PALADIN ADVANTAGE
UNIVERSAL PROGRAMMABLE TRANSDUCER
COMMUNICATIONS GUIDE

USER PROGRAMMABLE TRANSDUCER FOR ALL ELECTRICAL SYSTEMS

TE connectivity

Contents

1 254-TXX Modbus Protocol implementation

1.1 Modbus Protocol Overview

This section provides basic information for interfacing the 254-TXX Transducer to a Modbus Protocol network. If background information or more details of the Dual Load implementation is required please refer to section 2 and 3 of this document.

Dual Load offers the option of an RS485 communication facility for direct connection to SCADA or other communications systems using the Modbus Protocol RTU slave protocol. The Modbus Protocol establishes the format for the master's query by placing into it the device address, a function code defining the requested action, any data to be sent, and an error checking field. The slave's response message is also constructed using Modbus Protocol. It contains fields confirming the action taken, any data to be returned, and an error-checking field. If an error occurs in receipt of the message, Dual Load will make no response. If the Dual Load is unable to perform the requested action, it will construct an error message and send it as the response.

The electrical interface is 2-wire RS485, via 3 screw terminals. Connection should be made using twisted pair screened cable (Typically 22 gauge Belden 8761 or equivalent). All "A" and "B" connections are daisy chained together. The screens should also be connected to the “Gnd” terminal. To avoid the possibility of loop currents, an Earth connection should be made at only one point on the network.

Line topology may or may not require terminating loads depending on the type and length of cable used. Loop (ring) topology does not require any termination load. The impedance of the termination load should match the impedance of the cable and be at both ends of the line. The cable should be terminated at each end with a 120 ohm (0.25 Watt min.) resistor.

A total maximum length of 3900 feet (1200 metres) is allowed for the RS485 network. A maximum of 32 electrical nodes can be connected, including the controller.

The address of each Dual Load can be set to any value between 1 and 247. Broadcast mode (address 0) is not supported.

The maximum latency time of an Dual Load Digital meter is 60ms i.e. this is the amount of time that can pass before the first response character is output. The supervisory programme must allow this period of time to elapse before assuming that the Dual Load Digital meter is not going to respond.

The format for each byte in RTU mode is:

Coding System:	8-bit per byte
Data Format:	4 bytes (2 registers) per parameter.
	Floating point format (to IEEE 754)
	Most significant register first (Default). The default may be changed if required - See Holding Register "Register Order" parameter.
Error Check Field:	2 byte Cyclical Redundancy Check (CRC)
Framing:	1 start bit
	8 data bits, least significant bit sent first
	1 bit for even/odd parity (or no parity)
	1 stop bit if parity is used; 1 or 2 bits if no parity

Data Coding

All data values in the 254-TXX Transducer are transferred as 32 bit IEEE 754 floating point numbers, (input and output) therefore each 254-TXX Transducer value is transferred using two MODBUS Protocol registers. All register read requests and data write requests must specify an even number of registers. Attempts to read/write an odd number of registers prompt the 254-TXX Transducer to return a MODBUS Protocol exception message. However, for compatibility with some SCADA systems, 254-TXX Transducer will respond to any single input or holding register read with an instrument type specific value

The DUAL LOAD can transfer a maximum of 40 values in a single transaction, therefore the maximum number of registers requestable is 80. Exceeding this limit prompts the DUAL LOAD to generate an exception response.

Data Transmission speed is selectable between 2400, 4800, 9600, 19200 and 38400 baud.

1.2 Input Registers

Input registers are used to indicate the present values of the measured and calculated electrical quantities.
Each parameter is held in two consecutive 16 bit registers. The following table details the 3X register address, and the values of the address bytes within the message.
A tick (✓) in the column indicates that the parameter is valid for the particular wiring system. Any parameter with a cross (X) will return the value Zero.
Each parameter is held in the 3X registers. Modbus Protocol Function Code 04 is used to access all parameters.

For example, to request:-	Amps 1	Start address	= 0006
		No of registers	= 0002
	Amps 2	Start address	= 0008
		No of registers	= 0002

Each request for data must be restricted to 40 parameters or less. Exceeding the 40 parameter limit will cause a Modbus Protocol exception code to be returned.

1.3 Modbus Protocol Holding Registers and Digital meter set up

Holding registers are used to store and display instrument configuration settings. All holding registers not listed in the table below should be considered as reserved for manufacturer use and no attempt should be made to modify their values.
The holding register parameters may be viewed or changed using the Modbus Protocol. Each parameter is held in two consecutive 4X registers. Modbus Protocol Function Code 03 is used to read the parameter and Function Code 16 is used to write. Write to only one parameter per message.

Register Order controls the order in which the Dual Load Digital meter receives or sends floating-point numbers: - normal or reversed register order. In normal mode, the two registers that make up a floating point number are sent most significant register first. In reversed register mode, the two registers that make up a floating point number are sent least significant register first. To set the mode, write the value '2141.0' into this register - the instrument will detect the order used to send this value and set that order for all Modbus Protocol transactions involving floating point numbers.

It is perfectly feasible to change 254-TXX Transducer set-up using a general purpose Modbus Protocol master, but often easier to use the Dual Load Digital meter display or Dual Load Digital meter configurator software, especially for gaining password protected access. The Dual Load Digital meter configurator software has facilities to store configurations to disk for later retrieval and rapid set up of similarly configured products.

Password
Some of the parameters described above are password protected and thus require the password to be entered at the Password register before they can be changed. The default password is 0000. When the password has been entered it will timeout in one minute unless the Password or Password Lock register is read to reset the timeout timer. Once the required changes have been made to the protected parameters the password lock should be reapplied by

a) allowing the password to timeout, or

b) writing any value to the Password Lock register, or

c) power cycling the instrument.

2 RS485 General Information

RS485 or EIA (Electronic Industries Association) RS485 is a balanced line, half-duplex transmission system allowing transmission distances of up to 1.2 km. The following table summarises the RS-485 Standard:

PARAMETER	
Mode of Operation	Differential
Number of Drivers and Receivers	32 Drivers, 32 Receivers
Maximum Cable Length	1200 m
Maximum Data Rate	10 M baud
Maximum Common Mode Voltage	12 V to –7 V
Minimum Driver Output Levels (Loaded)	+/– 1.5 V
Minimum Driver Output Levels (Unloaded)	+/– 6 V
Drive Load	Minimum 60 ohms
Driver Output Short Circuit Current Limit	150 mA to Gnd, 250 mA to 12 V 250 mA to –7 V
Minimum Receiver Input Resistance	12 kohms
Receiver Sensitivity	+/– 200 mV

Further information relating to RS485 may be obtained from either the EIA or the various RS485 device manufacturers, for example Texas Instruments or Maxim Semiconductors. This list is not exhaustive.

2.1 Half Duplex

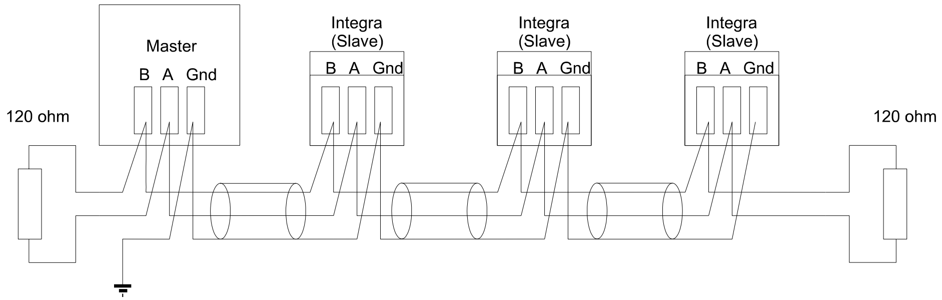
Half duplex is a system in which one or more transmitters (talkers) can communicate with one or more receivers (listeners) with only one transmitter being active at any one time. For example, a “conversation” is started by asking a question, the person who has asked the question will then listen until he gets an answer or until he decides that the individual who was asked the question is not going to reply.
In a 485 network the “master” will start the “conversation” with a “query” addressed to a specific “slave”, the “master” will then listen for the “slave’s” response. If the “slave” does not respond within a pre-defined period, (set by control software in the “master”), the “master” will abandon the “conversation”.

2.2 Connecting the Instruments

If connecting an RS485 network to a PC use caution if contemplating the use of an RS232 to 485 converter together with a USB to RS485 adapter. Consider either an RS232 to RS485 converter, connected directly to a suitable RS232 jack on the PC, or use a USB to RS485 converter or, for desktop PCs a suitable plug in RS485 card. (*Many 232:485 converters draw power from the RS232 socket. If using a USB to RS232 adapter, the adapter may not have enough power available to run the 232:485 converter.*)

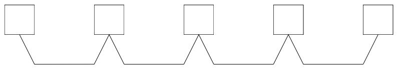
Screened twisted pair cable should be used. For longer cable runs or noisier environments, use of a cable specifically designed for RS485 may be necessary to achieve optimum performance. All “A” terminals should be connected together using one conductor of the twisted pair cable, all “B” terminals should be connected together using the other conductor in the pair. The cable screen should be connected to the “Gnd” terminals.

A Belden 9841 (Single pair) or 9842 (Two pair) or similar cable with a characteristic impedance of 120 ohms is recommended. The cable should be terminated at each end with a 120 ohm, quarter watt (or greater) resistor. Note: Diagram shows wiring topology only. Always follow terminal identification on Dual Load Digital meter product label.

