Vector Control of Three-Phase Induction Motor

RL78/G14

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Abstract

This application note aims at explaining sample programs for operating vector control of three-phase induction motors, by using the RL78/G14 microcontroller, and how to use a library of the development support tool, In Circuit Scope.

The sample programs are only to be used as reference and Renesas Electronics Corporation does not guarantee the operations. Please use the sample programs after carrying out a thorough evaluation in a suitable environment.

In particular, the use of high voltage is extremely dangerous. Before using each development environment, be sure to read respective user's manuals carefully. Renesas Electronics assumes no liability whatsoever for any damages arising from the use of development environment described in this application note.

Operation Confirmation Device

The sample programs described in this application note have been confirmed with the device below.

- RL78/G14 (R5F104LEA)

Target Sample Programs

The target sample programs of this application note are shown below.

RL78G14_T1102_3IM_LESS_FOC_CSP_V100

Vector control sample program of a three-phase induction motor for RL78/G14 (R5F104LEA) T1102

Reference Documents

- RL78/G14 User's Manual: Hardware (R01UH0186EJ0200)
- Vector Control of Three-phase Induction Motor: Algorithm (R01AN2193EJ0100)
- 'In Circuit Scope Manual' and 'How to set CubeSuite+ for using ICS'
  Downloadable from: http://www.desktoplab.co.jp/download.html
- Trial series "T1102" 3kW 4kVA Inverter Unit User's Manual
- Trial series "T5101" RL78G14 64pin CPU card User's Manual

Contents

1. Overview

This application note explains the sample programs for operating vector control of three-phase induction motors, by using the RL78/G14 microcontroller, and how to use a library of the development support tool, In Circuit Scope[Note1] (hereinafter referred to as ICS). These sample programs use algorithm described in application notes: 'Vector Control of Three-phase Induction Motor: Algorithm'.

1.1 Development Environment

Table 1-1 shows development environment for the target sample programs of this application note.

Table 1-1 Development Environment for the Sample Programs

Microcontroller	Inverter board	Motor	CS+
R5F104LEAFP	T1102 [Note1]	SF-JR-4P-0.75kw [Note2]	V3.00.00

Please contact Renesas Electronics sales agents for purchase and technical support of the inverter board T1102.

Notes

1. The inverter board T1102 and the development support tool In Circuit Scope are the products of Desk Top Laboratories Inc.

   Desk Top Laboratories Inc. (http://www.desktoplab.co.jp/)

2. SF-JR-4P-0.75kw is the products of MITSUBISHI ELECTRIC CO., LTD.

   MITSUBISHI ELECTRIC CO., LTD. (http://www.mitsubishielectric.com/fa/index.html)

2. System Overview

Overview of this system is explained below.

2.1 Hardware Configuration

Hardware configuration is illustrated below.

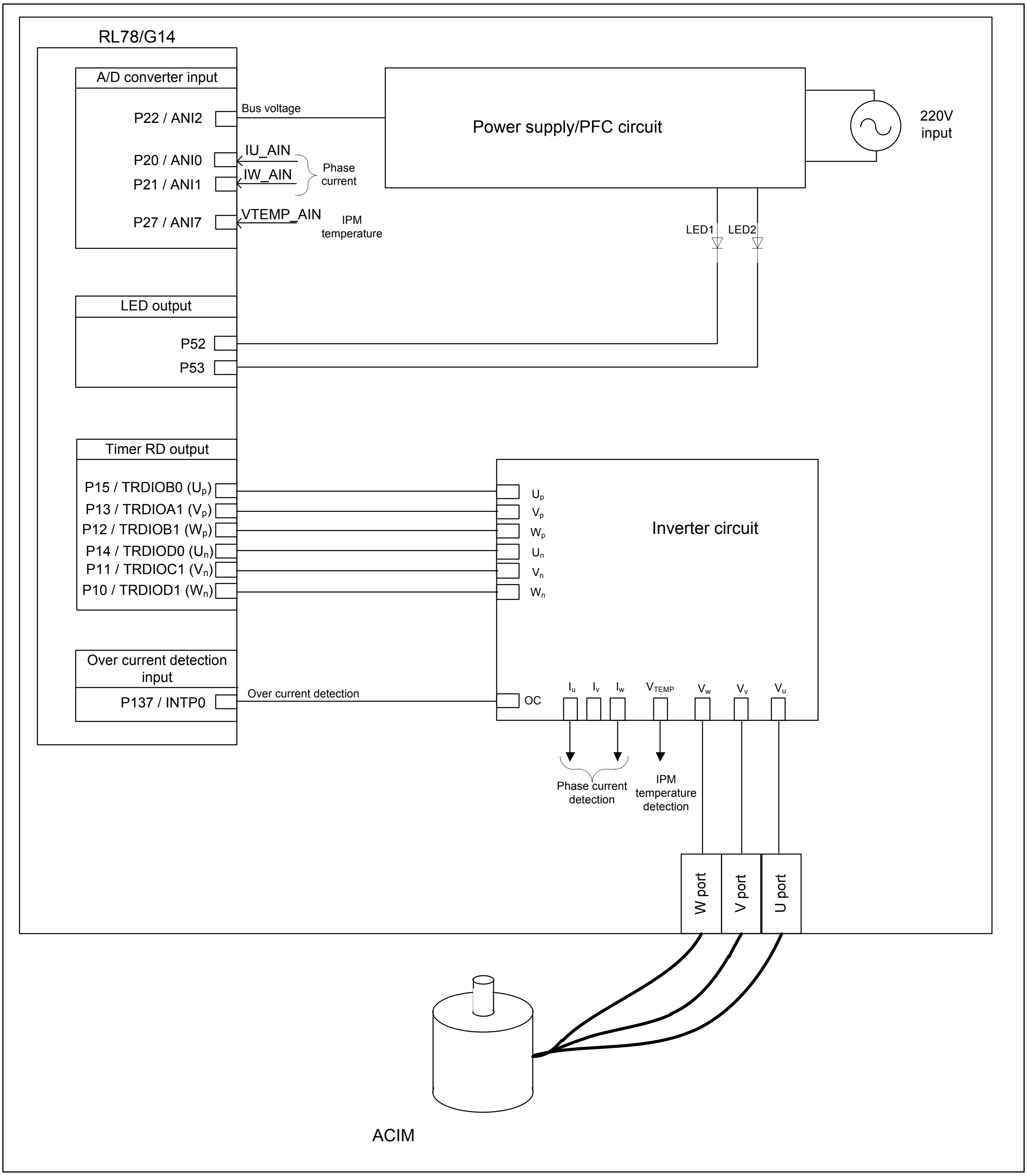

Figure 2-1 Hardware Configuration Diagram

2.2 Hardware Specifications

2.2.1 User Interface

A list of user interfaces of this system is given in Table 2-1.

Table 2-1 User Interface

Item	Interface component	Function
LED1	Yellow green LED	・At the time of Motor rotation: ON ・At the time of stop: OFF
LED2	Yellow green LED	・At the time of error detection: ON ・At the time of normal operation: OFF
RESET	Push switch (RESET1)	System reset

Table 2-2 is a list of terminal interfaces of this system.

Table 2-2 Terminal Interface

R5F104LEA Terminal name	Function
P52	LED1 ON/OFF control
P53	LED2 ON/OFF control
P55	Inrush current prevention circuit relay
P20 / ANI0	U phase current measurement
P21 / ANI1	W phase current measurement
P22 / ANI2	Bus voltage measurement
P27 / ANI7	IPM temperature measurement
P15 / TRDIOB0	PWM output (U_p)
P13 / TRDIOA1	PWM output (V_p)
P12 / TRDIOB1	PWM output (W_p)
P14 / TRDIOD0	PWM output (U_n)
P11 / TRDIOC1	PWM output (V_n)
P10 / TRDIOD1	PWM output (W_n)
P137 / INTP0	Over current detection

2.2.2 Peripheral Functions

Table 2-3 shows a list of peripheral functions used for this system.

Table 2-3 Peripheral Functions for Each Sample Program

10-bit A/D	Timer array unit	Timer RD
・Current of each U/W phase ・Inverter bus voltage ・IPM temperature	・125 [μs] interval timer ・1 [ms] interval timer	・Complimentary PWM output ・Pulse output forced shut down

1. 10-bit A/D converter
   A 10-bit A/D converter is used for measuring the U phase current, W phase current, inverter bus voltage, and IPM temperature.

   'Software trigger mode (select mode, one-shot conversion mode)' is used for conversion mode.

2. Timer array unit
   Channel 0 and channel 1 of unit 0 are used for 125-μs interval timer and 1-ms interval timer respectively.

3. Timer RD
   Output with dead time ("High" active) is perfomed using the complementary PWM mode. The pulse output forced shut down function is used with over current signals from IPM.

2.3 Software Configuration

2.3.1 Software File Configuration

Folder and file configuration of the sample programs are given in Table 2-4.

Table 2-4 Folder and File Configuration of the Sample Program

RL78G14_T1102_3IM_LESS_FOC_CSP_V100	inc	main.h	Main function, user interface control header
		mtr_common.h	Common definition header
		mtr_ctrl_rl78g14.h	RL78/G14 dependent processing header
		mtr_ctrl_rl78g14_t1102.h	Board & RL78/G14 dependent processing header
		mtr_ctrl_t1102.h	Board dependent processing header
		mtr_3im_less_foc.h	Vector control header
		control_parameter.h	Control parameter header
		motor_parameter.h	Motor parameter header
		r_dsp.h	Header for operation library
		r_stdint.h	Header for operation library
	ics	ics_R5F104LE.rel	ICS library
		RL78G14_vector.c	Vector setting for ICS
		ics_R5F104LE.h	Header for ICS
	lib	angle_speed_R5F104LE.rel	Angle and speed estimation library
		R_dsp_rl78.lib	Operation library
	src	main.c	Main function, user interface control
		mtr_ctrl_rl78g14.c	RL78/G14 dependent processing
		mtr_ctrl_rl78g14_t1102.c	Board & RL78/G14 dependent processing
		mtr_ctlr_t1102.c	Board dependent processing
		mtr_interrupt.c	Interrupt handler
		mtr_3im_less_foc.c	Vector control

2.3.2 Module Configuration

Figure 2-2 and Table 2-5 show the module configuration of the sample programs.

