R-IN32M4 series

CC-Link IE TSN CiA402 Sample Program

R18AN0057EJ0100
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Introduction

This document describes a sample program that supports the CiA402 drive profile, which is used especially for motor control in CC-Link IE TSN communication, which is one of the industrial Ethernet communication protocols.

Target Device

R-IN32M4-CL3

Contents

1. Operating Environment

The sample program in this manual assumes the following environment.

Table 1.1 Operating Environment

Item	Description
Board	R-IN32M4-CL3 Shimafuji Electric Incorporated. : SBEV-RIN32M4CL3
CPU	Arm Cortex-M4 Processor (100 MHz)
Operating Frequency	100 MHz
Operating Voltage	3.3 ± 0.165 V, 2.5 ± 0.125 V, 1.15 ± 0.06 V
Operating Mode	Boot from external serial Flash ROM Boot from instruction RAM
Device	External serial Flash ROM 8 Mbytes (MX25L6433FM2I-08G)
Communication Protocol	CC-Link IE TSN
Integrated Development Environment	Embedded Workbench for Arm (IAR Systems)
Emulator	I-jet, I-jet Trace for Arm Cortex-M (IAR Systems)

1.1 IAR EWARM

Obtain the IAR Embedded Workbench for Arm software from the IAR Systems website and install it according to its “Installation and License Registration Quick Reference”.
When using the free evaluation version, choose a 30-day time-limited license. The sample programs of R-IN32M4 series cannot be written with a size-limited license since the code size exceeds the limit.

IAR Systems URL: https://www.iar.com/

2. Setting and Connecting the Evaluation Board

R-IN32M4-CL3 has the following boards.

- Shimafuji evaluation board SBEV-RIN32M4CL3

For more information on these boards, refer to the following website.

Shimafuji Electric Incorporated.URL: http://www.shimafuji.co.jp/

2.1 Setting and Connecting the SBEV-RIN32M4CL3

2.1.1 Board Startup Settings

R-IN32M4-CL3 selects the boot target using the external pins (BOOT0, BOOT1). The boot mode of the SBEV-RIN32M4CL3 board is selected by setting the SW1.

Table 2.1 Boot Mode Selection (SBEV-RIN32M4CL3)

SW1		
1 (BOOT1)	2 (CLK2MSEL)	Boot Mode Selection
ON (High)	OFF (Low)	Boot from instruction RAM (for debug only)
OFF (Low)	OFF (Low)	Boot from external serial Flash ROM

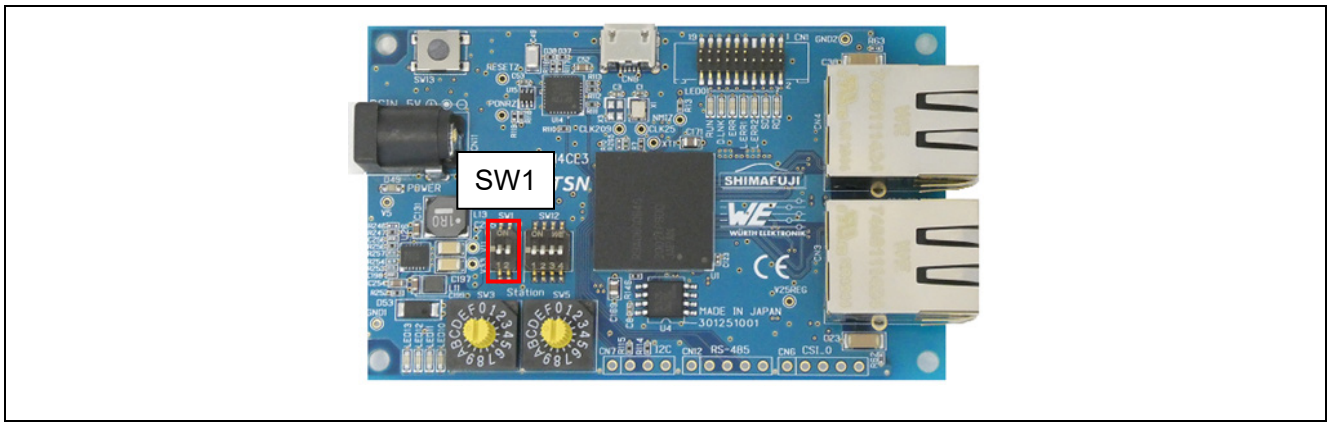

Figure 2-1 Boot Mode Selection Switch (SBEV-RIN32M4CL3)

2.1.2 Board Setup Procedure

Start the board in the following procedure.

(1) Use an Ethernet cable (category 5e or later recommended) to connect either Port 0 or Port 1 of the board to the PC Ethernet port
(2) Connect the 20-pin half connector to the ICE
Notice: No.1 terminal of the cable, which is Red one, must be on the right.
And connect the ICE to PC by USB cable that comes with ICE I-jet
(3) Set DIP-SW (SW1) to select boot mode
(4) Connect the 5 V DC power adapter to the power jack on the evaluation board
*Power supply is also possible from the USB-micro port of CN8.

