

RZ/N2L Group

BACnet to OPC UA Gateway Sample Software

Introduction

This document describes sample software for running Gateway, which converts the BACnet communication protocol for Building Automation (BA) to OPC UA, on the RZ/N2L.

Target Device

RZ/N2L Group

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List of Abbreviations and Acronyms

Terms	Description			
FSP	Flexible Software Package			
RSK	Renesas Starter Kit			
BA	Building Automation			
BACnet	Building Automation and Control Networking			
B-SS	BACnet Smart Sensor			
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers			
ANSI	American National Standards Institute			
BIBB	BACnet Interoperability Building Blocks			
API	Application Program Interface			
APDU	Application Layer Protocol Data Unit			
OPC UA	Open Platform Communications Unified Architecture			
XML	Extensible Markup Language			

Related documents

Document Type	Document Title	Document No.	
Data Sheet	RZ/N2L Group Datasheet	R01DS0397EJ****	
User's Manual	RZ/N2L Group User's Manual: Hardware	R01UH0955EJ****	
User's Manual	Renesas Starter Kit+ for RZ/N2L User's Manual	R20UT4984EG****	
Application Note	RZ/N2L Group TCP/IP IwIP Sample Program Package	R01AN6588EJ****	
Application Note	RZ/N2L BACnet Sample Software	R01AN6789EJ****	



1. Overview

1.1 Abstract

OPC UA, which enables interoperability of industrial applications, is becoming widely used not only in factory automation (FA) but also in various industries. OPC 30030, a companion spec to OPC UA and BACnet, the major communication protocol for Building Automation (BA), has been developed, and interoperability across industries has been started.

This document describes the sample software configuration and its usage to realize Gateway between OPC UA and BACnet on RZ/N2L, which is the RZ processor for industrial networks.



Fig. 1-1 RSK+ for RZ/N2L

The sample software described in this document is for the Gateway, an interface device that connects different protocol devices.

Therefore, as shown in Fig. 1-2, the operation test in this document uses an application on a PC as the OPC Client, and RZ/N2L BACnet Sample Software (r01an6789xx0101-rzn2l-bacnet) as the BACnet server on the other end of the network. For the convenience of explanation, the Gateway described in this document is referred to as B-GW, and the BACnet server on the other side is referred to as B-SS.

Also, the sample software includes code to generate BACnet pseudo data so that it can be evaluated with a single RZ/N2L RSK board.



Fig. 1-2 Subject of this document and test setup



1.2 Operating Environment

1.2.1 Software Environment

The operating environment of this sample software is shown in Table 1-1

Table 1-1	Operating	Environment
-----------	-----------	-------------

Category	Name	Version	Link	備考
RZ/N2L BACnet sample software	Sample Package			
IDE	e2studio	22.10.0	https://www.renesas.com/document/sw s/e-studio-and-rzn2l-fsp-installer	Included with e2studio installer
Flexible Software Package	FSP	1.1.0		Included with e2studio installer
GNU Arm Embedded Toolchain	GCC Toolchain	V9.3.1.20200408 (*1)		Included with e2studio installer
OPC UA Client Tool	UaExpert	1.6.3	OPC UA Clients - Unified Automation (unified-automation.com)	
Packet analyzer	Wireshark	4.0.7	Wireshark · Download	

(*1). V10.3.1.20210824 is also installed when installing e2studio, but we recommend using V9.3.1.20200408.

1.2.2 Hardware Environment

This sample software is tested under the hardware environment of Table 1-2.

Table 1-2 Hardware Environment

Name	Type Name	Maker	Link	Note
Renesas Starter Kit+ for RZ/N2L	RTK9RZN2L0S00 000BE	Renesas Electronics	www.renesas.com/rskrzn2l	RSK Board 2pcs
Air Velocity Sensor Pmod™ Board	US082- FS3000EVZ	Renesas Electronics	<u>US082-FS3000EVZ - Air</u> <u>Velocity Sensor Pmod™ Board</u> <u>(Renesas Quick-Connect IoT) </u> <u>Renesas</u>	Renesas Quick Connect IoT



2. Hardware configuration

This section describes the hardware configuration of executing the sample software.

2.1 RSK Board Settings

When executing the sample software, configure the RSK board settings in Fig. 2-1

- The boot mode is NOR Flash ROM boot mode.
- Use SD-RAM as external memory
- Ethernet port 2 (ETH2) is not available on the RSK board with the settings.



Fig. 2-1 Board Configuration

Each switch and jumper setting is shown in Table 2-1 and Table 2-2. The red text indicates differences from the RSK board settings for the BACnet sample software (r01an6789xx0101-rzn2l-bacnet).

Table 2-1 DIPSW Settings

DIPSW		Setting	Description
SW11	1	ON	Enable LED_RED2 signal
	2	OFF	



	3	OFF	
	4	OFF	Enable RS485_RX signal
	5	ON	
	6	OFF	Disable P21_5、M2_VP、CAN_RX、ADTRG、P01_7
	7	OFF	
	8	OFF	
	9	OFF	
	10	OFF	
SW4	1	ON	16bit Bus boot mode (NOR Flash ROM Boot)
	2	OFF	
	3	ON	
	4	ON	JTAG Authentication by Hash is disabled
	5	OFF	-
	6	OFF	Enables signals other the trace. (Motor, RS485, etc.) (TRACE_OPTION_SEL=H)
	7	OFF	Enables external bus. (BSC_OPTION_SW=H)
	8	OFF	Enable SW3 (general purpose DIPSW)
SW8	1	OFF	Enable LED_GREEN
	2	ON	
	3	OFF	
	4	ON	Enable LED5
	5	OFF	
	6	OFF	Enable RS485_DE
	7	ON	
	8	OFF	Disable P02_2, IRQ4, CAN_TX
	9	OFF	
	10	OFF	

Table 2-2 Jumper Settings

Jumper	Setting	Setting Description		
J9 open When using the J-Link [®] OB		When using the J-Link [®] OB		
	short	When using the external emulator or not using the emulator		
CN31	2-3short	RS485 Half Duplex		
CN32	2-3short	RS485 Half Duplex		
CN20	1-2short When using 3 ports in the same PHY mode			
CN21	1-2short When using 3 ports in the same PHY mode			
CN22	1-2short	1-2short When using 3 ports in the same PHY mode		
CN24	1-2short	Connect 3.3V Power rail to VCC1833_3. (Using External Bus)		
CN8	2-3short	Select QSPI Serial Flash (QSPI_CS)		
CN29	1-2short	USB Serial (UART_USB_RX)		
CN27	1-2short	HyperRAM (IC41)		
CN25	1-2short	Other than the SHOST interface. (Trace, SPI, external bus)		
CN17	1-2short	Use 3.3V for VCC1833_2 (disable ETH2)		





2.2 Pmod[™] Connection

In the sample software, Renesas Quick Connect IOT air velocity sensor (US082-FS3000EVZ) is connected to J26 of RZ/N2L RSK board and input a sensor signal for the B-SS (BACnet Smart Sensor).

To support Pmod[™] Type 6A (Extended I2C), connect E2 and E3 of the RSK board (solder bridge) and cut E23 and E24 (trace cut) as shown in Fig.2-2



Fig.2-2 Pmod[™] Type6A(I2C)



3. Sample Software

This chapter describes the structure and usage of the sample software.

3.1 Folder structure

The folder structure of the sample software is shown below. As a guide, the bolded text indicates folders containing files that users will customize with this sample software.

_OPC_BGW_	V1.0.0	
BACNETOSS	BACnet Open Source Software	
bacnet	BACnet Protocol Stack	
OPC UA SERVER	Open62541 , BACnet related OPC UA files	
zn	RZ	
⊢—arm	ARM	
CMSIS_5	CMSIS	
aws	AWS	
└──amazon-freertos	FreeRTOS	
board	Board	
└──rzn2l_rsk	RZ/N2L Renesas Starter Kit	
fsp	Flexible Software Package	
-rzn_cfg	Configuration	
⊢—aws	AWS	
└──fsp_cfg	FSP	
└—bsp	Board Support Package	
rzn_gen	Generated files	
-script	Linker Script	
src	User Thread Entry	
-user	User files	
OSS	Other OSS	
amazon-freertos	AWS_OSS	
└—-lwip	IwIP_OSS	
renesas	Renesas common files	
application	User IwIP application, OPCfeature	
module	User module	
└──oss_deps	IwIP OSS dependencies	

Fig.3-1 Folder Structure



3.2 Boot Sequence

Describes the boot procedure and memory allocation.

The boot mode of the sample software is 16-bit bus NOR flash boot mode. The figure below shows the BSP tag in the Smart Configurator.

3 workspace_FSP110_NORboot_sample_GW5 - RZN2L_BACnetBGW_V100/configuration.xml - e ² studio	- [
File Edit Source Refactor Navigate Search Project Renesas Views Run Window Help		
🔨 🕸 🔳 🎄 Debug 🗸 😨 RZN2L_FreeRTOS_LwIP Debug_Flat 🗸 🌼 🗄 🐨 🔚 🌚 👻 🗞 🗸	ਛੇ ! 🐂 ! 🔌 ! 🕸 ! 🔆 ▾ 💁 ▾ ! फ ▾ ላጜ 💷 ▾ 🕬 😭	
# : ☆ - ☆ - ☆ - ☆ - : ഈ # - : ഈ ◎ 11 : ☆ - ? - ? ↔ → → - *	Q 🕴 💼 c/c++	🎄 Debug
陷 Project Explorer 🗙 🖳 🖸 wip_port_main.c 🕼 startup.c 🕼 main.c 🔅 [RZN2L_BACnetBGW_V100] FSP	Configuration ×	× ¬ ¬
□ Image: State St	Generate Project Content	ere is no
> 💥 Binaries > 🔊 Includes	Restore Default	ive editor t provides an line
BACNETOSS Device Selection		
> @ rzn_cfg/aws FSP version: 1.1.0 > @ rzn_cfg/aws Board: RSK+RZN2L (16-bit bus NOR flash boot mode) Image: Construction of the second	Board Details Renesas Starter Kit+ for RZ/N2L CPU Board (16-bit bus NOR flash boot mode)	
> Script		Ŷ - □ □
Configuration.xml Repartice and the second		· · ·
	https://www2.renespositeContent.xml 💼 👘 🕅 🗍	r 🗡 🔘

Fig.3-2 Boot mode

After downloading the program to the flash memory, the board operates independently by pressing the RESET button on the RSK board or turning the power ON without a debugger connection. You can still connect the debugger for evaluation. However, if jumper 9 (J9) of the RSK board is shorted, the debugger (J-Link OB) cannot be connected.



Fig.3-3 J9



This is the Smart Configurator screen showing the terminal settings (Pins tag) of the NOR flash memory device. No changes are required because they have already been configured.

When 16-bit bus NOR flash boot mode is selected, the pin settings for address buses A0-A20 are made automatically, however, if the program size is 2 MB or larger, the pin settings for A21-A25 must be made individually in BSC. In this sample project, the settings have already been made and need not to be changed.

Pin Configuration				Ge	nerate Project Conte	nt
Select Pin Configuration		Exp	ort to CSV file	🗆 Configure Pi	n Driver Warnings	
RSK+RZN2L	✓ Manage configurations	Ŀ	Generate data:	g_bsp_pin_cf	ig	
Pin Selection	Z Pin Configuration				😲 Cycle Pin Group	>
Type filter text	Name	Value	Lock	Link		^
Connectivity:SPI	Pin Group Selection	Mixed				
> ✓ Connectivity:USB HS	Operation Mode	SDRAM 16bit				
> Connectivity:XSPI	✓ Input/Output			$\langle \rangle$		
> ✓ Debug:JTAG/SWD	Ao	None		\Rightarrow		
> Debug:TRACE	A1	✓ P05_3				
> Delta sigmalF:DSMIF	A2	✓ P05_2				
✓ ✓ ExBus:BSC	A3	✓ P05_1				
BSC	A4	✓ P05_0				
> Interrupt:IRQ	A5	♥ P04_7				
> 🗸 System:CGC	A0 A7	✓ P04 5				
> System:MBXSEM	A8	✓ P04_4	, and the second			~
> System:SYSTEM	A9	✓ P04_0	i iii			
> IRGADC	A10	✓ P03_7		\Rightarrow		1
> TimerCMTW	A11	✓ P03_6		\Rightarrow		
< >	A12	✓ P03_5	a î	\Rightarrow		
端子機能 従子乗号	A13	✓ P00_1	a 🕯	\Rightarrow		-
加丁版肥加丁世方	A14	✓ P03_0	L 💣	\Rightarrow		
Summary BSP Clocks Pins Interrupts	Ever A15	✓ P02_3	L D	\Rightarrow		
	A16	✓ P02_2	L 🗊 🗌			
	A17	✓ P02_1		↓		
	A18	✓ P02_0				
	A19	✓ P01_7				
	A20	✓ PUI_6				
	A21	♥ P14_0 Ø D14 7				
	A22	✓ P15.0				
	A24	✓ P15_0				
	A25	✓ P15 2				
	-	None				
	BS#	✓ P14 4	a c	4		
	CAS#	✓ P01_0	- A			
	CKE	✓ P01_1	6	\Rightarrow		
	CKIO	✓ P04_1	e e e e e e e e e e e e e e e e e e e	\Rightarrow		
	CS0#	None		\Rightarrow		
	CS2#	None		\Rightarrow		
	CS3#	✓ P14_5	l 💼	\Rightarrow		
	CS5#	None				
	Do	✓ P21_1				
	D1	✓ P21_2				
	D2	✓ P21_3				
	D3	✓ P21_4				
	D4	✓ P21_5				
	Ds	✓ P21_0				
	D7					
	Da	♥ P22_0 Ø P22_1				
	Da	✓ P22_1				
	D10	✓ P22 3	-			
	D11	✓ P23 7	- A			
	D12	✓ P24 0	- A	4		
	D13	✓ P24_1	- F			
	D14	✓ P24_2	l dî			
	D15	✓ Poo_0	l dî	\Rightarrow		
	RAS#	✓ P00_7		\Rightarrow		
	-	None		\Rightarrow		
	RD_WR#	✓ P00_3	e e e e e e e e e e e e e e e e e e e	\Rightarrow		
	WAIT#	✓ P00_4	e e e e e e e e e e e e e e e e e e e	\Rightarrow		
	DOMLL	✓ P01 5	e e e e e e e e e e e e e e e e e e e	\Rightarrow		

Fig.3-4 BSC Pin Configuration



The order of memory writing in the boot sequence is shown in the writing order column in Fig.3-5. For an overview of (1) through (5), see Section エラー! 参照元が見つかりません。.

