USER MANUAL

Quartz Monitor QM20

rev 1.1

MCVAC
MANUFACTURING CO. INC.

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1 INTRODUCTION

Please read this manual carefully to ensure optimum operating conditions right from the start. This user manual handbook contains important information about the functionality, installation, start-up and operation of the Quartz Monitor QM20 .

1.1 INTENDED TO USE

The QM20 combines simplicity of operation with unrivalled accuracy in a compact form factor, delivering precise measurements up to 0.01Hz resolution. In addition, this unique instrument boasts two independent measurement channels and also features MODBUS protocol for implementation in both laboratory and industrial applications alike. QM20 is available in three versions: serial, USB and Ethernet(with PoE).
The measurement channels can be configured depending on needs to work with external(QM20-EO) or internal oscillator. First channel is universal and allows to work with external or internal oscillator depending on software configuration. The second channel is permanently set to work with external oscillator QM20-EO .

1.1.1 SERIAL INTERFACE VERSION

QM20 with a serial interface is available in two configurations: RS232 or RS485(2 wire). MODBUS-RTU protocol is implemented in both cases. An external power connection in range 12-24VDC is required for operation.
The RS485 interface configuration allows connection of multiple QM20 devices in configuration Single Master - Multi Slave.

1.1.2 USB INTERFACE VERSION

QM20 with a USB interface has the MODBUS-RTU protocol implemented. . Communication and power supply is provided via a single cable. Although QM20 connects via USB, it integrates as a virtual serial port. Therefore, QM20 may be used like any serial port.

1.1.3 ETHERNET INTERFACE VERSION

QM20 with a Ethernet interface have implemented protocol MODBUS-TCP. The interface utilises PoE technology and therefore requires only a single network cable for data transmission and power supply.

1.2 LIABILITIES AND WARRANTY

MCVAC MANUFACTURING CO. INC. company is not liable for damages resulting from improper use of the device and the guarantee expires, if the user, or third party:

- ignores information contained in this manual,

- utilizes the product in a manner inconsistent with intended purpose,
- makes any modification or alteration of the product,
- unit should not be used with unauthorized accessories (compatible accessories, types and models can be found in the product documentation)

MCVAC MANUFACTURING CO. INC. company reserves the right to make changes without prior notice. Illustrations may vary depending on the version of the device.

1.3 Instrument Safety

1.3.1 Definition of Notes, Cautions and Warnings

When using this manual, please pay attention to the notes, cautions and warnings found throughout. For the purposes of this manual they are defined as follows:

NOTE: Pertinent information that is useful in achieving maximum QM20 efficiency when followed.

CAUTION

Indicates particularly important, but not safety-relevant information.
Failure to heed these messages could result in damage to QM20 or the loss of data.

WARNING

Failure to heed these messages could result in personal injury.
Information on correct handling or use. Disregarding safety notes can lead to malfunctions.

WARNING

Risk Of Electric Shock
Dangerous voltages are present, which could result in personal injury.

1.3.2 PERSONNEL QUALIFICATIONS

All work described in this document may only be carried out by persons who have suitable technical training and the necessary experience or who have been instructed by the end user of the product.

1.3.3 GENERAL SAFETY INSTRUCTIONS

	**CAUTION** **QM20 contains delicate circuitry, susceptible to transient power line voltages. Disconnect the power cord whenever making any sensor connections**

	**CAUTION** **QM20 may not be suitable for use with RF sputtering systems or other electrically noisy environments.**

	**CAUTION** **Do not open the instrument case! There are no user-serviceable components within instrument case**

For all work you are going to do, adhere to the applicable safety regulations. Also observe all safety notes given in this document and forward the information to all other users of the product.

WARNING

Failure to operate QM20 in the manner intended by MCVAC MANUFACTURING CO. INC. can circumvent the safety protection provided by the instrument and may result in personal injury.

2 TECHNICAL DATA

PARAMETER	VERSION	VALUE
Frequency Resolution	All	0.01 Hz at 10 readings/s for High resolution version 0.1 Hz at 10 readings/s for standard resolution version
Measurement Interval	All	0.1s to 2s
Quartz oscillator type	All	6 MHz
Reference frequency stability	All	0.5 ppm
Sensor inputs	All	2
External oscillator support inputs	All	2
Input type	All	female BNC
Interface	RS232	RS232
	RS485	RS485
	USB	USB
	Ethernet	Ethernet
Protocol	RS232 RS485 USB	ModBUS - RTU
	Ethernet	ModBUS - TCP
Supply & Interface connector	RS232 RS485	removable, screw terminal block, 3.81mm spacing
	USB	USB socket type B
	Ethernet	Modular Jack socket RJ45

Table 2.1: Technical specifications

PARAMETER	VERSION	VALUE
Supply voltage	RS232/RS485	12...24V DC
	USB	5V DC
	PoE	48V DC
Supply current	RS232/RS485	max 250mA
	USB	max 500mA
	PoE	max 80mA

Table 2.2: Power

PARAMETER	VALUE
Usage	Use indoors only
Storage temperature	-20...50°C
Operation temperature	15...40°C
Relative humidity	Max. 80% (up to 31°C), decreasing to max. 50% (above 30°C)
Altitude	Up to 2000 meters
Pollution Degree	2

Table 2.3: Operating Environment

PARAMETER	VERSION	VALUE
Size	RS232/RS485	26.0 x 61.3 x 106.5 mm
	USB	26.0 x 61.3 x 96.4 mm
	Ethernet	26.0 x 61.3 x 116.4 mm
Weight	RS232/RS485	126 g
	USB	128 g
	Ethernet	155 g

Table 2.4: Dimensions and Weight

PARAMETER	VALUE
Operating system	Windows 8, Windows 7, Windows Vista, Windows XP, or Windows 2000
USB Port(s)	One USB 1.1 (or later) port for each QM20
Ethernet version	PCs with a working Ethernet Adapter and an Ethernet cable with RJ45 connectors and TCP/IP protocol on each PC

Table 2.5: Computer Requirements

2.1 External dimensions

QM20 occurs in two types of housings depending on the version of the communication interface. Generally version of Ethernet (PoE) is approx. 20 mm longer than the others.

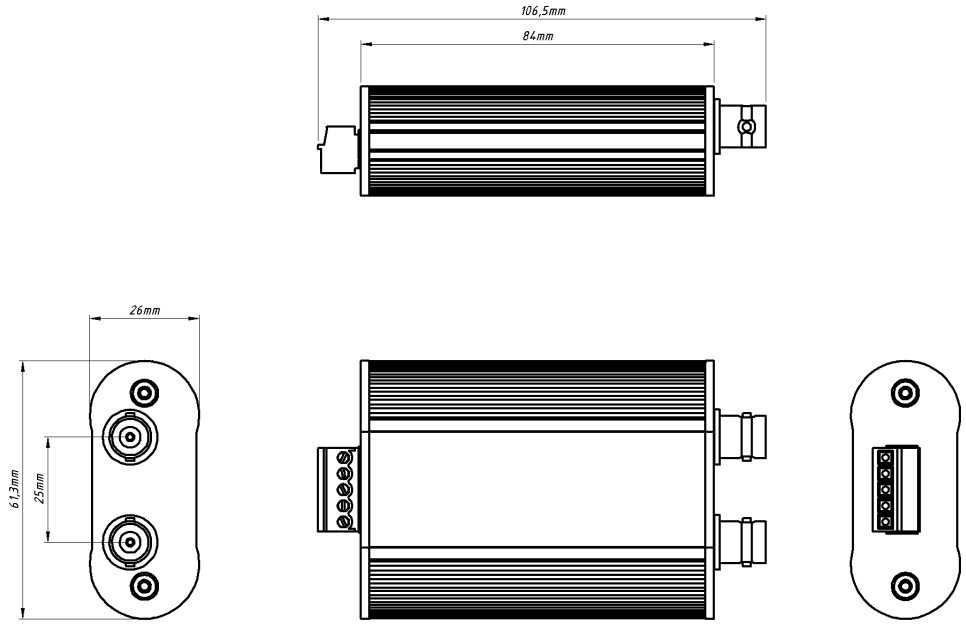

Figure 2.1: External dimensions RS232/RS485 version

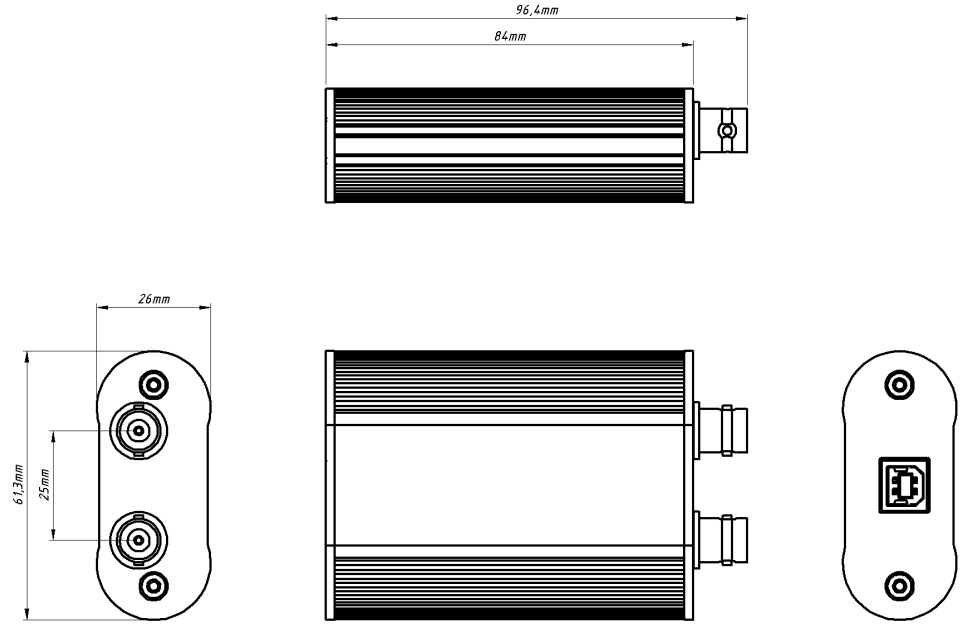

Figure 2.2: External dimensions USB version

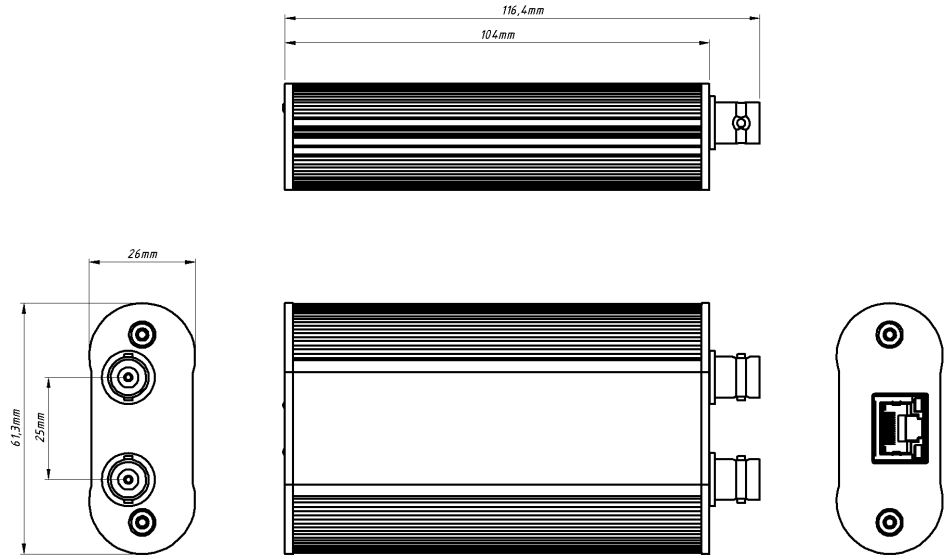

Figure 2.3: External dimensions Ethernet(PoE) version

Module cooperating with QM20 is the external oscillator and the dimensions shown below.

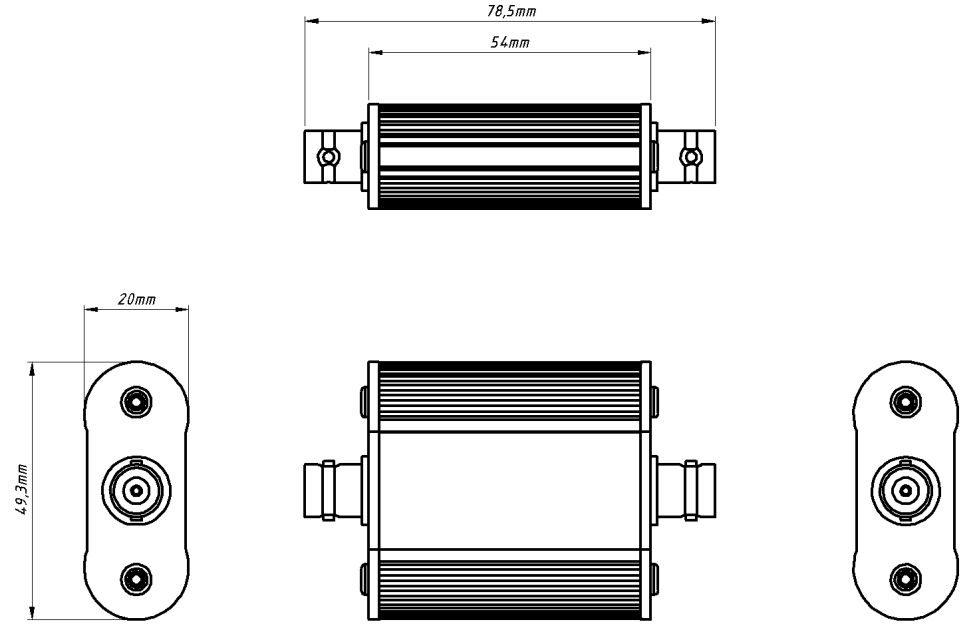

Figure 2.4: External dimensions External oscillator(EO)

3 INSTALLATION

This chapter describes the procedures for unpacking, mechanical installation and electrical installation.

