Atlas Copco Airpower NV

ELEKTRONIKON MkIV

User Guide : Elektronikon MkIV Modbus

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Preface

This document describes how to implement a Modbus connection to the Elektronikon MkIV compressor controller network.

Table of Contents

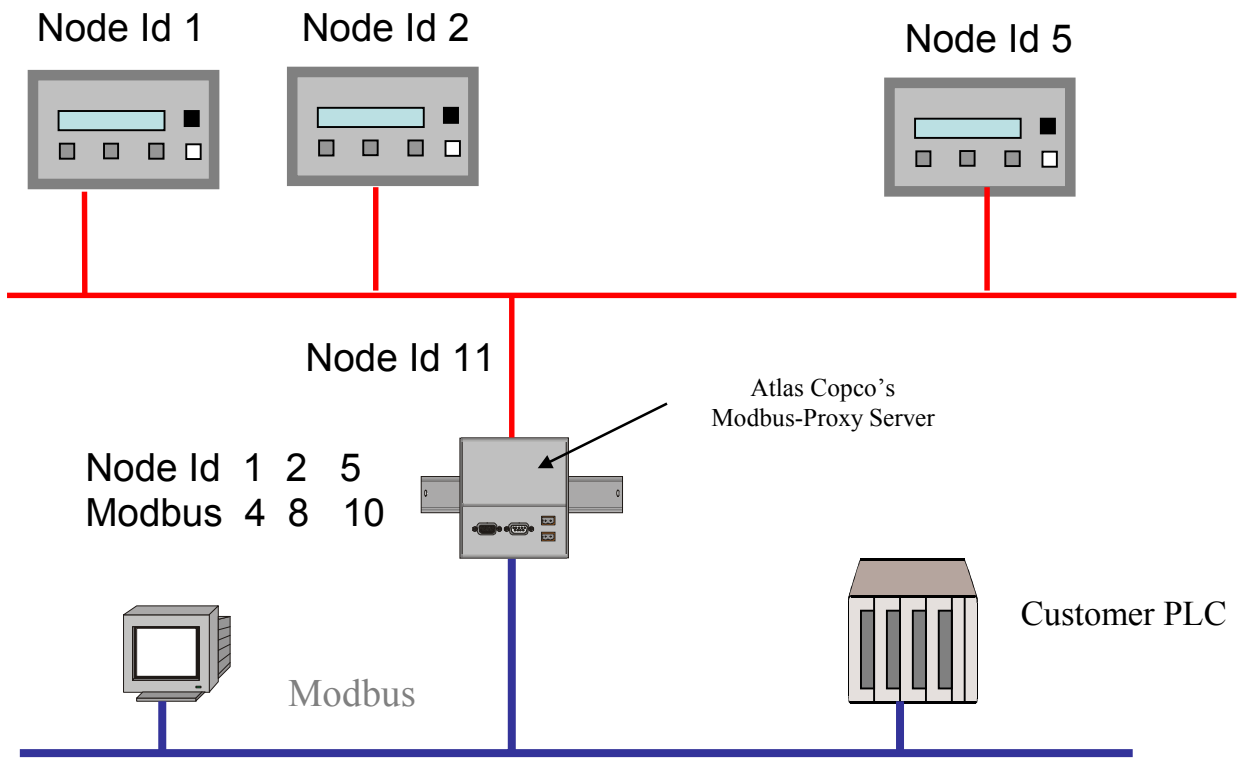
1. The Physical set-up

1.1 Modbus & the Network

In the Elektronikon MkIV system all compressors in an installation can be connected by a data and/or control network. This is done according the Compressor Network Cabling Instruction (9820 3585 00). This instruction explains what connectors and cables should be used to interconnect the different compressors/controllers in the network. Basically this is a CAN-based local network.

In order to setup a modbus connection to one or several of the compressors in this network, a special module as to be inserted in this network.

This module will then behave as a modbus-proxy that allows access to all compressors in the network, whereby each compressor has its own modbus address (proxy concept).



In this drawing the proxy is used to access the compressors with Node Id 1,2 and 5, by using the modbus addresses 4,8 and 10. (This proxy-conversion table has to be set with proper tools). The Node Id the Proxy itself if 11 on the CAN side.

