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USER'S MANUAL

NX FREQUENCY CONVERTERS

ETHERNET OPTION BOARD

OPT-CI

INDEX

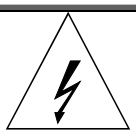
1. INTRODUCTION

Vacon NX frequency converters can be connected to Ethernet using an Ethernet fieldbus board OPT-CI.

The OPT-CI 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 frequency converter 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.*

2. ETHERNET BOARD TECHNICAL DATA

2.1 Overview

General	Card Name	OPT-CI
Ethernet connections	Interface	RJ-45 connector
Communications	Transfer cable	Foiled CAT5e
	Speed	10 / 100 Mb
	Duplex	half / full
	Default IP-address	192.168.0.10
Protocols	Modbus / TCP	
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. Ethernet board technical data

2.2 OPT-CI card

Figure 2-1. OPT-CI card

2.3 Ethernet, introduction

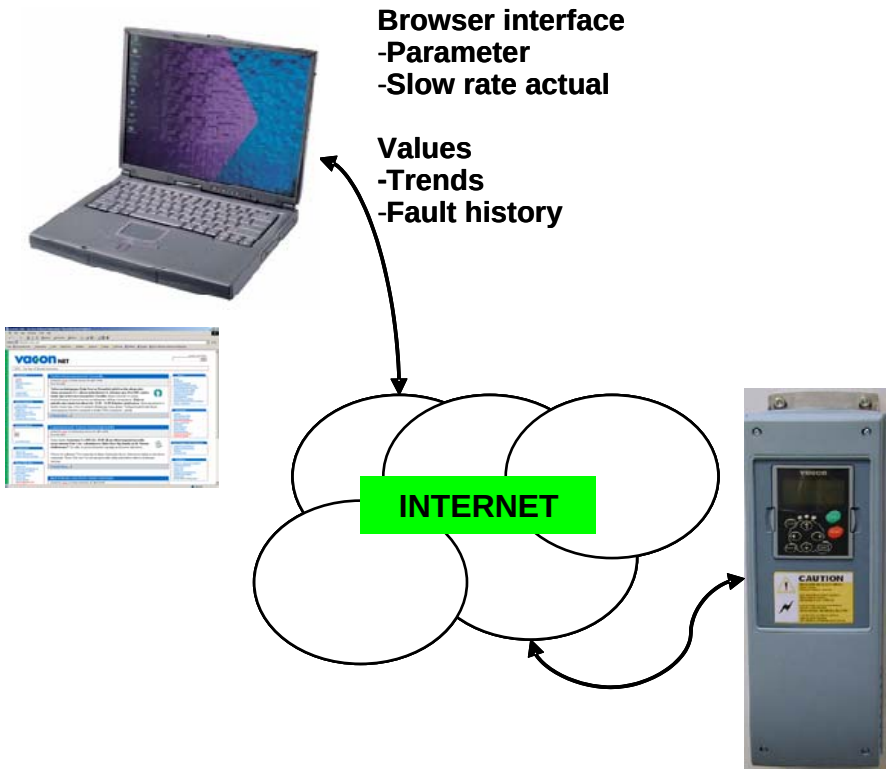
The Ethernet consist of different layers shown in the picture below. Due to the modular structure of Ethernet it is easy to add new protocols such as fieldbuses or user interfaces to the Vacon Ethernet option board in the future.

