Model Q46

Modbus Communications Manual

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Part 1 – Modbus Description

1.1 Modbus Technical Overview

Modbus protocol is a messaging structure, widely used to establish master-slave communication between intelligent devices. A message sent from a master to a slave contains a one-byte slave address, a one-byte command, data bytes (depending on command), and a two byte CRC. The protocol is independent of the underlying physical layer and is traditionally implemented using RS232, RS422, or RS485 over a variety of media (e.g. fiber, radio, cellular, etc.).

The protocol comes in 2 flavors – ASCII and RTU. The formats of messages are identical in both forms, except that the ASCII form transmits each byte of the message as two ASCII hexadecimal characters. Therefore, ASCII messages are twice as long as RTU messages. The main advantage of the RTU mode is that it achieves higher throughput, while the ASCII mode allows time intervals of up to 1 second to occur between characters without causing an error. As stated earlier, the transmitter uses the RTU form and does not support the ASCII form.
The basic structure of an RTU frame is shown below:

[ADDRESS][FUNCTION][DATA][CRC]

The address field of a message frame contains an eight-bit slave device address in the range of 0 ... 247 decimal. The individual slave devices are assigned addresses in the range of 1 ... 247, and address 0 is reserved as a broadcast address. A master addresses a slave by placing the slave address in the address field of the message. When the slave sends its response message, it places its own address in this address field of the response to let the master know which slave is responding. All slaves accept broadcast messages (address 0) as though they were addressed specifically to them, but do not transmit a response message.

The function code field of a message frame contains an eight-bit code in the range of 1 ... 255 decimal. When a query message is sent from the master, the function code field tells the slave device what kind of action to perform. Examples include reading the contents of a group of registers, writing to a single register, writing to a group of registers, and reading the exception status.

When the slave device responds to the master, it uses the function code field to indicate either a normal (error-free) response or that some kind of error occurred (called an exception response). For a normal response, the slave simply echoes the original function code. For an exception response, the slave returns a code that is equivalent to the original function code with its most significant bit set to logic 1.

The data field is constructed of one or more bytes and contains additional information, which the slave must use to take the action defined by the function code. This can include items like discrete and register addresses, the quantity of items to be handled, and the count of actual data bytes in the field.

If no error occurs, the data field of a response from a slave to a master contains the data requested. If an error occurs, the field contains an exception code that the master application can use to determine the next action to be taken.

The data field can be nonexistent (of zero length) in certain kinds of messages. For example, in a request from a master device for a slave to respond with its communications event log (function code 0B hexadecimal), the slave does not require any additional information. The function code alone specifies the action.

Messages are terminated with a 16-bit CRC value that is computed from all of the bytes of the message. The two byte CRC is superior to just simple checksums because it can help reject more types of errors.