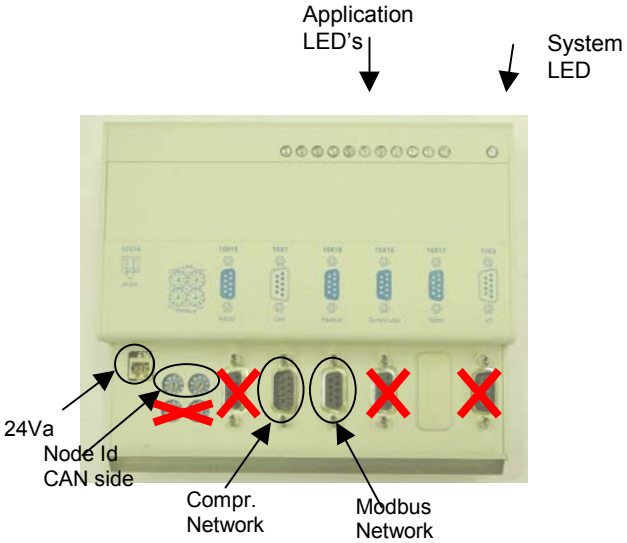
1.2 The Module (Combox-S)

For the modbus connection a so-called Combox-S module has to be used (AC n° 19000711 41). This is a general purpose serial communication module. By downloading the correct software in it, it will perform the modbus proxy function.

Because this is a general purpose module, not all connections/switches will be used for this connection.
For modbus the following will be used

- 10x14 :
  - to connect a 24Vac supply
- 2 top address switches (LAN)
  - to set the Atlas Copco Lan address (= CAN side address !!), the Fieldbus switches are NOT used, because the Modbus addresses (proxy) are defined by software and programmed with an external (PC) software.
- 10x1:
  - to connect to the compressor network (CAN)
- 10x16 :
  - to connect the RS485 modbus line

The other connectors/switches are NOT used for this application



The module itself can be mounted on a DIN-rail inside one of the compressor cubicles, or on a separate location. Before installation check the available power of the 24Vac transformer, if connecting to an already supplied transformer inside a cubicle..

1.3 LED's

The module also has a number of LED's on type. They are used as follows :

System LED

Blinking : no program loaded or not running
Lit continuously : program running OK

Application LED's from left to right

1. not used
2. not used
3. CAN receive (Combox receives CAN message)
4. CAN transmit (Combox transmits CAN message)
5. Modbus receive (Combox receives Modbus message)
6. Modbus transmit (Combox transmits Modbus message)
7. not used
8. not used
9. not used
10. Modbus Mode
11. not used

1.4 Connector lay-out

1.4.1 Power Supply

This is a two pole Wago (type …) connector. Power supply is 24Vac, 10VA

1.4.2 LAN connector

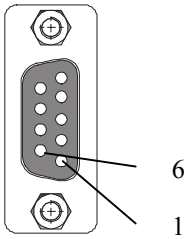
Connect here the cable of the compressor network, according AC instruction : Compressor Network Cabling Instruction (9820 3585 00).

1.4.3 Modbus connection

The module supports the RS485A variant of modbus, with the following pin-layout and termination requirements as specified

