VACON® 100 INDUSTRIAL
VACON® 100 FLOW
VACON® 100 HVAC
VACON® 100 X
AC DRIVES

MODBUS TCP/UDP AND MODBUS RTU
USER MANUAL

VACON®

Table of Contents

1.   SAFETY

This manual contains clearly marked cautions and warnings which are intended for your personal safety and to avoid any unintentional damage to the product or connected appliances.

Please read the information included in cautions and warnings carefully.

The cautions and warnings are marked as follows:

Table 1. Warning signs

⚡	**= DANGER! Dangerous voltage**
⚠	**= WARNING or CAUTION**
♨	**= Caution! Hot surface**

1.1   DANGER

⚡	The **components of the power unit are live** when the drive is connected to mains potential. Coming into contact with this voltage is **extremely dangerous** and may cause death or severe injury.
⚡	The **motor terminals U, V, W and the brake resistor terminals are live** when the AC drive is connected to mains, even if the motor is not running.
⚡	**After disconnecting** the AC drive from the mains, **wait** until the indicators on the keypad go out (if no keypad is attached see the indicators on the cover). Wait 5 more minutes before doing any work on the connections of the drive. Do not open the cover before this time has expired. After expiration of this time, use a measuring equipment to absolutely ensure that no voltage is present. **Always ensure absence of voltage before starting any electrical work!**
⚡	The control I/O-terminals are isolated from the mains potential. However, the **relay outputs and other I/O-terminals may have a dangerous control voltage** present even when the AC drive is disconnected from mains.
⚡	**Before connecting** the AC drive to mains make sure that the front and cable covers of the drive are closed.
⚡	During a ramp stop (see the Application Manual), the motor is still generating voltage to the drive. Therefore, do not touch the components of the AC drive before the motor has completely stopped. Wait until the indicators on the keypad go out (if no keypad is attached see the indicators on the cover). Wait additional 5 minutes before starting any work on the drive.

1.2   Warnings

⚠️ The AC drive is meant for **fixed installations only**.

⚠️ **Do not perform any measurements** when the AC drive is connected to the mains.

⚠️ The **earth leakage current** of the AC drives exceeds 3.5mA AC. According to standard EN61800-5-1, **a reinforced protective ground connection** must be ensured. See chapter 1.3.

⚠️ If the AC drive is used as a part of a machine, the **machine manufacturer is responsible** for providing the machine with a **supply disconnecting device** (EN 60204-1).

⚠️ Only **spare parts** delivered by VACON® can be used.

⚠️ At power-up, power break or fault reset **the motor will start immediately** if the start signal is active, unless the pulse control for Start/Stop logic has been selected. Futhermore, the I/O functionalities (including start inputs) may change if parameters, applications or software are changed. Disconnect, therefore, the motor if an unexpected start can cause danger.

⚠️ The **motor starts automatically** after automatic fault reset if the auto restart function is activated. See the Application Manual for more detailed information.

⚠️ **Prior to measurements on the motor or the motor cable**, disconnect the motor cable from the AC drive.

⚠️ **Do not touch the components on the circuit boards**. Static voltage discharge may damage the components.

⚠️ Check that the **EMC level** of the AC drive corresponds to the requirements of your supply network.

1.3   Earthing and earth fault protection

⚠ CAUTION!

The AC drive must always be earthed with an earthing conductor connected to the earthing terminal marked with (⏚).

The earth leakage current of the drive exceeds 3.5mA AC. According to EN61800-5-1, one or more of the following conditions for the associated protective circuit shall be satisfied:

b)   The protective conductor shall have a cross-sectional area of at least 10 mm2 Cu or 16 mm2 Al, through its total run.

c)   Where the protective conductor has a cross-sectional area of less than 10 mm2 Cu or 16 mm2 Al, a second protective conductor of at least the same cross-sectional area shall be provided up to a point where the protective conductor has a cross-sectional area not less than 10 mm2 Cu or 16 mm2 Al.

d)   Automatic disconnection of the supply in case of loss of continuity of the protective conductor.

The cross-sectional area of every protective earthing conductor which does not form part of the supply cable or cable enclosure shall, in any case, be not less than:

- 2.5mm² if mechanical protection is provided or
- 4mm² if mechanical protection is not provided.

The earth fault protection inside the AC drive protects only the drive itself against earth faults in the motor or the motor cable. It is not intended for personal safety.

Due to the high capacitive currents present in the AC drive, fault current protective switches may not function properly.

⚠   **Do not perform any voltage withstand tests** on any part of the AC drive. There is a certain procedure according to which the tests shall be performed. Ignoring this procedure may result in damaged product.

NOTE! You can download the English and French product manuals with applicable safety, warning and caution information from http://drives.danfoss.com/knowledge-center/technical-documentation/.
REMARQUE Vous pouvez télécharger les versions anglaise et française des manuels produit contenant l'ensemble des informations de sécurité, avertissements et mises en garde applicables sur le site http://drives.danfoss.com/knowledge-center/technical-documentation/.

2.   Modbus - general info

Modbus is a communication protocol developed by Modicon systems. In simple terms, it is a way of sending information between electronic devices. The device requesting the information is called the Modbus Master (or the Client in Modbus TCP/UDP) and the devices supplying information are Modbus Slaves (in Modbus TCP/UDP servers). The Master can also write information to the Slaves. Modbus is typically used to transmit signals from instrumentation and control devices back to a main controller or data gathering system.

Standard Modbus network contains one Master device and up to 247 Slave devices. In ModbusRTU and ModbusUDP networks it is mandatory to define a unique Slave Address (or Unit identifier number) for the every Slave Device. Slave Address is a number between 1 and 247. In ModbusTCP networks, it is not mandatory to define a unique Slave Address, because the IP address identifies the device.

The Modbus communication interface is built around messages. The format of these Modbus messages is independent of the type of physical interface used. The same protocol can be used regardless of the connection type. Because of this, Modbus gives the possibility to easily upgrade the hardware structure of an industrial network, without the need for large changes in the software. A device can also communicate with several Modbus nodes at once, even if they are connected with different interface types, without the need to use a different protocol for every connection.
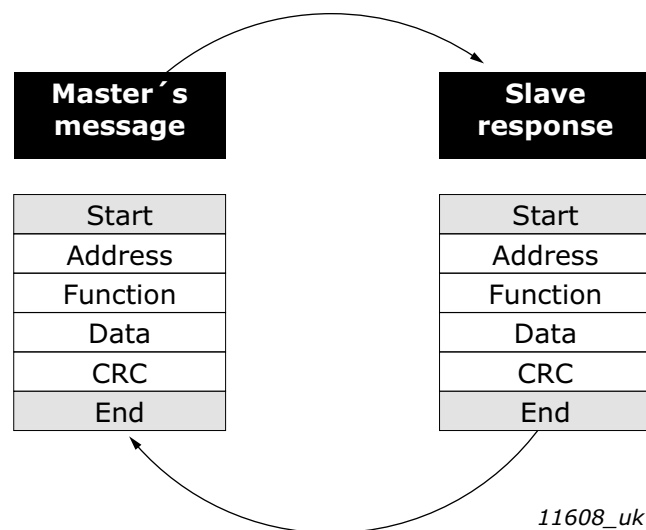
Figure 1.Basic structure of Modbus frame

On simple interfaces like RS485, the Modbus messages are sent in plain form over the network. In this case the network is dedicated to Modbus. When using more versatile network systems like TCP/IP over Ethernet, the Modbus messages are embedded in packets with the format necessary for the physical interface. In that case Modbus and other types of connections can co-exist at the same physical interface at the same time. Although the main Modbus message structure is peer-to-peer, Modbus is able to function on both point-to-point and multidrop networks.

Each Modbus message has the same structure. Four basic elements are present in each message. The sequence of these elements is the same for all messages, to make it easy to parse the content of the Modbus message. A conversation is always started by a master in the Modbus network. A Modbus master sends a message and—depending of the contents of the message—a slave takes action and responds to it. There can be more masters in a Modbus network. Addressing in the message header is used to define which device should respond to a message. All other nodes on the Modbus network ignore the message if the address field does not match their own address.

Your VACON® 100 family AC drive is equipped with Modbus support as standard. If you need to con-
tact VACON® service in problems related to Modbus, send a description of the problem together
with the Drive Info File taken with VACON® Live to customer support. If possible, also send a "Wire-
shark" log from the situation if applicable.
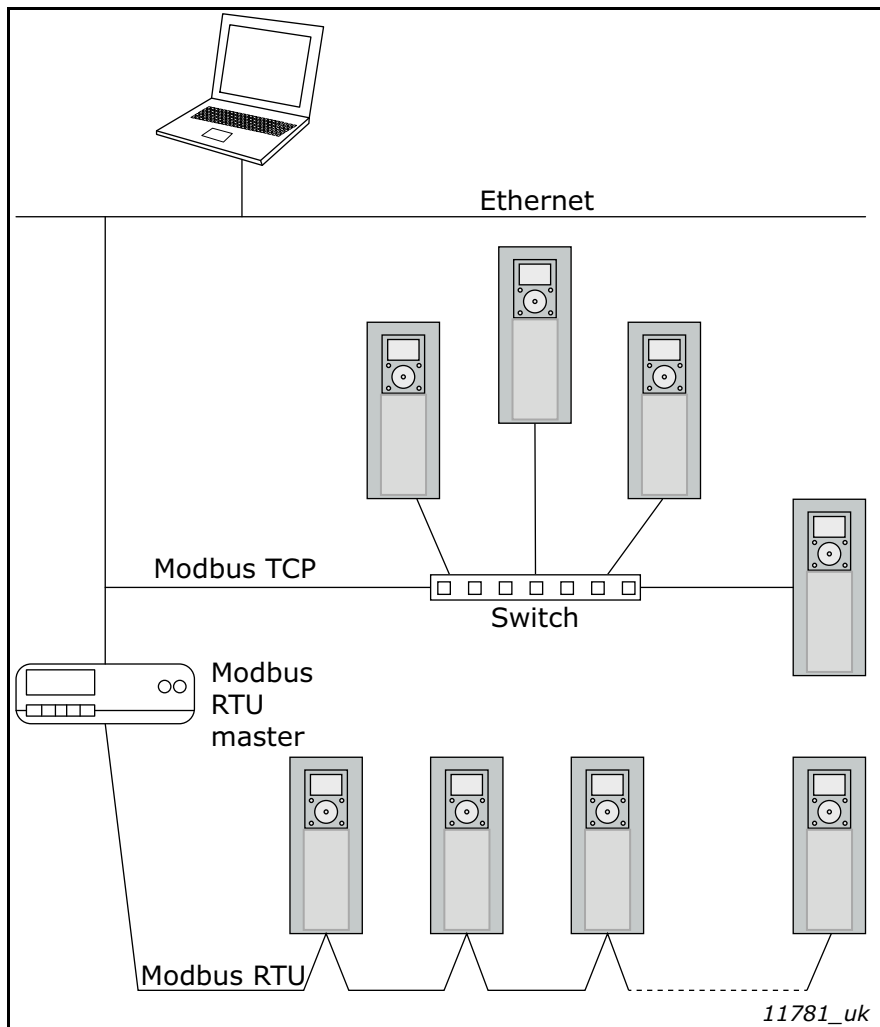
Figure 2.Principal example diagram of Modbus

3.   Modbus technical data

3.1   Modbus RTU protocol

Table 2.

Connections and communications	Interface	RS-485
	Data transfer method	RS-485 MS/TP, half-duplex
	Transfer cable	STP (Shielded Twisted Pair), type Belden 9841 or similar
	Connector	2.5 mm^2
	Electrical isolation	Functional
	Modbus RTU	As described in "Modicon Modbus Protocol Reference Guide"
	Bitrate	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 76800, 115200 and 230400 bits/s
	Addresses	1 to 247

3.2   Modbus TCP protocol

Table 3.

Connections and communications	Interface	100BaseTX, IEEE 802.3 compatible
	Data transfer method	Ethernet half/full -duplex
	Data transfer speed	10/100 MBit/s, autosensing
	Protocol	Modbus TCP
	Connector	Shielded RJ45 connector
	Cable type	CAT5e STP
	Modbus TCP	As described in Modbus Messaging Implementation Guide
	Default IP	Selectable: Fixed or DHCP (AutoIP)

3.3   Modbus UDP vs TCP

In addition to TCP, the VACON® 100 family AC drive supports also UDP starting from following firmware versions:

- VACON® 100 INDUSTRIAL and VACON® 100 X: FW0072V025
- VACON® 100 FLOW: FW0159V016
- VACON® 100 HVAC: FW0065V035

It is recommended that UDP is used when reading and writing rapidly and repetitively (cyclically) the same data as in case of process data. TCP must be used for single operations, like service data (e.g. reading or writing parameter values).

