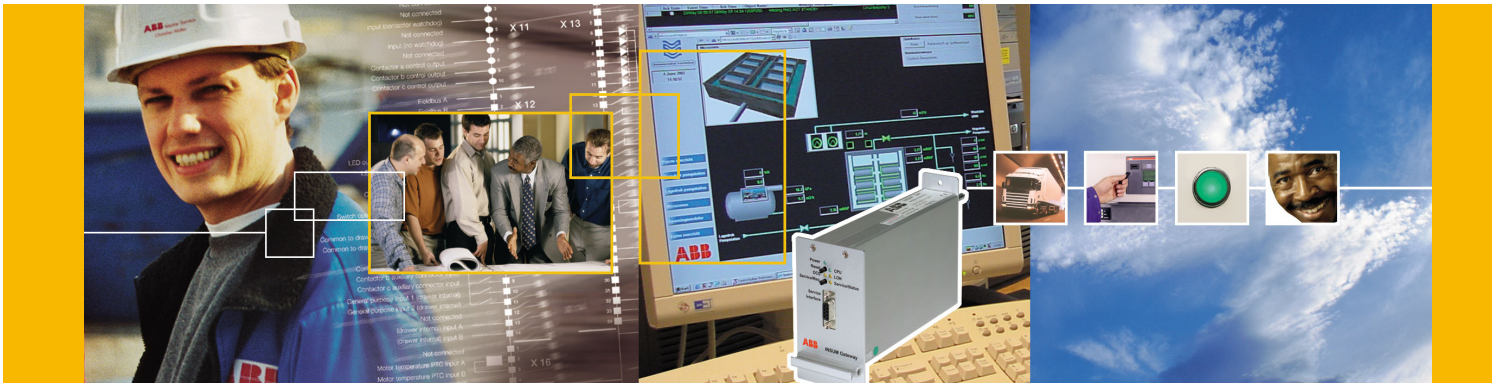
Protect^{IT} – MNS Motor Management INSUM®

MODBUS Gateway Manual
Version 2.3



INSUM®
MODBUS Gateway Manual

Version 2.3

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Reference document 1TGB 350004 R1.8

MODBUS Gateway Manual

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Notes:

1 General Information

1.1 Introduction

This manual describes the INSUM® communication with MODBUS protocol in RTU mode. The MODBUS RTU communication protocol is implemented in INSUM System in order to provide interface possibilities to the PCS systems or any other external systems that supports MODBUS RTU protocol.
The MODBUS configuration can be used in point to point configuration or in multidrop mode. In Master-Slave MODBUS architecture, INSUM System should always be used in a slave mode. The master station controls the traffic on the bus, in this case, by PCS or PLC system. The INSUM system responds to the queries received from master station as per the MODBUS specification.

1.2 Objective

This manual provides detailed information on technical implementation of the protocol in INSUM System. It is primarily intended for the PCS application programmer's implementation and to provide help during installation and commissioning of the PCS-INSUM System interfacing.
All efforts were made to give the detailed technicality of standard MODBUS protocol in order to equip the user with full understanding of MODBUS implemented in INSUM MODBUS Gateway
The knowledge of MODBUS protocol (e.g. as specified by Gould Electronics) and DCS programming is an added advantage to the reader of this manual.

1.3 Product Highlights

- The information needed from the Gateway is configurable and it gives the user unprecedented flexibility on data transfer thus optimises memory requirement in other system considerably.
- Logical combinations AND, OR and XOR can be performed to group the different binary data.
- The maximum transmission speed on the INSUM MODBUS can be set up to 38400 bit/s.
- Configurable physical media RS232/RS422/RS485.

1.4 Acronyms and Definitions

The user of this document should have understanding of the following LON® terminology. Further terms and abbreviations used are explained in Annex B.

LON®
Local Operating Network. LON is used as shortening for LON Network.

LonTalk® protocol
Communication protocol used in LON networks.

LON network
A communication network built using LON technology, including e.g. Neuron chip and LonTalk protocol.

Network variable (NV)
A data item in LonTalk application protocol containing maximum 31 bytes of data. The selector is used as network wide identification of the Network Variable. The selector is a 14-bit number in the range 0…12287 (2FFFhex).

SNVT
Standard Network Variable Type. The definition of a SNVT includes unit, range, resolution and data format. SNVTs are listed in the SNVT Master List and Programmer's Guide. This list is updated by Echelon® and it includes network variable types that are commonly agreed to be used by multiple manufacturers.

Monitoring device
A device in the system, which collects information from the other devices to be further, transferred to another system or to be presented to the user. The device also provides the controlling interface for the system. In INSUM system Gateways, MMI, and INSUM OS are termed as Monitoring devices.

Interoperability
Interoperability means that devices can be integrated into a single system without requiring custom node or tool development. Interoperability can also be defined as being the ability of two or more devices or systems to interact with another and exchange data according to a predefined method in order to achieve predictable results.

LonMark®
LonMark® interoperability association is an independent world-wide industry association, which facilitates the development and implementation of open, interoperable LonWork based control products and systems. LonMark association includes manufacturers, end-users, and integrators of LON products. The association establishes guidelines such as "LonMark Application Layer Interoperability Guidelines."

LonMark object
A set of one or more network variable inputs and/or outputs implemented as SNVTs with semantic definitions relating the behaviour of the object to the network variable values, in addition to a set of configuration properties (parameters).

Notes:

1.5 Related Documentation

1TGC 901007 B0201 INSUM Technical Information
1TGC 901021 M0201 INSUM MCU Users Guide
1TGC 901026 M0201 INSUM MCU Parameter Description
1TGC 901034 M0201 INSUM MMI Operating Instruction
1TGC 901030 M0201 INSUM MMI Quick Guide
1TGC 901052 M0201 INSUM Profibus Gateway Manual
1TGC 901060 M0201 INSUM Ethernet Gateway Manual
1TGC 901080 M0201 INSUM System Clock Manual
1TGC 901090 M0201 INSUM Control Access Guide
1TGC 901091 M0201 INSUM Failsafe Guide
1TGC 901092 M0201 INSUM Dual Redundancy Guide
1TGC 901093 M0201 INSUM Network Management Guide
SACE RH 0080 Rev.I PR112/ PD-L LON Works Interface V2.0
1SEP 407948 P0001 Users Manual Intelligent Tier Switch (ITS)

1.6 Product Overview

The INSUM MODBUS Gateway gives access to the PCS/PLC/SCADA System to INSUM Field Units. The FUs accept the control commands from the external control system via the Gateway and update continuously the status information and measuring values.
The FUs generate various information depending upon type. Since the MODBUS Gateway allows configuration of information, the control system can request the specific information needed.

Available FUs together with reported information are listed hereunder (details in chapter 5).

MCU1/ MCU2

- Status Information according to chosen drive type (Runs, Stopped, Tripped, Test, Failsafe...)
- Detailed alarm/ trip information of all protection functions, maintenance...
- Status of "Control Access" (Bus, Local...)
- Measuring values (current, voltage, power, maintenance counters...)
-

PR112

- Detailed status data
- Alarm/Trip information (warnings and trips for different protection characteristics)
- Measuring values (phase current, trip current, maintenance counters...)

ITS

- Status data
- Alarm/trip information
- Measuring values (phase current, active/reactive power, power factor...)

Notes:

2 Mechanical Setup

The MODBUS protocol in INSUM System is implemented in a module called MODBUS Gateway.
The mechanical setup of the Gateway is like any other component mounted on the backplane, plug-in type.The Gateway draws power from the backplane. Pictures 1-1 and 1-2 show the INSUM MODBUS Gateway.

1-1 MODBUS Gateway Module - Front Plate

1-2 MODBUS Gateway Module - Rear Side

2.1 Indications

Indication	Function
Power	A green LED indicates that the 24VDC-power supply for the module is available
CPU	A flashing green LED indicates that the Gateway CPU is functioning properly
DCS	A flashing yellow LED indicates that the Gateway communication to DCS is running
LON	A flashing yellow LED indicates that the Gateway is communicating on the main LON bus
Service/Status	A yellow LED indicates the Service/Status of the NEURON (LON Communication Chip) inside the Gateway

2.2 Pushbuttons

Pushbutton	Function
Reset	Executes a hardware reset of the Gateway
Service/Req.	Used during the installation of Gateway on LON network via MMI. The pressing of switch sends a 'Service Pin Message' that is used by the MMI or LNT to locate the Gateway and logically install it on the network (assigning LON network address)

Notes:

2.3 GW Interfaces

PCS/DCS Communication Interface:
The MODBUS interface is based on the physical interfaces according to RS485, RS422, and RS232C standard. The internal serial link to the processor MC68331 is galvanically isolated. One out of these 3 physical interfaces (hardware) can be selected using parameters.
The terminals/connectors for the MODBUS interface are located on the backplane and available as follows:

- 9-pin SUB-D female connector for RS485, RS422
- In addition, terminals for RS485, RS422, RS232C

Service Interface (Gateway Firmware Download Interface)
A 9-pin SUB-D female connector is provided for communication to RS232 interface of PC. The new system software (firmware) can be down loaded via this port using "Windows terminal program" (16 Bit version).
Physical connection RS232C; Baudrate 19.2 fixed. Recognition using bridge in download cable.