3.1 UNPACKING

1. If the QM20 has not been removed from its packaging, do so now.
2. Carefully examine QM20 for damage that may have occurred during shipping. It is especially important to note obvious rough handling on the outside of the container. Immediately report any damage to the carrier and to MCVAC MANUFACTURING CO. INC. .

   NOTE: Do not discard the packaging material until inventory has been taken and installation is successful.
3. Refer to the invoice and take inventory.
4. To install QM20 , see next sections in this Chapter.
5. For additional information or technical assistance, contact MCVAC MANUFACTURING CO. INC. .

3.1.1 Package contents

Compare the contents of the package with the list below appropriate for your version of the hardware device.

Description	Quantity
QM20 (RS232 or RS485)	1 pcs.
Communication cable	1 pcs.
Power supply(12V output)	1 pcs.
Test crystal 6 MHz	1 pcs.
BNC cable	1 pcs.(10 cm)

Table 3.1: Package set - Serial version

Description	Quantity
QM20 (USB)	1 pcs.
Communication cable	1 pcs.
Test crystal 6 MHz	1 pcs.
BNC cable	1 pcs.(10 cm)

Table 3.2: Package set - USB version

Description	Quantity
QM20 (Ethernet)	1 pcs.
Communication cable	1 pcs.
Power supply(48V output)	1 pcs.
PoE adapter	1 pcs.
Path cord	1 pcs.(2 m)
Test crystal 6 MHz	1 pcs.
BNC cable	1 pcs.(10 cm)

Table 3.3: Package set - Ethernet(PoE) version

Description	Quantity
QM20-EO	1 pcs.
Test crystal 6 MHz	1 pcs.
BNC cable	1 pcs.(10 cm)

Table 3.4: Package set - external oscillator

3.2 Installation Requirements

- QM20 Monitor
- Crystal sensor with feedthrough
- Oscillator kit for the crystal sensor
- Quartz crystals appropriate for the application
- Windows computer meeting minimum specifications (refer to table 2).

3.3 QM20 Indicators

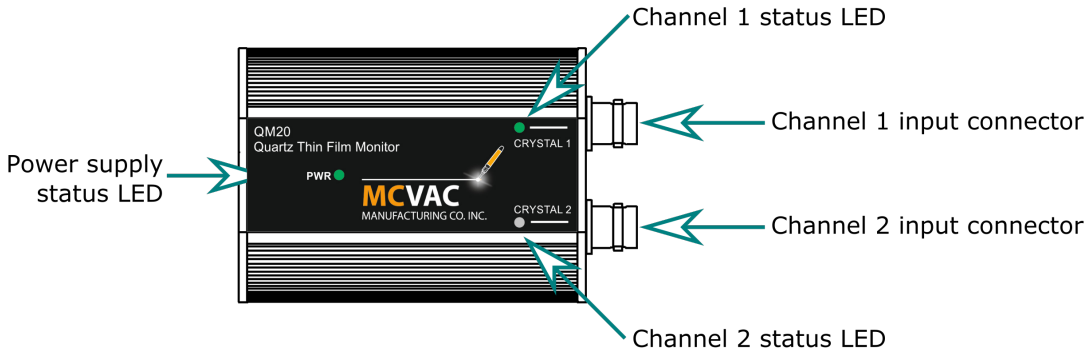

Figure 3.1: QM20 description

The device is equipped with 3 LEDs indicating the current status of the device: **Power**, **Crystal 1** and **Crystal 2**.

3.3.1 Power

Illuminated LED indicates that the device is properly powered. If the device is connected to power and the LED is not illuminated, see chapter 9 to determine the possible cause.

3.3.2 Crystal 1/2

Illuminated LED(Crystal 1/Crystal 2) indicates that crystal connected to channel is good. This means the operating frequency is in the range 4500000 - 6100000Hz. If crystal is connected but LED is not illuminated, see chapter 9 to determine the possible cause.

3.4 CONNECTING TO COMPUTER

Depending on the hardware version(Serial/USB/Ethernet) connected to PC runs in a different way. In order to properly connect the device, read appropriate paragraph for your hardware version.

3.4.1 Serial QM20 connecting

1. Connect QM20 directly to COM port in computer or use any external ”USB-Serial” adapter,
2. Connect supplied power supply unit to QM20 . The power supply provides voltage 12V/0.5A. Optionally connect own DC power supply 12..24V and appropriate output current.
3. The QM20 will start to work - this is indicated by a lighted Power LED.
4. The device is available in the installed COM port,
5. Setup connection to the device according to the information contained in chapter 5

WARNING

The maximum / minimum voltage supply
In the case of the use of its own power supply, make sure that the supplied voltage is in the range acceptable by the device.
Too low voltage can cause a malfunction.
Excess voltage range may damage the device permanently

WARNING

The correct polarity of the supply voltage
When connecting power pay attention to the correct connection of power cables.
Reverse polarity can permanently damage the device

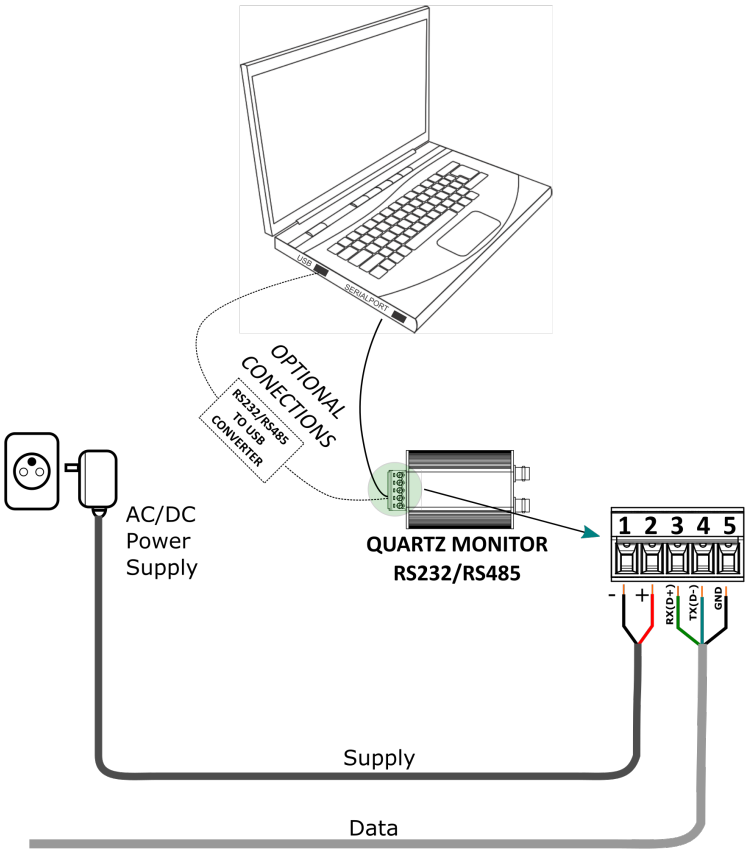

Figure 3.2: Serial(RS232/RS485) connection

3.4.2 Multi RS485 devices connections

The RS485 standard allows one or more instruments to be connected (multi dropped) using a three wire connection. Example wiring diagram see Fig.3.3.

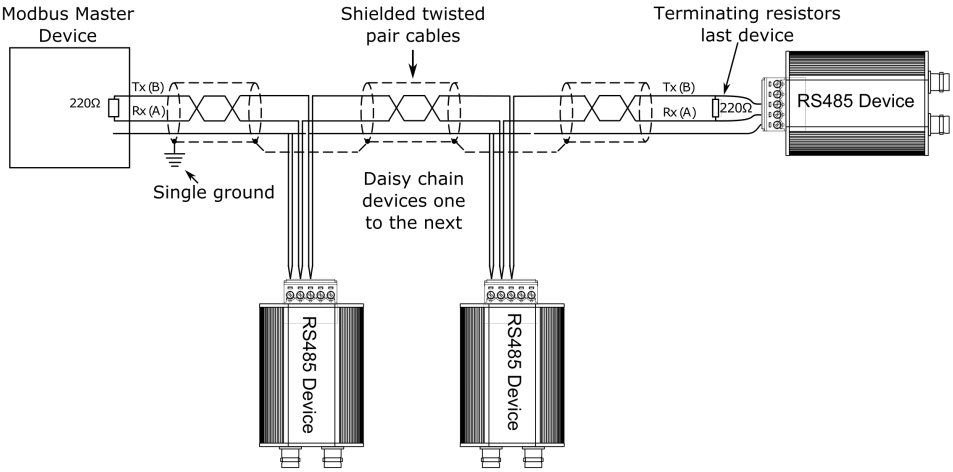

Figure 3.3: Example diagram for RS485 Communication

CAUTION

- **Do not use redundant wires in the communications cable for other signals.**
- **Ensure cable runs have sufficient slack to ensure that movement does not cause abrasion of the insulating sheath.**
- **Do not over tighten cable clamps to avoid accidental multiple grounding of the screen conductors.**
- **Ensure that the cable is 'daisy chained' between instruments, i.e. the cable runs from one instrument to the next to the final instrument in the chain.**

3.4.3 USB QM20 connecting

In order to connect QM20 to the computer, perform the following steps:

1. Connect QM20 to computer using supplied USB type B cable,
2. The QM20 will start to work - this is indicated by a lighted Power LED.
3. Install Virtual COM Port Drivers.
   Detailed procedure for installing drivers, see 7.3.
4. The device is available in the installed COM port,
5. Setup connection to the device according to the information contained in chapter 5

CAUTION

USB cable length The maximum recommended length of USB cable connecting the computer and the device should not be longer than 3m. The use of a longer cable may result in poor performance and is not recommended.

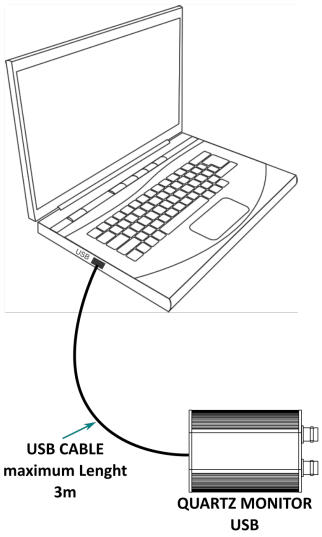

Figure 3.4: USB connection

3.4.4 Ethernet QM20 connecting

QM20 -Ethernet must be properly connected, there are two possible way:

1. Direct connection with devices supporting PoE function(picture 3.5)
   - Connect one side of the network cable to the QM20 and the other to device with PoE.
   - The QM20 will start to work - this is indicated by a lighted Power LED.
2. Connection via the included PoE adapter and power supply(picture 3.6), when PoE device is not available.
   - Connect one side of the network cable to the QM20 and the other to PoE input in PoE adapter,
   - Connect one side of the network cable to LAN input in PoE adapter,
   - Connect the power supply to the power socket in PoE adapter, and the other end into an electrical outlet.
   - The QM20 will start to work - this is indicated by a lighted Power LED.

	CAUTION
	QM20 -Ethernet version out of the box is factory configured to static network settings. The default IP address is 192.168.0.1, and the default Subnet Mask is 255.255.255.0. These values can be changed as required For detail information see section 4.3.

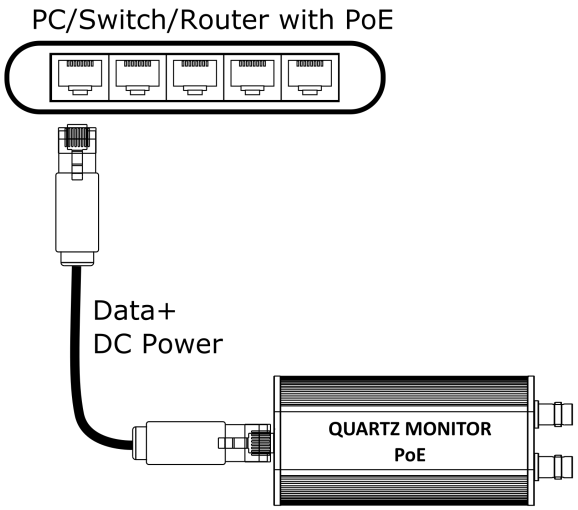

Figure 3.5: QM20 -PoE simple connection

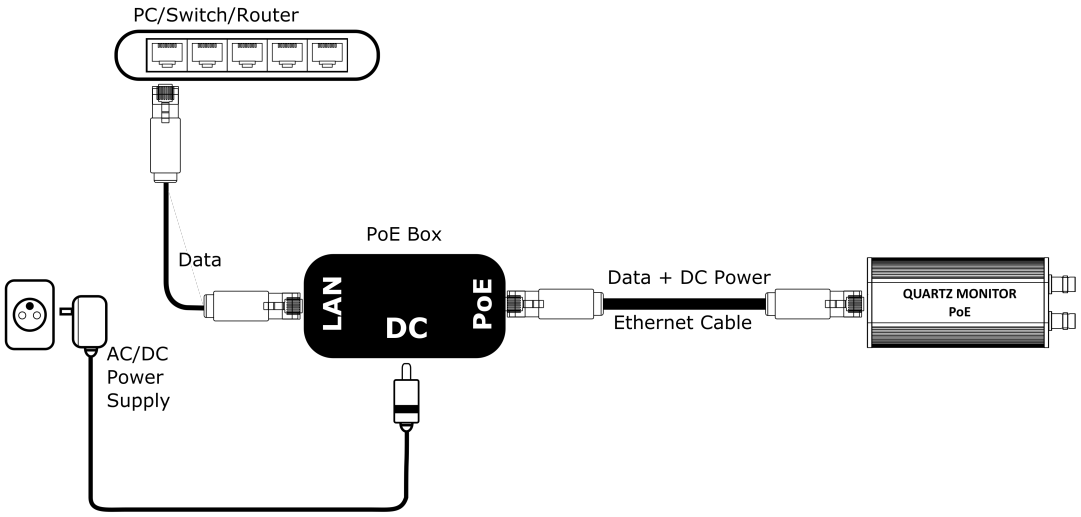

Figure 3.6: QM20 -PoE via adapter connection

	CAUTION
	WI-FI connections Use WI-FI connection on any connection path between QM20 and computer may result in poor performance and is not recommended. Wireless connections are slower than wired connections and prone to interference from radio signals or other electronic devices. Weak Wi-Fi signals lead to slow data transfer, dropped connections and lost data packets.