Protocol Layer (HTTP, DHCP , Modbus/TCP, Ethernet / IP, etc)	7 Application
	6 Presentation
TCP / **UDP**	5 Session
	4 Transport
IP	3 Network
Ethernet Data Link Layer	2 Data Link
Ethernet Physical Layer	1 Physical

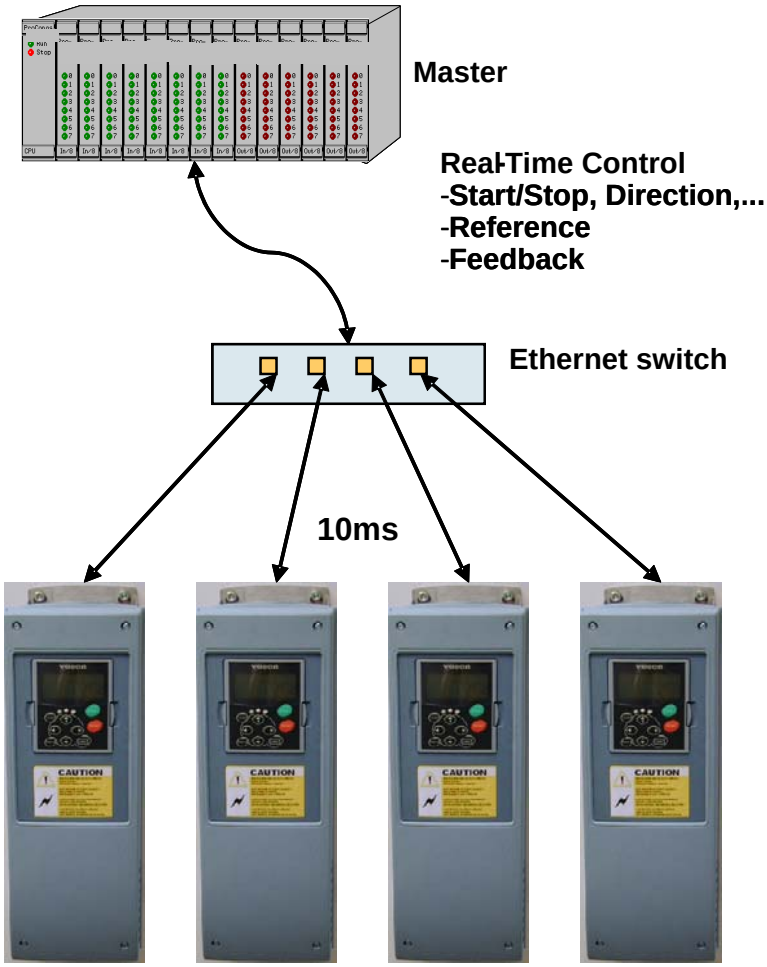
2.4 Ethernet

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)



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



2.5 Connections and Wiring

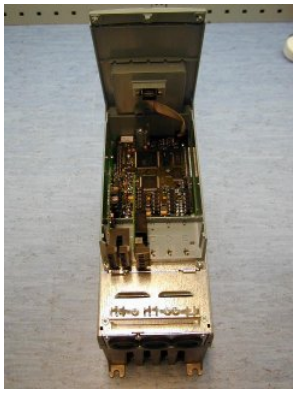
The Ethernet board supports 10/100Mb speeds in both Full and Half-duplex modes. The boards must be connected to the Ethernet network with a shielded CAT-5e cable. Use a so-called crossover cable if you want to connect the Ethernet option board directly to the master appliance.

