Sensorless Vector Control for Permanent Magnet Synchronous Motor

RA6T1

Introduction

This application note aims at explaining sensorless vector control software for a permanent magnet synchronous motor. The explanation includes, how to use the library of 'Renesas Motor Workbench' tool, which is a support tool for motor control development.

Target Device

Operation of the sample programs have been verified by using the following device.

- RA6T1 (R7FA6T1AD3CFP)

Related Documents

- RA6T1 Group User's Manual: Hardware (R01UH0897)
- RA Flexible Software Package Documentation
- Application note: 'Sensorless vector control for permanent magnet synchronous motor (Algorithm)' (R01AN3786)
- Renesas Motor Workbench User's Manual (R21UZ0004)
- Evaluation System For BLDC Motor User's Manual (R12UZ0062)
- Motor Control Evaluation System for RA Family (R12UZ0078)
- RA6T1 CPU CARD User's Manual (R12UZ0077)

Contents

1. Overview

This application note explains how to implement the sensorless vector control sample programs of permanent magnetic synchronous motor (PMSM) *1 using the RA6T1 microcontroller and how to use the motor control development support tool, 'Renesas Motor Workbench'. Note that this sample program use the algorithm described in the application note 'Sensorless vector control of permanent magnetic synchronous motor: algorithm'.

Note: 1. PMSM is also known as brushless DC motor (BLDC).

2. System overview

Overview of this system is explained below.

2.1 Hardware configuration

The hardware configuration is shown below.

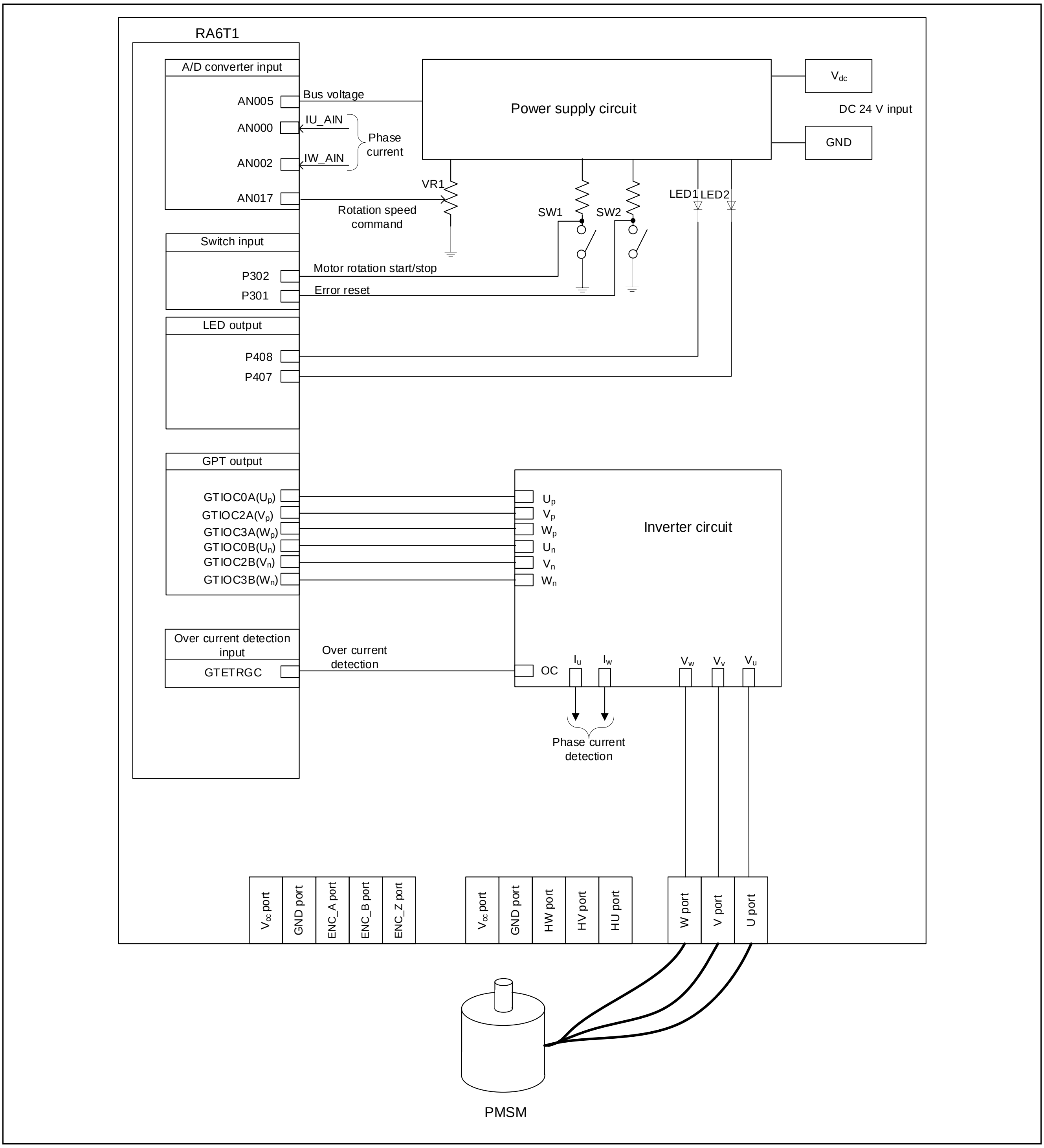

Figure 2-1 Hardware Configuration Diagram

2.2 Hardware specifications

2.2.1 User interface

Table 2-1 is a list of user interfaces of this system.

