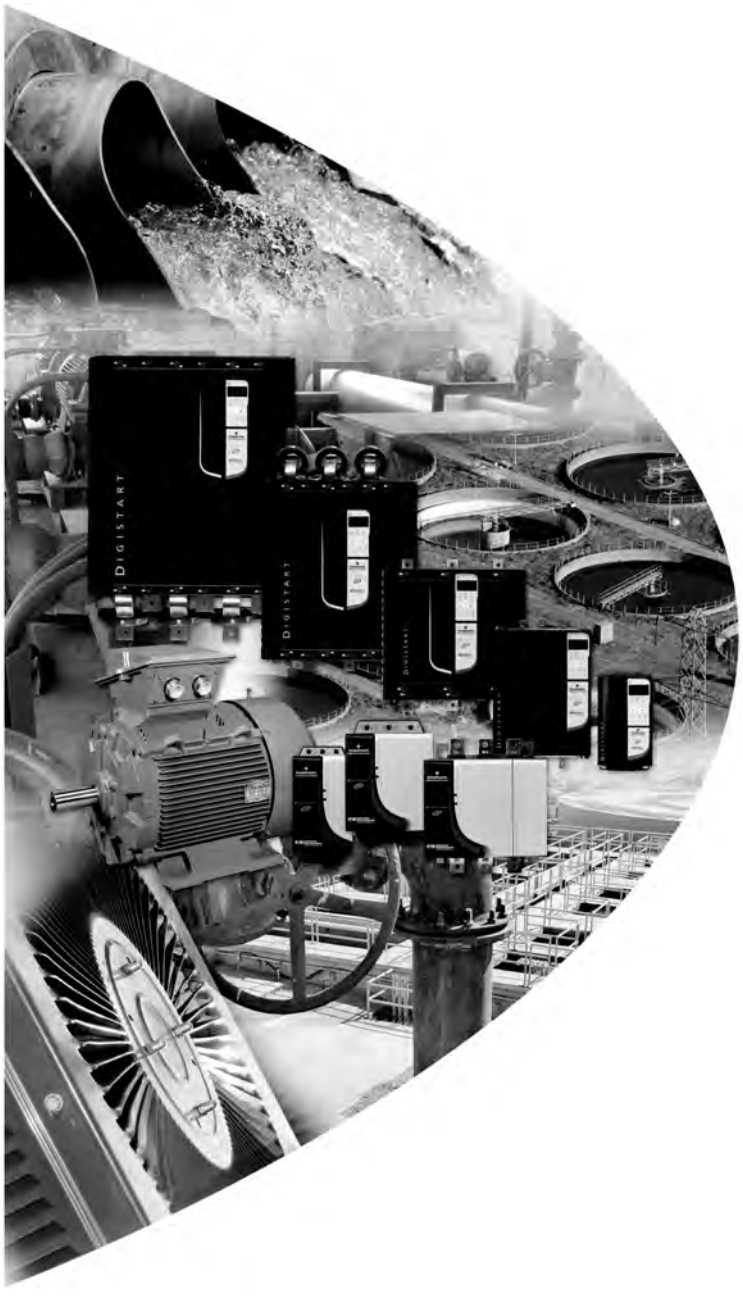
EMERSON
Industrial Automation



User Guide

Modbus Module

For Digistart soft starters

Part Number: 0477-0009-03
Issue: 3

CONTROL TECHNIQUES

www.controltechniques.com

General Information

The manufacturer accepts no liability for any consequences resulting from inappropriate, negligent or incorrect installation or adjustment of the optional parameters of the equipment or from mismatching the starter with the motor.

The contents of this guide are believed to be correct at the time of printing. In the interests of commitment to a policy of continuous development and improvement, the manufacturer reserves the right to change the specification of the product or its performance, or the content of the guide without notice.

Contents

1. Introduction

Control Techniques soft starters can be controlled and monitored across an RS485 serial communication network using the Modbus RTU and AP ASCII protocols.

For users requiring simple control of Digistart CS and Digistart IS soft starters using Modbus RTU or AP ASCII, the instructions below describe the installation and operation of the Modbus Module.

Digistart CS soft starters can also connect to the network via a correctly configured Remote Keypad - see *Modbus Control via Remote Operator* for details.

2. Important User Information

Observe all necessary safety precautions when controlling the soft starter remotely. Alert personnel that machinery may start without warning.

It is the installer's responsibility to follow all instructions in this manual and to follow correct electrical practice.

3. Installation

CAUTION

Remove mains and control voltage from the soft starter before attaching or removing accessories. Failure to do so may damage the equipment.

Install the Modbus Module using the following procedure:

3.1 Physical installation

1. Fully pull out the top and bottom retaining clips on the module.
2. Line up the module with the comms port slot.
3. Push in the top and bottom retaining clips to secure the module to the starter.

