

CC-Link IE TSN system construction method using Mitsubishi Electric PLC (RJ71GN11-T2) and Hirschmann switches (RSPE35)



CC-Link Partner Association
Hirschmann Automation and Control GmbH
Mitsubishi Electric Corporation

Revision history

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1. Introduction

In order to interconnect CC-Link IE TSN compliant devices, appropriate configurations must be made for the CC-Link IE TSN system that you want to build on each device. If the configurations of each device are not consistent throughout the TSN system, proper operation cannot be expected.

This document describes the configurations required to interconnect the RSPE35 which is a TSN compliant switch manufactured by Hirschmann Automation and Control GmbH (hereafter referred to as "Hirschmann"), RJ71GN11-T2 which is a master/local station product manufactured by Mitsubishi Electric Corporation (hereafter referred to as "Mitsubishi"), with Certification class B of CC-Link IE TSN compliant devices.

This document assumes the following firmware versions:

Table 1-1 Device and the firmware version required

No	Device	Type	Manufacturer	F/W version (*)
1	RSPE35	Switching HUB	Hirschmann Automation and Control GmbH	HiOS 08.1.00
2	RJ71GN11-T2	PLC Master/Local Station	Mitsubishi Electric Corporation	Ver.05

(*) Please check with each manufacturer for the applicable F/W.

2. CC-Link IE TSN

2.1. Overview

CC-Link IE TSN utilizes the time of synchronization in the network to transmit both output and input communication frames simultaneously at a fixed time. By combining this method with the TSN technology used in Ethernet, it is possible to reduce the time required to update cyclic data over the entire network.

TSN technology consists of multiple international standards, and the major ones are IEEE802.1AS and IEEE1588v2, which specifies the time synchronization methods, and IEEE802.1Qbv, which specifies a time division method. By combining these standards, it is possible to achieve determinism, which guarantees transmission within a certain period of time, and to mix different communication protocols on the same trunk line. For example, devices can be controlled by real-time cyclic communication by giving higher priority for cyclic communication on the devices and assigning a band priority over information communication. Devices used for monitoring and analyzing such as vision sensors and surveillance cameras that communicate with production sites using UDP and TCP can be connected to a single network with high precision.

2.2. Time synchronization system

In the CC-Link IE TSN network, all stations perform time synchronization using either IEEE1588v2 or IEEE802.1AS. The time synchronization method of each node and switch must be unified in the network. Please be consistent with either IEEE1588v2 or IEEE802.1AS.

If you are using IEEE802.1AS, all of the devices in the TSN system (Master, local, remote, switch, etc.) must support IEEE802.1AS and must be configured accordingly.

On the other hand, if you are using IEEE1588v2, not all devices in the TSN system need to support IEEE1588v2. It is only necessary to configure IEEE1588v2 relevant devices.

2.3. Time division system

In the CC-Link IE TSN network, communication is performed by dividing the communication cycle into time slots as a time division method. Up to eight time slots are available, and each time slot can be used for any purpose. The total time allocated to all time slots is the cyclic communication.

When the RJ71GN11-T2 is used as the network master, the communication cycle is divided into 3 time slots, and each time slot is used for the following purposes.

- TSLT0: A band that allows each node to communicate freely. Used for transient communication and IP communication.
- TSLT1: Used for cyclic communication
- TSLT2: Used for communication for time synchronization of IEEE802.1AS and IEEE1588v2

Table 2.3-1 Cyclic communication and time slot configuration items

No	Time slot	Configurations				RJ71GN11-T2 network master example of usage
		Cycle Start Offset	Cycle End Offset	Time slot length	Cyclic Communication	
1	TSLT1	t1	t2	A (= t2 - t1)	T	Cyclic communication
2	TSLT2	t2	t3	B (= t3 - t2)		Time synchronization (IEEE802.1AS, IEEE1588v2)
3	TSLT3	t3	t4	C (= t4 - t3)		Not used
4	TSLT4	t4	t5	D (= t5 - t4)		Not used
5	TSLT5	t5	t6	E (= t6 - t5)		Not used
6	TSLT6	t6	t7	F (= t7 - t6)		Not used
7	TSLT7	t7	t0	G (= t0 - t7)		Not used
8	TSLT0	t0	t_end	H (= t_end - t0)		Transient communication IP communications (SLMP), etc.

(*) $T = A + B + C + D + E + F + G + H$ (The cyclic communication is the sum of all time slots.)

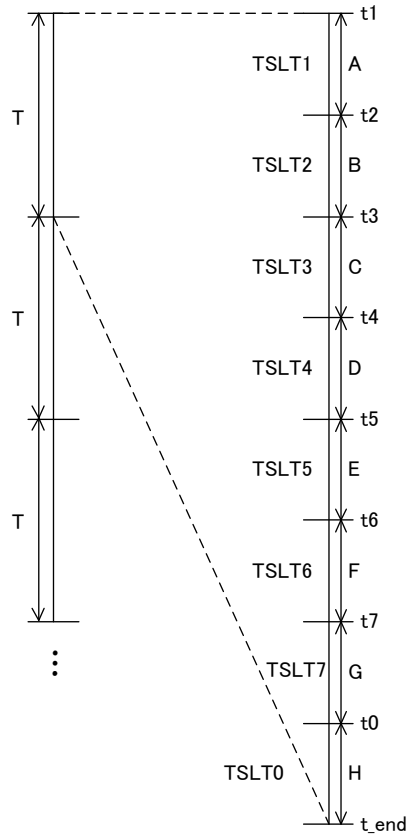


Figure 2.3-1 Cyclic communication and time slot configuration items

3. CC-Link IE TSN system configurations

3.1. RSPE35/RJ71GN11-T2 common configurations

This section describes common configurations for the Hirschmann RSPE35 and Mitsubishi RJ71GN11-T2. Any configurations can be made according to the application of the TSN system to be applied, but the configurations must be consistent within the same TSN system. This section describes the time synchronization method only for IEEE802.1AS.