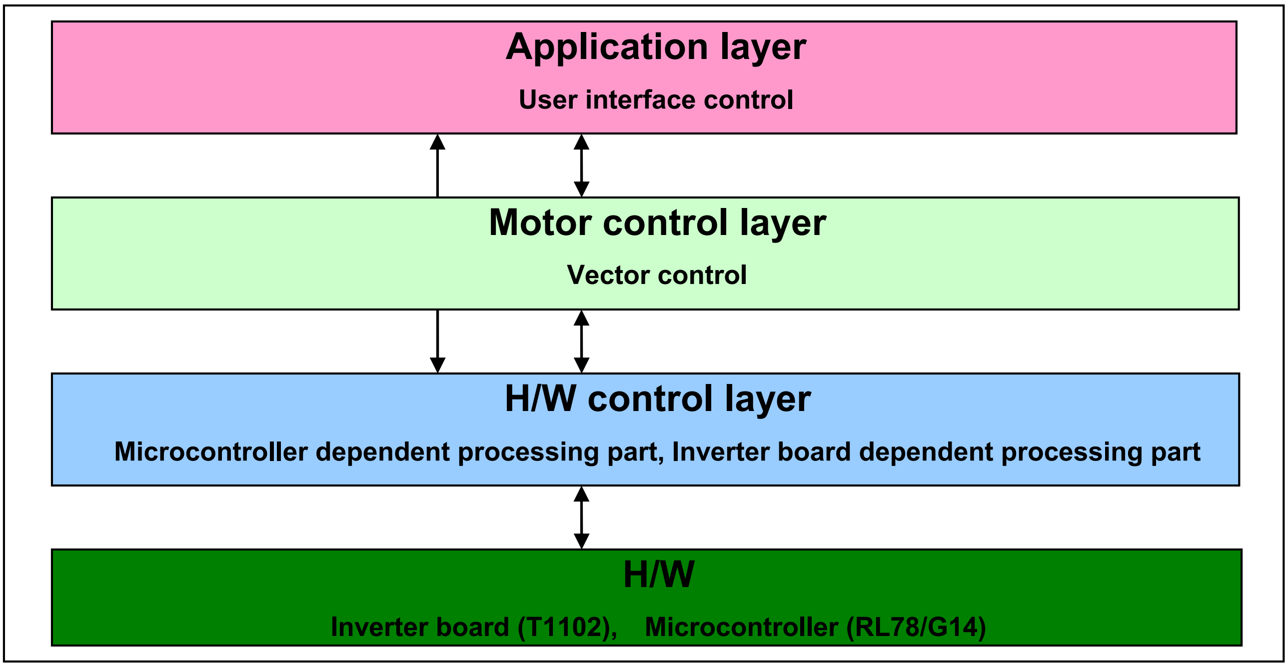

Figure 2-2 Module Configuration of the Sample Programs

Table 2-5 Module Structure of the Sample Programs

Application layer	main.c
Motor control layer	mtr_3im_less_foc.c
H/W control layer	mtr_ctrl_rl78g14_t1102.c mtr_ctrl_rl78g14.c mtr_ctrl_t1102.c

2.4 Software Specifications

Table 2-7 shows basic software specifications of this system. For details on vector control, refer to the application note 'Vector control of Three-phase Induction Motor: Algorithm.

Table 2-6 Basic Specification of Sensorless Vector Control Software

Item	Content
Control method	Vector control
Motor rotation start/stop	Input from ICS Note1
Position detection sensor	Sensorless
Input voltage	AC220 V
Carrier frequency (PWM)	16 [kHz]
Control cycle	125 [μs] (Carrier cycle × 2)
Inverter output frequency range	500 [rpm] to 2000 [rpm] Note2
Processing stop for protection	・Disables the motor control signal output (six outputs), under any of the following five conditions. 1. Current of each phase exceeds 10 [A] (monitored per 125 [μs]) 2. Inverter bus voltage exceeds 400 [V] (monitored per 125 [μs]) 3. Inverter bus voltage is less than 85 [V] (monitored per 125 [μs]) 4. Rotation speed exceeds 2400[rpm] (monitored per 125 [μs]) 5. IPM temperature output value exceeds 3 [V] (60 ± 10 [˚C]) (monitored per 125 [μs]) ・When an external over current signal is detected (when low level of the INTP0 port is detected), the ports executing PWM output are set to high impedance state.

Note:

1. For more details, refert to 4. Development Support Tool: In Circuit Scope.
2. There may be a difference in the speed and the reference speed depending on environment.

3. Control Program

The target sample programs of this application note are explained here.

3.1 Contents of Control

3.1.1 Motor Start/Stop

Starting and stopping the motor are controlled by input from ICS.

3.1.2 Inverter Output Frequency Command Change Amount

The variation amount of the inverter output frequency command is determined by input from ICS.

3.1.3 Inverter Bus Voltage

The inveter bus voltage is measured as shown in below table.

It is used for calculating the modulation factor and detecting over voltage (PWM is stopped in case of the occurrence of the abnormality)

Table 3-1 Inverter Bus Voltage Conversion Ratio

Item	Conversion ratio (Inverter bus voltage : A/D conversion value)	Channel
Inverter bus voltage	0 [V] to 686.5 [V] : 0000H to 03FFH	ANI2

3.1.4 Phase Current

As shown in the below table, U phase and W phase currents are measured to be used for over current detection.

Table 3-2 Conversion Ratio of U and W Phase Current

Item	Conversion ratio (U phase, W phase current : A/D conversion ratio)	Channel
U phase, W phase current	-50 [A] to 50 [A] : 0000H to 03FFH	Iu : ANI0 Iw : ANI1

3.1.5 IPM Temperature

The IPM temperature is measured as shown in Table 3-4 and used for IPM temperature error detection.

For the relation of IPM temperature and the voltage, refer to the datasheet of IPM.

Table 3-3 Conversion Ratio of IPM temperature

Item	Conversion ratio (IPM temperature: A/D conversion value)	Channel
IPM temperature	0 [V] to 5 [V]: 0000H to 03FFH	ANI7

3.1.6 Modulation

The target sample software of this application note uses pulse width modulation (hereinafter called PWM) and the triangular wave comparison method to generate the input voltage to the motor and the PWM waveform respectively.

(1) Triangular wave comparison method

As one of the methods to actually output the command value voltage, the triangular wave comparison method which determines the pulse width of the output voltage by comparing the carrier waveform (triangular wave) and command value voltage waveform is used. Output of the command value voltage of the pseudo sinusoidal wave can be performed by turning the switch on or off when the command value voltage is larger or smaller than the carrier wave voltage respectively.

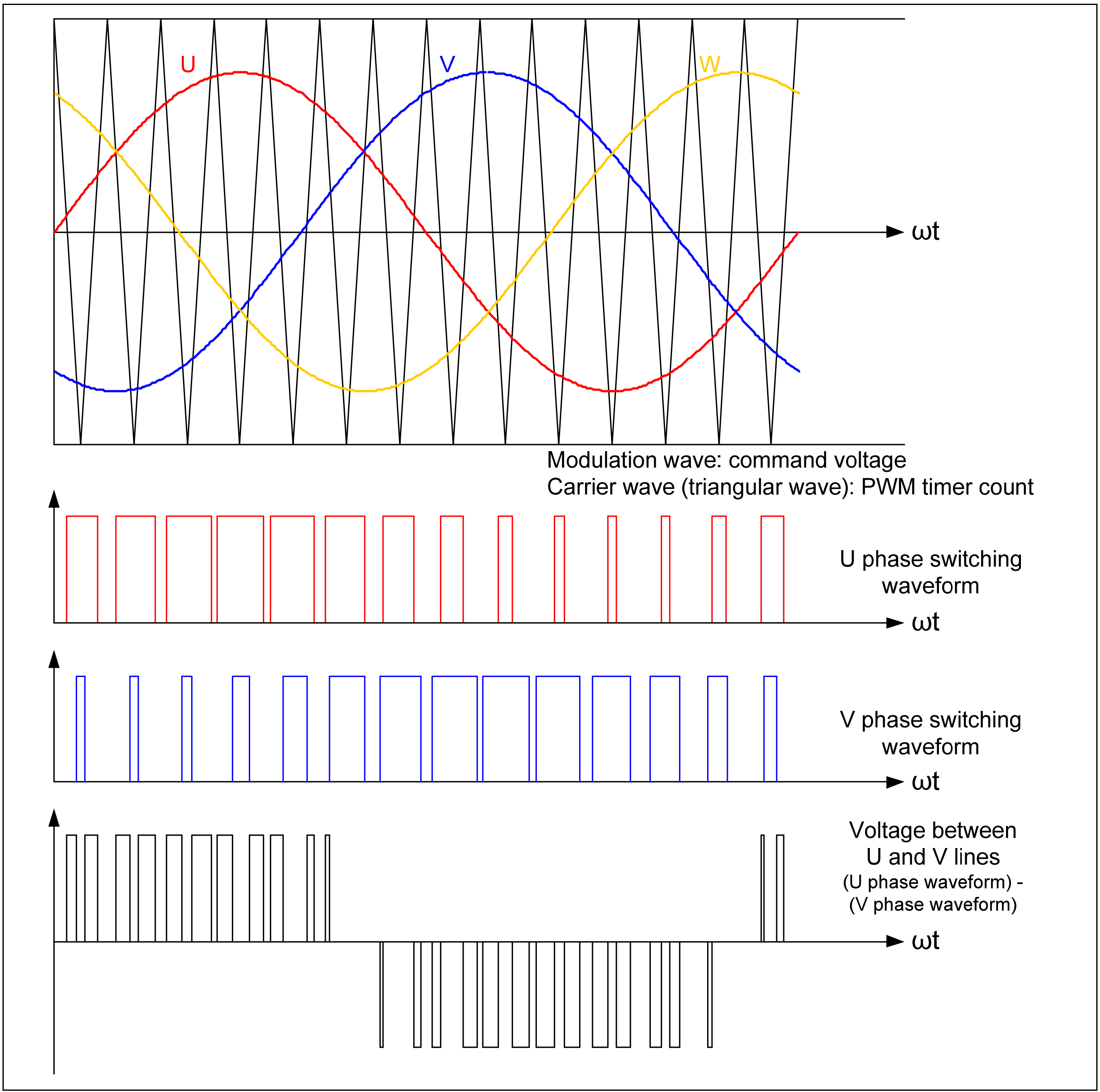

Figure 3-1 Conceptual Diagram of the Triangular Wave Comparison Method

Here, as shown in the Figure 3-2, the ratio of the output voltage pulse to the carrier wave is called duty.

