

# RL78 MOTOR CONTROL SOLUTION

## - HOW TO DRIVE SENSORLESS VECTOR CONTROL

### Supplementary Material for RL78 Motor Control Solution Introductory Video

#### Summary

This document explains supplementary information about RL78 motor control solution introductory video “RL78 MOTOR CONTROL SOLUTION – HOW TO DRIVE SENSORLESS VECTOR CONTROL”. The video and this document introduce how to use RL78 motor control solution development tools, but these do not completely guarantee the operation. Please use them with great care. No liability shall be accepted for any consequences arising from the use of these tools.

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## 1. Overview

This document explains supplementary information such as advanced functions and precautions for using development tools explained in RL78 motor control solution introduction video “RL78 MOTOR CONTROL SOLUTION – HOW TO DRIVE SENSORLESS VECTOR CONTROL”.

### 1.1 Reference

For details on each development tools of RL78 motor control solution introduced in the video, refer to the following documents and websites.

- Sample software  
“Sensorless vector control for permanent magnetic synchronous motor with 1-shunt resistor current detection”  
R01AN3992EJ0220 Rev.2.20  
<https://www.renesas.com/us/en/document/apn/rl78g1f-sensorless-vector-control-permanent-magnetic-synchronous-motor-1-shunt-resistor-current>
- Configuration File Generator (CFG)  
“Configuration File Generator for RL78 Motor Control Sample Software User’s Manual”  
R01AN5907EJ0110 Rev.1.10  
<https://www.renesas.com/us/en/document/apn/configuration-file-generator-rl78-motor-control-sample-software>
- Renesas Motor Workbench (RMW)  
“Motor Control Development Support Tool Renesas Motor Workbench 2.0 User’s Manual”  
R21UZ0004EJ0203 Rev.2.03  
“Renesas Motor Workbench Function Description”  
R20AN0527EJ0100 Rev.1.00  
<https://www.renesas.com/us/en/application/key-technology/motor-control-robotics/motor-control-solutions>
- Inverter board  
“RL78/G1F Motor Driver Board GB01 User’s Manual”  
R12UT0012EJ0100 Rev.1.00  
<https://www.renesas.com/us/zh/document/mat/rl78g1f-motor-driver-board-gb01-users-manual-rev100?r=1355616>
- Emulator  
“E2 emulator Lite RTE0T0002LKCE00000R User’s Manual”  
R20UT3240EJ0300 Rev.3.00  
<https://www.renesas.com/us/en/document/qsg/e2-emulator-lite-rte0t0002lkce00000r-users-manual>
- Integrated development environment  
“CS+”  
<https://www.renesas.com/us/en/software-tool/cs>  
“e<sup>2</sup> studio”  
<https://www.renesas.com/us/en/software-tool/e-studio>

## 2. Part1

### 2.1 Development environment

#### 2.1.1 Development environment for RL78 motor control solution

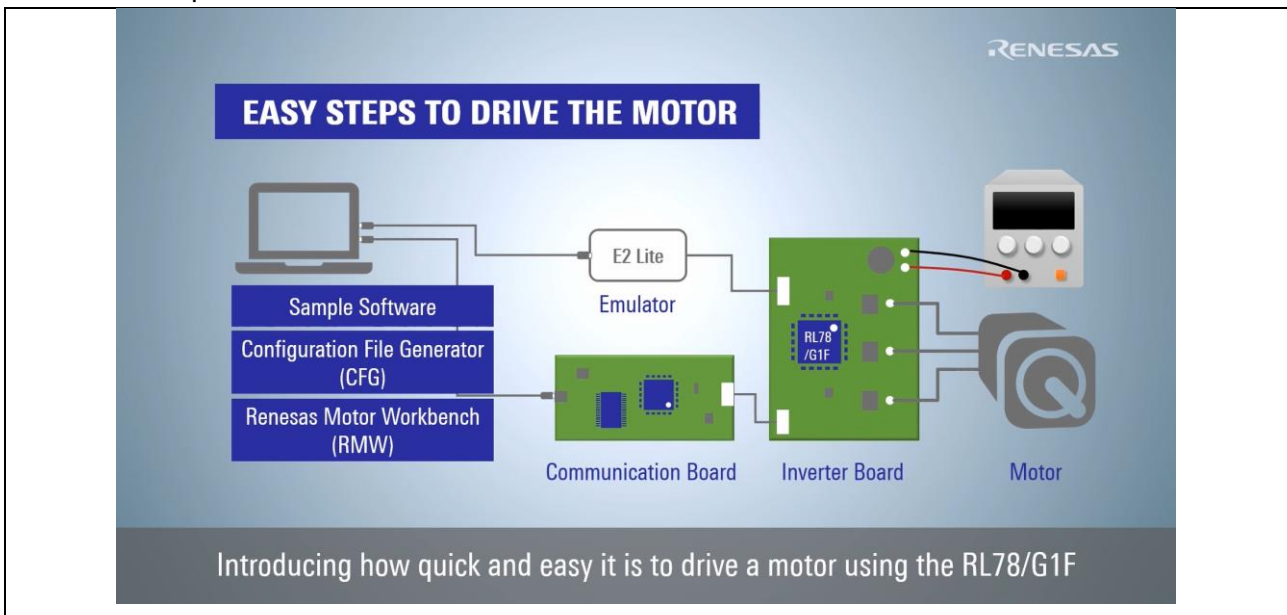


Figure 2-1 Introduction of RL78 motor control solution development environment

The conditions of the development environment targeted by the RL78 motor control solution development tool introduced in this video are shown below.

- Motor
  - Using 3-phase permanent magnet synchronous motor.
- Inverter board
  - Equipped with RL78/G1F.
  - Being able to connect a emulator provided by Renesas ( E2 emulator / E2 emulator Lite / E1 emulator).
  - Being able to connect a communication board (RTK0EMX6B0Z00000BJ) or a third-party board microcontroller waveform display tool “ICS++ (In Circuit Scope plus)”, manufactured by Desk Top Laboratories Inc.) .
  - Being able to detect 3-shunt current or 1-shunt current.
- PC
  - Using the described environment in “Configuration File Generator for RL78 Motor Control Sample Software User’s Manual” ‘1.2. System requirements’ and ”Motor Control Development Support Tool Renesas Motor Workbench 2.0 User’s Manual” ‘1.3. System Requirement’.