■Time synchronization system

Table 3.1-1 Configuration items for the time synchronization method

Device	Configuration Path	Configuration	Set value
RSPE35	"Time" → "PTP" → "Global"	Operation IEEE 1588/PTP	Off
	"Time" → "802.1AS" → "Global"	Operation	On
RJ71GN11-T2	"RJ71GN11-T2 Module Parameters" → "Preferences" → "Connection Device Information"	Authentication Class Setting (*)	Authentication Class B only(*)

With the above configurations, IEEE802.1AS is selected as the time synchronization method. The RSPE35 and RJ71GN11-T2 must select the same standard. (Either IEEE802.1AS or IEEE1588v2)

* Authentication class in RJ71GN11-T2 (GX Works3 engineering tool) is same as certification class.

■Communication Cycle

Table 3.1-2 Configuration items for cyclic communication

Device	Configuration Path	Configuration	Set value
RSPE35	"Switching" → "TSN" → "Configuration"	Cyclic time/ Configured	User arbitrary cyclic communication (*)
RJ71GN11-T2	"RJ71GN11-T2 Module Parameters" → "Preferences" → "Connectivity device information"	Cyclic communication interval configuration	User arbitrary cyclic communication (*)

* RSPE35 and RJ71GN11-T2 must have the same communication cycle.

■Time slot

Table 3.1-3 Configuration for time slots

Device	Configuration Path	Configuration	Set value
RSPE35	"Switching" → "TSN" → "Gate Control List" → "Configured"	Gate states	Refer to the purpose of communication from 2.3
		Interval [ns]	Timeslot time
RJ71GN11-T2	"RJ71GN11-T2 Module Parameters" → "Preferences" → "Connectivity device information"	System reservation time	Timeslot time for time synchronization
		Cyclic communication time (CC IE TSN)	Timeslot time for cyclic communications

3.2. RSPE35 specific configuration items

This section describes what to configure only for the RSPE35. Mitsubishi's RJ71GN11-T2 has parameters already built in as fixed values for time synchronization, and the RSPE35 must have corresponding parameters. In addition, the RSPE35 must be configured for the type of device connected to each communication port and for enabling the time division method. Again, the table below describes the configuration only for IEEE802.1AS.

■Time Synchronization Parameters

Table 3.2-1 Configuration items for time synchronization parameters

Device	Configuration Path	Configurations	Set value
RSPE35	"Time" → "802.1AS" → "Global" → "Configuration"	Priority 1	246
		Priority 2	248
		Sync upper bound	5,000
		Sync lower bound	30
	"Time" → "802.1AS" → "Port"	Active	Used Ports Only
		Announcement interval	1
		Announce timeout	3
		Peer delay interval	1
		Peer delay timeout	3
		Peer delay threshold	10,000
		Sync interval	0.125
		Sync timeout	3

Set the above value to match to RJ71GN11-T2. However, check only the ports that use CC-Link IE TSN for "Active" of "Time" → "802.1AS" → "Port".

■Configuration Items for Time Division Method

Table 3.2-2 Configuration items for time division method

Device	Configuration Path	Configurations	Set value
RSPE35	"Switching" → "TSN" → "Configuration"	Operation	On
		Active	Used Ports Only (*)
		Default gate states	Communication Usage

* Check the "Active" column only for ports that use the time-sharing function. The "Default gate state" column is used to set the purpose of the communication that flows to each port. Here 0 represents communication by an IP Device, 6 represents communication related to time synchronization, and 7 represents communication by a CC-Link IE TSN Device.

■ Connection Device Configurations

Table 3.2-3 Connection device configurations

Device	Configuration Path	Configurations	Set value
RSPE35	"Switching" → "QoS/Priority" → "Port Configuration"	Port priority	TSN Device: 7 IP Device: 0

Ports that are not used do not need to be configured.

■ Configuration on Unnecessary Traffic Class.

For the traffic classes that are not used, below configuration is required so that the unnecessary frames will not reserve in the RSPE35.

Table 3.2-4 Configuration on unnecessary traffic class.

Device	Configuration Path	Configurations	Set value
RSPE35	"Switching" → "TSN" → "SDU"	Max. SDU	0(Traffic class 0,6,7) 1(Traffic class 1,2,3,4,5)

Apply above for all of the ports using CC-Link IE TSN.

4. Configuration example

4.1. Example of system configuration

In this chapter, the way to configure the RSPE35 and RJ71GN11-T2 shown in Figure 4.1-1 will be explained.

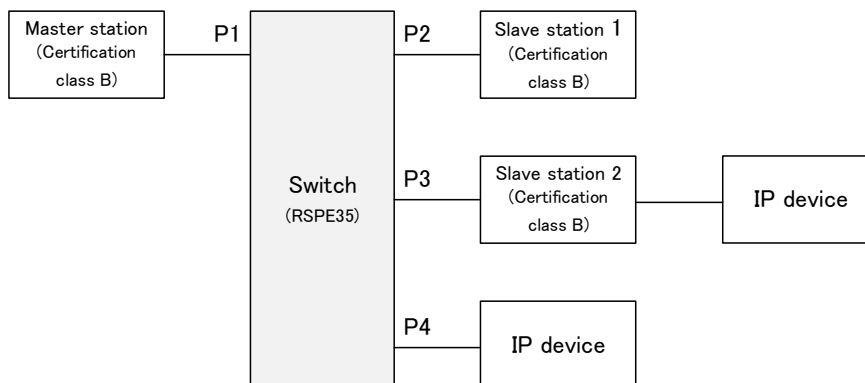


Figure 4.1-1 System configuration

The devices that support CC-Link IE TSN are the master station, slave station 1, slave station 2, and switches. They implement time synchronization using IEEE802.1AS and construct a system of Certification class B by using the time division method using IEEE 802.1Qbv.

Here, the master station and slave station in the figure above correspond to RJ71GN11-T2, the switch corresponds to the RSPE35, and the IP Device corresponds to a general TCP/IP based information device such as a PC.