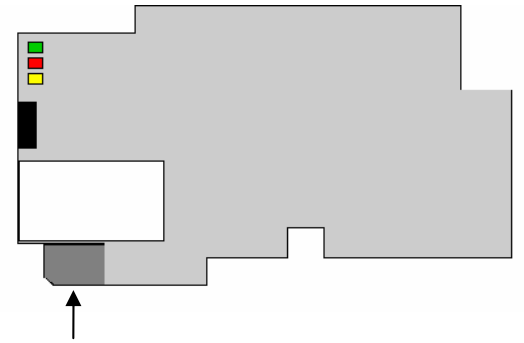
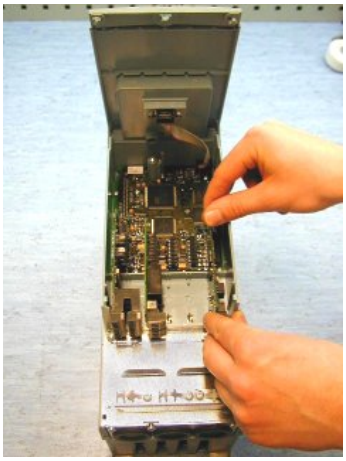
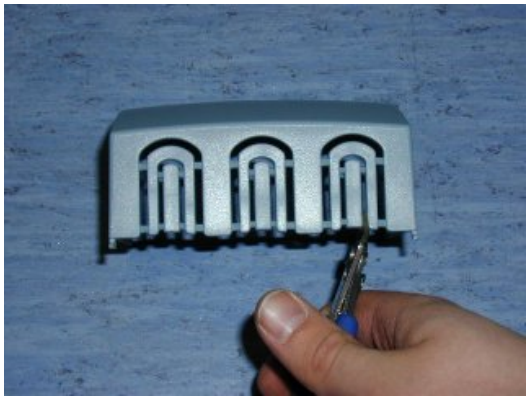
Use only industrial standard components in the network and avoid complex structures to minimize the length of response time and the amount of incorrect dispatches.

3. INSTALLATION

3.1 Installing the Ethernet Option Board in a Vacon NX Unit

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

A	Vacon NX frequency converter.	
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 frequency converter. 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.	

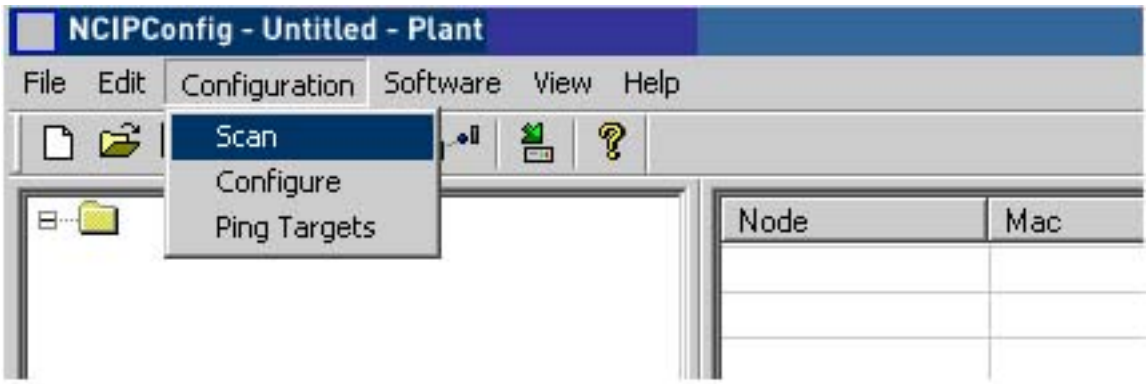
3.2 IP Tool NCIPConfig

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.

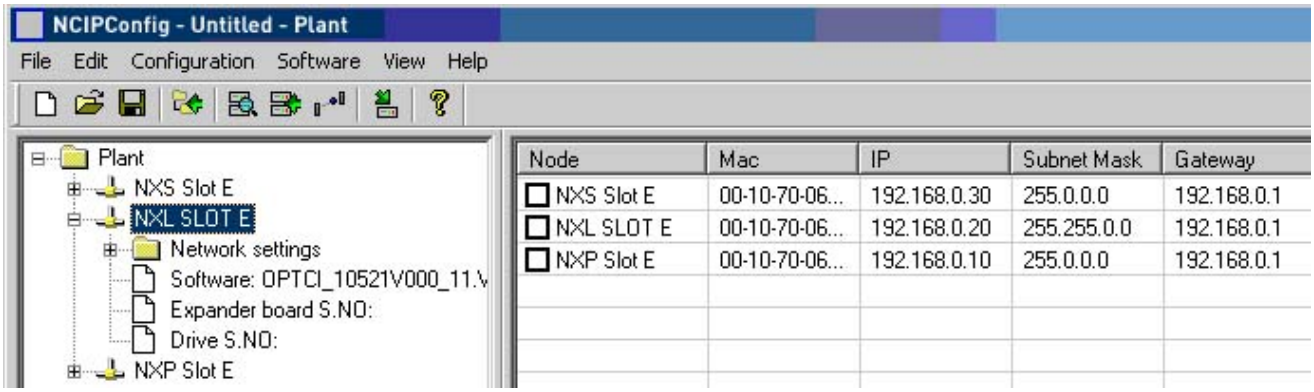
You need a PC with an Ethernet connection and NCIPConfig tool installed to set the Ethernet board's IP addresses. To Install NCIPConfig tool start the installation program from CD or download it from www.vacon.com – web site. After starting the installation program please follow the on-screen instructions.