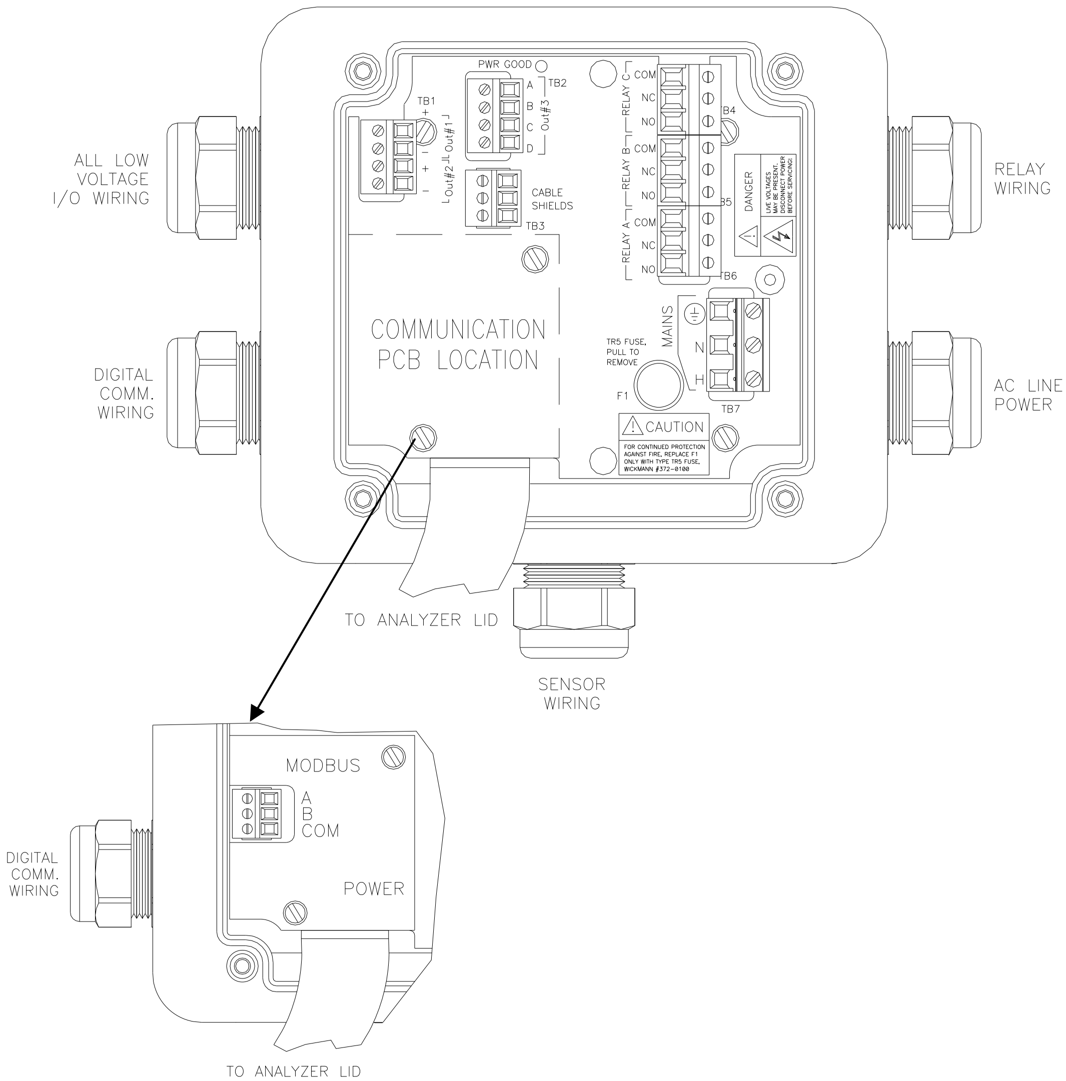


Figure 1 - Modbus Terminal Connections

1.2 Modbus Connection

Modbus wiring is done at a plug-in communication circuit board located in the outlined section of Figure 12 above. A call-out in that figure shows the location of RS-485 connections. The earth ground wire in the 485 cable should be terminated at TB-3 marked “Cable Shields”.

1.3 Registers and Coils

Modbus protocol was originally designed to transfer data to and from PLCs (Programmable Logic Controllers), which organize data into groups of registers and coils. PLC registers containing i/o information are called input registers and are numbered 30001 to 39999, while registers containing data or the results of calculations are known as holding registers and are numbered from 40001 to 49999. The term coils, on the other hand, refers to discrete (0 or 1) inputs and outputs. Traditionally, these are inputs from such things as switch closures and outputs to the coils of relays, which are under the control of the PLC.

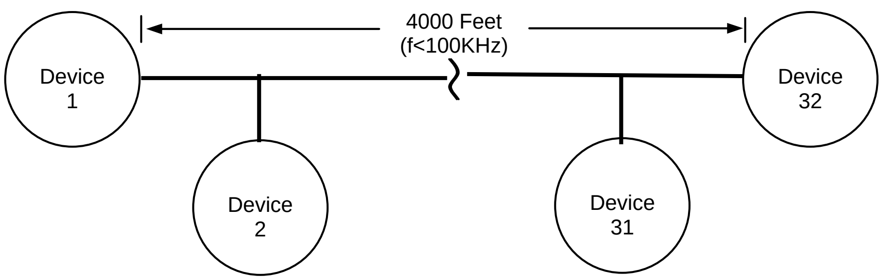
All registers are 16 bit values, which may be read or written to individually, or in blocks by using specific functions. Likewise for coils, which are one bit values. Since register functions transfer 16 bits and discrete (coil) functions transfer only one, it is usually more efficient to use register functions, which reduces the number of messages required to transfer data. For this reason, the Q46 Series transmitter organizes all of its data into input registers only, or more specifically, data is organized into the holding registers starting at 30001.

The protocol specifies which registers to access by the value of the function code embedded into the message. For example, to read one or more holding registers in a slave device, the master must use function 3 – “Read Holding Register”. Similarly, the master must use function 4 – “Read Input Register” to read one or more of the input registers. The Q46 only responds to request for reading input registers (Function 4).

For more information on the protocol, please refer to the “Modicon Modbus Protocol Reference Guide” at http://www.modicon.com/techpubs/toc7.html or, “Modbus Protocol Specification”, available for download at http://www.modbus-ida.org/specs.php. Deviations from this guide are noted in the appropriate section. More information regarding Modbus, in general, may be viewed at: http://www.modbus-ida.org/

