# Schneider Electric Modbus Slave Protocol XBT N/R/RT

33003980 06/2008

33003980.01

# Table of Contents

# Safety Information

## Important Information

**NOTICE**

Read these instructions carefully, and look at the equipment to become familiar with the device before trying to install, operate, or maintain it. The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

The addition of this symbol to a Danger or Warning safety label indicates that an electrical hazard exists, which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

| ⚠ DANGER |
|---|
| DANGER indicates an imminently hazardous situation, which, if not avoided, **will result** in death or serious injury. |

| ⚠ WARNING |
|---|
| WARNING indicates a potentially hazardous situation, which, if not avoided, **can result** in death, serious injury, or equipment damage. |

| ⚠ CAUTION |
|---|
| CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage. |

**PLEASE NOTE**

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

# About the Book

## At a Glance

**Document Scope**

This document describes communication between automation systems and the XBT N/R/RT product range using the Modbus Slave protocol.

**Validity Note**

The data and illustrations found in this document are not binding. We reserve the right to modify our products in line with our policy of continuous product development. The information in this document is subject to change without notice and should not be construed as a commitment by Schneider Electric.

**Related Documents**

| Title of Documentation | Reference Number |
|---|---|
| XBT N/R/RT Instruction sheet | W916810140111 A08 |
| Modbus Protocol Reference Guide | PI-MBUS-300 (available at www.modbus.org |
| XBT N/R/RT User Manual | 33003962 |
| Vijeo-Designer Lite | Online help |

**Product Related Warnings**

Schneider Electric assumes no responsibility for any errors that may appear in this document. If you have any suggestions for improvement or amendments or have found errors in this publication, please notify us.

All pertinent state, regional and local safety regulations must be observed when installing and using this product. For reasons of safety and to ensure compliance with documented system data, only the manufacturer should perform repairs to components.

Since the XBT N/R/RT terminals are not designed to pilot safety critical processes, no specific instructions apply in this context.

**User Comments**

We welcome your comments about this document. You can reach us by e-mail at techpub@schneider-electric.com

# Operating Principle

# 1

## At a Glance

**Overview**

This chapter describes the operating principle of XBT terminals in applications using the Modbus slave protocol.

| ⚠ WARNING |
|---|
| **LOSS OF CONTROL**<br><br>● The designer of any control scheme must consider the potential failure modes of control paths and, for certain critical functions, provide a means to achieve a safe state during and after a path failure. Examples of critical control functions are emergency stop and overtravel stop.<br>● Separate or redundant control paths must be provided for critical for critical control functions.<br>● System control paths may include communication links. Consideration must be given to the implications of unanticipated transmission delays or failures of the link.*<br>● Each implementation of a Magelis XBT N/R/RT must be individually and thoroughly tested for proper operation before being placed into service.<br>**Failure to follow these instructions can result in death, serious injury, or equipment damage.** |

*For additional information, refer to NEMA ICS 1.1 (latest edition), *Safety Guidelines for the Application, Installation, and Maintenance of Solid State Control*

**What's in this Chapter?**

This chapter contains the following topics:

## General Information on Bus Communications

**Overview**

XBT terminals can be connected to PLCs using different protocols. This document describes the communication on Modbus field buses using the Modbus RTU protocol with the XBT terminal acting as slave.

**⚠ WARNING**

**UNINTENDED EQUIPMENT OPERATION**

The protocol must be installed and used by authorized and properly trained personnel.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

**Roles of XBT Terminals**

The terminals are usually connected to a communication equipment (PLC or other) via a field bus. The XBT and the PLCs work autonomously of each other.

XBT terminals perform the following functions:
- monitoring function: XBT terminals visualize the processes that are active in the PLCs and indicate alarm states
- command function: XBT terminals send information to the PLC upon user request

**Roles of Buses**

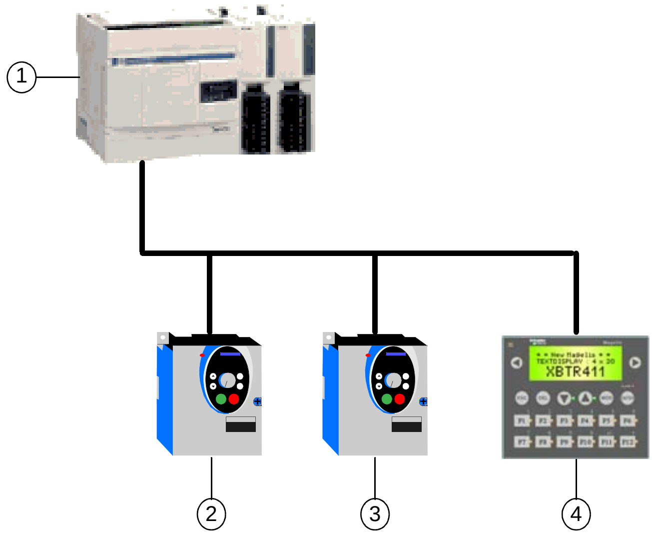
A bus system provides the possibility to connect different devices via a unique cabling.

**Roles of Protocols**

The protocol defines the language that is used by all the equipment connected to the bus.

## Application Principle

The following figure shows a basic Modbus application with XBT acting as slave:




**1** TWIDO, connected via the TER connector
**2** Speed drive Altivar 31
**3** Speed drive Altivar 31
**4** XBT R

The XBT is totally passive with respect to communication. The PLC reads or writes the data in the XBT memory. If the PLC does not send any data to the XBT (or does not attempt to read from the XBT memory), the values of the XBT memory are not refreshed. After expiration of the communication time-out, the values displayed by the XBT are replaced by `??` characters and a system message appears to signal connection error. To avoid any time-out check by the XBT, the value 0 should be entered for this time-out parameter.

When you press a key, if the `Function key status` word has not been read by the PLC, the LED associated with the key flashes rapidly and pressing the key again has no effect. Once the word has been read by the PLC, the LED stops flashing and the key can be used again.

**Note:** In Modbus slave mode, the XBT terminal does not read/write PLC variables.

## Master / Slave Communication Principle

**Overview**

Modbus communications are performed according to the master / slave principle that is described in the following.

**Characteristics of the Master / Slave Principle**

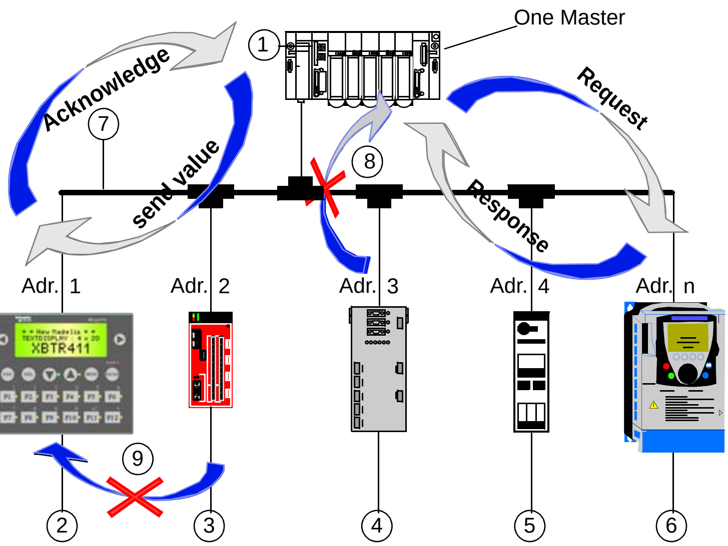
The master / slave principle is characterized as follows:

- Only one master is connected to the bus at a time.
- One or several slaves can be connected to the same serial bus.
- Only the master is allowed to initiate communication, i.e. to send requests to the slaves.
- In Modbus communications, the master can only initiate one Modbus transaction at the same time.
- In Modbus communications, the master can address each slave individually (unicast mode) or all slaves simultaneously (broadcast mode).
- The slaves can only answer requests they received from the master.
- The slaves are not allowed to initiate communication, neither to the master nor to any other slaves.
- In Modbus communications, the slaves generate an error message and send it as response to the master if an error occurred in receipt of the message or if the slave is unable to perform the requested action.

**Terminals acting as Slave in Modbus Applications**

In Modbus slave applications, the XBT terminal acts as slave device, i.e. as server.