All devices shall be connected via 1Gbps Ethernet, with switch port 1 ~ 3 used to connect the CC-Link IE TSN device and port 4 used to connect the IP device.

The communication cycle is 1ms and is divided into three time slots. Assign times as described in Table 4.1-1.

Table 4.1-1 Time slot allocation for example system configuration

Time slot	Usage	Assigned Time
TSLT1	Cyclic communication	500 [μs]
TSLT2	Time synchronization communication (IEEE802.1AS)	20 [μs]
TSLT0	Transient communication IP communication	480 [μs]

4.2. Configuration of Hirschmann RSPE35

The time synchronization method and time division method are set by the GUI of the Web interface. (It can also be configured through a console connection, via the CLI using ssh/telnet, or through administrative tools.)

The configuration screens shown from the next page can be accessed through web browser after connecting RSPE35 and PC for configuration via Ethernet cable.

■ Time synchronization system

In this system, 2 locations are set to use IEEE 802.1AS as the time synchronization method. First, to disable IEEE1588v2 , set "Time" → "PTP" → "Global" → "Operation IEEE1588/PTP" to off.

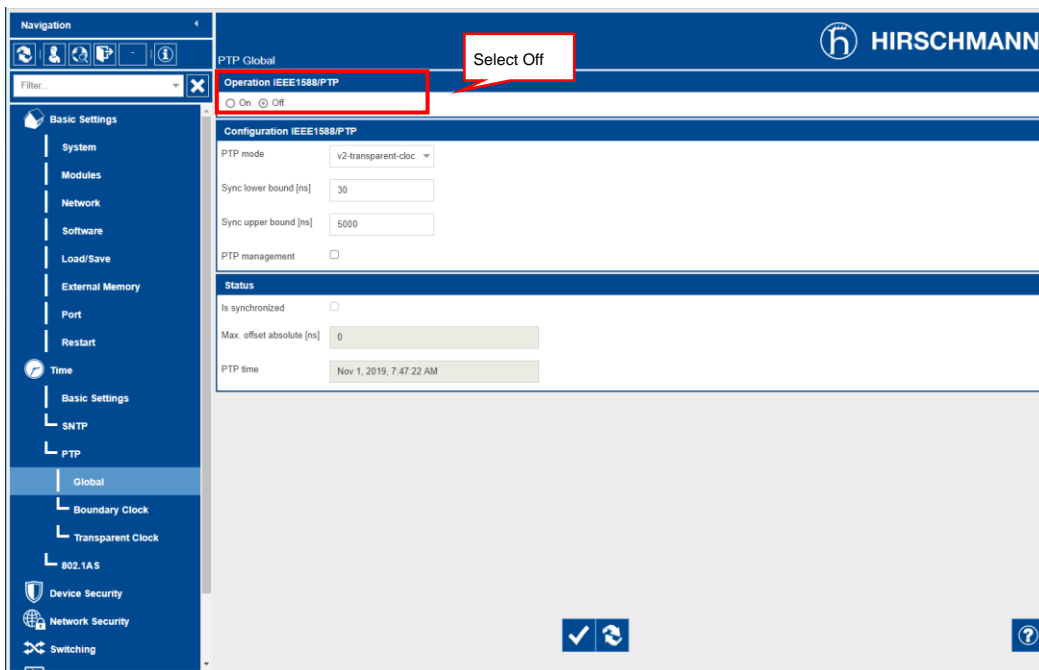


Figure 4.2-1 Choosing an RSPE35 time synchronization method (1/2)

Next, to enable IEEE802.1AS, set "Time" → "802.1AS" → "Global" → "Operation" to on.

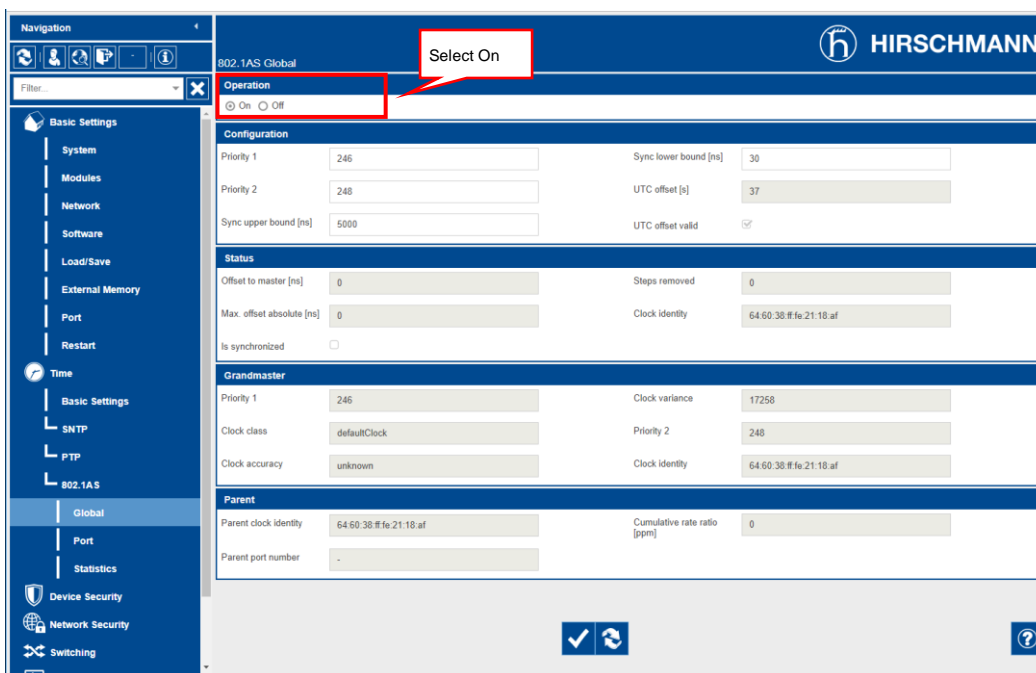


Figure 4.2-2 Choosing an RSPE35 time synchronization method (2/2)

■ Communication cycle

To set the communication cycle in the RSPE35, enter 1,000,000[ns] for "Configured" of "Cycle time [ns]" which is under "Switching" → "TSN" → "Configuration". Figure 4.2-3 shows the configuration example.

