V/f Control of Single Phase Induction Motor

Algorithm

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Abstract

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

2. Inverter Drive of the Single Phase Induction Motor

2.1 Rotation Principles of the Single Phase Induction Motor

The single phase induction motor is an induction motor which is driven using a single phase alternating current power supply as input. Of various types of single phase induction motors, a capacitor drive induction motor is used here as an example. This motor is driven using a capacitor by applying the current with a phase difference to two coils which are disposed in positions displaced 90 degrees each other.

Figure 2-1 shows a configuration diagram of a general capacitor drive induction motor.

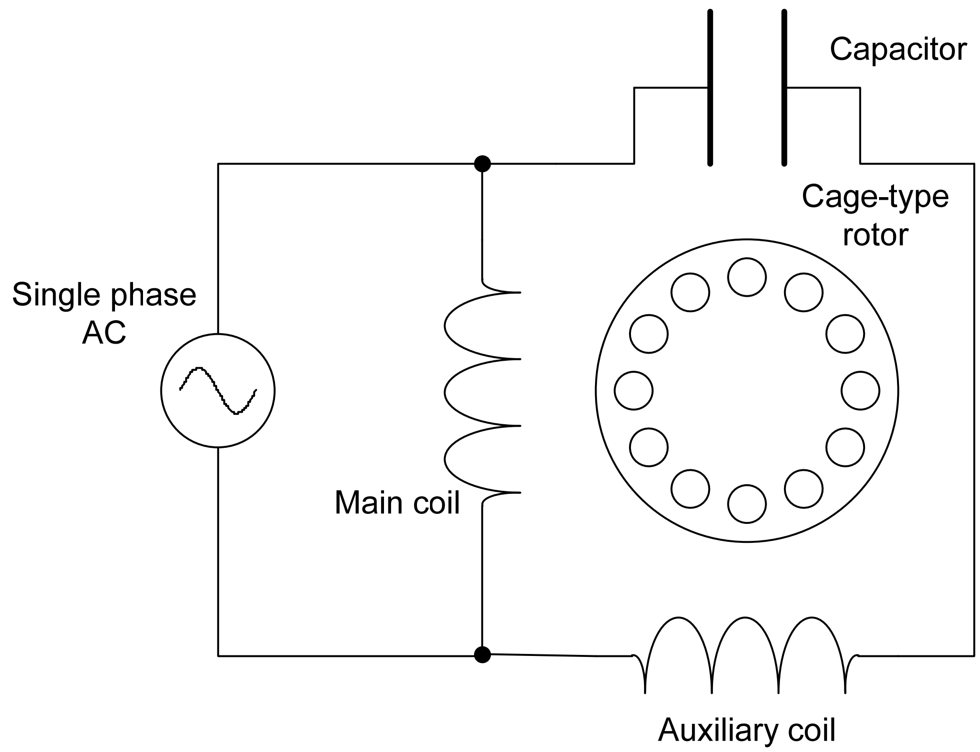


Figure 2-1 Configuration Diagram of A Capacitor Drive Induction Motor

In the capacitor drive induction motor, two coils of main coil and auxiliary coil are disposed in positions displaced 90 electrical degrees of the phase difference. The capacitor is connected in series to the auxiliary coil.

When a single phase AC power supply is connected here, the current flowing in the auxiliary coil connected to the capacitor becomes an approximately 90-degree advanced phase from the main coil. This generates a two-phase AC 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 single phase induction motor driven by an inverter.

