EC-1 Series

EtherCAT® CiA402 Drive Profile Implementation Manual

R01AN3854EJ0110
Rev.1.10
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Summary

This application note provides information to introduce CiA402 mainly used for motor control in EtherCAT communication used for controlling industrial AC servo motors from the PLC.

Contents <contents header>

1. Overview

1.1 Structure of This Application Note

This application note consists of the following contents.

Table 1-1 Structure of This Application Note

Component	Content
Application note	This document and EC-1 Series Communication Board EtherCAT Manual (R01AN3853EJxxx)
Source code	main.c,kernel_cfg.c,kernel_id.h renesashw.h,renesashw.c
ESI file	EC-1_CiA402_yymmdd.xml

1.2 Development Environment

The following describes software development tools.

1.2.1 Tool Chain

The table below shows the tool chain of this sample software.

Table 1-2 Development Tools

Tool Chain	IDE	Compiler	Debugger	ICE
IAR	Embedded Workbench for ARM V7.70.1 or later (Use the latest version.) (IAR Systems)			i-Jet JTAGjet-Trace-CM (IAR Systems)

1.2.2 EtherCAT Slave Stack Code Tool

The EtherCAT sample software uses the EtherCAT Slave Stack Code generated by the EtherCAT Slave Stack Code Tool. To obtain the EtherCAT Slave Stack Code Tool, join the EtherCAT Technology Group and acquire a vendor ID.

Contact the EtherCAT Technology Group about the EtherCAT Slave Stack Code Tool.

https://www.ethercat.org/

1.2.3 TwinCAT®

In this application note, TwinCAT (software system of Beckhoff Automation) is used for programming in EEPROM and for EtherCAT sample software operation check.

TwinCAT is available from the Beckhoff Automation homepage.

http://www.beckhoff.com/

1.3 System Configuration

The figure below shows an example of system configuration where the CiA402 sample software is used.

In the system example shown in Figure 1-1, the system operates by combining the motor control program (provided in the main CPU) with the EtherCAT control program (created by SSCTool) and the CiA402 drive profile (provided by this application note).

In this application note, an actual usage method using communication between Soft PLC(TwinCAT) and EC-1 is introduced in “EC-1 Series Application Note Communication Board EtherCAT Manual (R01AN3853JJxxx)”.

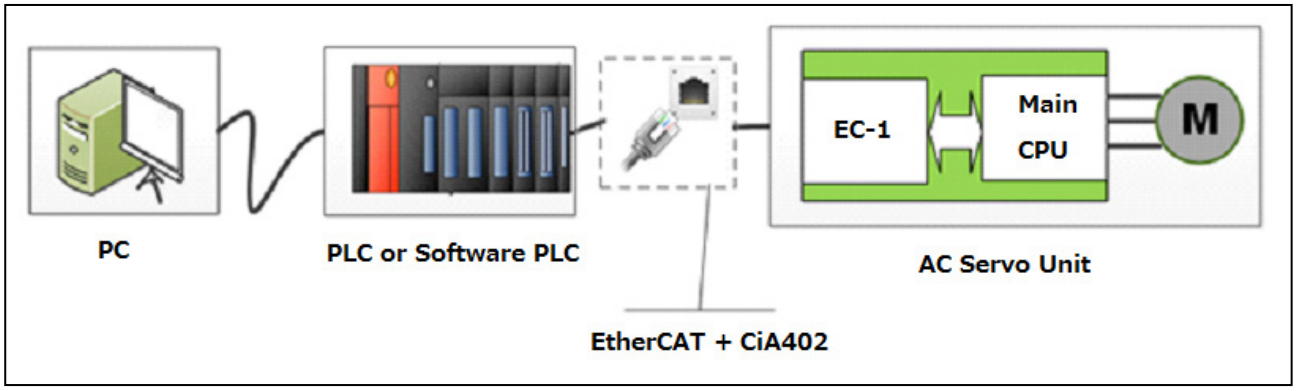

Figure 1-1 Example of System Configuration

1.4 Software Configuration

The figure below shows the entire software configuration including a protocol stack.