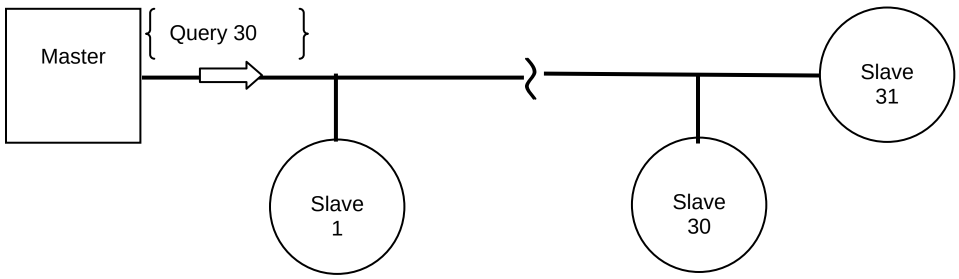
1.4 RS-485 Communication

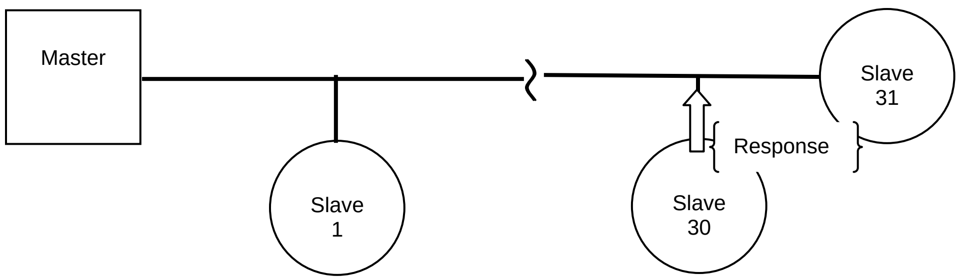
Modbus data transmission is an RS-485 based communication protocol. The RS485 standard specifies a two-wire, half-duplex serial data bus for connecting up to 32 devices in parallel, at distances of up to 4000 feet at transmission rates at or below 100KHz. The RS485 standard allows the user to configure inexpensive local networks and multi-drop communications links using a twisted pair cable. A typical RS485 network can operate properly in the presence of reasonable ground differential voltages, withstand driver contentious situations, and provide reliable communications in electrically noisy environments with good common mode rejection.



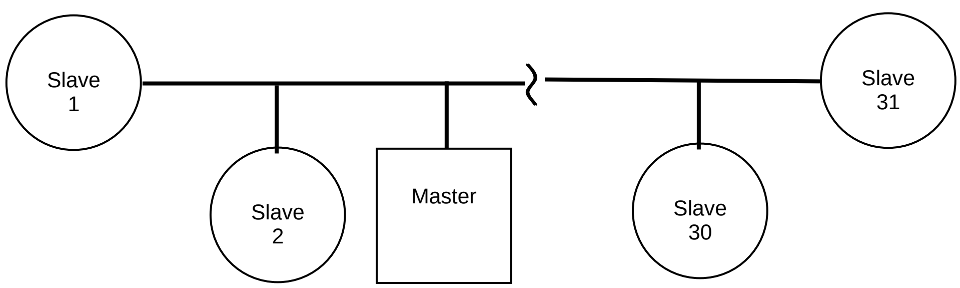
Half-duplex means outgoing messages share the same physical medium with incoming messages. Only one device may transmit at any given time. During any exchange of data communication, one device must act as master and one or more devices act as slaves. With no activity on the bus, the master device sends an addressed query to a slave and then gives up the bus. All slaves receive the message, but only the addressed slave responds.

Series Q46 Analyzer use a plug-in Modbus circuit board shown in Figure 6 on of this manual. Wiring connections for the communication bus are shown in that Figure.



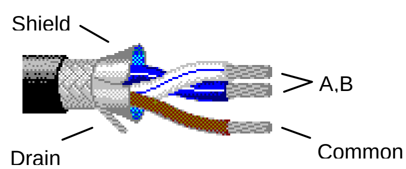


The master node may be located anywhere on the network, not just at one end.

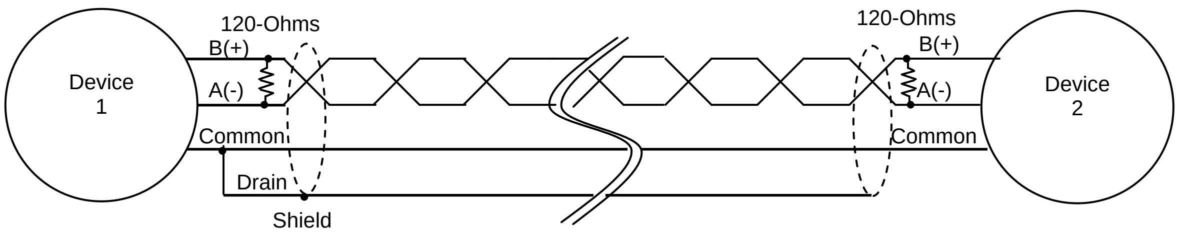


1.5 Cable Specification

The bus is a cable composed of a twisted pair of wires with a characteristic impedance of 120 ohms, and a 120-ohm termination resistor connecting the pair of wires at each end. Several manufacturers offer cables specifically designed for RS485, such as Belden's 3106A, which features one twisted pair, a separate signal common, a foil shield, and a drain wire in contact with the shield.