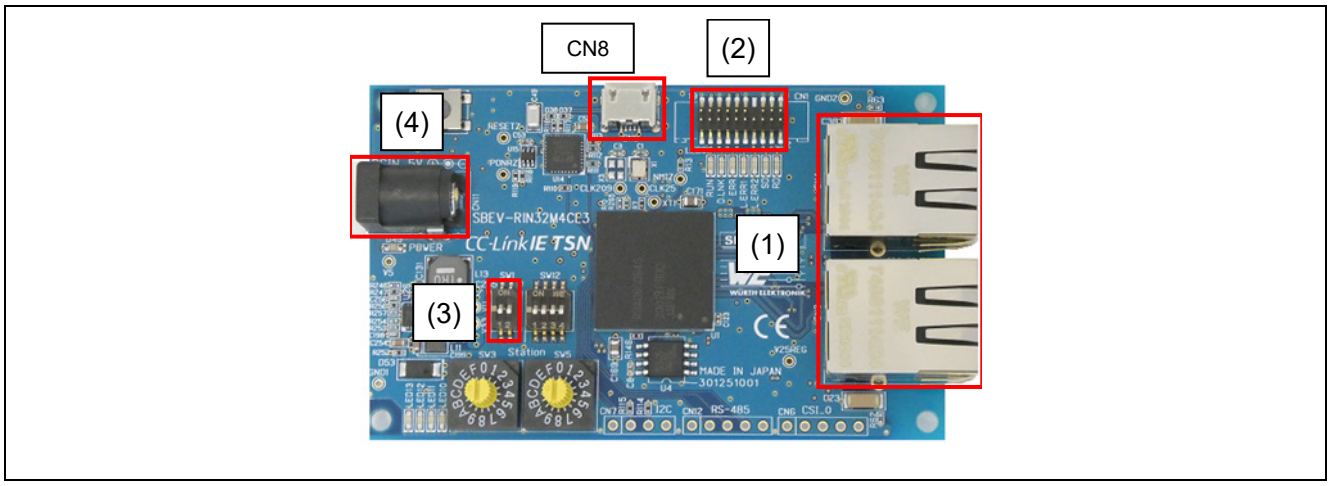

Figure 2-2 Board Setup Procedure (SBEV-RIN32M4CL3)

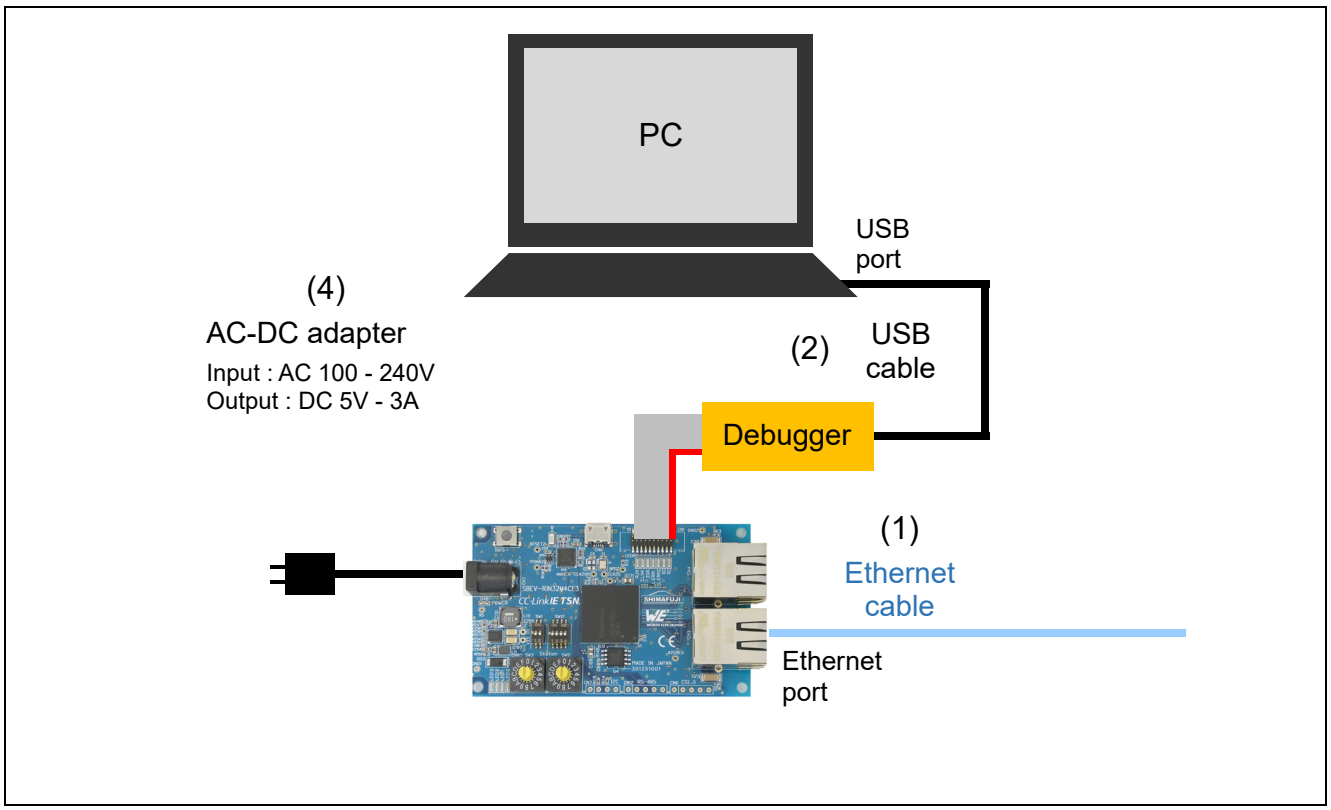

Figure 2-3 Board Connection Configuration (SBEV-RIN32M4CL3)

3. Sample Program

CC-Link IE TSN CiA402 sample program extends the CiA402 drive profile with the "CC-Link IE TSN remote station CANOpen communication sample program".
For "CC-Link IE TSN Remote Station CANOpen Communication Sample Program", refer to the following manual.