Figure 3-1 Attach the module to the starter

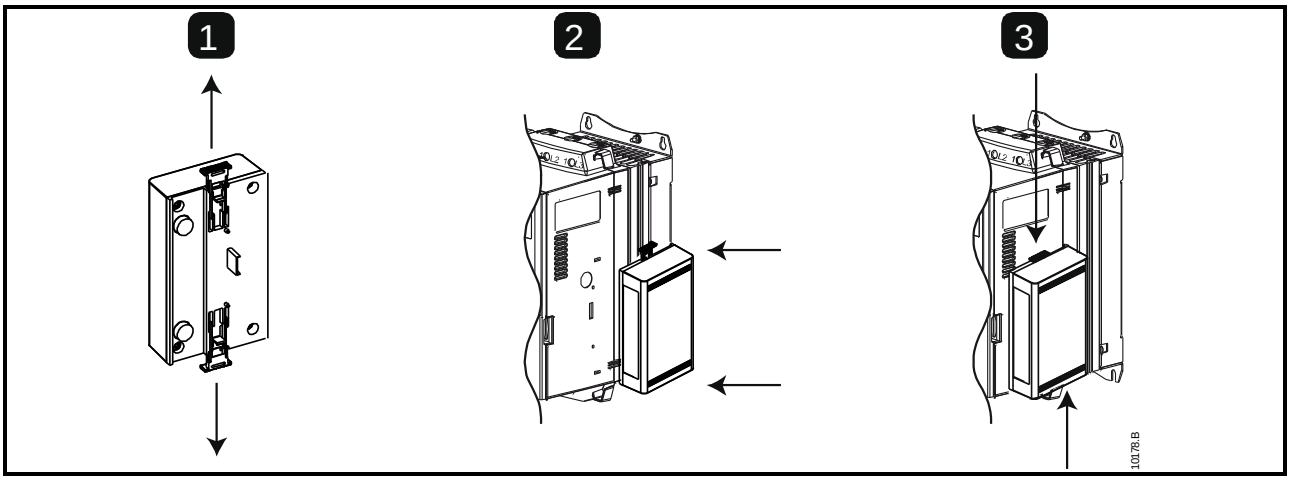
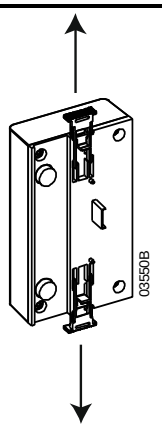


Figure 3-2 Remove the module from the starter

Remove the Modbus Module using the following procedure:

1. Remove control power and mains supply from the soft starter.
2. Disconnect all field wiring from the module.
3. Fully pull out the top and bottom retaining clips on the module.
4. Pull the module away from the soft starter.

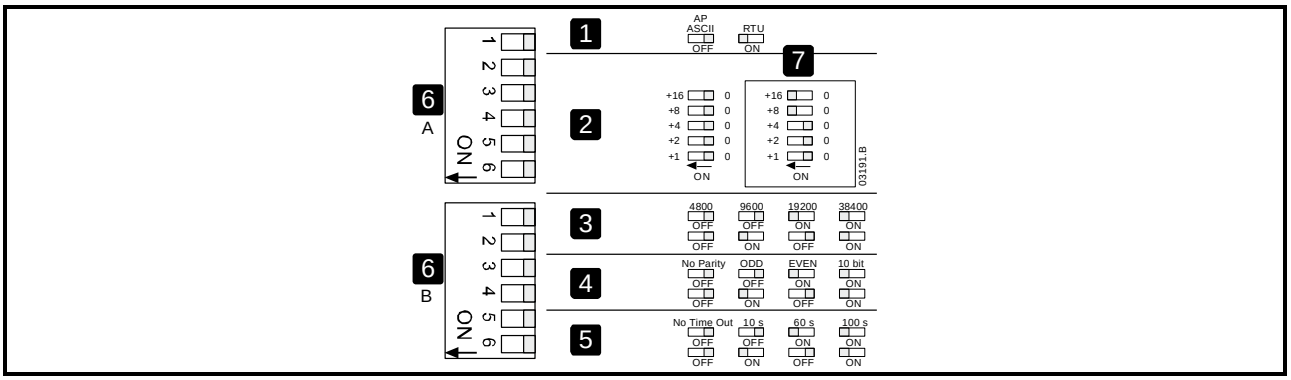


4. Modbus Module Connection and Configuration

4.1 Adjustment

Network communication parameters must be set on the Modbus Module. DIP switch settings take effect on the power-up of the Modbus Module via the soft starter.

