CHINO KOREA

THYRISTOR REGULATOR

MODBUS Serial Master Driver

Supported version TOP Design Studio V1.4.2 or higher

CONTENTS

We want to thank our customers who use the Touch Operation Panel.

1. System configuration

The following driver is CHINO KOREA's "THYRISTOR REGULATOR"

Depending on the external device (MODBUS Slave Protocol supported), you may set the "command code", "protocol frame format" etc., of the driver separately. In this case, set the detailed settings according to the external device side based on the communication method.

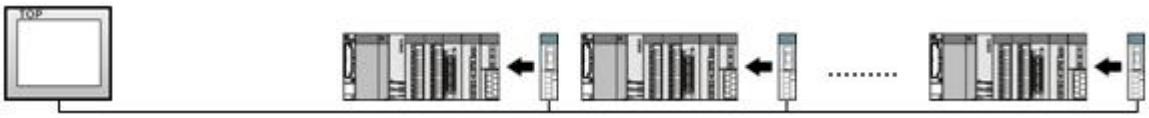
The system configuration with an external device supported by this driver is as follows:

Series	CPU	Link I/F	Communication method	System setting	Cable
THYRISTOR REGULATOR			RS-232C	3.1 Settings example 1 (Page 4)	5.1. Cable table 1 Page 10
			RS-422 (4 wire)	3.2 Settings example 2 (Page 5)	5.2. Cable table 2 (Page 11)
			RS-485 (2 wire)	3.3 Settings example 3 (Page 6)	5.3. Cable table 3 (Page 12)

■ Connection configuration M O D B U S

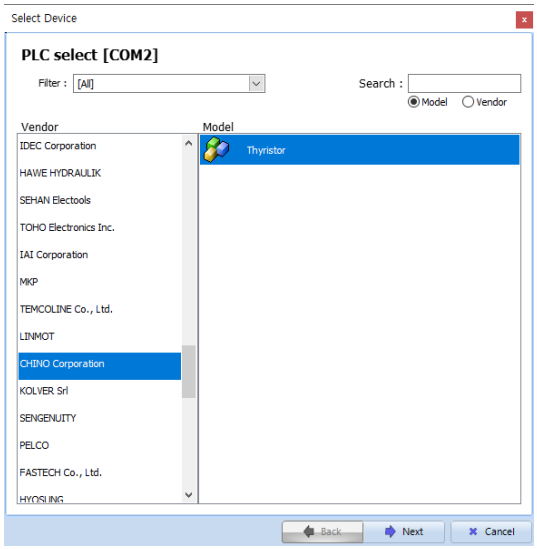
• 1:1 (one TOP and one external device) connection – configuration which is possible in RS232C/422/485 communication.

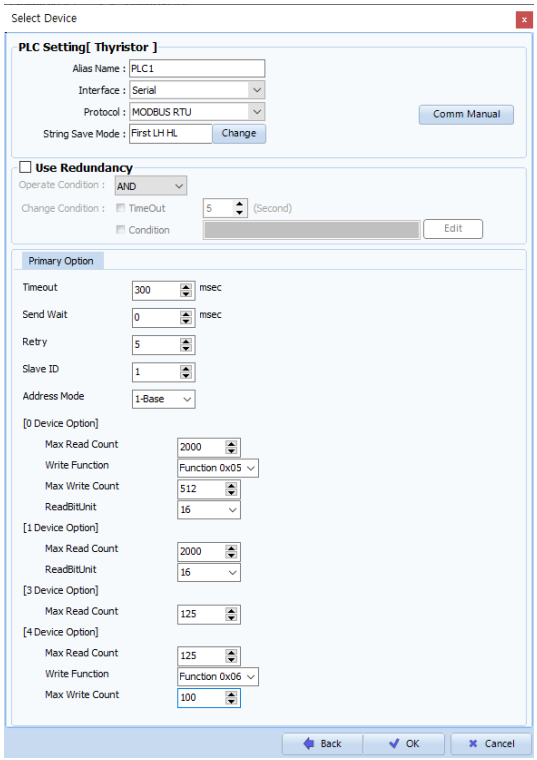
• 1:N (one TOP and multiple external devices) connection – configuration which is possible in RS422/485 communication.



2. External device selection

■ Select a TOP model and a port, and then select an external device.





Settings		Contents
TOP	Model	Check the TOP display and process to select the touch model.
External device	Vendor	Select the vendor of the external device to be connected to TOP. Select "chino".
	PLC	Select an external device to connect to TOP.

Model	Interface	Protocol
THYRISTOR REGULATOR	Serial	Set Users

Supported Protocol	
MODBUS RTU	MODBUS ASCII

Please check the system configuration in Chapter 1 to see if the external device you want to connect is a model whose system can be configured.

3. TOP communication setting

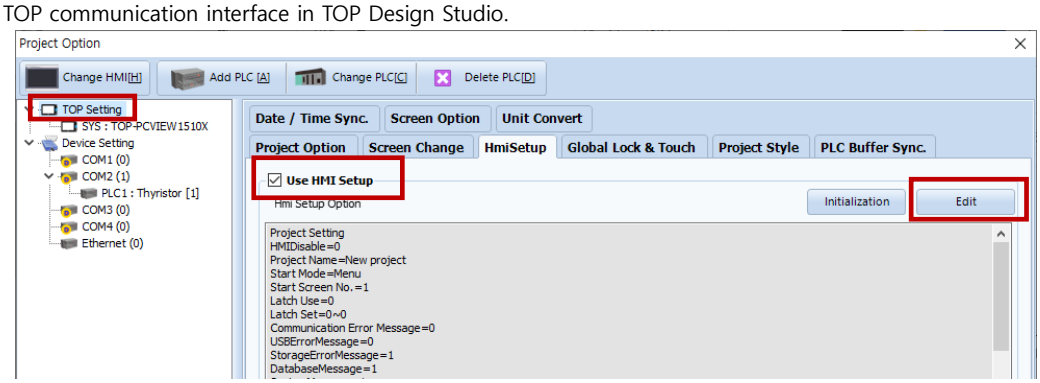
The communication can be set in TOP Design Studio or TOP main menu. The communication should be set in the same way as that of the external device.