2.4 Converter

As the mode of communication is configurable to the commonly used interfaces (RS232, RS485, RS422), it is only necessary to use an interface converter on the PCS side in case the physical PCS interface is different from the desired one.
In case fiber optics shall be used in order to reduce interferences, a converter has to be used on both sides. It is recommended to use a fibre optics / RS232 or fibre optics / RS 422 converter in this case. RS485 is not suitable due to missing check signals.

The following brands are recommended, but other standard converter types can be used as well:

- Phoenix converters
- Westermo

Notes:

3 INSUM® MODBUS_RTU Protocol

The software on the Gateway supports the pure master slave operation as defined in the MODBUS RTU specification, with the Gateway operating in slave-mode, i.e. the MODBUS software will only be active when a query from the Master station i.e. PCS is being received.
Certain characteristics of the MODBUS protocol, as specified by Gould Electronics, are fixed such as the frame format, frame sequences, handling of communication errors and exception conditions, and the functions performed. In case of INSUM MODBUS Gateway, the transmission mode is also fixed i.e. RTU.
Other characteristics are user selectable. These include a choice of transmission medium, baud rate, character parity, number of stop bits. These parameters can not be changed while the communication interface is active.
The OSI layers 1, 2, and 7 and its firmware are implemented on the Gateway processor MC68331.

Layer 1, 2:
In these layers the physical sending and receiving of bytes, i.e. triggering of the interface hardware including monitoring of timeouts and CRC-check generation as well as processing of addresses is realised. Upon receipt, the fault states, time-out and CRC-Error are being detected and treated according to the MODBUS/RTU specification.

Layer 7:
In this layer the analysis and treatment of the function codes (FC) is implemented. This includes processing the received commands (read and write of MODBUS-registers) and generation of the response-message together with the addressed data.

3.1 Mode of Transmission

The mode of transmission is the structure of the individual units of information within a message, and the numbering system used to transmit the data. Two modes of transmission are available for use in a standard MODBUS communication, ASCII (American Standard Code for Information Interchange), and RTU (Remote Terminal Unit). Both modes provide the same capabilities for communication. Selecting ASCII or RTU mode defines the bit contents of message fields, and how information is packed and decoded.
INSUM MODBUS Gateway supports MODBUS communication in RTU mode only. The main advantage of this mode is its greater character density, which allows better data throughput than ASCII for the same baud rate.

Characteristic	RTU (8-bit)
Coding System	8-bit
Number of bits per character:	
Start bits	1
Data bits (least significant first)	8
Parity	1 (1 bit set for even or odd parity, no bits for no parity)
Stop bits	1 or 2
Error Checking	CRC (Cyclical Redundancy Check)

3.2 Error Detection

There are two types of errors, which may occur in a communication system:

- Transmission error and
- programming or communication error

The INSUM MODBUS Gateway deals with either type of error as specified in MODBUS specification.
The most frequent cause of communication error is noise, unwanted electrical signals in a communication channel. These signals occur because of electrical interference from machinery, damage to the communication channel, impulse noise (spikes), etc. Character framing, a parity check, and a redundancy check detect these errors. When the error occurs, the message is unreliable and the processing of the message stops.
Programming or operational errors are those involving illegal data in a message or difficulty in communicating with a slave. These errors result in an exception response either from Master or Slave station.

Notes:

4 Configuration - in general

The configuration part can be classified into two main activities:

- Configuration of the LON network variables received by the Gateway normally referred as 'LON Binding' of the network. This is already pre-configured and not advisable to be changed. Activation of 'LON Binding' is possible via MMI.
- Configuration of the MODBUS register address mapping to the LON network variables using the POCT Configuration tool.

4.1 LON Network Binding

The INSUM components on the LON network communicate to each other using LON data items named network variables (NVs). The process of defining the connections among NVs of INSUM is called LON Network Binding. The Binding thus specifies how LON devices communicate and share information with each other.
The default LON Network Binding is part of the firmware of each device and can be activated in each device using the MMI *(available with ModGW SW ≥ 1.2c).* This pre-configured Binding covers the whole functionality of the system.

4.2 Configuration of the MODBUS Registers

The INSUM utilises the LON network for its internal communication. The interface to any external system on MODBUS protocol is realised using a Gateway.
The task of the Gateway is to interface the LON Network at the field unit (FU) level and the MODBUS RTU network on the PCS level. The commands (queries) that are sent as messages from the PCS system will be applied by the Gateway according to the MODBUS specification and the return response messages will be send.
The basic functionality of the Gateway is to map the registers on the MODBUS side into the corresponding LON NVs (data items of FU's) and vice versa. The MODBUS address mapping is flexible so that only the needed information as per the application can be configured. A tool to perform the mapping is available named as 'POCT Gateway Configuration Tool.'

4.2.1 POCT Gateway Configuration Tool

The POCT Tool is a configuration tool for the INSUM Gateways. POCT is a PC-based software that runs under MS Windows. It is a tool to generate the mapping description between data objects of the LON and the MODBUS-side of the Gateway. The POCT allows configuration off-line.
The result of the mapping definition is a binary configuration file generated by the POCT Tool that has to be loaded upon time of installation via the LON network into all existing Gateways using "FUMU.EXE". This file has the extension "PBF".
The program allows the user to allocate all NVs (MCU data items such as status, measured values) requested from the PCS/PLC System to the Gateway MODBUS registers and vice versa to map data written to MODBUS registers to output NVs (e.g. switching commands). The mapping in this definition means at the run-time of the GW program, that the value of one data object coming from the LON side is transferred to the relevant data object on the MODBUS side as soon as an external event is changed. An event on the LON side is a NV-message whereas it is a query-response-cycle on the MODBUS side.

Important
In the *input.mdb* file all data items of the field devices are defined. The *input.mdb* file has to match the firmware version of the Gateway. Further on it has to be assured that *project.mdb* files are always opened with the respective *input.mdb* file.

4.2.2 Mapping Rules

- All MODBUS-Registers can be mapped 1:1 to LON network variables.
- The nv-type should be selected in an appropriate manner, i.e. bit-orientated registers should be mapped to SNVT_lev_disc or other bit oriented types, and word-orientated Registers accordingly to nv's of a type size 2 or more Bytes.
- All NVs of any type except SNVT_lev_disc can be mapped 1:1 to any word-orientated MODBUS register. With NVs of a data type longer than the relevant register length, the value of the variable will be written starting from specified register address and as many successive registers as necessary to take the value of the variable. The double addressing of such additional registers will be prevented by a checking functionality within the POCT.
- NV's of type SNVT_lev_disc will be treated as binary variables and can be combined with any number of other binary variables using one-step logical functions. The result of these logical operations can be allocated to any bit-orientated MODBUS register.

Notes:

- NV's of type SNVT_state can be directly allocated to a MODBUS register. Additionally their bits can be individually considered as binary variables. In addition, they can be combined with any number of binary variables (also of type SNVT_lev_disc) using one step logical functions (operations). The result of these logical operations can be allocated to any bit-orientated MODBUS register.
- NV's of type SNVT_alarm can be allocated to one (or better to a series of) MODBUS register(s). SNVT_alarm is a structure of alarm code plus time tag. Additionally the included alarm-code will be treated as a bit variable that can be combined with any number of other binary variables using one-step logical operations. The result of these logical operations can be allocated to any bit-orientated MODBUS register.
- A binary variable resulting out of a NV can be used in any number of logical functions as input value. As logical functions for binary values the following are defined: AND, OR, XOR
- Additionally binary variables can be inverted as inputs of a function. Only one level of such a Boolean combination is possible e.g. $A = X_1$ OR X_2 OR X_3 **but not** $A = X_1$ OR X_2 OR (X_3 AND X_4)

Notes:

5 INSUM Data - in detail

5.1 Fixed MODBUS Registers – Life List, MODBUS communication data

Important
The following MODBUS registers are already occupied for standard functions, thus they are not available for allocation of other functions.

Function Code	Register	Function
02	10001	Life bit for field unit 01/01
02	10002	Life bit for field unit 01/02
02	10003	Life bit for field unit 01/03
	:	:
02	10128	Life bit for field unit 04/32
02	10129	Life bit Backbone Device with CA priority 1 *
	:	:
02	10145	Life bit Backbone Device with CA priority 16 *
02	10146	
	:	
02	10200	Reserved for future use
03	49998	MODBUS communication data

Baudrate, Parity and Stopbit definitions can be changed during operation by change of configuration parameters, e.g. from MMI, INSUM OS or from the PCS via MODBUS.