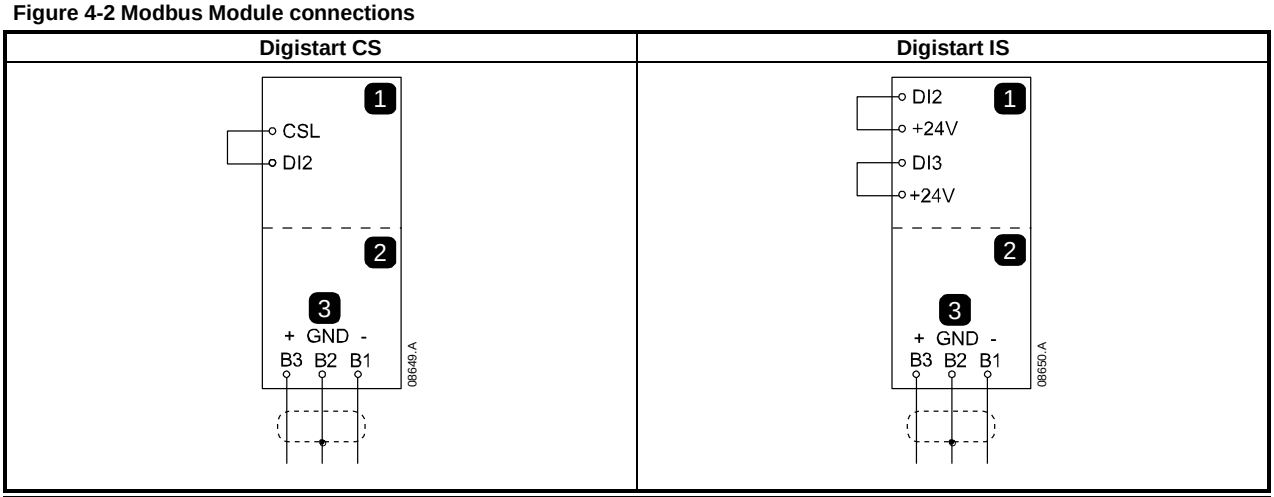
Figure 4-1 Adjustment switches



1	Protocol	5	Timeout (seconds)
2	Address	6	DIP switch
3	Baud rate	7	Example: Address = 24
4	Parity		

4.2 Connection

Figure 4-2 Modbus Module connections



1	Digistart CS	1	Digistart IS (Remote mode) DI2, +24V: Stop DI3, +24V: Reset
2	Modbus Module – RS485 serial port	2	Modbus Module – RS485 serial port
3	RS485 connection onto Modbus network	3	RS485 connection onto Modbus network

For the Modbus Module to accept serial commands, a link must be fitted across terminals CSL-DI2 on the soft starter.

Input links are required across the stop and reset inputs if the soft starter is being operated in Remote mode. In Local mode, links are not required.

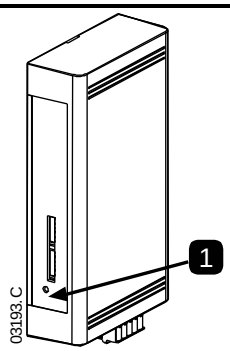
If emergency stop is not required, change the setting of Pr 3A or connect a link across C53, C54.

NOTE Digistart IS Pr **3O** *Comms in Remote* selects whether the soft starter will accept Start, Stop or Reset commands from the Serial Network Master while in Remote mode. See the Digistart IS User Manual for parameter details.

4.3 Network Status LED

The Network Status LED (1) indicates the state of the communications link between the module and the network. LED operation is as follows:

Figure 4-3 Feedback LEDs



1	Off	No connection or soft starter not powered up
	On	Communication active
	Flashing	Communication inactive

NOTE If communication is inactive, the soft starter may trip if the Communications Timeout function has been set on the module. When communication is restored, the soft starter will require a Reset.

5. Master Configuration

For standard Modbus 11-bit transmission, the Master must be configured for 2 stop bits with No Parity and 1 stop bit for odd or even parity.

For 10-bit transmission, the Master must be configured for 1 stop bit.

In all cases, the Master baud rate and slave address must match those set on the Modbus Module DIP switches.

6. Modbus Functions

The Modbus Module supports the following Modbus functions:

- 03 Read multiple registers
- 06 Write single register
- 16 Write multiple registers

Modbus broadcast functions are not supported.

Digistart CS soft starters (including Remote Keypad):

- Read multiple registers 40003 to 40008
- Write single register 40002

Digistart IS soft starters:

- Read multiple registers starting from 40003 up to a maximum of 119 register blocks.
- Single write single register 40002 or multiple write registers 40009 to 40599.

NOTE A multiple read across register boundary 40008/40009 will result in a Modbus Error code 05 at the Master.

