux current i_{ds}^* is compared with i_{ds} , and the error is processed through another PI controller to produce V_{ds}^* . These voltages are then converted from the rotating reference frame to the stationary frame using Park inverse transformation to obtain V_{α}^* and V_{β}^* .

These signals are input into the Space Vector PWM (SVPWM) block to generate precise gate signals for the three-phase inverter, which drives the induction motor with controlled stator voltages. Feedback signals i_{α} and i_{β} are obtained through current sensors and transformed using Clarke and Park transformations for use in the control loop. The angle θ_r , derived from the rotor speed via integration, is essential for coordinate transformations and is also used to calculate the electrical angle θ_e required in the control algorithm.

CONCLUSION

From the results of the research carried out, the IFOC method for regulating the speed of a 3-phase induction motor with a PI controller at several setpoints, namely 1000, 2000 and 3000 RPM, can be adjusted to a fairly short risetime value of only 0.16 seconds. In other conditions, the PI controller can minimize maximum overshoot conditions. The problem is that the PI controller has a weakness in terms of setting the size of the initial rotation. Therefore, to overcome these weaknesses and improve the performance of the induction motor speed control circuit, the indirect field oriented control (IFOC) method can be used.

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