MODBUS RTU Gateway
for MCD 3000 Series Soft Starters
User Manual

Ver. 1.3

10 October 2003

REVISION NOTES

Index	Date	Chapter	Author	Rev.	Revision note
1	25-APR-2002	All	AMcN	1.0	Created
2	16-DEC-2002	All	JP, AJ	1.1	Clarifications, removal of 300 bps option
3	1-OCT-2003		JP	1.2	Added comments re. firmware version 2.02 and code compliance with Danfoss manual AMB00000 Rev. G
4	10-OCT-2003	All	JP	1.3	Reflects status of firmware version 2.10

TECHNICAL SUPPORT

In case of any questions or problems, please contact Fieldbus Specialists on

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We will endeavour to reply immediately.

PREFACE

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This manual applies to gateways with firmware version 2.10.

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1 INTRODUCTION

1.1 Important user information

The MODBUS RTU to MCD 3000 Gateway allows remote control of the MCD 3000 series soft starters over a MODBUS RTU communications network.

Observe all the necessary safety precautions when controlling any MCD 3000 series device over the serial communications link, including alerting personnel that the machinery may start without warning.

1.2 General

The MCD 3000 series of solid state soft starters incorporate a serial communications facility that allows for the remote control and interrogation of the MCD 3000 from an intelligent host (master) via a multi-drop RS-485 communications network using a proprietary protocol, specific to MCD 3000 devices.

The RS-485 link may be used to interface a MCD 3000 device to a MODBUS RTU network using the MODBUS RTU to MCD 3000 gateway. The MODBUS RTU Master can then control any connected MCD 3000 device – start it, stop, reset trip conditions and read operational status, motor conditions or trip status.

The MODBUS RTU to MCD 3000 Gateway is a strictly compliant MODBUS RTU slave device. A number of gateways and other MODBUS RTU slave devices can be connected to the same network, subject only to standard MODBUS RTU limitations.

The gateway is a master on a RS-485 multi-drop MCD 3000 communications network. **Up to 30** MCD 3000 devices may be connected to a single Gateway. In this way up to 30 MCD 3000 devices will share one MODBUS RTU address on the MODBUS RTU communications network.

When reading this manual, it may help to refer to the MCD 3000 Operating Instructions - Danfoss document no. AMB00000 Rev. G.

2 INSTALLATION

2.1 Gateway connection diagram

The diagram below shows how the gateway is connected to the MODBUS network and to the RS-485 sub-network.

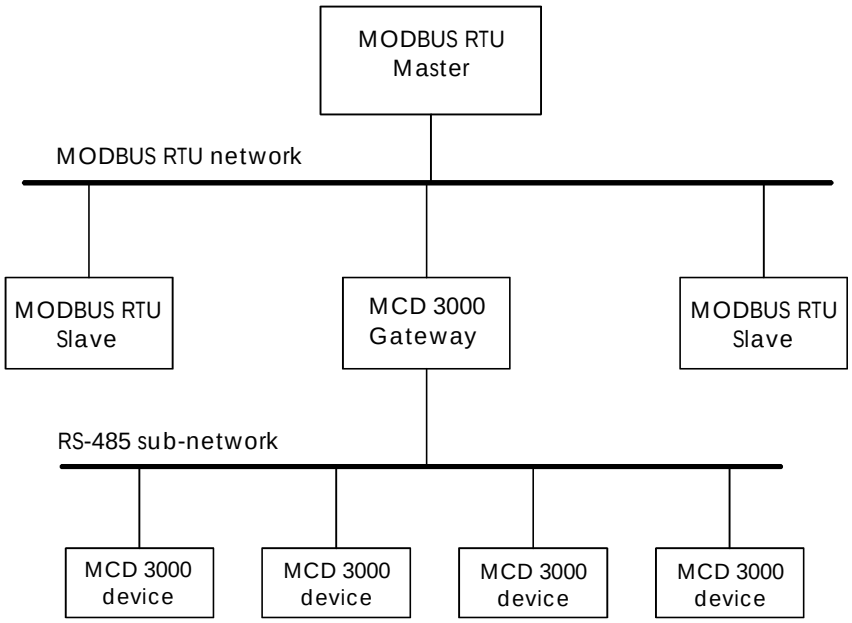


Figure 1. Typical diagram of a MODBUS RTU network, a gateway and an RS-485 sub-network.

A gateway can coexist with a number of other MODBUS RTU nodes, including other gateways. Each gateway constitutes a single MODBUS RTU node, even if it connects to a number of MCD 3000 devices.