6.1 Modbus Register

Table 6-1 Modbus register

Register Address	Type	Description		Digistart CS	Digistart IS	Remote Keypad
40002 Command	Single write	1 = Start		●	●	●
		2 = Stop		●	●	●
		3 = Reset		●	●	●
		4 = Quick stop (coast to stop)		●	●	●
		5 = Forced communication trip		●	●	●
		6 = Start using Parameter Set 1 [3]			●	
		7 = Start using Parameter Set 2 [3]			●	
40003 Starter status	Multiple read	Bit	Description			
		0 to 3	1 = Ready	●	●	●
			2 = Starting	●	●	●
			3 = Running	●	●	●
			4 = Stopping (including braking)	●	●	●
			5 = Restart delay (including Temperature check)		●	
			6 = Tripped	●	●	●
			7 = Program mode		●	
			8 = Jog forward		●	
			9 = Jog reverse		●	
		4	1 = Positive phase sequence (only valid if bit 6 = 1)	●	●	●
		5	1 = Current exceeds full load current	●	●	●
		6	0 = Uninitialised 1 = Initialised	●	●	●
		7	0 = Communications are OK 1 = Communications device fault			●
40004 Trip Code	Multiple read	See Trip Code table				
40005 [1] Motor current	Multiple read	Average 3 phase motor current (A)		●	●	●
40006 Motor temperature	Multiple read	Motor 1 temperature (thermal model)		●	●	●
40007 Product type and version	Multiple read	Bit	Description			
		0 to 2	Product parameter list version	●	●	●
		3 to 7	4 = Digistart CS 8 = Digistart IS	●	●	●
40008 Serial protocol version	Multiple read			●	●	●
40009 [2] Parameter management	Single write and multiple read		Pr **1A** *Motor Full Load Current* to Digistart IS maximum register address (starter software dependent)		●	

[1] For models IS0430N and smaller this value will be 10 times greater than the value displayed on the keypad.

[2] See the relevant soft starter literature for a complete parameter list. The first product parameter is always allocated to register 40009. The last product parameter is allocated to register 40XXX, where XXX = 008 plus total number of available parameters in the product.

[3] Ensure that the programmable input is not set to Motor Set Select before using this function.

NOTE If Pr **3A** *Input A Function* for Digistart IS is set to motor set select, this will cause a conflict with motor set selection via serial communications.

6.2 Trip Codes

Table 6-2 Trip messages

Trip Code	Trip Name	Digistart CS	Digistart IS
1	Excess start time	●	●
2	Motor overload (thermal model)	●	●
3	Motor thermistor	●	●
4	Current imbalance	●	●
5	Frequency (Mains supply)	●	●
6	Phase sequence	●	●
7	Instantaneous overcurrent		●
8	Power loss/Power circuit	●	●
10	Heatsink overtemperature		●
11	Motor connection Tx		●
12	Input A trip		●
13	FLC too high (FLC out of range)		●
14	Unsupported option (function not available in inside delta)		●
15	Starter communication (between module and soft starter)	●	●
16	Network communication (between module and network)	●	●
17	Internal fault x (where x is the fault code detailed in the table below).		●
20[1]	Ground fault		●
23	Parameter out of Range		●
24	Input B trip		●
26	L1 phase loss		●
27	L2 phase loss		●
28	L3 phase loss		●
29	L1-T1 shorted		●
30	L2-T2 shorted		●
31	L3-T3 shorted		●
32	Motor 2 overload (thermal model)		●
33[2]	Time-overcurrent (Bypass overload)	●	●
35	Battery/clock		●
36	Thermistor circuit		●
37	RTD/PT100 A		●
38[1]	RTD/PT100 B		●
39[1]	RTD/PT100 C		●
40[1]	RTD/PT100 D		●
41[1]	RTD/PT100 E		●
42[1]	RTD/PT100 F		●
43[1]	RTD/PT100 G		●
45	RTD/PT100 X Circt		●
46	Analog input trip		●
47	Overpower		●
48	Underpower		●
255	No trip	●	●

[1] Available with Digistart IS only if the appropriate option card is fitted.

[2] For Digistart IS, time-overcurrent protection is only available on internally bypassed models.

6.2.1 Internal Fault x

The table below details the internal fault code associated with trip code 17.

Table 6-3 Internal fault X

Internal fault	Message displayed on the keypad
70	Current Read Err Lx
71	
72	
73	Power On in Simulation mode
74	Motor connection Tx
75	
76	
77	Firing fail SCRx
78	
79	
80	VZC Fail Px
81	
82	
83	Low Control Volts
84	Internal fault X Contact your local supplier with the fault code (X).
85	
86	
87	
89	
90	
91	
92	
93	
94	
95	
96	
97	
98	

6.3 Cyclic redundancy check (CRC)

The CRC is a 16bit cyclic redundancy check using a polynomial with a value A001.