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## 2.1.2 Development environment used in video

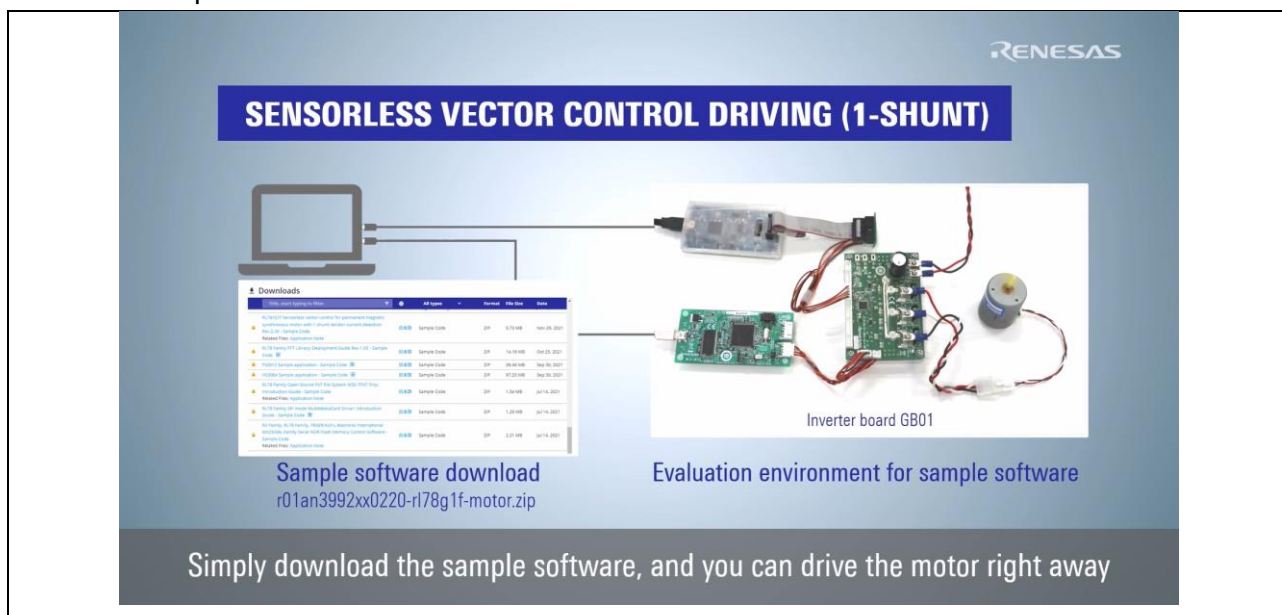


Figure 2-2 Motor drive in default development environment

The development environment used in this video is shown below. For details of each development tool, refer to the corresponding application notes, etc.

- Sample software  
“Sensorless vector control for permanent magnetic synchronous motor with 1-shunt resistor current detection”
- Inverter board  
“RL78/G1F Motor Driver Board GB01”
  - Support the microcontroller RL78/G1F (R5F11BGAEAFB/LFQFP/48 pins)
  - Input voltage : 12 – 50 [V]
  - Output peak current : 30 [A]
  - Can detect 3-shunt and 1-shunt resistor current
  - Support the input from Hall sensors and ABZ encoder signal
- Emulator  
“E2 emulator Lite”

## 2.2 Configuration File Generator

### 2.2.1 Precautions for use

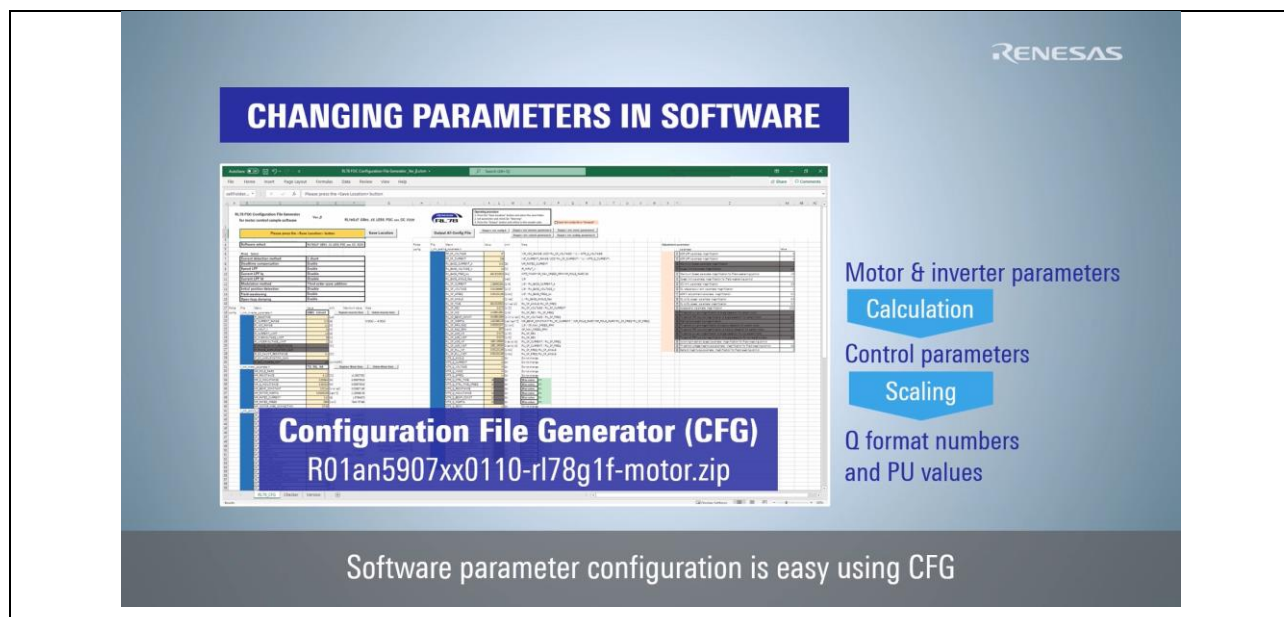


Figure 2-3 Overview of CFG

Configuration File Generator is a software tool that supports the redesign of various parameters with changes in inverter board or motor. Please note the following before using CFG.

- CFG cannot configure ports and peripheral functions. When using an inverter board with different pin assignments, it is necessary to modify the initial setting in sample software.
- CFG supports only the sample software “Sensorless vector control for permanent magnetic synchronous motor with 1-shunt resistor current detection”.
- CFG is made for the purpose of supporting the redesign of various parameters of the sample software, but it does not completely guarantee the operation. And no liability shall be accepted for any consequences arising from the use of this tool.