Addrose						
Address	Memory	Content	Leng	th	writing order	remarks
0x00000000		intvec(64B)				Internal
0x00000040	ATCM	Unused	0x00020000	128KB	(3)	tightly coupled memory
0x00000100		hal_entry,ROMdata				ugility coupled memory
0x00020000	Reserved area	-	-			
0x00100000		Unused				Internal
0x00102000	BTCM	Loader program(24KB)	0x00020000	128KB	(2)	tightly coupled memory
0x00108000		stack(60KB)				ughuy coupled memory
0x00120000	Reserved area	-	-			
0x10000000	SYSTEM_RAM	Body of program and data	0x00180000	1.5MB	(4)	Cached system RAM
0x10180000	Reserved area	-	-			
0x30000000	SYSTEM_RAM_MIRROR	Unused	0x00180000	1.5MB		
0x30180000	Reserved area	-	-			
0x40000000	xSPI0_CS0_SPACE_MIRROR	Unused	0x04000000	64MB		
0x44000000	xSPI0_CS1_SPACE_MIRROR	Unused	0x04000000	64MB		
0x48000000	xSPI1_CS0_SPACE_MIRROR	Unused	0x04000000	64MB		
0x4C000000	xSPI1_CS1_SPACE_MIRROR	Unused	0x04000000	64MB		
0x50000000	CS0_SPACE_MIRROR	Unused	0x04000000	64MB		
0x54000000	CS2_SPACE_MIRROR	Unused	0x04000000	64MB		
0x58000000	CS3_SPACE_MIRROR	Unused	0x04000000	64MB		
0x5C000000	CS5_SPACE_MIRROR	Unused	0x04000000	64MB		
0x60000000	xSPI0_CS0_SPACE	Unused	0x04000000	64MB		
0x64000000	xSPI0_CS1_SPACE	Unused	0x04000000	64MB		
0x68000000	xSPI1_CS0_SPACE	Unused	0x04000000	64MB		
0x6C000000	xSPI1_CS1_SPACE	Unused	0x04000000	64MB		
0x70000000		Parameters for the loader(76B)				
0x7000004C	CS0 SPACE	Loader program(24KB)	0x02000000	32MB	(1)	256M bits NOR Flash
0x7000604C	USU_SPACE	Body of program and data				
0x72000000		Unused	0x02000000	32MB		
0x74000000	CS2_SPACE	Unused	0x04000000	64MB		
0x78000000		Body of program and data	0x02000000	32MB	(5)	256M bits SDRAM
0x7A000000	USS_SFACE	Unused	0x02000000	32MB		
0x7C000000	CS5_SPACE	Unused	0x04000000	64MB		

Fig.3-5 Memory layout



3.3 OPC UA Stack

3.3.1 OPC UA

OPC UA was developed by the OPC Foundation as an open communication standard to realize secure and reliable data exchange for various industries including the industrial automation field. OPC Classic, the predecessor of OPC UA, was Windows-based, but OPC UA is now multi-platform and able to run on various platforms from Windows systems including cloud computing to RTOS for field devices.

This sample software implements the open source open62541 protocol stack on FreeRTOS, which is provided as sample software for RZ/N2L.

3.3.2 Information Model

To achieve interoperability among vendors and industries, OPC UA provides a unified data model called the Information Model in xml file format. It includes built-in models commonly used in OPC UA, companion models used by each industry or organization, and vendor-specific models that can be customized by each vendor. (Fig. 3-6)

In this sample software, the .xml file of the information model is converted to C language code. For details, please refer to chapter 5.1.



Fig. 3-6 Information Model

(1) Opc.Ua.Xml.NodeSet2.xml

It provides the "Meta Model", which is a set of rules for describing the OPC UA information model, and the "Built-in Information Model", which is the basic information model of OPC UA described by the Meta Model.

In this sample software, the following versions are applied.

The OPC UA XML version 1.05.01 (<u>UA-Nodeset/XML/Opc.Ua.Xml.NodeSet2.xml at</u> d1bb6a22125bd7cd986272b1ee98a18a91d76fff · OPCFoundation/UA-Nodeset · GitHub)

(2) Opc.Ua.BACnet.NodeSet2.xml

This is one of the information models defined for each industry segment according to companion specifications, and is a companion information model for BACnet, a communication protocol for building automation.

(OPC UA Companion Specification : OPC 30030: BACnet)

In this sample software, the following versions are applied.

bacnet XML version 2.0 (<u>UA-Nodeset/BACnet/Opc.Ua.BACnet.NodeSet2.xml at</u> <u>d1bb6a22125bd7cd986272b1ee98a18a91d76fff · OPCFoundation/UA-Nodeset · GitHub</u>)



3.3.3 Open62541

This sample software adopts the open source open62541 as the protocol stack for the OPC UA server. For more information on Open62541, refer to the following Link.

open62541

(1) Version

Base version of open62541 in this sample software is the following.

Base Version : v1.3.4-564-gb7e5e49f3

(commit b7e5e49f32d00490be74c2eacef892c7fbd0be60)

(2) License

The license terms for the Open62541 are MPL v2.0.

Please refer <u>https://www.mozilla.org/en-US/MPL/2.0/</u> for more information and comply with the license terms and conditions.

(3) open62541 files

To run Open62541 in the environment of freeRTOS + LwIP, the method to generate open62541.c and open62541.h files using CMake as described in the following link is applied

Building open62541 — open62541 1.3.0-dirty documentation

For more information, please refer to chapter 5.1 in the Appendix.

3.3.4 Restrictions

The released version V1.0.0 of this sample software has the following restrictions.

- ✓ Not supported for security certificates.
- ✓ Not supported for NTP client. (It is possible to obtain UTC time by Time Synchronization Method.)



3.4 BACnet Stack

BACnet (Building Automation and Control Network) is the major communication protocol for Building Automation (BA) standardized in ASHRAE/ANSI Standard 135. Air conditioning, lighting, disaster prevention, access control, etc. can be integrated to control and monitor buildings.

BACnet devices are classified into different profiles according to their function and application, such as operator or controller. Major profiles include the central monitoring profile B-OWS (BACnet Operator Workstation), the controller profile B-BC (BACnet Building Controller), and the profile for various sensors B-SS (BACnet Sensor). In addition, there are also B-RTR (BACnet Router) and B-GW (BACnet Gateway) profiles for relaying between different communication protocol devices as Miscellaneous profiles that can be used in combination with the above-mentioned controller profiles.

This sample software realizes a Gateway (B-GW) between BACnet and OPC UA and consists of two device profiles, B-GW and B-BC. B-GW maps properties of objects defined in BACnet to node variables defined in OPC UA according to OPC UA's Companion Specification <u>OPC 30030: BACnet</u>. The B-GW forward access requests from OPC UA clients to BACnet server equipment (in this case, B-SS sample software) in BACnet/IP networks, and then forwards responses from the BACnet server to the OPC UA client.

Details on how to build and start the B-SS sample software are described in the application note (<u>R01AN6789EJ****</u>). Refer to Section 5. BACnet I/P Communication in the application note.

3.4.1 BACnet Protocol Stack

BACnet Protocol Stack (bacnet-stack) is an open-source stack for the BACnet communication protocol. This sample software is a port of BACnet Protocol Stack to RZ/N2L.

Base Version : eb36033f (Commits on Jan 18, 2023)

<u>GitHub - bacnet-stack/bacnet-stack: BACnet Protocol Stack library provides a BACnet application layer,</u> network layer and media access (MAC) layer communications services.

3.4.2 License

The license terms for the BACnet Protocol Stack are GPL with exception license. The original text is transcribed below for reference. Please refer <u>BACnet Protocol Stack download | SourceForge.net</u> for more information and comply with the license terms and conditions.

This BACnet protocol stack implementation is specifically designed for the embedded BACnet appliance, using a GPL with exception license (like eCos), which means that any changes to the core code that are distributed are shared, but the BACnet library can be linked to proprietary code without the proprietary code becoming GPL. Note that some of the source files are designed as skeleton or example or template files, and are not copyrighted as GPL.

The text of the GPL exception included in each source file is as follows:

"As a special exception, if other files instantiate templates or use macros or inline functions from this file, or you compile this file and link it with other works to produce a work based on this file, this file does not by itself cause the resulting work to be covered by the GNU General Public License. However the source code for this file must still be made available in accordance with section (3) of the GNU General Public License."



3.4.3 Specifications

3.4.3.1 Restrictions

This sample software supports the gateway (B-GW) device profile defined in the BACnet standard. It also includes some B-BC controller device profile features, but does not meet the requirements for standard B-BC device profiles in the BACnet specification and is not supported in this version.

B-BC will be supported in the next version or later. Please refer to Chapter 5.2 for the support status of B-BC in this version.

3.4.3.2 BACnet Revision

The protocol version and revision of the BACnet stack used in this sample software are as follows

- BACnet standard Protocol Version : 1
- BACnet standard Protocol Revision : 22

The BACnet standard document (ANSI/ASHRAE Standard 135-2020) indicates version 1 and revision 22.

The define value of the ported open-source stack revision is 24, but the objects added in revisions 23 and 24 are not supported and changed to 22 in this release, as shown below.

BACNETOSS\bacnet\bacdef.h #define BACNET_PROTOCOL_REVISION 22

3.4.3.3 Service

The sequence of BACnet stack implemented in the sample software is service driven. Interoperability of BACnet devices is provided by the connection between users and providers via services (Whols, I-Am, ReadProperty, etc.).

There are two types of services: Unconfirmed and Confirmed. In the unconfirmed type, the provider does not return an Ack for the service requested by the user. On the other hand, confirmed type will return an Ack.

- Users of the sample software mean the following.
 - It corresponds to a client that connects to BACnet server through the BACnet /IP protocol.
- **Providers** mean the following.

It corresponds to a server that connects to BACnet clients through BACnet /IP protocol.

The B-GW running this sample software is a user to other providers (B-SS) in the BACnet internetwork.

However, it could also be a provider to other users in the BACnet Internetwork.

The services implemented in the sample software are as follows.

Table 3-1 Implemented Services in the sample software

BACnet service	Initiate ¹	Execute ²
Who-Is	✓	1
I-Am	1	1
Who-Has	1	1
I-Have	1	1



BACnet service	Initiate ¹	Execute ²
ReadProperty	1	1
WriteProperty	1	1
DeviceCommunicationControl		
ReinitializeDevice		
AtomicReadFile		
AtomicWriteFile		
TimeSynchronization		
UTCTimeSynchronization		
SubscribeCOV		
ConfirmedCOVNotification		
UnconfirmedCOVNotification		
ReadPropertyMultiple		
ReadPropertyConditional		
ReadRange		
WritePropertyMultiple		
GetAlarmSummary		
GetEventInformation		
GetEnrollmentSummary		
AcknowledgeAlarm		
ConfirmedEventNotification		
UnconfirmedEventNotification		
UnconfirmedTextMessage		
ConfirmedTextMessage		
AddListElement		
RemoveListElement		
CreateObject		
DeleteObject		
UnconfirmedPrivateTransfer		
ConfirmedPrivateTransfer		
VTOpen		
VTData		
VTClose		

 \checkmark is applicable, blank is not applicable.

1. Send a BACnet service request or notification.

2. Execute the BACnet service and send a response (if a confirmed service is requested).



The following is an overview of the implemented services

Table 3-2 Implemented services in the B-SS samp	ple software
---	--------------

BACnet service	Description
Who-Is	Who-Is service is used by BACnet users to know which other BACnet devices are sharing the network. Who-Is service is a broadcasted, unconfirmed (does not require an Ack) service.
I-Am	I-Am service is intended to respond to Who-Is service requests. However, I-Am service requests are broadcast transmissions that can be sent anytime. Receipt of Who-Is service request need not be preceded.
Who-Has	Who-Has service is used by BACnet users to identify BACnet devices with specific objects. Who-Has service is a broadcasted, unconfirmed type of service.
I-Have	I-Have service is available to respond to Who-Has service requests. However, I-Have service requests can be issued at any time. Receipt of Who-Has service requests need not be preceded; I-Have service is sent broadcast and is an unconfirmed type of service.
ReadProperty	ReadProperty service is used by BACnet users to request the value of one property of one BACnet object; the BACnet provider responds with Ack and returns the result.
WriteProperty	WriteProperty service is used by BACnet users to change the value of a specified property of one of the BACnet objects. BACnet provider responds with an Ack. If you want to restrict the write access to a specified property, an error with "Error Class" PROPERTY and "Error Code" WRITE_ACCESS_DENIED is returned.

3.4.3.4 Object

A BACnet device consists of a set of objects. An object is represented by an object type and an instance number from 0 to 4194303, which is called an object ID. However, the number 4194303 means invalid and is not used.

The device itself is also an object and is defined in Device object; the object ID of the device is called the device ID. Each BACnet device is required to have a Device object.

Furthermore, objects consist of a set of properties of various data types, and a BACnet device accesses hardware to read and write these properties.

The implemented Objects of the sample software is as follows.

Table 3-3 Implemented Objects in the sample software

BACnet object type	Object ID	Implementation
Accumulator		
Analog Input	Analog Input, 0	1
	Analog Input, 1	1
Analog Output		
Analog Value		
Averaging		
Binary Input		
Binary Output		
Binary Value		
Calendar		



BACnet object type	Object ID	Implementation
Command		
Device	Device, 12	✓
Event Enrollment		
File		
Group		
Life Safety Point		
Life Safety Zone		
Loop		
Multi state Input		
Multi state Output		
Multi state Value		
Notification Class		
Program		
Pulse Converter		
Schedule		
Trend Log		
Access Door		
Event Log		
Load Control		
Structured View		
Trend Log Multiple		
Access Point		
Access Zone		
Access User		
Access Rights		
Access Credential		
Credential Data Input		
CharacterString Value		
DateTime Value		
Large Analog Value		
BitString Value		
OctetString Value		
Time Value		
Integer Value		
Positive Integer Value		
Date Value		
DateTime Pattern Value		



BACnet object type	Object ID	Implementation
Time Pattern Value		
Date Pattern Value		
Network Security		
Global Group		
Notification Forwarder		
Alert Enrollment		
Channel		
Lighting Output		
Network Port	NetworkPort,1	1
Binary Lighting Output		

✓ is applicable, blank is not applicable, and "Not available" is restriction of this sample software version.

Outlines of the implemented object types are as follows.

Table 3-4 Outlines of the imple	lemented object typ	bes
---------------------------------	---------------------	-----

BACnet Object Type	Description
Analog Input	Analog Input object has properties that represent analog inputs from hardware.
Device	Binary Value object has properties that represent two states, ACTIVE or INACTIVE, resident in the memory of the BACnet device.
Network Port	The Network Port object has properties that represent the network configuration of the BACnet device; BACnet devices must have at least one Network Port object.

3.4.3.5 BIBB

BIBB (BACnet Interoperability Building Blocks) defines a set of services that apply to interoperating BACnet devices. "A" and "B" devices are defined, with the "A" device representing the BACnet user and the "B" device representing the BACnet provider.

BACnet standard (Annex L) defines various device profiles that describe the characteristics of each device, such as B-SS (BACnet Smart Sensor), B-BC (BACnet Building Controller), B-OWS (BACnet Operator WorkStation) and else. B-GW in this sample software have "B" characteristics.

The implemented BIBB of the sample software is as follows.

Table 3-5 In	nplemented BIBB	of B-GW c	device profile
--------------	-----------------	-----------	----------------

BIBB Class	BIBB	BACnet Service	Initiate ¹	Execute ²	B-GW Standardized ³
DataSharing	DS-RP-B	ReadProperty		1	1
	DS-WP-B	WriteProperty		1	1
Device &	DM-DDB-B	Who-Is		1	1
Management		I-Am	1		1
	DM-DOB-B	Who-Has		1	1
		I-Have	1		1



RZ/N2L Group

BACnet to OPC UA Gateway Sample Software

BIBB Class	BIBB	BACnet Service	Initiate ¹	Execute ²	B-GW Standardized ³
	GW-EO-B	The B device provides access to BACnet devices.	o data and functiona	lity in non-	>

✓ is applicable, blank is not applicable.

