

# HBC

Holding brake controller

Product manual

V2.01, 03.2011



## Important information

This manual is part of the product.

Carefully read this manual and observe all instructions.

Keep this manual for future reference.

Hand this manual and all other pertinent product documentation over to all users of the product.

Carefully read and observe all safety instructions and the chapter "Before you begin - safety information".

Some products are not available in all countries.

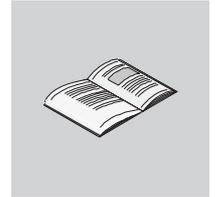
For information on the availability of products, please consult the catalog.

Subject to technical modifications without notice.

All details provided are technical data which do not constitute warranted qualities.

Most of the product designations are registered trademarks of their respective owners, even if this is not explicitly indicated.

## Table of contents

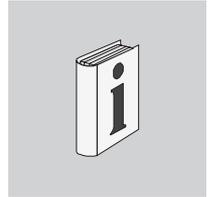


<b>Important information</b> . . . . .	<b>2</b>
<b>Table of contents</b> . . . . .	<b>3</b>
<b>About this manual</b> . . . . .	<b>5</b>
<b>1 Introduction</b> . . . . .	<b>7</b>
1.1 Overview of product properties . . . . .	7
<b>2 Before you begin - safety information</b> . . . . .	<b>9</b>
2.1 Qualification of personnel . . . . .	9
2.2 Intended use . . . . .	9
2.3 Hazard categories . . . . .	10
2.4 Basic information . . . . .	11
2.5 Standards and terminology . . . . .	12
<b>3 Technical Data</b> . . . . .	<b>13</b>
3.1 Ambient conditions . . . . .	13
3.2 Mechanical data . . . . .	15
3.2.1 Dimensions . . . . .	15
3.3 Electrical Data . . . . .	15
3.4 Declaration of conformity . . . . .	16
<b>4 Installation</b> . . . . .	<b>17</b>
4.1 Electromagnetic compatibility, EMC . . . . .	17
4.2 Mechanical installation . . . . .	17
4.3 Electrical installation . . . . .	18
4.3.1 Overview . . . . .	19
4.3.2 Connection of holding brake controller (HBC) . . . . .	20
4.3.3 Checking installation . . . . .	22
<b>5 Commissioning</b> . . . . .	<b>23</b>
5.1 Voltage reduction . . . . .	23
5.2 Checking the holding brake . . . . .	24

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<b>6</b>	<b>Service, maintenance and disposal</b>	<b>25</b>
6.1	Service address	25
6.2	Replacing products	25
6.3	Maintenance	25
6.4	Shipping, storage, disposal	26
<b>7</b>	<b>Glossary</b>	<b>27</b>
7.1	Units and conversion tables	27
7.1.1	Length	27
7.1.2	Mass	27
7.1.3	Force	27
7.1.4	Power	27
7.1.5	Rotation	28
7.1.6	Torque	28
7.1.7	Moment of inertia	28
7.1.8	Temperature	28
7.1.9	Conductor cross section	28
7.2	Terms and Abbreviations	29
<b>8</b>	<b>Index</b>	<b>31</b>

## About this manual



	This manual is valid for the holding brake controller HBC, VW3M3103.
<i>Source manuals</i>	The latest versions of the manuals can be downloaded from the Internet at: <a href="http://www.schneider-electric.com">http://www.schneider-electric.com</a>
<i>Corrections and suggestions</i>	We always try to further optimize our manuals. We welcome your suggestions and corrections. Please get in touch with us by e-mail: <a href="mailto:techcomm@schneider-electric.com">techcomm@schneider-electric.com</a> .
<i>Work steps</i>	If work steps must be performed consecutively, this sequence of steps is represented as follows: <ul style="list-style-type: none"> <li>■ Special prerequisites for the following work steps</li> <li>▶ Step 1</li> <li>◁ Specific response to this work step</li> <li>▶ Step 2</li> </ul> <p>If a response to a work step is indicated, this allows you to verify that the work step has been performed correctly.</p> <p>Unless otherwise stated, the individual steps must be performed in the specified sequence.</p>
<i>Making work easier</i>	Information on making work easier is highlighted by this symbol: <div style="display: flex; align-items: center; margin-top: 10px;"> <div style="border: 2px solid black; padding: 5px; margin-right: 10px;"> <div style="font-size: 2em; font-weight: bold; text-align: center;">i</div> </div> <div> <p><i>Sections highlighted this way provide supplementary information on making work easier.</i></p> </div> </div>
<i>SI units</i>	SI units are the original values. Converted units are shown in brackets behind the original value; they may be rounded. Example: Minimum conductor cross section: 1.5 mm <sup>2</sup> (AWG 14)
<i>Glossary</i>	Explanations of special technical terms and abbreviations.
<i>Index</i>	List of keywords with references to the corresponding page numbers.