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## 2.2.2 Control mode selection

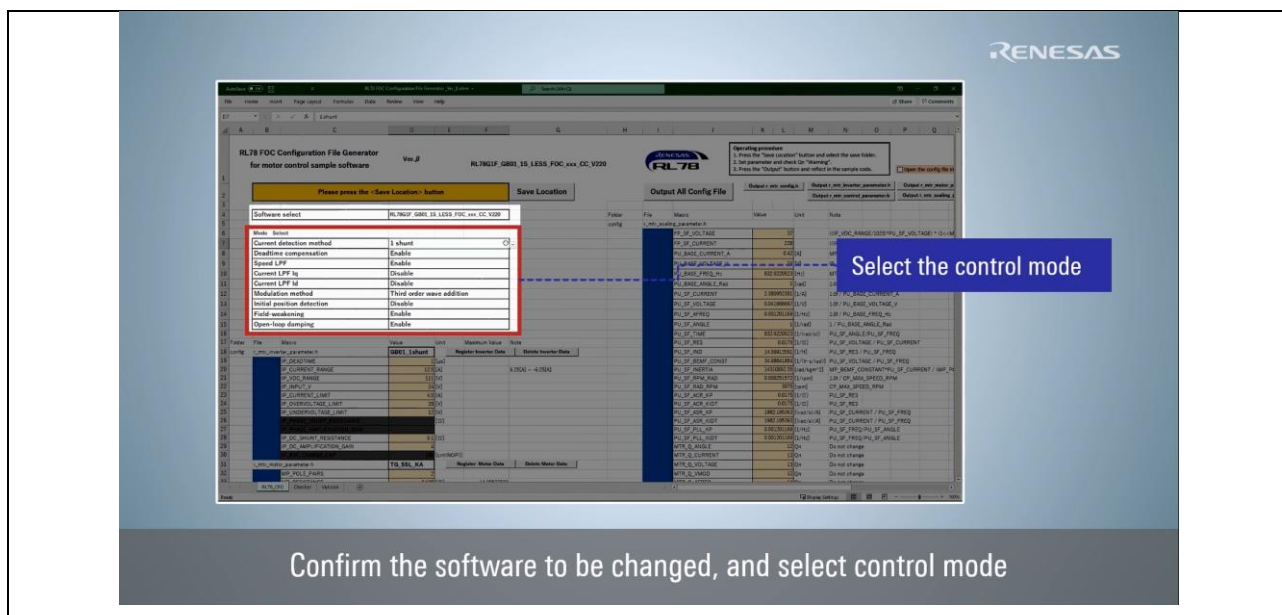


Figure 2-4 How to select the control mode

Table 2-1 shows control modes displayed in “Mode Select”. For details of each control mode, refer to “Sensorless vector control for permanent magnetic synchronous motor with 1-shunt resistor current detection” ‘3.5. List of Sensorless Vector Control Software Macro Definitions’.

Table 2-1 List of Mode Select

Mode name	Description	Remarks
Current detection method	Current detection method (3-shunt /1-shunt)	Default setting: 1 shunt
Deadtime compensation	Select deadtime compensation process	Default setting: Enable
Speed LPF	Select speed LPF	Default setting: Enable
Current LPF Iq	Select q-axis current LPF	Default setting: Disable
Current LPF Id	Select d-axis current LPF	Default setting: Disable
Modulation method	Modulation method (Sine wave modulation/ Third harmonic calculation)	Default setting: Third harmonic calculation
Initial position detection	Select initial position detection	Default setting: Disable
Field-weakening	Select Field-Weakening Control	Default setting: Enable
Open-loop damping	Select Openloop damping Control	Default setting: Enable

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## 2.2.3 Setting inverter parameters

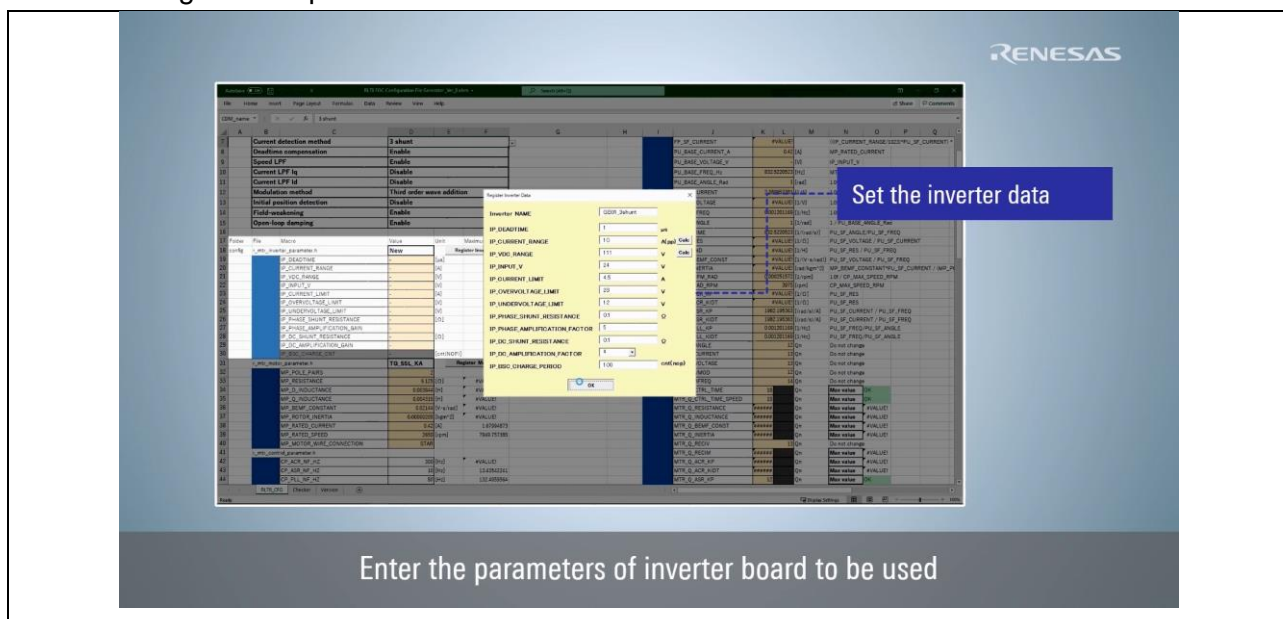


Figure 2-5 How to set the inverter parameters

Table 2-2 shows inverter parameters displayed in “Register Inverter Data”. For details of each inverter parameter, refer to “Sensorless vector control for permanent magnetic synchronous motor with 1-shunt resistor current detection” ‘3.5. List of Sensorless Vector Control Software Macro Definitions’.

Table 2-2 List of inverter parameters

Macro	Description
IP_DEADTIME	Deadtime [ $\mu$ s]
IP_CURRENT_RANGE	Current scaling range [A]
IP_VDC_RANGE	Voltage scaling range [V]
IP_INPUT_V	Input voltage [V]
IP_CURRENT_LIMIT	Current limit value [A]
IP_OVERVOLTAGE_LIMIT	Overvoltage limit [V]
IP_UNDERVOLTAGE_LIMIT	Undervoltage limit [V]
IP_PHASE_SHUNT_RESISTANCE	3-shunt resistance [ $\Omega$ ]
IP_PHASE_AMPLIFICATION_FACTOR	3-phase current amplification gain
IP_DC_SHUNT_RESISTANCE	DC link shunt resistance [ $\Omega$ ]
IP_DC_AMPLIFICATION_FACTOR	DC link current amplification gain
IP_BSC_CHARGE_PERIOD	Period of charging bootstrap capacitor

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Using the “Calc” button, the following parameters can be designed from the parameters of the detection circuit on the inverter board. For details of operation procedure, refer to “Configuration File Generator for RL78 Motor Control Sample Software User’s Manual” ‘2.1.5. Setting inverter characteristic parameters’.