Table 2-1 User Interface

Item	Interface component	Function
Rotation speed	Variable resistance (VR1)	Rotation speed command value input (analog values)
ON / OFF	Toggle switch (SW1)	Motor rotation start/stop command
ERROR RESET	Push switch (SW2)	Command of recovery from error status
LED1	Orange LED	• At the time of Motor rotation: ON • At the time of stop: OFF
LED2	Orange LED	• At the time of error detection: ON • At the time of normal operation: OFF
RESET	Push switch (SW1 on CPU card)	System reset

Table 2-2 is a list of port interfaces of RA6T1 microcontroller of this system.

Table 2-2 Port Interface

R7FA6T1AD3CFP Port name	Function
P014 / AN005	Inverter bus voltage measurement
P502 / AN017	For inputting rotation speed command values (analog values)
P302	START/STOP toggle switch
P301	ERROR RESET push switch
P408	LED1 ON/OFF control
P407	LED2 ON/OFF control
P000 / AN000	U phase current measurement
P002 / AN002	W phase current measurement
P415 / GTIOC0A	PWM output (U_p) / Low Active
P113 / GTIOC2A	PWM output (V_p) / Low Active
P111 / GTIOC3A	PWM output (W_p) / Low Active
P414 / GTIOC0B	PWM output (U_n) / High Active
P114 / GTIOC2B	PWM output (V_n) / High Active
P112 / GTIOC3B	PWM output (W_n) / High Active
P503 / GTETRGC	PWM emergency stop input at the time of overcurrent detection

2.2.2 Peripheral functions

Table 2-3 is a list of peripheral functions used in this system.

Table 2-3 Peripheral Functions List

12-bit A/D	AGT	GPT	POEG
• Rotation speed command value input • Inverter bus voltage measurement • Electric current of each phase U and W	• 500 [µs] interval timer	Complementary PWM output	Sets ports executing PWM output to high impedance state when an overcurrent is detected by external circuit.

(1) 12-bit A/D converter

U phase current (Iu), W phase current (Iw), inverter bus voltage (Vdc) and rotation speed reference are measured by using the single scan mode (use hardware trigger). The sample-and-hold function is used for U phase current (Iu) and W phase current (Iw) measurement.

(2) Asynchronous General-Purpose Timer (AGT)

· 500 [µs] interval timer
The channel 0 of the AGT is used as 500 [µs] interval timer for speed control loop.

(3) General Purpose Timer (GPT)

On the channel 0, 2 and 3, output with dead time is performed by using the complementary PWM Output Operating Mode.

(4) Port Output Enable for GPT (POE)

The ports executing PWM output are set to high impedance state when an overcurrent is detected by the external circuit (when a falling edge of the GTETRGC port is detected) or when an output short circuit is detected.

2.2.3 A/D Converter

(1) Motor rotation speed command value

The motor rotation speed command value can be set by A/D conversion of the VR1 output value (analog value). The A/D converted VR1 value is used as rotation speed command value, as shown below.

Table 2-4 Conversion Ratio of the Rotation Speed Command Value

Item	Conversion ratio (Command value: A/D conversion value)		Channel
Rotation speed command value	CW	0 [rpm] to 2650 [rpm]: 07FFH to 0000H	AN017
	CCW	0 [rpm] to 2650 [rpm]: 0800H to 0FFFH	

(2) Inverter bus voltage

It is used for modulation factor calculation and over or low voltage detection. (When an abnormality is detected, PWM is stopped.)

Table 2-5 Inverter Bus Voltage Conversion Ratio

Item	Conversion ratio (Inverter bus voltage: A/D conversion value)	Channel
Inverter bus voltage	0 [V] to 111 [V]: 0000H to 0FFFH	AN005

(3) U, V, W phase current

The U and W phase currents are measured as shown in Table 2-6 and used for vector control.

Table 2-6 Conversion Ratio of U and W Phase Current

Item	Conversion ratio (U, V, and W phase current: A/D conversion value)	Channel
U, W phase current	-12.5 [A] to 12.5 [A]: 0000H to 0FFFH *1	Iu: AN000 Iw: AN002

Note: 1. For more details of A/D conversion characteristics, refer to RA6T1 Group User's Manual: Hardware.

