General Specifications

GC8000
Modbus Communication

GC8000

GS 11B08B02-01E

1. GENERAL

The Modbus protocol is used for DCS communication with the GC8000.

This communication protocol was first established for the Programmable Logic Controller (PLC) made by Gould, Inc., and is now used as a standard communication protocol between different systems.

In this specification we describe the Modbus communication as it is used for the GC8000.

For specifics on Modbus, please refer to the MEDICON document Modbus Protocol Reference Guide.

[Modbus Configuration]

Modbus was started as a method to allow a master device to control multiple slave devices. Each device with a device number is connected to the master device.

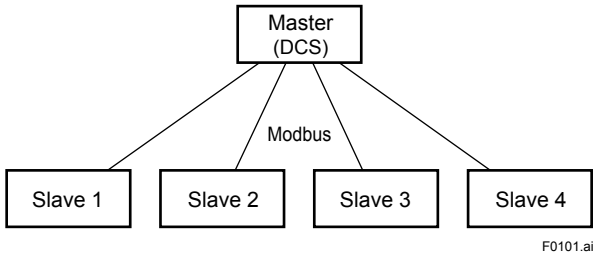

Figure 1.1 Modbus configuration

The master can send a query (i.e. poll) or command to a slave on a regular basis or when required. In either case, the master starts signal transmission and the slave responds.

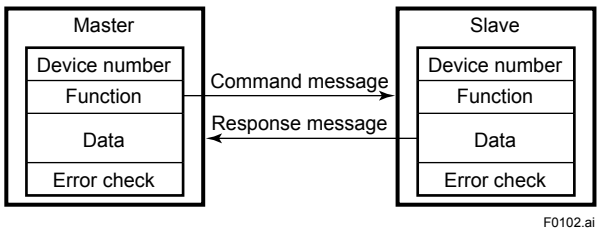

Figure 1.2 Master-slave command and response cycle

A message transmitted between devices contains the device number, function, data, and error check code. The function is encoded and depends on the message characteristics and data type.

The error check code checks the validity of the entire message.

2. Specifications

2.1 Communication Transmission Modes

There are two modes for signal transmission between the master and slave; RTU (Remote Terminal Unit) mode and ASCII mode.

GC8000 also supports Modbus/TCP.

[Communication]

Kind	Mode	Support Type
Serial communication	ASCII	Slave
	RTU	Slave
Ethernet	Modbus/TCP	Server

[Serial communication]

Item	ASCII mode	RTU mode
Number of data bits	7 bits (ASCII)	8 bits (binary)
Message starting character	Colon " : "	None
Message ending character	Carriage return/line feed "<cr><lf>"	None
Message length	2N+1	N
Time interval of data	1 second or shorter	24 bit-time or shorter
Error detection	LRC (logical redundancy check)	CRC-16 (cyclic redundancy check)

[Ethernet]

Item	TCP Mode
Protocol	Modbus/TCP
No. of Session	4 (Max.)
Port No.	502

2.2 Message Configuration

A message consists of four fields: device number, function, data and error check. It is always sent in this sequence.

Device number
Function
Data
Error check

In ASCII mode, a colon ":" is the starting character and carriage return/line feed "<cr><lf>" is the ending message string. The portion between the starting character and ending string is the message body. The communication message is entirely ASCII codes, i.e. the message excluding the starting character and ending string consists of "0" to "9" and "A" to "F" representing hexadecimal numbers.

In RTU mode, the message consists of binary codes and can be transmitted faster than in ASCII mode. Signal intervals of more than 24 bit-time in the transmission line, identify the start of a new message. In this system, the time-out is 10 ms regardless of the transmission speed.

In TCP mode, the foregoing message is displayed at an unique header (6 bite) of Modbus/TCP (Device No. is ignored).

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(1) Device number
The device number is user pre-assigned for each slave and ranges from 1 to 240. This number is the same as the Analyzer ID. The master performs signal transmission to each slave simultaneously.

Each slave checks the device number in the message to determine whether the received message is directed to the slave itself and if so, returns a response message.

(2) Functions
The master specifies the function to be executed by the slave. The GC8000 supports the following functions in the Modbus protocol.