- Clicking on the “Calc” button of “IP\_CURRENT\_RANGE” will open the “Current range calculation” window, where the current scaling range can be calculated from the parameters of the amplifier circuit.
- Clicking on the “Calc” button of “IP\_VDC\_RANGE” will open the “Voltage range calculation” window, where the voltage scaling range can be calculated from the parameters of the voltage divider circuit.



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## 2.2.4 Setting motor parameters

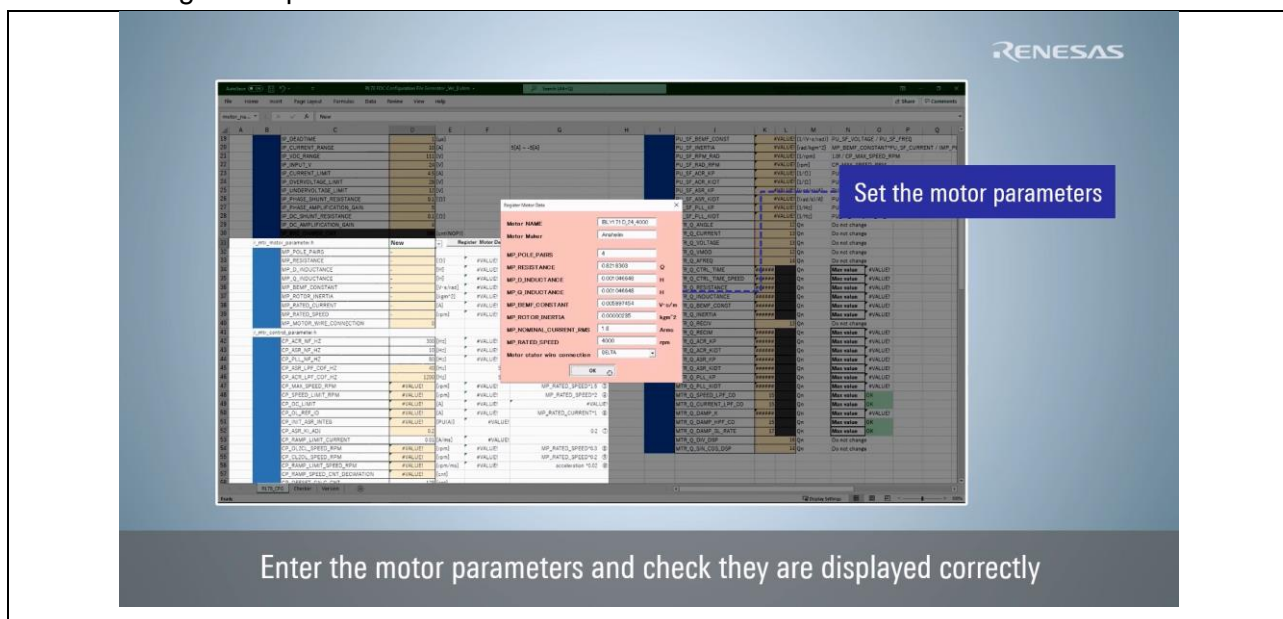


Figure 2-6 How to set the motor parameters

Table 2-3 shows motor parameters displayed in “Register Motor Data”. For details of each motor parameter, refer to “Sensorless vector control for permanent magnetic synchronous motor with 1-shunt resistor current detection” ‘3.5. List of Sensorless Vector Control Software Macro Definitions’.

Table 2-3 List of motor parameters

Macro	Description
MP_POLE_PAIRS	Number of pole pairs
MP_RESISTANCE	Resistance [ $\Omega$ ]
MP_D_INDUCTANCE	d-axis inductance [H]
MP_Q_INDUCTANCE	q-axis inductance [H]
MP_BEMF_CONSTANT	Back-EMF constant [ $V \cdot s/m$ ]
MP_ROTOR_INERTIA	Inertia [ $kgm^2$ ]
MP_NOMINAL_CURRENT_RMS	Nominal current [A]
MP_RATED_SPEED	Rated speed [rpm]
Motor stator wire connection	Motor Wiring Connection

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## 2.2.5 Setting control parameters