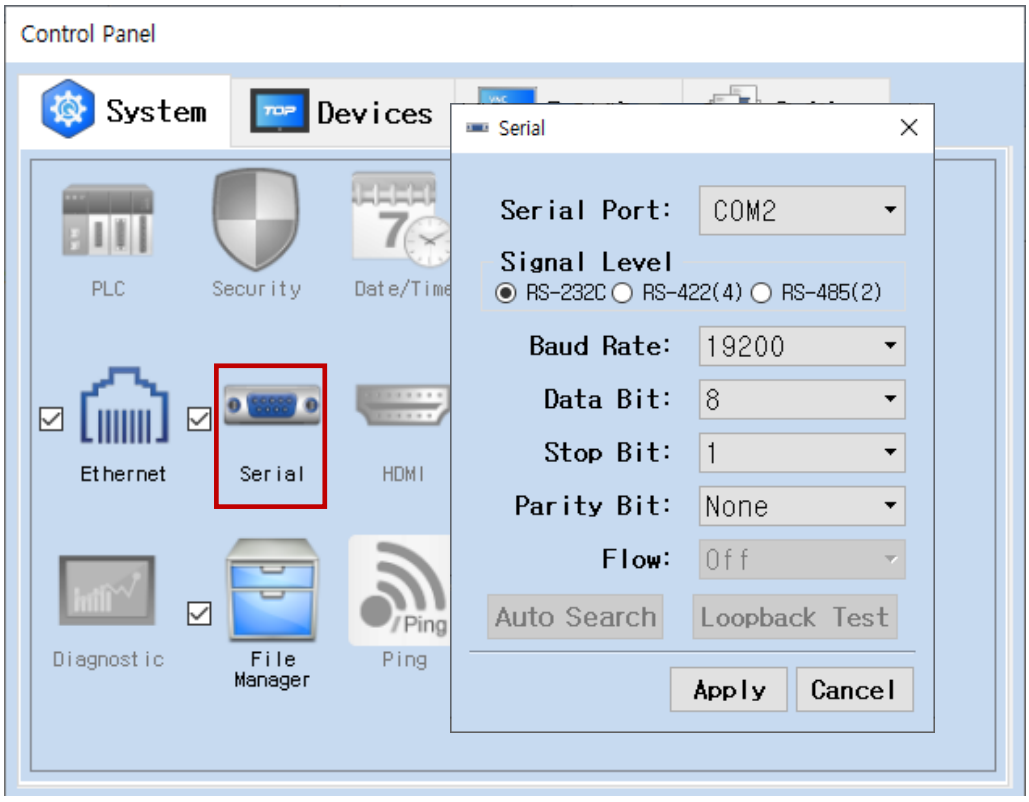
3.1 Communication setting in TOP Design Studio

(1) Communication interface setting

■ [Project > Project Property > TOP Setting] → [Project Option > "Use HMI Setup" Check > Edit > Serial]

– Set the TOP communication interface in TOP Design Studio.





Items	TOP	External device	Remarks
Signal Level (port)	RS-232C RS-422/485		
Baud Rate	19200		
Data Bit	8		
Stop Bit	1		
Parity Bit	None.		

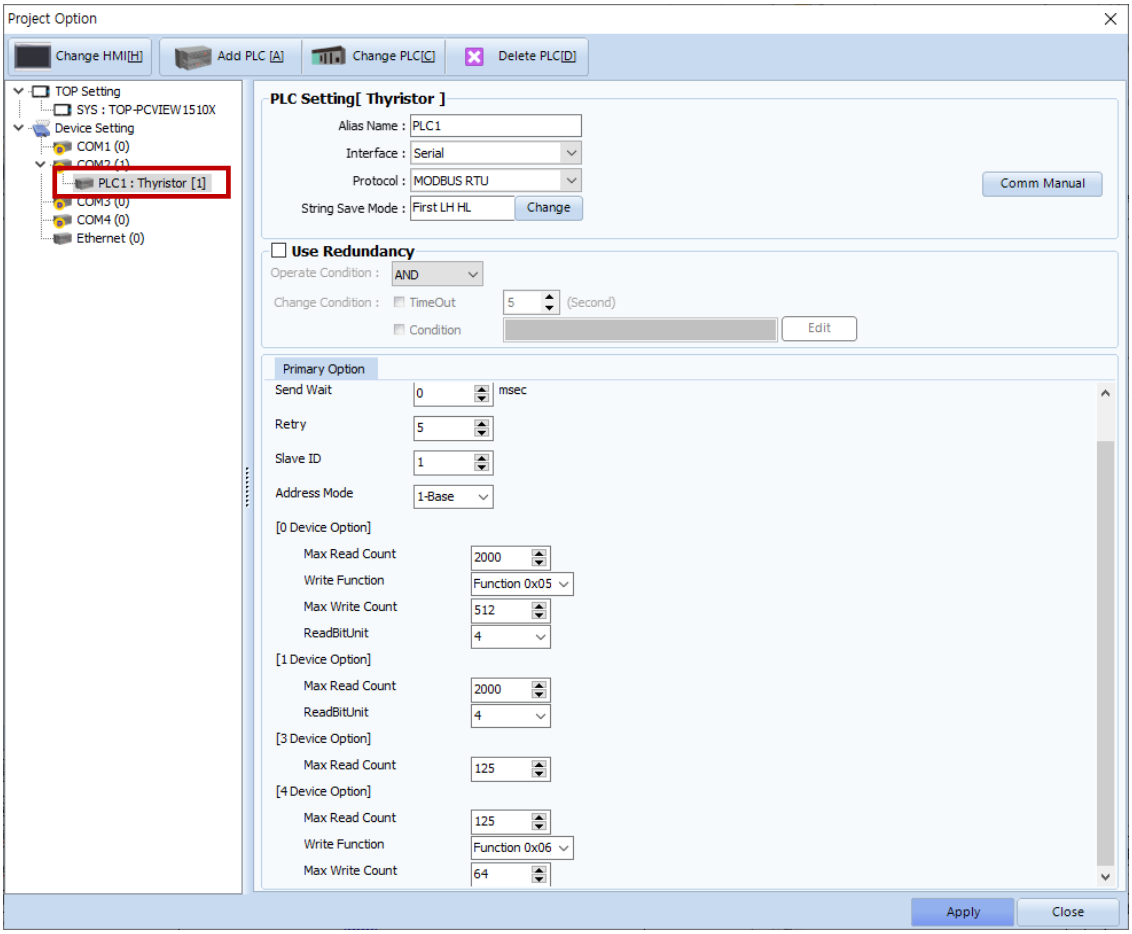
* The above settings are examples recommended by the company.

Items	Description
Signal Level	Select the serial communication method between the TOP and an external device.
Baud Rate	Select the serial communication speed between the TOP and an external device.
Data Bit	Select the serial communication data bit between the TOP and an external device.
Stop Bit	Select the serial communication stop bit between the TOP and an external device.
Parity Bit	Select the serial communication parity bit check method between the TOP and an external device.

(2) Communication option setting

■ [Project > Project Property > Device Setting > COM > "PLC1 : chino"]

– Set the options of the THYRISTOR REGULATOR communication driver in TOP Design Studio.