# 1 Introduction

# 1

## 1.1 Overview of product properties

The holding brake controller, also referred to as HBC (Holding Brake Controller), is an accessory for drive systems used to control holding brakes with 24 V nominal voltage. Holding brakes with a current of up to 1.6 A can be controlled via a signal input.

Feature of the holding brake controller:

- Galvanic isolation of signal input and holding brake output
- Button for manual release of the holding brake to facilitate commissioning
- Rapid application of the holding brake by fast reduction of the holding brake current
- Automatic reduction of the voltage at holding brake output. This reduces the power dissipation of the holding brake by approx. 44%. (However, this function must be disabled for some motor types.)

Power supply (24 V, PELV-compliant) must be provided by the customer.



## 2 Before you begin - safety information

# 2

### 2.1 Qualification of personnel

Only appropriately trained persons who are familiar with and understand the contents of this manual and all other pertinent product documentation are authorized to work on and with this product. In addition, these persons must have received safety training to recognize and avoid hazards involved. These persons must have sufficient technical training, knowledge and experience and be able to foresee and detect potential hazards that may be caused by using the product, by changing the settings and by the mechanical, electrical and electronic equipment of the entire system in which the product is used.

All persons working on and with the product must be fully familiar with all applicable standards, directives, and accident prevention regulations when performing such work.

### 2.2 Intended use

This product is a controller for holding brakes and intended for industrial use according to this manual.

The product may only be used in compliance with all applicable safety regulations and directives, the specified requirements and the technical data.

Prior to using the product, you must perform a risk assessment in view of the planned application. Based on the results, the appropriate safety measures must be implemented.

Since the product is used as a component in an entire system, you must ensure the safety of persons by means of the design of this entire system (for example, machine design).

Operate the product only with the specified cables and accessories. Use only genuine accessories and spare parts.

The product must NEVER be operated in explosive atmospheres (hazardous locations, Ex areas).

Any use other than the use explicitly permitted is prohibited and can result in hazards.

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel.

## 2.3 Hazard categories

Safety instructions to the user are highlighted by safety alert symbols in the manual. In addition, labels with symbols and/or instructions are attached to the product that alert you to potential hazards.

Depending on the seriousness of the hazard, the safety instructions are divided into 4 hazard categories.

### DANGER

DANGER indicates an imminently hazardous situation, which, if not avoided, **will result** in death or serious injury.

### WARNING

WARNING indicates a potentially hazardous situation, which, if not avoided, **can result** in death, serious injury, or equipment damage.

### CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

### CAUTION

CAUTION used without the safety alert symbol, is used to address practices not related to personal injury (e.g. **can result** in equipment damage).

## 2.4 Basic information

### **⚠ DANGER**

#### **ELECTRIC SHOCK**

High voltages at the motor connection may occur unexpectedly.

- Verify that no voltage is present (this includes the DC bus) prior to taking up work on the drive system.
- AC voltage can couple voltage to unused conductors in the motor cable. Insulate both ends of unused conductors in the motor cable.
- The motor generates voltage when the shaft is rotated. Prior to performing any type of work on the drive system, block the motor shaft to prevent rotation.

**Failure to follow these instructions will result in death or serious injury.**

### **⚠ WARNING**

#### **LOSS OF CONTROL**

- The designer of any control scheme must consider the potential failure modes of control paths and, for certain critical functions, provide a means to achieve a safe state during and after a path failure. Examples of critical control functions are emergency stop, overtravel stop, power outage and restart.
- Separate or redundant control paths must be provided for critical functions.
- System control paths may include communication links. Consideration must be given to the implication of unanticipated transmission delays or failures of the link.
- Observe all accident prevention regulations and local safety guidelines.<sup>1)</sup>
- Each implementation of the product must be individually and thoroughly tested for proper operation before being placed into service.

**Failure to follow these instructions can result in death or serious injury.**

<sup>1)</sup> For USA: Additional information, refer to NEMA ICS 1.1 (latest edition), "Safety Guidelines for the Application, Installation, and Maintenance of Solid State Control" and to NEMA ICS 7.1 (latest edition), "Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drive Systems".

## **2.5 Standards and terminology**

Technical terms, terminology and the corresponding descriptions in this manual are intended to use the terms or definitions of the pertinent standards.

In the area of drive systems, this includes, but is not limited to, terms such as "safety function", "safe state", "fault", "fault reset", "failure", "error", "error message", "warning", "warning message", etc.