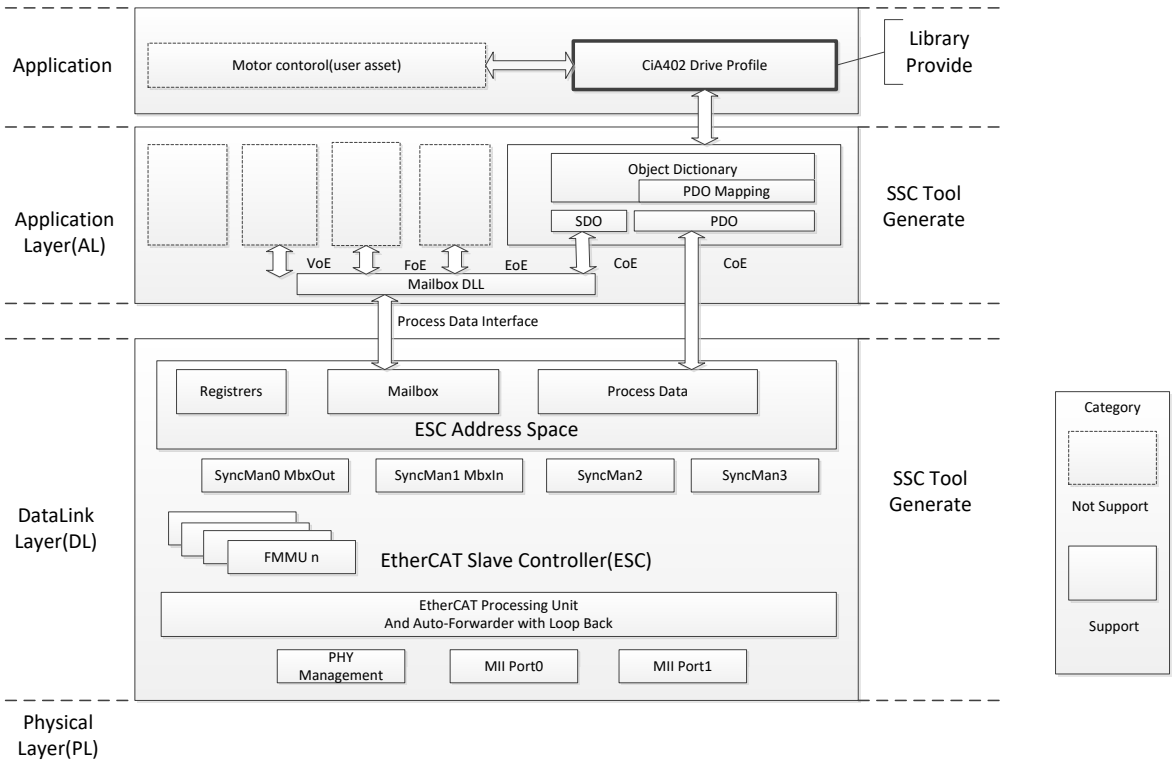

Figure 1-2 Software Configuration

SSCTool: EtherCAT control program creation tool provided by Beckhoff Automation GmbH, Germany

ESC: EtherCAT control unit with R-IN engine

As shown in Figure 1-2, CAN application protocol over EtherCAT (CoE) is used in the AL layer to apply EtherCAT communication to the CiA402 drive profile format.

The process data object (PDO) is used for real-time data transfer in cyclic communication.

PDO includes RxPDO to receive data from the PLC and TxPDO to send information (including status information) from the AC-Servo Unit to the PLC.

In asynchronous message communication, object dictionaries are read and written using mailbox communication (SDO).

2. CiA402 Drive Profile

The CiA402 drive profile is a device profile for controlling drive and motion, which mainly defines functional operation of servo drives, sine-wave inverters, and stepping motor controllers.

This profile defines setting parameters corresponding to operating modes as object dictionaries. Furthermore, this profile includes Finite State Automaton (FSA) that defines internal and external operations in each state. When changing the status, the result after transition is reflected in the status word object that shows the current status by specifying the status through the control word object.

Control words and command values (such as speed) are assigned to RxPDO, and status words and inspected values (such as position) are assigned to TxPDO. For details, see the description of the CiA402 specifications (Reference (1)).