5.2 MCU data

The following tables show

- the network variables (data items), their meanings and their data format
- possible MODBUS function codes and address ranges

5.2.1 Control Commands

Network Variable:	nvoDesState nvoCAPass, nvoCAReq
Purpose:	Operational commands from PCS can be mapped to NV 'nvoDesState'. Commands handling 'Control Access' can be mapped to NV 'nvoCAPass and nvoCAReq' The PCS sends commands in terms of codes.
Function Code:	FC06, FC16
Address Range:	40001-49999

Notes:

The table below shows the different codes in the nvoDesState to set the different commands in different drive types.

Drive Type	Commands	NvoDesState codes
All drive types	STOP	03
	RESET	04
	TOL Bypass	07
NR-DOL NR-DOL/RCU NR-S/D AUTOTRANSF.	START	01
REV-DOL REV-DOL/RCU REV-S/D	CW-> <-CCW	01 02
ACTUATOR	OPEN	01
	CLOSE	02
NR-2N	START>N1	01
	START>N2	05
REV-2N	CW>N1	01
	CW>N2	05
	CCW>N1	02
	CCW>N2	06

Network variables available in POCT	Meaning	Type	Dependence of Parameters
nvoCAPass	Passing of CA to other stations	2 Byte (16 Bit)	CA priority
nvoCAReq	Requesting CA for own station	2 Byte (16 Bit)	CA priority

Codes:

CA priority 2: 0x0002 (hex)
CA priority 3: 0x0004
CA priority 4: 0x0008
CA priority 5: 0x0010
CA priority 6: 0x0020
CA priority 7: 0x0040
CA priority 8: 0x0080
CA priority 9: 0x0100
CA priority 10: 0x0200
CA priority 11: 0x0400
CA priority 12: 0x0800
CA priority 13: 0x1000

Special codes (fix):

0x0000 Release (Passing only)
0x0001 Local (HW setting)
0x2000 Soft local (Passing only)

Notes:

5.2.2 Status Information

Network Variable: MotorStateExt (single Bit 0...15 or Word)
ActualCA1 (Word)
CARequestFb (Word)
Purpose: The PCS can fetch the status information via this NV's either as a word or binary bits.
Function Code: FC02 for binary bits
FC03 for word oriented register.
Address Range: 10201-19999 if FC02
40001-49999 if FC03

The NV 'MotorStateExt' word oriented information can be interpreted as follows.
Bits shaded grey depend on drive type, see next table for more details.

Status Information		
Bit	**MotorStateExt, meaning**	
0	CW/Run (ClockWise Run)	
1	CCW (CounterClockWise Run)	
2	Stopped (Normal Stop Position)	
3	Tripped (Fault Status)	
4	Alarm (Warning)	
5	Actuator Open, Limit switch 1 closed-(Only in MCU2)	
6	Actuator Closed, Limit switch 2 closed-(Only in MCU2)	
7	Staggered Start Initialised (Only in MCU2)	
8	Failsafe Activated	
9	TOL Trip Bypass Activated (Only in MCU2)	
10	Test Position (e.g. on MNS drawer)	
11	Star/N1 (Only in MCU2)	
12	Delta/N2 (Only in MCU2)	
13	Softstart or Softstop in Progress	
14	-	
15 *	if CA = disabled: =1: LOCAL-SW or LOCAL-HW =0: BUS	if CA = enabled LOCAL/REMOTE information should be taken from ActualCA1

* for MCU 2.1 onward

Notes:

The table below shows the interpretation of binary bits in 'MotorState', Bit 0..Bit 15 as per the drive types.

NV-MotorStateExt		Softstart/stop in progress	Delta N2	Star N1		Actuator closed, Limit 2	Actuator open, Limit 1		Tripped	Stopped	CCW	Runs/CW	Meaning of status
Bit Nos.	...	13	12	11	...	6	5	...	3	2	1	0	
Drive Type													
NR-DOL												X	RUNS
NR-DOL/RCU										X			STOPPED
		X										X	SOFTSTART
		X								X			SOFTSTOP
									X				TRIPPED
									X			X	WELDED
REV-DOL												X	RUNS>CW
REV-DOL/RCU											X		RUNS>CCW
										X			STOPPED
		X										X	SOFT>CW
		X									X		SOFT>CCW
		X								X			SOFTSTOP
									X				TRIPPED
									X			X	WELDED
									X		X		WELDED
									X		X	X	WELDED
ACTUATOR												X	RUNS>OPEN
						X						X	RUNS>OPEN
											X		RUNS>CLOSE
							X				X		RUNS>CLOSE
							X			X			OPEN
						X				X			CLOSE
										X			STOPPED
									X				TRIPPED
							X		X				TRIPPED
						X			X				TRIPPED
									X			X	WELDED
							X		X			X	WELDED
						X			X			X	WELDED
									X		X		WELDED
							X		X		X		WELDED
						X			X		X		WELDED
							X		X		X	X	WELDED
						X			X		X	X	WELDED
NR-S/D				X								X	RUNS>STAR
			X									X	RUNS>DELTA
										X			STOPPED
									X				TRIPPED
									X			X	WELDED
									X		X		WELDED
									X		X	X	WELDED

Notes:

NV-MotorStateExt		Softstart/stop in progress	Delta N2	Star N1		Actuator closed, Limit 2	Actuator open, Limit 1		Tripped	Stopped	CCW	Runs/CW	Meaning of status
Bit Nos.	...	13	12	11	...	6	5	...	3	2	1	0	
Drive Type													
AUTOTRANSF.		X										X	STARTING
												X	RUNS
										X			STOPPED
									X				TRIPPED
									X			X	WELDED
									X		X		WELDED
									X		X	X	WELDED
NR-2N				X									RUNS N1
			X										RUNS N2
										X			STOPPED
									X				TRIPPED
									X			X	WELDED
									X		X		WELDED
									X		X	X	WELDED
REV-S/D				X								X	CW>STAR
			X									X	CW>DELTA
				X							X		CCW>STAR
			X								X		CCW>DELTA
										X			STOPPED
									X				TRIPPED
									X			X	WELDED
									X		X		WELDED
									X		X	X	WELDED
REV-2N				X								X	CW-N1
			X									X	CW-N2
				X							X		CCW-N1
			X								X		CCW-N2
										X			STOPPED
									X				TRIPPED
									X			X	WELDED
									X		X		WELDED
									X		X	X	WELDED

Notes:

Note: With SW version 2.1 NVs 'Actual CA1' and 'CARequestFb' are accessible only via FC 03

The NV's 'ActualCA1' can be interpreted as follows:

Control Access = Disabled (Bit 15 = 0)	
Bit	meaning nvwActualCA1
Bits 0...13 = 0 Bit 14 = 0	CA = BUS All devices connected to the "BUS" (such as GW, MMI, OS) are allowed to switch the motor
Bit 0 = 1 Bits 1...13 = 0 Bit 14 = 0	CA = LOCAL-HW
Bit 13 = 1 Bit 0...12 = 0 Bit 14 = 0	CA = LOCAL-SW
One out of Bits 1...12 = 1 Bit 0 = 0, Bit 13 = 0 Bit 14 = 0	--- (no valid combination)

Control Access = Enabled (Bit 15 = 1)	
Bit	meaning nvwActualCA1
Bits 0...13 = 0 Bit 14 = 0	CA = RELEASED MCU does not execute any control command. Using "CA-Pass" the CA can be assigned to one of the stations. **For more details refer to the chapters below.**
Bit 0 = 1 Bits 1...13 = 0 Bit 14 = 0	CA = LOCAL-HW
Bit 13 = 1 Bit 0...12 = 0 Bit 14 = 0	CA = LOCAL-SW
One out of Bits 1...12 = 1 Bit 0 = 0, Bit 13 = 0 Bit 14 = 0	--- (no valid combination)

The NV 'CARequestFb' can be interpreted as follows:

Control Access = Enabled	
Bit	meaning CARequestFb
one out of Bit 0...Bit15 = 1	shows which device with respective CA priority is requesting CA for the MCU having sent CARequestFb.

5.2.3 Alarms/Trips

Network Variable: Alarm Report
Purpose: The PCS can fetch the Alarm/Trip information via this NV either as binary bits or word.

Note:
29 Byte structure of SNVT_alarm with alarm/trip codes plus time tag. MODBUS Gateway Firmware > 1.2d AlarmReport structure

Function Code: FC02 for binary bits.
FC03 for word oriented register -> Alarm (29 Bytes)
Address Range: 10201-19999 if FC02
40001-49999 if FC03

Notes:

The following table shows the Alarm/Trip bits derived from Alarm Report and their meanings.