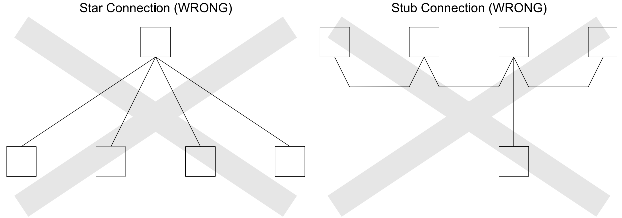


There must be no more than two wires connected to each terminal, this ensures that a “Daisy Chain or “straight line” configuration is used. A “Star” or a network with “Stubs (Tees)” is not recommended as reflections within the cable may result in data corruption.

Daisy Chained Connection (Correct)

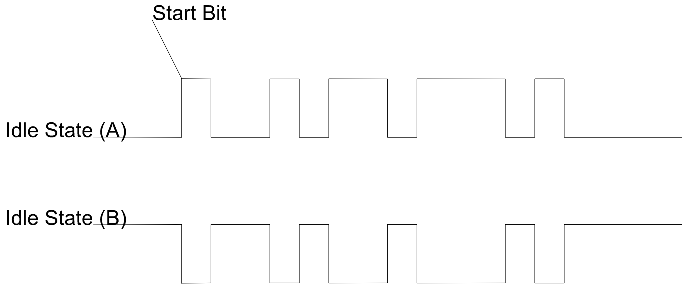


Star Connection (WRONG) Stub Connection (WRONG)



2.3 A and B terminals

The A and B connections to the Dual Load Digital meter products can be identified by the signals present on them whilst there is activity on the RS485 bus:

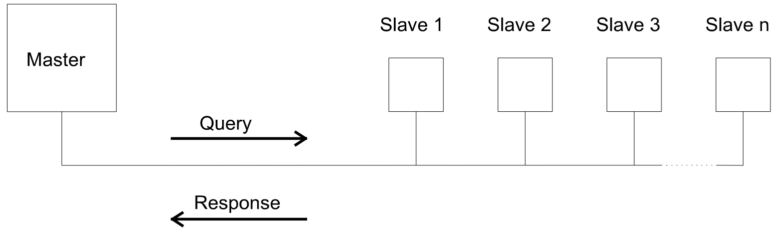


2.4 Troubleshooting

- Start with a simple network, one master and one slave. With 254-TXX Transducer product this is easily achieved as the network can be left intact whilst individual instruments are disconnected by removing the RS485 connection from the rear of the instrument.
- Check that the network is connected together correctly. That is all of the “A’s” are connected together, and all of the “B’s” are connected together, and also that all of the “Gnd’s” are connected together.
- Confirm that the data “transmitted” onto the RS485 is not echoed back to the PC on the RS232 lines. (This facility is sometimes a link option within the converter). Many PC based packages seem to not perform well when they receive an echo of the message they are transmitting. SpecView and PCView (PC software) with a RS232 to RS485 converter are believed to include this feature.
- Confirm that the Address of the instrument is the same as the “master” is expecting.
- If the “network” operates with one instrument but not more than one check that each instrument has a unique address.
- Each request for data must be restricted to 40 parameters. Violating this requirement will impact the performance of the instrument and may result in a response time in excess of the specification.
- Check that the MODBUS Protocol mode (RTU or ASCII) and serial parameters (baud rate, number of data bits, number of stop bits and parity) are the same for all devices on the network.
- Check that the “master” is requesting floating-point variables (pairs of registers placed on floating point boundaries) and is not “splitting” floating point variables.
- Check that the floating-point byte order expected by the “master” is the same as that used by 254-TXX Transducer products. (PCView and Citect packages can use a number of formats including that supported by Dual Load Digital meter).
- If possible obtain a second RS232 to RS485 converter and connect it between the RS485 bus and an additional PC equipped with a software package, which can display the data on the bus. Check for the existence of valid requests.

3 MODBUS Protocol General Information

Communication on a MODBUS Protocol Network is initiated (started) by a "Master" sending a query to a "Slave". The "Slave", which is constantly monitoring the network for queries addressed to it, will respond by performing the requested action and sending a response back to the "Master". Only the "Master" can initiate a query.



In the MODBUS Protocol the master can address individual slaves, or, using a special "Broadcast" address, can initiate a broadcast message to all slaves. The Dual Load Digital meter does not support the broadcast address.

3.1 MODBUS Protocol Message Format

The MODBUS Protocol defines the format for the master's query and the slave's response.
The query contains the device (or broadcast) address, a function code defining the requested action, any data to be sent, and an error-checking field.
The response contains fields confirming the action taken, any data to be returned, and an error-checking field. If an error occurred in receipt of the message then the message is ignored, if the slave is unable to perform the requested action, then it will construct an error message and send it as its response.
The MODBUS Protocol functions used by the Dual Load Digital meter copy 16 bit register values between master and slaves. However, the data used by the Dual Load Digital meter is in 32 bit IEEE 754 floating point format. Thus each instrument parameter is conceptually held in two adjacent MODBUS Protocol registers.
Query
The following example illustrates a request for a single floating point parameter i.e. two 16-bit Modbus Protocol Registers.

First Byte							Last Byte
Slave Address	Function Code	Start Address (Hi)	Start Address (Lo)	Number of Points (Hi)	Number of Points (Lo)	Error Check (Lo)	Error Check (Hi)

Slave Address: 8-bit value representing the slave being addressed (1 to 247), 0 is reserved for the broadcast address. The Dual Load Digital meter do not support the broadcast address.
Function Code: 8-bit value telling the addressed slave what action is to be performed. (3, 4, 8 or 16 are valid for Dual Load Digital meter)
Start Address (Hi): The top (most significant) eight bits of a 16-bit number specifying the start address of the data being requested.

Start Address (Lo):	The bottom (least significant) eight bits of a 16-bit number specifying the start address of the data being requested. As registers are used in pairs and start at zero, then this must be an even number.
Number of Points (Hi):	The top (most significant) eight bits of a 16-bit number specifying the number of registers being requested.
Number of Points (Lo):	The bottom (least significant) eight bits of a 16-bit number specifying the number of registers being requested. As registers are used in pairs, then this must be an even number.
Error Check (Lo):	The bottom (least significant) eight bits of a 16-bit number representing the error check value.
Error Check (Hi):	The top (most significant) eight bits of a 16-bit number representing the error check value.

Response

The example illustrates the normal response to a request for a single floating point parameter i.e. two 16-bit Modbus Protocol Registers.

First Byte ... Last Byte

Slave Address	Functio n Code	Byte Count	First Register (Hi)	First Register (Lo)	Second Register (Hi)	Second Register (Lo)	Error Check (Lo)	Error Check (Hi)

Slave Address:	8-bit value representing the address of slave that is responding.
Function Code:	8-bit value which, when a copy of the function code in the query, indicates that the slave recognised the query and has responded. (See also Exception Response).
Byte Count:	8-bit value indicating the number of data bytes contained within this response
First Register (Hi)*:	The top (most significant) eight bits of a 16-bit number representing the first register requested in the query.
First Register (Lo)*:	The bottom (least significant) eight bits of a 16-bit number representing the first register requested in the query.
Second Register (Hi)*:	The top (most significant) eight bits of a 16-bit number representing the second register requested in the query.
Second Register (Lo)*:	The bottom (least significant) eight bits of a 16-bit number representing the second register requested in the query.
Error Check (Lo):	The bottom (least significant) eight bits of a 16-bit number representing the error check value.
Error Check (Hi):	The top (most significant) eight bits of a 16-bit number representing the error check value.

* These four bytes together give the value of the floating point parameter requested.

Exception Response

If an error is detected in the content of the query (excluding parity errors and Error Check mismatch), then an error response (called an exception response), will be sent to the master. The exception response is identified by the function code being a copy of the query function code but with the most-significant bit set. The data contained in an exception response is a single byte error code.

First Byte ... Last Byte

Slave Address	Function Code	Error Code	Error Check (Lo)	Error Check (Hi)

Slave Address:	8-bit value representing the address of slave that is responding.
Function Code:	8 bit value which is the function code in the query OR'ed with 80 hex, indicating that the slave either does not recognise the query or could not carry out the action requested.
Error Code:	8-bit value indicating the nature of the exception detected. (See "Table Of Exception Codes" later).
Error Check (Lo):	The bottom (least significant) eight bits of a 16-bit number representing the error check value.
Error Check (Hi):	The top (most significant) eight bits of a 16-bit number representing the error check value.

3.2 Serial Transmission Modes

There are two MODBUS Protocol serial transmission modes, ASCII and RTU. Dual Load Digital meter do not support the ASCII mode.

In RTU (Remote Terminal Unit) mode, each 8-bit byte is used in the full binary range and is not limited to ASCII characters as in ASCII Mode. The greater data density allows better data throughput for the same baud rate, however each message must be transmitted in a continuous stream. This is very unlikely to be a problem for modern communications equipment.
The format for each byte in RTU mode is:

Coding System:	Full 8-bit binary per byte. In this document, the value of each byte will be shown as two hexadecimal characters each in the range 0-9 or A-F.
Line Protocol:	1 start bit, followed by the 8 data bits. The 8 data bits are sent with least significant bit first.
User Option Of Parity And Stop Bits:	No Parity and 2 Stop Bits No Parity and 1 Stop Bit Even Parity and 1 Stop Bit. Odd Parity and 1 Stop Bit.
User Option of Baud Rate:	2400 ; 4800 ; 9600 ; 19200 ; 38400

The baud rate, parity and stop bits must be selected to match the master's settings.