2.2 Front panel

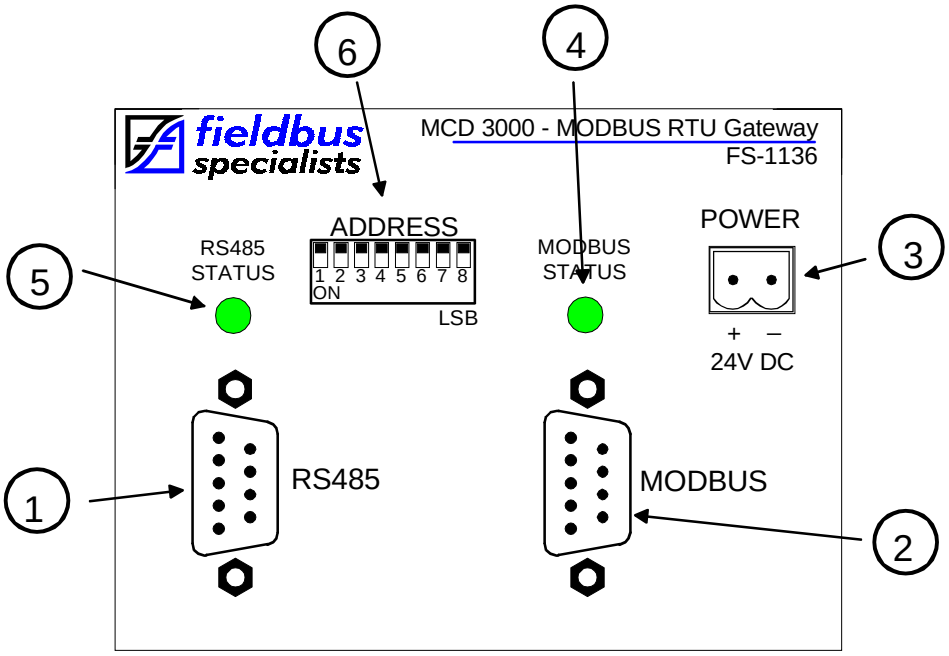


Figure 2. Gateway front panel

Fig. 2 shows the front panel of the gateway. Located there are:

1. RS-485 sub-network connector for connecting up to 30 MCD 3000 devices, DB9, male,
2. MODBUS RTU network connector, DB9, female,
3. Power connector, 2 pin removable terminal block,
4. Bi-colour MODBUS RTU status LED,
5. Bi-colour RS-485 status LED,
6. Dip switches for MODBUS address selection and device configuration.

The following table indicates the status of the MODBUS connection.

MODBUS LED	RS-485 LED	Gateway status
B	B	Gateway starting (max. 4 sec) or no power
R/B	ANY	MODBUS RTU link down – no commands received from MODBUS RTU Master,
G/R	ANY	Single MODBUS RTU link error – wrong checksum, invalid command, invalid register address, invalid value
G	ANY	MODBUS link up and problem-free
ANY	R/B	No communication on the RS-485 link
ANY	G/R	Occasional errors on the RS-485 link
G	G	Both MODBUS RTU and RS-485 links operational and error-free

Legend:

B - LED off

G - LED steady green

R/B - LED flashing red

G/R - LED flashing green/red

ANY – applies irrespective of LED status

Table 1 – LED Indication

These simple rules may be worth remembering:

- Flashing indicates errors on the relevant link,
- Flashing red means that the gateway attempts to communicate but fails every time,
- Flashing red/green means that the gateway can communicate, but errors occur.

2.3 Installation sequence

When installing the gateway, we recommend the following sequence:

- Connect power, see section 2.4 for details. If there are no indications of power, check voltage and polarity.
- Configure parameters of the MODBUS RTU port, see section 2.5 for instructions. Program the MODBUS RTU Master to poll the gateway, see section 3. On success the MODBUS status LED will go green. If the LED stays red, check the cable, address on the gateway and address setting in the master. If the LED flashes green/red, check configuration

of the gateway (MODBUS port baud rate, character format and address) and see whether the MODBUS RTU Master sends valid commands.

- Configure and connect the first MCD 3000 device, see section 2.6 for details. On success, the RS-485 status LED should go green if the gateway configuration in the MODBUS master defines only one MCD 3000 or should flash green/red. If the RS-485 status LED stays solid red, check the RS-485 cable, the MCD 3000 device configuration (set to Remote), wiring to MCD 3000 and the values of the two configuration MODBUS registers – the number of slaves to scan and the RS-485 sub-network baud rate setting.

- Configure and connect the remaining MCD 3000 devices. On success the RS-485 LED should go solid green. If it flashes green/red, one or more MCD 3000 does not communicate with the gateway or the gateway has been configured for more MCD3000 devices than are present.

2.4 Power connection

The gateway requires 24V DC power, approx. 60mA. The voltage can be unregulated – the gateway will operate correctly for power voltage in the range 12-32V. The current drawn changes with voltage – it is ~120mA for 12V and ~45mA for 32V. The device is reverse polarity protected – in the case of reversed connection it will not get damaged but it will not operate either.

Presence of correct power can be verified by looking at the LEDs on the front panel – at least one LED should be illuminated at all times, whether green or red.

2.5 MODBUS connection

The MCD 3000 devices are connected to the MODBUS network using the 9 pin female DB connector, located to the left side of the enclosure. The gateway can be connected to a MODBUS master using either RS-232 link or RS-485 link. The link type depends on the pins used on the connector, both links are active at all times. It is theoretically possible to use both links simultaneously, but this should never be attempted.

Pin assignment is as the following tables indicate. Pins not listed there are unused or reserved and **MUST NOT** be connected.

Pin Number	Purpose
1	+ Signal
5	Shield/Ground
9	- Signal

Table 2 – MODBUS Pin Assignment, RS-485 link

Pin Number	Purpose
2	Tx
3	Rx
5	Shield/Ground

Table 3 – MODBUS Pin Assignment, RS-232 link

Pin assignment for RS-232 link is in line with the standard for DCE type devices. If the gateway is connected to a DTE type device (ex. a personal computer), it is possible to use a straight through cable. This cable should use only the three pins listed. If you use a cable utilizing other pins as well, behaviour of the gateway is undefined.

We recommend using a shielded cable. When the gateway is located away form the MODBUS master controller, the communications cable should always be shielded and should not be run in the vicinity of high current power cabling. The cable length should not exceed length limits as applicable to the link type and the selected baud rate, for details refer to the relevant standards. For RS-485 type link it is advisable to fit termination resistors at each end of the cable to match its characteristic impedance, typically in the range of 100-120 ohm.

