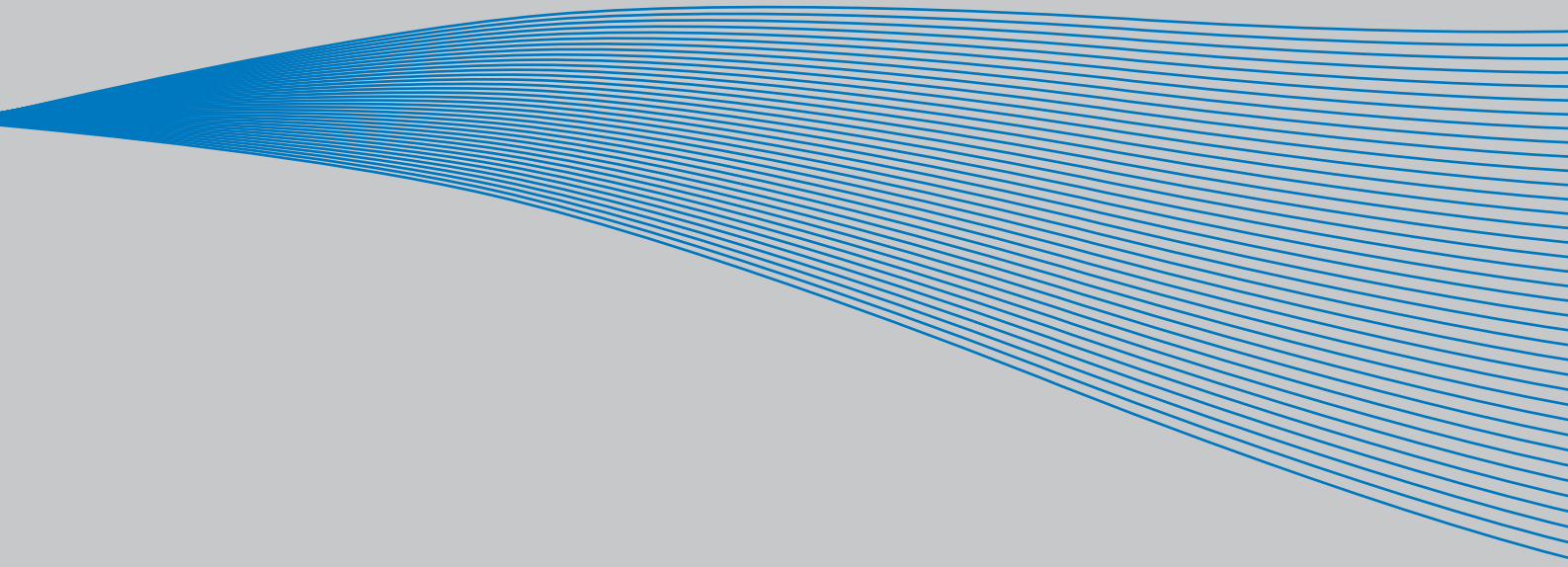
VACON® NX
AC DRIVES

OPTCI

MODBUS TCP OPTION

USER MANUAL



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INDEX

Document code: DPD00900B
Last edited: 30.09.2015

1. Introduction 2

2. Ethernet board technical data 3

2.1 Overview 3
2.2 LED indications 3
2.3 Ethernet 4
2.4 Connections and Wiring 5

3. Installation 6

3.1 Installing the Ethernet Option Board in a Vacon NX Unit 6
3.2 NCDrive 8
3.3 IP Tool NCIPConfig 8

4. Commissioning 12

5. MODBUS TCP 14

5.1 Overview 14
5.2 MODBUS TCP vs. MODBUS RTU 15
5.3 Modbus UDP 15
5.4 Ethernet Option Board's Modbus Addresses 17
5.5 Supported Modbus Functions 17
5.6 Coil Register 18
5.7 Input Discrete 20
5.8 Holding Registers 22
5.9 Input Registers 26

6. Start-up Test 29

6.1 AC drive Settings 29
6.2 Master Unit Programming 29

7. Error Codes and Errors 30

7.1 AC drive Error Codes 30
7.2 Modbus TCP 30

8. Appendix 31

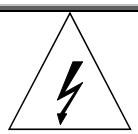
1. INTRODUCTION

Vacon NX AC drives can be connected to Ethernet using an Ethernet fieldbus board OPTCI.

The OPTCI can be installed in the card slots D or E.

Every appliance connected to an Ethernet network has two identifiers; a MAC address and an IP address. The MAC address (Address format: xx:xx:xx:xx:xx:xx) is unique to the appliance and cannot be changed. The Ethernet board's MAC address can be found on the sticker attached to the board or by using the Vacon IP tool software NCIPConfig. Please find the software installation at www.vacon.com

In a local network, IP addresses can be defined by the user as long as all units connected to the network are given the same network portion of the address. For more information about IP addresses, contact your Network Administrator. Overlapping IP addresses cause conflicts between appliances. For more information about setting IP addresses, see Section 3, Installation.

 WARNING!	*Internal components and circuit boards are at high potential when the AC drive is connected to the power source. This voltage is extremely dangerous and may cause death or severe injury if you come into contact with it.*

If you need further information related to Modbus TCP, please contact ServiceSupportVDF@vacon.com.

NOTE! You can download the English and French product manuals with applicable safety, warning and caution information from www.vacon.com/downloads.
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 www.vacon.com/downloads.

2. ETHERNET BOARD TECHNICAL DATA

2.1 Overview

General	Card Name	OPTCI
Ethernet connections	Interface	RJ-45 connector
Communications	Transfer cable	Shielded Twisted Pair
	Speed	10 / 100 Mb
	Duplex	half / full
	Default IP-address	192.168.0.10
Protocols	Modbus TCP, UDP	
Environment	Ambient operating temperature	–10°C...50°C
	Storing temperature	–40°C...70°C
	Humidity	<95%, no condensation allowed
	Altitude	Max. 1000 m
	Vibration	0.5 G at 9...200 Hz
Safety		Fulfils EN50178 standard

Table 2-1. Modbus TCP board technical data

2.2 LED indications

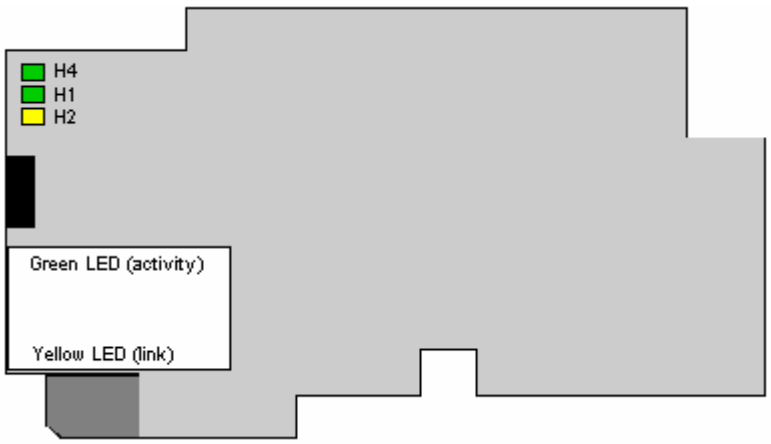


Figure 2-1. LED indications on the OPTCI board

LED:	Meaning:
H4	LED in ON when board is powered
H1	Blinking 0.25s ON / 0.25s OFF when board firmware is corrupted (chapter 3.2.1 NOTE). OFF when board is operational.
H2	Blinking 2.5s ON / 2.5s OFF when board is ready for external communication. OFF when board is not operational.