3.3 MODBUS Protocol Message Timing (RTU Mode)

A MODBUS Protocol message has defined beginning and ending points. The receiving devices recognises the start of the message, reads the "Slave Address" to determine if they are being addressed and knowing when the message is completed they can use the Error Check bytes and parity bits to confirm the integrity of the message. If the Error Check or parity fails then the message is discarded.
In RTU mode, messages starts with a silent interval of at least 3.5 character times.

The first byte of a message is then transmitted, the device address.
Master and slave devices monitor the network continuously, including during the ‘silent’ intervals. When the first byte (the address byte) is received, each device checks it to find out if it is the addressed device. If the device determines that it is the one being addressed it records the whole message and acts accordingly, if it is not being addressed it continues monitoring for the next message.
Following the last transmitted byte, a silent interval of at least 3.5 character times marks the end of the message. A new message can begin after this interval.
The entire message must be transmitted as a continuous stream. If a silent interval of more than 1.5 character times occurs before completion of the message, the receiving device flushes the incomplete message and assumes that the next byte will be the address byte of a new message.
Similarly, if a new message begins earlier than 3.5 character times following a previous message, the receiving device may consider it a continuation of the previous message. This will result in an error, as the value in the final CRC field will not be valid for the combined messages.

3.4 How Characters are Transmitted Serially

When messages are transmitted on standard MODBUS Protocol serial networks each byte is sent in this order (left to right):

Transmit Character = Start Bit + Data Byte + Parity Bit + 1 Stop Bit (11 bits total):

Least Significant Bit (LSB) ↓ Most Significant Bit (MSB) ↓

Start	1	2	3	4	5	6	7	8	Parity	Stop

Transmit Character = Start Bit + Data Byte + 2 Stop Bits (11 bits total):

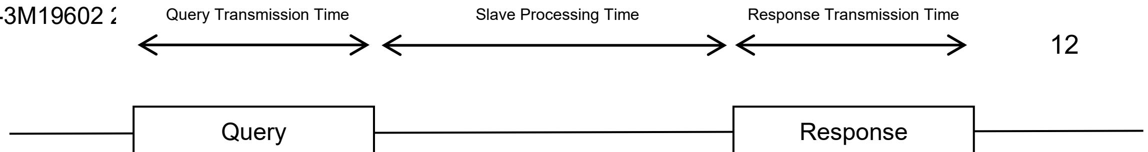
Start	1	2	3	4	5	6	7	8	Stop	Stop

Dual Load Digital meter additionally support No parity, One stop bit.

Transmit Character = Start Bit + Data Byte + 1 Stop Bit (10 bits total):

Start	1	2	3	4	5	6	7	8	Stop

The master is configured by the user to wait for a predetermined timeout interval. The master will wait for this period of time before deciding that the slave is not going to respond and that the transaction should be aborted. Care must be taken when determining the timeout period from both the master and the slaves’ specifications. The slave may define the ‘response time’ as being the period from the receipt of the last bit of the query to the transmission of the first bit of the response. The master may define the ‘response time’ as period between transmitting the first bit of the query to the receipt of the last bit of the response. It can be seen that message transmission time, which is a function of the baud rate, must be included in the timeout calculation.



3.5 Error Checking Methods

Standard MODBUS Protocol serial networks use two error checking processes, the error check bytes mentioned above check message integrity whilst Parity checking (even or odd) can be applied to each byte in the message.

3.51 Parity Checking

If parity checking is enabled – by selecting either Even or Odd Parity - the quantity of "1's" will be counted in the data portion of each transmit character. The parity bit will then be set to a 0 or 1 to result in an Even or Odd total of "1's".
Note that parity checking can only detect an error if an odd number of bits are picked up or dropped in a transmit character during transmission, if for example two 1's are corrupted to 0's the parity check will not find the error.
If No Parity checking is specified, no parity bit is transmitted and no parity check can be made. Also, if No Parity checking is specified and one stop bit is selected the transmit character is effectively shortened by one bit.

3.52 CRC Checking

The error check bytes of the MODBUS Protocol messages contain a Cyclical Redundancy Check (CRC) value that is used to check the content of the entire message. The error check bytes must always be present to comply with the MODBUS Protocol, there is no option to disable it.
The error check bytes represent a 16-bit binary value, calculated by the transmitting device. The receiving device must recalculate the CRC during receipt of the message and compare the calculated value to the value received in the error check bytes. If the two values are not equal, the message should be discarded.
The error check calculation is started by first pre-loading a 16-bit register to all 1's (i.e. Hex (FFFF)) each successive 8-bit byte of the message is applied to the current contents of the register. Note: only the eight bits of data in each transmit character are used for generating the CRC, start bits, stop bits and the parity bit, if one is used, are not included in the error check bytes.
During generation of the error check bytes, each 8-bit message byte is exclusive OR'ed with the lower half of the 16 bit register. The register is then shifted eight times in the direction of the least significant bit (LSB), with a zero filled into the most significant bit (MSB) position. After each shift the LSB prior to the shift is extracted and examined. If the LSB was a 1, the register is then exclusive OR'ed with a pre-set, fixed value. If the LSB was a 0, no exclusive OR takes place.
This process is repeated until all eight shifts have been performed. After the last shift, the next 8-bit message byte is exclusive OR'ed with the lower half of the 16 bit register, and the process repeated. The final contents of the register, after all the bytes of the message have been applied, is the error check value.

In the following pseudo code "ErrorWord" is a 16-bit value representing the error check values.

```
BEGIN
    ErrorWord = Hex (FFFF)
    FOR Each byte in message
        ErrorWord = ErrorWord XOR byte in message
        FOR Each bit in byte
            LSB = ErrorWord AND Hex (0001)
            IF LSB = 1 THEN ErrorWord = ErrorWord – 1
            ErrorWord = ErrorWord / 2
            IF LSB = 1 THEN ErrorWord = ErrorWord  XOR Hex (A001)
        NEXT bit in byte
    NEXT Byte in message
END
```

3.6 Function Codes

The function code part of a MODBUS Protocol message defines the action to be taken by the slave. Dual Load Digital meter support the following function codes:

Code	MODBUS Protocol name	Description
03	Read Holding Registers	Read the contents of read/write location (4X references)
04	Read Input Registers	Read the contents of read only location (3X references)
08	Diagnostics	Only sub-function zero is supported. This returns the data element of the query unchanged.
16	Pre-set Multiple Registers	Set the contents of read/write location (4X references)

3.7 IEEE floating point format

The MODBUS Protocol defines 16 bit "Registers" for the data variables. A 16-bit number would prove too restrictive, for energy parameters for example, as the maximum range of a 16-bit number is 65535. However, there are a number of approaches that have been adopted to overcome this restriction. Dual Load Digital meter use two consecutive registers to represent a floating-point number, effectively expanding the range to +/- $1x10^{37}$.

The values produced by Dual Load Digital meter can be used directly without any requirement to "scale" the values, for example, the units for the voltage parameters are volts, the units for the power parameters are watts etc.

What is a floating point Number?

A floating-point number is a number with two parts, a mantissa and an exponent and is written in the form 1.234×10^5. The mantissa (1.234 in this example) must have the decimal point moved to the right with the number of places determined by the exponent (5 places in this example) i.e. $1.234x\ 10^5 = 123400$. If the exponent is negative the decimal point is moved to the left.

What is an IEEE 754 format floating-point number?

An IEEE 754 floating point number is the binary equivalent of the decimal floating-point number shown above. The major difference being that the most significant bit of the mantissa is always arranged to be 1 and is thus not needed in the representation of the number. The process by which the most significant bit is arranged to be 1 is called normalisation, the mantissa is thus referred to as a "normal mantissa". During normalisation the bits in the mantissa are shifted to the left whilst the exponent is decremented until the most significant bit of the mantissa is one. In the special case where the number is zero both mantissa and exponent are zero.

The bits in an IEEE 754 format have the following significance:

Data Hi Reg, Hi Byte.	Data Hi Reg, Lo Byte.	Data Lo Reg, Hi Byte.	Data Lo Reg, Lo Byte.
SEEE EEEE	EMMM MMMM	MMMM MMMM	MMMM MMMM

Where:

S represents the sign bit where 1 is negative and 0 is positive

E is the 8-bit exponent with an offset of 127 i.e. an exponent of zero is represented by 127, an exponent of 1 by 128 etc.

M is the 23-bit normal mantissa. The 24th bit is always 1 and, therefore, is not stored.

Using the above format the floating point number 240.5 is represented as 43708000 hex:

Data Hi Reg, Hi Byte	Data Hi Reg, Lo Byte	Data Lo Reg, Hi Byte	Data Lo Reg, Lo Byte
43	70	80	00

The following example demonstrates how to convert IEEE 754 floating-point numbers from their hexadecimal form to decimal form. For this example, we will use the value for 240.5 shown above

Note that the floating-point storage representation is not an intuitive format. To convert this value to decimal, the bits should be separated as specified in the floating-point number storage format table shown above. For example:

Data Hi Reg, Hi Byte	Data Hi Reg, Lo Byte	Data Lo Reg, Hi Byte	Data Lo Reg, Lo Byte
0100 0011	0111 0000	1000 0000	0000 0000

From this you can determine the following information.