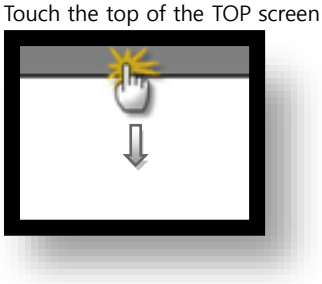


Items	Settings	Remarks
Interface	Select "Serial".	Refer to "2. External device selection".
Protocol	Select the communication protocol between the TOP and an external device.	
TimeOut (ms)	Set the time for the TOP to wait for a response from an external device.	
SendWait (ms)	Set the waiting time between TOP's receiving a response from an external device and sending the next command request.	
Slave Equipment Address No	Enter the prefix number of an external device (Slave).	
Address Mode	Select the Address Mode. (1-base: "address-1" operation/0-base: no operation)	
[0 Device Option]		
Max Read Count	Set the maximum number of consecutive reads for the Coil.	
Write Function	Set the write command for the Coil. Force Single Coil : 05(Hex) / Force Multiple Coils : 0F(Hex)	
Max Write Count	Set the number of consecutive writes for the Coil.	
ReadBitUnit	Bit read amount(Cannot be configured from the main body)	
[1 Device Option]		
Max Read Count	Set the number of consecutive reads for the Discrete Input.	
ReadBitUnit	Bit read amount(Cannot be configured from the main body)	
[3 Device Option]		
Read Boundary	Set the number of consecutive reads for the Input Register.	
[4 Device Option]		
Max Read Count	Set the number of consecutive reads for the Holding Register.	
Write Function	Set the write command for the Holding Register. Preset Single Register : 06(Hex) / Preset Multiple Registers : 10(Hex)	
Max Write Count	Set the number of consecutive writes for the Holding Register.	

3.2. Communication setting in TOP

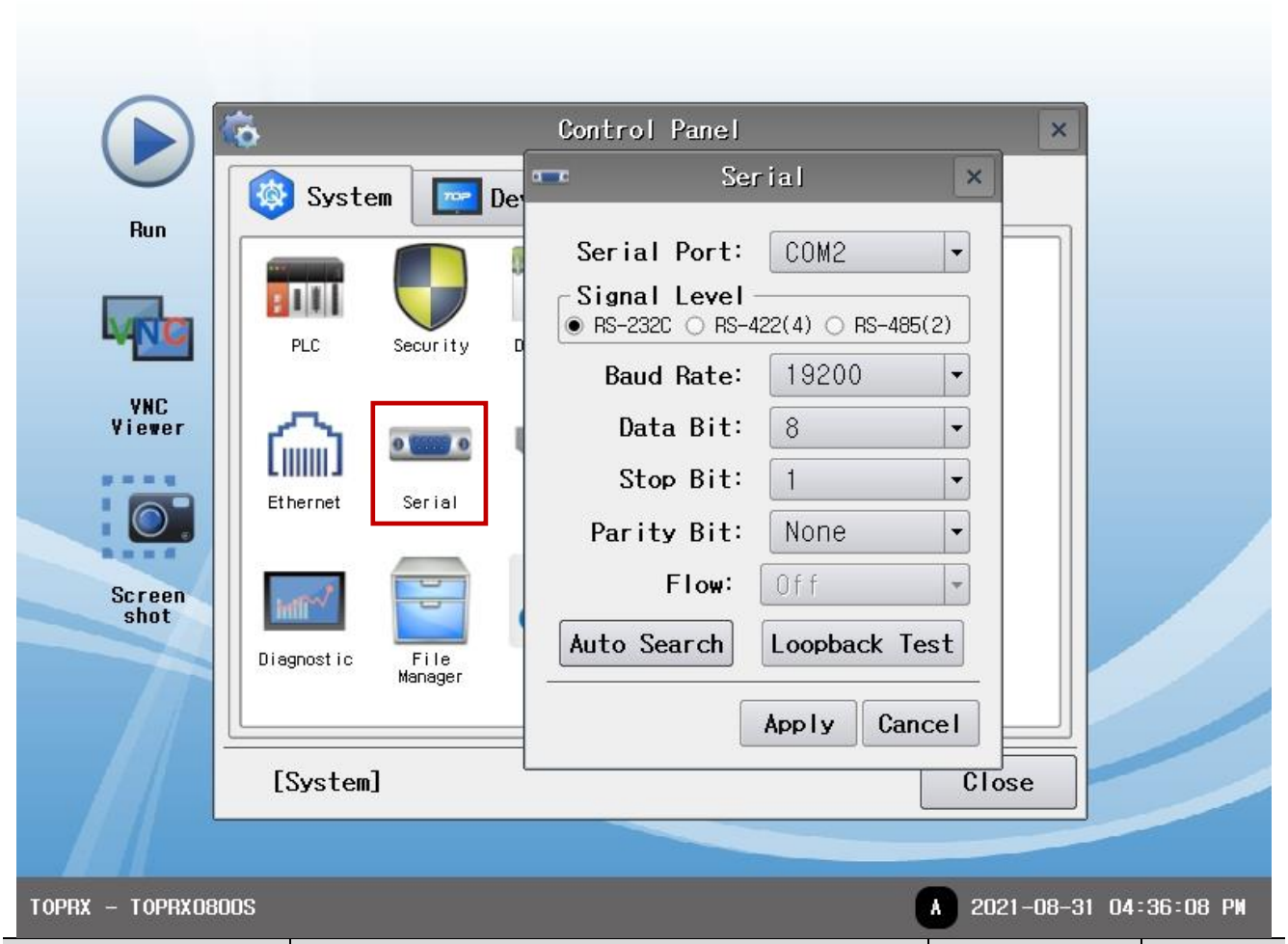
*** This is a setting method when "Use HMI Setup" in the setting items in "3.1 TOP Design Studio" is not checked.**

■ Touch the top of the TOP screen and drag it down. Touch "EXIT" in the pop-up window to go to the main screen.



(1) Communication interface setting

■ [Main Screen > Control Panel > Serial]