The shield/ground signal on the MODBUS socket is galvanically connected to the metal top lid on the enclosure. An earthing lug is provided for earthing the top lid. When the MODBUS cable plug is in the socket, the shield on the MODBUS cable is connected with the socket shield, the top lid and the earthing lug.

2.6 Gateway configuration

Before it starts normal operation, the gateway requires these settings:

a. baud rate and the character format on the MODBUS network, if other than the default (9600 bps, no parity),

b. MODBUS RTU address of the gateway.

These settings must be selected using dip switches on the top panel.

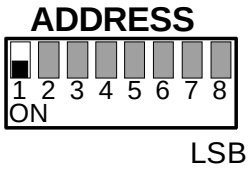
2.6.1 Setting MODBUS baud rate and character format

As the very first step in setting up the gateway, you must program baud rate and character format (parity) on the MODBUS network. This has to be done once before you use the gateway the first time if the values required are different than factory defaults – 9600 bps, no parity. The selected values will be stored in the non-volatile memory. These settings can be changed at any time, if needed. If the default settings are satisfactory, skip this step and proceed directly to section 2.6.2.

To set or change MODBUS network baud rate and parity, follow these steps:

a. make sure that the gateway is powered off,

b. set the leftmost DIP switch(labeled 1) to ON, as on the drawing:



LSB

c. set switches 2, 3 and 4 to select word format:

two stop bits:

LSB

one stop bit,
odd parity bit:

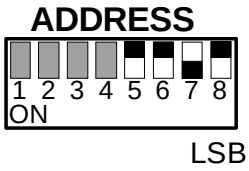
LSB

one stop bit,
even parity bit:

LSB

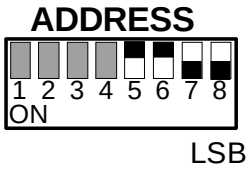
d. set switches 5 to 8 to select baud rate:

1,200 bps:



LSB

2,400 bps:

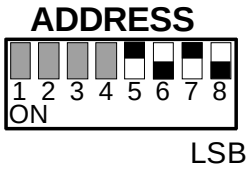


LSB

4,800 bps:

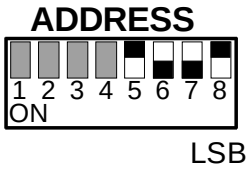
LSB

9,600 bps:



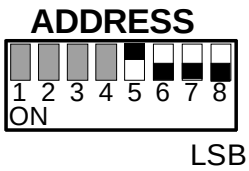
LSB

19,200 bps:



LSB

38,400 bps:



LSB

Note: All other combinations of these four switches are illegal and will be rejected by the gateway.

e. as the last step – power the gateway, wait 1-5 sec and then change leftmost dip switch (labeled 1) to OFF (up

position). If you do not change this switch within 15 sec, the gateway will commence normal operation with the values saved previously or with defaults. Wait until either both LEDs turn green – the required values have been saved in non-volatile memory, or both LEDs turn red – there is an error in settings and you must repeat the whole process from the beginning.

Example of setting the MODBUS line parameters to 19,200 bps, one stop bit, even parity bit:

Steps a-d – set dip switches as on the picture:

step e – power the gateway, wait 1-5 sec and toggle switch 1 from ON to OFF (up). Wait until both LEDs turn green. The gateway has been set as required and will use the required baud rate and word format on each subsequent restart.

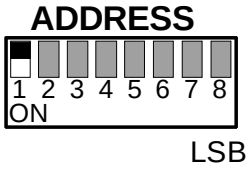
The parameters can be changed at any time by repeating steps a-e.

2.6.2 Setting MODBUS address

You must execute this procedure every time after you have programmed MODBUS baud rate and character format. Follow these steps:

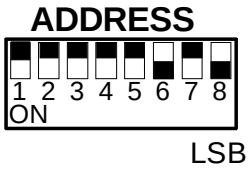
a. make sure that the gateway is powered off,

b. set the leftmost DIP switch(labeled 1) to OFF, as on the drawing:



c. set the required MODBUS address of the gateway using the remaining switches, where the rightmost switch is the least significant one and setting a switch to ON signifies value 1.

Example setting for address 5, binary 0000101:



c. as the last step – connect the gateway to MODBUS master, power the gateway and observe the MODBUS STATUS LED. If the MODBUS master is operational and the address has been set correctly, the LED will turn green or flash green/red. If it flashes red, the master is not operational, it does not scan the slave at the address selected or the address is incorrect.

We recommend leaving the dipswitches in the address setting position while the gateway is operational.

2.7 MCD3000 connection

The MCD 3000 devices should be connected to the RS-485 serial sub-network as per the MCD 3000 Operating Instructions. The gateway is connected to the RS-485 sub-network using a 9 pin male DB connector, located to the left side of the enclosure. Pin assignment is as the following table indicates.

Pins not listed there are unused or reserved and **MUST NOT** be connected.

Pin Number	Purpose
1	+ Signal
5	Shield/Ground
9	- Signal

Table 4 – RS-485 Pin Assignment

We recommend using a shielded twisted pair cable. When the gateway is located away from the soft starter, the communications cable should be shielded and should not be run in the vicinity of high current power cabling. It is advisable to fit termination resistors at each end of the cable to match its characteristic impedance, typically in the range of 100-120 ohm.

The recommended connection diagram is shown in fig. 3 below. Note that we recommend connecting cable shield on the gateway side only and we recommend that the connection point 61 on the MCD3000 device be left unconnected.