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.

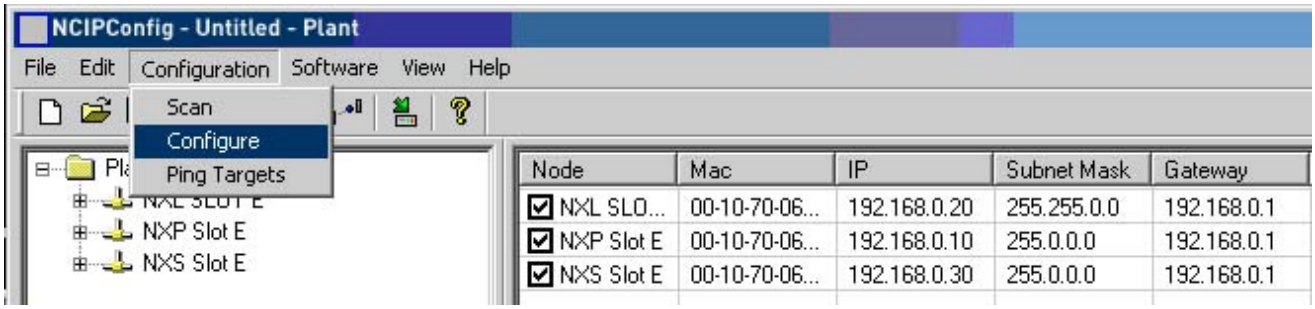
Step 1. Scan network nodes. Select '**Scan**' '**Configuration**' and wait until the devices connected to the bus in the tree structure are displayed on the left of the screen. Note! Some switches block broadcast messages, and in that case, each network node must be scanned separately.



Step 2. Set IP addresses. 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.



