

The MODBUS<sup>®</sup> protocol was developed by Modicon (now part of Schneider Automation). It is an open communications protocol initially used for communication with Modicon PLC systems, but is now used by many manufacturers for instrument and control communications. Northern Design Meters using the Modbus protocol use the RTU (Remote Terminal Unit) mode and CRC (not LRC) error checking, with all Meters acting as Slaves. Software run on a PC or PLC will act as a MODBUS Master, initiating communication with the meters.

Diagnosing problems in serial communications systems can be quite complex. Many systems can be installed and commissioned simply by following the recommendations in the instrument user documentation. However when the system does not work as anticipated, the engineer working to locate and rectify the problem will need to appreciate the topics raised in this troubleshooting guide. The topics covered are:

- 1 Getting Started
- 2 Preferred Method of Testing
- 3 Software Used During Tests
- 4 Custom Drivers and Terminal Emulators
- 5 Check for Identical Meter and Master Configuration
- 6 Check the Wiring
- 7 Cabling for RS422/485
- 8 Protocol Converters
- 9 Meter Address
- 10 Register Addresses
- 11 *If Using Application Software* Test Meter using Application Software
- 12 *If Using MODBUS Test Software* Test Meter using MODBUS Test Software
- 13 Loop Back Diagnostics
- 14 Read Multiple registers
- 15 Set Energy to ZERO
- 16 SpecView for Testing
- 17 ModScan32 for Testing
1. PM305 only – External Power

## 1 Getting Started

If all that is required is an overview of getting communications running between a meter and a Modbus Master, this “Getting Started” section may provide all that is required without digesting the full document.

Connections to each meter are described in the meter manuals, which also lists the parameters that can be accessed via communications and their Modbus register addresses. An overview of RS422 and RS485 cabling principles can be obtained from many communications hardware companies, there is a comprehensive one available from B&B Electronics at [www.bb-europe.com](http://www.bb-europe.com) or at [www.bb-elec.com](http://www.bb-elec.com). Although all reference documents describe the use of terminating resistors, for short cable runs at the lower speeds used with Northern Design meters (19,200 baud or less) terminating resistors serve no useful purpose. However when terminations are fitted we recommend that “biasing terminations” are used, and these are described in the reference documents.

In most cases the Modbus Master (usually a PC software package) will be running on a personal computer or on hardware which has RS232 communications ports. In these instances a protocol converter will be needed to convert the RS232 signals to the RS422 or RS485 standard used by the meters and other instruments. Only where the Modbus Master is running on hardware fitted with RS422 or RS485 ports is a protocol converter unnecessary. The protocol converter will need automatic direction control if used with 2-wire RS485 systems, and direction control is optional on 4-wire systems. Where direction control is used by the protocol converter it must be “automatic”, not “RTS direction control” – discussed in more detail later in this document. This is because most software running under Windows (including software recommended by Northern Design) will not provide RTS control of direction.

Protocol converters from many vendors can be used, Northern Design normally use a model 485DRJ from B&B Electronics, in Europe at [www.bb-europe.com](http://www.bb-europe.com) or Tel +353-91-792444, in USA [www.bb-elec.com](http://www.bb-elec.com) or Tel +1-815-433-5100. The 485DRJ converter is available from Northern Design as a kit that includes a cable and connection details for Northern Design meters.

Northern Design is a hardware manufacturer, and does not usually supply application software. In many instances Northern Design power and energy meters will be used with application software for energy management or for monitoring power/energy used by an installation or process. Energy management software is available from many specialist software vendors, and SCADA software from process supervision specialists can provide display, logging and reporting facilities for a huge range of remotely connected instruments. The SpecView SCADA package has a pre-defined driver set for Northern Design instruments, is quick and easy to use and is ideal for small and medium sized installations. Specview can be contacted at [www.specview.com](http://www.specview.com), Tel +44-1825-766566 in Europe and Tel +1-925-275-0600 in USA.

Application software may not provide the required test and diagnostics facilities for a Modbus installation. A versatile Modbus test program called ModScan32 is available from Wintech Software. This can be used for testing Modbus installations incorporating hardware from Northern Design and other vendors. The software can be obtained from Wintech at [www.win-tech.com](http://www.win-tech.com) or Tel +1-304-645-5966. Northern Design does have some restricted function test utilities that are specific to certain product groups, but cannot supply a universal Modbus test package.