Alarm data			Availability			
			Type	Firmware		
POCT text	Code	Former input database representation	MCU2 only	MCU V3.0	MCU V2.1	MCU earlier Vers.
Ext.ROM not present	30	Alarm,Node				X
Ext.ROM write fail	31	Alarm,Node				X
Ext.ROM read fail	32	Alarm,Node				X
Drawer location alarm	33	Alarm,Node				X
Device Temperature	35	Alarm,Node	X			X
Internal fault trip	48	Alarm,Node		X	X	X
Parametering failure	49	Alarm,Node		X	X	X
O/L alarm	32	Alarm,TOL		X	X	X
TOL alarm	33	Alarm,TOL		X	X	X
TOL trip	48	Alarm,TOL		X	X	X
Startup inhibit trip	49	Alarm,TOL				X
Startup inhibit alarm	34	Alarm,TOL		X	X	X
Motor still running	50	Alarm,TOL		X	X	X
Phase Loss alarm L1	32	Alarm,CRLS		X	X	X
Phase Loss alarm L2	33	Alarm,CRLS		X	X	X
Phase Loss alarm L3	34	Alarm,CRLS		X	X	X
Phase Loss trip L1	48	Alarm,CRLS		X	X	X
Phase Loss trip L2	49	Alarm,CRLS		X	X	X
Phase Loss trip L3	50	Alarm,CRLS		X	X	X
U/L alarm	32	Alarm,UNDL		X	X	X
U/L trip	48	Alarm,UNDL		X	X	X
N/L alarm	33	Alarm,UNDL		X	X	X
N/L trip	49	Alarm,UNDL		X	X	X
Stall alarm	32	Alarm,STAL		X	X	X
Stall trip	48	Alarm,STAL		X	X	X
Both limit switches active trip			X	X		
Both torque switches active trip			X	X		
Torque close direction trip			X	X		
Torque open direction trip			X	X		
Maintenance hours run	32	Alarm,MCTL		X	X	X
Failsafe activated	33	Alarm,MCTL		X	X	X
External trip	48	Alarm,MCTL		X	X	X
Testmode failure trip	49	Alarm,MCTL		X	X	X
EM-Stop activated	50	Alarm,MCTL		X	X	X
External trip command	51	Alarm,MCTL		X	X	X
Main switch OFF	52	Alarm,MCTL		X	X	X
MCB trip	53 "other"	Alarm,MCTL[1])		X	X	X
Feedback alarm CFc	32	Alarm,CT3(K3)	X	X	X	X
Maintenance CCc	33	Alarm,CT3(K3)	X	X	X	X
Feedback trip CFc	48	Alarm,CT3(K3)	X	X	X	X
Feedback alarm CFd			X	X		
Feedback alarm CFe			X	X		

[1]) Bits referenced in the POCTt with "other" have no meaning except for "Alarm,MCTL other = MCB trip".

Notes:

Alarm data			Availability			
			Type	Firmware		
POCT text	Code	Former input database representation	MCU2 only	MCU V3.0	MCU V2.1	MCU earlier Vers.
Feedback trip CFd			X	X		
Feedback trip CFe			X	X		
Feedback alarm CFa	32	Alarm,CT1/CT2	X	X	X	X
Maintenance CCa	33	Alarm,CT1/CT2	X	X	X	X
Feedback trip CFa	48	Alarm,CT1/CT2	X	X	X	X
Feedback alarm CFb	34	Alarm,CT1/CT2	X	X	X	X
Maintenance CCb	35	Alarm,CT1/CT2	X	X	X	X
Feedback trip CFb	49	Alarm,CT1/CT2	X	X	X	X
Earth fault alarm	32	Alarm,EARF	X	X	X	X
Earth fault trip	48	Alarm,EARF	X	X	X	X
Unbalance alarm	32	Alarm,UNBA	X	X	X	X
Unbalance trip	48	Alarm,UNBA	X	X	X	X
U/L Cosphi alarm	33	Alarm,UNBA	X	X	X	X
U/L Cosphi trip	49	Alarm,UNBA	X	X	X	X
Rotation alarm	34	Alarm,UNBA	X	X	X	X
Rotation trip	50	Alarm,UNBA	X	X	X	X
PTC temperature alarm	32	Alarm,PTC	X	X	X	X
PTC temperature trip	48	Alarm,PTC	X	X	X	X
PTC short circuit alarm	49	Alarm,PTC	X	X	X	X
PTC shortcircuit trip	49	Alarm,PTC	X	X	X	X
PTC opencircuit alarm	34	Alarm,PTC	X	X	X	X
PTC opencircuit trip	50	Alarm,PTC	X	X	X	X
Undervoltage alarm	32	Alarm,UNVL	X	X	X	X
Autoreclosure alarm	33	Alarm,UNVL	X	X	X	X
Undervoltage trip	48	Alarm,UNVL	X	X	X	X
Torque trip	49	Alarm,UNVL	X	X	X	X
Start Limitation alarm	30	Alarm,STLM	X	X	X	X
Start Limitation trip	48	Alarm,STLM	X	X	X	X
Start interlock alarm	33	Alarm,STLM	X	X	X	X
Start interlock trip	49	Alarm,STLM	X	X	X	X

Notes:

5.2.4 Measuring Values

Network Variable: Recommended variables are shown in the table below
Purpose: The PCS can fetch measuring values (Analog) via these NV's.
Function Code: FC03, FC04
Address Range: 40001-49999 if FC03
30001-39999 if FC04

The following table shows the NVs for respective measuring values.

POCT text	Former representation	Unit	Type[2])	Only MCU2	Dependence of Parameters
Phase1 current	CurrRep-IL1/A	A	4 Byte float		
Phase2 current	CurrRep-IL2/A	A	4 Byte float		
Phase3 current	CurrRep-IL3/A	A	4 Byte float		
Phase1 current	CurrRep-IRL1	%	2 Byte integer		
Phase2 current	CurrRep-IRL2	%	2 Byte integer		
Phase3 current	CurrRep-IRL3	%	2 Byte integer		
Earth fault current	CurrRep-IEF	A	4 Byte float	X	Not to be used if Earth-fault Protection Function = Disabled
Phase1 voltage	2VoltRep-V1	V	4 Byte float	X	Not to be used if voltage unit not present
Phase2 voltage	2VoltRep-V2	V	4 Byte float	X	Not to be used if voltage unit not present
Phase3 voltage	2VoltRep-V3	V	4 Byte float	X	Not to be used if voltage unit not present
Frequency	2VoltRep-Freq	Hz	2 Byte value * 0.1 e.g. Modbus register = 503 -> interpretion 50.3	X	Not to be used if voltage unit not present
Active power	2PowRep-Active	W	4 Byte float	X	Not to be used if voltage unit not present
Reactive power	2PowRep-Reactive	var	4 Byte float	X	Not to be used if voltage unit not present
Power factor	2PowRep-PowFact	---	4 Byte float	X	Not to be used if voltage unit not present
Thermal image	CalcProcValue	%	1 Byte integer		
Time to trip	TimeToTrip	s	2 Byte integer 0xFFFF means: no trip expected		
Time to reset	TimeToReset	s	2 Byte integer		
Rotation	2Rotation	1/min	2 Byte integer 0xFFFF means: no rotation measured	X	Not to be used if Rotation Monitor/Function = Disabled
Motor hours run	CumRunT	h	4 Byte float		
CCa Switching cycles	NbrOfOp1	---	4 Byte float		
CCb Switching cycles	NbrOfOp2	---	4 Byte float		Not to be used if motor type = NR-DOL
CCc Switching cycles	2NbrOfOp3	---	4 Byte float	X	Not to be used if motor type = NR-DOL, REV-DOL, NR-DOL/RCU, NR-2N
Apparent Power	2AppPwr	VA	4 Byte float	X	Not to be used if voltage unit not present

[2]) The representation for the **float values** is ANSI/IEEE 754 floating point: 1 sign bit, 8 exponent bits, and 23 mantissa bits, for a total of 32 bits.

Notes:

5.2.5 General Purpose I/O

Command:

Network Variable: nvoGpOut1, nvoGpOut2
Purpose: Controlling of General Purpose Outputs from PCS. The PCS sends commands in terms of codes. (ON/OFF value can be parameterized in MCU, one code has to be "0", range 0...255).
Function Code: FC06, FC16
Address Range: 40000-49999

Status:

Network Variable: GpOut1FB, GpOut2FB, GpIn1, GpIn2
Purpose: The PCS can fetch the status information of General Purpose I/O via these NV's as binary bits.
Function Code: FC02
Address Range: 10201-19999

The following table shows the nv's reporting the status of General Purpose I/O:

Network variables available in POCT	Meaning	Type	Only MCU2	Dependence of Parameters
GpOut1FB	status of General purpose Out 1	Bit (lev_disc *)	X	ON/OFF value can be parameterized in MCU
GpOut2FB	status of General purpose Out 2	"	X	"
GpIn1	status of General purpose In 1	"	X	"
GpIn2	status of General purpose In 2	"	X	"

*lev_disc is interpreted as follows: value 0 -> Bit=0, value 1...255 -> Bit=1
texts on MMI: 00 = OFF, 01 = LOW, 02 = MEDIUM, 03 = HIGH, 04 = ON

Notes:

5.3 PR 112 data

The following tables show

- the network variables (data items), their meanings and their data format
- possible MODBUS function codes and address ranges

of circuit breakers with integrated PR112.