Among others, these standards include:

- IEC 61800 series: "Adjustable speed electrical power drive systems"
- IEC 61158 series: "Industrial communication networks - Fieldbus specifications"
- IEC 61784 series: "Industrial communication networks - Profiles"
- IEC 61508 series: "Functional safety of electrical/electronic/programmable electronic safety-related systems"

Also see the glossary at the end of this manual.

### 3 Technical Data

# 3

This chapter contains information on the ambient conditions and on the mechanical and electrical properties of the product family and the accessories.

#### 3.1 Ambient conditions

##### *Ambient conditions transportation and storage*

The environment during transport and storage must be dry and free from dust. The maximum vibration and shock load must be within the specified limits.

Temperature	°C	-25 ... +70
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##### *Climatic environmental conditions operation*

The maximum permissible ambient temperature during operation depends on the mounting distances between the devices and on the required power. Observe the pertinent instructions in the chapter 4 "Installation".

Ambient temperature (no icing, non-condensing)	[°C]	0 ... 50
--	------	----------

The following relative humidity is permissible during operation:

Relative humidity (non-condensing)	[%]	5 ... 85 As per IEC 60721-3-3, class 3K3
------------------------------------	-----	---

The installation altitude is defined as altitude above mean sea level.

Installation altitude without derating	[m]	<1000
Installation altitude if the following condition is met: • Reduction of the output current by 1% per 100 m above 1000 m	[m]	1000 ... 2000

##### *Pollution degree and degree of protection*

Pollution degree		2
Degree of protection		IP 20

##### *Vibration and shock*

Vibration, sinusoidal		Type test with 10 runs as per IEC 60068-2-6 1.5 mm (from 3 Hz ... 13 Hz) 10 m/s <sup>2</sup> (from 13 Hz ... 150 Hz)
Shock, semi-sinusoidal		Type test with 3 shocks in each direction as per IEC 60068-2-27 150 m/s <sup>2</sup> (for 11 ms)

*EMC*

Emission		IEC 61800 category C3, second environment (industrial)
Immunity		IEC 61800 second environment (industrial)

### 3.2 Mechanical data

#### 3.2.1 Dimensions

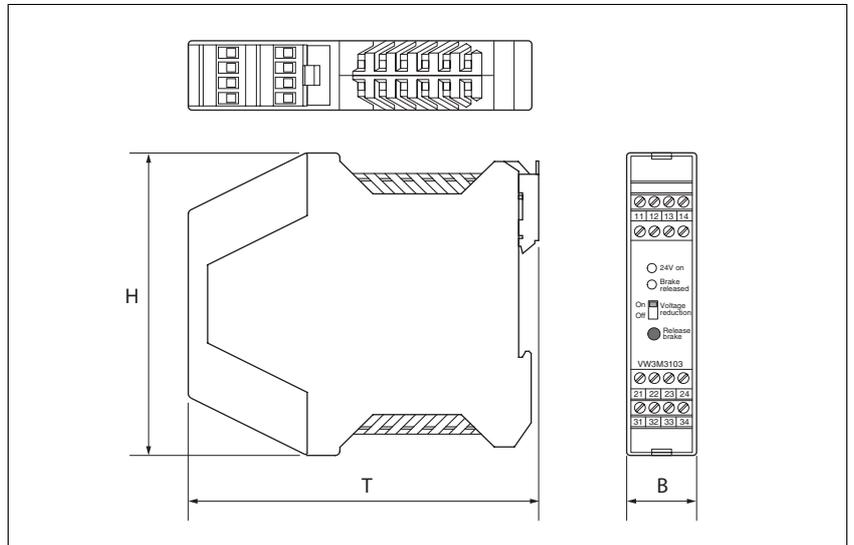


Figure 3.1 Dimensions

H	[mm]	99
B	[mm]	22.5
T	[mm]	114.5
Mass	[kg]	0.125

### 3.3 Electrical Data

*Supply* The supply voltage must meet the requirements of IEC 61131-2 (PELV standard power supply unit):

Nominal voltage	[V]	24
Voltage range	[V]	19.2 ... 30
Input current	[A]	0.5 + holding brake current

*Signal input*

Voltage range	[V]	19.2 ... 30
Input current at 24V	[mA]	<10

*Holding brake output*

The holding brake output is galvanically isolated from the supply voltage and from the signal input.

Output voltage without voltage reduction	[V]	23 ... 25
Output voltage with voltage reduction	[V]	17 ... 19
Time to voltage reduction	[ms]	1000
Output current	[A]	≤1.6

3.4 Declaration of conformity



SCHNEIDER ELECTRIC MOTION DEUTSCHLAND GmbH  
Breslauer Str. 7 D-77933 Lahr

**EC DECLARATION OF CONFORMITY**  
**YEAR 2011**

according to EC Directive on Machinery 2006/42/EC  
 according to EC Directive EMC 2004/108/EC  
 according to EC Directive Low Voltage 2006/95/EC

We hereby declare that the products listed below meet the requirements of the EC Directives indicated with respect to design, construction and version distributed by us. This declaration becomes invalid in the case of any modification to the products not authorized by us.