The key difference between UDP and TCP is that when using TCP, each and every Modbus frame needs to be acknowledged by the receiver (see the figure below). This adds extra traffic to the network and more load to the system (PLC and drives) because software needs to keep track of sent frames to make sure that they have reached their destination.

11716_uk
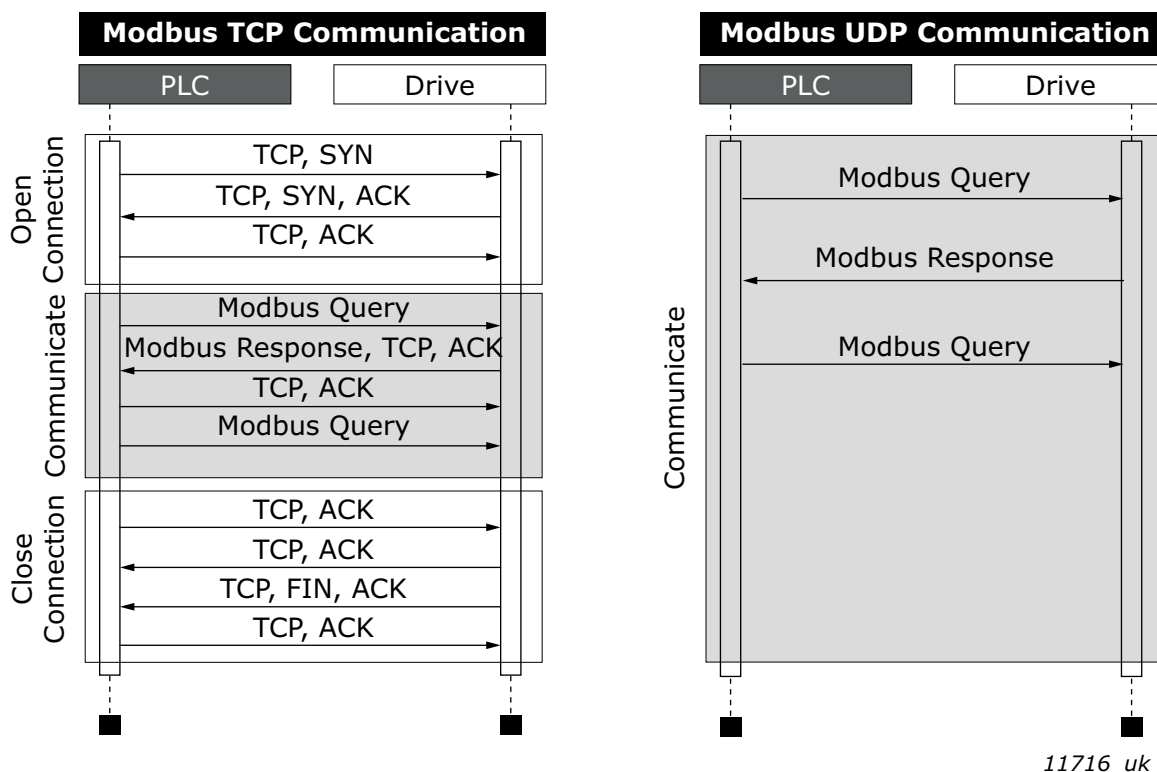
Figure 3. Modbus TCP and UDP communication comparison

Another difference between TCP and UDP is that UDP is connectionless. TCP connections are always opened with TCP SYN messages and closed with TCP FIN or TCP RST. With UDP, the first packet is already a Modbus query. IP address and port combination is treated as a connection. If port number changes, it is considered as a new connection or as a second connection if both stay active.

When using UDP, it is not guaranteed that the sent frame reaches its destination. The PLC must keep track of the Modbus requests by using the Modbus transaction id-field. It actually must do this also when using TCP. If the PLC does not receive response in time from the AC drive in UDP connection, it needs to send the query again. When using TCP, the TCP/IP stack will keep resending the request until it has been acknowledged by the receiver (see Figure 4). If the PLC sends new queries during this time, some of those may not be sent to the network (by TCP/IP stack) until previous sent package(s) has been acknowledged. This can cause small packet storms when the connection is resumed between the PLC and the AC drive (See Figure 5).

Modbus TCP Communication

PLC	Drive

Modbus Query (1)
Modbus Response (1), TCP, ACK
TCP, ACK
Modbus Query (2)

Packet lost, no response

TCP retransmission, Modbus Query (2)

Packet lost, no response

TCP retransmission, Modbus Query (2)
Modbus Response (2), TCP, ACK

Normal communication continues

Modbus UDP Communication

PLC	Drive

Modbus Query (1)
Modbus Response (1)
Modbus Query (2)

Packet lost, no response

Modbus Query (3)

Packet lost, no response

Modbus Query (4)
Modbus Response (4)

Normal communication continues

11717_uk

Figure 4. Modbus TCP and UDP communication errors comparison

Modbus TCP Communication

PLC			Drive
Modbus	TCP stack	TCP stack	Modbus

Modbus Query (1)
TCP Modbus Query
Modbus Query (2)
Retransmission Modbus Query (1)
Retransmission Modbus Query (1,2)
Modbus Query (3)
Retransmission Modbus Query (1,2,3)

Packet lost

Modbus Query (4)
Retransmission Modbus Query (1,2,3)
Modbus Query (1,2,3)
TCP, ACK
TCP, Modbus Query (4)
TCP, ACK
Modbus Response (1,2,3)
TCP, Modbus Response (1,2,3)
Modbus Response (1,2,3)
Modbus Response (1,2,3)
TCP, ACK
Modbus Query (4)
TCP, Modbus Response (4)
Modbus Response (4)
Modbus Response (4)
TCP, ACK
Modbus Response (4)

Normal communication continues

11718_uk

Figure 5. Modbus TCP retransmissions

3

Local contacts: http://drives.danfoss.com/danfoss-drives/local-contacts/

Losing one packet is not a big issue because the same request can be sent again after timeout. In TCP, the packages always reach their destination but if network congestion causes retransmissions, the resent packages will most likely contain old data or instructions when they reach their destination.

3.4   Connections and wiring

The VACON® 100 family AC drive supports 10/100Mb speeds in both Full- and Half-duplex modes. However, real-time process control requires the Full-duplex mode and the 100-megabit speed. Drives must be connected to the Ethernet network with a Shielded Twisted Pair (STP) CAT-5e cable (or better). Use only industrial standard components in the network and avoid complex structures to minimize the length of response time and the amount of incorrect dispatches.

The maximum length of an RS-485 cable depends on the bitrate used, the cable (gauge, capacitance or characteristic impedance) and the number of devices in the bus. The Modbus RTU specification states that for a maximum 9600 bits/second bitrate and AWG26 or wider gauge, the maximum length is 1000 meters. The actual cable length used in an installation can be lower than this number depending on the aforementioned parameters.

3.5   ACD (Address Conflict Detection) in Ethernet network

The VACON® 100 family AC drive implements the ACD algorithm (IETF RFC 5227).

The ACD algorithm tries to actively detect if the IP address configured to this device is used by another device in the same network. To accomplish this, the ACD sends four ARP request packets when the device's Ethernet interface goes up or when its IP address changes. The ACD prevents the use of the Ethernet interface until the ARP probing finishes. This delays the startup of fieldbus protocols about one second. During the delay or after it, the ACD passively checks incoming ARP messages for use of the device's IP address. If another device with the same IP address is detected, the ACD will try to defend its IP address with a single ARP message. If the other device with the same IP address also supports ACD, it should stop using the address. If not, the ACD will close the Ethernet connection and indicate the situation with an Alarm. This is done according the "DefendWithPolicyB". Acknowledging of the Alarm is not possible if the problem is active. The ACD opens an Ethernet connection if the other device with the same IP address disappears from the network. The alarm can be acknowledged after this. Other policies are not supported. If the fieldbus protocol has been active, a fieldbus fault may be activated (depends on the fieldbus and drive application configuration).

The ACD functionality can be enabled and disabled with Duplicate IP Detection panel parameter (see Chapter 5.3.1 Ethernet common settings (M5.9.1)).

4.   INSTALLATION
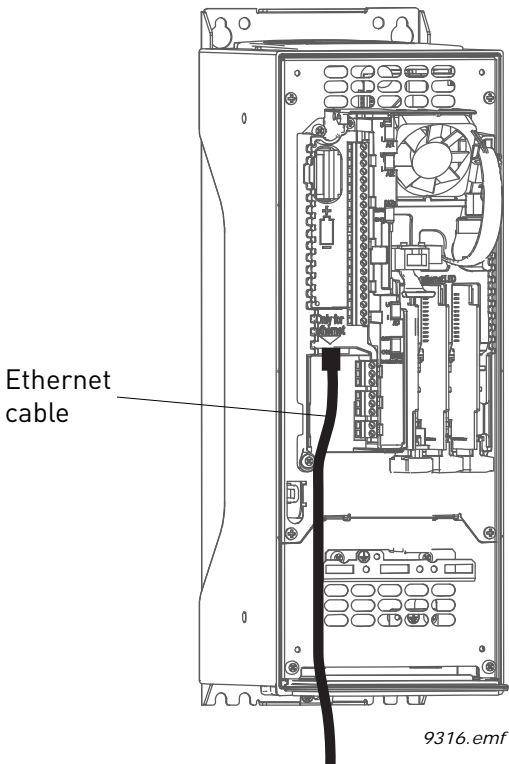
4.1   INSTALLATION IN VACON® 100 FAMILY AC DRIVES

1	Open the cover of the AC drive. M4x55 *9174.emf*

⚠	The relay outputs and other I/O-terminals may have a dangerous control voltage present even when the AC drive is disconnected from mains.

2	Open the inner cover of the drive. PUSH *9235.emf*

4.1.1   PREPARE FOR USE THROUGH ETHERNET

3	Connect the Ethernet cable (see specification in Chapter 3.2) to its terminal as shown in figure below. Ethernet cable *9316.emf*

4	**Protection class IP21:** Cut free the opening on the AC drive cover for the Ethernet cable. **Protection class IP54:** Cut the rubber grommets open to slide the cables through. Should the grommets fold in while inserting the cable, just draw the cable back a bit to straighten the grommets up. Do not cut the grommet openings wider than what is necessary for the cables you are using. **NOTE!** To meet the requirements of the enclosure class IP54, the connection between the grommet and the cable must be tight. Therefore, lead the first bit of the cable out of the grommet **straight** before letting it bend. If this is not possible, the tightness of the connection must be ensured with insulation tape or a cable tie. 9068.emf
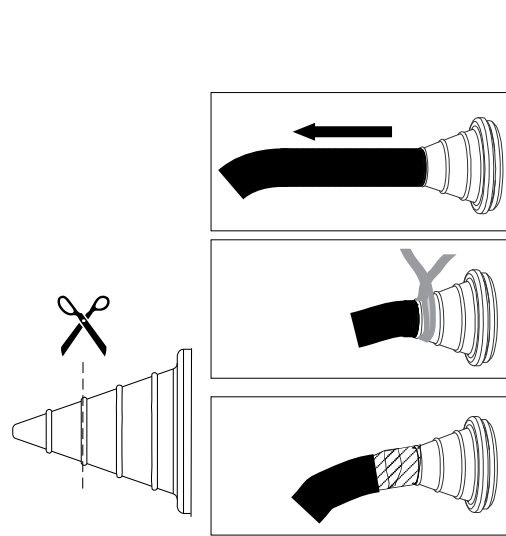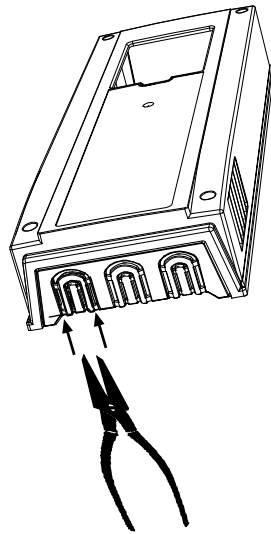
5	Remount the AC drive cover. **NOTE!** When planning the cable runs, remember to keep the distance between the Ethernet cable and the motor cable at a **minimum of 30 cm**. See figure below. Ethernet cable IP21 IP54 9265.emf