$$\mathrm{Duty} = \frac{T_{ON}}{T_{ON} + T_{OFF}} \times 100\ [\%]$$

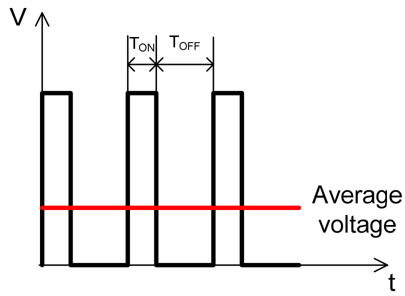

Figure 3-2 Definition of Duty

Modulation factor m is defined as follows.

$$m = \frac{V}{E}$$

m: Modulation factor V: Command value voltage E: Inverter bus voltage

A desired control can be performed by setting this modulation factor to the register which determines the PWM duty.

3.1.7 State Transition

Figure 3-3 is a state transition diagram of the vector control software.

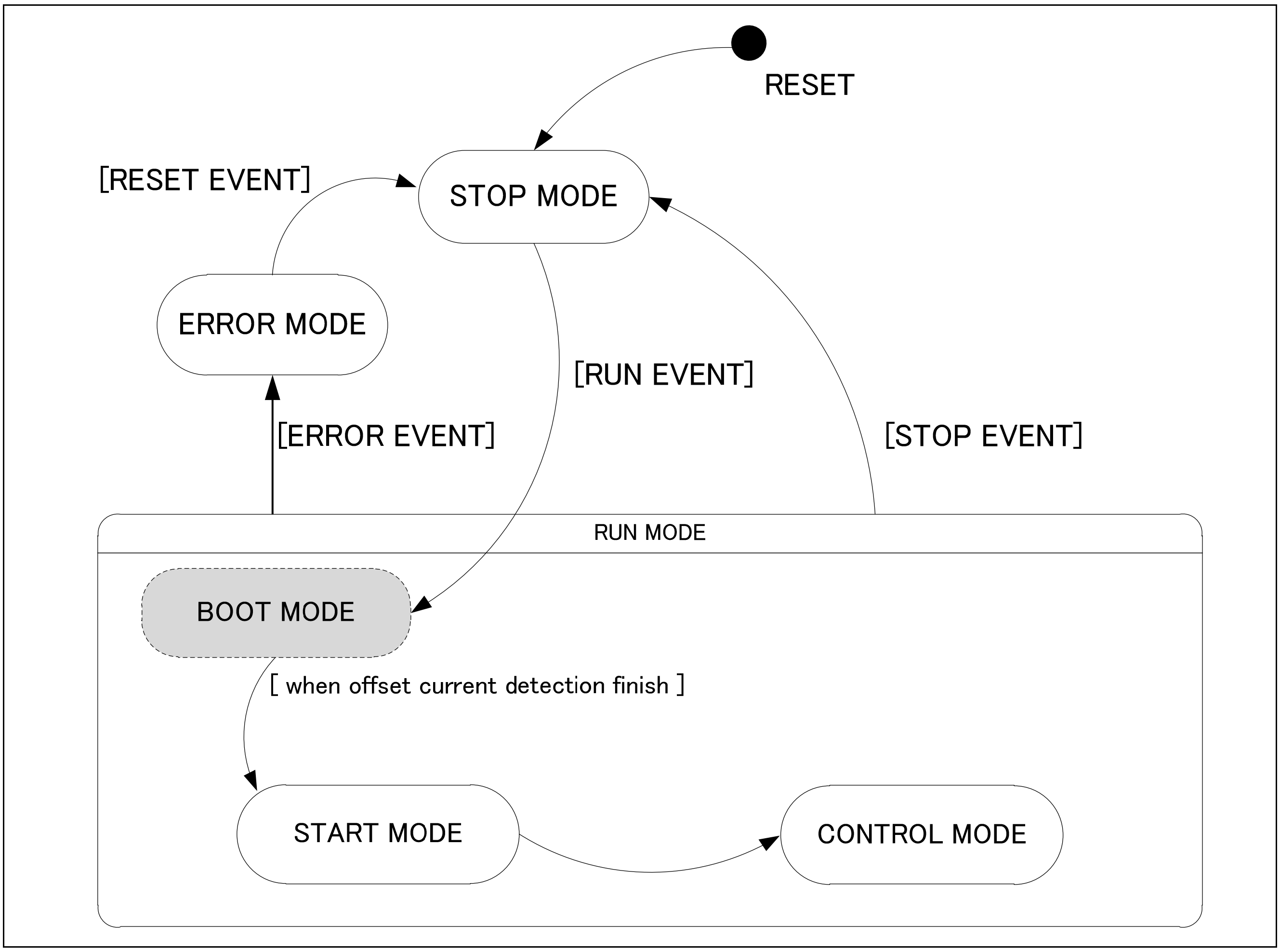

Figure 3-3 Sate Transition Diagram of Vector Control Software

3.1.8 System Protection Function

These control programs have the following four types of error status and execute emergency stop functions in case of occurrence of respective errors. Table 3-4 shows each setting value for the system protection function.

• Over current error

High impedance output is made to the PWM output port in response to an emergency stop signal (over current detection) from hardware. In addition, U, V, and W phase currents are monitored. When an over current (when the current exceeds the over current limit value) is detected, the CPU executes emergency stop (software detection).

• Over voltage error

The inverter bus voltage is monitored by over current monitoring cycles. When an over voltage is detected (when the voltage exceeds the over voltage limit value), the CPU performs emergency stop.

• Low voltage error

The inverter bus voltage is monitored by low-voltage monitoring cycles. The CPU performs emergency stop when low voltage (when voltage falls below the limit value) is detected.

· Over speed error

The rotation speed is monitored in rotation speed monitoring cycle. The CPU performs emergency stop when the speed is over the limit value.

• IPM temperature error

The IPM temperature is monitored by IPM temperature monitoring cycles. When high temperature is detected (when it exceeds the IPM temperature limit value), the CPU performs emergency stop

Table 3-4 Setting Value of Each System Protection Function

Over current error	Over current limit value [A]	10
	Monitoring cycle [μs]	125
Over voltage error	Over voltage limit value [V]	400
	Monitoring cycle [μs]	125
Low voltage error	Low voltage limit value [V]	85
	Monitoring cycle [μs]	125
Rotation speed abnormality error	Speed limit value [rpm]	2400
	Monitoring cycle [μs]	125
IPM temperature error	High temperature limit value [V]	3
	Monitoring cycle [μs]	125

3.2 Function Specifications of V/f Control Software

These control programs use multiple control functions. The following tables show lists of the control functions.

For more details on processing, refer to flowcharts or source files.

Table 3-5 List of Control Functions (1/6)

File name	Function name	Processing overview
main.c	main Input: None Output: None	・Hardware initialization function call ・User interface initialization function call ・Initialization function call of the variable used in the main processing ・Status transition and event execution function call ・Main processing ⇒ Main process execution function call ⇒ Watchdog timer clear function call
	ics_ui Input: None Output: None	Using ICS user interface
	software_init Input: None Output: None	Initialization of the variable used in the main processing
mtr_ctrl_t1102.c	R_MTR_ChargeCapacitor Input: None Output: None	Wait for smoothing capacitor charge time
	ic_gate_on Input: None Output: None	Turn a gate signal for inrush current prevention ON
	led1_on Input: None Output: None	Turning LED1 ON
	led2_on Input: None Output: None	Turning LED2 ON
	led1_off Input: None Output: None	Turning LED1 OFF
	led2_off Input: None Output: None	Turning LED2 OFF

Table 3-6 List of Control Functions (2/6)

File name	Function name	Processing overview
mtr_ctrl_rl78g14.c	R_MTR_InitHardware Input: None Output: None	Initialization of the clock and peripheral functions
	mtr_init_clock Input: None Output: None	Initialization of CLOCK
	mtr_init_tau Input: None Output: None	Initialization of the timer array unit
	mtr_init_intp Input: None Output: None	Initialization of INTP0
	mtr_init_ic_gate Input: None Output: None	Initialization of the inrush current gate
	clear_wdt Input: None Output: None	Clearing the watchdog timer
	mtr_clear_oc_flag Input: None Output: None	Clearing the high impedance state

Table 3-7 List of Control Functions (3/6)

File name	Function name	Processing overview
mtr_interrupt.c	mtr_over_current_interrupt Input: None Output: None	Over current detection processing ・Event processing selection function call ・Changing the motor status ・High impedance state clearing function call
	mtr_tau00_interrupt Input: None Output: None	Calling per 125 [μs] ・Vector control ・Current PI control
	mtr_tau01_interrupt Input: None Output: None	Calling per 1 [ms] ・Startup control ・Speed PI control

Table 3-8 List of Control Functions (4/6)