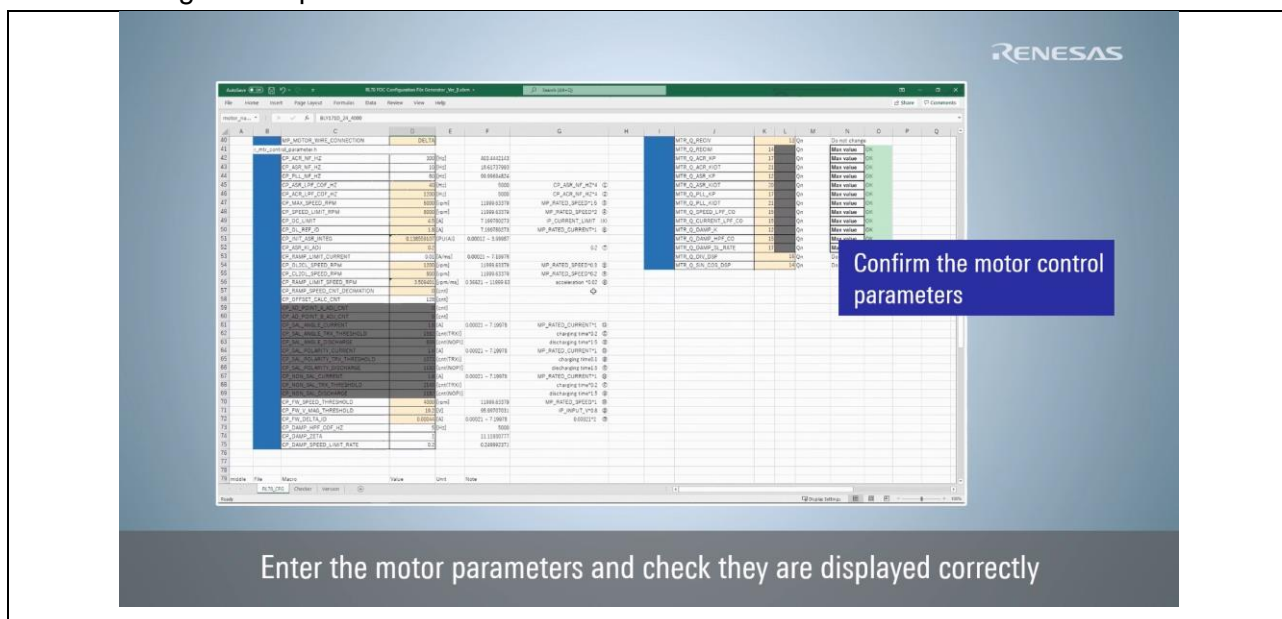


Figure 2-7 How to set the inverter parameters

When setting the control parameters, please note the following points. For details of operation procedure, refer to “Configuration File Generator for RL78 Motor Control Sample Software User’s Manual” ‘2.1.7. Setting control parameters’. For details of each control parameter, refer to “Sensorless vector control for permanent magnetic synchronous motor with 1-shunt resistor current detection” ‘3.5. List of Sensorless Vector Control Software Macro Definitions’.

- Changing the value in the parameter cell  
The value in white cell can be edited directly. The calculated value in orange cell can be adjusted by changing the corresponding “Adjustment parameter” value.
- Range of values that can be set  
The control parameter value can be set to a value smaller than that displayed in “maximum value”.

2.2.6 Setting scaling parameters

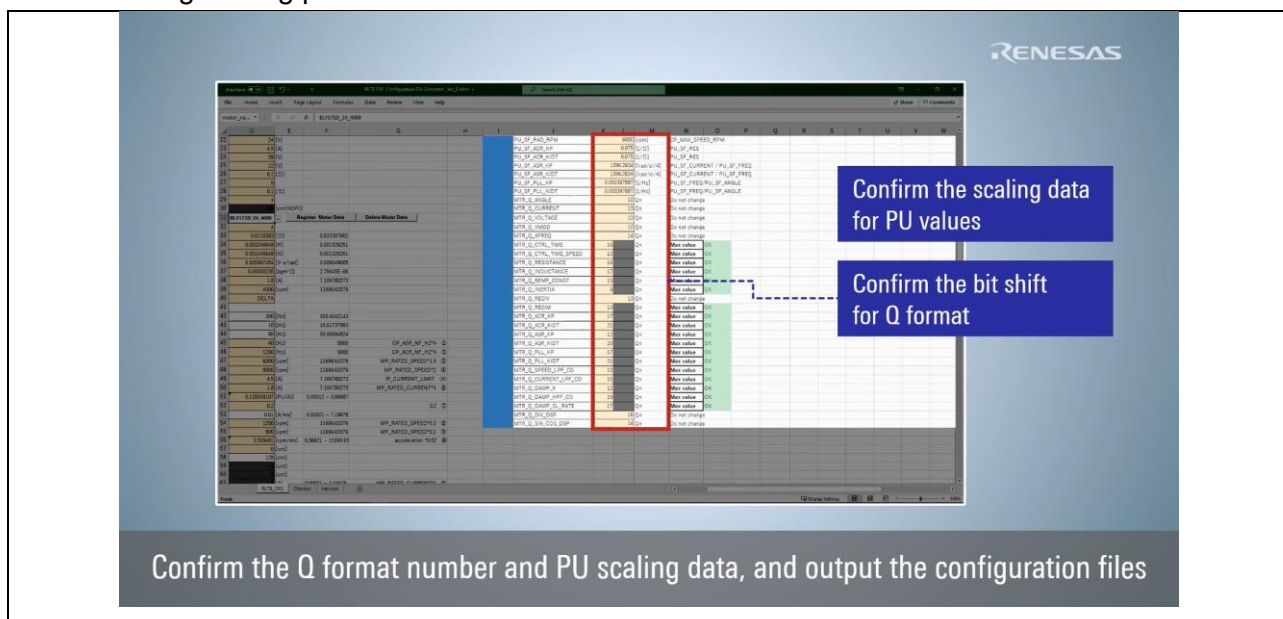


Figure 2-8 How to set the scaling parameters

The following is a description of the scaling parameters. For details of operation procedure, refer to “Configuration File Generator for RL78 Motor Control Sample Software User’s Manual” ‘2.1.8. Setting scaling parameters’. For details of each scaling parameter, refer to “Sensorless vector control for permanent magnetic synchronous motor with 1-shunt resistor current detection” ‘3.5. List of Sensorless Vector Control Software Macro Definitions’.

- PU (Per-unit) system
  - The PU system is a unit system that expresses physical quantities such as current and voltage as multiples of a reference quantity.
  - Each scaling value for physical quantity is indicated by the macro labeled PU\_SF\_XXX.
- Q format number
  - The Q format number is the value of the exponent part when the numerical value is displayed in fixed point.
  - Each Q format number is indicated by the macro labeled MTR\_Q\_XXX.
  - When “Max value” is selected, the Q format numbers are automatically set to fit into 15 bits.
  - When “User input” is selected, the Q format numbers can be edited directly.
  - If the set Q format number is invalid, “Warning” will be displayed. In that case, readjust the Q format number and use the value that displays “OK”.

