Contents

The MCD 200 contains dangerous voltages when connected to line voltage. Only a competent electrician should carry out the electrical installation. Improper installation of the motor or the MCD 200 may cause equipment failure, serious injury or death. Follow this manual, National Electrical Codes (NEC®) and local safety codes.

■ Safety regulations

1. The soft starter must be disconnected from the mains if repair work is to be carried out.

It is the responsibility of the user or the person installing the MCD 200 to provide proper grounding and branch circuit protection according to the National Electric Code (NEC®) and local codes.

■ Warning against unintended start

1. The motor can be brought to a stop by means of digital or bus commands while the soft starter is connected to the mains.
   If personal safety considerations make it necessary to ensure that no unintended start occurs, these stop functions are not sufficient.
2. A motor that has been stopped may start if faults occur in the electronics of the soft starter, or a temporary fault in the supply mains or the motor connection ceases.

■ Symbols used in this manual

When reading this manual you will come across different symbols that require special attention. The symbols used are the following:

Indicates something to be noted by the reader

Indicates a general warning

Indicates a high voltage warning

■ Avoiding soft starter damage

Please read and follow all instructions in this manual. Additionally, take special note of the following:

1. Do not connect power factor correction capacitors to the soft starter output. Static power factor correction, if used, must be connected on the mains side of the soft starter.
2. Do not apply incorrect voltages to the MCD 200 control inputs.

Electrostatic Precaution; Electrostatic discharge (ESD). Many electronic components are sensitive to static electricity. Voltages so low that they cannot be felt, seen or heard, can reduce the life, affect performance, or completely destroy sensitive electronic components. When performing service, proper ESD equipment should be used to prevent possible damage from occurring.

■ Description

The Danfoss MCD 200 Soft Starter series comprises two separate ranges.

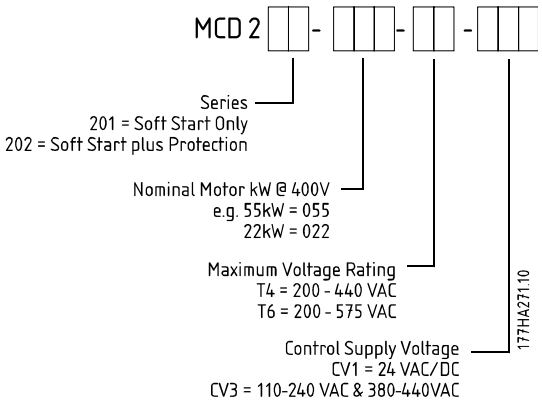
- MCD 201
- MCD 202

MCD 201 and MCD 202 soft starters share a common power and mechanical design, but offer different levels of functionality.
MCD 201 soft starters provide TVR (Timed Voltage Ramp) starting and stopping control and are designed for use with an external motor protection device.
MCD 202 soft starters provide Current Limit starting control, TVR soft stop and include a range of motor protection functions.

ATTENTION
This manual makes reference to MCD 200, MCD 201 and MCD 202. The MCD 200 designation is used when referring to characteristics common to both the MCD 201 and MCD 202 ranges. In all other cases the text refers to the specific range MCD 201 or MCD 202.

MCD 200 soft starters include an integral bypass function that bypass the soft starter SCRs during run. This minimizes heat dissipation during run and makes the MCD 200 suitable for installation within non ventilated enclosures without the need for an external bypass contactor.

■ Ordering type code



■ Ratings

MCD 200 Model	Continuous Ratings (Internally bypassed) @ 40°C Ambient Temperature, <1000 meters★	
	Normal	Heavy
007	18A AC53b 4-6:354	16A AC53b 4-20:340
015	34A AC53b 4-6:354	31A AC53b 4-20:340
018	42A AC53b 4-6:354	37A AC53b 4-20:340
022	48A AC53b 4-6:354	46A AC53b 4-20:340
030	60A AC53b 4-6:354	48A AC53b 4-20:340
037	75A AC53b 4-6:594	67A AC53b 4-20:580
045	85A AC53b 4-6:594	72A AC53b 4-20:580
055	100A AC53b 4-6:594	92A AC53b 4-20:580
075	140A AC53b 4-6:594	116A AC53b 4-20:580
090	170A AC53b 4-6:594	138A AC53b 4-20:580
110	200A AC53b 4-6:594	160A AC53b 4-20:580

MCD 200 Model	Continuous Ratings (Internally bypassed) @ 50°C Ambient Temperature, <1000 meters★	
	Normal	Heavy
007	17A AC53b 4-6:354	16A AC53b 4-20:340
015	32A AC53b 4-6:354	28A AC53b 4-20:340
018	40A AC53b 4-6:354	33A AC53b 4-20:340
022	51A AC53b 4-6:354	41A AC53b 4-20:340
030	53A AC53b 4-6:354	44A AC53b 4-20:340
037	69A AC53b 4-6:594	61A AC53b 4-20:580
045	74A AC53b 4-6:594	65A AC53b 4-20:580
055	92A AC53b 4-6:594	86A AC53b 4-20:580
075	126A AC53b 4-6:594	108A AC53b 4-20:580
090	145A AC53b 4-6:594	126A AC53b 4-20:580
110	176A AC53b 4-6:594	150A AC53b 4-20:580

★ For ambient temperature or altitude conditions beyond those listed contact Danfoss

■ General Technical Data

Mains supply (L1, L2, L3):

MCD 200-xxx-T4-xxx	3 x 200 VAC ~ 440 VAC (+10% / - 15)
MCD 200-xxx-T6-xxx	3 x 200 VAC ~ 575 VAC (+10% / - 15)
Supply frequency (at start)	45HZ - 66 Hz

Control supply (A1, A2, A3):

MCD 200-xxx-xx-CV1	24 VAC/VDC (±20%)
MCD 200- xxx-xx-CV3	110-240VAC (+10% / - 15%) or 380-440 VAC (+10% / - 15%)

Control Inputs

Start Terminal N1	Normally Open, 300 VAC max.
Stop Terminal N2	Normally Closed 300 VAC max.

Relay Outputs

Main Contactor (Terminals 13 & 14)	Normally Open
	6 A, 30 VDC resistive / 2 A, 400 VAC, AC11
Programmable Relay (Terminals 23 & 24)	Normally Open
	6 A, 30 VDC resistive / 2 A, 400 VAC, AC11

Environmental

Degree of protection MCD 200-007 to MCD 200-055	IP20
Degree of protection MCD 200-075 to MCD 200-110	IP00
Operating Temperatures	-10°C / +60°C
Humidity	5%-95% Relative Humidity
Pollution Degree	Pollution Degree 3
Vibration	IEC 60068 Test Fc Sinusoidal
	4Hz - 13.2Hz: ± 1mm displacement
	13.2Hz - 100Hz: ± 0.7g

EMC Emission

Equipment class (EMC)	Class A
Conducted radio frequency emission	0.15 MHz - 0.5 MHz : <90dB(µV)
	0.5 MHz - 5 MHz : <76dB(µV)
	5 MHz - 30 MHz : 80-60dB(µV)
Radiated radio frequency emission	30 MHz - 230 MHz : <30dB(µV/m)
	230 MHz - 1000 MHz : <37dB(µV/m)

This product has been designed for Class A equipment. Use of the product in domestic environments may cause radio interference, in which case the user may be required to employ additional mitigation methods.

