General Specifications

GC1000MarkII and GCAS
Communication Function
MODBUS Communication

GS 11B03G02-02E

1. General

The MODBUS protocol is used for DCS communication with the GC1000MarkII and GCAS.

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 GC1000MarkII and GCAS.

For specifics on Modbus, please refer to the Gould 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.

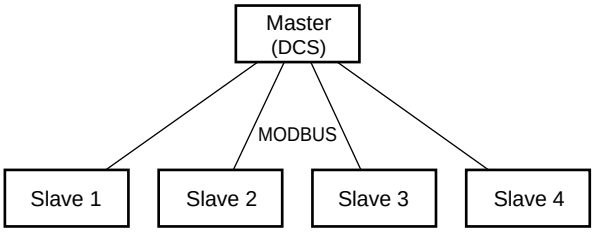

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Figure 1.1 MODBUS configuration

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.

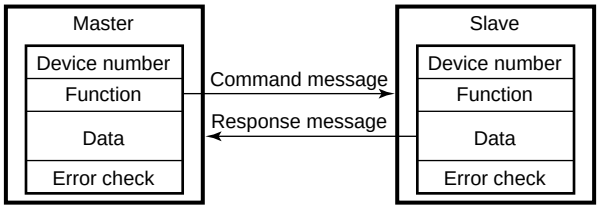

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Figure 1.2 Master-slave command and response cycle

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. The GC1000MarkII supports both modes, however the GCAS supports only the RTU mode.

GC1000MarkII supports Modbus/TCP.

[Communication]

Kind	Mode	Support Type
Sirial comm.	ASCII	Slave
	RTU	Slave
Ethernet	Modbus/TCP	Server

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[Serial comm]

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)

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[Ethernet]

Item	TCP Mode
Protocol	Modbus/TCP
No. of Session	2 (Max.)
Port No.	502

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2.2 Message Configuration

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

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.

GS 11B03G02-02E

2nd Edition Dec. 2006(YG)

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 following message is displayed at an unique header (6 bite) of Modbus/TCP (Device No. is not indicated).

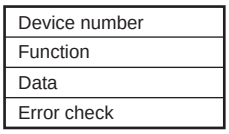

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Figure 2.3 Message configuration

(1) Device number

The device number is user pre-assigned for each slave and ranges from 1 to 254. This number is the same as the Analyzer ID. 1 to 240 is recommended for GC1000MarkII and 241 to 254 for the GCAS. 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.

When “0” is specified as the device number for some functions, all slaves execute the command, however no response message is sent back. Device number 0 is supported by the GCAS only. For the GC1000MarkII, device number 0 results in a device number error.

(2) Functions

The master specifies the function to be executed by the slave. The GC1000MarkII or GCAS 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	Loopback test	Sends back the same message as the command message.
15	Multiple Coils status change	Forcibly changes the status of a series of coils.
16	Multiple holding registers write	Write the valves info a series of holding resisters.

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* GC1000MarkII does not support F15 and F16.

(3) Data

There are two types of data “coil/relay” in bits and “register” as 16-bit data. The coil uses two values (ON/OFF or 0/1), while the register ranges from 0 to 65535. Up to 8000 coils/relays or registers can be accessed and 1 to 8000 addresses are assigned. However the maximum number of addresses which can be read at a time is limited as follows:

		MODBUS name	Address	Max. read	Application
Device		Device number			Analyzer number
Contact	R/W	Coil	0XXXX	800	Command
	R	Input relay	1XXXX	2000	Status
Data	R/W	Holding register	4XXXX	100	Set value
	R	Input register	3XXXX	125	Measured value

xxxx: 0001 to 8000

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(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 then sends back a normal response if the command is normal, or an error response if the command is abnormal.

(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. For the multiple coil status change and the multiple holding register write, the parts of the message (the device number, the start number and the number of the coils/the holding registers) are sent back as the response message. For the read function, the device number plus function added with the read data are sent back as the response message. 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.