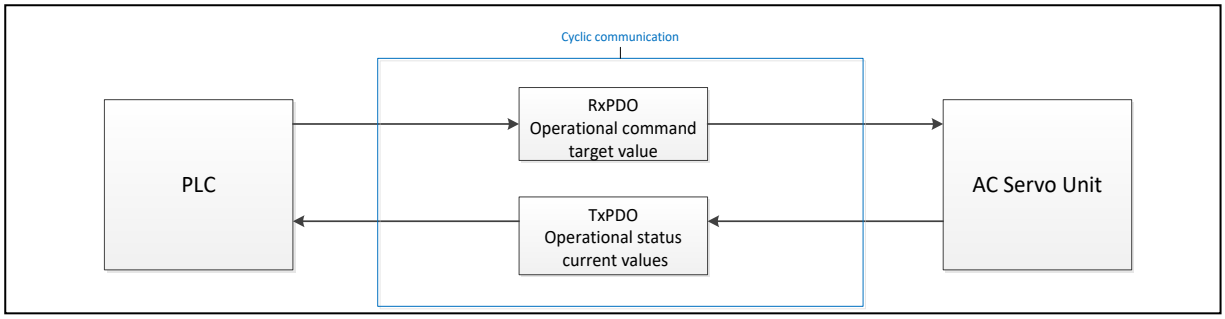

Figure 2-1 CiA402 Communication Flow

2.1 Operating Modes

This application note supports the following operating modes specified for CiA402.

Table 2-1 Supported Operating Modes

Operation Mode	Support
Profile position mode	Not supported
Velocity mode (frequency converter)	Not supported
Profile velocity mode	Not supported
Profile torque mode	Not supported
Homing mode	Not supported
Interpolated position mode	Not supported
Cyclic synchronous position mode	Supported
Cyclic synchronous velocity mode	Supported
Cyclic synchronous torque mode	Not supported
Cyclic synchronous torque mode with commutation angle	Not supported
Manufacturer specific mode	Not supported

2.2 State Transitions

This application note supports state transitions shown below as FSA specified for CiA402.

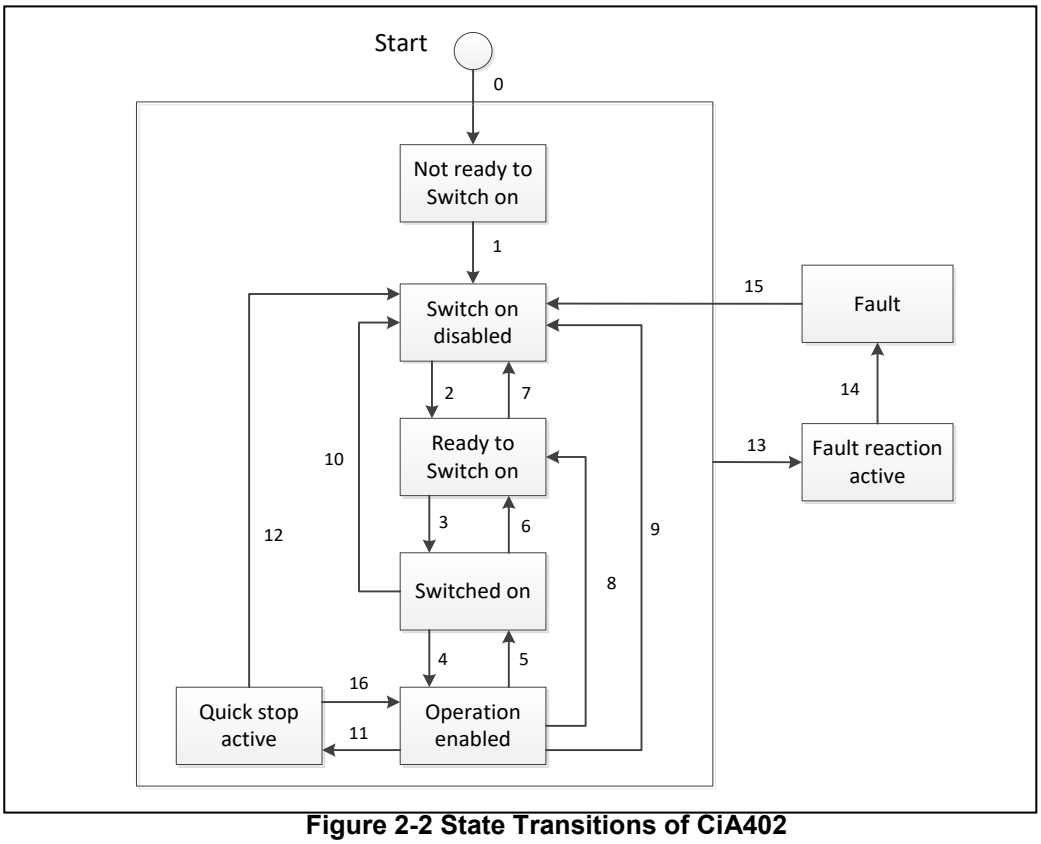

Figure 2-2 State Transitions of CiA402

2.3 Object Dictionaries

This application note supports object dictionaries listed in the table below.