1. Sends a BACnet service request or notification. However, the B-SS does not send service requests, only notifications.

2. Execute the BACnet service and send a response (if a confirmed service is requested).

3. BIBBs which is defined as normalized for B-GW in ANNEX L of BACnet standards.

Outlines of the implemented BIBB in the B-SS sample software is as follows.

Table 3-6 Outlines of the implemented BIBB

BIBB	Description
DS-RP-B	Device B returns one property value to device A.
DS-WP-B	Device B writes value from device A to one property.
DM-DDB-B	Device B responds to the identification request from Device A.
DM-DOB-B	Device B responds to an identification request from Device A with the specified object.
DM-RD-B	Device B responds to the reinitialization request from Device A.
GW-EO-B	B devices provide access to the data and functionality of non-BACnet devices; B devices contain the data and functionality of other devices through BACnet objects and services.



3.5 Installation of Development Environment

3.5.1 e2studio

3.5.1.1 Install

Download the version listed in Table 1-1 and install it on your PC. The latest version has a downloadable installer that includes FSP, e2studio, and the GCC toolchain as a single package.

• Double-click the downloaded "setup_rznfsp_v1_1_0_e2s_v2022-10.exe".

26% Extracting	×]
	Cancel	

Fig.3-7 e2studio Install (1)

Select Users

Renes	as Installer	
Ţ	Select which users to install for	
	→ All Users Install for all users on this computer Requires Administrator permissions	
	Current user Install for X00000000 only Parts may require Administrator permissions	
	\rightarrow Cancel installation	

Fig.3-8 e2studio Install (2)



· Select Install Type



Fig.3-9 e2studio Install (3)

Select Install folder



Fig.3-10 e2studio Install (4)

· Check and Click "Next"



Fig.3-11 e2studio Install (5)

· Click "Install"

ackage (FSP) v1.1.0 with e ² studio 2022-10 Setup ログラムおよびファイルへのショートカットは、次の場所に作成されます: -ト・メニュー・グルーブ: Renesas RZ¥N v1.1.0 ・アフォルトを復元(R)
ログラムおよびファイルへのショートカットは、次の場所に作成されます: -ト・メニュー・グループ: Renesas RZ¥N v1.1.0 € デフォルトを復元(R)

Fig.3-12 e2studio Install (6)

🛃 Renesas RZ/N Flexible S	Software Package (FSP) v1.1.0 with e² studio 2022-10 Setup	— 🗆 X
Renesas RZ/N Flexible S	Software Package (FSP) v1.1.0 with e ² studio 2022-10 Setup	RENESAS
ようこそ ライセンス ショートカット ・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・・	Renesas RZ/N Flexible Software Package (FSP) v1.1.0 with e ² studio 2 ください。 Installing IUs Installing org.eclipse.xtext.xbase	022-10がインストールされるまでお待ち
v202212160219	User: All Users < Back Next >	インストール Cancel

Fig.3-13 e2studio Install (7)

· Click "OK"



Fig.3-14 e2studio Install (8)



3.5.1.2 Project start-up

(1) Unzip package

First, unzip the archived package of this sample software (RZN2L_OPC_BGW_V^{***}.zip) and store it in arbitrary folder. Because e2studio cannot recognize project properly if file path is too long in the folder hierarchy, place it in shorter path. Also, do not use multi-byte character, such as Japanese, in the folder path.

(2) Execute e2studio

Execute "e2studio.exe" to start e2studio in the following folder (default case) installed:

```
\Renesas\rzn\e2studio_v2022-10_fsp_v1.1.0\eclipse¥e2studio.exe
```

Fig.3-15 Launch project (1)

(3) Import Project

Enter any workspace directory and click "Launch".

🧧 e² studio Launcher	×
Select a directory as workspace	
e ² studio uses the workspace directory to store its preferences and development artifacts.	
Workspace: ⁹ C:¥Users¥XXXXXXX¥e2_studio¥workspace_FSP110_NORboot_sample_GW6 ✓	rowse
Use this as the default and do not ask again	
<u>R</u> ecent Workspaces	
Launch	Cancel



Г

Select the toolchain "GNU ARM Embedded - 9.3.1.20200408"

	- L X
Toolchain Integration	
 New toolchains available for integration 	C
ツールチェーンの登録	
ツールチェーン・タイプ	インストール・パス
✓ 🗹 GNU ARM Embedded	
GNU ARM Embedded - 10.3.1.20210824	C:¥Program Files (x86)¥GNU Arm Embedd
GNU ARM Embedded - 9.3.1.20200408	C:¥Program Files (x86)¥GNU Arm Embedd
<	>
Select all Deselect all	
beselectan	
☑ 起動時に 'ツールチェーンの登録' を有効にする	
	登録 Cancel

Fig.3-17 Launch project (3)

Select "Import existing projects"

File Edit Source Ref	actor Navigate Search Project Renesas Views Run Wind	ow Help		
	No Lower Confirmentions			m = @ =: A
	No Launch Configurations	• on:		😁 🕇 🔥 🕇 : 💯
📸 • 🚳 • 💽 • G	▼ 🥭 🔌 ▼ 🖻 🗉 11 🧤 🖉 🦓 🎄 ▼ 🚰 ▼	us - 🌾 I	▶ • • • • ¥ 🖏 & ≫ ⊻ • § • < ↔ -> <	
				Q
🖶 🚱 Welcome 🗙			<u>~</u>	- <> A* A* 🛅 - 8
Renesa	S Welcome to e ² studio			Hide
0	Create a new C/C++ project Create a new e ² studio C/C++ project		Overview Get an overview of the features	
*	Import existing projects Import existing e ² studio projects from the filesystem or archive	₹	Tutorials Go through tutorials	
*	Import sample projects Download and import sample projects from Renesas website	%	Samples Try out the samples	
o	Review IDE configuration settings Review the IDE's most fiercely contested preferences		What's New Find out what is new	
Ľ	Open an existing file Open a file from the filesystem	1	Quick Start Guides Quickly getting familiar with the tool 口Am ^{8 件の} 2 件の	5知らせ × ソール・トビック があります。 ルネサス・ニュース があります。
			詳細は	ここをクリックしてください。

Fig.3-18 Launch project (4)



Click "Browse" at "Select root directory" and enter the project folder to be imported.

Check the "Copy projects into workspace" checkbox to copy the import project.

Import				×
Import Projects Select a directory to searc	h for existing Eclipse project	5,		
Select root directory:	C:¥Users¥XXXXXXX¥e2_studi	o¥workspace_FS ~	Browse	
O Select archive file:		~	Browse	
Projects:				
RZN2L_FreeRTOS_I	wIP (C:¥Users¥XXXXXXXX¥e2_	tudio¥workspace_F	Select A	All
			Deselect	All
			Refrest	1 I
 Options Search for nested proj ✓ Copy projects into wo Close newly imported Hide projects that alree Working sets Add project to working Working sets: 	jects prkspace projects upon completion eady exist in the workspace ing sets	>	New Select	
0		Finish	Cance	

Fig.3-19 Launch project (5)

Click "Finish" in Fig.3-19 to display the following and click "Yes To All".

Overwrite '.settings' in folder 'RZN2L_FreeRTOS_IwIP'? Yes Yes Yes No No No Cancel	(Question	×
Yes To All No No To All Cancel	Overwrite '.settings' in folder 'RZN2L_FreeRTOS_IwIP'?	
	Yes Ves To All No No To All	Cancel

Fig.3-20 Launch project (6)



Г

🕲 Import —	D X
Import Projects	
Select a directory to search for existing Eclipse projects.	
	-
⑤ Select root directory: C¥Users¥XXXXXXXXX fe2_studio¥workspace_FS ∨	Browse
○ Select archive file: 🔍	Browse
Projects:	
RZN2L_FreeRTOS_IwIP (C:¥Users¥XXXXXXXX ¥e2_studio¥workspace_F	Select All
	Deselect All
	Refresh
Ontions	
Search for nested projects	
Copy projects into workspace	
Close newly imported projects upon completion	
Working sets	
Add project to working sets	Nau
	new
Working sets:	Select
Ci¥Users¥71768836¥e2_studio¥workspace_FSP110_sample_B-SS¥RZN2L_FreeRTC)S_lwIP¥Debuq¥
	Canaal
Finish	Câncel

Fig.3-21 Launch project (7)

• When the project import is complete, the following will be displayed. The subsequent sections will be explained in chapter 4.3.1.

workspace_FSP110_NORboot_sample_	GW - e² studio	- 🗆	×
File Edit Source Refactor Navigate	Search Project Renesas Views Run Window Help		
🔦 🔅 🔳 🎄 Debug	✓ RZN2L_OPC_BGW_V1.0.0 Debug	🍕 🕶 🔜 🗄	
🔍 🗈 🗉 🖬 🕅 🤉 🖓 . r. 🗟	🕱 徽 徽 本 • 💁 • फ • 木 🗰 • 💷 😭 🖏 Ø Ø Ø 🔞 •	• 🚳 • 🔂 • 🎯 • 🍅	<i></i>
EV ■ ¶ E V → V → V ↔	- ⇔ + ⊡	Q 🗄 🔛 🖬 C/C++ 🔅	Debug
🎦 Project Explorer 🔀 🗖	-	🗖 🗖 📴 Outline 🗙	- 0
□\$7 8			
> 🕞 RZN2L_OPC_BGW_V1.0.0 [Debug]		There is no active ed that provides an out	ditor tline.
	😰 Problems 📃 Console 🗙 🔲 Properties 🦓 スマート・ブラウザー 🔑 スマート・マ	ニュアル 🎋 Debug	
		r .	• 🖻 •
		ialaa	
KZINZL_OPC_BGW_V1.0.0		: 🐴 🛄 🎓	/ 🕲

Fig.3-22 Launch project (8)



3.5.2 UaExpert

UaExpert is an OPC UA client tool. In this document, it is used to connect to the OPC UA server (B-GW) to access the object nodes of B-SS in the BACnet /IP network.

Download the version listed in Table 1-1 from the website and install it on your PC. Before downloading, you must register on the Unified Automation website and activate your account. All content is provided free of charge, but by downloading or installing the software from this web page, you automatically accept the Unified Automation Software License Agreement (SLA). For license terms for software and information, please refer to the following link.

https://www.unified-automation.com/products/sdk-overview/licenses.html#c341

Please check the above conditions of use before usage.

G https://www.unified-automa	ation.com/downloads/opc-ua-clients.html
Auton	Jnified
Home Solutions Products S	ervices Downloads Support Partners
O Downloads	OPC UA Clients - Downloads
• Documentation	
 Online Documentation SDKs 	UaExpert
	UaExpert is a full-featured OPC UA Client which is capable of several OPC UA Profiles and
 Online Manual for Tools 	
 Online Manual for Tools CMake Troubleshooting 	features.
 Online Manual for Tools CMake Troubleshooting Build Instructions OpenSSL 	features.
 Online Manual for Tools CMake Troubleshooting Build Instructions OpenSSL OPC UA Quickstart Guide 	features.

Fig.3-23 UaExpert

3.5.3 Wireshark

Wireshark is a free network protocol analyzer. Download and install Wireshark from the link in Table 1-1.

	We're now a non-profit! Support open source packet analysis
WIRESHARK	News SharkFest Get Acquainted - Get Help - De
	Download Wireshark
	The current stable release of Wireshark is 4.0.4. It supersedes all previous releases.
	▼ Stable Release: 4.0.4
	Windows Installer (64-bit)
	 windows PortableApps® (64-bit) macOS Arm 64-bit.dmg
	macOS Intel 64-bit.dmg
	Source Code
	Old Stable Release: 3.6.12
	Documentation

Fig.3-24 download Wireshark



4. Operation check

4.1 Connection

Fig.4-1 shows a connection diagram when running the sample software. Connect the Ethernet cable, J-Link OB debugger, and 5V DC cables to the RZ/N2L RSK board. As shown in the figure, when connecting board for B-SS, connect the air velocity sensor to the J26 connector on the board.

Note that the hardware settings (jumpers and DIP SW) for the B-GW board and the B-SS board are different. Please refer to chapter 2.1 for details. ETH2 (Ethernet2) connector on board for B-GW cannot be used. When using the debugger J-Link OB on the RSK board, open J9 and connect the USB Micro cable.



Fig.4-1 OPC UA - BACnet /IP Hardware Diagram

4.2 IP Address Settings

Set the address of the Ethernet on the PC that serves as the OPC UA Client.

Click on settings¹⁰ in Windows Start¹¹. Configure the IP address as follows.

Settings > Network and Internet > Change adapter options > Ethernet

>Properties > Internet Protocol Version 4 (TCP/IPv4) > Properties



Fig.4-2 network connection



Internet Protocol Version 4 (TCP/IPv4) Properties X
General
You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.
O <u>O</u> btain an IP address automatically
Use the following IP address:
IP address: 192 . 168 . 10 . 20
Subnet mask: 255 . 255 . 0
Default gateway:
Obtain DNS server address automatically
Use the following DNS server addresses:
Preferred DNS server:
Alternate DNS server:
Validate settings upon exit Advanced
OK Cancel

Fig.4-3 TCP/IPv4 properties

The IP address of the RSK board set in the B-GW sample software is 192.168.10.100. The IP address of the PC needs to be set to 192.168.10.XXX. In this document, 192.168.10.20 is used.



4.3 Start Project

First, import the project as described in section 3.5.1.2.

4.3.1 Build Configuration

Select the project name in the Project Explorer window, then open Properties in the Project menu.

File Edit Source Refactor Navigate S	earch	Project	Renesas Views Run	Window	Help							
Image: Second state of the second		C C C B B B C B B B B B B B B B B B B B	Ipen Project Iose Project Ipen FSP Configuration uild All uild Configurations uild Project uild Working Set Iean uild Automatically uild Targets	Ctrl+A Ct	lt+B irl+B >]} → (11) (¹ / ₁₀) (, * * • • <u>1</u> : ⊗ : 2 •	□ • - - - - - - - - - -	C C C C C C C C C C C C C C C C C C C		ditor th	Ø C/C++ nat
	0 iten Desc		/C++ Index · べての依存関係を更新 hange Device hange Toolchain Version /C++ Project Settings roperties	A Ctrl+A	> It+D It+P	・ブラウザー 🔑 /	スマート・マニュアル Path	Location		ਹ Type	2 00	- 6
SRZN2L_OPC_BGW_V1.0.0										- - (1	1 🖻	% 6

Fig.4-4 Open project properties

Select GNU C in Languages from the #Symbols tag in C/C++General > Paths and Symbols.

(1) Evaluation with a single RSK board

To evaluate the B-GW RSK board alone without connecting the B-SS RSK board, change #WITHOUT_B_SS_BOARD in Symbol to 1. Click "Edit..." to make changes

This allows to generate pseudo sensor input values inside the B-GW which are originally read from the B-SS, and read them from the PresentValue node of the AnalogInput,0 object of the B-GW, which is explained in Chapter 4.5.

(2) Evaluation with two RSK boards

To connect another RSK board for B-SS, change #WITHOUT_B_SS_BOARD in Symbol to 0 as shown in Fig. 4 5.