Designation:	Holding brake controller
Type:	HBC
Applied harmonized standards, especially:	EN 50178:1998 EN 61800-3:2001, second environment
Applied national standards and technical specifications, especially:	Product documentation

Company stamp: **Schneider Electric Motion Deutschland GmbH**  
Postfach 11 80 • D-77901 Lahr  
Breslauer Str. 7 • D-77933 Lahr

Date/Signature: 22 February 2011 *ppa. Hagemann*

Name/Department: Björn Hagemann/R & D

0198441113316, V2.01, 03.2011

## 4 Installation

# 4

### 4.1 Electromagnetic compatibility, EMC

#### ⚠ WARNING

##### SIGNAL AND DEVICE INTERFERENCE

Signal interference can cause unexpected responses of device.

- Install the wiring in accordance with the EMC requirements.
- Verify compliance with the EMC requirements.

**Failure to follow these instructions can result in death, serious injury or equipment damage.**

An EMC-compliant design is required to meet the specified limit values.

### 4.2 Mechanical installation

*Mounting distances, ventilation* When selecting the position of the product in the control cabinet, note the following:

- Adhere to the minimum installation distances for required cooling. Avoid heat accumulations.
- Do not mount the device close to heat sources.
- Do not mount the device on flammable materials.
- The heated airflow from other devices and components must not heat up the air used for cooling the device.

The mounting distances depend on the output current.

Condition	Mounting position and mounting distance
Output current <1 A	Any mounting position and no minimum mounting distance
Output current ≥1 A	Vertical (±10°) mounting position only and a lateral mounting distance of ≥10 mm.

*Mounting the product* ► Snap the product onto a TH35 rail as per IEC 60715 (DIN rail 35 mm).

### 4.3 Electrical installation

#### **⚠ DANGER**

##### **ELECTRIC SHOCK**

High voltages at the motor connection may occur unexpectedly.

- Verify that no voltage is present (this includes the DC bus) prior to taking up work on the drive system.
- AC voltage can couple voltage to unused conductors in the motor cable. Insulate both ends of unused conductors in the motor cable.
- The motor generates voltage when the shaft is rotated. Prior to performing any type of work on the drive system, block the motor shaft to prevent rotation.

**Failure to follow these instructions will result in death or serious injury.**

#### **⚠ WARNING**

##### **UNEXPECTED BEHAVIOR DUE TO EXTERNAL OBJECTS**

External objects, deposits or humidity can cause unexpected behavior.

- Do not use damaged products.
- Prevent external objects such as chips, screws or wire clippings from entering the product.
- Do not use products that contain external objects.