5.3.1 Control Commands

Network Variable: nvoNodeCommand
nvoCAPassCB, nvoCAReqCB
Purpose: Operational commands from PCS can be mapped to NV 'nvoNodeCommand'
Commands handling 'Control Access' can be mapped to NV 'nvoCAPassCB' and nvoCAReqCB'
The PCS sends commands in terms of codes.
Function Code: FC06, FC16
Address Range: 40001-49999

Command	NvoNodeCommand code
Close CB	04
Open CB	05
Reset all trips	00

5.3.2 Status Information

Network Variable: NodeStatusRep (single Bit 0...15 or Word)
ActualCA1CB (Word)
CARequestFbCB (Word)
Purpose: The PCS can fetch the status information either as a word or binary bits.
Function Code: FC02 for binary bits
FC03 for word oriented register.
Address Range: 10201-19999 if FC02
40001-49999 if FC03

Status information	
Bit	**Description**
0	Nc
1	Nc
2	Nc
3	Nc
4	Nc
5	Nc
6	Nc
7	Local

Bit	**Description**
8	CB spring discharged
9	CB spring charged
10	CB closed
11	CB open
12	CB isolated
13	CB connected
14	any trip
15	any warning

Notes:

5.3.3 Alarms / Trips

Network Variable: NodeAlarmRep
Purpose: The PCS can fetch the Alarm/Trip information via this NV either as binary bits or word.
Note: 25 Byte structure of SNVT_alarm with alarm/trip codes plus time tag.
Function Code: FC02 for binary bits.
FC03 for word oriented register -> Alarm (25 Bytes)
Address Range: 10201-19999 if FC02
40001-49999 if FC03

The following table shows the Alarm/Trip bits derived from Alarm and their meanings:

Alarm data		
POCT text	**Code**	**Former input database representation**
I.B. connection	32	Node
T.U. connection	33	Node
Remote programming fail	48	Node
Harm. Dist.	32	RMS AMTR
Unbal. Ph.	33	RMS AMTR
Prot. L pre-alarm	32	Prot L
Prot. L alarm	33	Prot L
Prot. L trip	48	Prot L
Prot. S alarm	32	Prot S
Prot. S trip	48	Prot S
Prot. I trip	48	Prot I
Prot. G alarm	32	PROT G
Prot. G trip	48	PROT G
Prot. T pre-alarm	32	PROT T
Prot. T alarm	33	PROT T
Prot. T trip	48	PROT T
LC1 timing to open	32	Load Contr 1
LC1 has opened	48	Load Contr 1
LC2 timing to open	32	Load Contr 2
LC2 has opened	48	Load Contr 2
Reached MAX AR LC2	49	Load Contr 2
CB Undef.	32	CB
Contact wear pre-alarm	33	CB
CB trip	48	CB
Trip cmd fail	49	CB
Contact wear alarm	50	CB

Notes:

5.3.4 Measuring Values

Network Variable: Recommended variables are shown in the table below
Purpose: The PCS can fetch measuring values (Analog) via these NV's.
Function Code: FC03, FC04
Address Range: 40001-49999 if FC03
30001-39999 if FC04

Measuring Values			
SymbNVName	**SNVT**	**Type**	**Register**
Phase current L1 [A]	amp_f	4 Byte float	2
Phase current L2 [A]	amp_f	4 Byte float	2
Phase current L3 [A]	amp_f	4 Byte float	2
Earth fault G [A]	amp_f	4 Byte float	2
Phase current L1 [%]	count	2 Byte integer	1
Phase current L2 [%]	count	2 Byte integer	1
Phase current L3 [%]	count	2 Byte integer	1
Current at trip L1 [A]	amp_f	4 Byte float	2
Current at trip L2 [A]	amp_f	4 Byte float	2
Current at trip L3 [A]	amp_f	4 Byte float	2
Current at trip G [A]	amp_f	4 Byte float	2
Current at trip L1 [%]	count	2 Byte integer	1
Current at trip L2 [%]	count	2 Byte integer	1
Current at trip L3 [%]	count	2 Byte integer	1
Neutral current [A]	amp_f	4 Byte float	2
Trip-Neutral [A]	amp_f	4 Byte float	2
NbrOfOperations	count	2 Byte integer	1
NbrManOpens	count	2 Byte integer	1
NbrPrTrips	count	2 Byte integer	1
NbrOfPrtrFail	count	2 Byte integer	1
NbrOfTrips	count	2 Byte integer	1
ActualCA	count	2 Byte bitvariable	1
CARequestFb	count	2 Byte bitvariable	1
CpOutOfRange	str_asc	31 byte	16
NodeCommandFb	user1	1 Byte	1
RemElectLife	lev_cont	1Byte	1
LastMaintT	time_stamp	7Byte	4

Notes:

5.4 ITS (Intelligent Tier Switch)

5.4.1 ITS Control commands

ITS allows only manual operation so there is no possibility to control it from PCS

5.4.2 Status Information

Network Variable: StateExt (single Bit 0...15 or Word)
Purpose: The PCS can fetch the status information as a word or binary bits.
Function Code: FC02 for binary bits
FC03 for word oriented register.
Address Range: 10201-19999 if FC02
40001-49999 if FC03

Status Information	
Bit	**MMI Text**
0	Fuse L1 blown
1	Fuse L2 blown
2	Fuse L3 blown
3	Any Trip
4	Any Alarm
5	Nc
6	Nc
7	Nc
8	Nc
9	Connected /closed
10	Over-current L1
11	Over-current L2
12	Over-current L3
13	Nc
14	Module temperature
15	Nc

Notes:

5.5 Alarms/Trips

Network Variable: AlarmRep
Purpose: The PCS can fetch the Alarm/Trip information via this NV either as binary bits or word.
Note: 25 Byte structure of SNVT_alarm with alarm/trip codes plus time tag.
Function Code: FC02 for binary bits.
FC03 for word oriented register -> Alarm (25 Bytes)
Address Range: 10201-19999 if FC02
40001-49999 if FC03

The following table shows the Alarm/Trip bits derived from Alarm and their meanings.

Alarm data		
POCT Text	**Code**	**Former input database representation**
Fuse L1 blown	48	Alarm, Node
Fuse L2 blown	49	Alarm, Node
Fuse L3 blown	50	Alarm, Node
Over-current Phase 1	32	Alarm, AMTR
Over-current Phase 2	33	Alarm, AMTR
Over-current Phase 3	34	Alarm, AMTR
nc	35	Alarm, Temp
Module overtemperature	36	Alarm, Temp
nc	37	Alarm, Temp

5.5.1 Measuring Values

Network Variable: Recommended variables are shown in the table below
Purpose: The PCS can fetch measuring values (Analog) via these NV's.
Function Code: FC03, FC04
Address Range: 40001-49999 if FC03
30001-39999 if FC04

POCT text	**SNVT**	**Type**	**Registers**
Phase current L1 [A]	amp_f	4 Byte float	2
Phase current L2 [A]	amp_f	4 Byte float	2
Phase current L3 [A]	amp_f	4 Byte float	2
Phase current G [A]	amp_f	4 Byte float	2
Phase current L1 [%]	count	2 Byte integer	1
Phase current L2 [%]	count	2 Byte integer	1
Phase current L3 [%]	count	2 Byte integer	1
VoltRep-V1	volt_f	4 Byte float	2
VoltRep-V2	volt_f	4 Byte float	2
VoltRep-V3	volt_f	4 Byte float	2
VoltRep-Freq	freq_hz	2 Byte integer	1
Active power	power_f	4 Byte float	2
Reactive power	power_f	4 Byte float	2
Power Factor	pwr_fact_f	4 Byte float	2
unused	temp_f	4 Byte float	2
module temp.	temp_f	4 Byte float	2
unused	temp_f	4 Byte float	2

Notes:

6 MODBUS Interface to PCS System

The order of the necessary steps in setting up the MODBUS Gateway and its communication to PCS system is as defined below:

- Set LON-address of Gateway, activate the standard binding in Gateway via MMI
- Define the desired MODBUS registers mapping on the Gateway with POCT Tool
- Download the description of the mapping to Gateway (*.PBF file via File Transfer with Fumu)
- Set the MODBUS communication parameters based on application/PCS requirement (with MMI or OS).

6.1 MODBUS communication - setting

To set-up the MODBUS communication to the PCS system, define the following Gateway parameters using the MMI or OS:

MODBUS slave address	Can be set between 1 to 99
Baudrate of serial interface:	Allowed baudrates 9.6,19.2 and 38.4 kb/s
Definition of parity:	Can be set None, Even or Odd
Definition of stop-bit:	Always set to 1
Selection of physical interface:	Can be selected RS232, RS422, or RS485

Baudrate, Parity und Stopbit-Definitions can be changed during operation by change of configuration parameters, e.g. from MMI or OS or from the PCS via MODBUS.