2.2.4 Modulation

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

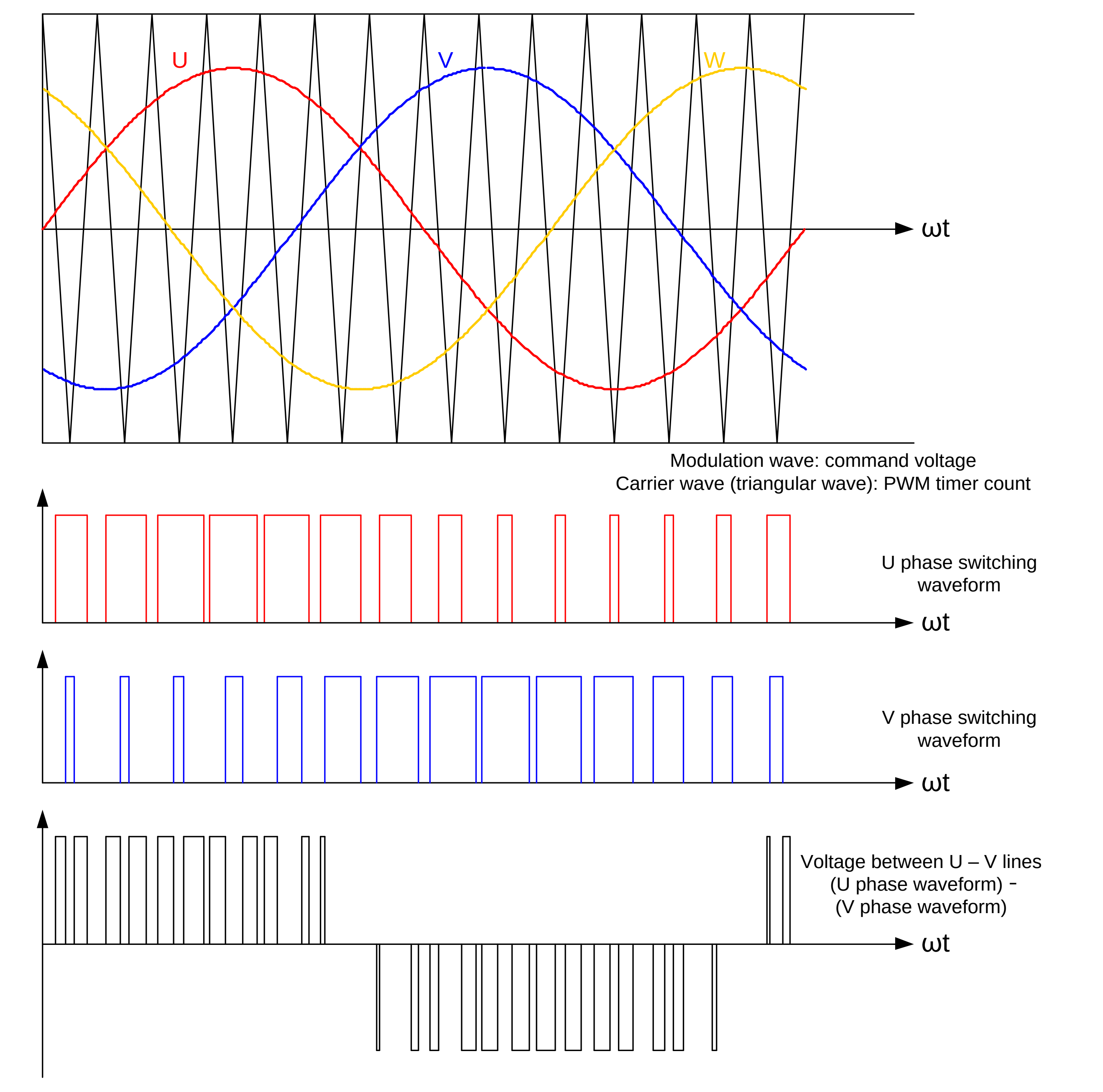

Figure 2-2 Conceptual Diagram of the Triangular Wave Comparison Method

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

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

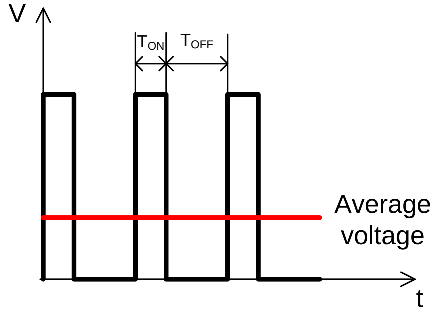

Figure 2-3 PWM Control

Here, modulation factor m is defined as follows.

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

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

This modulation factor is reflected in the setting value of the register that determines the PWM duty.

2.2.5 Startup Method

Figure 3-4 shows startup control of sensorless vector control software. Each reference value setting of d-axis current, q-axis current and speed has several processing modes.