3.5 System Connections

Depending on the needs QM20 can be connected to a vacuum system in several ways. Pay attention to the functionality of the individual channels:

- Measuring **channel 1** is a channel universal. It can be configured to work with external or internal oscillator.
- Measuring **channel 2** is a channel permanently configured to work with external oscillator.

For detail information how to change **channel 1** function see section 4.5. The default software setting for **channel 1** is to use the internal oscillator. To connect an external oscillator to the **channel 1** you must first correctly configure it by software settings.

Below is a sample configuration that uses both channels. It is also possible to work with only one measurement channel, while the other remains unconnected.

CAUTION

Proper QM20 performance

- To maintain proper QM20 performance, use only the provided 15 cm BNC cable to connect QM20 or the oscillator to the crystal sensor. The length of the in-vacuum cable (Front Load and Sputtering sensors) or electrical conduit tube (Cool Drawer and Bakeable sensors) must not exceed 75cm.
- The maximum BNC cable length between external oscillator QM20 -EO and QM20 is 10m.

3.6 QM20 sockets

The device has connectors for:

- connecting to microbalance/or external oscillator,
- communication
- power supply

3.6.1 BNC connector

Each module is equipped with two BNC connectors, which are used to connect Monitor to External oscillator or directly to crystal sensor.

3.6.2 USB connector

This is a standard USB type B is used for data transmission and power supply unit.

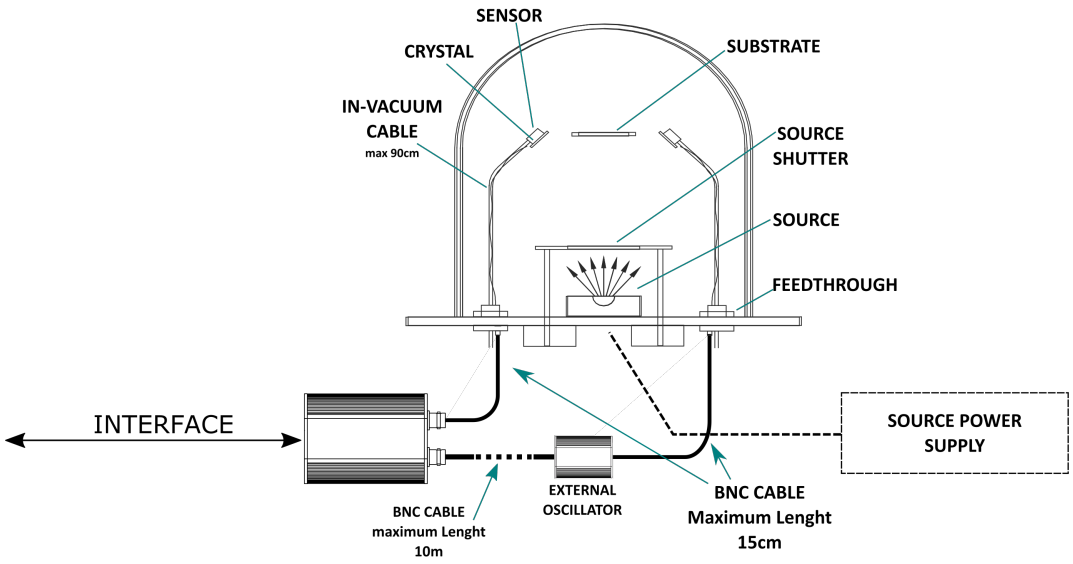

Figure 3.7: Channel 1 with internal oscillator, channel 2 external oscillator - example connection

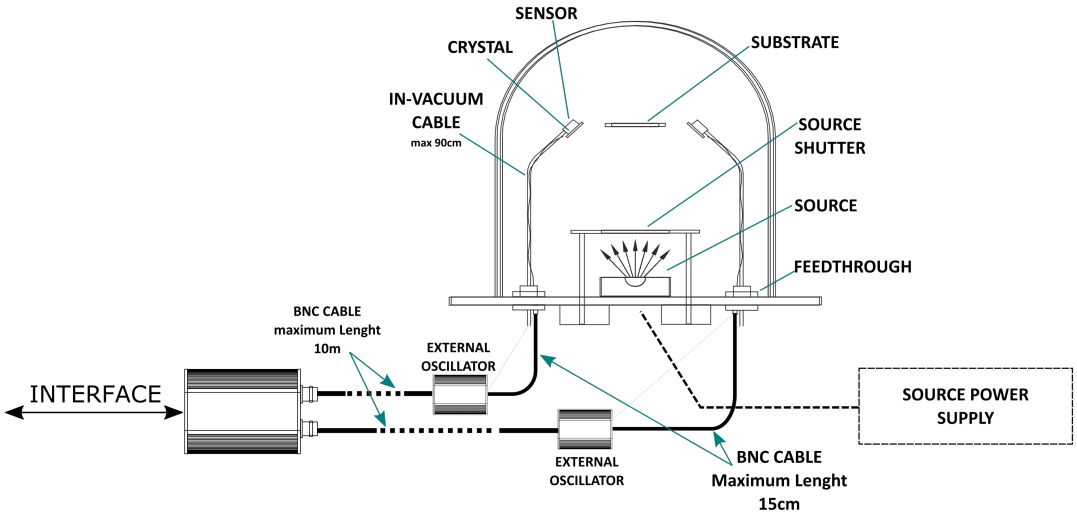

Figure 3.8: Both channels with external oscillator - example connection

	CAUTION
	Proper QM20 performance Never attach the jumper BNC to measuring inputs. This can damage the measuring inputs as well as the entire device.

3.6.3 Terminal Block Connector

Terminal block connector(3.81 pitch spacing) provides pins for communication and power supply. See table and picture below for details information. Depending on the hardware version, pins 3 and 4 meet a different function.

Figure 3.9: Terminal block connector

PIN NUMBER	FUNCTION	DESCRIPTION
Pin 1:	GND	power supply gnd
Pin 2:	12-24VDC	power supply positive pin
Pin 3:	RX(D+)	receive data pin
Pin 4	TX(D-)	transmit data pin
Pin 5	GND	reference pin for communication lines

Table 3.5: Terminal block pin description

CAUTION

Do not exceed the maximum supply voltage. Over voltage may cause permanent damage QM20

3.6.4 RJ45 and Reset button

The connection panel QM20 Ethernet version includes RJ45 socket and Reset button.

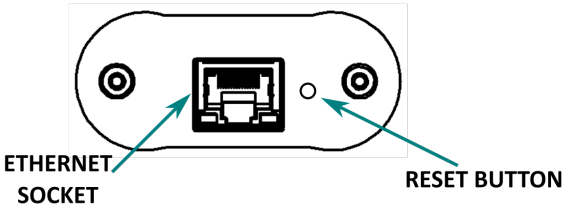

Figure 3.10: QM20 Left panel view

3.6.4.1 RJ45 Connector

RJ45 connector is used for data transmission and power QM20 .

PIN NUMBER	FUNCTION	DESCRIPTION
Pin 1:	RX+	Data receive(+)
Pin 2:	RX-	Data receive(-)
Pin 3:	TX+	Data transmit(+)
Pin 4	+Vdc	DC power(+)
Pin 5	+Vdc	DC power(+)
Pin 6	TX-	Data transmit(-)
Pin 7	-Vdc	DC power(-)
Pin 8	-Vdc	DC power(-)

Table 3.6: RJ-45 Connector Pinout(Data & Power)

3.6.4.2 Reset button

The button is located next to RJ45 socket. It is used to put the device in firmware update mode and restore factory settings. For detail information see section 7.7.

CAUTION

Activate reset button
Use a pin or the end of a paper clip to press the reset button

3.7 External Oscillator

An external oscillator QM20-EO can be used for applications where QM20 must be located farther away from the feedthrough.

Connecting to the QM20 :

1. Connect one end of the oscillator cable(coaxial cable) to selected QM20 sensor connector.
2. Connect the other end of the oscillator cable(coaxial cable) to BNC connector on the external oscillator(QM20-EO) labelled **INSTRUMENT**
3. Connect one end of the 10cm BNC cable to the BNC connector on the external oscillator(QM20-EO) labelled **SENSOR**.
4. Connect the other end of the 10cm BNC cable to the BNC connector on the feedthrough
5. If external oscillator is connected to Channel 1, then make sure that it has been configured to work with an external oscillator.

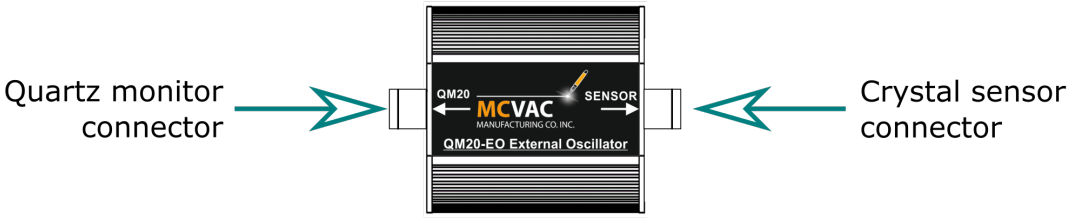

Figure 3.11: QM20-EO connectors

3.8 TEST DEVICE

In order to verify proper functionality of the QM20 , connect test quartz to the measuring channel input. After connecting the test quartz, the properly functioning device will indicate by lighted crystal LED onto QM20 case and measurement frequency are similar to 6000000 Hz.

4 USING DEVICE

4.1 Change baudrate

To change the default speed serial transmission must modify the registry value at 0x22 and reset the device to apply the changes.

1. Establish communication with the device.
2. Change value in register 0x22 to value corresponding to the desired speed transmission. Baudrate:
    - 0 – 2400 bps
    - 1 – 4800 bps
    - 2 – 9600 bps
    - 3 – 19200 bps
    - 4 – 38400 bps
    - 5 – 57600 bps
    - 6 – 115200 bps (default value)
3. Reset device for apply changes. See section 7.4 to read more information about reset device procedures.
4. Establish a connection to the new baud rate.

CAUTION

If, after a reset, it is not possible to connect even though the correct parameters have been set. You can restore the default baudrate of the device using the appropriate procedure described in the section 7.6. And then try again to change the baudrate of the device.

4.2 Change device address

This functionality is only available in QM20 with serial interface RS485 version. It allows you to change the default device address equal '1' to any address in the range from 1 to 254. To change the address of the device, modify the contents of the register 0x21 and reset the device to apply the changes.
For version QM20 with serial interface RS232 and USB change of address it is not possible. This address is fixed equal to 1.

1. Establish communication with the device.

2. Change value in register 0x21 to desired device address.
3. Reset device for apply changes. See section 7.4 to read more information about reset device procedures.
4. Connect to the device at the new address.

	**CAUTION**
	If, after a reset, it is not possible to connect even though the correct parameters have been set. You can restore the default address of the device using the appropriate procedure described in the section 7.6. And then try again to change the address of the device.

4.3 Change default network configuration

Network default settings version with Ethernet interface can be changed by modifying the registry in range 0x31 to 0x36 and 0x3A.

1. Connect QM20 directly to the local PC using included adapter for power supply
2. Configure the static network parameters in your PC.
   IP address is 192.168.0.2
   Subnet Mask is 255.255.255.0.
3. Run the Ping command in the command prompt to verify the network connection between your PC and the QM20 .
   If the result displayed is similar to the Figure , it means the connection between your PC and the QM20 has been established well.
4. Using the MODBUS protocol, change the network settings(register 0x31 to 0x36 or 0x3A)
5. Enable DHCP set register 0x3A to '0x0001' value and go to step 10 or go to next step for configure static IP and net mask.
6. To setup own static network settings follow steps below
7. Write new IP address(*aaa.bbb.ccc.ddd*) to registers 0x31(part aaa and bbb) and 0x32(part ccc and ddd). For detail information see external document: ***QM_Register_Map***.
8. Write new Mask addres (*aaa.bbb.ccc.ddd*) to registers 0x33(part aaa and bbb) and 0x34(part ccc and ddd). For detail information see external document: ***QM_Register_Map***.
9. Writing gateway address is possible but not necessary.
10. Save network settings in non-volatile memory by write 0x0001 to register 0x43.
11. Reset device for apply changes. See section 7.4 to read more information about reset device procedures.