Pin Assignment Modbus

Sub-D 9 pole female

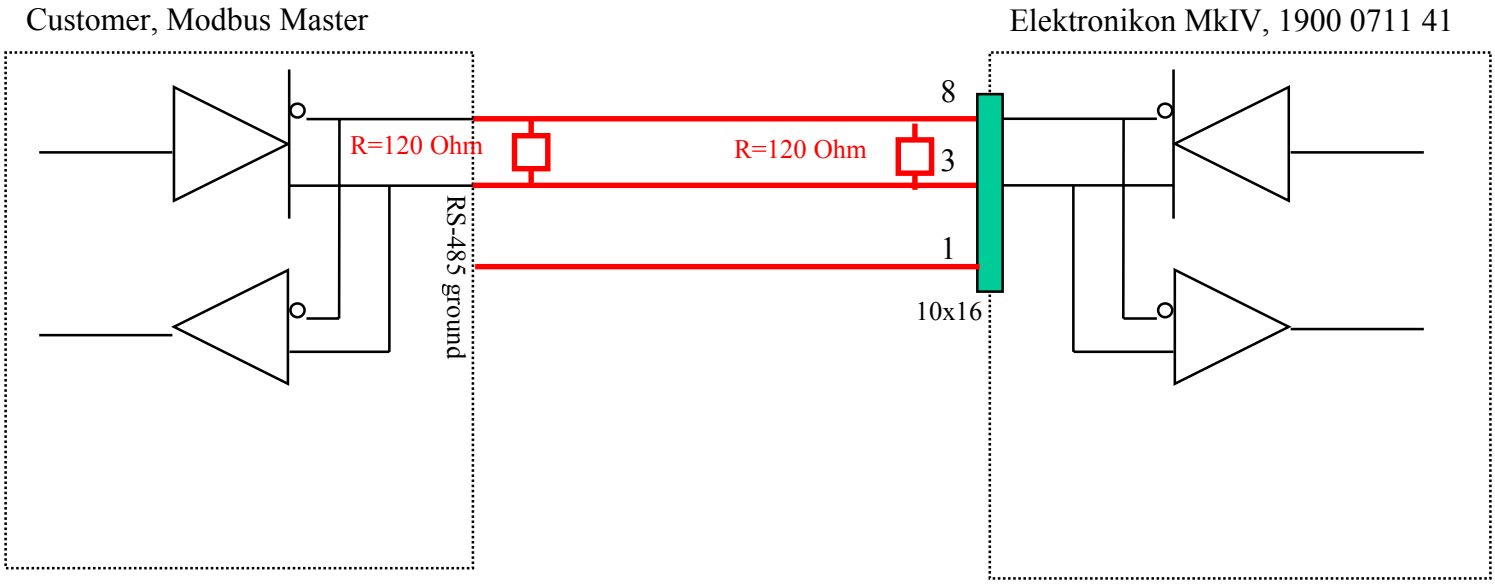


Pin	Function
1	GND
2	Reserved
3	TxD/RxD +
4	RTS
5	GND*
6	+5V*
7	Reserved
8	TxD/RxD -
9	Reserved