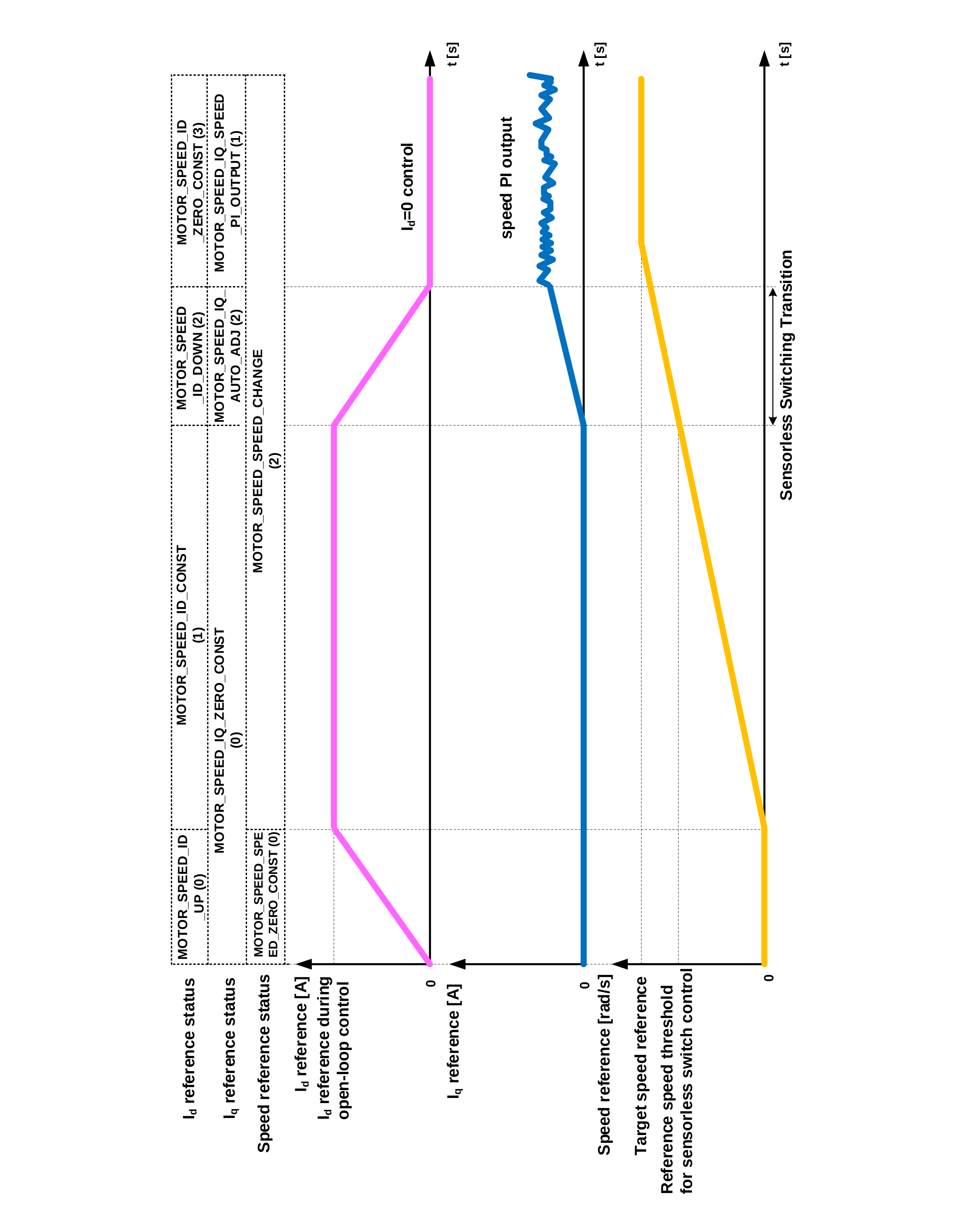

Figure 2-4 Startup Control of Sensorless Vector Control Software

2.2.6 System protection function

This control software has the following error status and executes emergency stop functions in case of occurrence of respective errors. Table 2-7 shows each setting value for the system protection function.

- Overcurrent error
  The over-current detection is performed through both hardware detection method and software detection method. In response to over-current detection, an emergency stop signal is generated by the hardware (hardware detection). When the emergency stop signal is generated, the PWM output ports are set to high impedance state.
  In addition, U, V, and W phase currents are monitored in every over-current monitoring cycle. When an over-current is detected, the CPU executes emergency stop (software detection).

- Overvoltage error
  The inverter bus voltage is monitored in every over-voltage monitoring cycle. When an over-voltage is detected, the CPU performs emergency stop. Here, the over-voltage limit value is set in consideration of the error of resistance value of the detect circuit.

- Low voltage error
  The inverter bus voltage is monitored in every low-voltage monitoring cycle. The CPU performs emergency stop when low voltage is detected. Here, the low-voltage limit value is set in consideration of the error of resistance value of the detect circuit.

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

Table 2-7 Setting Value of Each System Protection Function

Overcurrent error	Over current limit value [A]	0.89
	Monitoring cycle [μs]	50
Overvoltage error	Overvoltage limit value [V]	28
	Monitoring cycle [μs]	50
Low voltage error	Under voltage limit value [V]	14
	Monitoring cycle [μs]	50
Over-speed error	Speed limit value [rpm]	3000
	Monitoring cycle [μs]	50

2.3 Software structure

2.3.1 Directory/File Structure

Table 2-8 shows the directory/file structure of the software operating the Motor control module.

Table 2-8 Directory/File Structure

Directory Structure				Files
ra	fsp	inc	api	rm_motor_angle_api rm_motor_current_api.h rm_motor_driver_api.h rm_motor_speed_api.h rm_motor_api.h
			instances	rm_motor_estimate.h rm_motor_current.h rm_motor_driver.h rm_motor_speed.h rm_motor_sensorless.h
		src	rm_motor_estimate	rm_motor_estimate.c rm_motor_estimate_library.h
			rm_motor_current	rm_motor_current.c rm_motor_current_library.h
			rm_motor_driver	rm_motor_driver.c
			rm_motor_speed	rm_motor_speed.c rm_motor_speed_library.h
			rm_motor_sensorless	rm_motor_sensorless.c

2.4 Software specifications

Table 2-9 shows the basic specifications of target software of this application note. For details of sensorless vector control, refer to the application note ‘Sensorless vector control with permanent magnetic synchronous motor: algorithm’.

Table 2-9 Basic Specifications of Software

Item	Content
Control method	Vector Control
Position detection method	Sensorless
Motor rotation start/stop	Determined depending on the level of SW1 (‘Low’: rotation start, ‘High’: stop) or input from Renesas Motor Workbench.
Input voltage	DC24 [V]
Carrier frequency (PWM)	20 [kHz]
Control cycle	• Current control / Position and speed estimation : 50 [μs] • Speed control : 500 [μs]
Rotation speed control range	CW: 0 [rpm] to 2650 [rpm] CCW: 0 [rpm] to 2650 [rpm]
Processing stop for protection	• Disables the motor control signal output (six outputs), under any of the following conditions. 1. Current of each phase exceeds 0.89 [A] (monitored every 50 [μs]) 2. Inverter bus voltage exceeds 28 V (monitored per 50 [μs]) 3. Inverter bus voltage is less than 14 V (monitored per 50 [μs]) 4. Rotation speed exceeds 3000 rpm (monitored per 50 [μs]) • The ports executing PWM output are set to high impedance state when an overcurrent is detected (when a falling edge of the GTETRGC port is detected) and when an output short circuit is detected.

3. Sample Application

3.1 Operating Environment

Table 3-1 shows the hardware requirements for building and debugging Motor control software.

Table 3-1 Hardware Requirements

Hardware	Description
Inverter Board	RA6T1-RSSK [RTK0EM0000B10020BJ]
CPU Card	RA6T1 CPU Card [RTK0EMA170C00000BJ]
Motor	Brushless DC Motor (TG-55L-KA 24V)
On-chip debugging Emulator	The RA6T1 CPU Card has an on-board debugger (J-Link OB), so there is no need to prepare an emulator.

Table 3-2 shows the software requirements for build and debug Motor control software.