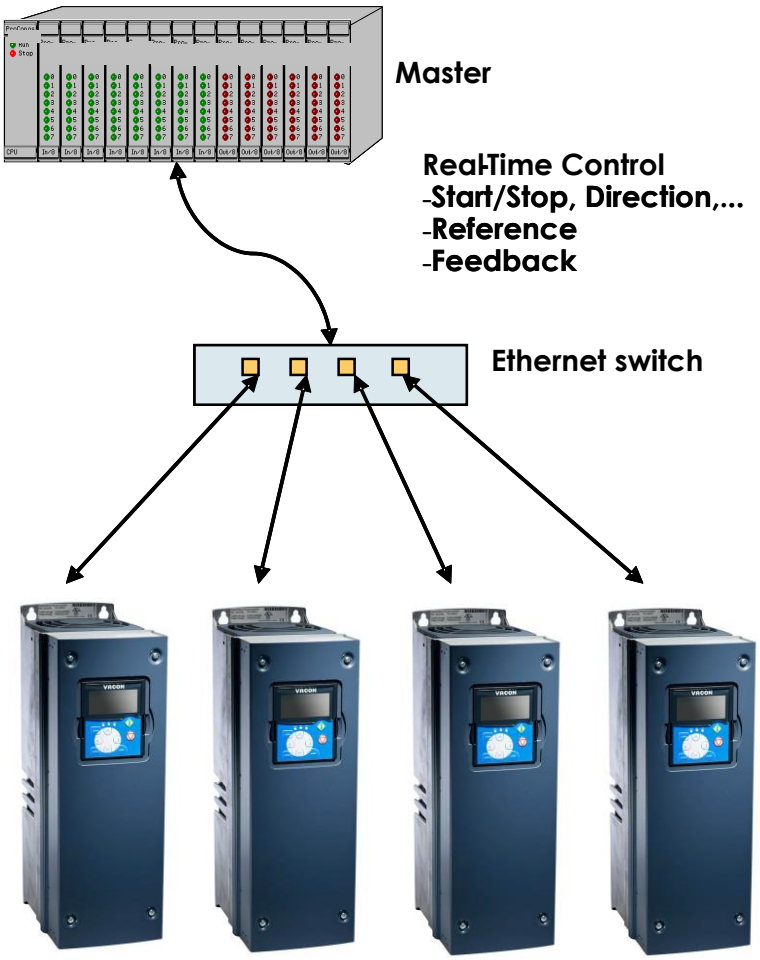
2.3 Ethernet

Common use-cases of Ethernet – devices are 'human to machine' and 'machine to machine'. Basic features of these two use-cases are presented in the pictures below.

1. Human to machine (Graphical User interface, relatively slow communication)

Note! NCDrive can be used in NXS and NXP drives via Ethernet. In NXL drives this is not possible.

2. Machine to machine (Industrial environment, fast communication)



2.4 Connections and Wiring

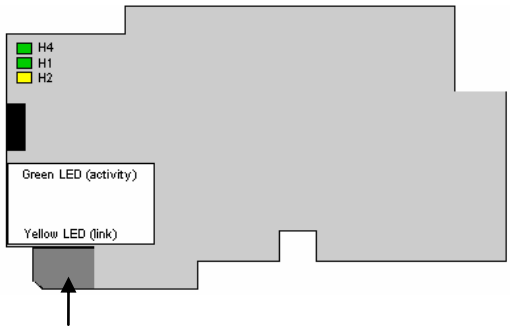
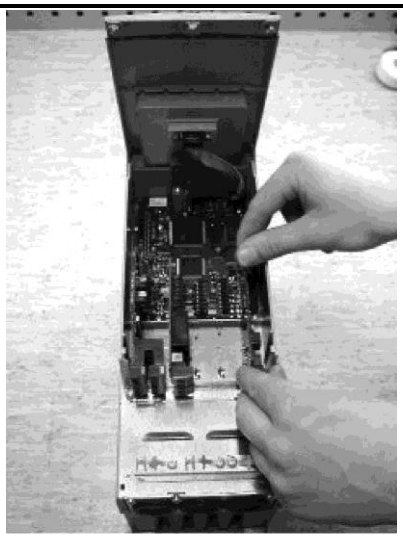
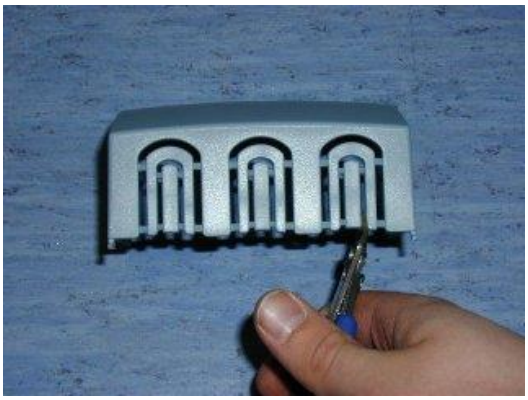
The Ethernet board supports 10/100Mb speeds in both Full and Half-duplex modes. The boards must be connected to the Ethernet network with a shielded CAT-5e cable. The board will connect the shield to its ground. Use a so-called crossover cable (at least CAT-5e cable with STP, Shielded Twisted Pair) if you want to connect the Ethernet option board directly to the master appliance.
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.

3. INSTALLATION

3.1 Installing the Ethernet Option Board in a Vacon NX Unit

NOTE	MAKE SURE THAT THE AC DRIVE **IS SWITCHED OFF** BEFORE AN OPTION OR FIELDBUS BOARD IS CHANGED OR ADDED!

A	Vacon NX AC drive.	
B	Remove the cable cover.	
C	Open the cover of the control unit.	

D	Install EtherNET option board in slot D or E on the control board of the AC drive. Make sure that the grounding plate (see below) fits tightly in the clamp. 	
E	Make a sufficiently wide opening for your cable by cutting the grid as wide as necessary.	
F	Close the cover of the control unit and the cable cover.	

3.2 NCDrive

NCDrive software can be used with the Ethernet board in NXS and NXP drives.

NOTE! Does not work with NXL

NCDrive software is recommended to be used in LAN (Local Area Network) only.

NOTE! If OPTCI Ethernet Option board is used for NC Tools connection, like NCDrive, the OPTD3 board cannot be used.

NOTE! NCLoad does not work via Ethernet. See NCDrive help for further information.

3.3 IP Tool NCIPConfig

To begin using the Vacon Ethernet board, you need to set an IP address. The factory default IP address is 192.168.0.10. Before connecting the board to the network, its IP addresses must be set according to the network. For more information about IP addresses, contact your network administrator.

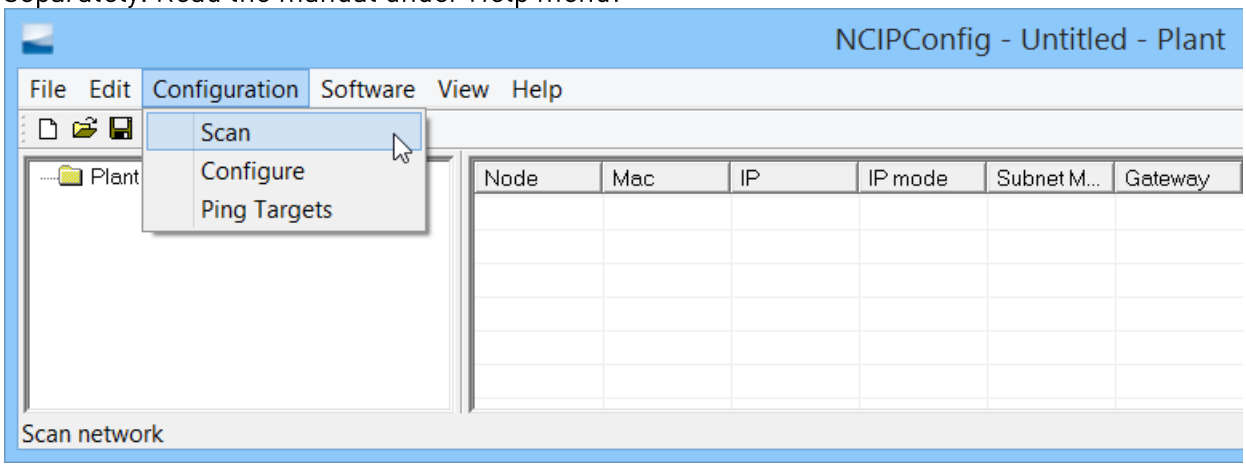
You need a PC with an Ethernet connection and the NCIPConfig tool installed to set the Ethernet board's IP addresses. To install the NCIPConfig tool, start the installation program from CD or download it from www.vacon.com website. After starting the installation program, follow the on-screen instructions.

Once the program is installed successfully, you can launch it by selecting it in the Windows Start menu. Follow these instructions to set the IP addresses. Select **Help** --> **Manual** if you want more information about the software features.

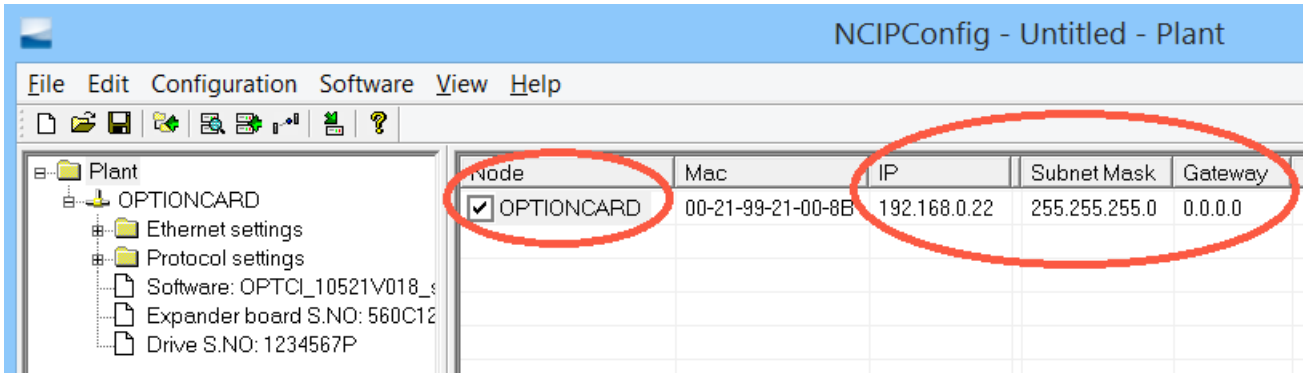
Step 1. Connect your PC to the Ethernet network with an Ethernet cable. You can also connect the PC directly to the device using a crossover cable. This option may be needed if your PC does not support Automatic crossover function.