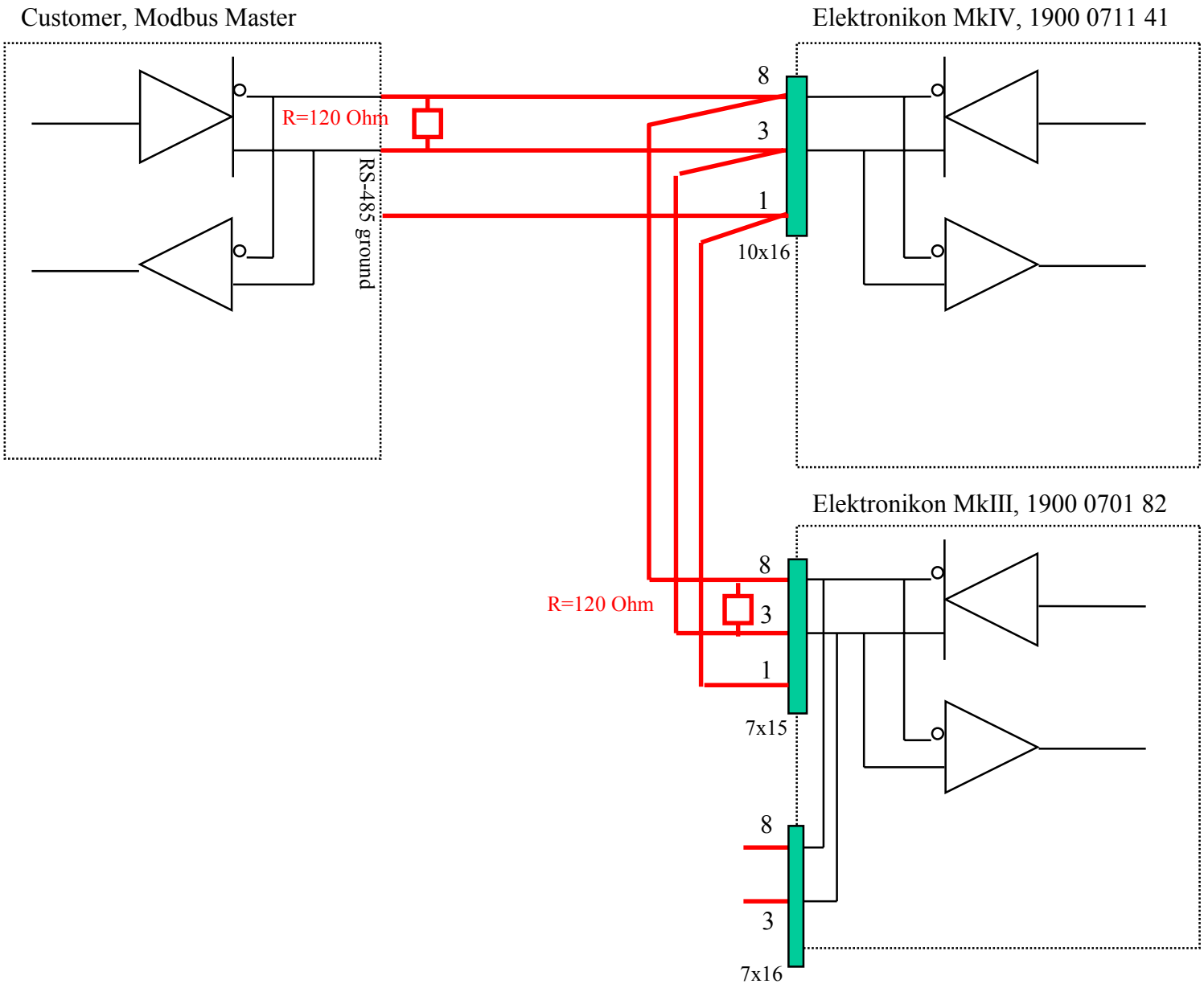
* galvanic isolated

1.5 RS485 connections

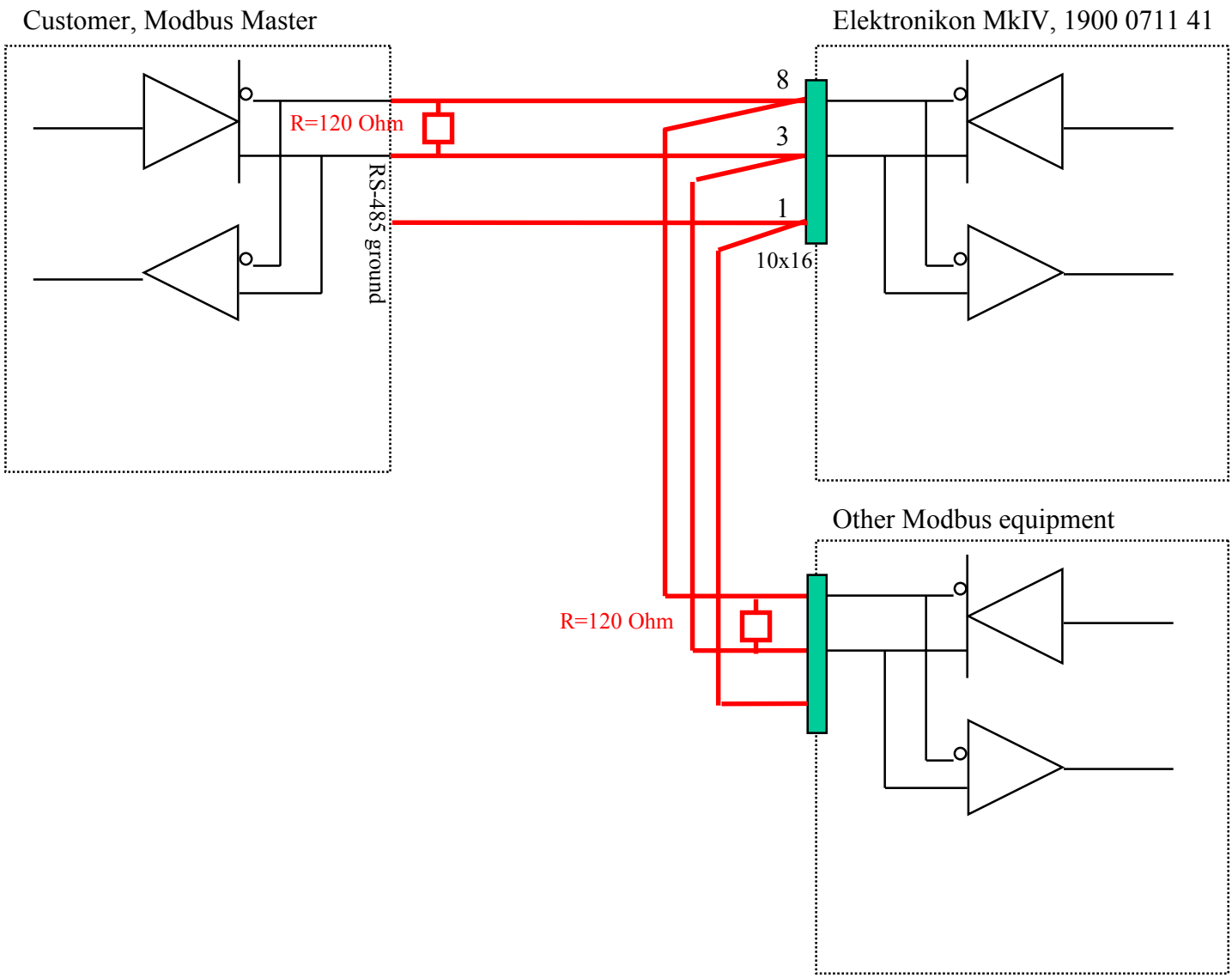
1.5.1 Modbus with MKIV



1.5.2 Modbus with MKIV and MKIII



1.5.3 Modbus with MKIV and Other Equipment



1.6 Software downloading

Before the module can be used for a modbus connection the appropriate software must be loaded. This can be done by AC Service personal with the AC Field Downloading Program (FDP).

With this program it is also possible to program the modbus/CAN address conversions.

After programming , put power off/on of the combox-S to activate the modbusaddresses.
Before powering the Combox –S module , check all cables.