Table 3-2 Software Requirements

Software		Version	Description
GCC environment	e^2studio	2020-10	Integrated development environment (IDE) for Renesas devices.
	GCC ARM Embedded	V9	C/C++ Compiler. (download from e^2studio installer)
	Renesas Flexible Software Package (FSP)	V2.1.0	Software package for writing applications for the RA microcontroller series.

3.2 Importing the Demo Project

The sample application provided with this document may be imported into e^2studio using the steps in this section.

1. Select File → Import.

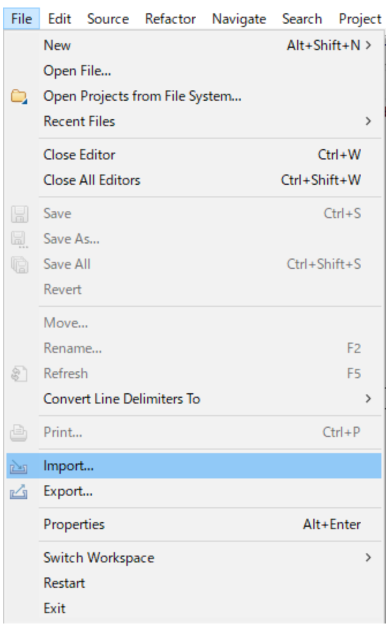

Figure 3-1 File Menu

2. Select “Existing Projects into Workspace”.

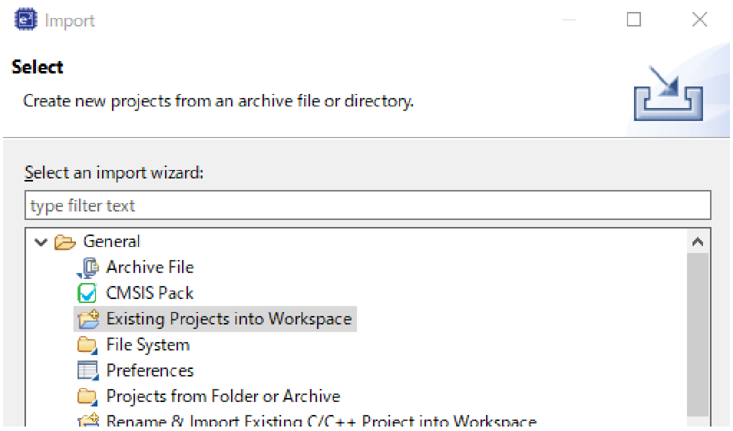

Figure 3-2 Import Wizard Selection

3. Click “Browse…” button and select the demo project. Click Finish button and the demo project is imported.

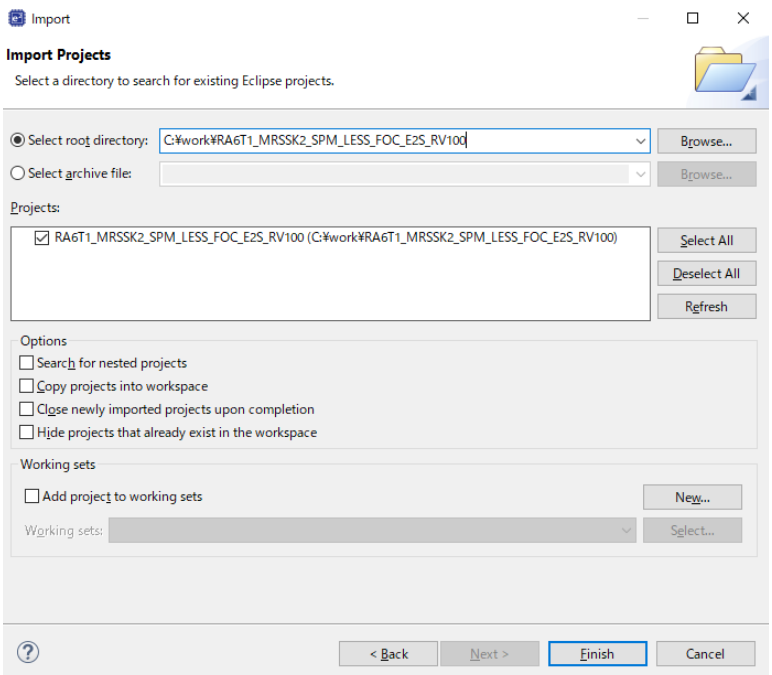

Figure 3-3 Import Projects

3.3 Building and Debugging

Refer to the "e²studio Getting Started Guide (R20UT4204)”.

3.4 Motor Demonstration Project Overview

3.4.1 Quick Start

Follow the below steps to execute the Quick Start Sample Project.

(1) After turning on power supply or executing reset, LED1 and LED2 on the inverter board are both off and the motor stops.

(2) IF the toggle switch (SW1) on the inverter board is turned on, the motor starts to rotate. Every time the toggle switch (SW1) is changed, motor rotation starts/stops alternately. If the motor rotates normally, LED1 on the inverter board is on. However, if LED2 on the inverter board is also on, error is occurring.

(3) In order to change the direction of the motor rotation, adjust it with the variable resistor (VR1) on the inverter board.

- Turn the variable resistor (VR1) right : the motor rotates clockwise
- Turn the variable resistor (VR1) left : The motor rotates counterclockwise

(4) If error occurs, LED2 on the inverter board lighten, and the motor rotation stops. To restore, the toggle switch (SW1) on the inverter board needs to be turned off, the push switch (SW2) to be pushed and rereased

(5) In order to stop the operation check, turn off the output of the stabilized power supply after making sure that the motor rotation has already stopped

3.4.2 Renesas Motor Workbench

- Launch of RMW

‘Renesas Motor Workbench’ is support tool for development of motor control system. ‘Renesas Motor Workbench’ can be used with target software of this application note to analyze the control performance. The user interfaces of ‘Renesas Motor Workbench’ provide functions like rotating/stop command, setting rotation speed reference, etc... Please refer to ‘Renesas Motor Workbench User’s Manual’ for usage and more details. ‘Renesas Motor Workbench’ can be downloaded from Renesas Electronics Corporation website.