Local contacts: http://drives.danfoss.com/danfoss-drives/local-contacts/

4.1.2   Prepare for use through RS485

1	Strip about 15 mm of the RS485 cable (see specification in Chapter 3.1) and cut off the grey cable shield. Remember to do this for both bus cables (except for the last device). Leave no more than 10 mm of the cable outside the terminal block and strip the cables at about 5 mm to fit in the terminals. See picture below. *9189.emf* Also strip the cable now at such a distance from the terminal that you can fix it to the frame with the grounding clamp. Strip the cable at a maximum length of 15 mm. **Do not strip the aluminum cable shield!** *9188.emf*
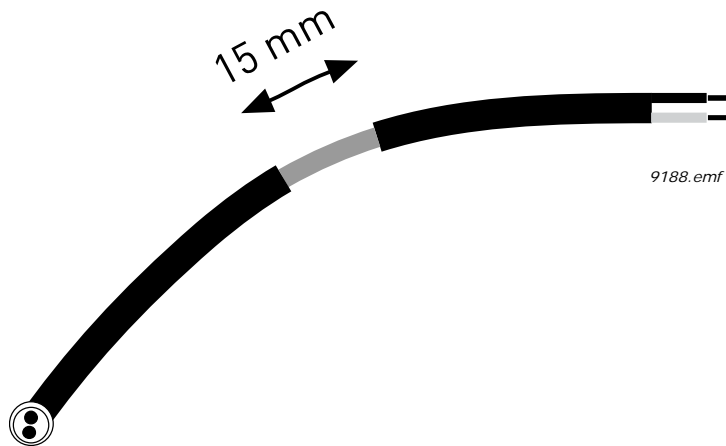
2	Then connect the cable to its appropriate terminals on VACON® 100 family AC drive standard terminal block, terminals **A and B** (A = negative, B = positive). See figure below. *9115.emf*
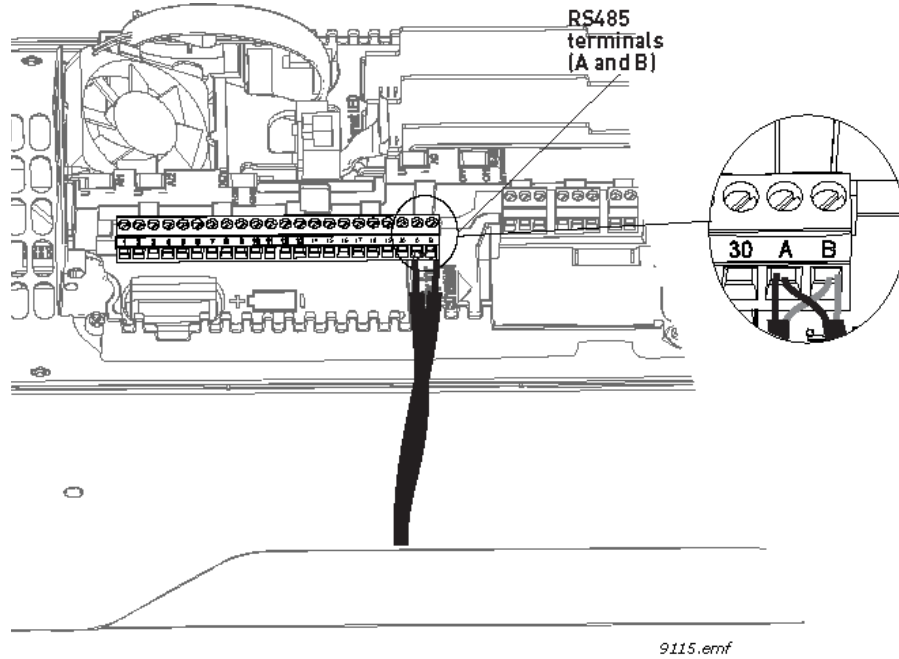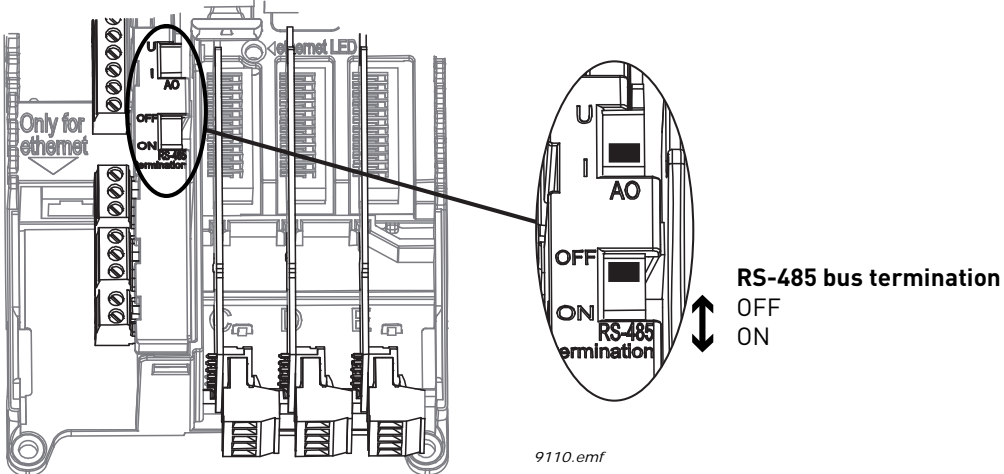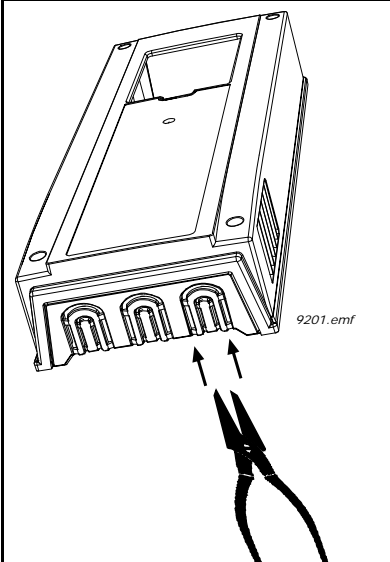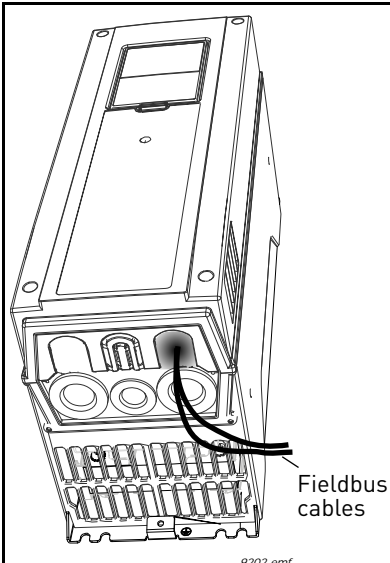
3	Using the cable clamp included in the delivery of the drive, ground the shield of the RS485 cable to the frame of the AC drive. **NOTE!** This can be done in all drives if there is no difference in PE potentialbe-tween the drives. However, if there is PE potential difference then the shield-should be connected to PE only at one point in the system. The shields of thecables shall be joint but not connected to several PE points with different poten-tial. **NOTE!** This is only a principle drawing and the actual drive may look different. Cable clamp *3020.emf*

4	**If VACON**® **100 family AC drive is the last device on the bus**, the bus termination must be set. Locate the DIP switches to the right of the control keypad of the drive and turn the switch for the RS485 bus termination resistor to position ON. Biasing is built in the termination resistor. See also step 6 on page 18. *9110.emf* **RS-485 bus termination** OFF ON
5	Unless already done for the other control cables, cut free the opening on the AC drive cover for the RS485 cable (protection class IP21). **NOTE!** This is only a principle drawing and the actual drive may look different. *9201.emf*
6	Remount the AC drive cover and run the RS485 cables as shown in picture. **NOTE!** When planning the cable runs, remember to keep the distance between the fieldbus cable and the motor cable at a **minimum of 30 cm**. Fieldbus cables *9202.emf*

7	The bus termination must be set for the first and the last device of the fieldbus line. See picture below. See also step 3 on page 17. We recommend that the first device on the bus and, thus, terminated was the Master device.
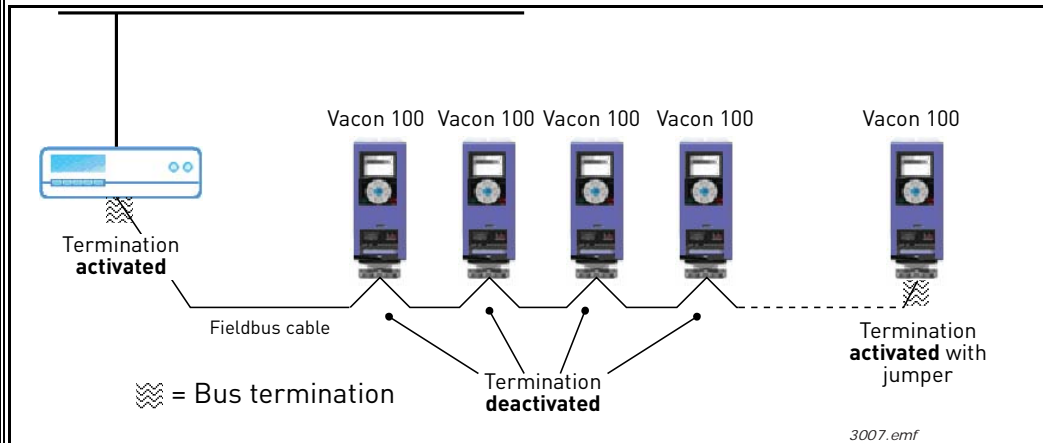
4.2   INSTALLATION IN VACON® 100 X

The AC drive can be connected to fieldbus either through RS485 or Ethernet. The connection for RS485 is on the standard I/O terminals (A and B) and the connection for Ethernet is left to the control terminals.
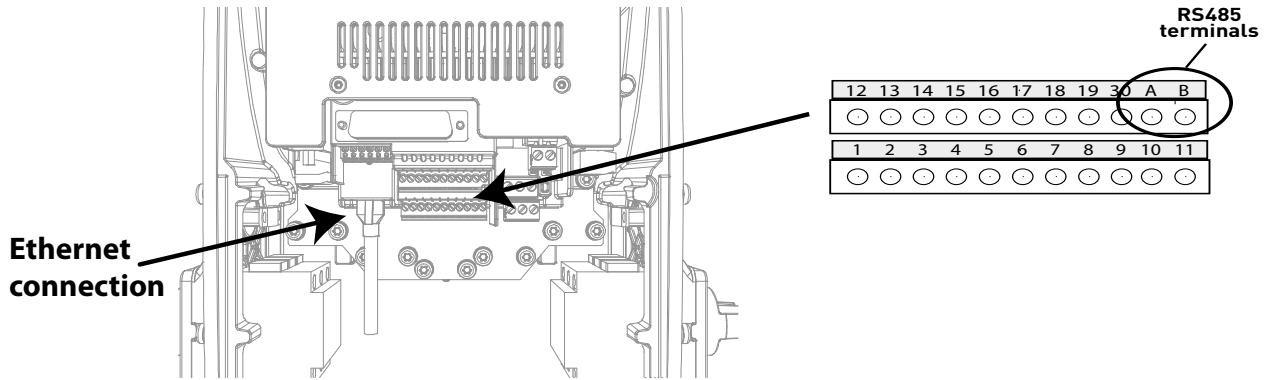
Figure 6.
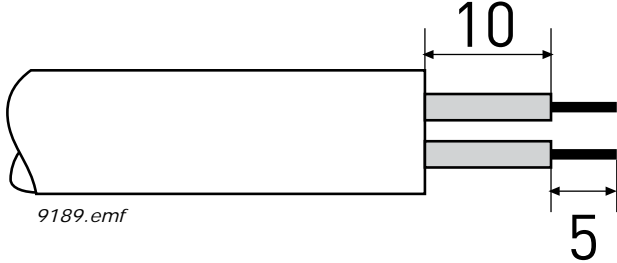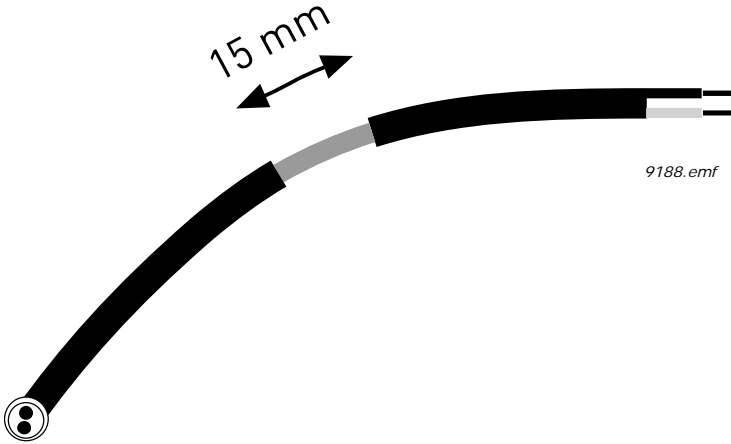
4.2.1   PREPARE FOR USE THROUGH ETHERNET

1	Connect the Ethernet cable (see specification in Chapter 3.2) to its terminal and run the cable through the conduit plate.

