DISTRIBUTION SOLUTIONS

LVS Digital
with UMC motor controller
Interface Manual Modbus

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1. General

1.1. Target Group

This document describes communication and control interfaces used in LVS Digital (includes MNS Digital and NeoGear Digital switchgear) and LVS Digital Upgrade (upgrade from INSUM1 / 2) projects utilizing ABB motor controller UMC [supported from UMC100.3 onwards].

The manual is primarily intended for those requiring information on how to access information and data provided from Digital Gateway.

Furthermore, the document provides information for control system and application engineers how to integrate MNS Digital [Upgrade] as Fieldbus component into PLC or higher-level Process Control Systems.

It is assumed that the reader of this manual is familiar with basic terms of Fieldbus and control communication (e.g. basic knowledge about Modbus etc.).

1.2. Use of Warning, Caution, Information and Tip icon

This publication includes Warning, Caution, and Information icons where appropriate to point out safety related or other important information. It also includes Tip icons to point out useful hints to the reader. The corresponding symbols should be interpreted as follows:

The electrical warning icon indicates the presence of a hazard that could result in *electrical shock*.

The warning icon indicates the presence of a hazard that could result in *personal injury*

The caution icon indicates important information or warnings related to the concept discussed in the text. It might indicate the presence of a hazard that could result in *corruption of software or damage to equipment/property*

The information icon alerts the reader to pertinent facts and conditions

The tip icon indicates advice on, for example, how to design your project or how to use a certain function

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1.3. Terminology

List of the terms, acronyms, abbreviations and definitions that the document uses.

Abbreviation	Term	Description
	Alarm	Alarm is defined as status transition from any state to abnormal state. Status transition to abnormal state can be data crossing over the pre-defined alarm limit.
	Bus Local	A Control Access term describing that the UMC accepts its commands from a device on the switchgear control network, e.g. the Web Interface, MView.
COTS	Commercial off the shelf	Commercial off the shelf product, term to describe products available on the market, ready to use
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 Fieldbus (e.g. motor control units or circuit breaker protection)
GPS	Global Positioning System	System to detect local position, universal time and time zone, GPS technology provides accurate time to a system
	Hardware Local	A Control Access term describing that the UMC accepts its commands from the Hardwired inputs, when the respective Local control input is set to true.
HMI	Human Machine Interface	Generic expression
LVS	Low voltage switchgear	A factory built assembly built to conform with IEC 61439-1

UMC100	Universal Motor Controller	An intelligent motor controller for 3-phase AC induction motors combining the two classical functions of motor protection and motor management in a single device plus offering diagnostic and fieldbus communication
MCC	Motor Control Centre	Common term for switchgear used for motor control and protection.
MNavigate		Configuration and parameterization tool for MNS Digital
MNS		Modular Low Voltage Switchgear family from ABB
	MODBUS	Fieldbus communication protocol
	MODBUS RTU	Fieldbus communication protocol
	MODBUS TCP/IP	Fieldbus communication protocol based on Ethernet hardware
	Motor Starter	Consists of motor controller and electrical components to control and protect a motor, part of Motor Control Center
NeoGear		Modular Low Voltage Switchgear family from ABB
NLS	Native Language Support	Providing the ability to change the language of software tools in order to support native languages (English is basis, others are optional)
OPC		The industrial standard for exchange of information between components and process control application.
PLC	Programmable Local Controller	Low level control unit
RCU	Remote Control Unit	Local control unit with pushbutton and indicator to operate a device (e.g. motor) from field level.
RS232		Standard No. 232 for PC communication, established by EIA (Electronics Industries Association, USA)

RS485		Communication interface standard from EIA (Electronics Industries Association, USA), operating on voltages between 0V and +5V. RS-485 is more noise resistant than RS-232C, handles data transmission over longer distances, and can drive more receivers.
RTC	Real Time Clock	Integrated clock function in devices used to generate time and date information if a remote clock system is not present
	Software Local	A Control Access term describing that the UMC accepts its commands from the hardwired inputs as a result of either the PCS or MView passing the Control Access Authority to Soft-Local. Note: Does not require the hardwired local input to be set to true.
SNTP	Simple Network Time Protocol	A protocol used for time synchronization in Control Network through Ethernet
	Switchgear Bus Network	Term used to describe the internal switchgear communication network, between Digital Gateway and UMC
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 heterogeneous systems.
	Trip	A consequence of an alarm activated or an external trip command from another device to stop the motor or trip the circuit breaker.
UTC	Coordinated Universal Time	Coordinated Universal Time is the international time standard. It is the current term for what was commonly 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 hour clock.
	Warning	A warning is defined as status transition from any state to pre-alarm state to inform in advance before an alarm level is reached.

1.4. Related Documentation

- 2CDC194003D0202 Technical Description FBP Fieldbus Plug MTQ-22FBP
- 1TGC908001M0206 ABB Ability Condition Monitoring for electrical systems user manual
- 1TNA810039 Manufacturing Instruction - Installation of MService and MNS Digital Gateway in MNS

2. Introduction

The Digital Gateway is an industrial PC equipped with interface cards and ports required for communication internally to UMC and externally to process control systems as well as to the CMES Edge which provides condition monitoring features and functions as well as edge connectivity to ABB Ability™ cloud based solutions.

Figure 1: Digital Gateway

One Digital Gateway can communicate internally to up to 128 UMC / field devices by Modbus TCP. If more than 128 UMC / field devices are installed, then additional Digital Gateway must be configured.

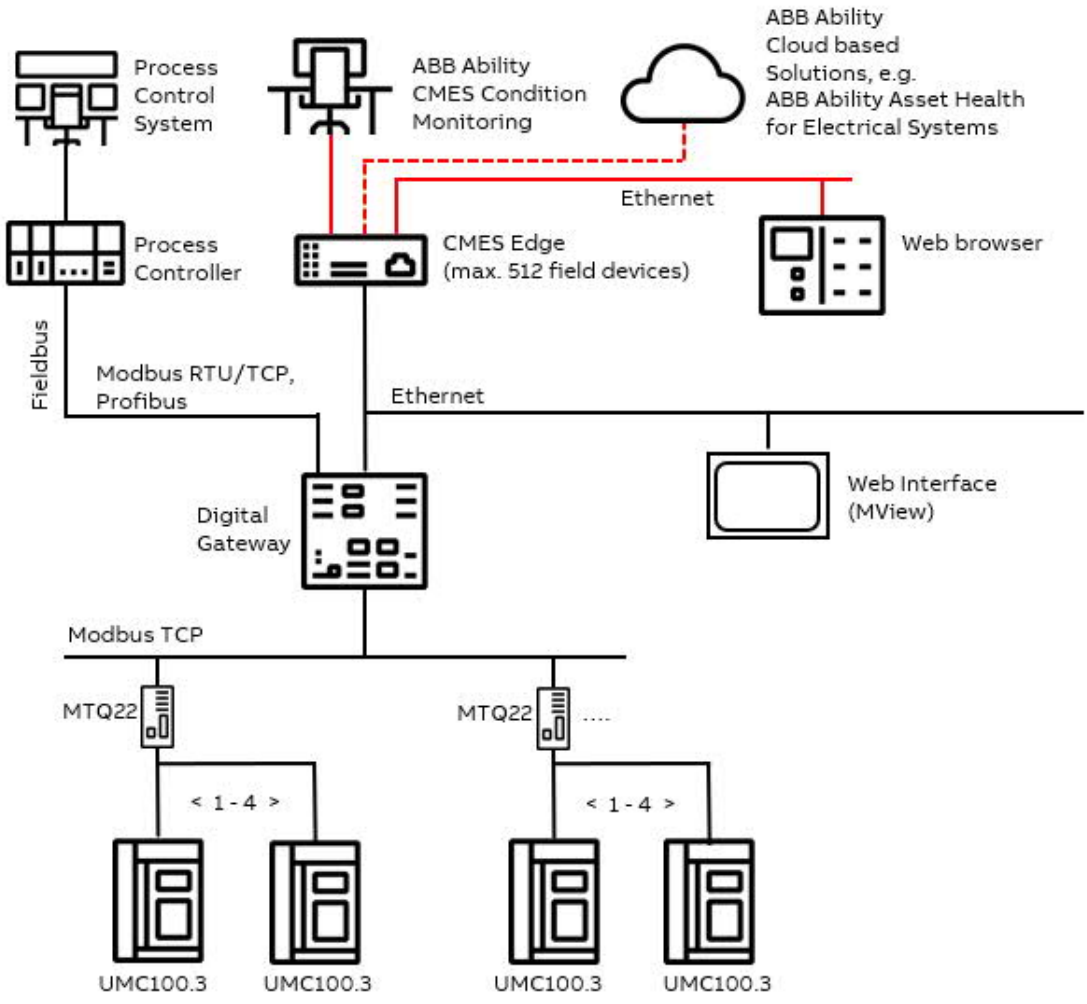


Figure 2: LVS Digital System Configuration with UMC

2.1. Hardware Types and Technical Data

The configuration of Digital Gateway depends on the selected communication protocol to the DCS. For the Modbus communication to DCS the hardware shown in the table below is applicable

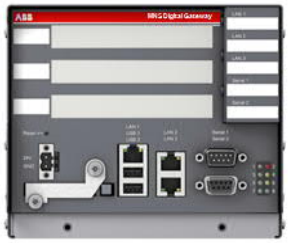
Fieldbus Protocol	Modbus		
Fieldbus Hardware Interface	RS 485 & Ethernet TCP/IP IEEE 802.3	RS 422 & Ethernet TCP/IP IEEE 802.3	RS 232 & Ethernet TCP/IP IEEE 802.3
Digital Gateway ID	1TGE120021R0610		
Picture			

Table 1 Digital Gateway Modbus Hardware

For communication to UMC, Digital Gateway need to be connected to MTQ22-FBP via a dedicated Ethernet port (LAN 3) which must be used dependent on system configuration (redundant, non-redundant system).

ELECTRICAL DATA	
Power Supply	24V DC (19 – 31V DC)
Power Consumption	Typical 800mA, maximum 1000mA
MECHANICAL DATA	
Weight	2.5 kg
Dimensions H x W x D	140 x 160 x 165 mm
ENVIRONMENTAL DATA	
Storage Temperature	-20°C to + 70°C
Operating Temperature	0°C to 55°C
Degree of Protection	IP51
MTBF (Mean Time Between Failures)	46 years @ 40°C

Table 2 Digital Gateway Technical Data

2.2. Modbus Standard

MODBUS is a serial data communication protocol and was originally developed as a communication language for MODICON programmable controllers, its rights now reside with the Modbus-IDA organization.

The software on the Digital Gateway supports the pure Master-Slave operation as defined in the MODBUS RTU specification. This manual describes the Digital Gateway communication with MODBUS protocol in RTU and TCP modes.

The MODBUS communication protocol is implemented within the Digital Gateway to enable LVS Digital to provide interface possibilities to process control systems or any other external systems that supports MODBUS RTU / TCP protocol handling.

The MODBUS configuration can be used in point to point configuration or in multi-drop mode. In Master-Slave MODBUS architecture, the Digital Gateway is always used in a slave (TCP: Server) mode. The master station controls the traffic on the bus, in this case, by PCS/DCS or PLC system. The Digital Gateway responds to the queries received from master station as per the MODBUS specification.

2.2.1. Basics

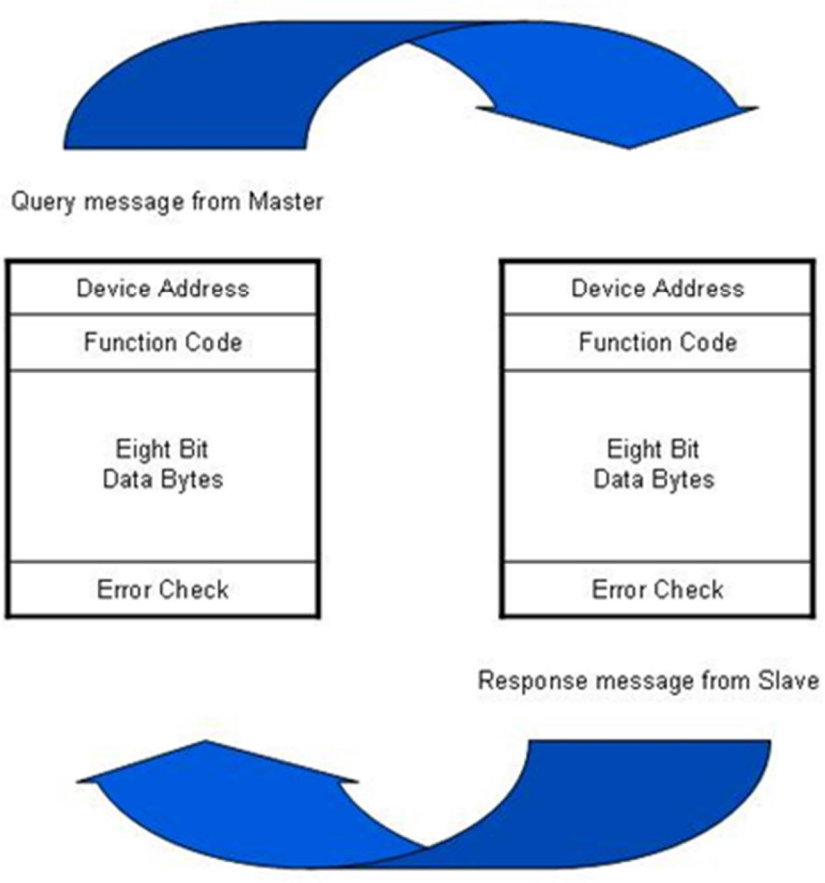


Figure 3 Master Slave Query Response Cycle

2.2.1.1. The Query

The function code (FC) in the query tells the addressed slave device what kind of action to perform. The data bytes contain any additional information that the slave will need to perform the function. For example, function code 03 will query the slave to read holding registers and respond with their contents. The data field must contain the information telling the slave which register to start at and how many registers to read. The error check field provides a method for the slave to validate the integrity of the message contents.

2.2.1.2. The Response

If the slave makes a normal response, the function code in the response is an echo of the function code in the query. The data bytes contain the data collected by the slave, such as register values or status. If an error occurs, the function code is modified to indicate that the response is an error response, and the data bytes contain a code that describes the error. The error check field allows the master to confirm that the message contents are valid.

2.2.1.3. Characteristics

Certain characteristics of the MODBUS protocol, as specified by the reference document, are fixed such as the frame format, frame sequences, handling of communication errors and exception conditions, and the functions performed. In case of the Digital Gateway, the transmission mode is also limited to RTU or TCP.