Master / slave communication




**1** Automation Platform Premium PLC
**2** XBT R411 (in Modbus slave operation)
**3** XPSMF40 Safety PLC
**4** XPSMF30 Safety PLC
**5** TesysU
**6** Altivar 71
**7** Modbus SL bus
**8** slaves cannot initiate the communication
**9** slaves cannot communicate with other slaves

## Communication according to the OSI Model

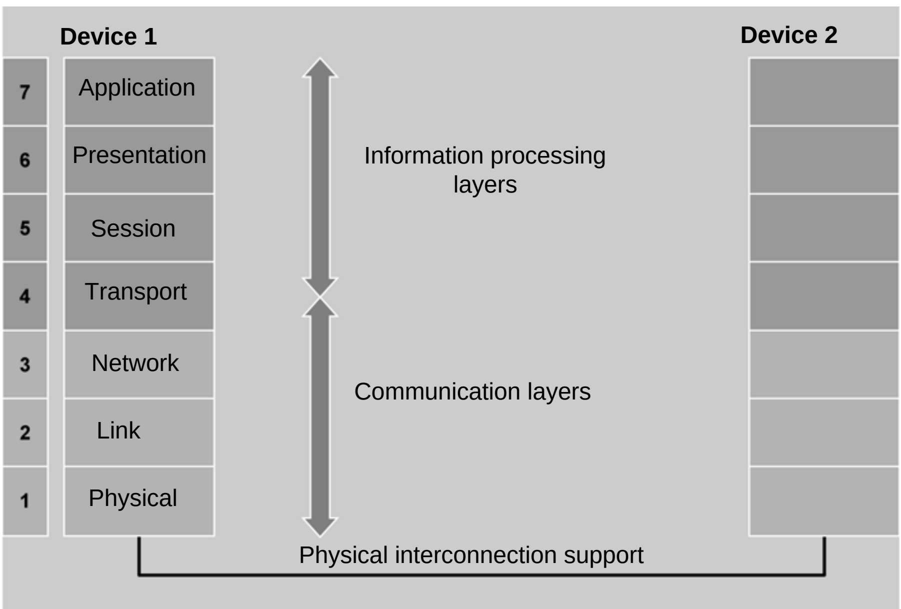
**At a Glance**

Communication between same-type devices can only take place by defining interconnection standards that define the behavior of each device in relation to the others. These standards were developed by ISO (the International Standard Organization), which defined a standardized Network Architecture more commonly known as the OSI (Open System Interconnection) model.

This model is made up of seven ranked layers that each perform a specific part of the functions necessary for interconnecting systems.

The layers communicate with equivalent layers from other devices, via standardized protocols. Within a single device, layers communicate with their immediate neighbors via hardware or software interfaces.

**Layers of the OSI Model**




> **Note:** The Modbus RTU bus matches this model in terms of layers, without possessing all of them. Only the Application (Modbus), Link and Physical (Modbus RTU) layers are necessary for this field bus.

## Application Layer

The application layer of the RTU Modbus serial field bus is the one visible to the programs of the interconnected devices. This is used to formulate the requests (reading/writing words and bits, etc.) that will be sent to the remote device.

The application layer used by the Modbus RTU bus is the Modbus application protocol.

**Example for Modbus Master**: An XBT terminal connected as master to a Modbus RTU bus will send Modbus requests to a Modbus slave device to read variables in order to update values represented by the semigraphic objects displayed on its panels.

**Example for Modbus Slave**: An XBT terminal connected as a slave to a Modbus RTU bus will receive the Modbus requests from the master in order to update the values represented by the semigraphic objects displayed on its panels.

**Note:** For further details on the Modbus application protocol (request codes, class details, etc.), visit *http://www.modbus.org*.

## Link Layer

The link layer of the serial Modbus RTU bus uses the master/slave communication principle. The principle of a link layer is to define a low-level communication method for the communication medium (physical layer).

**Note:** One reason for master/slave management is that at any time it is possible to calculate transfer time for requests and the answers from each device. This therefore enables the terminal to size the volume of the communication on the buses precisely, in order to avoid any saturation or information loss.

**Note:** When using the Modbus (RTU) driver, the XBT terminal is the bus master. When using the Modbus Slave (RTU) driver, the XBT terminal is a slave on the bus.

**Note:** For further details (datagrams, frame sizes, etc.) visit *http://www.modbus.org*.

## Physical Layer

The physical layer of the OSI model characterizes the topology of the communication bus or network, as well as the medium (cable, wire, fiber optic, etc.) that will transport the information and its electrical coding.

Within the framework of a serial Modbus RTU bus, topology may be daisy-chained, derived or a mix of both. The medium is made up of shielded twisted pairs, and the signal is a base band signal with a default speed of 19,200 bit/s

**Note:** In order for all devices to be able to communicate among themselves on the same bus, the speed must be identical.

## Modbus RTU Transmission Mode

**Overview**

RTU is the standard Modbus transmission mode that is supported by XBT terminals. In this transmission mode each 8-bit byte of a message contains 2 x 4-bit hexadecimal characters.

The outdated ASCII transmission mode is not supported by XBT terminals.

**Byte Format**

Each byte (11 bits) has the following format

| | |
|---|---|
| Coding System | 8-bit binary |
| Bits per Byte | 1 start bit<br>8 data bits, least significant bit sent first<br>1 bit for parity completion<br>1 stop bit |
| Parity | even parity<br>odd parity<br>no parity |

Start and stop bits are integrated in front of (start bit) and at the end (stop bit) of a byte to indicate that a byte is beginning (start bit) or ending (stop bit).

A parity bit is usually included in Modbus RTU transmission mode in order to perform an error check on the byte content. Deviating from the Modbus standard, XBT terminals also support data transmission with 1 start bit, 8 data bits, with only 1 stop bit and without parity bit. You can choose to transmit data with or without parity check, but always make sure that all equipment connected to the Modbus bus are configured to the same mode otherwise no communication will be possible.

Bit sequence in RTU mode with parity checking

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Start | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Parity | Stop |

**Note:** In order for all devices to be able to communicate among themselves on the same bus, the parity and data bit number characteristics must be identical for all the devices.

## Modbus RTU Framing

**Overview**

A Modbus message is transmitted in a frame with a defined beginning and a defined end point. This indicates to the receiving devices when a new message starts and when it is completed. The receiving devices can detect incomplete messages and inform the master by issuing error codes.

**RTU Frame**

In addition to the user data, the RTU frame includes the following information:

- slave address (1 byte)
- function code (1 byte)
- Cyclic Redundancy Checking (CRC) field

The maximum size of an RTU frame is 256 bytes.

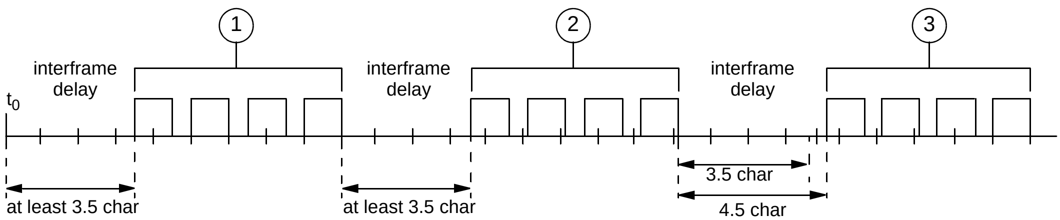
RTU message frame

| Slave Address | Function Code | Data | CRC | |
|---|---|---|---|---|
| 1 byte | 1 byte | 0...252 byte(s) | 2 bytes | |
| | | | CRC Low Byte | CRC High Byte |

## Separating Message Frames by Silent Times

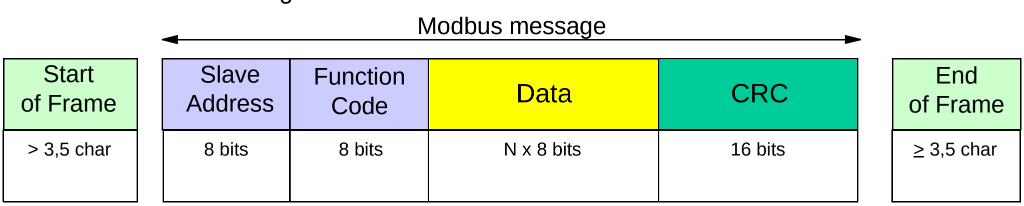
Individual frames are separated by a silent interval, also called interframe delay, of at least 3.5 character times. The following figure provides an overview of 3 frames being separated by an interframe delay of at least 3.5 character times.

Message frames separated by silent times




**1** Frame 1
**2** Frame 2
**3** Frame 3

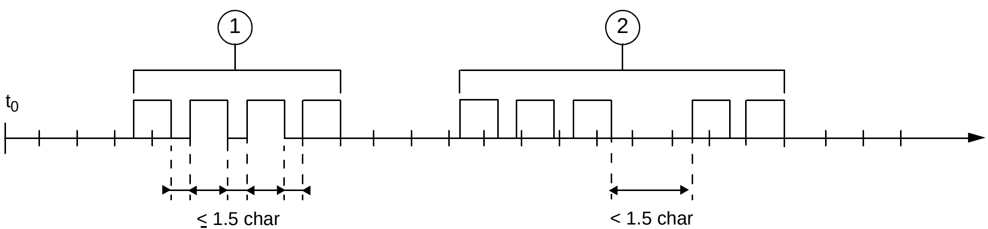
RTU message frame with start and end silent times




## Detecting Incomplete Frames

In RTU mode it is required that the entire message frame is transmitted as a continuous stream of characters because silent times larger than 1.5 character times between 2 characters will be interpreted by the receiving device as incomplete frame. The receiver will discard this frame.