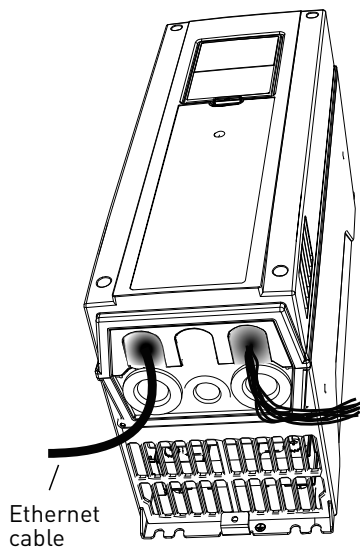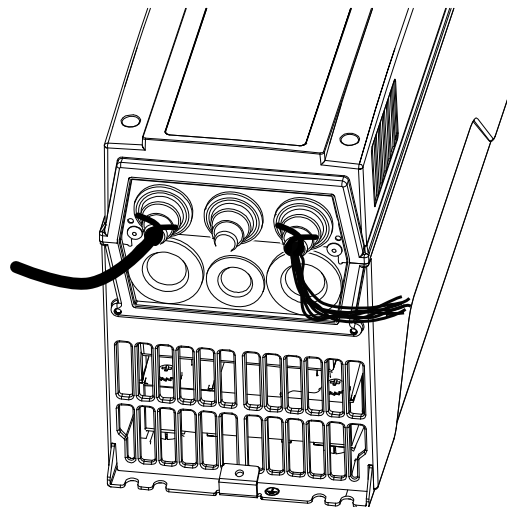| 2	Remount the powerhead. **NOTE:** When planning the cable runs, remember to keep the distance between the Ethernet cable and the motor cable at a minimum of 30 cm.

For more detailed information, see the user's manual of the fieldbus you are using.

4.2.2   Prepare for use through RS485

1	Strip about 15 mm of the RS485 cable (see specification in Chapter 3.1) and cut off the grey cable shield. Remember to do this for both bus cables (except for the last device). Leave no more than 10 mm of the cable outside the terminal block and strip the cables at about 5 mm to fit in the terminals. See picture below. 10 9189.emf 5 Also strip the cable now at such a distance from the terminal that you can fix it to the frame with the grounding clamp. Strip the cable at a maximum length of 15 mm. **Do not strip the aluminum cable shield!** 15 mm 9188.emf

2	Then connect the cable to its appropriate terminals on VACON® 100 X AC drive standard terminal block, terminals A and B (A = negative, B = positive). See Figure 6.

3	Using the cable clamp included in the delivery of the drive, ground the shield of the RS485 cable to the frame of the AC drive.

4

If VACON® 100 X AC drive is the last device on the bus, the bus termination must be set. Locate the DIP switches to the top of the control unit (see figure below).
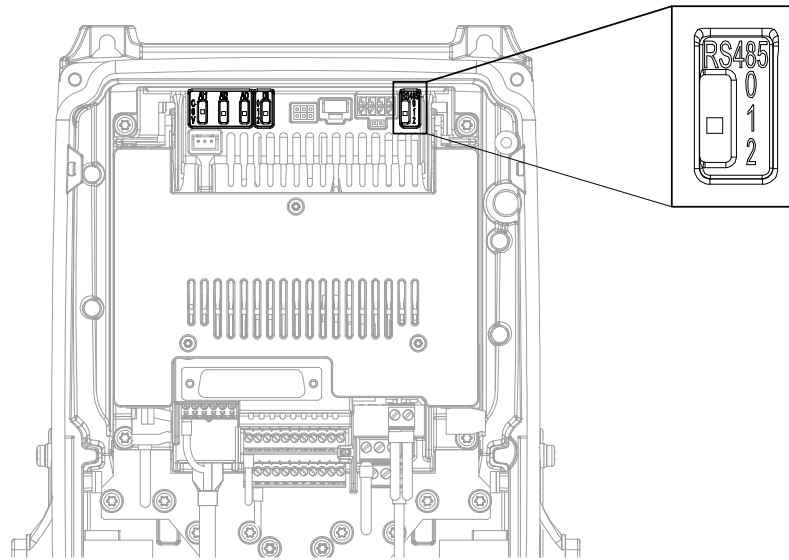
Turn the right most switch to position "1". Biasing is built in the termination resistor. See also step 6.

NOTE: When planning the cable runs, remember to keep the distance between the fieldbus cable and the motor cable at a **minimum of 30 cm**.
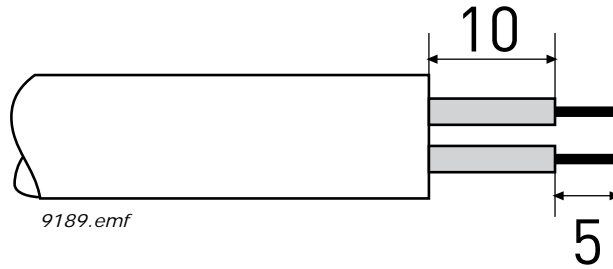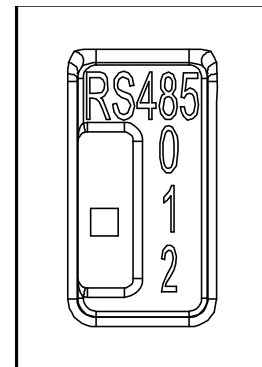
5

The bus termination must be set for the first and the last device of the fieldbus line. See picture below and step 4. We recommend that the first device on the bus and, thus, terminated, was the Master device.

Vacon 100   Vacon 100   Vacon 100   Vacon 100   Vacon 100

Termination
activated

Modbus RTU

Termination
activated with
DIP switch

▨ = Bus termination

Termination
deactivated
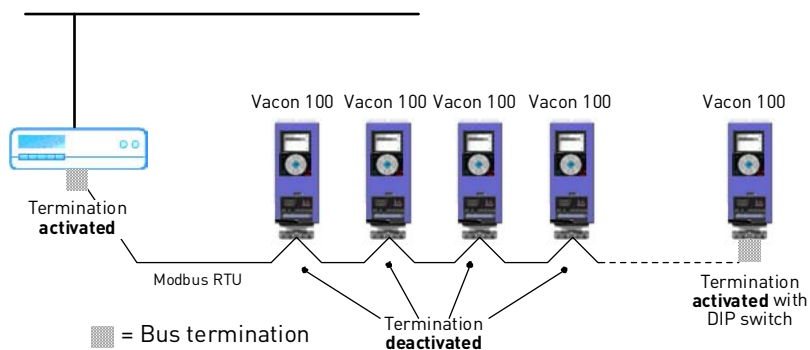
5.   FIEDLBUS PARAMETRIZATION

The following chapter describes briefly how to parametrise the AC drive in order for the motor to be controllable via fieldbus. These instructions are written for basic applications. For more information, consult the application-specific manual.

In order for the AC drive to accept commands from the fieldbus network, the control place of the AC drive has to be set to fieldbus. The default value of the parameter "Control Place" is usually I/O. Note that if the control unit firmware is updated, the default settings are restored. In addition, some applications may have the remote speed reference selection set by default to other than fieldbus. In these cases, the speed reference selection must be set to fieldbus, in order for the speed reference to be controlled via fieldbus.

NOTE! The motor control mode should be selected to support the used process and profile.

The navigation path to the fieldbus parameters may differ from application to application. The exemplary paths below apply to the VACON$^®$ 100 family AC drive.

5.1   FIELDBUS CONTROL AND BASIC REFERENCE SELECTION

The following tables list some of the parameters related to fieldbus control in case of VACON$^®$ applications for the VACON$^®$ 100 family AC drive. See the application specific manuals for more detailed information.

Parameters can be read and written by using the drive panel, PC Tool or fieldbus protocol. See Chapter 6.3.5 for reading and writing application parameters over Modbus. Notice that some of connection parameters for fieldbus may need to be set (depending on your configuration) via panel or PC tool, before you can connect over fieldbus and write application parameters.

Table 4. Parametrization for VACON$^®$ 100 family AC drive (Standard application)

Parameter name	ID	Value	Default	Panel Tree
Control mode	600	0 = Frequency 1 = Speed 2 = Torque	0	P 3.1.2.1
Remote control place	172	1 = Fieldbus CTRL	0	P 3.2.1
Local / remote	211	0 = Remote	0	P 3.2.2
Fieldbus ref. sel.	122	3 = Fieldbus	3	P 3.3.1.10

5.1.1   TORQUE CONTROL PARAMETRIZATION

Some extra parametrisation has to be made in order to control the frequency control with torque control. The following instructions are for the VACON$^®$ 100 family AC drives, see the application specific manual for more detailed information.

- Motor control mode (ID 600) must be configured to "Torque control" (2).

   To configure the drive to use correct torque reference, select the parameter "Torque Reference Selection" to ProcessDataIn1 (9). This can be done with: PC-tool or panel in panel tree: P 3.3.2.1, ID 64

5.1.2   Enabling Modbus protocol

Modbus TCP/UDP is always enabled in VACON$^{®}$ 100 family devices. You need to parametrize the network settings (IP address etc) before using it. See Chapter 5.3.1.

When using Modbus RTU, you need to enable the protocol. After enabling it, protocol settings will appear under panel tree P5.8.3.

Table 5. Enabling Modbus RTU protocol

Parameter name	ID	Value	Default	Panel Tree
RS-485 protocol	2208	0 = No Protocol 1 = Modbus RTU 2 = BACnet MSTP 3 = N2	No protocol	P 5.8.1.1

5.2   Modbus RTU parameters and monitoring values (M5.8.3)

Table 6. Parameters related with Modbus used through RTU

Panel Tree	Parameter	Range	Default	ID	Description
P5.8.3.1.1	Slave address	1...247	1	2320	Unique slave device address.
P5.8.3.1.2	Baud rate	300...230400	6	2378	Communication speed 300 600 1200 2400 4800 9600 19200 38400 57600 76800 115200 230400
P5.8.3.1.4	Stopbits	1...3	3	2380	1 = 1 stop bit 2 = 1.5 stop bits 3 = 2 stop bits
P5.8.3.1.3	Parity type	0...2	0	2379	0 = Even 1 = Odd 2 = None
P5.8.3.1.5	Communication time-out	0...65535	10	2321	Unit is seconds 0 = Not used
P5.8.3.1.6 *	Operate Mode	0...1	0	2374	0 = Slave 1 = Master
P5.8.3.1.7.1-30	IDMap IDs	0...65535	0	3130-3159	IDMap IDs

* This feature is not supported in VACON$^{®}$ 100 HVAC. The default application in the VACON$^{®}$ 100 family AC drives supports only Slave mode. A special application is required for Master functionality.

5.2.1   Slave address

Each slave must have a unique address (from 1 to 247) so that it can be addressed independently from other nodes.

5.2.2   Baud rate

Select the communication speed for the network. The default value is 9600 baud.

5.2.3   Parity type

You can select the parity type for the network. Modbus RTU specifies the stop bit configuration shown in table below. You can modify this stop bit configuration manually using parameter P5.X.3.1.4.

Table 7. Parity type and stop bits

Parity	Stopbits
Even	1
Odd	1
None	2

5.2.4   Stop bits

You can select the stop bit amount for the Modbus RTU network.

5.2.5   Communication timeout

Modbus initiates a communication error for a time defined with this parameter. '0' means that no fault is generated.

5.2.6   Operate mode

Used to select the operate mode of the Modbus RTU protocol (slave / master). This feature is not supported in VACON® 100 HVAC. The default application in the VACON® 100 family AC drives supports only Slave mode. A special application is required for Master functionality.

Table 8. Operate mode values

Value	Description
0	Slave
1	Master

5.2.7   IDMap IDs

See Chapter 6.3.8.

Table 9. Monitoring values related with Modbus used through RTU

Panel Tree	Parameter	Range	ID	Description
P5.8.3.2.1	Fieldbus protocol status	1...3	2381	0 = Init 1 = Stopped 2 = Operational 3 = Faulted
P5.8.3.2.2	Communication status	0.0...99.999	2382	0-99 Number of messages with errors 0-999 Number of messages without communication errors Reset on drive restart
P5.8.3.2.3	Illegal functions	0...65535	2383	
P5.8.3.2.4	Illegal data addresses	0...65535	2384	
P5.8.3.2.5	Illegal data values	0...65535	2385	
P5.8.3.2.6	Slave device busy	0...65535	2386	
P5.8.3.2.7	Memory parity error	0...65535	2387	
P5.8.3.2.8	Slave device failure	0...65535	2388	
P5.8.3.2.9	Last fault response	0...65535	2389	
P5.8.3.2.10	Control word	-	2390	Shown as hex value
P5.8.3.2.11	Status word	-	2391	Shown as hex value

5.2.8   Fieldbus protocol status

Fieldbus Protocol Status tells the status of the protocol.

Table 10. Fieldbus protocol status descriptions

Status	Description
INITIALIZING	Protocol is starting up
STOPPED	No connections active via fieldbus
OPERATIONAL	Protocol is running. At least one active connection
FAULTED	Fieldbus connection has timedout.

5.2.9   Communication status

The Communication status shows how many good and bad messages the drive has received. The Communication status includes a common error counter that counts CRC and parity errors and a counter for good messages.

Only messages to the current slave in use are counted in the good messages.