Function No.	Function	Description
01	Coil status read	Reads the ON/OFF status of a series of coils.
02	Input relay status read.	Reads the ON/OFF status of a series of input relays.
03	Holding register content read.	Reads the current value of a series of holding registers.
04	Input register content read.	Reads the current value of a series of input registers.
05	Single coil status change	Forcibly changes the status of a coil.
06	Single holding register write	Writes a value to a holding register.
08	Loop back test	Sends back the same message as the command message.

(3) Data
There are two types of data “coil/relay” in bits and “register” in 16 bits. The coil uses two values (ON/OFF or 0/1), while the register ranges from 0 to 65535.
In the coil/relay, there is coil data that is both readable and writable from the master, and input relay contact data that is read-only. There are read/write data holding registers, read-only input registers, and write-only holding registers for real numeric data.

Data			Address	Max. read	Application
Bit	Coil	Read/write	0XXXX	800	Command
	Input relay	Read only	1XXXX	2000	Status
Register	Holding register	Read/write	4XXXX	100	Set value
	Input register	Read only	3XXXX	125	Measured value

xxxx: 0001 to 9999

(4) Error check
All messages are followed by an error check code to detect a Signal transmission error (i.e. bit changes). In ASCII mode, an error check code according to LRC (logical redundancy check) is used. In RTU mode, an error check code according to CRC-16 (cyclic redundancy check) is used.

2.3 Slave Response

When the slave receives a command from the master, it performs an error check of the command then sends back a normal response if the command message is normal, and an error response or no response if the command message is faulty.

(1) Normal response
For the single coil status change, single holding register write, and loop back function, the same message as the command message is sent back. As a response message, the read function returns the retrieved data appended to the device number and function code. If an address to which data is not allocated is read, an error is not generated but zero (0) is responded as the read data.

(2) Error response
If the command message is faulty, the slave does not execute the command but sends back an error response.

The master can check whether the command is accepted successfully by checking the function in the response message. If an error is identified, the details can be checked from the error code.

In addition, access to the data consisting of several registers will return an error unless the correct start address of data has been given. Therefore, the correct data boundary must be specified.

Device number
Error function (command function + 128)
Error code
Error check

Error code	Description
01	Function code error (non-existent function)
02	Address error of coil, input relay, or register (out of range)
03	Number error of coils, input relays, or registers (out of range)
04	An unrecoverable error occurred on the slave while the command message was being executed.
11	Set data error (out of range)

(3) No response
In the following cases, the slave ignores the command message and does not send back a response (no response).

1. When a transmission error (overrun, framing error, parity error or CRC error) is detected in the command message
2. When the device number in the command message does not match the slave number assigned to the slave

Note: The master should set a timer to watch the response from the slave, and re-send the same command or the message to the slave when the slave does not respond within the time set by the timer. We recommend 3 to 5 seconds for the timer.

3. Communication specifications

* Note: Components, wiring cables and construction materials are not supplied by us; these must be provided by the customer.

[Ethernet communications]

The GC8000 is equipped with Ethernet communication ports as standard.

Note: Once the connection of Modbus/TCP is established, be sure to keep it connected. Frequent connection/disconnection may cause an error in analyzer operation.

Connection type:
IEEE802.3U
100Base-TX (RJ-45 shielded twisted pair cable) or 100Base-FX (SC fiber-optic cable)
Channels: 1 or 2
Maximum length:
50 m (100Base-TX)
2 km (100Base-FX)

[Serial communications]

Up to two DCS communication ports are available for the GC8000 using an optional serial communication card.

Channels: 1 or 2
Communication standard:
RS-422
Transmission:
Full duplex (4-wire system)
Start-stop synchronization:
1 start bit, 7 data bits (ASCII)/8 data bits (RTU), 1 parity bit, 1 stop bit
Communication speed:
1200/2400/4800/9600/19200/38400 bps (selectable)
Parity check:
Odd /even /none (selectable)
Transmission mode:
ASCII mode/RTU mode
Maximum length: 1 km

4. System configuration

[Ethernet communications]

For using twisted pair cables, a rack-mounted type K9806AA signal interrupter (desktop type: K9806AB) is installed in the non-hazardous area.