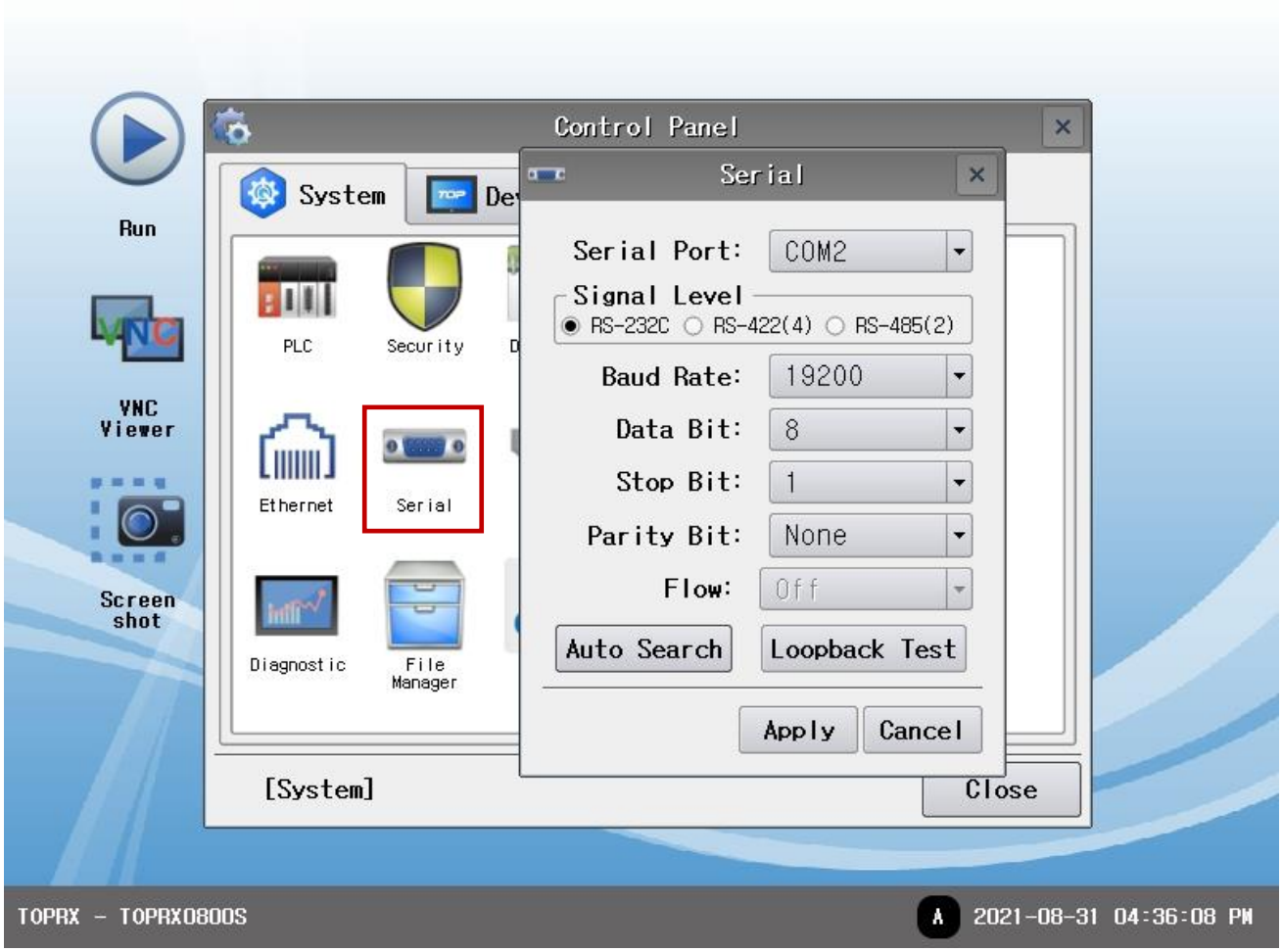
Items	TOP	External device	Remarks
Signal Level (port)	RS-232C RS-422/485		
Baud Rate	19200		
Data Bit	8		
Stop Bit	1		
Parity Bit	None.		

* The above settings are setting examples recommended by the company.

Items	Description
Signal Level	Select the serial communication method between the TOP and an external device.
Baud Rate	Select the serial communication speed between the TOP and an external device.
Data Bit	Select the serial communication data bit between the TOP and an external device.
Stop Bit	Select the serial communication stop bit between the TOP and an external device.
Parity Bit	Select the serial communication parity bit check method between the TOP and an external device.

(2) Communication option setting

■ [Main Screen > Control Panel > PLC]



Items	Settings	Remarks
Interface	Select "Serial".	Refer to "2. External device selection".
Protocol	Select the communication protocol between the TOP and an external device.	
TimeOut (ms)	Set the time for the TOP to wait for a response from an external device.	
SendWait (ms)	Set the waiting time between TOP's receiving a response from an external device and sending the next command request.	
Slave Equipment Address No	Enter the prefix number of an external device (Slave).	
Address Mode	Select the Address Mode. (1-base: "address-1" operation/0-base: no operation)	
[0 Device Option]		
Max Read Count	Set the maximum number of consecutive reads for the Coil.	
Write Function	Set the write command for the Coil. Force Single Coil : 05(Hex) / Force Multiple Coils : 0F(Hex)	
Max Write Count	Set the number of consecutive writes for the Coil.	
ReadBitUnit	Bit read amount(Cannot be configured from the main body)	
[1 Device Option]		
Max Read Count	Set the number of consecutive reads for the Discrete Input.	
ReadBitUnit	Bit read amount(Cannot be configured from the main body)	
[3 Device Option]		
Read Boundary	Set the number of consecutive reads for the Input Register.	
[4 Device Option]		
Max Read Count	Set the number of consecutive reads for the Holding Register.	
Write Function	Set the write command for the Holding Register. Preset Single Register : 06(Hex) / Preset Multiple Registers : 10(Hex)	
Max Write Count	Set the number of consecutive writes for the Holding Register.	

3.3 Communication diagnostics

■ Check the interface setting status between the TOP and an external device.

- Touch the top of the TOP screen and drag it down. Touch "EXIT" in the pop-up window to go to the main screen.
- Check if the COM port settings you want to use in [Control Panel > Serial] are the same as those of the external device.

■ Diagnosis of whether the port communication is normal or not

- Touch "Communication diagnostics" in [Control Panel > PLC].
- The Diagnostics dialog box pops up on the screen and determines the diagnostic status.

OK	**Communication setting normal**
Time Out Error	**Communication setting abnormal** - Check the cable, TOP, and external device setting status. **(Reference: Communication diagnostics sheet)**

■ Communication diagnostics sheet

- If there is a problem with the communication connection with an external terminal, please check the settings in the sheet below.

Items	Contents		Check		Remarks
System configuration	How to connect the system		OK	NG	1. System configuration
	Connection cable name		OK	NG	
TOP	Version information		OK	NG	2. External device selection 3. Communication setting
	Port in use		OK	NG	
	Driver name		OK	NG	
	Other detailed settings		OK	NG	
	Relative prefix	Project setting	OK	NG	
		Communication diagnostics	OK	NG	
	Serial Parameter	Transmission Speed	OK	NG	
		Data Bit	OK	NG	
		Stop Bit	OK	NG	
		Parity Bit	OK	NG	
External device	CPU name		OK	NG	4. External device setting
	Communication port name (module name)		OK	NG	
	Protocol (mode)		OK	NG	
	Setup Prefix		OK	NG	
	Other detailed settings		OK	NG	
	Serial Parameter	Transmission Speed	OK	NG	
		Data Bit	OK	NG	
		Stop Bit	OK	NG	
		Parity Bit	OK	NG	
	Check address range		OK	NG	6. Supported addresses (For details, please refer to the PLC vendor's manual.)

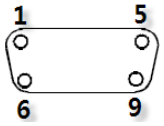
4. External device setting

Refer to the vendor's user manual to identically configure the communication settings of the external device to that of the TOP.

5. Cable table

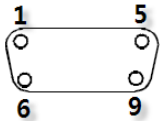
This chapter introduces a cable diagram for normal communication between the TOP and the corresponding device.
(The cable diagrams described in this section may differ from the external device vendor's recommendations.)

■ **RS-232C** (1:1 connection)

TOP			Cable connection	External device	
Pin arrangement*Note 1)	Signal name	Pin number		Signal name	
 Based on communication cable connector front, D-SUB 9 Pin male (male, convex)	CD	1			
	RD	2		SD	
	SD	3		RD	
	DTR	4		DTR	
	SG	5		SG	
	DSR	6		DSR	
	RTS	7		RTS	
	CTS	8		CTS	
		9			

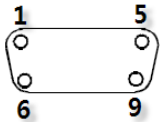
*Note 1) The pin arrangement is as seen from the connecting side of the cable connection connector.