Table 2-2 Supported Object Dictionaries

Operating Mode	Object Name	Index	Category	Access	Data Type	PDO Mapping
Cyclic synchronous position mode + Cyclic synchronous velocity mode	Position actual value	0x6064	Mandatory (CSP)	ro	INT32	Yes
	Following error window	0x6065	Optional	rw	UINT32	No
	Following error time out	0x6066	Optional	rw	UINT16	No
	Velocity actual value	0x606C	Mandatory (CSV)	ro	INT32	Yes
	Torque actual value	0x6077	Conditional	ro	INT16	No
	Target position	0x607A	Mandatory (CSP)	rw	INT32	Yes
	Position range limit	0x607B	Optional	c, rw	INT32	No
	Software position limit	0x607D	Optional	c, rw	INT32	No
	Velocity offset	0x60B1	Optional	rw	INT32	No
	Torque offset	0x60B2	Optional	rw	INT16	No
	Interpolation Time Period	0x60C2	Mandatory	c, rw	RECORD	No
	Following error actual value	0x60F4	Optional	ro	INT32	No
	Target velocity	0x60FF	Mandatory (CSV)	rw	INT32	Yes
Another object	**Object Name**	**Index**	**Category**	**Access**	**Data Type**	**PDO Mapping**
Controlling the power drive system	Error code	0x603F	Optional	Ro	UINT16	Yes
	Controlword	0x6040	Mandatory	rw	UINT16	Yes
	Statusword	0x6041	Mandatory	ro	UINT16	Yes
	Quick stop option code	0x605A	Optional	rw	INT16	No
	Shutdown option code	0x605B	Optional	rw	INT16	No
	Disable operation option code	0x605C	Optional	rw	INT16	No
	Fault reaction option code	0x605E	Optional	rw	INT16	No
	Modes of operation	0x6060	Optional	rw	INT8	Yes
	Modes of operation display	0x6061	Optional	ro	INT8	Yes
	Quick stop deceleration	0x6085	Optional	rw	UINT32	No
	Supported drive modes	0x6502	Mandatory	ro	UINT32	No

3. Application Development Procedure

3.1 Creating SSC Sample Software

For creating SSC sample software, see section 3.1, Creating SSC Sample Software in “EC-1 Series Application Note Communication Board EtherCAT Manual (R01AN3853EJxxx)”.

3.2 Embedding Motor Control Program

Embed the motor control application program according to the CiA402 standard from the list of CiA402 protocol stack interface functions shown in Table 3-1 CiA402 Protocol Stack Interface Functions.

Each function links with the number of each state transition of CiA402 FSA shown in Figure 2-2 State Transitions of CiA402. When a state transition occurs, the corresponding function is called.

In each function, describe the processing that calls the motor control program or the relevant processing of the main CPU.

Table 3-1 CiA402 Protocol Stack Interface Functions

CiA402_StateTransition1	
	Description This function is used when the state transition 1 occurred Describe the operation in the case of the state transition.
	Usage #include "cia402appl.h"
	Parameters TCiA402Axis *pCiA402Axis
	Return Value 0 Normal end 1 Error
	Remark In the case of error occurance during processing, exit the function by setting the appropriate values for each object in accordance with CiA402 standard . If 1 is seto to return value, state transition does not occur.
CiA402_StateTransition2	
	Description This function is used when the state transition 2 occurred Describe the operation in the case of the state transition.
	Usage #include "cia402appl.h"
	Parameters TCiA402Axis *pCiA402Axis
	Return Value 0 Normal end 1 Error
	Remark In the case of error occurance during processing, exit the function by setting the appropriate values for each object in accordance with CiA402 standard . If 1 is seto to return value, state transition does not occur.