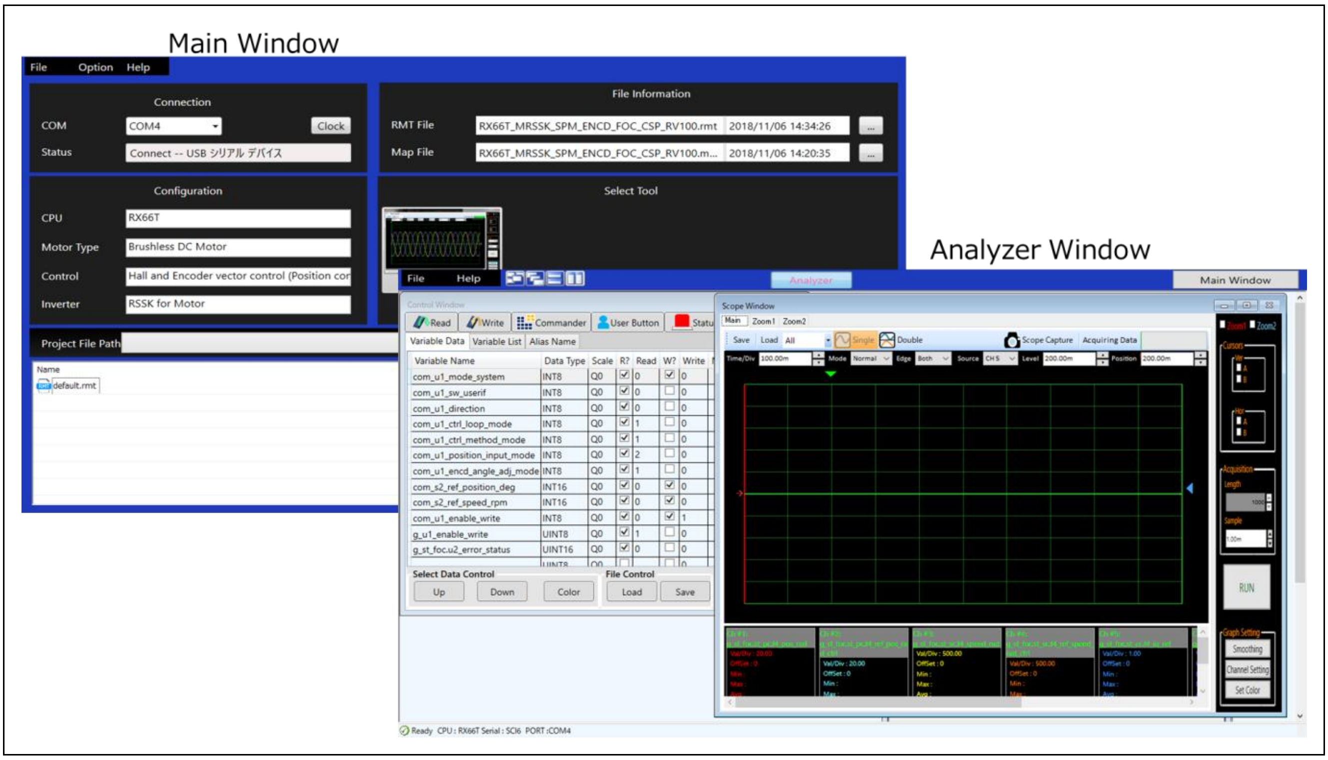

Figure 3-4 Renesas Motor Workbench – Appearance

- Set up for ‘Renesas Motor Workbench’

(1) Start ‘Renesas Motor Workbench’ by clicking icon.

(2) Click on [File] and select [Open RMT File(O)] from drop down Menu.
Select the RMT file(xxx.rmt) from following location of e²studio/CS+ project folder.

‘[Project Folder]/src/application/user_interface/ics/’

(3) Use the ‘Connection’ [COM] select menu to choose the COM port.

(4) Click on the ‘Analyzer’ icon of Select Tool panel to open Analyzer function window.

(5) Please refer to ‘4.3 Operation Example for Analyzer’ for motor driving operation.

- List of Variables for Analyzer function

Table 3-3 is a list of variables for Analyzer. These variables are reflected to the corresponding variables when the same value as of g_u1_enable_write is written to com_u1_enable_write. However, note that variables with (*) do not depend on com_u1_enable_write.

Table 3-3 List of Variables for Analyzer

Variable name	Type	Content
com_u1_sw_userif (*)	uint8_t	User interface switch 0: GUI use 1: Board user interface use (default)
com_u1_mode_system (*)	uint8_t	State management 0: Stop mode 1: Run mode 3: Reset
com_f4_ref_speed_rpm	float	Speed reference (Mechanical) [rpm]
com_u2_mtr_pp	uint16_t	Number of pole pairs
com_f4_mtr_r	float	Resistance [Ω]
com_f4_mtr_ld	float	d-axis Inductance [H]
com_f4_mtr_lq	float	q-axis Inductance [H]
com_f4_mtr_m	float	Flux [Wb]
com_f4_mtr_j	float	Inertia [kgm^2]
com_f4_current_omega	float	Natural frequency of current control system [Hz]
com_f4_current_zeta	float	Damping ratio of current control system
com_f4_speed_omega	float	Natural frequency of speed control system [Hz]
com_f4_speed_zeta	float	Damping ratio of speed control system
com_f4_e_obs_omega	float	Natural frequency of BEMF estimation system [Hz]
com_f4_e_obs_zeta	float	Damping ratio of BEMF estimation system
com_f4_pll_est_omega	float	Natural frequency of position estimation system [Hz]
com_f4_pll_est_zeta	float	Damping ratio of position estimation system
com_f4_ref_id	float	d-axis current reference in open loop mode [A]
com_f4_ol_id_up_step	float	d-axis current reference ramping up rate
com_f4_ol_id_down_step	float	d-axis current reference ramping down rate
com_f4_id_down_speed_rpm	float	Speed threshold to ramp down the d-axis current
com_f4_id_up_speed_rpm	float	Speed threshold to ramp up the d-axis current
com_f4_max_speed_rpm	float	Maximum speed
com_f4_overspeed_limit_rpm	float	Over speed limit
com_f4_overcurrent_limit	float	Over current limit
com_f4_iq_limit	float	q-axis current limit
com_f4_limit_speed_change	float	Speed limit change rate (Electrical) [rpm]
com_u1_enable_write	uint8_t	Enable to rewriting variables