Other characteristics are user selectable. These include a choice of transmission medium, baud rate and character parity, number of stop bits. These parameters cannot be changed while the communication interface is active.

The OSI layers 1, 2, and 7 are implemented in the Digital Gateway

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 realized. 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.

2.2.1.4. 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.

Digital Gateway does not support ASCII transmission.

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)

Table 3 Modbus RTU mode of Transmission

2.2.1.5. Error Detection

There are two types of errors, which may occur in a communication system:
- Transmission error and
- Programming or Communication error

The Digital 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 last received erroneous 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.

3. Interfaces

3.1. Front View

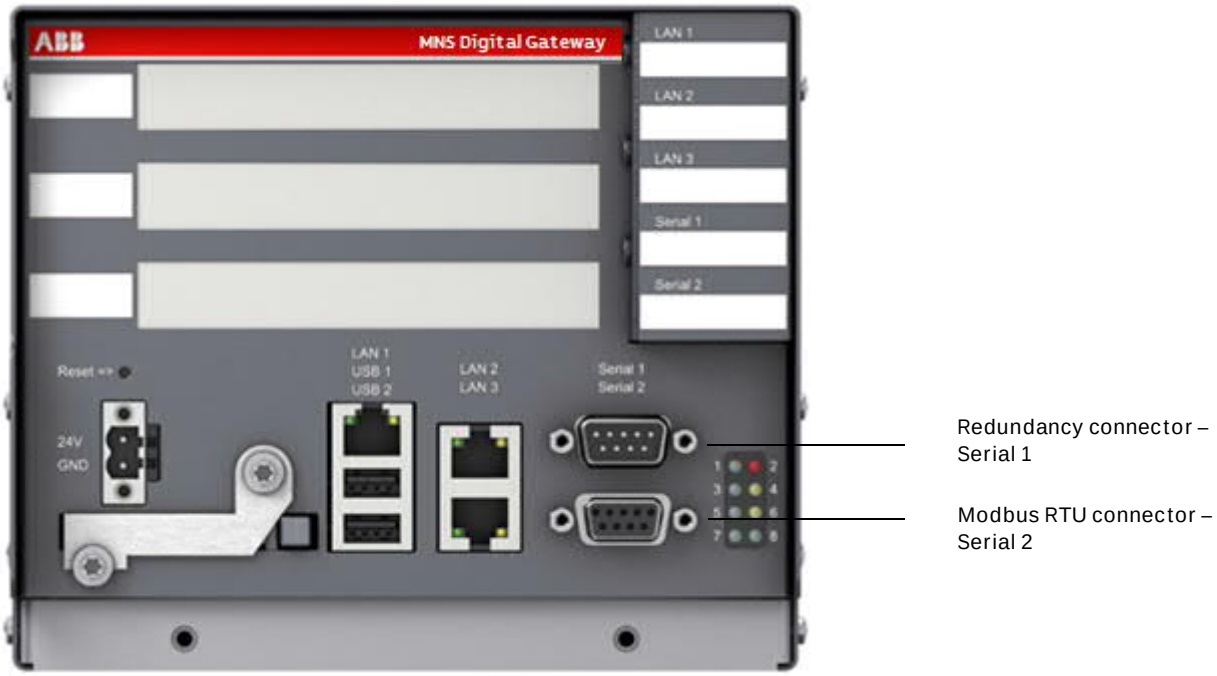


Figure 4 Digital Gateway front view

POWER SUPPLY	
Button Reset	Reset button (Restart of Digital Gateway)
24V	Power Supply +24VDC
GND	Power Supply 0V
CF CARD	
CF Card	CF card is protected against unintentional removal after closing the flap and connecting the power supply
PORTS	
LAN 1	LAN 1 Interface (Modbus TCP to DCS/PCS)
LAN 1 – LED left, green	Link LAN 1 active
LAN 1 – LED right, yellow	Communication Ethernet LAN 1
LAN 2	LAN 2 Interface (Switchgear Control Network to MView, CMES Edge)
LAN 2 – LED left, green	Link LAN 2 active
LAN 2 – LED right, yellow	Communication Ethernet LAN 2

LAN 3	LAN3 Interface (UMC100.3, Modbus TCP)
LAN 3 – LED left, green	Link LAN3 active
LAN 3 – LED right, yellow	Communication Ethernet LAN 3
USB 1, 2	Not used
Serial 1	Redundancy Interface (male plug)
Serial 2	Modbus RTU Interface (female plug)
LED INDICATIONS	
LED 1	Digital Gateway Run indication (CF card application loaded and running)
LED 2	Digital Gateway Fault
LED 3	Application dependent (see section LED indication, page 60)
LED 4	Application dependent (see section LED indication, page 60)
LED 5	Application dependent (see section LED indication, page 60)
LED 6	DCS Communication active
LED 7	Digital Gateway Power On Indication
LED 8	Application dependent (see section LED indication, page 60) In redundant configurations: Digital Gateway primary

Table 4 Front View Connectors, LED and Push Buttons

3.2. Power Supply

The Digital Gateway requires 24V DC supply voltage. The connection is on the left side of the device with terminal plugs:

- Terminal 1 connects to +24V DC
- Terminal 2 connects to 0V DC

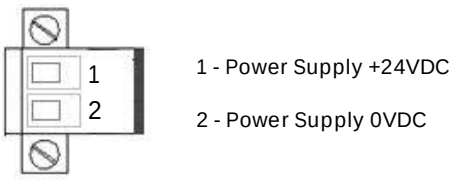


Figure 5 Power Supply Connector

4.Digital Gateway Installation

4.1. Digital Gateway Mounting

The Digital Gateway is typically installed inside the switchgear utilizing a Digital Gateway mounting kit which is housed in an 8E withdrawable module compartment of the MNS cubicle (mounting kit part ID: 1TNA704001R0003) or respective compartment in NeoGear switchgear.

The Digital Gateway mounting kit for MNS is capable to support mounting of up to three Digital Gateway.

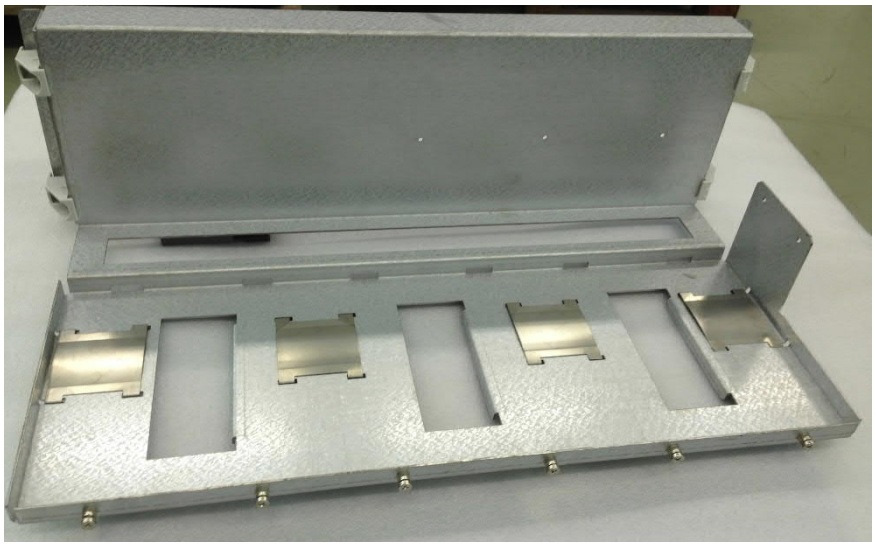


Figure 6 Digital Gateway Mounting Kit for MNS

4.2.CF Card Installation

The Compact Flash (CF) card is required to start and run the Digital Gateway. The procedure to create the CF card configuration and copy all mandatory files is described in the MNavigate help file.

Only Industrial Grade CF cards shall be utilized to ensure correct function of the Digital Gateway in the switchgear environment!

The CF card slot is located on the Digital Gateway front side. To remove or insert the CF card the power supply connector must be removed and the metal cover must be lifted. This ensures that CF card can only be removed / inserted while power supply is off.

CF card shall be inserted with the correct side up and with care as the card is mechanically coded and insertion should not be forced.

The following example shows the ABB standard CF card.

Figure 7 CF Card Insertion

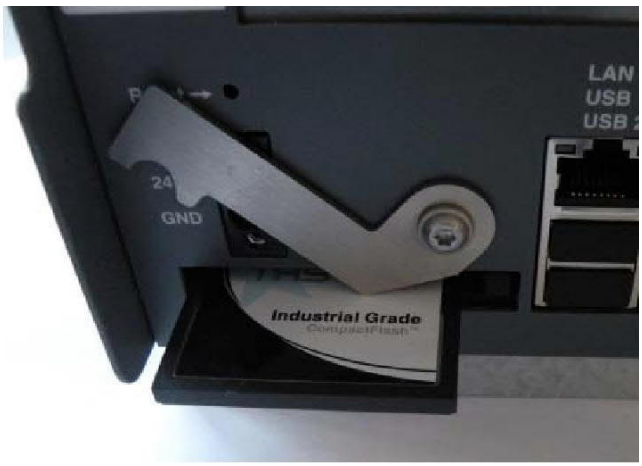


Figure 8 CF Card Insertion Detail

5.Communication Interface Connection

5.1. Switchgear Bus Network

The communication between Digital Gateway and UMC is established via Modbus TCP protocol.

The hardware interface between Digital Gateway and UMC requires an Ethernet adapter module (MTQ 22 FBP) to convert signals from UMC FBP to Modbus TCP. Ethernet cable needs to be connected between Digital Gateway LAN3 port and either port E1/E2 of the MTQ 22. One MTQ 22 can support up to 4 UMC devices.

The 2 Ethernet ports on MTQ22 act as integrated switch, thus increasing the flexibility in configuration. The figure below shows possible Ethernet topology connections to the Digital Gateway.

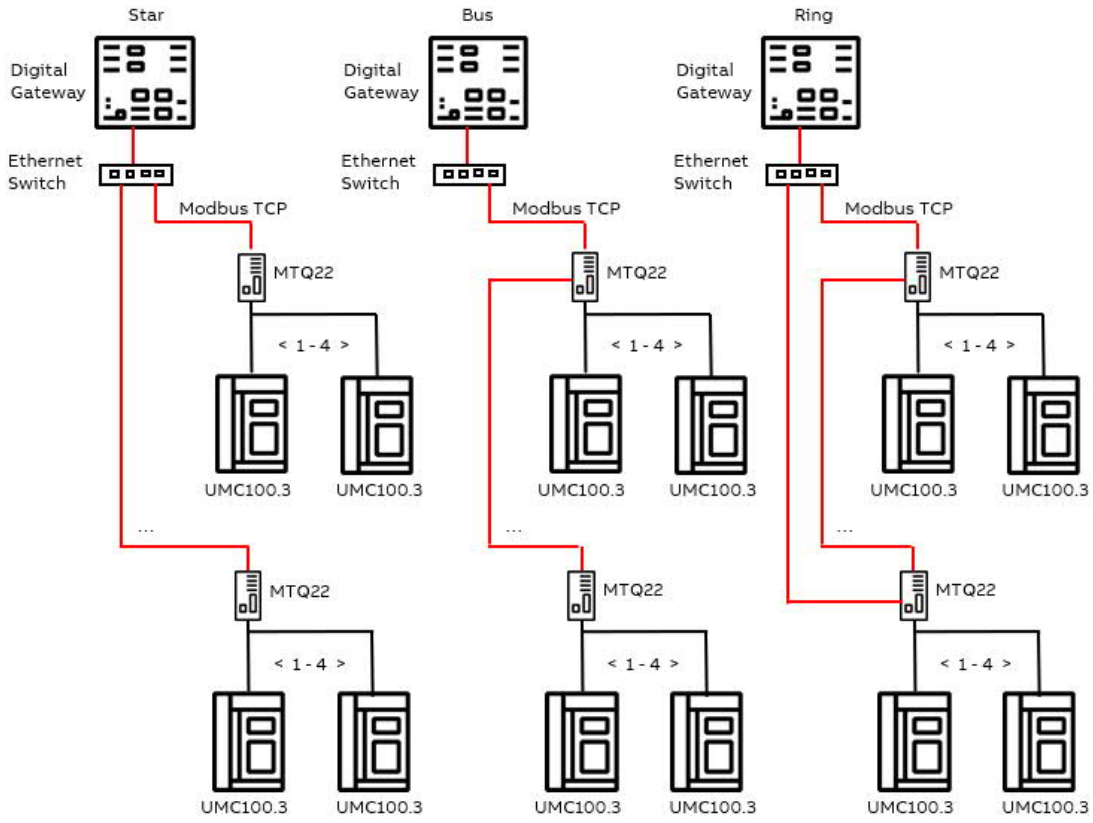


Figure 9 Different hardware connections possible between Digital Gateway and MTQ22

The ring topology offers cable redundancy on Ethernet side. This topology requires a managed switch which supports MRP (Media Redundancy Protocol). The redundancy protocol implemented in the MTQ22-FBP is according to EN/IEC 62439-2.

Before any Ethernet communication can be established, it is required for every MTQ22-FBP to have a unique IP address.

The internal switchgear network (FBP) connects UMC and MTQ22-FBP via a prefabricated field bus plug communication cable. Each of the UMC devices need its address to be configured, in accordance to the port number connection in the MTQ22-FBP.

For further details about MTQ22-FBP, refer the following document “2CDC194003D0202 Technical Description FBP Fieldbus Plug MTQ-22FBP”.

5.2. Switchgear Control Network

The Digital Gateway can be connected to a standard 10/100/1000 Base-T Ethernet network through LAN2 interface (Switchgear Control Network). Network components are standard (COTS – commercial of the shelf) components but shall be of industrial grade design (e.g. no office switches shall be used).

Examples of connections are shown in the following figures. All System configuration tools (e.g. MNavigate) and system components (CMES Edge, Time Server) are connected to this network (see Figure 2). The cable shall be CAT5 / CAT6 depending on requirements based on the selected Ethernet communication speed. The connector type is standard RJ45 type.

If the switchgear control network has any connection to other networks (e.g. plant management network etc.) measures must be taken to protect the switchgear control network against unauthorized access (e.g. through Router and Firewall). This is a project specific configuration. Contact always the local network administrator and review the project specific requirements.

If managed switches or routers are used in the Ethernet network, it has to be taken care that sent ARP messages can pass through. Background: After reboot, Digital Gateway will send an ARP (Address Resolution Protocol) message to force all connected Ethernet devices to update their internal ARP table. This special ARP message is used to map the network layer address (MAC address) to a dedicated link layer address (IP address). This ARP table refresh is required to be able to establish an Ethernet communication.