MODBUS register 9998, word with following structure:

Bit 8-15:	Slave address
Bit 6-7:	Baudrate: 00=9600, 01=19200, 10=38400, 11=76800 Baud
Bit 5:	Parity Enable
Bit 4:	Parity Odd
Bit 0-1:	Interface: 00=485, 01=422, 10=232

MODBUS_default setting: 0x0162 (addr. 01, 19200bd, even parity, RS232)

Important
A start-up time of approx.2 minutes should be allowed to get all the updated values in the PCS system after the successful start of communication interface.

6.2 MODBUS Function Codes

Interface to the PCS system is realised using the MODBUS standard Function Codes. The standard Function Codes supported by the INSUM system are as follows.

FC02 *Read Input Status*
Bit-orientated reading from register file.
FC03 *Read Holding Registers*
Word-orientated reading from register file.
FC04 *Read Input Registers*
Word-orientated reading from register file.
FC06 *Preset Single Register*
Writing of a word into register file.
FC08 *Diagnostics*
To check the communication between master and slave. Supported is
Subfunction Code 00 = Return Query Data (loop back)
FC16 *Pre-set multiple Registers*
Write of several successive words into register file.

In a MODBUS protocol Master-Slave configuration, the INSUM Gateway is slave. The Master station initiates the communication by sending the 'Query Messages' and the INSUM Gateway replies the requested information in 'Response Messages'.

Notes:

6.2.1 Message format

Query Messages
The MODBUS query messages have the standard query structure as below.

- The slave address
- Function code for Read or Write operation
- Start address of the desired information
- Register length or data code to be read
- CRC-Error checking field

Response Messages
The standard MODBUS response message structure is

- The slave address
- Applied function code
- Length of response (byte)
- Requested information/Action performed
- CRC-Error checking field

Function code and their relevant address range is shown in the tabular form below.

Function Codes	Address Area
FC02	10201-19999
FC04	30001-39999
FC03, 06, 16	40001-49999

6.2.2 Function Code 02 - Read Input Status

This function allows the control system to obtain the ON/OFF status of discrete inputs from the INSUM Gateway. With function code 2 following information can be requested.

- Status Information
- Control Access Information if applicable
- Alarms and
- Trips

The valid address range: 10201—19999.

The discrete inputs to be read can be configured for the addresses in the above range appropriate to the control system with the help of POCT Tool.

FC02-Query Message
The query message consists of 8 bytes. Their content is shown below:

Byte	01	02	03	04	05	06	07	08
Content	Modbus GW (Slave) address	Function Code	start address		bit counter		CRC	
			Hi	Lo	Hi	Lo	Hi	Lo

FC02-Response Message
Depending on the bit counter requested the length of response message varies. The data is packed one bit for each input (1=ON, 0=OFF). The lower order bit of the first character contains the addressed input, and the remainder follows. For input quantities that are not even multiples of eight, the last characters will be filled in with zeros at high order end.

byte	01	02	03	04	05	…		
content	Modbus GW (Slave) address	Function Code	Byte counter	first data byte	second data byte	…	CRC	
							Hi	Lo

Notes:

FC02-Exception Responses
An exception response will be constructed if an error occurred in receiving the message; e.g., a value range is hurt. The following exception responses can occur using Function Code 02:

Exception code	Error cause
02	Invalid start address range
03	Invalid bit counter range
06	The control system tries to read a status while a collective command (Function Code 16) is executed.

6.2.3 Function Code 03 - Read Output Registers

With function code 03, the control system can read the registers that can store the numerical data, which can be driven to external devices as mentioned below.

- Measuring Values
- Status as Word-oriented bits
- Alarm structure (Warnings/Trips)

The valid address range: 40001-49999

The registers to be read can be configured for the addresses in the above range appropriate to the control system with the help of POCT Tool.

FC03-Query Message
The content of the 8 query bytes is shown below:

Byte	01	02	03	04	05	06	07	08
Content	Gateway address	Function Code	start address		register counter		CRC	
			Hi	Lo	Hi	Lo	Hi	Lo

FC03-Response Message
Depending on the register counter requested the length of response message varies. The Gateway responds with its address and the function code, followed by the information field. The information field contains 1 byte describing the quantity of data bytes to be returned. The contents of the registers requested (DATA) are two bytes each, with the binary content right justified within each pair of characters. The first byte includes the high order bits, second byte contains low order bits.

Byte	01	02	03	04	05	06	07	…		
Content	Gateway address	Function Code	byte counter	register content		register content		…	CRC	
				Hi	Lo	Hi	Lo		Hi	Lo

Exception Responses
The following exception responses can occur using Function Code 03:

Exception code	Error cause
02	invalid start address range
03	invalid bit counter range start address + bit counter > start address + 1
06	the control system tries to read values while a collective command (Function Code 16) is executed

Notes:

6.2.4 Function code 04 - Read Input registers

Function code 04 obtains the contents of the input registers. These locations receive their values from devices connected to the I/O structure of field units and can only be referenced, not altered within the system or via MODBUS as mentioned below.

- Status as Word-oriented bits
- Alarm structure (Warnings/Trips)

The valid address range: 30001-39999

The registers to be read can be configured for the addresses in the above range appropriate to the control system with the help of POCT Tool.

FC04-Query Message
The query message format is as follows.

Byte	01	02	03	04	05	06	07	08
Content	Gateway address	Function Code	start address		bit counter		CRC	
			Hi	Lo	Hi	Lo	Hi	Lo

FC04-Response Message
The length of the response message varies according to the amount of data to be sent:

Byte	01	02	03	04	05	06	07	…		
Content	Gateway address	Function Code	byte counter	register content		register content		…	CRC	
				Hi	Lo	Hi	Lo		Hi	Lo

FC04-Exception responses
The following exception responses can occur using Function Code 04:

Exception code	Error cause
02	Invalid start address range
03	Invalid bit counter range Start address + bit counter > start address + 1

6.2.5 Function Code 06 - Preset Single Register

Function code 06 allows control system to modify the contents of a single output register. Any output register that exists within the system can have its contents changed by this message i.e.

- Switching Commands, other commands

The valid address range: 40001-49999
The user can configure the address range via POCT as desired.
The registers to be modified can be configured for the addresses in the above range appropriate to the control system with the help of POCT Tool.

FC06-Query Message
Structure and content of the query:

Byte	01	02	03	04	05	06	07	08
Content	Gateway address	Function Code	start address		data value		CRC	
			Hi	Lo	Hi	Lo	Hi	Lo

Notes:

FC06-Response Message
Structure and content of the response:

Byte	01	02	03	04	05	06	07	08
Content	Gateway address	Function Code	address		data		CRC	
			Hi	Lo	Hi	Lo	Hi	Lo

6.2.6 Function Code 08 - Diagnostic Loopback

The purpose of the loopback test is to test the communication between Master and Slave station. The information field contains 2 bytes for the designation of diagnostic code followed by 2 bytes to designate the action to be taken. The use of loopback test also allows the user to fetch the diagnostic register contents that is useful for communication error analysis.

FC08-Query Message
Structure and content of the query:

Byte	01	02	03	04	05	06	07	08
Content	Gateway address	Function Code	Data Diag Code		data value		CRC	
			Hi	Lo	Hi	Lo	Hi	Lo

FC08-Response Message
Structure and content of the response:

Byte	01	02	03	04	05	06	07	08
Content	Gateway address	Function Code	Data Diag Code		data		CRC	
			Hi	Lo	Hi	Lo	Hi	Lo

6.2.7 Function Code 16 - Preset Multiple Registers

Function code 16 performs the same function as FC06 but allows modifying the contents of multiple output registers. That means its possible to send the switching commands to several MCUs.

The valid address range: 40001-49999

The registers to be modified can be configured for the addresses in the above range appropriate to the control system with the help of POCT Tool.

Please note: The Gateway will only send outgoing commands via FC 16 if there is a change in value compared with the commands previously sent (see section 7.7) thus decreasing bus load. If this does not comply with users communication philosophy, FC 06 should be used for commands so that each single command will be passed by the Gateway without limitations.

FC16-Query Message
The structure of the query message is shown below:

Byte	01	02	03	04	05	06	07	08	09		
Content	Gateway address	Function Code	start address		register counter		byte counter	register content		.....	CRC
			Hi	Lo	Hi	Lo		Hi	Lo		Hi Lo

FC16-Response Message
The response message has the following structure:

Byte	01	02	03	04	05	06	07	08
Content	Gateway address	Function Code	address		register counter		CRC	
			Hi	Lo	Hi	Lo	Hi	Lo

Notes:

6.3 Exception Code Handling

Handling of exception code is supported according to MODBUS specification.
The following response telegrams will be sent if a query could not be served:

Exception code 1 (Illegal function)
A Function Code was received that is not supported
Exception code 2 (Illegal data address)
A register address is out of the valid range.
Exception code 3 (Illegal data value)
The length of the telegram is not valid. (start address + register counter > start address range + 1)
Exception code 8 (Memory parity error)
The CRC of the received telegrams is not correct.