This interrupter terminates communications automatically if the GC8000 becomes unable to maintain explosionproof conditions. In a hazardous area, the relevant parts must be mounted in a flameproof enclosure that has been certified by the relevant explosionproof inspection organization.

If fiber-optic cables are used, no signal interrupters are required.

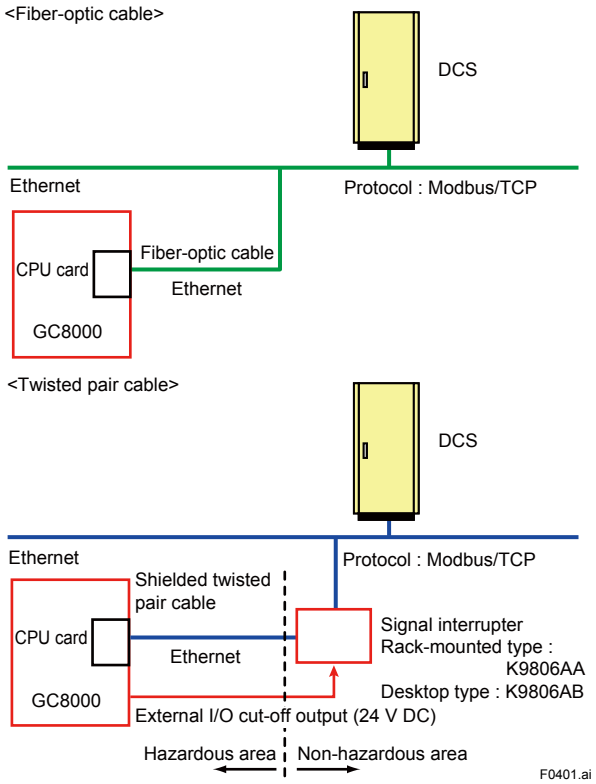


Figure 4.1 Ethernet communication (except for FM-Y explosionproof specification)

[Serial communications]

RS-422 serial communication is used for communication ports. To connect a DCS, communications are converted into RS-232C by a rack-mounted K9806AS communication converter (desktop type: K9806AS). This converter terminates communications automatically if the GC8000 becomes unable to maintain explosionproof requirements. It is installed in a non-hazardous area. To use two-channel communications, two converters are required. In the hazardous area, the relevant parts must be mounted in a flameproof enclosure that has been certified by the relevant explosionproof inspection organization.

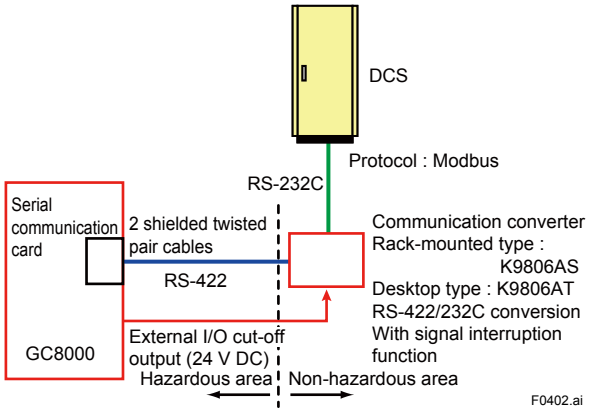


Figure 4.2 Serial communication (except for FM-Y explosionproof specification)

5. Communication data

5.1 Coils (command contacts)

(1) Run command
This instructs the GC8000 to start continuous analysis.

(2) Stop command
This instructs the GC8000 to stop continuous analysis.

If the unit receives this command during continuous analysis, it stops the operation after it has finished the current analysis.

(3) Pause command
This instructs the GC8000 to pause.

If the unit receives this command during continuous analysis, it pauses at the pause time of the current analysis. If the unit receives the command during the stop mode, the status is changed immediately from stop to pause.

(4) Time Setting request
This requests the GC8000 to set the system clock to the value which is in the Time Setting holding register. Before executing this request, the date/time values need to be loaded into the Time Setting holding register.

(5) Stream Sequence command
This executes the stream sequence of the specified GC module (GCM). If the operation mode is Calibration/Validation including the wait status, the command cannot be accepted.