2. Modbus protocol implementation

2.1 Supported modbus specification

The Combox-S when downloaded with the proper modbus software supports the following modbus- variant

- RTU mode of transmission
- Coding system : binary
- Mode : half duplex (RS485)
- Number of start bits : 1
- Number of data bits : 8
- Baudrate : 300,600,1200,2400,4800,9600*,19200*,38400
- Parity control : even*,odd*,none *
- Number of stop bits : 1 or 2
- Error checking : CRC-16

* These parameters are defined during downloading of the controller.
Frame synchronization in the RTU mode is done by simulating a synchronous message. The slave device monitors the elapsed time between receipt of characters. If three character time elapsed without a new character, then the device assumes that the message is completed and the next byte will be the address

The message frame format is following :

T1 T2 T3	ADDRESS	Message body	CRC	T1 T2 T3

2.2 Supported Modbus functions

The Elektronikon MkIV modbus implemenentation supports the following message type , depending on the type of data involved (see details below)

Function 01 : read coil status
Function 03 : read holding register
Function 06 : preset single register
Function 08 : loop back test

2.3 Modbus registers and coils for Data Reading

2.3.1 System Overview

2.3.1.1 General Compressor Condition

Function to be used : Read Coil Status (01)

Modbus Coil	Status Information	Load/Unload	VSD
0001	Stopped (=0) / Running (=1)	X	X
0002	Unload (=0)/ Load (=1)	X	
0003	General Warning	X	X
0004	General Shutdown-Warning	X	X
0005	General Shutdown	X	X
0006	General Service	X	X
0007	General Start Failure	X	X
0008	Emergency Stop	X	X
0009	Manual (=0) /Automatic (=1)	X	X
0010	Local (=0)/ Remote (=1)	X	X

2.3.1.2 Detailed General Compressor Condition

Function to be used : Read Holding Register (03)

Modbus register	High Byte	Low Byte
0401	CMS	COM
0402	CS	CCM
0403	GENERAL STATUS	
0404	CS_MCC	0

Parameter	Bit	
General status	0	Pre – Warning
	1	General Warning
	2	General Shutdown-Warning
	3	General Shutdown
	4	General Service
	5	General Start Failure
	6	Emergency Stop
	7	Manual/Automatic (COS1)
	8	Local/Remote
	9	Timer Not Active/Active
	10	Pre-warning Service Running Hours
	11	Pre-warning Service Accumulated M3

CCM (Compressor Controller Mode)	CCM2a CCM2b CCM3a CCM3b CCM4a CCM4b CCM4c (Speed control) CCM4d (MCC)	00 10 01 11 02 12 22 32
CMS (Compressor Mechanical State)	No Valid Data Stopped Unloaded Loaded	00 01 02 04
CS (Compressor State) Load Unload	No Valid Data A ……. V	0 1 …. 22
CS MCC (Compressor State) MCC	No Valid Data A …… D	0 1 …. 4
CS (Compressor State) VSD	No Valid Data A …… V	0 1 …. 22

Very Important Note !!!!!.

When CS is 0 or CMS is 0 ALL data for that compressor is not Valid. → Check Cables .
When there is bad communication , only the detailed general compressor condition will be set to 0.

2.3.2 Inputs & Outputs

2.3.2.1 Analogue Inputs – Sensors & Calculated

The Elektronikon MkIV supports up to 55 analogue sensor inputs and 5 additional analogue calculated (virtual) inputs. Each input has a 'value' and a 'status' register assigned.
The contents of these registers depend on the actual type of sensor that is connected. This can be different for every type of compressor. E.g. standard compressors may have 1 to 4 pressure inputs, 1 to 10 temperature inputs, up to 7 SPM inputs,… Also, features and options may increment the number of sensors that are actually installed on your compressor.
Before using the modbus system it is therefore required to find out what sensors are really connected to your compressors. This can e.g. be done with the FDP program. This program has a function that lists the sensors + modbus registers for a selected compressor type (including features and options).

Once the list of sensors is known, the contents of the registers can be interpreted as described below.

2.3.2.2 Registers

Sensor Inputs
Function to be used : Read Holding Register (03)

Modbus register	Information
0001	Analogue Input 1 – Status
0002	Analogue Input 1 – Value
0003	Analogue Input 2 – Status
0004	Analogue Input 2 – Value
0005	Analogue Input 3 – Status
0006	Analogue Input 3 – Value
…	…
0109	Analogue Input 55 – Status
0110	Analogue Input 55 – Value

Calculated (virtual) Inputs
Function to be used : Read Holding Register (03)

Modbus register	Information
0111	Calculated Input 1 – Status
0112	Calculated Input 1 – Value
0113	Calculated Input 2 – Status
0114	Calculated Input 2 – Value
0115	Calculated Input 3 – Status
0116	Calculated Input 3 – Value
0117	Calculated Input 4 – Status
0118	Calculated Input 4 – Value
0119	Calculated Input 5 – Status
0120	Calculated Input 5 – Value

2.3.2.3 "Status" register Interpretation

High order byte = **00**
Low order byte = **Input Status**

The Input Status must be interpreted as **Binary data (bit coded)**.
Each part (bit) of the data (byte) is indicating a specific item that applies on the Input function. In the following table, an overview is given of all bits together with the corresponding meaning and interpretation.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Function Description	Input Set/Not Set	Sensor Error	Permissive Start	Service	Shutdown	Shutdown Warning	Warning	Pre-Warning
Bit "1"	Set	Active	Active	Active	Active	Active	Active	Active
Bit "0"	Not Set	Not Active	Not Active	Not Active	Not Active	Not Active	Not Active	Not Active

2.3.2.4 "Value" register Interpretation

This depends on the type of inputs.