Table 11. Communication status description

Good messages	
0...999	Number of messages received without errors
Bad messages	
0...99	Number of messages received with errors

5.2.10   Illegal functions

This value counts error situations. The function code received in the query refers to a not allowed action for the server (or slave). This corresponds to Modbus fault code 01h.

5.2.11   Illegal data addresses

This value counts error situations. The data address received in the query refers to not allowed address for the server (or slave). This corresponds to Modbus fault code 02h.

5.2.12   Illegal data values

This value counts error situations. A value contained in the query data field refers to a not allowed value for server (or slave). This corresponds to Modbus fault code 03h.

5.2.13   Slave device busy

This value counts error situations. The server (or slave) is engaged in processing a long-duration program command. The client (or master) should retransmit the message later when the server (or slave) is free. This corresponds to Modbus fault code 06h.

5.2.14   Memory parity error

This value counts error situations. The server (or slave) attempted to read record file but detected a parity error in the memory. This corresponds to Modbus fault code 08h.

5.2.15   Slave device failure

This value counts error situations. An unrecoverable error occurred while the server (or slave) was attempting to perform the requested action. This corresponds to Modbus fault code 04h.

5.2.16   Last fault response

Shows the last fault response as Fault code.

5.2.17   Control word

Shows the Control Word received from the bus.

5.2.18   Status word

Shows the current Status Word that is sent to the bus.

5.3   Modbus TCP/UDP parameters and monitoring values

5.3.1   Ethernet common settings (M5.9.1)

Table 12. Ethernet common settings (M5.9.1)

Panel Tree	Parameter	Range	Default	ID	Description
P5.9.1.1	IP address mode	Fixed (1), DHCP(2)	DHCP (2)	2482	IP Mode
P5.9.1.2	Duplicate IP Detection	Disabled (0), Enabled (1)	enabled	2569	This is setting for enabling ACD (See Chapter 3.4). When disabled drive does not check for or react to address conflict situation.
P5.9.1.3.1	IP address	1.0.0.0 - 223.255.255.255	192.168.0.10	2529	Fixed IP address
P5.9.1.3.2	Subnet mask	0.0.0.0- 255.255.255.255	255.255.0.0	2530	Fixed Subnet mask
P5.9.1.3.3	Default gateway	0.0.0.0- 255.255.255.255	192.168.0.1	2531	Fixed default gateway
P5.9.1.4	Active IP address	-	-	2483	Shows current active IP address. It is same as fixed value if IP mode is "Fixed".
P5.9.1.5	Active subnet mask	-	-	2484	Shows current active subnet mask. It is same as fixed value if IP mode is "Fixed".
P5.9.1.6	Active default gateway	-	-	2485	Shows current active default gateway. It is same as fixed value if IP mode is "Fixed".
P5.9.1.7	MAC address	-	-	2486	Drive MAC address

5.3.2   IP Address mode

Selectable alternatives are DHCP (Dynamic Host Configuration Protocol) and Fixed. The DHCP protocol gives IP addresses to new devices connecting to local network. This address is valid for a certain period of time. If no DHCP server is found, an automatic random IP is given. A fixed IP address is specified manually and it does not change. When the mode is changed from DHCP to Fixed the addresses will read:

IP: 192.168.0.10

Subnet mask: 255.255.0.0

Default gateway: 192.168.0.1

5.3.3   Fixed IP address

An IP address is a series of numbers (like above) specific to the device connected to the Internet.

5.3.4   Fixed Subnet Mask

The network mask marks all the bits of an IP address for the identification of the network and the subnetwork.

5.3.5   Fixed default gateway

Gateway address is the IP address of a network point that acts as an entrance to another network.

5.3.6   Active IP address, subnet mask and default gateway

This value cannot be changed. If the IP mode is "fixed", it will display the same value as in Fixed IP address (5.3.3). If the mode is "DHCP", the value is 0.0.0.0 when the DHCP is retrieving IP settings or 169.x.x.x if it could not retrieve an address. Otherwise it shows the currently active IP address.

5.3.7   MAC Address

The MAC address of the control board. The MAC address (Media Access Control) is a unique address given to each network host. It is not editable.

5.3.8   Modbus TCP/UDP settings (M5.9.2)

Table 13. Modbus TCP/UDP parameters

Panel Tree	Parameter	Range	Default	ID	Description
P5.9.2.1.1	Connection limit	0...3	3	2446	Number of allowed connections
P5.9.2.1.2	Unit identifier number	0...255	255	2447	See Chapter 5.2.10
P5.9.2.1.3	Communication time-out	0...65535	10	2448	Unit is seconds 0 = Not used
P5.9.2.1.4.1-30	IDMap IDs	0...65535	0	3100-3129	IDMap IDs

The monitoring values menu structure is duplicated to all connections. Maximum number of connections is three (3). Monitoring menus are visible even though connection has not been opened.

Table 14. Modbus TCP/UDP Monitoring values

Panel Tree	Parameter	Range	Unit	Default	ID	Description
P5.9.2.2.1.1	Fieldbus protocol status	1...3	-	-	2449	1 = Stopped 2 = Operational 3 = Faulted See 5.2.8
P5.9.2.2.1.2	Communication status	0.0...99.9999	-	0.0	2450	0-99 Number of messages with errors 0-999 Number of messages without communication errors See 5.2.9
P5.9.2.2.1.3	Illegal functions	0...65535	-	-	2451	See 5.2.10
P5.9.2.2.1.4	Illegal data addresses	0...65535	-	-	2452	See 5.2.11

Table 14. Modbus TCP/UDP Monitoring values

Panel Tree	Parameter	Range	Unit	Default	ID	Description
P5.9.2.2.1.5	Illegal data values	0...65535	-	-	2453	See 5.2.12
P5.9.2.2.1.6	Slave device busy	0...65535	-	-	2454	See 5.2.13
P5.9.2.2.1.7	Memory parity error	0...65535	-	-	2455	See 5.2.14
P5.9.2.2.1.8	Slave device fail-ure	0...65535	-	-	2456	See 5.2.15
P5.9.2.2.1.9	Last fault response	0	-	-	2457	See 5.2.16
P5.9.2.2.1.10	Control word	-	hex	-	2458	See 5.2.17
P5.9.2.2.1.11	Status word	-	hex	-	2459	See 5.2.18

5.3.9 Connection limit

Defines how many clients can access the server simultaneously.

5.3.10 Unit Identifier number

The Modbus 'slave address' field usually used on Modbus Serial Line is replaced by a single byte 'Unit Identifier'.

When the TCP is used as the communications protocol, the AC drive is addressed by its IP address and broadcast messages are not possible. In this case, the unit identifier is useless. In the UDP, it is possible to send broadcast messages and therefore the unit identifier becomes important.

To keep things simple, the unit identifier is checked when using both TCP and UDP. In TCP you can use value 255 (non-significant) as a unit identifier and send the messages to all slaves with that value.

5.3.11 Communication timeout

For Modbus, this value defines the time in which a message must be received (from Client in Modbus TCP/UDP) before a fieldbus fault is generated. If timeout is set to zero, no fault is created.

5.3.12 IDMap IDs

See Chapter 6.3.8.

6.   COMMUNICATIONS

Features of the Modbus-Vacon interface:

- Direct control of VACON® drive (e.g. Run, Stop, Direction, Speed reference, Fault reset)
- Full access to all VACON® parameters
- Monitor VACON® status (e.g. Output frequency, Output current, Fault code)

6.1   DATA ADDRESSES IN MODBUS MESSAGES

All data addresses in Modbus messages are referenced to zero. The first occurrence of a data item is addressed as item number zero. For example:

- The coil known as 'Coil 1' in a programmable controller is addressed as 'Coil 0000' in the data address field of a Modbus message.
- Coil 127 decimal is addressed as 'Coil 007E hex' (126 decimal).
- Holding register 40001 is addressed as register 0000 in the data address field of the message. The function code field already specifies a 'holding register' operation. Therefore the '4XXXX' reference is implicit.
- Holding register 40108 is addressed as register 006B hex (107 decimal).

6.2   SUPPORTED MODBUS FUNCTIONS

The VACON® variables and fault codes as well as the parameters can be read and written from Modbus. The parameter addresses are determined in the application. Every parameter and actual value have been given an ID number in the application. The ID numbering of the parameter as well as the parameter ranges and steps can be found in the application manual in question. The parameter value must be given without decimals. If several parameters/actual values are read with one message, the addresses of the parameters/actual values must be consecutive.

Table 15. Supported functions

Function (dec)	Function (hex)	Modbus Function Name	TCP/ UDP	RTU	Access type	Address range (hex)
1	1	Read coils	x		Discrete (1-bit)	00000-0FFFF
2	2	Read Discrete Inputs	x		Discrete (1-bit)	10000-1FFFF
3	3	Read Holding Registers	x	x	Register (16bit)	40000-4FFFF
4	4	Read Input Registers	x	x	Register (16bit)	30000-3FFFF
5	5	Write Single Coils	x		Discrete (1-bit)	00000-0FFFF
6	6	Write Single Register	x	x	Register (16bit)	40000-4FFFF
15	F	Write Multiple Coils	x		Discrete (1-bit)	00000-0FFFF
16	10	Write Multiple Registers	x	x	Register (16bit)	40000-4FFFF
23	17	Read/Write Multiple Registers	x	x	Register (16bit)	40000-4FFFF
NOTE! Broadcasting not supported in TCP. Broadcast supported with function code 06 and 16 in RTU and in UDP.						

The address ranges of the different function codes are in many cases not relevant to the user and can be ignored. The targeted information type (coil, register etc.) can be selected separate from the address.

6.3   Modbus data mapping

6.3.1   Coils registers

A "coil" in Modbus is a single-bit binary data item which can be both read and written. In VACON®
100 family AC drives, the coils refer to some bits in the fieldbus control word." See page 34.

Table 16. Defined coil registers

Address	Function	Purpose
0001	RUN/STOP	Control Word, bit 0
0002	Direction	Control Word, bit 1
0003	Fault reset	Control Word, bit 2
0017	Reset	Clears operation days trip counter
0018	Reset	Clears energy trip counter

6.3.2   Clearing resettable counters

The VACON® AC drives have trip counters for operation days and energy. These counters can be
reset to zero by writing value '1' to addresses defined in table below. You can also use coils defined
in chapter 6.3.1.

Table 17. Clearing trip counters

Address	Function	Purpose
40101	Reset	Clears operation days trip counter
40301	Reset	Clears energy trip counter

6.3.3   Discrete inputs

A "discrete input" in Modbus is a single-bit binary data item which is read-only. In VACON® 100
family AC drives, the discrete inputs refer to the fieldbus status word bits. See Chapter 10.

Table 18. Defined Input Discrete

Address	Function	Purpose
10001	Ready	Status Word, bit 0
10002	Run	Status Word, bit 1
10003	Direction	Status Word, bit 2
10004	Fault	Status Word, bit 3
10005	Alarm	Status Word, bit 4
10006	At reference	Status Word, bit 5
10007	Zero speed	Status Word, bit 6
10008	Flux ready	Status Word, bit 7

6.3.4   HOLDING REGISTERS AND INPUT REGISTERS

An "input register" in Modbus is a 16-bit value which is read-only. A "holding register" in Modbus is a 16-bit value which can be both read and written. Holding and input registers are accessed using different function codes, and the address ranges are different. In VACON® 100 family AC drives, the same information can be accessed as input registers and holding registers, i.e. input register X refers to the same 16-bit value as the holding register X.

The Modbus registers are mapped to the VACON® 100 family AC drive as follows:

Table 19. Defined holding registers

Address range	Purpose	Access type	See	R/W	Max R/W size
0001 - 2000	Vacon Application IDs	16bit	Table 20	RW	30/30
2001 - 2019	FBProcessDataIN	16bit	Table 21	RW	19/19
2051 - 2086	FBProcessDataIN	32bit	Table 21	RW	36/36
2101 - 2119	FBProcessDataOUT	16bit	Table 22	RO	19/0
2151 - 2186	FBProcessDataOUT	32bit	Table 22	RO	36/0
2200 - 10000	Vacon Application IDs	16bit	Table 20	RW	30/30
10501 - 10530	IDMap	16bit	Figure 7.	RW	30/30
10601 - 10630	IDMap Read/Write	16bit	Table 23	RW	30/30
10701 - 10760	IDMap Read/Write	32bit	Table 24	RW	30/30
20001 - 40000	Vacon Application IDs	32bit	Table 20	RW	30/30
40001 - 40005	Operation day counter	16bit	Table 26	RO	5/0
40011 - 40012	Operation day counter	32bit	Table 25	RO	2/0
40101 - 40105	Resettable operation day counter	16bit	Table 28	R, Write 1 to first index to reset	5/0
40111 - 40112	Resettable operation day counter	32bit	Table 27	RO	2/0
40201 - 40203	Energy counter	16bit	Table 30	RO	3/0
40211 - 40212	Energy counter	32bit	Table 29	RO	2/0
40301 - 40303	Resettable energy counter	16bit	Table 32	R, Write 1 to first index to reset	3/0
40311 - 40312	Resettable energy counter	32bit	Table 31	RO	2/0
40401 - 40430	Fault history	16bit	Table 33	RO	30/0
40501	Communication time out	16bit	Table 35	RW	1/1
40511-40568	Fault history with 16 bit fault codes	16bit	Table 34	RO	30/0

Accessing unsupported values returns the error code "Illegal Data Address".