Click "Apply and Close" to apply the settings. Click "Yes" on the pop-up dialog.



21	Paths and Symbols		< → ⇒ × §
 > Resource Builders > C/C++ Build ✓ C/C++ General > Code Analysis Documentation 	Configuration: Debug [Active]	V Manag	e Configurations
File lypes Formatter Indexer Language Mappings MISRA-CIディタ・チェッカ Paths and Symbols Preprocessor Include Pat MCU Project Natures Project References Reneas QE Run/Debug Settings Task Tags > Validation	Languages Symbol Assembly # UA_ARCHITECTURE_FR # BACAPP_PRINT_ENABLI # BACADL_BIP # IPADR1 # IPADR2 # IPADR3 # IPADR3 # IPADR4 MAX_TSM_TRANSACTIL # OPEN62541_FEERTOS_L # WITHOUT_B_SS_BOARI # USR_DEBUG_PRINT # WITHOUT_B_SS_BOARI ① "Preprocessor Include Paths, Macros etc." property ☑ Show built-in values Import Settings	EERTOSLWIP	Add Edit Delete Export
		Restore Defaul	ts Apply

Fig.4-5 Change #WITHOUT_B_SS_BOARD

Changes made will not be reflected in the index until it is rebuilt. Do you wish to rebuild it now?	×
Remember my decision	
Yes No	

Fig.4-6 Click YES

4.3.2 Build

Select the project name in the Project Explorer window and click "Clean..." in the Project menu.


File Edit Source Refactor Navigate S	- e ² stu	udio Proi	ect Benesas Views Run V	Window Help				_)
 () <lp>() </lp> <lp>() </lp> <li< th=""><th></th><th></th><th>Open Project Close Project Open FSP Configuration</th><th></th><th> De = 000 ;</th><th>** • ⊵:%:5</th><th> <mark> →</mark> + - → ></th><th></th><th>▼ 🗟</th><th>: Ø</th></li<>			Open Project Close Project Open FSP Configuration		 De = 000 ;	** • ⊵:%:5	<mark> →</mark> + - → >		▼ 🗟	: Ø
Project Explorer X		010	Build All Build Configurations Build Project Build Working Set	Ctrl+Alt+B > Ctrl+B >	-			Outline X There is no active provides an outli	e edito ne.	r that
		<	Clean Build Automatically Build Targets	>						
	O iten	e²	C/C++ Index すべての依存関係を更新 Change Device	> Alt+D	・・ブラウザー [₽ スマート・マニュアル			78	-
	onen		Change Toolchain Version		Resource	Path	Location	Туре		
	Des		C/C++ Project Settings Properties	Ctrl+Alt+P	-					
	Des	1	C/C++ Project Settings Properties	Ctrl+Alt+P			Updates	Available		x

Fig.4-7 Open project Clean...

Enable the followings in the pop-up dialog and click "Clean" to start all builds.

📵 Clean		- [×	
Clean discards all build results and state projects will be rebuilt from scratch.	es. The next time a build occ	urs the se	lected		
Clean all projects					
RZN2L_BACnet_BSS_V1.0.0					
Start a build immediately Build the entire workspace					
 Build only the selected projects 	Clean		Cancel		
	Clean		concer		

Fig.4-8 clean and rebuild

4.3.3 Debug Configurations

After confirming that the build result is 0 errors, select the project name in the Project Explorer window and click Debug Configurations... in the Run menu. Ignore the warning message that appears.



workspace_FSP110_NORboot_sample_GW	- e² studio					-		<
File Edit Source Refactor Navigate Se	earch Project Renesas Views	Run	Wndow Help					
	✓ No Launch Configurations		Renesas Debug Tools	>	- 🔅 : 🔁 🕶 🖫	🕞 📎 - 🔨 -	- 🗟 💋	
📸 - 🚳 - 🖸 - 🎯 - 🍅 🛷 - 🔛	Π 🐂 🔍 🔅 😵	Q,	Run	Ctrl+F11	盘▼祠▼や	-* ↔ • -> •		
		椮	Debug	F11		Q : 🖻	Ec/C+	++
Project Explorer × □			Run History	>		Be Outline ×		
		0	Run As	>		There is no active	editor that	
RZN2L_OPC_BGW_V1.0.0 [Debug]			Run Configurations			provides an outlin	e.	
			Debug History	>				
		*	Debug As	>				
		<	Debug Configurations					
			Breakpoint Types	>				
		0	Toggle Breakpoint	Ctrl+Shift+B				
	શ Problems 📮 Console 🗙	0	Toggle Line Breakpoint		บเ			
		65	Toggle Watchpoint) 🗘 🔁 🗔 🖥] = 🔒 🛃 🗖	1 💷 👻 📑	} -
	CDT Build Console [RZN2L_OPC	Θ	Toggle Method Breakpoint					
	text data bss 1723158 14234714 2969)Ø	Skip All Breakpoints		.0.elf			^
		×	Remove All Breakpoints					
	10:56:47 Build Finished.	Q	External Tools	>	ms)			
		_		_	3			~
			& _				0 🞓 🎾	0
la ner marte i		-				-		

Fig.4-9 Open Debug Configurations...

Operations when starting the debugger for the first time after importing a project

Only when importing a project and launching the debugger for the first time, the following operations should be performed.

- Create RZN2L_OPC_BGW_V*** Debug[local]
- Select Target Device
- Debut Tool Settings

See the following explanation of the above.



a. Create RZN2L_OPC_BGW_V*** Debug[local]

Double click on Renesas GDB Hardware Debugging to generate RZN2L_OPC_BGW_V*** Debug[local]



Fig.4-10 Debug Configurations(1)

b. Select Target Device

Click on the Debugger tag in the displayed dialog and select Target Device.

Debug Configurations	— 🗆 X
Create, manage, and run configurations	
Image: Second	Name: RZN2J_OPC BGW_V1.0.0 Debug Mail Debugger Startup Debug hardware: I-Link ARM Target Device GDB Settings Connection Settings Debug Tool Settings GDB Connection Settings Host name or IP address: Iocalhost O Connect to remote GDB server GDB port number: 61234 Connection timeout (s): 30 GDB GDB Step Mode
Filter matched 13 of 16 items	Reyert Apply
0	Debug Close

Fig.4-11 Debug Configurations(2)



Select R9A07G084M04 and click OK.

Device Selection You can filter devices by regular expression Search Device Device > RZ/A1 > RZ/A1 > RZ/T1 > RZ/GIM > RZ/GIM > RZ/GIE > RZ/GIE > RZ/GIE > RZ/GIE > RZ/RJN2L R9A07G084M08 > EC-1	Device Selection You can filter devices by regular expression Search Device Device VRZ RZ/A1 RZ/T1 RZ/T1 RZ/GIE RZ/GIE RZ/GIE RZ/G1E RZ/R2N2L R9A07G084M04 R9A07G084M08 > EC-1
You can filter devices by regular expression Search Device Device V RZ > RZ/A1 > RZ/A1 > RZ/T1-M > RZ/T1-M > RZ/G1M > RZ/G1E V RZ/G1E V RZ/RZN2L R9A07G084M04 R9A07G084M08 > EC-1	You can filter devices by regular expression Search Device Device V RZ RZ/A1 RZ/T1 RZ/A2 RZ/G1M RZ/G1M RZ/G1E RZ/RZN2L R9A07G084M04 R9A07G084M08 > EC-1
Search Device Device ∨ RZ > RZ/A1 > RZ/T1 > RZ/T1 > RZ/G1E > RZ/G1E ∨ RZ/R2N2L R9A07G084M04 > EC-1	Search Device Device V RZ > RZ/A1 > RZ/T1 > RZ/T1 > RZ/GIE > RZ/G1E V RZ/RZN2L R9A07G084M04 R9A07G084M08 > EC-1
Device	Device
> RZ/A1 > RZ/T1 > RZ/T1-M > RZ/A2 > RZ/G1M > RZ/G1E V RZ/RZN2L R9A07G084M04 R9A07G084M08 > EC-1	> RZ/A1 > RZ/T1 > RZ/T1-M > RZ/A2 > RZ/G1M > RZ/G1E V RZ/RZN2L R9A07G084M04 R9A07G084M08 > EC-1
> RZ/T1 > RZ/T1-M > RZ/A2 > RZ/G1M > RZ/G1E * RZ/RZN2L R9A07G084M04 R9A07G084M08 > EC-1	> RZ/T1 > RZ/T1-M > RZ/A2 > RZ/G1M > RZ/G1E * RZ/RZN2L R9A07G084M04 R9A07G084M08 > EC-1
> RZ/T1-M > RZ/A2 > RZ/G1M > RZ/G1E V RZ/RZN2L R9A07G084M04 R9A07G084M08 > EC-1	> RZ/T1-M > RZ/A2 > RZ/G1M > RZ/G1E V RZ/RZN2L R9A07G084M04 R9A07G084M08 > EC-1
> RZ/A2 > RZ/G1M > RZ/G1E	> RZ/A2 > RZ/G1M > RZ/G1E V RZ/RZN2L R9A07G084M04 R9A07G084M08 > EC-1
> RZ/G1M > RZ/G1E V RZ/RZN2L R9A07G084M04 R9A07G084M08 > EC-1	> RZ/G1M > RZ/G1E V RZ/RZN2L R9A07G084M04 R9A07G084M08 > EC-1
> RZ/G1E	> RZ/G1E
	 ✓ RZ/RZN2L R9A07G084M04 R9A07G084M08 > EC-1
R9A07G084M04 R9A07G084M08 > EC-1	R9A07G084M04 R9A07G084M08 > EC-1
R9A07G084M08	R9A07G084M08
> EC-1	> EC-1

Fig.4-12 Debug Configurations(3)

c. Debug Tool Settings

Click the Debut Tool Settings tag and write 400 at Operating Frequency [MHz].

Click on "Debug" to start the download. Continue to Fig.4-16 for instructions.

Debug Configurations			- L X
Create, manage, and run configurations			Ś
1 • • • • × • • 7 •	Name: RZN2L_OPC_BGW_V1.0.0 Debug		
type filter text	Agin Debugger 🕨 Startup 🔲 Common 🦉 So	urce	
C/C++ Application C/C++ Remote Application EASE Script COMPAREMENT	Debug hardware: J-Link ARM V Target Device:	9A07G084M04	
GDB Hardware Debugging	Semihosting	angs	A
GDB Simulator Debugging (BH850)	Semihosting breakpoint address		
Java Applet	✓ RTOS		
Java Application	RTOS Integration in Debug View	Yes	~
Launch Group	RTOS Debugging - Large Number of Threads.	No	~
Remote Java Application	✓ System		
🗸 📧 Renesas GDB Hardware Debugging	Allow caching of flash contents	Yes	~
* RZN2L_OPC_BGW_V1.0.0 Debug [local]	✓ Time Measurement		
Renesas Simulator Debugging (RX, RL78)	Run Break Time Measurement	Yes	~
	Count Every Core Cycle	Vec	~
	Operating Frequency [MHz]	400.000	~
		David	art Applu
Filter matched 13 of 16 items		Re <u>v</u> i	ert Appi <u>y</u>
(2)		Det	Close

Fig.4-13 Debug Configurations(4)

4.3.4 Debug

The download procedure after completing the build is shown below.

At the second and subsequent debugger launches, click the Run menu with the project name selected in the C/C++ view. Place the cursor on "Debug As" and click on "Renesas GDB Hardware Debugging".





Fig.4-14 Run menu Debug As

Download the program to NOR flash memory. (It will take a few minutes.)



Fig.4-15 Download

Click Switch to change to debug view.



Confirm Perspective Switch	×
This kind of launch is configured to open the Debug perspective when it suspend This Debug perspective supports application debugging by providing views for displaying the debug stack, variables and breakpoints. Switch to this perspective?	ls.
Remember my decision	

Fig.4-16 Perspective Switch

The CPU automatically extracts the loader program included in the download data to the BTCM. After extraction, it breaks in system_init() at the beginning of the initialization on the loader program.

• In case of operating the RSK board alone without using the debugger, turn off the board power supply, disconnect the debugger cable, and then turn on the board power supply again.

When using the debugger, click the "reset"[™] icon and then "resume"[™] after switching to the Debug screen.



Fig.4-17 Break at system_init()



RZ/N2L Group

After completing initialization, the loader program stops at the beginning of main(), Then, click "resume" ^{IP} to return to the running state.



Fig.4-18 Break at main()



4.4 BACnet to OPC UA Gateway Communication

Launch UaExpert

```
Open Windows Start menu and 🔳 click UaExpert
```

UaExpert ^	
Libxml2_License	
OpenSSL_License	
Qt_License	
QWT_License	
README	
UaExpert	
UnifiedAutomation_Software_Licens	
U Website	

Fig.4-19 Launch UaExpert

Add OPC UA server

Click 🗣 on the tool bar in UaExpert.

Open the Advanced tab, set the Endpoint Url to "opc.tcp://192.168.10.100:4840", select Anonymous. Check "Connect Automatically" and then click OK at the end.

											Address		~	~ 🎵	Project	File	- Un	
											Space	📁 Data Access	Servers Documents	Project	6 8 6	View Server Doo	iified Automation Ua	
Connect Automatically	Private Key Session Settings Session Name	Certificate	Username Password	Authentication Setti	Message Security Mode	Security Policy	Reverse Connect	Endpoint Url 🔇	Server Information	Discovery Advanced	Configuration Name B-G RKI Store	Add Server	[cument Settings Help	Expert - The OPC Unified Arc	
>				ngs	None	None		opc.tcp://192.168.10.100	/		w			# Serve		0.0000	hitecture Client - NewProjec	
			Store		•	•		4840		-		? ×		er Node Id		-	ŧ	

Fig.4-20 UaExpert Add server



When the OPC UA server, namely the B-GW, is connected, an indicator icon is displayed in the Project window to show that the B-GW is connected. BACnet-Client-Mapping displayed under the Object tree in the Address Space window is an object of B-GW.

An object called BACnet-Server-Mapping also appears below it, accessing the object node of the BACnet device connected to the B-GW.



Fig.4-21 UaExpert OPC UA server connection

4.4.1 TimeSynchronization Method

The TimeSynchronization method sets the UTC time to the B-GW. The setting time is applied to the timestamp internally in the B-GW. After correcting the received UTC time to the local time, it is forwarded to the BACnet server device with local broadcast.

Select *Root>Objects>BACnet-Client-Mapping>OBJECT_INTERNETWORKTYPE>TimeSynchronization* in the Address Space window, right-click and select "Call...".



Fig.4-22 UaExpert OPC UA TimeSynchronization Method call(1)



Set the UTC time in the dialog displayed and click "Call".

Correct the UTC time to the local time of your time zone. For example, in the case of TOKYO JAPAN, UTC time is the result of subtracting 9 hours from the local time.

Call time.	synchronization on Object		1	^
Input Argu	ments			
Name Time Result	Value 2023-07-24T08:28:	DataType	Description	n
nesun				
			all Clo	se

Fig.4-23 UaExpert OPC UA TimeSynchronization Method call(2)

Confirm that the method ends successfully and click "Close".