File name	Function name	Processing overview
mtr_3im_less_foc.c	R_MTR_InitSequence Input: None Output: None	Initialization of the sequence processing
	R_MTR_ExecEvent Input: (uint8)u1_event / occurred event Output: None	・Changing the status ・Calling an appropriate process execution function for the occurred event
	mtr_act_run Input: (uint8)u1_state / motor status Output: (uint8)u1_state / motor status	・Variable initialization function call upon motor startup ・Motor control start function call
	mtr_act_stop Input: (uint8)u1_state / motor status Output: (uint8)u1_state / motor status	Motor control stop function call
	mtr_act_none Input: (uint8)u1_state / motor status Output: (uint8)u1_state / motor status	No processing is performed.
	mtr_act_reset Input: (uint8)u1_state / motor status Output: (uint8)u1_state / motor status	Initialization of the global variables
	mtr_act_error Input: (uint8)u1_state / motor status Output: (uint8)u1_state / motor status	Motor control stop function call
	mtr_start_init Input: None Output: None	Initializes only those variables needed at motor startup
	mtr_angle_speed Input: None Output: None	Position and speed calculation processing
	mtr_pi_ctrl Input: MTR_PI_CTRL *pi_ctrl / structure for PI control Output: (int16)s2_ref / PI 制御出力値	PI control
	mtr_set_variables Input: None Output: None	Setting motor variables
	R_MTR_IcsInput Input: MTR_ICS_INPUT *ics_input /structure for ICS Output: None	Setting the buffer
	R_MTR_GetSpeed Input: None Output: (int16)g_s2_speed_rpm / motor speed	Acquires the speed calculation value
	R_MTR_GetDir Input: None Output: (uint8) g_u1_direction	Acquires the direction of rotation
	R_MTR_GetStatus Input: None Output: (uint8)g_u1_mode_system / motor status	Obtaining the motor status
	mtr_error_check Input: None Output: None	Monitoring and detecting errors
	mtr_set_speed_ref Input: None Output: None	Sets the command used for speed control

Table 3-9 List of Control Functions (5/6)

File name	Function name	Processing overview
mtr_3im_less_foc.c	mtr_set_id_ref Input: None Output: None	Sets the γ axis current command
	mtr_set_iq_ref Input: None Output: None	Sets the δ axis current command
	mtr_calc_mod Input: (int16)s2_vu / (int16)s2_vv / (int16)s2_vv / (uint16)u2_vdc / Output: None	Modulation factor calculation

Table 3-10 List of Control Functions (6/6)

File name	Function name	Processing overview
mtr_ctrl_rl78g14_t1102.c	mtr_init_trd Input: None Output: None	Initial setting of the timer RD
	mtr_init_ad_converter Input: None Output: None	Initial setting of the A/D converter
	init_ui Input: None Output: None	Initialization of UI
	mtr_ctrl_start Input: None Output: None	Motor start processing
	mtr_ctrl_stop Input: None Output: None	Motor stop processing
	mtr_get_adc Input: uint8 ad_ch/ AD conversion channel Output: u2_temp / AD conversion value	AD conversion
	mtr_inv_set_uvw Input: int16 s2_u / U phase modulation factor : int16 s2_v / V phase modulation factor : int16 s2_w / W phase modulation factor Output: None	Setting PWM output
	mtr_init_register Input: None Output: None	Initial setting of PWM

3.3 Vector Control Software Variables

Lists of variables used in these control programs are given below. Note that the local variables are not mentioned.

Table 3-11 List of Variables (1/3)

Variable name	Type	Q	Content	Remarks
g_u1_mode_system	unit8	-	State management	0 : Stop mode 1 : Run mode 2 : Error mode
g_u2_run_mode	unit16	-	Operation mode management	0: Boot mode 1: Start mode 2: Control mode
g_u2_ctrl_mode	unit16	-	Control mode	1: Open loop mode 5: Sensorless vector control mode
g_u1_error_status	unit8	-	Error status management	1 : Over current error 2 : Over voltage error 7 : Low voltage error 8 : IPM temperature error 0xFF : Undefined error
g_u1_cnt_ics	uint8	-	ICS counter	
g_s2_vdc_ad	int16	Q6	Inverter bus voltage	[V]
g_s2_vd_ref	int16	Q6	γ axis output voltage command	[V]
g_s2_vq_ref	int16	Q6	δ axis output voltage command	[V]
g_s2_va_ref	int16	Q6	a axis output voltage command value	[V]
g_s2_vb_ref	int16	Q6	b axis output voltage command value	[V]
g_s2_iu_ad	int16	Q12	U phase current	[A]
g_s2_iu_lpf	int16	Q12	U phase current(LPF)	[A]
g_s2_pre_iu_lpf	int16	Q12	Previous U phase current value	[A]
g_s2_iv_lpf	int16	Q12	V phase current(LPF)	[A]
g_s2_iw_ad	int16	Q12	W phase current	[A]
g_s2_iw_lpf	int16	Q12	W phase current(LPF)	[A]
g_s2_pre_iw_lpf	int16	Q12	Previous W axis current value	[A]
g_s2_offset_iu	int16	Q12	U phase current offset value	[A]
g_s2_offset_iw	int16	Q12	W phase current offset value	[A]
g_s2_ia_lpf	int16	Q10	a phase current(LPF)	[A]
g_s2_ib_lpf	int16	Q10	b phase current(LPF)	[A]
g_s2_id_lpf	int16	Q12	γ phase current(LPF)	[A]
g_s2_iq_lpf	int16	Q12	δ phase current(LPF)	[A]
g_s2_kp_iq	int16	Q10	δ axis current PI control proportional gain	
g_s2_ki_iq	int16	Q10	δ axis current PI control integral gain	
g_s2_kp_speed	int16	Q14	speed PI control proportional gain	
g_s2_ki_speed	int16	Q22	speed PI control integral gain	
g_s2_lim_stator_speed_rad	int16	Q6	Stator speed PI control limit value	Electrical angle [rad/s]
g_s4_ilim_stator_speed_rad	int32	Q22	Stator speed PI control integral limit value	Electrical angle [rad/s]
g_s2_id_ref	int16	Q12	γ axis current command	[A]
g_s2_iq_ref	int16	Q12	δ axis current command	[A]
g_s2_ref_stator_speed_rad	int16	Q6	Stator speed command	Electrical angle [rad/s]

Table 3-12 List of Variables (2/3)

Variable name	Type	Q	Content	Remarks
g_s2_slip_speed_rad	int16	Q6	Slip speed	Electrical angle [rad/s]
g_s2_slip_k	int16	Q10	Slip speed gain	
g_s2_speed_rad	int16	Q6	Calculated speed value	Electrical angle [rad/s]
g_s2_ref_speed_rad_pi	int16	Q6	Command value for speed PI control	Electrical angle [rad/s]
g_s2_ref_speed_rad	int16	Q6	Speed command	Electrical angle [rad/s]
g_s2_angle_rad	int16	Q12	Stator interlinkage flux phase	[rad]
g_s2_max_speed_rad	int16	Q6	Maximum speed command value	
g_s2_min_speed_rad	int16	Q6	Minimum speed command value	
g_s2_refu	int16	Q6	U phase voltage command	[V]
g_s2_refv	int16	Q6	V phase voltage command	[V]
g_s2_refw	int16	Q6	W phase voltage command	[V]
g_s2_inv_limit	int16	Q6	Phase voltage limit value	[V]
g_s2_speed_lpf_k	int16	Q14	Speed LPF gain	
g_s2_current_lpf_k	int16	Q14	Current LPF gain	
g_s2_offset_lpf_k	int16	Q14	Current offset LPF gain	
g_u1_direction	uint8	-	Rotation direction	0: CW 1: CCW
g_u1_dir_buf	uint8	-	Command rotation direction	0: CW 1: CCW
g_u1_enable_write	uint8	-	Variable for ICS UI	
g_u2_cnt_adjust	uint16	-	Counter for current offset calculation	
g_s2_id_ref_buf	int16	Q12	Variable for storing γ axis current command	[A]
g_s2_iq_ref_buf	int16	Q12	Variable for storing δ axis current command	[A]
g_u1_flag_id_ref	uint8	-	δ axis current command management flag	0: δ axis current = 0 1: Speed PI output
g_u1_flag_iq_ref	uint8	-	q axis current command value management flag	0: q axis current 0 1: Speed PI output 2: q axis current increase 3: q axis current decrease
g_s2_temp_speed_rad	int16	Q6	Variable to store speed	Electrical angle [rad/s]
g_s2_temp_ref_speed_rad	int16	Q6	Variable to store speed command value	Electrical angle [rad/s]
g_s2_angle_compensation	int16	-	Phase compensation constant	
g_s2_offset_calc_time	int16	-	Current offset calculation time	[ms]
g_s2_accel	int16	Q6	Acceleration	[rad/s^2]
g_s2_voltage_drop	int16	Q6	Voltage drop correction threshold	[V]
g_s2_voltage_drop_k	int16	Q6	Voltage drop correction gain	
g_s2_modu	int16	Q12	U phase modulation factor	
g_s2_modv	int16	Q12	V phase modulation factor	
g_s2_modw	int16	Q12	W phase modulation factor	

Table 3-13 List of Variables (3/3)

Variable name	Type	Q	Content	Remarks
g_u1_flag_offset_calc	uint8	-	Current offset calculation flag	0: Calculated at transition to boot mode 1: Calculated at transition to boot mode (first time only)
g_s2_boot_id_up_step	int16	Q12	γ axis current step at startup	[A]
g_s2_fluctuation_limit	int16	Q6	Speed fluctuation limit	[rad/s]
g_s2_ctrl_ref_id	int16	Q12	γ axis current command	[A]
g_u2_cnt_id_const	uint16	-	γ axis current and flux stabilization wait time counter	
g_s2_id_const_time	int16	-	γ axis current and flux stabilization wait time	[ms]
g_s2_ipm_temperature_ad	int16	Q12	IPM temperature voltage conversion value	[V]
g_s2_iq_pip	int16	Q12	speed PI control proportional output	[A]
g_s4_iq_pii	int32	Q28	speed PI control integral output	[A]
g_u1_flag_speed_ref	uint8	-	Speed command management flag	0: Speed = 0 1: Speed changes
g_s2_id_ref_slip_lim	int16	Q12	γ axis current command limit for slip speed gain calculate	[A]
stator_speed	MTR_PI_CTRL	-	Stator speed PI control structure	
mtr_p	MTR_PARAMETER	-	Motor parameters and control parameters	
ics_input_buff	MTR_ICS_INPUT	-	ICS UI structure	

3.4 Vector Control Software Structures

A list of structure used in these control programs is given below.