- The sign bit is 0, indicating a positive number.
- The exponent value is 10000110 binary or 134 decimal. Subtracting 127 from 134 leaves 7, which is the actual exponent.
- The mantissa appears as the binary number 11100001000000000000000

There is an implied binary point at the left of the mantissa that is always preceded by a 1. This bit is not stored in the hexadecimal representation of the floating-point number. Adding 1 and the binary point to the beginning of the mantissa gives the following:
1.11100001000000000000000
Now, we adjust the mantissa for the exponent. A negative exponent moves the binary point to the left. A positive exponent moves the binary point to the right. Because the exponent is 7, the mantissa is adjusted as follows:
11110000.1000000000000000
Finally, we have a binary floating-point number. Binary bits that are to the left of the binary point represent the power of two corresponding to their position. For example, 11110000 represents $(1 \times 2^7) + (1 \times 2^6) + (1 \times 2^5) + (1 \times 2^4) + (0 \times 2^3) + (0 \times 2^2) + (0 \times 2^1) + (0 \times 2^0) = 240$.
Binary bits that are to the right of the binary point also represent a power of 2 corresponding to their position. As the digits are to the right of the binary point the powers are negative. For example: .100 represents $(1 \times 2^{-1}) + (0 \times 2^{-2}) + (0 \times 2^{-3}) + \ldots$ which equals 0.5.
Adding these two numbers together and making reference to the sign bit produces the number +240.5.
For each floating point value requested two MODBUS Protocol registers (four bytes) must be requested. The received order and significance of these four bytes for Dual Load Digital meter is shown below:

Data Hi Reg, Hi Byte	Data Hi Reg, Lo Byte	Data Lo Reg, Hi Byte	Data Lo Reg, Lo Byte

3.8 MODBUS Protocol Commands supported

All 254-TXX Transducer support the “Read Input Register” (3X registers), the “Read Holding Register” (4X registers) and the “Pre-set Multiple Registers” (write 4X registers) commands of the MODBUS Protocol RTU protocol. All values stored and returned are in floating point format to IEEE 754 with the most significant register first.

3.8.1Read Input Registers

MODBUS Protocol code 04 reads the contents of the 3X registers.
Example
The following query will request ‘Volts 1’ from an instrument with node address 1:

Field Name	Example (Hex)
Slave Address	01
Function	04
Starting Address High	00
Starting Address Low	00
Number of Points High	00
Number of Points Low	02
Error Check Low	71
Error Check High	CB

Note: Data must be requested in register pairs i.e. the “Starting Address“ and the “Number of Points” must be even numbers to request a floating point variable. If the “Starting Address” or the “Number of points” is odd then the query will fall in the middle of a floating point variable the product will return an error message.
The following response returns the contents of Volts 1 as 230.2. But see also “Exception Response” later.

Field Name	Example (Hex)
Slave Address	01
Function	04
Byte Count	04
Data, High Reg, High Byte	43
Data, High Reg, Low Byte	66
Data, Low Reg, High Byte	33
Data, Low Reg, Low Byte	34
Error Check Low	1B
Error Check High	38

3.9 Holding Registers

3.9.1 Read Holding Registers

MODBUS Protocol code 03 reads the contents of the 4X registers.
Example
The following query will request the prevailing ‘Demand Time’:

Field Name	Example (Hex)
Slave Address	01
Function	03
Starting Address High	00
Starting Address Low	00
Number of Points High	00
Number of Points Low	02
Error Check Low	C4
Error Check High	0B

Note: Data must be requested in register pairs i.e. the “Starting Address“ and the “Number of Points” must be even numbers to request a floating point variable. If the “Starting Address” or the “Number of points” is odd then the query will fall in the middle of a floating point variable the product will return an error message.

The following response returns the contents of Demand Time as 1, But see also “Exception Response” later.

Field Name	Example (Hex)
Slave Address	01
Function	03
Byte Count	04
Data, High Reg, High Byte	3F
Data, High Reg, Low Byte	80
Data, Low Reg, High Byte	00
Data, Low Reg, Low Byte	00
Error Check Low	F7
Error Check High	CF

3.9.2 Write Holding Registers

MODBUS Protocol code 10 (16 decimal) writes the contents of the 4X registers.
Example
The following query will set the Demand Period to 60, which effectively resets the Demand Time:

Field Name	Example (Hex)
Slave Address	01
Function	10
Starting Address High	00
Starting Address Low	02
Number of Registers High	00
Number of Registers Low	02

Byte Count	04
Data, High Reg, High Byte	42
Data, High Reg, Low Byte	70
Data, Low Reg, High Byte	00
Data, Low Reg, Low Byte	00
Error Check Low	67
Error Check High	D5

Note: Data must be written in register pairs i.e. the “Starting Address“ and the “Number of Points” must be even numbers to write a floating point variable. If the “Starting Address” or the “Number of points” is odd then the query will fall in the middle of a floating point variable the product will return an error message. In general only one floating point value can be written per query

The following response indicates that the write has been successful. But see also “Exception Response” later.

Field Name	Example (Hex)
Slave Address	01
Function	10
Starting Address High	00
Starting Address Low	02
Number of Registers High	00
Number of Registers Low	02
Error Check Low	E0
Error Check High	08

3.10 Exception Response

If the slave in the “Write Holding Register” example above, did not support that function then it would have replied with an Exception Response as shown below. The exception function code is the original function code from the query with the MSB set i.e. it has had 80 hex logically ORed with it. The exception code indicates the reason for the exception. The slave will not respond at all if there is an error with the parity or CRC of the query. However, if the slave can not process the query then it will respond with an exception. In this case a code 01, the requested function is not support by this slave.

Field Name	Example (Hex)
Slave Address	01
Function	10 OR 80 = 90
Exception Code	01
Error Check Low	8D
Error Check High	C0

3.11 Exception Codes

3.11.1 Table of Exception Codes

254-TXX Transducer support the following exception codes:

Exception Code	MODBUS Protocol name	Description
01	Illegal Function	The function code is not supported by the product
02	Illegal Data Address	Attempt to access an invalid address
03	Illegal Data Value	Attempt to set a floating point variable to an invalid value

4 Appendix – Input Registers

Address	TE Reg	Type	Desciption	UOM	1P2W	3P4 UNB	3P4 BAL	3P3 UNB	3P3 BAL
30000	1	F32	Volts Phase 1	Volts	Y	Y	Y	N	N
30002	2	F32	Volts Phase 2	Volts	N	Y	Y	N	N
30004	3	F32	Volts Phase 3	Volts	N	Y	Y	N	N
30006	4	F32	Amps Phase 1	Amps	Y	Y	Y	Y	Y
30008	5	F32	Amps Phase 2	Amps	N	Y	Y	N	N
30010	6	F32	Amps Phase 3	Amps	N	Y	Y	Y	Y
30012	7	F32	Phase 1 power	Watts	Y	Y	Y	Y	Y
30014	8	F32	Phase 2 power	Watts	N	Y	Y	N	N
30016	9	F32	Phase 3 power	Watts	N	Y	Y	Y	Y
30018	10	F32	VA Phase 1	VA	Y	Y	Y	N	N
30020	11	F32	VA Phase 2	VA	N	Y	Y	N	N
30022	12	F32	VA Phase 3	VA	N	Y	Y	N	N
30024	13	F32	VAR 1	VAR	Y	Y	Y	N	N
30026	14	F32	VAR 2	VAR	N	Y	Y	N	N
30028	15	F32	VAR 3	VAR	N	Y	Y	N	N
30030	16	F32	Power factor phase 1	-	Y	Y	Y	N	N
30032	17	F32	Power factor phase 2	-	N	Y	Y	N	N
30034	18	F32	Power factor phase 3	-	N	Y	Y	N	N
30036	19	F32	Phase angle - phase 1	deg	Y	Y	Y	N	N
30038	20	F32	Phase angle - phase 2	deg	N	Y	Y	N	N
30040	21	F32	Phase angle - phase 3	deg	N	Y	Y	N	N
30042	22	F32	Volts live-neutral (VLN) Avg	V	Y	Y	Y	N	N
30044									
30046	24	F32	Amps average value (AAvg)	A	Y	Y	Y	Y	Y
30048	25	F32	Total amps (ASum)	A	Y	Y	Y	Y	Y
30050									
30052	27	F32	Total power (PSum)	W	Y	Y	Y	Y	Y