(6) Calibration command
This executes calibration of the specified GCM. If the operation mode is Calibration/Validation including the wait status, the command cannot be accepted.

(7) Validation command
This executes validation of the specified GCM. If the operation mode is Calibration/Validation including the wait status, the command cannot be accepted.

(8) Calibration Method command
This changes the calibration method of the specified GCM.

(9) Validation Method command
This changes the validation method of the specified GCM.

(10) Automatic Calibration command
This changes the automatic specification of the specified GCM and calibration number.

(11) Automatic Validation command
This changes the automatic validation of the specified GCM and calibration number.

(12) Stream Specification command
This instructs the setting of the stream measurement count of the specified GCM. The count value is set via the Stream Measurement Count holding register. If the operation mode is Calibration/Validation including the wait status, the command cannot be accepted.

(13) Stream Execution command
This changes the specified stream sequence operation of a GCM to “Execute.”

(14) Stream Non-execution command
This changes the specified stream sequence operation of a GCM to “Do not execute.”

(15) Contact Input On command
This sets the specified contact input to “On.”

(16) Contact Input Off command
This sets the specified contact input to “Off.”

5.2 Input relays (status contacts)

(1) Analyzer Normal
This indicates that the GC8000 is in normal status. The value is 1 if the unit has no Level 1 (major failure) or Level 2 (minor failure) alarms.

(2) Analyzer Error
This indicates that the GC8000 is in error status. The value becomes 1 when the unit has any Level 1 (major failure) alarms. If the Analyzer Normal and Analyzer Error status values are both zero, the unit has Level 2 (minor failure) alarms but measurement is in progress.

(3) Alarm Status Change
This indicates that the alarm status has changed. The value becomes 1 for a new alarm or a cancelled alarm, then it is reset to zero when any alarm status is read.

(4) Measuring
This indicates with the value of 1 that the GC8000 is performing measurement. In other modes, the value is zero.

(5) Stop
This indicates with the value of 1 that the operation is stopped, regardless of the operation mode. If the status is “Manual,” the value is zero.

(6) Pause
This indicates with the value of 1 that the operation is paused, regardless of the operation mode. If the status is “Manual,” the value is zero.

(7) Stream Sequence Command Not Executed
If the Stream Sequence command is unable to be executed when being sent from the coil, the value of 1 is read.

If the command is sent again and then executed successfully, the value is cleared.

(8) Stream Specification Command Not Executed
If the Stream Specification command is unable to be executed when being sent from the coil, the value of 1 is read.

If the command is sent again and then executed successfully, the value is cleared.

(9) Calibration/Validation Command Not Executed
If the Calibration/Validation command is unable to be executed when being sent from the coil, the value of 1 is read.

If the command is sent again and then executed successfully, the value is cleared.

(10) Data Updated
This indicates that the new analysis value of a SYS stream can be obtained. When an analysis value is updated, the value of 1 is read and reset to zero after five seconds.

(11) Calibration Factor Updated
This indicates that the new calibration factor of a GCM stream can be obtained. When a calibration factor is updated, the value of 1 is read and reset to zero after five seconds.

(12) Alarm Status
This indicates the occurrence status of alarms by alarm number. If an alarm has occurred, the value is 1; otherwise, zero. Level 1 alarms are numbered from 1 to 200, and Level 2 alarms from 201 to 400.

(13) Malfunctioning Concentration
This indicates the occurrence status of malfunctioning concentration by the peak. If a malfunctioning concentration has occurred, the value is 1; otherwise, zero.

(14) Malfunctioning Peak
This indicates the occurrence status of malfunction of the retention time, the coefficient of variation and the tailing factor by the peak. If any malfunction in any of these items has occurred, the value is 1; otherwise, zero.

(15) Contact Input Status
This indicates the status of the specified contact input.

(16) Contact Output Status
This indicates the status of the specified contact output.

(17) Analyzer Normal (in total)
This bit indicates that all the GCM is normal.

If all of the analyzer normal input relays are 1 (level 1 alarm and level 2 alarm does not occur), this bit indicates 1.