Table 3-14 List of Structure(1/3)

	Member name	Type	Q	Content	Remarks
MTR_ICS_INPUT	s2_ref_speed	int16	-	Speed command	Mechanical angle [rpm]
	s2_direction	int16	-	Rotation direction	0: CW 1: CCW
	s2_kp_speed	int16	Q10	Speed PI control proportional gain	
	s2_ki_speed	int16	Q10	Speed PI control integral gain	
	s2_kp_iq	int16	Q14	δ axis current PI control proportional gain	
	s2_ki_iq	int16	Q22	δ axis current PI control integral gain	
	s2_speed_lpf_k	int16	Q14	Speed LPF gain	
	s2_current_lpf_k	int16	Q14	Current LPF gain	
	s2_mtr_rs	int16	Q13	Stator resistance	[Ω]
	s2_mtr_rr	int16	Q13	Rotor resistance	[Ω]
	s2_mtr_m	int16	Q17	Magnetizing inductance	[H]
	s2_mtr_lls	int16	Q24	Stator leakage inductance	[H]
	s2_mtr_llr	int16	Q24	Rotor leakage inductance	[H]
	s2_offset_lpf_k	int16	Q14	Current offset LPF gain	
	s2_max_speed	int16	-	Maximum speed	Mechanical angle [rpm]
	s2_min_speed	int16	-	Minimum speed	Mechanical angle [rpm]
	s2_ctrl_ref_id	int16	Q12	γ axis current command	[A]
	s2_id_ref_slip_lim	int16	Q12	γ axis current command limit for slip speed gain calculate	[A]
	s2_boot_id_up_time	int16	-	γ axis current/flux stabilization wait time	[ms]
	s2_id_const_time	int16	-	Speed command acceleration step	[rad/s]
	s2_accel	int16	Q6	Speed fluctuation limit	[rad/s]
	s2_fluctuation_limit	int16	Q6	Voltage output delay compensation coefficient	
	s2_delay	int16	-	Current offset adjustment time	[ms]
	s2_offset_calc_time	int16	-	Voltage drop correction threshold	[V]
	s2_voltage_drop	int16	Q6	Voltage drop correction gain	
	s2_voltage_drop_k	int16	Q6	γ axis current/flux stabilization wait time	[ms]

Table 3-15 List of Structure(2/3)

	Member name	Type	Content	Remarks
MTR_PI_CTRL	s2_diff	int16	Differential	
	s2_kp	int16	PI control proportional gain	
	s2_ki	int16	PI control integral gain	
	s2_limit	int16	PI control output limit value	
	s4_refi	int32	PI control output value	
	s4_ilimit	int32	PI control output limit value	

Table 3-16 List of Structure(3/3)

	Member name	Type	Q	Content	Remarks
MTR_PARAMETER	s2_mtr_rs	int16	Q13	Stator resistance	[Ω]
	s2_mtr_rr	int16	Q13	Rotor resistance	[Ω]
	s2_mtr_m	int16	Q17	Magnetizing inductance	[H]
	s2_mtr_ls	int16	Q24	Stator leakage inductance	[H]
	s2_mtr_lr	int16	Q24	Rotor leakage inductance	[H]
	s2_mtr_rr_lr	int16	Q11	f4_mtr_rr / f4_mtr_lr	
	s2_mtr_sigma	int16	Q21	1.0 - f4_mtr_m / f4_mtr_ls * f4_mtr_m_lr	
	s2_mtr_ls_sigma	int16	Q23	f4_mtr_ls * f4_mtr_sigma	

3.5 Vector Control Software Macro Definitions

Lists of macro definitions used in these control programs are shown below. The macros with a figure in [ ] are used only in the indicated sample software.

Table 3-17 List of Macro Definitions (1/8)

File name	Macro name	Definition value	Q	Remarks
main.h	MAX_SPEED	CP_MAX_SPEED_RPM	-	Maximum value of the speed command (mechanical angle) [rpm]
	MIN_SPEED	CP_MIN_SPEED_RPM	-	Minimum value of the speed command (mechanical angle) [rpm]
	IQ_PI_KP	CP_IQ_PI_KP	Q10	δ axis current PI control proportional gain
	IQ_PI_KI	CP_IQ_PI_KI	Q10	δ axis current PI control integral gain
	SPEED_PI_KP	CP_SPEED_PI_KP	Q14	Speed PI control proportional gain
	SPEED_PI_KI	CP_SPEED_PI_KI	Q22	Speed PI control integral gain
	SPEED_LPF_K	CP_SPEED_LPF_K	Q14	Speed LPF gain
	CURRENT_LPF_K	CP_CURRENT_LPF_K	Q14	Current LPF gain
	STATOR_RESISTANCE	MP_STATOR_RESISTANCE	Q13	Stator resistance [Ω]
	ROTOR_RESISTANCE	MP_ROTOR_RESISTANCE	Q13	Rotor resistance [Ω]
	MUTUAL_INDUCTANCE	MP_MUTUAL_INDUCTANCE	Q17	Magnetizing inductance [H]
	STATOR_LEAKAGE_INDUCTANCE	MP_STATOR_LEAKAGE_INDUCTANCE	Q24	Stator leakage inductance [H]
	ROTOR_LEAKAGE_INDUCTANCE	MP_ROTOR_LEAKAGE_INDUCTANCE	Q24	Rotor leakage inductance [H]
	OFFSET_LPF_K	CP_OFFSET_LPF_K	Q14	Current offset LPF gain
	CTRL_REF_ID	CP_CTRL_REF_ID	Q12	γ axis current command [A]
	ID_REF_SLIP_LIMIT	CP_ID_REF_SLIP_LIMIT	Q12	γ axis current command limit for slip speed gain calculate
	BOOT_ID_UP_TIME	CP_BOOT_ID_UP_TIME	-	Rise time at γ axis current startup [ms]
	ID_CONST_TIME	CP_ID_CONST_TIME	-	γ current/flux stabilization wait time [ms]
	ACCEL_MODE0	CP_ACCEL_MODE0	Q6	Acceleration
	FLUCTUATION_LIMIT	CP_FLUCTUATION_LIMIT	Q6	Speed fluctuation limit
	DELAY	CP_DELAY	Q12	Voltage output delay compensation coefficient
	OFFSET_CALC_TIME	CP_OFFSET_CALC_TIME	-	Current offset calculation time [ms]
	VOLTAGE_DROP	CP_VOLTAGE_DROP	Q6	Voltage drop correction threshold [V]
	VOLTAGE_DROP_K	CP_VOLTAGE_DROP_K	Q6	Voltage drop correction gain
	POLE_PAIRS	MP_POLE_PAIRS	-	Constant used for pole pairs count correction
	M_CW	0	-	Rotation direction
	M_CCW	1	-	
	ICS_INT_LEVEL	6	-	ICS interrupt priority level

Table 3-18 List of Macro Definitions (2/8)

File name	Macro name	Definition value	Remarks
motor_parameter.h	MP_POLE_PAIRS	2	Pole pairs count
	MP_STATOR_RESISTANCE	2.2	Stator resistance [Ω]
	MP_ROTOR_RESISTANCE	2.4	Rotor resistance [Ω]
	MP_MUTUAL_INDUCTANCE	0.2	Magnetizing inductance [H]
	MP_STATOR_LEAKAGE_INDUCTANCE	0.0015	Stator leakage inductance [H]
	MP_INDUCTANCE	0.0015	Rotor leakage inductance [H]

Table 3-19 List of Macro Definitions (3/8)

File name	Macro name	Definition value	Q	Remarks
mtr_ctrl_rl78g14_t1102.h	MTR_PWM_TIMER_FREQ	64.0	-	PWM timer count frequency [MHz]
	MTR_CARRIER_FREQ	16.0	-	Carrier frequency [kHz]
	MTR_DEADTIME	3.0	-	Dead time [μs]
	MTR_DEADTIME_SET	MTR_DEADTIME * MTR_PWM_TIMER_FREQ	-	Dead time setting
	MTR_AD_FREQ	8.0	-	A/D converter operating frequency [MHz]
	MTR_AD_SAMPLING_CYCLE	27.5	-	A/D sampling cycle count
	MTR_AD_SAMPLING_TIME	MTR_AD_SAMPLING_CYCLE / MTR_AD_FREQ	-	A/D sampling time
	MTR_AD_TIME_SET	MTR_PWM_TIMER_FREQ * MTR_AD_SAMPLING_TIME	-	Setting used to assure the A/D sampling time
	MTR_CARRIER_SET	(MTR_PWM_TIMER_FREQ * 1000 / MTR_CARRIER_FREQ / 2)+ MTR_DEADTIME_SET-2	-	Carrier setting
	MTR_HALF_CARRIER_SET	MTR_CARRIER_SET / 2	-	Carrier setting (intermediate value)
	MTR_PWM_DUTY_RANGE	4096	-	Range of modulation factor
	MTR_PORT_UP	P1.5	-	U phase (positive phase) output port
	MTR_PORT_UN	P1.4	-	U phase (negative phase) output port
	MTR_PORT_VP	P1.3	-	V phase (positive phase) output port
	MTR_PORT_VN	P1.1	-	V phase (negative phase) output port
	MTR_PORT_WP	P1.2	-	W phase (positive phase) output port
	MTR_PORT_WN	P1.0	-	W phase (negative phase) output port
	MTR_ADCCH_IU	0	-	U phase current AD convert CH
	MTR_ADCCH_IW	1	-	W phase current AD convert CH
	MTR_ADCCH_VDC	2	-	VDC AD convert CH
	MTR_ADCCH_VU	3	-	U phase voltage AD convert CH
	MTR_ADCCH_VV	4	-	V phase voltage AD convert CH
	MTR_ADCCH_VW	5	-	W phase voltage AD convert CH
	MTR_ADCCH_IMPTEMPERATURE	7	-	IPM temperature AD convert CH
	MTR_INPUT_V	220.0f * 1.41421	Q6	Power supply voltage [V]
	MTR_HALF_VDC	MTR_INPUT_V / 2	Q6	Power supply voltage /2 [V]
	MTR_IC_GATE_ON_V	MTR_INPUT_V * 0.8f	Q6	Power supply voltage times 80% [V]