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

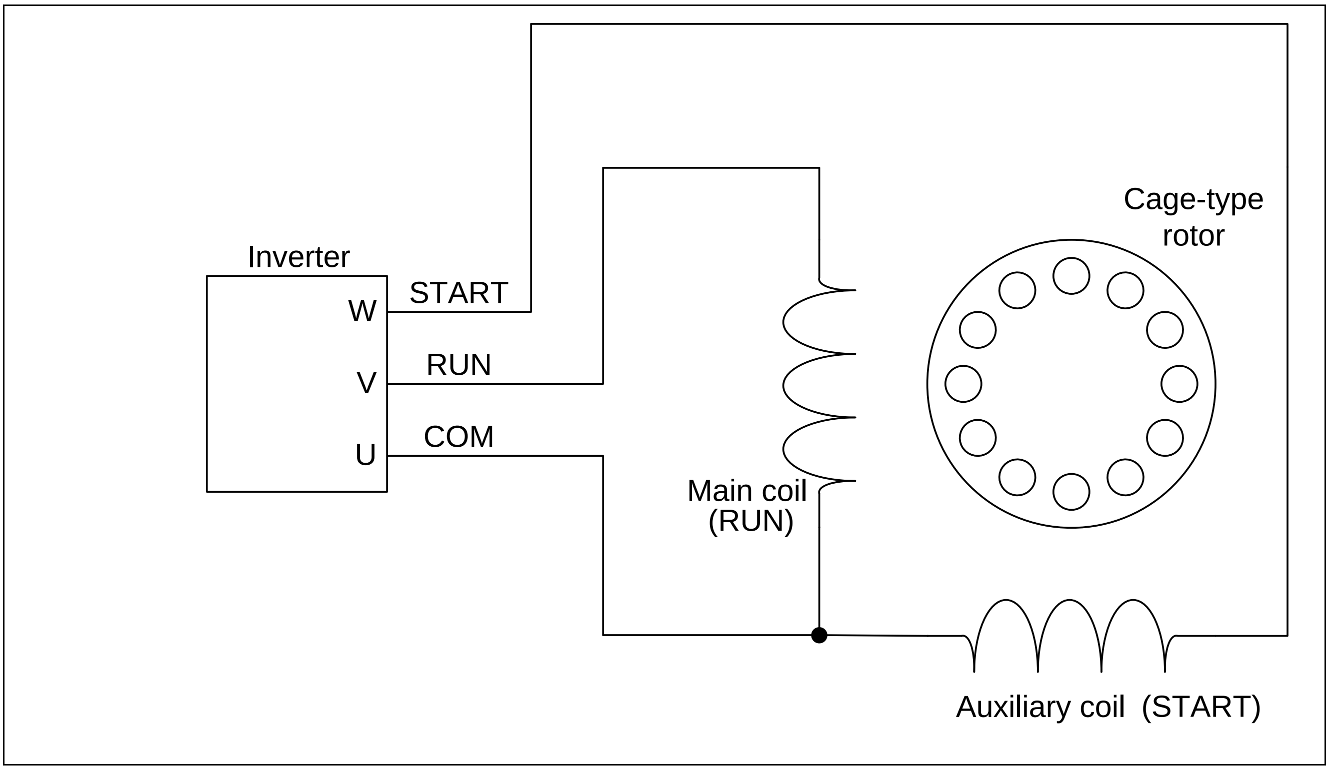


Figure 2-2 Configuration Diagram of Inverter Drive

At this time, the voltages to be applied to the main and auxiliary coils are V to U voltage and W to U voltage respectively. For example as shown in Figure 2-3, without a capacitor, the two-phase AC with 90-degree phase differences may be generated by the line voltages using the inverter to apply the three-phase AC voltage with 90-degree phase differences.