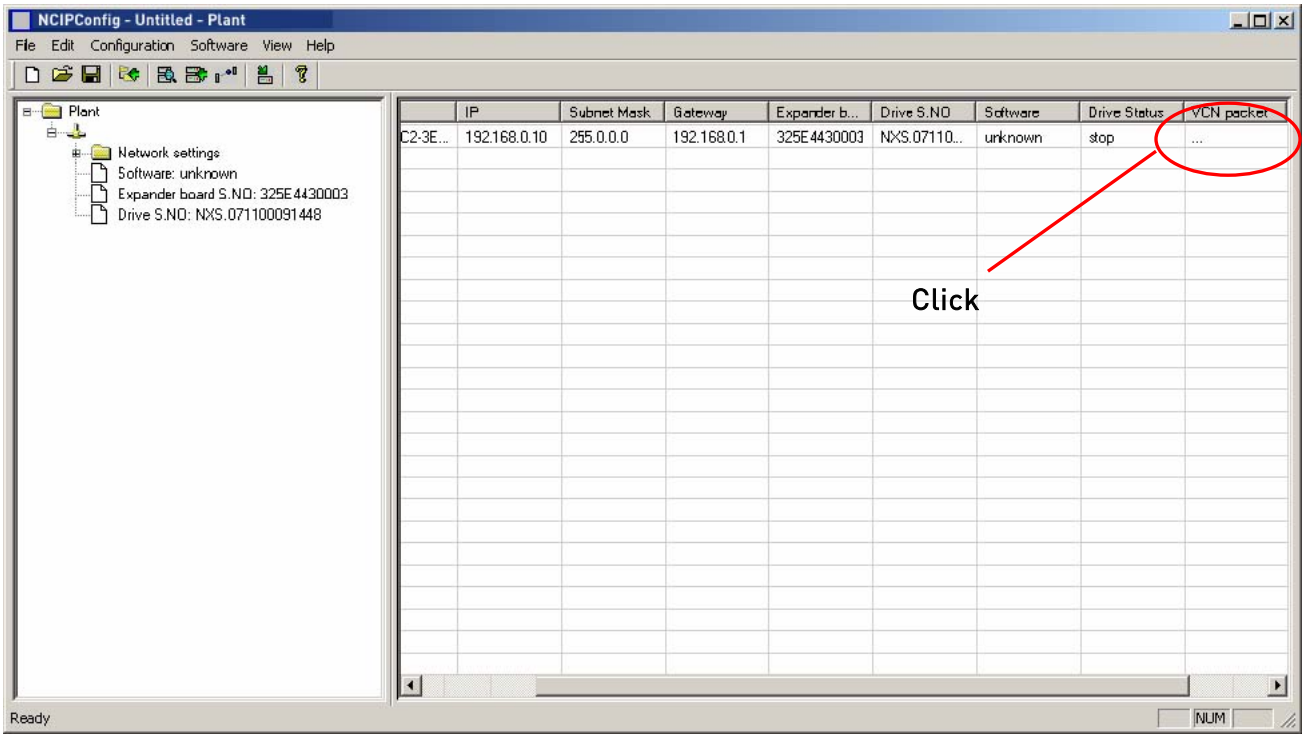
Step 3. Send configuration to boards. In the table view, check the boxes for boards whose configuration you want to send and select '**Configuration**', then '**Configure**'. Your changes are sent to the network and will be valid immediately.



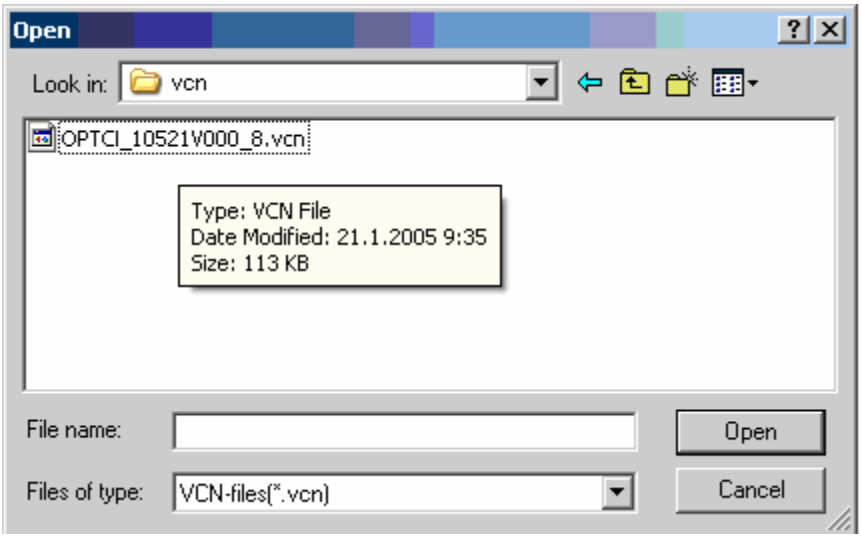
3.2.1 Update OPT-CI Option Board program with the NCIPConfig Tool

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 software.