CAUTION

If, after a reset, it is not possible to connect even though the correct parameters. You can restore the default network settings using the appropriate procedure described in the section 7.7. And then try again to change device address

4.4 Change default bootloader address

Bootloader in QM20 -Ethernet is default run with static IP=192.168.0.200. Default bootloader address can be change to another **static** value by change registers 0x3C - 0x42. Register 0x42 is responsible for selecting network configuration. For detail information see external document: ***QM_Register_Map***

1. Establish connection to the device.
2. Using the MODBUS protocol, change the network settings(register 0x3C to 0x42)
3. Write new IP address(*aaa.bbb.ccc.ddd*) to registers 0x3C(part aaa and bbb) and 0x3D(part ccc and ddd).
4. Write new Mask addres (*aaa.bbb.ccc.ddd*) to registers 0x3E(part aaa and bbb) and 0x3F(part ccc and ddd).
5. Writing gateway address is possible but not necessary.
6. Write 0x0001 value to register 0x42 for run booloader by parameters storing in registers 0x3C-0x41. If register 0x42 value is equal 0x0000 then booloader run with default network settings.
7. Save network settings in non-volatile memory by write 0x0001 to register 0x43.
8. Reset device for apply changes. See section 7.4 to read more information about reset device procedures.

CAUTION

Bootloader network settings
For the bootloader can only set a static IP address/netmask/gateway. It is not possible to run a DHCP.

4.5 Switching between external/internal oscillator

To switch the channel 1 in external oscillator mode:

1. Switch OFF QM20 (disconnect power supply),

2. Connect QM20-EO to channel 1,
3. Connect QM20-EO to to the sensor feedthrough,
4. Switch ON QM20 ,
5. The POWER indicator on QM20 illuminates
6. Establish connection to the device.
7. Set the Holding Register 0x06 value to 0x0001.
8. QM20 channel 1 is now working in external oscillator mode.
9. The CRYSTAL indicator for channel connected to quartz illuminates.

For details information about remote control connection, see chapter 5.

To switch the channel 1 in internal oscillator mode:

1. Switch OFF QM20 (disconnect power supply),
2. Use the (provided) 10 cm BNC cable to connect QM20 directly to the sensor(sensors) feedthrough.
3. Switch ON QM20 ,
4. The POWER indicator on QM20 illuminates
5. Establish connection to the device.
6. Set the Holding Register 0x06 value to 0x0000.
7. QM20 channel 1 is now working in internal oscillator mode.
8. The CRYSTAL indicator for channel connected to quartz illuminates.

4.6 Change measurement window size

Depending of used vacuum application QM20 allow to change windows size for frequency measurement. A small window size value(100ms) corresponds to a greater amount of measurements per second(10/s).
Windows size is setup independent for each channel. Value is write in milliseconds value as integer in rage 100 to 2000.

1. Establish communication with the device.
2. Change register 0x04(for channel 1)/0x14(for channel 2) value.
3. Entered value immediately changes windows size.

5 OPERATION - REMOTE CONTROL

This chapter describes the communication interface.
The Modbus protocol is a well-established industry standard. It is commonly found in data loggers and PLCs. QM20 has enabled Modbus-RTU or Modbus-TCP. For information specific to the Modbus Protocol, you can refer to: http://www.modbus.org/specs.php.

5.1 Modbus RTU Implementation

This implementation is designed to provide a popular data exchange format connecting these instruments to both MCVAC MANUFACTURING CO. INC. and foreign master devices. The Modbus RTU allows the instrument to be a citizen on a data link shared with other devices that subscribe to the Modbus RTU(Remote Terminal Unit) specification.
Controllers communicate using a master–slave technique, in which only one device (the master) can initiate transactions (called 'queries'). The other devices (the slaves) respond by supplying the requested data to the master, or by taking the action requested in the query. Typical master devices include host processors and programming panels. Typical slaves include programmable controllers. The master can address individual slaves, or can initiate a broadcast message to all slaves. Slaves return a message (called a 'response') to queries that are addressed to them individually. Responses are not returned to broadcast queries from the master.

5.1.1 General Modbus RTU frame format

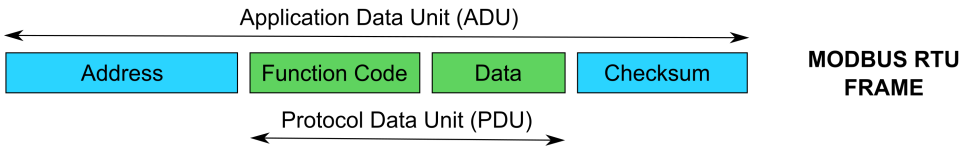

Figure 5.1: Modbus RTU frame format

Between messages, the RS-485/232 link is in a high impedance state. During this time receiving devices are more susceptible to noise generated false start of messages. Although noise-generated messages are rejected due to address, framing, and CRC checking, they can cause the loss of a good message when they are included in the message stream. In the slave, the transmitting device enables its transmitter line driver and forces an idle line state onto the link for three character time slots prior to transmitting. This action forces termination of any noise generated messages and improves message frame synchronization.

5.1.2 Modbus TCP frame format

The Modbus commands and user data are themselves encapsulated into the data container of a TCP/IP telegram without being modified in any way. However, the Modbus error checking field (checksum) is not used, as the standard Ethernet TCP/IP link layer checksum methods are instead used to guaranty data integrity. Further, the Modbus frame address field is supplanted by the unit identifier in Modbus TCP/IP, and becomes part of the Modbus Application Protocol (MBAP) header.

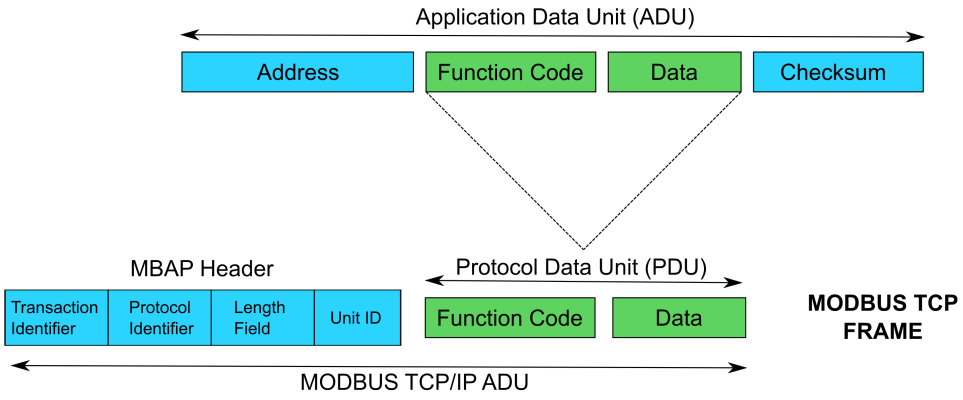

Figure 5.2: Modbus TCP frame format

A dedicated header is used on TCP/IP to identify the MODBUS Application Data Unit. It is called the MBAP header (MODBUS Application Protocol header). This header provides some differences compared to the MODBUS RTU application data unit used on serial line:

- The MODBUS 'slave address' field usually used on MODBUS Serial Line is replaced by a single byte 'Unit Identifier' within the MBAP Header. The 'Unit Identifier' is used to communicate via devices such as bridges, routers and gateways that use a single IP address to support multiple independent MODBUS end units.
- All MODBUS requests and responses are designed in such a way that the recipient can verify that a message is finished. For function codes where the MODBUS PDU has a fixed length, the function code alone is sufficient. For function codes carrying a variable amount of data in the request or response, the data field includes a byte count.
- When MODBUS is carried over TCP, additional length information is carried in the MBAP header to allow the recipient to recognize message boundaries even if the message has been split into multiple packets for transmission. The existence of explicit and implicit length rules, and use of a CRC-32 error check code (on Ethernet) results in an infinitesimal chance of undetected corruption to a request or response message

5.1.3 Function Codes - Read Input Registers

Function code 03 is used to read the binary contents of input registers in the slave referenced. The specific supported registers available in an instrument or available via one Function Code 03 message is instrument-model specific. When a master station requests a register that is not supported by the specific device the slave will respond with zeros for that register.

5.1.4 Modbus RTU Exception Codes

When a master device sends a query to a slave device it expects a normal response. One of four possible events can occur from the master's query:

- Slave device receives the query without a communication error and can handle the query normally. It returns a normal response.

- Slave does not receive the query due to a communication error. No response is returned. The master program will eventually process a time-out condition for the query.

- Slave receives the query but detects a communication error (parity, LRC or CRC). No response is returned. The master program will eventually process a time-out condition for the query.

- Slave receives the query without a communication error but cannot handle it (i.e., request is to a nonexistent coil or register). The slave will return with an exception response informing the master of the nature of the error (Illegal Data Address.)

The exception response message has two fields that differentiate it from a normal response:

- **Function Code Field:**
  In a normal response, the slave echoes the function code of the original query in the function code field of the response. All function codes have a most-significant bit (MSB) of 0 (their values are below 80 hex). In an exception response, the slave sets the MSB of the function code to 1. This makes the function code value in an exception response exactly 80 hex higher than the value would be for a normal response. With the function code's MSB set, the master's application program can recognize the exception response and can examine the data field for the exception code.

- **Data Field:**
  In a normal response, the slave may return data or statistics in the data field. In an exception response, the slave returns an exception code in the data field. This defines the slave condition that caused the exception.

5.1.5 Modbus Communication

QM20 uses Modbus Holding Register Functions ONLY. All QM20 data is accessed by using the Modbus Holding Register functions. There are no coils or discrete inputs to be read. The only Modbus commands are read and write Holding Registers.

Modbus Functions:

- Function 01 (0x01) Read Coils - not used

- Function 02 (0x02) Read Discrete Inputs - not used

- **Function 03 (0x03) Read Holding Registers - used**

- Function 04 (0x04) Read Input Registers - not used

- Function 05 (0x05) Write Single Coil - not used

- **Function 06 (0x06) Write Single Register - used**

- Function 15 (0x0F) Write Multiple Coils - not used

- Function 16 (0x10) Write Multiple Registers - not used

5.2 USB connection

Although QM20 connects via USB, it integrates as a virtual serial port. Therefore, QM20 may be opened, read from, and written to just like any serial port. QM20 USB uses the Modbus-RTU for communication. Default values:

- Baudrate: 115.2kbit/s(register 0x22 value = 0x06),
- Device address(fixed): 1(register 0x21 value = 0x01),

5.3 Serial connection

A data communication protocol defines the rules and structure of messages used by all devices on a network for data exchange. This protocol also defines the orderly exchange of messages, and the detection of errors. Modbus defines a digital communication network to have only one MASTER and one or more SLAVE devices. Either a single or multi-drop network is possible. The two types of communications networks are illustrated in the diagram below;

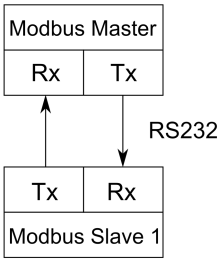

Figure 5.3: Block diagram for single connection

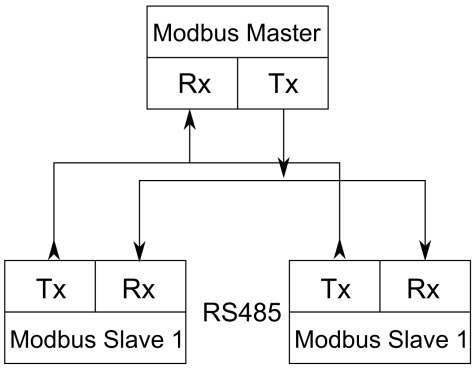

Figure 5.4: Block diagram for multi-drop communication

Default values:

- Baud rate: 115.2kbit/s(register 0x22 value = 0x06),
- Device address: 1(register 0x21 value = 0x01),

Baud rate can be changed to another value by write correct value to register 0x22.
Device address can be changed only for RS485 version(for RS232 is fixed to 1). See section 4.2 for step-by-step device address change procedure description.

5.4 Ethernet connection

Default network configuration is:

- IP: 192.168.0.200 (stored in registers 0x31-0x32)
- SN: 255.255.255.0 (stored in registers 0x33-0x34)
- GW: 192.168.0.1 (stored in registers 0x35-0x36)
- DHCP: OFF (stored in registers 0x3A)
- MAC address: unique number of the network interface, the value is read-only (stored in registers 0x37-0x39)

5.5 Register Map Overview

Register map is contained in a separate document called ***QM Register Mapping***. Refer to it for more information.

6 Measurement and Theory

The Quartz Monitor (QM) utilizes the piezoelectric sensitivity of a quartz monitor crystal to added mass. The QM uses this mass sensitivity to control the deposition rate and final thickness of a vacuum deposition. When a voltage is applied across the faces of a properly shaped piezoelectric crystal, the crystal is distorted and changes shape in proportion to the applied voltage. At certain discrete frequencies of applied voltage, a condition of sharp electro-mechanical resonance is encountered. When mass is added to the face of a resonating quartz crystal, the frequency of these resonances are reduced. This change in frequency is very repeatable and is precisely understood for specific oscillating modes of quartz. This heuristically easy-to-understand phenomenon is the basis of an indispensable measurement and process control tool that can easily detect the addition of less than an atomic layer of an adhered foreign material.

