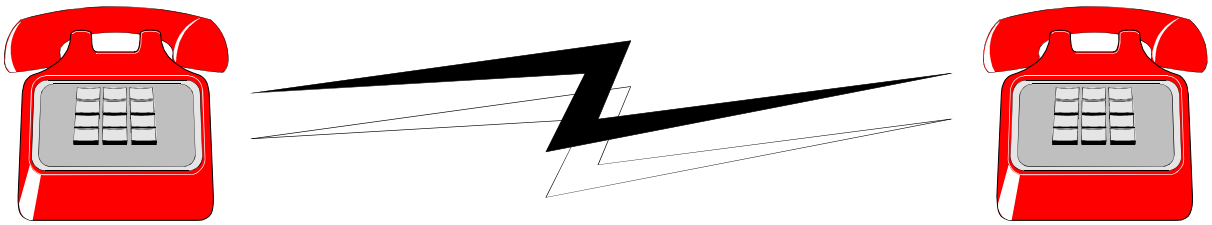
MODBUS Communications on the 1/4-DIN, 1/8-DIN & 1/16-DIN Temperature Controllers

Application Note

59047-2



1 INTRODUCTION

This document specifies the MODBUS communications protocol as implemented on the $\frac{1}{4}$-DIN, $\frac{1}{8}$-DIN and $\frac{1}{16}$-DIN Temperature Controllers.

Certain restrictions have been imposed upon this implementation:

(i) Baud rates may be set to 1200, 2400, 4800 and 9600 only

(ii) Support for multi-parameter Writes is limited to support of the Multi-word Write Function (Number 16) but will permit writing of one parameter only per message

(iii) The multi-parameter Read function supports a maximum of 10 parameters in one message.

2 MODBUS FUNCTIONS SUPPORTED

In the following list, the original Gould MODBUS function names have been used, followed by the JBUS names in italics, where such an equivalence exists. The MODBUS Function number follows the names.

A	Read Coil Status *(Read n Bits)*	01/02
B	Read Holding Registers *(Read n Words)*	03/04
C	Force Single Coil *(Write 1 Bit)*	05
D	Preset Single Register *(Write 1 Word)*	06
E	Loopback Diagnostic Test	08
F	Preset Multiple Registers *(Write n Words)*	16

The instrument will identify itself in reply to a Read Holding Registers message which enquires the values of parameter numbers 121 & 122, as specified in the CNOMO documentation, and MODBUS Function 17 (Report Slave ID) is not supported.

3 MESSAGE FORMATS

The first character of every message is an instrument address. The valid range of such an address is 0 to 255. The second character is always the Function Number. The contents of the remainder of the message depends upon the function number.

In most cases the instrument is required to reply by echoing the address and function number, together with an echo of all or part of the message received (in the case of a request to write a value or carry out a command) or the information requested (in the case of a read parameter operation). Broadcast Messages (to which the controller responds by taking some action without sending back a reply) are supported at instrument address zero. Commands which can be broadcast are marked with the symbol 𝔹.

Data is transmitted as eight-bit binary bytes with 1 start bit, 1 stop bit and optional parity checking (None, Even or Odd).

A message is terminated solely by a delay of more than three character lengths at the given Baud Rate, and any character received after such a delay is treated as a potential address at the start of a new message.

The following individual message formats apply. Since only the RTU form of the protocol is supported, each message is followed by a two-byte CRC16. Details of how the checksum must be calculated are given at the end of this Section.

A. Read Coil Status *(Read n Bits)* 01/02

The message sent to the controller will consist of 8 bytes, as follows:

Addr.	Func.	Addr. of 1st Bit		No. of bits		CRC16	
	1/2	*HI*	*LO*	*HI*	*LO*	*HI*	*LO*

The normal reply will echo the first two characters of the message received, and will then contain a single-byte data byte count, which will not include itself or the CRC. For this message, there will be one byte of data per eight bits-worth of information requested, with the LSbit of the first data byte transmitted depicting the state of the lowest-numbered bit required.

Addr.	Func.	Count	1 - 8	9 - 16	17 - 24	...	Last	CRC16	
	1/2							*HI*	*LO*

This function will be used largely to report controller status information, and so a bit set to 1 indicates that the corresponding feature is currently enabled/active, and a bit reset to 0 indicates the opposite. If an exact multiple of eight bits is not requested, the data is padded with trailing zeros to preserve the 8-bit format. After the data has been transmitted, the CRC16 value is sent.