The 16bit CRC is appended to the message and transmitted LSB first.

The CRC is calculated on all the bytes in the frame.

For further Modbus information, including the CRC calculation, refer to the Modbus protocol specifications available at http://www.modbus.org/specs.php http://www.modbus.org/specs.php.

6.4 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: Running

Message	Starter Address	Function Code	Register Address	Data	CRC
In	20	03	40003	1	CRC1, CRC2
Out	20	03	2	xxxx0011	CRC1, CRC2

Trip code: Motor overload

Message	Starter Address	Function Code	Register Address	Data	CRC
In	20	03	40004	1	CRC1, CRC2
Out	20	03	2	00000010	CRC1, CRC2

Download parameter from starter
Digistart IS: Read parameter 3 (Pr **1C**) *Locked Rotor Time*, 10 seconds

Message	Starter Address	Function Code	Register Address	Data	CRC
In	20	03	40011	1	CRC1, CRC2
Out	20	03	2	10	CRC1, CRC2

Upload parameter to starter
Digistart IS: Write parameter 12 (Pr **2H**), *Stop Mode*, set = 2 'Adaptive Control'

Message	Starter Address	Function Code	Register Address	Data	CRC
In	20	06	40020	2	CRC1, CRC2
Out	20	06	40019	2	CRC1, CRC2

6.5 Modbus Error Codes

Table 6-4 Error codes

Code	Description	Example
01	Illegal function code	Function other than 03 or 06
02	Illegal data address	Register number invalid
03	Not readable data	Register not allowed for data reading
04	Not writable data	Register not allowed for data writing
05	Data boundary fault	Multiple data transfer across data boundary or data size more than 125
06	Invalid command code	e.g. writing "6" into 40003
07	Illegal parameter read	Invalid parameter number
08	Illegal parameter write	Invalid parameter number, read only, or hidden parameter
09	Unsupported command	Sending a serial command to Digistart IS with Pr **3O** = Disable control in RMT.
10	Local communication error	Communication error between Modbus slave and starter

NOTE Some of the above codes are different from those defined in the Modbus Application Protocol Specification available on www.modbus.org.

7. AP ASCII Protocol

The message fragments used to communicate with the Modbus Module as an AP ASCII slave device are shown below. The message fragments may be assembled into complete messages as described in the sections that follow.

NOTE Data must be transmitted in 8-bit ASCII, no parity, one stop bit.

Table 7-1 AP ASCII message fragments

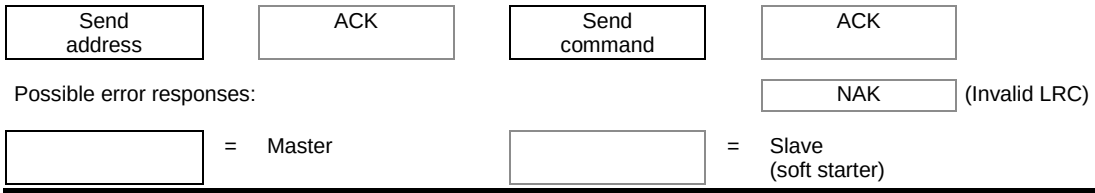
Message Fragment Type	ASCII Character String or (Hexadecimal Character String)			
Send address	EOT [04h]	nn nn	lrc lrc	ENQ [05h]
Send command Send request	STX [02h]	ccc ccc	lrc lrc	ETX [03h]
Receive data	STX [02h]	dddd dddd	lrc lrc	ETX [03h]
Receive status	STX [02h]	ssss ssss	lrc lrc	ETX [03h]
ACK (acknowledge)	ACK [06h]			
NAK (negative acknowledge)	NAK [15h]			
ERR (error)	BEL [07h]			

nn = two byte ASCII number representing the soft starter address where each decimal digit is represented by n.
lrc = two byte longitudinal redundancy check in hexadecimal.
ccc = three byte ASCII command number where each character is represented by c.
dddd = four byte ASCII number representing the current or temperature data where each decimal digit is represented by d.
ssss = four byte ASCII number. The first two bytes are ASCII zero. The last two bytes represent the nibbles of a single byte of status data in hexadecimal.