5.2.1. Connection Examples of Switchgear Control Network

5.2.1.1. Option 1

If the Digital Gateway is directly connected to CMES Edge a cross-over network cable is used. On the Digital Gateway, the cable must be connected to the LAN2 Ethernet port, on CMES Edge the cable has to be connected to the designated Ethernet connector. The cable type is CAT5 or higher.

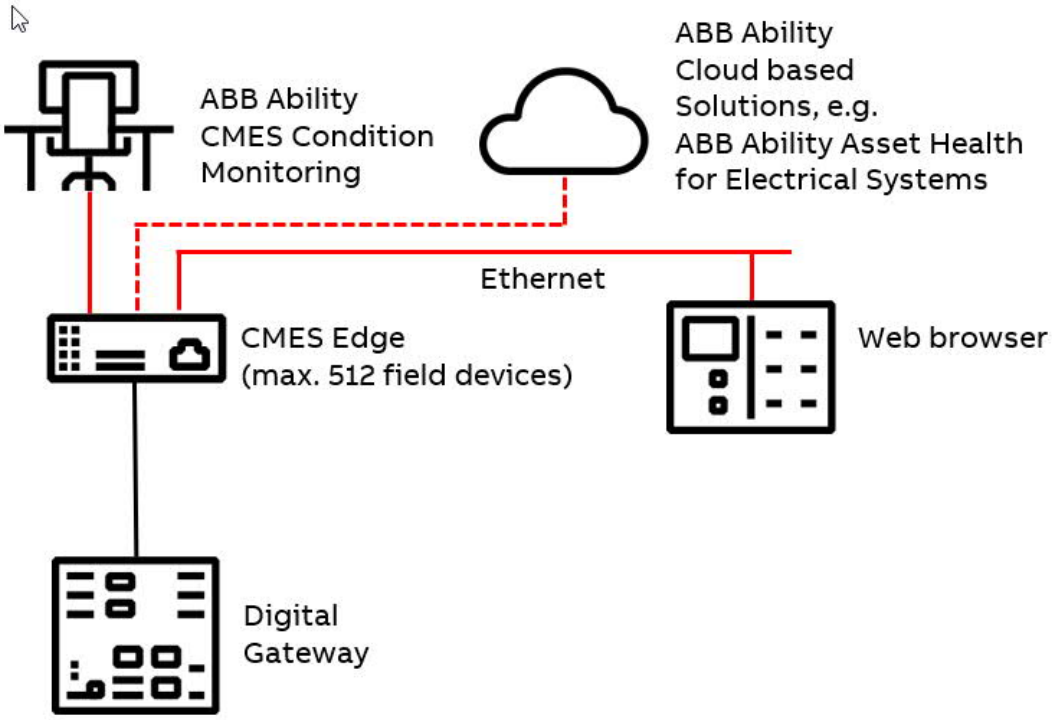


Figure 10 Digital Gateway directly connected to CMES Edge

5.2.1.2. Option 2

The Digital Gateway is connected to Switchgear Control Network providing facility to connect additional Digital Gateway and other system tools and components (e.g. CMES Edge, Web browser, Time Server, configuration tool, etc.). A network switch must be installed in the plant. All network components are connected to the switch with standard CAT5 / CAT6 patch cable.

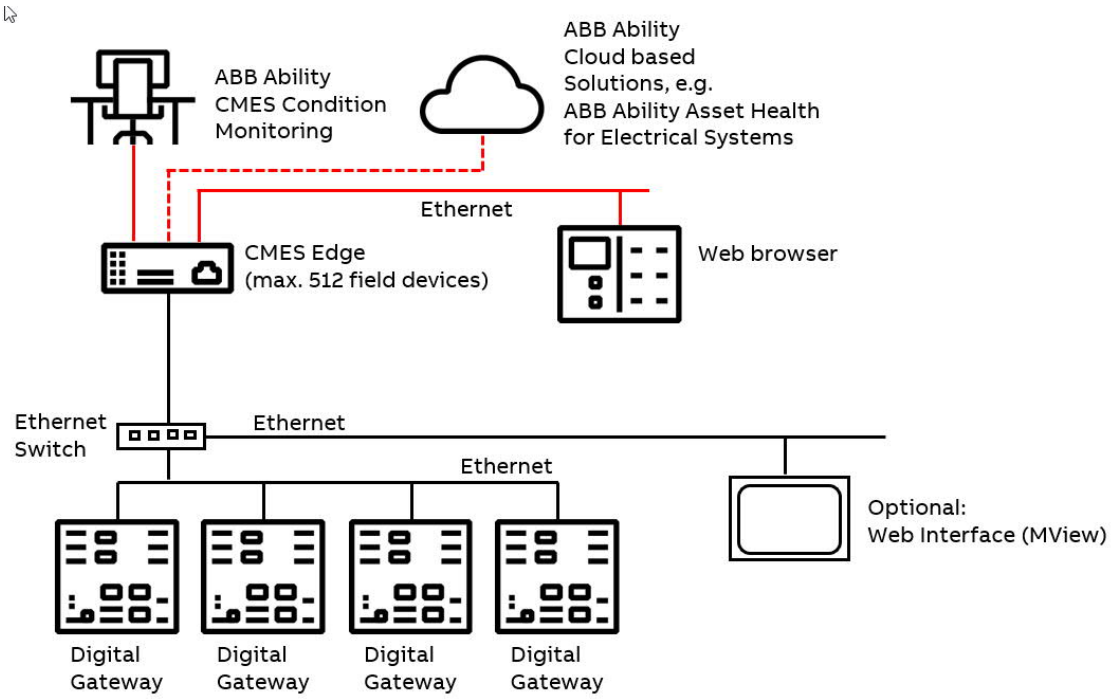


Figure 11 Network connection of Digital Gateway and CMES Edge

It is recommended that a managed network switch is used to connect the Digital Gateway to the PCS or PLC. The switch may be delivered together with the switchboard depending on project scope definition.

To ensure proper system performance following design rules shall be obeyed:

- Not more than 2 MView (optional) shall be connect to one Digital Gateway at the same time.
- If many Digital Gateway are connected to the same network, then network performance slows down. In such a case the network shall be split into different LAN segments (e.g. VLANs – can be configured in managed switches).

5.3. Time Synchronization

In order to provide the correct time and date the Time Sync option must be activated in Digital Gateway and it may require a time server in the Switchgear Control Network.

The protocol used for time synchronization is the standard Network Time Protocol (NTP).

Time Sync must be activated through the ABB Engineering Tool.

5.3.1. Option 1

A standard network component is installed which can provide the time signal as NTP Server. Such an NTP Server can be a computer or network server as well as Ethernet switches. As an option, this NTP Server can be equipped with a GPS Receiver to provide accurate time for the location.

In case of Option 1, Time Server hardware is typically not part of LVS switchgear delivery and must be supplied separately, depending on scope of project.

If the Time Server is out of service, the Digital Gateway runs with the internal RTC (Real Time Clock) until a new Time Server signal is available. Redundant Time Servers are not supported.

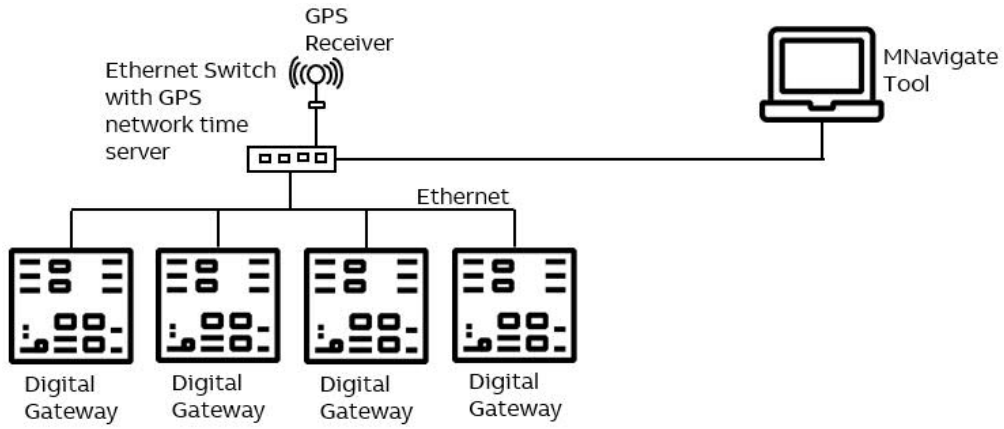


Figure 12 Example, showing 3rd party Network Switch and 3rd party NTP Server in a Switchgear Control Network

5.3.2. Option 2

One Digital Gateway in the network is configured as NTP Server (Time Sync mode = RTC). In this case the date and time for this Digital Gateway must be set through the web interface of Digital Gateway. All other Digital Gateway are configured as NTP Client (Time Sync mode = NTP) and their internal clock is synchronized by the NTP Server Digital Gateway.

In case of a power down the Digital Gateway buffers the system time (RTC) for about 3 hours. Afterwards its internal clock is reset to 2009-01-01.

This time synchronization method is less accurate than Option 1 since one Digital Gateway internal clock is used as time reference and not a high accurate GPS synchronized Time Server.

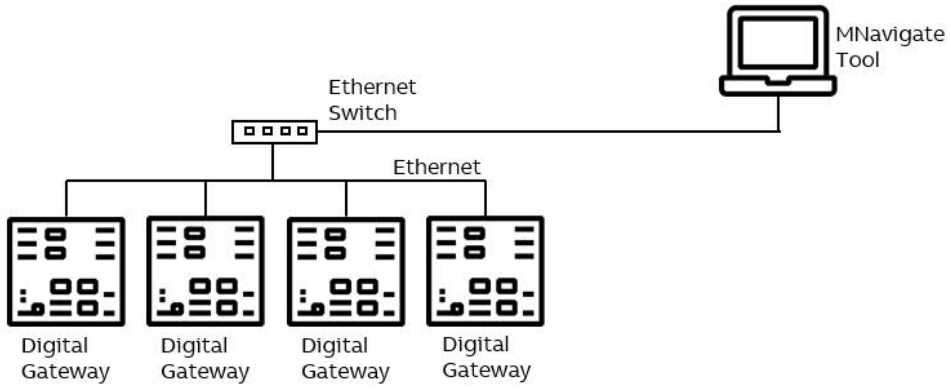


Figure 13 Example, using Digital Gateway as NTP Server

5.4. Fieldbus

5.4.1. Modbus RTU Topology

There are three options for MODBUS RTU interface (Serial 2 Sub-D connector) available for the Digital Gateway which can be selected by parameter in MNavigate tool: RS 232, RS 422 and RS 485.

Max. cable length varies from 15m (RS232) up to 1200m (RS485/422) depending on transmission speed and repeater type in use. Cable length can be extended using fiber optic modems which in addition also galvanically isolate the communication, prevent shield currents and provides best option for EMC immunity.

The serial port interface of the Digital Gateway is not galvanically isolated. To achieve this, it is recommended to use 3rd party products.

5.4.1.1. RS232

Allows only a simple point to point topology between Master and Slave. The maximum distance according to the standard is 15 meters.

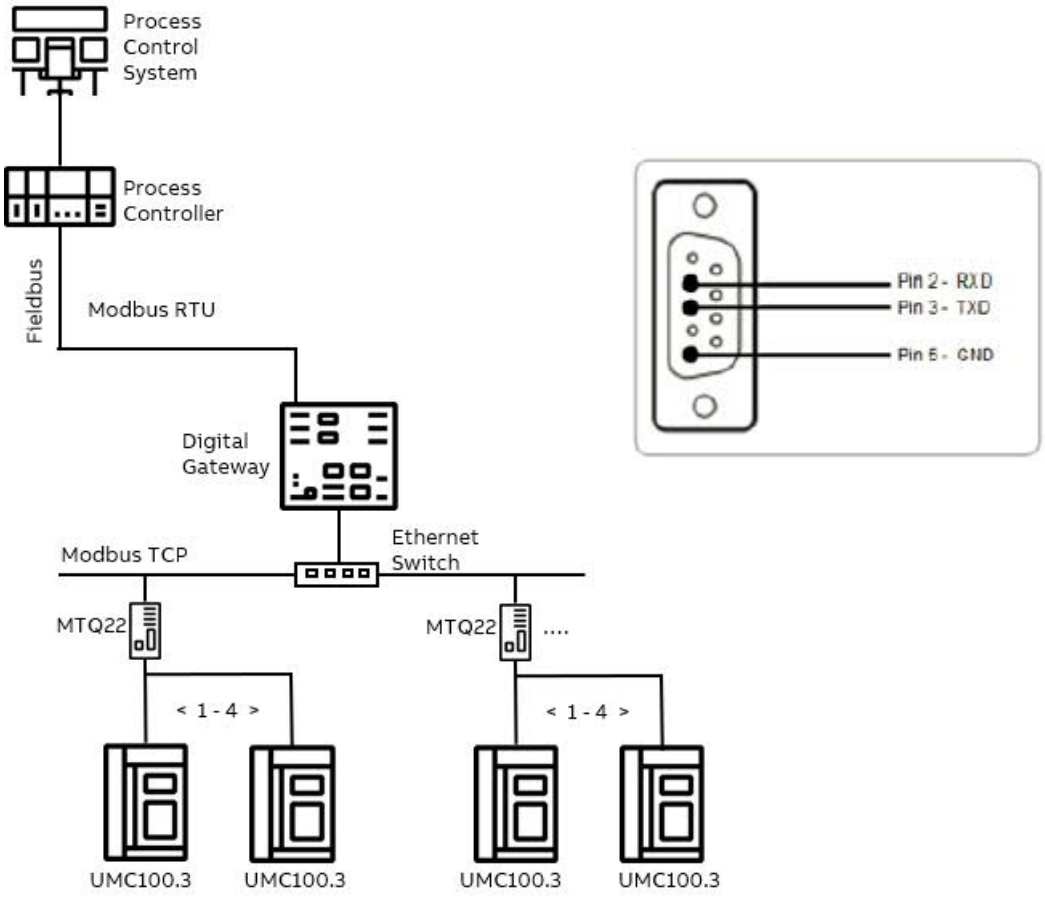


Figure 14 Digital Gateway RS232 connection via Serial 2

5.4.1.2. RS422

Allows simple point to point topology between Master and Slave. The maximum distance according to the standard is 1000 meters (depending on communication speed).