## 2.3 Integrated development environment

### 2.3.1 Confirmation of parameter design results

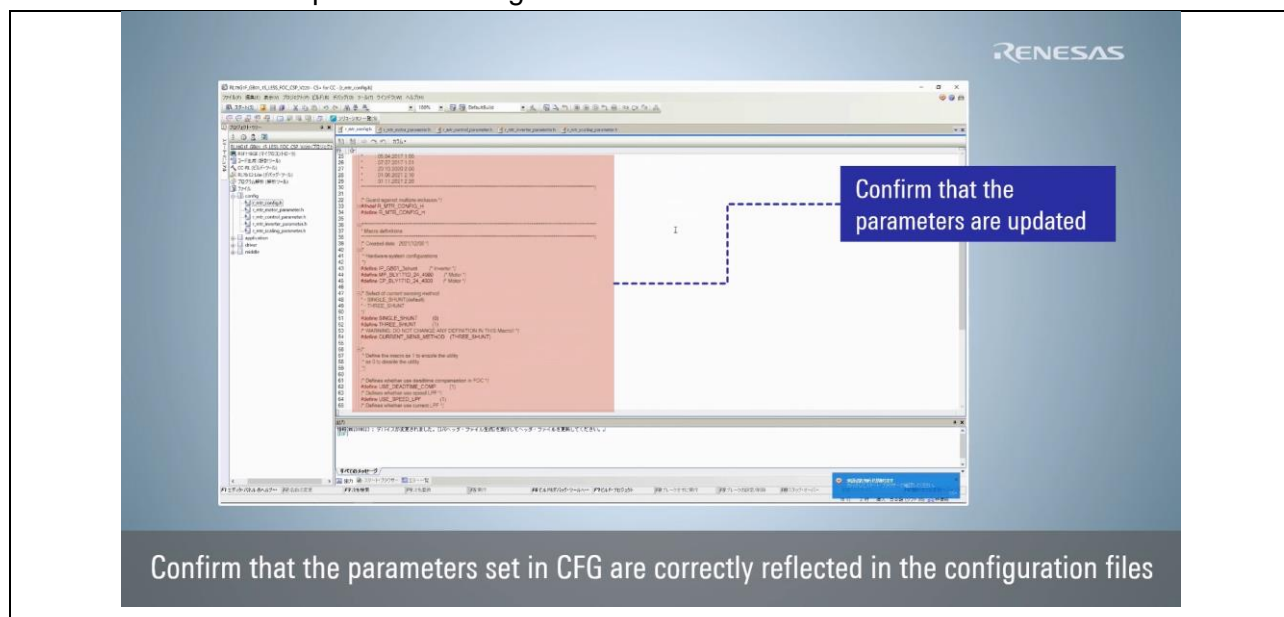


Figure 2-9 Confirmation of parameter design results

The following two integrated development environments can be used with “Sensorless vector control for permanent magnetic synchronous motor with 1-shunt resistor current detection”. This video explains the operation procedure when using CS+.

- CS+  
project folder : RL78G1F\_GB01\_1S\_LESS\_FOC\_CSP\_CC\_V220
- e<sup>2</sup> studio  
project folder : RL78G1F\_GB01\_1S\_LESS\_FOC\_E2S\_CC\_V220

By using CFG, the design result of each parameter can be reflected in the file included in the “project folder” > “config” folder. Table 2-4 shows the files contained in the “config” folder.

Table 2-4 List of files in “config folder

Folder	File	Content
config	r_mtr_config.h	Configuration definition
	r_mtr_motor_parameter.h	Motor parameter definition
	r_mtr_control_parameter.h	Control parameter definition
	r_mtr_inverter_parameter.h	Inverter parameter definition
	r_mtr_scaling_parameter.h	Scaling parameter definition

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## 2.3.2 How to build

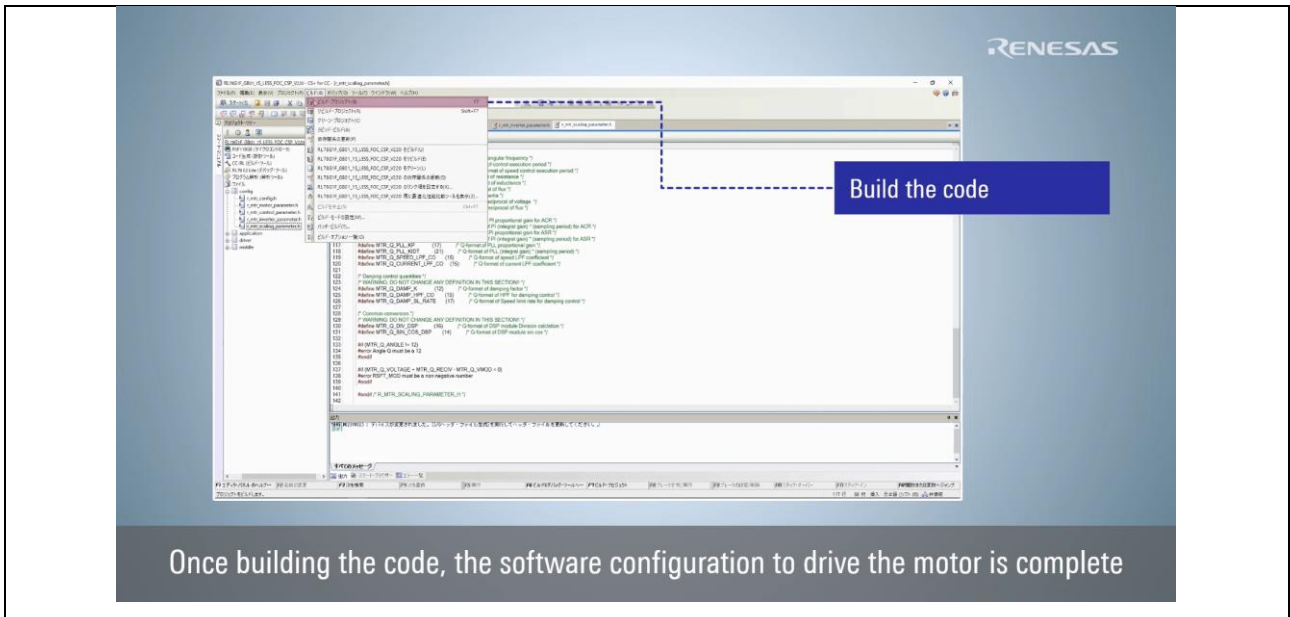


Figure 2-10 How to build the sample software

To build using CS+, click “Build” > “Build Project”. The build is complete when the “Output” panel shows “Ended(Success:1 Projects, Failed:0 Projects)”.