Base program:
R-IN32M4-CL3 Driver Middleware Release Notes TSN Edition Sample Program
(r18an0045xx ****-r-in32m4-ccietsn)

CC-Link IE TSN CANOpen communication sample program for remote stations.

Reference manual:
R-IN32M4 Series Startup Manual CC-Link IE TSN Edition (R18AN0042JJ ****)

3.1 CSP+ File

CC-Link IE TSN CiA402 sample program includes a CSP + file. If you need it for profile registration of CSP + file, please use the following CSP + file.

Table 3-1 CSP + file path

File	File path
CSP+File	(root)¥CSPP¥0x1234_CiA402Sample_1_en.CSPP.zip

3.2 Project

To start up EWARM, double-click the project file of the sample program to be used.

Table 3-2 Project File Path

Sample Program	Project File Path
EWARM Project File	(root)¥Software¥CCLinkIE_TSN¥IAR¥ProjectCiA402¥main.eww

3.3 Select Build Configuration

After EWARM starts up, select the build configuration from the following two types (RAM debug or serial flash boot).

[To execute a program in R-IN32M4-CL3 internal RAM (iRAM) from ICE]
In the case of executing from R-IN32M4-CL3 internal RAM (iRAM), select “RAM Debug”.
In this case, the boot mode selection switch must be set to “Instruction RAM boot” in Section 2.1.1 "Board Startup Settings".

[To boot with R-IN32M4-CL3 external serial flash ROM from ICE]
In the case of booting from R-IN32M4-CL3 external serial Flash ROM, select “Serial Flash Boot”.
In this case, the boot mode selection switch must be set to “External serial flash ROM boot” in Section 2.1.1 "Board Startup Settings".

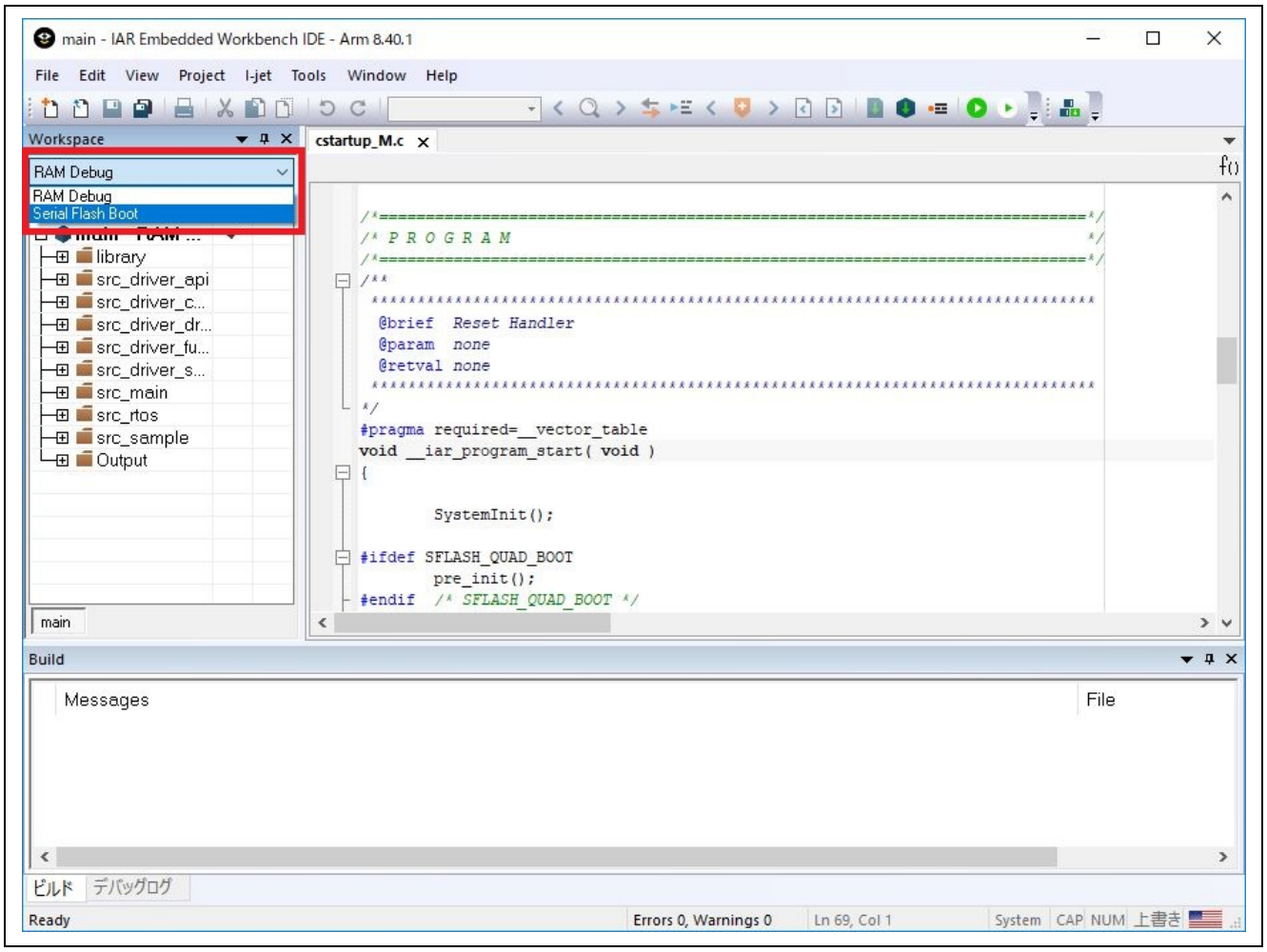

Figure 3.1 Selection of Sample Program Build Configuration

3.4 Building and Running the Programs

Click on the menu [Project] → [Rebuild All] to build.