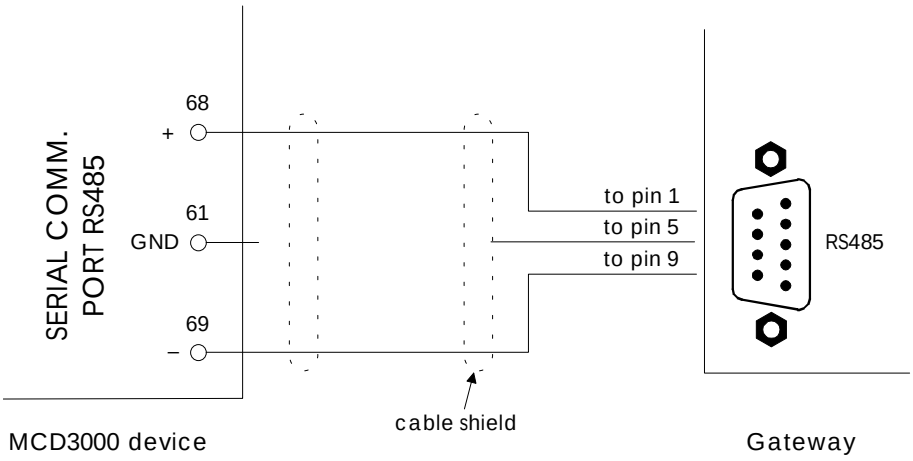


Figure 3. Recommended wiring diagram for one MCD3000 device.

If a number of MCD3000 devices are connected to a single gateway, we recommend to wire them in series, with the gateway at the end of the cable, see fig. 4. The cable should constitute a single line, without side branches.

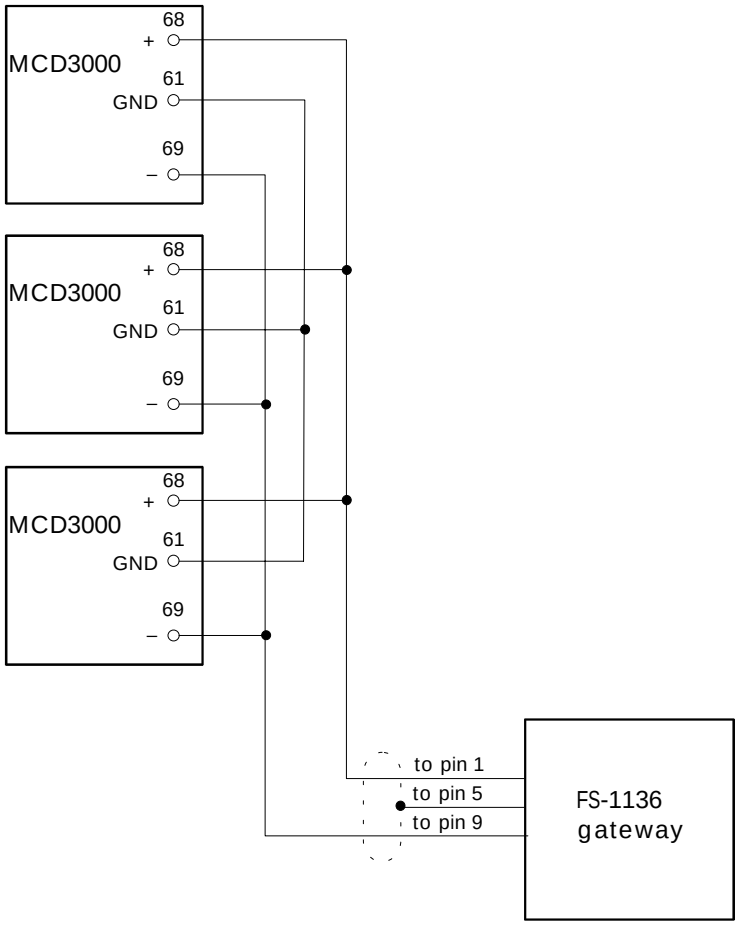


Figure 4. Wiring diagram for a number of MCD3000 devices connected to the same gateway

Note that we recommend connecting GND points (61) on all MCD 3000 devices, to guarantee that they share the same ground potential. If the devices are connected to the common ground in some other way (ex. via a metallic mounting), it may not be necessary to connect points 61. We recommend connecting cable shield to the gateway ground (pin 5), but not to GND points on MCD3000 devices.

RS-485 ports on MCD3000 devices are not galvanically isolated. Failure to equalize ground potential on all devices connected to the same link may lead to their damage.

2.8 MCD3000 configuration

The gateway can communicate at any of the baud rates that MCD 3000 devices can support. All MCD 3000 devices connected to the same sub-network must be configured for the same baud rate.

Each MCD 3000 device must be configured with a node address. Each must have a different address and each address must be in the range from 1 to the number of MCD 3000 devices connected to the gateway, inclusive. Example: if four MCD3000 devices are connected to a gateway, addresses 1, 2, 3 and 4 must be used.

Each MCD 3000 Local/Remote Mode parameter (Parameter 20) must be set to 0, 1 or 2. Setting this parameter to 3 disables the RS-485 communications port. For more detailed explanation refer to the MCD 3000 Operating Instructions.

MCD 3000 devices must be set for Local operation using the Local/Remote pushbutton on the front panel. When this is done, the LED labeled "REMOTE" on the front panel is OFF.