Call Times	synchronization on OBJECT_INTER	NETWORKTIPE	I	^
Input Argu	ments			
Name Time	Value 2023-07-24T08:28:15.000Z	DataType	Description	
Result				
Succeeded				
			Call 🚺 Clos	е

Fig.4-24 UaExpert OPC UA TimeSynchronization Method call(3)

The following wireshark log shows the above methods CallRequest and CallResResponse. Edit View Sco Capture Analyze Statistics Telephony Wireless Icols Help 🔏 🐵 📄 🖾 🕅 🗣 🗢 🗢 🖼 🐺 🚊 🧮 🗣 🔍 🚭 🖽 ×+
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 bytes on wire (1248 bits), 156 bytes captured (1248 bits) on inter TP-Link_1c:9a:fe (7c:c2:c6:ic:9a:fe), Dst: RenesasE_10:f9:ed (74: Version 4, Src: 192.168.10.20, Dst: 192.168.10.100 rol Protocol, Src Port: 40931, Dst Port: 4840, Seq: 22075, Ack: 11 98 odeable Object Modeld er: RequestHeader 11: Array of CallMeth n is yo i calificationopart i Nooldenuest i Noold 0080 = IncodingNask: Numeric of an pare Index: 2 Fider Numeric: 102001 i Noold 1 Noold 00801 = fincodingNask: Four byte enc pare Index: 2 Tiefer Numeric: 7021 uments: Array of Variant Size: 1 (後): Variant Variant Type: DateTime (0x0d) DateTime: Jul 24, 2023 17:28:15.000000000 夏京 (後知時) wiresback (-###ob-11VU581pcappe Packets: 31231 - Displayed: 11808 (37.790 Profile: Default

Fig.4-25 UaExpert OPC UA TimeSynchronization Method call(4)



4.4.2 NetworkScan Method

The NetworkScan method obtains IP addresses and device instance numbers for other devices connected to the network to which the B-GW is connected.

Select *Root>Objects>BACnet-Client-Mapping>OBJECT_INTERNETWORKTYPE> NetworkScan* in the Address Space window, right-click and select "Call...".



Fig.4-26 UaExpert OPC UA NetworkScan Method call(1)

Set the followings in the dialog that appears

• Wait TimeInSeconds : Set the I-Am response wait time from other devices in seconds.

• *ApplyRange* : Check to enable search range setting for connected devices. If disabled (unchecked), all device instances range 0~ 4194303 are searched.

• DeviceRangeLow : If search range is enabled, set the minimum instance number of the connected device.

• *DeviceRangeHigh* : If search range is enabled, set the maximum instance number of the connected device.

After setting the above, click "Call".

Call NetworkScan on C	DBJECT_INTERNETWORKTY	PE	? ×
Input Arguments			
Name	Value	DataType	Description
WaitTimeInSeconds		Ulint32	
ApplyRange (Boolean	
DeviceRangeLow		UInt32	
DeviceRangeHigh	200	UInt32	
Output Arguments	·		
Name	Value	DataType	Description
Device Address Bindings	lick '' to display value	BaseDataType	
MaxAPDULengthAccepted	Ð	Ulint32	
SegmentationSupported	Ð	BACnetSegmentation	
VendorIdentifier	Ð	UInt16	
Result			
		Call	Close

Fig.4-27 UaExpert OPC UA NetworkScan Method call(2)



Confirm the method completes successfully and click on _____ of DeviceAddressBindings in Output Arguments. This example shows B-SS detected, connected device IP: 192.168.10.101, device instance number: 100.

Call NetworkScan on	OBJECT_INTERNETWORKTYP	E	? ×					
Input Arguments								
Name	Value	DataType	Description		/alue			×
WaitTimeInSeconds	1	Ulint32						
ApplyRange		Boolean		Name	2	Value		^
DeviceRangeLow	0	Ulint32		~		UInt32 Arra	y[5100]	
DeviceRangeHigh	200	Ulint32			[0]	192		
Output Arguments					[1]	168		
Name	Value	DataType	Description		[2]	10		
DeviceAddressBindings	0,	BaseDataType			[3]	101		
MaxAPDULengthAccepter	lick '' to display value	Ulint32			[4]	100		
SegmentationSupported	lick '' to display value	BACnetSegmentatio	n		[5]	0		
VendorIdentifier	lick '' to display value	Ulint 16			[6]	0		
Result					[7]	0		
Succeeded					[8]	0		
						-		

Fig.4-28 UaExpert OPC UA NetworkScan Method call(3)

The following wireshark log shows the above methods CallRequest and CallResResponse.



Fig.4-29 UaExpert OPC UA TimeSynchronization Method call(4)



4.4.3 Write property Method

Write property method changes the property values of the B-SS device object connected over BACnet.

Select *Root>Objects>BACnet-Client-Mapping> Write property* in the Address Space window, right-click and select "Call...".



Fig.4-30 UaExpert OPC UA Write property Method call(1)

Set the followings in the dialog displayed.

Table 4-1 Write	e property	Method	Input	Arguments	s(1)
-----------------	------------	--------	-------	-----------	------

Input Arguments	Property	Object_Type									
		AnalogInput	AnalogValue	BinaryOutput	BinaryValue	MultiStateValue	PositiveIntegerValue				
DEVICE_ID			100								
OBJECT_TYPE		0	2	4	5	19	48				
OBJECT_INSTANCE		0 or 1	0 or 1	0 or 1 or 2 or 3	0 or 1	0 or 1	0 or 1				
PROPERTY_ID	Present_Value	85	85	85	85	85	85				
PRIORITY			1~16								
TAG		4	4	9	9	2	2				
OBJECT_VALUE		0.0~	0.0~	0 or 1	0 or 1	1 or 2 or 3	0~4294967295				

Table 4-2 Write property Method Input Arguments(2)

Input Arguments	Property	Objec	t_Type			
		Device				
DEVICE_ID		1	00			
OBJECT_TYPE		1	8			
OBJECT_INSTANCE		1	00			
	Apdu_Timeout	11				
PROPERTI_ID	Number_Of_Apdu_Retries	73				
PRIORITY		1~	·16			
TAG		:	2			
OBJECT_VALUE (Recommended value)		1~ (6000)	0~ (3)			



DEVICE_ID : Device instance number of the B-SS.

OBJECT_TYPE : The input is the value defined in BACNETOSS\bacnet\bacenum.h

OBJECT_INSTANCE : Instance number of each object.

PROPERTY_ID : The input is a value defined in *BACNETOSS\bacnet\bacenum.h*

PRIORITY : The priority for writing the same property across multiple clients, where 16 is the lowest priority and 1 is the highest priority.

TAG : Data type of the property value defined in BACNETOSS\bacnet\bacenum.h

OBJECT_VALUE : The set value for the property.

The following example writes B-SS device 100, AnalogOutput,0 object, Present_Value property, priority 16, data type Enumerated, and set value Active(1).

Write property					
Input Arguments					
Name	Value			DataType	Description
device_id	100			UInt32	device_id
OBJECT_TYPE				Int32	OBJECT_TYPE
OBJECT_INSTANCE				UInt32	OBJECT_INSTANC
PROPERTY_ID	85			Int32	PROPERTY_ID
PRiority	(16)			UIInt32	priority
TAG	ň		Load file	String	TAG
OBJECT_VALUE] 📖 🖬	Load file	String	OBJECT_VALUE
Output Arguments	-				
Name	Value			DataType	Description
BOOLEAN VALUE				Boolean	BOOLEAN VALUE
UNSIG INT VALUE				UInt32	UNSIG INT VALUE
INTEGER VALUE				Int32	INTEGER VALUE
REAL VALUE				Float	REAL VALUE
DOUBLE VALUE				Double	DOUBLE VALUE
OCTANT STRING VALUE			Save as	ByteString	OCTANT STRING VALUE
CHAR STRING VALUE				SByte	CHAR STRING VALUE
STRING VALUE			Save as	String	STRING VALUE
ENUM VALUE				Int32	ENUM VALUE
Result					

Fig.4-31 UaExpert OPC UA Write property Method call(2)



Check for successful completion and Output Arguments as follows

The readback value represents Active(1), which has the same data type Enumerated as the set value.

Write property					
Input Arguments					
Name	Value		DataType	Description	
device_id	100	 	UInt32	device_id	
OBJECT_TYPE	4	 	Int32	OBJECT_TYPE	
OBJECT_INSTANCE	0	 	UInt32	OBJECT_INST	ANCE
PROPERTY_ID	85	 	Int32	PROPERTY_ID	
PRiority	16	 	UInt32	priority	
TAG	9	 Load file	String	TAG	
OBJECT_VALUE	1	 Load file	String	OBJECT_VALU	E
Output Arguments					
Name	Value		DataType	Description	
BOOLEAN VALUE	L		Boolean	BOOLEAN VAL	UE
UNSIG INT VALUE		 	UInt32	UNSIG INT VA	LUE
INTEGER VALUE		 	Int32	INTEGER VAL	JE
REAL VALUE		 	Float	REAL VALUE	
DOUBLE VALUE		 	Double	DOUBLE VALU	Æ
OCTANT STRING VALUE		 Save as	ByteString	OCTANT STRI VALUE	NG
CHAR STRING VALUE			SByte	CHAR STRING	
STRING VALUE		 Save as	String	STRING VALU	E
ENUM VALUE			Int32	ENUM VALUE	
Result	-				
Succeeded					

Fig.4-32 UaExpert OPC UA Write property Method call(3)



The following wireshark log shows the above methods CallRequest and CallResResponse.

┫ *イーサネ	ላማት 11					- 🗆 ×
le <u>E</u> dit	View Go Capture	Analyze Statistics T	elephony <u>W</u> ireless <u>T</u> o	ools <u>H</u> elp		
opcua or	bacnet	100212	3 = 444			+ ~ 🛛
),	Time	Source	Destination	Protocol	Length Info	
45413	3 20:44:44.326707	192.168.10.20	192.168.10.100	OpcUa	162 UA Secure Conversation Message: ReadRequest	
45414	4 20:44:44.328663	192.168.10.100	192.168.10.20	OpcUa	128 UA Secure Conversation Message: ReadResponse	
45418	8 20:44:48.652223	192.168.10.20	192.168.10.100	OpcUa	198 UA Secure Conversation Message: CallRequest	
45419	9 20:44:48.712625	192.168.10.100	192.168.10.255	BACnet-APDU	60 Unconfirmed-REQ who-Is	
45420	0 20:44:48.712977	192.168.10.101	192.168.10.255	BACnet-APDU	67 Unconfirmed-REQ i-Am device,100	
45421	1 20:44:48.713358	192.168.10.100	192.168.10.255	BACnet-APDU	60 Unconfirmed-REQ who-Has binary-output,0	
45423	3 20:44:48.723146	192.168.10.101	192.168.10.255	BACnet-APDU	71 Unconfirmed-REQ i-Have device,100 binary-output,0	
45424	4 20:44:48.745094	192.168.10.100	192.168.10.20	OpcUa	143 UA Secure Conversation Message: CallResponse	
6		50				P 5
Sect	Jrity Requestid: 14	object			0010 00 b8 85 03 40 00 80 06 00 00 c0 a8 0a 14 c0 a8	@
+ oper	Sa Service : chcode	deId			0020 0a 64 fd c1 12 e8 98 e1 0e 1b 00 04 17 6a 50 18	gjF
- ú	allRequest	ueru			0030 04 00 96 73 00 00 4d 53 47 46 90 00 00 00 01 00	···s··MS GF·····
	> RequestHeader: R	equestHeader			0040 00 00 0f 00 00 00 aa 05 00 00 aa 05 00 00 01 00	
	✓ MethodsToCall: A	rrav of CallMethodRe	equest		0050 C8 02 04 01 00 ae 43 fb C/ C0 04 ab /9 0C 00 30	05uN @\$1
	ArraySize: 1				0070 00 e7 00 00 00 ff ff ff 10 27 00 00 00 00 0	20un. ea.
	✓ [0]: CallMeth	odRequest			0080 01 00 00 00 01 02 d9 27 03 01 00 0e 00 00 00 57	
	✓ ObjectId: I	VodeId			0090 72 69 74 65 20 70 72 6f 70 65 72 74 79 07 00 00 r	ite pro perty.
	000	01 = EncodingMask: F	our byte encoded Nu	meric (0x1)	00a0 00 07 64 00 00 06 04 00 00 07 00 00 00 0	d
	Namespac	e Index: 2				J1
	Identifi	ler Numeric: 10201				
	✓ MethodId: N	NodeId				
	001	l1 = EncodingMask: S	itring (0x3)			
	Namespac	e Index: 1				
	Identifi	ler String: Write pr	operty			
	✓ InputArgume	ents: Array of Varia	int			
	Arraysia V [0]: Var	ier /				
	v [0]. Varia	nt Type: UInt32 (0v	97)			
	UInt3	12: 100	,			
	✓ [1]: Var	iant				
	Varia	nt Type: Int32 (0x0	6)			
	Int32	2:4				
	✓ [2]: Var	iant				
	Varia	nt Type: UInt32 (0x	07)			
	UInt3	2: 0				
	✓ [3]: Var	riant				
	Varia	nt Type: Int32 (0x0	6)			
	Int32	: 85				
	✓ [4]: Var	nant 1ant Jupan UInt22 (0:	07)			
	Varia	nic Type: 01nt52 (0X				
	V [5] · Var	riant				
	- Loj: Varia	ant Type: String (Av	0c)			
	Strin	ig: 9				
	✓ [6]: Var	iant				
	Varia	ant Type: String (0x	0c)			
	Strin	ig: 1				

Fig.4-33 UaExpert OPC UA Write property Method call(4)



4.4.4 Read property Method

Read property method reads the property values of the B-SS device object connected over BACnet.

Select *Root>Objects>BACnet-Client-Mapping> Read property* in the Address Space window, right-click and select "Call...".



Fig.4-34 UaExpert OPC UA Read property Method call(1)

Set the followings in the dialog displayed.

Table 4-3 Reaed property Method Input Arguments(1)

Input Arguments	Property		Object_Type									
		AnalogInput	AnalogValue	BinaryOutput	BinaryValue	MultiStateValue	PositiveIntegerValue					
DEVICE_ID			100									
OBJECT_TYPE		0	2	4	5	19	48					
OBJECT_INSTANCE		0 or 1	0 or 1	0 or 1 or 2 or 3	0 or 1	0 or 1	0 or 1					
PROPERTY_ID	Present_Value	85	85	85	85	85	85					

Table 4-4 Reaed property Method Input Arguments(2)

Input Arguments	out Arguments Property		t_Type			
		Device				
DEVICE_ID		100				
OBJECT_TYPE		8				
OBJECT_INSTANCE		1(00			
	Apdu_Timeout	11				
PROPERTY_ID	Number_Of_Apdu_Retries		73			

DEVICE_ID : Device instance number of the B-SS.

OBJECT_TYPE : The input is the value defined in BACNETOSS\bacnet\bacenum.h

OBJECT_INSTANCE : Instance number of each object.

PROPERTY_ID : The input is a value defined in BACNETOSS\bacnet\bacenum.h

The following example reads B-SS device 100, AnalogInput,0 object, and Present_Value property.