EMC Immunity

Electro static discharge	4 kV contact discharge, 8 kV air discharge
Radio-frequency electromagnetic field	0.15 MHz - 1000 MHz: 140dB(µV)
Rated impulse withstand voltage (Fast transients 5/50 ns)	2 kV line to earth
Rated insulation voltage (Surges 1.2/50 µs – 8/20 ms)	2 kV line to earth, 1 kV line to line
Voltage dip and short time interruption	100 ms (at 40% nominal voltage)

Short Circuit

Rated short-circuit current MCD 200-007 to MCD 200-037	5 kA
Rated short-circuit current MCD 200-045 to MCD 200-110	10 kA

Heat Dissipation

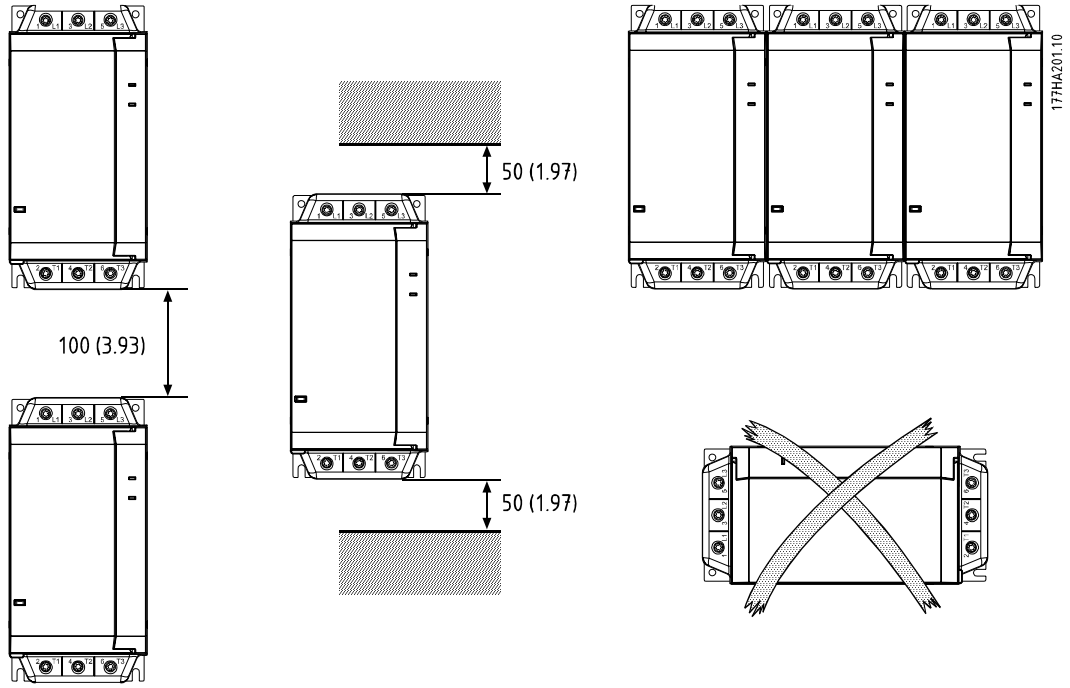
During Start ..... 3 watts / Ampere
During Run ..... < 4 watts

Standards Approvals

C✓ ..... IEC 60947-4-2
UL / C-UL UL508
CE ..... IEC 60947-4-2
CCC ..... GB 14048.6

Description

■ Mechanical Installation

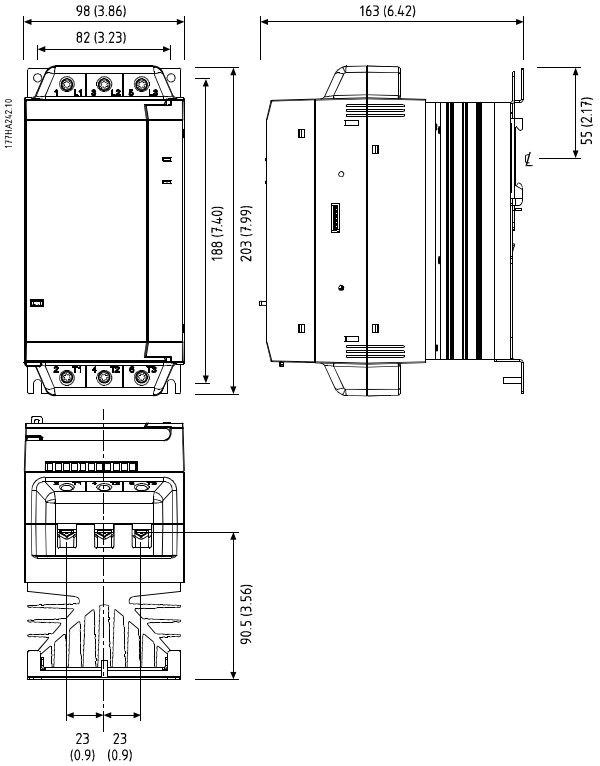


mm (inches)

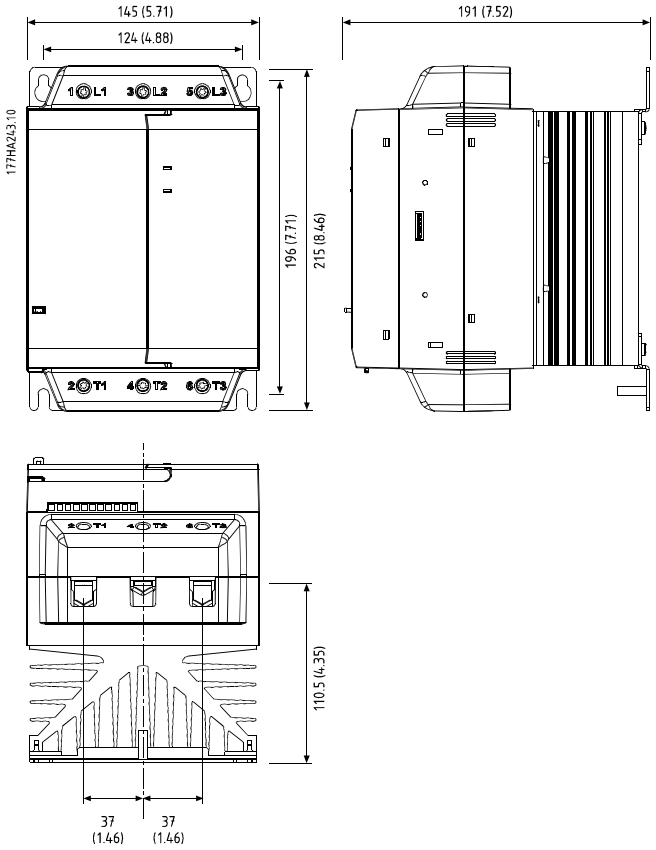
MCD 200	Din Rail	Foot Mounting
MCD 200-007 ~ MCD 200-030	30 mm	Yes
MCD 200-037 ~ MCD 200-110	Not available	Yes

■ Dimensions mm (inches)

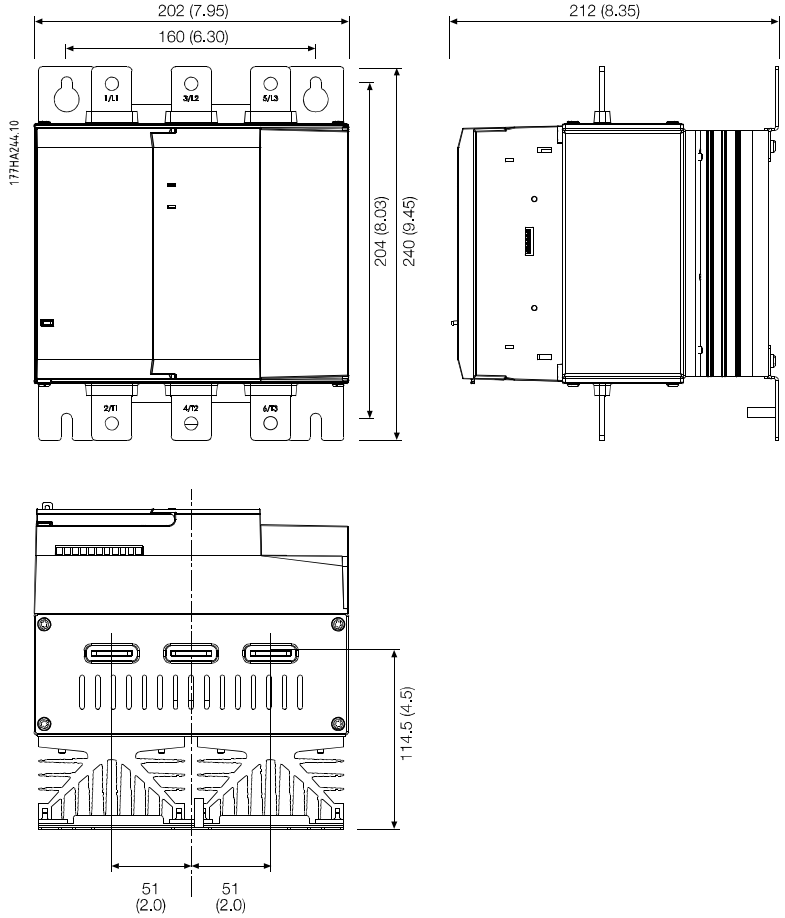
MCD 201-007 ~ MCD 201-030 (2.0 kg / 4.4 lbs)
MCD 202-007 ~ MCD 202-030 (2.1 kg / 4.6 lbs)