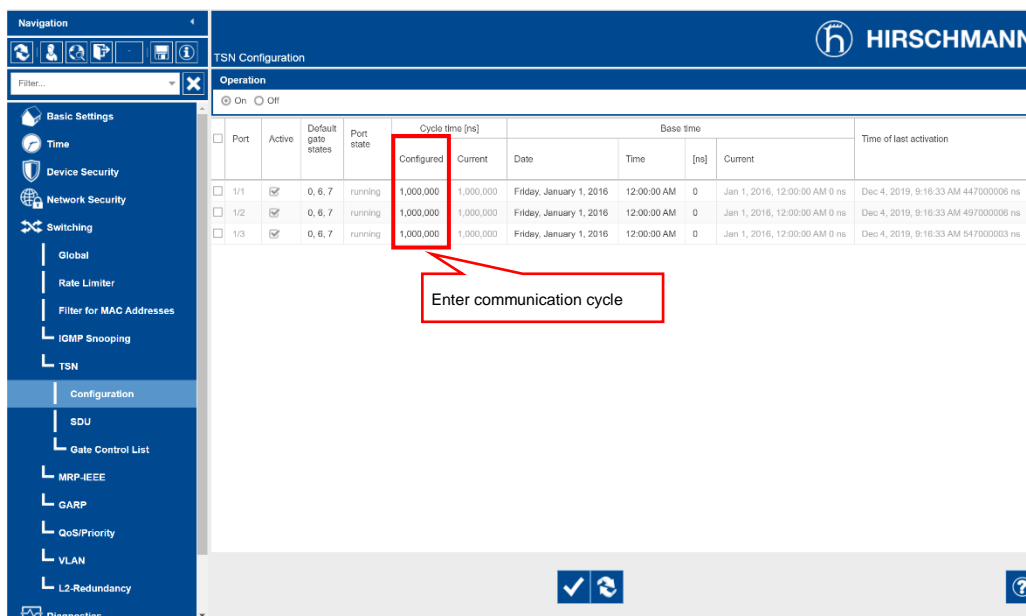


Figure 4.2-3 Configuring the RSPE35 communication frequency

■ Time slot

In order to set the time slot, follow Table 4.1-1 and enter "Gate states" and "interval [ns]" for the ports after choosing "Switching" → "TSN" → "Gate Control List" → "Configured", where the index is ordered as TSLT1, TSLT2, then TSLT0.

Cyclic communication can be received only from TSN supporting device so set only 7 in the "Gate states" in "index 1". Communication such as transient or IP communication will receive from both TSN supporting devices or IP devices so 0 and 7 should be set in "Gate states" in "index 3."

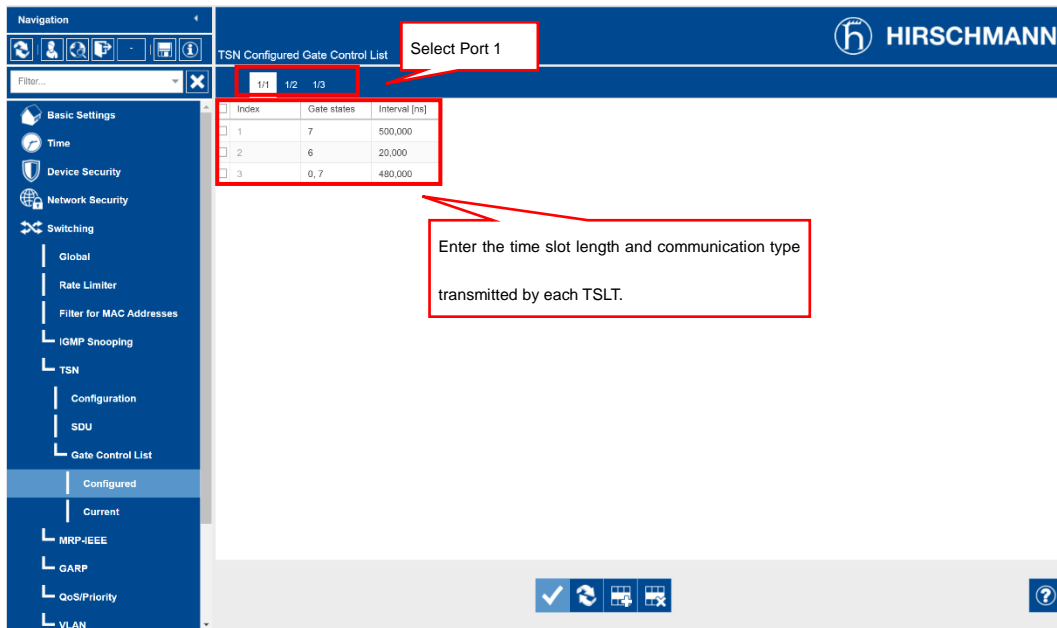


Figure 4.2-4 RSPE35 timeslot configuration (port1)