- Operation Example for Analyzer

The section shows an example below for motor driving operation using Analyzer. Operation is using ‘Control Window’ of Analyzer. Regarding specification of ‘Control Window’, refer to ‘Renesas Motor Workbench User’s Manual’.

- Change the user interface to Analyzer

(1) Confirm the check-boxes of column [W?] for ‘com_u1_sw_userif’ marks.

(2) Input ‘1’ in the [Write] box of ‘com_u1_sw_userif’.

(3) Click the ‘Write’ button.

- Driving the motor

(1) Confirm the check-boxes of column [W?] for ‘com_u1_mode_system’, ‘com_f4_ref_speed_rpm’, ‘com_u1_enable_write’ marks.

(2) Input a reference speed value in the [Write] box of ‘com_f4_ref_speed_rpm’.

(3) Click the ‘Write’ button.

(4) Click the ‘Read’ button. Confirm the [Read] box of ‘com_f4_ref_speed_rpm’, ‘g_u1_enable_write’.

(5) Set a same value of ‘g_u1_enable_write’ in the [Write] box of ‘com_u1_enable_write’.

(6) Write ‘1’ in the [Write] box of ‘com_u1_mode_system’.

(7) Click the ‘Write’ button.

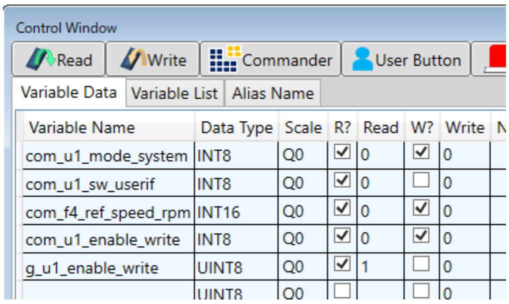

Figure 3-5 Operation Example for Analyzer

- Stop the motor

(1) Write ‘0’ in the [Write] box of ‘com_u1_mode_system’

(2) Click the ‘Write’ button.

- Error cancel operation

(1) Write ‘3’ in the [Write] box of ‘com_u1_mode_system’

(2) Click the ‘Write’ button.

4. Motor control Module Detail

4.1 Contents of control

4.1.1 Configuration Options

The configuration options of the sensorless vector control module for motor can be configured using the RA Configurator. The changed options are automatically reflected to the rm_motor_sensorless_cfg.h when generating code. The option names and setting values are listed in the Table 4-1 Configuration Options shown as follows.

Table 4-1 Configuration Options for sensorless module

Configuration Options (rm_motor_sensorless.h)	
Options	**Description**
f_overcurrent_limit Default : 0.42F	When a phase current exceeds this value, PWM output ports are set to off.
f_overvoltage_limit Default : 28.0F	When an inverter voltage exceeds this value, PWM output ports are set to off.
f_overspeed_limit Default : 3000.0F	When a rotation speed exceeds this value, PWM output ports are set to off.
f_lowvoltage_limit Default : 14.0F	When an inverter voltage becomes below this value, PWM output ports are set to off.

4.1.2 Configuration Options for included modules

The sensorless vector control module for motor includes below modules.

・Current Module

・Speed Module

・Angle Module

・Driver Module

And also these included modules have each configuration parameters as same as the sensorless vector control module. The option names and setting values are listed in the tables shown as follows.

Table 4-2 Configuration Options for Current Control [1/2]

Configuration Options (rm_motor_current.h)	
Options	**Description**
vcomp_enable Default: Enable	Select the effectiveness of voltage error compensation process.
mtr_param.u2_mtr_pp Default : 2U	Pole pairs of target motor.
mtr_param.f4_mtr_r Default : 8.5F	Resistance of motor [ohm].
mtr_param.f4_mtr_ld Default : 0.0045F	D-axis inductance [H].
mtr_param.f4_mtr_lq Default : 0.0045F	Q-axis inductance [H].
mtr_param.f4_mtr_m Default : 0.02159F	Magnetic flux [Wb].
mtr_param.f4_mtr_j Default : 0.0000028F	Rotor inertia [kgm^2].

Table 4-3 Configuration Options for Current Control [2/2]

Configuration Options (rm_motor_current.h)	
Options	**Description**
d_param.f_current_omega Default : 300.0F	Current PI control omega parameter.
d_param.f_zeta Default : 1.0F	Current PI control zeta parameter.