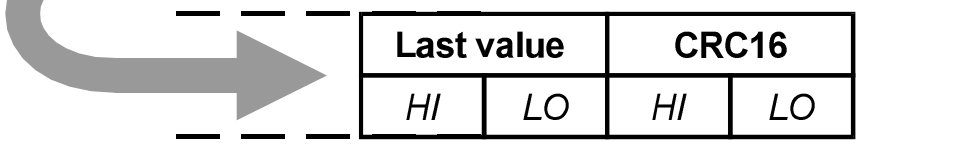
B. Read Holding Registers *(Read n Words)* 03/04

The message sent to the controller to obtain the value of one or more registers is an eight-byte message as follows:

Addr.	Func.	Addr. of 1st Word		No. of words		CRC16	
	3/4	*HI*	*LO*	*HI*	*LO*	*HI*	*LO*

The reply sent by the controller echoes the first 2 characters received and then contains a single-byte data byte count, the value of which does not include either itself or the CRC value to be sent. For this message, the count equals the number of parameters read times two. Following the byte count, that number of parameter values are transmitted, MSB first, followed by the CRC16.

Addr.	Func.	Count	1st value		2nd value	
	3/4		*HI*	*LO*	*HI*	*LO*



Last value		CRC16	
HI	*LO*	*HI*	*LO*

C. Force Single Coil *(Write 1 Bit)* 05

The message received by the controller is 8 bytes long, consisting of the standard preamble and the address of the bit to force, followed by a two-byte word whose MSB contains the desired truth value of the bit expressed as 0xFF (TRUE) or 0x00 (FALSE).

Addr.	Func.	Addr. of Bit		State		CRC16	
	5	*HI*	*LO*	*FF/00*	*0*	*HI*	*LO*

Generally, this function will be used to control such features as Auto/Manual and Tuning. The normal reply sent by the controller will be a byte-for-byte echo of the message received.

D. Preset Single Register *(Write 1 Word)* 06

The message sent to the controller consists of 8 bytes: the address and function number as usual, the address of the parameter to be written, and the two-byte value to which the parameter will be set, and finally the CRC16.

Addr.	Func.	Addr. of Word		Value		CRC16	
	6	*HI*	*LO*	*HI*	*LO*	*HI*	*LO*

The normal response is to echo the message in its entirety.

E. Loopback Diagnostic Test 08

The controller is sent an 8 byte message consisting of the usual preamble, a two-byte diagnostic code, and two bytes of data, followed by the CRC16.

Addr.	Func.	Diag. Code		Value		CRC16	
	8	*HI*	*LO*	*HI*	*LO*	*HI*	*LO*

Full MODBUS support in this area is not appropriate - consequently, the only Diagnostic Code supported is code 00. In response to the message, the controller must echo the message received exactly.

F. Preset Multiple Registers *(Write n Words)* 16 B

This message consists of eleven bytes. Only one parameter may be written at a time, even though this function number is supported. The preamble is followed by the address of the parameter to be written, and then a two-byte word count (always set to 1) and a single-byte byte count (always set to 2). Finally, the value to be written is followed by the CRC16.

Addr.	Func.	Addr. of Word		No. of Words		Count
	16	*HI*	*LO*	*0*	*1*	*2*

Value		CRC16	
HI	*LO*	*HI*	*LO*

The controller normally responds with a eight-byte reply, as follows:

Addr.	Func.	Addr. of Word		No. of Words		CRC16	
	16	*HI*	*LO*	*0*	*1*	*HI*	*LO*

G. Error and Exception Responses

If the controller receives a message which contains a corrupted character (parity check fail, framing error etc.), or if the CRC16 check fails, the controller ignores the message. If the message is otherwise syntactically flawed (e.g. the byte count or word count is incorrect) the controller will also not reply.

However, if the controller receives a syntactically correct message which nonetheless contains an illegal value, it will send an exception response, consisting of five bytes as follows:

Addr.	Func.	Exception No.	CRC16	
			HI	*LO*

The Function Number field consists of the function number contained in the message which caused the error, with its top bit set (i.e. function 3 becomes 0x83), and the Exception Number is one of the codes contained in the following table:

Code	Name	Cause
1	ILLEGAL FUNCTION	Function Number out of range
2	ILLEGAL DATA ADDRESS	Parameter ID out of range or not supported
3	ILLEGAL DATA VALUE	Attempt to write invalid data/action not carried out
4	DEVICE FAILURE	N/A
5	ACKNOWLEDGE	N/A
6	BUSY	N/A
7	NEGATIVE ACKNOWLEDGE	N/A

H. CRC16 Calculation

This is a 16-bit cyclic redundancy checksum. It is calculated in accordance with a formula which involves recursive division of the data by a polynomial, with the input to each division being the remainder of the results of the previous one.

