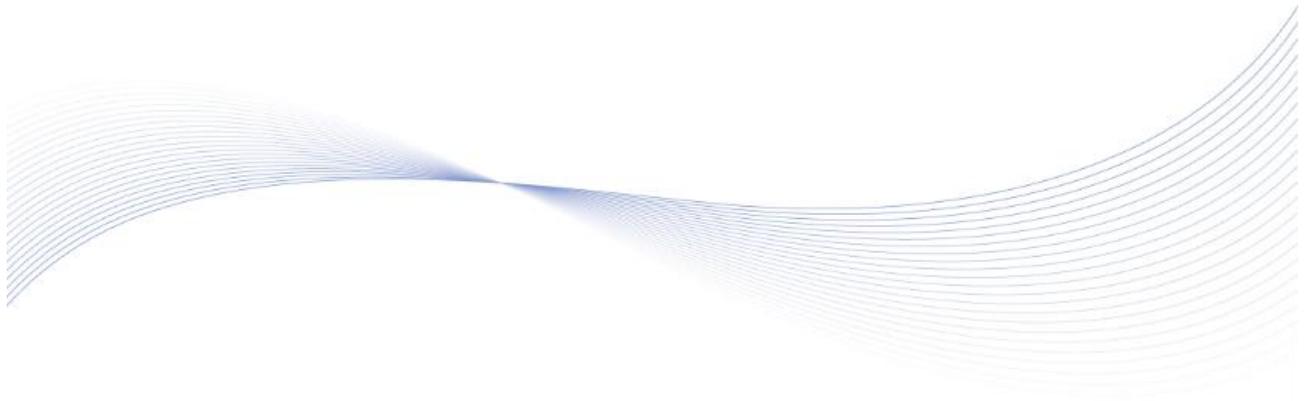

SmartGen

MAKING CONTROL SMARTER

HEM4100
ENGINE CONTROLLER
COMMUNICATION PROTOCOL



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Table 1 Software Version

Date	Version	Content
2018-08-02	V1.0	Original release.
2024-06-20	V1.1	1. Add new data of function code 03 and 05 2. Update the latest template

CONTENTS

1 INTRODUCTION.....	4
2 MODBUS BASIC RULES	4
3 DATA FRAME FORMAT	4
4 COMMUNICATION PROTOCOL.....	5
4.1 DESCRIPTION	5
4.2 MESSAGE FRAME FORMAT	5
4.3 ADDRESS CODE.....	5
4.4 FUNCTION CODE.....	5
4.4.1 FUNCTION CODE 01H READ COILS	5
4.4.2 FUNCTION CODE 03H READ REGISTERS	6
4.4.3 FUNCTION CODE 05H WRITE SINGLE COIL.....	6
4.5 DATA FIELD	6
4.5.1 FUNCTION CODE 01H MAPPING DATA FIELD FORMAT.....	6
4.5.2 FUNCTION CODE 03H MAPPING DATA FIELD FORMAT.....	6
4.5.3 FUNCTION CODE 05H MAPPING DATA FIELD FORMAT.....	7
4.6 ERROR CHECK CODE (CRC)	8
4.7 EXAMPLES OF MESSAGE FRAME FORMAT	9
4.7.1 FUNCTION CODE 01H.....	9
4.7.2 FUNCTION CODE 03H.....	10
4.7.3 FUNCTION CODE 05H.....	11
4.8 ERROR HANDLING	12
5 APPENDIX: ADDRESS AND DATA.....	13
5.1 FUNCTION CODE 03H MAPPING DATA FIELD.....	13
5.2 FUNCTION CODE 05H MAPPING COIL FIELD	26
5.3 ENGINE RUNNING STATUS	27
5.4 REMOTE START STATUS.....	27
5.5 REMOTE START TYPE	27

1 INTRODUCTION

This protocol describes the controller serial ports' read and write command format, and the definition of internal message & data for the third-party to develop and use.

MODBUS communication protocol allows the controller to transfer information and data effectively with PLC, RTU, SCADA system, and DCS of international brands, such as Schneider, Siemens, and Modicon, etc., or the third-party supervisory control system that is compatible with MODBUS. The monitoring system can be set up by installing the central communication master control software (such as KingView, Intouch, FIX, Synall, etc.) on PC (or IPC).

2 MODBUS BASIC RULES

- All RS232 communication loops should follow the master-slave mode. Data can be transmitted between a master (e.g. PC) and 32 slaves by this mode.
- The master can transmit all information to the initialized device via RS232 communication loops.
- No request communication can be sent from slave.
- All communication via RS232 loops should be transmitted in "frame".
- If master or slave receives frame which contains unknown command, no response will be sent.