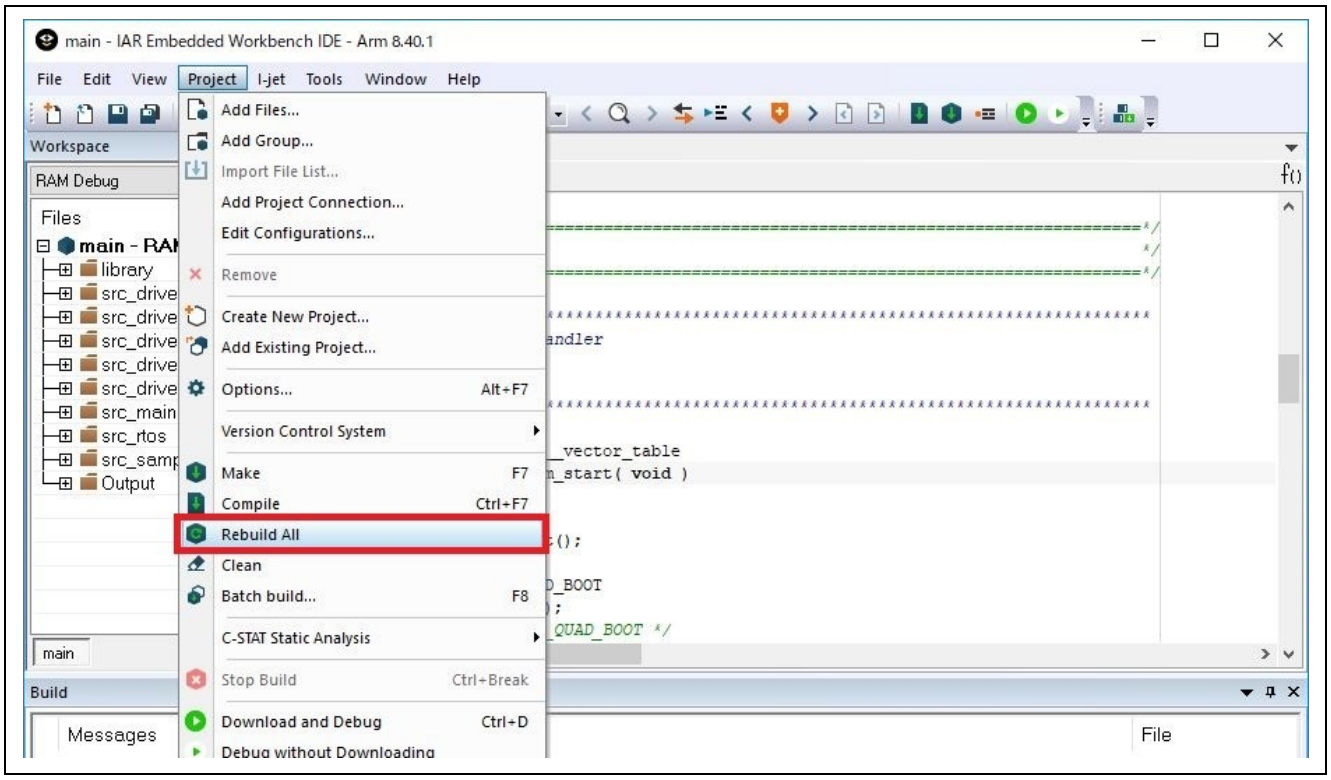

Figure 3.2 Building the sample program

After a successful build, download the program to the target.

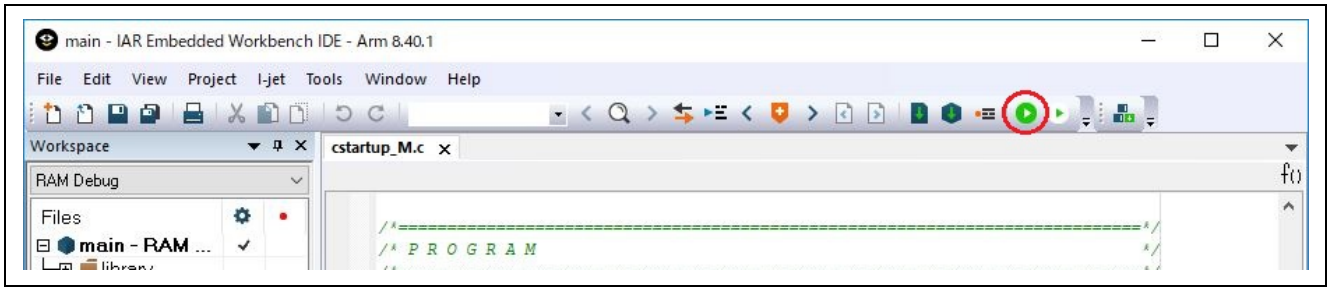

Figure 3.3 Download Sample Program

And then launch the program.