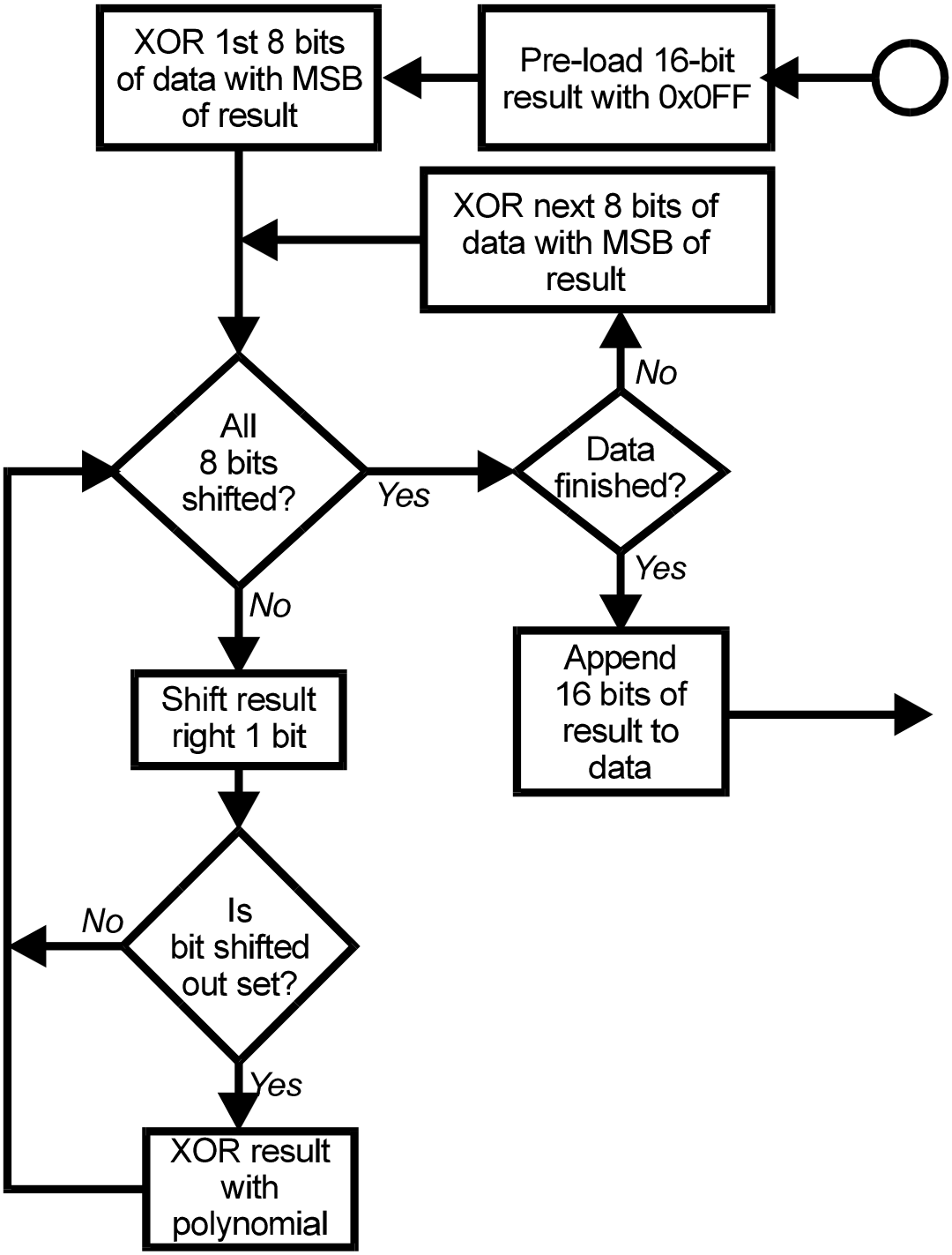
The formula specifies that input is treated as a continuous bit-stream binary number, with the most significant bit being transmitted first. However, the transmitting device sends the least significant bit first.