Step 2. Scan network nodes. Select **Configuration** --> **Scan** and wait until the devices connected to the bus in the tree structure are displayed to the left of the screen.

NOTE!
Some switches block broadcast messages. In this case, each network node must be scanned separately. Read the manual under Help menu!

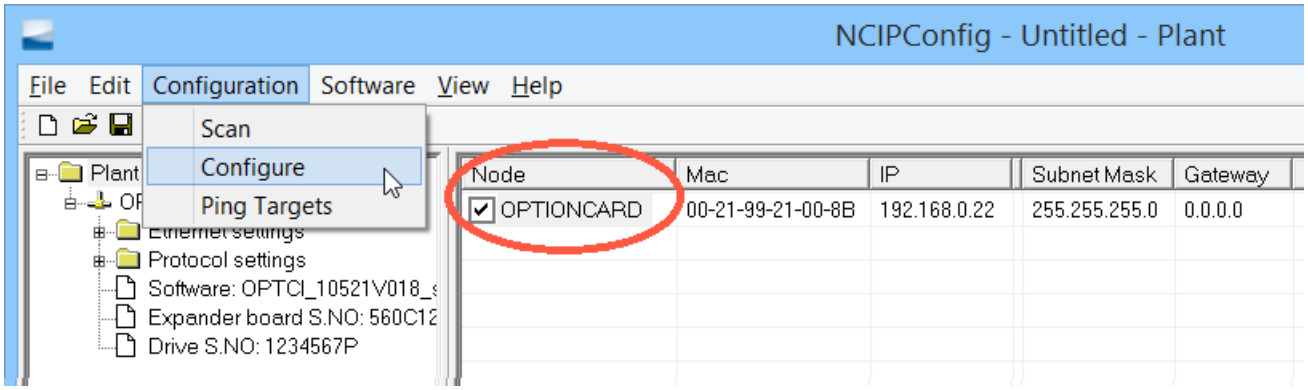


Step 3. Set IP adresses. Change the node's IP settings according to the network IP settings. The program will report conflicts with a red color in a table cell. Read the manual under Help menu!



Step 4. Send configuration to boards. In the table view, check the boxes for boards whose configuration you want to send and select Configuration, then Configure. Your changes are sent to the network and will be valid immediately.

NOTE! Only **A-Z, a-z and 0-9** symbols can be used in the drive name, **no** special characters, or Scandinavian letters (ä, ö, etc.)! The drive name can be freely formed using the allowed characters.

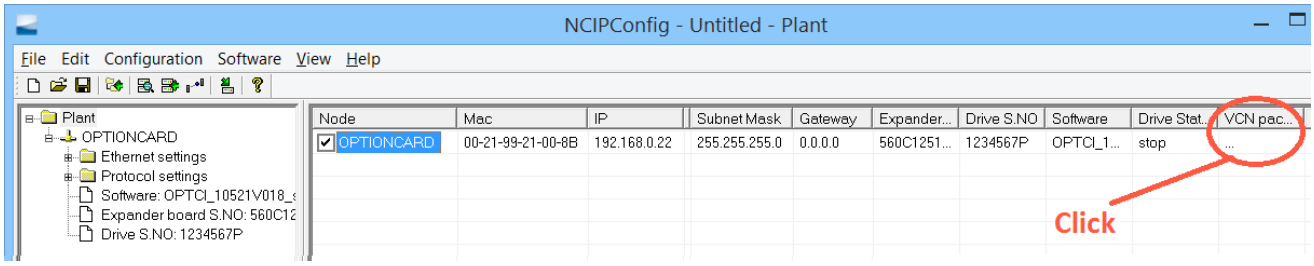


3.3.1 Update OPTCI Option Board program with the NCIPConfig Tool

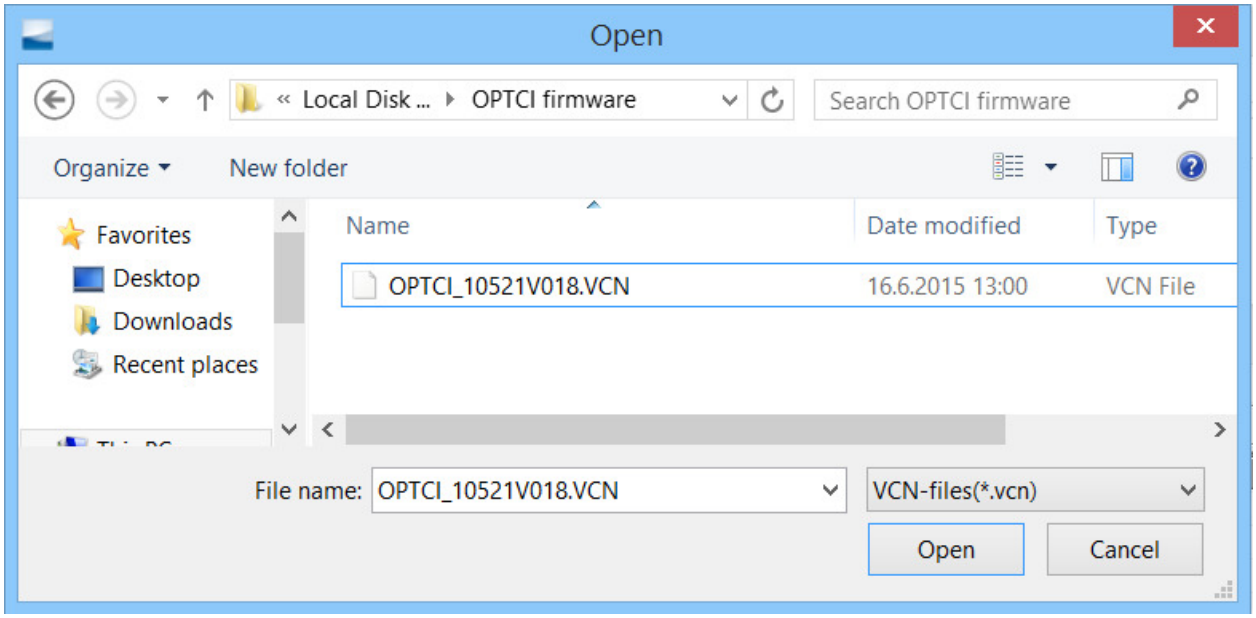
In some cases it may be necessary to update the option board's firmware. Differing from other Vacon option boards, the Ethernet option board's firmware is updated with the NCIPConfig tool.

NOTE! The IP addresses of the PC and the option board must be in the same area when the software is loaded.

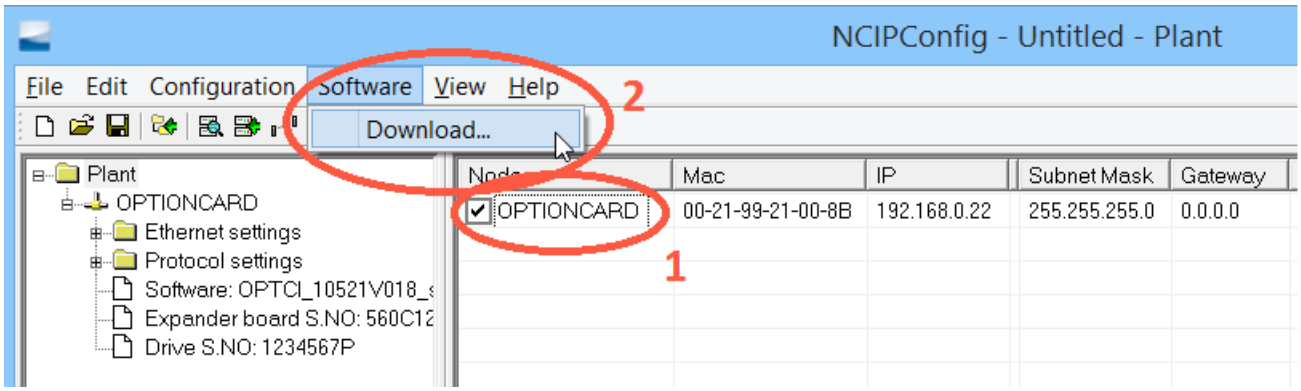
To start the firmware update, scan the nodes in the network according to the instructions in section **Error! Reference source not found.**. Once you can see all nodes in the view, you can update the new firmware by clicking the **VCN packet** field in NCIPCONFIG 's table view on the right.