## 2 Preferred Method of Testing

The preferred method of testing communications configuration is to operate with a single Meter located close to the Master (PC, PLC etc) and minimum cable length.

Once cable connections, meter configuration and MODBUS Master configuration have been successfully tested the system may be connected to the final installation (multiple meters and extended cabling systems as needed to meet user requirements). Full system configuration and testing can then take place.

### 3 Software Used During Tests

The software used to provide the MODBUS Master functionality is usually not supplied by Northern Design, and therefore we cannot provide detailed instructions on the use of the software for test purposes. The commissioning engineer should be familiar with the use of the desired software both while testing connection to meters and during full system configuration. In general software used during testing can be classed as either application software or MODBUS test software, the principal differences between these two types are as follows.

Application software (such as Data Loggers or SCADA systems) is intended to use MODBUS devices to perform a measurement, control or logging function. It often provides tools for quick configuration of known types of instrument - SpecView, a SCADA system from SpecView Inc, and Busker, a test utility from Northern Design, have this capability. Such packages make it easy for a user to start a system without needing to know MODBUS commands, but may not provide the tools for a commissioning engineer to diagnose problems when a system does not respond as anticipated.

A MODBUS test package normally allows MODBUS commands to be generated as required and the responses analysed. Some knowledge of the MODBUS protocol and the instrument register addresses will be required before using such a package. Test packages will assist a commissioning engineer in diagnosing communication problems. We have used Modscan32 from WinTECH Software, and have found that this package can be used for MODBUS diagnostics with Northern Design meters. Other packages are available from specialist communication vendors, and it should be possible to use any generic MODBUS test package.

Further notes on the use of SpecView and Modscan32 for communications checks are provided later in this document.

### 4 Custom Drivers and Terminal Emulators

The MODBUS RTU protocol has unusual timing restrictions on message transmission, and the communications drivers must implement these restrictions in order to operate successfully. For this reason it is NOT POSSIBLE to test MODBUS communications using commonly available terminal programs such as Windows Hyper Terminal and ProComm. The timing restrictions also prevent the use of simple programs written in the common programming environments. We recommend that users do not try to write custom drivers unless they fully appreciate the requirements of MODBUS RTU and the control of the timing of the communication hardware on the target platform.

### 5 Check for Identical Meter and Master Configuration

<b>Meter Set-up</b>	Check the label on the meter and ensure that the meter set-up matches the desired communications configuration
<b>Communications Link</b>	RS232 (2 wire plus Common) RS485 (2 wire plus Common) RS422 (4 wire plus Common) <b>Note:</b> RS422 & RS230 communications is not supported on current ND Meters. Information is however provided for the sake of completeness
<b>Baud Rate</b>	Enter Meter Programming Menu to ensure that both Meter and Master are set to the same Baud Rate. We advise using 9600 baud for initial testing
<b>Address</b>	Enter Meter Programming Menu to ensure that both Meter and Master are set to the same Address. (See Note below)

### 6 Check the Wiring

RS232	Check that <i>Rx</i> and <i>Tx</i> are not reversed.
RS485	Check that <i>Rx/Tx+</i> and <i>Rx/Tx-</i> (possibly labelled as <i>B</i> and <i>A</i> ) are not reversed.
RS422	Check that <i>Rx</i> and <i>Tx</i> are not reversed. Check that <i>Rx/Tx+</i> and <i>Rx/Tx-</i> (possibly labelled as <i>B</i> and <i>A</i> ) are not reversed.

## 7 Cabling for RS422/485

All Northern Design manuals for MODBUS products include basic data on cabling of RS485 or RS422 systems as applicable. The issues involved in these multi-drop cabling systems are far from simple, and the product manuals only cover the minimum requirements and recommendations. For test and simple installations the data in the manual should be more than adequate. For larger installations we recommend that the cabling engineer is familiar with all issues involved, and we recommend that engineers have reference documentation on multi-drop communications systems. Most communications hardware vendors provide reference documents explaining the issues involved and listing industry accepted good practice for such systems. B&B Electronics have an excellent reference, available from their web site at [www.bb-europe.com](http://www.bb-europe.com).