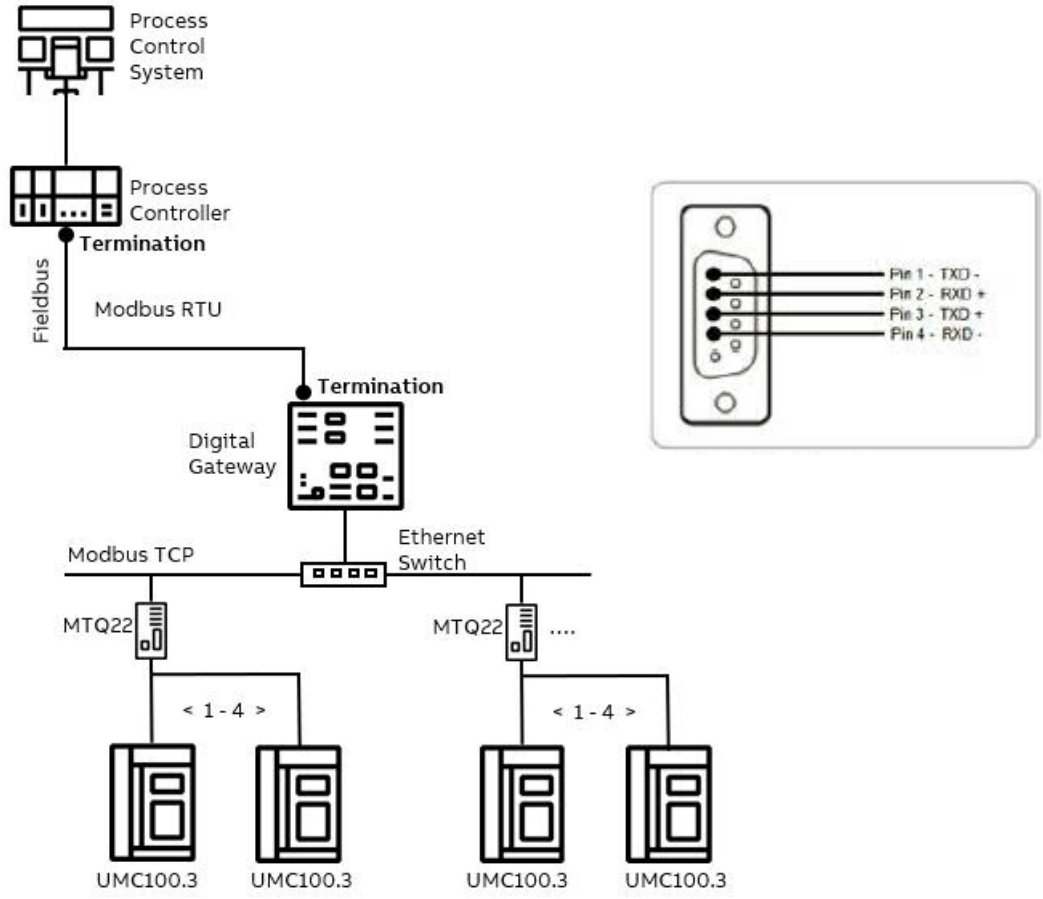


Figure 15 Digital Gateway RS422 connection via Serial 2

5.4.1.3. RS485

Allows multi drop topology with a maximum of 31 devices on the link. The maximum distance according to the standard is 1000 meters (depending on communication speed

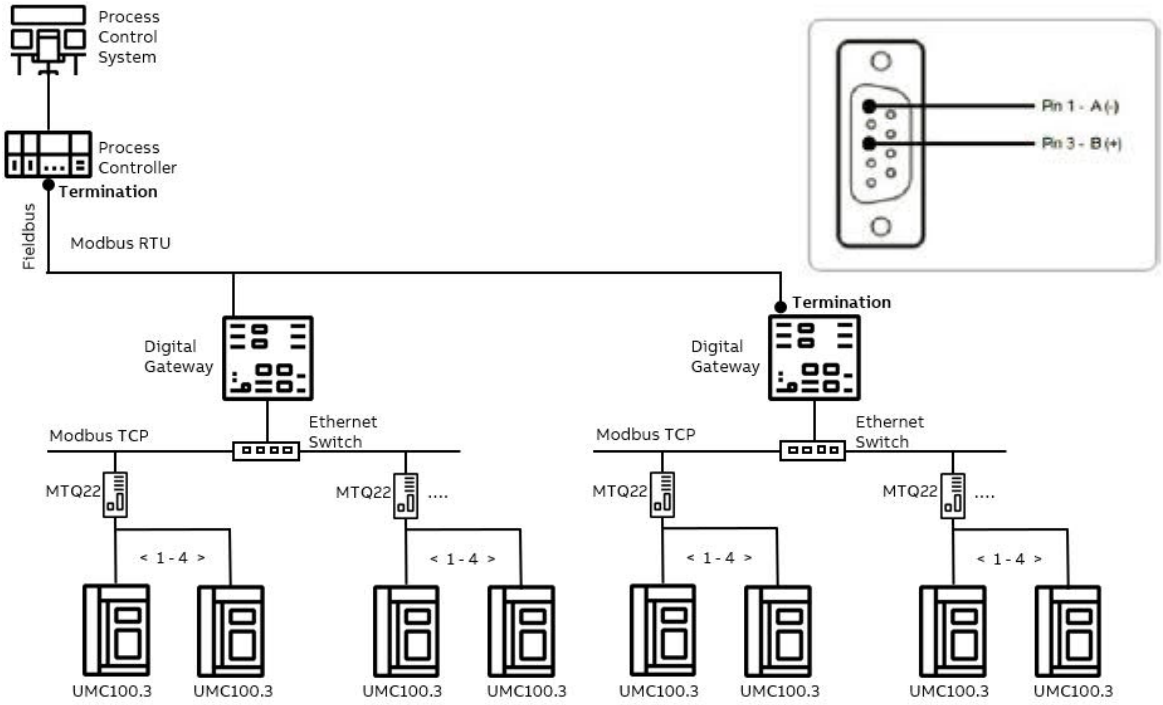


Figure 16 Digital Gateway RS485 connection via Serial 2

5.4.1.4. Termination

The RS485 bus must be terminated at both ends.

The Digital Gateway does not provide an in-built MODBUS RTU termination for RS485 communication; therefore, correct measures must be taken to connect termination to both ends of the segment.

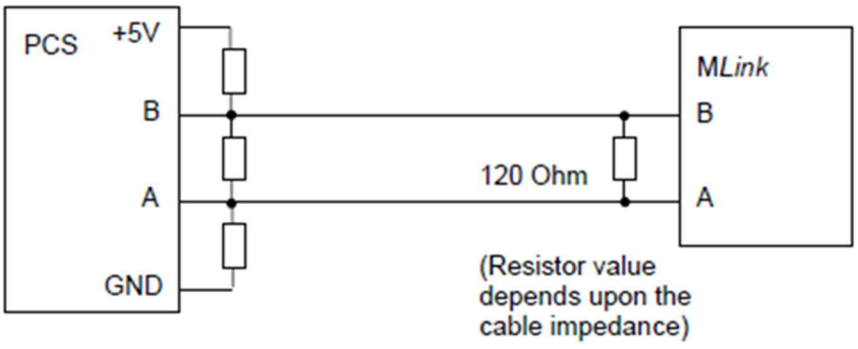


Figure 17 Example for RS485 bus termination and biasing:

5.4.2. Modbus TCP Topology

MODBUS TCP connection is available via the standard RJ45 LAN 1 connector on the Digital Gateway. For a direct connection min. CAT 5 (or higher) cross-over cable is to be used. For a network with multiple slaves via a network switch the standard CAT 5 patch cables are used.

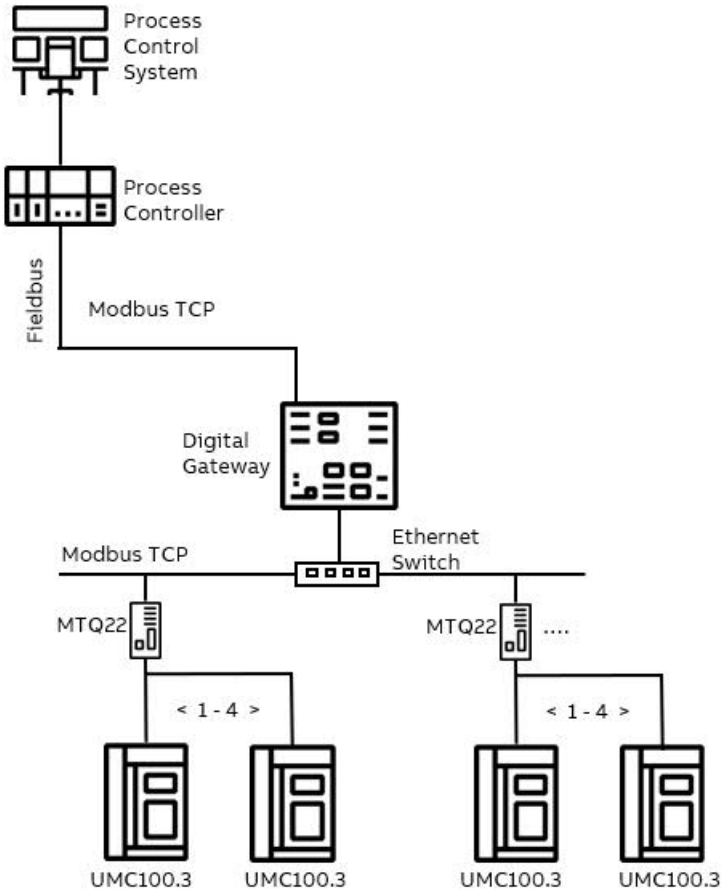


Figure 18 Digital Gateway Modbus TCP connection with Crossover cable

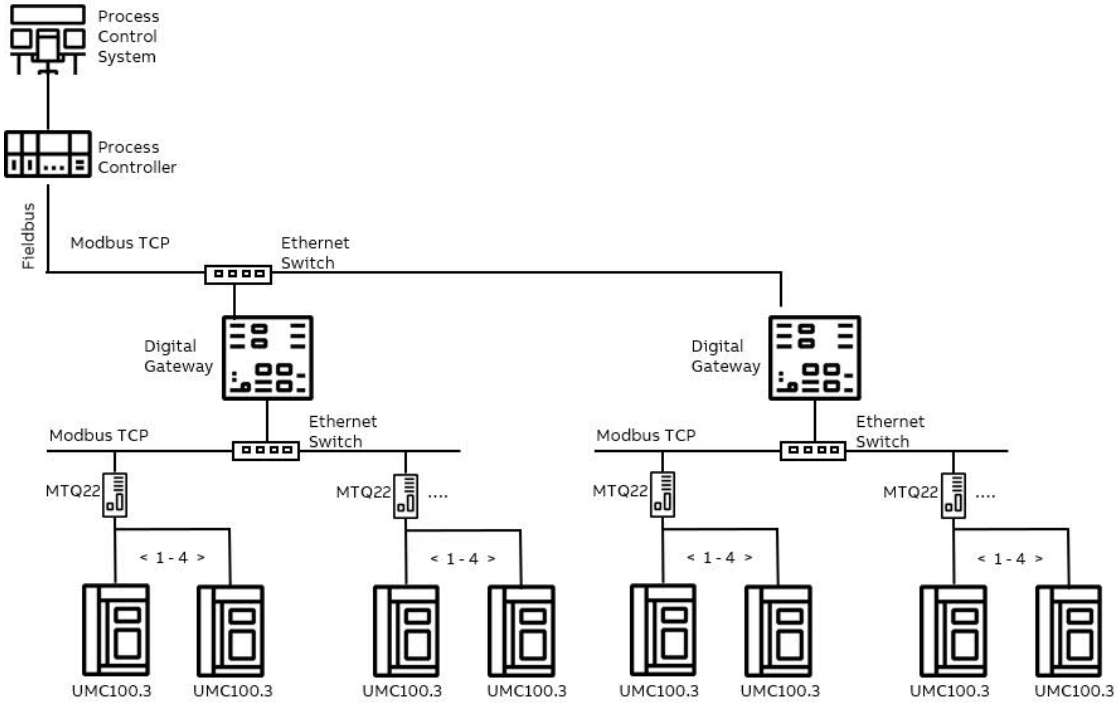


Figure 19 Digital Gateway Modbus TCP connection with standard CAT5 cable

6.Redundancy

6.1. Redundant Architecture

A redundant system requires two Digital Gateway connected to the same internal switchgear bus. One Digital Gateway acts as Primary and the other acts as a Backup.

The primary Digital Gateway polls the UMC via internal Modbus TCP and is responsible for sending the switching commands, as well as reading the information fed back from the UMC via the Digital Gateway.

The Backup Digital Gateway reads the information only and is inhibited from sending switching commands.

The Primary and Backup Digital Gateway is synchronized using a redundant link cable.

A redundant system can cover single system failures. Following theoretical failure situations are covered by a redundant system configuration:

On an active communication link:

- Failure in a PLC Fieldbus master or failure in a Fieldbus cable connection between one master and slave.
- Failure in a Digital Gateway *or* failure at the switchgear bus connection to a single Digital Gateway.

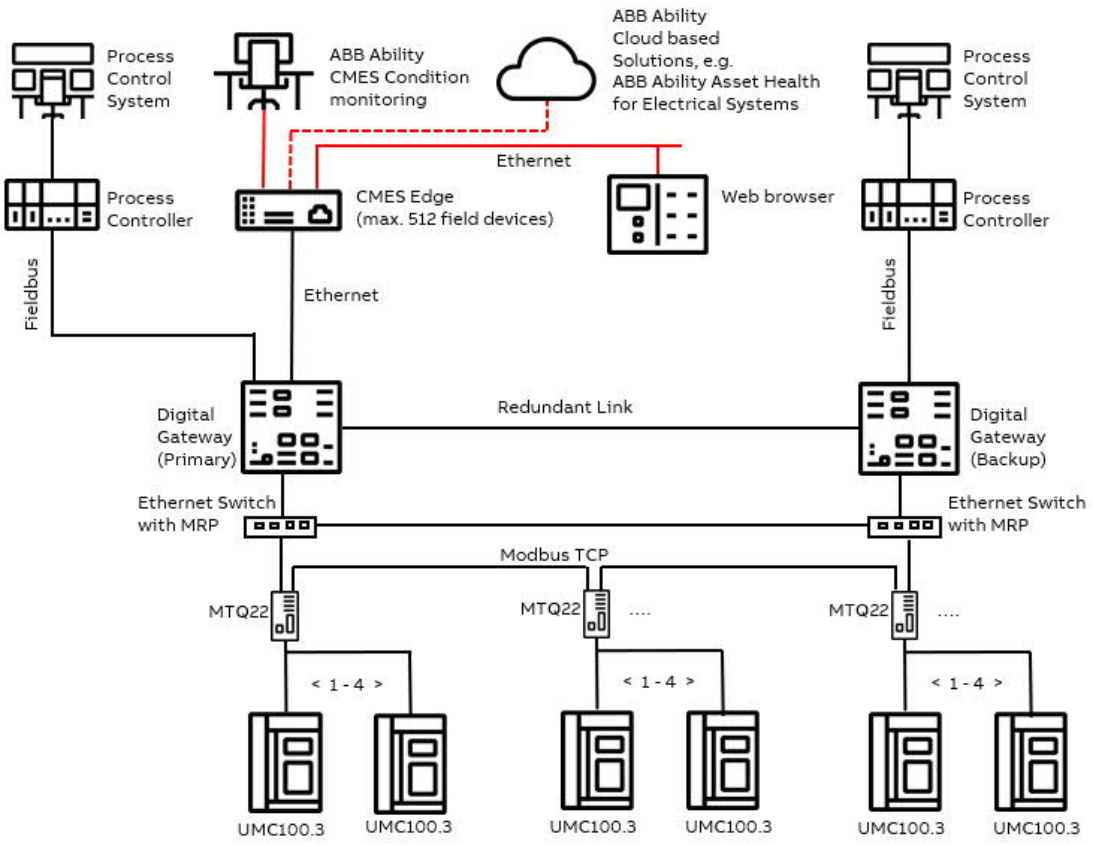


Figure 20 Redundancy configuration and possible failure scenario

If a failure is detected, from one of the 2 cases detailed above an integrated system mechanism ensures a bump less changeover from the 'Primary' Digital Gateway to the 'Backup' Digital Gateway. All process data, alarms and events and the system status information are then available from the Backup Digital Gateway which will become the Primary Digital Gateway after the switch over.