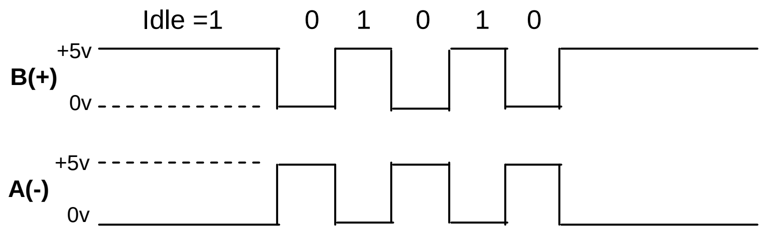


The twisted pair, labeled A and B (or – and +, respectively), form a differential transmission line capable of operating over a common mode voltage range from –7v to +12v (note 2). That is, the ground potential at each end of the network may differ by this amount. Connecting a signal common to each slave device will keep this potential to a minimum. The shield around the conductors provides protection from EMI (electromagnetic interference) and should be connected to common or ground at only one point to avoid circulating currents that might actually generate interference on the inner conductors. A schematic of the bus is shown below.



1.6 RS-485 Line Drivers/Receivers

The differential lines, A and B, may be operated at TTL levels of 0 and 5 volts. The RS485 line driver outputs the logic high state (marking, or idle state) by driving 5 volts on B, and 0 volts on A. Conversely, the driver outputs the logic low state (spacing) by driving 5 volts on A, and 0 volts on B.



Over a distance of 4000 feet, the 5 volts applied to either line may be dropped significantly. This usually doesn't present a problem since RS485 receivers are specified to operate with a differential voltage of only 0.200 volts. In practice, however, the differential voltage should remain above 1.5v.

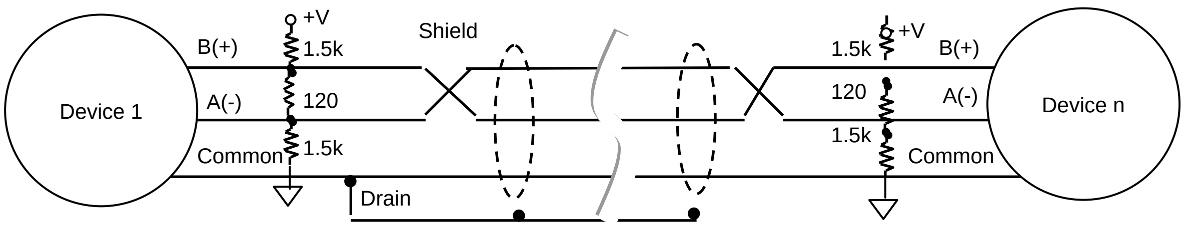
Logic State High	(Idle or Marking State):	(B – A) >= 200mV
LogicState Low	(SpacingState):	(A – B) >= 200mV

1.7 120 Ohm Termination

The two devices at the furthest end of the bus require termination resistors to cancel reflections. Intermediate devices do not.

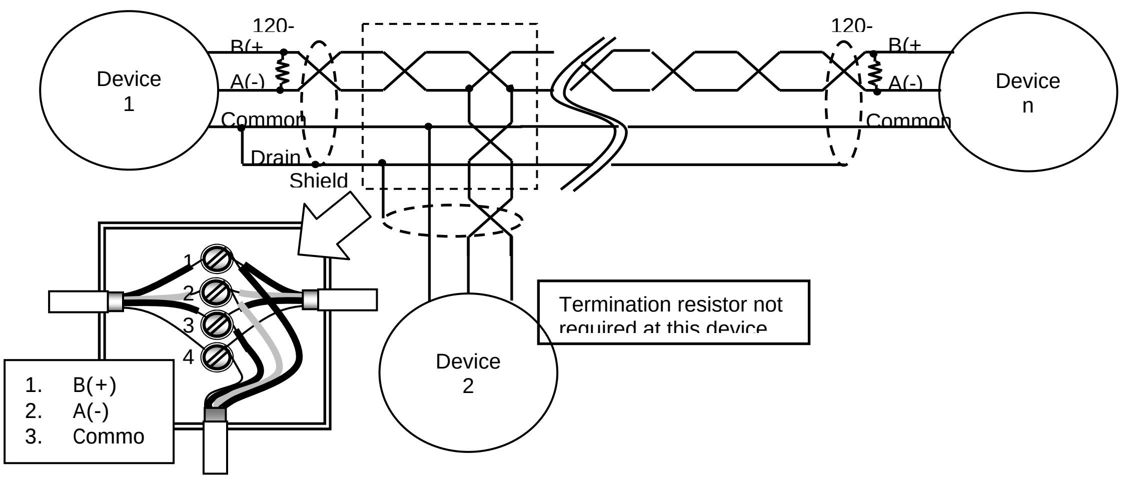
1.8 Bias

When there is no communication on the network, the A and B lines are floating. A small amount of noise could appear as the start of a message, which might interfere with the framing of valid messages. Biasing the transmission line keeps it in the idle state while it is not driven. The bias resistors maintain a differential of 200mV between the A and B lines. Note that bias resistors are not required for Q46 Series transmitters.