After clicking the **VCN packet** field, a file open window where you can choose a new firmware packet is displayed.



Send the new firmware packet to the option board by checking its box in the 'VCN Packet' field at the right corner of the table view. After selecting all nodes to be updated by checking the boxes, send the new firmware to the board by selecting 'Software' then 'Download'.

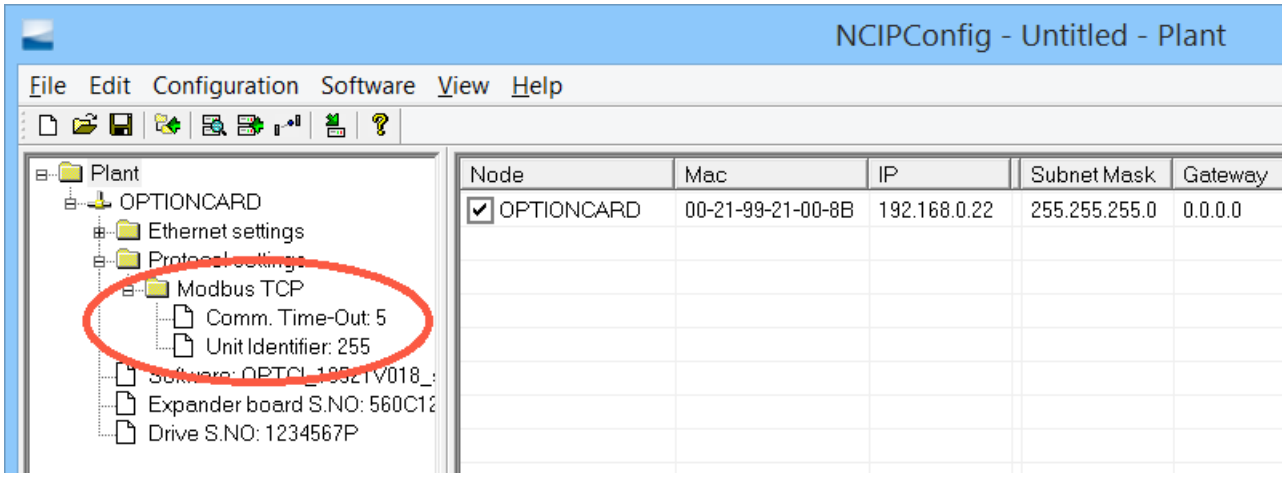


NOTE!
Do not do a power up cycle within 1 minute after downloading the option board software. This may cause the option board to go to "Safe Mode". This situation can only be solved by re-downloading the software. The Safe Mode triggers a fault code (F54). The Board slot error F54 may also appear due to a faulty board, a temporary malfunction of the board or disturbance in the environment.

3.4 *Configure Option board parameters*

These features are available from NCIPConfig tool version 1.6.

In the tree-view, expand the folders until you reach the board parameters. Slowly double-click the parameter (*Comm. Time-out* in figure below) and enter new value. New parameter values are automatically sent to the option board after the modification is complete.



NOTE! If the fieldbus cable is broken at the Ethernet board end or removed, a fieldbus error is immediately generated.

4. COMMISSIONING

The Vacon Ethernet board is commissioned with the control keypad by giving values to appropriate parameters in menu M7 (or with NCIPConfig tool, read chapter *IP Tool NCIPConfig*). Keypad commissioning is only possible with NXP- and NXS-type AC drives, not possible with NXL-type AC drives.

Expander board menu (M7)
The *Expander board menu* makes it possible for the user to see what expander boards are connected to the control board and to reach and edit the parameters associated with the expander board.
Enter the following menu level (G#) with the *Menu button right*. At this level, you can browse through slots A to E with the *Browser buttons* to see what expander boards are connected. On the lowermost line of the display you see the number of parameter groups associated with the board. If you still press the *Menu button right* once you will reach the parameter group level where there are one group in the Ethernet board case: Parameters. A further press on the *Menu button right* takes you to Parameter group.

Modbus TCP parameters

#	Name	Default	Range	Description
1	Comm. Timeout	10	0...255 s	0 = Not used
2	IP Part 1	192	1...223	IP Address Part 1
3	IP Part 2	168	0...255	IP Address Part 2
4	IP Part 3	0	0...255	IP Address Part 3
5	IP Part 4	10	0...255	IP Address Part 4
6	SubNet Part 1	255	0...255	Subnet Mask Part 1
7	SubNet Part 2	255	0...255	Subnet Mask Part 2
8	SubNet Part 3	0	0...255	Subnet Mask Part 3
9	SubNet Part 4	0	0...255	Subnet Mask Part 4
10	DefGW Part 1	192	0...255	Default Gateway Part 1
11	DefGW Part 2	168	0...255	Default Gateway Part 2
12	DefGW Part 3	0	0...255	Default Gateway Part 3
13	DefGW Part 4	1	0...255	Default Gateway Part 4
14	*InputAssembly*	-	-	*NOT USED in Modbus TCP*
15	*OutputAssembly*	-	-	*NOT USED in Modbus TCP*

Table 4-1. Ethernet parameters

IP Address
IP is divided to 4 parts. (Part = Octet) Default IP Address is 192.168.0.10.

Communication timeout
Defines how much time can pass from the last received message from the Client Device before fieldbus fault is generated. Communication time out is disabled when given the value **0**. Communication timeout value can be changed from the keypad or with NCIPConfig tool (read chapter *IP Tool NCIPConfig*).

NOTE!
If fieldbus cable is broken from Ethernet board end, fieldbus error is generated immediately.

All Ethernet parameters are saved to the Ethernet board (not to the control board). If new Ethernet board is changed to control board you must configure the new Ethernet board. Option board parameters are possible to save to the keypad, with NCIPConfig tool or with NCDrive.

Unit Identifier

Modbus Unit Identifier is used to identify multiple endpoints at the Modbus server (i.e. gateway to serial line devices). As there is only one endpoint the Unit Identifier default is set to its non-significant value of 255 (0xFF). The IP address is used to identify the individual boards. It is however possible to change it with the NCIPConfig tool. When 0xFF value is selected, also 0 is accepted. If unit identifier parameter has different value than 0xFF, only this value is accepted.

- Default Unit Identifier changed from 0x01 to 0xFF in software version 10521V005.
- Added possibility to change Unit Identifier with NCIPConfig (V1.5) tool in software version 10521V006.

5. MODBUS TCP

5.1 Overview

Modbus TCP is a variant of the MODBUS family. It is a manufacturer-independent protocol for monitoring and controlling automatic devices.

Modbus TCP is a client server protocol. The client makes queries to the server by sending "request" messages to the server's **TCP port 502.** The server answers client queries with "response" messages.

The term 'client' can refer to a master device that runs queries. Correspondingly, the term 'server' refers to a slave device that serves the master device by answering its queries.

Both the request and response messages are composed as follows:

Byte 0: Transaction ID
Byte 1: Transaction ID
Byte 2: Protocol ID
Byte 3: Protocol ID
Byte 4: Length field, upper byte
Byte 5: Length field, lower byte
Byte 6: Unit identifier
Byte 7: Modbus function code
Byte 8: Data (of variable length)