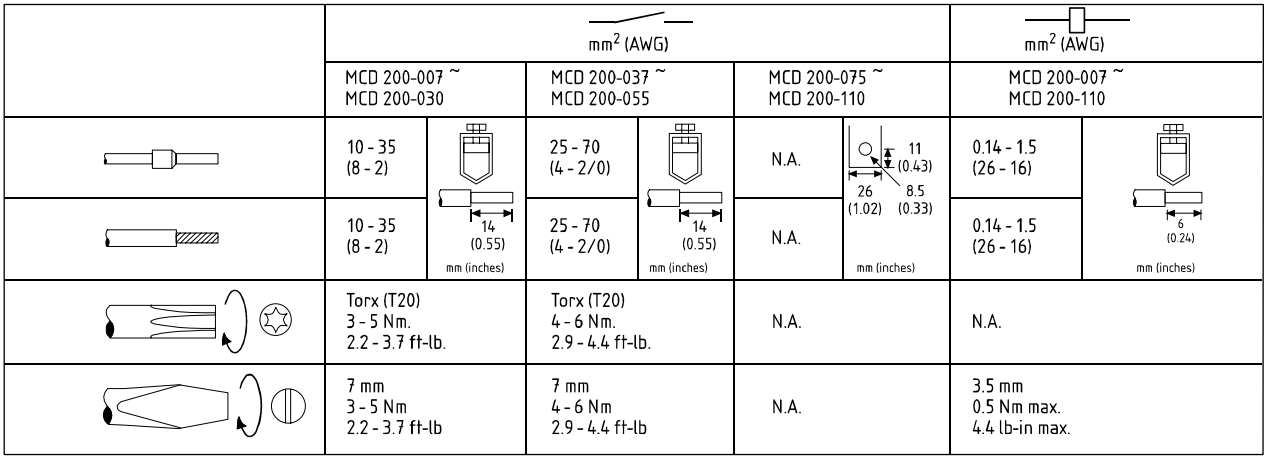
MCD 201-037 ~ MCD 201-055 (4.0 kg / 8.8 lbs)
MCD 202-037 ~ MCD 202-055 (4.3 kg / 9.5 lbs)



MCD 201-075 ~ MCD 201-110 (6.1 kg / 13.5 lbs)
MCD 202-075 ~ MCD 202-110 (6.8 kg / 15.0 lbs)



■ Cable Size



177HA245.10

75ºC Wire. Use copper conductors only.

■ Semiconductor Fuses

Semiconductor fuses may be used with the MCD 200 soft starters. Use of semiconductor fuses will provide Type 2 coordination and reduce the potential of SCR damage due to transient overload currents and short circuits.

The following table provides a list of suitable Ferraz and Bussman fuses. If selecting alternate brands ensure the selected fuse has a lower total clearing I^2t rating than the SCR, and can carry start current for the full starting duration.

MCD 200	SCR I^2t (A^2s)	Ferraz Fuse European/IEC Style (North American Style)	Bussman Fuse
MCD 200-007	1150	6.6URD30xxxA0063 (A070URD30xxx0063)	170M-1314
MCD 200-015	8000	6.6URD30xxxA0125 (A070URD30xxx0125)	170M-1317
MCD 200-018	10500	6.6URD30xxxA0160 (A070URD30xxx0160)	170M-1318
MCD 200-022	15000	6.6URD30xxxA0160 (A070URD30xxx0160)	170M-1318
MCD 200-030	18000	6.6URD30xxxA0160 (A070URD30xxx0160)	170M-1319
MCD 200-037	51200	6.6URD30xxxA0250 (A070URD30xxx0250)	170M-1321
MCD 200-045	80000	6.6URD30xxxA0315 (A070URD30xxx0315)	170M-1321
MCD 200-055	97000	6.6URD30xxxA0315 (A070URD30xxx0315)	170M-1321
MCD 200-075	168000	6.6URD31xxxA0450 (A070URD31xxx0450)	170M-1322
MCD 200-090	245000	6.6URD31xxxA0450 (A070URD31xxx0450)	170M-3022
MCD 200-110	320000	6.6URD31xxxA0450 (A070URD31xxx0450)	170M-3022

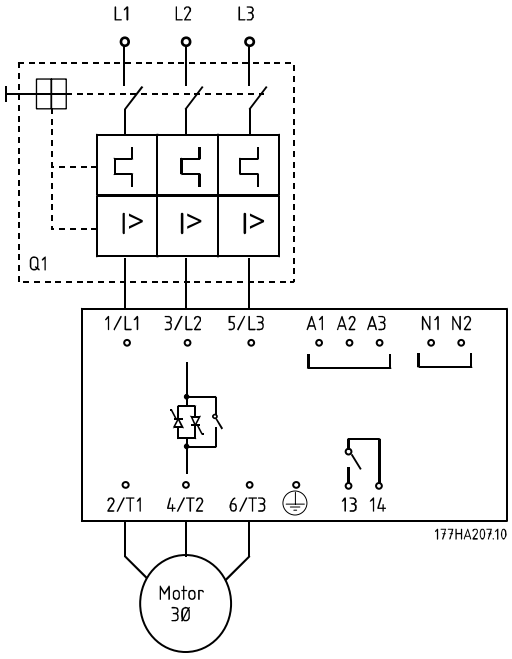
xxx = Blade Type.
Refer Ferraz for options.

MCD 201 Series

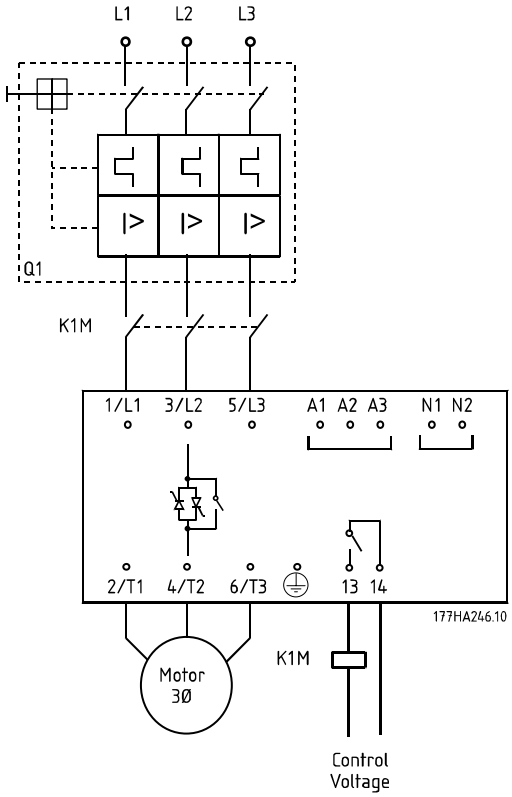
MCD 201 soft starters provide TVR (Timed Voltage Ramp) starting and stopping control and are designed for use with an external motor protection device.