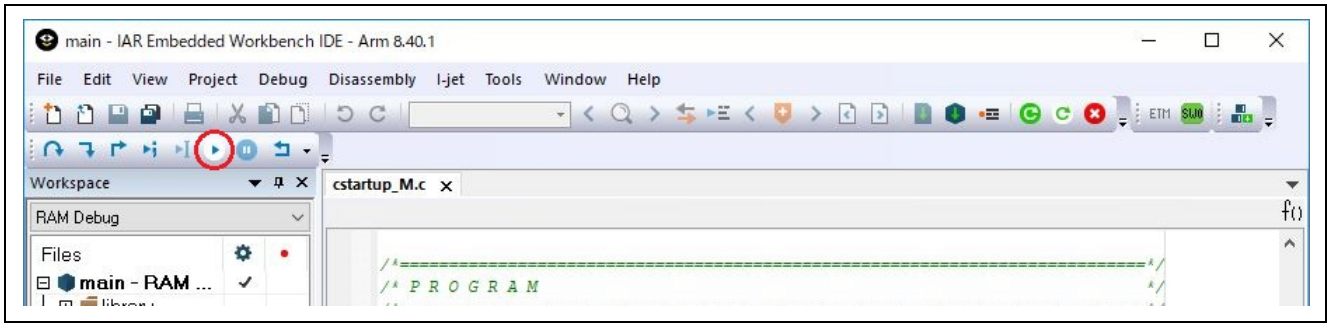

Figure 3.4 Launch Sample Program

4. CiA402 Drive Profile

The CiA402 drive profile is a device profile for driving motors and motion control and mainly defines functional operations for servo drives, sine-wave inverters and stepping motor controllers. In this profile, the multiple operation modes and corresponding parameters are defined as an object dictionary. Also, Finite State Automaton (FSA) to define the internal and external behavior in every state is included. When changing the state, the result after transition is reflected in the status word object that shows the current state by specifying the state through the control word object. The control word and various command values (such as speed) are assigned to RxPDO, and the status word and various real values (such as position) are assigned to TxPDO. Please see the contents of the CiA402 standard for more details

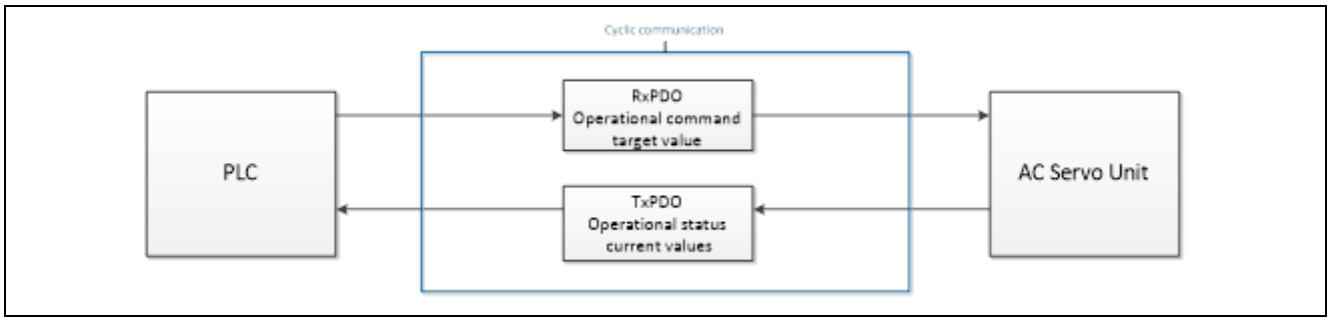

Figure 4-1 CiA402 Communication Flow

4.1 Operation Modes

In the application note, the following modes are supported from among the operation modes defined in the CiA402 standard.

Table 4-1 List of Supported Operation Modes

Operation Mode	Support
Profile position mode	○
Velocity mode (frequency converter)	×
Profile velocity mode	○
Profile torque mode	×
Homing mode	○
Interpolated position mode	×
Cyclic synchronous position mode	○
Cyclic synchronous velocity mode	○
Cyclic synchronous torque mode	×
Cyclic synchronous torque mode with commutation angle	×
Manufacturer specific mode	×

4.2 State Transition

In this application note, the following is supported as FSA defined in the CiA402 standard.

