V/f Control of Three-phase Induction Motor Algorithm

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Abstract

This application note explains V/f control algorithm of a three-phase induction motor used in sample programs of Renesas Electronics Corporation's microcontrollers.

Contents

1. Overview

This application note explains V/f control algorithm of the three-phase induction motor (ACIM) used in the sample programs of Renesas Electronics Corporation's microcontrollers.

2. Inverter Drive of the Three-phase Induction Motor

2.1 Rotation Principles of the Three-phase Induction Motor

The three-phase induction motor is an induction motor which is driven using a three-phase AC power supply as input.

Figure 2-1 shows a configuration diagram of a general three-phase induction motor.

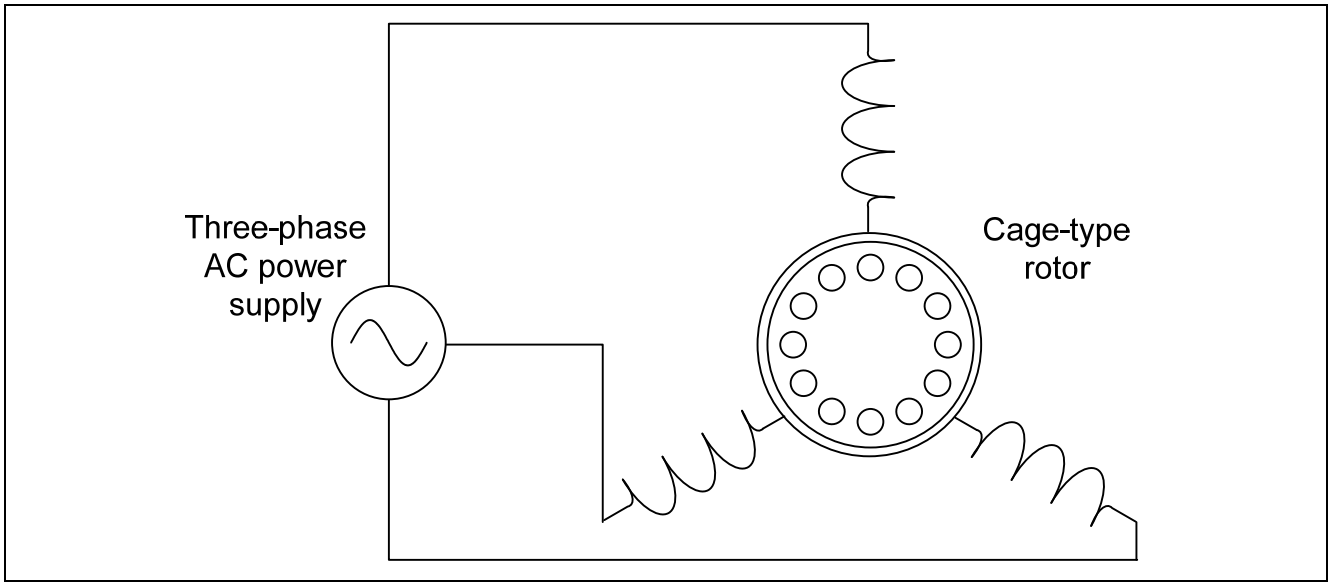


Figure 2-1 Configuration Diagram of A Three-phase Induction Motor

In the three-phase induction motor, three coils are disposed in positions displaced 120 electrical degrees of the phase difference.

When a three-phase AC power supply is connected here, the current flowing in each coil has a 120-degree phase difference one another. This generates a rotating magnetic field to rotate the rotor.

At this time, the rotor rotates at a speed slightly slower than that of the rotating magnetic field. This ratio of the rotor's speed to the rotating magnetic field's speed is called 'slip'.

2.2 Inverter Drive Method

Figure 2-2 shows a configuration diagram of the three-phase induction motor driven by an inverter.

Three-phase output pins of the inverter are connected to the coils of the motor.