6.3.5   Vacon Application IDs

Application IDs are parameters that depend on the drive's application. These parameters can be read and written by pointing the corresponding memory range directly or by using the so-called ID map (more information below). The easiest way to read a single parameter value or parameters with consecutive ID numbers is to use a straight address. It is possible to read 30 consecutive ID addresses. Notice that the operation will fail if even one of the consecutive IDs do not exist for such case see Chapter 6.3.8 ID map.

Parameters which have 32 bit value can be read from their own range. For example, if you want to read the value for ID 864 (FB Status Word), the address must be set to 21726. This address value comes from values: 20000 + ((ID -1) * 2). The ID value is reduced with one because of zero-based addressing and the result is multiplied with 2 because one 32 bit value will take two (16 bit) addresses.

Table 20. Application IDs

Address range	Purpose	Application ID
0001–2000	16 bit application parameters	1–2000
2200–10000	16 bit application parameters	2200–10000
20001–40000	32 bit application parameters	1–10000

6.3.6   FB Process data IN

The process data fields are used to control the drive (e.g. Run, Stop , Reference, Fault Reset) and to quickly read actual values (e.g. Output frequency, Output current, Fault code). The fields are structured as follows:

Process Data Master -> Slave (max 22 bytes)

Table 21. Fieldbus Process Data IN

Address		Name	Range/Type
16-bit[*]	32-bit		
2001	2051 = High data 2052 = Low data	FB Control Word	Binary coded
2002	-	FB General Control Word	Binary coded
2003	2053 = High data 2054 = Low data	FB Speed Reference	0...10000 (100%)
2004	2055 = High data 2056 = Low data	FB Process Data In 1	See Chapter 9. APPENDIX 1 - PROCESS DATA
2005	2057 = High data 2058 = Low data	FB Process Data In 2	
2006	2059 = High data 2060 = Low data	FB Process Data In 3	
2007	2061 = High data 2062 = Low data	FB Process Data In 4	
2008	2063 = High data 2064 = Low data	FB Process Data In 5	
2009	2065 = High data 2066 = Low data	FB Process Data In 6	
2010	2067 = High data 2068 = Low data	FB Process Data In 7	
2011	2069 = High data 2070 = Low data	FB Process Data In 8	

[*]. In VACON® 100 family AC drives, the Control Word and the Status Word are formed of 32 bits. Only the initial 16 bits can be read in the 16-bit area.

Control word bits

For control word bit descriptions, see Chapter 10. APPENDIX 2 - CONTROL AND STATUS WORD.

6.3.7   FB Process data OUT

Process Data Slave -> Master (max 22 bytes)

Table 22. Fieldbus Process Data Out

Address		Name	Range/Type
16-bit	32-bit		
2101	2151 = High data 2152 = Low data	FB Status Word	Binary coded
2102	-	In case of 16-bit, FB General Status Word (High data)	Binary coded
2103	2153 = High data 2154 = Low data	FB Actual Speed	0...10000 (100.00%)

Table 22. Fieldbus Process Data Out

Address		Name	Range/Type
16-bit	32-bit		
2104	2155 = High data 2156 = Low data	FB Process Data Out 1	See Chapter 9. APPENDIX 1 - PROCESS DATA
2105	2157 = High data 2158 = Low data	FB Process Data Out 2	
2106	2159 = High data 2160 = Low data	FB Process Data Out 3	
2107	2161 = High data 2162 = Low data	FB Process Data Out 4	
2108	2163 = High data 2164 = Low data	FB Process Data Out 5	
2109	2165 = High data 2166 = Low data	FB Process Data Out 6	
2110	2167 = High data 2168 = Low data	FB Process Data Out 7	
2111	2169 = High data 2170 = Low data	FB Process Data Out 8	

Status Word bits

For status word bit descriptions, see Chapter 10. APPENDIX 2 - CONTROL AND STATUS WORD.

6.3.8   ID MAP

Using the ID map, you can read consecutive memory blocks that contain parameters whose ID's are not in a consecutive order. The address range 10501 - 10530 is called 'IDMap', and it includes an address map in which you can write your parameter ID's in any order. The address range 10601 to 10630 is called 'IDMap Read/Write,' and it includes values for parameters written in the IDMap. As soon as one ID number has been written in the map cell 10501, the corresponding parameter value can be read and written in the address 10601, and so on. The address range 10701 - 10760 contains the ID Map read/write for 32bit values. Maximum of 30 IDs and ID values can be written and read with single request.

IDMap IDs can be also configured from the panel or VACON® Live PC tool. IDmap menu is located under Modbus TCP and Modbus RTU settings. See details in chapters 5.1 and 5.2.2.

Parameters	
ID	Value
699	123
700	321
701	456
702	654
703	1789
704	987
705	2741
706	1147
707	258
708	3852

ID Map			
Address	Data: ID	Address	Data: ID
10501	700	10601	321
10502	702	10602	654
10503	707	10603	258
10504	704	10604	987
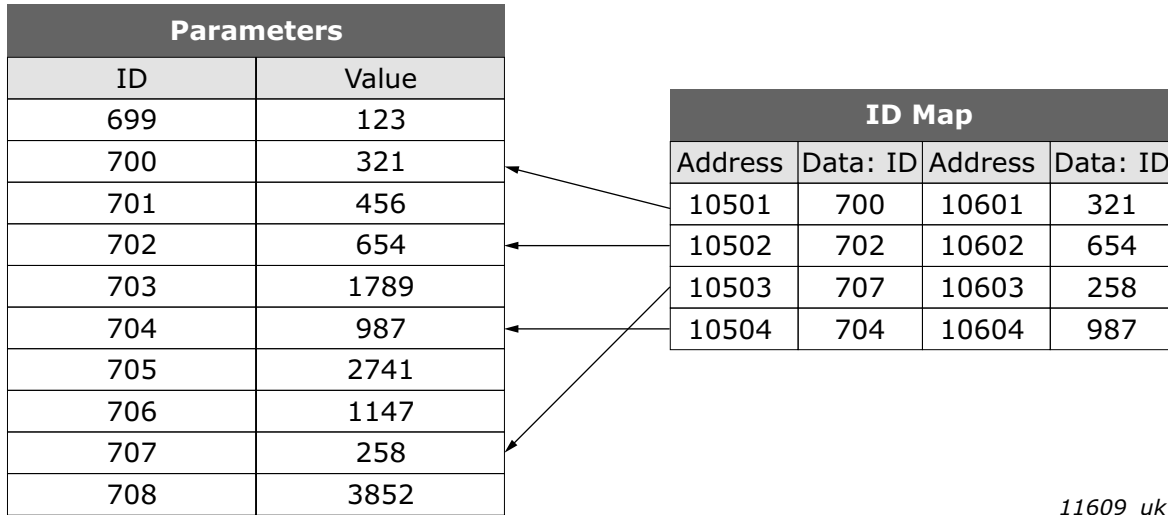
11609_uk

Figure 7. IDMap initialization

Once the IDMap address range has been initialized with any parameter ID number, the parameter value can be read and written in the IDMap Read/Write address range address IDMap address + 100.

Table 23. Parameter Values in 16-bit IDMap Read/Write registers

Address	Data
10601	Data included in parameter ID700
10602	Data included in parameter ID702
10603	Data included in parameter ID707
10604	Data included in parameter ID704

If the IDMap table has not been initialized, all data fields are showing the value '0'. Once the IDMap table has been initialized, the parameter ID's are stored in the VACON® 100 family AC drive's flash memory.

Example of 32Bit IDMap

Table 24. Example of parameter values in 32-bit IDMap Read/Write registers

Address	Data
10701	Data High, parameter ID700
10702	Data Low, parameter ID700
10703	Data High, parameter ID702
10704	Data Low, parameter ID702

6.3.9   OPERATION DAY COUNTER

Control unit operating time counter (total value). This counter cannot be reset. The values are read only.

Operation day counter as seconds

This counter in registers 40011d to 40012d holds the value of operation days as seconds in a 32-bit unsigned integer.

Table 25. Operation days counter as seconds

Address	Description
40011 High data 40012 Low data	Holds the counter value as seconds.

Operation day counter

This counter in registers 40001d to 40005d holds the value of operation days counter. The values are read only.

Table 26. Operation day counter

Holding register address	Input register address	Purpose
40001	1	Years
40002	2	Days
40003	3	Hours
40004	4	Minutes
40005	5	Seconds

6.3.10   Resettable operation day counter

This register holds the value for resettable control unit operating time counter (trip value). The values are read only.

For resetting this counter see Chapter 6.3.2.

Resettable operation day counter as seconds

This counter in registers 40111d to 40112d holds the value of resettable operation days as seconds in a 32-bit unsigned integer.

Table 27. Resettable operation days counter as seconds

Address	Description
40111 High data 40112 Low data	Holds the counter value as seconds.

Resettable operation day counter

This counter in registers 40101d to 40105d holds the value of operation days counter.

Table 28. Resettable operation day counter

Holding register address	Input register address	Purpose
40101	101	Years
40102	102	Days
40103	103	Hours
40104	104	Minutes
40105	105	Seconds

6.3.11   ENERGY COUNTER

This counter holds the value of total amount of energy taken from a supply network. This counter cannot be reset. The values are read only.

Energy counter as kWh

This counter is in registers 40211d to 40212d and is a 32-bit floating point (IEEE 754) value containing the number of kilowatt-hours (kWh) that is in the drive's energy counter. This value is read-only.

Table 29. Energy counter as kWh

Address	Description
40211 High data 40212 Low data	Holds the value of energy counter in kWh. Datatype is 32 bit float IEEE 754

Energy counter

These registers hold three values for the energy counter, amount of energy used, format of the energy value and unit of the energy value.

Example: If energy = 1200, format = 52, unit = 1, then actual energy is 12.00 kWh.

Table 30. Energy counter

Holding register address	Input register address	Purpose	Description
40201	201	Energy	Amount of energy taken from a supply network.
40202	202	Format	The last number of the Format field indicates the decimal point place in the Energy field. **Example:** 40 = 4 number of digits, 0 fractional digits 41 = 4 number of digits, 1 fractional digit 42 = 4 number of digits, 2 fractional digits
40203	203	Unit 1 = kWh 2 = MWh 3 = GWh 4 = TWh	Unit of the value.

6.3.12   RESETTABLE ENERGY COUNTER

This counter holds the value of total amount of energy taken from a supply network since the counter was last reset. For resetting this counter see Chapter 6.3.2". The values are read only.

Resettable energy counter as kWh

This counter is in registers 40311d to 40312d and is a 32-bit floating point (IEEE 754) value containing the number of kilowatt-hours (kWh) that is in the drive's resettable energy counter.

Table 31. Resettable energy counter as kWh

Address	Description
40311 High data 40312 Low data	Holds the value of energy counter in kWh since last counter reset. Datatype is 32 bit float IEEE 754

Resettable energy counter

These registers hold three values for the energy counter, amount of energy used, format of the energy value and unit of the energy value.

Example: If energy = 1200, format = 52, unit = 1, then actual energy is 12.00 kWh

Table 32. Resettable energy counter

Holding register address	Input register address	Purpose	Description
40301	301	Energy	Amount of energy taken from a supply network.
40302	302	Format	The last number of the Format field indicates the decimal point place in the Energy field. **Example:** 40 = 4 number of digits, 0 fractional digits 41 = 4 number of digits, 1 fractional digit 42 = 4 number of digits, 2 fractional digits
40303	303	Unit 1 = kWh 2 = MWh 3 = GWh 4 = TWh	Unit of the value.

6.3.13   Fault history

The fault history can be viewed by reading from address 40401 onward. The faults are listed in chronological order so that the latest fault is mentioned first and the oldest last. The fault history can contain 29 faults at the same time. The fault history contents are represented as follows.

NOTE! Reading the fault history items is slow. Reading all 30 items at once might take up to 600 milliseconds.

Table 33. Fault history

Holding register address	Input register address	Purpose
40401	401	Upper byte is a fault code, lower byte is a sub code
40402	402	
40403	403	
...	...	
40429	429	

6.3.14   Fault history with 16-bit error codes

The fault history can be viewed by reading from address 40511 onward. The faults are listed in a chronological order so that the latest fault is mentioned first and the oldest last. These addresses contain the fault code and the subcode for the fault. Reading can be started from any address.