In accordance with standard practice, the Northern Design manuals recommend terminations on the communications cabling. It is widely accepted that at low data speeds and with short cable runs in interference free environments terminations are not necessary. All communications with Northern Design products would be classed as low speed (max speed available is 19,200 baud at time of writing this note). However once cable length increases and devices are installed in industrial environments, which are electrically noisy, it would be standard practice to recommend that terminations are used. We now recommend that if terminations are used they should ALWAYS be biasing terminations (described in RS485 reference documents such as the B&B Electronics document mentioned above). The use of biasing terminations eliminates problems arising during changeover from transmit to receive and further improves noise immunity.

## 8 Protocol Converters

Many installations will require a protocol converter to connect the RS232 port on the host system (typically a PC) to the RS422/485 ports on the meters. Most ND Meters with communications are provided with a communications port conforming to the RS485 standard. This standard is used because it supports both long cable runs (up to 1200 metres) and multi-drop systems (i.e. systems with multiple devices on one communications cable). The communications port on a computer, and many other devices used to communicate with a group of meters, conforms to the RS232 standard. A protocol converter is a device used to connect communications systems operating on different standards.

Northern Design currently supplies protocol converters from B&B Electronics (model 485DRJ). We supply this as a kit complete with a connecting cable and wiring details, but many other devices from B&B Electronics and other communication hardware vendors can be used successfully. The 485DRJ is powered from the RS232 port, can be configured for 2-wire or 4-wire systems and provides automatic direction control at any baud rate.

Northern Design previously supplied converters from KK Electronics (model K485-4Wire). These are excellent converters, but do not provide automatic direction control. This converter requires direction control by the MODBUS master software package, and many software packages (particularly those running under Microsoft Windows) do not provide this. For this reason the KK converter is NOT SUITABLE for operation with the SpecView and ModScan32 software packages discussed elsewhere in these notes.

Many protocol converters used to convert RS422/485 signals to RS232 (including the B&B converter currently supplied by Northern Design) can be powered from the RS232 port. These use power from the RS232 handshake lines to energise the converter. However some converters also have external power options (such as the KK Systems converters previously supplied by Northern Design), and where these are supplied they should be used. Software packages do not always set handshake lines in a state that provides power for these converters, and failure to use the external power supply can occasionally cause some unexpected communications problems.

## 9 Meter Address

Each device on a MODBUS system has an address and the MODBUS Master software needs to know the addresses of the devices with which it communicates. Application software usually provides simple methods for input of the addresses of the connected devices, and may even hide addressing from the user using automatic configuration routines. MODBUS test software will require the user to be fully familiar with addressing. As well as the MODBUS address programmed into the instrument using the set-up functions, the commissioning engineer using test packages should be familiar with the following addresses.

**Address = 0. Broadcast Messages**, which are to be acted on by all connected devices and do not require a reply, are sent by the master to Address 0.

**Address = 253.** All Northern Design Meters will respond to address 253, irrespective of the actual programmed meter address. This allows Modbus communication to take place without needing to know the programmed meter address, but because all products respond it can only be used with one meter connected to the Master. This address may not be available on all Masters, as it is outside the normal address range as defined in Modbus.

## 10 Register Addresses

The topic of register addressing is one of the most frequent sources of confusion when dealing with MODBUS communications systems. The confusion arises because two different register-addressing schemes are in use by MODBUS Master software systems, one for Modicon PLCs and the other for register addressing within the MODBUS protocol. When the MODBUS protocol is used for communication with process instrumentation (such as the Northern Design metering products) the convention is to publish register locations using the MODBUS register addressing, and Northern Design follows this convention.

A register is the name used in both MODBUS communications and in Modicon PLCs for the storage location of a 16-bit data value. The MODBUS protocol only handles data as single or multiple register values when making transfers between master and slave, any larger data structures (such as long integers and floating point values) being handled as multiple registers by the MODBUS protocol. The MODBUS protocol does have commands for handling single bit input and output locations, but these have little value when communicating with process instruments and are usually only used in communications between Modicon PLCs.

In the MODBUS communications protocol register addresses always have values of 0 to 65,535 (0000 to FFFF hex). In communications with process instrumentation the convention is to assume a single data storage space addressed as registers 0 to 65,535. However it would be unusual for all of these register addresses to be active (and thus regarded as valid) in any given instrument.