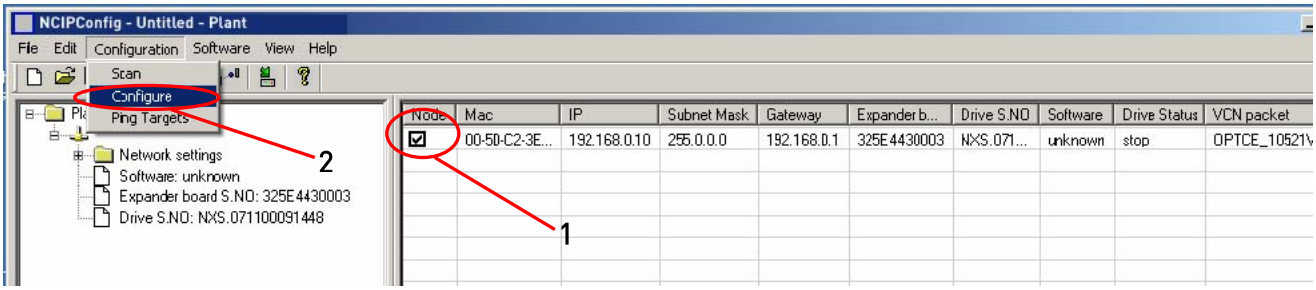
To start the firmware update, scan the nodes in the network according to the instructions in section 3.2. Once you can see all nodes in the view, you can update the new firmware by clicking the 'VCN Packet' field in NCIPCONFIG 's right table view.



After clicking the 'VCN Packet' field, a file open window from 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 '*Configuration*' then '*Configure*'.



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4. MODBUS/TCP

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)

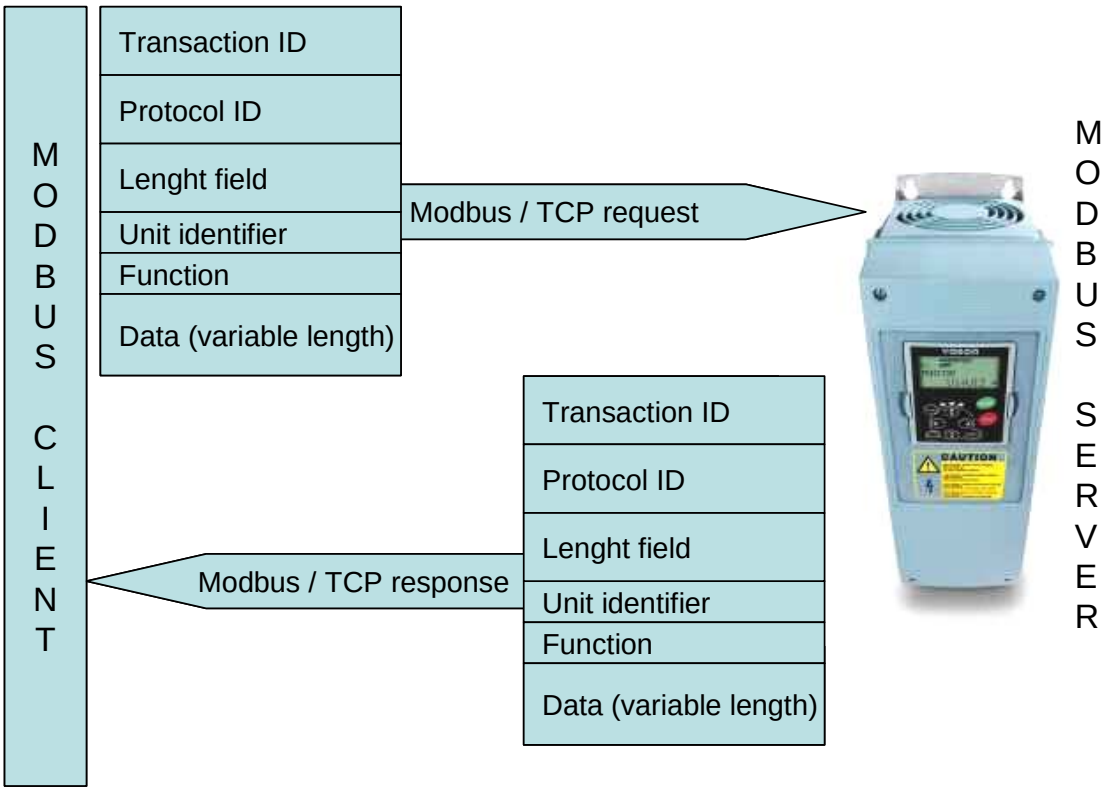

Figure 4-1. Modbus Transaction

4.1 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 named as the unit identifier field in MODBUS/TCP, and it is only used when one IP address stands for several endpoints.