1.9 Drops

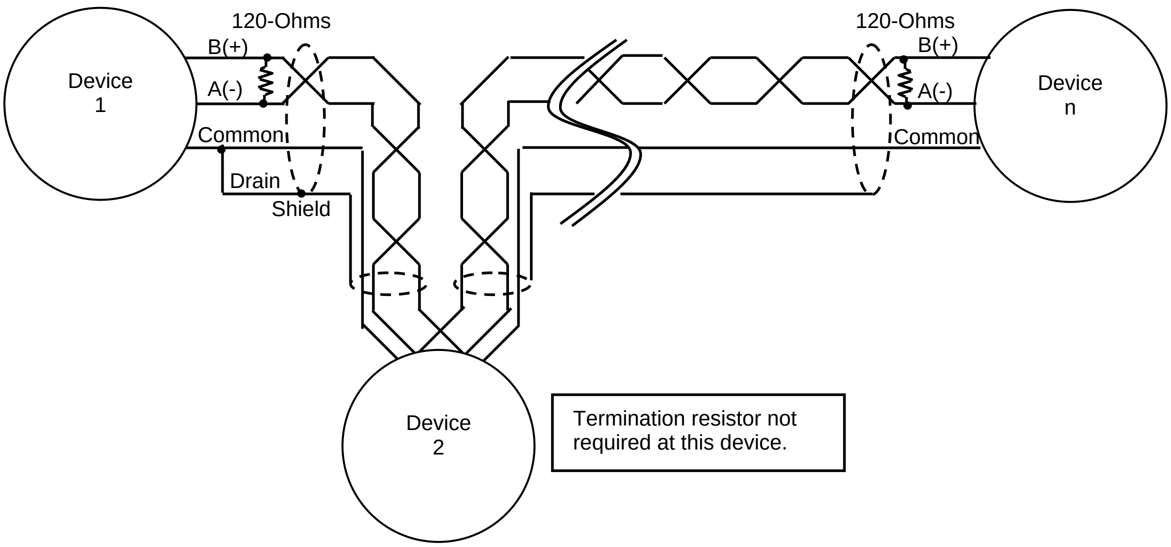
Often, a short length of cable is used at a junction box to form a branch, or “drop”, from the bus to the device. These cables must very short as compared to the main trunk length of the bus so as to avoid signal reflections and require termination that would load the bus excessively. A rule of thumb is to not allow any single branch length to exceed 3% of the total trunk length. Again, only the devices at each end of bus require termination resistors, intermediate connections along the bus do not (bias resistors not shown for clarity).



Long branches requiring termination may be connected, however, a repeater must be used at a short distance from the connection. Star topologies should be avoided, since terminating each spoke will load the network excessively and reliable communications cannot be guaranteed.

1.10 Daisy Chaining

For devices not located at the ends of the bus, it may be possible to run the cable in and out of the device, a practice referred to as “daisy-chaining”. Although this method eliminates the need for a separate drop wire, it will require more connections inside the transmitter housing and therefore consume more space.



1.11 Shielding

While it goes against conventional wisdom and can cause a problem with circulating currents, grounding a shielded cable at both ends can be very effective at keeping induced lightening noise away from the communications lines. In the alternative, ground one end of the shield and connect the other end to ground through a bi-directional transient protector (from a few volts to a few hundred volts depending on the situation).

Note that Q46 Series transmitters are galvanically isolated from the RS-485 (Modbus) port.

1.12 Q46 Register Assignment

The following table summarizes the registers used for the Modbus data in the Q46 communication board using the Q46D as an example. Tables for all other Q46 series monitors follow. As mentioned previously, the Q46 only supports the "04 – Read Input Register" function.

Register	Data Type	Sensor	Description	Data Format
30001 (HI) 30002 (LO)	long(32)	D.O.	Dissolved Oxygen	8.40 PPM = 840
30003 (HI) 3004 (LO)	long(32)	D.O.	Measured Temperature	25.00° C = 2500
30005 (HI) 30006 (LO)	long(32)	D.O.	Measured % Saturation	98.0% sat = 980
30007 (HI) 30008 (LO)	long(32)	NA	PID value	17.0% = 170
30009	Char(8)	NA	System Status 1	(binary) 00000000
	Char(8)	NA	System Status 2	(binary) 00000000
30010	Char(8)	NA	Alarm Status	(binary) 00000000
	Char(8)	NA	Instrument ID	49 = 49

(Long = Long Integer, requires 4 bytes; Char = Character, requires 1 byte)

Figure 2 - Q46 Modbus Input Register Data

Detailed status data from registers 30009 and 30010 are detailed in Figure 3 below.