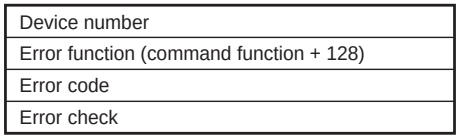

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Figure 2.4 Response to a faulty command message

Error code	Description
01	Function code error (non-existent function)
02	Coil, input relay, or register number error (more than 8000)
03	Number of coils, input relays, or registers error (registers: more than 125, coils/input relays:more than 2000)
04	An unrecoverable error occurred on the slave while the command message was being executed.
11	Set data error (out of range)

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(3) No response

In the following cases, the slave ignores the command message and does not send back a response (no response). If the device number is 0 (broadcasting via GCAS only), all slaves execute the command but do not send back a 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

[Serial comm.]

For MODBUS communication, the DCS communication port of the GC1000MarkII or GCAS is used. The GC1000MarkII has one DCS communication port, while the GCAS can have up to four DCS communication ports.

Communication standard: RS-422 (GC1000MarkII output)/ RS- 232C (GCAS output)

Start-stop synchronization: Start bit 1, data bit 7/8, parity bit 1, stop bit 1

Communication speed: 1200, 2400, 4800, 9600 bps (selectable)

Error detection: Odd number parity, even number parity, none(selectable)

Transmission mode: ASCII mode (GC1000MarkII)/RTU mode

[Ethernet]

LAN specification

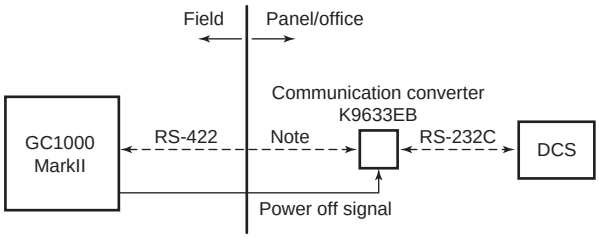
Standard: IEEE802.3 compliance
Phsical Layer: 100Base-Tx or 100Base-Fx
No. of physical port: 2 ports (Max.)
Max. length: 100 m

4. System Configuration

(1) GC1000MarkII (Serial comm.)

For the communication port, an RS-422 standard serial port is used. The signal can be converted to RS-232C using an external communication converter (K9633EB).

This communication converter has a protection feature that automatically disconnects communication if the explosion protection feature of the GC1000MarkII is compromised.



Note : Dedicated communication line (RS-422)
0.75 mm^2 twisted pair x 3, cable outside diameter 10 to 15.9 mm, up to 1 km (*)
Flameproof packing cable must be constructed on the analyzer side.
Refer to "GC1000 MarkII Installation Manual (TI 11B03A03-13E)."
* Parts, cables, and construction materials must be prepared by the customer.

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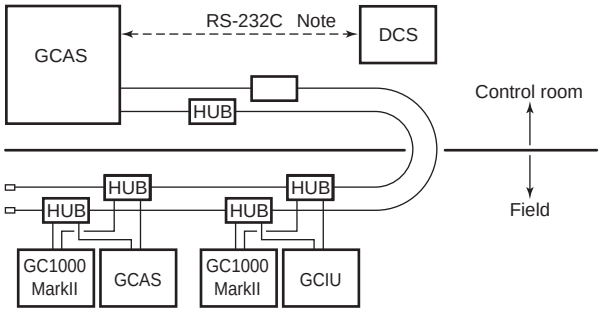
Figure 4.1 GC1000MarkII (Serial comm.)

(2) GCAS



Note : GCAS is connected to DCS with the cable of RS232C D-sub 25 pin straight.