**Failure to follow these instructions can result in death, serious injury or equipment damage.**

## 4.3.1 Overview

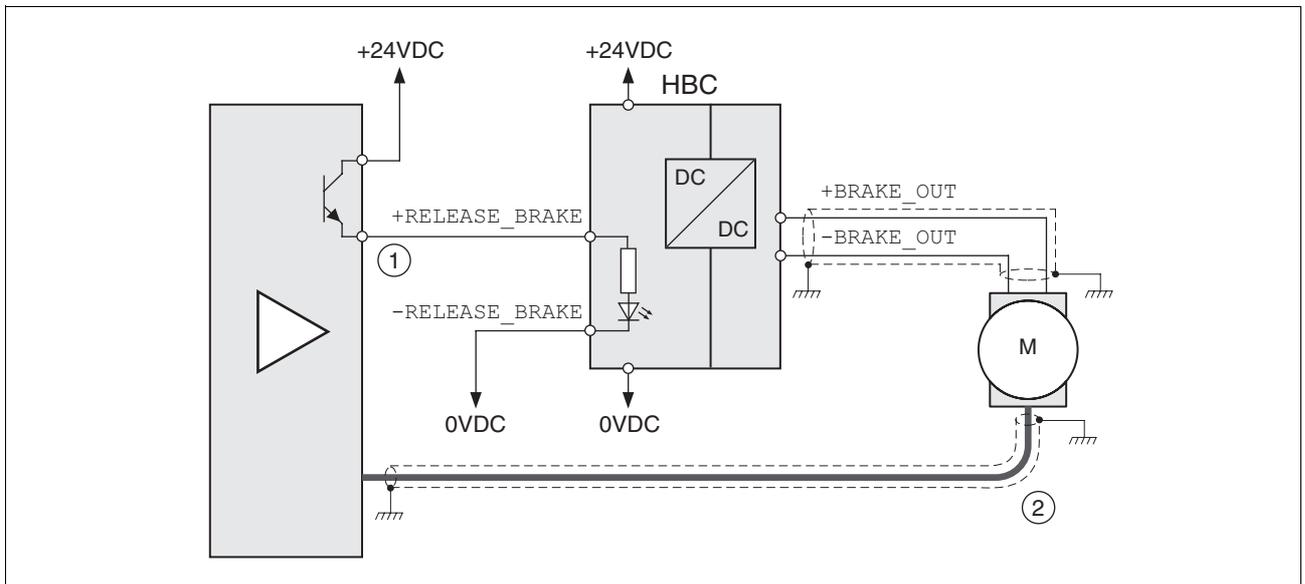


Figure 4.1 Connecting the HBC to the drive and the holding brake

- (1) Signal output of drive  
(for example, : +BRAKE\_OUT, ACTIVE1\_OUT or ACTIVE\_CON)
- (2) Motor cable (in the case of servo motors, the brake line is usually integrated in the motor cable.)

The circuit applies to the logic type "Source". For logic type "Sink", +RELEASE\_BRAKE must be connected to +24VDC and -RELEASE\_BRAKE must be connected to the signal output of the drive.

## 4.3.2 Connection of holding brake controller (HBC)

**⚠ DANGER****ELECTRIC SHOCK CAUSED BY INCORRECT POWER SUPPLY UNIT**

The +24VDC supply voltage is connected with many exposed signal connections in the drive system.

- Use a power supply unit that meets the PELV (Protective Extra Low Voltage) requirements.
- Connect the negative output of the power supply unit to PE (ground).

**Failure to follow these instructions will result in death or serious injury.**

**⚠ CAUTION****MISOPERATION OF THE HOLDING BRAKE CAUSED BY INCORRECT VOLTAGE**

If the voltage is incorrect, the holding brake cannot be released which causes wear.

- Note that if the voltage is higher than the specified value, the holding brake may be re-applied.
- Note that if the voltage polarity is incorrect, the holding brake cannot be released.
- Note the voltage drop in the cable according to the conductor cross section.
- Verify that the specified voltage is available at the holding brake connection.

**Failure to follow these instructions can result in injury or equipment damage.**

**CAUTION****DAMAGE TO CONTACTS**

The connection for the controller supply voltage at the product does not have an inrush current limitation. If the voltage is switched on by means of switching of contacts, damage to the contacts or contact welding may result.

- Use a power supply unit that limits the peak value of the output current to a value permissible for the contact.
- Switch the power input of the power supply unit instead of the output voltage.

**Failure to follow these instructions can result in equipment damage.**

*Connecting the supply*

Shield:	Not required
Twisted Pair:	Not required
PELV:	Required
Minimum conductor cross section:	The conductors must have a sufficiently large cross section so that the upstream fuse can trip in the case of overcurrent.
Maximum cable length:	-

- ▶ Verify that wiring, cables and connected interfaces meet the PELV requirements.
- ▶ Route the power supply cable from a power supply unit (PELV) to the holding brake controller.
- ▶ Ground the negative output at the power supply unit.

*Connecting the signal input*

Shield:	Not required
Twisted Pair:	Not required
PELV:	Required
Minimum conductor cross section:	0.2 mm <sup>2</sup> (AWG 24)
Maximum cable length:	-

- ▶ Connect the holding brake controller according to the wiring diagram.

*Connecting the holding brake output*

Shield:	Required
Twisted Pair:	Not required
PELV:	Not required
Minimum conductor cross section:	1.0 mm <sup>2</sup> (AWG 16)
Maximum cable length:	-

- ▶ Use a shielded cable to connect the holding brake. The length of the unshielded part of the cable must not exceed 150 mm.
- ▶ Insulate both ends of unused conductors of the cable.

*Properties of the terminals*

Maximum connection cross section with wire ferrule without plastic collar	[mm <sup>2</sup> ]	2.5 (AWG 14)
Maximum connection cross section with wire ferrule with plastic collar	[mm <sup>2</sup> ]	1.5 (AWG 16)
Stripping length	[mm]	7
Tightening torque	[Nm]	0.5 ... 0.6 (4.43 ... 5.31)

The terminals are approved for fine wire conductors and rigid conductors. Observe the maximum permissible connection cross section. Take into account the fact that wire ferrules increase the conductor cross section.