Register	Bitfield	Description
30009	0 (lsb)	mV Hi
	1	mV Lo
	2	D.O. Hi
	3	D.O. Lo
	4	Temp Hi
	5	Temp Lo
	6	NU
	7	NU
	0	EE Fail
	1	NU
	2	LCD Controller Fail
	3	Cal D.O. Fail
	4	PID Controller Fail
	5	Cal TC Fail
	6	TC Error
	7	Acknowledge Fail (global)
30010	0	Alarm 1, Relay A
	1	Alarm 2, Relay B
	2	Alarm 3, Relay C
	3	Alarm 4, Relay D (optional)
	4	Alarm 5, Relay E (optional)
	5	Alarm 6, Relay F (optional)
	6	NU
	7	NU

Figure 3 - Status Register Bitfield Flags

Q46H/62 or Q45H/63 Residual Chlorine Tables

Q46H/62/63 Input Register Detail

Register	Byte	Data Type	Sensor	Description	Data Format
30001 (HI) 30002 (LO)	1 to 4	long(32)	Chorine	Measured Chlorine	1.4920 PPM = 14920
30003 (HI) 3004 (LO)	5 to 8	long(32)	Chlorine	Measured Temperature	25.00° C = 2500
30005 (HI) 30006 (LO)	9 to 12	long(32)	pH	Measured pH	7.00 pH = 700
30007 (HI) 30008 (LO)	13 to 16	long(32)	NA	PID value	17.0% = 170
30009	17	Char(8)	NA	System Status 1	(binary) 00000000
	18	Char(8)	NA	System Status 2	(binary) 00000000
30010	19	Char(8)	NA	Alarm Status	(binary) 00000000
	20	Char(8)	NA	Instrument ID	41 = 41

(Long = Long Integer, requires 4 bytes; Char = Character, requires 1 byte)

Q46H/62/63 Status/Alarm Bit Detail

Register	Byte	Bitfield	Description
30009	17	0 (lsb)	NU
	17	1	Cal pH Fail
	17	2	Chlor Hi
	17	3	Chlor Low
	17	4	Temp Hi
	17	5	Temp Lo
	17	6	pH Hi
	17	7	pH Low
	18	0	EE Fail
	18	1	pH Auto-comp Fail
	18	2	LCD Controller Fail
	18	3	Cal Chlor Fail
	18	4	PID Controller Fail
	18	5	Cal TC Fail
	18	6	TC Error
	18	7	Acknowledge Fail (global)
30010	19	0	Alarm 1, Relay A
	19	1	Alarm 2, Relay B
	19	2	Alarm 3, Relay C
	19	3	Alarm 4, Relay D (optional)
	19	4	Alarm 5, Relay E (optional)
	19	5	Alarm 6, Relay F (optional)
	19	6	NU
	19	7	NU

Q46H/64 Dissolved Ozone Tables

Q46H/64 Input Register Detail

Register	Byte	Data Type	Sensor	Description	Data Format
30001 (HI) 30002 (LO)	1 to 4	long(32)	Ozone	Measured Ozone	1.4920 PPM = 14920
30003 (HI) 3004 (LO)	5 to 8	long(32)	Ozone	Measured Temperature	25.00° C = 2500
30005 (HI) 30006 (LO)	9 to 12	long(32)	pH	Measured pH	7.00 pH = 700
30007 (HI) 30008 (LO)	13 to 16	long(32)	NA	PID value	17.0% = 170
30009	17	Char(8)	NA	System Status 1	(binary) 00000000
	18	Char(8)	NA	System Status 2	(binary) 00000000
30010	19	Char(8)	NA	Alarm Status	(binary) 00000000
	20	Char(8)	NA	Instrument ID	41 = 41

(Long = Long Integer, requires 4 bytes; Char = Character, requires 1 byte)

Q46H/64 Status/Alarm Bit Detail

Register	Byte	Bitfield	Description
30009	17	0 (lsb)	NU
	17	1	Cal pH Fail
	17	2	Ozone Hi
	17	3	Ozone Low
	17	4	Temp Hi
	17	5	Temp Lo
	17	6	pH Hi
	17	7	pH Low
	18	0	EE Fail
	18	1	NU
	18	2	LCD Controller Fail
	18	3	Cal Ozone Fail
	18	4	PID Controller Fail
	18	5	Cal TC Fail
	18	6	TC Error
	18	7	Acknowledge Fail (global)
30010	19	0	Alarm 1, Relay A
	19	1	Alarm 2, Relay B
	19	2	Alarm 3, Relay C
	19	3	Alarm 4, Relay D (optional)
	19	4	Alarm 5, Relay E (optional)
	19	5	Alarm 6, Relay F (optional)
	19	6	NU
	19	7	NU