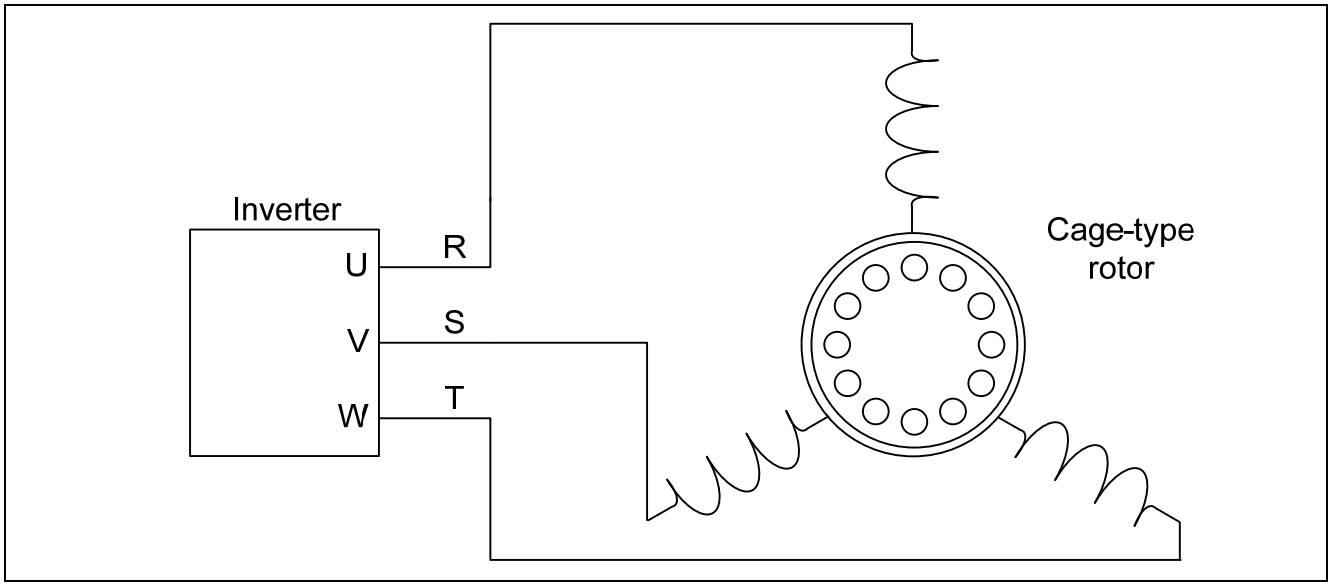


Figure 2-2 Configuration Diagram of Inverter Drive

At this time, as shown in Figure 2-3, the three-phase AC with 120-degree phase differences may be generated by using the inverter to apply the three-phase AC voltage with 120-degree phase differences.

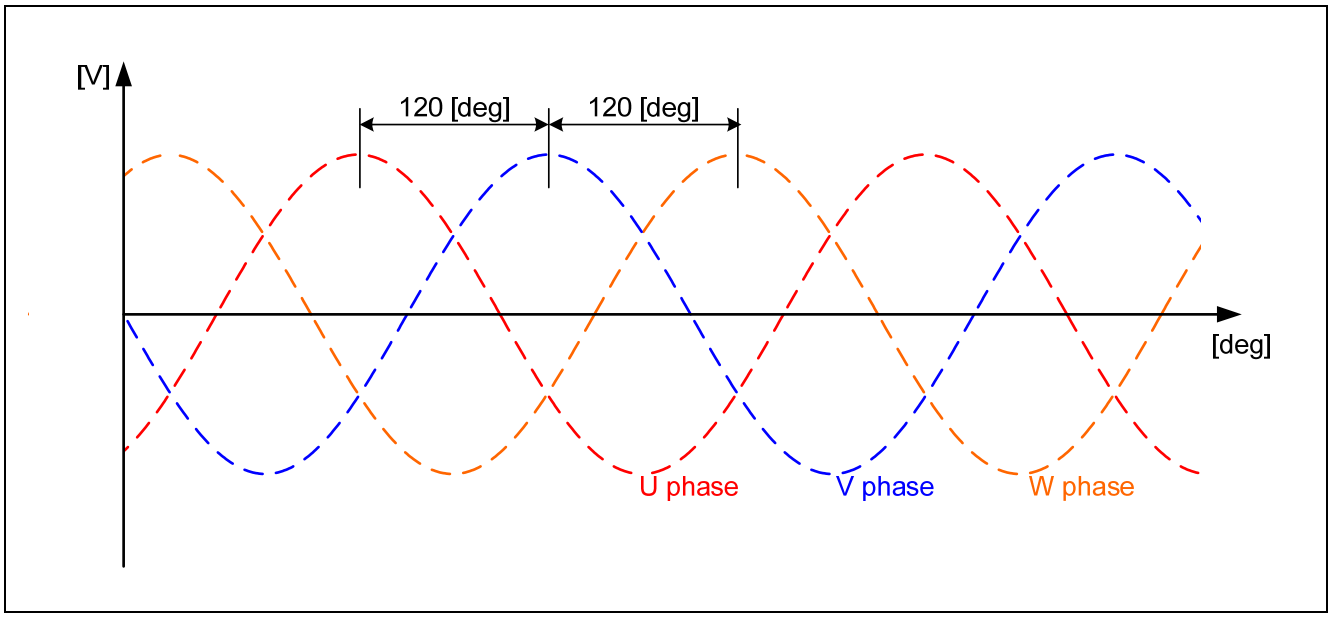


Figure 2-3 Three-phase Voltage Waveforms with 120-degree Phase Differences

3. V/f Control of the Three-phase Induction Motor

3.1 Principles

V/f control is a method to control a ratio between primary voltage (V) to be applied to the induction motor and inverter output frequency (f) to be constant. This control enables to obtain satisfactory torque characteristics in a wide frequency range by maintaining the magnitude of the rotating magnetic field vector independently from the inverter output frequency a when voltage drop due to a primary winding resistance is ignored.