3 DATA FRAME FORMAT

Communication transmission is in asynchronously way, which uses byte (or frame) as data unit. Every frame will be 11-bit serial data stream when it is transmitted between master and slaves.

Table 2 Data Frame Format

Item	Bits
Start	1-bit
Data	8-bit
Parity	None
Stop	2-bit

4 COMMUNICATION PROTOCOL

4.1 DESCRIPTION

When the communication command is sent to the device, the device that matches the corresponding address code will receive the communication command. It removes the address code, reads the message, performs the corresponding task if there is no error, and then returns the execution result to the sender. The message returned includes the address code, the function code of the action, the data after the action, and the error check code (CRC). If an error occurs, no message will be sent.

4.2 MESSAGE FRAME FORMAT

Table 3 Message Frame Format

Start Structure	Address Code	Function Code	Data Field	Error Check Code	End Structure
Delay (equivalent to 4 bytes)	1 byte 8-bit	1 byte 8-bit	N bytes N*8-bit	2 bytes 16-bit	Delay (equivalent to 4 bytes)

4.3 ADDRESS CODE

Address code is the first data frame (8-bit) in each transmitted information frame, from 0 to 255. Single device address range is 1-247; this byte shows that the slave defined by users will receive the information sent by the master. Each slave has a unique address code, and responses begin with the address code. A master addresses a slave by placing the slave address in the address field of the message. When the slave sends its response, it places its own address in this address field of the response to let the master know which slave is responding.

4.4 FUNCTION CODE

This is the second data of each transmission. ModBus communication protocol defined function code as 1-255 (01H-0FFH). HEM4100 controller uses part of it. Master sends the request and the slave executes actions according to the function code. If the function code sent by slave is same as that sent by master, it means the response is active. But if the function code MSB is 1 (function code range>127), it means there is no response or response has error.

The following table shows the specific signification and operation of function code.

Table 4 ModBus Partial Function Codes

Function Code	Definition	Operation
01H	Read Coils	Read single coil or multiple coils
03H	Read Registers	Read the data of single register or multiple registers
05H	Write Single Coil	Write single coil

4.4.1 FUNCTION CODE 01H READ COILS

The master can use function code 01H as communication command to read various coil status inside the device (such as close, open, fault of breaker, auto or manual status, etc.).

4.4.2 FUNCTION CODE 03H READ REGISTERS

The master can use function code 03H as communication command to read value register inside the device (value register saves various analog data and set value of parameters); The input register values of function code 03H mapping data field are 16-bit (2 bytes). So, registers values read from the device are 2 bytes. Maximum number of readable registers is 125 each time.

The slave received command format is slave address, function code, data field and the CRC code. The data of data field is in double bytes with every two bytes for a group, and high order byte is in advance.

4.4.3 FUNCTION CODE 05H WRITE SINGLE COIL

The master can use function code 03H as communication command to save the data of single coil into the bit memory inside the device (such as coil for ATS transfer control). The slave also uses the same function code to send response information to the master.

4.5 DATA FIELD

Data field varies with different function codes.

4.5.1 FUNCTION CODE 01H MAPPING DATA FIELD FORMAT

Table 5 Master Request

Data Sequence	Data Signification	Byte Count
1	Start address	2
2	Number of Read Coils	2

Table 6 Slave Response

Data Sequence	Data Signification	Byte Count
1	Number of Loopback Bytes	1
2	N * Coil Data	1

4.5.2 FUNCTION CODE 03H MAPPING DATA FIELD FORMAT

Table 7 Master Request

Data Sequence	Data Signification	Byte Count
1	Start address	2
2	Number of Read Registers	2

Table 8 Slave Response

Data Sequence	Data Signification	Byte Count
1	Number of Loopback Bytes	1
2	N * Register Data	N

4.5.3 FUNCTION CODE 05H MAPPING DATA FIELD FORMAT

Table 9 Master Request

Data Sequence	Data Signification	Byte Count
1	Coil address	2
2	Write single coil value	2

Table 10 Slave Response

Data Sequence	Data Signification	Byte Count
1	Coil address	2
2	Single coil value	2

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4.6 ERROR CHECK CODE (CRC)

The CRC code allows the master or slave to check if the frame or packet has errors. Sometimes, the message occur imperceptible changes due to electronic noise and other interference when transmitted, and the error check code ensures the error information does not work during the transmission process, which increases the system's reliability and efficiency. Error check code adopts CRC-16 method.

The CRC code contains two bytes, and the low-order byte is appended first, followed by the high-order byte.

NOTE: All message frame format is same: address code, function code, data field and CRC code.

The CRC code contains two bytes, which is a 16-bit binary value. The CRC code is calculated by the transmitting device, and follows the entire data/message. The receiving device recalculates the CRC code of the message received, and compares the recalculated value to the actual value it received. If the two values are not equal, an error occurs.