NOTE: When the MCD3000 device is set for "Remote" or its Parameter 20 is set to 3, the device does not execute commands received over the RS-485 link. However, it still acknowledges these commands. Consequently, the gateway or MODBUS master cannot detect this condition. For working with a gateway, we recommend to set Local/Remote Mode parameter (Parameter 20) to 2 – "Local control only". This will eliminate the possibility of the MCD3000 device being set for "Remote" accidentally or by mistake

The MCD 3000 devices must be configured using the keypad/ LCD display on its front panel. The method of setting parameters is described in details in the MCD 3000 Series Soft Starter Operating Instructions.

The following tables show the required configuration for the MCD 3000 soft starter parameters relevant to the operation of the gateway.

Parameter 20		**Local/Remote Mode**
Configuration Options	0	Local/Remote enabled
	1	Local/Remote enabled only when motor stopped
	2	Local control only
	3	Remote control only
Default Setting	**0**	**Local/Remote enabled**

Table 5 – MCD 3000 Local/Remote modes

Parameter 22	**Serial communication baud rate**	
Configuration Options	1	1200 baud
	2	2400 baud
	3	4800 baud
	4	9600 baud
	5	19200 baud
Default Setting	**4**	**9600 baud**

Table 6 – MCD 3000, RS-485 baud rate values

Parameter 23	**MCD 3000 address for RS-485 serial communications**
Configuration Options	1 – 99
Required Setting	A number between 1 and the total number of MCD 3000 devices on the network

Table 7 – MCD 3000 node address on RS-485 network

3 PROGRAMMING MODBUS MASTER

3.1 Valid MODBUS RTU commands

The gateway supports these MODBUS commands from the host:

- Read Registers, code 0x03,
- Preset Register, code 0x06,
- Preset Multiple Registers, code 0x10.

All other commands are rejected and the gateway returns an exception reply to the MODBUS master. For Read Registers and Preset Multiple Registers commands there is a limit of 125 registers to be read/preset with a single command.

For a MODBUS command to be accepted, it must satisfy these tests:

- correct address, as set in the device,
- correct checksum,
- valid register address/address range,
- for Preset commands only: valid data content.

3.2 Valid MODBUS registers

The gateway provides the following registers accessible for reading and writing:

40001 – Configuration Register 1
40002 – Configuration Register 2
40003 – Configuration Register 3
40004 – Configuration Register 4

40005 – Master Handshake Register
40006 – Command Code Register
40007 – Slave Address Register

The gateway provides the following registers accessible for reading only:

40101 – Slave Handshake Register
40102 – Command Result Register
40103 and 40104 – Result Data Registers

40107 and 40108 – Slave Status Registers

40110 and above – Slave Data Registers, with four data registers allocated for each slave.

Any attempt to access registers other than the ones listed above or an attempt to write to read-only register generates an exception reply.

3.3 Configuring the gateway

The gateway has four configuration registers, defining gateway's operation. The content of these registers is as follows:

Configuration Register 1, address 40001 – the number of the MCD3000 devices to scan, 1-30,

Configuration Register 2, address 40002 – baud rate on the RS-485 sub-network:

Configuration Register 2	Baud Rate
1	1,200 bps
2	2,400 bps
3	4,800 bps
4	**9,600 bps**
5	19,200 bps

Table 8 – Configuration Register 2, RS-485 link baud rate

Default value for Configuration Register 2 is 4 – baud rate of 9600 bps.

Configuration Register 3, address 40003 – gateway operation if communication with the master stops:

Configuration Register 3	Action on communication breakdown
1	Stop polling MCD3000 devices
2	**STOP command sent to all MCD3000 devices**
3	COAST TO STOP sent to all devices

Table 9 – Configuration Register 3, gateway operation on communication loss

The selected action will be executed when the gateway had established initial communication with the master and subsequently this communication stops.

If the Configuration Register 3 is set to 1, the gateway will stop poling MCD3000 devices on communications breakdown. This

may cause MCD3000 devices to trip, if they are so programmed (Parameter 24). For other values of the Configuration Register 3, the gateway will keep on polling and will prevent MCD3000 tripping.

Configuration Register 4, address 40004 – timeout, in seconds, for communication with the master.

If there is no command from the master for the time period as set in the Configuration Register 4, the gateway will take action as per Configuration Register 3. Allowed range – 0 to 255. Default value – 5, setting the timeout at 5 sec. If the Configuration Register 4 is set to 0, no timeout supervision will be carried out and once communication with master commences, the gateway will keep on polling MCD3000 devices irrespective of the status of gateway-master link.

On receiving an invalid value for a configuration register, the gateway issues an exception reply. After receiving nonzero value for Configuration Register 1, the gateway commences scanning of MCD3000 devices. The initial (factory default) content of Configuration Register 1 is 0 and no scanning of MCD3000 devices takes place until the host changes this value.

Every time the master writes a new value to any configuration register, the gateway will save this new value in nonvolatile memory and will use it on subsequent restart. There is no need to reload these values on startup.

After a new value has been written to Configuration Register 1 or Configuration Register 2, the gateway resets.

3.4 MODBUS master-slave data exchange

Data exchanged between MODBUS master and slave are of four types:

- Configuration data, required for the gateway to commence scanning of MCD3000 devices,
- Command related data - process data related to commands sent by MODBUS master controller to the gateway and gateway responses.
- Slave status data, reflecting the status (online/offline) of each slave,
- Slave information data – information retrieved cyclically from MCD3000 devices,

3.5 Command related data

The command related data are exchanged using registers 40005-40007 (read/write data, master controller can both read and write) and 40101-40106 (read only data, master controller can only read).

Register 40005 is the Master Handshake Register. Only the two least significant bits B0 and B1 are used, the other bits are ignored by the gateway. Meaning of the value of bits B0 and B1 is explained later in this document.