30056	29	F32	Total VA (VASum)	VA	Y	Y	Y	Y	Y
30060	31	F32	VArSum	VAR	Y	Y	Y	Y	Y
30062	32	F32	Power factor total (PFTot)	-	Y	Y	Y	Y	Y
30064									
30066	34	F32	Phase angle total (PATot)	deg	Y	Y	Y	Y	Y
30068									
30070	36	F32	Frequency	Hz	Y	Y	Y	Y	Y
30072	37	F32	Watt hour Import	Wh	Y	Y	Y	Y	Y
30074	38	F32	Watt hour Export	Wh	Y	Y	Y	Y	Y
30076	39	F32	VAr hour Import	VArh	Y	Y	Y	Y	Y
30078	40	F32	VAr hour Export	VArh	Y	Y	Y	Y	Y
30080	41	F32	VA hour	VAh	Y	Y	Y	Y	Y
30082									
30084	43	F32	Sum Watt Demand	W	Y	Y	Y	Y	Y
30086	44	F32	Sum Watt Max Demand	W	Y	Y	Y	Y	Y
30098									
30100	51	F32	Sum VA Demand	VA	Y	Y	Y	Y	Y
30102	52	F32	Sum VA Max Demand	VA	Y	Y	Y	Y	Y
30104	53	F32	Sum Amp Demand	A	Y	Y	Y	Y	Y
30106	54	F32	Sum Amp Demand Max	A	Y	Y	Y	Y	Y
30108	55	F32	V1 Max	Volts	Y	Y	Y	N	N
30110	56	F32	V1 Min	Volts	Y	Y	Y	N	N
30112	57	F32	V2 Max	Volts	N	Y	Y	N	N
30114	58	F32	V2 Min	Volts	N	Y	Y	N	N
30116	59	F32	V3 Max	Volts	N	Y	Y	N	N
30118	60	F32	V3 Min	Volts	N	Y	Y	N	N
30120	61	F32	A1_Max	A	Y	Y	Y	Y	Y
30122	62	F32	A1_Min	A	Y	Y	Y	Y	Y
30124	63	F32	A2_Max	A	N	Y	Y	Y	Y
30126	64	F32	A2_Min	A	N	Y	Y	Y	Y

30128	65	F32	A3_Max	A	N	Y	Y	Y	Y
30130	66	F32	A3_Min	A	N	Y	Y	Y	Y
30132	67	F32	Vln_Avg_Max	Volts	Y	Y	Y	N	N
30134	68	F32	Vln_Avg_Min	Volts	Y	Y	Y	N	N
30138									
30140	71	F32	A_Avg_Max	A	Y	Y	Y	Y	Y
30142	72	F32	A_Avg_Min	A	Y	Y	Y	Y	Y
30144	73	F32	A_Sum_Max	A	Y	Y	Y	Y	Y
30146	74	F32	A_Sum_Min	A	Y	Y	Y	Y	Y
30148	75	F32	P1_Max	W	Y	Y	Y	Y	Y
30150	76	F32	P1_Min	W	Y	Y	Y	Y	Y
30152	77	F32	P2_Max	W	N	Y	Y	N	N
30154	78	F32	P2_Min	W	N	Y	Y	N	N
30156	79	F32	P3_Max	W	N	Y	Y	Y	Y
30158	80	F32	P3_Min	W	N	Y	Y	Y	Y
30160	81	F32	Psum_Max	W	Y	Y	Y	Y	Y
30162	82	F32	Psum_Min	W	Y	Y	Y	Y	Y
30164	83	F32	VAr1_Max	VA	Y	Y	Y	N	N
30166	84	F32	VAr1_Min	VA	Y	Y	Y	N	N
30168	85	F32	VAr2_Max	VA	N	Y	Y	N	N
30170	86	F32	VAr2_Min	VA	N	Y	Y	N	N
30172	87	F32	VAr3_Max	VA	N	Y	Y	N	N
30174	88	F32	VAr3_Min	VA	N	Y	Y	N	N
30176	89	F32	VAr_Sum_Max	VA	Y	Y	Y	Y	Y
30178	90	F32	VAr_Sum_Min	VA	Y	Y	Y	Y	Y
30180	91	F32	VA1_Max	VA	Y	Y	Y	N	N
30182	92	F32	VA1_Min	VA	Y	Y	Y	N	N
30184	93	F32	VA2_Max	VA	N	Y	Y	N	N
30186	94	F32	VA2_Min	VA	N	Y	Y	N	N
30188	95	F32	VA3_Max	VA	N	Y	Y	N	N

30190	96	F32	VA3_Min	VA	N	Y	Y	N	N
30192	97	F32	VA_Sum_Max	VA	Y	Y	Y	Y	Y
30194	98	F32	VA_Sum_Min	VA	Y	Y	Y	Y	Y
30196	99	F32	Frequency_Max	Hz	Y	Y	Y	Y	Y
30198	100	F32	Frequency_Min	Hz	Y	Y	Y	Y	Y
30198									
30200	101	F32	Volts live-live phase 12 (V12)	V	N	Y	Y	Y	Y
30202	102	F32	Volts live-live phase 23 (V23)	V	N	Y	Y	Y	Y
30204	103	F32	Volts live-live phase 31 (V31)	V	N	Y	Y	Y	Y
30204									
30206	104	F32	VLL_Avg	V	N	Y	Y	Y	Y
30208	105	F32	Volts LL 12 Max (V12_Max)	V	N	Y	Y	Y	Y
30210	106	F32	Volts LL 12 Min (V12_Min)	V	N	Y	Y	Y	Y
30212	107	F32	Volts LL 23 Max (V23_Max)	V	N	Y	Y	Y	Y
30214	108	F32	Volts LL 23 Min (V23_Min)	V	N	Y	Y	Y	Y
30216	109	F32	Volts LL 31 Max (V31_Max)	V	N	Y	Y	Y	Y
30218	110	F32	Volts LL 31 Min (V31_Min)	V	N	Y	Y	Y	Y
30220	111	F32	Volts LL average max	V	N	Y	Y	Y	Y
30222	112	F32	Volts LL average min	V	N	Y	Y	Y	Y
30222									
30224	113	F32	Amps neutral (An)	A	Y	Y	Y	N	N
30226	114	F32	Amps neutral max (An_Max)	A	Y	Y	Y	N	N
30228	115	F32	Amps neutral min (An_Min)	A	Y	Y	Y	N	N
30230	116	F32	Amps neutral (An_Demand)	A	Y	Y	Y	N	N
30232	117	F32	Amps neutral max demand An_Max_Demand	A	Y	Y	Y	N	N
30234	118	F32	V1_THD total harmonic distortion	%	Y	Y	Y	N	N
30236	119	F32	V2_THD total harmonic distortion	%	N	Y	Y	N	N
30238	120	F32	V3_THD total harmonic distortion	%	N	Y	Y	N	N
30240	121	F32	A1_THD total harmonic distortion	%	Y	Y	Y	Y	Y
30242	122	F32	A2_THD total harmonic distortion	%	N	Y	Y	Y	Y

30244	123	F32	A3_THD total harmonic distortion	%	N	Y	Y	Y	Y
30246									
30248	125	F32	VLN_Avg_THD	%	Y	Y	Y	N	N
30250	126	F32	A_AVG_THD	%	Y	Y	Y	Y	Y
30252	127	F32	Hours_Run	hr	Y	Y	Y	Y	Y
30254	128	F32	PF_Total(sign modified)	-	Y	Y	Y	Y	Y
30256									
30258	130	F32	A1_Dmd	A	Y	Y	Y	Y	Y
30260	131	F32	A2_Dmd	A	N	Y	Y	Y	Y
30262	132	F32	A3_Dmd	A	N	Y	Y	Y	Y
30264	133	F32	A1_Max_Dmd	A	Y	Y	Y	Y	Y
30266	134	F32	A2_Max_Dmd	A	N	Y	Y	Y	Y
30268	135	F32	A3_Max_Dmd	A	N	Y	Y	Y	Y
30268									
30270	136	F32	Phase_Rotation	deg	N	Y	Y	Y	Y
30272	137	F32	VLN_Unbalanced	V	N	Y	N	N	N
30274	138	F32	VLL_Unbalanced	V	N	Y	N	Y	N
30276	139	F32	A_Unbalance	A	N	Y	N	Y	N
30278	140	F32	VLN_Unbalance_Max	V	N	Y	N	Y	N
30280	141	F32	VLN_Unbalance_Min	V	N	Y	N	Y	N
30282	142	F32	VLL_Unbalance_Max	V	N	Y	N	Y	N
30284	143	F32	VLL_Unbalance_Min	V	N	Y	N	Y	N
30286	144	F32	A_Unbalance_Max	A	N	Y	N	Y	N
30288	145	F32	A_Unbalance_Min	A	N	Y	N	Y	N
30290	146	F32	PF1_Max	-	Y	Y	Y	N	N
30292	147	F32	PF1_Min	-	Y	Y	Y	N	N
30294	148	F32	PF2_Max	-	N	Y	Y	N	N
30296	149	F32	PF2_Max	-	N	Y	Y	N	N
30298	150	F32	PF3_Max	-	N	Y	Y	N	N
30300	151	F32	PF3_Max	-	N	Y	Y	N	N