Table 34. Fault history with 16-bit error codes

Holding register address	Purpose	Description
40511	Fault code 1	16-bit fault code in index 1.
40512	Sub code 1	16-bit sub code for the fault in index 1.
40513	Fault code 2	16-bit fault code in index 2.
40514	Sub code 2	16-bit sub code for the fault in index 2.
...	...	
40567	Fault code 29	
40568	Sub code 29	

6.4   Modbus TCP/UDP communication and connection timeout

It is possible to open up to three Modbus TCP/UDP connections to the VACON® 100 family AC drive. One of the connections could be used for process data and other just for reading monitoring data. In most cases it is desirable that if "monitor" connection gets disconnected, no fault is generated but when the connection is handling the process data, a fault should be generated in the time specified.

This register address enables the user to give custom communication timeout for each connection. If a custom timeout value is used, it must be given every time a connection is opened. Timeout can be set only to the connection which is been used to access this register. By default the connection uses the communication timeout value given via panel parameters.

If the cable is disconnected, a fieldbus fault is activated after the timeout period. When communication timeout is zero, no fault is activated.

In Modbus RTU you can only have one connection, so there is no need to use this value.

Table 35. Communication timeout register

Holding register address	Purpose	Description
40501	Communication timeout	Connection timeout value for this connection in seconds.
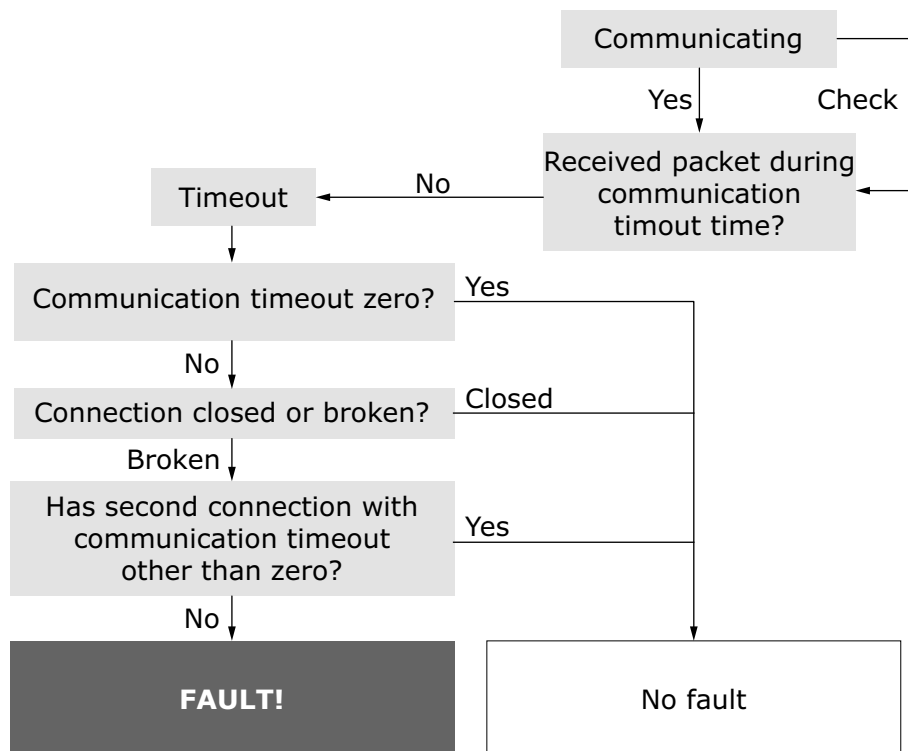
7092_uk

Figure 8. The Modbus TCP/UDP function in case of timeout

6.5   Example messages

6.5.1   Example 1 - Write Process Data

Write the process data 42001...42003 with command 16 (Preset Multiple Registers).

Command Master - Slave:

Table 36.

ADDRESS		01 hex	Slave address 1 hex (= 1)
FUNCTION		10 hex	Function 10 hex (= 16)
DATA	Starting address HI	07 hex	Starting address 07D0 hex (= 2000)
	Starting address LO	D0 hex	
	No. of registers HI	00 hex	Number of registers 0003 hex (= 3)
	No. of registers LO	03 hex	
	Byte count	06 hex	Byte count 06 hex (= 6)
	Data HI	00 hex	Data 1 = 0001 hex (= 1). Setting control word run bit to 1.
	Data LO	01 hex	
	Data HI	00 hex	Data 2 = 0000 hex (= 0).
	Data LO	00 hex	
	Data HI	13 hex	Data 3 = 1388 hex (= 5000), Speed Reference to 50.00%
	Data LO	88 hex	
ERROR CHECK	CRC HI	C8 hex	CRC field C8CB hex (= 51403)
	CRC LO	CB hex	

Message frame:

Table 37.

01	10	07	D0	00	03	06	00	01	00	00	13	88	C8	CB

The reply to Preset Multiple Registers message is the echo of 6 first bytes.

Answer Slave - Master:

Table 38.

ADDRESS		01 hex	Slave address 1 hex (= 1)
FUNCTION		10 hex	Function 10 hex (= 16)
DATA	Starting address HI	07 hex	Starting address 07D0 hex (= 2000)
	Starting address LO	D0 hex	
	No. of registers HI	00 hex	Number of registers 0003 hex (= 3)
	No. of registers LO	03 hex	
ERROR CHECK	CRC HI	80 hex	CRC 8085 hex (= 32901)
	CRC LO	85 hex	

Reply frame:

Table 39.

01	10	07	D0	00	03	80	85

6.5.2 Example 2 – Read process data

Read the Process Data 42103...42104 with command 4 (Read Input Registers).

Command Master - Slave:

Table 40.

ADDRESS		01 hex	Slave address 1 hex (= 1)
FUNCTION		04 hex	Function 4 hex (= 4)
DATA	Starting address HI	08 hex	Starting address 0836 hex (= 2102)
	Starting address LO	36 hex	
	No. of registers HI	00 hex	Number of registers 0002 hex (= 2)
	No. of registers LO	02 hex	
ERROR CHECK	CRC HI	93 hex	CRC field 93A5 hex (= 37797)
	CRC LO	A5 hex	

Message frame:

Table 41.

01	04	08	36	00	02	93	A5

The reply to the Read Input Registers message contains the values of the read registers.

Answer Slave - Master:

Table 42.

ADDRESS		01 hex	Slave address 1 hex (= 1)
FUNCTION		04 hex	Function 4 hex (= 4)
DATA	Byte count	04 hex	Byte count 4 hex (= 4)
	Data HI	13 hex	Speed reference = 1388 hex (=5000 => 50.00%)
	Data LO	88 hex	
	Data HI	09 hex	Output Frequency = 09C4 hex (=2500 =>25.00Hz)
	Data LO	C4 hex	
ERROR CHECK	CRC HI	78 hex	CRC field 78E9 hex (=30953)
	CRC LO	E9 hex	

Reply frame:

Table 43.

01	04	04	13	88	09	C4	78	E9

6.5.3   Example 3 – Exception response

In an exception response, the Slave sets the *most-significant bit (MSB)* of the function code to 1. The Slave returns an exception code in the data field.

Command Master - Slave:

Table 44.

ADDRESS		01 hex	Slave address 1 hex (= 1)
FUNCTION		04 hex	Function 4 hex (= 4)
DATA	Starting address HI	17 hex	Starting address 1770 hex (= 6000)
	Starting address LO	70 hex	
	No. of registers HI	00 hex	Invalid number of registers 0005 hex (= 5)
	No. of registers LO	05 hex	
ERROR CHECK	CRC HI	34 hex	CRC field 3466 hex (=13414)
	CRC LO	66 hex	

Message frame:

Table 45.

01	04	17	70	00	05	34	66

Exception response:

Answer Slave - Master:

Table 46.

ADDRESS		01 hex	Slave address 1 hex (= 1)
FUNCTION		84 hex	Most significant bit set to 1
DATA	Error code	04 hex	Error code 04 => Slave Device Failure
ERROR CHECK	CRC HI	42 hex	CRC field 42C3 hex (= 17091)
	CRC LO	C3 hex	

Reply frame:

Table 47.

01	84	04	42	C3

7. Fault tracing

When an unusual operating condition is detected by the AC drive control diagnostics, the drive initiates a notification visible, for example, on the keypad. The keypad will show the ordinal number of the fault, the fault code and a short fault description.

The fault can be reset with the Reset button on the control keypad or via the I/O terminal. The faults are stored in the Fault history menu which can be browsed. The different fault codes you will find in the table below. This fault table presents only the faults related to the fieldbus in use.

NOTE! When contacting distributor or factory because of a fault condition, always write down all texts and codes on the keypad display and send a description of the problem together with the *Drive Info File* to your local support.

7.1 Typical fault conditions

Table 48. Typical fault conditions

Fault condition	Possible cause	Remedy
Termination resistor	Missing or excessive termination resistor.	Install termination resistors at both ends of the fieldbus line.
Cabling	• Supply or motor cables are located too close to the fieldbus cable • Wrong type of fieldbus cable • Too long cabling	
Grounding	Inadequate grounding.	Ensure grounding in all points on the net
Connections	Faulty connections. • Excessive stripping of cables • Conductors in wrong terminals • Too loose connections of conductors	
Parameter	• Faulty address • Overlapping slave addresses • Wrong baud rate • Wrong control place selected	

7.2 RS-485 bus biasing

When none of the devices on the RS-485 bus is sending data, all devices are in idle status. This being the case, the bus voltage is in indefinate state, usually near 0 V due to the termination resistors. This may cause problems in character reception because the single characters in serial communication begin with start bit referring to bus status '0' with voltage of less than -200mV whereas the bus status '1' corresponds to bus voltage of more than +200mV. The RS-485 standard considers the voltage interval -200mV...+200mV as undefined state. Bus biasing is therefore needed to maintain the voltage in status '1' (above +200mV) also between the messages.

To bias the bus you will have to add a separate active termination resistor specifically designed for the RS-485 bus (e.g. Siemens active RS 485 terminating element (6ES7972-0DA00-0AA0)).

7.3　OTHER FAULT CONDITIONS

The following fault tracing diagram will help you to locate and fix some of the most usual problems.
If the problem persists contact your local distributor.
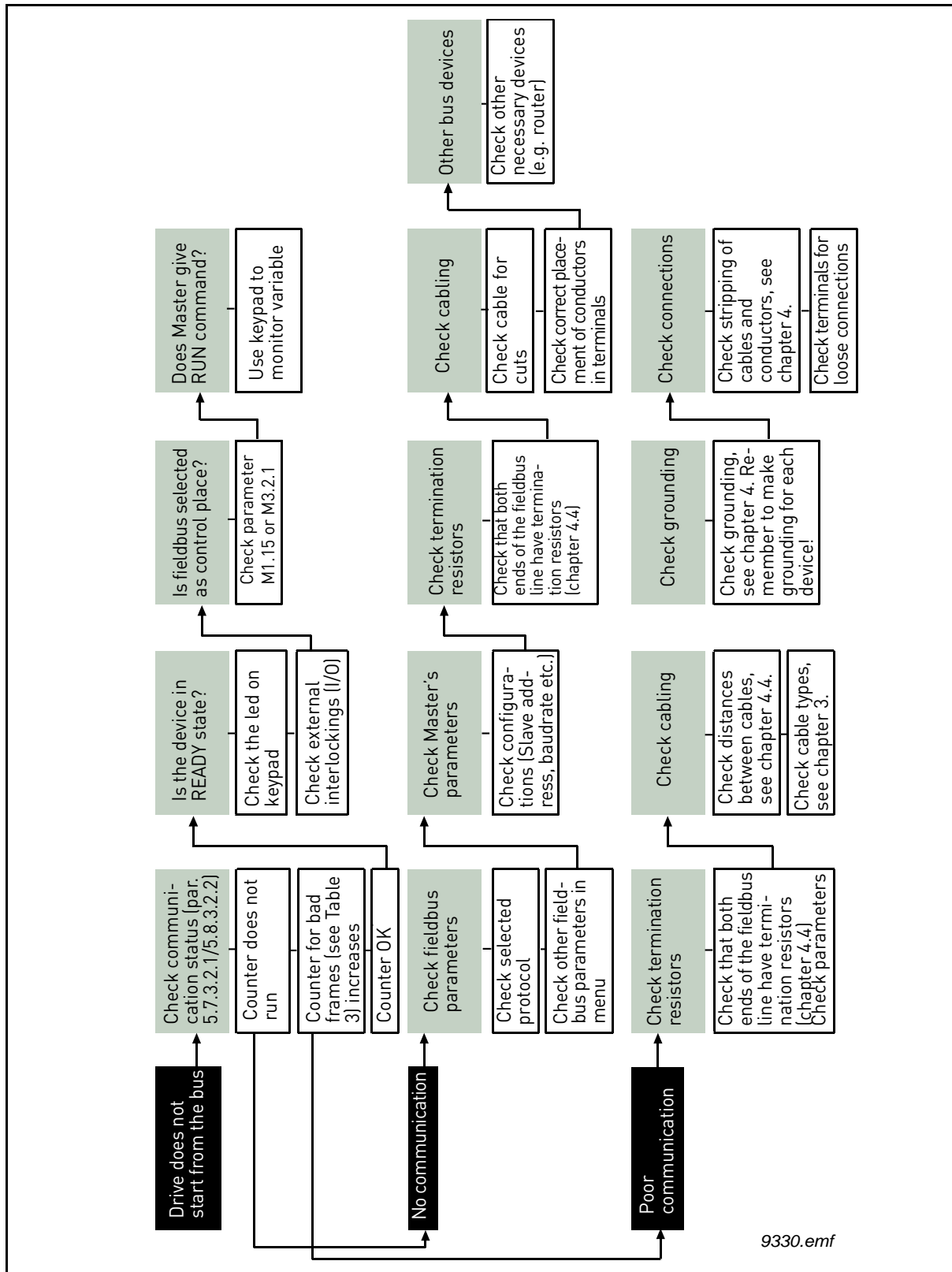
Figure 9. Fault tracing diagram for Modbus RTU

Drive does not start from the bus

Check communication status (par. 5.7.3.2.1/5.8.3.2.2)
- Counter does not run
- Counter for bad frames (see Table 3) increases
- Counter OK

Is the device in READY state?
- Check the led on keypad
- Check external interlockings (I/O)

Is fieldbus selected as control place?
- Check parameter M1.15 OR P3.2.1

Does Master give RUN command?
- Use keypad to monitor variable

No communication

Check fieldbus parameters
- Check selected protocol
- Check other fieldbus parameters in menu

Check Master's parameters
- Check IP address, gateway etc.