Detecting incomplete frames



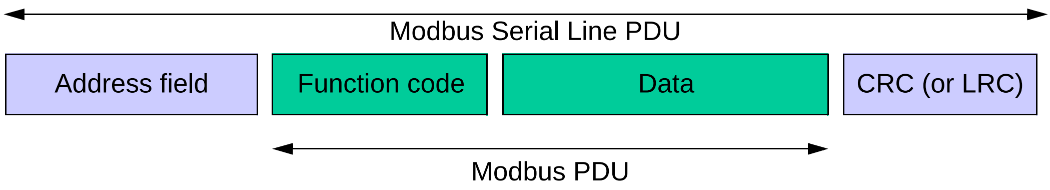

**1** Frame 1 OK
**2** Frame 2 Not OK

## Modbus Frame Description

**Overview**

A Modbus frame is also referred to as data frame or telegram. The basic Modbus frame consists of the protocol data unit (PDU) that is extended in Modbus SL communications by the address field of the Modbus SL slave and the error checking field.

Modbus frame




**Frame Segments**

The extended Modbus Serial Line frame consists of the following segments:

| Frame Segment | Size | Description |
|---|---|---|
| Address Field | 1 byte | contains address of requested slave |
| Function Code | 1 byte | contains the function code |
| Data | n bytes (high-byte, low-byte) | contains the data belonging to the request |
| CRC | 2 bytes (low-byte, high-byte) | contains the error check sum |

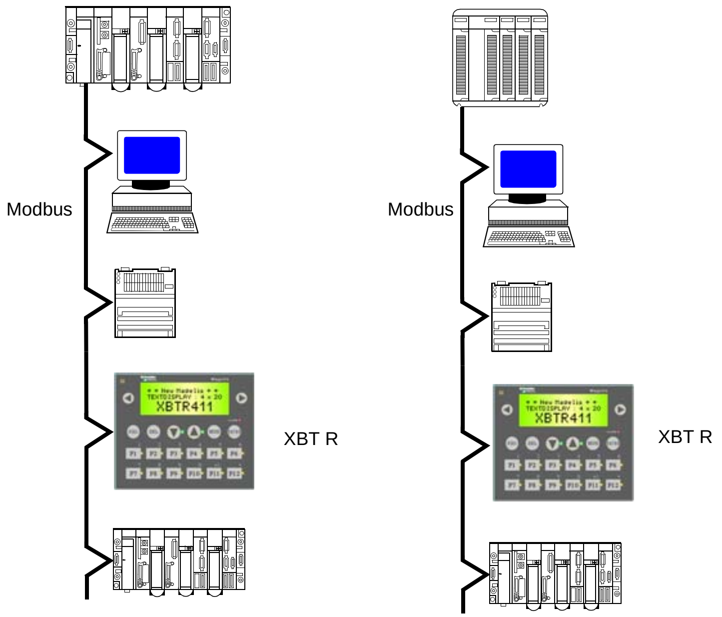
## Example of a Serial Modbus RTU Communication Bus

**At a Glance**

Schneider devices are used to associate serial Modbus RTU communication buses with stand-alone stations, enabling them to communicate with XBT operator dialog terminals.

**Examples of Buses**

The following figures show two examples of serial Modbus RTU buses, that can be used with stand-alone Premium or Quantum stations:



## Cable Length and Grounding

**Overview**

When setting up a new Modbus application, always use a shielded twisted pair cable and consider the maximum cable length allowed. Restrictions apply to the trunk cable (bus) as well as to the individual derivations.

**Factors Influencing the Length of the Trunk Cable**

The following factors influence the length of the trunk cable:

- transmission rate
- cable type (gauge, capacitance or characteristic impedance)
- number of loads that are directly connected (daisy chaining)
- network configuration (2-wire or 4-wire)

**Note:** If you are using a 4-wire cabling system for a 2-wire application, please note that the maximum cable length must be divided by two.

**Cable Length Examples**

The following table provides an example of determining the cable length according to the transmission rate and the cable type:

| | |
|---|---|
| Transmission Rate | 19,200 bit/s |
| Cable Type (Gauge) | 0.125...0.161 $mm^2$ (AWG 26) (or larger) |
| Maximum Cable Length | 1000 m (3280 ft) |

**Expanding the Cable Length Using Repeaters**

To expand the length of your Modbus SL trunk cable you can integrate repeaters in your system. With a maximum of 3 repeaters being allowed in 1 system, you can expand the allowed cable length by factor 4, i.e. to a maximum cable length of 4,000 m (13,123 ft).

**Length of Derivation Cables**

The length of each derivation must not exceed 20 m (65 ft).

If you are using a multi-port tap with n derivations, make sure that the maximum length of 40 m (131.23 ft) is not exceeded for all n derivations together.

**Grounding**

The shield of the connector must be connected to protective ground at least at 1 point.

## RC Termination

### Overview

To help prevent unintended effects, like reflections, from occurring in your Modbus application, make sure to terminate the transmission lines properly.

**CAUTION**

**LOSS OF DATA AND ELECTROMAGNETIC COMPATIBILITY ISSUES**

- Terminate transmission lines at both ends. This minimizes loop current and line reflections, increases the electromagnetic compatibility, and helps protect an open input receiver.
- Program Modbus slaves such that an incomplete data transfer is sent back to the Modbus master.Failure to follow these instructions can result in injury or equipment damage.

**Failure to follow these instructions can result in injury or equipment damage.**

### Terminating Your Network with RC Termination

To terminate your network with RC termination, proceed as follows:

| Step | Action |
|---|---|
| 1 | Choose 2 serial capacitors of 1 nF, 10 V minimum and two 120 Ω (0.25 W) resistors as line termination. |
| 2 | Integrate these components at both ends of your Modbus communication line as shown in pos. 5 of the schematic diagram in section *Integrating Polarization Resistors into the Application, p. 26*. |
| 3 | Connect these line terminations between the 2 conductors of the balanced Modbus line. |

## Line Polarization

**Overview**

In cases when there is no data activity, the bus is subjected to external noise or interference. In order to prevent the receivers from adopting improper states, some Modbus devices need to be biased, i.e. the constant state of the line must be maintained by an external pair of resistors connected to the RS485 balanced pair.

**Biasing Your Network**

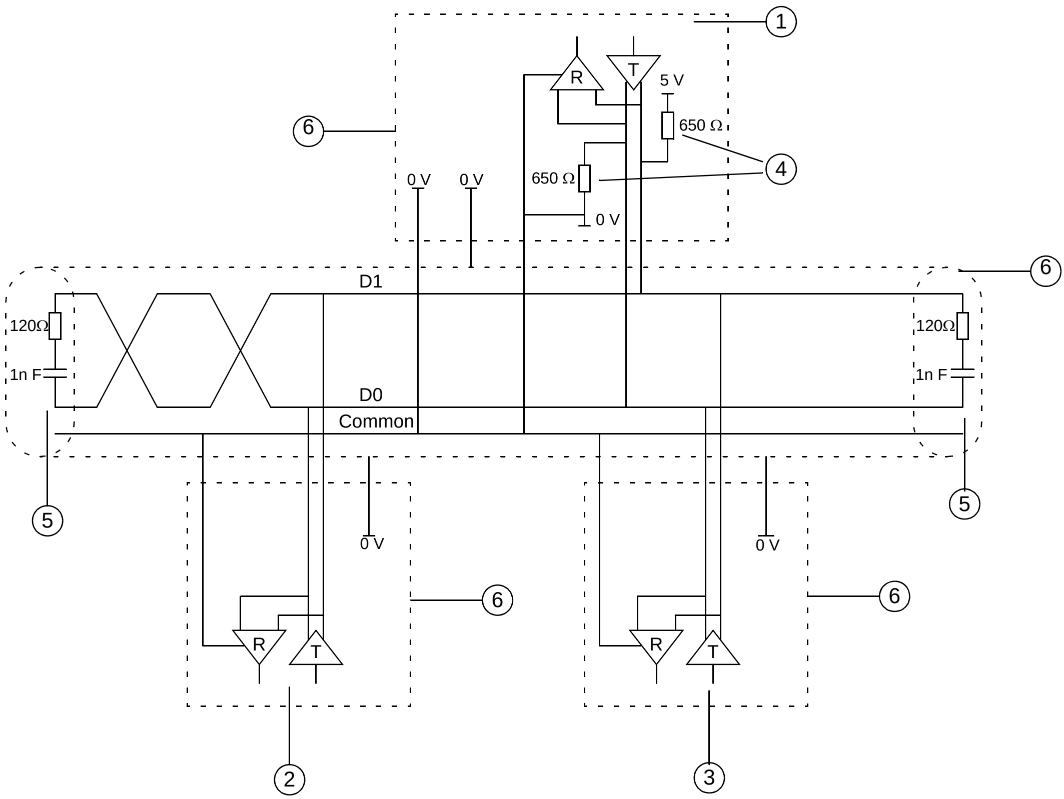
To provide proper line polarization, proceed as follows:

| Step | Action |
|---|---|
| 1 | Check the devices you want to integrate into your Modbus application: Is there any device that needs external line polarization? If at least 1 of the devices needs external line polarization, proceed with step 2, otherwise no line polarization is required for your current application. For further details on the polarization resistors integrated in XBT terminals refer to the chapter on cables and connectors. |
| 2 | Integrate a pull-up resistor (650 Ω recommended) to a 5 V voltage into the D1 circuit. |
| 3 | Integrate a pull-down resistor (650 Ω recommended) to the common circuit into the D0 circuit. |

## Integrating Polarization Resistors into the Application

> **Note:** The pair of polarization resistors must only be integrated at one location for the whole serial bus. You should integrate these resistors at the master device or its tap as shown in the figure below.