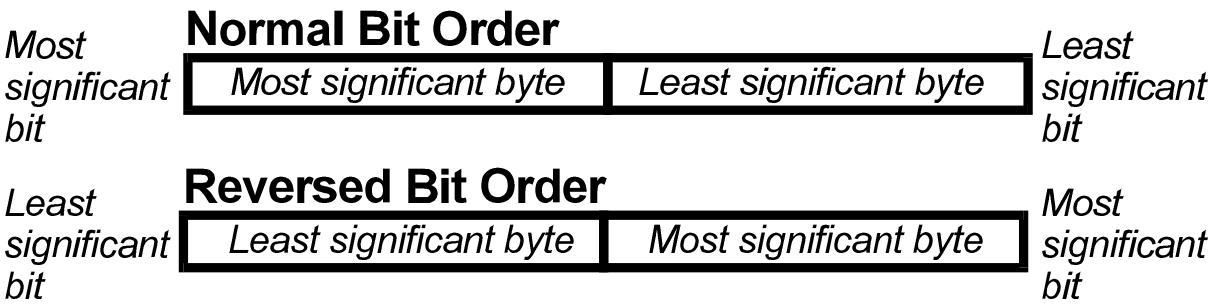
According to the formula, the dividing polynomial is $2^{16} + 2^{15} + 2^2 + 1$ (Hex 18005), but this is modified in two ways:

i. Because the bit-order is reversed, the binary pattern is reversed also, making the MSB the rightmost bit, and

ii. Because only the remainder is of interest, the MSB (the rightmost bit) may be discarded.

This means the polynomial has the value Hex A001. The CRC algorithm is as shown overleaf:





REVERSED BIT ORDER USED

4 PARAMETER NUMBERS

The parameter numbering system, in order to conform to the CNOMO standard, splits parameters into BITS and WORDS and numbers each group independently.

A. Bit Parameters (Controller Status Byte)

There are a maximum of sixteen of these:

No.	Parameter	Notes
1	Communications Write Status	Read only - 1 = enabled, 0 = disabled
2	Auto/Manual Control	1 = Manual, 0 = Auto
3	Self-Tune Status	1 = active, 0 = inactive
4	Pre-Tune Status	1 = active, 0 = inactive
5	Alarm 1 Status	Read only - 1 = active, 0 = inactive
6	Alarm 2 Status	Read only - 1 = active, 0 = inactive
7	Setpoint Ramp Enable(d)	1 = enable(d), 0 = disable(d)
8	Reserved	
9	Reserved	
10	Loop Alarm Enable(d)	1 = enable(d), 0 = disable(d)
11	Reserved	
12	Reserved	
13	Reserved	
14	Reserved	
15	Reserved	
16	Reserved	

B. Word Parameters

No.	Parameter	Notes
1	Process Variable	Read only
2	Setpoint	Target setpoint, if ramping
3	Output Power	Read only, unless in Manual Control
4	Arithmetic Deviation	Read only
5	Proportional Band 2	Read only, if Self-tuning
6	Proportional Band 1	Read only, if Self-tuning
7	Control action (direct/reverse)	
8	Reset (or Loop Alarm Time)	Read only, if Self-tuning
9	Rate	Read only, if Self-tuning
10	Output 1 Cycle Time	

No.	Parameter	Notes
11	Scale Range Low	Read only if non-linear input
12	Scale Range High	Read only if non-linear input
13	Alarm 1 value	
14	Alarm 2 value	
15	Manual Reset	
16	Overlap/Deadband	
17	ON/OFF Differential	
18	Decimal Point Position	Read only if non-linear input
19	Output 2 Cycle Time	
20	Output 1 Power Limit	
21	Internal setpoint	Read only - current value
22	Setpoint High Limit	
23	Setpoint Low Limit	
24	Setpoint Ramp Rate	
25	Input Filter Time Constant	
26	Process Variable Offset	
27	Recorder Output Max.	
28	Recorder Output Min.	

Some of the parameters which do not apply to a particular instrument configuration (e.g. Proportional Band 2 on a single output instrument) will accept reads & writes. Others will accept reads only, and will return an exception if an attempt is made to write values to them. The values read will in all cases be undefined. It is the user's responsibility to make sure that values read reflect a possible state of the instrument.