It is generally accepted that when the mass loading from the deposit causes a change in frequency of less than 2% of the frequency of the unloaded crystal, Sauerbrey's equation can be used to obtain accurate results in thin-film thickness calculations. As the thickness of the film increases, the Sauerbrey equation must be extended to incorporate the elasticity of the deposit. Lu and Lewis gave a simple equation for the calculation of the dependence of Δf on Δm, which is currently applied by most Quartz Monitor users to calculate rigid thin-film thicknesses:

$$T_f = \frac{Z_q \cdot 10^4}{2\pi \cdot z \cdot p}\left[\frac{1}{F_{co}} ATan\left(z \cdot Tan\frac{\pi F_{co}}{F_q}\right) - \left(\frac{1}{F_c}\right) ATan\left(z \cdot Tan\left(\frac{\pi \cdot F_c}{F_q}\right)\right)\right] \tag{6.1}$$

where:

T_f Thicknes of deposided film (kA)

F_{co} Starting frequency of the sensor crystal (Hz)

F_c Final frequency of the sensor crystal (Hz)

F_q Nominal blank frequency = 6045000(Hz)

z Z-Ratio of deposited film material

Z_q Specific acoustic impedance of quartz = 8765000$\left(\frac{kg}{m^2 \cdot s}\right)$

p Density of deposited film $\frac{g}{cm^3}$

This analysis of frequency changes, including the acoustic impedances of the quartz and film, is often called the "Z-match" method. The accuracy of the mass load and film thickness calculation is often limited by how well the Z-Factor and density of the material are known. Density and Z-Factor values are typically very close to bulk values. The bulk density and shear modulus values for common film materials can be found in many material reference handbooks. The Lu and Lewis equation is generally considered to be a good match to the experimental results11 for frequency changes up to 40% (relative to the unloaded crystal). Keep also in mind that the Z-match equation strictly applies to "rigid" deposits. Films which behave viscoelastically, such as some organic polymer films with large thickness or viscosity, will exhibit significant deviations from equation. Crystal failures are also often seen before a 40% shift in frequency is reached. Common problems are shorts in the crystal electrodes due to excessive buildup, mode hopping to other (anharmonic)

resonant frequencies due to the buildup of composite resonant modes, deviations from theory due to fringing electrode fields developed between the electrodes and the film, unexpected shifts in fundamental frequency due to stress build up on the crystal surface, splitting of source material resulting in nonuniform films, etc.

6.1 Tooling factor

Tooling Factor is a correction for the difference in material deposited on the quartz sensor versus the substrate. Illustrated below is an example of how difference in distance between the sensor and substrate causes an incorrect reading as you would see in an electron or thermal evaporation system. It is impossible to place a sensor in exactly the same place as your substrate unless the sensor is your substrate.

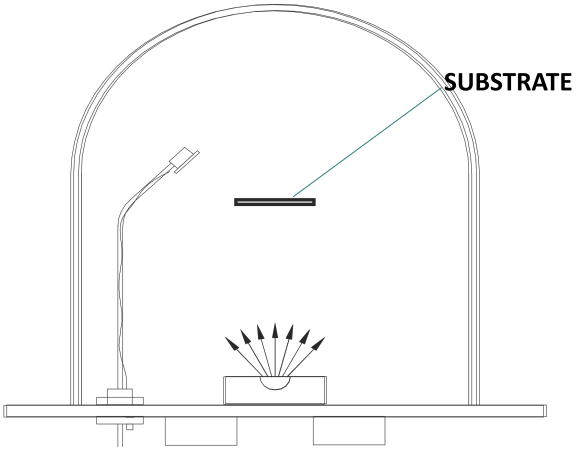

Figure 6.1: Tooling factor over 100%

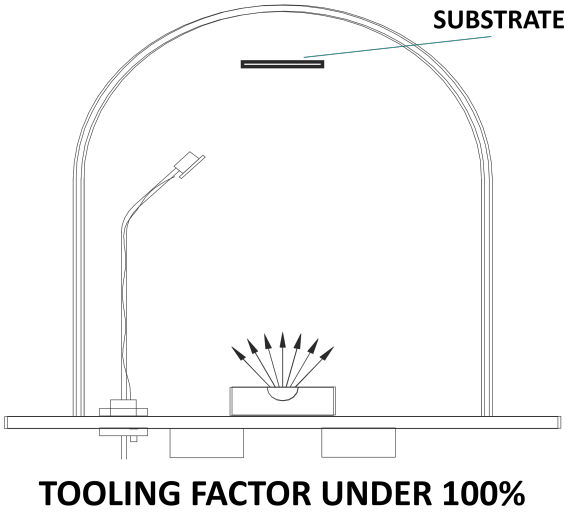

Figure 6.2: Tooling factor under 100%

6.2 Material List

The following Table represents the density and Z-Ratio for various materials. The list is alphabetical by chemical formula An * is used to indicate that a Z-Ratio has not been established for a certain material. A value of 1.000 is defaulted in these situations.

Formula	Density	Z-Ratio	Material Name
Formula	Density	Z-Ratio	Material Name
Ag	10.500	0.539	silver
$AgBr$	6.470	1.180	silver bromide
$AgCl$	5.560	1.320	silver chloride
Al	2.700	1.080	aluminum
Al_2O_3	3.970	0.336	aluminum oxide
Al_4C_3	2.360	*1.000	aluminum carbide
AIF_3	3.070	*1.000	aluminum fluoride
AIN	3.260	*1.000	aluminum nitride
$AlSb$	4.360	0.743	aluminum antimonide
As	5.730	0.966	arsenic
As_2Se_3	4.750	*1.000	arsenic selenide
Au	19.300	0.381	gold
B	2.370	0.389	boron
B_20_3	1.820	*1.000	boron oxide
B_4C	2.370	*1.000	boron carbide
BN	1.860	*1.000	boron nitride
Ba	3.500	2.100	barium
BaF_2	4.886	0.793	barium fluoride
BaN_2O_6	3.244	1.261	barium nitrate
BaO	5.720	*1.000	barium oxide
$BaTiO_3$	5.999	0.464	barium titanate (tetr)
$BaTiO_3$	6.035	0.412	barium titanate (cubic)
Be	1.850	0.543	beryllium

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Formula	Density	Z-Ratio	Material Name
BeF_2	1.990	*1.000	beryllium fluoride
BeO	3.010	*1.000	beryllium oxide
Bi	9.800	0.790	bismuth
Bi_2O_3	8.900	*1.000	bismuth oxide
Bi_2S_3	7.390	*1.000	bismuth trisulfide
Bi_2Se_3	6.820	*1.000	bismuth selenide
Bi_2Te_3	7.700	*1.000	bismuth telluride
BiF_3	5.320	*1.000	bismuth fluoride
C	2.250	3.260	carbon (graphite)
C	3.520	0.220	carbon (diamond)
C_8H_8	1.100	*1.000	parlyene (union carbide)
Ca	1.550	2.620	calcium
CaF_2	3.180	0.775	calcium fluoride
CaO	3.350	*1.000	calcium oxide
$CaO - SiO_2$	2.900	*1.000	calcium silicate (3)
$CaSO_4$	2.962	0.955	calcium sulfate
$CaTiO_3$	4.100	*1.000	calcium titanate
$CaWO_4$	6.060	*1.000	calcium tungstate
Cd	8.640	0.682	cadmium
CdF_2	6.640	*1.000	cadmium fluoride
CdO	8.150	*1.000	cadmium oxide
CdS	4.830	1.020	cadmium sulfide
$CdSe$	5.810	*1.000	cadmium selenide
$CdTe$	6.200	0.980	cadmium telluride
Ce	6.780	*1.000	cerium
CeF_3	6.160	*1.000	cerium (III) fluoride
CeO_2	7.130	*1.000	cerium (IV) dioxide
Co	8.900	0.343	cobalt
CoO	6.440	0.412	cobalt oxide

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Formula	Density	Z-Ratio	Material Name
Cr	7.200	0.305	chromium
Cr_2O_3	5.210	*1.000	chromium (III) oxide
Cr_3C_2	6.680	*1.000	chromium carbide
CrB	6.170	*1.000	chromium boride
Cs	1.870	*1.000	cesium
Cs_2SO_4	4.243	1.212	cesium sulfate
$CsBr$	4.456	1.410	cesium bromide
$CsCI$	3.988	1.399	cesium chloride
CsI	4.516	1.542	cesium iodide
Cu	8.930	0.437	copper
Cu_2O	6.000	*1.000	copper oxide
Cu_2S	5.600	0.690	copper (I) sulfide (alpha)
Cu_2S	5.800	0.670	copper (I) sulfide (beta)
CuS	4.600	0.820	copper (II) sulfide
Dy	8.550	0.600	dysprosium
DY_2O_3	7.810	*1.000	dysprosium oxide
Er	9.050	0.740	erbium
Er_2O_3	8.640	*1.000	erbium oxide
Eu	5.260	*1.000	europium
EuF_2	6.500	*1.000	europium fluoride
Fe	7.860	0.349	iron
Fe_2O_3	5.240	*1.000	iron oxide
FeO	5.700	*1.000	iron oxide
FeS	4.840	*1.000	iron sulfide
Ga	5.930	0.593	gallium
Ga_2O_3	5.880	*1.000	gallium oxide (B)
$GaAs$	5.310	1.590	gallium arsenide
GaN	6.100	*1.000	gallium nitride
GaP	4.100	*1.000	gallium phosphide

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Formula	Density	Z-Ratio	Material Name
$GaSb$	5.600	*1.000	gallium antimonide
Gd	7.890	0.670	gadolinium
Gd_2O_3	7.410	*1.000	gadolinium oxide
Ge	5.350	0.516	germanium
Ge_3N_2	5.200	*1.000	germanium nitride
GeO_2	6.240	*1.000	germanium oxide
$GeTe$	6.200	*1.000	germanium telluride
Hf	13.090	0.360	hafnium
HfB_2	10.500	*1.000	hafnium boride
HfC	12.200	*1.000	hafnium carbide
HfN	13.800	*1.000	hafnium nitride
HfO_2	9.680	*1.000	hafnium oxide
$HfSi_2$	7.200	*1.000	hafnium silicide
Hg	13.460	0.740	mercury
Ho	8.800	0.580	holmium
H_2O_3	8.410	*1.000	holmium oxide
In	7.300	0.841	indium
In_2O_3	7.180	*1.000	indium sesquioxide
In_2Se_3	5.700	*1.000	indium selenide
In_2Te_3	5.800	*1.000	indium telluride
$InAs$	5.700	*1.000	indium arsenide
InP	4.800	*1.000	indium phosphide
$InSb$	5.760	0.769	indium antimonide
Ir	22.400	0.129	iridium
K	0.860	10.189	potassium
KBr	2.750	1.893	potassium bromide
KCI	1.980	2.050	potassium chloride
KF	2.480	*1.000	potassium fluoride
KI	3.128	2.077	potassium iodide

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Formula	Density	Z-Ratio	Material Name
La	6.170	0.920	lanthanum
La_2O_3	6.510	*1.000	lanthanum oxide
LaB_6	2.610	*1.000	lanthanum boride
LaF_3	5.940	*1.000	lanthanum fluoride
Li	0.530	5.900	lithium
$LiBr$	3.470	1.230	lithium bromide
LiF	2.638	0.778	lithium fluoride
$LiNbO_3$	4.700	0.463	lithium niobate
Lu	9.840	*1.000	lutetium
Mg	1.740	1.610	magnesium
$MgAl_2O_4$	3.600	*1.000	magnesium aluminate
$MgAl_2O_6$	8.000	*1.000	spinel
MgF_2	3.180	0.637	magnesium fluoride
MgO	3.580	0.411	magnesium oxide
Mn	7.200	0.377	manganese
MnO	5.390	0.467	manganese oxide
MnS	3.990	0.940	manganese (II) sulfide
Mo	10.200	0.257	molybdenum
Mo_2C	9.180	*1.000	molybdenum carbide
MoB_2	7.120	*1.000	molybdenum boride
MoO_3	4.700	*1.000	molybdenum trioxide
MoS_2	4.800	*1.000	molybdenum disulfide
Na	0.970	4.800	sodium
Na_3AlF_6	2.900	*1.000	cryolite
$Na_5Al_3F_{14}$	2.900	*1.000	chiolite
$NaBr$	3.200	*1.000	sodium bromide
$NaCl$	2.170	1.570	sodium chloride
$NaClO_3$	2.164	1.565	sodium chlorate
NaF	2.558	1.645	sodium fluoride

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Formula	Density	Z-Ratio	Material Name
$NaNO_3$	2.270	1.194	sodium nitrate
Nb	8.578	0.492	niobium(columbium)
Nb_2O_3	7.500	*1.000	niobium trioxide
Nb_2O_5	4.470	*1.000	niobium (V) oxide
NbB_2	6.970	*1.000	niobium boride
NbC	7.820	*1.000	niobium carbide
NbN	8.400	*1.000	niobium nitride
Nd	7.000	*1.000	neodymium
Nd_2O_3	7.240	*1.000	neodymium oxide
$NdF3$	6.506	*1.000	neodymium fluoride
Ni	8.910	0.331	nickel
$NiCr$	8.500	*1.000	nichrome
$NiCrFe$	8.500	*1.000	Inconel
$NiFe$	8.700	*1.000	permalloy
$NiFeMo$	8.900	*1.000	supermalloy
NiO	7.450	*1.000	nickel oxide
P_3N5	2.510	*1.000	phosphorus nitride
Pb	11.300	1.130	lead
$PbCl_2$	5.850	*1.000	lead chloride
PbF_2	8.240	0.661	lead fluoride
PbO	9.530	*1.000	lead oxide
PbS	7.500	0.566	lead sulfide
$PbSe$	8.100	*1.000	lead selenide
$PbSnO_3$	8.100	*1.000	lead stannate
$PbTe$	8.160	0.651	leadtelluride
Pd	12.038	0.357	palladium
PdO	8.310	*1.000	palladium oxide
Po	9.400	*1.000	polonium
Pr	6.780	*1.000	praseodymium