To ensure the highest availability of the communication between Digital Gateway and UMC a ring topology is recommended.
To create an Ethernet Ring topology the switches used must support MRP (Media Redundancy Protocol). The MRP protocol implemented in the MTQ22-FBP is according to EN/IEC 62439-2.

6.2. Redundancy Configuration

There are three options available to connect DCS or PLC to both Digital Gateway

- One DCS / PLC Master connected to both Digital Gateway.
- One DCS / PLC with at least redundant (two) master interfaces
- Redundant (two) DCS / PLC Master where each is connected to one Digital Gateway (see example Figure 21)

6.2.1. Redundant Digital Gateway connection

Both Digital Gateway must be connected via a RS232 Null Modem cable (port Serial 1 on both Digital Gateway) to enable data synchronization and ensure correct operation

Figure 21 Serial 1 to serial 1 redundant link connections with ferrite core

The length of this cable should not exceed 10 meters

Redundant Link Cables		2m	1TGE120109R0002
		3m	1TGE120109R0003
		5m	1TGE120109R0005
		10 m	1TGE120109R0010
Ferrite Core		1TGB000197P0001	

Table 5 Serial Redundant Link Cable ordering code

6.2.2. Digital Gateway Redundant Configuration

Configuration and Parameterization of LVS Digital [Upgrade] projects are done via M*Navigate* tool.

The parameters must then be downloaded to both the Primary and Backup Digital Gateway to become effective.

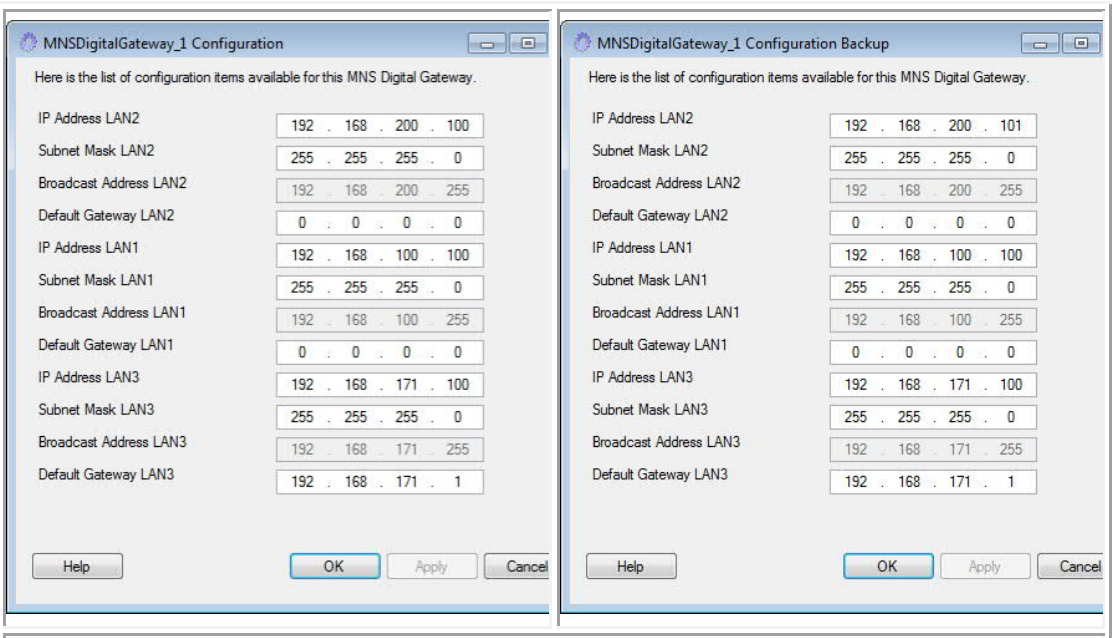
In a project with multiple Digital Gateway the majority of the Digital Gateway parameter are identical. To ease the parameterization such parameters could be copied among the Digital Gateway (Assign to Digital Gateway).

As Network address settings are different between the Digital Gateway*s* if connected to the same network those must be configured individually.

The steps of configuring the redundant Digital Gateway is as following:

1. Set the Ethernet IP address of LAN1 and LAN2 for Primary and Backup Digital Gateway.

Figure 22 MNavigate IP address Parameterization for Primary and Backup Digital Gateway



Network addresses must be set for both Primary and Backup Digital Gateway.

Table 6 Primary and Backup IP address setting

- It is essential that the IP address setting for LAN 2 of Primary and Backup Digital Gateway is different (e.g. Primary = 192.168.200.100 / Backup = 192.168.200.101).
- The same subnet mask is used because both Ethernet ports are connected to the same Ethernet network for M*View* and M*Navigate* communication.

2. Set the slave address for the selected Fieldbus / Field network interface.

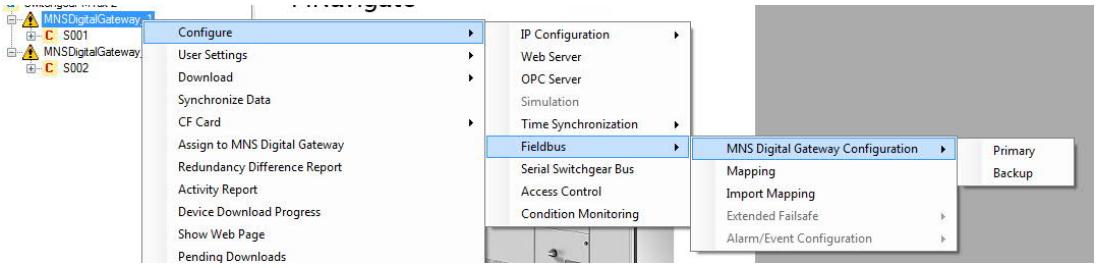


Figure 23 MNavigate Fieldbus Slave address Parameterization for Primary and Backup Digital Gateway

6.3. Handling of redundancy faults

Both Digital Gateway always supervise the redundancy conditions, detecting faults and problems according following table:

Event	Action
PLC or DCS connection interrupted for more than 1 second to Primary Digital Gateway	Redundancy change over if backup Digital Gateway has an active PLC or DCS connection
Power loss or internal error of Primary Digital Gateway	Redundancy change over, Redundancy error indicated
Power loss of backup Digital Gateway	No change over, Redundancy error indicated
Problems in redundancy setup	No change over possible, Redundancy error indicated
Switchgear Bus at Primary Digital Gateway disconnected	Redundancy change over

Table 7 Primary and Backup IP address setting

A change over from Primary to Backup Digital Gateway will only be performed if there is no redundancy error.

Nevertheless, it is also possible that the DCS/PLC initiates a change over by sending respective change over command. It needs to be ensured that the switch over commands are configured in Digital Gateway mapping for the respective fieldbus.

6.4. MView / Web Interface

In a dual redundant configuration, the MView is connected via the same Ethernet network to both Primary and Backup Digital Gateway.

If a changeover takes place, the current Primary will become the Backup (if still functioning) and the Backup will become Primary Digital Gateway.

The MView is automatically redirected to the new Primary Digital Gateway (which was the Backup Digital Gateway before) without user interaction.

While redirecting, the MView shows the following window: Prior to the re-direction the background in MView changes to yellow to indicate that current Web Interface is connected to the Backup Digital Gateway. Once it has re-directed to the new Primary Digital Gateway the background returns to its usual color.

Below screenshots are showing such a change-over scenario:

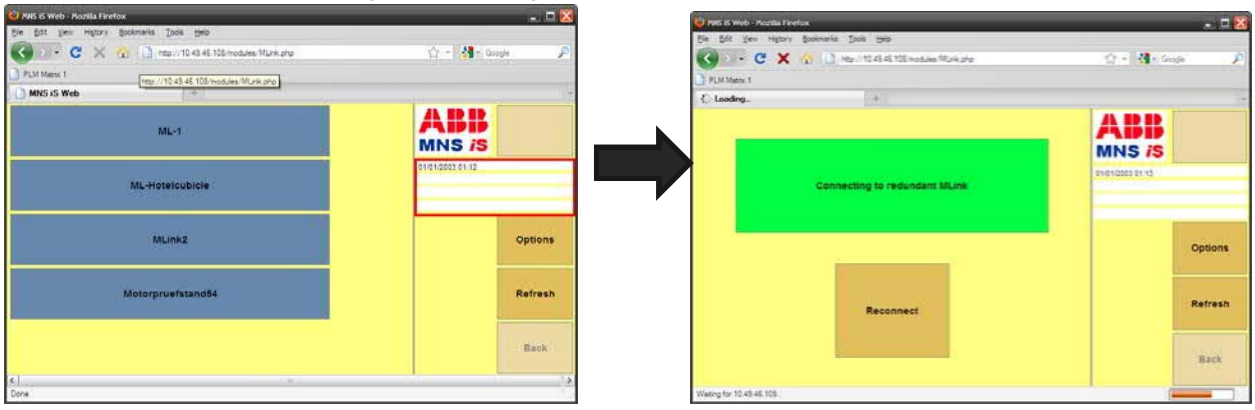


Figure 24 MView Redirecting to Redundant Digital Gateway

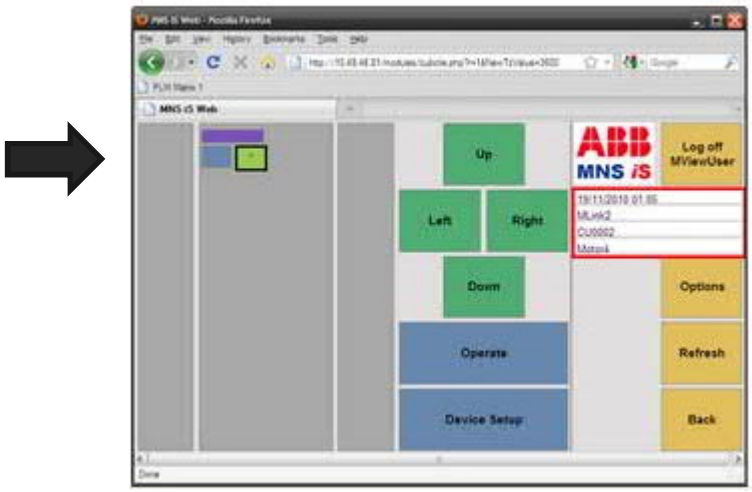


Figure 25 Redundancy error shown in MView by a red square

Note: If a change-over fails or in case any other redundancy error occurs that will be indicated by red square in MView (see Fig26 above).

7. Configurations

7.1. Initial Values – IP Configuration

Digital Gateway requires parameter settings as initial values for network operation. The parameters are required depending on Digital Gateway configuration. Additionally, parameter for Web Server, OPC Server and Fieldbus are also required.

The parameters must be loaded onto the Compact Flash (CF) card using MNavigate tool before power up. After successful communication between MNavigate and Digital Gateway (either direct or via network) the parameters can then be changed from MNavigate through the network.

Any change of communication related parameter for Ethernet network (e.g. IP address) requires a restart of Digital Gateway. Fieldbus communication related parameter (e.g. comm. speed, or slave address) can be change during runtime of Digital Gateway.

Parameter	Default Value	Range	Remarks
IP Address LAN 2 (LAN2)	192.168.200.100		Settings according to network administrator
Subnet Mask LAN2	255.255.255.0		Settings according to network administrator
Broadcast Address LAN2	192.168.200.255		Calculated automatically
Default Gateway LAN2	0.0.0.0		Settings according to network administrator
IP Address LAN 1 (LAN1)	192.168.100.100		Settings according to network administrator
Subnet Mask LAN1	255.255.255.0		Settings according to network administrator
Broadcast Address LAN1	192.168.200.255		Calculated automatically
Default Gateway LAN1	0.0.0.0		Settings according to network administrator
IP Address LAN 3 (LAN3)	192.168.171.100		Settings according to MTQ22 FBP addressing
Subnet Mask LAN3	255.255.255.0		Settings according to MTQ22 FBP addressing
Broadcast Address LAN3	192.168.171.255		Calculated automatically

Default Gateway LAN3	192.168.171.1		Settings according to MTQ22 FBP addressing
Time Synchronization	RTC	RTC, NTP	RTC=internal clock, NTP=if external NTP server is available
Time Server Address	0.0.0.0		Settings according to network administrator

Table 8 Digital Gateway Default Parameters – IP Configuration

7.2. Settings – IP Configuration

All configuration settings and parameterization for the Digital Gateway are configured with the M*Navigate* software tool.