Table 3-20 List of Macro Definitions (4/8)

File name	Macro name	Definition value	Q	Remarks
mtr_ctrl_rl78g14_t1102.h	MTR_AD_BIT_SGN	0x8000U	-	Current value convert
	MTR_ADSCALE_CUR	(100.0f / 1023)	Q18	Current measurement A/D converter resolution
	MTR_ADSCALE_VDC	(686.8f / 1023)	Q14	Inverter bus voltage measurement A/D converter resolution
	MTR_ADSCALE_IPMTEMPERATURE	(5.0f / 1023)	Q20	IPM temperature measurement A/D converter resolution
	MTR_OVERCURRENT_LIMIT	4.0	Q12	Current limit value [A]
	MTR_OVERVOLTAGE_LIMIT	400	Q6	Voltage limit value (maximum) [V]
	MTR_UNDERVOLTAGE_LIMIT	85	Q6	Voltage limit value (minimum) [V]
	MTR_OVERIPMTEMPERATURE_LIMIT	3.0	Q12	IPM temperature limit [V]
	MTR_PORT_LED1	P5.2	-	LED1 output port
	MTR_PORT_LED2	P5.3	-	LED2 output port
	MTR_LED_ON	0	-	Active low
	MTR_LED_OFF	1	-	
	MTR_PORT_IC_GATE	P5.5	-	Inrush current prevention circuit port
	MTR_IC_GATE_ON	1	-	Active high

Table 3-21 List of Macro Definitions (5/8)

File name	Macro name	Definition value	Q	Remarks
mtr_3im_less_foc.h	MTR_INT_DECIMATION	1	-	Interrupt decimation count
	MTR_CTRL_PERIOD	(MTR_INT_DECIMATION + 1)/ (MTR_CARRIER_FREQ*1000)	Q26	Control period [s]
	MTR_CONTROL_FREQ	(MTR_CARRIER_FREQ*1000)/ (MTR_INT_DECIMATION + 1)	-	Control frequency [Hz]
	MTR_POLE_PAIRS	MP_POLE_PAIRS	-	Pole pairs
	MTR_RS	MP_STATOR_RESISTANCE	Q13	Stator resistance [Ω]
	MTR_RR	MP_ROTOR_RESISTANCE	Q13	Rotor resistance [Ω]
	MTR_M	MP_MUTUAL_INDUCTANCE	Q17	Magnetizing inductance [H]
	MTR_LLS	MP_STATOR_LEAKAGE_INDUCTANCE	Q24	Stator leakage inductance [H]
	MTR_LLR	MP_ROTOR_LEAKAGE_INDUCTANCE	Q24	Rotor leakage inductance [H]
	MTR_LS	MTR_M + MTR_LLS	Q17	
	MTR_LR	MTR_M + MTR_LLR	Q17	
	MTR_RR_LR	MTR_RR / MTR_LR	Q11	
	MTR_SIGMA	1.0f - MTR_M / MTR_LS * MTR_M_LR	Q21	
	MTR_LS_SIGMA	MTR_LS * MTR_SIGMA	Q23	
	MTR_1_2PI	0.159155	Q16	
	MTR_RPM_RAD	3.14159 / 30	Q16	
	TWOPI	4096	-	
	MTR_IQ_PI_KP	CP_IQ_PI_KP	Q10	δ axis current PI control proportional gain
	MTR_IQ_PI_KI	CP_IQ_PI_KI	Q10	δ axis current PI control integral gain
	MTR_SPEED_PI_KP	CP_SPEED_PI_KP	Q14	Speed PI control proportional gain
	MTR_SPEED_PI_KI	CP_SPEED_PI_KI	Q22	Speed PI control integral gain
	MTR_SPEED_LPF_K	CP_SPEED_LPF_K	Q14	Speed LPF gain
	MTR_CURRENT_LPF_K	CP_CURRENT_LPF_K	Q14	Current LPF gain
	MTR_OFFSET_LPF_K	CP_OFFSET_LPF_K	Q14	Current offset LPF gain
	MTR_LIMIT_IQ	3.0	Q12	Speed PI control output limit value [A]
	MTR_I_LIMIT_IQ	3.0	Q28	Speed PI control integral limit value[A]
	MTR_MAX_SPEED_RPM	CP_MAX_SPEED_RPM	-	Maximum speed (mechanical angle) [rpm]
	MTR_MAX_SPEED_RAD	MTR_MAX_SPEED_RPM* MTR_POLE_PAIRS*MTR_TWOPI/60	Q6	Maximum speed (electrical angle) [rad/s]
	MTR_MIN_SPEED_RPM	CP_MIN_SPEED_RPM	-	Minimum speed (mechanical angle) [rpm]
	MTR_MIN_SPEED_RAD	MTR_MIN_SPEED_RPM*MTR_POLE_PAIRS*MTR_TWOPI/60	Q6	Minimum speed (electrical angle) [rad/s]

Table 3-22 List of Macro Definitions (6/8)

File name	Macro name	Definition value	Q	Remarks
mtr_3im_less_foc.h	MTR_SPEED_LIMIT	MTR_MAX_SPEED_RAD*1.2	Q6	Speed limit value [rad/s]
	MTR_LIMIT_STATOR_SPEED_RAD	MTR_SPEED_LIMIT	Q6	δ axis current PI control output limit value [rad/s]
	MTR_I_LIMIT_STATOR_SPEED_RAD	MTR_SPEED_LIMIT	Q6	δ axis current PI control output limit [rad/s]
	MTR_CTRL_REF_ID	CP_CTRL_REF_ID	Q12	γ axis current command
	MTR_ID_REF_SLIP_LIMIT	CP_ID_REF_SLIP_LIMIT	Q12	γ axis current command limit for slip speed gain calculate[A]
	MTR_BOOT_ID_UP_TIME	CP_BOOT_ID_UP_TIME	-	Rise time at γ axis current startup [ms]
	MTR_BOOT_ID_UP_STEP	CP_CTRL_REF_ID/MTR_BOOT_ID_UP_TIME	-	Step at γ axis current startup
	MTR_ID_CONST_TIME	CP_ID_CONST_TIME	-	γ axis current/flux stabilization wait time [ms]
	MTR_ACCEL_MODE0	CP_ACCEL_MODE0	Q6	Acceleration
	MTR_FLUCTUATION_LIMIT	CP_FLUCTUATION_LIMIT	Q6	Speed fluctuation limit [rad/s]
	MTR_DELAY	CP_DELAY	-	Phase compensation constant
	MTR_ANGLE_COMPENSATION	MTR_CTRL_PERIOD*MTR_DELAY/6.283185	Q16	
	MTR_OFFSET_CALC_TIME	CP_OFFSET_CALC_TIME	-	Current offset calculation time [ms]
	MTR_VOLTAGE_DROP	CP_VOLTAGE_DROP	Q6	Voltage drop correction value [V]
	MTR_VOLTAGE_DROP_K	CP_VOLTAGE_DROP_K	Q6	Voltage drop correction gain
	MTR_EVERY_TIME	0	-	Calculate current value
	MTR_ONE_TIME	1	-	Calculate current offset value (first time only)
	MTR_CW	0	-	Rotation direction
	MTR_CCW	1	-	
	MTR_FLG_CLR	0	-	Flag management
	MTR_FLG_SET	1	-	
	MTR_ID_UP	0	-	γ axis current increases
	MTR_ID_CONST	1	-	γ axis current fixed
	MTR_ID_CONST_CTRL	2	-	Normal operation
	MTR_IQ_ZERO	0	-	δ axis current is 0
	MTR_IQ_SPEED_PI_OUTPUT	1	-	Normal
	MTR_SPEED_ZERO	0	-	
	MTR_SPEED_CHANGE	1	-	

Table 3-23 List of Macro Definitions (7/8)

File name	Macro name	Definition value	Q	Remarks
mtr_3im_less_foc.h	MTR_BOOT_MODE	0x00	-	Boot mode
	MTR_START_MODE	0x01	-	Start mode
	MTR_CTRL_MODE	0x02	-	Control mode
	MTR_ZERO_PEC_MODE	0x00	-	Zero position measurement mode
	MTR_OPENLOOP_MODE	0x01	-	Open loop mode
	MTR_HALL_120_MODE	0x02	-	Hall sensor 120° operating mode
	MTR_LESS_120_MODE	0x03	-	BEMF sensorless 120° operating mode
	MTR_ENCD_FOC_MODE	0x04	-	Encoder vector operating mode
	MTR_LESS_FOC_MODE	0x05	-	Sensorless vector control mode
	MTR_OVER_CURRENT_ERROR	0x01	-	Overcurrent error
	MTR_OVER_VOLTAGE_ERROR	0x02	-	Overvoltage error
	MTR_OVER_SPEED_ERROR	0x03	-	Excessive speed error
	MTR_TIMEOUT_ERROR	0x04	-	Timeout error
	MTR_BEMF_ERROR	0x07	-	BEMF error
	MTR_UNDER_VOLTAGE_ERROR	0x00	-	Low voltage error
	MTR_OVER_IPMTEMPERATURE_ERROR	0x08	-	IPM temperature limit exceeded error
	MTR_UNKNOWN_ERROR	0xff	-	Undefined error
	MTR_MODE_STOP	0x00	-	Stop state
	MTR_MODE_RUN	0x01	-	Motor running state
	MTR_MODE_ERROR	0x02	-	Error state
	MTR_SIZE_STATE	3	-	Number of states
	MTR_EVENT_STOP	0x00	-	Motor stop event
	MTR_EVENT_RUN	0x01	-	Motor start event
	MTR_EVENT_ERROR	0x02	-	Motor error event
	MTR_EVENT_RESET	0x03	-	Motor reset event
	MTR_SIZE_EVENT	4	-	Number of events