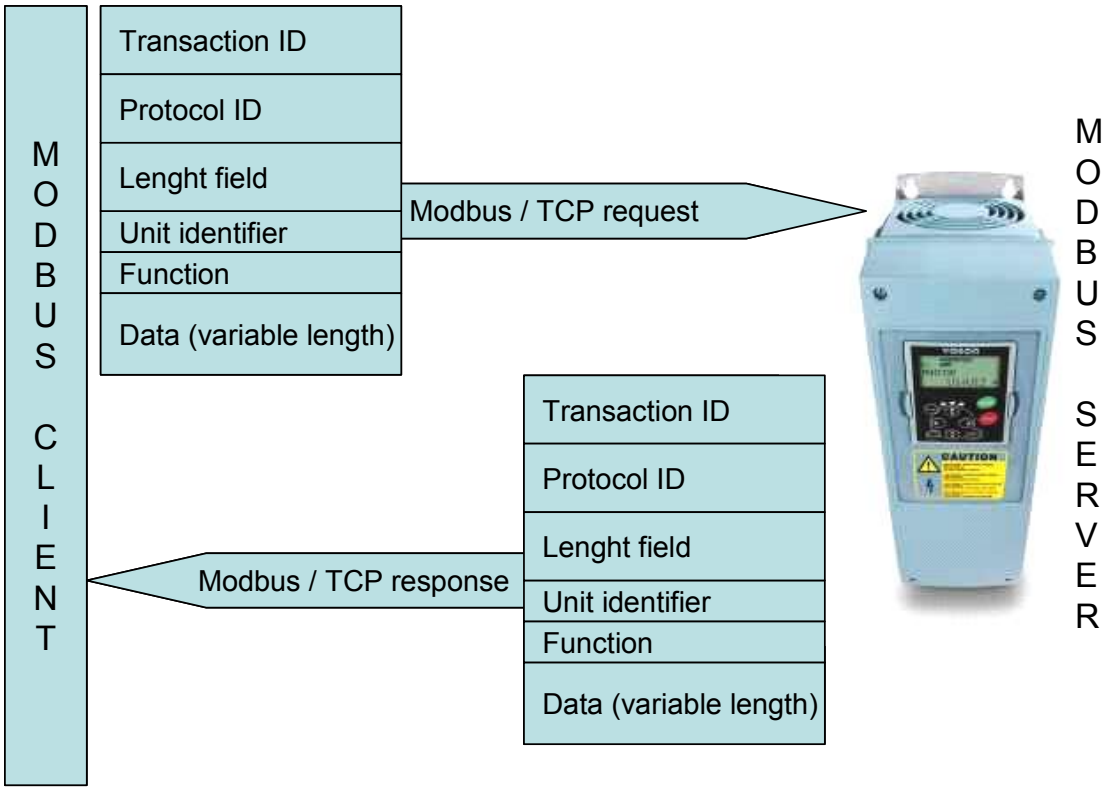


Figure 5-1.Modbus Transaction

5.2 MODBUS TCP vs. MODBUS RTU

Compared to the MODBUS RTU protocol, the MODBUS TCP differs mostly in error checking and slave addresses. As the TCP already includes an efficient error checking function, the MODBUS TCP protocol does not include a separate CRC field. In addition to the error checking functionality, the TCP is responsible for resending packets and for splitting long messages so that they fit the TCP frames.

The slave address field of the MODBUS/RTU is called unit identifier field in MODBUS TCP.

5.3 Modbus UDP

In addition to TCP, OPTCI option board supports also UDP (since option board firmware version V018). It is recommended that UDP would be used when reading and writing rapidly and repetitively (cyclically) same data, like in case of process data. TCP should be used for single operations, like service data (e.g. reading or writing parameter values). Key difference between UDP and TCP is that when using TCP each and every Modbus frame needs to be acknowledged by the receiver (see figure below). This adds extra traffic to the network and bit 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.

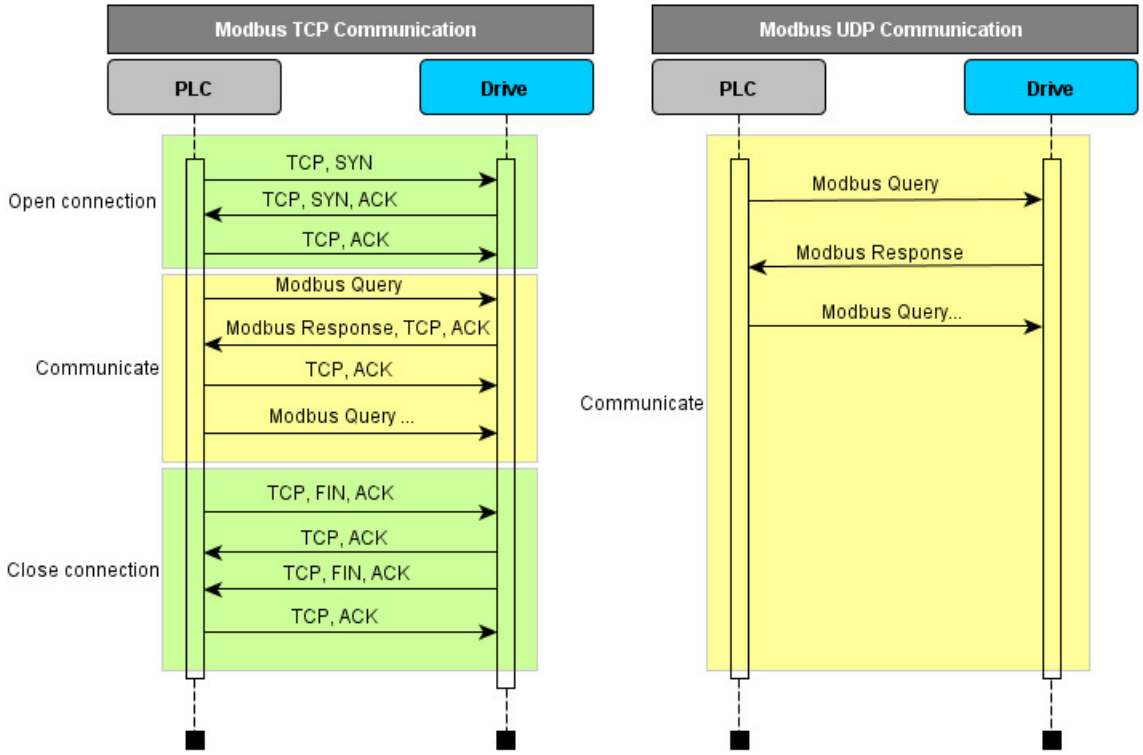


Figure 5-2. Modbus TCP and UDP communication comparison

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 first packet is already a Modbus query. OPTCI treats senders IP address and port combination as a connection. If port changes then it is considered as new connection or as second connection if both stay active.

When using UDP it is not guaranteed that the sent frame reaches its destination. 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 PLC does not receive response in time from 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 5-3. Modbus TCP and UDP communication errors comparison). If PLC sends new queries during this time, some of those may not be sent to network (by TCP/IP stack) until previously sent package(s) has been acknowledged. This can cause small packet storms when the connection is resumed between PLC and drive (see Figure 5-4. TCP retransmissions) .