Schematic diagram




Elements of the application

| No. | Element |
|---|---|
| 1 | master |
| 2 | slave 1 |
| 3 | slave n |
| 4 | polarization resistors (required for XBT N, already included in XBT R) |
| 5 | line termination |
| 6 | shield |

## Addressing

### Overview

With the Modbus slave protocol, the terminal behaves like a slave. It can therefore answer requests to addresses between 0 and 30.

| Value | Meaning |
|---|---|
| 0 | The value 0 is reserved for broadcasting. Messages sent to address 0 will be received by all equipment connected to the bus. This can be used to send identical data to all the equipment, instead of sending a message to each item of equipment. |
| 31 | The value 31 is synonymous with disconnection for the terminal. A terminal detects an address 31 when no cable is connected to it. For this reason, any terminal configured with this address believes itself to be disconnected and displays messages requesting reconnection. |

### Connection to the Modbus Slave

Several types of connection are offered:

| Using an... | Then ... |
|---|---|
| • XBT Z968 cable (straight) or,<br>• XBT Z9680 cable (angled) | the address of the terminal is hard-wired and is worth 4. |
| XBT Z938 cable | the terminal address is configured in the software. |
| XBT Z908 cable and an SCA62 box | the address is "hard-wired" using the jumpers on the SCA62 box (the address will be between 1 and 30). |

## Equipment Symbols

**Overview**

Since the XBT terminal is totally passive, the Modbus slave protocol does not require equipment symbols to be declared.

# Software Configuration

# 2

## At a Glance

**Overview**

This chapter contains the protocol parameters you must configure in the Vijeo-Designer Lite software for operating XBT terminals as Modbus slave.

**What's in this Chapter?**

This chapter contains the following topics:

## Vijeo-Designer Lite

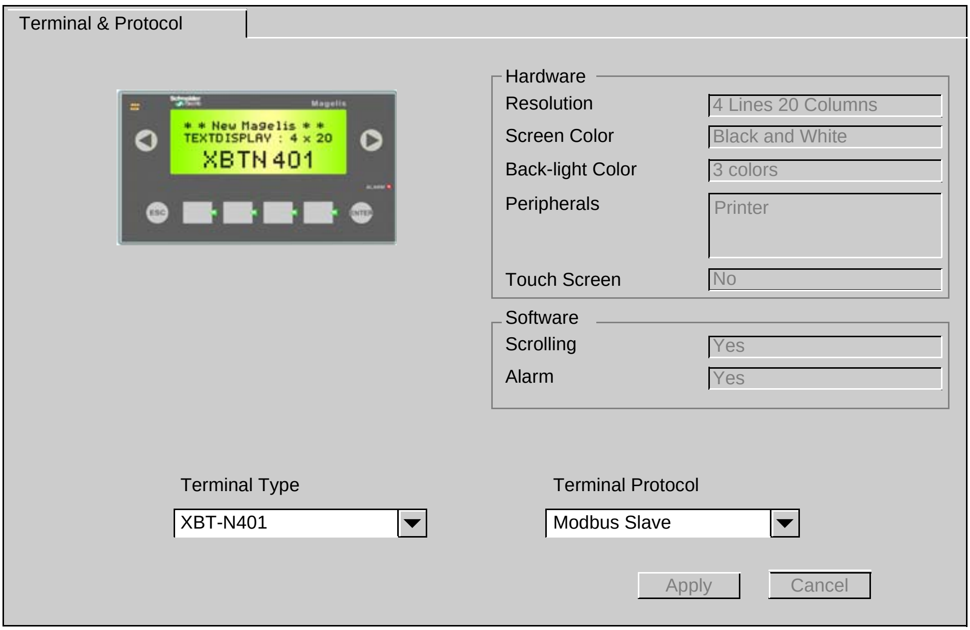
**Overview**

Use the Vijeo-Designer Lite software to configure your XBT terminal as Modbus slave.

| ⚠ WARNING |
|---|
| **INCOMPATIBLE SOFTWARE**<br>Use only Schneider Electric manufactured or approved software to program hardware.<br>**Failure to follow these instructions can result in death, serious injury, or equipment damage.** |

### Opening the Protocol - Modbus Slave Dialog Box

To open the **Protocol - Modbus Slave** dialog box in Vijeo-Designer Lite for setting the protocol parameters, proceed as follows:

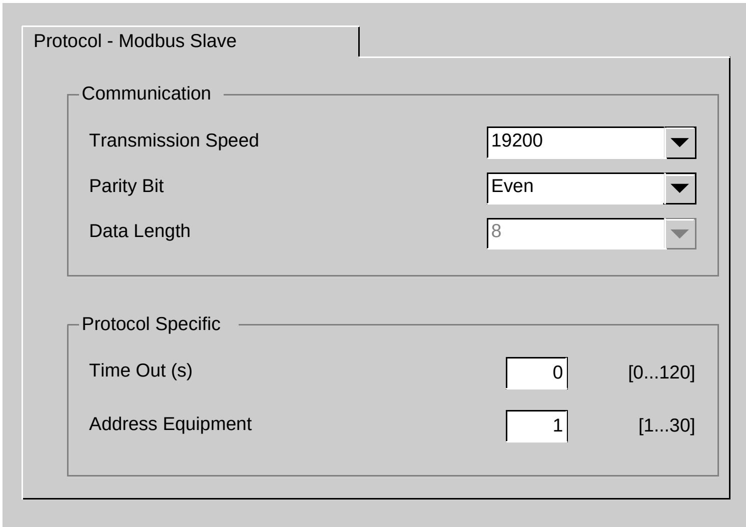
| Step | Action |
|---|---|
| 1 | Start Vijeo-Designer Lite.<br>To create a new application, continue with step 2, if you have already created a Modbus slave application, skip steps 2 and 3 and execute step 4. |
| 2 | From the application browser on the left-hand side of the Vijeo-Designer Lite window select the item **Configuration** → **Terminal & Protocol**.<br>**Result**: The following dialog box will be displayed on the right-hand side of the Vijeo-Designer Lite window.<br> |
| 3 | From the **Terminal Protocol** list in the lower right corner select the item **Modbus Slave** and click **Apply**. |
| 4 | Select from the application browser the item **Protocol - Modbus Slave**.<br>**Result**: The dialog box **Protocol - Modbus Slave** will be displayed on the right-hand side of the Vijeo-Designer Lite window where you can configure the protocol parameters for Modbus slave communication. |

# Protocol - Modbus Slave Dialog Box

## Purpose

Use this dialog box to configure the protocol parameters for Modbus slave communication.

## Representation




Elements of the dialog box

| Element | Description |
|---|---|
| **Communication** | |
| **Transmission Speed** | Select the transmission speed (in bit/s) on your Modbus bus from the list. Make sure to configure the same transmission speed for all devices connected to the bus. |
| **Parity Bit** | Select either even, odd or no parity. Make sure to configure the same parity value for all devices connected to the bus. |
| **Data Length** | You cannot edit this parameter because in Modbus RTU communications the length of user data is always 8 bits. |
| **Protocol Specific** | |

| Element | Description |
|---|---|
| **Time Out (s)** | Enter a value (in seconds).<br>In times when the PLC does not send any data to the XBT (or does not attempt to read from the XBT memory), the values of the XBT memory are not refreshed.<br>After the time configured with this parameter has elapsed without any data interchange with the PLC, the XBT terminal replaces the values on its display unit by ??? characters and issues a system message to indicate that a connection error has occurred.<br>To avoid any time-out check by the XBT, enter the value 0 for this parameter. |
| **Address Equipment** | Enter a unique Modbus address (between 1 and 247). This address will be ignored if the XBT terminal detects a hard-wired address on the address pins of its SUB-D25 connector. |

# Variable Types Supported

3

## Variable Types for Modbus Slave

**Table of Variable Types Supported by the XBT**

The addressable XBT internal memory is limited to 300 words, of address 0...299.

| Variable Type Supported | Syntax | Identifiers |
|---|---|---|
| Word Bit | %MWi:Xj | i: (0...299)<br>j: (0...F) |
| Word | %MWi | i: (0...299) |
| Double Word | %MDi | i: (0...298) |
| Floating Point | %MFi | i: (0...298) |

# Cables and Connectors

**4**

## At a Glance

**Overview**

This chapter specifies the cables and connectors required for XBT terminals in Modbus slave applications.