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Figure 4.2 GCAS

(3) GC1000MarkII (Ethernet)

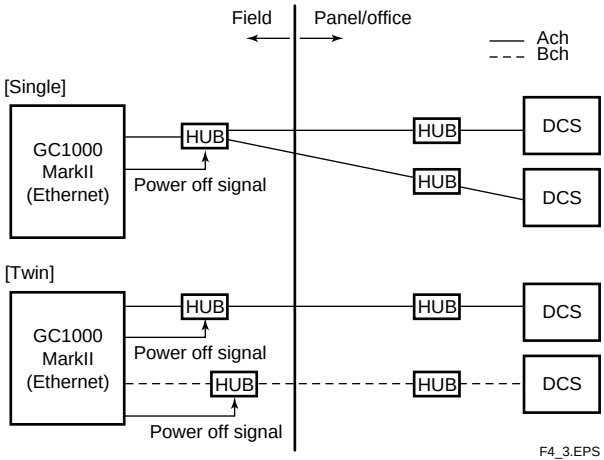

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Figure 4.3 GC1000MarkII (Ethernet)

Single: It is connected by A channel only.
Twin: Both A channel and B channel are connected independently. The connection is built up by each session. The destination uses a physical IP address.

5. Communication Data

5.1 Coil (command contact)

(1) Run command
Commands the start of continuous analysis to the GC1000MarkII.

(2) Stop command
Commands the stop of continuous analysis to the GC1000MarkII.

(3) Time setting request
Requests the GC1000MarkII, GCIU or GCAS to set the device clock to values in addresses 40001-40004.

(4) Stream sequence command
Execute a selected stream sequence on GC1000MarkII. This command is not accepted when the status is on Calibration/Validation including the status waiting for this change or on stream(1 cycle) including the status waiting for this change.

(5) Calibration/Validation command
Execute a selected calibration or validation stream on GC1000MarkII. The correspondence of the calibration or validation number and the address is as follows.
Cal.stream 1-3: 1-3, Val. Stream 1-3: 4-6. This command is not accepted when the status is on stream(1 cycle) including the status waiting for this change or calibration method is automatic or manual.

(6) Stream(continuous) command
Execute a selected measurement stream continuously on GC1000MarkII. This command is not accepted when the status is on stream(1 cycle) including the status waiting for this change.

(7) Contact output ON
Requests the GCIU to Turn ON a specific contact output.

(8) Contact output OFF
Requests the GCIU to Turn OFF a specific contact output.

Note 1: Coils are automatically reset from 1 to 0 when the GC1000MarkII or GCIU accepts the message.
Note 2: Input relays should be monitored to determine when commands actually activate.
Note 3: When the master sends multiple commands to the slave simultaneously, the slave executes it in the order received regardless of the content of the commands.

5.2 Input Relay (status contact)

(1) Analyzer normal
The GC1000markII, GCIU or GCAS is normal. A 1 is displayed if there is no active level 1 (critical failure) or level 2 (minor failure) alarm.

(2) Analyzer error
The GC1000MarkII, GCIU or GCAS is faulty. A 1 is displayed if there is at least one active level 1 (critical failure) alarm.

(3) Analyzer status change
A 1 is displayed when a new alarm occurs on the GC1000MarkII or GCIU. After this status is read and when at least one alarm status is read, this bit is automatically reset to 0.

(4) Measuring (run mode)
The GC1000MarkII is analyzing. A 1 is displayed when it is in RUN mode. Otherwise, 0 is displayed.

(5) Stop (ready mode)
The GC1000MarkII is not analyzing. A 1 is displayed when it is in READY mode. Otherwise, 0 is displayed.

(6) Maintenance (other modes)
If the GC1000MarkII is in MANUAL, LAB, or PAUSE mode, a 1 is displayed. Otherwise, 0 is displayed.

(7) GCAS normal
The GCAS is normal. A 1 is displayed if there is no active alarm.

(8) GCAS error
The GCAS is faulty. A 1 is displayed if there is at least one active level 1 (critical failure) alarm.

(9) Executing the stream sequence
The corresponding stream sequence on the GC1000MarkII is being executed.