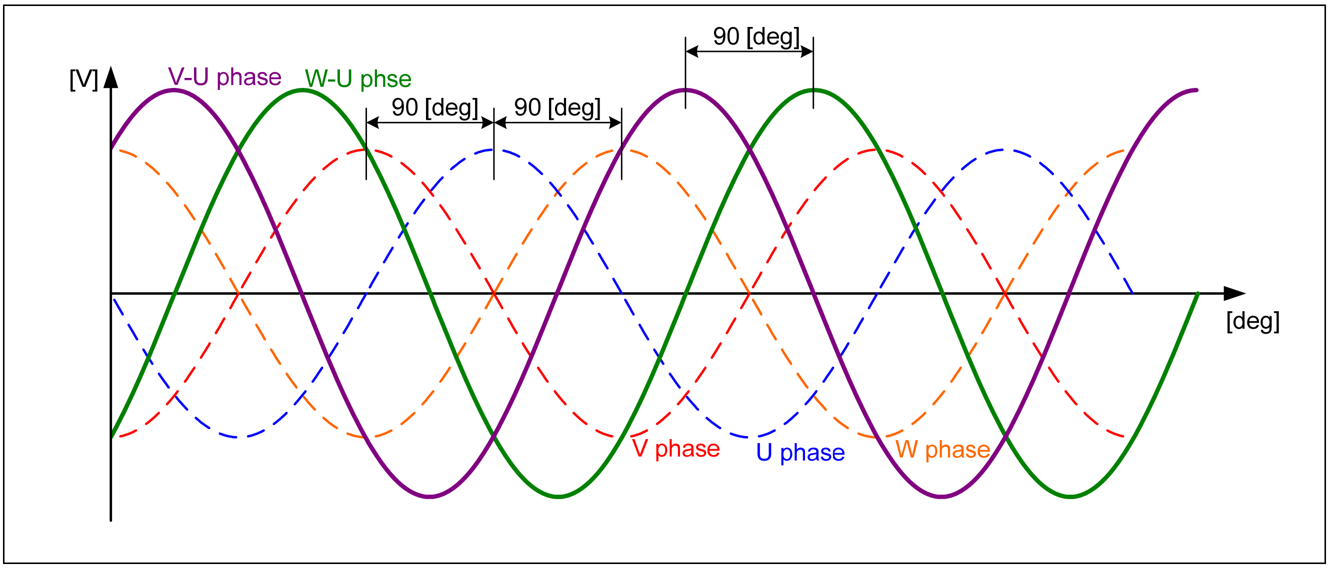


Figure 2-3 Three-phase Voltage Waveforms with 90-degree Phase Differences and Line Voltage Waveforms

3. V/f Control of the Single 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 when a 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.

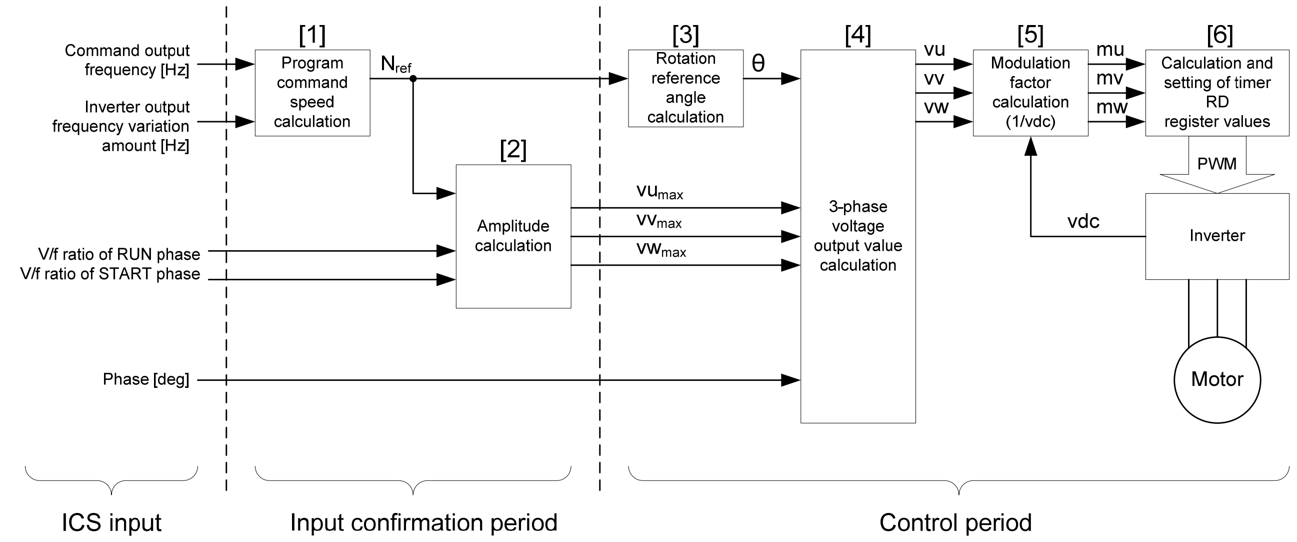
3.2 Control Parameters

This control uses the following five parameters to adjust the RUN phase and the START phase respectively.

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.
RUN phase V/f ratio	Specifies the V/f ratio in the RUN phase.
START phase V/f ratio	Specifies the V/f ratio in the START phase.
Phase difference between RUN-START phases	Specifies the voltage phase difference between RUN phase and START 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

Website and Support

Renesas Electronics Website

http://www.renesas.com/

Inquiries

http://www.renesas.com/contact/

Revision History

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

General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Handling of Unused Pins

   Handle unused pins in accordance with the directions given under Handling of Unused Pins in the manual.

   — The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible. Unused pins should be handled as described under Handling of Unused Pins in the manual.

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.
   In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the moment when power is supplied until the reset process is completed.
   In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses

   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.

   — When the clock signal is generated with an external resonator (or from an external oscillator) during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Moreover, when switching to a clock signal produced with an external resonator (or by an external oscillator) while program execution is in progress, wait until the target clock signal is stable.

5. Differences between Products

   Before changing from one product to another, i.e. to a product with a different part number, confirm that the change will not lead to problems.

   — The characteristics of an MPU or MCU in the same group but having a different part number may differ in terms of the internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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