**What's in this Chapter?**

This chapter contains the following topics:

# Cables

## Technical Data

The following table lists the cables required to connect the different XBT terminals as Modbus slave to different Schneider PLCs using RS485 or RS232C lines.

| XBT Type | Connected Device | Physical Link | Cable Reference | Length and Type |
|---|---|---|---|---|
| XBT N401/N410<br>XBT R411 | Twido | RS485 | XBT Z908 +<br>TSX SCA62 | 1.8 m (5.9ft.)<br>(SUB-D25 <--> SCA62 box) |
| | Micro | | | |
| | Premium | | | |
| | Nano | | | |
| | LU9GC3 | RS232C | XBT Z938 | 2.5 m (16.4 ft.)<br>(SUB-D25 <--> RJ45) |
| | Quantum | | XBT Z9710 | 2.5 m (16.4 ft.)<br>(SUB-D25 <--> SUB-D9) |
| | Momentum | | XBT Z9711 | 2.5 m (16.4 ft.)<br>(SUB-D25 <--> RJ45) |
| XBT RT511 | Twido | RS485 | XBT Z9780<br>XBT Z9782 | 2.5 m (8.2 ft.)<br>2.5 m (8.2 ft.)<br>(RJ45 <--> MiniDin) |
| | Micro | | | |
| | Premium | | | |
| | Nano | | | |
| | Modicon M340 | RS485 | XBT Z9980<br>XBT Z9982 | 2.5 m (8.2 ft.)<br>10 m (32.8 ft.)<br>(RJ45 <--> RJ45) |
| | LU9GC3 | RS485 | VW3A8306R03<br>VW3A8306R10<br>VW3A8306R30 | 0.3 m (1 ft.)<br>1 m (3.3 ft.)<br>3 m (9.8 ft.)<br>(RJ45 <--> RJ45) |
| | Quantum | RS232C | XBT Z9710 +<br>XBT ZG939 | 2.5 m (16.4 ft.)<br>(SUB-D25 <--> SUB-D9) |
| | Momentum | | XBT Z9711 +<br>XBT ZG939 | 2.5 m (16.4 ft.)<br>(SUB-D25 <--> RJ45) |

In Modbus slave applications, when power is first applied to the XBT N terminals, the XBT N terminals will issue noise on the bus for approximately 100 ms. This noise will disturb the communication of the equipment connected to the bus. Always apply power to the XBT N terminal first, before applying power to the master of the bus.

**⚠ WARNING**

**UNINTENDED EQUIPMENT OPERATION**

When XBT N terminals are operated as Modbus slaves, always power-on these terminals before starting the master of the bus.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

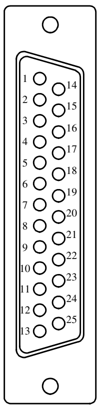
## SUB-D25 Pin Connections

**Overview**

The following XBT terminals provide a SUB-D25 connector on their rear panels:

- XBT N401
- XBT N410
- XBT R411

The SUB-D25 connector supports RS232 as well as RS485 lines. The pin assignment is shown in the following figure.

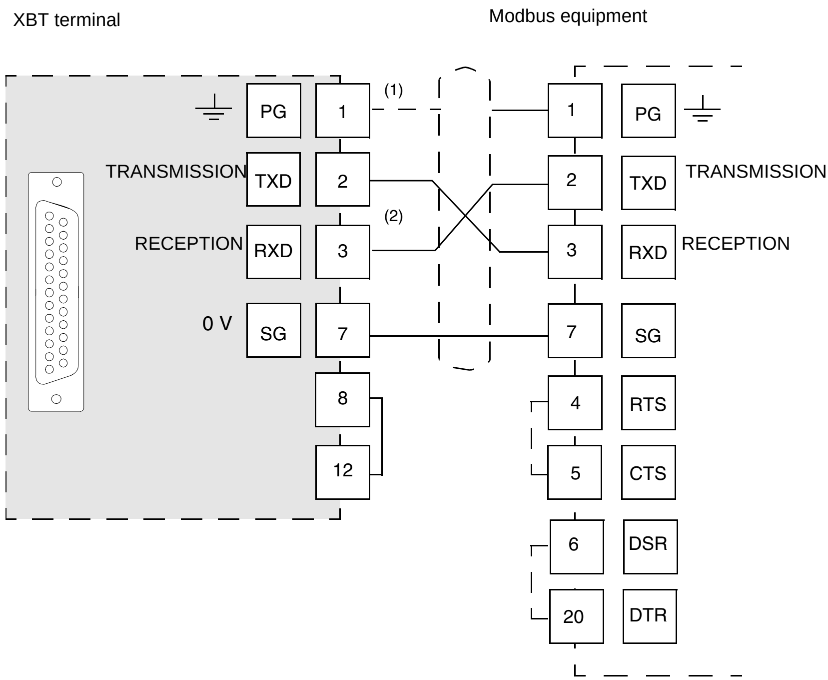



| | |
|---|---|
| 1 | ⏚ |
| 2 | TXD |
| 3 | RXD |
| 4 | 0 |
| 5 | 1 |
| 6 | |
| 7 | 0V iso |
| 8 | COM |
| 9 | |
| 10 | |
| 11 | |
| 12 | REG |
| 13 | CONF |
| 14 | B0 |
| 15 | B1 |
| 16 | B2 |
| 17 | B3 |
| 18 | |
| 19 | B4 |
| 20 | |
| 21 | |
| 22 | 0V iso |
| 23 | |
| 24 | PAR |
| 25 | |

**RS232 Cabling**

The illustration below shows the cabling for RS232C equipment.

RS232C link example



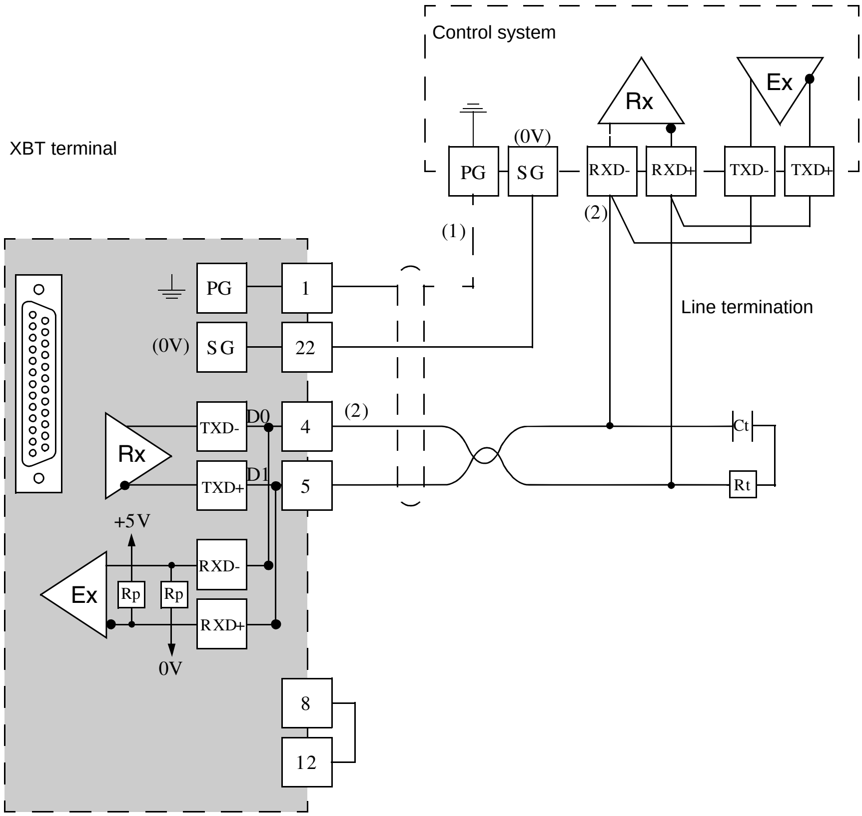

Legend

| | |
|---|---|
| (1) | Connection of the shielding at both ends depends on any electrical restrictions affecting the installation. |
| (2) | In some configurations, it is not necessary to invert pins 2 and 3. Please refer to the documentation for the equipment being used. |

**RS485 Cabling**

The illustration below shows the cabling for RS485 equipment.