Call read property on	BACnet-Sen	ver-Mapping		?	×
read_property					
Input Arguments					
Name	Value		DataType	Descriptio	n
DEVICE_ID			UInt82	DEVICE_ID	
OBJECT_TYPE			Int32	OBJECT_T	ΥPE
OBJECT_INSTANCE			UInt32	OBJECT_IN	STANCE
PROPERTY_ID	(85)		Int32	PROPERTY	ID
Output Arguments					
Name	Value		DataType	Descriptio	n
BOOLEAN VALUE			Boolean	BOOLEAN	VALUE
UNSIG INT VALUE			Ulint32	UNSIG INT	VALUE
INTEGER VALUE			Int32	INTEGER V	ALUE
REAL VALUE			Float	REAL VALU	JE
DOUBLE VALUE			Double	DOUBLE V	ALUE
OCTANT STRING VALUE		Save as	ByteString	OCTANT S' VALUE	TRING
CHAR STRING VALUE			SByte	CHAR STR VALUE	ING
STRING VALUE		Save as	String	STRING VA	LUE
ENUM VALUE			Int32	ENUM VAL	UE
obj VALUE	Ð		Int32	obj VALUE	
Result					
			Cal		lose
			Cal		lose

Fig.4-35 UaExpert OPC UA Read property Method call(2)

Check for successful completion and Output Arguments as follows.

The readback value represents a read value of the same data type REAL_VALUE (float) as the set value.

et-Server-Mapping			~
		f	~
e	DataType	Description	
	UInt32	DEVICE_ID	
	Int32	OBJECT_TYPE	
	UIInt32	OBJECT_INSTA	NCE
	Int32	PROPERTY_ID	
e	DataType	Description	
	Boolean	BOOLEAN VAL	UE
	UInt32	UNSIG INT VAI	.UE
	Int32	INTEGER VALU	JE
1917	Float	REAL VALUE	
	Double	DOUBLE VALU	E
Save as	ByteString	OCTANT STRIN VALUE	lG
	SByte	CHAR STRING VALUE	
Save as	String	STRING VALUE	
	Int32	ENUM VALUE	
	Int32	obj VALUE	
	Call	Close	,
e e	17	DataType UInt32 UInt32 UInt32 UInt32 DataType Boolean UInt32 Int32	DataType Description Uint32 DEVICE_JD Int32 0BJECT_INSTA Uint32 0BJECT_INSTA Int32 PROPERTY_JD DataType Description Boolean BOOLEAN VAL Uint32 UNSIG INT VAL Int32 INTEGER VALL Int32 INTEGER VALL Int32 Boolean Boolean BOOLEAN VAL Int32 INTEGER VALL Int32 Boolean Save as

Fig.4-36 UaExpert OPC UA Read property Method call(3)



The following wireshark log shows the above methods CallRequest and CallResResponse.

▲ *イーサネット 11				– 🗆 X
File Edit View Go Capture Ana	alvze Statistics Telephony Wireless To	ools Help		
		1005 <u>H</u> eip		
		200		
opcua or bacnet				
No. Time So	iource Destination	Protocol Lene	gth Info	^
14938 11:44:47.283842 19	92.168.10.20 192.168.10.100	BACnet-APDU	180 UA Secure Conversation Message: Calikequest	
14940 11:44:47.286168 19	92.168.10.101 192.168.10.255	BACnet-APDU	67 Unconfirmed-REO i-Am device.100	
14941 11:44:47.286188 19	92.168.10.100 192.168.10.255	BACnet-APDU	60 Unconfirmed-REQ who-Has analog-input,0	
14942 11:44:47.288090 19	92.168.10.100 192.168.10.20	OpcUa	144 UA Secure Conversation Message: CallResponse	
14943 11:44:47.296385 19	92.168.10.101 192.168.10.255	BACnet-APDU	98 Unconfirmed-REQ i-Have device,100 analog-input,0	
1494/ 11:44:50.868350 19	92.168.10.20 192.168.10.100	Opcua .	162 UA Secure Conversation Message: ReadRequest	
14954 11:44:55.881987 19	92.168.10.20 192.168.10.100	OpcUa	162 UA Secure Conversation Message: ReadRequest	
14955 11:44:55.883854 19	92.168.10.100 192.168.10.20	OpcUa	128 UA Secure Conversation Message: ReadResponse	
14060 11.45.00 004460 10	01 160 10 10 100 101 100	Opella	162 UA Secure Conversition Messager ReadPequest	>
-		(1150 bits) inter	0000 75 52 55 15 05 55 74 00 50 10 50 od 00 00 45 00	
Frame 14942: 144 bytes on Wire Ethernet II. Src: RenesasE 10	'e (1152 bits), 144 bytes captured):f9:ed (74:90:50:10:f9:ed). Dst: T	(1152 Dits) on inter	0010 00 82 04 c4 00 00 ff 06 20 e9 c0 a8 0a 64 c0 a8	1d.
> Internet Protocol Version 4,	Src: 192.168.10.100, Dst: 192.168.	10.20	0020 0a 14 12 e8 e6 d4 00 02 a0 ee c7 ac 27 40 50 18	·····'@P·
> Transmission Control Protocol	, Src Port: 4840, Dst Port: 59092,	Seq: 165584, Ack: 8	0030 2e d7 38 6a 00 00 4d 53 47 46 5a 00 00 00 02 00	8jMS GFZ
✓ OpcUa Binary Protocol			0050 cb 02 70 91 d5 fb a1 be d9 01 d8 4a 0f 00 00 00	pJ
Message Type: MSG			0060 00 00 0f ff ff ff 00 00 00 1 00 00 00 00 00 00 00 00 00 0	
Message Size: 90			0070 00 00 tt tt tt tt tt tt tt tt tt 0a 00 00 00 00 00 00 00 00 00 00 00 00	
SecureChannelId: 2				
Security Token Id: 7				
Security Sequence Number: 6	666			
Security RequestId: 666				
 Opcua Service : Encodeable TypeId : ExpandedNodeId 	Object			
 CallResponse 				
> ResponseHeader: Respo	onseHeader			
✓ Results: Array of Cal	11MethodResult			
ArraySize: 1				
v [0]: Calimethodkes StatusCode: 0x0	Sult 20000000 [Good]			
> InputArgumentRe	esults: Array of StatusCode			
> InputArgumentDi	iagnosticInfos: Array of Diagnostic	cInfo		
 OutputArguments 	s: Array of Variant			
ArraySize: 1	10			
> [1]: Variant				
> [2]: Variant				
✓ [3]: Variant	:			
Variant T	ype: Float (0x0a)			
Float: 0.	.551917			
> [5]; Variant				
> [6]: Variant	:			
> [7]: Variant	:			
> [8]: Variant				
> [9]: Variant > DiagnosticInfos: Appa	: av of DiagnosticInfo			
<	ay of bidghosticinto	>		
○ ② wiresbark イーサネット 11SMK-1810	DCappg		Packets: 15359 · Displayed: 4945 (92.9%)	Profile: Default
				Tromo bolduit

Fig.4-37 UaExpert OPC UA Read property Method call(4)



4.4.5 ADD/READ_OBJECT_TREE Method

The ADD_OBJECT_TREE method creates an object tree for the B-SS device.

Add target objects to the tree in order to read multiple objects at once (instead of reading them out one by one like the Read property method).

The object types to be read in batch in this version are as follows

AnalogInput, BinaryOutput, MultiStateValue AnalogValue, BinaryInput, PositiveIntegerValue

<Restrictions>

The following object types are not supported for batch read in this version

Device, AnalogOutput, BinaryValue

Select *Root>Objects>BACnet-Client-Mapping> ADD_OBJECT_TREE* in the Address Space window, rightclick and select "Call...".

 ✓ No Highlight ✓ Root ✓ Objects ✓ ADD_OBJECT_TREE > & OBJECT_DEVICE > & OBJECT_INTERNETWC 	Add	iress Space 🗗 🗙
	9	No Highlight 🔹
Cojects Control Contro Control Control Control Control Control Control Contro		Root
ADD_OBJECT_TREE Rebrowse ADD_OBJECT_DEVICE AOD_OBJECT_DEVICE AOD_OBJECT_INTERNETWC Call	ľ	✓ Objects ✓ ☐ BACnet-Client-Mapping
		ADD_OBJECT_TREE

Fig.4-38 UaExpert OPC UA ADD_OBJECT_TREE Method call(1)

Set the followings in the dialog displayed, then click "Call".

Call ADD_OBJECT_TREE on BACnet-Client-Mapping		?	х
ADD_OBJECT_TREE			
Input Arguments Name Value	DataType	Descript	tion
DEVICE_ID 100	Ulint32	DEVICE	D
OFFSET	Int82	OFFSET	
FOLDER NAME BS_DEVICE_100 Load file	String	FOLDER	NAME
Result			
	Call		e

Fig.4-39 UaExpert OPC UA ADD_OBJECT_TREE Method call(2)

DEVICE_ID : Device instance number of the B-SS targeted. In the example, 100 is set.

OFFSET : A value for internal use of B-GW. 1~255 to be selected. In the example, 1 is set.

FOLDER_NAME : Name of the B-SS object tree. In the example, it is set to B_SS_DEVICE_100.



Select *Root>Objects>BACnet-Server-Mapping* in the Address Space window, right-click and select "Rebrowse".



Fig.4-40 UaExpert OPC UA ADD_OBJECT_TREE Method call(3)

Expand *Root>Objects>BACnet-Server-Mapping* in the Address Space window to see the object tree that was added.



Fig.4-41 UaExpert OPC UA ADD_OBJECT_TREE Method call(4)

Expand the added object tree.



Fig.4-42 UaExpert OPC UA ADD_OBJECT_TREE Method call(5)



Expand each object in the object tree and drag and drop the Present_Value node into the Data Access View window. In the figure, only Object_Analog_Input_0 is expanded, but expand all objects and drag and drop each Present_Value. However, Device objects indicated as OBJECT_DEVICE are excluded.

The initial value of Present_Value for each object is displayed in the Value column of the Data Access View window.



Fig.4-43 UaExpert OPC UA ADD_OBJECT_TREE Method call(6)

Call READ_OBJECT_TREE method.



Fig.4-44 UaExpert OPC UA READ_OBJECT_TREE Method call(1)



Set 1 to the next dialog and click "Call". The B-GW internally makes a ReadProperty service request to the B-SS, and the result of the response from the B-SS is reflected in the value in the Value column. Thus, the value is updated each time the READ_OBJECT_TREE method is called with read_object_tree=1 set. Since it does not automatically read the data in succession, call the READ_OBJECT_TREE method before reading the data.

Call READ_OBJECT_TREE on BACnet-Server-Mapping		?	×
READ_OBJECT_TREE Input Arguments	_		
Name Value read_object_tree	DataType Int32	• Descrip read_obje	tion ct_tree
	Call	D Clo	se

Fig.4-45 UaExpert OPC UA READ_OBJECT_TREE Method call(2)

After the B-SS object has been successfully read, check the Value column in the Data Access View window.

			-				-		
			READ_OB	BJECT_TREE					
			Input A	rguments					
			Name	Value			DataType Descrip	otion	
			rood obio	ot trop 1			Int ² 1 rood obj	ant tran	
			reau_obje					ect_tree	
			Result						
			Succeede	ed					
							Call Ok	100	
D-+	. 0	- View							
Dat	a Acces: Server	s View	ld	Display Name	Value	Datatype	Source Timestamp	Server Timestamp	Statuscode
Dat # 1	a Acces Server B-GW	s View Node NS1INume	ld icl51759	Display Name Present Value	Value 0.543459	Datatype Float	Source Timestamp 13:10:10.641	Server Timestamp 13:10:10.641	Statuscode Good
Dat # 1 2	a Acces Server B-GW B-GW	s View Node NS1 Nume NS1 Nume	ld ric 51759 ric 51765	Display Name Present Value Present Value	Value 0.543459 0	Datatype Float Float	Source Timestamp 13:10:10.641 12:57:30.642	Server Timestamp 13:10:10.641 12:57:30.642	Statuscode Good Good
Dat # 1 2 3	a Acces Server B-GW B-GW B-GW	s View Node NS1 Nume NS1 Nume NS2 Nume	id ric 51759 ric 51765 ric 51771	Display Name Present Value Present Value Present Value	Value 0.543459 0 234.567	Datatype Float Float Float	Source Timestamp 13:10:10.641 12:57:30.642 12:58:50.643	Server Timestamp 13:10:10.641 12:57:30.642 12:58:50.643	Statuscode Good Good Good
Dat # 1 2 3 4	a Acces Server B-GW B-GW B-GW B-GW	s View Node NS1 Nume NS1 Nume NS2 Nume NS2 Nume	ld ric 51759 ric 51765 ric 51771 ric 51777	Display Name Present Value Present Value Present Value Present Value	Value 0.543459 0 234.567 765.432	Datatype Float Float Float Float	Source Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.645	Server Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.645	Statuscode Good Good Good Good
Dat # 1 2 3 4 5	a Acces Server B-GW B-GW B-GW B-GW B-GW	s View Node NS1 Nume NS1 Nume NS2 Nume NS2 Nume	e ld ric 51759 ric 51765 ric 51771 ric 51777 ric 51786	Display Name Present Value Present Value Present Value Present Value	Value 0.543459 0 234.567 765.432 true	Datatype Float Float Float Float Boolean	Source Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.645 12:58:50.645	Server Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.645 12:58:50.645 12:58:50.648	Statuscode Good Good Good Good Good
Dat. # 1 2 3 4 5 6	a Acces Server B-GW B-GW B-GW B-GW B-GW B-GW	s View Node NS1 Nume NS2 Nume NS2 Nume NS2 Nume NS2 Nume	e ld ric 51759 ric 51765 ric 51771 ric 51778 ric 51786 ric 51796	Display Name Present Value Present Value Present Value Present Value Present Value	Value 0.543459 0 234.567 765.432 true true	Datatype Float Float Float Float Boolean Boolean	Source Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.648 12:58:50.648 12:58:50.648	Server Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.645 12:58:50.648 12:58:50.648	Statuscode Good Good Good Good Good
Dat. # 1 2 3 4 5 6 7	B-GW B-GW B-GW B-GW B-GW B-GW B-GW B-GW	s View Node NS1 Nume NS2 Nume NS2 Nume NS2 Nume NS2 Nume NS2 Nume NS2 Nume	e ld ric 51759 ric 51775 ric 51771 ric 51776 ric 51786 ric 51806	Display Name Present Value Present Value Present Value Present Value Present Value Present Value Present Value	Value 0.543459 0 234.567 765.432 true true true	Datatype Float Float Float Boolean Boolean Boolean	Source Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.645 12:58:50.648 12:58:50.649 12:58:50.651	Server Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.645 12:58:50.649 12:58:50.649 12:58:50.649	Statuscode Good Good Good Good Good Good
Dat # 1 2 3 4 5 6 7 8	B-GW B-GW B-GW B-GW B-GW B-GW B-GW B-GW	s View Node NS1 Nume NS2 Nume NS2 Nume NS2 Nume NS2 Nume NS2 Nume NS2 Nume NS2 Nume	e ld ric 51759 ric 51765 ric 51776 ric 51776 ric 51776 ric 51786 ric 51806 ric 51816	Display Name Present Value Present Value Present Value Present Value Present Value Present Value Present Value Present Value	Value 0.543459 0 234.567 765.432 true true true true	Datatype Float Float Float Float Boolean Boolean Boolean Boolean	Source Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.645 12:58:50.648 12:58:50.659 12:58:50.651 12:58:50.653 12:58:50.653	Server Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.645 12:58:50.649 12:58:50.651 12:58:50.651 12:58:50.651 12:58:50.651	Statuscode Good Good Good Good Good Good Good G
Dat # 1 2 3 4 5 6 7 8 9 10	Acces Server B-GW B-GW B-GW B-GW B-GW B-GW B-GW B-GW	s View Node NS1 Nume NS2 Nume NS2 Nume NS2 Nume NS2 Nume NS2 Nume NS2 Nume NS2 Nume NS2 Nume NS2 Nume	ld ric 51759 ric 51765 ric 51776 ric 51777 ric 51786 ric 51786 ric 51816 ric 51823	Display Name Present Value Present Value Present Value Present Value Present Value Present Value Present Value Present Value Present Value	Value 0.543459 0 234.567 765.432 true true true true true true	Datatype Float Float Float Boolean Boolean Boolean Boolean Boolean	Source Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.645 12:58:50.649 12:58:50.651 12:58:50.653 13:07:40.655 13:07:40.655	Server Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.648 12:58:50.648 12:58:50.648 12:58:50.651 12:58:50.653 13:07:40.655	Statuscode Good Good Good Good Good Good Good G
Dat # 1 2 3 4 5 6 7 8 9 10 11	a Access Server B-GW B-GW B-GW B-GW B-GW B-GW B-GW B-GW	s View Node NS1INume NS1INume NS2INume NS2INume NS2INume NS2INume NS2INume NS2INume NS2INume NS2INume NS2INume	ld ric 51759 ric 51765 ric 51776 ric 51786 ric 51786 ric 51868 ric 51818 ric 51823 ric 51830 ric 51830	Display Name Present Value Present Value Present Value Present Value Present Value Present Value Present Value Present Value Present Value Present Value	Value 0.543459 0 234.567 765.432 true true true true true true true true	Datatype Float Float Float Boolean Boolean Boolean Boolean Boolean Boolean	Source Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.645 12:58:50.648 12:58:50.659 12:58:50.653 13:07:40.655 13:07:40.655 13:07:40.655	Server Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.645 12:58:50.649 12:58:50.659 12:58:50.659 13:07:40.655 13:07:40.655 13:07:40.655	Statuscode Good Good Good Good Good Good Good G
Dat # 1 2 3 4 5 6 7 8 9 10 11 12	a Access Server B-GW B-GW B-GW B-GW B-GW B-GW B-GW B-GW	s View Node NS1 Nume NS2 Nume	ld ric 51759 ric 51765 ric 51771 ric 51776 ric 51786 ric 51806 ric 51803 ric 51837 ric 51837 ric 51837	Display Name Present Value Present Value	Value 0.543459 0 234.567 765.432 true true true true true true true 2 3	Datatype Float Float Float Boolean Boolean Boolean Boolean UInt32	Source Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.645 12:58:50.649 12:58:50.651 12:58:50.651 12:58:50.653 13:07:40.655 13:07:40.657 12:58:50.661	Server Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.645 12:58:50.649 12:58:50.651 12:58:50.651 12:58:50.651 13:07:40.655 13:07:40.657 12:58:50.661	Statuscode Good Good Good Good Good Good Good G
Dat. # 1 2 3 4 5 6 7 8 9 10 11 12 13	a Acces Server B-GW B-GW B-GW B-GW B-GW B-GW B-GW B-GW	s View Node NS1INume NS2INume NS2INume NS2INume NS2INume NS2INume NS2INume NS2INume NS2INume NS2INume NS2INume NS2INume NS2INume	ld ric 51759 ric 5171765 ric 51717 ric 517176 ric 51706 ric 51806 ric 51823 ric 51823 ric 51823 ric 51837 ric 51843 ric 51843	Display Name Present Value Present Value	Value 0.543459 0 234.567 765.432 true true true true true true true 2 3 100	Datatype Float Float Float Boolean Boolean Boolean Boolean UInt32 UInt32	Source Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.648 12:58:50.649 12:58:50.651 12:58:50.653 13:07:40.655 13:07:40.655 13:07:40.657 12:58:50.659 12:58:50.651 13:07:40.763	Server Timestamp 13:10:10.641 12:57:30.642 12:58:50.643 12:58:50.643 12:58:50.649 12:58:50.649 12:58:50.653 13:07:40.655 13:07:40.655 13:07:40.657 12:58:50.659 12:58:50.659 12:58:50.659	Statuscode Good Good Good Good Good Good Good G