In Modicon PLC register addressing there are several categories of register, including holding registers (numbered from 40001 upwards) and input registers (numbered from 30001 upwards). The category of register addressed is implicit in the Modbus function used, e.g. function 03 addresses holding registers (40001 onwards) and function 04 addresses input registers (30001 onwards). Irrespective of the function used the register address transmitted in the Modbus message has a value between 0 and 65,535, and register 30001 or 40001 would be addressed in the transmitted message as register 0, 30002 or 40002 as register 1, 30010 or 40010 as register 9 and so on.

So there are several conventions that a MODBUS master package might follow when asking for addresses from the user. It might follow the MODBUS protocol addressing convention and expect register addresses as 0 to 65,535 (or 0000 to FFFF hex), the addresses that Northern Design publishes. It might follow Modicon PLC register convention, assume input registers and expect addresses starting at 30001. It might recognise that there is a single register area, but use register addresses 1 to 65,536 (i.e. Northern Design published addresses plus 1). The scheme used can only be determined by examining the software documentation and/or trial and error.

## 11 *If Using Application Software* Test Meter using Application Software

Configure the software for the meter that has been connected, and initiate communications. It should be possible to read data collected from the meter.

After verifying communications the final application can be configured. The meter(s) can be re-located in the final location and the site communications cabling connected.

## 12 **If Using MODBUS Test Software** **Test Meter using MODBUS Test Software**

Consult the meter manual for register locations. If necessary configure the COM port and baud rate in the test software. Configure the test software or initiate commands to address the meter. Some Northern Design meters are fitted with MODBUS activity indicators. Some have receive and transmit LEDs, and some have Bus Activity, Command and Error LEDs. When the master transmits a command the meter MODBUS Receive (or Bus) LED should indicate that data is being received, but LED operation does not imply that data is valid or is correctly addressing this meter. If addressed by a valid command the meter command LED will light. For all commands other than broadcasts (sent to address 0) the meter will send a response, which will be apparent from the meter MODBUS Transmit (or Bus) LED. If cable connections and software configuration are correct the test software will receive the response and the data returned can be investigated.

MODBUS commands that may prove useful during tests are summarised in the following paragraphs.

## 13 **Loop Back Diagnostics**

All Northern Design Meters support **Function 8** (Loop Back Diagnostics) **Code=0**. This returns the host command string as sent and is a simple means of testing the communications network and detecting if a meter is present irrespective of meter type. This command is not available as a Broadcast command, so address should be set to the actual Meter Address or to **253**.

## 14 **Read Multiple registers**

Northern Design Meters recognise both **Function 3** and **Function 4** and handle them identically for register reads (except for PM305 & PM390 Meters with software V1.06 & earlier). Some MODBUS Masters are programmed to use Modbus **Function 3** (Read Holding Registers) for this function.

## 15 **Set Energy to ZERO**

Energy readings can be preset or reset to zero using MODBUS communications. If the Meter has an existing kWh reading that needs to be preserved, possibly through an instrument change for maintenance or reconfiguration, this should be noted. Once communication has been established, the kWh registers can be preset to the original value.

Modbus **Function 6** with appropriate register address and **Data Value = 0** will reset the Energy registers to Zero. Setting **Address = Meter Address** will reset only the Meter whose address is specified. If all meters connected have identical register addresses the broadcast command (Address = 0) may be used to reset all meters simultaneously.

## 16 **SpecView for Testing**

SpecView is a SCADA (Supervision, Control and Data Acquisition) package that has drivers for most Northern Design Meters as well as instruments from many other vendors. It is intended to allow users to create graphical displays of instruments and installations, gather data from those instruments over RS422/485 communications and provide data logging/reporting facilities. It includes automatic configuration facilities that will identify connected instruments and automatically build basic display screens and instrument parameter lists. It is this automatic configuration facility that makes SpecView useful as a communication test utility that is very simple to use. However it provides no facilities to assist a knowledgeable commissioning engineer in diagnosing a problematic installation.

It would be unusual, and unnecessary, to purchase the full SpecView package simply for communications testing. The package can be purchased with a demonstration license and security dongle for around £100. In this demonstration form it will communicate with instruments for up to 2 hours, after which it stops retrieving data from the meters and must be closed and re-started to restore communications. It may be run free-of-charge without a dongle in evaluation mode, and in this form will communicate with meters for only 10 minutes.