■ Electrical Schematic

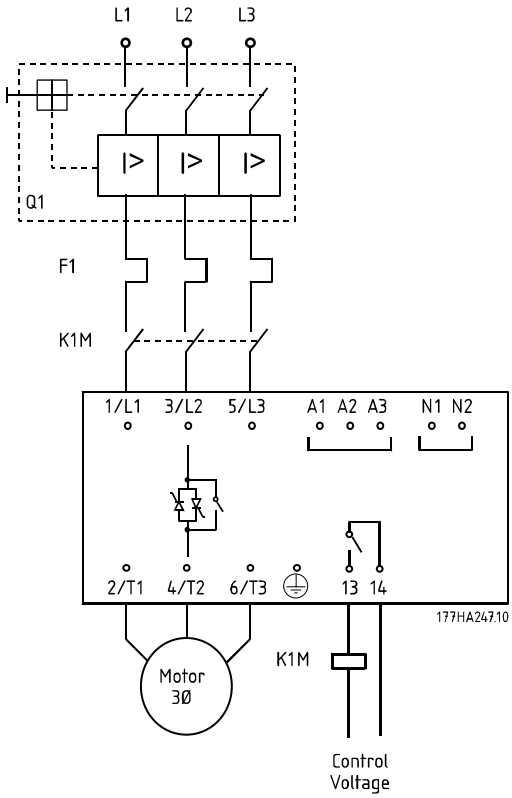
Example 1 – MCD 201 installed with motor protection circuit breaker.



Example 2 – MCD 201 installed with motor protection circuit breaker and line contactor.

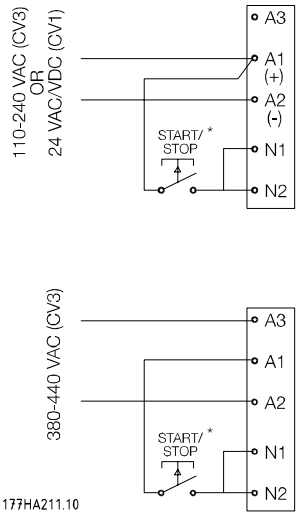


Example 3 – MCD 201 installed with circuit breaker, overload and line contactor.



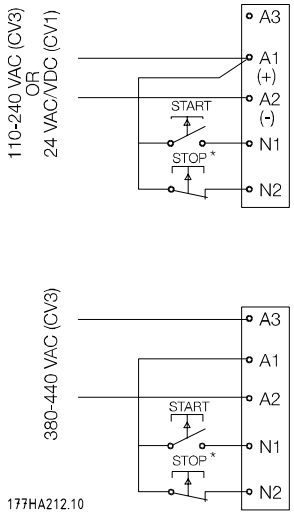
■ Control Circuits

2 Wire Control



* Also resets the MCD 201

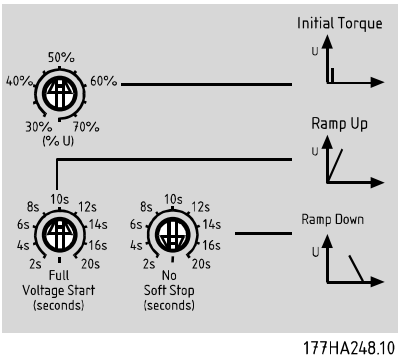
3 Wire Control



* Also resets the MCD 201

■ Functionality

User Adjustments



1 Initial Start Voltage

Value:

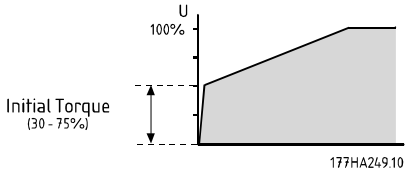
30% - 75% Line Voltage ✯ 50%

Function:

Determines the start torque generated by the motor when the start command is first applied.

Description of choice:

Set so that the motor begins to rotate as soon as the start command is given.



2 Ramp Up

Value:

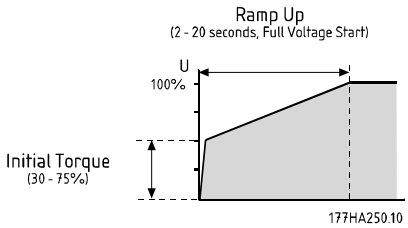
2 - 20 seconds, Full Voltage ✯ 10s

Function:

Determines the time taken for voltage to be ramped up to line voltage.

Description of choice:

Set to optimize motor acceleration and/or start current. Short ramp times result in quicker acceleration and higher start currents. Long ramp times result in slower acceleration and lower start current.



3 Ramp Down

Value:

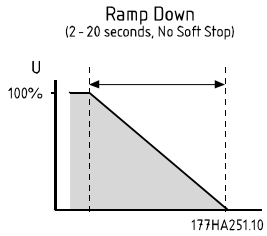
2 - 20 seconds, No Soft Stop ✯ No Soft Stop

Function:

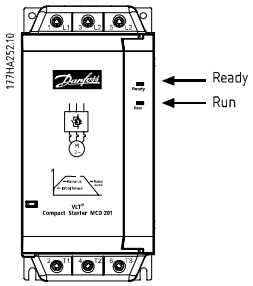
Sets the time of the soft stop voltage ramp. The soft stop function extends motor deceleration time by ramping down voltage supplied to the motor when a stop is initiated.

Description of choice:

Set the ramp time to optimise stopping characteristics for the load.



■ Indication



LED	OFF	ON	FLASH
Ready	No control power	Ready	Starter tripped
Run	Motor not running	Motor running at full speed	Motor starting or stopping

■ Fault Finding

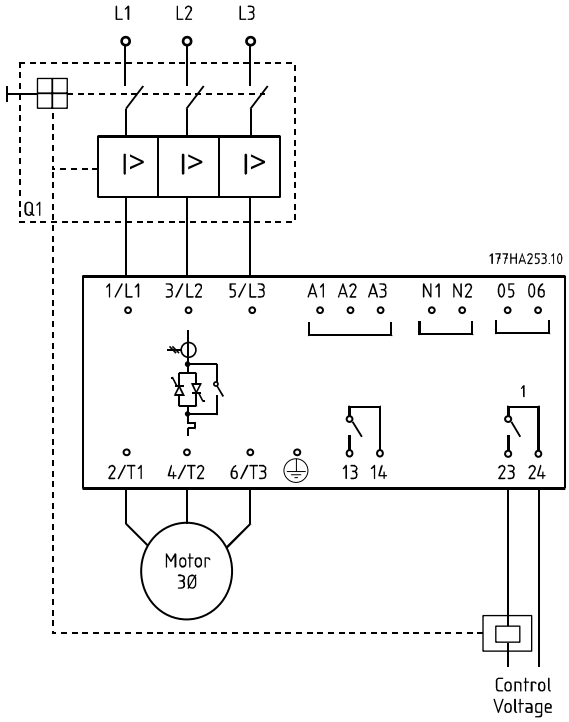
Ready LED	Description
☼ x 1	Power Circuit Fault Check mains supply L1, L2 & L3, motor circuit T1, T2 & T3 and soft starter SCRs.
☼ x 6	Supply Frequency Check supply frequency is in range
☼ x 8	Communications Failure Check serial communications link to MCD accessory module. Remove and refit accessory module.

MCD 202 Series

MCD 202 soft starters provide Current Limit control, TVR soft stop and include a range of motor protection features

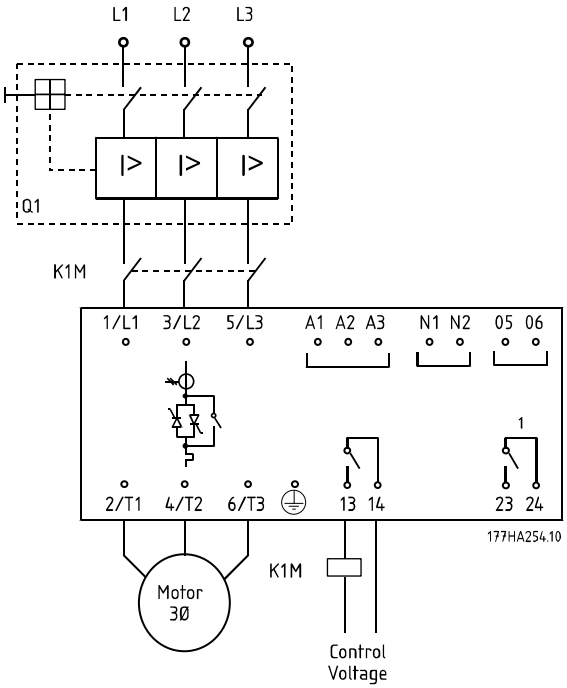
■ Electrical Schematic

Example 1 – MCD 202 installed with system protection circuit breaker complete with shunt trip device.