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Formula	Density	Z-Ratio	Material Name
Pr_2O_3	6.880	*1.000	praseodymium oxide
Pt	21.400	0.245	platinum
PtO_2	10.200	*1.000	platinum oxide
Ra	5.000	*1.000	radium
Rb	1.530	2.540	rubidium
RbI	3.550	*1.000	rubidium iodide
Re	21.040	0.150	rhenium
Rh	12.410	0.210	rhodium
Ru	12.362	0.182	ruthenium
$S8$	2.070	2.290	sulfur
Sb	6.620	0.768	antimony
Sb_2O_3	5.200	*1.000	antimony trioxide
Sb_2S_3	4.640	*1.000	antimony trisulfide
Sc	3.000	0.910	scandium
Sc_2O_3	3.860	*1.000	scandium oxide
Se	4.810	0.864	selenium
Si	2.320	0.712	silicon
Si_3N_4	3.440	*1.000	silicon nitride
SiC	3.220	*1.000	silicon carbide
SiO	2.130	0.870	silicon (II) oxide
SiO_2	2.648	1.000	silicon dioxide
Sm	7.540	0.890	samarium
$Sm2O_3$	7.430	*1.000	samarium oxide
Sn	7.300	0.724	tin
SnO_2	6.950	*1.000	tin oxide
SnS	5.080	*1.000	tin sulfide
$SnSe$	6.180	*1.000	tin selenide
$SnTe$	6.440	*1.000	tin telluride
Sr	2.600	*1.000	strontium

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Formula	Density	Z-Ratio	Material Name
SrF_2	4.277	0.727	strontium fluoride
SrO	4.990	0.517	strontium oxide
Ta	16.600	0.262	tantalum
$Ta2O_5$	8.200	0.300	tantalum (V) oxide
TaB_2	11.150	*1.000	tantalum boride
TaC	13.900	*1.000	tantalum carbide
TaN	16.300	*1.000	tantalum nitride
Tb	8.270	0.660	terbium
Tc	11.500	*1.000	technetium
Te	6.250	0.900	tellurium
TeO_2	5.990	0.862	tellurium oxide
Th	11.694	0.484	thorium
ThF_4	6.320	*1.000	thorium (IV) fluoride
ThO_2	9.860	0.284	thorium dioxide
$ThOF_2$	9.100	*1.000	thorium oxyfluoride
Ti	4.500	0.628	titanium
Ti_20_3	4.600	*1.000	titanium sesquioxide
TiB_2	4.500	*1.000	titanium boride
TiC	4.930	*1.000	titanium carbide
TiN	5.430	*1.000	titanium nitride
TiO	4.900	*1.000	titanium oxide
TiO_2	4.260	0.400	titanium (IV) oxide
TI	11.850	1.550	thallium
$TIBr$	7.560	*1.000	thallium bromide
$TICI$	7.000	*1.000	thallium chloride
TII	7.090	*1.000	thallium iodide (B)
U	19.050	0.238	uranium
U_3O_8	8.300	*1.000	tri uranium octoxide
U_4O_9	10.969	0.348	uranium oxide

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Formula	Density	Z-Ratio	Material Name
UO_2	10.970	0.286	uranium dioxide
V	5.960	0.530	vanadium
V_2O_5	3.360	*1.000	vanadium pentoxide
VB_2	5.100	*1.000	vanadium boride
VC	5.770	*1.000	vanadium carbide
VN	6.130	*1.000	vanadium nitride
VO_2	4.340	*1.000	vanadium dioxide
W	19.300	0.163	tungsten
WB_2	10.770	*1.000	tungsten boride
WC	15.600	0.151	tungsten carbide
WO_3	7.160	*1.000	tungsten trioxide
WS_2	7.500	*1.000	tungsten disulfide
WSi_2	9.400	*1.000	tungsten silicide
Y	4.340	0.835	yttrium
Y_20_3	5.010	*1.000	yttrium oxide
Yb	6.980	1.130	ytterbium
Yb_2O_3	9.170	*1.000	ytterbium oxide
Zn	7.040	0.514	zinc
Zn_3Sb_2	6.300	*1.000	zinc antimonide
ZnF_2	4.950	*1.000	zinc fluoride
ZnO	5.610	0.556	zinc oxide
ZnS	4.090	0.775	zinc sulfide
$ZnSe$	5.260	0.722	zinc selenide
$ZnTe$	6.340	0.770	zinc telluride
Zr	6.490	0.600	zirconium
ZrB_2	6.080	*1.000	zirconium boride
ZrC	6.730	0.264	zirconium carbide
ZrN	7.090	*1.000	zirconium nitride
ZrO_2	5.600	*1.000	zirconium oxide

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Formula	Density	Z-Ratio	Material Name

Table 6.1: Material table

7 MAINTANCE AND SERVICE

7.1 MAINTANCE

The QM20 does not require any special maintenance work.

7.2 CLEANING

For cleaning of the outside of the device, a slightly moistened cloth will usually do. Do not use any aggressive or abrasive cleaning agents.

7.3 Install FTDI drivers for USB version

CAUTION

Administrative privileges You will most likely need to obtain administrative privileges from your network or IT administrator in order to install these drivers.

1. Plug QM20 using a USB cable. Windows doesn't have the correct drivers, so you need find them!
2. Navigate to the FTDI website, and choose the 'VCP' (Virtual Com Port) option near the bottom.
3. Now choose either the 32 bit version or the 64 bit version.
4. Right-click on the correct version, and save it to your computer. Remember where the files are saved.
5. Navigate to the folder containing the files. They will be inside of a .zip file, so you'll need to extract them. Right-Click on the .zip file, and choose 'Extract All…' When the next window appears, pay attention to where it is extracting the files. Make sure that 'Show extracted files when complete' is checked, and click 'Extract'.
6. When the extraction is complete, the folder is opened. Again, take note of this folder location. This is the one containing the drivers.
7. Open the start menu, right-click on 'Computer', and left-click on 'Manage'. You will need administrator rights to do this.
8. Left-click on 'Device Manager' in the leftmost column. Here is where we see the offending hardware. It has an exclamation mark next to it.
9. Right-click on 'FT232R USB UART,' and left-click 'Update Driver Software…'
10. Now choose 'Browse my computer for driver software'.

11. Left-click 'Browse,' and navigate to the location of the extracted files. Choose the extracted folder. There is no need to search any further in the folder. Then left-click 'OK'.
12. Make sure 'Include subfolders' is checked (very important!), and left-click 'Next'.
13. After a moment, you will see a success message! Left-click 'Close'.
14. The Device Manager Page will refresh and show 'USB Serial Port (COMxx),' where xx = some number.

7.4 Resetting device

Resetting the device is possible in two ways:

1. Software reset: by write value '1' to register 0x23. This is a specific order for a device does not respond in case of entering a '1'. Immediately proceeds to the restart procedure.
2. At any time, it is also possible to reset the device by unplugging it from the power supply and reconnecting.

7.5 Firmware update

QM20 should be working in two modes: normal and firmware update mode. When the device is working in the normal mode it uses the Modbus-RTU/Modbus-TCP protocol for communication with master device. In firmware update mode the QM20 uses Xmodem protocol or TFTP protocol(Ethernet version). These relationships are illustrated in the table below.

	RS232/RS485/USB	Ethernet(PoE)
Normal mode	Modbus-RTU	Modbus-TCP
Firmware update mode:	XMODEM	TFTP

Table 7.1: QM20 used transmission protocols

7.5.1 Device programming (Serial/USB)

Setting „1" in 0x23 register sets device to the bootloading mode. In response device sends frequently „QM »" string.
If in response of this string device will receive „Boot" string, then unit switch to the programming mode – device awaiting for data package in XMODEM standard.
Bootloader always run with parameters specified below:

- Baud rate: 115200
- 8 data bits
- 1 stop bit
- no parity control

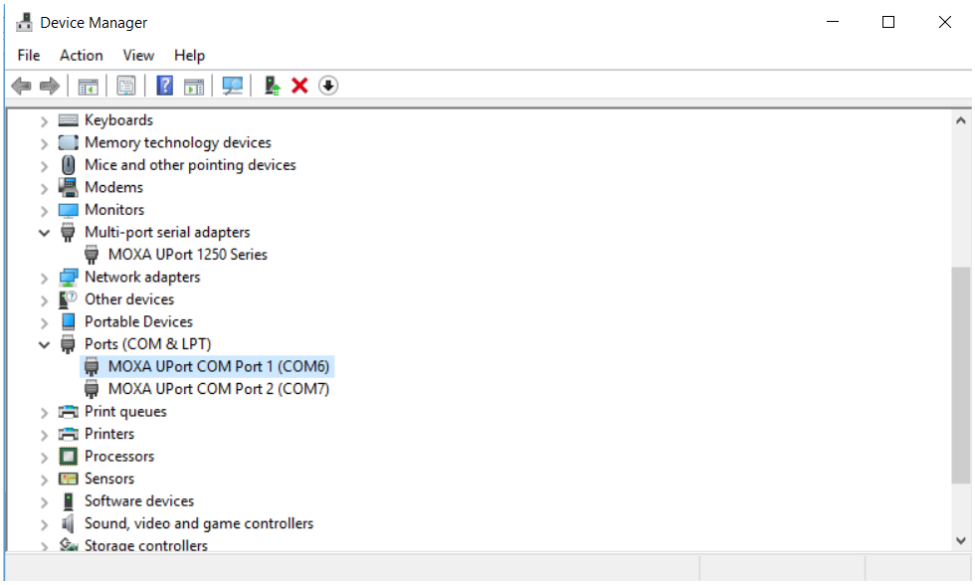

Figure 7.1: System manager - Serial ports

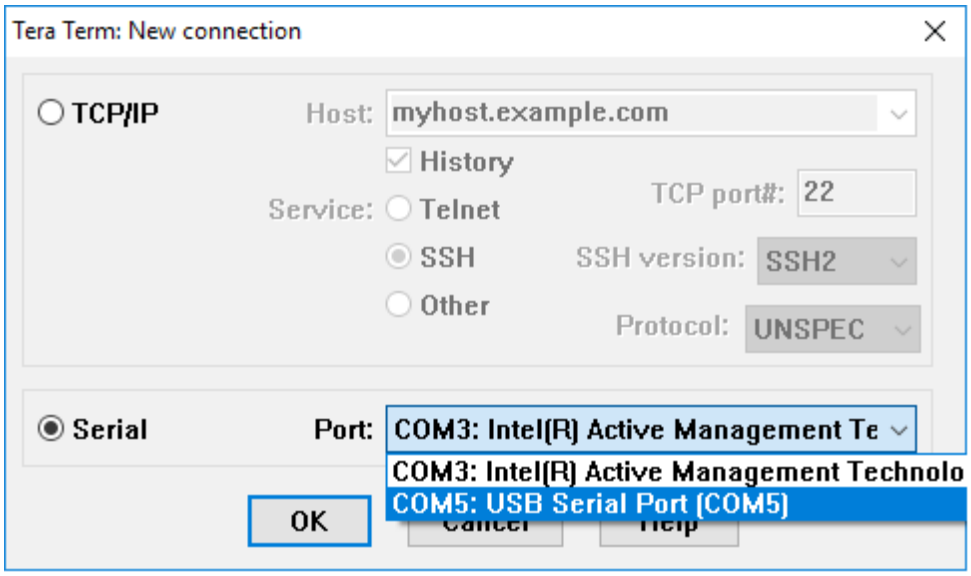

Figure 7.2: Terminal - new connection

The following procedure is described based on the program TeraTerm.