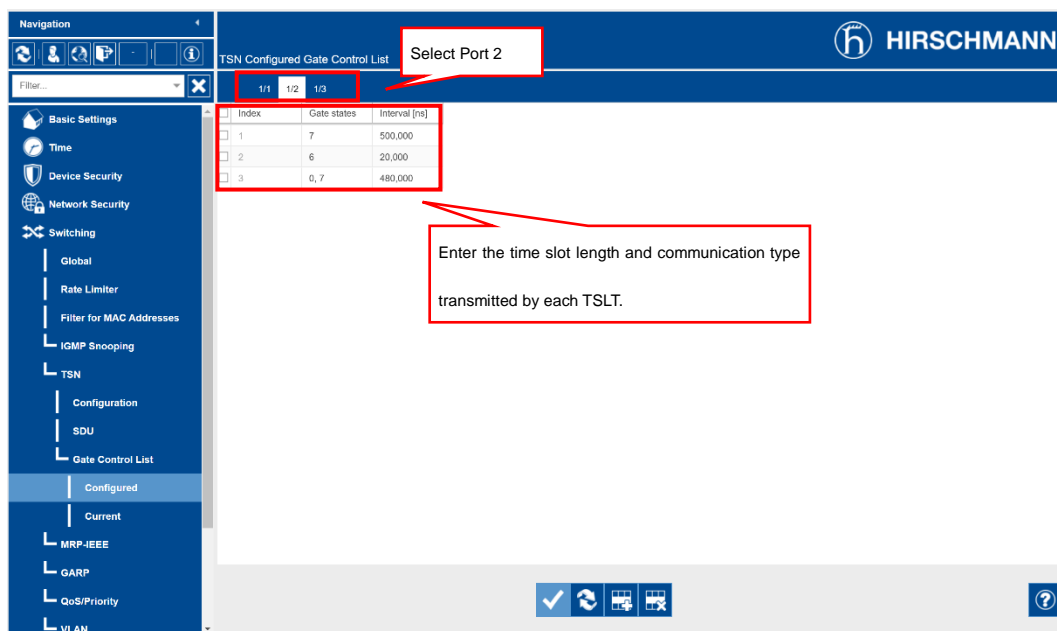


Figure 4.2-5 RSPE35 timeslot configuration (port2)

Due to device limitations, the RSPE35 requires a guard band of 13µs after TSLT1 and TSLT0 for port 3 which does not transmit any information. Therefore, the timeslot times for TSLT1 and TSLT0 need to subtract 13 µs from the designated time (In this configuration, 500 µs and 480 µs are used as examples). For the status of guard band, enter "-" in the "Gate states".

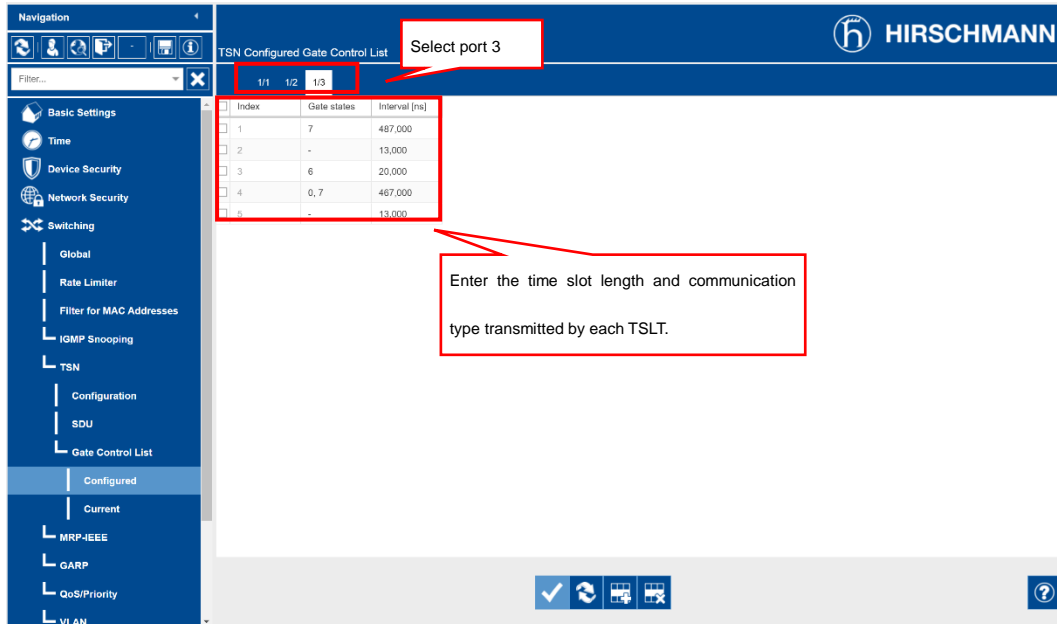


Figure 4.2-6 RSPE35 timeslot configuration (port3)

Time synchronization parameters

Please enter the setup shown in Table 3.2-1 to set the parameters for time synchronization after "Time"

→ "802.1AS" → "Port"

Port	Active	Role	AS capable	Measuring delay	Announce interval [s]	Announce timeout	Pdelay interval [s]	Pdelay timeout	Pdelay threshold [ns]	Sync interval [s]	Sync timeout	Neighbor rate ratio [ppm]	Pdelay [ns]
1/1	<input checked="" type="checkbox"/>	Disabled	<input type="checkbox"/>	<input type="checkbox"/>	1	3	1	3	10,000	0.125	3	0	0
1/2	<input checked="" type="checkbox"/>	Disabled	<input type="checkbox"/>	<input type="checkbox"/>	1	3	1	3	10,000	0.125	3	0	0
1/3	<input checked="" type="checkbox"/>	Disabled	<input type="checkbox"/>	<input type="checkbox"/>	1	3	1	3	10,000	0.125	3	0	0
1/4	<input type="checkbox"/>	Disabled	<input type="checkbox"/>	<input type="checkbox"/>	1	3	1	3	10,000	0.125	3	0	0
1/5	<input type="checkbox"/>	Disabled	<input type="checkbox"/>	<input type="checkbox"/>	1	3	1	3	10,000	0.125	3	0	0
1/6	<input type="checkbox"/>	Disabled	<input type="checkbox"/>	<input type="checkbox"/>	1	3	1	3	10,000	0.125	3	0	0
1/7	<input type="checkbox"/>	Disabled	<input type="checkbox"/>	<input type="checkbox"/>	1	3	1	3	10,000	0.125	3	0	0
1/8	<input type="checkbox"/>	Disabled	<input type="checkbox"/>	<input type="checkbox"/>	1	3	1	3	10,000	0.125	3	0	0
1/9	<input type="checkbox"/>	Disabled	<input type="checkbox"/>	<input type="checkbox"/>	1	3	1	3	10,000	0.125	3	0	0
1/10	<input type="checkbox"/>	Disabled	<input type="checkbox"/>	<input type="checkbox"/>	1	3	1	3	10,000	0.125	3	0	0
1/11	<input type="checkbox"/>	Disabled	<input type="checkbox"/>	<input type="checkbox"/>	1	3	1	3	10,000	0.125	3	0	0
1/12	<input type="checkbox"/>	Disabled	<input type="checkbox"/>	<input type="checkbox"/>	1	3	1	3	10,000	0.125	3	0	0

Figure 4.2-7 Setting RSPE35 time synchronization parameters (1/2)

In addition, please enter the value shown in Table 3.2-1 and after "Time" → "802.1AS" → "Global" "Configuration".