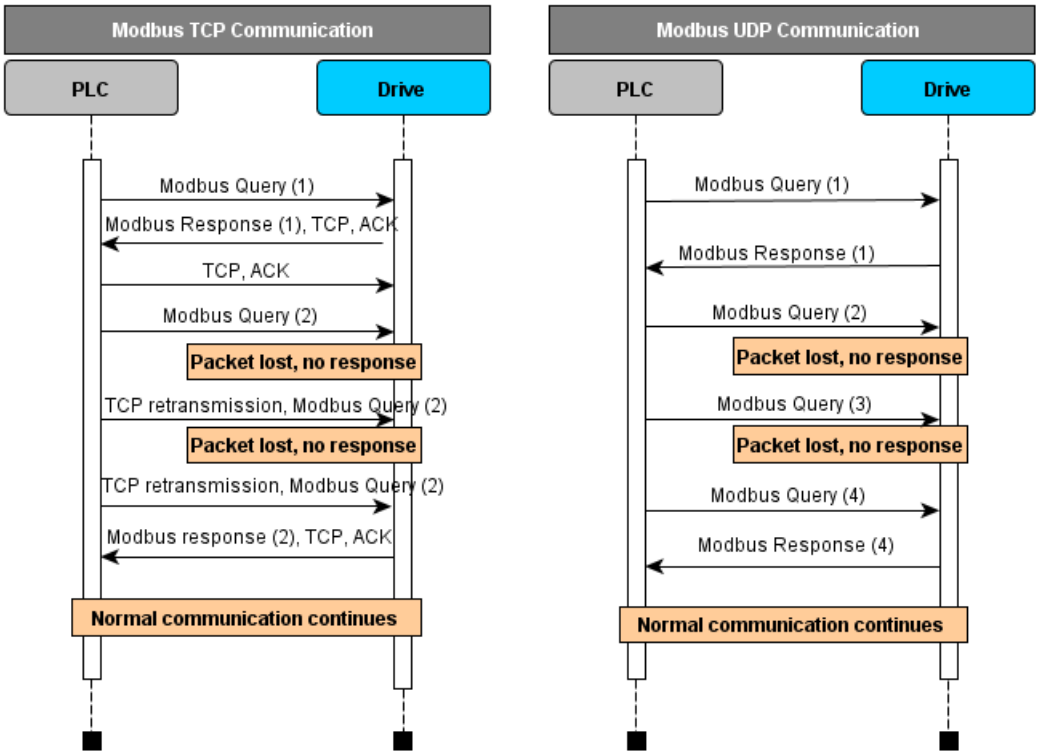


Figure 5-3. Modbus TCP and UDP communication errors comparison

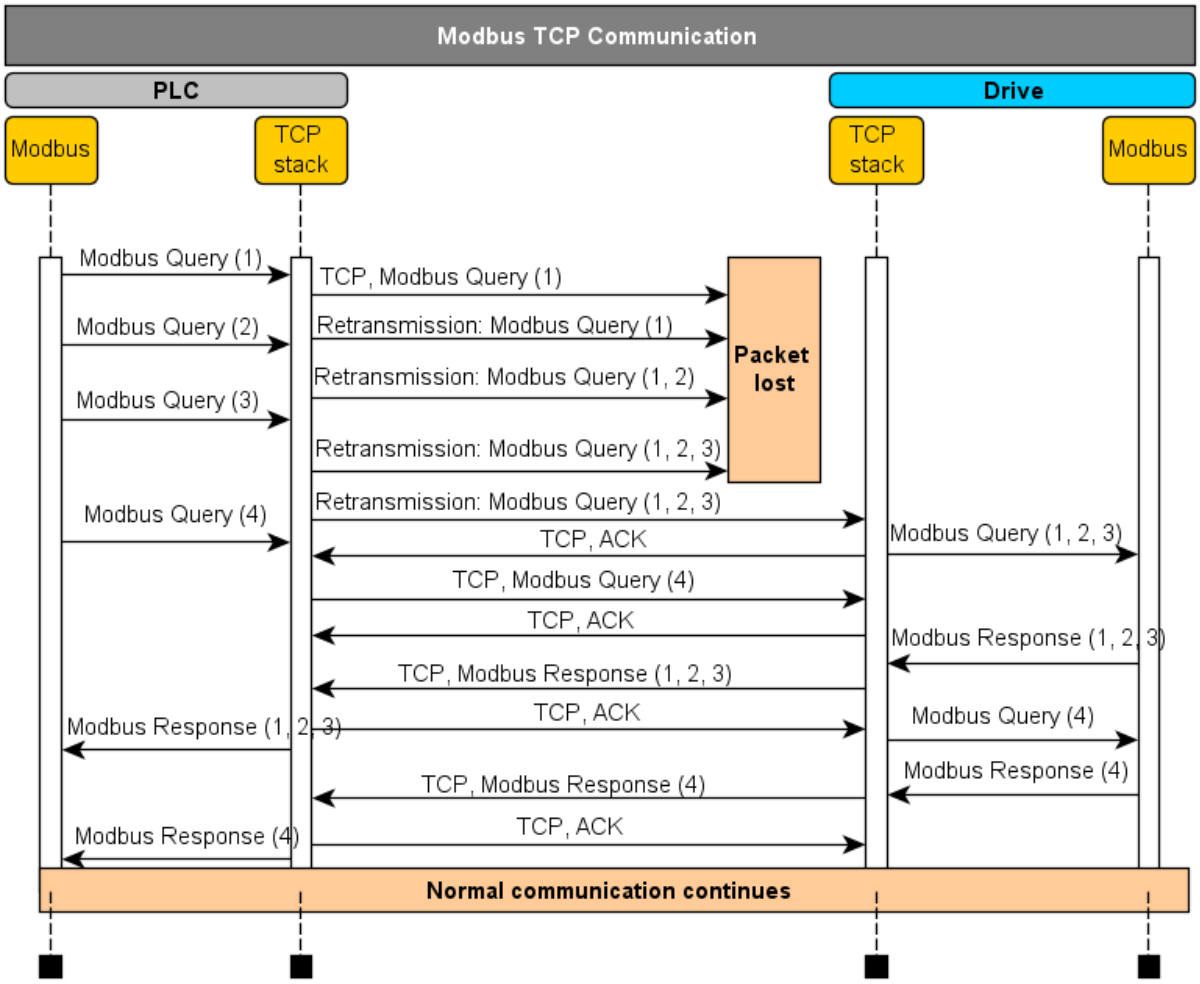


Figure 5-4. TCP retransmissions

Losing one packet should not be a big issue because the same request can be sent again after timeout. In TCP packages always reach their destination but if network congestions cause retrans-missions those packages will most likely contain old data or instructions when they reach their destination.

5.4 Ethernet Option Board's Modbus Addresses

A Modbus TCP class 1 functionality has been implemented in OPTCI board. The following table lists supported MODBUS registers.

Name	Size	Modbus address	Type
Input Registers	16bit	30001-3FFFF	Read
Holding Register	16bit	40001-4FFFF	Read / Write
Coils	1bit	00001-0FFFF	Read / Write
Input discretes	1bit	10001-1FFFF	Read

Table 5-1. Supported Registers

5.5 Supported Modbus Functions

Following table lists supporter MODBUS functions.

Function Code	Name	Access Type	Address Range
1 (0x01)	Read Coils	Discrete	00000-0FFFF
2 (0x02)	Read Input Discrete	Discrete	10000-1FFFF
3 (0x03)	Read Holding Registers	16 Bit	40000-4FFFF
4 (0x04)	Read Input Registers	16 Bit	30000-3FFFF
5 (0x05)	Force Single Coil	Discrete	00000-0FFFF
6 (0x06)	Write Single Register	16 Bit	40000-4FFFF
15 (0x0F)	Force Multiple Coils	Discrete	00000-0FFFF
16 (0x10)	Write Multiple Registers	16 Bit	40000-4FFFF
23 (0x17)	Read/Write Multiple Registers	16 Bit	40000-4FFFF

Table 5-2. Supported Function Codes

5.6 Coil Register

The Coil register represents data in a binary form. Thus, each coil can only be in mode "1" or mode "0". Coil registers can be written using the MODBUS function 'Write coil' (5) or the MODBUS function 'Force multiple coils' (16). The following tables include examples of both functions.

5.6.1 Control Word (Read / Write)

See chapter 5.6.4.

Address	Function	Purpose
0001	RUN/STOP	Control word, bit 1
0002	DIRECTION	Control word, bit 2
0003	Fault reset	Control word, bit 3
0004	FBDIN1	Control word, bit 4
0005	FBDIN2	Control word, bit 5
0006	FBDIN3	Control word, bit 6
0007	FBDIN4	Control word, bit 7
0008	FBDIN5	Control word, bit 8
0009	Not used	Control word, bit 9
0010	Not used	Control word, bit 10
0011	FBDIN6	Control word, bit 11
0012	FBDIN7	Control word, bit 12
0013	FBDIN8	Control word, bit 13
0014	FBDIN9	Control word, bit 14
0015	FBDIN10	Control word, bit 15
0016	Not used	Control word, bit 16

Table 5-3. Control Word Structure

The following table shows a MODBUS query that changes the engine's rotation direction by entering "1" for control-word bit 1 value. This example uses the '**Write Coil**' MODBUS function. Note that Control word is application specific and use of bits may vary depending on it.

Query:
0x00, 0x00, 0x00, 0x00, 0x00, 0x06, 0xFF, 0x05, 0x00, 0x01, 0xFF, 0x00

Data	Purpose
0x00	Transaction ID
0x00	Transaction ID
0x00	Protocol ID
0x00	Protocol ID
0x00	Length
0x06	Length
0xFF	Unit identifier
0x05	Write coil
0x00	Reference number
0x01	Reference number
0xFF	Data
0x00	Padding

Table 5-4. Writing a Single Control Word Bit

5.6.2 *Clearing trip counters*

The AC drive's operation day trip counter and energy trip counter can be reset by entering "1" as the value of the coil in request. When the value "1" is entered, the device resets the counter. However, the device does not change the Coil value after reset but maintains the "0" mode.

Address	Function	Purpose
0017	ClearOpDay	Clears resettable operation days counter
0018	ClearMWh	Clears resettable energy counter

Table 5-5. Counters

The following table represents a MODBUS query that resets both counters simultaneously. This example applies the '**Force Multiple Coils**' function. The reference number indicates the address after which the amount of data defined by the 'Bit Count' is written. This data is the last block in the MODBUS TCP message.

Data	Purpose
0x00	Transaction ID
0x00	Transaction ID
0x00	Protocol ID
0x00	Protocol ID
0x00	Length
0x08	Length
0xFF	Unit identifier
0x0F	Force multiple coils
0x00	Reference number
0x10	Reference number
0x00	Bit count
0x02	Bit count
0x01	ByteCount
0x03	Data

Table 5-6. Force Multiple Coils Query

5.7 Input Discrete

Both the 'Coil register' and the 'Input discrete register' contain binary data. However, the difference between the two registers is that the Input register's data can only be read. The Vacon Ethernet board's MODBUS TCP implementation uses the following Input discrete addresses.