1. Disconnect supply from QM20
2. Run on computer any program that allows you to communicate via serial interface, for example: *TeraTerm* (figure 7.2)
3. Connect supply to QM20 ,
4. Select the port and connection settings according information on figure 7.3 and 7.4.
5. QM20 sends frequently „QM»” string(figure 7.5).
6. Enter string ”Boot” from the keyboard(is case sensitive),

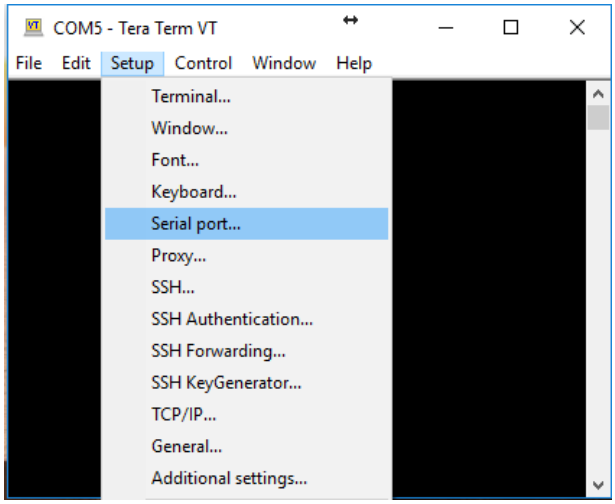

Figure 7.3: Terminal - serial port setup

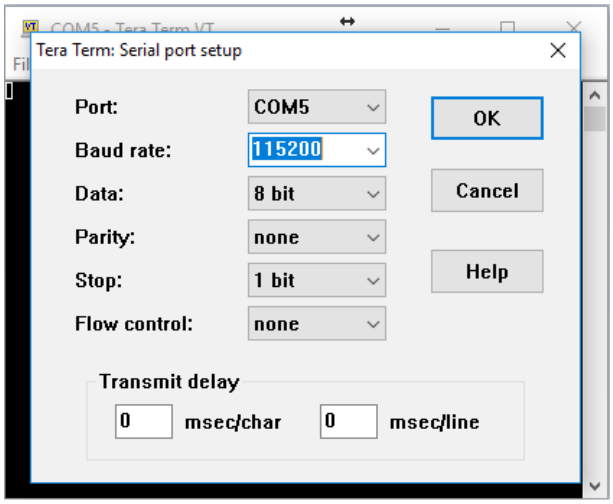

Figure 7.4: Terminal - serial port configuration

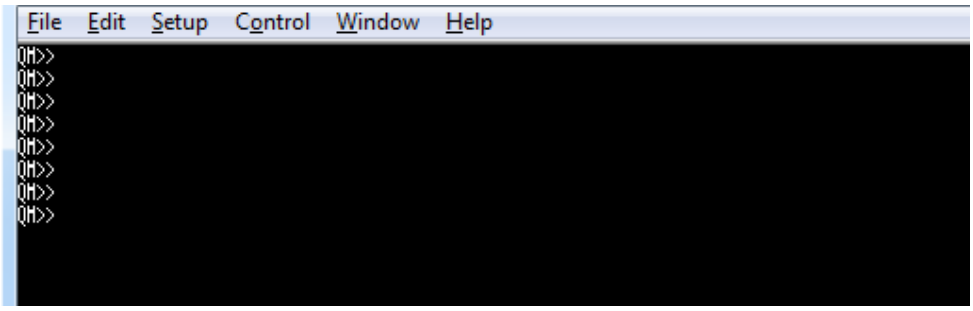

Figure 7.5: Terminal - booloader prompt, wait for ***"Boot"*** string

7. QM20 switch to the programming mode. This is indicated by the cyclic sending the character 'C'(figure 7.5).

8. Both crystal LEDs are blinking slowly,

9. Device awaiting for data package(*.bin file) in XMODEM protocol

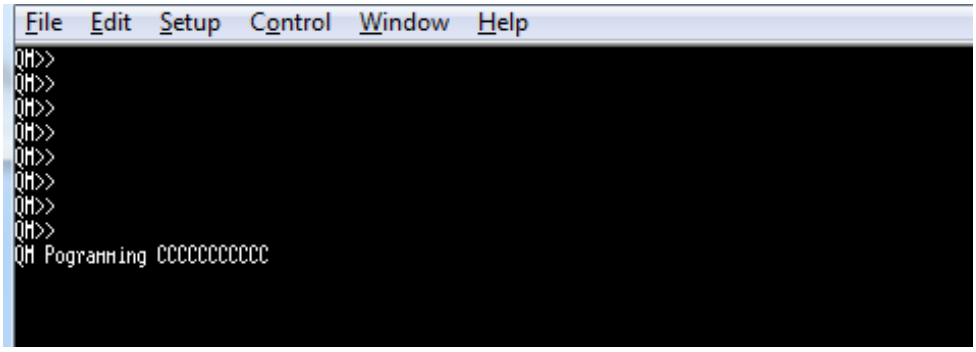

Figure 7.6: Terminal - wait for file transfer

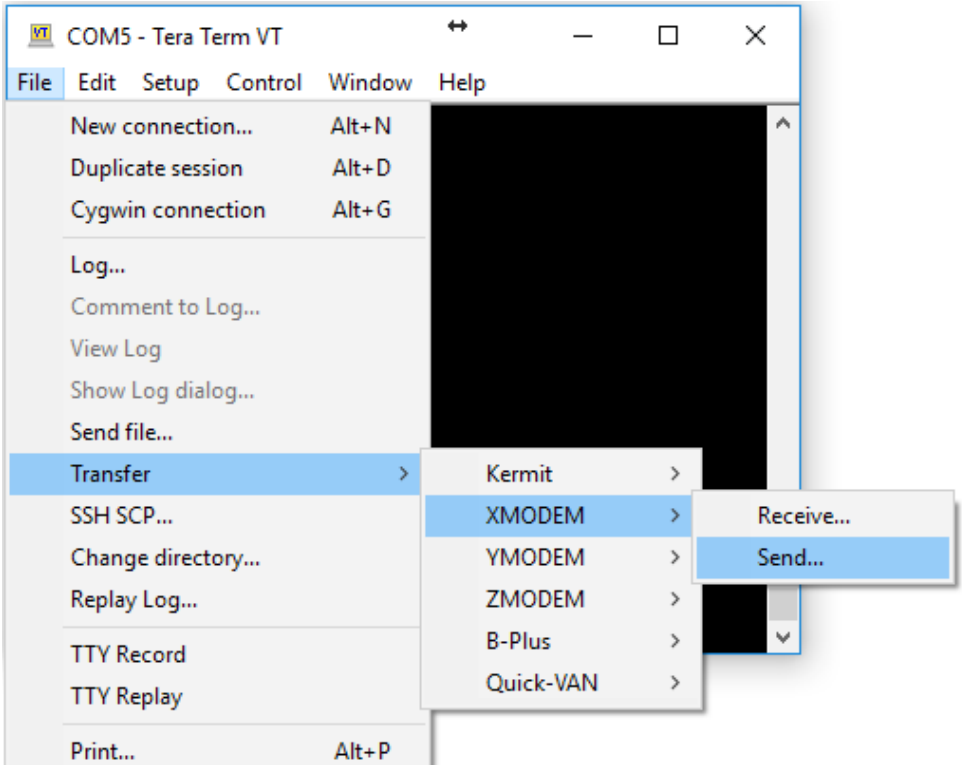

Figure 7.7: Terminal - XMODEM send

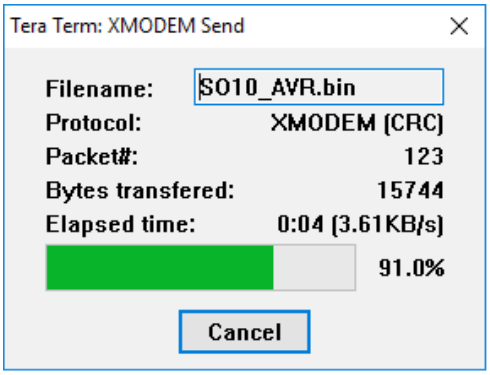

Figure 7.8: Terminal - upload new firmware

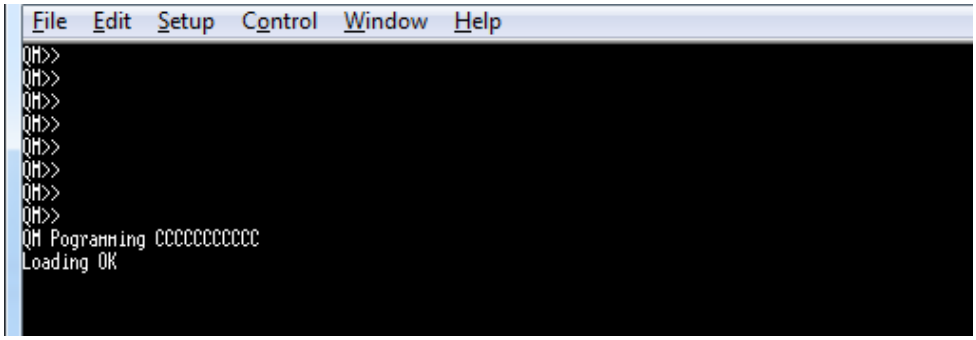

Figure 7.9: Terminal - load new firmware successful

10. Send firmware file to QM20 (figure 7.7)
11. During update procedure both Crystal LED are blinking rapidly, the application displays information about the progress of the file is sent(figure 7.8).
12. After few seconds firmware update procedure is finished(figure 7.9).

7.5.2 Device programming (Ethernet)

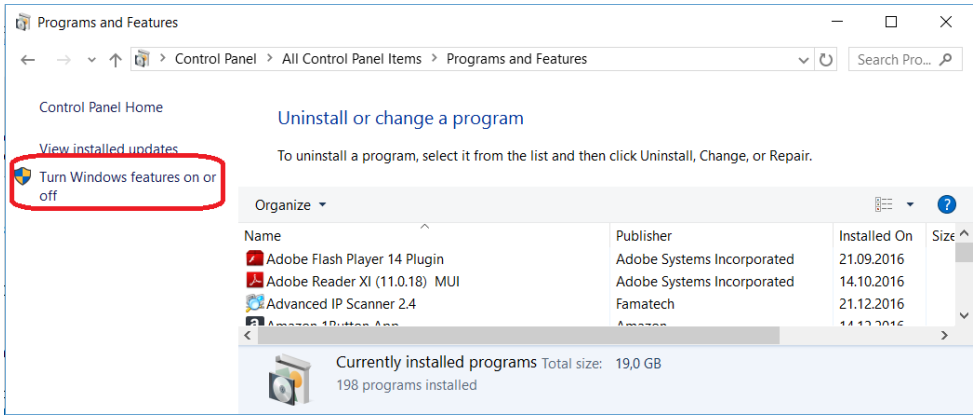

Figure 7.10: Control panel - windows features

For firmware upgrade, the following are required: PC Computer with enable Telnet and TFTP features.

To check If this option are enable please open Control Panel -> Programs(Fig. 7.10) and Features and click “Turn Windows features On or Off ” (Fig. 7.11)

In order to upload new software to the device, enter it in the firmware update mode:

1. Check the target device is powered, and connected to the ethernet.
2. When QM20 is running press reset button for 5 seconds to switch QM20 in firmware update mode.
3. Switching to firmware update mode is indicated by the slow blinking of the both Crystal LED.
4. In a console window (Windows) type: **tftp -i** *'IP_addres'* **put** *[firmware].bin* (Fig. 7.13)
   Example:
   tftp -i 192.168.0.200 put QM20 _PoE_09b75be_0.9.bin

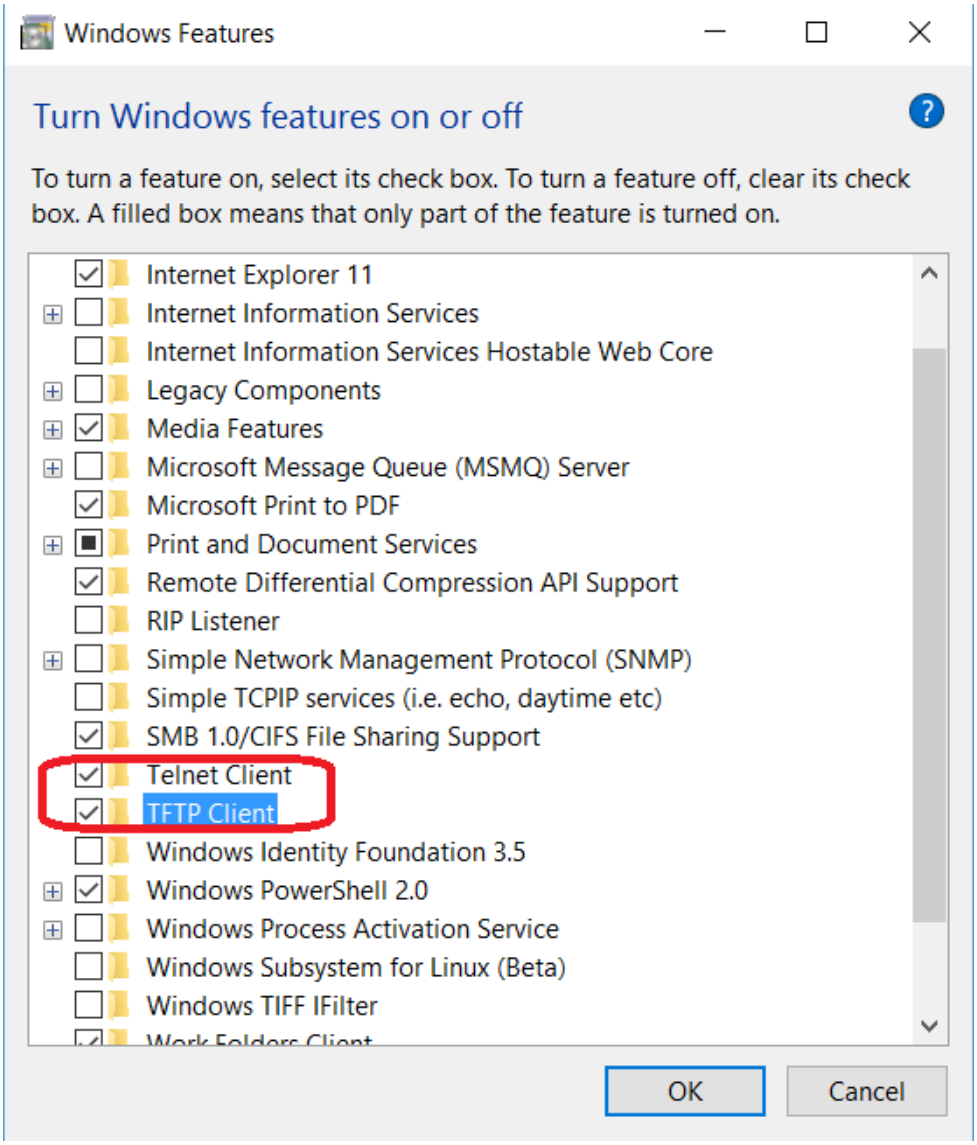

Figure 7.11: TFTP client - ON

5. The Crystal 1 LED will blink rapidly during programming procedure. After successful uploading the software will be displayed(Fig. 7.14):
   Uploaded successfully: bytes: 33138 in 4 s, bytes/s: 8284