7.1 Commands

Commands can be sent to the soft starter using the following format:

Figure 7-2 Command format

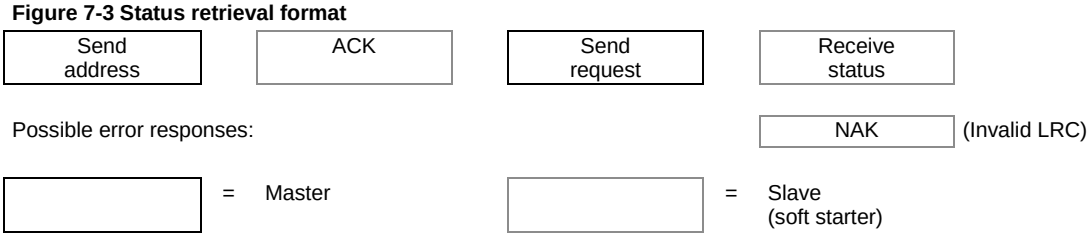


Command	ASCII	Comment
Start	B10	Initiates a start
Stop	B12	Initiates a stop
Reset	B14	Resets a trip state
Quick stop	B16	Initiates an immediate removal of voltage from the motor. Any soft stop settings are ignored.
Forced communication trip	B18	Causes a communications trip

7.2 Status Retrieval

Soft starter status can be retrieved using the following format:

Figure 7-3 Status retrieval format

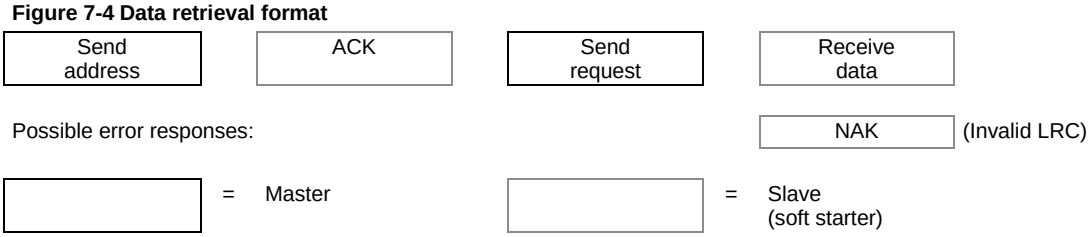


Request	ASCII	Receive Status (ssss)	
Trip code	C18	See the trip code table.	
Starter status	C22	Bit	Description
		0 to 3	1 = Ready 2 = Starting 3 = Running 4 = Stopping (including braking) 5 = Restart delay (including Temperature check) 6 = Tripped 7 = Program mode
		4	1 = Positive phase sequence (only valid if bit 6 = 1)
		5	1 = Current exceeds FLC
		6	0 = Uninitialised 1 = Initialised
		7	0 = Communications are OK 1 = Communications device fault

7.3 Data Retrieval

Data can be retrieved from the soft starter using the following format:

Figure 7-4 Data retrieval format



Request	ASCII	Receive Data (dddd)
Motor current	D10	Requests motor current. The data is four byte decimal ASCII. Minimum value 0000 A, maximum value 9999 A.
Motor temperature	D12	Requests the calculated value of the motor thermal model as a % of motor thermal capacity. The data is four byte decimal ASCII. Minimum value is 0000%. Trip point is 0105%.

7.4 Calculating the Checksum (LRC)

Each command string sent to and from the starter includes a checksum. The form used is the longitudinal redundancy check (LRC) in ASCII hex. This is an 8-bit binary number represented and transmitted as two ASCII hexadecimal characters.

To calculate LRC:

1. Sum all ASCII bytes
2. Mod 256
3. 2's complement
4. ASCII convert

For example Command String (Start):

ASCII	STX	B	1	0
or	02h	42h	31h	30h

ASCII	Hex	Binary	
STX	02h	0000 0010	
B	42h	0100 0010	
1	31h	0011 0001	
0	30h	0011 0000	
	A5h	1010 0101	SUM (1)
	A5h	1010 0101	MOD 256 (2)
	5Ah	0101 1010	1's COMPLEMENT
	01h	0000 0001	+ 1 =
	5Bh	0101 1011	2's COMPLEMENT (3)

ASCII	5	B		ASCII CONVERT (4)
or	35h	42h		LRC CHECKSUM

The complete command string becomes:

ASCII	STX	B	1	0	5	B	ETX
or	02h	42h	31h	30h	35h	42h	03h

To verify a received message containing an LRC:

1. Convert last two bytes of message from ASCII to binary
2. Left shift second to last byte four bits
3. Add to last byte to get binary LRC
4. Remove last two bytes from message
5. Add remaining bytes of message
6. Add binary LRC
7. Round to one byte
8. The result should be zero

Response or status bytes are sent from the starter as an ASCII string:

STX	[d1]h	[d2]h	[d3]h	[d4]h	LRC1	LRC2	ETX

d1 = 30h
d2 = 30h
d3 = 30h plus upper nibble of status byte right shifted by four binary places
d4 = 30h plus lower nibble of status byte

For example status byte = 1Fh, response is:

STX	30h	30h	31h	46h	LRC1	LRC2	ETX

8. Modbus Control via Remote Keypad

The Modbus Module can be used to connect a Remote Operator to the soft starter, enabling control via an RS485 serial communications network. See the Remote Operator instructions for details.