Fig.4-46 UaExpert OPC UA READ_OBJECT_TREE Method call(3)



4.5 Evaluation with a Single Board

This section describes the means to check OPC UA server operation with a single board without a B-SS board connected. See chapter 4.3.1(1) for the build procedure.

After building, execute the TimeSynchronization method described in section 4.4.1 at first.

Air velocity sensor input values that are originally read from the B-SS can be pseudo-generated inside the B-GW and read from the PresentValue node of the AnalogInput,0 object of the B-GW.

As shown in the following figure, drag and drop the *Root>Objects>BACnet-Client-*

Mapping>Object_Analog_Input_0>Present_Value node in the Address Space window to the Data Access View window to change the value in the Value column.

The value repeatedly changes in the range of 0.0[m/sec]~7.23[m/sec] according to the air velocity sensor specification.



Fig.4-47 B-SS pseudo input value reading



5. Appendix

5.1 File Generation of open62541

The OPC UA stack of this sample software uses the open source open62541. To run Open62541 in a freeRTOS + LwIP environment, the following link recommends an approach to generate open62541.c and open62541.h using CMake, which is also used in this sample software.

Building open62541 — open62541 1.3.0-dirty documentation

This chapter describes the procedure for generating open62541 and BACnet information models as files for e2studio execution in a Windows 10 environment. Here Window 10 version 1903 or later (OS Build 19044.2965) is used, in which WSL2 is executable.

5.1.1 Linux environment Setup

Set up a Linux environment to run CMake. In this document, we will run CMake on a Linux (Ubuntu 18.04) environment installed using WSL2 with reference to the following linked pages.

(Reference) Manual installation steps for older versions of WSL | Microsoft Learn

- 1) Launch PowerShell as Administrator. Search PowerShell > right-click > Run as Administrator
- Enter the following command to enable the Windows Subsystem for Linux. dism.exe /online /enable-feature /featurename:Microsoft-Windows-Subsystem-Linux /all /norestart



Fig.5-1 Microsoft-Windows-Subsystem-Linux

3) Enter the following command to enable the virtual machine platform feature: *dism.exe /online /enable-feature /featurename:VirtualMachinePlatform /all /norestart*



Fig.5-2 VirtualMachinePlatform

- 4) Restart your PC and complete the WSL installation.
- 5) Download and run the WSL2 Linux kernel update package for x64 machines below. WSL2 Linux kernel update package for x64 machines





Fig.5-3 wsl_update_x64.msi

- 6) Run the following command to set WSL 2 as the default version. *wsl --set-default-version 2*
- 7) Download Linux distribution. Here download Ubuntu 18.04 below. <u>Ubuntu 18.04</u>
- Go to the folder containing the downloaded file and execute the following command. Add-AppxPackage .\app_name.appx
- 9) Double-click Ubuntu_1804.2019.522.0_x64.appx to install.

Ubuntu 18.04 LTS をインストールしますか? Microsoft Store アプリ 発行元: 23596F84-C3FA-4CD8-A7DF-550DCE37BCD0 バージョン: 1804.2019.522.0 機能: ・すべてのシステム リソースを使用する	
✓ 準備ができたら起動	インストール
0	

Fig.5-4 Ubuntu Install

10) Set the Linux username and password. (Reference) <u>Set up a WSL development environment | Microsoft Learn</u>

🕙 Ubuntu 18.04 LTS	-	×
nstalling, this may take a tew minutes Jease create a default UNIX user account. The username does not need to match your Windows username. or more information visit: https://aka.ms/wslusers inter new UNIX username:		

Fig.5-5 UNIX username

5.1.2 Install CMake



11) Execute the following Linux command to update apt-get

sudo apt-get update

sv@JPN-5CG3013VTD:~≸ sudo apt-get update
Hit:1 http://archive.ubuntu.com/ubuntu bionic InRelease
Get:2 http://archive.ubuntu.com/ubuntu bionic-updates InRelease [88.7 kB]
Get:3 http://security.ubuntu.com/ubuntu bionic-security InRelease [88.7 kB]
Get:4 http://archive.ubuntu.com/ubuntu bionic-backports InRelease [83.3 kB]
Get:5 http://archive.ubuntu.com/ubuntu bionic/universe amd64 Packages [8570 kB]
Get:6 http://security.ubuntu.com/ubuntu bionic-security/main amd64 Packages [2717 kB]
Get:7 http://archive.ubuntu.com/ubuntu bionic/universe Translation-en [4941 kB]
Get:8 http://security.ubuntu.com/ubuntu bionic-security/main Translation-en [467 kB]
Get:9 http://security.ubuntu.com/ubuntu bionic-security/restricted amd64 Packages [1317 kB]
Get:10 http://security.ubuntu.com/ubuntu bionic-security/restricted Translation-en [182 kB]
Get:11 http://archive.ubuntu.com/ubuntu bionic/multiverse amd64 Packages [151 kB]
Get:12 http://security.ubuntu.com/ubuntu bionic-security/universe amd64 Packages [1303 kB]
Get:13 http://archive.ubuntu.com/ubuntu bionic/multiverse Translation-en [108 kB]
Get:14 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 Packages [3045 kB]
Get:15 http://security.ubuntu.com/ubuntu bionic-security/universe Translation-en [308 kB]
Get:16 http://security.ubuntu.com/ubuntu bionic-security/multiverse amd64 Packages [19.8 kB]
Get:17 http://archive.ubuntu.com/ubuntu bionic-updates/main Translation-en [553 kB]
Get:18 http://security.ubuntu.com/ubuntu bionic-security/multiverse Translation-en [3928 B]
Get:19 http://archive.ubuntu.com/ubuntu bionic-updates/restricted amd64 Packages [1347 kB]
Get:20 http://archive.ubuntu.com/ubuntu bionic-updates/restricted Translation-en [187 kB]
Get:21 http://archive.ubuntu.com/ubuntu bionic-updates/universe amd64 Packages [1914 kB]
Get:22 http://archive.ubuntu.com/ubuntu bionic-updates/universe Translation-en [420 kB]
Get:23 http://archive.ubuntu.com/ubuntu bionic-updates/multiverse amd64 Packages [25.6 kB]
Get:24 http://archive.ubuntu.com/ubuntu bionic-updates/multiverse Translation-en [6088 B]
Get:25 http://archive.ubuntu.com/ubuntu bionic-backports/main amd64 Packages [53.3 kB]
Get:26 http://archive.ubuntu.com/ubuntu bionic-backports/main Translation-en [14.6 kB]
Get:27 http://archive.ubuntu.com/ubuntu bionic-backports/universe amd64 Packages [18.2 kB]
Get:28 http://archive.ubuntu.com/ubuntu bionic-backports/universe Translation-en [8668 B]
Fetched 27.9 MB in 21s (1338 kB/s)
Reading package lists Done

Fig.5-6 apt-get update

12) Execute the following Linux command

sudo apt-get install git build-essential gcc pkg-config cmake python



Fig.5-7 install

If the following screen appears during the process, select OK.



Fig.5-8 restart



13) Execute each of the following commands.

sudo apt-get install cmake-curses-gui sudo apt-get install libmbedtls-dev sudo apt-get install liburcu-dev sudo apt-get install check sudo apt-get install python-sphinx graphviz sudo apt-get install python-sphinx-rtd-theme

- # Needed for CMAKE GUI
- # For encryption
- # For multithreading
- # For unit tests
- # For doc generation
- # For doc's style



Fig.5-9 install

5.1.3 Open62541 File Generation

14) Clone open62541 to any folder

git clone https://github.com/open62541/open62541.git



Fig.5-10 git clone

15) Go to /open62541 directory and check out the specific version (here, version v1.3.4-564-gb7e5e49f3).

git clone https://github.com/open62541/open62541.git

cd open62541/

git log -1

git checkout b7e5e49f32d00490be74c2eacef892c7fbd0be60

git submodule init

git submodule update





Fig.5-11 git submodule

16) Open the Linux folder from File Explorer. Confirm that CMakeLists.txt is present in /home/(username)/open62541 directory. Copy the following four patch files obtained by unzipping patch_open62541.zip attached to the sample software to this directory.

include-bacnet-xmls.patch

CMakeLists.txt.patch

Opc.Ua.NodeSet2.Reduced.xml.patch

datatypes_dataaccess.txt.patch



Fig.5-12 Copy patch files

17) Execute patch commands below in /open62541 directory

patch -p1 < include-bacnet-xmls.patch
patch -p1 < CMakeLists.txt.patch
patch -p1 < Opc.Ua.NodeSet2.Reduced.xml.patch
patch -p1 < datatypes_dataaccess.txt.patch</pre>





Fig.5-13 patch command

18) Compile the library according to the standard procedures of the cmake project. Create /open62541/build directory and run cmake . (Some items will be Failed, but there is no problem. (Some items will be Failed, but that is not a problem.)

mkdir build && cd build

cmake ..



Fig.5-14 cmake

19) Execute the following command to start the ccmake setting window.

ccmake ..

20) Change the settings as follows, and after executing [c] to configure, close it by [q] to quit without generating.