Table 4-4 Configuration Options for Speed Control [1/2]

Configuration Options (rm_motor_speed.h)	
Options	**Description**
f_speed_ctrl_period Default : 0.0005F	The period of speed control process [sec].
f_limit_speed_change Default : 0.5F	The step of speed fluctuation [rpm]. Program controls speed by this step at acceleration and deceleration.
f_max_speed_rad Default : 2650.0F	Maximum speed [rad/s] The calculation to translate rpm to radian/second is performed internally. Therefore, user input “rpm” value simply.
f_omega_t Default : 10.0F	Speed LPF parameter omega.
f_id_up_speed_rad Default : 500.0F	The threshold speed to control d-axis current increase [rad/s]. Program increases d-axis current at start up the motor rotation until the speed reaches this value.
f_iq_limit Default : 0.42F	Limit of q-axis current [A].
f_ol_fb_speed_limit_rate Default : 0.2F	Rate of reference speed for feedback speed limiter at Open-Loop.
u1_openloop_damping Default : Enable	Select enable/disable of damping control at Open-Loop.
u1_flux_weakening Default : Disable	Select enable/disable of flux weakening control at high speed.
u1_less_switch Default : Enable	Select enable/disable of soft switching at the transition from Open-Loop to PI control.
ol_param.f4_ol_id_up_step Default : 0.3F	The d-axis current reference ramping up rate [A/msec].
ol_param.f4_ol_id_down_step Default : 0.3F	The d-axis current reference ramping down rate [A/msec].
ol_param.f4_ol_iq_down_step_ratio Default : 1.0F	The q-axis current reference ramping down proportion to reference before open-loop.
ol_param.f4_ol_id_ref Default : 0.3F	The d-axis current reference in open-loop drive.
ol_param.f4_id_down_speed_rad Default : 600.0F	The speed threshold[rad/s] to ramp down the d-axis current.
ol_param.f4_id_up_speed_rad Default : 500.0F	The speed threshold[rad/s] to ramp up the d-axis current.
ol_param.f4_opl2less_sw_time Default : 0.025F	Time to switch open-loop to sensor-less [s].
ol_param.f4_switch_phase_err_rad Default : 10.0F	Phase error to decide sensor-less switch timing [rad].

Table 4-5 Configuration Options for Speed Control [2/2]

Configuration Options (rm_motor_speed.h)	
Options	**Description**
d_param.f_speed_omega Default : 5.0F	Speed PI Control parameter omega.
d_param.f_speed_zeta Default : 1.0F	Speed PI Control parameter zeta.
d_param.f_ed_hpf_omega Default : 2.5F	Natural frequency [Hz] for HPF in open-loop damping gain design.
d_param.f_ol_damping_zeta Default : 1.0F	Damping ratio for open-loop damping gain design.
d_param.f_phase_err_lpf_cut_freq Default : 10.0F	The cut-off frequency [Hz] of phase error LPF gain design.
mtr_param.u2_mtr_pp Default : 2U	Pole pairs of target motor.
mtr_param.f4_mtr_r Default : 8.5F	Resistance of motor [ohm].
mtr_param.f4_mtr_ld Default : 0.0045F	D-axis inductance [H].
mtr_param.f4_mtr_lq Default : 0.0045F	Q-axis inductance [H].
mtr_param.f4_mtr_m Default : 0.02159F	Magnetic flux [Wb].
mtr_param.f4_mtr_j Default : 0.0000028F	Rotor inertia [kgm^2].

Table 4-6 Configuration Options for Angle and Speed Estimation [1/2]

Configuration Options (rm_motor_estimate.h)	
Options	**Description**
openloop_damping Default : Enable	Select enable/disable of Open-Loop Damping Control
f_e_obs_omega Default : 1000.0F	Natural frequency for BEMF observer [Hz].
f_e_obs_zeta Default : 1.0F	Damping ratio for BEMF observer.
f_pll_est_omega Default : 20.0F	Natural frequency for rotor position Phase-Locked Loop [Hz].
f_pll_est_zeta Default : 1.0F	Damping ratio for rotor position Phase-Locked Loop.
f4_ctrl_period Default : 0.0005F	Period of Speed Control [sec]

Table 4-7 Configuration Options for Angle and Speed Estimation [2/2]

Configuration Options (rm_motor_estimate.h)	
st_motor_params.u2_mtr_pp Default : 2U	Pole pairs of target motor.
st_motor_params.f4_mtr_r Default : 8.5F	Resistance of motor [ohm].
st_motor_params.f4_mtr_ld Default : 0.0045F	D-axis inductance [H].
st_motor_params.f4_mtr_lq Default : 0.0045F	Q-axis inductance [H].
st_motor_params.f4_mtr_m Default : 0.02159F	Magnetic flux [Wb].
st_motor_params.f4_mtr_j Default : 0.0000028F	Rotor inertia [kgm^2].

Table 4-8 Configuration Options for Driver Access

Configuration Options (rm_motor_driver.h)	
u2_pwm_timer_freq Default : 120U	PWM Timer Clock Frequency [MHz]
u2_pwm_carrier_freq Default : 50U	PWM Carrier Period [Micro seconds]
u2_deadtime Default : 240U	PWM Deadtime [Raw Counts]
f_current_range Default : 27.5F	Measurement Range of Electric current [A]
f_vdc_range Default : 111.0F	Measurement Range of Inverter Voltage [V]
u2_offset_calc_count Default : 500U	Counts of measurement the offset of A/D Conversion at electric current input.

Website and Support

Visit the following vanity URLs to learn about key elements of the RA family, download components and related documentation, and get support.

RA Product Information	www.renesas.com/ra
RA Product Support Forum	www.renesas.com/ra/forum
RA Flexible Software Package	www.renesas.com/FSP
Renesas Support	www.renesas.com/support

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Oct.28.20	-	First release document

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit 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. Precaution against Electrostatic Discharge (ESD)

   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on

   The state of the product is undefined at the time 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 time 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 time 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 time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state

   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. 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 the 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.
5. Clock signals

   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is 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. Additionally, 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.
6. Voltage application waveform at input pin

   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses

   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of 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.

Notice

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Contact information

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