Configuration	
Priority 1	245
Priority 2	248
Sync lower bound [ns]	30
UTC offset [s]	37
Sync upper bound [ns]	5000
UTC offset valid	<input checked="" type="checkbox"/>

Figure 4.2-8 Configuration RSPE35 time synchronization parameters (2/2)

■ Time division system

To activate the time division function, set "Switching" → "TSN" → "Configuration" → "Operation" to on. Check the "Active" box for ports that use the time division function. In addition, since each port can receive all types of communication, enter "0,6,7" for "Default gate states".

The screenshot shows the Hirschmann TSN Configuration web interface. The 'Operation' section is set to 'On'. The table below shows the configuration for three ports (1/1, 1/2, 1/3). Red callout boxes highlight the 'Active' checkbox, the 'Default gate states' field containing '0, 6, 7', and the 'Operation' radio button. Text boxes provide instructions: 'Check the port using the division function.' and 'Enter "0, 6, 7" at the port using the time division function.'

Port	Active	Default gate states	Port state	Cyclo time [ns]		Base time			Time of last activation	
				Configured	Current	Date	Time	[ns]		Current
1/1	<input checked="" type="checkbox"/>	0, 6, 7	running	1,000,000	1,000,000	Friday, January 1, 2016	12:00:00 AM	0	Jan 1, 2016, 12:00:00 AM 0 ns	Dec 4, 2019, 9:16:33 AM 447000006 ns
1/2	<input checked="" type="checkbox"/>	0, 6, 7	running	1,000,000	1,000,000	Friday, January 1, 2016	12:00:00 AM	0	Jan 1, 2016, 12:00:00 AM 0 ns	Dec 4, 2019, 9:16:33 AM 497000006 ns
1/3	<input checked="" type="checkbox"/>	0, 6, 7	running	1,000,000	1,000,000	Friday, January 1, 2016	12:00:00 AM	0	Jan 1, 2016, 12:00:00 AM 0 ns	Dec 4, 2019, 9:16:33 AM 547000003 ns

Figure 4.2-9 RSPE35 time division configuration

■Connecting devices

You must set the type of device connected to each port. Enter 7 if a CC-Link IE TSN device is connected, and enter 0 if a PC or other device that performs IP communication is connected, in "Port priority" of "Switching" → "QoS/Priority" → "Port Configuration". If nothing is connected, also enter 0.

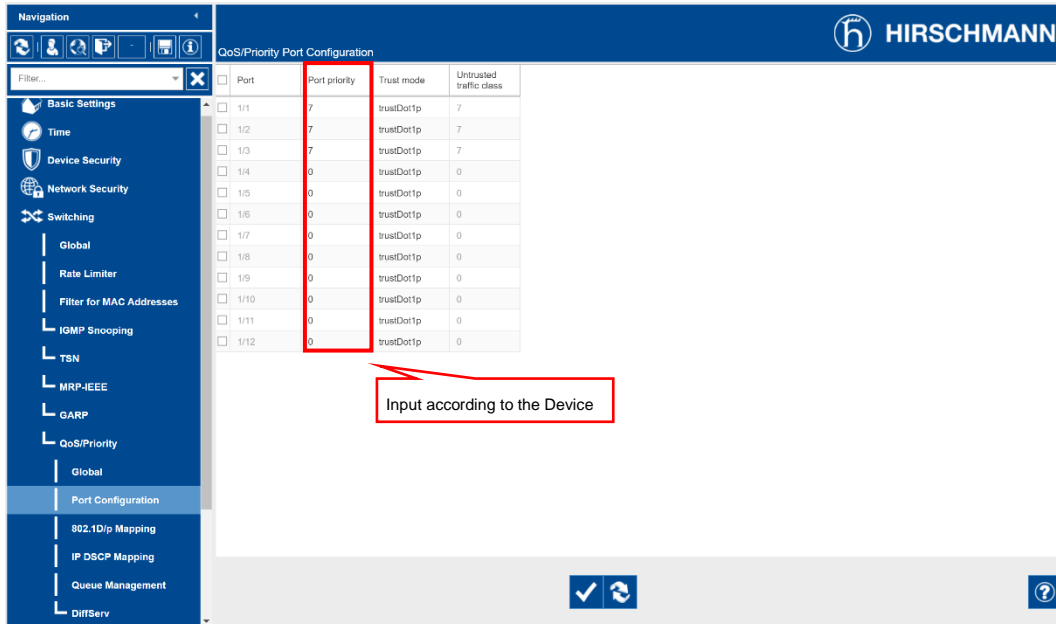


Figure 4.2-10 Configuring RSPE35 attached devices (1/2)

In addition, for "Switching" → "QoS/Priority" → "802.1 D/p Mapping" follow Figure 4.2-11.