Notes:

7 Supervision and additional functions in INSUM

7.1 Supervision of Field Units

The presence of each field unit on the bus is supervised. The fault situation is defined as a field unit has not sent any message for a certain time. This will lead to marking of the allocated MODBUS-Register (MCU Lifebit disappears).
refer to chapter 5.1 Fixed MODBUS Registers – Life List, MODBUS communication data

The timeout value valid for all field units can be configured with GW parameter:

- SYSTEM/Field Device timeout

7.2 Supervision of Backbone/SU - devices (GW's, MMI's, OS)

The backbone devices cyclically send heartbeats to each other which are then supervised according to a timeout. Expiration of timeout will lead to marking of the allocated MODBUS-Register (Backbone device Lifebit disappears).
refer to chapter 5.1 Fixed MODBUS Registers – Life List, MODBUS communication data

The heartbeat cycle time and the timeout are configurable with GW parameters

- SYSTEM/SU lifesign heartbeat
- SYSTEM/SU lifesign timeout

7.3 Failsafe

In decentralized systems as INSUM the motor protection devices are interfaced with serial busses. If this bus fails it's important for the process that the motors are driven into a safe state. Failure in the bus connections are caused by short circuit, open links or defects in the bus interface of the device. The safe state for a motor depends from the needs of the process and may be different for each motor. Safe states for motors are defined as follows:

- Stop of a running drive
- Start of a drive according to drive type
- Remain in actual state (NOP)

The analysis of the INSUM system structure shows two different situations / locations for a damaged link.

- The connection to the external PCS system (MODBUS) – section 1
- The connection between Backbone and Field Unit (fully or partly) – section 2

According to this the faults will be managed by different devices in the system. Faults in section 1 will be managed by the Gateway and faults in section 2 will be managed by the Field Unit (MCU) itself.

7.3.1 Supervision of Fieldbus (LON)

The GW sends cyclically nvoFailsafe according to "Failsafe heartbeat" to all MCU's as broadcast (contence "normal operation"). When MCU receives first time nvoFailsafe it activates the supervision of this heartbeat. In case nvoFailsafe is not received by MCU after "Failsafe timeout" expires MCU goes to parameterized "Failsafe Status".

- nvoFailsafe-heartbeat can be interrupted due to broken communication link between GW and MCU (e.g. cable broken, GW-Transceiver damage, Router broken, MCU-Transceiver damage...)
- Failsafe supervision in MCU is not active when set to LOCAL.

7.3.2 Supervision of MODBUS (link to DCS)

The communication on the MODBUS is supervised using a timeout-mechanism on the message layer, i.e. a fault situation is recognised when no query is received on the MODBUS interface for a certain time. This timeout value can be configured (GW parameter "Failsafe timeout PLC"). The Gateway responds the fault situation by stopping the broadcast of the Failsafe heatbeat message. After "Failsafe timeout" MCU goes to parameterized "Failsafe Status".
When the communication from PLC to GW is established again the GW starts sending nvoFailsafe as heartbeat again.

After power-on this supervision function is deactivated. Upon receiving the first valid telegram via MODBUS the supervision is activated. Valid telegrams are those with correct syntax (CRC) even if they are addressed to other devices (important in dual redundant systems).

Notes:

7.3.3 Configuration of Failsafe

MCU reports "Failsafe via nvoMotorStateExt/Bit8"

GW-parameters

- Failsafe heartbeat (0 = Disabled)
- Failsafe timeout PLC

MCU-parameters

- MOTOR CONTROL/Failsafe Status
- SYSTEM/Failsafe timeout
- MCU/Failsafe timeout >= 3 * GW/Failsafe heartbeat

7.4 Reset, Supply voltage loss

Data stored in the MODBUS registers can be buffered using an on board capacitor. The data buffering is done after a reset of the Gateway or a loss of supply voltage. The behaviour in case of reset or supply voltage loss is configurable with the GW parameter:

- MODBUS/Hold data at reset (YES/NO)

It is strongly recommended to chose 'Hold data at reset' = NO. Otherwise data from removed devices is stored in the MODBUS registers "forever".

7.5 Control Access

A Field Unit such as MCU can be controlled by commands (START, STOP, RESET) coming via bus or commands coming via hardware inputs. There are 2 scenarios to define the interlocking between bus and hardware commands.

The simple way of interlocking between commands coming via bus or hardware is done via the hardware switch LOCAL/REMOTE. In case the switch is in position LOCAL commands coming via bus are ignored. In case the switch is in position REMOTE only commands via bus are executed. The MCU does not evalute from which "bus device" a command was received. A bus device in this sense is the GW, MMI or OS.

With "Control Access" the INSUM system can be set up in such a way that the interlocking mechanism takes also into account which of the bus devices sent a command. The MCU accepts commands via bus only from one of the devices **at a time**.
"Control Access" also covers a mechanism to pass the "right to send commands" from one bus device to the other. For this purpose priorities are assigned to the devices.

7.6 Control command supervision

When a control command is transmitted via nvoDesState the MCU "acknowledges" the receipt via nvwDesStateFb then containing the actual value of the control command. In case the Gateway did not receive the "Feedback" signal before the time parameterized by "Control cmd timeout" elapses, the control command is automatically repeated.

7.7 Handling of outgoing commands (initiated via FC 16, FC 06) from ModGW SW 1.3 onward

The Gateway will only send outgoing commands via Function code FC 16 if there is a change in value compared with the commands previously sent.

This delivers the following advantage:
Several Process Control Systems continously send control commands in a background loop containing always the same value (e.g. start - start - start...) even though the motor/motors are already started. If all these commands were always updated via LON it would create an enormous busload. Therefore the Gateway just updates the "effective" commands (only those which had a change in value compared with the previously sent command).

The following commands are handled in the way described:

- NvoDesState
- NvoCAPass
- NvoCAReq
- NvoGpOut1,
- nvoGpOut2

Outgoing commands initiated via Function code FC 06 are always updated, regardless any change of command value.

Notes:

7.8 Statistics of Gateway

The Gateway statistics can be read out via the MMI. The following data are available:

Entry 1:	LON busload in packets per second
Entry 2:	LON bus collisions per second
Entry 10:	Hours run counter (elapsed time since last reset of Gateway) - available from ModGW SW 1.3 onward
(Entry 3 ... Entry 9:	for future use)

Notes:

8 Overview of GW Parameters

Group	Name	Range	Default setting	refer to
SYSTEM	Field device timeout:	1 (1) 100 sec	10 sec	chapter 7.3.1 Supervision of Field Units
SYSTEM	Control cmd timeout:	0: DISABLED 0.4 (0.1) 20 sec	1 sec	document [3] (control cmd sequence)
SYSTEM	Failsafe heartbeat:	0: DISABLED 0.5 (0.5) 60 sec	DISABLED	chapter 7.3.3 Configuration of Failsafe
SYSTEM	Failsafe timeout PLC:	0: DISABLED 1 (0.5) 100 sec	DISABLED	"
SYSTEM	SU lifesign heartb:	1 (1) 60 sec	2 sec	chapter 7.2 Supervision of Back-bone/SU – devices (GW´s, MMI´s, OS)
SYSTEM	SU lifesign timeout:	1 (1) 100 sec	6 sec	"
SYSTEM	SU lifelist heartb.:	0: DISABLED 1 (1) 60 sec	DISABLED	document [1]
SYSTEM	CA priority:	priority 2...priority 13 code Bit1...Bit15 =1	priority 2	document [1]
SYSTEM	CA name:	10 characters	MOD GW	document [1]
DEVICE DATA	Firmware version:	21 characters	Read only	
DEVICE DATA	Hardware version:	21 characters	Read only	
DEVICE DATA	Parameterfile version:	000.000 ... 999.999	Read only	
MODBUS	MODBUS slave ad-dress:	1 (1) 99	1	chapter 6.1 MODBUS communica-tion - setting
MODBUS	MODBUS baudrate:	9600 – code 00 19200 – code 01 38400 – code 10 76800 – code 11	19200 bd	"
MODBUS	MODBUS interface:	RS485 – code 00 RS422 – code 01 RS232 – code 10	RS232	"
MODBUS	MODBUS parity:	NO - 01 or 00 EVEN - code 10 ODD - code 11	EVEN	"
MODBUS	Hold data at reset:	NO - code 0 YES - code 1	YES	chapter 7.4 Reset, Supply voltage loss

Notes:

9 Annex A - Technical Data

9.1 Mechanical Data

Enclosure	Aluminium Metal Case
Dimensions	135 x 67 x 215 mm (HxWxD)
Weight	ca. 0,75 kg