RS485 link example




Legend

| | |
|---|---|
| (1) | Connection of the shielding at both ends depends on any electrical restrictions affecting the installation. |
| (2) | If your automation systems provides connectors for 4-wire connections, wire the RXD and TXD pins as shown in the above figure to form a 2-wire connection. |
| (3) | Rp: Polarization resistors. The following polarization resistors are integrated in XBT N, XBT R and XBT RT:<br>● XBT N: Rp = 4.7 kΩ<br>● XBT R: Rp = 100 kΩ |

## RJ45 Pin Connections

**Overview**

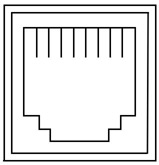
The following XBT RT terminal provides RJ45 connectors on its rear panels:

In industrial environments, it is compulsory to use a

- double shielded twisted pair cable with impedance 100 Ω  15 Ω (1...16 MHz),
- maximum attenuation 11.5 dB/100 m (11.5 dB/328 ft.),
- maximum length 100 m (328 ft.).

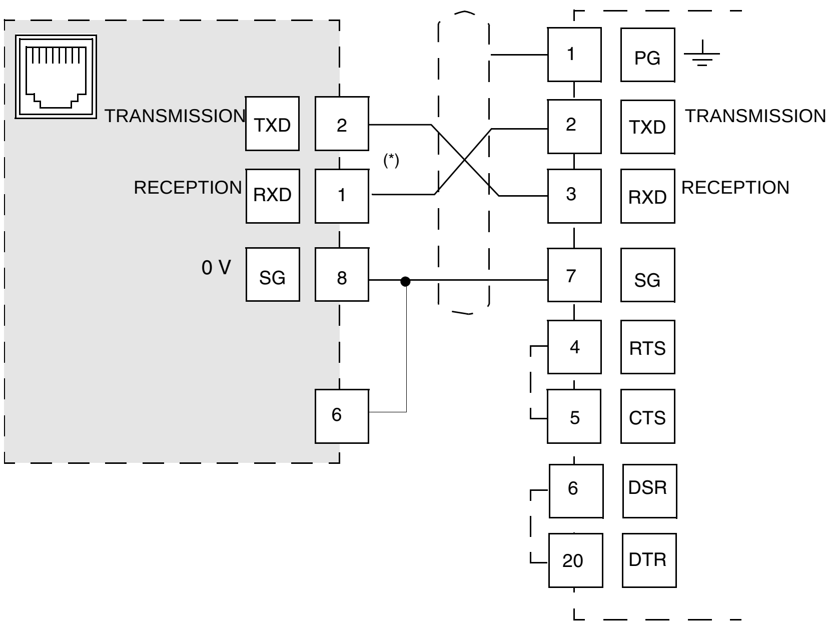
## XBT RT511

Pin assignment of the RJ45 connector on XBT RT511 terminals

| Representation | Pin | Signal | Comments |
|---|---|---|---|
| RJ45<br>12345678<br> | 1 | RXD | RXD RS232 signal |
| | 2 | TxD | TXD RS232 signal |
| | 3 | IN1 | Input configuration signal |
| | 4 | D1 | RS485 + signal |
| | 5 | D0 | RS485 - signal |
| | 6 | IN2 | Input operating signal |
| | 7 | - | - |
| | 8 | 0 V ISO | 0 V isolated |

The illustration below shows the cabling for RS232C equipment.

RS232C link example

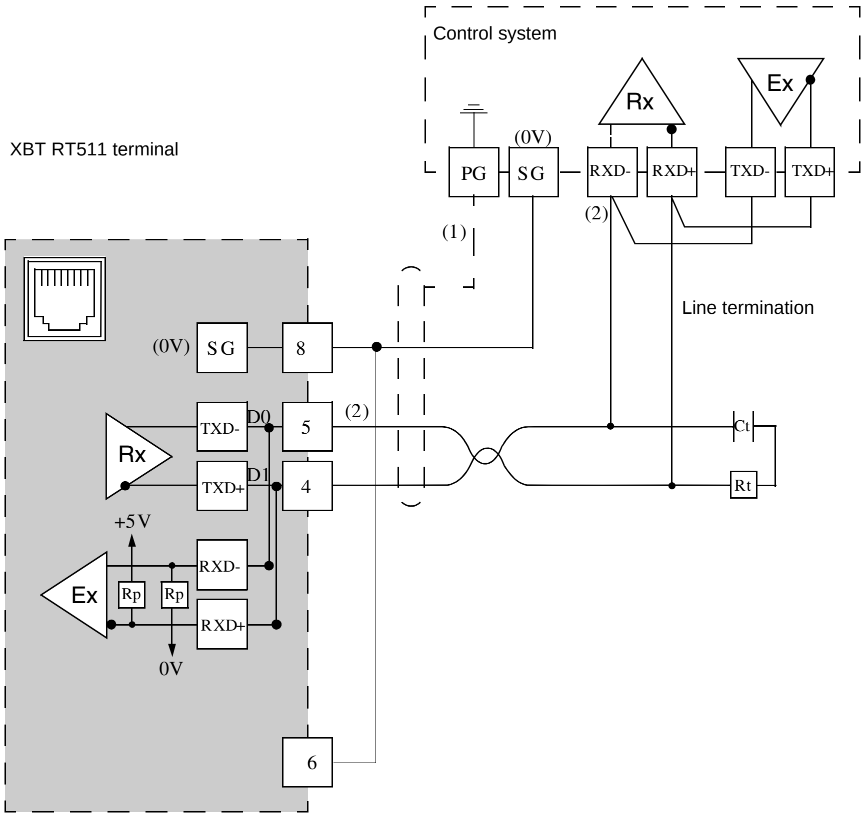



Legend

| | |
|---|---|
| (*) | In some configurations, it is not necessary to invert pins 1 and 2. Please refer to the documentation for the equipment being used. |

The illustration below shows the cabling for RS485 equipment.

## RS485 link example




### Legend

| | |
|---|---|
| (1) | Connection of the shielding at both ends depends on any electrical restrictions affecting the installation. |
| (2) | If your control systems provides connectors for 4-wire connections, wire the RXD and TXD pins as shown in the above figure to form a 2-wire connection. |
| (3) | Rp: Polarization resistors: 100 kΩ |

# Diagnostics

# 5

## XBT Detected Error Indication

**Overview**

XBT terminals indicate detected errors in 3 different ways

- by displaying question marks ?????? on alphanumerical fields
- by displaying crosses for graphic objects
- by displaying hash characters in alphanumerical fields
- by blinking alphanumerical fields
- by issuing system error messages

The following paragraphs list these three detected errors and their possible reasons.

**Question Marks and Crosses**

When question marks ??????  and crosses XXXXXX are displayed on the display of your XBT terminal, a transmission error has occurred. To correct this, check the following:

| If... | Then ... |
|---|---|
| question marks are displayed | verify that all cables are correctly connected. If yu configured a time-out, verify that the master can access the XBT at least once during the configured time. If necessary, increase the time-out value, or set the time-out parameter to 0. |
| question marks are displayed | verify that the communication parameters set in the **Protocol - Modbus Slave** dialog box are identical for all equipment connected to the Modbus bus i.e. same transmission speed, same use of parity. |

**Hash Characters**

Hash characters displayed in alphanumerical fields on your XBT terminal indicate that the value to be displayed is too long for this alphanumerical field and cannot completely be displayed. The value `100` can, for example, not be displayed in a 2-digit alphanumerical field. To correct this, enter a shorter value or adapt the size of the alpanumerical field so that it can display any of the possible values of the PLC variable.

**Blinking Alphanumerical Fields**

Blinking alphanumerical fields on your XBT terminal indicate that the value of this field has exceeded or fallen below a user-defined threshold.

**System Error Messages**

A variety of system error messages is by default configured for the terminals. All these standard system messages are assigned a panel number 200+x. A distinction is made between system error messages indicating communication interruptions and status messages provoked by inputs at the terminal.

These 2 message types differ by the numbers they are assigned and by the way they are displayed at the terminal as shown in the list below:

| System Error Message Caused by: | System Error Message Numbers | Display Mode |
| --- | --- | --- |
| Communication Interruptions | 201 – 204 | To indicate that a communicaton interruption has occurred, the message is displayed in a popup dialog box every 10 seconds. |
| Input at Terminal | 241 – 258 | The status message is displayed as a response to user input at the terminal. |

**Messages Caused by Communication Interruptions**

Messages 201 to 204 are issued by the terminal to indicate that a communication interruption has occurred. They are displayed in a popup dialog every 10 seconds.

| If... | Then ... |
|---|---|
| message `201: DIALOG TABLE AUTHORIZATION INCORRECT` is displayed | the authorization word in the dialog table does not have the expected value. (Refer to the Vijeo-Designer Lite online help for information on how this word is working.) To correct this, verify that:.<br>● you are connected to the right PLC<br>● the correct value has been written by the PLC in the authorization word of the dialog table located in the terminal memory. |
| message `203: DIALOG TABLE READING IMPOSSIBLE` is displayed | the read cycle from the dialog table of the PLC could not be ended.<br>● too much load on the communication bus<br>● EMC disturbances on the communication bus<br>● The PLC has never read all the status words (XBT->PLC) of the dialog table since the XBT has been powered ON. |