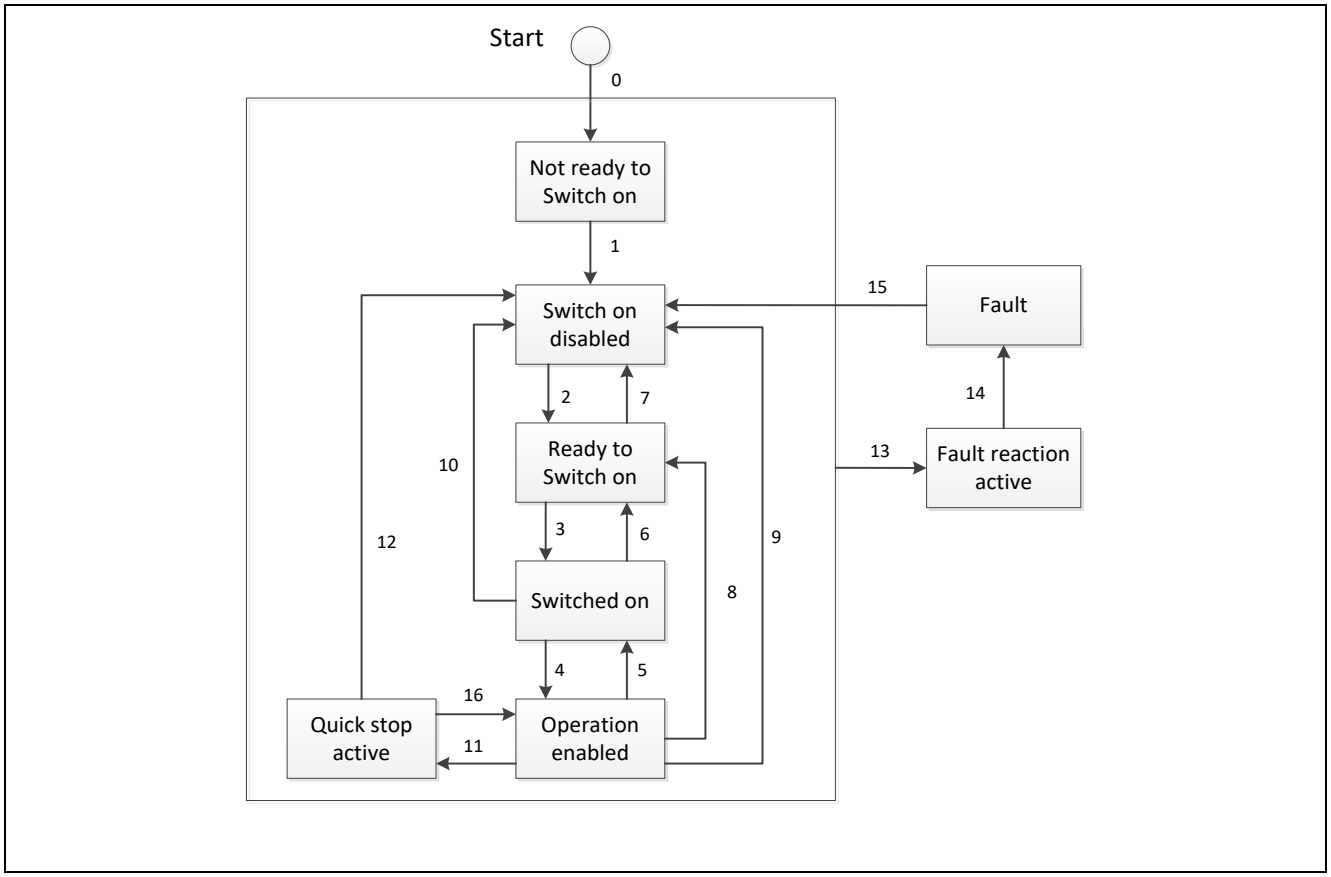

Figure 4-2 CiA402 State Transition Diagram

4.3 CiA402 Drive Profile

The following is the list of the drive profile supported in this application note.

Table 4-2 List of Supported Object Dictionaries

Operation Mode	OBJECT Name	Index	Access	Data Type	Mapping
Profile position mode	Target position	607A	RW	INT32	RxPDO
	Profile velocity	6081	RW	UINT32	RxPDO
	Profile acceleration	6083	RW	UINT32	RxPDO
	Profile deceleration	6084	RW	UINT32	RxPDO
	Motion profile type	6086	RW	INT16	RxPDO
	Profile jerk	60A4	RO	UINT8	RxPDO
Profile velocity mode	Profile acceleration	6083	RW	UINT32	RxPDO
	Profile deceleration	6084	RW	UINT32	RxPDO
	Target velocity	60FF	RW	INT32	RxPDO
Homing mode	Home offset	607C	RW	INT32	RxPDO
	Homing method	6098	RW	INT8	RxPDO
	Homing speeds	6099	RO	UINT8	RxPDO
	Homing acceleration	609A	RW	UINT32	RxPDO
Cyclic synchronous position mode	Torque actual value	6077	RO	INT16	TxPDO
	Target position	607A	RW	INT32	RxPDO
	Motion profile type	6086	RW	INT16	RxPDO
	Profile jerk	60A4	RO	UINT8	RxPDO
	Velocity offset	60B1	RW	INT32	RxPDO
	Torque offset	60B2	RW	INT16	RxPDO
Cyclic synchronous velocity mode	Torque actual value	6077	RO	INT16	TxPDO
	Torque offset	60B2	RW	INT16	RxPDO
	Target velocity	60FF	RW	INT32	RxPDO
All	Error code	603F	RO	UINT16	TxPDO
	Controlword	6040	RW	UINT16	RxPDO
	Statusword	6041	RO	UINT16	TxPDO
	Quick stop option code	605A	RW	INT16	No
	Shutdown option code	605B	RW	INT16	No
	Disable operation option code	605C	RW	INT16	No
	Fault reaction option code	605E	RW	INT16	No
	Modes of operation	6060	RW	INT8	RxPDO
	Modes of operation display	6061	RO	INT8	TxPDO
	Position actual value	6064	RO	INT32	TxPDO
	Following errror window	6065	RW	UINT32	No
	Following errror time out	6066	RW	UINT16	No
	Velocity actual value	606C	RO	INT32	TxPDO
	Position range limit	607B	RO	UINT8	No
	Software position limit	607D	RO	UINT8	No
	Max profile velocity	607F	RW	UINT32	No
	Max motor speed	6080	RW	UINT32	No
	Quick stop deceleration	6085	RW	UINT32	No
	Position offset	60B0	RW	INT32	No
	Interpolation time period	60C2	RO	UINT8	No
	Following error actual value	60F4	RO	INT32	No
	Following error actual value	6402	RW	UINT16	No
	Supported drive modes	6502	RO	UINT32	No