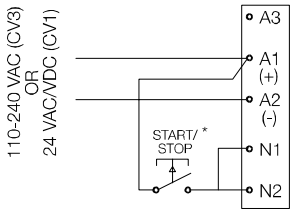
[1] Auxiliary Relay Function = Trip

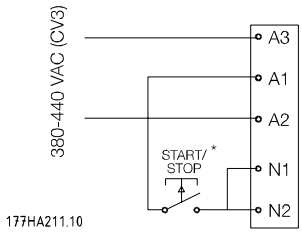
Example 2 – MCD 202 installed with system protection circuit breaker and line contactor.



■ Control Circuits

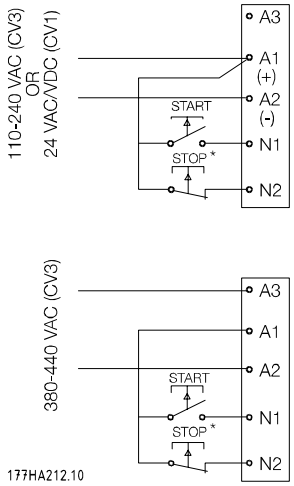
2 Wire Control





* Also resets the MCD 202

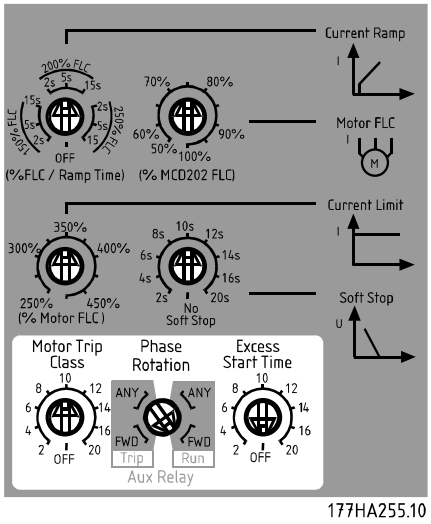
3 Wire Control



* Also resets the MCD 202

■ Functionality

User Adjustments



1 Motor FLC

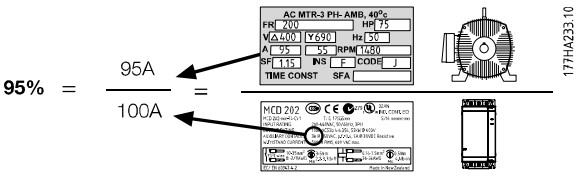
Value:

50% - 100% MCD 202 FLC ✯ 100%

Function:

Calibrates the MCD 202 for the Full Load Current of the motor.

Description of choice:



2 Current Limit

Value:

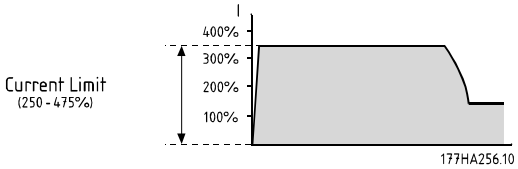
250% - 475% Motor FLC ✯ 350%

Function:

Sets the desired starting current limit.

Description of choice:

The current limit should be set so that the motor accelerates easily to full speed.



ATTENTION

Start current must be great enough to allow the motor to produce sufficient torque to accelerate the connected load. The minimum current required to do this is dependent on motor design and load torque requirements.

3 Current Ramp

Value:

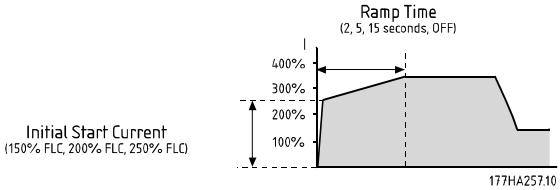
150% Motor FLC (2, 5 0r 15 seconds) ✯ Off
200% Motor FLC (2, 5 0r 15 seconds)
250% Motor FLC (2, 5 0r 15 seconds)
Off

Function:

Sets the initial starting current and ramp time for the Current Ramp start mode.

Description of choice:

The Current Ramp start mode modifies the Current Limit start mode by adding an extended ramp.



Typically the Current Ramp start mode would be used in two circumstances.

1. For applications where start conditions vary between starts the Current Ramp mode provides an optimum soft start irrespective of motor

loading e.g. A conveyor that may start loaded or unloaded.
In this case make the following settings.

- Set Parameter 2 *Current Limit* so that the motor can accelerate to full speed when fully loaded.
- Set Parameter 3 *Current Ramp* so that;
  - the initial start current allows the motor to accelerate when unloaded;
  - the ramp time provides the desired starting performance.

2. On generator set supplies where a gradual increase in current is required to allow greater time for the generator set to respond to the increased loading.
   In this case make the following settings.
   - Set Parameter 2 *Current Limit* as desired.
   - Set Parameter 3 *Current Ramp* so that*;*
     - The *Initial Start Current* is lower level than the *Current Limit*.
     - The ramp time achieves the desired gradual draw of start current.

4 Soft Stop Ramp Time

Value:

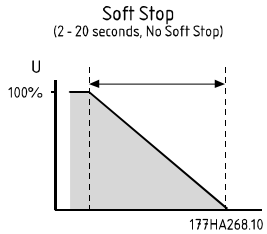
2 - 20 seconds, No Soft Stop ✯ No Soft Stop

Function:

Sets the time of the soft stop voltage ramp. The soft stop function extends motor deceleration time by ramping down voltage supplied to the motor when a stop is initiated.

Description of choice:

Set the ramp time to optimise stopping characteristics for the load.



5 Motor Trip Class

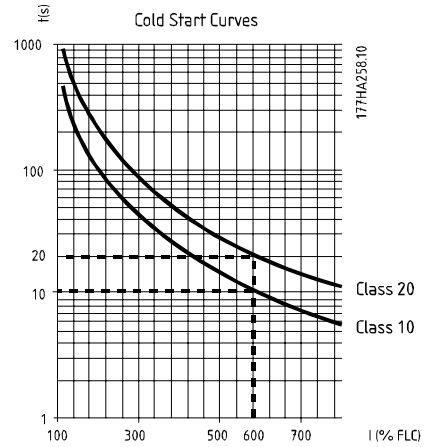
Value:

2 - 20 seconds, Off ✯ 10

Function:

Calibrates the MCD 202 motor thermal model according to the desired motor trip class.

Description of choice:



6 Excess Start Time Protection

Value:

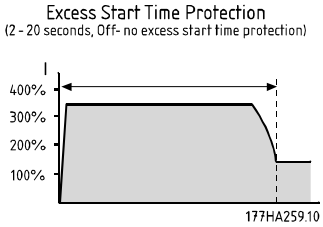
2 - 20 seconds, Off ✯ 10 seconds

Function:

Sets the maximum allowable start time.

Description of choice:

Set for a period slightly longer than the normal motor starting time. The MCD 202 will then trip if the start time exceeds normal.



This provides early indication that the application conditions have changed or that the motor has stalled. It can also protect the soft starter from being operated outside its rated start capability.

ATTENTION
Ensure the Excess Start Time protection setting is within the MCD 202 rated capability.

7 Phase Rotation Protection

Value:

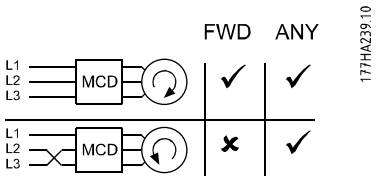
ANY, FWD ✯ ANY

ANY = Forward & Reverse rotation permitted
FWD = Forward Rotation Only

Function:

Sets the allowable phase rotation sequence of the incoming supply.

Description of choice:



The MCD 202 itself is phase rotation insensitive. This function allows motor rotation to be limited to one direction only. Set the protection according to application requirements.

8 Auxiliary Relay Function (Terminals 23, 24)

Value:

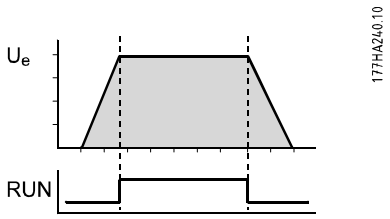
Trip, Run ✯ Trip

Function:

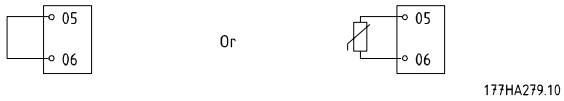
Sets the functionality of Relay Output A (Terminals 23,24)

Description of choice:

Set as required.