The calculation method of CRC code is started by first preloading a 16-bit register to all 1's. Then it begins to process successive 8-bit bytes of the message. Only the eight bits of data in each character are used for generating the CRC code. Start and stop bits do not apply to the CRC code.

During generation of the CRC code, each 8-bit character is exclusive OR 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 1, the register is then exclusive OR with a preset, fixed value. If the LSB was 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 byte is exclusive OR 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 bytes of the message have been applied, is the value of CRC code.

CRC-16 CALCULATION PROCEDURE:

- 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 LSB of the 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 A001 hex;
- 5) Repeat Step 3 and Step 4 until 8 shifts have been performed. When this is done, a complete 8-bit byte has been processed;
- 6) Repeat Step 2 to Step 5 for the next 8-bit byte of the message. Continue repeating this procedure until all bytes have been processed;
- 7) The final contents of the CRC register are the CRC value. 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.

NOTE: The calculating of CRC code starts from <slave address> and except for all bytes of <CRC code>.

4.7 EXAMPLES OF MESSAGE FRAME FORMAT

4.7.1 FUNCTION CODE 01H

The slave address is 00, read 20H coils (32 in decimal) from the start address 0000H.

Table 11 Master Request Data

Master Request	Bytes	Examples (Hex)	
Slave Address	1	01	Send to Slave 01
Function Code	1	01	Read coils
Start Address	2	00 00	Start address is 0000
Quantity of Registers	2	00 1C	Read 28 coils
CRC Code	2	3D C3	CRC code calculated by the master

Table 12 Slave Response Data

Slave Response	Bytes	Examples (Hex)	
Slave Address	1	01	Return the slave address 01
Function Code	1	01	Read coils
Quantity of Bytes	1	04	Quantity of coils returned: 28 coils (4 bytes in total)
Data 1	1	30	Content of Address 07-00
Data 2	1	00	Content of Address 0F-08
Data 3	1	93	Content of Address 17-10
Data 4	1	0A	Content of Address 1C-18
CRC Code	2	18 26	CRC code calculated by the slave

In this example, the value of Coil 07-00 is 30H in hexadecimal, and 00110000 in binary. The Coil 07 is the high order bit and Coil 00 is the low order bit. The status of the Coil 07-00 is OFF-OFF-ON-ON-OFF-OFF-OFF-OFF.

4.7.2 FUNCTION CODE 03H

The slave address is 01, read 3 registers from the start address 0026H.
 In this example, the data addresses are as follows:

Table 13 Data Address

Address	Data (Hex)
0026	0014
0027	0014
0028	0005

Table 14 Master Request Data

Master Request	Bytes	Examples (Hex)
Slave Address	1	01 Send to Slave 01
Function Code	1	03 Read single point register
Start Address	2	00 Start address is 0026 26
Quantity of Registers	2	00 Read 3 registers (6 bytes in total) 03
CRC Code	2	E4 CRC code calculated by the master 00

Table 15 Slave Response Data

Slave Response	Bytes	Examples (Hex)
Slave Address	1	01 Return the slave address 01
Function Code	1	03 Read single point register
Quantity of Bytes	1	06 3 registers (6 bytes in total)
Register 1 Data	2	00 Content of Address 0026 14
Point 2 Data	2	00 Content of Address 0027 14
Point 3 Data	2	00 Content of Address 0028 05
CRC Code	2	91 CRC code calculated by the slave 71

4.7.3 FUNCTION CODE 05H

The slave address is 01, one coil from the start address 0002H, write the value of this coil as 1. In this example, the coil addresses are as follows:

Table 16 Data Address

Address	Data (Hex)
0000	0
0001	1
0002	0

NOTE: A value of FF00H requests the coil to be 1. A value of 0000H requests it to be 0. All other values are illegal and will not affect the coil.

Table 17 Master Request Data

Master Request	Bytes	Examples (Hex)	
Slave Address	1	01	Send to Slave 01
Function Code	1	05	Write coils
Start Address	2	00 00	Start address is 0000
Data	2	FF 00	Set coil as 1
CRC Code	2	CD FB	CRC code calculated by the master

Table 18 Slave Response Data

Slave Response	Bytes	Examples (Hex)	
Slave Address	1	01	Return the slave address 01
Function Code	1	05	Write coils
Start Address	2	00 00	Start address is 0000
Data	2	FF 00	Set coil as 1
CRC Code	2	CD FB	CRC code calculated by the master

4.8 ERROR HANDLING

When the device detects an error (exclude CRC error), it must return message to the master/host, and the MSB of the function code is 1, that is, the function code returned by the slave device is the function code sent by the master plus 128 (0x80). The following codes indicate that an exception error has occurred.