3. Part2

3.1 Integrated development environment

3.1.1 How to write

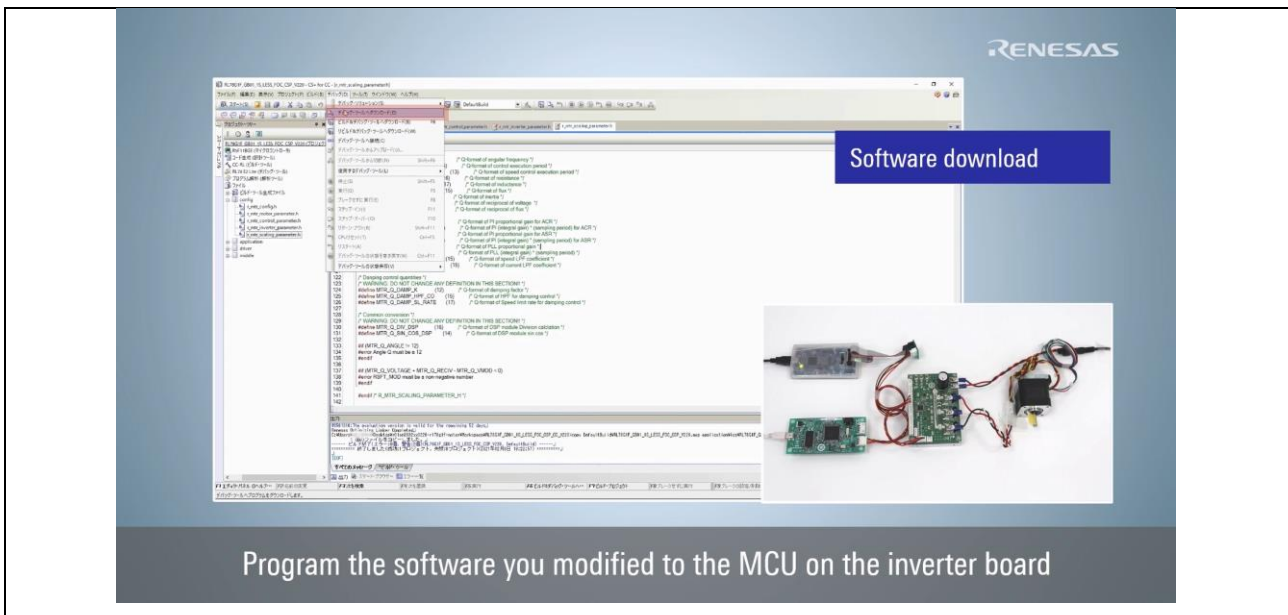


Figure 3-1 How to write the sample software

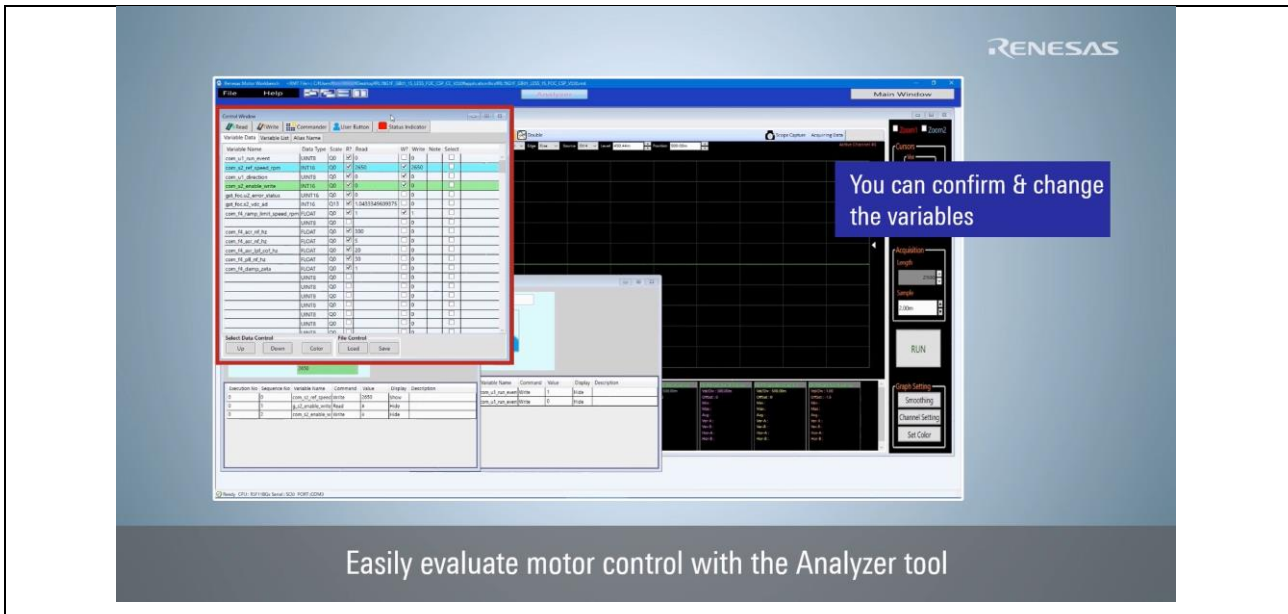
To write the modified sample software to the microcontroller, click “Debug” > “Download” with the emulator connected to the inverter board. At this time, make sure that the inverter board is not tuned on before connecting to the emulator. After confirming that the debug mode is displayed, click “Debug” > “Disconnect from Debug Tool” to remove the emulator. Finally, turn on the power to the microcontroller.

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## 3.2 Renesas Motor Workbench

### 3.2.1 Control Window



Easily evaluate motor control with the Analyzer tool

Figure 3-2 How to use the “Control Window”

By using the “Control Window”, variables recorded in RAM inside the microcontroller can be read or written. Refer to “Renesas Motor Workbench Function Description” '3. [Analyzer] Control Window' for details on how to add variables and set the Q format numbers, etc.