Fig.5-15 ccmake

21) Execute the following command to make in the */open62541/build* directory. The make process will finish with an error, but it does not matter.

make -j

Fig.5-16 make

22) After "make -j" is completed, execute each of the following commands.

find ./ -type f -exec sed -i -e 's/fields\.unsigned\;/fields\.unsignedValue\;/g' {} \;
find ./ -type f -exec sed -i -e 's/fields\.boolean\;/fields\.booleanValue\;/g' {} \;
find ./ -type f -exec sed -i -e 's/fields\.enum\;/fields\.enumValue\;/g' {} \;
find ./ -type f -exec sed -i -e 's/fields\.enum\/fields\.enumValue\;/g' {} \;

find ./ -type f -exec sed -i -e 's/fields\.boolean)/fields\.booleanValue)/g' {} \; find ./ -type f -exec sed -i -e 's/fields\.unsigned)/fields\.unsignedValue)/g' {} \; find ./ -type f -exec sed -i -e 's/fields\.signed)/fields\.signedValue)/g' {} \; find ./ -type f -exec sed -i -e 's/enum\;/enumValue\;/g' {} \; find ./ -type f -exec sed -i -e 's/boolean\;/booleanValue\;/g' {} \; find ./ -type f -exec sed -i -e 's/unsigned\;/unsignedValue\;/g' {} \; find ./ -type f -exec sed -i -e 's/signed\;/unsignedValue\;/g' {} \;

<pre>PN-SGG3013VTD:-/openG2541/build\$ find ./ -type f -exec sed i -e 's/enumy:/enumValue';/g' {} \; DN-SGG3013VTD:-/openG2541/build\$ find ./ -type f -exec sed i -e 's/enumy:/enumValue';/g' {} \;</pre>	sv@TML-5C301370T:-/open62541/build\$ find // type f exec sed -i -e 's/unsigned/s/unsignedValue's/g' () \;	<pre>vqDPH-5C63013VD:-/open62541/build\$ find ./ -type vqDPH-5C63013VD:-/open62541/build\$ find ./ -type svqDPH-5C63013VD:-/open62541/build\$ find ./ -type svqDPH-5C63013VD:-/open62541/build\$ find ./ -type vqDPH-5C63013VD:-/open62541/build\$ find ./ -type vqDPH-5C63013VD:-/open62541/build\$ find ./ -type svqDPH-5C63013VD:-/open62541/build\$ find ./ -type svqDPH-5C63013VD:-/open62541/build\$ find ./ -type svqDPH-5C63013VD:-/open62541/build\$ find ./ -type</pre>	<pre>-exec sed -i -e 's/fields\.unsigned\;/fields\.unsignedNalue\;/g' {} }; -exec sed -i -e 's/fields\.boolean\;/fields\.boolean\laue\;/g' {} }; -exec sed -i -e 's/fields\.boolean\;/fields\.enumNalue\;/g' {} }; -exec sed -i -e 's/fields\.boolean\/fields\.enumNalue\/g' {} }; -exec sed -i -e 's/fields\.unsigned\/fields\.unsignedValue\/g' {} }; -exec sed -i -e 's/fields\.unsigned\/fields\.unsignedValue\/g' {} }; -exec sed -i -e 's/fields\.unsigned\/fields\.unsignedValue\/g' {} }; -exec sed -i -e 's/fields\.signed\/fields\.unsignedValue\/g' {} }; -exec sed -i -e 's/fields\.isigned\/fields\.unsignedValue\/g' {} }; -exec sed -i -e 's/fields\.isigned\</pre>
--	---	---	--

Fig.5-17 substitution command

- 23) Confirm that the following files are generated in /opn62541 and /src_generated/open62541 directories.
 - open62541.c
 - open62541.h
 - types_bacnet_generated.c
 - types_bacnet_generated.h
 - types_bacnet_generated_handling.h
 - Namespace_bacnet_generated.h
 - Namespace_bacnet_generated.c
 - Bacnet_nodeids.h

sv@JPN-5CG3013VTD:~/open62541/build\$ ls -1	
total 17160	
-rw-rr 1 sv sv 32799 Jul 21 20:20 CMakeCache.txt	
drwxr-xr-x 1 sv sv 4096 Jul 21 20:24 CMakeFiles	
-rw-rr 1 sv sv 3724 Jul 21 20:15 CPackConfig.cmake	
-rw-rr 1 sv sv 4178 Jul 21 20:15 CPackSourceConfig	.cmake
-rw-rr 1 sv sv 16683 Jul 21 20:24 Makefile	
drwxr-xr-x 1 sv sv 4096 Jul 21 20:24 arch	
drwxr-xr-x 1 sv sv 4096 Jul 21 20:15 bin	
-rw-rr 1 sv sv 5151 Jul 21 20:24 cmake_install.cma	ke
-rw-rr 1 sv sv 887 Jul 21 20:24 compile_commands.	json
drwxr-xr-x 1 sv sv 4096 Jul 21 20:24 doc	
drwxr-xr-x 1 sv sv 4096 Jul 21 20:24 doc src	
-rw-rr 1 sv sv 5911101 Jul 21 20:24 open62541.c	
-rw-rr 1 sv sv 1930296 Jul 21 20:24 open62541.h	
-rw-rr 1 sv sv 2133 Jul 21 20:20 open62541Config.c	make
-rw-rr 1 sv sv 1269 Jul 21 20:15 open62541ConfigVe	rsion.cmake
-rw-rr 1 sv sv 28898 Jul 21 20:15 open62541Macros.c	make
-rw-rr 1 sv sv 2283 Jul 21 20:24 open62541Targets.	cmake
drwxr-xr-x 1 sv sv 4096 Jul 21 20:24 src_generated	
drwxr-xr-x 1 sv sv 4096 Jul 21 20:15 tools	
sv@JPN-5CG3013VTD:~/open62541/build\$ Is -1 src_generated/	open62541
total 6100	
-rw-rr 1 sv sv 89243 Jul 21 20:24 bacnet_nodeids.h	
-rw-rr 1 sv sv 4470 Jul 21 20:20 config.h	
-rw-rr 1 sv sv 153130/ Jul 21 20:24 namespace0_genera	ted.c
-rw-rr 1 sv sv 1423 Jul 21 20:24 namespace0 genera	ted.h
-rw-rr 1 sv sv 2309284 Jul 21 20:24 namespace_bacnet_	generated.c
-rw-rr 1 sv sv 444 Jul 21 20:24 namespace_bacnet_	generated.n
-rw-rr 1 sv sv 9/53/9 Jul 21 20:24 nodelds.h	
-IW-IPP I SV SV 18357 JUL 21 20:24 statuscodes.c	
-TW-PP 1 SV SV 32/40 Jul 21 20.24 statuscodes.	
nu p p 1 sv sv 2004 Jul 21 20:24 transport_generat	eu.e
num n 1 sv sv 2209 Jul 21 20:24 transport_generat	eun
-rw-nn 1 sv sv - 02200 Jul 21 20:24 transport_generat	
-rw = r = -r = -1 sv sv $-6/387$ Jul 21 20.24 types bachet gene	nated h
-rw-rr 1 sv sv 89416 Jul 21 20:24 types bachet gene	nated handling h
-rw-r 1 sv sv 245684 Jul 21 20:24 types_backet_gene	
-rw-r1 sv sv 53299 Jul 21 20:24 types_generated b	
-rw-rr 1 sv sv 177739 Jul 21 20:24 types generated h	andling h

Fig.5-18 Generated Files

24) Create a folder in the IDE project and import the generated files into the project as shown in the figure. Where OPC_UA_SERVER is the file created under the e2studio project.

🗸 🔁 R	ZN2L_OPC_BGW_V1.0.0 [Debug]
> **	Binaries
> 🛱	l Includes
> 🚝	BACNETOSS
✓ (²	OPC_UA_SERVER
>	h bacnet_nodeids.h
>	h common.h
>	🝺 namespace_bacnet_generated.c
>	h namespace_bacnet_generated.h
>	🖻 open62541.c
>	h open62541.h
>	h types_bacnet_generated_handling.h
>	🖻 types_bacnet_generated.c
>	h types_bacnet_generated.h
> 🖉	rzn
> 🖉	rzn_cfg/aws
> 🖻	rzn_gen
> 🖻	src
> 🖻	user/oss/amazon-freertos/libraries/3rdparty/lwip_osal/src
> 🖻	user/oss/lwip
> 🖻	user/renesas
> 🚈	-> Debug
> 🖻	י rzn_cfg
> 🖻	♭ script
> 🖻	b user
the second se	configuration.xml
) rzn_cfg.txt
	RZN2L_OPC_BGW_V1.0.0 Debug.jlink

Fig.5-19 Import

5.1.4 Changes in Generated Files

Several changes have been made to the open62541 files generated by this procedure. A summary is given below.

1. Open62541.c

The open62541.c is modified during integration to avoid namespace mismatch and merging BACnet namespace with the default application namespace as in below Fig.5-20

include the following code snippet to merge bacnet namespace in application

```
for(size_t i = 0; i < UA_TYPES_BACNET_COUNT; ++i) {
    if(UA_Nodeld_equal(&UA_TYPES_BACNET[i].typeId, typeId))
        return &UA_TYPES_BACNET[i];</pre>
```

```
}
```

Replace the following

value->value.data = booleanValue; to value->value.data = boolean;

Comment the following code snippet to avoid namespace mismatch between application namespace and bacnet namespace.

//if(n1->namespaceIndex != n2->namespaceIndex)

// return (n1->namespaceIndex < n2->namespaceIndex) ? UA_ORDER_LESS : UA_ORDER_MORE;

The nodeset compiler uses python script the order in which the nodes are created are not specific.

 D:\Documents\generated files\open62541.c 	- P 🔁 - 🖽 🛛	E D:\Documents\Integrated files\open62541.c V	- 🗁 🔻
7/27/2023 4:07:06 PM 5,911,553 bytes C,C++	,C#,ObjC Source ▼ UTF-8 ▼ UNIX	7/27/2023 2:32:08 PM 4,471,487 bytes C,C++,C#,ObjC Source VITF-8 V PC	
		<pre></pre>	
	276 FILTERED LINES	<pre>2/ 276 FRITERED LINES</pre>	
if(n1->namespaceIndex != n2	<pre>>namespaceIndex)</pre>	<pre>//if(n1->namespaceIndex != n2->namespaceIndex)</pre>	
return (n1->namespaceIn	dex < n2->namespaceIndex) ? UA_ORDER_LESS : UA — 9FILTERED LINES E	<pre>// return (n1->namespaceIndex < n2->namespaceIndex) ? UA_ORDER_</pre>	LESS :
= 📄 ///////////////////////////////////			
- value->value data - bealean	- 16598 HUTERED LINES	value->value data - boolean:	

Fig.5-20 difference in open62541.c

2. Open62541.h NO CHANGES

3. bacnet nodeids

NO CHANGES

types_bacnet_generated_handling.h 4 NO CHANGE

5. Namespace_bacnet_generated.c

UA_TYPES->UA_TYPES_BACNET

&UA_TYPES->&UA_TYPES_BACNET

78LU->80LU

78LU is macro for optional node

80LU is macro for Mandatory node

To enable optional node to mandatory nodes like network scan, reinitialization, time synchronization method and include them in Object folder In address space above change is made.

Fig.5-21 difference in namespace_bacnet_generated.c

6. Namespace_bacnet_generated.h

Remove types_bacnet_generated.h since open62541.h is included.

T IN FILTERED LINES		
#include "types bacnet generated.h"	//#include "types bacnet generated.h"	
T 10 FILTERED LINES	TT 10 FILTERED LINES	

Fig.5-22 difference in namespace_bacnet_generated.h

7. types_bacnet_generated.h

Remove #include "types_generated.h"

ISFILTERDUNES
 ISFILTERDUNES
 ISFILTERDUNES
 ISFILTERDUNES

Fig.5-23 difference in types_bacnet_generated.h

8. types_bacnet_generated.c

Remove the included types_generated .h and include open62541.h

APUTERDINES

Fig.5-24 difference in types_bacnet_generated.c

5.2 B-BC Device Profile (Reference)

Indicates the support status of the B-BC device profile in this sample software version. The "Not available" in the subsequent tables does not meet the requirement in this version. They will be supported in the next version or later.

Table 5-1 BAC	net Service	implementation	status	required for	B-BC
---------------	-------------	----------------	--------	--------------	------

BACnet Service	Initiate ¹	Execute ²
Who-Is	1	1
I-Am	1	1
Who-Has	1	1
I-Have	1	1
ReadProperty	1	1
WriteProperty	1	1
DeviceCommunicationControl		Not available
ReinitializeDevice		Not available
AtomicReadFile		Not available
AtomicWriteFile		Not available
TimeSynchronization		Not available
UTCTimeSynchronization		
SubscribeCOV		
ConfirmedCOVNotification		
UnconfirmedCOVNotification		
ReadPropertyMultiple	Not available	Not available
ReadPropertyConditional		
ReadRange		Not available
WritePropertyMultiple	Not available	Not available
GetAlarmSummary		
GetEventInformation		Not available
GetEnrollmentSummary		
AcknowledgeAlarm		Not available
ConfirmedEventNotification	Not available	
UnconfirmedEventNotification	Not available	
UnconfirmedTextMessage		
ConfirmedTextMessage		
AddListElement		
RemoveListElement		
CreateObject		

BACnet Service	Initiate ¹	Execute ²
DeleteObject		
UnconfirmedPrivateTransfer		
ConfirmedPrivateTransfer		
VTOpen		
VTData		
VTClose		

 \checkmark is applicable, blank is not applicable, and "Not available" does not meet the requirements.

Sends a BACnet service request or notification. However, the B-SS does not send service requests, only notifications.
 Execute the BACnet service and send a response (if a confirmed service is requested).

Table 5-2 BACnet Object implementation status required for B-BC

BACnet Object Type	Object ID	Implementation
Accumulator		
Analog Input	Analog Input, 0	1
	Analog Input, 1	Not available
Analog Output		
Analog Value	Analog Value, 0	Not available
	Analog Value, 1	Not available
Averaging		
Binary Input		
Binary Output	Binary Output, 0	Not available
	Binary Output, 1	Not available
Binary Value	Binary Value, 0	Not available
	Binary Value, 1	Not available
Calendar		
Command		
Device	Device, 12	Not available
Event Enrollment		
File		
Group		
Life Safety Point		
Life Safety Zone		
Loop		
Multi state Input		
Multi state Output		
Multi state Value	Multi state Value, 0	Not available
	Multi state Value, 1	Not available



BACnet Object Type	Object ID	Implementation
Notification Class		Not available
Program		
Pulse Converter		
Schedule		Not available
Trend Log		Not available
Access Door		
Event Log		
Load Control		
Structured View		
Trend Log Multiple		
Access Point		
Access Zone		
Access User		
Access Rights		
Access Credential		
Credential Data Input		
CharacterString Value		
DateTime Value		
Large Analog Value		
BitString Value		
OctetString Value		
Time Value		
Integer Value		
Positive Integer Value	Positive Integer Value, 0	Not available
	Positive Integer Value, 1	Not available
Date Value		
DateTime Pattern Value		
Time Pattern Value		
Date Pattern Value		
Network Security		
Global Group		
Notification Forwarder		
Alert Enrollment		
Channel		
Lighting Output		
Network Port		Not available



BACnet Object Type	Object ID	Implementation
Binary Lighting Output		

✓ is applicable, blank is not applicable, and "Not available" does not meet the requirements.

Table 5-3 BIBB implementation	n status required for B-BC
-------------------------------	----------------------------

BIBB Class	BIBB	BACnet Service	Initiate ¹	Execute ²	B-BC Standardized ³
DataSharing	DS-RP-A,B	ReadProperty	1	1	1
	DS-WP-A,B	WriteProperty	1	1	1
	DS-RPM-A,B	ReadPropertyMultiple	Not available	Not available	1
	DS-WPM-A,B	WritePropertyMultiple	Not available	Not available	1
Alarm & Event	AE-N-I-B	ConfirmedEventNotification	Not available		1
Management		UnconfirmedEventNotification	Not available		1
	AE-ACK-B	AcknowledgeAlarm		Not available	1
	AE-INFO-B	GetEventInformation		Not available	1
Scheduling	SCHED-E-B	WriteProperty	Not available	Not available	1
		ReadProperty		Not available	1
Trending	T-VMT-I-B	ReadRange		Not available	1
	T-ATR-B	ConfirmedEventNotification	Not available		1
		UnconfirmedEventNotification	Not available		1
		ReadRange		Not available	1
Device &	DM-DDB-A,B	Who-Is	1	1	1
Network Management		I-Am	1	1	1
	DM-DOB-A,B	Who-Has	1	1	1
		I-Have	1	1	1
	DM-DCC-B	DeviceCommunicationControl		Not available	1
	DM-TS-B	TimeSynchronization		Not available	1
	DM-RD-B	ReinitializeDevice		Not available	1
	DM-BR-B	AtomicReadFile		Not available	1
		AtomicWriteFile		Not available	1
		ReinitializeDevice		Not available	1

 \checkmark is applicable, blank is not applicable, and "Not available" does not meet the requirements.



Revision History

		Description	
Rev.	Date	Page	Summary
1.00	Jul/31/2023	-	First Edition

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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 is supplied until the 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.

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