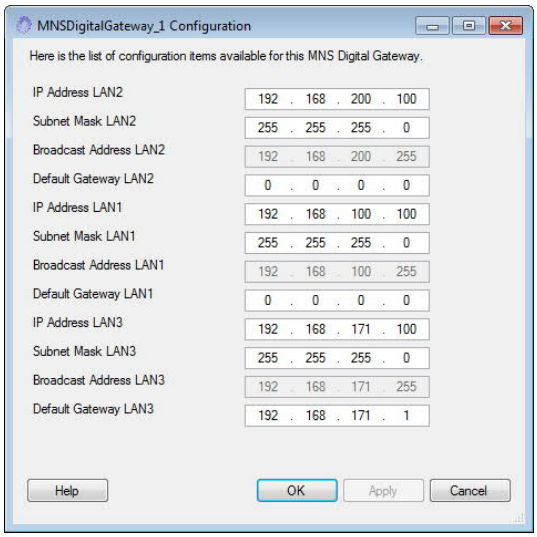


Figure 26 IP Address Settings

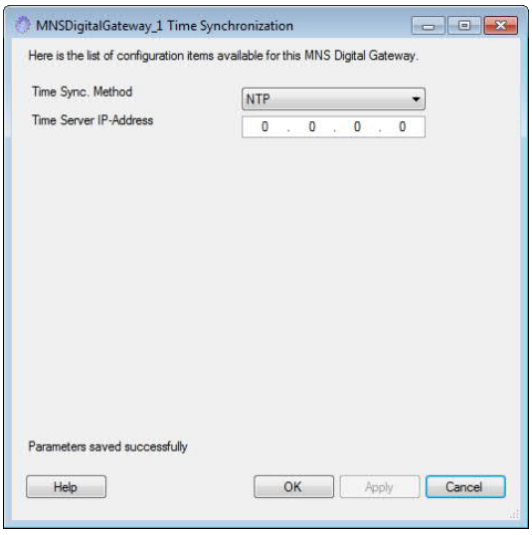


Figure 27 Time Sync Settings

Digital Gateway does not support DHCP service to get automatic network address. If the default IP Address and Subnet Mask must be manually adjusted, the parameter above must be modified and copied to the Digital Gateway. Any change in the address requires the Digital Gateway to be restarted before the change is activated.

It must be ensured that the Subnet address (xxx.xxx.xxx.yyy) for LAN1, LAN2 & LAN3 port is different. For example, LAN1 = 192.168.100.100 and LAN2 = 192.168.200.100

7.2.1. Definition of IP Addresses

An IP Address is a required setting in order to allow data communication in an Ethernet network. If the devices are integrated in a plant network, the local network administrator has to be consulted to find correct settings.

The Subnet Mask defines the size of the network. In typical applications the subnet mask is as per default settings. However, the local network administrator has to be consulted, if other IP addresses than the default settings apply.

The Broadcast Address is required for the Digital Gateway to send data to other devices. Since the Digital Gateway does not know which IP address is used by the other devices, data is sent as broadcast messages. The broadcast address is calculated automatically by MNavigate.

The Default Gateway is an address for a network gateway, if the switchgear control network is connected to a plant network. The gateway is not part of the MNS scope. If a gateway is used, the local network administrator is to be consulted for correct settings.

If it is not possible to communicate to the Digital Gateway, please refer to the trouble shooting section in this document or the Digital Gateway section in the MNavigate Help file

7.3. Settings – Modbus RTU Communication

Parameter	Default Value	Range	Remarks
Slave address 1	247	1…247	RTU Slave Address
Slave address 2	0	1…247	*Only for MNS Digital Upgrade solution for INSUM 1:* Slave address 1 define device number 1 to 32, slave address 2 define device number 33 to 64
Baud rate	19200	9600, 19200, 38400, 115200	Data Transmission Speed
Parity bit	Even	None, Even, Odd	Used for Error checking
Stop bit	1	1 or 2	Required if no Parity check is used
PLC Time Out enable	No	Yes / No	Activates PLC time out
PLC Failsafe Time Out	10	1….100	Delay until Failsafe is activated
Modbus Interface	RS232	RS232, RS485, RS422	Type of serial interface

DCS Command Format	MNSiS	MNSiS, INSUM 1, INSUM 2	*Only for MNS Digital Upgrade solution for INSUM 1 and 2:* Support of DCS command format in INSUM 1, INSUM 2 and MNS iS (default)

Table 9 Digital Gateway Default Parameters – Modbus RTU configuration

Configuration of the parameters is done via MNavigate. The parameters must then be downloaded to the Digital Gateway.

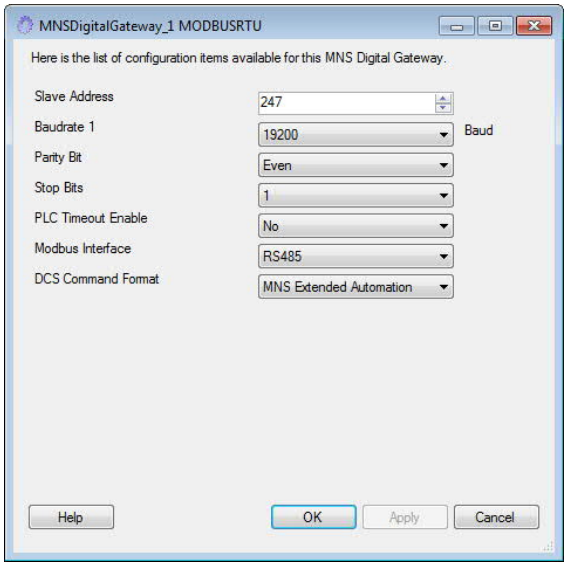


Figure 28 Parameter Window for MODBUS RTU parameters in MNavigate

7.4. Settings – Modbus TCP Communication

Parameter	Default Value	Range	Remarks
IP Address LAN 1 (LAN1)	192.168.100.100		Settings according to network administrator
Subnet Mask LAN1	255.255.255.0		Settings according to network administrator
Broadcast Address LAN1	192.168.100.255		Calculated automatically
Default Gateway LAN1	0.0.0.0		Settings according to network administrator
Slave address	247	1…247	RTU Slave Address
Port	502	502	TCP Port Number

PLC Time Out enable	No	Yes / No	Activates PLC time out
PLC Failsafe Time Out	10	1….100	Delay until Failsafe is activated
DCS Command Format	MNSiS	MNSiS, INSUM 1, INSUM 2	*Only for MNS Digital Upgrade solution for INSUM 1 and 2:* Support of DCS command format in INSUM 1, INSUM 2 and MNS iS

Table 10 Digital Gateway Default Parameters – Modbus RTU configuration

Configuration of the parameters is done via MNavigate. The parameters must then be downloaded to the Digital Gateway.

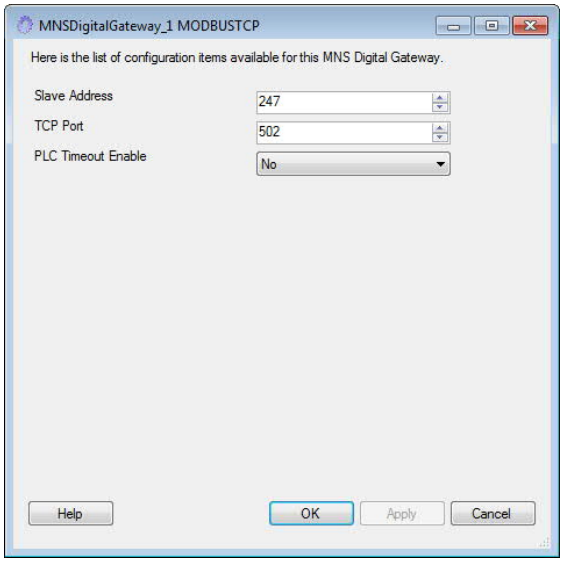


Figure 29 Parameter Window for MODBUS TCP parameters in MNavigate

7.4.1. Multiple Master in Modbus TCP applications

The Digital Gateway offers the possibility to support up to 4 MODBUS TCP masters. This function can only be utilized if also the PCS or PLC MODBUS master supports such configuration.

7.5. Failsafe

In circumstances where a disturbance in the MODBUS communication network needs to be monitored it is possible to select a ‘Failsafe’ state for each UMC. This state must be defined as a parameter for each UMC separately. The Digital Gateway supervises the MODBUS communication to the PCS or PLC if the parameter PLCTimeOut is set to “YES”. The timeout for this connection is set by using the parameter PLCTimeOut (see Table 9 and 10 for initial values).

The UMC must be operating in ‘Remote’ mode for the Failsafe function to be active.

7.6. Start-up of Digital Gateway and application download

7.6.1. Power-On procedure

Before Power On, complete a visual check of power cable connection and overall wiring of the switchboard. The Digital Gateway requires parameter settings to function correctly. Parameter settings are completed with MNavigate. If Digital Gateway is configured with an optional single MView in a stand-alone configuration then the default settings can be applied. Otherwise the settings must be configured before start-up.

Any change of configuration settings on the Digital Gateway requires restart of the Digital Gateway. During Digital Gateway restart all communication on the switchgear bus network as well as communication to DCS/PLS/PLC is stopped. After reboot is completed all communications are re-established.

7.6.2. Power On the control voltage supply

The Digital Gateway boots automatically. At this time the Digital Gateway performs internal software checks and verifies that the data available on the CF card is correct.

At the end of boot sequence, the LED 7 & LED 1 (Run) should be on as a minimum.

7.6.3. Confirm operation

Once correct operation has been established it is then possible to proceed with system configuration and application download.

8.Function Codes

The MOBDUS protocol implemented in Digital Gateway is using the MODBUS standard function codes (FC). The standard function codes supported are as follows:

Function Code	Function	Description
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*	Check communication between master and slave, (loop back)
FC16	*Pre-set multiple Registers*	Write of several successive words into register file

Table 11 Function Codes

The Digital Gateway is a ‘standard MODBUS slave device. The PLC or PCS master initiates the communication by sending the 'Query Messages' and the Digital Gateway replies the requested information in 'Response Messages'.

8.1. Message Format

8.1.1. 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

8.1.2. Response Messages

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

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

Function codes and their relevant address range are shown in the table below.

Function Codes	Address / Mapping Area	Starting Address used in Modbus Frame
FC02	10001-19999	0-9999
FC04	30001-39999	0-9999
FC03, 06, 16	40001-49999	0-9999

Table 12 Address ranges of Function Codes

8.2. Function Code 02 – Read Input Status

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

- Life Bits
- Status Information
- Control Access Information
- Alarms
- Trips

The valid address range: 10001-19999.

8.3. Function Code 03 – Read Holding 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

8.4. 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

8.5. Data Presentation for Function Code 03 and 04

Function code 03 and 04 using a 16 bit Modbus register. In the first byte of register is high part of data in second byte is the low data part.

Bit Number	15 - 8	7 - 0
Register n	Data High	Data Low

Table 13 Byte representation for function code 03 and 04

A float value has 4 bytes and uses two 16-bit Modbus registers. See following table:

Bit Number	15 - 8	7 - 0
Register n	Data High	Data Low
Register n+1	Data Low-High	Data Low-Low

Table 14 Byte representation for Float

In case Mapping Tool parameter “Float Register Big Endian” is set to “No” data presentation of float value is as follows:

Bit Number	15 - 8	7 - 0
Register n	Data Low-High	Data Low-Low
Register n+1	Data High-High	Data High-Low

Table 15 Byte representation for Float Big Endian

8.6. 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

Outgoing commands utilizing FC06 are always sent, regardless of any change to the command value.

8.7.Function Code 08 – Preset Single Register

The purpose of the loop back test is to test the communication between Master and Slave station. The data passed in the request data field is returned (looped back) in the response (Sub-function 0000). The entire response message should be identical to the request.

8.8. Function Code 16 – Preset Multiple Register

Function code 16 performs the same function as FC06 but allows modifying the contents of multiple output registers. That means it is possible to send the switching commands to several UMC on a single write command.
The valid address range: 40001-49999

The Digital Gateway will only send outgoing commands via FC 16 if there is a change in value compared with the commands previously sent, 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 without limitations.

When utilizing FC 16 it is good practice to, once the desired command has been sent and successfully acted upon, then change the command code to NOP. This will ensure that the UMC acts upon a 'change of state' from the command control

8.9. Restrictions

8.9.1. General

To ensure optimal performance, a maximum of 60 modbus requests per second is allowed.

According Modbus standard Digital Gateway supports up to 16 simultaneous requests. Simultaneous means Modbus master don't wait until response of Digital Gateway, DCS could send more new requests. Please keep in mind: DCS has to count open requests and has to check that never more than 16 requests are open.

8.9.2. Modbus RTU

Digital Gateway with Modbus RTU in redundant configuration does not reply to Modbus requests (except FC08) if switchgear bus is not connected properly. Thus the DCS can easily detect a communication problem and use the redundant communication line.

The response time of a modbus slave depends on several parameters, for instance baudrate, number of registers in request and/or reply. Due to this the following procedure for DCS is recommended:

1. DCS sends modbus requests
2. DCS receives modbus reply from slave
3. After receiving of complete modbus reply DCS waits 100ms (or more if from DCS application required)
4. DCS sends next modbus request

8.10. 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.

9.Data Mapping

Two possibilities exist for data mapping, the default data map as described below and a user defined data map which can be created by the MNavigate Mapping Tool for project specific tailoring of the communication data.

The default data map is a selection of data based on typical requirements. If this selection is not accepted in the project, a user data map has to be created.

9.1. User Data Map

All available data in a UMC can be assigned to the corresponding register addresses by using the MNavigate Mapping Tool. This is a proprietary tool for ABB to program the MODBUS registers according to customer requirements.

9.2. Default Data Map

9.2.1. Monitoring (Inputs from UMC)

Monitoring of the UMC data handled by the Digital Gateway is possible utilizing the following function codes and address ranges.

FC 02	10001 19999	Bit registers
FC 03	40001 49999	Word registers
FC 04	30001 39999	Word registers

For MNS Digital Upgrade projects only:

For INSUM 1 Upgrade projects with Modbus RTU interface, a default Modbus mapping is available for the interface between Digital Gateway and DCS. This mapping follows the INSUM PK default mapping.

In addition to INSUM 1 PK mapping, INSUM 2 mapping for Digital Gateway is also available for INSUM 2 Upgrade solution with Modbus RTU interface.

9.2.2. Monitoring with Function Code 02

Monitoring of the life and status bits of each UMC via the Digital Gateway is detailed in the following tables.