(10) Not Executing the status change command
A 1 is displayed if the corresponding status change command which is stream(continuous) command, calibration/validation command or stream sequence command is not accepted. The coil is reset when this command is accepted next time.

(11) Data update
New analysis data is now available from the GC1000MarkII or GCIU. Data update is automatically reset to 0 once data update is read and at least one analysis value is read.

(12) Calibration factor update
The GC1000MarkII has new calibration factors for a particular stream. The address is reset to 0 after the calibration factor update is read and when at least one calibration factor is read.

(13) Contact input
The contact input of the GCIU is read.

(14) Contact output
The contact output of the GCIU is read.

(15) Mode of contact output
Contacts on the GCIU can be manually or automatically activated. When in manual mode a 0 is read and automatic mode is designated by a 0.

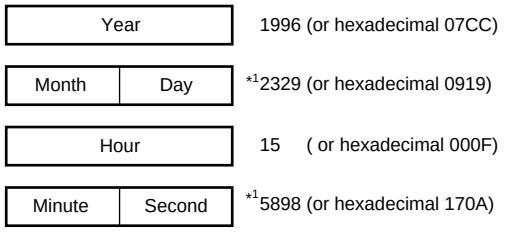
(16) Data valid
Data is valid for a particular peak on the GC1000markII. For analysis peaks, the analysis value must be between the upper and lower limits and the retention time is at or below the upper limit. For operation peaks, the data to be used for operation is valid. A 1 is displayed when data is valid.

(17) Alarm status
The alarm status of the GC1000markII, GCIU or GCAS is displayed for each alarm number. If an alarm occurs, 1 is displayed. Otherwise, 0 is displayed. The alarm number is 1 to 100 for level 1 alarms of the GC1000MarkII or GCIU, 101 to 200 for level 2 alarms of the GC1000MarkII or GCIU, and 201 to 249 of the GCAS alarms. The analyzer bus regular cycle communication off alarm is assigned to 249.

5.3 Holding Register (set data)

(1) Time setting value
This is a set of four registers used by the DCS to set the device clock. When the time setting request coil (address 00003 for GC1000MarkII and GCIU, 00001 for the GCAS) is activated, these entries are used for the year, month/day, hour, and minute/second. Since all devices on the highway synchronize to the GCAS clock on a regular basis, the GCAS clock should be regularly set.

Example: September 25, 1996, 15:23:10



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*1: month/day value = month*256 + day (minute/second value = mintue*256 + second)

Figure 5.1 Time register configuration

(2) Range change
This address allows to change the range which is shown by the specified stream and peak number via MODBUS. An integer entry is required. This feature allows for the selection of a change of analysis to a particular stream in a multi-stream application.

(3) Analysis value
These addresses display the same data as the analysis value in the input register, however values cannot be written to these addresses. Only These addresses support real number (floating point) form.

(4) Average value
This is present on only the GCIU. One minute averages of analog inputs are displayed. However values cannot be written to these addresses Only the real number (floating point) format is supported.

5.4 Input Register (measured data)

(1) Stream number
The currently active stream number on the GC1000MarkII is displayed. In READY or MANUAL mode, the stream number is 0. In LAB mode, the stream number is 32.

(2) Starting peak number
The starting peak number assigned to each task on the GC1000MarkII is displayed. The number is 0 if no peak is assigned.

(3) Peak number
Peak number assigned to each stream on the GC1000MarkII is displayed. See the figure below.

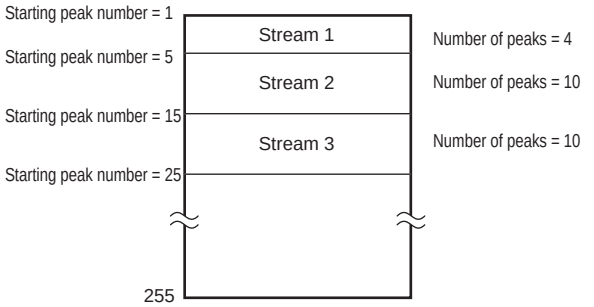

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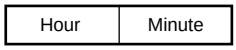
Figure 5.2 Example of peak allocation

(4) Sampling time
This register contains the latest sampling time for each stream on the GC1000MarkII. Hour and minute are stored.