Wiring diagram

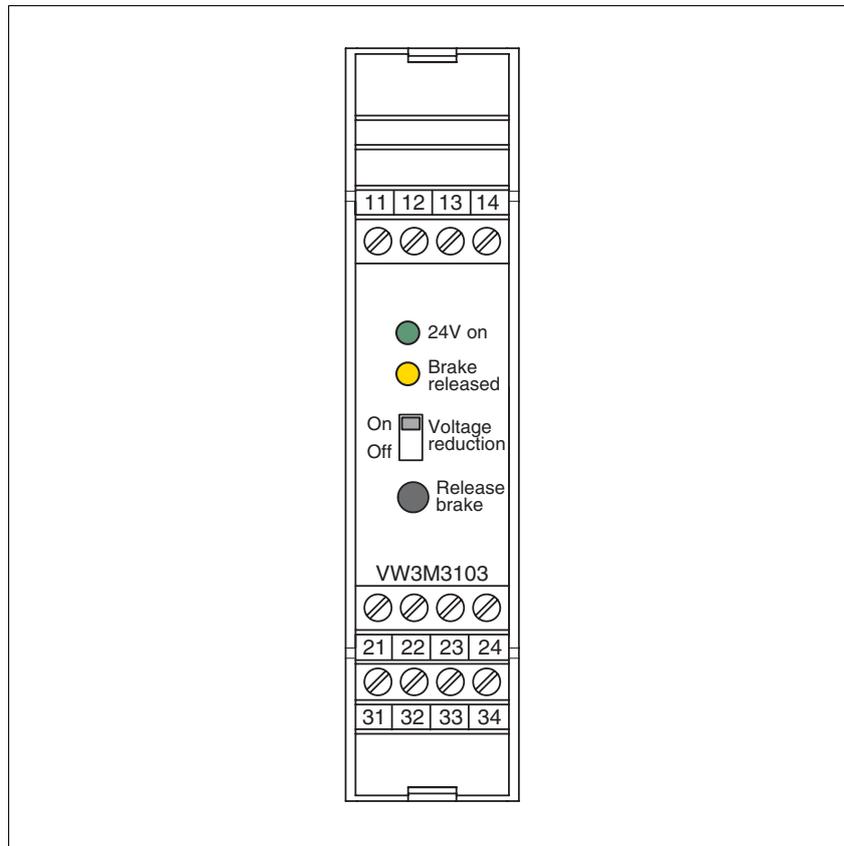


Figure 4.2 Wiring diagram holding brake controller

Pin	Signal	Meaning	I/O
11 or 21	+24VDC	Supply	I
12 or 22	0VDC	Reference potential to +24VDC	I
13 or 23	+RELEASE_BRAKE	Signal input	I
14 or 24	-RELEASE_BRAKE	Reference potential to +RELEASE_BRAKE	I
32	+BRAKE_OUT	Holding brake output	O
34	-BRAKE_OUT	Reference potential to +BRAKE_OUT	O

4.3.3 Checking installation

- ▶ Verify proper installation:
  - Did you properly connect the supply?
  - Did you properly connect the shields and PE (ground)?

## 5 Commissioning

# 5

Depending on the drive type, the following parameters for the holding brake must be set in the drive:

- Delay for releasing the holding brake
- Delay for applying the holding brake

See the product manual of the drive for information on parameter settings.

### 5.1 Voltage reduction

#### **▲ CAUTION**

##### **MISOPERATION OF THE HOLDING BRAKE CAUSED BY INCORRECT VOLTAGE**

If the voltage is incorrect, the holding brake cannot be released which causes wear.

- Note that if the voltage is higher than the specified value, the holding brake may be re-applied.
- Note that if the voltage polarity is incorrect, the holding brake cannot be released.
- Note the voltage drop in the cable according to the conductor cross section.
- Verify that the specified voltage is available at the holding brake connection.

**Failure to follow these instructions can result in injury or equipment damage.**

If the holding brake controller voltage reduction is activated, the voltage at the holding brake output is reduced after a delay time. This reduces the power dissipation of the holding brake by approximately 44%.

- ▶ Use the "Voltage reduction" switch to set the voltage reduction as required for the type of motor used.

Observe the specifications in the motor manual.

## 5.2 Checking the holding brake

### ⚠ WARNING

#### UNEXPECTED MOVEMENT

Releasing the holding brake may cause an unexpected movement in the system, for example if vertical axes are used.

- Take appropriate measures to avoid damage caused by falling or lowering loads.
- Only run the test if there are no persons or obstacles in the hazardous area.

**Failure to follow these instructions can result in death, serious injury or equipment damage.**

#### *Checking from HBC to holding brake*

- Supply voltage is available at the holding brake controller. The "24 V on" LED is on.
- ▶ Switch off the power stage supply of the drive.
- ▶ Press the "Release brake" button at the HBC several times to alternately release and apply the holding brake.
- ◁ The LED "Brake released" at the HBC flashes when voltage is available at the holding brake output and the brake is released via the button.
- ▶ Check whether the motor can be moved manually when the holding brake is released (take the gearbox into consideration, if applicable).