Check cabling
- Check cable for cuts
- Check correct placement of conductors in terminals

Other bus devices
- Check other necessary devices (e.g. router)

Poor communication

Check cabling
- Check distances between cables, see chapter 4.4.
- Check cable types and lenghts, see chapter 3.

Check connections
- Check stripping of cables and conductors, see chapter 4.
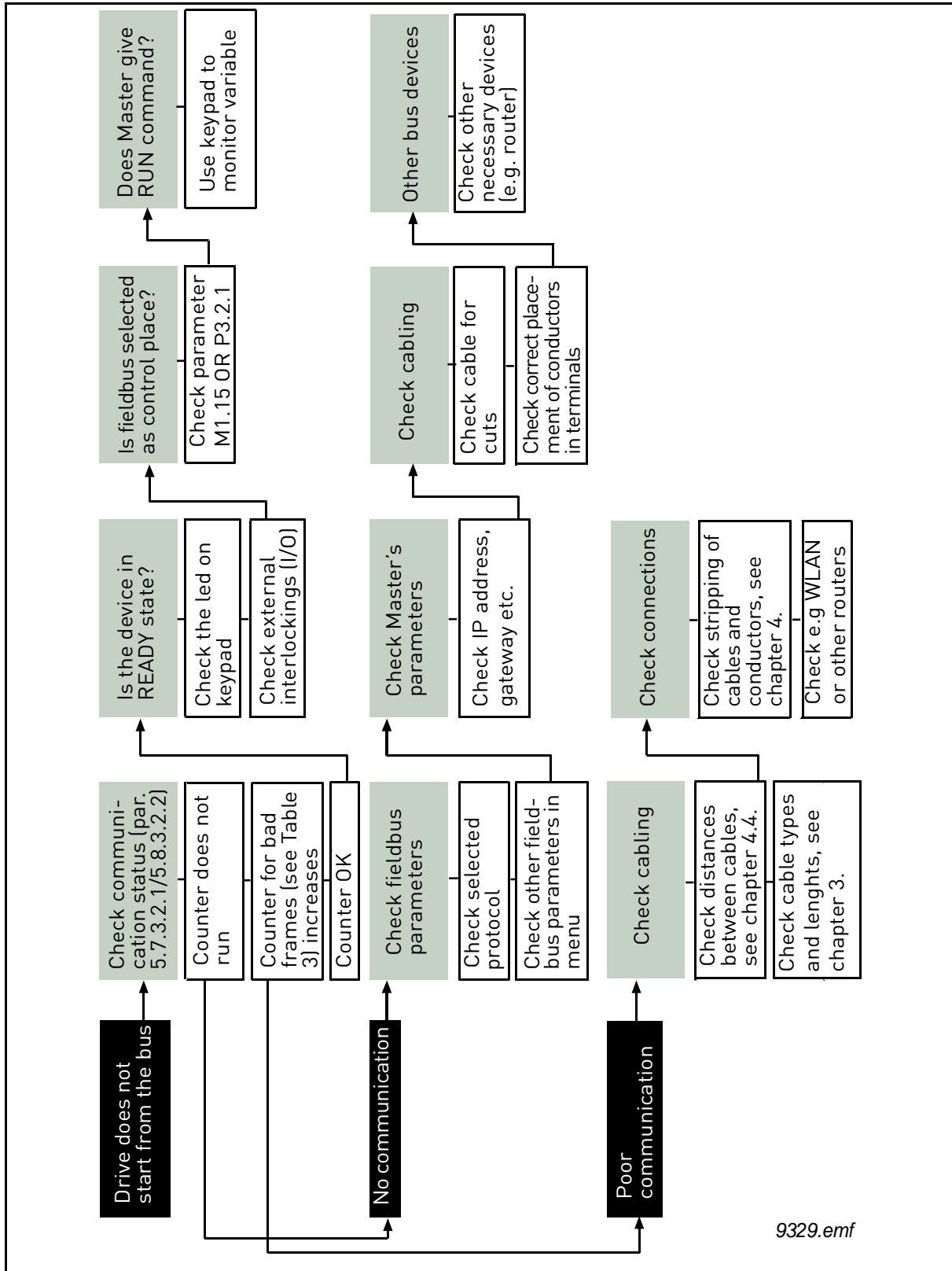- Check e.g WLAN or other routers

9329.emf

Figure 10. Fault tracing diagram for Modbus TCP

8.   QUICK SETUP

Following these instructions, you can easily and fast set up your Modbus for use:

1	Choose control place.
	A. Press LOC/REM button on keypad to select *Remote Control Place*
	B. Select *Fieldbus* as remote control place: *Main Menu > Quick Setup (M1) > Rem. Ctrl. Place (P1.15) > FieldbusCTRL*
2	Make these settings in the master software
	A. Set Control Word to '0' by writing the data 0000h to the register 2001_d.
	B. Set Control Word to '1' by writing the data 0001h to the register 2001_d.
	C. AC drive status is RUN
	D. Set Speed Reference value to '5000' (=50.00%) by writing the data 1388h to the register 2003_d.
	E. *Actual speed* is 5000 (25.00 Hz if MinFreq is 0.00 Hz and MaxFreq is 50.00 Hz)
	F. Set Control Word to '0' by writing the data 0000h to the register 2001_d.
	G. AC drive status is STOP.

9. APPENDIX 1 – PROCESS DATA

Process Data IN (Master to Slave)

Use of Process Data In variables depends on the used application. The configuration of the data is free.

Process Data OUT (Slave to Master)

Use of Process Data Out variables depends on the used application.

The Fieldbus Master can read the AC drive's actual values using process data variables. Control applications use process data as follows:

Table 49. Process Data OUT variables

Table 50.

2104	Process data OUT 1	1	Output Frequency	0.01 Hz
2105	Process data OUT 2	2	Motor Speed	1 rpm
2106	Process data OUT 3	3(45)[2]	Motor Current	0.1 A
2107	Process data OUT 4	4	Motor Torque	0.1 %
2108	Process data OUT 5	5	Motor Power	0.1 %
2109	Process data OUT 6	6	Motor Voltage	0.1 V
2110	Process data OUT 7	7	DC link voltage	1 V
2111	Process data OUT 8	37	Active Fault Code	-

NOTE 1! In VACON® 100 family AC drives, the Motor Current scale depends on the drive size. In VACON® 100 HVAC the Motor Current scale is always 0.1 A.

NOTE 2! In VACON® 100 HVAC, the default ID is 45 meaning "Motor Current 1 Decimal". In VACON® 100 family AC drives, the default ID is 3 for Motor Current. The ID 45 can be mapped by the user to this variable also in VACON® 100 family AC drives.

Local contacts: http://drives.danfoss.com/danfoss-drives/local-contacts/

10.   APPENDIX 2 – CONTROL AND STATUS WORD

10.1   Control Word bit description

The Control word is composed of 32 bits. FBFixedControlWord consist of the first 16 bits. FBGeneralControlWord consist of the remaining 16 bits. While the functionality of FBFixedControlWord is fixed in the VACON® standard applications, the functionality of FBGeneralControlWord is totally application specific and can vary even in the VACON® standard applications.

The meanings of FBFixedControlWord bits are described below. Unused bits have to be set to zero.

NOTE! This table is valid for VACON® standard applications. VACON® 100 HVAC may not support all functions. See Table 52.

Table 51. Control Word

Bit	Function	Value	Description
0	Start/Stop	0	Stop request from fieldbus.
		1	Run request from fieldbus.
1	Direction	0	Requested direction is "FORWARD".
		1	Requested direction is "REVERSE".
2	Fault reset	0	No action.
		1	Rising edge (0->1) = Active faults, alarms and infos are reset.
3	Stop mode 1	0	Stop mode is unmodified.
		1	Stop mode is overridden to "Coasting".
4	Stop mode 2	0	Stop mode is unmodified.
		1	Stop mode is overridden to "Ramping".
5	Quick ramp time	0	Normal deceleration ramp time.
		1	Deceleration ramp time is switched to shorter than normal.
6	Freeze Setpoint	0	Changes in the setpoint value from fieldbus (FB Speed Reference) are taken into use by the application.
		1	Changes in the setpoint value from fieldbus (FB Speed Reference) are not taken into use by the application.
7	Setpoint to Zero	0	The setpoint value from fieldbus is taken from FB Speed Reference.
		1	The setpoint value from fieldbus is changed to 0.
8	Request Fieldbus Control	0	Control Place is as parameterized in the drive (unchanged).
		1	Control Place is overridden to Fieldbus Control.
9	Request Fieldbus Reference	0	Source of the setpoint value is as parameterized in the drive (unchanged).
		1	Source of the setpoint value is overridden to Fieldbus.
10	Jogging 1	0	No action.
		1	Jogging request with reference 1.

Table 51. Control Word

Bit	Function	Value	Description
11	Jogging 2	0	No action.
		1	Jogging request with reference 2.
12	Quick stop	0	No action
		1	Drive executes quick stop / emergency stop.
13 - 15	Reserved		

Table 52. Control word bit support in VACON® 100 family AC drives

Bit	Function	VACON® 100 INDUSTRIAL / FLOW	VACON® 100 HVAC
0	Start/Stop	x	x
1	Direction	x	x
2	Fault reset	x	x
3	Stop mode 1	x	x
4	Stop mode 2	x	x
5	Quick ramp time	x	
6	Freeze setpoint	x	x
7	Setpoint to Zero	x	
8	Request Fieldbus Control	x	x
9	Request Fieldbus Reference	x	x
10	Jogging 1	x	
11	Jogging 2	x	
12	Quick stop	x	
13-15	Reserved		

10.2   Status Word Descriptions

The Status word is composed of 32 bits. FBFixedStatusWord consist of the first 16 bits. FBGeneralStatusWord consist of the remaining 16 bits. While the functionality of FBFixedStatusWord is fixed in the VACON® standard applications, the functionality of FBGeneralStatusWord is totally application specific and can vary even in the VACON® standard applications.

The meanings of FBFixedStatusWord bits are described below. Unused bits have to be set to zero.

Table 53. Status Word

Bit	Function		Description
B0	Ready	0	Drive is not ready.
		1	Drive is ready to run.
B1	Run	0	Motor is not running.
		1	Motor is running.
B2	Direction	0	Motor is running clockwise.
		1	Motor is running counterclockwise.
B3	Fault	0	No fault active.
		1	Drive has an active fault.
B4	Alarm	0	No alarm active.
		1	Drive has active alarm.
B5	At reference	0	Motor is not running at reference speed.
		1	Motor is running at reference speed.
B6	Zero speed	0	Motor is not at zero speed.
		1	Motor is running at zero speed.
B7	Flux ready	0	Motor is not magnetized.
		1	Motor is magnetized.
B8-B12	Reserved		

The following table is valid for most of VACON 100 applications.

Table 54. Status Word bits B29-B31, descriptions of bit connections

B29 Control place	B30 Control place	B31 Control place	Description
0	0	1	Fieldbus
0	1	0	Keypad
0	1	1	PC tool
1	0	0	I/O terminals

11.   APPENDIX 6 – LWIP LICENCE

License for LWIP

Copyright (c) 2001, 2002 Swedish Institute of Computer Science.

All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.

2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

3. The name of the author may not be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE AUTHOR "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHOR BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

VACON®

www.danfoss.com