Q46H/65 Dissolved Chlorine Dioxide Tables

Q46H/65 Input Register Detail

Register	Byte	Data Type	Sensor	Description	Data Format
30001 (HI) 30002 (LO)	1 to 4	long(32)	Chorine	Measured Chlorine Dioxide	1.4920 PPM = 14920
30003 (HI) 3004 (LO)	5 to 8	long(32)	Chlorine	Measured Temperature	25.00° C = 2500
30005 (HI) 30006 (LO)	9 to 12	long(32)	pH	Measured pH	7.00 pH = 700
30007 (HI) 30008 (LO)	13 to 16	long(32)	NA	PID value	17.0% = 170
30009	17	Char(8)	NA	System Status 1	(binary) 00000000
	18	Char(8)	NA	System Status 2	(binary) 00000000
30010	19	Char(8)	NA	Alarm Status	(binary) 00000000
	20	Char(8)	NA	Instrument ID	41 = 41

(Long = Long Integer, requires 4 bytes; Char = Character, requires 1 byte)

Q46H/65 Status/Alarm Bit Detail

Register	Byte	Bitfield	Description
30009	17	0 (lsb)	NU
	17	1	Cal pH Fail
	17	2	ClO_2 Hi
	17	3	ClO_2 Low
	17	4	Temp Hi
	17	5	Temp Lo
	17	6	pH Hi
	17	7	pH Low
	18	0	EE Fail
	18	1	pH Auto-comp Fail
	18	2	LCD Controller Fail
	18	3	Cal ClO_2 Fail
	18	4	PID Controller Fail
	18	5	Cal TC Fail
	18	6	TC Error
	18	7	Acknowledge Fail (global)
30010	19	0	Alarm 1, Relay A
	19	1	Alarm 2, Relay B
	19	2	Alarm 3, Relay C
	19	3	Alarm 4, Relay D (optional)
	19	4	Alarm 5, Relay E (optional)
	19	5	Alarm 6, Relay F (optional)
	19	6	NU
	19	7	NU

Q46P & Q46R pH and ORP Tables

Q46P or Q46R Input Register Detail

Register	Byte	Data Type	Sensor	Description	Data Format
30001 (HI) 30002 (LO)	1 to 4	long(32)	pH	Measured pH Measured ORP	7.00 pH = 700 -137 mv = -137
30003 (HI) 3004 (LO)	5 to 8	long(32)	pH	Measured Temperature	25.00° C = 2500
30005 (HI) 30006 (LO)	9 to 12	long(32)	pH	NU	0
30007 (HI) 30008 (LO)	13 to 16	long(32)	pH	PID value	47.5% = 475
30009	17	Char(8)	NA	System Status 1	(binary) 00000000
	18	Char(8)	NA	System Status 2	(binary) 00000000
30010	19	Char(8)	NA	Alarm Status	(binary) 00000000
	20	Char(8)	NA	Instrument ID	53 (Q46P) 57 (Q46R)

(Long = Long Integer, requires 4 bytes; Char = Character, requires 1 byte)

Q46P or Q46R Status/Alarm Bit Detail

Register	Byte	Bitfield	Description
30009	17	0 (lsb)	mv High
	17	1	mv Low
	17	2	pH High
	17	3	pH Low
	17	4	Temp High
	17	5	Temp Low
	17	6	pH Glass Break – Not Used for ORP
	17	7	Reference Fail
	18	0	EE Fail
	18	1	Checksum Fail
	18	2	LCD Controller Fail
	18	3	Cal pH or ORP Fail
	18	4	PID Controller Fail
	18	5	Cal TC Fail
	18	6	TC Error
	18	7	Acknowledge Fail (global)
30010	19	0	Alarm 1, Relay A
	19	1	Alarm 2, Relay B
	19	2	Alarm 3, Relay C
	19	3	Alarm 4, Relay D (optional)
	19	4	Alarm 5, Relay E (optional)
	19	5	Alarm 6, Relay F (optional)
	19	6	NU
	19	7	NU

Q46N Total and Free Ammonia Tables

Q46N & Q46FN Input Register Detail

Register	Byte	Data Type	Sensor	Description	Data Format
30001 (HI) 30002 (LO)	1 to 4	long(32)	Ammonia	Measured Total Ammonia	1.00 PPM = 100
30003 (HI) 3004 (LO)	5 to 8	long(32)	Ammonia	Measured Temperature	25.00°C = 2500
30005 (HI) 30006 (LO)	9 to 12	long(32)	Monochlor	Measured Monochloramine	0.51 PPM = 51
30007 (HI) 30008 (LO)	13 to 16	long(32)	Amm/Mono	Measured Free Ammonia	3.21 PPM = 321
30009	17	Char(8)	NA	System Status 1	(binary) 00000000
	18	Char(8)	NA	System Status 2	(binary) 00000000
30010	19	Char(8)	NA	Alarm Status	(binary) 00000000
	20	Char(8)	NA	Instrument ID	45 = 45