The message received from the master/host will be ignored by the device if there is a CRC error. Error code format returned from the slave (CRC excluded):

Table 19 CRC Check

Type	Bytes
Address Code	1 byte
Function Code	1 byte (the MSB is 1)
Error Code	1 byte
CRC Code	2 bytes

Exception Function Code

- 01 Illegal Function Code
The function code received is not supported
- 02 Illegal Data Address
The specified address exceeds the range of the slave address
- 03 Illegal Data Value
The data value received from the master is outside the data range of the corresponding address.

5 APPENDIX: ADDRESS AND DATA

5.1 FUNCTION CODE 03H MAPPING DATA FIELD

Table 20 Function Code 03H Mapping Data Field

Address	Item	Description	Bytes
0000	Common Alarm	1 as active	1bit
	Common Shutdown	1 as active	1bit
	Common Warning	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	In Test Mode	1 as active	1bit
	In Auto Mode	1 as active	1bit
	In Manual Mode	1 as active	1bit
	In Stop Mode	1 as active	1bit
	In Speed Regulation Mode	1 as active	1bit
	In Manual/Auto Speed Regulation Mode	1 as active	1bit
	Reserved	1 as active	1bit
	In Lock Mode	1 as active	1bit
	0001	Emergency Stop	1 as active
Overspeed Shutdown		1 as active	1bit
Underspeed Shutdown		1 as active	1bit
Loss of Speed Signal Shutdown		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
Start Failure Shutdown		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
ECU Shutdown		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
High Temp. Input Shutdown		1 as active	1bit
Low Oil Pressure Input Shutdown		1 as active	1bit
0002		ECU Comm. Failure Shutdown	1 as active
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit

Address	Item	Description	Bytes
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Engine Temp. Sensor Open Shutdown	1 as active	1bit
	High Engine Temp. Shutdown	1 as active	1bit
	Low Engine Temp. Shutdown	1 as active	1bit
	Reserved	1 as active	1bit
	Engine OP Sensor Open Shutdown	1 as active	1bit
	High Engine Oil Pressure Shutdown	1 as active	1bit
	Low Engine Oil Pressure Shutdown	1 as active	1bit
	Reserved	1 as active	1bit
0003	Flexible Sensor 1 Open Shutdown	1 as active	1bit
	Flexible Sensor 1 High Shutdown	1 as active	1bit
	Flexible Sensor 1 Low Shutdown	1 as active	1bit
	Reserved	1 as active	1bit
	Flexible Sensor 2 Open Shutdown	1 as active	1bit
	Flexible Sensor 2 High Shutdown	1 as active	1bit
	Flexible Sensor 2 Low Shutdown	1 as active	1bit
	Reserved	1 as active	1bit
	Flexible Sensor 3 Open Shutdown	1 as active	1bit
	Flexible Sensor 3 High Shutdown	1 as active	1bit
	Flexible Sensor 3 Low Shutdown	1 as active	1bit
	Reserved	1 as active	1bit
	Flexible Sensor 4 Open Shutdown	1 as active	1bit
	Flexible Sensor 4 High Shutdown	1 as active	1bit
	Flexible Sensor 4 Low Shutdown	1 as active	1bit
	Reserved	1 as active	1bit
0004	Suction Pump Crank Failure Shutdown	1 as active	1bit
	Suction Pump Fault Shutdown	1 as active	1bit
	Flexible Sensor 5 Open Shutdown	1 as active	1bit
	Flexible Sensor 5 High Shutdown	1 as active	1bit
	Flexible Sensor 5 Low Shutdown	1 as active	1bit
	Reserved	1 as active	1bit
	Flexible Sensor 6 Open Shutdown	1 as active	1bit
	Flexible Sensor 6 High Shutdown	1 as active	1bit
	Flexible Sensor 6 Low Shutdown	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit

Address	Item	Description	Bytes
	Reserved	1 as active	1bit
0005	Input 1 Shutdown	1 as active	1bit
	Input 2 Shutdown	1 as active	1bit
	Input 3 Shutdown	1 as active	1bit
	Input 4 Shutdown	1 as active	1bit
	Input 5 Shutdown	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	End of Mandate Time Shutdown	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Over Flow Shutdown	1 as active	1bit
0006	Maintenance 1 Due Shutdown	1 as active	1bit
	Maintenance 2 Due Shutdown	1 as active	1bit
	Maintenance 3 Due Shutdown	1 as active	1bit
	Maintenance 4 Due Shutdown	1 as active	1bit
	Maintenance 5 Due Shutdown	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	0007	Reserved	Two bytes
0008	Reserved	Two bytes	2Bytes
0009	Reserved	Two bytes	2Bytes
0010	Reserved	Two bytes	2Bytes
0011	Reserved	Two bytes	2Bytes
0012	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit

Address	Item	Description	Bytes
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
0013	Reserved	Two bytes	2Bytes
0014	Reserved	Two bytes	2Bytes
0015	Reserved	Two bytes	2Bytes
0016	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
0017	Reserved	Two bytes	2Bytes
0018	Reserved	Two bytes	2Bytes
0019	Reserved	Two bytes	2Bytes
0020	Engine Overspeed Warning	1 as active	1bit
	Engine Underspeed Warning	1 as active	1bit
	Loss of Speed Signal Warning	1 as active	1bit
	DPF Regeneration Warning (Please regenerate manually)	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit

Address	Item	Description	Bytes
	Reserved	1 as active	1bit
	Stop Failure Warning	1 as active	1bit
	Charging Failure Warning	1 as active	1bit
	Battery Overvoltage Warning	1 as active	1bit
	Battery Undervoltage Warning	1 as active	1bit
	Maintenance Due Warning	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	ECU Warning	1 as active	1bit
0021	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Engine Temp. Sensor Open Warning	1 as active	1bit
	High Engine Temp. Warning	1 as active	1bit
	Low Engine Temp. Warning	1 as active	1bit
	Reserved	1 as active	1bit
	Engine OP Sensor Open Warning	1 as active	1bit
	High Engine Oil Pressure Warning	1 as active	1bit
	Low Engine Oil Pressure Warning	1 as active	1bit
Engine OP Sensor Error	1 as active	1bit	
0022	Flexible Sensor 1 Open Warning	1 as active	1bit
	Flexible Sensor 1 High Warning	1 as active	1bit
	Flexible Sensor 1 Low Warning	1 as active	1bit
	Reserved	1 as active	1bit
	Flexible Sensor 2 Open Warning	1 as active	1bit
	Flexible Sensor 2 High Warning	1 as active	1bit
	Flexible Sensor 2 Low Warning	1 as active	1bit
	Reserved	1 as active	1bit
	Flexible Sensor 3 Open Warning	1 as active	1bit
	Flexible Sensor 3 High Warning	1 as active	1bit
	Flexible Sensor 3 Low Warning	1 as active	1bit
	Flexible Sensor 3 Error	1 as active	1bit
	Flexible Sensor 4 Open Warning	1 as active	1bit
	Flexible Sensor 4 High Warning	1 as active	1bit
	Flexible Sensor 4 Low Warning	1 as active	1bit
	Flexible Sensor 4 Error	1 as active	1bit
0023	Flexible Sensor 5 Open Warning	1 as active	1bit

Address	Item	Description	Bytes
	Flexible Sensor 5 High Warning	1 as active	1bit
	Flexible Sensor 5 Low Warning	1 as active	1bit
	Reserved	1 as active	1bit
	Flexible Sensor 6 Open Warning	1 as active	1bit
	Flexible Sensor 6 High Warning	1 as active	1bit
	Flexible Sensor 6 Low Warning	1 as active	1bit
	Flexible Sensor 6 Error	1 as active	1bit
	Over Flow Warning	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	End of Mandate Time Warning	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
0024	Input 1 Warning	1 as active	1bit
	Input 2 Warning	1 as active	1bit
	Input 3 Warning	1 as active	1bit
	Input 4 Warning	1 as active	1bit
	Input 5 Warning	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Battery Under Voltage Warning	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
0025	Maintenance 1 Due Warning	1 as active	1bit
	Maintenance 2 Due Warning	1 as active	1bit
	Maintenance 3 Due Warning	1 as active	1bit
	Maintenance 4 Due Warning	1 as active	1bit
	Maintenance 5 Due Warning	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit

Address	Item	Description	Bytes
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
0026	Reserved	Two bytes	2Bytes
0027	Reserved	Two bytes	2Bytes
0028	Reserved	Two bytes	2Bytes
0029	Reserved	Two bytes	2Bytes
0030	Reserved	Two bytes	2Bytes
0031	Reserved	Two bytes	2Bytes
0032	Reserved	Two bytes	2Bytes
0033	Input 1 Indication	1 as active	1bit
	Input 2 Indication	1 as active	1bit
	Input 3 Indication	1 as active	1bit
	Input 4 Indication	1 as active	1bit
	Input 5 Indication	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	0034	Maintenance 1 Indication	1 as active
Maintenance 2 Indication		1 as active	1bit
Maintenance 3 Indication		1 as active	1bit
Maintenance 4 Indication		1 as active	1bit
Maintenance 5 Indication		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit

Address	Item	Description	Bytes
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
0035	Emergency Input Status	1 as active	1bit
	Input 1 Status	1 as active	1bit
	Input 2 Status	1 as active	1bit
	Input 3 Status	1 as active	1bit
	Input 4 Status	1 as active	1bit
	Input 5 Status	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
0036	Reserved	Two bytes	2Bytes
0037	Fuel Relay Output Status	1 as active	1bit
	Crank Relay Output Status	1 as active	1bit
	Aux. Output 1 Status	1 as active	1bit
	Aux. Output 2 Status	1 as active	1bit
	Aux. Output 3 Status	1 as active	1bit
	Aux. Output 4 Status	1 as active	1bit
	Aux. Output 5 Status	1 as active	1bit
	Aux. Output 6 Status	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
0038	Reserved	Two bytes	2Bytes
0039	Reserved	Two bytes	2Bytes
0040	Reserved	Two bytes	2Bytes
0041	Reserved	Two bytes	2Bytes
0042	Reserved	Two bytes	2Bytes
0043	Reserved	1 as active	1bit
	Reserved	1 as active	1bit

Address	Item	Description	Bytes
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Running Status Indicator	1 as active	1bit
	Speed Drop Indication	1 as active	1bit
	Speed Raise Indication	1 as active	1bit
	Reserved	1 as active	1bit
	Idle Running Status	1 as active	1bit
	Shutdown Inhibit Status	1 as active	1bit
	Instrument Mode Status	1 as active	1bit
	Idle Mode Status	1 as active	1bit
	Auto Stop Inhibit Status	1 as active	1bit
	Auto Start Inhibit Status	1 as active	1bit
	Scheduled Run Inhibit Status	1 as active	1bit
	Scheduled Not Run Status	1 as active	1bit
	0044	DPF Fault	1 as active
DPF Request		1 as active	1bit
DPF Inhibit Indicator		1 as active	1bit
DPF Exhaust Temp. Indicator		1 as active	1bit
DPF Status Indicator		1 as active	1bit
DPF EGR System Fault		1 as active	1bit
Low DEF Level Warning/Driver Warning Indicator		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
Reserved		1 as active	1bit
Manual DPF Regeneration Required (CUMMINS)		1 as active	1bit
0045		Input 1 Active	1 as active
	Input 2 Active	1 as active	1bit
	Input 3 Active	1 as active	1bit
	Input 4 Active	1 as active	1bit
	Input 5 Active	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit

Address	Item	Description	Bytes
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
	Reserved	1 as active	1bit
0046	Reserved	Two bytes	2Bytes
0047	Reserved	Two bytes	2Bytes
0048	Reserved	Two bytes	2Bytes
0049	Pump Head	Unsigned	2Bytes
0050	Engine Speed	Unsigned	2Bytes
0051	Battery Voltage	Signed (*10)	2Bytes
0052	Charger Voltage	Signed (*10)	2Bytes
0053	W/L Frequency	Unsigned	2Bytes
0054	Reserved	Unsigned	2Bytes
0055	Pump Flow (m ³ /h)	Unsigned (*10)	2Bytes
0056	GOV Output Percentage	Signed (*10)	2Bytes
0057	Sensor 1 Resistance	Unsigned (*10)	2Bytes
0058	Sensor 1 Value (Water Temp.)	Signed	2Bytes
0059	Sensor 2 Resistance/Current/Voltage Value	Unsigned (*10)	2Bytes
0060	Sensor 2 Value (Oil Pressure)	Signed	2Bytes
0061	Sensor 3 Resistance	Unsigned (*10)	2Bytes
0062	Sensor 3 Value (Flexible 1)	Signed	2Bytes
0063	Sensor 4 Resistance	Unsigned (*10)	2Bytes
0064	Sensor 4 Value (Flexible 2)	Signed	2Bytes
0065	Sensor 5 Resistance/Current/Voltage Value	Unsigned (*10)	2Bytes
0066	Sensor 5 Value (Flexible 3)	Signed	2Bytes
0067	Sensor 6 Resistance/Current/Voltage Value	Unsigned (*10)	2Bytes
0068	Sensor 6 Value (Flexible 4)	Signed	2Bytes
0069	Reserved	Unsigned (*10)	2Bytes
0070	Reserved	Signed	2Bytes
0071	Reserved	Unsigned (*10)	2Bytes
0072	Reserved	Signed	2Bytes
0073	Reserved	Unsigned (*10)	2Bytes
0074	Reserved	Signed	2Bytes
0075	Reserved	Unsigned (*10)	2Bytes
0076	Reserved	Signed	2Bytes
0077	Coolant Pressure	Signed	2Bytes
0078	Coolant Level	Signed	2Bytes
0079	Fuel Pressure	Signed	2Bytes
0080	Fuel Temp.	Signed	2Bytes
0081	Oil Temp.	Signed	2Bytes
0082	Air Inlet Temp.	Signed	2Bytes