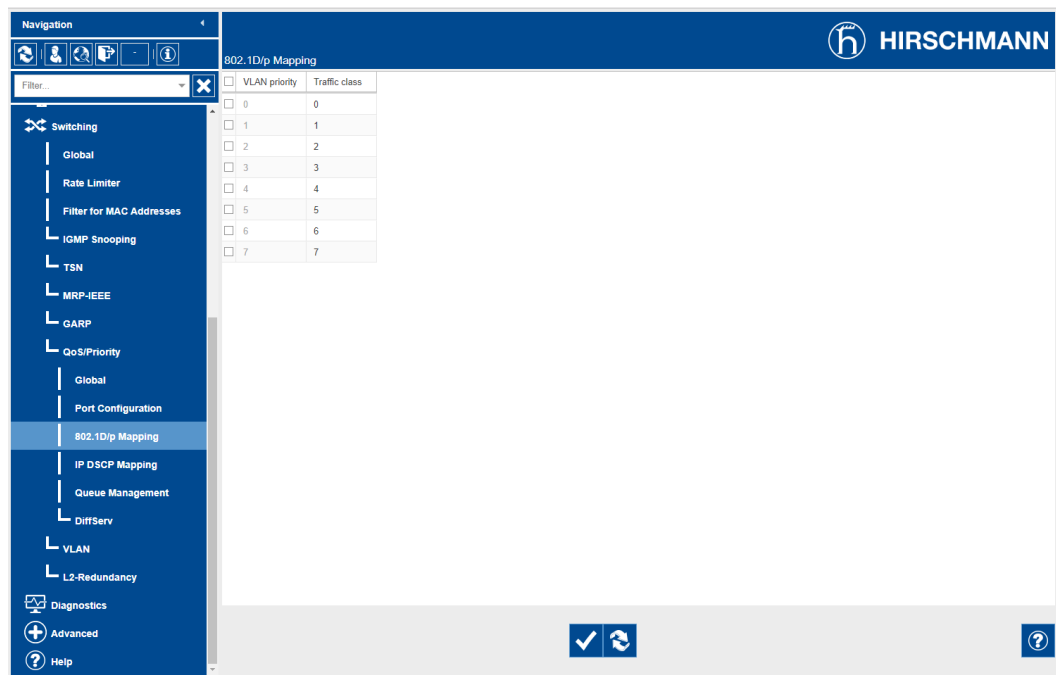


Figure 4.2-11 Configuring RSPE35 attached devices (2/2)

■ Unnecessary Traffic Class

“Switching”→”TSN”→”SDU” needs to be set as Figure 4.2-12. During this time, port 1, 2, 3 needs to have identical configuration.

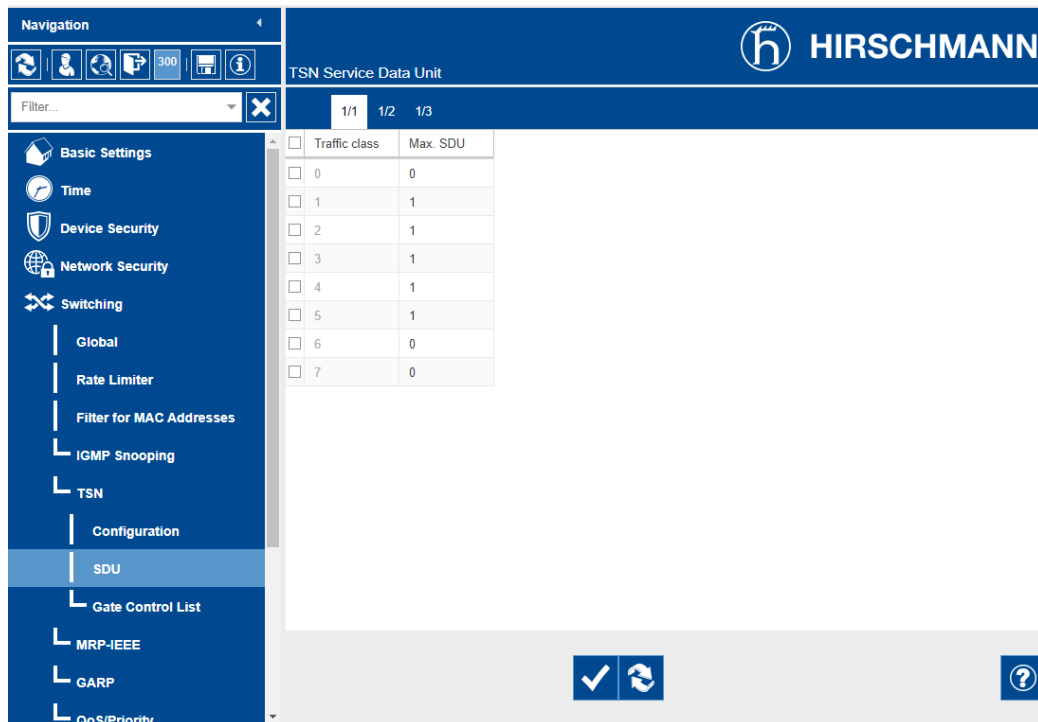


Figure 4.2-12 RSPE35 configuring unnecessary traffic classes

4.3. Configuration of Mitsubishi RJ71GN11-T2

Time synchronization method, communication cycle and time slot configuration are configured by module parameters of the GX Works 3 engineering tool.

RJ71FN11-T2 module parameter explained from below can be accessed by double clicking "RJ71GN11-T2" under "Navigation"-> "Parameter"-> "Module information" in GX Works3.

Also Authentication Class in the GX Works 3 is same as certification class explained above.

■Time synchronization system

Select "Authentication Class B Only" for "Authentication Class Setting" under "RJ71GN11-T2 Module Parameters" → "Connection Device Information" → "Authentication Class Setting"