Example: 15: 23



3863 (or hexadecimal 0F17)

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(5) Current value
This is present on only the GCIU. One second averages of analog inputs are displayed. Only the fraction format is supported.

(6) Analysis value
This register contains each analysis value. The value is represented by a fraction to the full scale or by a real number (floating point format). The full scale is set in advance for each analysis value and the scaling factor is user selectable as either 9999 or 65535. The real number format conforms to the IEEE standard and requires two registers per peak.

The fraction format is calculated as follows:

(Analysis value x Scaling factor)/Full scale value For example, if the analysis result is 5 ppm and the range is 0-20 ppm

The value read using a scaling factor of 9999 is (5 x 9999) / 20 = 2499 (or hexadecimal 09C3)

$$\frac{5}{20} \times 9999 = 2499 \quad (09C3)$$

F5_4.EPS

For the real number format, units (such as %, ppm, etc.) are considered. For example, the real number value converted from 1.5 is directly transmitted as 1.5 %. The GC1000MarkII updates analysis values at the end of each cycle.

The GCIU updates the average values according to the userset scan interval.

(7) Retention time
This register contains the retention time for each peak of the GC1000MarkII. The unit is in seconds.

(8) Calibration factor
This register contains the calibration factor for each peak of the GC1000MarkII. Since the factors are in the range of 0.000 to 9.999, each value is multiplied by 1000 and displayed as integers (i.e. 0000 to 9999).

(9) Average value
This is present on only the GCIU. One minute averages of analog inputs are displayed.Both the fraction and the real number (floating point) format are supported.

6. Addressing

6.1 General Rules

The process control system must be the master device, and the GC1000MarkII, GCIU, or GCAS is the slave device. The GC1000MarkII or GCIU ID number corresponds to the slave device number. Since the GCAS controls multiple GC1000MarkIIs, an GCAS will accept multiple device numbers corresponding to these GC1000MarkIIs.

There are four categories available in modbus addressing; coil, input relay, holding register, and input register. Coils are operational commands, input relays are status flags, holding registers are where data can be set, and input registers are where analysis results are retrieved. Up to 8000 coils/relays or registers are available. Addresses 1 to 8000 are assigned for access from the master. All GC1000MarkIIs or GCIUs utilize the same modbus addresses.

The data is differentiated by requesting from a different device number. When using real number format for analysis values, please note that two sequential addresses are needed for each peak.

6.2 Mapping Feature (MODBUS map)

In addition to the standard addressing method (described above) using unique device numbers for each device, the GCAS has the added feature of being able to map data from multiple devices into mapping registers on the GCAS. The master can then access this mapped data in the more efficient block format using only one slave device number. There are 512 registers available for each coil, relay, holding or input register. The GCAS mapping registers are addressed from