Address	Item	Description	Bytes
0083	Turbo Pressure	Signed	2Bytes
0084	Exhaust Outlet Temp.	Signed	2Bytes
0085	Fuel Consumption	Signed	2Bytes
0086	Total Fuel Consumption (LSB)	Signed	4Bytes
0087	Total Fuel Consumption (MSB)		
0088	Reserved	Unsigned	2Bytes
0089	Reserved	Unsigned	2Bytes
0090	Reserved	Unsigned	2Bytes
0091	Reserved	Unsigned	2Bytes
0092	Reserved	Unsigned	2Bytes
0093	Reserved	Unsigned	2Bytes
0094	Engine Running Status	Engine Running Status	2Bytes
0095	Engine Delay	Unsigned	2Bytes
0096	Remote Start Status	Remote Start Status	2Bytes
0097	Remote Start Delay	Unsigned	2Bytes
0098	Remote Start Type	Remote Start Type	2Bytes
0099	Reserved	Unsigned	2Bytes
0100	Reserved	Unsigned	2Bytes
0101	Total Running Hours	Unsigned	2Bytes
0102	Total Running Minutes	Unsigned	2Bytes
0103	Total Running Seconds	Unsigned	2Bytes
0104	Total Start Times	Unsigned	2Bytes
0105	Total Flow (m ³)	Unsigned	4Bytes
0106			
0107	Current Accumulated Flow	Unsigned	4Bytes
0108			
0109	Self-Start Failure Count	Unsigned	2Bytes
0110	Reserved	Unsigned	2Bytes
0111	Reserved	Unsigned	2Bytes
0112	Reserved	Unsigned	2Bytes
0113	Controller Model	Unsigned	2Bytes
0114	Controller Software Version	Unsigned (*10)	2Bytes
0115	Controller Hardware Version	Unsigned (*10)	2Bytes
0116	Release Year	Save the last two digits of the Year only.	2Bytes
0117	Release Month	Unsigned	2Bytes
0118	Released Day	Unsigned	2Bytes
0119	Reserved	Unsigned	2Bytes
0120	Number of Event Logs	Unsigned	2Bytes
0121	Controller Date: Year	Save the last two digits of the Year only.	2Bytes
0122	Controller Date: Month	Unsigned	2Bytes

Address	Item	Description	Bytes
0123	Controller Date: Day	Unsigned	2Bytes
0124	Controller Date: Week	Unsigned	2Bytes
0125	Controller Time: Hour	Unsigned	2Bytes
0126	Controller Time: Minute	Unsigned	2Bytes
0127	Controller Time: Second	Unsigned	2Bytes
0128	Current Running Hours	Unsigned	2Bytes
0129	Current Running Minutes	Unsigned	2Bytes
0130	Current Running Seconds	Unsigned	2Bytes
0131	Reserved	Unsigned	2Bytes
0132	Reserved	Unsigned	2Bytes
0133	Reserved	Unsigned	2Bytes
0134	Reserved	Unsigned	2Bytes
0135	Maintenance 1 Countdown Hour	Unsigned	2Bytes
0136	Maintenance 1 Countdown Minute	Unsigned	2Bytes
0137	Maintenance 1 Countdown Second	Unsigned	2Bytes
0138	Maintenance 2 Countdown Hour	Unsigned	2Bytes
0139	Maintenance 2 Countdown Minute	Unsigned	2Bytes
0140	Maintenance 2 Countdown Second	Unsigned	2Bytes
0141	Maintenance 3 Countdown Hour	Unsigned	2Bytes
0142	Maintenance 3 Countdown Minute	Unsigned	2Bytes
0143	Maintenance 3 Countdown Second	Unsigned	2Bytes
0144	Maintenance 4 Countdown Hour	Unsigned	2Bytes
0145	Maintenance 4 Countdown Minute	Unsigned	2Bytes
0146	Maintenance 4 Countdown Second	Unsigned	2Bytes
0147	Maintenance 5 Countdown Hour	Unsigned	2Bytes
0148	Maintenance 5 Countdown Minute	Unsigned	2Bytes
0149	Maintenance 5 Countdown Second	Unsigned	2Bytes
0150	User Accumulated Running Hours A	Unsigned	2Bytes
0151	User Accumulated Running Minutes A	Unsigned	2Bytes
0152	User Accumulated Running Seconds A	Unsigned	2Bytes
0153	Engine Load Ratio	Signed	2Bytes
0154	User Accumulated Running Hours B	Unsigned	2Bytes
0155	User Accumulated Running Minutes B	Unsigned	2Bytes
0156	User Accumulated Running Seconds B	Unsigned	2Bytes
0157	Start Times	Unsigned	2Bytes
0158	Reserved	Unsigned	2Bytes
0159	Reserved	Unsigned	2Bytes
0160	Engine Time (LSB)	Signed	4Bytes
0161	Engine Time (MSB)		
0162	Air Inlet Pressure	Signed (ANGLE-POWER)	2Bytes
0163	Throttle Valve Position	Signed (ANGLE-POWER)	2Bytes