Modbus Function Code	Modbus Register	Device Number	Description	Remarks
2	10001	1	Life-Bit UMC 1	UMC 1 is available (comm. ok)
2	10002	2	Life-Bit UMC 2	UMC 2 is available (comm. ok)
2	10003	3	Life-Bit UMC 3	UMC 3 is available (comm. ok)
2	10004	4	Life-Bit UMC 4	UMC 4 is available (comm. ok)
2	10005	5	Life-Bit UMC 5	UMC 5 is available (comm. ok)
2	10006	6	Life-Bit UMC 6	UMC 6 is available (comm. ok)
2	10007	7	Life-Bit UMC 7	UMC 7 is available (comm. ok)
2	10008	8	Life-Bit UMC 8	UMC 8 is available (comm. ok)
:	:	:	:	:
:	:	:	:	:
:	:	:	:	:
2	10128	128	Life-Bit UMC 128	UMC 128 is available (comm. ok)

Table 16 Default Modbus Map Life Bit of UMC

Modbus Function Code	Modbus Register	Device Number	Description	Remarks
2	11001	1	Stopped	1 = Motor Stopped or Tripped or Feeder open
2	11002	1	Runs	1 = Motor Runs or Feeder closed
2	11003	1	CW or K1	1 = Motor Runs Clock-wise
2	11004	1	CCW or K2	1 = Motor Runs Coun-ter Clockwise
2	11005	1	Ready	1 = Off and Ready for Operation. No alarm / trip is available
2	11006	1	Alarm	1 = Any Alarm condi-tion of protection or supervision functions.
2	11007	1	New Trip	1 = Any Trip condition of the protection or supervision functions
2	11008	1	Test	1 = Main switch set to test position. (Motor cannot start)
2	11009	1	HW local	1 = Control Access is selected to hardwired I/O from Local / Re-mote input on UMC
2	11010	1	Bus local	1 = Control Access is passed to any control station on the switch-gear control network.
2	11011	1	Remote	1=Control Access is passed to the Process Control System
2	11012	1	DI0	1= Digital Input 0 of UMC is on

Continued the next page

Modbus Function Code	Modbus Register	Device Number	Description	Remarks
2	11013	1	DI1	1= Digital Input 1 of UMC is on
2	11014	1	DI2	1= Digital Input 2 of UMC is on
2	11015	1	DI3	1= Digital Input 3 of UMC is on
2	11016	1	DI4	1= Digital Input 4 of UMC is on
2	11017	1	DI5	1= Digital Input 8 of UMC is on
2	11018	1	1DI0	1= Digital Input 9 of UMC is on
2	11019	1	1DI1	1= Digital Input 10 of UMC is on
2	11020	1	1DI2	1= Digital Input 11 of UMC is on
2	11021	1	1DI3	1= Digital Input 12 of UMC is on
2	11022	2	Stopped	1 = Motor Stopped or Tripped or Feeder open
2	11023	2	Runs	1 = Motor Runs or Feeder closed
2	11024	2	CW or K1	1 = Motor Runs Clock-wise
:	:	:	:	:
2	13668	128	Stopped	1 = Motor Stopped or Tripped or Feeder open
2	13669	128	Runs	1 = Motor Runs or Feeder closed
2	13670	128	CW or K1	1 = Motor Runs Clock-wise

Continued the next page

Modbus Function Code	Modbus Register	Device Number	Description	Remarks
2	13671	128	CCW or K2	1 = Motor Runs Counter Clockwise
2	13672	128	Ready	1 = Off and Ready for Operation. No alarm / trip is available
2	13673	128	Alarm	1 = Any Alarm condition of protection or supervision functions.
2	13674	128	New Trip	1 = Any Trip condition of the protection or supervision functions
2	13675	128	Test	1 = Main switch set to test position. (Motor cannot start)
2	13676	128	HW local	1 = Control Access is selected to hardwired I/O from Local / Remote input on UMC
2	13677	128	Bus local	1 = Control Access is passed to any control station on the switchgear control network.
2	13678	128	Remote	1=Control Access is passed to the Process Control System
2	13679	128	DI0	1= Digital Input 0 of UMC is on
2	13680	128	DI1	1= Digital Input 1 of UMC is on
2	13681	128	DI2	1= Digital Input 2 of UMC is on
2	13682	128	DI3	1= Digital Input 3 of UMC is on
2	13683	128	DI4	1= Digital Input 4 of UMC is on

Continued the next page

Modbus Function Code	Modbus Register	Device Number	Description	Remarks
2	13684	128	DI5	1= Digital Input 8 of UMC is on
2	13685	128	1DI0	1= Digital Input 9 of UMC is on
2	13686	128	1DI1	1= Digital Input 10 of UMC is on
2	13687	128	1DI2	1= Digital Input 11 of UMC is on
2	13688	128	1DI3	1= Digital Input 12 of UMC is on

Table 17 Default Modbus Map Bit Status of UMC

9.2.3. Monitoring with Function Code 03 and 04

Monitoring of the measured (analogue) values from the individual UMC is detailed in the following table.

Modbus Function Code	Modbus Register	Device Number	Modbus Register Name	Format	Remarks
3	40001	1	Phase current L1 %	Unsigned Int, 2Byte	% age L1 Current
3	40002	1	Thermal image	Unsigned Int, 2 Byte	Used thermal capacity (only available if TOL protection function is used)
3	40003	1	Time to trip	Unsigned Int, 2Byte	Time before UMC will trip the motor (only available if TOL protection function is used)
3	40004	1	Time to reset	Unsigned Int, 2Byte	Time required before reset allowed (only available if TOL protection function is used)
3	40005	2	Phase current L1 %	Unsigned Int, 2Byte	% age L1 Current
3	40006	2	Thermal image	Unsigned Int, 2Byte	Used thermal capacity
:	:	:	:	:	:
3	40509	128	Phase current L1 %	Unsigned Int, 2Byte	% age L1 Current
3	40510	128	Thermal image	Unsigned Int, 2Byte	Used thermal capacity
3	40511	128	Time to trip	Unsigned Int, 2Byte	Time before UMC will trip the motor
3	40512	128	Time to reset	Unsigned Int, 2Byte	Time required before reset allowed

Table 18 Default Modbus Map Measured Values of UMC

9.2.4. Extended Status Description

In addition to the above within the Default Modbus Map, the following 'Extended Status' is also supported in 4 bytes of data.

Modbus Function Code	Modbus-Register	Device Number	Modbus Register Name	Format
3	41001	1	Extended status	2Byte
3	41002	1	Extended status	2Byte
3	41003	2	Extended status	2Byte
3	41004	2	Extended status	2Byte
3	41005	3	Extended status	2Byte
3	4100	3	Extended status	2Byte
:	:	:	:	:
3	41253	127	Extended status	2 Byte
3	41254	127	Extended status	2 Byte
3	41255	128	Extended status	2 Byte
3	41256	128	Extended status	2 Byte

Table 19 Default Modbus Map Extended Status for UMC

The content of the Extended Status 'Byte 1' is described in following table:

BYTE 1	Description	Remark
Bit 0	Stopped	1 = Motor Stopped or Tripped
Bit 1	Runs	1 = Motor Runs
Bit 2	Runs CW/ Close	1 = Motor Runs, Clockwise
Bit 3	Runs CCW /Open	1 = Motor Runs, Counter Clockwise
Bit 4		
Bit 5	Actuator Close	1= Actuator at End Position Close
Bit 6	Actuator Open	1= Actuator at End Position Open
Bit 7	Ready	1 = UMC in correct location & main switch on & no trip & no start inhibit

Table 20 Extended Status Byte 1

The content of the Extended Status ‘Byte 2’ contains the Events and Alarm Repository Log (EARO). This is general information for each UMC.

BYTE 2	Description	Remark
Bit 0	Any Alarm	Set when any Alarm is present
Bit 1	New Trip	Set when any New Trip is present
Bit 2		Reserved
Bit 3		Reserved
Bit 4		Reserved
Bit 5		Reserved
Bit 6		Reserved
Bit 7		Reserved

Table 21 Extended Status Byte 2

The content of the Extended Status ‘Byte 3’ contains availability information for the power module

BYTE 3	Description	Remark
Bit 0	Test Input	Isolator set to ‘Test’ position
Bit 1	Main Switch Input	Isolator set to ‘On’ position
Bit 2		Reserved
Bit 3		Reserved
Bit 4		Reserved
Bit 5	Start Inhibit	Set when start is inhibited
Bit 6	TOL Start Inhibit	Set when start is inhibited by TOL protection
Bit 7		Reserved

Table 22 Extended Status Byte 3

The content of the Extended Status ‘Byte 4’ is related to the Control Access function, for more information please refer to the Control Access section within this document.

BYTE 4	Description	Remark
Bit 0	HW -Local	UMC accepts control commands from the hardwired inputs on UMC, when the respective Local control input is set to true.
Bit 1		Reserved
Bit 2	BUS-Local	UMC accepts control commands from a device on the switchgear control network, e.g. MView.
Bit 3		Reserved
Bit 4		Reserved
Bit 5		Reserved
Bit 6		Reserved
Bit 7	Remote	UMC accepts control commands from DCS only

Table 23 Extended Status Byte 4

9.2.5. Control Commands

Control commands written to the UMC handled by the Digital Gateway is possible utilizing the following function codes and address ranges.

FC06, FC 16 40001 .... 49999 Word registers

The following default Modbus registers must be used for writing control commands to the UMC via the Digital Gateway.

Modbus Function Code	Modbus-Register	Device Number	Modbus Register Name	Description/Remarks
6/16	43001	1	Command	Note: content of the register indicates the command
6/16	43002	2	Command	
6/16	43003	3	Command	
6/16	:	:	:	
6/16	43128	128	Command	

Table 24 Default Modbus Command Registers

9.2.6. Switching Commands

The following table details the commands that are required from the Master (DCS / PLC) to be sent to the UMC in order to control the motor or feeder module.

Operation Type	Description	Modbus Command	Remarks
Control Access	Remote control	0x2100	UMC is controlled via DCS.
	Bus-Local control	0x2104	DCS allows control via local HMI.
Stop Stop (Act) Open (CF)	Stop Stop for Actuator Applications Open for Feeder Applications	0x0201	Stops the UMC, Opens contactor K1 for Contactor Feeder / Actuator application
Start Start CW Start N1 Close (CF) Open (Act)	Start Start Clockwise Start N1 for Pole Changing Close for Feeder Applications Open for Actuator application	0x0202	Starts the UMC. Close contactor K1 for Contactor Feeder / Actuator application
Start CCW Close (Act)	Start Counterclockwise Close for Actuator Application	0x0203	Start the UMC Counterclockwise. Close contactor K2.
Start N2	Start N2 for Pole Changing	0x0204	Start the UMC N2.
Reset	Reset	0x1100	Reset of all trips

Table 25 Switching Commands sent from DCS to Digital Gateway

In addition to above listed control commands the Digital Gateway provides an additional extended control sequence feature.

For that reason, a new set of control commands is introduced which are described below:

Control Schema Type 1:

This type is introduced for following UMC starter types:

- Direct Starter
- Reverse Starter
- Star Delta Starter
- Pole Changing Starter (i.e. DOL 2 Speed)
- Softstarter

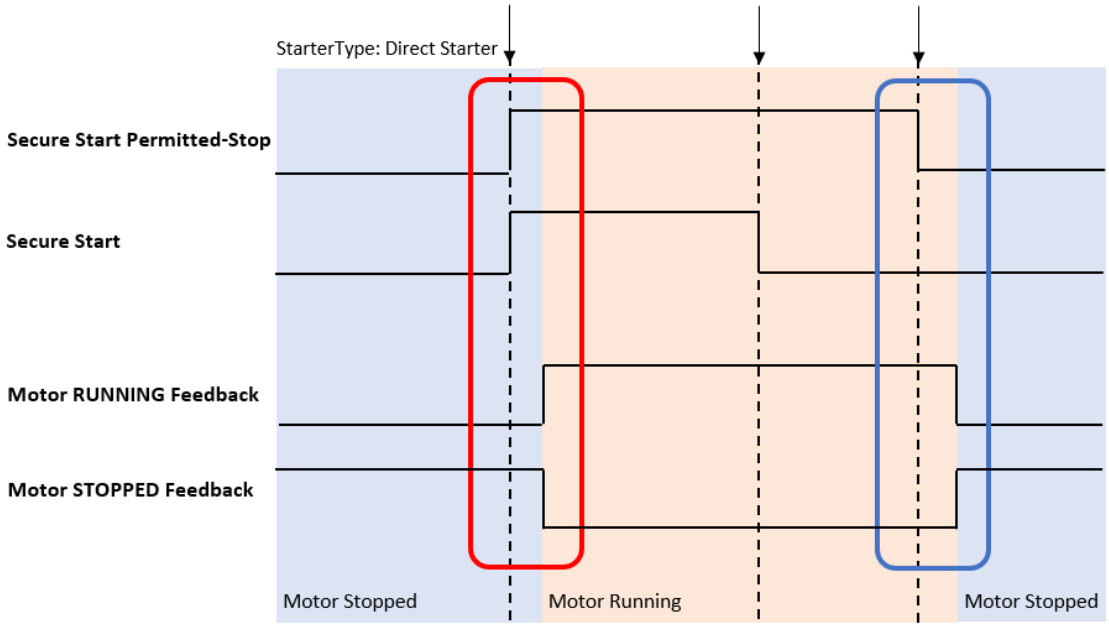


Figure 30 Control Schema Type 1 (Direct Starter, Reverse Starter, Star Delta Starter, Pole Changing Starter, Softstarter)

The START command is only transferred by Digital Gateway to the connected UMC device if the “Secure Start” command is received by Digital Gateway and the “Secure Start Permitted-Stop” signal is active (red frame).

The STOP command is transferred by the Digital Gateway to the connected UMC devices if the “Secure Start Permitted-Stop” signal is reset. In that point of time the status of the “Secure Start” is not considered (blue frame).