4.2 Ethernet Option Board's Modbus Addresses

A Modbus/TCP class 1 functionality has been implemented in OPT-CI 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 4-1. Supported 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 4-2. Supported Registers

4.3 Coil (0x01) 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.

4.3.1 0001 –00016 Control Word (Read / Write)

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	BusCtrl	Control word, bit 9
0010	BusRef	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	FBFaultIN	Control word, bit 16

Table 4-3. 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, 0x01, 0x05, 0x00, 0x01, 0xFF, 0x00

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

Table 4-4. Writing a Single Control Word Bit

4.3.2 0017 – 00018 Counters (Read Only)

The frequency converter'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 OpDay counter
0018	ClearMWh	Clears MWh counter

Table 4-5. 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
0x01	Unit identifier
0x0F	Force multiple coils
0x00	Reference number
0x10	Reference number
0x00	Bit count
0x02	Bit count
0x01	ByteCount
0x03	Data

Table 4-6. Force Multiple Coils Query

4.4 Input Discrete (1x)

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.

4.4.1 10001 – 1008, Status Word (Read Only)

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	Warning	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 4-7. 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, 0x01, 0x02, 0x00, 0x00, 0x00, 0x08

Data	Purpose
0x00	Transaction ID
0x00	Transaction ID
0x00	Protocol ID
0x00	Protocol ID
0x00	Length
0x06	Length
0x01	Unit identifier
0x02	Read input discretes
0x00	Reference number
0x00	Reference number
0x00	Bit count
0x08	Bit count

Table 4-8. Status Word Read - Query

Response:
0x00, 0x00, 0x00, 0x00, 0x00, 0x06, 0x01, 0x02, 0x01, 0x41

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

Table 4-9. Status Word Read - Response

In the responses' data field, you can read the bit mask (0x41) that corresponds to the read discretes' 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 4-10. Response's Data Block Broken into Bits

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

4.5 Holding Registers (400001 - 410633)

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
0001 - 2000	Vacon Application ID's
2001 - 2099	FBProcessDataIN
2101 - 2199	FBProcessDataOUT
2200 - 10000	Vacon Application ID's
10001 - 10033	IndexMap
10101 - 10133	IndexMapRead/Write
10301 - 10333	MeasureTable
10501 - 10533	IDMap
10601 - 10633	IDMap Read/Write
10634 - 65535	Not Used

Table 4-11. Holding Registers

4.5.1 400001 – 402000 and 402200 – 410000, 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.

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

Table 4-12. Parameter ID's

4.5.2 10501 – 10533, 10601 – 10633, 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 - 10533 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 10633 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.