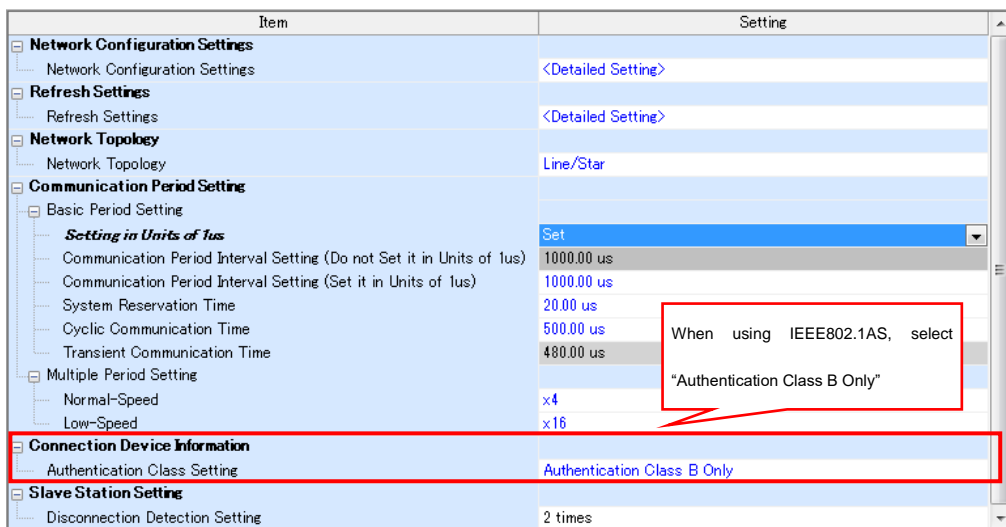


Figure 4.3-1 RJ71GN11-T2 set time synchronization method

■Communication cycle

Enter "1000 μs" corresponding to the 1ms cycle used in this system under the configuration of "RJ71GN11-T2 Module Parameters" → "Communication Period Setting" → "Basic Period Setting" → "Communication Period Interval Setting (Set it in Units of 1μs)".

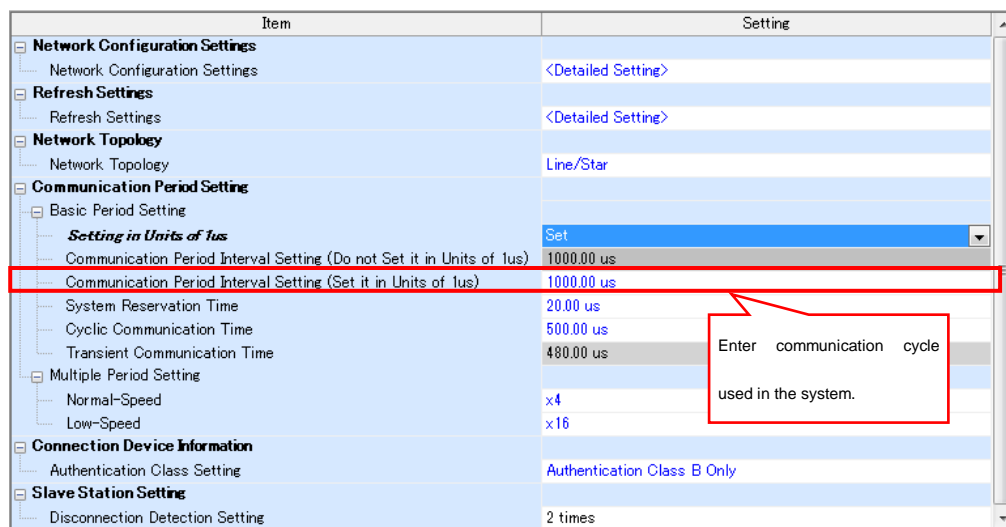


Figure 4.3-2 Configuration the RJ71GN11-T2 communication frequency

■ Time slot

Enter "System Reservation Time" and "Cyclic Communication Time" under "RJ71GN11-T2 Module Parameters" → "Communication Period Setting" → "Basic Period Setting". The system reservation time is automatically applied to TSLT2 and the cyclic communication time is automatically applied to TSLT1. From the communication cycle and the above two settings, the transient communication field corresponding to TSLT0 is automatically entered.

Item	Setting
Network Configuration Settings	<Detailed Setting>
Refresh Settings	<Detailed Setting>
Network Topology	Line/Star
Communication Period Setting	
Basic Period Setting	
<i>Setting in Units of 1us</i>	Set
Communication Period Interval Setting (Do not Set it in Units of 1us)	1000.00 us
Communication Period Interval Setting (Set it in Units of 1us)	1000.00 us
System Reservation Time	20.00 us
Cyclic Communication Time	500.00 us
Transient Communication Time	480.00 us
Multiple Period Setting	
Normal-Speed	x4
Low-Speed	x16
Connection Device Information	
Authentication Class Setting	Authentication Cl
Slave Station Setting	
Disconnection Detection Setting	2 times

Corresponds to TSLT2, TSLT1, and TSLT0, from top to bottom

Figure 4.3-3 RJ71GN11-T2 timeslot configurations

5. Troubleshooting

5.1. Situation

Incorrect configuration or connections may detect the following symptoms from RJ71GN11-T2.

- Data link not Starting/Slow
- Node detects an error
- Nodes are disconnected
- Time out of sync occurs

5.2. Remedies

5.1 If symptoms appear, check the product documentation and take the following actions:

Items to check	Devices	Response
Wiring	All	Check if only a 1 Gbps station is connected to a 100 Mbps port.
	All	Check if a TSN device is connected to a port that does not have TSN enabled.
	RSPE35	Check if there is a loop connection in the system.
Time synchronization configurations	All	Verify that the time synchronization method is enabled.
	All	Check if the time synchronization method is set to the same one in the system.
	RSPE35	Verify that the time synchronization parameter is set correctly.
Time division configurations	All	Check if the time division function is enabled (Entire device, per port).
	All	Confirm that the cyclic communication is consistent in the system.
	All	Ensure timeslot times are consistent across systems.
	All	The time slot verifies that the transmission delay of the RSPE35 is taken into account.
	RSPE35	Verify Gate states are set correctly.
	RSPE35	Check if the guard band is set for Port 3 only.
	RSPE35	Verify that the priority is set correctly for each port.
	RSPE35	Verify that the 802.1 D/p mapping is configured correctly.
Others	All	Check for duplicate IP addresses in the system.

6. Limitations

- The TSN feature is only available on ports 1, 2 and 3 on the RSPE35.
- Only 3(not 8) time slots are available on RJ71GN11-T2 systems.

7. Related documents

- CC-Link IE TSN Specification(BAP-C2011ENG-001 to 006)
- CC-Link IE TSN Installation Manual(BAP-C3007ENG-001-A)

CC-Link **ETS**N