Control Schema Type 2:

This type is introduced for following UMC starter type:

- Actuator

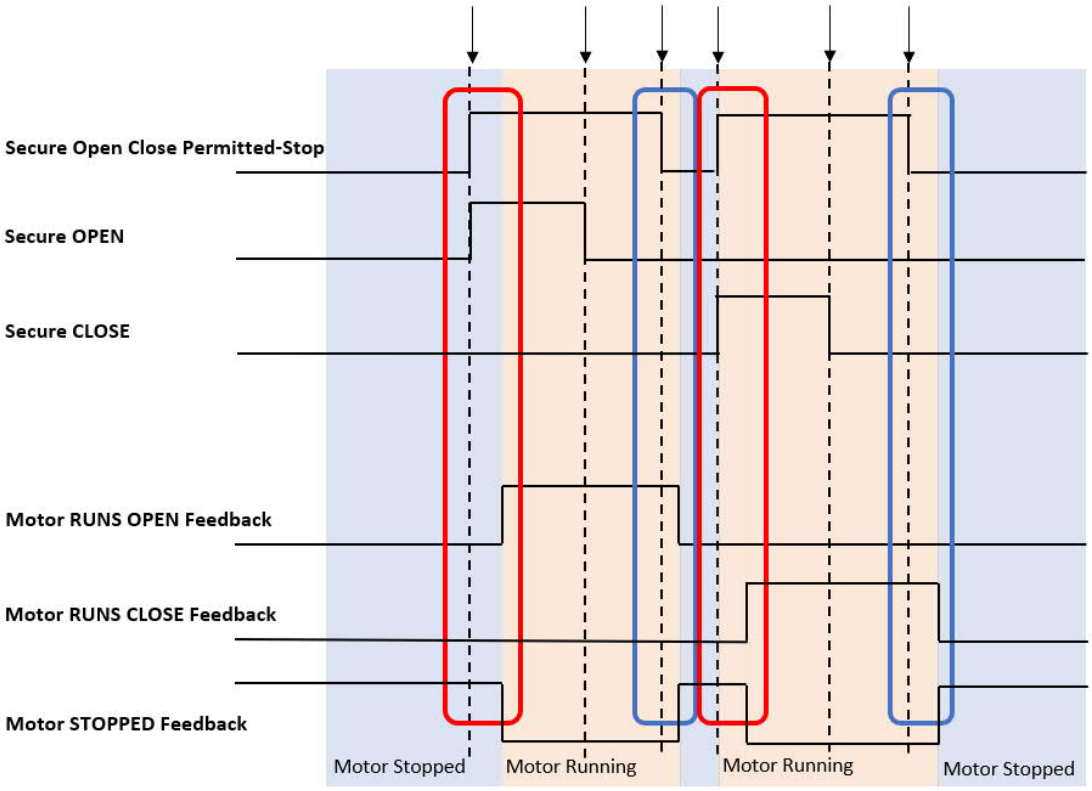


Figure 31 Control Schema Type 2 (Actuator)

The OPEN (/CLOSE) command is only transferred by Digital Gateway to the connected UMC device if the “Secure Open” (/”Secure Close”) command is received by Digital Gateway and in the “Secure Open Close Permitted-Stop” signal is or becomes active (red frame).

The STOP command is transferred by the Digital Gateway to the connected UMC devices if the “Secure Open close Permitted-Stop” signal is reset. In that point of time the status of the “Secure Open” & “Secure Close” is not considered (blue frame).

To use the new control philosophy the following commands needs to be used:

Operation Type	Description	Modbus Command	Remarks
Control Access	Remote control	0x2100	UMC is controlled via DCS.
	Bus-Local control	0x2104	DCS allows control via local HMI.
Secure Start Permitted-Stop	See above Control Schema Type 1	0x0301	Stops the UMC
Secure Open Close Permitted-Stop (Act)	See above Control Schema Type 2		Opens contactor K1
Secure Start Secure Start CW Secure Start N1 Secure Open (Act)	Secure Start Secure Start Clockwise Start N1 for Pole Changing Secure Open (Actuator)	0x0302	Starts the UMC. Close contactor K1
Secure Start CCW Secure Close (Act)	Secure Start Counterclockwise Secure Close (Actuator)	0x0303	Start the UMC Counterclockwise. Close contactor K2.
Secure Start N2	Start N2 for Pole Changing	0x0304	Start the UMC N2. Close contactor K2.
Reset	Reset	0x1100	Reset of all trips

Table 26 Switching Commands (Secure) sent from DCS to Digital Gateway

9.2.7. Switching Commands–Bit Control

The bit control command gives the possibility to control a starter by setting of a single bit. (In addition to control a starter by command codes as described in previous chapter.)

16 single command bits are in one Modbus word register. More than one bit can set at simultaneously. For example, it is possible to set a UMC to remote and to start it with one Modbus register write command.

9.2.7.1. Function Codes

Depending from Modbus function code the commands are handled as described below.

Function 06: Commands (bit =1) are always sent to UMC, regardless of any change to the command bit value.

Function 16: Commands Are sent only when the command bit is toggled, (either 0 to 1 or 1 to 0)

The following tables detail the registers, bit functionalities and show examples of utilizing Modbus bit commands.

Modbus Function Code	Modbus-Register	Device Number	Modbus Register Name	Description/Remarks
6/16	45001	1	Bit Commands	Note: content of the register indicates up to 16 commands
6/16	45002	2	Bit Commands	
6/16	45003	3	Bit Commands	
6/16	:	:	:	
6/16	45128	128	Bit Commands	

Table 27 Default Modbus Bit Command Registers

Following table shows how to control a starter by control command bits

Execution order is from highest (bit 15) to lowest bit (bit 0).

Bit 07	Bit 06	Bit 05	Bit 04	Bit 03	Bit 02	Bit 01	Bit 00	Register 45001
1	1	1	1	1	1	1	1	Device Number
	Trip Reset	CA to Remote	Open K1	Close K1	Start CW	Stop	Start CCW	Bit Function

Table 28 Default Bit Map Control Commands Low Byte

Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 09	Bit 08	Register 45001
1	1	1	1	1	1	1	1	Device Number
GO1 Reset	GO1 Set	GO0 Reset	GO0 Set	Bus Local			TOL Bypass	Bit Function

Table 29 Default Bit Map Control Commands High Byte

9.2.8. Redundant Digital Gateway Modbus Data

The following additional data mapping is provided for a redundant data interface to determine the status of Digital Gateway (Primary/Backup, Redundancy Error). It is also possible to send commands to force a change-over.

Modbus Function Code	Modbus-Register	Modbus Register Name	Format	Description/Remarks
2	12001	Primary MNS Digital Gateway	Bit	Set to 1 indicates Digital Gateway is Primary
2	12002	Redundancy Error	Bit	Set to 1 indicates Redundancy error.

Table 30 Redundant data for monitoring by the Modbus master

Modbus Function Code	Modbus-Register	Modbus Register Name	Format	Description/Remarks
6/16	44001	Force to changeover to Backup Digital Gateway	Unsigned Integer 2Byte	Master must send 0x0001 to force to changeover
	This command may be sent to either the Primary or Backup Digital Gateway to initiate a changeover.			

Table 31 Redundant Command possible from the Modbus Master

In case of a project specific mapping is used it is mandatory that above redundancy information is configured in the mapping of the respective fieldbus.

9.2.9. Control Access

Control Access (CA) is a mechanism within LVS Digital to define and determine which user interface has control rights to operate the UMC modules. These interfaces are defined below in command handling. Control Access rights can be given, for example, by a specific command sent to switch operation rights from push-button (hardwired to UMC) to any other interface connected via the Digital Gateway (e.g. MView or DCS).

9.2.9.1. Command Handling

The control access command defines the control rights of defined interfaces for an UMC.

Remote – UMC switches to Remote operation mode and can be operated via Fieldbus from process control system (DCS / PLC)

Bus-Local – UMC switches to the Bus-Local mode and operation is possible:

– via MView (local operation panel in switchboard) or

– via web interface (like MView).

Hardware-Local – UMC switches to the Hardware-Local mode and operation is possible only through digital inputs on UMC Hardware. Hardware-Local must be activated by the setting the input on the UMC !

	Command	Command	Status Bit
CA Interface	Auto Mode (CA Remote)	Bus Local (CA BusLocal)	Auto Mode (Bus Control)
DCS only	1	0	1
MView (Web interface)	0	1	1
Hardware Local (Hardware Inputs)	X	X	0

Table 32 Command and Status for Control Access

Notes:
At any time, any control station can obtain the control access by sending a control access command to UMC. On MView (or web interface) the user must have the appropriate user right to do so.

Hardware-Local must be activated by setting the input on the UMC.

CA Remote is set if the command ‘Remote Control’ is sent to the UMC from the DCS. Only then it is possible to send switching commands from the DCS.

CA Bus Local will be active if Auto Mode is not set and the Bus Local command bit goes from 0 to 1.

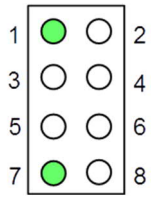
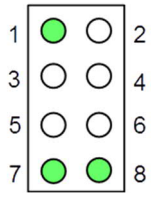
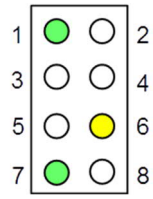
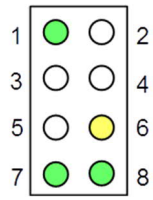
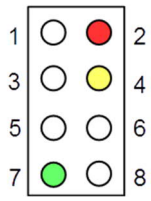
Hardware-Local overrides all other CA Levels. It is not possible for the DCS or MView to take control when the UMC is set to HW-Local.

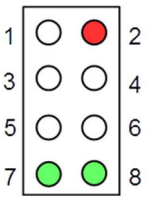
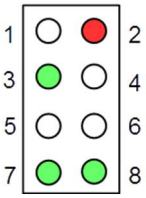
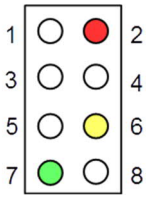
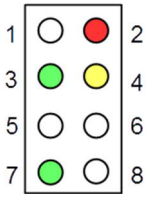
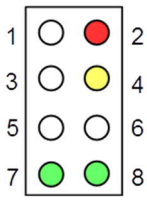
Recommended procedure for sending control commands for a motor starter

1. Set the UMC to "Remote" with the command “0x2100”
2. Set the desired state, "Run Reverse", "Off", "Run Forward" or "Trip Reset"
3. Wait until desired state is shown in motor state (received from Slave).
4. Reset previous command "Run Reverse", "Off", "Run Forward" or "Trip Reset"

10. Troubleshooting and Maintenance

10.1. Digital Gateway LED Indication

LED indication	Description	Additional Information / Actions
	Digital Gateway is running Ok	
	Digital Gateway is running Ok	LED 8 Digital Gateway is Primary in Dual Redundant configuration.
	Digital Gateway is running Ok	LED 6 DCS communication active
	Digital Gateway is running Ok	LED6 DCS communication active LED 8 Digital Gateway is Primary in Dual Redundant configuration.
	Digital Gateway missing application files	Possible cause could be an interrupted or disturbed communication between MNavigate and Digital Gateway while downloading. Please use MNavigate to download the Digital Gateway configuration again.

LED indication	Description	Additional Information / Actions
	Error in Digital Gateway XML Configuration file	Possible cause could be an interrupted or disturbed communication between MNavigate and Digital Gateway while downloading. Please use MNavigate to download the Digital Gateway configuration again
	Error in Digital Gateway XML Parameter file	Possible cause could be an interrupted or disturbed communication between MNavigate and Digital Gateway while downloading. Please use MNavigate to download the Digital Gateway parameter again
	Internal Digital Gateway error	Digital Gateway is not able to create internal database. Please reboot the Digital Gateway. If that doesn't resolve the problem, use MNavigate to download the Digital Gateway configuration again.
	XML file missing	During startup Digital Gateway is checking if all required xml files are available. In case of a missing file that error is indicated. Please use MNavigate to download the Digital Gateway configuration again.
	Network configuration error	Digital Gateway is not able to configure the IP settings as mentioned in configuration file e.g. due to wrong setting of Default Gateway parameter for that Ethernet Interface. Please use MNavigate to check the settings and download the Digital Gateway configuration again. If a download is not possible please use a flash card reader (ref. to MNavigate Help or MNavigate Manual).

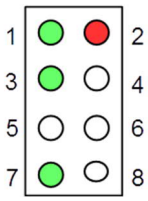
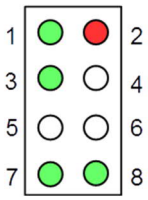
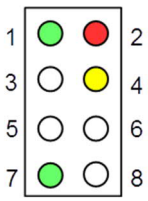
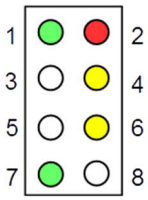
LED indication	Description	Additional Information / Actions
	General DCS fault (only available if configured)	Please check if Digital Gateway hardware (the identity number) matches to the project specification (e.g. Profibus Digital Gateway <-> Profibus project). Furthermore, the Data Mapping should be checked. Please use MNavigate to download the Digital Gateway configuration or download Mapping file again (ref. to MNavigate Help or MNavigate Manual)
	General DCS fault (only available if configured)	See above LED 8 Digital Gateway is Primary in Dual Redundant configuration.
	General redundancy fault (only available if configured)	Please use MNavigate to check the redundancy status (Redundancy Report). If a mismatch was found, please download the regarding file. For details please refer to MNavigate Help or MNavigate Manual.
	General redundancy fault (only available if configured)	See above LED 6 DCS communication active

Table 33 Digital Gateway LED indication

10.2. Troubleshooting

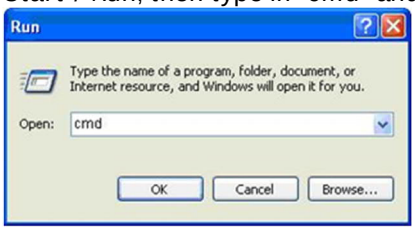
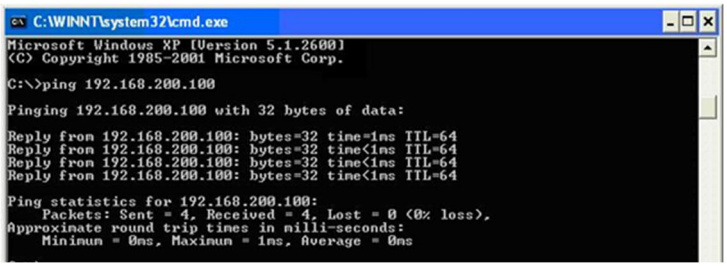
Problem	Solution
No access to Digital Gateway with the web interface or M*Navigate*	Check if the correct IP address in the address bar of the web browser has been entered.
	Check if the Digital Gateway is powered on and no fault indication is on the LED indication of Digital Gateway.
	Check if the Web Server option is activated. This option is customer project specific and can only be enabled using MNS Engineering Tools. If available, it can be used to check communication to the Digital Gateway.
	Check if the network configuration is correct; use a ping command to verify that the Digital Gateway is reachable. Open a command window on the PC: • Start / Run, then type in “cmd” and click Enter  • Enter the ping command with the correct IP address of Digital Gateway: ping xxx.yyy.zzz.aaa  • If no reply is received, check the cable connection of the PC or M*View* and Digital Gateway. If a reply is received the connection is ok.  If the Digital Gateway is still not reachable; Remove the CF card from Digital Gateway, insert the CF card into a card reader connected to M*Navigate* and write the Digital Gateway data again to the CF card. Ensure that correct address settings are entered for Digital Gateway. Re-insert the card to Digital Gateway and start Digital Gateway and check communication

Table 34 Digital Gateway Troubleshooting

Revision History

Rev.	Page	Change Description	Date / Initial
M0201	all	Initial release	2018-05-09 EPDS/HE
M0202	all	Update of drawings / device naming Update Chapter 9.2.6 Switching Commands	2020-05-18 ELDS/FS

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