Register 40006 is the Command Register. When MODBUS master controller issues a command to a MCD3000 device, it writes the code of the command to the Command Register. Table 10 below shows all the valid values – command codes - that can be written to the Command Register and the commands associated with these values. The values in the table are shown in hexadecimal. These values have been chosen to resemble the original command codes as used by MCD3000 devices. For example, the ASCII command code for Stop is "B12". The hexadecimal value selected for Stop is B2 (hex), 0xB2 in C language notation and 1011 0010 in binary.

Register 40007 – Address Register – contains the RS-485 sub-network address of the MCD device that the command is for.

Address	Contents	Comments
40005	Master Handshake Register	Bit B0: New Command Bit. Bit B1: Result Acknowledge Bit.
40006	Command Register	0xB0: Start 0xB2: Stop 0xB4: Reset a trip state 0xB6: Coast to Stop 0xC0: Request Status 0xC2: Request Status_1 0xC4: Request Trip Status 0xC6: Request Protocol Version
40007	Address Register	Address of the slave that the command is for.

Table 10 – MODBUS master read/write registers

Registers at addresses 40101 – 40104 are read-only for the MODBUS master – the master can read them, write requests will be denied.

Register 40101, Slave Handshake Register – operates in the way similar to the Master Handshake Register. Only the bits B0 and B1 are used. More detailed explanation can be found later in this document.

Register 40102 carries the code of the outcome of the command – 1 for success, error codes 2, 3 or 4 in case of failure, see the table below for details.

Result code	Description
1	Successful completion
2	The gateway rejected the command – invalid command code or data
3	No reply from the target or target rejecting the command
4	Invalid target address

Table 11 – Command result codes

Registers at addresses 40103-40104 return data read from a MCD3000 device. For a detailed description refer to section 3.7.

3.6 Status of MCD3000 devices

Status of each MCD3000 device is shown in registers at address 40107 and 40108. Master controller can only read these registers.

Register 40107 shows status of MCD3000 devices with addresses 1 to 16, register 40108 shows status for addresses 17 to 30. One bit is allocated for each RS-485 subnetwork address – bit B0 in register 40107 relates to address 1, bit B1 to address 2 and so on.

A bit set means that the relevant device responds to commands from the gateway, a bit set to 0 indicates that the relevant MCD3000 device is not connected or is not responding to commands.

3.7 MCD3000 devices information data

The gateway allocates four registers for each address on the RS-485 subnetwork, starting with register 40110. Allocation of registers is as follows:

40110 – 40113 – relate to the device at address 1,
40114 – 40117 – relate to the device at address 2,
40118 – 40121 – relate to the device at address 3

and so on until address 40229.

The structure of each data block, made of four 16-bit registers, is shown in Table 12 below.

Register offset	Contents	Comments
0	Status_1	As last read, only the 5 least significant bits are valid
1	Trip	As last read, only the 8 least significant bits are valid
2	Current	As last read, in Amperes
3	Temperature	As last read, in % of motor thermal capacity

Table 12 – Structure of MCD device data block in MODBUS registers

The value in Status_1 is read from the MCD3000 device and then inverted, to yield positive logic – 1 meaning YES/TRUE and 0 meaning NO/FALSE.

The value in Trip register is as read from the MCD3000 device. Value of 255 means no trip, other values are as per command C18, refer Danfoss manual AMB00000 Rev. G, page 13.

The value in Current register is an unsigned integer in the range 0-9999, indicating current in Amperes.

The last register – Temperature - carries information about motor's temperature, given as percentage of the motor's thermal capacity, encoded as an unsigned integer.

All the registers in the range 40110-40229 can be read by the master controller, but cannot be written into.

3.8 Issuing Commands

MODBUS master can issue commands to each MCD 3000 at any time. This is done to allow access to more information about a soft starter than is provided autonomously. Another purpose of issuing commands is to control the motors by starting and stopping them. The following table lists the commands as well as the purpose of these commands. The commands are shown in hexadecimal notation.

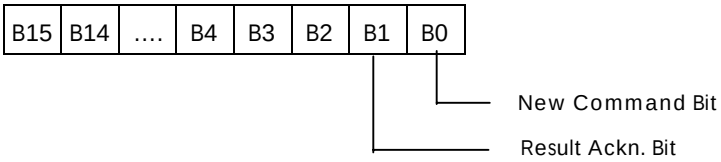
Command	Action
0xB0	Starts Motor
0xB2	Stops Motor
0xB4	Resets a Trip State
0xB6	Coast To Stop
0xC0	Read Status

0xC2	Read Status_1
0xC8	Read Trip Status
0xC6	Read RS-485 Protocol Version

Table 13 – Valid Soft Starter Commands

The MODBUS Master uses three registers for issuing and executing commands:

Register 40005, Master Handshake Register:

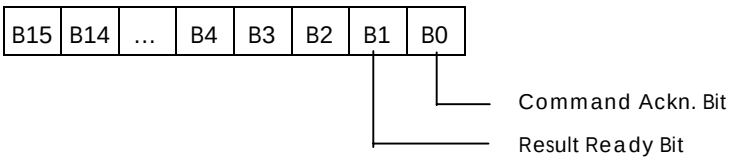


Register 40006, Command Register,

Register 40007, Slave Address Register.