4.4 RPDO Object

Table 4-3 List of Supported RPDO Object

Index	Sub Index	Index	Sub Index	Size	OBJECT Name
1600	0			UINT8	RPDO1: Number of objects assigned
	1	1D01	1	UINT16	Watchdog Counter DL
	2	6040	0	UINT16	Controlword
	3	6060	0	UINT8	Modes of operation
	4			UINT8	Padding
	5	607A	0	UINT32	Target position
	6	6081	0	UINT32	Profile velocity
	7	6083	0	UINT32	Profile acceleration
	8	6084	0	UINT32	Profile deceleration
	9	6086	0	UINT16	Motion profile type
	10	60A4	1	UINT32	Profile jerk
	11	60A4	2	UINT32	Profile jerk
1601	0			UINT8	RPDO2: Number of objects assigned
	1	1D01	1	UINT16	Watchdog Counter DL
	2	6040	0	UINT16	Controlword
	3	6060	0	UINT8	Modes of operation
	4			UINT8	Padding
	5	6083	0	UINT32	Profile acceleration
	6	6084	0	UINT32	Profile deceleration
	7	60FF	0	UINT32	Target velocity
1602	0			UINT8	RPDO3: Number of objects assigned
	1	1D01	1	UINT16	Watchdog Counter DL
	2	6040	0	UINT16	Controlword
	3	6060	0	UINT8	Modes of operation
	4			UINT8	Padding
	5	607C	0	UINT32	Home offset
	6	6098	0	UINT8	Homing method
	7			UINT8	Padding
	8	6099	1	UINT32	Homing speeds
	9	6099	2	UINT32	Homing speeds
	10	609A	0	UINT32	Homing acceleration
1603	0			UINT8	RPDO4: Number of objects assigned
	1	1D01	1	UINT16	Watchdog Counter DL
	2	6040	0	UINT16	Controlword
	3	6060	0	UINT8	Modes of operation
	4			UINT8	Padding
	5	607A	0	UINT32	Target position
	6	6086	0	UINT16	Motion profile type
	7	60A4	1	UINT32	Profile jerk
	8	60A4	2	UINT32	Profile jerk
	9	60B1	0	UINT32	Velocity offset
	10	60B2	0	UINT16	Torque offset
1604	0			UINT8	RPDO5: Number of objects assigned
	1	1D01	1	UINT16	Watchdog Counter DL
	2	6040	0	UINT16	Controlword
	3	6060	0	UINT8	Modes of operation
	4			UINT8	Padding
	5	60B2	0	UINT16	Torque offset
	6	60FF	0	UINT32	Target velocity

4.5 TPDO Object

Table 4-4 List of Supported TPDO Object

Index	Sub Index	Index	Sub Index	Size	OBJECT Name
1A00	0				TPDO1: Number of objects assigned
	1	1D02	1	10	Watchdog Counter UL
	2	603F	0	10	Error code
	3	6041	0	10	Statusword
	4	6061	0	8	Modes of operation display
	5			8	Padding
	6	6064	0	20	Position actual value
	7	606C	0	20	Velocity actual value
1A01	0				TPDO2: Number of objects assigned
	1	1D02	1	10	Watchdog Counter UL
	2	603F	0	10	Error code
	3	6041	0	10	Statusword
	4	6061	0	8	Modes of operation display
	5			8	Padding
	6	6064	0	20	Position actual value
	7	606C	0	20	Velocity actual value
1A02	0				TPDO3: Number of objects assigned
	1	1D02	1	10	Watchdog Counter UL
	2	603F	0	10	Error code
	3	6041	0	10	Statusword
	4	6061	0	8	Modes of operation display
	5			8	Padding
	6	6064	0	20	Position actual value
	7	606C	0	20	Velocity actual value
1A03	0				TPDO4: Number of objects assigned
	1	1D02	1	10	Watchdog Counter UL
	2	603F	0	10	Error code
	3	6041	0	10	Statusword
	4	6061	0	8	Modes of operation display
	5			8	Padding
	6	6064	0	20	Position actual value
	7	606C	0	20	Velocity actual value
	8	6077	0	10	Torque actual value
1A04	0				TPDO5: Number of objects assigned
	1	1D02	1	10	Watchdog Counter UL
	2	603F	0	10	Error code
	3	6041	0	10	Statusword
	4	6061	0	8	Modes of operation display
	5			8	Padding
	6	6064	0	20	Position actual value
	7	606C	0	20	Velocity actual value
	8	6077	0	10	Torque actual value

4.6 Implementing the Motor Control Program

According to the CiA402 standard from the list of CiA402 protocol stack I/F functions in Table 4-5, implement the motor control application. Each function links the number of each state transition of CiA402 FSA shown in Figure 4-2 and the corresponding function is called in case of state transition. In each function, describe the processing that calls the motor control program or the relevant processing of the main CPU.

Table 4-5 List of CiA402 Protocol Stack I/F Functions

serR_IN_CiA402_StateTransition_1	
	Description This function is used when state transition 1 has occurred. Describe the operation in the case of the state transition.
	Usage
	Parameters none
	Return Value R_IN_OK : Normal end R_IN_ERR : Error
	Remark In the case of error occurrence during processing, exit the function by setting the appropriate values for each object in accordance with the CiA402 standard.If 1 is set to return value, state transition does not occur.
serR_IN_CiA402_StateTransition_2	
	Description This function is used when state transition 2 has occurred. Describe the operation in the case of the state transition.
	Usage
	Parameters none
	Return Value R_IN_OK : Normal end R_IN_ERR : Error
	Remark In the case of error occurrence during processing, exit the function by setting the appropriate values for each object in accordance with the CiA402 standard. If 1 is set to return value, state transition does not occur.