Address	Item	Description	Bytes
0164	Gas Pressure	Unsigned (ANGLE-POWER)	2Bytes
0165	Exhaust Oxygen Content	Unsigned (ANGLE-POWER)	2Bytes
0166	Turbo Inlet Temp.	Signed (ANGLE-POWER)	2Bytes
0167	Fuel Valve Position	Unsigned (ANGLE-POWER)	2Bytes
0168	Vehicle Speed Display	Unsigned	2Bytes
0169	Vehicle Speed Enable Status	Unsigned	2Bytes
0170	Sensor 7 Resistance	Unsigned (*10)	2Bytes
0171	Sensor 7 Value (Flexible 5)	Signed	2Bytes
0172	Sensor 8 Resistance/Current/Voltage Value	Unsigned (*10)	2Bytes
0173	Sensor 8 Value (Flexible 6)	Signed	2Bytes
0174	Urea Level	Signed	2Bytes
0175	Throttle Valve Position 1	Signed (*10) (Unit: %) (KING BAND)	2Bytes
0176	Air-Gas Ratio	Signed (KING BAND)	2Bytes
0177	Throttle Valve Position 2	Signed (*10) (Unit: %) (KING BAND)	2Bytes
0178	Ignition Timing	Signed (*100) (Unit: °) (KING BAND)	2Bytes
0179	Engine Rated Speed	Unsigned (Unit: RPM) (KING BAND)	2Bytes
0180	Reserved	Unsigned	2Bytes
0181	Reserved	Unsigned	2Bytes

5.2 FUNCTION CODE 05H MAPPING COIL FIELD

Table 21 Function Code 03H Data

Coils		
Address	Item	Description
0000	Remote Start Key	1 as active
0001	Remote Stop Key	1 as active
0002	Reserved	
0003	Remote Auto Key	1 as active
0004	Remote Manual Key	1 as active
0005	Remote Speed Adjusting Key	1 as active
0006	Reserved	
0007	Remote Up Key	1 as active
0008	Remote Down Key	1 as active
0009	Reserved	1 as active
0010	Reserved	1 as active
0011	Remote Confirm Key	1 as active
0012	Remote Lock	1 as active
0013	Remote Unlock	1 as active
0014	Reserved	
0015	Remote Quick Stop	1 as active
0016	Speed Raise Activate Output	1 as active
0017	Emergency Stop	1 as active
0018	Unload+Idle Speed	1 as active
0019	Onload+Rated Speed	1 as active
0020	Remote Output 1	1 as active, 0 as inactive
0021	Remote Output 2	1 as active, 0 as inactive
0022	Remote Output 3	1 as active, 0 as inactive
0023	Remote Output 4	1 as active, 0 as inactive
0024	Remote Output 5	1 as active, 0 as inactive
0025	Remote Output 6	1 as active, 0 as inactive
0026-0032	Reserved	
0033	Reset Total Flow	1 as active
0034	Speed Raise X1	1 as active
0035	Speed Drop X1	1 as active
0036	Speed Raise X10	1 as active
0037	Speed Drop X10	1 as active

5.3 ENGINE RUNNING STATUS

Table 22 Engine Running Status

No.	Item	Range	Description
0	Standby		No delay value is shown in the status
1	Preheat		
2	Diesel-Driven Suction Pump Start		
3	Suction Pump Crank Rest Time		
4	Wait Suction Pump Pressure Ready		
5	Fuel Output		
6	Start Delay		
7	Crank Rest Time		
8	Safety On		
9	Start Idle		
10	High Speed Warming up		
11	Wait to Onload		No delay value is shown in the status
12	Normal Running		No delay value is shown in the status
13	High Speed Cooling		
14	Stop Idle		
15	ETS Solenoid Hold		
16	Wait to Stop		
17	Stop Failure		No delay value is shown in the status
18	After Stop Time		
19	Battery Detection Delay		

5.4 REMOTE START STATUS

Table 23 Remote Start Status

No.	Item & Description
0	No Delay
1	Start Delay
2	Stop Delay

5.5 REMOTE START TYPE

Table 24 Remote Start Type

No.	Item & Description
0	Invalid
1	Remote Start
2	High Water Level Start
3	Low Pipe Pressure Start
4	Scheduled Start