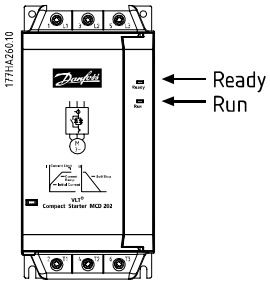


■ Motor Thermistor Protection



Motor thermistor cut out value = 2.8kΩ.

■ Indication



LED	OFF	ON	FLASH
Ready	No control power	Ready	Starter tripped
Run	Motor not running	Motor running at full speed	Motor starting or stopping

■ Fault Finding

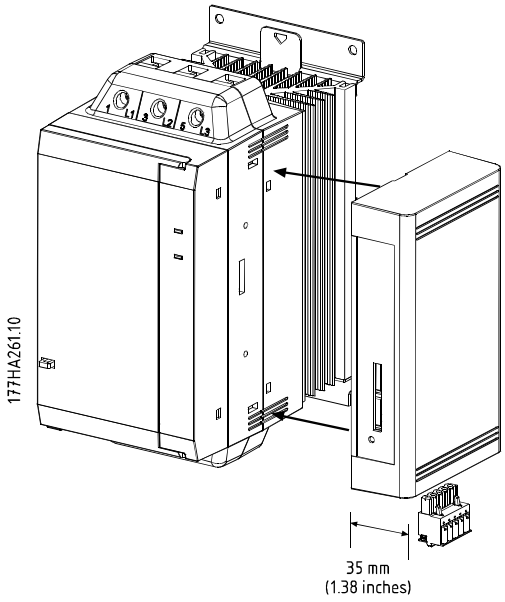
Ready LED	Description
x 1	Power Circuit Fault Check mains supply L1, L2 & L3, motor circuit T1, T2 & T3 and soft starter SCRs.
x 2	Excess Start Time Check load, increase start current or adjust Excess Start Time setting.
x 3	Motor Overload Allow motor to cool, reset soft starter and restart. (MCD 202 cannot be reset until motor has cooled adequately).
x 4	Motor Thermistor Check motor ventilation and thermistor connection 05 & 06. Allow motor to cool.
x 5	Phase Imbalance Check line current L1, L2 & L3.
x 6	Supply Frequency Check supply frequency is in range
x 7	Phase Rotation Check for correct phase rotation.
x 8	Communications Failure Check serial communications link to MCD accessory module. Remove and refit accessory module.

■ Overview

The following optional accessory items are available for use with MCD 200 soft starters.

- MCD 200 Modbus RTU Module (Order Code 175G9000)
- MCD 200 Profibus Module (Order Code 175G9001)
- MCD 200 DeviceNet Module (Order Code 175G9002)
- MCD 200 ASi Module (Order Code 175G9003)
- MCD 200 Remote Operator (Order Code 175G9004)
- MCD PC Software

Accessory items are integrated with the MCD 200 soft starters by means of a plug in module as shown below.



Control power and mains supply must be removed from the MCD 200 before attachment or removal of accessory modules. Failure to do so may result in equipment damage.

■ MCD 200 Remote Operator

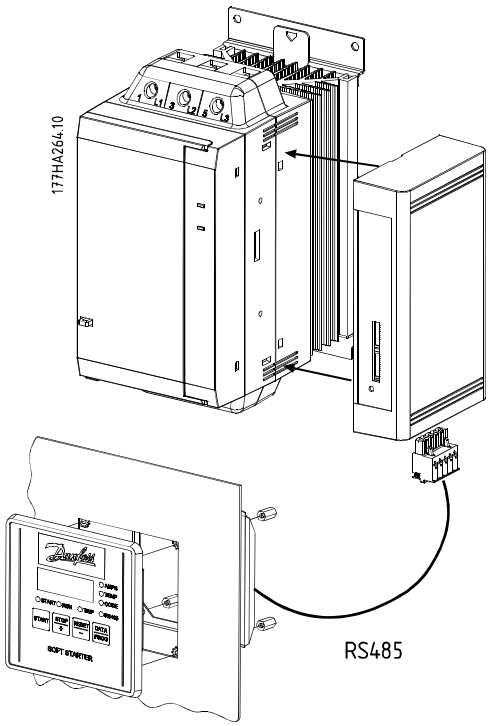
Order Code: 175G9004

The Danfoss Remote Operator can be used with MCD 201, MCD 202 and MCD 3000 to provide the following functionality.

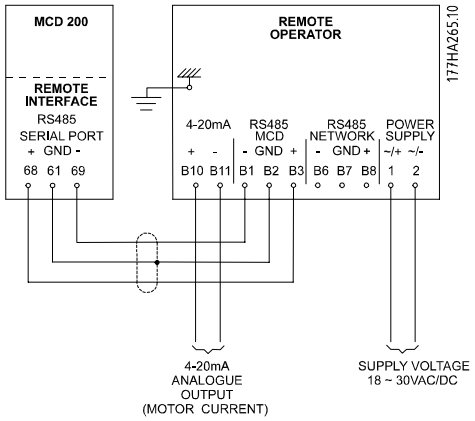
Feature	MCD 201	MCD 202	MCD 3000
Push button control (start, stop, reset)	●	●	●
Starter Status LEDs (starting, running, tripped)	●	●	●
Motor current display		●	●
Motor temperature display		●	●
Trip code display		●	●
4-20mA output (motor current)		●	●

Installation

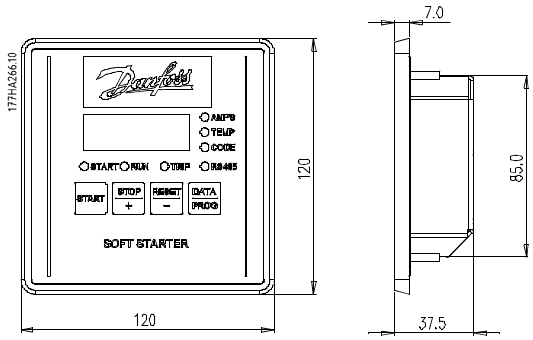
The MCD 200 Remote Operator (175G9004) includes both the Remote Operator (IP54 rated when installed) and the MCD 200 interface module.



Connection



Dimensions

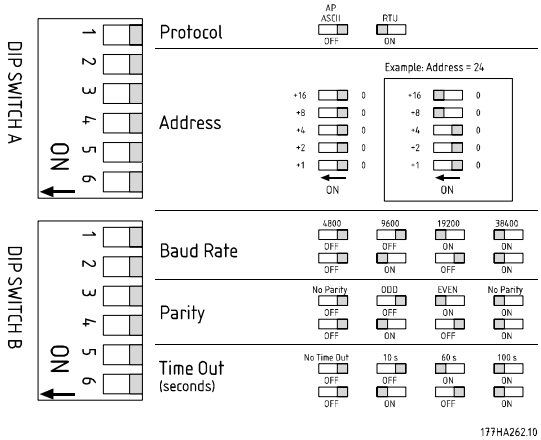


■ MCD 200 MODBUS Module

Order Code: 175G9000

The MODBUS Module supports MODBUS RTU and AP ASCII.

Adjustment



Register

Address	Function	Type	Description	
40002	Command	Write	1=Start 2=Stop 3=Reset 4=Quick Stop 5=Forced Comms Trip	
40003	Starter Status	Read	Bit 0-3	Description 0=Not used 1=Ready 2=Starting 3=Running 4=Stopping 5=Not used 6=Tripped
			4	1=Forward Phase Rotation
			5	Unallocated
			6	Unallocated
			7	Unallocated
40004	Trip Code	Read	255=No Trip 0=Shorted SCR 1=Excess start time✯ 2=Motor overload✯ 3=Motor thermistor✯ 4=Phase imbalance✯ 5=Supply frequency 6=Phase sequence✯ 16=Comms failure	
40005	Current	Read	✯	
40006	Temp	Read	✯	

✯ Not available on MCD 201

MODBUS HEX Functions

Two functions are supported:
03 (Multiple Read)
06 (Single write)
The MCD 200 does not accept broadcast functions

ATTENTION
Command, Starter Status, Trip Code, Current and Temperature must be sent individually. ie one data word request at a time.