3.2.2 User Button

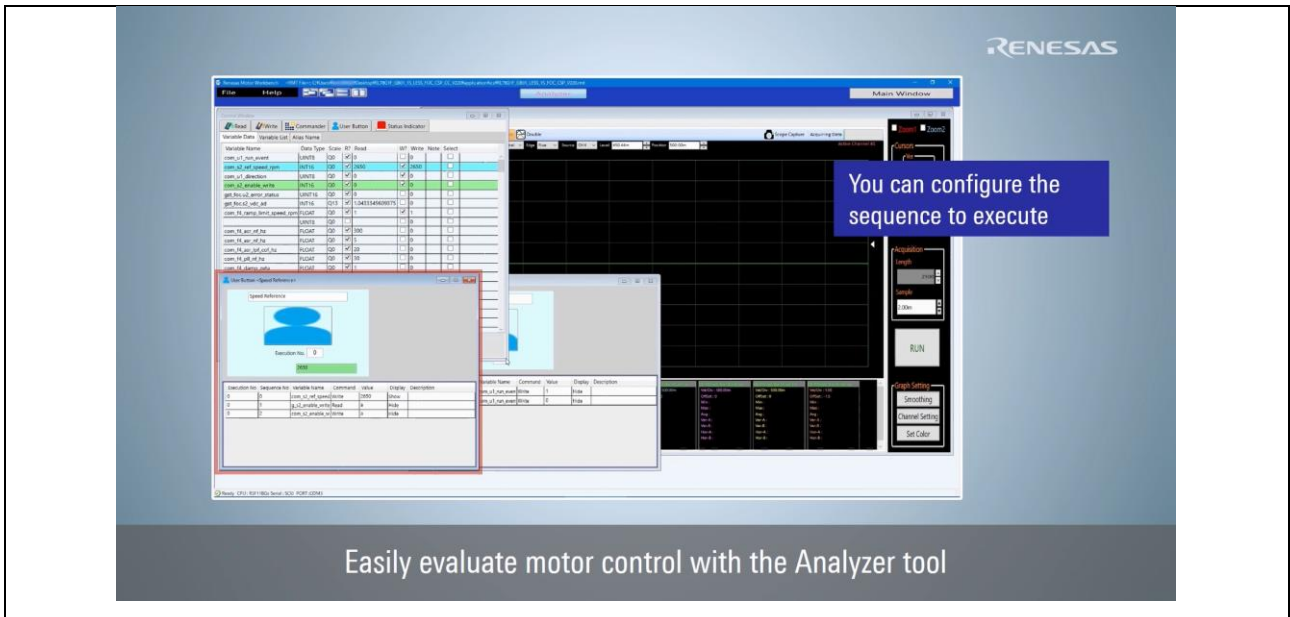
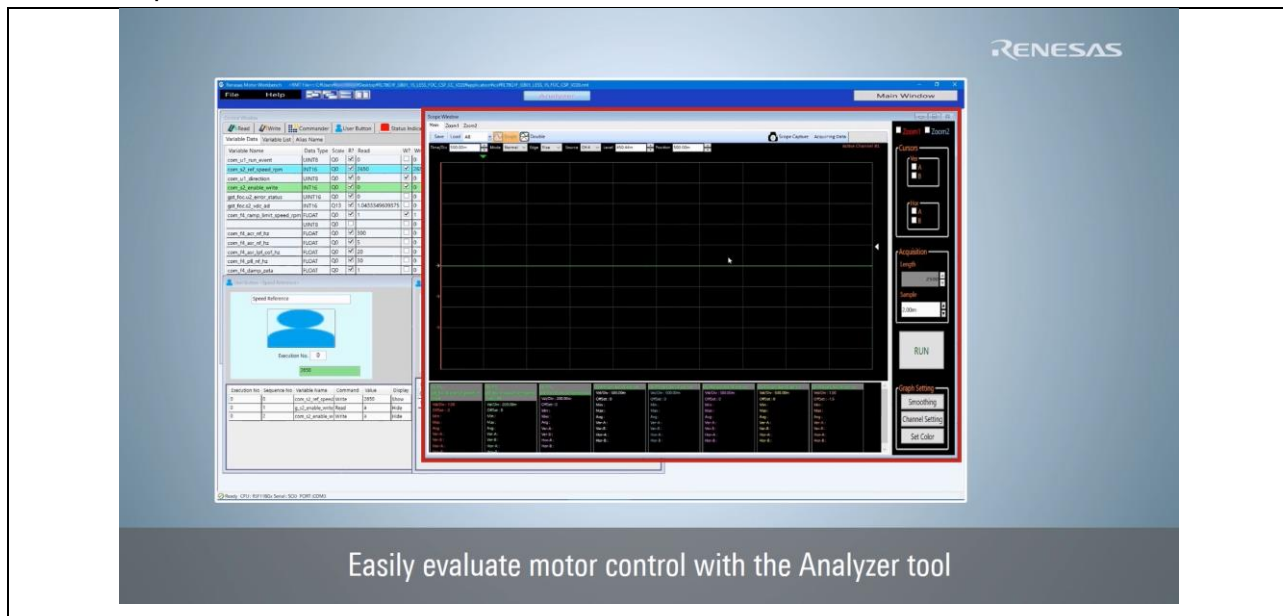


Figure 3-3 How to use the “User Button”

By using “User Button”, preregistered sequences are executed sequentially by user’s instruction (button clicking). Refer to “Renesas Motor Workbench Function Description” '6. [Analyzer] User button' for detailed instructions on how to set up the sequence, etc.



3.2.3 Scope Window



Easily evaluate motor control with the Analyzer tool

Figure 3-4 How to use the “Scope Window”

By using the “Scope Window”, variables inside the microcontroller can be displayed as a waveform with an oscilloscope-like operation. By using “Channel Setting” window, the setting of the waveform displayed is also changed. Refer to “Renesas Motor Workbench Function Description” '4. [Analyzer] Scope' for detailed operations such as setting triggers and changing scales, etc.

3.3 Reference website

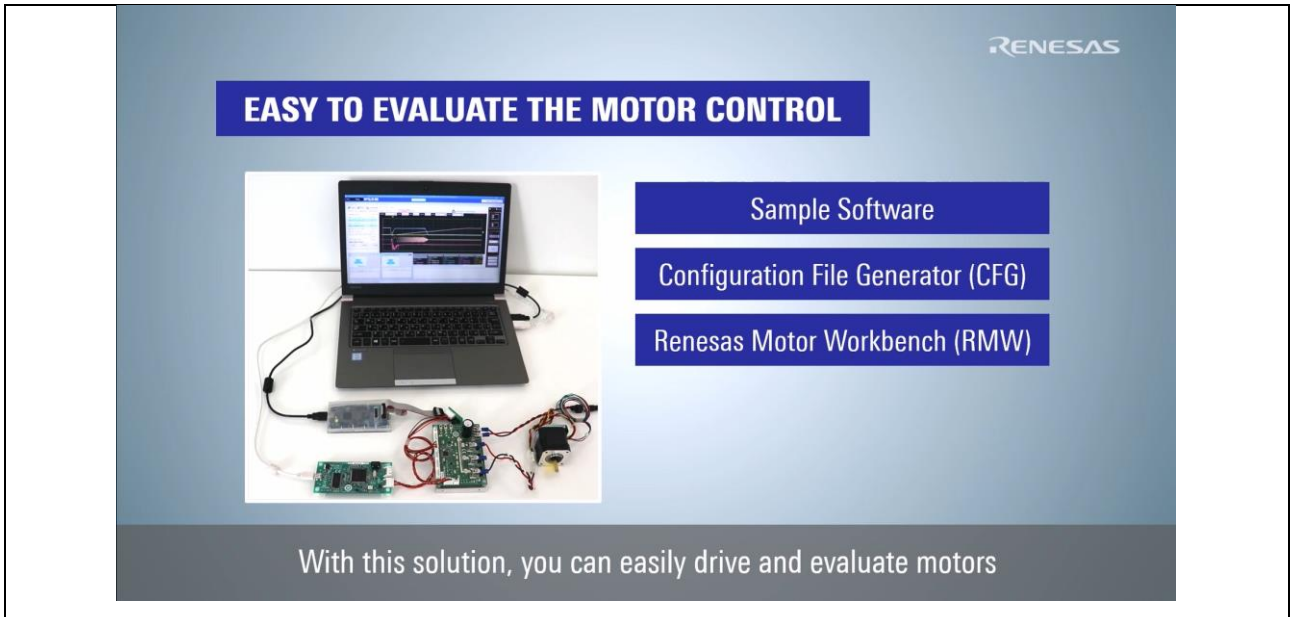


Figure 3-5 Summary of video introduction contents

For more information about Renesas motor control solutions and RL78 motor control solutions, please visit the following websites.

- Renesas motor control solution  
<https://www.renesas.com/sg/en/application/key-technology/motor-control-robotics/motor-control-solutions>
- RL78 motor control solution  
<https://www.renesas.com/us/en/products/microcontrollers-microprocessors/rl78-low-power-8-16-bit-mcus/rl78-motor-control-solutions>

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## Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Dec. 28. 2021	-	First edition issued

## 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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