Table 3-24 List of Macro Definitions (8/8)

File name	Macro name	Definition value	Remarks
control_parameter.h	CP_IQ_PI_KP	4.0	δ axis current PI control proportional gain
	CP_IQ_PI_KI	0.008	δ axis current PI control integral gain
	CP_SPEED_PI_KP	0.01	Speed PI control proportional gain
	CP_SPEED_PI_KI	0.001	Speed PI control integral gain
	CP_SPEED_LPF_K	0.1	Speed LPF gain
	CP_CURRENT_LPF_K	0.1	Current LPF gain
	CP_OFFSET_LPF_K	0.01	Current offset LPF gain
	CP_MAX_SPEED_RPM	2000	Maximum speed (mechanical angle) [rpm]
	CP_MIN_SPEED_RPM	500	Minimum speed (mechanical angle) [rpm]
	CP_CTRL_REF_ID	2.2	γ axis current command[A]
	CP_ID_REF_SLIP_LIMIT	0.25	γ axis current command limit for slip speed gain calculate[A]
	CP_BOOT_ID_UP_TIME	100.0	Rise time at γ axis current startup [ms]
	CP_ID_CONST_TIME	500.0	γ axis current/flux stabilization wait time [ms]
	CP_ACCEL_MODE0	0.1	Acceleration during start mode [rad/s^2]
	CP_FLUCTUATION_LIMIT	20.0	Speed fluctuation limit [rad/s]
	CP_DELAY	1.5	Phase delay compensation constant
	CP_OFFSET_CALC_TIME	10000	Current offset calculation time
	CP_VOLTAGE_DROP	8.0	Voltage drop correction threshold [V]
	CP_VOLTAGE_DROP_K	100.0	Voltage drop correction gain