#### *Checking from drive to HBC*

- Depending on the drive type, the parameters for the holding brake must be set in the drive. See the product manual of the drive for information on parameter settings.
- ▶ Start the drive and trigger a motor movement.
- ◁ The holding brake is released. The LED "Brake released" at the HBC lights when voltage is available at the holding brake output and the brake is released.

#### *"Release brake" button*

A holding brake released via the "Release brake" button is applied when the supply voltage is interrupted or when the edge at the signal input `RELEASE_BRAKE` falls.

The holding brake is not released again when the supply voltage is switched on.

## 6 Service, maintenance and disposal

# 6

### 6.1 Service address

If you cannot resolve an error yourself please contact your sales office. Have the following details available:

- Nameplate (type, identification number, serial number, DOM, ...)
- Type of error (with LED flash code or error number)
- Previous and concomitant circumstances
- Your own assumptions concerning the cause of the error

Also include this information if you return the product for inspection or repair.



*If you have any questions please contact your sales office. Your sales office staff will be happy to give you the name of a customer service office in your area.*

<http://www.schneider-electric.com>

### 6.2 Replacing products

Observe the following procedure when replacing products.

- ▶ Record the settings.
- ▶ Switch off all supply voltages. Verify that no voltages are present (safety instructions).
- ▶ Label all connections and uninstall the product.
- ▶ Note the identification number and the serial number shown on the product nameplate for later identification.
- ▶ Install the new product as per chapter 4 "Installation".
- ▶ Commission the product as per chapter 5 "Commissioning".

### 6.3 Maintenance

Check the product for pollution or damage at regular intervals.



*The product may only be repaired by a Schneider Electric customer service center. No warranty or liability is accepted for repairs made by unauthorized persons.*

### 6.4 Shipping, storage, disposal

- Shipping* The product must be protected against shocks during transportation. If possible, use the original packaging for shipping.
- Storage* The product may only be stored in spaces where the specified permissible ambient conditions are met.  
Protect the product from dust and dirt.
- Disposal* The product consists of various materials that can be recycled. Dispose of the product in accordance with local regulations.

## 7 Glossary

# 7

### 7.1 Units and conversion tables

The value in the specified unit (left column) is calculated for the desired unit (top row) with the formula (in the field).

Example: conversion of 5 meters [m] to yards [yd]  
 $5 \text{ m} / 0.9144 = 5.468 \text{ yd}$

#### 7.1.1 Length

	in	ft	yd	m	cm	mm
in	-	/ 12	/ 36	* 0.0254	* 2.54	* 25.4
ft	* 12	-	/ 3	* 0.30479	* 30.479	* 304.79
yd	* 36	* 3	-	* 0.9144	* 91.44	* 914.4
m	/ 0.0254	/ 0.30479	/ 0.9144	-	* 100	* 1000
cm	/ 2.54	/ 30.479	/ 91.44	/ 100	-	* 10
mm	/ 25.4	/ 304.79	/ 914.4	/ 1000	/ 10	-

#### 7.1.2 Mass

	lb	oz	slug	kg	g
lb	-	* 16	* 0.03108095	* 0.4535924	* 453.5924
oz	/ 16	-	* $1.942559 \cdot 10^{-3}$	* 0.02834952	* 28.34952
slug	/ 0.03108095	/ $1.942559 \cdot 10^{-3}$	-	* 14.5939	* 14593.9
kg	/ 0.45359237	/ 0.02834952	/ 14.5939	-	* 1000
g	/ 453.59237	/ 28.34952	/ 14593.9	/ 1000	-

#### 7.1.3 Force

	lb	oz	p	dyne	N
lb	-	* 16	* 453.55358	* 444822.2	* 4.448222
oz	/ 16	-	* 28.349524	* 27801	* 0.27801
p	/ 453.55358	/ 28.349524	-	* 980.7	* $9.807 \cdot 10^{-3}$
dyne	/ 444822.2	/ 27801	/ 980.7	-	/ $100 \cdot 10^3$
N	/ 4.448222	/ 0.27801	/ $9.807 \cdot 10^{-3}$	* $100 \cdot 10^3$	-

#### 7.1.4 Power

	HP	W
HP	-	* 746
W	/ 746	-

## 7.1.5 Rotation

	min <sup>-1</sup> (RPM)	rad/s	deg./s
min <sup>-1</sup> (RPM)	-	* $\pi / 30$	* 6
rad/s	* $30 / \pi$	-	* 57.295
deg./s	/ 6	/ 57.295	-