30302	152	F32	PFTot_Max	-	Y	Y	Y	Y	Y
30304	153	F32	PFTot_Min	-	Y	Y	Y	Y	Y
30306	154	F32	PATot_Max	-	Y	Y	Y	Y	Y
30308	155	F32	PATot_Min	-	Y	Y	Y	Y	Y
30310	156	F32	V1_THD_Max	%	Y	Y	Y	Y	Y
30312	157	F32	V1_THD_Min	%	Y	Y	Y	N	N
30314	158	F32	V2_THD_Max	%	N	Y	Y	N	N
30316	159	F32	V2_THD_Min	%	N	Y	Y	N	N
30318	160	F32	V3_THD_Max	%	N	Y	Y	N	N
30320	161	F32	V3_THD_Min	%	N	Y	Y	N	N
30322	162	F32	A1_THD_Max	%	Y	Y	Y	Y	Y
30324	163	F32	A1_THD_Min	%	Y	Y	Y	Y	Y
30326	164	F32	A2_THD_Max	%	N	Y	Y	Y	Y
30328	165	F32	A2_THD_Min	%	N	Y	Y	Y	Y
30330	166	F32	A3_THD_Max	%	N	Y	Y	Y	Y
30332	167	F32	A3_THD_Min	%	N	Y	Y	Y	Y
30332									
30334	168	F32	P1_Dmd	Wh	Y	Y	Y	Y	Y
30336	169	F32	P2_Dmd	Wh	N	Y	Y	N	N
30338	170	F32	P3_Dmd	Wh	N	Y	Y	Y	Y
30340	171	F32	P1_Max_Dmd	Wh	Y	Y	Y	Y	Y
30342	172	F32	P2_Max_Dmd	Wh	N	Y	Y	N	N
30344	173	F32	P3_Max_Dmd	Wh	N	Y	Y	Y	Y
30346	174	F32	VA1_Dmd	VAh	Y	Y	Y	N	N
30348	175	F32	VA2_Dmd	VAh	N	Y	Y	N	N
30350	176	F32	VA3_Dmd	VAh	N	Y	Y	N	N
30352	177	F32	VA1_Max_Dmd	VAh	Y	Y	Y	N	N
30354	178	F32	VA2_Max_Dmd	VAh	N	Y	Y	N	N
30356	179	F32	VA3_Max_Dmd	VAh	N	Y	Y	N	N
30358	180	F32	VLN_Avg_THD_Max	%	Y	Y	Y	N	N

30360	181	F32	VLN_Avg_THD_Min	%	Y	Y	Y	N	N
30362	182	F32	A_Avg_THD_Max	%	Y	Y	Y	Y	Y
30364	183	F32	A_Avg_THD_Min	%	Y	Y	Y	Y	Y
30366	184	F32	PA1_Max	deg	Y	Y	Y	N	N
30368	185	F32	PA2_Max	deg	N	Y	Y	N	N
30370	186	F32	PA3_Max	deg	N	Y	Y	N	N
30372	187	F32	PA1_Min	deg	Y	Y	Y	N	N
30374	188	F32	PA2_Min	deg	N	Y	Y	N	N
30376	189	F32	PA3_Min	deg	N	Y	Y	N	N
30378	190	F32	Nominal power measurement	W	Y	Y	Y	Y	Y
30386									
30388	195	F32	System_Type	-	Y	Y	Y	Y	Y
30390	196	F32	Energy_Prefix	-	Y	Y	Y	Y	Y
30392	197	F32	Volts_LN_Scale	-	Y	Y	Y	N	N
30394	198	F32	System_Amps	A	Y	Y	Y	Y	Y
30396	199	F32	Volts_LN * System_Amps	W	Y	Y	Y	N	N
30416									
30418	210	F32	V1Angle		Y	Y	Y	N	N
30420	211	F32	V2Angle		N	Y	Y	N	N
30422	212	F32	V3Angle		N	Y	Y	N	N
30424	213	F32	A1Angle		Y	Y	Y	N	N
30426	214	F32	A2Angle		N	Y	Y	N	N
30428	215	F32	A3Angle		N	Y	Y	N	N

**Availability of individual measurements depends on the selected wiring configuration. Phase-specific power quantities are only available where they are directly measurable. In three-phase three-wire systems, system power values should be used.*

Why some measurements are not available in certain wiring modes
The 254-TXX Transducer supports multiple wiring configurations, including single-phase and three-phase three-wire (3P3W) and four-wire (3P4W) systems.
The availability of individual measured parameters depends on the selected wiring configuration, because not all electrical quantities are physically measurable or uniquely defined in all systems.

Phase-specific power quantities and wiring configuration
In three-phase four-wire (3P4W) systems, each phase has an independent line-to-neutral voltage reference. This allows phase-specific power quantities (e.g. L1, L2, L3 watts, vars, and power factor) to be directly measured and therefore reliably reported.
In three-phase three-wire (3P3W) systems, there is no neutral reference and phase voltages are not independently available. As a result, phase-by-phase active power, reactive power, and power factor are not uniquely defined physical measurements. While total (system) power quantities remain fully valid and measurable, phase-specific power values would require mathematical assumptions about load balance and system symmetry.
To ensure measurement integrity and avoid the presentation of potentially misleading data, the 254-TXX therefore does not provide certain phase-specific power measurements in 3P3W configurations.

Interpretation of “Y / N” availability in the communications guide
In the communications register tables:
- **“Y” (Yes)** indicates that the measurement is available and meaningful for the selected wiring configuration.
- **“N” (No)** indicates that the measurement is not available in that wiring mode, either because it cannot be directly measured or because its value would be inherently ambiguous.

An “N” reflects an intentional design decision based on sound electrical measurement principles.

What measurements remain available in 3-phase 3-wire systems
In 3P3W systems, the following categories of measurements remain fully supported and valid:
- Total active power (kW)
- Total reactive power (kVAr)
- Total apparent power (kVA)
- System / average power factor
- Line currents
- Line-to-line voltages
- Frequency and energy values

These quantities are well-defined and meaningful regardless of the presence of a neutral conductor.

5 Appendix - HOLDING Registers

Modbus Holding Register Address Name	Holding Register Address	TE Reg	Type	Read / Write	Need Password	Description	Value Range	Default	UOM
MB_HREG_DEMANDTIME	40000	1	F32	R	0	Demand reading minutes into first demand calculation.			m
MB_HREG_DEMANDPERIOD	40002	2	F32	RW	0	Demand period in minutes	2,5,8,10,15,20,30 or 60		m
MB_HREG_BALANCEDSYSTEM	40004	3	F32	RW	0	Balanced system	1 = balanced, 0 = unbalanced	0	
MB_HREG_SYSTEMVOLTS	40006	4	F32	RW	0	Write primary (system) voltage value	1 to 999000	277.0 (1P2W & 4P4W) 480 (3P3W)	V
MB_HREG_SYSTEMCURRENT	40008	5	F32	RW	0	Write system current	1 to 9999		A
MB_HREG_SYSTEMTYPE	40010	6	F32	RW	0	Write system type	1P2W = 1, 3P3W = 2 or 3P4W = 3	SYSTYPE_3P4W	
MB_HREG_RELAYPULSEWIDTH	40012	7	F32	RW	0	Write relay pulse period	3 = 60ms, 5 = 100ms or 10 = 200ms		
MB_HREG_APPLYPASSWORDLOCK	40015	8	F32	RW	0	Write any value to password lock protected registers.	Any		
MB_HREG_MBUS_RTU_PARITYSTOP	40018	10	F32	RW	0	Modbus RTU parity/stop bits.	0 = One stop bit and no parity, default. 1 = One stop bit and even parity 2 = One stop bit and odd parity 3 = Two stop bits and no parity	0	
MB_HREG_MBUS_SLAVE_ID	40020	11	F32	RW	0	Modbus RTU slave address	1-240	1	
MB_HREG_PASSWORD	40024	13	F32	RW	0	Read zero			
MB_HREG_SET_MODE	40026	14	F32	RW	0	Operational mode	0 = normal mode 1 = calibration mode	0	

MB_HREG_MBUS_RTU_BAUDRATE	40028	15	F32	RW	0	Modbus RTU baud date setting (0 = 2400 baud	0 = 2400 baud, 1= 4800, 2 = 9600, 3 = 19K2, 4=38K4	2	
MB_HREG_ENERGYUNITSPREFIX	40030	16	F32	RW	0	Units prefix for energy output	0 = x1, 1=x1000(k), 2=x1000000(M), 3=x1000000000(G)	1	
MB_HREG_LOWPOWERLIMITFLAG	40032	17	F32	RW	0	Enable / disable low power limit			
MB_HREG_SERIALNUMBERHI	40042	22	U32	RW	1	Product serial number (MSW)			
MB_HREG_SERIALNUMBERLO	40044	23	U32	RW	1	Product serial number (LSW)			
	40000								
MB_HREG_INPUTVOLTAGERANGE	40058	30	F32	RW	0	Secondary input volts (voltage transformer secondary windings value)	57.5-277.0 (live-neutral) (277 defaul) 100.0-480.0 (3 wire Live-live) (480 default)	270.0 (1P2W, 3P4W), 480 (3P3W)	
MB_HREG_INPUTCURRENTRANGE	40060	31	F32	RW	0	Current transformer secondary current value	0.1-5.0	1	A
	40000								
MB_HREG_RELAY1_MODE	40082	42	F32	RW	0	Relay 1 operational mode - (0=pulse	0=pulse, 1=alarm, 2=watchdog, 3 = disabled		
MB_HREG_RELAY2_MODE	40084	43	F32	RW	0	Relay 2 operational mode - (0=pulse	0=pulse, 1=alarm, 2=watchdog, 3 = disabled		