However, as the frequency declines, the voltage drop due to the primary winding resistance becomes too large to be ignored, and consequently it becomes impossible to obtain sufficient torque. In such a case, applying a higher voltage than the voltage calculated from the V/f ratio which was used for a high frequency makes it possible to secure enough torque even at a low frequency.

3.2 Control Parameters

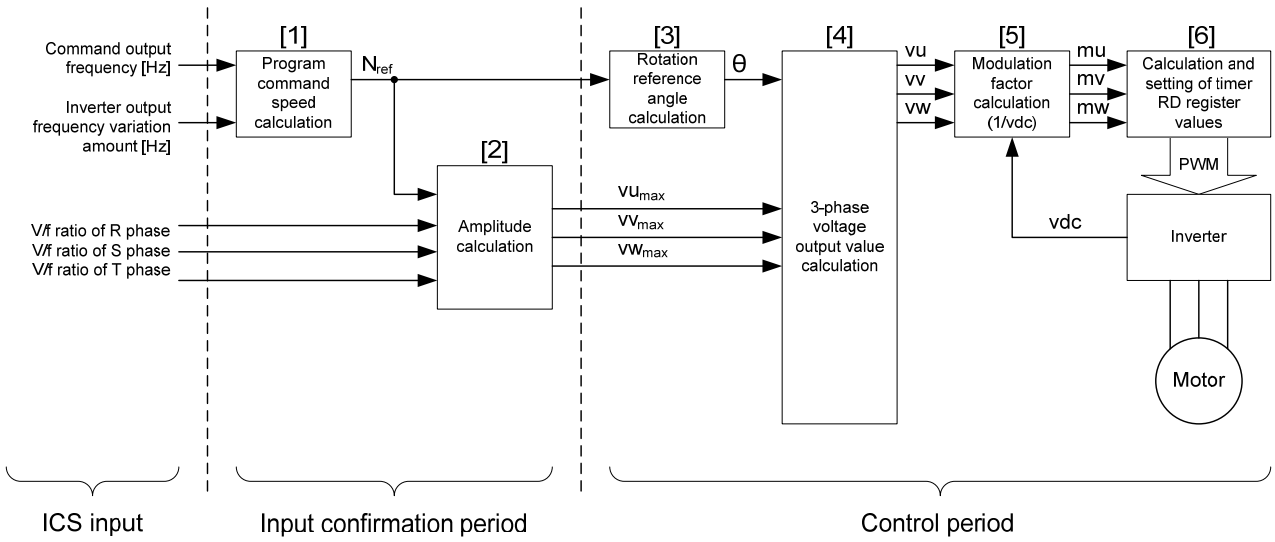
This control uses the following five parameters to adjust parameters respectively.

Table 3-1 Control Parameters

Parameter for control	Content
Inverter output frequency variation amount	Specifies the variation amount in inverter output frequency in each command output confirmation period.
Inverter command output frequency (f)	Specifies the output frequency from the inverter.
R phase V/f ratio	Specifies the V/f ratio in the R phase
S phase V/f ratio	Specifies the V/f ratio in the S phase
T phase V/f ratio	Specifies the V/f ratio in the T phase

3.3 Control Flow

The control flow is shown in Figure 3-1.



[1] Compare the user command speed with the program command speed, and increase or decrease a difference in the amount of speed change, if any.

[2] Calculate amplitude of each phase from the program command speed and the V/f ratio of each phase.

[3] Calculate the angle which moves through from the program command speed to the control period and add it to the last time's rotation angle.

[4] Calculate the phase difference from the rotation angle by adding the phase of each phase to the reference angle, and compute the instant output voltage of each phase together with amplitude.

[5] Calculate the modulation factor of the output voltage of each phase from inverter bus voltage.

[6] Do the corrections for the improvement of voltage use efficiency, and execute conversion into a register setting value.

Symbol	Meaning	Unit
N_{ref}	Program command speed	[rpm]
θ	Rotation angle	[deg]
vu_{max}, vv_{max}, vw_{max}	3-phase voltage amplitude	[V]
vu, vv, vw	3-phase output voltage value	[V]
mu, mv, mw	3-phase output voltage modulation factor	[-]
vdc	Inverter bus voltage	[V]

Figure 3-1 Control Flow of V/f Control

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Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Aug. 22, 2014	-	First edition issued

General Precautions in the Handling of MPU/MCU Products

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2. Processing at Power-on

   The state of the product is undefined at the moment when power is supplied.

   — The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the moment when power is supplied.
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   Access to reserved addresses is prohibited.

   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals

   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has stabilized.

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