(18) Analyzer Error (in total)
This bit indicates that one or more GCMs has error.

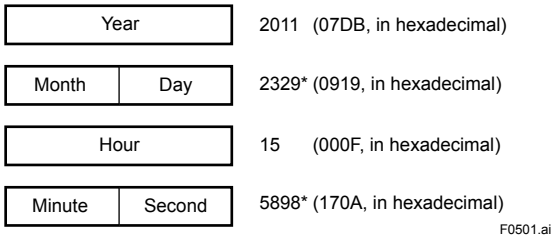
If any of the analyzer error input relays are 1 (GC has level 1 alarm), this bit indicates 1.

5.3 Holding registers (setting data)

This data don't show current setting condition, but shows latest setting data sent from DCS.

(1) Time Setting Value
This is a set of four registers for a DCS to set the time on the GC8000. If the Time Setting request is executed, this value is loaded into the system clock of the GC8000.

Example: 2011/09/25, 15:23:10



*: Month/day value = 256 x month + day
Minute/second value = 256 x minute + second

(2) Stream Measurement Count
This indicates the number of times the Stream Specification command has been executed.

(3) Range Change
This allows the peak range for the stream and peak number associated with each register address to be changed. For the specified peak, it sets the measurement range and unit according to the configuration parameter for the specified range number. It also overwrites the range number of the specified peak.

(4) Automatic Start Time
This sets the automatic start time in the automatic calibration.

(5) Time Interval
This sets the time interval in the automatic calibration.

(6) Stream Sequence Measurement Stream
This changes the stream number of the specified stream sequence operation of a GCM to the specified value.

5.4 Input registers (measured data)

(1) Stream Number
This indicates the stream number under measurement in each GCM. The value is zero when the operation is stopped.

(2) Stream Sequence Number
This indicates the stream sequence number under measurement in each GCM. The value is zero when the measurement status is in stream specification, calibration, or validation, or in the manual status.

(3) Calibration Number
This indicates the calibration number under execution in each GCM. The value is zero when the measurement status is in stream specification, stream sequence, validation, or in the manual status.

(4) Validation Number
This indicates the validation number under execution in each GCM. The value is zero when the measurement status is in stream specification, stream sequence, calibration, or in the manual status.

(5) Starting Peak Number
This indicates the number of the first peak among those assigned to each stream. The analysis value is 999 or below including all the assigned peaks. If no peaks are assigned to the stream, the value is zero.

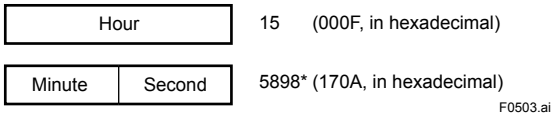
See Figure 5.1.

(6) Assigned Peak Number
This indicates the overall number of peaks assigned to each stream. If no peaks are assigned to the stream, the value is zero.

See Figure 5.1.

(7) Analysis Start Time
This is a register which stores the analysis start time for each SYS. Hour, minute and second are stored in two addresses.

Example: 15:23:10



*: Minute/second value = 256 x minute + second

(8) Analysis Value
This is a register which stores an analysis value for each analysis as a fraction of a full-scale value or as a real number. The full-scale value is set in advance and the scaling factor can be selected as either 9999 or 65535. One real number data item requires two registers under the IEEE standard format. The upper two-byte data are allocated to a register with the smaller-number address.

Fraction format: (Scaling factor x Analysis value)/ Full-scale value

In the fraction number format, units such as “%” and “ppm” are taken into consideration. For example, if the value is 1.5%, the data is represented as 1.5 in floating-point format.

In addition, an absolute peak number is derived from the assigned peak number of each stream.

Absolute peak numbers form a single numeric sequence starting with the first detected peak of the first stream and progressing through all detected peaks of each stream in ascending order.