2.3.2.4.1 Pressure Input

The Pressure Input Value is a 2 byte integer, and contains the actual reading in mbar (0.001 bar)
For negative values, standard 2-complement notation is used.

Example: Value = 7040 decimal or 0x1B80 hexadecimal = 7.040 bar.
Value = -1000 decimal (2-complement) or 0xFC18 = -1.000 bar

For sensor error the value the value 32767 or 7FFF (hex) is returned.

On some high pressure compressors (with working pressures above 30 bar) a special Pressure Input can be defined that returns data in cBar (0.01 bar) in stead of mBar.

2.3.2.4.2 Temperature Input

The Temperature Input Value is a 2 byte integer, and contains the actual reading in 0.1°C
For negative values, standard 2-complement notation is used.

Example: Value = 855 decimal or 0x0357 hexadecimal = 85.5 °C
Value = -250 decimal (2-complement) or 0xFF06 = -25.0 °C

For sensor error the value the value 32767 or 7FFF (hex) is returned.

2.3.2.4.3 Vibration Input

tbd

2.3.2.4.4 Level Input

tbd

2.3.2.4.5 Conductivity Input

tbd

2.3.2.4.6 SPM Input

The SPM Input Value is a 2 byte register that must be seen as 2 x 1 byte.

- Byte 1 : carpet value (in dB)
- Byte 2 : peak value (in dB)

Example: Value = 0x1120 = > carpet value = 0x11, peak value = 0x20

For sensor error the value the value 0xFFFF (hex) is returned.
SPM values cannot be negative

2.3.2.4.7 Current Input

tbd

2.3.2.4.8 Speed Input

tbd

2.3.2.5 Digital (Voltage free contacts) Inputs

The Elektronikon MkIV supports up to 18 digital (voltage free) inputs. Each input has a 'value' and a 'status' register assigned.
The contents of these registers is for digital inputs always the same, if the input is used. Before using the modbus system it is therefore required to find out what inputs are used on your compressors. This can e.g. be done with the FDP program. This program has a function that lists the digital inputs + modbus registers for a selected compressor type (including features and options).

Once the list of inputs is known, the contents of the registers can be interpreted as described below.

Function to be used : Read Holding Register (03)

Modbus register	Information
0201	Digital Input 1 – Status
0202	Digital Input 1 – Value
0203	Digital Input 2 – Status
0204	Digital Input 2 – Value
0205	Digital Input 3 – Status
0206	Digital Input 3 – Value
…	…
0241	Digital Input 21 – Status
0242	Digital Input 21 – Value

2.3.2.6 "Status" register Interpretation

High order byte = **00**
Low order byte = **Input Status**

The Input Status must be interpreted as **Binary data**.
Each part (bit) of the data (byte) is indicating a specific item that applies on the Input function. In the following table, an overview is given of all bits together with the corresponding meaning and interpretation.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Function Description	Input Set/Not Set	Sensor Error	Permissive Start	Service	Shutdown	Shutdown Warning	Warning	Pre-Warning
Value "1"	Set	Active	Active	Active	Active	Not used	Active	Active
Value "0"	Not Set	Not Active	Not Active	Not Active	Not Active	Not used	Not Active	Not Active

2.3.2.7 "Value" register Interpretation

Value: 00 Digital input is **Open**
Value: 01 Digital input is **Closed**

2.3.2.8 Digital (Relays) Output (Not Yet Implemented)

tbd

2.3.3 Counters

2.3.3.1 Compressor Counters

The Elektronikon MkIV supports up to 28 counters (32-bit counters). Each input as 2 x 16bit 'value' register assigned, to allow a 32-bit value to be read.
Not all types of compressors use all types of counters. The list in this chapter provides an overview of the used counters / compressor type, and the units that are used

Function to be used : Read Holding Register (03)

Modbus registers	Information	Units	Load/Unload	VSD
0301+0302	Running Hours	s	X	X
0303+0304	Loaded Hours	s	X	-
0305+0306	Motor Starts	number	X	-/X *
0307+0308	Module Hours	s	X	X
0309+0310	Accumulated Volume	1000 m³	-	X
0311+0312	Load cycle	number	X	-/X *
0313+0314	VSD 0-20% RPM	%	-	X
0315+0316	VSD 20-40% RPM	%	-	X
0317+0318	VSD 40-60% RPM	%	-	X
0319+0320	VSD 60-80% RPM	%	-	X
0321+0322	VSD 80-100% RPM	%	-	X
0323+0324	Not yet used			
0355+0356	Not yet used			