MB_HREG_RELAY1ENERGYTYPE	40086	44	F32	RW	0	Write Modbus input parameter for pulse relay 1	37 = import W, 38 = export W, 39 = import VAr, 40 = export VAr		
MB_HREG_RELAY2ENERGYTYPE	40088	45	F32	RW	0	Write Modbus input parameter for pulse relay 2	2=watch37 = import W, 38 = export W, 39 = import VAr, 40 = export VArdog,		
MB_HREG_RELAY1PULSEWIDTH	40090	46	F32	RW	0	Write Modbus pulse width for pulse relay 1	3 = 60ms, 4 = 80ms, 5 = 100ms		
MB_HREG_RELAY2PULSEWIDTH	40092	47	F32	RW	0	Write Modbus pulse width for pulse relay 2	3 = 60ms, 4 = 80ms, 5 = 100ms		
MB_HREG_RELAY1PULSEDIVISOR	40094	48	F32	RW	0	Write Modbus pulse divisor for pulse relay 1	(1-14)		
MB_HREG_RELAY2PULSEDIVISOR	40096	49	F32	RW	0	Write Modbus pulse divisor for pulse relay 2	(1-14)		
MB_HREG_RELAY1_ALARM_TRIP_POINT	40098	50	F32	RW	0	Relay 1 (when configured as an alarm output) - alarm trip point			
MB_HREG_RELAY2_ALARM_TRIP_POINT	40100	51	F32	RW	0	Relay 2 (when configured as an alarm output) - alarm trip point			
MB_HREG_RELAY1_ALARM_DEAD_BAND	40102	52	F32	RW	0	Relay 1 (when configured as an alarm output) - alarm dead band			
MB_HREG_RELAY2_ALARM_DEAD_BAND	40104	53	F32	RW	0	Relay 2 (when configured as an alarm output) - alarm dead band			

MB_HREG_RELAY1_ALARM_DELAY	40106	54	F32	RW	0	Relay 1 (when configured as an alarm output) - alarm delay	0-5000		ms
MB_HREG_RELAY2_ALARM_DELAY	40108	55	F32	RW	0	Relay 2 (when configured as an alarm output) - alarm delay	0-5000		ms
MB_HREG_RESETLOGGEDDATA	40110	56	F32	RW	0	Write code to reset data group.	0 = reset all 1 = reset energy value 2 = reset demands 3 = reset demand min / max 4 = reset hours run 5 = reset parameter min / max 6 = reset THD min / max		
MB_HREG_RELAY1_ALARM_SOURCE	40112	57	F32	RW	0	Relay 1 monitored variable (0 = V1	*see monitored variable list*		
MB_HREG_RELAY2_ALARM_SOURCE	40114	58	F32	RW	0	Relay 2 monitored variable (0 = V1	*see monitored variable list*		
	40000								
MB_HREG_PRODIPROJECT	40230	116	F32	R	0	Read the project number - 2402	2402		
MB_HREG_PRODIDPRODUCT	40232	117	F32	R	0	Read the product number - TBD			
MB_HREG_PRODIDSOFTWARE	40234	118	F32	R	0	Read the firmware version number			
MB_HREG_PRODIDBUILD	40236	119	F32	R	0	Read the firmware build number			
MB_HREG_PRODIDPSCISSUE	40238	120	F32	R	0	Read the PSC issue number			
MB_HREG_PRODIDPSCNUMBER	40240	121	F32	R	0	Read the PSC number			
	40000								
MB_HREG_SECONDARYVOLTSMAX	40264	133	F32	R	0	Read the maximum secondary voltage that can be set.			
MB_HREG_SECONDARYVOLTSMIN	40266	134	F32	R	0	Read the minimum secondary voltage that can be set.			
	40000								

MB_HREG_LOWVOLTSLIMIT	40268	135	F32	RW	0	Low voltage limit value - minimum measurement otherwise 0			
MB_HREG_LOWAMPSLIMIT	40270	136	F32	RW	0	Low amps limit value - minimum measurement otherwise 0			
MB_HREG_LOWTHDPARAMETERLIMIT	40272	137	F32	RW	0	Write the lowest			
MB_HREG_SMOOTHPARAMLIMIT	40274	138	F32	RW	0	Write limit of parameter change for smoothing (not used)	0-1.0	0.002	
MB_HREG_SMOOTHPARAMFACTOR	40276	139	F32	RW	0	Write proportion of parameter change to use when smoothing	0-1.0	0.002	
MB_HREG_SMOOTHTHDLIMIT	40278	140	F32	RW	0	Write limit of THD change for smoothing			
MB_HREG_SMOOTHTHDFACTOR	40280	141	F32	RW	0	Write proportion of THD change to use when smoothing			
MB_HREG_INSTRUMENTSTATUS	40282	142	F32	R	0	Read the instrument status			
MB_HREG_LOWVAFORPOWERFACTOR	40284	143	F32	RW	0	Write phase VA proportion required to include phase in power factor and phase angle calculations.			
MB_HREG_LOWPOWERLIMIT	40286	144	F32	RW	0	Lowest measureable power, belo w which power is set to zero.			
	40000								
MB_HREG_SECONDARYVOLTS	40298	150	F32	RW	0	Write required secondary voltage. (note same as reg 30)	57.5 to 277.0 (1P2W, 3P4W), 100.0 to 480.0 (3P3W)	270.0 (1P2W, 3P4W), 480 (3P3W)	
	40000								
MB_HREG_INSTSTATUSFLAGSHI	40318	160	F32	R	0	Read the higher 16 bits of the instrument status			

MB_HREG_INSTSTATUSFLAGSLO	40320	161	F32	R	0	Read the lower 16 bits of the instrument status			
	40000								
MB_HREG_SYS_MODE	40400	201	F32	RW	0	System mode normal (0) or calibration mode (1)			
	40000								
MB_HREG_AO1_ANALOGUERANGE	40634	318	U32	RW	0	Channel 1 analogue range code	0 = 4to20MA, 1 = 0to20mA, 2= 0to10V	0	
MB_HREG_AO1_OUTPUTENABLE	40636	319	U32	RW	0	Channel 1 analogue output enable flag	0 = disable, 1 = enabled	1	
MB_HREG_AO1_OUTPUTPARAMNO	40638	320	U32	RW	0	Channel 1 analogue parameter number (0 = V1	*see monitored variable list*		
MB_HREG_AO1_DUALSLOPEFLAG	40640	321	U32	RW	0	Channel 1 analogue dual slope flag (0 = linear	0 = linear (2 point), 1 = dual slope (3 point)		
MB_HREG_AO1_LOWERLIMITANA	40642	322	F32	RW	0	Channel 1 lower analogue scale value	0-20/0-10		mA/V
MB_HREG_AO1_MIDLIMITANA	40644	323	F32	RW	0	Channel 1 middle analogue scale value	0-20/0-10		mA/V
MB_HREG_AO1_UPPERLIMITANA	40646	324	F32	RW	0	Channel 1 upper analogue scale value	0-20/0-10		mA/V
MB_HREG_AO1_LOWERLIMITREG	40648	325	F32	RW	0	Channel 1 lower parameter scale value.			
MB_HREG_AO1_MIDLIMITREG	40650	326	F32	RW	0	Channel 1 middle parameter scale value.			
MB_HREG_AO1_UPPERLIMITREG	40652	327	F32	RW	0	Channel 1 upper parameter scale value.			
MB_HREG_AO1_GAINADJUST	40654	328	notused	--	0	Channel 1 gain adjustment (M).			
MB_HREG_AO1_OFFSETADJUST	40656	329	notused	--	0	Channel 1 offset adjustment (C).			

MB_HREG_AO1_ERRORCODE	40658	330	notused	--	0	Channel 1 analogue error code.			
MB_HREG_AO1_LOWERLIMITDIG	40660	331	notused	--	0	Channel 1 lower digital limit.			
MB_HREG_AO1_MIDLIMITDIG	40662	332	notused	--	0	Channel 1 middle digital limit.			
MB_HREG_AO1_UPPERLIMITDIG	40664	333	notused	--	0	Channel 1 upper digital limit.			
MB_HREG_AO1_PRESENTANA	40666	334	notused	--	0	Channel 1 current analogue value.			
MB_HREG_AO1_REGISTERVAL	40668	335	notused	--	0	Channel 1 current parameter value.			
MB_HREG_AO1_CALLOWPOINT	40670	336	notused	--	0	Channel 1 calibration low point.			
MB_HREG_AO1_CALHIGHPOINT	40672	337	notused	--	0	Channel 1 calibration high point.			
MB_HREG_AO1_PRESENTDIGVAL	40674	338	notused	--	0	Channel 1 current digital value.			
MB_HREG_AO1_RESERVED_1	40676	339	notused	--	0	Channel 1 reserved location 1.			
MB_HREG_AO1_RESERVED_2	40678	340	notused	--	0	Channel 1 reserved location 2.			
MB_HREG_AO1_RESERVED_3	40680	341	notused	--	0	Channel 1 reserved location 3.			
MB_HREG_AO2_ANALOGUERANGE	40682	342	U32	RW	0	Channel 2 analogue range code (0 = 4to20MA	0 = 4to20MA, 1 = 0to20mA, 2= 0to10V	0	
MB_HREG_AO2_OUTPUTENABLE	40684	343	U32	RW	0	Channel 2 analogue output enable flag (0 = disabled	0 = disable, 1 = enabled	1	
MB_HREG_AO2_OUTPUTPARAMNO	40686	344	U32	RW	0	Channel 2 analogue parameter number (0 = V1	*see monitored variable list*		
MB_HREG_AO2_DUALSLOPEFLAG	40688	345	U32	RW	0	Channel 2 analogue dual slope flag (0 = linear	0 = linear (2 point), 1 = dual slope (3 point)		
MB_HREG_AO2_LOWERLIMITANA	40690	346	F32	RW	0	Channel 2 lower analogue scale value	0-20/0-10		