5.7.1 *Status Word (Read Only)*

See chapter 5.6.3.

Address	Name	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	AtReference	Status word, bit 5
10007	ZeroSpeed	Status word, bit 6
10008	FluxReady	Status word, bit 7
10009-	Manufacturer reserved	

Table 5-7. Status Word Structure

The following tables show a MODBUS query that reads the entire status word (8 input discretes) and the query response.

Query:
0x00, 0x00, 0x00, 0x00, 0x00, 0x06, 0xFF, 0x02, 0x00, 0x00, 0x00, 0x08

Data	Purpose
0x00	Transaction ID
0x00	Transaction ID
0x00	Protocol ID
0x00	Protocol ID
0x00	Length
0x06	Length
0xFF	Unit identifier
0x02	Read input discretes
0x00	Reference number
0x00	Reference number
0x00	Bit count
0x08	Bit count

Table 5-8. Status Word Read - Query

Response:
0x00, 0x00, 0x00, 0x00, 0x00, 0x04, 0xFF, 0x02, 0x01, 0x41

Data	Purpose
0x00	Transaction ID
0x00	Transaction ID
0x00	Protocol ID
0x00	Protocol ID
0x00	Length
0x04	Length
0xFF	Unit identifier
0x02	Read input discretes
0x01	Byte count
0x41	Data

Table 5-9. Status Word Read - Response

In the responses' data field, you can read the bit mask (0x41) that corresponds to the read discrete status after shifting with the 'Reference number' field value (0x00, 0x00).

LSB 0x1				MSB 0x4			
0	1	2	3	4	5	6	7
1	0	0	0	0	0	1	0

Table 5-10. Response's Data Block Broken into Bits

In this example, the AC drive is in the 'ready' mode because the first 0 bit is set. The motor does not run because the 6 bit is set.

5.8 Holding Registers

You can both read and write data from the MODBUS holding registers. The Ethernet board's MODBUS TCP implementation uses the following address map.

Address range	Purpose	R/W	Max R/W size
0001 - 2000	Vacon Application ID's	RW	12/12
2001 - 2099	FBProcessDataIN	RW	11/11
2101 - 2199	FBProcessDataOUT	RO	11/0
2200 - 10000	Vacon Application ID's	RW	12/12
10301 – 10333	MeasureTable	RO	30/0
10501 – 10530	IDMap	RW	30/30
10601 - 10630	IDMap Read/Write	RW	30/30*
10634 - 65535	Not Used		

Table 5-11. Holding Registers

*Changed from 12 to 30 in firmware version V017.

5.8.1 Application ID

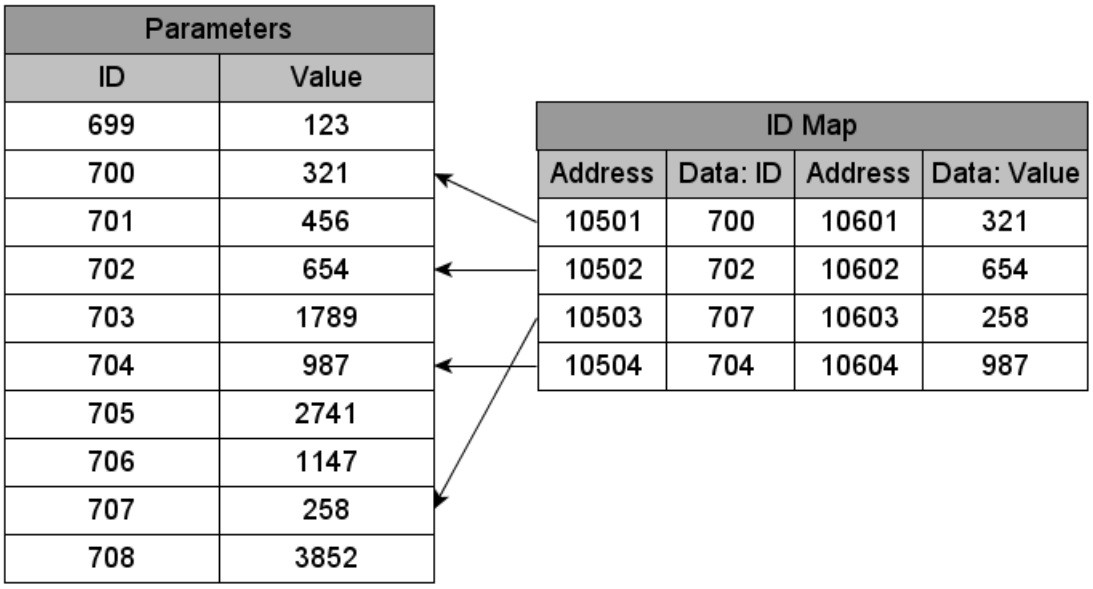
Application ID's are parameters that depend on the frequency converter's application. These parameters can be read and written by pointing the corresponding memory range directly or by using a so-called ID map (more information below). It is easiest to use a straight address if you want to read a single parameter value or parameters with consecutive ID numbers. Read restrictions, possible to read 12 consecutive ID address.

Address range	Purpose	ID
0001 - 2000	Application parameters	1 – 2000
2200 – 10000	Application parameters	2200 – 10000

Table 5-12. Parameter ID's

5.8.2 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.



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: Value
10501	700	10601	321
10502	702	10602	654
10503	707	10603	258
10504	704	10604	987

Figure 5-5. 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**.

Address	Data
410601	Data included in the parameter ID 700
410602	Data included in the parameter ID 702
410603	Data included in the parameter ID 707
410604	Data included in the parameter ID 704

Table 5-13. Parameter Values in IDMap Read / Write Registers

If the IDMap table has not been initialized, all fields show the index '0'. If the IDMap has been initialized, the parameter ID's included in it are stored in the OPTCI board's FLASH memory.

5.8.3 FB Process Data Out (Read)

The 'Process data out' registers are mainly used for controlling AC drives. You can read temporary values, such as frequency, voltage and moment, using the process data. The table values are updated every 10ms.

Address	Purpose	Range / Type
2101	FB Status Word	See chapter 5.6.3.1
2102	FB General Status Word	See chapter 5.6.3.1
2103	FB Actual Speed	0 .. 10 000
2104	FB Process Data out 1	See Appendix 1
2105	FB Process Data out 2	See Appendix 1
2106	FB Process Data out 3	See Appendix 1
2107	FB Process Data out 4	See Appendix 1
2108	FB Process Data out 5	See Appendix 1
2109	FB Process Data out 6	See Appendix 1
2110	FB Process Data out 7	See Appendix 1
2111	FB Process Data out 8	See Appendix 1

Table 5-14. Process Data Out

5.8.3.1 FB Status Word

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
-	-	-	-	-	-	-	-	FR	Z	AREF	W	FLT	DIR	RUN	RDY

Meaning of the FB Status Word bits are explained in the next table

Bits	Description	
	Value = 0	Value = 1
0	Not Ready	Ready
1	Stop	Run
2	Clockwise	Counterclockwise
3	No Fault	Faulted
4	No Alarm	Alarm
5	Ref. Freq. not reached	Ref. Freq. reached
6	Motor not running at zero speed	Motor running at zero speed
7	Flux Ready	Flux Not Ready
8...15	Not In Use	Not In Use

Table 5-15. Status Word bit description

5.8.4 FB Process Data In (Read / Write)

The use of process data depends on the application. Typically, the motor is started and stopped using the '*Control Word*' and the speed is set by writing a '*Reference*' value. Through using other process data fields, the device can give other required information to the MASTER device, depending on the application.

Address	Purpose	Range / Type
2001	FB Control Word	See chapter 5.6.4.1
2002	FB General Control Word	See chapter 5.6.4.1
2003	FB Speed Reference	0 .. 10 000
2004	FB Process Data in 1	See Appendix 1
2005	FB Process Data in 2	See Appendix 1
2006	FB Process Data in 3	See Appendix 1
2007	FB Process Data in 4	See Appendix 1
2008	FB Process Data in 5	See Appendix 1
2009	FB Process Data in 6	See Appendix 1
2010	FB Process Data in 7	See Appendix 1
2011	FB Process Data in 8	See Appendix 1

Table 5-16. Process Data In

5.8.4.1 FB Control Word

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
-	FBD10	FBD9	FBD8	FBD7	FBD6	-	-	FBD5	FBD4	FBD3	FBD2	FBD1	RST	DIR	RUN

Meaning of the FB Control Word bits are explained in the next table

Bits	Description	
	Value = 0	Value = 1
0	Stop	Run
1	Clockwise	Counterclockwise
2	-	Fault Reset
3	Fieldbus Din 1 OFF	Fieldbus Din 1 ON
4	Fieldbus Din 2 OFF	Fieldbus Din 2 ON
5	Fieldbus Din 3 OFF	Fieldbus Din 3 ON
6	Fieldbus Din 4 OFF	Fieldbus Din 4 ON
7	Fieldbus Din 5 OFF	Fieldbus Din 5 ON
8	No meaning	No meaning (Control from FB)
9	No meaning	No meaning (Reference from FB)
10	Fieldbus Din 6 OFF	Fieldbus Din 6 ON
11	Fieldbus Din 7 OFF	Fieldbus Din 7 ON
12	Fieldbus Din 8 OFF	Fieldbus Din 8 ON
13	Fieldbus Din 9 OFF	Fieldbus Din 9 ON
14	Fieldbus Din 10 OFF	Fieldbus Din 10 ON
15	Not in use	Not in use

Table 5-17. Control Word bit description

5.8.5 *Measurement Table*

The measurement table provides 25 readable values as listed in the following table. The table values are updated every 100ms. Read restrictions, possible to read 25 consecutive ID address.