- yes, if VSD has unloading cycle (e.g. Z-VSD)

Interpretation of data in the registers

Example Running Hours

	Higher Byte	Lower Byte
301	B4	B3
302	B2	B1

DWORD : Running Hours → B4 B3 B2 B1
00 2C 93 45

→ 2921285 sec → 811 hrs

2.3.3.2 Multi Compressor Controller Counters

The Elektronikon MkIV contains 4 counters (32-bit counters) to perform the MCC load balancing between up to 4 compressors. Each such counter as 2 x 16bit 'value' register assigned, to allow a 32-bit value to be read.
Only units where the MCC master function is active contain real data for this registers.

Function to be used : Read Holding Register (03)

Modbus registers	Information	unit
501+502	Compressor 1 counter	s
503+504	Compressor 2 counter	s
505+506	Compressor 3 counter	s
504+507	Compressor 4 counter	s

Data interpretation is the same as for the other counters

2.3.4 Special

2.3.4.1 VSD motor data

The Elektronikon MkIV on VSD units contains some important data about the motor speed.This data can be read over the modbus system.

Function to be used : Read Holding Register (03)

Modbus registers	Information	unit
0801	Required motor speed	rpm
0802	Actual motor speed motor 1	rpm
0803	Actual motor speed motor 2	rpm
0804	Actual motor speed motor 3	rpm

Each register contains a 16-bit value that is directly readable as the equivalent rpm.

2.4 Modbus registers and coils for parameters change

2.4.1 Load/Unload Pressure Band change

It is possible to change the operating pressure band inside the Elektronikon MkIV, or to switch between the two available pressure bands. These registers are only valid for Load/Unload compressors

Functions to be used :
For reading : Read Holding Register (03)
For writing :Preset Single Register (06)

Modbus registers	Description
1061	Pressure Band Selection
1062	Loading pressure band 1
1063	Unloading Pressure band 1
1064	Loading pressure band 2
1065	Unloading Pressure band 2

Pressure Band Selection : 1 = band 1, 2 = band 2

Attention : when writing values the following relations should be maintained :
Loading pressure < unloading pressure (per band)
Loading pressure should not be below the minimum setting that was factory defined.
Unloading pressure should not be above the maximum setting that was factory defined.

Values not fulfilling this will be refused.

2.4.2 VSD Setpoint change

It is possible to change the operating set point inside the Elektronikon MkIV, or to switch between the two available pressure set points. These registers are only valid for VSD compressors

For reading : Read Holding Register (03)
For writing :Preset Single Register (06)

Modbus address	Description
1051	Setpoint Selection
1052	Setpoint 1
1053	Setpoint 2

Setpoint Selection : 1 = Setpoint 1, 2 = Setpoint 2

The set point must be within the limits that are factory defined for your machine type.

Values not fulfilling this will be refused by the MKIV.

2.4.3 MCC Pressure Band change

In Elektronikons where the MCC master function is active it is possible to change the operating pressure band for this master, or to switch between the two available pressure bands.

Functions to be used :
For reading : Read Holding Register (03)
For writing :Preset Single Register (06 or 16 for multiple registers)

Modbus registers	Description
1081	MCC Pressure Band Selection
1082	MCC Loading pressure band 1
1083	MCC Unloading Pressure band 1
1084	MCC Loading pressure band 2
1085	MCC Unloading Pressure band 2

Pressure Band Selection : 0 = band 1, 1 = band 2

Attention : when writing values the following relations should be maintained :

Loading pressure < unloading pressure (per band)

Values not fulfilling this will be refused by the MKIV.

2.5 Modbus registers and coils for remote control

2.5.1 Control Commands

2.5.1.1 Compressor Control Mode Selection

The Elektronikon MkIV has a number of control modes that define the behaviour of a compressor in relation to external inputs (pressure reading, start/stop commands,…).
Each mode has a main type (= number 1 to 4), and a sub-type (a,b,c,..). The number of sub-types is different for each main type.

When Modbus has to be used to control a compressor the main type ust be set to 4 (=remote control over communication line). This has to be done through the display, select "LAN Control". By default the compressor will then enter the "4a" mode.

Through Modbus it is now possible to activate the other sub-types.

Functions to be used : writing method: Preset Single Register – Function 06

Modbus address	Value to write	Description	Accepted in mode
2002	1 2 3	Switch from 4a or 4c to 4b Switch from 4b or 4c to 4a Switch from 4a or 4b to 4c	4a – 4c 4b 4a – 4b

Note
Mode 4a : remote control of start/stop but pressure control is done by the controller
Mode 4b : remote control of start/stop and pressure control is done from remote (Supervisory control) (also for VSD → setpoint control)
Mode 4c : remote control of start/stop with external speed (only vsd) → speed control)

2.5.1.2 Compressor Commands

The commands that are described here are only available in the defined Compressor Control Modes.
Carefully consult the control concept of the compressors before using them.