■ **RS-422** (1:1 connection)

TOP			Cable connection	External device	
Pin arrangement*Note 1)	Signal name	Pin number		Signal name	
 Based on communication cable connector front, D-SUB 9 Pin male (male, convex)	RDA(+)	1		SDA(+)	
		2		SDB(-)	
		3		RDA(+)	
	RDB(-)	4		RDB(-)	
	SG	5		SG	
	SDA(+)	6			
		7			
		8			
	SDB(-)	9			

*Note 1) The pin arrangement is as seen from the connecting side of the cable connection connector.

■ **RS-485** (1:1 connection)

TOP			Cable connection	External device	
Pin arrangement*Note 1)	Signal name	Pin number		Signal name	
 Based on communication cable connector front, D-SUB 9 Pin male (male, convex)	RDA(+)	1		SDA(+)	
		2		SDB(-)	
		3		RDA(+)	
	RDB(-)	4		RDB(-)	
	SG	5		SG	
	SDA(+)	6			
		7			
		8			
	SDB(-)	9			

*Note 1) The pin arrangement is as seen from the connecting side of the cable connection connector.

☞ Continued on next page.

■ **RS-485** (1:1 connection)

TOP		Cable connection	External device	
Pin arrangement	Signal name		Signal name	
	+		SDA(+)	
	-		SDB(-)	
	SG		RDA(+)	
			RDB(-)	
			SG	

■ **RS-422** (1:N connection) – Refer to 1:1 connection to connect in the following way.

TOP	Cable connection and signal direction	**External device**	Cable connection and signal direction	**External device**
Signal name		Signal name		Signal name
RDA(+)		SDA(+)		SDA(+)
RDB(-)		SDB(-)		SDB(-)
SDA(+)		RDA(+)		RDA(+)
SDB(-)		RDB(-)		RDB(-)
SG		SG		SG

■ **RS-485** (1:N/N:1 connection) – Refer to 1:1 connection to connect in the following way.

TOP	Cable connection and signal direction	**External device**	Cable connection and signal direction	**External device**
Signal name		Signal name		Signal name
RDA(+)		SDA(+)		SDA(+)
RDB(-)		SDB(-)		SDB(-)
SDA(+)		RDA(+)		RDA(+)
SDB(-)		RDB(-)		RDB(-)
SG		SG		SG

6. Supported addresses

The devices available in TOP are as follows:

The device range (address) may differ depending on the CPU module series/type. The TOP series supports the maximum address range used by the external device series. Please refer to each CPU module user manual and be take caution to not deviate from the address range supported by the device you want to use.

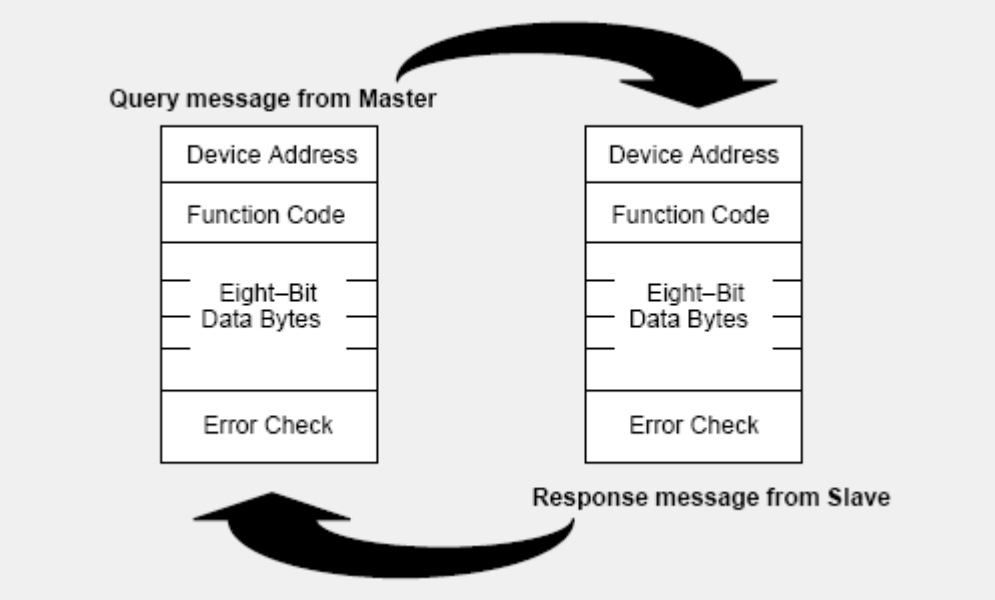
	Bit Address	Word Address	32 bits	Remarks
Coil	001001 – 065536	001001 – 065521	L/H	
Discrete Input	101001 – 165536	101001 – 165521		*Note 1)
Input Register	301101.00 – 365536.15	301101 – 365536		*Note 1)
Holding Register	401001.00 – 465536.15	401001 – 465536		

***Note 1)** Cannot be written (Read-only)

Appendix A. Standard MODBUS Protocol

Describes MODBUS protocol commands and devices supported by "MODBUS Serial Master Driver" of this device.

At the message level, the MODBUS protocol still applies the master–slave principle even though the network communication method is peer–to–peer. If a controller originates a message, it does so as a master device, and expects a response from a slave device. Similarly, when a controller receives a message it constructs a slave response and returns it to the originating controller.



The Query: The function code in the query tells the addressed slave device what kind of action to perform. The data bytes contain any additional information that the slave will need to perform the function. For example, function code 03 will query the slave to read holding registers and respond with their contents. The data field must contain the information telling the slave which register to start at and how many registers to read. The error check field provides a method for the slave to validate the integrity of the message contents.

The Response: If the slave makes a normal response, the function code in the response is an echo of the function code in the query. The data bytes contain the data collected by the slave, such as register values or status. If an error occurs, the function code is modified to indicate that the response is an error response, and the data bytes contain a code that describes the error. The error check field allows the master to confirm that the message contents are valid.

Read Single Coil : 01

Describes "01" command frame through the example where "**0**00020–**0**00056 Coil" data of the Slave device side (prefix: 17) is read from the MASTER device.