Address	Purpose	Type
10301	MotorTorque	Integer
10302	MotorPower	Integer
10303	MotorSpeed	Integer
10304	FreqOut	Integer
10305	FreqRef	Integer
10306	REMOTEIndication	Unsigned short
10307	MotorControlMode	Unsigned short
10308	ActiveFault	Unsigned short
10309	MotorCurrent	Unsigned integer
10310	MotorVoltage	Unsigned integer
10311	FreqMin	Unsigned integer
10312	FreqScale	Unsigned integer
10313	DCVoltage	Unsigned integer
10314	MotorNomCurrent	Unsigned integer
10315	MotorNomVoltage	Unsigned integer
10316	MotorNomFreq	Unsigned integer
10317	MotorNomSpeed	Unsigned integer
10318	CurrentScale	Unsigned integer
10319	MotorCurrentLimit	Unsigned integer
10320	DecelerationTime	Unsigned integer
10321	AccelerationTime	Unsigned integer
10322	FreqMax	Unsigned integer
10323	PolePairNumber	Unsigned integer
10324	RampTimeScale	Unsigned integer
10325	MsCounter	Unsigned integer

Table 5-18. Measurement Table

5.9 Input Registers

The Input Registers include read only data. See below for a more specific description of the registers.

Address range	Purpose	R/W	Max R/W size
1 - 5	Operation day counter	RO	5/0
101 - 105	Resettable operation day counter	R, Cleared using coils	5/0•
201 - 203	Energy counter	RO	5/0
301 - 303	Resettable energy counter	R, Cleared using coils	5/0
401 - 430	Fault History	RO	30/0

Table 5-19 Input Registers

5.9.1 Operation Day Counter 1 – 5

Address	Purpose
1	Years
2	Days
3	Hours
4	Minutes
5	Seconds

Table 5-20. Operation Day Counter

5.9.2 Resettable Operation Day Counter 101 – 105

Address	Purpose
101	Years
102	Days
103	Hours
104	Minutes
105	Seconds

Table 5-21. Resettable Operation Day Counter

5.9.3 Energy Counter 201 – 203

The last number of the 'Format' field indicates the decimal point place in the 'Energy' field. If the number is bigger than 0, move the decimal point to the left by the number indicated. For example, Energy = 1200, Format = 52. Unit = 1. **Energy = 12.00kWh**

Address	Purpose
201	Energy
202	Format
203	Unit 1 = kWh 2 = MWh 3 = GWh 4 = TWh

Table 5-22. Energy Counter

5.9.4 Resettable Energy Counter 301 – 303

Address	Purpose
301	Energy
302	Format
303	Unit 1 = kWh 2 = MWh 3 = GWh 4 = TWh

Table 5-23. Resettable Energy Counter

5.9.5 Fault History 401 – 430

The fault history can be viewed by reading from the address 401 onward. The faults are listed in chronological order so that the latest fault is mentioned first and the oldest is mentioned last. The fault history can contain 29 faults at any time. The fault history contents are represented as follows.

Fault code	Sub-code
Value as a hexadecimal	Value as a hexadecimal

Table 5-24. Fault Coding

For example, the IGBT temperature fault code 41, sub-code 00: 2900Hex -> 4100Dec. For complete list of fault codes please see AC drive's manual

Note!
It is very slow to read whole fault history (401-430) at a time. It is recommended to read only parts of the fault history at a time.

6. START-UP TEST

Once the option board has been installed and configured, its operation can be verified by writing a frequency instruction and giving a run command to the AC drive via fieldbus.

6.1 AC drive Settings

Select fieldbus as the active control bus. (For more information see the Vacon NX User´s Manual, section 7.3.3).

6.2 Master Unit Programming

1. Write a FB 'Control Word' (Holding register address: 2001) of value **1Hex**
2. The AC drive is now in the RUN mode.
3. Set the FB 'Speed Reference' (Holding register address: 2003) value of **5000** (= 50.00%).
4. The engine is now running at a 50% speed.
5. Write a 'FB Control Word' (Holding register address: 2001) value of **0Hex**'
6. Following this, the engine stops.

7. ERROR CODES AND ERRORS

7.1 AC drive Error Codes

To make sure that the board functions are correctly in all circumstances and that no errors occur, the board set the **fieldbus error 53** if it doesn't have a functional connection to the Ethernet network or if the connection is faulty.

In addition, the board assumes that there is always at least one functional connection after the first Modbus TCP connection. If this is not true, the board will set the **fieldbus error 53** in the AC drive. Confirm the error by pressing the 'reset' button.

Card slot error 54 may be due to a faulty board, a temporary malfunction of the board or a disturbance in the environment.

7.2 Modbus TCP

This section discusses Modbus TCP error codes used by the OPTCI board and possible causes of the errors.

Code	Modbus exception	Possible cause
0x01	Illegal function	The appliance does not support the function
0x02	Illegal data address	Attempt to read the query over the memory range
0x03	Illegal data value	Register or amount of values out of range.
0x04	Slave device failure	The appliance or connections are faulty
0x06	Slave device busy	Simultaneous query from two different masters to the same memory range
0x08	Memory parity error	Drive returned fatal response.
0x0B	No response from slave	No such slave connected with this Unit Identifier.

Table 7-1. Error Codes

8. APPENDIX

Process Data OUT (Slave to Master)

The Fieldbus Master can read the AC drive's actual values using process data variables. *Basic, Standard, Local/Remote Control, Multi-Step Speed Control, PID control and Pump and Fan Control* applications use process data as follows:

ID	Data	Value	Unit	Scale
2104	Process data OUT 1	Output Frequency	Hz	0,01 Hz
2105	Process data OUT 2	Motor Speed	rpm	1 rpm
2106	Process data OUT 3	Motor Current	A	0,1 A
2107	Process data OUT 4	Motor Torque	%	0,1 %
2108	Process data OUT 5	Motor Power	%	0,1 %
2109	Process data OUT 6	Motor Voltage	V	0,1 V
2110	Process data OUT 7	DC link voltage	V	1 V
2111	Process data OUT 8	Active Fault Code	-	-

Table 8-1. Process data OUT variables

The *Multipurpose Control application* has a selector parameter for every Process Data. The monitoring values and drive parameters can be selected using the ID number (see NX All in One Application Manual, Tables for monitoring values and parameters). Default selections are as in the table above.

Process Data IN (Master to Slave)

ControlWord, Reference and Process Data are used with All in One applications as follows.

Basic, Standard, Local/Remote Control and Multi-Step Speed Control applications

ID	Data	Value	Unit	Scale
2003	Reference	Speed Reference	%	0.01%
2001	ControlWord	Start/Stop Command Fault reset Command	-	-
2004–2011	PD1 – PD8	Not used	-	-

Table 8-2.

Multipurpose Control application

ID	Data	Value	Unit	Scale
2003	Reference	Speed Reference	%	0.01%
2001	ControlWord	Start/Stop Command Fault reset Command	-	-
2004	Process Data IN1	Torque Reference	%	0.1%
2005	Process Data IN2	Free Analogia INPUT	%	0.01%
2006–2011	PD3 – PD8	Not Used	-	-

Table 8-3.

PID control and Pump and fan control applications

ID	Data	Value	Unit	Scale
2003	Reference	Speed Reference	%	0.01%
2001	ControlWord	Start/Stop Command Fault reset Command	-	-
2004	Process Data IN1	Reference for PID controller	%	0.01%
2005	Process Data IN2	Actual Value 1 to PID controller	%	0.01%
2006	Process Data IN3	Actual Value 2 to PID controller	%	0.01%
2007–2011	PD4–PD8	Not Used	-	-

Table 8-4.

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Document ID:
DPD00900B
Rev. B

Sales code: DOC-OPTCI+DLUK