ATTENTION
The MODBUS RTU protocol is restricted to transferring a maximum of 6 data words at a time.

Examples

Command: Start

Message	Starter Address	Function Code	Register Address	Data	CRC
In	20	06	40002	1	CRC1, CRC2
Out	20	06	40002	1	CRC1, CRC2

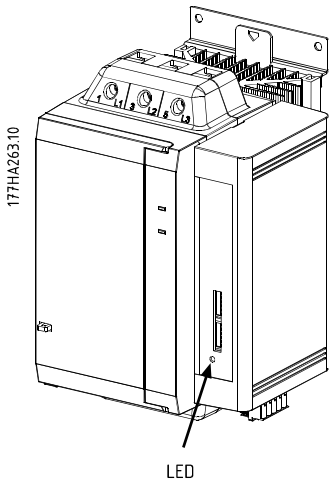
Starter Status: MCD 200 Running

Message	Starter Address	Function Code	Address / Bytes Read	Number / Value	CRC
In	20	03	40003	1	CRC1, CRC2
Out	20	03	2	xxxx0011	CRC1, CRC2

Trip Code: Motor overload

Message	Starter Address	Function Code	Address / Bytes Read	Number / Value	CRC
In	20	03	40004	1	CRC1, CRC2
Out	20	03	2	0000010	CRC1, CRC2

Network Status LED



OFF	ON	FLASH
No connection	Healthy communications	Communication failure

ATTENTION
When a communications failure occurs the Network Status LED will flash and the MCD 200 will trip if the communication time out function has been set. When communications are restored the Network Status LED will cease flashing but if the MCD 200 has tripped it will require an independent reset.

■ MCD 200 Profibus Module

Order Code: 175G9001

Available 2004

■ MCD 200 DeviceNet Module

Order Code: 175G9002

Available 2004

■ MCD 200 AS-i Module

Order Code: 175G9003

Available 2004

■ MCD PC Software

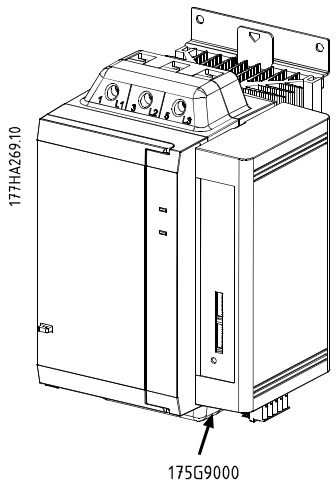
The Danfoss MCD PC Software can be used with MCD 201, MCD 202 and MCD 3000 to provide the following functionality for networks of up to 99 soft starters.

Feature	MCD 201	MCD 202	MCD 3000
Operational Control (start, stop, reset, quick stop)	●	●	●
Status monitoring (ready, starting, running, stopping, tripped)	●	●	●
Performance monitoring (motor current, motor temperature)		●	●
Upload parameter settings			●
Download parameter settings			●

System Requirements

- An x86-based personal computer (486 minimum, Pentium, or Pentium Pro). Pentium recommended.
- A hard disk with 6 megabytes of free space.
- A Microsoft Mouse or other compatible pointing device.
- An EGA, VGA, or compatible display (VGA or higher is recommended).
- 32 MB of random-access memory (48 MB recommended)
- Microsoft Windows 95/98/2000 and Windows NT or later
- An RS485 communication port or RS232 to RS485 converter

Additionally, each MCD 200 soft start connected to the network must be fitted with an MCD 200 MODBUS Module (Order Code: 175G9000).

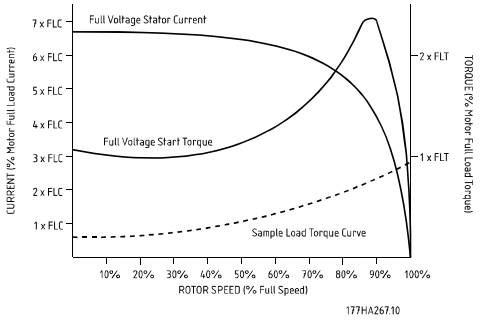


■ Application Guide

This section provides data useful in the selection and application of soft starters.

■ Reduced voltage starting

When started under full voltage conditions a.c.induction motors initially draw Locked Rotor Current (LRC) and produce Locked Rotor Torque (LRT). As the motor accelerates the current falls and the torque increases to break down torque before falling to full speed levels. Both the magnitude and shape of the current and torque curves are dependent on motor design.



Motors with almost identical full speed characteristics often vary significantly in their starting capabilities. Locked rotor currents range from as low as to 500%, to in excess of 900% of motor FLC. Locked rotor torque range from as low as 70%, to highs of around 230% motor Full Load Torque (FLT).
The motor's full voltage current and torque characteristics set the limits for what can be achieved with a reduced voltage starter. For installations in which either minimising start current, or maximising start torque is critical, it is important to ensure that a motor with low LRC and high LRT characteristics is used.
When a reduced voltage starter is used, motor start torque is reduced according to the following formula.

$$T_{ST} = LRT \times \left(\frac{I_{ST}}{LRC} \right)^2$$

T_{ST} = Start torque
I_{ST} = Start current
LRC = Motor Locked Rotor Current
LRT = Motor Locked Rotor Torque

Start current can be reduced only to the point where the resulting start torque still exceeds the torque required by the load. Below this point motor acceleration will cease and the motor/load will not reach full speed.
The most common reduced voltage starters are;

- Star/Delta starters
- Auto-transformer starters
- Primary resistance starters
- Soft starters

Star/Delta starting is the cheapest form of reduced voltage starting however performance is limited. The two most significant limitations are;

1. There is no control over the level of current and torque reduction, these are fixed at one third of the full voltage levels.
2. There are normally large current and torque transients as the starter changes from star to delta. This causes mechanical and electrical stress often resulting in damage. The transients occur because as the motor is spinning and then disconnected from the supply it acts as a generator with output voltage which may be at the same amplitude as the supply. This voltage is still present when the motor is reconnected in delta configuration, and can be exactly out of phase. The result is a current of up to twice locked rotor current and four times locked rotor torque.

Auto-transformer starting offers more control than the star/delta method, however voltage is still applied in steps. Limitations of auto-transformer starting include;

1. Torque transients caused by switching between voltages.
2. Limited number of output voltage taps restricts the ability to closely select the ideal starting current.
3. High price for models suitable for frequent or extended starting conditions.
4. Cannot provide an effective reduced voltage start for loads with varying start requirements. For instance, a material conveyor may start loaded or unloaded. The auto-transformer starter can only be optimised for one condition.

Primary resistance starters also provide greater starting control than star/delta starters. However, they to have a number of characteristics that reduce their effectiveness. These include;

1. Difficult to optimise start performance when commissioning because the resistance value must be calculated when the starter is manufactured and is not easily changed later.
2. Poor performance in frequent starting situations because the resistance value changes as heat is generated in the resistors during a start. A long cool down period is required between starts.
3. Poor performance for heavy duty or extended starts because heat build up in the resistors changes the resistance value.

4. Cannot provide an effective reduced voltage start for loads with varying start requirements.

Soft starters are the most advanced of the reduced voltage starters. They offer superior control over current and torque as well as incorporating advanced motor protection and interface features.
The main starting advantages soft starters offer are;

1. Simple and flexible control over starting current and torque.
2. Smooth control of voltage and current free from steps or transitions.
3. Capable of frequent starting.
4. Capable of handling changing start conditions.
5. Soft stop control to extend motor deceleration times.
6. Braking control to reduce motor deceleration times.

■ Types of soft start control

The term 'soft start' is applied to a range of technologies. These technologies all relate to motor starting but there are significant differences in the methods used and the benefits available.
Some of the key differences are described below.

Control philosophy: Soft starters can generally be divided into two groups.