The slave uses two registers to report the outcome of a command:

- Register 40101, Slave Handshake Register:



Register 40102, Command Result Register, see Table 11 for possible content

The following steps describe, in a simplified form, how the MODBUS Master can issue a command to a MCD 3000 Soft Starter Gateway:

- Write the slave address into the Slave Address Register, address 40007,
- Write the command into the Command Register, address 40006
- As the last step, toggle the Command Request Bit in the Master Handshake Register 40005 - change the bit from 0 to 1 or from 1 to 0 - so that it is different from the Command Acknowledgment Bit.

Then the following happens:

- The gateway toggles the Command Acknowledge Bit in Slave Handshake Register 40101 to make it the same as

the Command Request Bit and to indicate an acknowledgement of the command (but not its completion).

- When the command processing has finished (whether successfully or not), the gateway places the results into the Command Result Register 40102.

- In the last step the gateway toggles the Result Ready Bit in Slave Handshake Register 40101, indicating the completion of the command as well as the availability of the results.

The Master controller can read the outcome of the command in the following way.

- Upon detecting change of value of the Result Ready Bit, MODBUS Master should read the Command Result Register 40102.

- If the command was "Read Status", "Read Status_1" or "Read Trip Status", MODBUS master should also read the Data Read Registers 40103-40104. The content of these two registers is the same as the four bytes that MCD 3000 device sends in reply to a Status Read request, refer to the MCD 3000 device Operating Instructions for details.

  As the last step, the MODBUS Master should toggle the Result Acknowledge Bit in the Master Handshake Register 40005 to indicate to the gateway that the result/reply has been read.

The MODBUS master must **NOT** issue a command until the gateway has acknowledged the previous one and the reply to it has been acknowledged. An attempt to issue a command before the gateway has acknowledged and responded to the previous one will be ignored and may lead to an unpredictable behaviour of the gateway.

Status of the motor can be affected by a number of factors other than commands. Consequently, you **MUST NOT** assume that the motor is in any particular state even if a command has been accepted and returned Success in Command Result Register. To monitor status of the motor, the master controller should continuously monitor Status register.

On startup, the MODBUS Master should set the Master Handshake Register to 0. The gateway resets Slave Handshake Register to 0 while not on the MODBUS network. This guarantees proper startup conditions for the handshaking mechanism.

The tables below show possible combinations of handshaking bits and their meaning. Note that X means either 0 or 1 and /X means the opposite of X.

New Command Bit (B0)	Command Acknowledge Bit (B0)	Meaning
X	/X	Bits are different. MODBUS Master has issued a command, but the gateway has not accepted it yet.
X	X	Bits are the same. The gateway has accepted the command.

Table 14 – New Command / Command Acknowledge Handshaking

Result Ready Bit (B1)	Result Acknowledge Bit (B1)	Meaning
X	/X	Bits are different. The gateway placed command results in MODBUS data and awaits the master's confirmation.
X	X	Bits are the same. The result has been read and a new command can be sent to the gateway.

Table 15 – Result Ready / Result Acknowledge Handshaking

It is the gateway's responsibility to acknowledge the command bits via the 'Command Acknowledge Bit'. It is the MODBUS master's responsibility to acknowledge the result bits via the 'Result Acknowledge Bit'. Failure to follow the handshaking procedure may lead to unpredictable behaviour of the gateway.

Commands take precedence over scanning of slaves and will be executed within 250 msec. If the MODBUS master detects undue delay in gateway acknowledging the command or sending a response, it can restart the gateway by rewriting the Configuration Register 1.

Below is an example of the complete algorithm for reading status data of an MCD3000 device at address 3 using Read Status command:

1. Check that the device is on-line i.e. the network status bit is set – for address 3 check register 40107, bit B2. If this bit is set to 1, you can proceed. If the bit equals 0, the device at address 3 is offline.

2. Check that previous commands have been completed – bits B0 in register 40005, Master Handshake Register, and in register 40101, Slave Handshake Register, are equal and bits B1 in these registers are also equal.

3. Write command code 0xC0 (Request Status) to register 40006, Command Register. Also write slave address 3 to register 40007, Address Register. The sequence in which

these bytes are being written into is irrelevant.

4. Indicate to the gateway that a command is pending - modify bit B0 in register 40005, Master Handshake Register, i.e. change this bit from 0 to 1 or from 1 to 0, whichever is applicable,

5. Wait until the gateway has accepted the command – wait for the B0 in register 40101, Slave Handshake Register, to change to equal bit B0 in Master Handshake Register. Be aware that this change does not have to be immediate.

6. Wait for an indication that a reply is waiting – change of bit B1 in register 40101, Slave Handshake Register. This may take some time, needed for execution of the command.

7. Check the result code - read register 40102, Command Result Register. If it equals 1, retrieve the requested device status from Data Read Registers at addresses 40103 and 40104. If Command Result Register equals 2, 3 or 4, process the error. In either case, acknowledge the response by modifying bit B1 in register 40005, the Master Handshake Register, to make it equal B1 in register 40101, the Slave Handshake Register

For commands that do not return any data (such as Start or Stop), there is no need to read registers 40103 and 40104, Data Read Registers.

4 OPERATION OF THE GATEWAY

4.1 Scanning MCD300 devices

The gateway starts scanning MCD3000 devices only after the MODBUS Master sends the configuration data and the gateway goes online on RS-485 network. Note that for this to happen, MODBUS master must write valid values to Configuration Register 1 (address 40001) and Configuration Register 2 (address 40002), as described in section 3.3.

The gateway periodically retrieves Status_1, Trip Code, Current and Temperature from each slave and updates the MODBUS Process Read data in an autonomous fashion. Status_1 and Trip Code are being read most frequently – in each scan cycle, Current and Temperature less frequently.