serR_IN_CiA402_StateTransition_3	
	Description This function is used when state transition 3 has occurred. Describe the operation in the case of the state transition.
	Usage
	Parameters none
	Return Value R_IN_OK : Normal end R_IN_ERR : Error
	Remark In the case of error occurrence during processing, exit the function by setting the appropriate values for each object in accordance with the CiA402 standard. If 1 is set to return value, state transition does not occur.
serR_IN_CiA402_StateTransition_4	
	Description This function is used when state transition 4 has occurred. Describe the operation in the case of the state transition.
	Usage
	Parameters none
	Return Value R_IN_OK : Normal end R_IN_ERR : Error
	Remark In the case of error occurrence during processing, exit the function by setting the appropriate values for each object in accordance with the CiA402 standard. If 1 is set to return value, state transition does not occur.
serR_IN_CiA402_StateTransition_5	
	Description This function is used when state transition 5 has occurred. Describe the operation in the case of the state transition.
	Usage
	Parameters none
	Return Value R_IN_OK : Normal end R_IN_ERR : Error
	Remark In the case of error occurrence during processing, exit the function by setting the appropriate values for each object in accordance with the CiA402 standard. If 1 is set to return value, state transition does not occur.

serR_IN_CiA402_StateTransition_6	
	Description This function is used when state transition 6 has occurred. Describe the operation in the case of the state transition.
	Usage
	Parameters none
	Return Value R_IN_OK : Normal end R_IN_ERR : Error
	Remark In the case of error occurrence during processing, exit the function by setting the appropriate values for each object in accordance with the CiA402 standard. If 1 is set to return value, state transition does not occur.
serR_IN_CiA402_StateTransition_7	
	Description This function is used when state transition 7 has occurred. Describe the operation in the case of the state transition.
	Usage
	Parameters none
	Return Value R_IN_OK : Normal end R_IN_ERR : Error
	Remark In the case of error occurrence during processing, exit the function by setting the appropriate values for each object in accordance with the CiA402 standard. If 1 is set to return value, state transition does not occur.
serR_IN_CiA402_StateTransition_8	
	Description This function is used when state transition 8 has occurred. Describe the operation in the case of the state transition.
	Usage
	Parameters none
	Return Value R_IN_OK : Normal end R_IN_ERR : Error
	Remark In the case of error occurrence during processing, exit the function by setting the appropriate values for each object in accordance with the CiA402 standard. If 1 is set to return value, state transition does not occur.

serR_IN_CiA402_StateTransition_9	
	Description This function is used when state transition 9 has occurred. Describe the operation in the case of the state transition.
	Usage
	Parameters none
	Return Value R_IN_OK : Normal end R_IN_ERR : Error
	Remark In the case of error occurrence during processing, exit the function by setting the appropriate values for each object in accordance with the CiA402 standard. If 1 is set to return value, state transition does not occur.
serR_IN_CiA402_StateTransition_10	
	Description This function is used when state transition 10 has occurred. Describe the operation in the case of the state transition.
	Usage
	Parameters none
	Return Value R_IN_OK : Normal end R_IN_ERR : Error
	Remark In the case of error occurrence during processing, exit the function by setting the appropriate values for each object in accordance with the CiA402 standard. If 1 is set to return value, state transition does not occur.
serR_IN_CiA402_StateTransition_11	
	Description This function is used when state transition 11 has occurred. Describe the operation in the case of the state transition.
	Usage
	Parameters none
	Return Value R_IN_OK : Normal end R_IN_ERR : Error
	Remark In the case of error occurrence during processing, exit the function by setting the appropriate values for each object in accordance with the CiA402 standard. If 1 is set to return value, state transition does not occur.

serR_IN_CiA402_StateTransition_12	
	Description This function is used when state transition 12 has occurred. Describe the operation in the case of the state transition.
	Usage
	Parameters none
	Return Value R_IN_OK : Normal end R_IN_ERR : Error
	Remark In the case of error occurrence during processing, exit the function by setting the appropriate values for each object in accordance with the CiA402 standard. If 1 is set to return value, state transition does not occur.
serR_IN_CiA402_StateTransition_14	
	Description This function is used when state transition 14 has occurred. Describe the operation in the case of the state transition.
	Usage
	Parameters none
	Return Value R_IN_OK : Normal end R_IN_ERR : Error
	Remark In the case of error occurrence during processing, exit the function by setting the appropriate values for each object in accordance with the CiA402 standard. If 1 is set to return value, state transition does not occur.
serR_IN_CiA402_StateTransition_15	
	Description This function is used when state transition 15 has occurred. Describe the operation in the case of the state transition.
	Usage
	Parameters none
	Return Value R_IN_OK : Normal end R_IN_ERR : Error
	Remark In the case of error occurrence during processing, exit the function by setting the appropriate values for each object in accordance with the CiA402 standard. If 1 is set to return value, state transition does not occur.

serR_IN_CiA402_StateTransition_16	
	Description This function is used when state transition 16 has occurred. Describe the operation in the case of the state transition.
	Usage
	Parameters none
	Return Value R_IN_OK：Normal end R_IN_ERR：Error
	Remark In the case of error occurrence during processing, exit the function by setting the appropriate values for each object in accordance with the CiA402 standard. If 1 is set to return value, state transition does not occur.
gvR_IN_CiA402_DriveFault	
	Description This function is used when state transition 13 has occurred.
	Usage none
	Parameters ErrorCode：Error code defined in CiA402
	Return Value
	Remark Set error code is notified to the master.

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Oct 30, 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.).
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