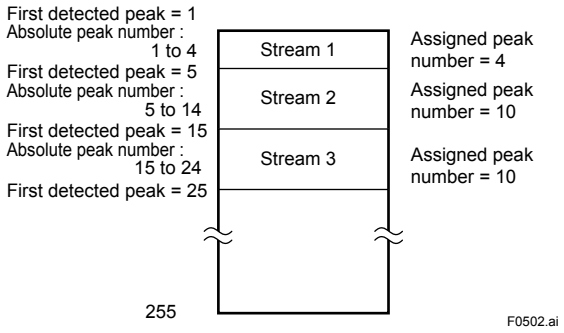


Figure 5.1 Example of assigning peaks

(9) Retention Time
This is a register which stores the retention time for each peak. The increment unit is 0.1 second.

(10) Calibration Factor
This is a register which stores a calibration factor for each peak of the target stream. The value is expressed as 0000 to 9999 for 0.000 to 9.999 by multiplying it by 1000.

(11) Loaded Analog Input Value
This indicates the specified analog input value. The value range is from -0.25 to 1.25. One data item requires two registers under the IEEE standard format.

(12) Loaded Analog Output Value
This indicates the specified analog output value. The value range is from -0.25 to 1.25. One data item requires two registers under the IEEE standard format.

(13) Current Time
This indicates the current time. The four registers must be read simultaneously. An error will occur if the four registers are not read simultaneously.

6. Address table

	Name	Address	Description
Coil	Run command	0G001	G: GCM number (0 to 6), 0 for all GCMs
	Stop command	0G002	G: GCM number (0 to 6), 0 for all GCMs
	Pause command	0G003	G: GCM number (0 to 6), 0 for all GCMs
	Time Setting request	00004	Change the value to the date and time set in a holding register.
	Calibration Cancel request	0G005	G: GCM number (1 to 6) Cancel automatic calibration.
	Stream Sequence command	0G01P	G: GCM number (1 to 6) P: Stream sequence number (1 to 8)
	Calibration command	0G02M	G: GCM number (1 to 6) M: 1 to 6 (calibration: 1 to 6)
	Validation command	0G03M	G: GCM number (1 to 6) M: 1 to 6 (validation: 1 to 6)
	Calibration/Validation Method (Manual) command	0G041	G: GCM number (1 to 6) Change the calibration/validation method to “Manual.”
	Calibration/Validation Method (Semi-automatic) command	0G042	G: GCM number (1 to 6) Change the calibration/validation method to “Semi-automatic.”
	Calibration/Validation Method (Automatic) command	0G043	G: GCM number (1 to 6) Change the calibration/validation method to “Automatic.”
	Automatic Calibration (Yes) command	0G05M	G: GCM number (1 to 6) M: 1 to 6 (calibration: 1 to 6)
	Automatic Calibration (No) command	0G06M	G: GCM number (1 to 6) M: 1 to 6 (calibration: 1 to 6)
	Automatic Validation (Yes) command	0G07M	G: GCM number (1 to 6) M: 1 to 6 (validation: 1 to 6)
	Automatic Validation (No) command	0G08M	G: GCM number (1 to 6) M: 1 to 6 (validation: 1 to 6)
	Stream Specification command	0G1TT	G: GCM number (1 to 6) TT: Stream number (1 to 31) * Specifying a stream not assigned to the target GCM results in an error.
	Stream Execution command	0GPTT	G: GCM number (1 to 6) P: Stream sequence number (2 to 9: actual stream sequence number + 1) TT: Stream operation order (1 to 31)
	Stream Non-execution command	0GPTT	G: GCM number (1 to 6) P: Stream sequence number (2 to 9: actual stream sequence number + 1) TT: Stream operation order (51 to 81: actual stream operation order + 50)
	Contact Output On command	070DD	DD: Contact output number (1 to 25)
	Contact Output Off command	071DD	DD: Contact output number (1 to 25)
Input relays	Analyzer Normal	1G001	G: GCM number (0 to 6), 0 for the entire GC8000 unit alarm
	Analyzer Error	1G002	G: GCM number (0 to 6), 0 for the entire GC8000 unit alarm
	Alarm Status Change	1G003	G: GCM number (0 to 6), 0 for the entire GC8000 unit alarm The value is retained for five seconds after the change.
	Run	1G004	G: GCM number (1 to 6)
	Stop	1G005	G: GCM number (1 to 6)
	Pause	1G006	G: GCM number (1 to 6)
	Manual	1G007	G: GCM number (1 to 6)
	Stream Sequence Command Not Executed	1G021	G: GCM number (1 to 6) * If the command fails, the value is 1; otherwise, zero.
	Stream Specification Command Not Executed	1G022	G: GCM number (1 to 6) * If the command fails, the value is 1; otherwise, zero.
	Calibration/Validation Command Not Executed	1G023	G: GCM number (1 to 6) * If the command fails, the value is 1; otherwise, zero.
	Data Updated	1S1TT	S: SYS number (1 to 6); the value is retained for five seconds after the update. TT: Stream number (1 to 31)
	Calibration Factor Updated	1G2TT	G: GCM number (1 to 6); the value is retained for five seconds after the update. TT: Stream number (1 to 31)
	Alarm Status	1GAAA	G: GCM number (0 to 6), 0 for the entire GC8000 unit alarm AAA: Alarm number (301 to 700: actual alarm number + 300)
	Malfunctioning Concentration	17CCC	CCC: Absolute peak number (1 to 999)
	Malfunctioning Peak	18CCC	CCC: Absolute peak number (1 to 999) If there is a malfunction in any of the retention time, the coefficient of variation or the tailing factor, the value is 1.
	Contact Input Status	190DD	DD: Contact input number (1 to 32)
	Contact Output Status	191DD	DD: Contact output number (1 to 25)
	Analyzer Normal (in total)	19901	This bit indicates that all the GCMs (0 to 6) are normal.
	Analyzer Error (in total)	19902	This bit indicates that one or more GCMs (0 to 6) have error.