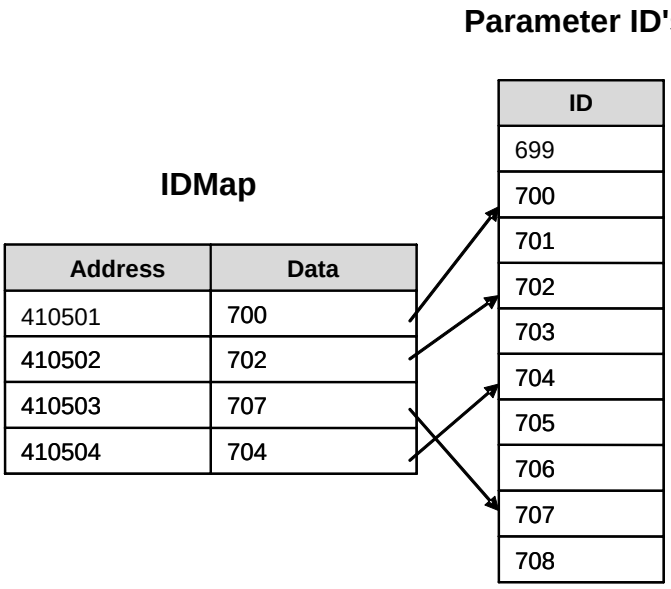

Figure 4-2. IDMap Initialization

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 4-13. 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 OPT-CI board's FLASH memory.

4.5.3 10001 – 10033, 10101 – 10133, Index MAP

IndexMap functions in almost entirely the same way as the IDMap. The difference between IndexMap and IDMap is that IndexMap is used to handle indexes instead of parameters. The address range 10001 – 10033 is called 'IndexMap' and you can write your index number in it. Correspondingly, the value of the written index can be read in the address range 10101 – 10133, called 'IndexMap Read / Write'.

Also the data contained in the 'IndexMap' address range is stored in the OPT-CI board's FLASH memory. IndexMap data has a default value of 0.

4.5.4 402200 – 410000, FB Process Data Out (Read)

The 'Process data out' registers are mainly used for controlling frequency converters. 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 4.4.1
2102	FB General Status Word	See chapter 4.3.1
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 4-14. Process Data Out

4.5.5 402200 – 410000, 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 4.4.1
2002	FB General Control Word	See chapter 4.3.1
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 4-15. Process Data In

4.5.6 10301 – 10333 Measurement Table

The measurement table provides 25 readable values as listed in the following table. The table values are updated every 100ms.

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 4-16. Measurement Table

4.6 Input Registers (3x)

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

4.6.1 Operation Day Counter 30001 – 30007

Address	Purpose
30001	Years
30002	Days
30003	Hours
30004	Minutes
30005	Seconds

Table 4-17. Operation Day Counter

4.6.2 Resettable Operation Day Counter 30101 – 30107

Address	Purpose
30101	Years
30102	Days
30103	Hours
30104	Minutes
30105	Seconds

Table 4-18. Resettable Operation Day Counter

4.6.3 Energy Counter 30201 – 30203

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
30201	Energy
30202	Format
30203	Unit 1 = kWh 2 = MWh 3 = GWh 4 = TWh

Table 4-19. Energy Counter

4.6.4 Resettable Energy Counter 30301 – 30303

Address	Purpose
30301	Energy
30302	Format
30303	Unit 1 = kWh 2 = MWh 3 = GWh 4 = TWh

Table 4-20 Resettable Energy Counter

4.6.5 Error History 30401 – 30417

The error history can be viewed by reading from the address 30401 onward. The errors are listed in chronological order so that the latest error is mentioned first and the oldest is mentioned last. The error history can contain 16 errors at any time. The error history contents are represented as follows.

Error code	Sub-code
Value as a hexadecimal	Value as a hexadecimal

Table 4-21. Error Coding

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

5. 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 frequency converter via fieldbus.

5.1 Frequency Converter Settings

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

5.2 Master Unit Programming

1. Write a FB 'Control Word' (address: 42001) of value 1Hex
2. The frequency converter is now in the RUN mode.
3. Set the FB 'Speed Reference' (address:42003) value of 5000 (= 50.00%).
4. The engine is now running at a 50% speed.
5. Write a 'FB Control Word' (address: 42001) value of 0Hex'
6. Following this, the engine stops.

6. ERROR CODES AND ERRORS

6.1 Frequency Converter 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 frequency converter. 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.

6.2 Modbus TCP

This section discusses Modbus/TCP error codes used by the OPT-CI 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
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

Table 6-1. Error Codes

7. APPENDIX

Process Data OUT (Slave to Master)

The Fieldbus Master can read the frequency converter'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 7-1. 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 7-2.

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 7-3.

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 7-4.

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