MB_HREG_AO2_MIDLIMITANA	40692	347	F32	RW	0	Channel 2 middle analogue scale value	0-20/0-10		
MB_HREG_AO2_UPPERLIMITANA	40694	348	F32	RW	0	Channel 2 upper analogue scale value	0-20/0-10		
MB_HREG_AO2_LOWERLIMITREG	40696	349	F32	RW	0	Channel 2 lower parameter scale value.			
MB_HREG_AO2_MIDLIMITREG	40698	350	F32	RW	0	Channel 2 middle parameter scale value.			
MB_HREG_AO2_UPPERLIMITREG	40700	351	F32	RW	0	Channel 2 upper parameter scale value.			
MB_HREG_AO2_GAINADJUST	40702	352	notused	-	0	Channel 2 gain adjustment (M).			
MB_HREG_AO2_OFFSETADJUST	40704	353	notused	-	0	Channel 2 offset adjustment (C).			
MB_HREG_AO2_ERRORCODE	40706	354	notused	--	0	Channel 2 analogue error code.			
MB_HREG_AO2_LOWERLIMITDIG	40708	355	notused	--	0	Channel 2 lower digital limit.			
MB_HREG_AO2_MIDLIMITDIG	40710	356	notused	--	0	Channel 2 middle digital limit.			
MB_HREG_AO2_UPPERLIMITDIG	40712	357	notused	--	0	Channel 2 upper digital limit.			
MB_HREG_AO2_PRESENTANA	40714	358	notused	--	0	Channel 2 current analogue value.			
MB_HREG_AO2_REGISTERVAL	40716	359	notused	--	0	Channel 2 current parameter value.			
MB_HREG_AO2_CALLOWPOINT	40718	360	notused	--	0	Channel 2 calibration low point.			
MB_HREG_AO2_CALHIGHPOINT	40720	361	notused	--	0	Channel 2 calibration high point.			
MB_HREG_AO2_PRESENTDIGVAL	40722	362	notused	--	0	Channel 2 current digital value.			
MB_HREG_AO2_RESERVED_1	40724	363	notused	--	0	Channel 2 reserved location 1.			
MB_HREG_AO2_RESERVED_2	40726	364	notused	--	0	Channel 2 reserved location 2.			
MB_HREG_AO2_RESERVED_3	40728	365	notused	--	0	Channel 2 reserved location 3.			

MB_HREG_AO3_ANALOGUERANGE	40730	366	U32	RW	0	Channel 3 analogue range code (0 = 4to20MA	0 = 4to20MA, 1 = 0to20mA, 2= 0to10V	0	
MB_HREG_AO3_OUTPUTENABLE	40732	367	U32	RW	0	Channel 3 analogue output enable flag (0 = disabled	0 = disable, 1 = enabled	0	
MB_HREG_AO3_OUTPUTPARAMNO	40734	368	U32	RW	0	Channel 3 analogue parameter number (0 = V1	*see monitored variable list*		
MB_HREG_AO3_DUALSLOPEFLAG	40736	369	U32	RW	0	Channel 3 analogue dual slope flag (0 = linear	0 = linear (2 point), 1 = dual slope (3 point)		
MB_HREG_AO3_LOWERLIMITANA	40738	370	F32	RW	0	Channel 3 lower analogue scale value	0-20/0-10		
MB_HREG_AO3_MIDLIMITANA	40740	371	F32	RW	0	Channel 3 middle analogue scale value	0-20/0-10		
MB_HREG_AO3_UPPERLIMITANA	40742	372	F32	RW	0	Channel 3 upper analogue scale value	0-20/0-10		
MB_HREG_AO3_LOWERLIMITREG	40744	373	F32	RW	0	Channel 3 lower parameter scale value.			
MB_HREG_AO3_MIDLIMITREG	40746	374	F32	RW	0	Channel 3 middle parameter scale value.			
MB_HREG_AO3_UPPERLIMITREG	40748	375	F32	RW	0	Channel 3 upper parameter scale value.			
MB_HREG_AO3_GAINADJUST	40750	376	notused	--	0	Channel 3 gain adjustment (M).			
MB_HREG_AO3_OFFSETADJUST	40752	377	notused	--	0	Channel 3 offset adjustment (C).			
MB_HREG_AO3_ERRORCODE	40754	378	notused	--	0	Channel 3 analogue error code.			
MB_HREG_AO3_LOWERLIMITDIG	40756	379	notused	--	0	Channel 3 lower digital limit.			
MB_HREG_AO3_MIDLIMITDIG	40758	380	notused	--	0	Channel 3 middle digital limit.			
MB_HREG_AO3_UPPERLIMITDIG	40760	381	notused	--	0	Channel 3 upper digital limit.			

MB_HREG_AO3_PRESENTANA	40762	382	notused	--	0	Channel 3 current analogue value.			
MB_HREG_AO3_REGISTERVAL	40764	383	notused	--	0	Channel 3 current parameter value.			
MB_HREG_AO3_CALLOWPOINT	40766	384	notused	--	0	Channel 3 calibration low point.			
MB_HREG_AO3_CALHIGHPOINT	40768	385	notused	--	0	Channel 3 calibration high point.			
MB_HREG_AO3_PRESENTDIGVAL	40770	386	notused	--	0	Channel 3 current digital value.			
MB_HREG_AO3_RESERVED_1	40772	387	notused	--	0	Channel 3 reserved location 1.			
MB_HREG_AO3_RESERVED_2	40774	388	notused	--	0	Channel 3 reserved location 2.			
MB_HREG_AO3_RESERVED_3	40776	389	notused	--	0	Channel 3 reserved location 3.			
MB_HREG_AO4_ANALOGUERANGE	40778	390	U32	RW	0	Channel 4 analogue range code (0 = 4to20MA	0 = 4to20MA, 1 = 0to20mA, 2= 0to10V	0	
MB_HREG_AO4_OUTPUTENABLE	40780	391	U32	RW	0	Channel 4 analogue output enable flag (0 = disabled	0 = disable, 1 = enabled	0	
MB_HREG_AO4_OUTPUTPARAMNO	40782	392	U32	RW	0	Channel 4 analogue parameter number (0 = V1	*see monitored variable list*		
MB_HREG_AO4_DUALSLOPEFLAG	40784	393	U32	RW	0	Channel 4 analogue dual slope flag (0 = linear	0 = linear (2 point), 1 = dual slope (3 point)		
MB_HREG_AO4_LOWERLIMITANA	40786	394	F32	RW	0	Channel 4 lower analogue scale value	0-20/0-10		
MB_HREG_AO4_MIDLIMITANA	40788	395	F32	RW	0	Channel 4 middle analogue scale value	0-20/0-10		
MB_HREG_AO4_UPPERLIMITANA	40790	396	F32	RW	0	Channel 4 upper analogue scale value	0-20/0-10		
MB_HREG_AO4_LOWERLIMITREG	40792	397	F32	RW	0	Channel 4 lower parameter scale value.			

MB_HREG_AO4_MIDLIMITREG	40794	398	F32	RW	0	Channel 4 middle parameter scale value.			
MB_HREG_AO4_UPPERLIMITREG	40796	399	F32	RW	0	Channel 4 upper parameter scale value.			
MB_HREG_AO4_GAINADJUST	40798	400	notused	--	0	Channel 4 gain adjustment (M).			
MB_HREG_AO4_OFFSETADJUST	40800	401	notused	--	0	Channel 4 offset adjustment (C).			
MB_HREG_AO4_ERRORCODE	40802	402	notused	--	0	Channel 4 analogue error code.			
MB_HREG_AO4_LOWERLIMITDIG	40804	403	notused	--	0	Channel 4 lower digital limit.			
MB_HREG_AO4_MIDLIMITDIG	40806	404	notused	--	0	Channel 4 middle digital limit.			
MB_HREG_AO4_UPPERLIMITDIG	40808	405	notused	--	0	Channel 4 upper digital limit.			
MB_HREG_AO4_PRESENTANA	40810	406	notused	--	0	Channel 4 current analogue value.			
MB_HREG_AO4_REGISTERVAL	40812	407	notused	--	0	Channel 4 current parameter value.			
MB_HREG_AO4_CALLOWPOINT	40814	408	notused	--	0	Channel 4 calibration low point.			
MB_HREG_AO4_CALHIGHPOINT	40816	409	notused	--	0	Channel 4 calibration high point.			
MB_HREG_AO4_PRESENTDIGVAL	40818	410	notused	--	0	Channel 4 current digital value.			
MB_HREG_AO4_RESERVED_1	40820	411	notused	--	0	Channel 4 reserved location 1.			
MB_HREG_AO4_RESERVED_2	40822	412	notused	--	0	Channel 4 reserved location 2.			
MB_HREG_AO4_RESERVED_3	40824	413	notused	--	0	Channel 4 reserved location 3.			
	40000								
MB_HREG_AO_TEST_VALUE	40826	414	F32	RW	0	AO test value (output percent)	0-100		%
MB_HREG_AO_STATE	40828	415	U32	RW	0	AO state			
	40000								
MB_HREG_CT_DIRECTION	49832	4917	F32	RW	0	CT direction - normal or reversed	0 = normal, 1= reversed	0 (normal)	

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