Functions to be used : writing method: Preset Single Register – Function 06

Modbus address	Value to write	Command	Accepted in mode
2001	1	Start	4a / 4b
	2	Stop	4a / 4b
	3	Load	4a / 4b
	4	Unload	4b (in 4a = Manual unload)
	5	MCC Start System	4a / 4d
	6	MCC Stop System	4d
	7	MCC Local	4d
2004	1	Reset Shutdown	In all Modes
	2	Reset Start Failures	In all Modes

2.5.2 VSD – external setpoint/speed control

On VSD units extended external control is possible whereby either the main motor speed of the pressure set point is directly controlled from remote over Modbus.
This can be done with the following Modbus registers

-> reading method: Read Holding Registers – Function 03
-> writing method: Preset Single Register – Function 06

Modbus address	Description
1071	External Setpoint
1072	External Speed

2.5.3 Reset Initial Settings (Analogue , Digital , Counter Inputs)

-> writing method: Preset Single Register – Function 06

Modbus address	Description
2101	Reset Initial Settings

2.6 Communication examples

2.6.1 Analogue - Digital Inputs

-> reading method: Read Holding Registers – Function 03

Example: read from Analogue input 1, Status and Value
Query

Field Name	Example (Hex)
Device Id Nr	04
Function	03
Starting Address High	00
Starting Address Low	00
Number of points High	00
Number of points Low	02
CRC	C4 5E

Response

Field Name	Example (Hex)
Device Id Nr	04
Function	03
Byte Count	04
Data register 0001	00 80 Status
Data register 0002	1D 15 (= Value : 7505 mbar)
CRC	DF CA

Example: read from Digital input 1, Status and Value
Query

Field Name	Example (Hex)
Device Id Nr	22
Function	03
Starting Address High	00
Starting Address Low	C8
Number of points High	00
Number of points Low	02
CRC	42 46

Response

Field Name	Example (Hex)
Device Id Nr	22
Function	03
Byte Count	04
Data register 0001	00 88 Status (Set , Shutdown)
Data register 0002	00 00 (Input → Open)
CRC	68 DB

2.6.2 Commands description

-> writing method: Preset Single Register – Function 06

Example: Send a Start command
Query

Field Name	Example (Hex)
Slave address	01
Function	06
Register Address High	07
Register Address Low	D0
Preset Data High	00
Preset Data Low	01
CRC	

Response

Field Name	Example (Hex)
Slave address	01
Function	06
Register Address High	07
Register Address Low	D0
Preset Data High	00
Preset Data Low	01
CRC	

2.6.3 Present System Status

-> reading method: Coil Status – Function 01

Example: Read present compressor status (= read 8 coils)
Query

Field Name	Example (Hex)
Slave address	01
Function	01
Starting Address High	00
Starting Address Low	00
Number of points High	00
Number of points Low	08
CRC	3D CC

Response

Field Name	Example (Hex)
Slave address	01
Function	01
Byte Count	01
Data Coils 1 to 8	00 (Coils 1 to 8 are = 0)
CRC	51 88

2.6.4 Loopback Test

Query

Field Name	Example (Hex)
Device Id Nr	04
Function	08
Starting Address High	00
Starting Address Low	00
Number of points High	A5
Number of points Low	37
CRC	

Response

Field Name	Example (Hex)
Device Id Nr	04
Function	08
Starting Address High	00
Starting Address Low	00
Number of points High	A5
Number of points Low	37
CRC	

3. Exception Responses

3.1 Function Code – Data Field

In a normal response, the slave echoes the function code of the orginal query.

In an exception response 80hex is added to the function code.
At the same time an **exception code** is added in the Data Field.

3.2 Exception Codes

Code	Name	Meaning
01	Illegal Function	The function code received in the query is not an allowable action for the slave.
02	Illegal Data Address	The data address received in the query is not an allowable address for the slave
03	Illegal Data Value	A value contained in the query data field is not an allowable value for the slave
06	Reprogramming Refused	Command Refused because previous command was not yet executed
07	Command Refused	Command Refused because previous command was not yet executed
08	Data Not Available	Check communication cable between MKIV and Combox-S .
09	Illegal Command	An unknown command is being sent

3.3 Example

Example: read from Analogue input 1, Status and Value
Query

Field Name	Example (Hex)
Slave address	01
Function	09 **(Wrong function, should be 03)**
Starting Address High	00
Starting Address Low	00
Number of points High	00
Number of points Low	02
CRC	5C 0A

Response

Field Name	Example (Hex)
Slave address	01
Function	89 **(Exception reply)**
Exception Code	01 **(Illegal Function in query)**
CRC	86 50