On the first scan the Status_1, Trip Code, Current and Temperature are read from all declared devices. The device network status bits in the Slave Status registers, read area, address 40107 and 40108, are set for all slaves that reply.

The addressing scheme for the MCD 3000 Soft Starters assumes that the node addresses of all the MCD 3000 devices are in the range from 1 up to the number of devices preset in the configuration. Devices with higher addresses are not scanned.

If a slave fails to respond to a data request command, it is considered an "Offline Slave" and has it's corresponding Slave Status bit cleared. Also cleared are the process data bytes related to this slave.

Note that Status_1, Trip code, Current and Temperature process data for each slave are valid only if the relevant network status bit is set. If the network status bit is not set, then the process data associated with that particular slave are invalid.

4.2 Scanning times

The following Table 16 gives an indication of the time required to complete a polling cycle for a number of slaves present on a serial link over the supported baud rates. The times are in seconds. These figures indicate possible delay in detecting changes to Status_1 and Trip code – data read in each scan cycle.

No. of Devices	1,200 bps	2,400 bps	4,800 bps	9,600 bps	19,200 bps
1	0.500	0.300	0.190	0.130	0.110
2	1.000	0.600	0.380	0.260	0.220
3	1.500	0.900	0.570	0.390	0.330
4	2.000	1.200	0.760	0.520	0.440
5	2.500	1.500	0.950	0.650	0.550
10	5.000	3.000	1.900	1.300	1.100
15	7.500	4.500	2.850	1.820	1.650
20	10.000	6.000	3.800	2.600	2.200
25	12.500	7.500	4.750	3.120	2.750
30	15.000	9.000	5.700	3.900	3.300

Table 16 – Scanning Rate, Baud Rate vs the number of MCD 3000 devices present

The gateway will automatically detect if a MCD 3000 device that was declared offline becomes available again. The following Table 17 shows the worst case time for detecting such a device. The following information assumes that only one device on the network is offline. The time is in seconds.

No. of Devices	1,200 bps	2,400 bps	4,800 bps	9,600 bps	19,200 bps
1	0.250*	0.250*	0.250*	0.250*	0.250*
2	5.000	3.000	1.900	1.300	1.100
3	7.500	4.500	2.850	1.950	1.650
4	10.000	6.000	3.800	2.600	2.200
5	12.500	7.500	4.750	3.250	2.750
10	25.000	15.000	9.500	6.500	5.500
15	37.500	22.500	14.250	9.750	8.250
20	50.000	30.000	19.000	13.000	11.000
25	62.500	37.500	23.750	16.250	13.750
30	75.000	45.000	28.500	19.500	16.500

Table 17 – Maximum Time To Detect An Offline Device

* Only the offline device is on the network, so no other scanning takes place.

4.3 Offline slaves

Since up to 30 slaves can share the same RS-485 serial link, it is critical that communication delays are kept to a minimum. Slaves that are slow to respond slow down the entire serial link. It is important that slaves that fail to respond do not hold up the gateway. The following scheme is used to handle offline slaves:

- If a slave fails to respond to a command, it is considered an offline slave and joins a list of offline slaves, internal to

the gateway.

- In each polling cycle all online slaves are polled. After 5 polling cycles, a command is sent to one of the offline slaves.
- On a subsequent offline slave poll, the next slave on the list of offline slaves is polled.
- Once an offline slave responds to a command it is no longer considered an offline slave.

This mechanism helps keeping network delays to a minimum while allowing to recover offline slaves when they return online.

The above mechanism allows to connect/disconnect MCD 3000 devices while the network is working, with minimal impact on the rest of the network.

5 SPECIFICATIONS

Item	Value
Enclosure	
- Width	100 mm
- Height	75 mm
- Depth	110 mm
Mounting	DIN Rail or Screw Mounting
MODBUS Interface	
- Interface type	RS-485 and RS-232
- Connector Type	9 Pin DB Male
- Galvanically Isolated	Yes (1000V)
- Status Indicator (Type)	5mm Bi-coloured LED
- Configured	With dip switches
MCD3000 Subnetwork Interface	
- Connector Type	9 Pin DB Male
- Galvanically Isolated	Yes (1000V)
- Status Indicator (Type)	5mm Bi-coloured LED
- Configured	Via MODBUS registers
Power	
- Voltage	24V
- Consumption	1.4 Watts
- Connector Type	Removable Screw Terminal
- Reverse Polarity Protection	Yes
- Surge / Short Protection	Fuse
Other Items	
- Field Programmable	Yes
- Weight	Approx. 320g
- Protection Class	IP 20

Table 18 – Gateway Specifications

6 TROUBLESHOOTING

Indications	Problem	Possible cause (check in the order listed)
Both LEDs off for an extended period	No power	No power Incorrect polarity Gateway's fuse blown
MODBUS Status LED flashing red	No connection to MODBUS Master	MODBUS Master is disconnected or off MODBUS cable is cut/broken/not installed correctly High inducted noise on the cable
RS-485 Status LED flashing red	No communication on RS-485 link	RS-485 cable fault (cut/broken/not installed correctly) No devices are configured correctly for operation over RS-485 No device addresses are set correctly
MODBUS Status LED flashing green/red	Communication errors on MODBUS link	Checksum errors, invalid command, invalid register address, invalid data value in a Preset command
RS-485 Status LED flashing green/red	Communication errors on RS-485 link, but some communication still takes place	Some devices not present Some devices are not configured for remote operation over RS-485 Some device addresses are set incorrectly Incorrect gateway configuration information MODBUS Master issues invalid command/request

Table 19 – Troubleshooting guide