■ RTU Mode

(Master → Slave: request frame)

Comment	Slave prefix	Command	Leading device		Device score		Check code (CRC)	
			H	L	H	L	L	H
Hex	11	01	00	13	00	25	—	—

(Slave → Master: response frame)

Comment	Slave prefix	Command	Number of data (bytes)	Data					Check code (CRC)	
				Coils 27~20	Coils 35~28	Coils 43~36	Coils 51~44	Coils 56~52		
				L	–	–	–	H	L	H
Hex	11	01	05	CD	6B	B2	0E	1B	—	—

■ Coils data status

Coils	27	26	25	24	23	22	21	20
on/off	1	1	0	0	1	1	0	1
Coils	35	34	33	32	31	30	29	28
on/off	0	1	1	0	1	0	1	1
Coils	43	42	41	40	39	38	37	36
on/off	1	0	1	1	0	0	1	0
Coils	51	50	49	48	47	46	45	44
on/off	0	0	0	0	1	1	1	0
Coils	59	58	57	56	55	54	53	52
on/off	–	–	–	1	1	0	1	1

0: OFF / 1:ON

■ ASCII Mode

(Master → Slave: request frame)

comment	Header	Slave prefix		Command		Leading device				Device score				Check code (LRC)		Tail	
		H	L	H	L	H	–	–	L	H	–	–	L	L	H		
ASCII	:	1	1	0	1	0	0	1	3	0	0	2	5			CR	LF
Hex	3A	31	31	30	31	30	30	31	33	30	30	32	35	—	—	0D	0A

(Slave → Master: response frame)

Comment	Header	Slave prefix		Command		Number of data (bytes)		Data										Check code (LRC)		Tail	
								Coils 27~20		Coils 35~28		Coils 43~36		Coils 51~44		Coils 56~52					
								H	L	H	L	H	L	H	L	H	L	L	H		
ASCII	:	1	1	0	1	0	5	C	D	6	B	B	2	0	E	1	B			CR	LF
Hex	3A	31	31	30	31	30	35	43	44	36	42	42	32	30	45	31	42	—	—	0D	0A

Force Single Coil : 05

Describes "05" command frame through an example where FORCE "ON" is done on Coil 000173 of the Slave device side in the MASTER device.

■ RTU Mode

(Master → Slave: request frame)

Comment	Slave prefix	Command	Leading device		Force data		Check code (CRC)	
			H	L	H	L	L	H
Hex	11	05	00	AC	FF	00	—	—

■ Force Data

	High	Low
Force ON	FF_H	00_H
Force OFF	00_H	00_H

(Slave → Master: response frame)

Comment	Slave prefix	Command	Leading device		Force data		Check code (CRC)	
			H	L	H	L	L	H
Hex	11	05	00	AC	FF	00	—	—

■ ASCII Mode

(Master → Slave: request frame)

comment	Header	Slave prefix		Command		Leading device				Force data				Check code (LRC)		Tail	
		H	L	H	L	H	–	–	L	H	–	–	L	L	H		
ASCII	:	1	1	0	5	0	0	1	3	0	0	2	5			CR	LF
Hex	3A	31	31	30	31	30	30	41	43	45	45	30	30	—	—	0D	0A

(Slave → Master: response frame)

comment	Header	Slave prefix		Command		Leading device				Force data				Check code (LRC)		Tail	
		H	L	H	L	H	–	–	L	H	–	–	L	L	H		
ASCII	:	1	1	0	5	0	0	1	3	0	0	2	5			CR	LF
Hex	3A	31	31	30	31	30	30	41	43	45	45	30	30	—	—	0D	0A

Read Input Status : 02

Describes "02" command frame through an example where "**1**00197–**1**00218 Input" data of the Slave device side (prefix: 17) is read from the MASTER device.

■ RTU Mode

(Master → Slave: request frame)

Comment	Slave prefix	Command	Leading device		Device score		Check code (CRC)	
			H	L	H	L	L	H
Hex	11	02	00	C4	00	16	—	—

(Slave → Master: response frame)

Comment	Slave prefix	Command	Number of data	Data (Inputs)			Check code (CRC)	
				10204~10197	10212~10205	10218~10213	L	H
Hex	11	02	03	AC	DB	35	—	—

■ Coils data status

Coils	204	203	202	201	200	199	198	197
on/off	1	0	1	0	1	1	0	0
Coils	212	211	210	209	208	207	206	205
on/off	1	1	0	1	1	0	1	1
Coils	220	219	218	217	216	215	214	213
on/off	–	–	1	1	0	1	0	1

0: OFF / 1:ON

■ ASCII Mode

(Master → Slave: request frame)

comment	Header	Slave prefix		Command		Leading device				Device score				Check code (LRC)		Tail	
		H	L	H	L	H	–	–	L	H	–	–	L	L	H		
ASCII	:	1	1	0	2	0	0	C	4	0	0	1	6			CR	LF
Hex	3A	31	31	30	32	30	30	43	34	30	30	31	36	—	—	0D	0A

(Slave → Master: response frame)

Comment	Header	Slave prefix		Command		Number of data (bytes)		Data (Inputs)						Check code (LRC)		Tail	
								10204~10197		10212~10205		10218~10213					
								H	L	H	L	H	L	L	H		
ASCII	:	1	1	0	2	0	3	A	C	D	B	3	5			CR	LF
Hex	3A	31	31	30	31	30	35	41	43	44	42	33	35	—	—	0D	0A

Read Input Registers : 04

Describes "03" command frame through an example where "**3**00009 Register" data of the Slave device side (prefix: 17) is read from the MASTER device.

■ RTU Mode

(Master → Slave: request frame)

Comment	Slave prefix	Command	Leading device		Device score (Word Count)		Check code (CRC)	
			H	L	H	L	L	H
Hex	11	04	00	08	00	01	—	—

(Slave → Master: response frame)

Comment	Slave prefix	Command	Number of data (bytes)	Data Register 30009		Check code (CRC)	
				H	L	L	H
Hex	11	04	02	00	0A	—	—

■ ASCII Mode

(Master → Slave: request frame)

comment	Header	Slave prefix		Command		Leading device				Device score (Word)				Check code (LRC)		Tail	
		H	L	H	L	H	–	–	L	H	–	–	L	L	H		
ASCII	:	1	1	0	1	0	0	0	8	0	0	0	1			CR	LF
Hex	3A	31	31	30	31	30	30	30	38	30	30	30	31	—	—	0D	0A

(Slave → Master: response frame)

Comment	Header	Slave prefix		Command		Number of data (bytes)		Data Register 40108				Check code (LRC)		Tail	
								H	–	–	L	L	H		
ASCII	:	1	1	0	4	0	2	0	0	0	A			CR	LF
Hex	3A	31	31	30	31	30	35	30	30	30	41	—	—	0D	0A

A.4 "4" Device (Holding Register)

Read Holding Registers : 03

Describes "03" command frame through an example where "**4**00108 – **4**00110 Register" data of the Slave device side (prefix: 17) is read from the MASTER device.

■ RTU Mode

(Master → Slave: request frame)

Comment	Slave prefix	Command	Leading device		Device score		Check code (CRC)	
			H	L	H	L	L	H
Hex	11	03	00	6B	00	03	—	—

(Slave → Master: response frame)

Comment	Slave prefix	Command	Number of data (bytes)	Data						Check code (CRC)	
				Register 40108		Register 40109		Register 40110			
				H	L	H	L	H	L	L	H
Hex	11	03	06	02	2B	00	00	00	64	—	—

■ ASCII Mode

(Master → Slave: request frame)

comment	Header	Slave prefix		Command		Leading device				Device score (Word)				Check code (LRC)		Tail	
		H	L	H	L	H	–	–	L	H	–	–	L	L	H		
ASCII	:	1	1	0	1	0	0	1	3	0	0	2	5			CR	LF
Hex	3A	31	31	30	31	30	30	31	33	30	30	32	35	—	—	0D	0A

(Slave → Master: response frame)

Comment	Header	Slave prefix		Command		Number of data (bytes)		Data												Check code (LRC)		Tail	
								Register 40108				Register 40109				Register 40110							
								H	–	–	L	H	–	–	L	H	–	–	L	L	H		
ASCII	:	1	1	0	3	0	6	0	2	2	B	0	0	0	0	0	0	6	4			CR	LF
Hex	3A	31	31	30	31	30	35	30	32	32	42	30	30	30	30	30	30	36	34	—	—	0D	0A

Preset Single Register : 06

Describes "06" command frame through an example where 00 03 (hex) data is entered in **4**00002 Register of the Slave device side .