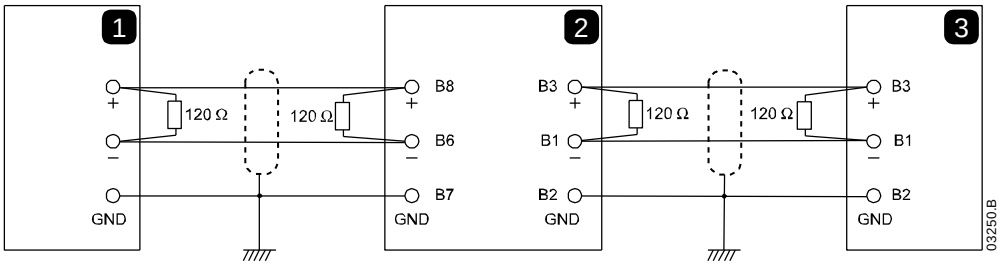
8.1 Grounding and Shielding

Twisted pair data cable with ground shield is recommended. The cable shield should be connected to the GND device terminal at both ends and one point of the site protective ground.

8.2 Termination Resistors

In long cable runs prone to excessive noise interference, termination resistors should be installed between the data lines at both ends of the RS485 cable. This resistance should match the cable impedance (typically 120 Ω). Do not use wire wound resistors.

Figure 8-1 Installation with termination resistors



1	Network master RS485
2	Remote Keypad RS485
3	Soft starter RS485

8.3 RS485 Data Cable Connection

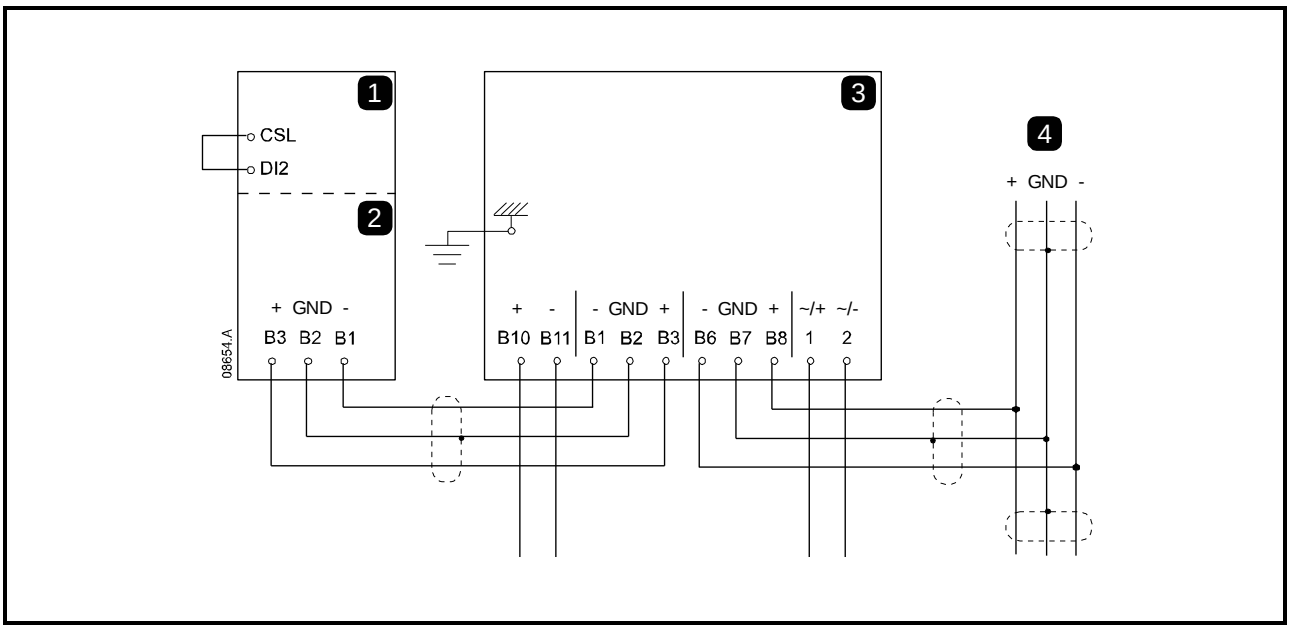
Daisy chain connection is recommended. This is achieved by parallel connections of the data cable at the actual device terminals.