- Timed Voltage Ramp (TVR) systems
- Current controlled systems

TVR starters control voltage applied to the motor in a preset manner and receive no feedback on motor starting current. Control of start performance is provided to the users through settings such as Initial Voltage and Ramp up time. Soft Stop is also commonly available and provides the ability to extend motor stopping times.
Current controlled soft starters monitor motor current and use this feedback to adjust voltage so that user specified starting current is maintained. Soft Stop is also provided as are range of motor protection functions.

Power assemblies: Soft starters can provide control of one, two or all three phases.
Single phase controllers remove the torque shock associated with motor starting but provide no significant current reduction. They must be used with a line contactor and motor overload. They are suitable for very small motors and should only be applied to light applications with low to medium start frequency.
Two phase controllers control two phases while the third phase is uncontrolled. These controllers provide soft start and current reduction. Care should be taken to ensure that the control algorithms of two phase controllers balance the output waveform in order to provide a symmetrical waveform. Basic two phase controllers subject the motor to an asymmetrical output waveform which creates a d.c. field in the motor. This stationary d.c.field increase the required start current and increases motor heating. Such unbalanced controllers should not be applied to high inertia loads or in situations with high start frequencies.
Three phase controllers control all phases and are best suited for very large motor.

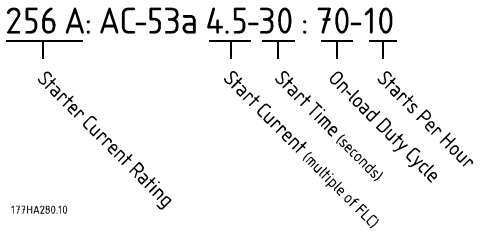
External or internal bypass connection: The SCRs in a soft starter can be bypassed once the motor is up to speed. This reduces heat generation and prevents damage to the SCR from overcurrent or overvoltage events that occur while the motor is running. Some soft starters include built-in bypass contactors while other provide terminals for connection of an external bypass contactor.

■ Understanding soft starter ratings

The maximum rating of a soft starter is calculated so the junction temperature of the power modules (SCRs) does not exceed 125°C. Five operating parameters effect the SCR junction temperature; *Motor Current*, *Start Curre*23*t*, *Start Duration*, *Number of Starts Per Hour*, *Off Time*. The full rating of a particular soft start model must account for all these parameters. A current rating on its own is not sufficient to describe the capability of a soft starter.

IEC 60947-4-2 details the AC53 utilisation categories for describing a soft starter's ratings. There are two AC53 codes;

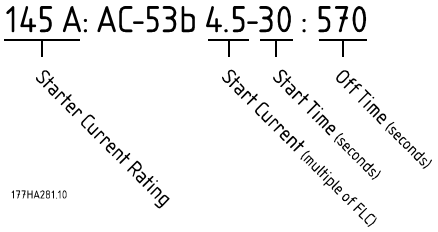
1. AC53a: for soft starters used without bypass contactors.
   For example, the following AC53a code describes a soft starter capable of supplying a 256 A run current and a start current of 4.5 x FLC for 30 seconds 10 times per hour where the motor runs for 70% of each operating cycle. (Operating cycle = 60 minutes / starts per hour)



- *Starter Current Rating*: Maximum FLC rating of the motor to be connected to the soft starter given the operating parameters

specified by the remaining items in the AC53a code.
- *Start Current*: The maximum start current that will be drawn during start.
- *Start Time*: The time taken for the motor to accelerate.
- *On-load Duty Cycle*: The percentage of each operating cycle that the soft starter will run.
- *Starts Per Hour*: The number of operating cycles per hour.

2. AC53b: for soft starters used with bypass contactors
   For example, the following AC53b code describes a soft starter which, when bypassed, is capable of supplying 145 A run current and a start current of 4.5 x FLC for 30 seconds with a minimum of 570 seconds between the end of one start and the commencement of the next.



In summary, a soft starter has many current ratings. These current ratings are dependent on the start current and operational performance required by the application.

To compare the current rating of different soft starters it is important to ensure that operating parameters are identical.

■ Model selection

ATTENTION
To fully understand the model selection procedures it is important to have a good knowledge of the fundamental principles of soft starter ratings. Please read the previous section of this manual, *Understanding soft starter ratings*.

To select the correct MCD 200 model first determine if the application requires a heavy duty or extreme duty ratings. The table below can be used as a guide.

ATTENTION
The application requires duties outside the heavy or extreme duty ratings, please consult your Danfoss representative.

Next, by referring to the appropriate section of the ratings tables at the front of this Design Guide select an MCD 200 model with a FLC ratings greater than that of the motor.

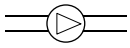
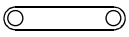
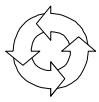
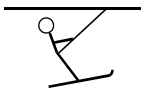
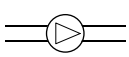
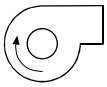
Application	Duty
General & Water	
Agitator	Normal
Centrifugal Pump	Normal
Compressor (Screw, unloaded)	Normal
Compressor (Reciprocating, unloaded)	Normal
Conveyor	Normal
Fan (damped)	Normal
Fan (undamped)	Heavy
Mixer	Heavy
Positive Displacement Pump	Normal
Submersible Pump	Normal
Metals & Mining	
Belt Conveyor	Heavy
Dust Collector	Normal
Grinder	Normal
Hammer Mill	Heavy
Rock Crusher	Normal
Roller Conveyor	Normal
Roller Mill	Heavy
Tumbler	Normal
Wire Draw Machine	Heavy
Food Processing	
Bottle Washer	Normal
Centrifuge	Normal
Dryer	Heavy
Mill	Heavy
Palletiser	Heavy
Separator	Heavy
Slicer	Normal
Pulp and Paper	
Dryer	Heavy
Re-pulper	Heavy
Shredder	Heavy
Petrochemical	
Ball Mill	Heavy
Centrifuge	Normal
Extruder	Heavy
Screw Conveyor	Normal
Transport & Machine Tool	
Ball Mill	Heavy
Grinder	Normal
Material Conveyor	Normal
Palletiser	Heavy
Press	Normal
Roller Mill	Heavy
Rotary Table	Normal
Lumber & Wood products	
Bandsaw	Heavy
Chipper	Heavy
Circular Saw	Normal
Debarker	Normal
Edger	Normal
Hydraulic Power Pack	Normal
Planer	Normal
Sander	Normal

ATTENTION
The above start current requirements are typical and appropriate in most circumstances. However, start torque requirements and performance

of motors and machines does vary. For greater accuracy use the advanced model selection procedure.

■ Typical applications

MCD 200 soft starters can offer benefits for almost all motor starting applications. Typical advantages are highlighted in the table below.

Application	Benefits
Pumps 	• Minimised hydraulic shock in pipelines during start and stop. • Reduced starting current. • Minimised mechanical stress on motor shaft. • Phase rotation protection prevents damage from reverse pump rotation.
Conveyor Belts 	• Controlled soft start without mechanical shocks, e.g. bottles on a belt do not fall over during starting, minimised belt stretch, reduced counter balance stress. • Controlled stop without mechanical shocks. Soft stop. • Optimum soft start performance even with varying starting loads, e.g. coal conveyors started loaded or unloaded. • Extended mechanical lifetime. • Maintenance-free.
Centrifuges 	• Smooth application of torque prevents mechanical stress. • Reduced starting times over star/delta starting.
Ski Lifts 	• Jerk free acceleration increases skier comfort and prevents swinging T-bars etc. • Reduced starting current allows starting of large motors on a weak power supply. • Smooth and gradual acceleration whether the ski lift is lightly or heavily loaded. • Phase rotation protection prevents operation in reverse direction.
Compressors 	• Reduced mechanical shock extends the life of the compressor, couplings and motor. • Limited start current enables large compressors to be started when maximum power capacity is limited. • Phase rotation protection prevents operation in reverse direction.
Fans 	• Extended coupling life through reduced mechanical shock. • Reduced start current enables large fans to be started when maximum power capacity is limited. • Phase rotation protection prevents operation in reverse direction.
Mixers 	• Gentle rotation during start-up reduces mechanical stress. • The starting current is reduced.

■ Power factor correction

If a soft starter is used with static power factor correction it must be connected to the supply side of the starter.

Connecting power factor correction capacitors to the output of the soft starter will result in damage to the soft starter.