■ RTU Mode

(Master → Slave: request frame)

Comment	Slave prefix	Command	Leading device		Preset data		Check code (CRC)	
			H	L	H	L	L	H
Hex	11	06	00	01	00	03	—	—

(Slave → Master: response frame)

Comment	Slave prefix	Command	Leading device		Preset data		Check code (CRC)	
			H	L	H	L	L	H
Hex	11	06	00	01	00	03	—	—

■ ASCII Mode

(Master → Slave: request frame)

comment	Header	Slave prefix		Command		Leading device				Preset data				Check code (LRC)		Tail	
		H	L	H	L	H	–	–	L	H	–	–	L	L	H		
ASCII	:	1	1	0	6	0	0	0	1	0	0	0	3			CR	LF
Hex	3A	31	31	30	36	30	30	30	31	30	30	30	33	—	—	0D	0A

(Slave → Master: response frame)

comment	Header	Slave prefix		Command		Leading device				Preset data				Check code (LRC)		Tail	
		H	L	H	L	H	–	–	L	H	–	–	L	L	H		
ASCII	:	1	1	0	6	0	0	0	1	0	0	0	3			CR	LF
Hex	3A	31	31	30	36	30	30	30	31	30	30	30	33	—	—	0D	0A

Preset Multiple Register : 10

Describes "10" command frame through an example where two consecutive data, "00 0A (hex)", "01 02 (hex)" are entered in **4**00002 Register of the Slave device side. (Error Code : 90_H)

■ RTU Mode

(Master → Slave: request frame)

Comment	Slave prefix	Command	Leading device		Quantity of Register (Word Count)		Number of data (bytes)	Data				Check code (CRC)	
								Register 40002		Register 40003			
			H	L	H	L		H	L	H	L	L	H
Hex	11	10	00	01	00	02	04	00	0A	01	02	—	—

(Slave → Master: response frame)

Comment	Slave prefix	Command	Leading device		Quantity of Register (Word Count)		Check code (CRC)	
			H	L	H	L	L	H
Hex	11	10	00	01	00	02	—	—

■ ASCII Mode

(Master → Slave: request frame)

comment	Header	Slave prefix		Command		Leading device				Quantity of Register (Word Count)				Number of data (bytes)		Data							
																Register 40002				Register 40003			
		H	L	H	L	H	–	–	L	H	–	–	L	–	L	H	–	–	L	H	–	–	L
ASCII	:	1	1	1	0	0	0	0	1	0	0	0	2	0	4	0	0	0	A	0	1	0	2
Hex	3A	31	31	31	30	30	30	41	43	30	30	30	32	30	34	30	30	30	41	30	31	30	32

Continued

...

Check code (LRC)		Tail	
L	H		
		CR	LF
—	—	0D	0A

(Slave → Master: response frame)

comment	Header	Slave prefix		Command		Leading device				Quantity of Register (Word Count)				Check code (LRC)		Tail	
		H	L	H	L	H	–	–	L	H	–	–	L	L	H		
ASCII	:	1	1	1	0	0	0	0	1	0	0	0	2			CR	LF
Hex	3A	31	31	30	31	30	30	30	31	30	30	30	32	—	—	0D	0A

A.5 LRC/CRC Generation

(1) LRC Generation

The Longitudinal Redundancy Check (LRC) field is one byte, containing an 8–bit binary value. The LRC value is calculated by the transmitting device, which appends the LRC to the message. The receiving device recalculates an LRC during receipt of the message, and compares the calculated value to the actual value it received in the LRC field. If the two values are not equal, an error results.

The LRC is calculated by adding together successive 8–bit bytes in the message, discarding any carries, and then two's complementing the result. The LRC is an 8–bit field, therefore each new addition of a character that would result in a value higher than 255 decimal simply 'rolls over' the field's value through zero. Because there is no ninth bit, the carry is discarded automatically.

A procedure for generating an LRC is:

1. Add all bytes in the message, excluding the starting 'colon' and ending CRLF. Add them into an 8–bit field, so that carries will be discarded.
2. Subtract the final field value from FF hex (all 1's), to produce the ones–complement.
3. Add 1 to produce the twos–complement.

– Placing the LRC into the Message

When the 8–bit LRC (2 ASCII characters) is transmitted in the message, the high–order character will be transmitted first, followed by the low–order character.

For example, if the LRC value is 61 hex (0110 0001):

Colon	Addr	Func	Data Count	Data	Data	Data	Data	LRC Hi	LRC Lo	CR	LF
								6	1		

– Example

An example of a C language function performing LRC generation is shown below.

The function takes two arguments:

```
unsigned char *auchMsg ;          // A pointer to the message buffer containing
                                  // binary data to be used for generating the LRC
unsigned short usDataLen ;        // The quantity of bytes in the message buffer.
```

The function returns the LRC as a type unsigned char.

– LRC Generation Function

```
static unsigned char LRC(auchMsg, usDataLen)
unsigned char *auchMsg ;          /* message to calculate LRC upon */
unsigned short usDataLen ;        /* quantity of bytes in message */
{
    unsigned char uchLRC = 0 ;    /* LRC char initialized */
    while (usDataLen—)            /* pass through message buffer */
    uchLRC += *auchMsg++ ;        /* add buffer byte without carry */
    return ((unsigned char)(–((char)uchLRC))) ;   /* return twos complement */
}
```

(2) CRC Generation

The Cyclical Redundancy Check (CRC) field is two bytes, containing a 16–bit binary value. The CRC value is calculated by the transmitting device, which appends the CRC to the message. The receiving device recalculates a CRC during receipt of the message, and compares the calculated value to the actual value it received in the CRC field. If the two values are not equal, an error results.

The CRC is started by first preloading a 16–bit register to all 1's. Then a process begins of applying successive 8–bit bytes of the message to the current contents of the register. Only the eight bits of data in each character are used for generating the CRC. Start and stop bits, and the parity bit, do not apply to the CRC.

During generation of the CRC, each 8–bit character is exclusive ORed with the register contents. Then the result is shifted in the direction of the least significant bit (LSB), with a zero filled into the most significant bit (MSB) position. The LSB is extracted and examined. If the LSB was a 1, the register is then exclusive ORed with a preset, fixed value. If the LSB was a 0, no exclusive OR takes place.