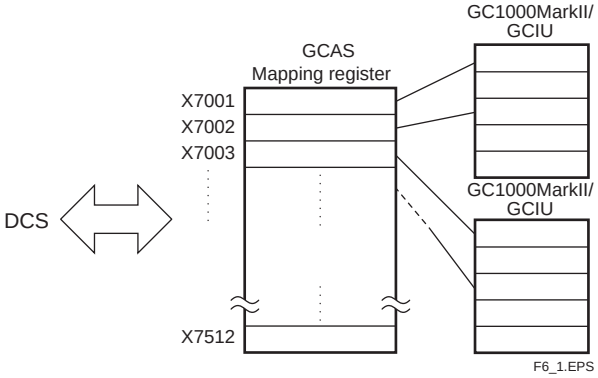

Figure 6.1 Mapping feature

7. Adress Table

7.1 Adress Table (GC1000MarkII/GCIU)

	Name	Address	Description
Coil	Run command	00001	Received the message by the master, the slave reset.
	Stop command	00002	Same as above
	Time setting request	00003	Same as above
	Stream sequence command	0001P	Same as above, P: stream sequence number(1 to4)
	Calibration/Validation command	0002M	Same as above, M: 1 to 3(Cal.1 to 3), 4 to 6(Val.1 to 3)
	Stream(continuous) command	001TT	TT: Stream number(01 to 31)
	Contact output ON	001SS	SS: Contact output number of GCIU(01 to 16)
	Contact output OFF	002SS	SS: Contact output number of GCIU(01 to 16)
Input relay	Analyzer normal	10001	
	Analyzer error	10002	
	Analyzer status change	10003	Reset when the alarm status is read after alarm status change is read.
	Measuring	10004	
	Stop	10005	
	Maintenance	10006	
	Analyzer server normal	10008	
	Analyzer server error	10009	
	Executing the Steam seguence	1001P	P: Stream sequence number(1 to 4)
	Not executing Stream (continuous) command	10021	
	Not executing calibration/validation command	10022	
	Not executing Stream sequence command	10023	
	Executing Calibration/Validation	1003M	M: 1 to 3(Cal.1 to 3), 4 to 6(Val.1 to 3)
	Data update	101TT	Reset when the analysis value is read after data update is read. (TT: Stream Number)
	Calibration factor update	102TT	Reset when the calibration factor is read after calibration factor update is read. (TT: Stream Number)
	Contact input	103RR	RR: Contact input number of GCIU(01 to 16)
	Contact output	103SS	SS: Contact output number of GCIU(01 to 16)
	Mode of contact output	104SS	SS: Contact output number of GCIU(01 to 16) (0: Manual mode, 1: Automatic mode)
	Data valid	11CCC	CCC: Peak number
	Alarm status	12AAA	AAA: Alarm number (001 -249)
	Concentration abnormal	13CCC	CCC: Peak number
	Retantion time out	14CCC	CCC: Peak number
	Invalid coefficient of variation	15CCC	CCC: Peak number
	Invalid Tailing coefficient	16CCC	CCC: Peak number
Holding register	Time setting request	40001- 40004	Year (40001), month/day (40002), hour (40003), minute/second (40004)
	Range change	4NNQQ	NN: Stream number + 40, QQ: Peak number
	Analysis value	41DDD	Read only (Write disabled) DDD(real format) ▫ CCC*2-1(CCC: Peak number)
	Average value	440ZZ	Read only (Write disabled) ZZ(real format) ▫ YY*2-1(YY: Analog input number)
Input register	Stream number	30001	
	Starting peak number	301TT	TT: Stream Number
	Peak number	302TT	TT: Stream Number
	Sampling time	303TT	TT: Stream Number
	Current value	304YY	YY: Analog input number
	Analysis value	31CCC/-31DDD	DDD(real format): CCC*2-1(CCC: Peak number)
	Retention time	32CCC	CCC: Peak Number
	Calibration factor	33CCC	CCC: Peak Number
	Average value	340YY/-340ZZ	ZZ(real format) ▫ YY*2-1(YY: Analog input number)

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7.2 Adress Table (GCAS)

	Name	Address	Description
Coil	Time setting request	00001	When the message is received, the slave is reset.
	MODBUS mapping	07XXX	Same as above. XXX: 001 to 512
Input Relay	Analyzer server normal	10001	
	Analyzer server error	10002	
	Alarm status change	10003	Reset when the alarm status is read after alarm status change is read.
	Alarm status	101AA	AA: Alarm number (1 to 49)
	MODBUS mapping	17XXX	XXX: 001 to 512
Holding Register	Time setting request	40001- 40004	Year (40001), month/day (40002), hour (40003), minute/second (40004)
	MODBUS mapping	47XXX	XXX: 001 to 512
Input Register	MODBUS mapping	37XXX	XXX: 001 to 512

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