6. The board will be reboot.

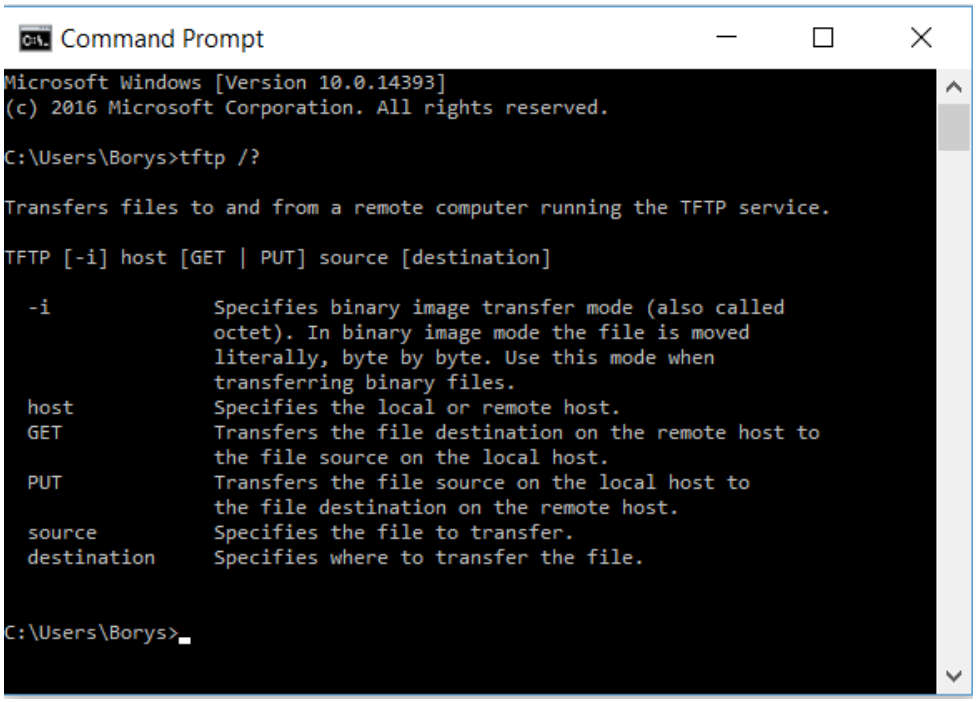

Figure 7.12: TFTP available parameters

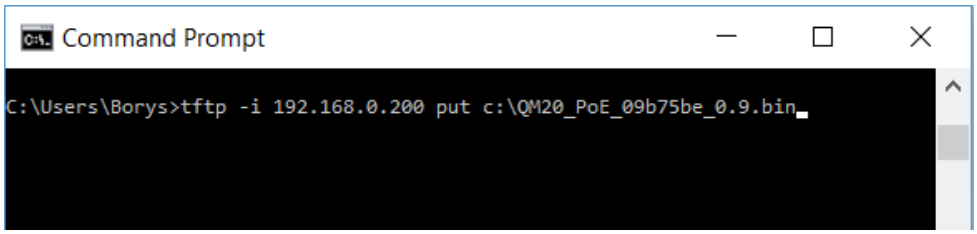

Figure 7.13: TFTP - upload firmware

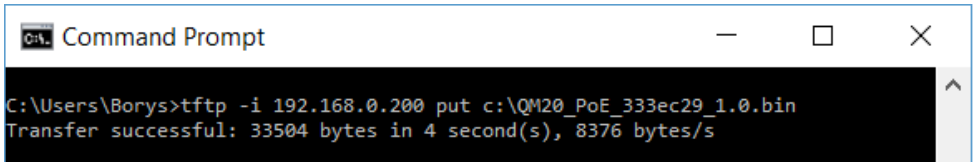

Figure 7.14: TFTP - file transfer successful

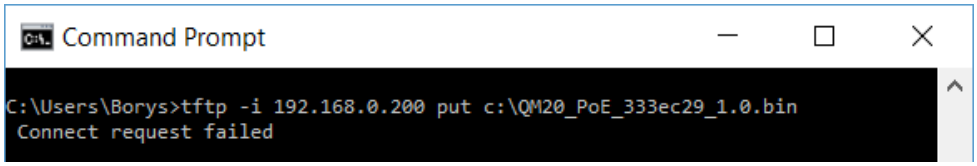

Figure 7.15: TFTP - transfer failed

CAUTION

Exit from firmware update mode
When QM20 is in firmware update mode - short pressing reset button causes finish update mode and run device in normal mode.

CAUTION

File transfer fail
When the file upload fails(figure 7.15), check:

- Firewall settings,
- Entered the IP address,
- Connect the QM20 to Ethernet and the status LEDs on the device,

7.6 Factory reset (USB/Serial)

If for some reason the QM20 device stops responding or you do not know the device address then is possible restore the factory settings for device address and baud rate value. In order to restore default settings perform the following steps:

1. Disconnect supply from QM20
2. Run on computer any program that allows you to communicate via serial interface, for example: *TeraTerm*
3. Connect supply to QM20 ,
4. Select the port and connection settings the same as for firmware update procedure(see 7.5.1)
5. QM20 sends frequently „QM»” string.
6. Enter string ”default” from the keyboard,
7. In response, a message appears: ”Reset to default...”(figure 7.16).
8. The both Crystal LED does light up for 2 seconds.
9. QM20 run in normal mode,
10. Restore procedure is finished,

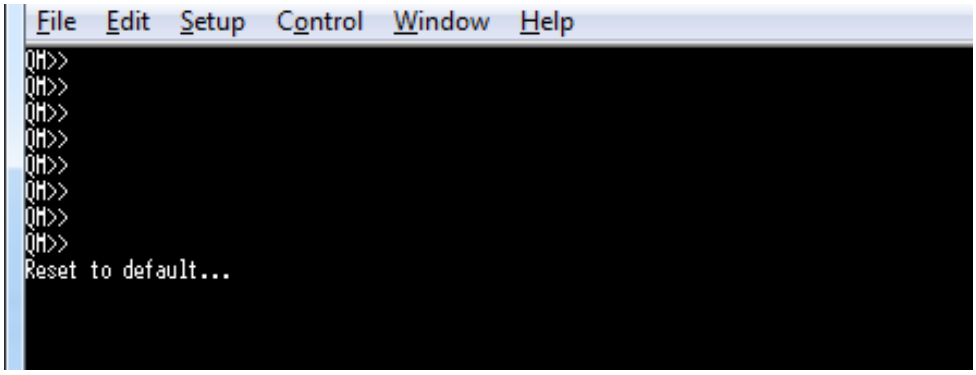

Figure 7.16: Terminal - load default settings

Default device address and baud rate (0x21 and 0x22 command) can be recalled at any time. This can be done with frequent “default” string sending during power on of the device.

7.7 Factory reset (Ethernet)

If for some reason the QM20 device stops responding or you do not know the device address then is possible restore the factory settings for network parameters In order to reset network settings to factory value perform the following steps:

1. Disconnect ethernet cable from QM20 .
2. Hold down the reset button
3. Connect the ethernet cable(while keeping the button pressed)
4. Do not release the reset button until the both Crystal LED does not light up.

After this procedure, the device restarts with the factory settings:

- DHCP: OFF (static)
- IP: 192.168.0.200
- Net mask: 255.255.255.0

8 STORAGE AND DISPOSAL

8.1 PACKING

Please retain the original packaging. The packaging is required for storing the device and for shipping it to an authorized service center.

8.2 STORAGE

The QM20 should only be stored in a dry room. The following requirements must be met:

PARAMETER	VALUE
Ambient temperature	-20...50°C
Humidity	as low as possible; preferably in an air-tight plastic bag with a desiccant

Table 8.1: Storage parameters

8.3 DISPOSAL

The product must be disposed of in accordance with the relevant local regulations for the environmentally safe disposal of systems and electronic components.

8.3.1 Waste Electrical and Electronic Equipment (WEEE)

The use of the WEEE symbol indicates that this product may not be treated as household waste. By ensuring this product is disposed of correctly you will protect the environment. Recycling information of this product can be obtained at the place of sale, your household waste disposal service provider, or local authority.

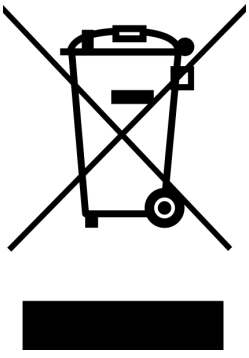

Figure 8.1: Waste Electrical and Electronic Equipment (WEEE) Symbol

9 TROUBLESHOOTING

SYMPTOM	CAUSE	REMEDY
Power indicator is OFF	Power supply not connected	check cable connections
	Supply voltage out of range	make sure that the power supply used has an appropriate voltage and adequate current efficiency
	Reverse polarity voltage supply	check the correct connection of the power cables to the terminal block connector
Frequency readings are unstable or incorrect	Temperature of the crystal is unstable (an AT-cut crystal may drift as much as 10 Hz/°C).	Control the vacuum chamber temperature. Move the crystal farther away from the source (at least 25cm from source). Check sensor water cooling for correct flow and temperature. Refer to the sensor operating manual. Clean or replace the crystal holder. Refer to the sensor operating manual.
	Humidity level on the crystal is changing. Moisture being absorbed or exuded from the crystal surface.	Avoid condensation by turning off cooling water to sensor before opening the vacuum chamber to air. Flow water above the dew point of the room through the sensor when the chamber is open.
	Defective in-vacuum cable or coax cables.	Use an ohmmeter to check electrical continuity and isolation.
	Crystal seating on the crystal holder surface is scratched or contaminated.	Clean or replace crystal holder. Refer to the sensor operating manual.

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SYMPTOM	CAUSE	REMEDY
	Excessive cable length between oscillator and crystal causes a self-oscillation condition.	Use no longer than a 90 cm in-vacuum cable. Use only the 15 cm cable between QM20 or oscillator and feedthrough.
Crystal indicator is OFF	Failed or defective crystal, or no crystal in sensor.	Install a new crystal.
	Two crystals were installed or crystal is upside down.	Remove extra crystal. Reverse crystal orientation. Inspect crystal for scratches; if scratched, replace with new crystal.
	Build-up of material at crystal holder aperture is touching the crystal.	Clean or replace the crystal holder. Refer to the sensor operating manual.
	Crystal frequency is not within the Min and Max frequency settings.	Install a new crystal. Use a 6 MHz crystal.
	Sensor not connected, or bad electrical connection in sensor head or feedthrough, or bad cables.	Check sensor connections. Refer to the sensor operating manual. Use an ohmmeter to check electrical continuity / isolation of sensor head, feedthrough, in-vacuum cable, SMA/BNC adapter cable, and BNC cables. Refer to the sensor operating manual. Substitute a 5.5 MHz test crystal or a known good sensor for the suspect sensor.
	Bad coax cable between feedthrough and QM20 or oscillator, or bad coax cable between oscillator and QM20 .	Use an ohmmeter to check electrical continuity / isolation. Substitute a known good coax cable.
	QM20 or QM20-EO is malfunctioning.	Substitute a known good QM20 (or other quartz monitor). Substitute a known good oscillator.

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SYMPTOM	CAUSE	REMEDY
Communication cannot by established between the host computer and QM20	Improper cable connection	check communication lines for swapped(*serial version)
	Device is not powered	check Power Led indicator status
		check PoE adapter connections(*ethernet version)

Table 9.1: Write device address

10 WARRANTY CONDITIONS

MCVAC MANUFACTURING CO. INC. warrants to the purchaser or end user of the equipment it sells that such equipment will be free from defects in material and workmanship under normal use and service. This warranty is for a period of 27 months from the date of original shipment or two years (24 months) from the date the equipment is placed in use by the purchaser or end user thereof, whichever occurs first. This warranty is void if the equipment is not used, operated, and maintained in accordance with the manual accompanying the equipment. MCVAC MANUFACTURING CO. INC. shall not be responsible for any direct or indirect loss or damage resulting from accident, negligence of a user, alteration, abuse, or misuse of the equipment. Upon acceptance of this Limited Warranty, purchaser waives all warranties, guarantee, or remedies not specifically stated in this Limited Warranty. This warranty does not cover ordinary wear and tear or expendable components.

MCVAC MANUFACTURING CO. INC. obligation under this Limited Warranty is, at EDFelectronics's option, to repair or replace any defective equipment or parts of the equipment, without charge to the purchaser, which are returned, shipping prepaid, to the MCVAC MANUFACTURING CO. INC. facility. For return or repair of equipment, purchaser must contact MCVAC MANUFACTURING CO. INC. for a Return Materials Authorization (RMA) prior to shipment of the equipment to MCVAC MANUFACTURING CO. INC. . If MCVAC MANUFACTURING CO. INC. has designated an Authorized Warranty Service Representative in the purchaser's country, contact may be made with the Authorized Warranty Service Representative and defective equipment may be delivered to such Authorized Warranty Service Representative to service warranty claims.

This warranty is in lieu of all other warranties, expressed or implied, including the implied warranties of merchantability and fitness for any particular purpose. The purchaser acknowledges the purchaser is not relying in MCVAC MANUFACTURING CO. INC. skill or judgment to select or furnish equipment suitable for any particular purpose.