This process is repeated until eight shifts have been performed. After the last (eighth) shift, the next 8–bit character is exclusive ORed with the register's current value, and the process repeats for eight more shifts as described above. The final contents of the register, after all the characters of the message have been applied, is the CRC value.

A procedure for generating a CRC is:

1. Load a 16–bit register with FFFF hex (all 1's). Call this the CRC register.
2. Exclusive OR the first 8–bit byte of the message with the low–order byte of the 16–bit CRC register, putting the result in the CRC register.
3. Shift the CRC register one bit to the right (toward the LSB), zero–filling the MSB. Extract and examine the LSB.
4. (If the LSB was 0): Repeat Step 3 (another shift). (If the LSB was 1): Exclusive OR the CRC register with the polynomial value A001 hex (1010 0000 0000 0001).
5. Repeat Steps 3 and 4 until 8 shifts have been performed. When this is done, a complete 8–bit byte will have been processed.
6. Repeat Steps 2 through 5 for the next 8–bit byte of the message. Continue doing this until all bytes have been processed.
7. The final contents of the CRC register is the CRC value.
8. When the CRC is placed into the message, its upper and lower bytes must be swapped as described below.

– Placing the CRC into the Message

When the 16–bit CRC (two 8–bit bytes) is transmitted in the message, the low-order byte will be transmitted first, followed by the high-order byte.

For example, if the CRC value is 1241 hex (0001 0010 0100 0001):

Addr	Func	Data Count	Data	Data	Data	Data	CR C_{Lo}	CR C_{Hi}
							41	12

– Example

An example of a C language function performing CRC generation is shown on the following pages. All of the possible CRC values are preloaded into two arrays, which are simply indexed as the function increments through the message buffer.

One array contains all of the 256 possible CRC values for the high byte of the 16–bit CRC field, and the other array contains all of the values for the low byte. Indexing the CRC in this way provides faster execution than would be achieved by calculating a new CRC value with each new character from the message buffer.

> **Note** This function performs the swapping of the high/low CRC bytes internally. The bytes are already swapped in the CRC value that is returned from the function. Therefore the CRC value returned from the function can be directly placed into the message for transmission.

The function takes two arguments:

```
unsigned char *puchMsg ;          //A pointer to the message buffer containing
                                  //binary data to be used for generating the CRC
unsigned short usDataLen ;        //The quantity of bytes in the message buffer.
```

The function returns the CRC as a type unsigned short.

– CRC Generation Function

```
unsigned short CRC16(puchMsg, usDataLen)
unsigned char *puchMsg ;                    /* message to calculate CRC upon */
unsigned short usDataLen ;                  /* quantity of bytes in message */
{
    unsigned char uchCRCHi = 0xFF ;         /* high byte of CRC initialized */
    unsigned char uchCRCLo = 0xFF ;         /* low byte of CRC initialized */
    unsigned uIndex ;                       /* will index into CRC lookup table */
    while (usDataLen—)                      /* pass through message buffer */
    {
        uIndex = uchCRCHi ^ *puchMsgg++ ;   /* calculate the CRC */
        uchCRCHi = uchCRCLo ^ auchCRCHi[uIndex} ;
        uchCRCLo = auchCRCLo[uIndex] ;
    }
    return (uchCRCHi << 8 | uchCRCLo) ;
}
```

– High-Order Byte Table

```
/* Table of CRC values for high–order byte */
static unsigned char auchCRCHi[ ] = {
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40,
0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40,
0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40,
0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40
} ;
```

– Low-Order Byte Table

```
/* Table of CRC values for low–order byte */
static char auchCRCLo[ ] = {
0x00, 0xC0, 0xC1, 0x01, 0xC3, 0x03, 0x02, 0xC2, 0xC6, 0x06, 0x07, 0xC7, 0x05, 0xC5, 0xC4, 0x04, 0xCC, 0x0C, 0x0D, 0xCD,
0x0F, 0xCF, 0xCE, 0x0E, 0x0A, 0xCA, 0xCB, 0x0B, 0xC9, 0x09, 0x08, 0xC8, 0xD8, 0x18, 0x19, 0xD9, 0x1B, 0xDB, 0xDA, 0x1A,
0x1E, 0xDE, 0xDF, 0x1F, 0xDD, 0x1D, 0x1C, 0xDC, 0x14, 0xD4, 0xD5, 0x15, 0xD7, 0x17, 0x16, 0xD6, 0xD2, 0x12, 0x13, 0xD3,
0x11, 0xD1, 0xD0, 0x10, 0xF0, 0x30, 0x31, 0xF1, 0x33, 0xF3, 0xF2, 0x32, 0x36, 0xF6, 0xF7, 0x37, 0xF5, 0x35, 0x34, 0xF4,
0x3C, 0xFC, 0xFD, 0x3D, 0xFF, 0x3F, 0x3E, 0xFE, 0xFA, 0x3A, 0x3B, 0xFB, 0x39, 0xF9, 0xF8, 0x38, 0x28, 0xE8, 0xE9, 0x29,
0xEB, 0x2B, 0x2A, 0xEA, 0xEE, 0x2E, 0x2F, 0xEF, 0x2D, 0xED, 0xEC, 0x2C, 0xE4, 0x24, 0x25, 0xE5, 0x27, 0xE7, 0xE6, 0x26,
0x22, 0xE2, 0xE3, 0x23, 0xE1, 0x21, 0x20, 0xE0, 0xA0, 0x60, 0x61, 0xA1, 0x63, 0xA3, 0xA2, 0x62, 0x66, 0xA6, 0xA7, 0x67,
0xA5, 0x65, 0x64, 0xA4, 0x6C, 0xAC, 0xAD, 0x6D, 0xAF, 0x6F, 0x6E, 0xAE, 0xAA, 0x6A, 0x6B, 0xAB, 0x69, 0xA9, 0xA8, 0x68,
0x78, 0xB8, 0xB9, 0x79, 0xBB, 0x7B, 0x7A, 0xBA, 0xBE, 0x7E, 0x7F, 0xBF, 0x7D, 0xBD, 0xBC, 0x7C, 0xB4, 0x74, 0x75, 0xB5,
0x77, 0xB7, 0xB6, 0x76, 0x72, 0xB2, 0xB3, 0x73, 0xB1, 0x71, 0x70, 0xB0, 0x50, 0x90, 0x91, 0x51, 0x93, 0x53, 0x52, 0x92,
0x96, 0x56, 0x57, 0x97, 0x55, 0x95, 0x94, 0x54, 0x9C, 0x5C, 0x5D, 0x9D, 0x5F, 0x9F, 0x9E, 0x5E, 0x5A, 0x9A, 0x9B, 0x5B,
0x99, 0x59, 0x58, 0x98, 0x88, 0x48, 0x49, 0x89, 0x4B, 0x8B, 0x8A, 0x4A, 0x4E, 0x8E, 0x8F, 0x4F, 0x8D, 0x4D, 0x4C, 0x8C,
0x44, 0x84, 0x85, 0x45, 0x87, 0x47, 0x46, 0x86, 0x82, 0x42, 0x43, 0x83, 0x41, 0x81, 0x80, 0x40
} ;
```