The product can be downloaded from the SpecView website at [www.specview.com](http://www.specview.com), or purchased from Specview at +44-1825-766566, e-mail [sales@specview.com](mailto:sales@specview.com). It is necessary to specify that drivers for Northern Design instruments are required, or to download them from the website in addition to downloading the basic program files. A protocol converter with automatic direction control will be required to communicate with RS422/485 meters from a PC RS232 port, and the B&B Electronics model 485DRJ is one of a number of suitable products (note the KK Systems model K485-4W is NOT suitable as it requires RTS direction control).

The package is easily installed from the downloaded files, and comes with comprehensive help and “getting started” instructions. Once the package is installed and started the “Test Comms for New Configuration” option should be selected. This will start the automatic configuration facility that will detect all connected meters and build a simple display screen. Consult the help files for assistance in running this facility.

Because of the limited diagnostic functions we recommend that this package is only used for simple Go-NoGo communications testing by un-trained staff, or is used in conjunction with a MODBUS master package such as ModScan32 that provides comprehensive facilities for MODBUS diagnostics. SpecView is an excellent SCADA package, which is its intended use for which we consider it is highly recommended.

## 17 ModScan32 for Testing

ModScan32 is a MODBUS master package for testing Modbus slaves. It is supplied by WinTECH Software, who provide a comprehensive range of utility and diagnostic software for Modbus and similar communication protocols. The data display functions require entry of MODBUS slave address, start register location, number of registers to read, display format and basic COM port set-up. Consequently the use of this package requires an appreciation of MODBUS addressing and the Northern Design meter data table addresses, but it provides a wide range of diagnostic and test facilities for a proficient commissioning engineer.

The package can be obtained from the WinTECH web site at [www.win-tech.com](http://www.win-tech.com), and is available as file ModScan32.zip from their demo download area. In its unregistered evaluation state it will maintain communication with MODBUS slaves for 200 seconds, and once licensed (\$64 at time of writing these notes, on-line licensing available via the web site) communications will run permanently. A protocol converter with automatic direction control will be required to communicate with RS422/485 meters from a PC RS232 port, and the B&B Electronics model 485DRJ is one of a number of suitable products (note the KK Systems model K485-4W is NOT suitable as it requires RTS direction control).

Installation of the ModScan32 software is very straightforward, and the product is supplied with comprehensive Help files. It should be noted that this product uses MODICON register addressing conventions, and hence Northern Design published MODBUS register addresses should be incremented by 1 before entry into ModScan32. The product allows display configuration settings to be saved and re-loaded quickly. Northern Design can provide a set of display configuration files that configure the display for our meters.

A typical configuration sequence to display the Instantaneous Meter Values of a MultiCube is as follows:

- Data address is 2817 (the start register of table 11, incremented by 1 because ModScan32 uses Modicon addressing convention).
- Length is 25 registers (there are 25 values in table 11).
- Device ID is the Modbus address of the instrument in decimal format (1 to 247 for the programmed address, 0 for broadcast or 253 for Northern Design single meter mode).
- Point type is 04, Input Registers (Northern Design meters also respond to 03, Holding Registers). This setting controls the Modbus function that is used to read data from the meter, functions 03 or 04.
- Display format is Integer to show meter parameters in the most meaningful format, the binary, decimal and hex formats also display data OK for MultiCube Instantaneous values.
- Select the Connect menu function, and configure the COM port with appropriate parameters. Typically this would be COM1 Direct Connection, Baud Rate of 9600, it is unlikely that any other parameters would change.

- The package will now establish connection with the meter and display the 25 values from the Instantaneous Values table. The parameters will be displayed identified with register address labels 32817 to 32841 (corresponding to meter register addresses 2816 to 2840).

## Obsolete ND Meters

### 1. PM305 only – External Power

The PM305 needs an external power supply for the communication circuits; the compact format of this meter will not accommodate an internal power supply. Check that auxiliary power is applied to the PM305 and that the Meter has an isolated supply to power the communications output. This supply should be rated at 9 - 12 volt dc @ 30mA per Meter connected, and several meters may be connected to one supply.

2.