**Messages Caused by Input at the Terminal**

Messages 242 to 254 are issued by the XBT as a response to user input at the terminal. These messages are displayed directly after the operator has sent an incorrect command to the terminal and will persist until the user has corrected the entered command or value. Messages 255 to 258 are status messages displayed after the user has initiated an operation at the terminal to indicate that it has (or has not) been accepted and is in progress.

| **If...** | **Then ...** |
|---|---|
| messages `243` to `249` are displayed | correct the value or command you have entered as indicated by the condition message. |
| message `250: LANGUAGE IMPOSED BY PLC` is displayed | the PLC forces the terminal to use a language. This language cannot be changed by the operator. For more information see the Vijeo-Designer Lite online help, functions of the dialog table. |
| messages `251` or `252` are displayed | correct the value or command you have entered as indicated by the condition message. |
| message `253: PASSWORD IMPOSED BY PLC` is displayed | you cannot change the password at the terminal because it is forced by the PLC. For more information see the Vijeo-Designer Lite online help, functions of the dialog table. |
| message `254: PROTECTED ACCESS PAGE` is displayed | you are trying to access a page that is password protected but you do not have the required authorization level. |
| messages `255` to `258` are displayed | the commands you entered at the terminal are executed or not executed, as indicated in these status messages. |

# Bandwidth Principle

# 6

## At a Glance

**Overview**

This chapter describes the operating principle and the calculating bandwidth usage.

**What's in this Chapter?**

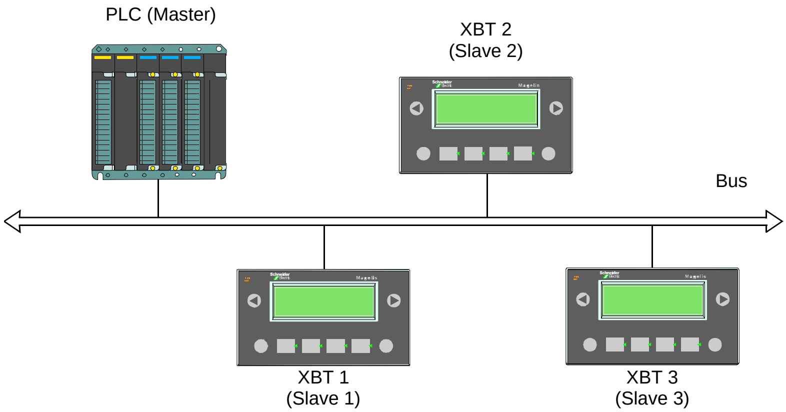
This chapter contains the following topics:

# General Operating Principle

## Connection Diagram

The Modbus slave protocol operates in point-to-point or multidrop mode.

The PLC is connected to 1 or more terminals.



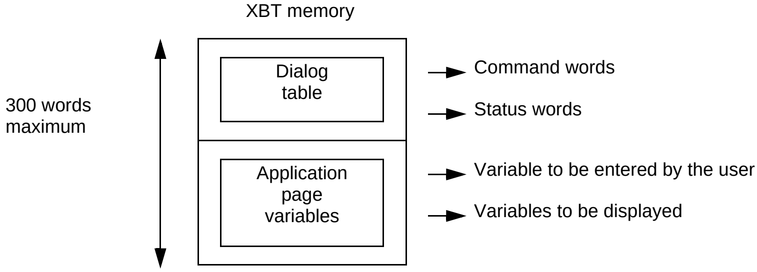
## Operating Principle

Data exchanges between the terminals and the PLC are made in data-transmission cycles, during which the PLC will read and write to the XBT memory (for example, a PLC can read the values every 300 ms in the XBT memory).

The PLC will carry out the following operations:

- writing in the dialog table (command words)
- reading words from the dialog table (status words)
- writing variables (display variables)
- reading variables (variables entered by the user)

Operating principle




Each request transmission by the PLC results in a certain level of bandwidth usage. Therefore, before a communication architecture can be set up, the rate of bandwidth usage must be calculated to prevent the possibility of saturation.

## General Reminders

Reminders and examples

| **Reminder** | **Example** |
|---|---|
| For a transmission speed of 19,200 bit/s, the transmission time for a word is approximately 1 ms. | – |
| A PLC sending to a terminal a request to write n words requires<br>● for sending: 9 bytes + 2 x n bytes<br>● 8 bytes for acknowledgment | (see *p. 61*). |
| A PLC sending to a terminal a request to read n words requires<br>● 8 bytes for sending<br>● for the answer: 5 bytes + 2 x n bytes | (see *p. 62*). |
| One word = 2 bytes | Therefore, for example, sending 1 write word requires 17 + 2 = 19 bytes |

# Calculating Bandwidth Usage

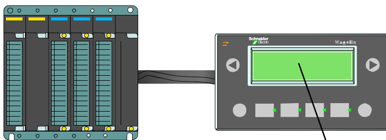
## Overview

The bandwidth specifies the quantity of data, which can circulate on the network per second. This depends on several parameters, such as the transmission speed and the number of items of equipment connected to the network.

To find out how much of the bandwidth is used, calculate the time it takes to send the data during each cycle. To do this, convert the data rate (in bit/s) into the time during which the bandwidth is occupied.

## Example of Calculating Bandwidth Usage in Point-To-Point Mode

Hypothesis: Say a terminal is connected to a PLC in point-to-point mode.



| Dialog table | |
|---|---|
| PLC -> XBT | 15 write words |
| PLC <- XBT | 10 read words |

| Variables | |
|---|---|
| PLC -> XBT | 60 display words |
| PLC <- XBT | 50 input words (values can be modified by the user of the terminal) |

The dialog table contains 25 words, with a cycle of 300 ms (terminal default value).

| | |
|---|---|
| Write Request | **15 words** PLC -> XBT |
| Read Request | **10 words** PLC <- XBT |

### Writing and displaying variables

60 words refreshed every 300 ms. Of these 60 words, 50 can be modified by the user.

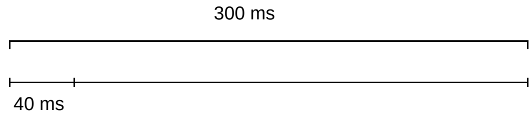
| | |
|---|---|
| Display | **60 words** PLC -> XBT |
| Write (words which value can be modified by the user) | **50 words** PLC <- XBT |

### Calculating how much of the bandwidth is used by the dialog table

We will apply the following formula:

No. of data bytes + bytes of the request + bytes of the answer

Say in our example

<table>
<tr><td>30 + 9 + 8 = 47</td><td>47 bytes for the write request</td></tr>
<tr><td>20 + 8 + 5 = 33</td><td>33 bytes for the read request</td></tr>
<tr><td colspan="2">A word is assumed to be sent in 1 ms (at a speed of 19,200 baud).<br>Knowing that 1 word = 2 bytes, we get:</td></tr>
<tr><td>(47 + 33) : 2 = 40</td><td>a transmission time of approximately 40 ms for the dialog table<br><br>The dialog table will therefore consume approximately 13% of the bandwidth.</td></tr>
</table>

**Calculating how much of the bandwidth is used by the variables**

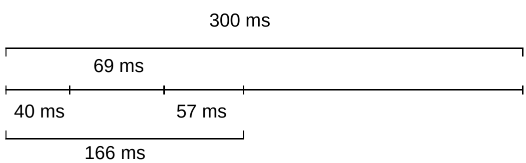
To write into the terminal the variables to be displayed, we will have bandwidth usage of:

| | |
|---|---|
| 60 words =<br>120 bytes + 9 bytes + 8 bytes = 137 bytes | a transmission time of approximately: 69 ms |

To read from the terminal the variables that a user can modify, we will have bandwidth usage of:

| | |
|---|---|
| 50 words =<br>100 bytes + 8 bytes + 5 bytes = 113 bytes | a transmission time of approximately: 57 ms |

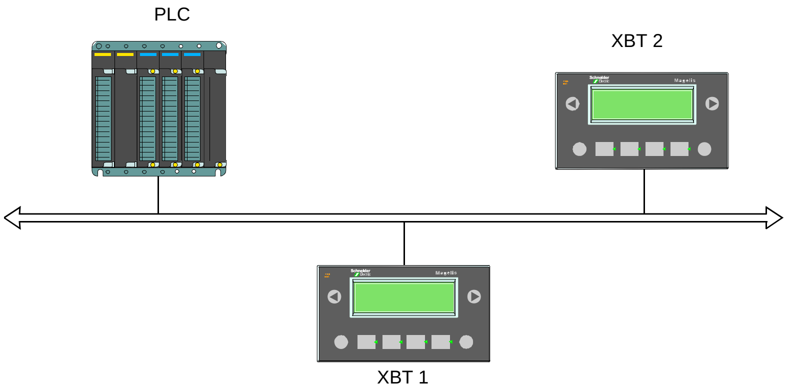
We will have a total consumption of 166 ms (40 + 69 + 57) of the bandwidth 300 ms (i.e., approximately 55% of the bandwidth).