CiA402_StateTransition3	
	Description This function is used when the state transition 3 occurred Describe the operation in the case of the state transition.
	Usage #include "cia402appl.h"
	Parameters TCiA402Axis *pCiA402Axis
	Return Value 0 Normal end 1 Error
	Remark In the case of error occurance during processing, exit the function by setting the appropriate values for each object in accordance with CiA402 standard . If 1 is seto to return value, state transition does not occur.
CiA402_StateTransition4	
	Description This function is used when the state transition 4 occurred Describe the operation in the case of the state transition.
	Usage #include "cia402appl.h"
	Parameters TCiA402Axis *pCiA402Axis
	Return Value 0 Normal end 1 Error
	Remark In the case of error occurance during processing, exit the function by setting the appropriate values for each object in accordance with CiA402 standard . If 1 is seto to return value, state transition does not occur.
CiA402_StateTransition5	
	Description This function is used when the state transition 5 occurred Describe the operation in the case of the state transition.
	Usage #include "cia402appl.h"
	Parameters TCiA402Axis *pCiA402Axis
	Return Value 0 Normal end 1 Error
	Remark In the case of error occurance during processing, exit the function by setting the appropriate values for each object in accordance with CiA402 standard . If 1 is seto to return value, state transition does not occur.

CiA402_StateTransition6	
	Description This function is used when the state transition 6 occurred Describe the operation in the case of the state transition.
	Usage #include "cia402appl.h"
	Parameters TCiA402Axis *pCiA402Axis
	Return Value 0 Normal end 1 Error
	Remark In the case of error occurance during processing, exit the function by setting the appropriate values for each object in accordance with CiA402 standard . If 1 is seto to return value, state transition does not occur.
CiA402_StateTransition7	
	Description This function is used when the state transition 7 occurred Describe the operation in the case of the state transition.
	Usage #include "cia402appl.h"
	Parameters TCiA402Axis *pCiA402Axis
	Return Value 0 Normal end 1 Error
	Remark In the case of error occurance during processing, exit the function by setting the appropriate values for each object in accordance with CiA402 standard . If 1 is seto to return value, state transition does not occur.
CiA402_StateTransition8	
	Description This function is used when the state transition 8 occurred Describe the operation in the case of the state transition.
	Usage #include "cia402appl.h"
	Parameters TCiA402Axis *pCiA402Axis
	Return Value 0 Normal end 1 Error
	Remark In the case of error occurance during processing, exit the function by setting the appropriate values for each object in accordance with CiA402 standard . If 1 is seto to return value, state transition does not occur.

CiA402_StateTransition9	
	Description This function is used when the state transition 9 occurred Describe the operation in the case of the state transition.
	Usage #include "cia402appl.h"
	Parameters TCiA402Axis *pCiA402Axis
	Return Value 0 Normal end 1 Error
	Remark In the case of error occurance during processing, exit the function by setting the appropriate values for each object in accordance with CiA402 standard . If 1 is seto to return value, state transition does not occur.
CiA402_StateTransition10	
	Description This function is used when the state transition 10 occurred Describe the operation in the case of the state transition.
	Usage #include "cia402appl.h"
	Parameters TCiA402Axis *pCiA402Axis
	Return Value 0 Normal end 1 Error
	Remark In the case of error occurance during processing, exit the function by setting the appropriate values for each object in accordance with CiA402 standard . If 1 is seto to return value, state transition does not occur.
CiA402_StateTransition11	
	Description This function is used when the state transition 11 occurred Describe the operation in the case of the state transition.
	Usage #include "cia402appl.h"
	Parameters TCiA402Axis *pCiA402Axis
	Return Value 0 Normal end 1 Error
	Remark In the case of error occurance during processing, exit the function by setting the appropriate values for each object in accordance with CiA402 standard . If 1 is seto to return value, state transition does not occur.

CiA402_StateTransition12

Description

This function is used when the state transition 12 occurred
Describe the operation in the case of the state transition.

Usage

#include "cia402appl.h"

Parameters

TCiA402Axis *pCiA402Axis

Return Value

0	Normal end
1	Error

Remark

In the case of error occurance during processing, exit the function by setting the appropriate values for each object in accordance with CiA402 standard .
If 1 is seto to return value, state transition does not occur.