(Long = Long Integer, requires 4 bytes; Char = Character, requires 1 byte)

Q46N & Q46FN Status/Alarm Bit Detail

Register	Bitfield	Description
30009	0 (lsb)	NU
	1	NU
	2	Ammonia Hi
	3	Ammonia Low
	4	Temp Hi
	5	Temp Lo
	6	MonoChlor Hi
	7	MonoChlor Low
	0	Cal Monochlor Fail
	1	NU
	2	LCD Controller Fail
	3	Cal Ammonia Fail
	4	PID Controller Fail
	5	Cal TC Fail
	6	TC Error
	7	Acknowledge Fail (global)
30010	0	Alarm 1, Relay A
	1	Alarm 2, Relay B
	2	Alarm 3, Relay C
	3	Alarm 4, Relay D (optional)
	4	Alarm 5, Relay E (optional)
	5	Alarm 6, Relay F (optional)
	6	NU
	7	NU

Q46C4 or Q46CT Conductivity Tables

Q46C4 & Q46CT Input Register Detail

Register	Byte	Data Type	Sensor	Description	Data Format
30001 (HI) 30002 (LO)	1 to 4	long(32)	Conductivity	Measured Conductivity	2.238 mS = 2238
30003 (HI) 3004 (LO)	5 to 8	long(32)	Conductivity	Measured Temperature	25.00° C = 2500
30005 (HI) 30006 (LO)	9 to 12	long(32)	Conductivity	*Measured Concentration	1.3 % = 13
30007 (HI) 30008 (LO)	13 to 16	long(32)	NA	**Calculated TDS Value	223.5 mg/l = 2235
30009	17	Char(8)	NA	System Status 1	(binary) 00000000
	18	Char(8)	NA	System Status 2	(binary) 00000000
30010	19	Char(8)	NA	Alarm Status	(binary) 00000000
	20	Char(8)	NA	Instrument ID	65 (Q46C4) 61 (Q46CT)

* For concentration versions only ** For conductivity versions only
(Long = Long Integer, requires 4 bytes; Char = Character, requires 1 byte)

Q46C4 or Q46CT Status/Alarm Bit Detail

Register	Byte	Bitfield	Description
30009	17	0 (lsb)	Concentration High
	17	1	Concentration Low
	17	2	Conductivity High
	17	3	Conductivity Low
	17	4	Temp Hi
	17	5	Temp Lo
	17	6	NU
	17	7	NU
	18	0	EE Fail
	18	1	Checksum Fail
	18	2	LCD Controller Fail
	18	3	Cal Conductivity Fail
	18	4	PID Controller Fail
	18	5	Cal TC Fail
	18	6	TC Error
	18	7	Acknowledge Fail (global)
30010	19	0	Alarm 1, Relay A
	19	1	Alarm 2, Relay B
	19	2	Alarm 3, Relay C
	19	3	Alarm 4, Relay D (optional)
	19	4	Alarm 5, Relay E (optional)
	19	5	Alarm 6, Relay F (optional)
	19	6	NU
	19	7	NU

Q46F Fluoride Tables

Q46P or Q46R Input Register Detail

Register	Byte	Data Type	Sensor	Description	Data Format
30001 (HI) 30002 (LO)	1 to 4	long(32)	Fluoride	Measured Fluoride	1.00 PPM = 1000
30003 (HI) 3004 (LO)	5 to 8	long(32)	RTD	Measured Temperature	25.00° C = 2500
30005 (HI) 30006 (LO)	9 to 12	long(32)		NU	0
30007 (HI) 30008 (LO)	13 to 16	long(32)	Fluoride	PID value	47.5% = 475
30009	17	Char(8)	NA	System Status 1	(binary) 00000000
	18	Char(8)	NA	System Status 2	(binary) 00000000
30010	19	Char(8)	NA	Alarm Status	(binary) 00000000
	20	Char(8)	NA	Instrument ID	73

(Long = Long Integer, requires 4 bytes; Char = Character, requires 1 byte)

Q46P or Q46R Status/Alarm Bit Detail

Register	Byte	Bitfield	Description
30009	17	0 (lsb)	mv High
	17	1	mv Low
	17	2	Fluoride High
	17	3	Fluoride Low
	17	4	Temp High
	17	5	Temp Low
	17	6	NU
	17	7	Reference Fail
	18	0	EE Fail
	18	1	Checksum Fail
	18	2	LCD Controller Fail
	18	3	Cal pH or ORP Fail
	18	4	PID Controller Fail
	18	5	Cal TC Fail
	18	6	TC Error
	18	7	Acknowledge Fail (global)
30010	19	0	Alarm 1, Relay A
	19	1	Alarm 2, Relay B
	19	2	Alarm 3, Relay C
	19	3	Alarm 4, Relay D (optional)
	19	4	Alarm 5, Relay E (optional)
	19	5	Alarm 6, Relay F (optional)
	19	6	NU
	19	7	NU