3.6 Control Flow (Flowcharts)

3.6.1 Main Processing

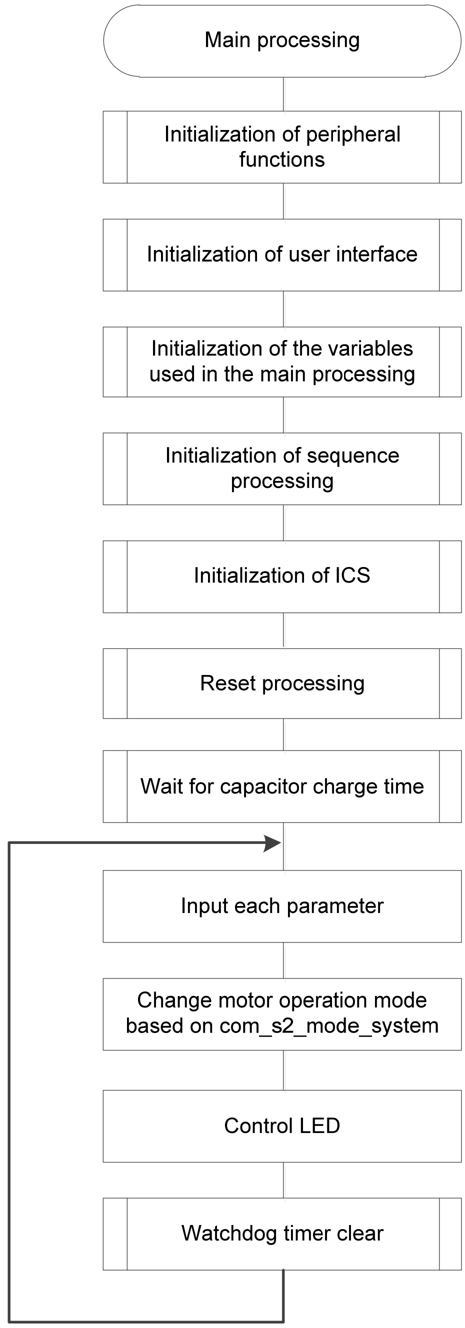

Figure 3-4 Main Processing

3.6.2 125 [μs] Cycle Interrupt Handling

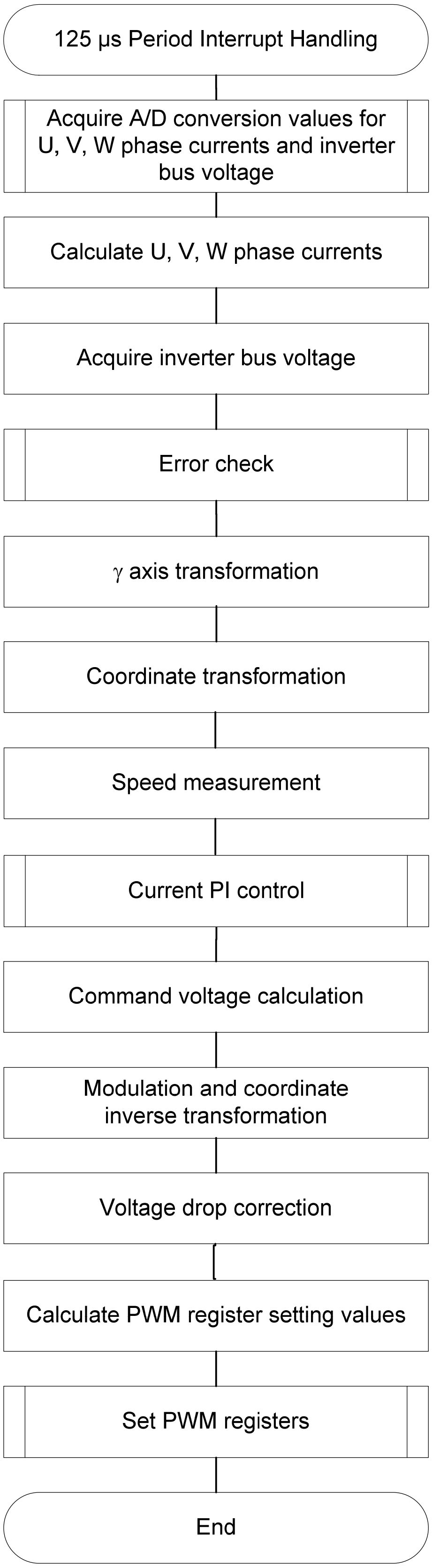

Figure 3-5 125 [μs] Cycle Interrupt Handling

3.6.3 1 [ms] Interrupt Handling

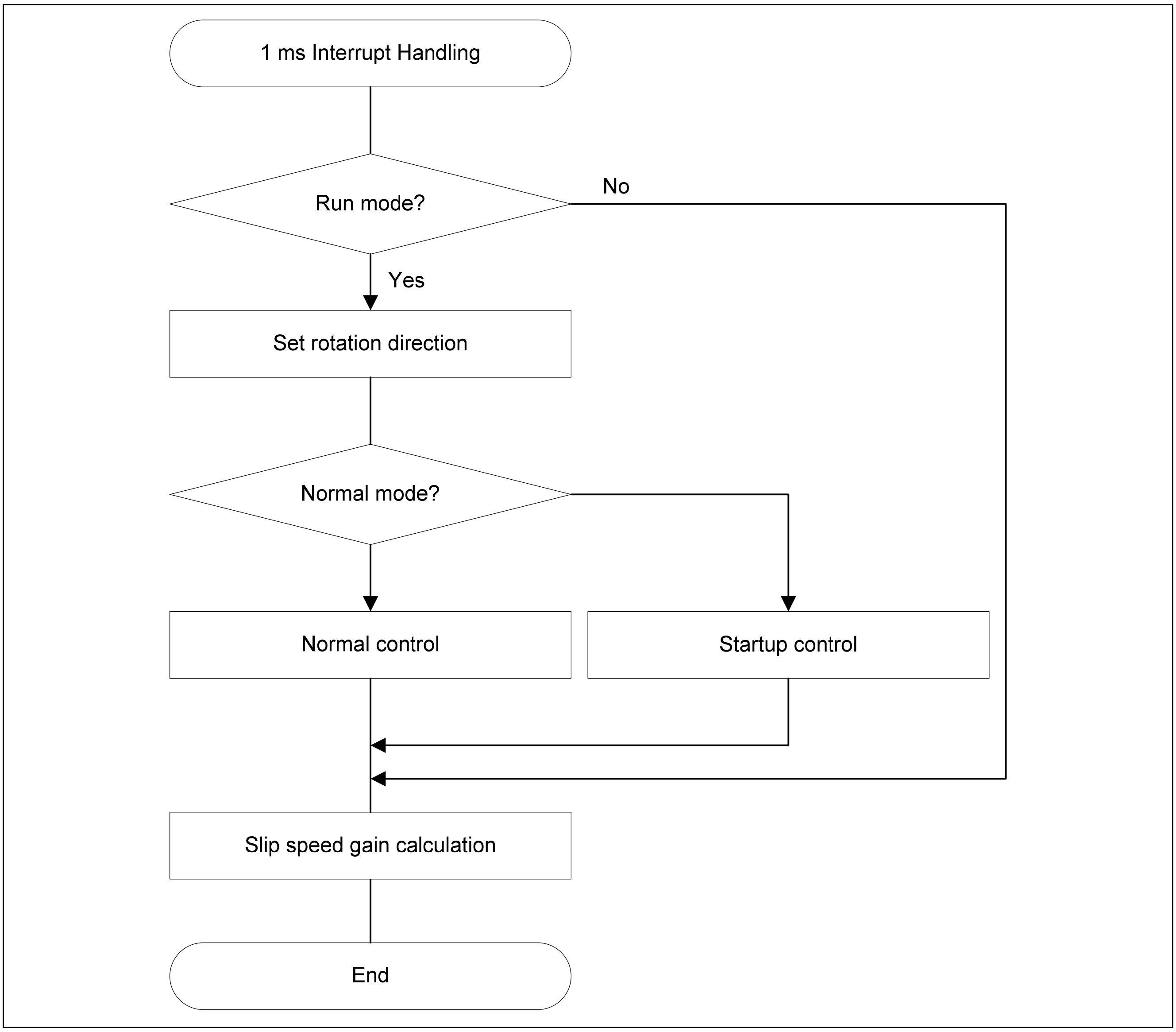

Figure 3-6 1 [ms] Interrupt Handling

3.6.4 Over Current Detection Interrupt Handling

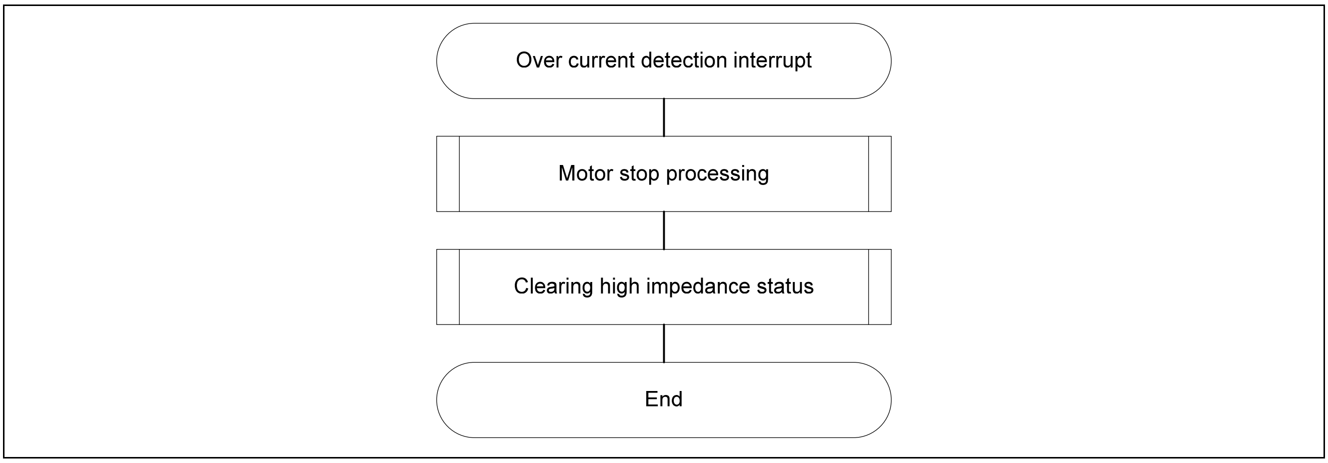

Figure 3-7 Over Current Detection Interrupt Handling

4. Development Support Tool: In Circuit Scope

4.1 Overview

In the target sample programs described in this application note, user interfaces (rotating/stop command, rotation speed command, etc.) based on the development support tool 'In Circuit Scope' (ICS) can be used. ICS is a tool which displays real-time waveforms on PC of global variables of the program being executed on the target system. Refer to 'In Circuit Scope manual' and 'How to set CubeSuite+ for using ICS' for usage and more details.

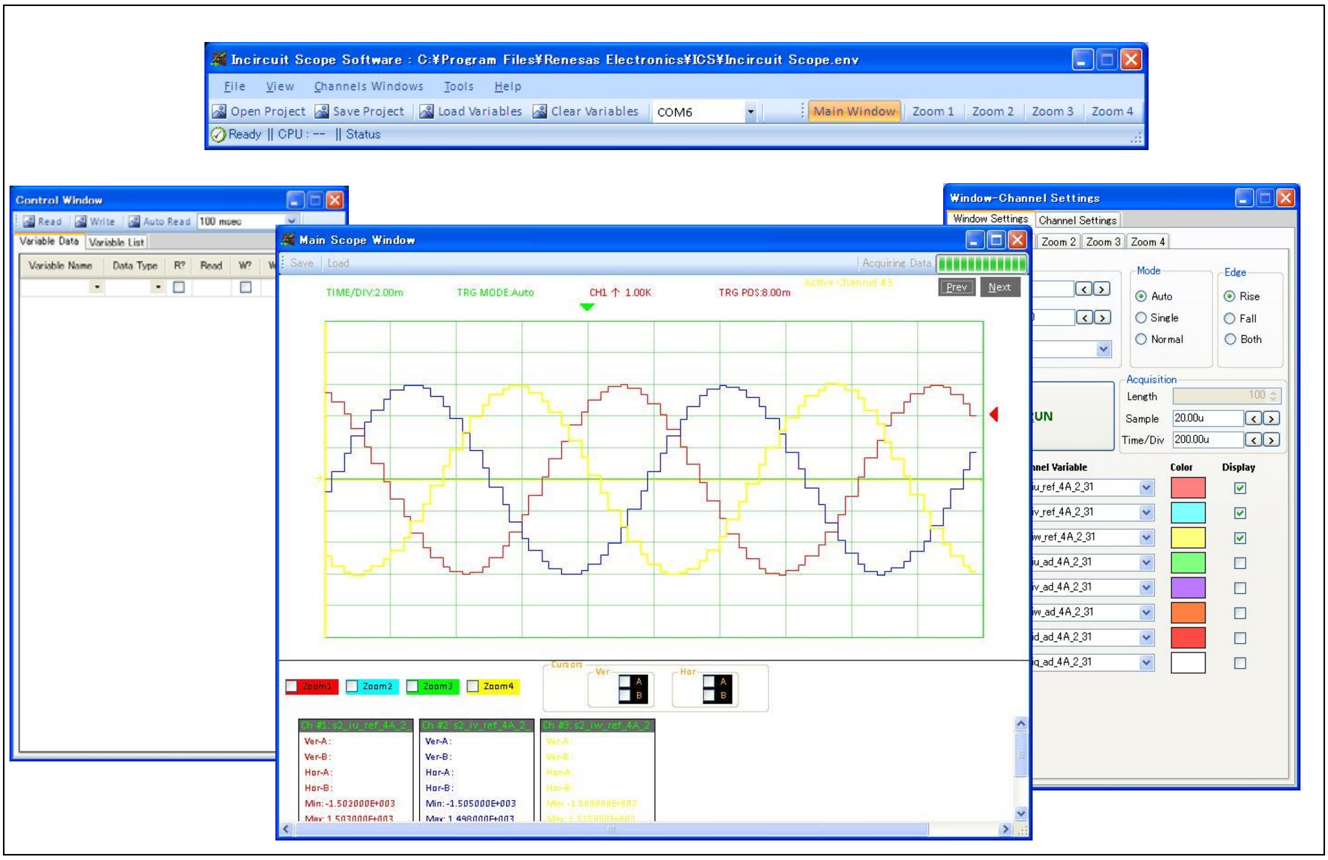

Figure 4-1 In Circuit Scope - Appearance

4.2 List of Variable for ICS

Table 4-1 is a list of variables for ICS. When a change is made to these variables for ICS, the change is not yet reflected to variables of the motor control layer. The variables of the motor control layer are rewritten when a same value is written to com_s2_enable_write and g_s2_enable_write. Note that the variables with (*) do not depend on com_s2_enable_write and the variables with a figure in [ ] are used only in the indicated sample software.

Table 4-1 List of Variables for ICS

Name of variable for ICS	Type	Content	Reflection destination variable (Variables of motor control layer)
com_s2_mode_system	int16	state management 0: stop mode 1: run mode 3: Reset	This variables value is reflected in g_s2_mode_system at the point it is written.
com_s2_direction	int16	Rotation direction	g_u1_dir_buff
com_s2_ref_speed_rpm	int16	Speed command	g_s2_ref_speed_rad
com_s2_kp_speed	int16	Speed PI control proportional gain	g_s2_kp_speed
com_s2_ki_speed	int16	Speed PI control integral gain	g_s2_ki_speed
com_s2_kp_iq	int16	δ axis current PI control proportional gain	g_s2_kp_iq
com_s2_ki_iq	int16	δ axis current PI control integral gain	g_s2_ki_iq
com_s2_speed_lpf_k	int16	Speed LPF gain	g_s2_speed_lpf_k
com_s2_current_lpf_k	int16	Current LPF gain	g_s2_current_lpf_k
com_s2_mtr_rs	int16	Stator resistance	mtr_p.s2_mtr_rs
com_s2_mtr_rr	int16	Rotor resistance	mtr_p.s2_mtr_rr
com_s2_mtr_m	int16	Magnetizing inductance	mtr_p.s2_mtr_m
com_s2_mtr_lls	int16	Stator leakage inductance	mtr_p.s2_mtr_ls
com_s2_mtr_llr	int16	Rotor leakage inductance	mtr_p.s2_mtr_lr
com_s2_offset_lpf_k	int16	Current offset LPF gain	g_s2_offset_lpf_k
com_s2_max_speed_rpm	int16	Maximum speed	g_s2_max_speed_rad
com_s2_min_speed_rpm	int16	Minimum speed	g_s2_min_speed_rad
com_s2_ctrl_ref_id	int16	γ axis current command	g_s2_ctrl_ref_id
com_s2_id_ref_slip_lim	Int16	γ axis current command limit for slip speed gain calculate	g_s2_id_ref_slip_lim
com_s2_boot_id_up_time	int16	Rise time at γ axis current startup	g_s2_boot_id_up_step
com_s2_id_const_time	int16	γ axis current/flux stabilization wait time	g_s2_id_const_time
com_s2_accel	int16	Speed command acceleration step	g_s2_accel
com_s2_fluctuation_limit	int16	Speed fluctuation limit	g_s2_fluctuation_limit
com_s2_offset_calc_time	int16	Current offset adjustment time	g_s2_offset_calc_time
com_s2_delay	int16	Voltage output delay compensation coefficient	g_s2_angle_compensation
com_s2_voltage_drop	int16	Voltage drop correction threshold	g_s2_voltage_drop
com_s2_voltage_drop_k	int16	Voltage drop correction gain	g_s2_voltage_drop_k
com_s2_enable_write	int16	Variable write enable	—

Website and Support

Renesas Electronics Website
http://www.renesas.com/

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

Revision History

Rev.	Date	Description	
		Page	Summary
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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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Refer to "http://www.renesas.com/" for the latest and detailed information.

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