CiA402_LocalError

Description

This function is used when the state transition 13 occurred
Describe the operation in the case of the state transition.

Usage

#include "cia402appl.h"

Parameters

UINT16 ErrorCode

Return Value

none

Remark

If the error corresponding to the state transition 13 occurs,
call this function after processing required and saving data at error location

CiA402_StateTransition14

Description

This function is used when the state transition 14 occurred
Describe the operation in the case of the state transition.

Usage

#include "cia402appl.h"

Parameters

TCiA402Axis *pCiA402Axis

Return Value

0	Normal end
1	Error

Remark

In the case of error occurance during processing, exit the function by setting the appropriate values for each object in accordance with CiA402 standard .
If 1 is seto to return value, state transition does not occur.

CiA402_StateTransition15	
	Description This function is used when the state transition 15 occurred Describe the operation in the case of the state transition.
	Usage #include "cia402appl.h"
	Parameters TCiA402Axis *pCiA402Axis
	Return Value 0 Normal end 1 Error
	Remark In the case of error occurance during processing, exit the function by setting the appropriate values for each object in accordance with CiA402 standard . If 1 is seto to return value, state transition does not occur.
CiA402_StateTransition16	
	Description This function is used when the state transition 16 occurred Describe the operation in the case of the state transition.
	Usage #include "cia402appl.h"
	Parameters TCiA402Axis *pCiA402Axis
	Return Value 0 Normal end 1 Error
	Remark In the case of error occurance during processing, exit the function by setting the appropriate values for each object in accordance with CiA402 standard . If 1 is seto to return value, state transition does not occur.
APPL_MOTOR_MotionControl_Main	
	Description Implement the motion control code when CiA402 FSA state is Operation enabled. Describe the process for each mode of operation.
	Usage #include "cia402appl.h"
	Parameters TCiA402Axis *pCiA402Axis
	Return Value 0 Normal end 1 Error
	Remark At the initial state, this function is described in "main.c" and calls "CiA402_DummyMotionControl" function for reference.

3.3 Notes on Embedding Protocol Stack

Note 1*) Note on alignment when using mailbox

The CiA402 protocol stack uses PDO communication and SDO communication.

For each structure used in SDO communication, ensure alignment by using the “pack” option, etc.

Note 2*) Note on watchdog timer for EtherCAT

If (TwinCAT+PC) is selected for the master device, a watchdog timer error may occur because the real-time of the SM event cycle is not ensured.

The sample software of this application note uses the generated source code with the watchdog timer setting of the SSC tool disabled and checks operation.

4. Checking Sample Software Operation

For checking sample software operation, see the following sections in “EC-1 Series Communication Board EtherCAT” (R01AN3853EJxxxx).

3.2 Downloading the Sample Software Program

3.3 Connecting TwinCAT

4.2 EtherCAT CiA402 Sample

5. Reference

(1) CiA402 standard:

IEC 61800-7-201 Edition 1.0

Adjustable speed electrical power drive systems Part 7-201: Generic interface and use of profiles for power drive systems Profile type 1 specification

IEC 61800-7-301 Edition 1.0

Adjustable speed electrical power drive systems Part 7-301: Generic interface and use of profiles for power drive systems Mapping of profile type 1 to network technologies

(2) EtherCAT standard:

ETG1000_1 V1.0.3	EtherCAT Specification- Part1 “Overview”
ETG1000_2 V1.0.3	EtherCAT Specification- Part2 “Physical Layer service and protocol specification”
ETG1000_3 V1.0.3	EtherCAT Specification- Part3 “Data Link Layer service definition”
ETG1000_4 V1.0.3	EtherCAT Specification- Part4 “Data Link Layer protocols specification”
ETG1000_5 V1.0.3	EtherCAT Specification- Part5 “Application Layer service definition”
ETG1000_6 V1.0.3	EtherCAT Specification- Part6 “Application Layer protocol specification”

(3) SSC tool:

ETG6010 Implementation Directive for CiA402 Drive Profile Version V1.0.0

Application Note ET9300 (EtherCAT Slave Stack Code) Version 1.5

6. Website and Support

Renesas Electronics Website
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Revision History

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	May.10, 2017	-	First Edition
1.10	Sep.17, 2018	-	Add trademark

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   — 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.
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   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.

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   Access to reserved addresses is prohibited.

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