At a speed of 9,600 baud, the bandwidth consumption would double. Consumption would therefore be 332 ms rather than 166 ms. The bandwidth would then saturated (332 ms for 300 ms maximum).

## Example of Calculating Bandwidth Usage in Multidrop Mode

We want to set up an architecture comprising 1 PLC and 2 terminals.




The 2 dialog tables are made up as follows.

First dialog table (XBT 1)

| | |
|---|---|
| Write Request | **5 words** PLC -> XBT |
| Read Request | **5 words** PLC <- XBT |

Second dialog table (XBT 2)

| | |
|---|---|
| Write Request | **10 words** PLC -> XBT |
| Read Request | **10 words** PLC <- XBT |

**Writing and displaying variables with the XBT 1 terminal**

10 words refreshed every 300 ms. Of these 10 words, 5 can be modified by the user.

| | |
|---|---|
| Display | **10 words** PLC -> XBT |
| Write (word which value can be modified by the user) | **5 words** PLC <- XBT |

**Writing and displaying variables with the XBT 2 terminal**

30 words refreshed every 300 ms. Of these 30 words, 20 can be modified by the user.

| | |
|---|---|
| Display | **30 words** PLC -> XBT |
| Write (word which value can be modified by the user) | **20 words** PLC <- XBT |

**Calculating how much of the bandwidth is used by the dialog tables**

XBT 1 terminal dialog table

| | |
|---|---|
| (10 + 9 + 8) + (10 + 8 + 5) = 50 bytes | The transmission time will be approximately 25 ms for this dialog table. |

XBT 2 terminal dialog table

| | |
|---|---|
| (20 + 9 + 8) + (20 + 8 + 5) = 70 bytes | The transmission time will be approximately 35 ms for this dialog table. |

**Calculating how much of the bandwidth is used by the variables**

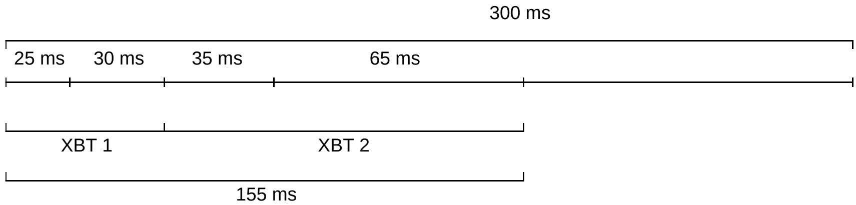
XBT 1 terminal variables (display and write)

| | |
|---|---|
| (20 + 9 + 8) + (10 + 8 + 5) = 60 bytes | a transmission time of approximately 30 ms |

XBT 2 terminal variables (display and write)

| | |
|---|---|
| (60 + 9 + 8) + (40 + 8 + 5) = 130 bytes | a transmission time of approximately 65 ms |

The bandwidth consumption can be represented as follows:




We have a total consumption of 155 ms (25 + 35 + 30 + 65) of the bandwidth 300 ms (i.e., approximately 52% of the bandwidth).

As in the example in point-to-point mode, we see that if we reduce the speed to 9,600 baud, the bandwidth would be saturated (310 ms for 300 ms maximum).

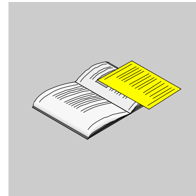
## Tips

**Tips for the User**

The previous examples demonstrate the following:
- The more terminals are added, the less bandwidth remains.
- The more values there are to display, the higher the bandwidth consumption by the write operation.

There are therefore a number of possibilities for freeing up the bandwidth:
- increase the transmission speed (depends on the quality of the network and the connected equipment)
- reduce the number of words in the dialog table
- reduce the number of words needing to be read or written by the PLC
- reduce the refresh speed for the display
- reduce the cycle speed of the dialog table

# Appendices



## At a Glance

**Overview**

This chapter describes communication requests.

**What's in this Appendix?**

The appendix contains the following chapters:

# Communication Requests

A

## Communication Requests

### Overview

The function code is in hexadecimal format.

### Writing of n Words

Request

| Slave no. | Function code 10 | Address of 1st word | | Number of words | | Number of bytes | Value of n words to be written | Check |
|---|---|---|---|---|---|---|---|---|
| | | Hi | Lo | Hi | Lo | | | |
| 1 byte | 1 byte | 2 bytes | | 2 bytes | | 1 byte | n bytes | 2 bytes |

| | |
|---|---|
| Address of 1st Word | same addressing field as for the read request |
| Number of Words | 125 words |
| Number of Bytes | twice the number of words |
| Value of Words to be Written | H’0000’ to H’FFFF’ |

Response

| Slave no. | Function code 10 | Address of 1st word written | | Number of words written | | Check |
|---|---|---|---|---|---|---|
| | | Hi | Lo | Hi | Lo | |
| 1 byte | 1 byte | 2 bytes | | 2 bytes | | 2 bytes |

| | |
|---|---|
| Slave number | same as request |
| Address of 1st Word Written | same as request |
| Number of Words Written | same as request |

## Writing of 1 Output or Internal Word

### Request

| Slave no. | Function code | Word address | | Value | | Check |
|---|---|---|---|---|---|---|
| | 06 | Hi | Lo | Hi | Lo | |
| 1 byte | 1 byte | 2 bytes | | 2 bytes | | 2 bytes |

### Response

| Slave no. | Function code | Word address | | Value | | Check |
|---|---|---|---|---|---|---|
| | 06 | Hi | Lo | Hi | Lo | |
| 1 byte | 1 byte | 2 bytes | | 2 bytes | | 2 bytes |

## Reading of n Output or Internal Words

### Request

| Slave no. | Function code | Address of 1st word | | Number of words | | Check |
|---|---|---|---|---|---|---|
| | 03 | Hi | Lo | Hi | Lo | |
| 1 byte | 1 byte | 2 bytes | | 2 bytes | | 2 bytes |

| | |
|---|---|
| Address of 1st Word | Corresponds to the address of the 1st word to be read in the slave. |
| Number of Words | 125 words |

### Response

| Slave no. | Function code | Number of bytes read | Value of $1^{st}$ word | | - - - | Value of last word | | Check |
|---|---|---|---|---|---|---|---|---|
| | 03 | | Hi | Lo | | Hi | Lo | |
| 1 byte | 1 byte | 1 byte | 2 bytes | | | 2 bytes | | 2 bytes |

| | |
|---|---|
| Slave number | same as request |
| Number of Bytes Read | twice the number of words read |
| Value of Words Read | H’0000’ to H’FFFF’ |

## Reading and Resetting Counters

Request

| Slave no. | Function code<br>08 | Sub-function<br>00xx | Data (d)<br>0000 | Check |
|---|---|---|---|---|
| 1 byte | 1 byte | 2 bytes | 2 bytes | 2 bytes |

One sub-function code for each function

| | |
|---|---|
| Reading Counter 1 | 0x000B |
| Reading Counter 2 | 0x000C |
| ... | ... |
| Reading Counter 8 | 0x0012 |
| Counter Reset | 0x000A |

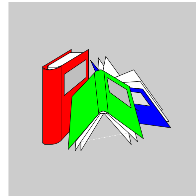
Response

| Slave no. | Function code<br>08 | Sub-function<br>00xx | Data (d) | Check |
|---|---|---|---|---|
| 1 byte | 1 byte | 2 bytes | 2 bytes | 2 bytes |

## Functions Supported

| | | Sub-Function | | Type of Functions |
|---|---|---|---|---|
| **Hex** | **Dec** | **Hex** | **Dec** | |
| 03 | 03 | – | – | reading n output or internal words initiated by the master |
| 06 | 06 | – | – | writing 1 output or internal word |
| 08 | 08 | 00XX | 00XX | reading and resetting counters initiated by the master |
| 10 | 16 | – | – | writing n words |
| 2B | 43 | 0E | 14 | read device identification |

# Glossary



## A

**ASCII** American standard code for information interchange = data transmission mode in Modbus communications

**AWG** American wire gauge (wire diameter)

## C

**CRC** cyclic redundancy checking

**CTS** clear to send (data transmission signal)

## D

**DSR** data set ready (data transmission signal)

**DTR** data terminal ready (data transmission signal)

## E

**EMC** electromagnetic compliance

## L

**LRC** longitudinal redundancy checking

## M

**Modbus SL** Modbus serial line

## O

**OSI Model** open system interconnection model

## P

**PDU** protocol data unit

## R

**RJ-45** registered jack = standardized physical interface

**RS232** recommended standard for connecting serial devices = EIA/TIA 232

**RS485** recommended standard for connecting serial devices = EIA/TIA 485

**RTS** request to send (data transmission signal)

**RTU** remote terminal unit = data transmission mode in Modbus communications

**RXD** receiving data (data transmission signal)

## T

**TXD** transmitting data (data transmission signal)

# Index