	Name	Address	Description
Holding registers	Time Setting request	40001-40004	Year (40001), month and day (40002), hour (40003), minute and second (40004)
	Stream Measurement Count	40011	0 to 999 (0: continuous)
	Range Change	4NNQQ	NN: Stream number (1 to 31) QQ: Peak number (relative peak number: 1 to 99)
	Automatic Start Time (HH:MM)	4G001	G: GCM number (4 to 9: actual GCM number + 3) The value is set in the “HH:MM” format. Upper 8 bits: HH Lower 8 bits: MM
	Time Interval (DDD)	4G002	G: GCM number (4 to 9: actual GCM number + 3) The value is set by the day.
	Time Interval (HH:MM)	4G003	G: GCM number (4 to 9: actual GCM number + 3) The value is set in the “HH:MM” format. Upper 8 bits: HH Lower 8 bits: MM
	Stream Sequence Measurement Stream	4GPTT	G: GCM number (4 to 9: actual GCM number + 3) P: Stream sequence number (1 to 8) TT: Stream operation order (1 to 31)
Input registers	Stream Number	3000G	G: GCM number (1 to 6)
	Analyzer ID	30010	Analyzer ID (1 to 240) * Modbus/TCP only
	Stream Sequence Number	3001G	G: GCM number (1 to 6)
	Calibration Number	3002G	G: GCM number (1 to 6)
	Validation Number	3003G	G: GCM number (1 to 6)
	Current Time	30041-30044	Year (30041), month and day (30042), hour (30043), minute and second (30044) * Modbus/TCP only
	Starting Peak Number	301TT	TT: Stream number (1 to 31)
	Assigned Peak Number	302TT	TT: Stream number (1 to 31)
	Analysis Start Time	303BB	Hour, minute and second BB: Hour (30300 + 2 x SYS number - 1), minute and second (30300 + 2 x SYS number) SYS number (1 to 6)
	Analysis Value	31CCC 3DDDD	CCC: Absolute peak number (1 to 999) For a real number: DDDD = 2 x CCC - 1 + 1000 * IEEE754 format
	Retention Time	33DDD	DDD: 2 x absolute peak number - 1 Absolute peak number (1 to 999) * The value is multiplied by 10 (Example: 284 for 28.4 seconds).
	Calibration Factor	35CCC	Calibration factor (CCC: component number)
	Analog Input Value	360AA	AA: Absolute AI number (1 to 32: 2 x actual absolute AI number - 1) Real number format
	Analog Output Value	361AA	AA: Absolute AO number (1 to 64: 2 x actual absolute AO number - 1) Real number format