8.4 Remote Keypad RS485 Network Connection Specifications

Input impedance: 12 kΩ
Common mode voltage range: - 7 V to + 12 V
Input sensitivity: ± 200 mV
Minimum differential output voltage: 1.5 V (with max loading of 54 Ω)

8.5 Using the Remote Keypad with Digistart CS

Figure 8-2 Modbus Module connections



1	Digistart CS	3	Remote Keypad
2	Module – RS485 serial port		B10, B11 - 4 to 20 mA analog output
			B1, B2, B3 - RS485 starter connection
			B6, B7, B8 - RS485 network connection
			1, 2 - Supply voltage (18 to 30 Vac/Vdc)
		4	RS485 Serial communication network connection (Modbus RTU or AP ASCII)

8.6 Programming

The Remote Keypad must be configured to operate on the network. In order to access Programming Mode, the Remote Keypad must be powered up when the soft starter is not running.

8.6.1 Programming Procedure

1. To enter Programming Mode, hold down the Data/Prog pushbutton for four seconds. The default value of the first parameter will be displayed.
2. Use the Data/Prog pushbutton to advance to the next parameter.
3. Use the Stop and Reset pushbuttons to adjust parameter values.

Programming Mode closes when the Data/Prog pushbutton is pressed after Pr **9**.

NOTE There is a 20 second timeout when the Remote Operator is in Programming Mode. Programming Mode will automatically close if no input is registered for 20 seconds. Any changes already made will be saved.

8.6.2 Programmable Parameters

The Remote Keypad offers the following programmable parameters:

Table 8-1 Programmable parameters

Parameter Number	Description	Default Setting	Adjustable Range
1	RS485 network baud rate	4 (9600 baud)	2 = 2400 baud 3 = 4800 baud 4 = 9600 baud 5 = 19200 baud 6 = 38400 baud
2	RS485 network satellite address	20	1 to 99
3	RS485 network timeout	0 seconds (= off)	0 to 100 seconds
4	RS485 network protocol	1 (AP ASCII)	1 = AP ASCII protocol 2 = Modbus RTU protocol
5	Modbus protocol parity	0 (no parity)	0 = no parity 1 = odd parity 2 = even parity 3 = 10-bit transmission
6	Motor FLC (A)	10	1 to 2868
7	Analog output 4 mA offset (%)	100	80 to 120
8	Start, Stop, Quick stop function disable	0	0 = Remote Keypad and Network start, stop, quick stop function enabled. 1 = Remote Keypad start, stop, quick stop function enabled. Network start, stop, quick stop function disabled. [2] 2 = Remote Keypad start, stop, quick stop function disabled. Network start, stop, quick stop function enabled. [1] 3 = Remote Keypad start, stop, quick stop function disabled. Network start, stop, quick stop function disabled. [1, 2]
9	Current ÷ 10	0	0 = off (required for Digistart CS) 1 = on (not suitable for Digistart CS)

[1] Remote Keypad Reset pushbutton is always enabled.

[2] RS485 Network reset and forced communication trip functions are always enabled.

NOTE Remote Operator Pr **9** *Current ÷ 10* normalises the displayed current and analog output for models IS0023B to IS0430N. Use Pr **9** in conjunction with Pr **6** *Motor FLC* as follows:

1. Set Pr **6** to a value 10 times greater than the actual motor nameplate FLC (e.g. for actual FLC = 4.6 A, set Pr **6** to **46**).
2. Set Pr **9** = 1.

8.7 Troubleshooting

The Remote Keypad display and status indication LEDs can indicate abnormal operating and system conditions.

Table 8-2 Error codes

Display Indication	Problem	Possible Solution
nEt on display	A loss of communication has been detected on the RS485 link to the network.	The Remote Keypad has an RS485 Network Timeout Protection setting (Pr **3**). This error is reported when no communication occurs for longer than the timeout setting. The system will become active as soon as communication is restored. To clear **nEt** from the display, press the Data/Prog pushbutton momentarily or send a Reset command from the network Master.
SP flashing on display	Soft starter is off and being programmed from the serial network.	Finish soft starter network programming procedure and exit Programming Mode.

9. Specifications

Enclosure

Dimensions ..... 40 mm (W) x 166 mm (H) x 90 mm (D)
Weight ..... 250 g
Protection IP20

Mounting

Spring-action plastic mounting clips (x 2)

Connections

Soft starter ..... 6-way pin assembly
Network ..... 5-way male and unpluggable female connector (supplied)
Maximum cable size 2.5 mm2

Settings

Protocol ..... Modbus RTU, AP ASCII
Address range ..... 0 to 31
Data rate (bps) 4800, 9600, 19200, 38400
Parity ..... None, Odd, Even, 10-bit
Timeout ..... None (off), 10 s, 60 s, 100 s

Certification

C✓ ..... IEC 60947-4-2
CE ..... IEC 60947-4-2
RoHS ..... Compliant with EU Directive 2002/95/EC

710-08009-00C