9.2 General Electrical Data

Power Supply	24 V DC (18 ... 36 V DC)
Power Consumption (max.)	4,8 W
Nominal Current (typ.)	130 mA
Inrush Current	< 350 mA
Storage Temperature	-20 °C to +80 °C
Operating Temperature	-5 °C to +70 °C
MTBF	15 years
Protection class	IP 30

9.3 Electromagnetic Compatibility (EMC)

Standard	Subject		Level	Class	Criteria
EN 50081-1	0.15 – 0.5 MHz	(230VAC *)	79/66	B	-
	0.5 – 30 MHz	(230VAC *)	73/60	B	-
EN 50081-1	30 – 230 MHz	(Case)	30 dBuV	B	-
	230 – 1000 MHz	(Case)	37 dBuV	B	-
EN 61000-4-2	Contact discharge		6 kV	3	A
EN 61000-4-3	Sinus modulation		10 V/m	3	A
EN 61000-4-4	230 VAC *		4 kV	4	A
	24 VDC power supply lines		2 kV	3	A
	LON XP 1250		2 kV	4	A
	RS232		2 kV	4	A
	RS485		2 kV	4	A
	RS422		2 kV	4	A
EN 61000-4-5	230 VAC * asymetrical / symetrical		2/1 kV	3	A
	24 VDC power supply lines asymetrical / symetrical		1/ 0.5 kV	2	A
	LON XP 1250		2 kV	3	A
	RS232		2 kV	3	A
	RS485		2 kV	3	A
	RS422		2 kV	3	A
EN 61000-4-6	230 VAC *		10 V	3	A
	24 VDC		10 V	3	A
	LON XP 1250		10 V	3	A
	RS232		10 V	3	A
	RS485		10 V	3	A
	RS422		10 V	3	A
EN 61000-4-11	230 VAC *	70 % Un	10 ms	A	-
		40 % Un	1000 ms	A	-
		<5 % Un	5000 ms	C	-
PR EN 61000-4-29	Voltage dips 24 VDC	70 % Un	1000 ms	A	-
	Voltage dips 24 VDC	40 % Un	100 ms	A	-
	Voltage dips 24 VDC	<5 % Un	30 ms	A	-

* With power supply unit 1TGB302006

Notes:

9.4 Insulation test

Standard	Subject	Reference Point	Level	Class
IEC 60255-5 chap.4	24 V DC	Ground plane	+/- 0.8 kV	3
	24 V DC	Internal bus lines	+/- 0.8 kV	3
	Bus lines	Ground plane	+/- 0.8 kV	3

9.5 Environmental Testing

Subject	International Standard	European Standard
Vibration (sinusodial)	IEC 255-21-1	
Shock and bump	IEC 255-21-2	
Cold	IEC 68-2-1	EN 60068-2-1
Dry heat	IEC 68-2-2	EN 60068-2-2
Vibration (sinusodial)	IEC 68-2-6	EN 60068-2-6
Damp heat, cyclic	IEC 68-2-30	EN 60068-2-30

Notes:

10 Annex B – Terms and Abbreviation

Abbreviation	Term	Explanation / Comments
	Alarm	Alarm is defined as status transition from any state to abnormal state. Status transition to abnormal state can be data crossing over the predefined alarm limit.
	Backplane	INSUM backbone, holds following INSUM devices: Router, Gateways, Clock, Power supply. Part of the INSUM Communication Unit, see ICU
CA	Control Access	A function of INSUM system that allows definition of operating privileges for each device level (e.g. PCS, Gateway, field device)
CAT	Control Access Table	Table containing control access privileges
CB	Circuit Breaker	Circuit breaker unit (here: ABB SACE Emax with electronic release PR112-PD/LON)
CT	Current Transformer	Current Transformer
DCS	Distributed Control System	see also PCS
Eth	Ethernet	Ethernet is a local area network (LAN) technology. The Ethernet standard specifies the physical medium, access control rules and the message frames.
	Event	An event is a status transition from one state to another. It can be defined as alarm, if the state is defined as abnormal or as warning as a pre-alarm state.
FD	Field Device	Term for devices connected to the LON fieldbus (e.g. motor control units or circuit breaker protection)
FU	Field Unit	see Field Device
GPI	General Purpose Input	Digital input on MCU for general use
GPO	General Purpose Output	Digital output on MCU for general use
GPS	Global Positioning System	System to detect local position, universal time and time zone, GPS technology provides accurate time to a system
GW	Gateway	A Gateway is used as an interface between LON protocol in INSUM and other communication protocols (e.g. TCP/IP, Profibus, Modbus)
HMI	Human Machine Interface	Generic expression for switchgear level communication interfaces to field devices, either switchboard mounted or hand held
ICU	INSUM Communications Unit	INSUM Communications Unit consists of devices such as backplane, Gateways, Routers, System Clock and Power Supply. It provides the communication interface within INSUM and between INSUM and control systems. Formerly used expressions: SGC, SU
INSUM	INSUM	Integrated System for User optimized Motor Management. The concept of INSUM is to provide a platform for integration of smart components, apparatus and software tools for engineering and operation of the motor control switchgea
INSUM OS	INSUM Operator Station	Tool to parameterise, monitor and control devices in the INSUM system
ITS	Integrated Tier Switch	The Intelligent Tier Switch is an ABB SlimLine switch fuse with integrated sensors and microprocessor based electronics for measurement and surveillance
LON	Local Operating Network	LON is used as an abbreviation for LonWorks network. A variation of LON is used as a switchgear bus in the INSUM system
LonTalk	LonTalk protocol	Fieldbus communication protocol used in LonWorks networks

Notes:

Abbreviation	Term	Explanation / Comments
LonWorks	LonWorks network	A communication network built using LonWorks network technology, including e.g. Neuron chip and LonTalk protocol
MCU	Motor Control Unit	Motor Control Unit is a common name for a product range of electronic motor controller devices (field device) in INSUM. A MCU is located in a MNS motor starter, where its main tasks are protection, control and monitoring of motor and the related motor starter equipment.
MMI	Man Machine Interface	The switchgear level INSUM HMI device to parameterize and control communication and field devices.
MNS	MNS	ABB Modular Low Voltage Switchgear
	Modbus, Modbus RTU	Fieldbus communication protocol
NV,nv	LON Network Variable	Network variable is a data item in LonTalk protocol application containing max. 31 bytes of data.
Nvi, nvi	LON Network Variable input	LON bus input variable
Nvo, nvo	LON Network Variable output	LON bus output variable
OS	Operator Station	see INSUM OS
PCS	Process Control System	High level process control system
PLC	Programmable Local Controller	Low level control unit
PR	Programmable Release	Circuit breaker protection/release unit (here: ABB SACE Emax PR112-PD/LON)
	Profibus DP	Fieldbus communication protocol with cyclic data transfer
	Profibus DP-V1	Fieldbus communication protocol, extension of Profibus DP allowing acyclic data transfer and multi master.
PTB	Physikalisch-Technische Bundesanstalt	Authorized body in Germany to approve Ex-e applications.
PTC	Positive Temperature Coefficient	A temperature sensitive resistor used to detect high motor temperature and to trip the motor if an alarm level is reached.
RCU	Remote Control Unit	Locally installed control device for motor starter, interacting directly with starter passing MCU for local operations.
	Router	Connection device in the LON network to interconnect different LON subnets. Part of the INSUM Communications Unit.
RTC	Real Time Clock	Part of the INSUM System Clock and and optionally time master of the INSUM system
SCADA	Supervisory Control and Data Acquisition	
SGC	Switchgear Controller	Former term used for INSUM Communications Unit
SU	Switchgear Unit	Former term used for INSUM Communications Unit
	System Clock	INSUM device providing time synchronisation between a time master and all MCUs. Part of the INSUM Communication Unit, see ICU
TCP/IP	Transmission Control Protocol /Internet Protocol	TCP/IP is a high-level, connection oriented, reliable, full duplex communication protocol developed for integration of the heterogenous systems.
TFLC	Thermal Full Load Current	See MCU Parameter Description for explanation
TOL	Thermal Overload	See MCU Parameter Description for explanation
	Trip	A consequence of an alarm activated or an external trip command from another device to stop the motor or trip the circuit breaker.

Notes:

Abbreviation	Term	Explanation / Comments
UTC	Coordinated Universal Time	Coordinated Universal Time is the international time standard, formerly referred to as Greenwich Meridian Time (GMT). Zero (0) hours UTC is midnight in Greenwich England, which lies on the zero longitudinal meridian. Universal time is based on a 24 hours clock.
VU	Voltage Unit	Voltage measurement and power supply unit for MCU 2
	Wink	The Wink function enables identifcation of a device on the LON network. When a device receives a Wink-message via the fieldbus, it responds with a visual indication (flashing LED)

Notes:

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Editor: DEAST/BT
Publication No: 1TGC901042M0201