## 7.1.6 Torque

	lb-in	lb-ft	oz-in	Nm	kp-m	kp-cm	dyne-cm
lb-in	-	/ 12	* 16	* 0.112985	* 0.011521	* 1.1521	* $1.129 \times 10^6$
lb-ft	* 12	-	* 192	* 1.355822	* 0.138255	* 13.8255	* $13.558 \times 10^6$
oz-in	/ 16	/ 192	-	* $7.0616 \times 10^{-3}$	* $720.07 \times 10^{-6}$	* $72.007 \times 10^{-3}$	* 70615.5
Nm	/ 0.112985	/ 1.355822	/ $7.0616 \times 10^{-3}$	-	* 0.101972	* 10.1972	* $10 \times 10^6$
kp-m	/ 0.011521	/ 0.138255	/ $720.07 \times 10^{-6}$	/ 0.101972	-	* 100	* $98.066 \times 10^6$
kp-cm	/ 1.1521	/ 13.8255	/ $72.007 \times 10^{-3}$	/ 10.1972	/ 100	-	* $0.9806 \times 10^6$
dyne-cm	/ $1.129 \times 10^6$	/ $13.558 \times 10^6$	/ 70615.5	/ $10 \times 10^6$	/ $98.066 \times 10^6$	/ $0.9806 \times 10^6$	-

## 7.1.7 Moment of inertia

	lb-in <sup>2</sup>	lb-ft <sup>2</sup>	kg-m <sup>2</sup>	kg-cm <sup>2</sup>	kp-cm-s <sup>2</sup>	oz-in <sup>2</sup>
lb-in <sup>2</sup>	-	/ 144	/ 3417.16	/ 0.341716	/ 335.109	* 16
lb-ft <sup>2</sup>	* 144	-	* 0.04214	* 421.4	* 0.429711	* 2304
kg-m <sup>2</sup>	* 3417.16	/ 0.04214	-	* $10 \times 10^3$	* 10.1972	* 54674
kg-cm <sup>2</sup>	* 0.341716	/ 421.4	/ $10 \times 10^3$	-	/ 980.665	* 5.46
kp-cm-s <sup>2</sup>	* 335.109	/ 0.429711	/ 10.1972	* 980.665	-	* 5361.74
oz-in <sup>2</sup>	/ 16	/ 2304	/ 54674	/ 5.46	/ 5361.74	-

## 7.1.8 Temperature

	°F	°C	K
°F	-	(°F - 32) * 5/9	(°F - 32) * 5/9 + 273.15
°C	°C * 9/5 + 32	-	°C + 273.15
K	(K - 273.15) * 9/5 + 32	K - 273.15	-

## 7.1.9 Conductor cross section

AWG	1	2	3	4	5	6	7	8	9	10	11	12	13
mm <sup>2</sup>	42.4	33.6	26.7	21.2	16.8	13.3	10.5	8.4	6.6	5.3	4.2	3.3	2.6

AWG	14	15	16	17	18	19	20	21	22	23	24	25	26
mm <sup>2</sup>	2.1	1.7	1.3	1.0	0.82	0.65	0.52	0.41	0.33	0.26	0.20	0.16	0.13

## 7.2 Terms and Abbreviations

See chapter 2.5 "Standards and terminology" for information on the pertinent standards on which many terms are based. Some terms and abbreviations may have specific meanings with regard to the standards.

<i>Degree of protection</i>	The degree of protection is a standardized specification for electrical equipment that describes the protection against the ingress of foreign objects and water (for example: IP 20).
<i>DOM</i>	<b>Date of manufacturing:</b> The nameplate of the product shows the date of manufacture in the format DD.MM.YY or in the format DD.MM.YYYY. Example: 31.12.09 corresponds to December 31, 2009 31.12.2009 corresponds to December 31, 2009
<i>EMC</i>	Electromagnetic compatibility
<i>Error</i>	Discrepancy between a detected (computed, measured or signaled) value or condition and the specified or theoretically correct value or condition.
<i>ESD</i>	<b>(electrostatic discharge)</b> is the electrostatic discharge and describes processes and effects occurring during the discharge of electric charges.
<i>LED</i>	Light Emitting Diode
<i>PELV</i>	Protective Extra Low Voltage, low voltage with isolation. For more information: IEC 60364-4-41
<i>Power stage</i>	The power stage controls the motor. The power stage generates current for controlling the motor on the basis of the positioning signals from the controller.



**8 Index****8****A**

Abbreviations 29  
Ambient conditions 13

**B**

Before you begin  
    Safety information 9

**C**

Commissioning 23  
    Holding brake, checking 24  
Connection  
    holding brake controller 20

**D**

Declaration of conformity 16  
Degree of protection 13  
dimensional drawing, see dimensions  
Dimensions 15  
Disposal 25, 26

**E**

Electrical installation 18  
EMC 17

**G**

Glossary 27

**H**

Hazard categories 10  
holding brake controller  
    connection 20  
Holding brake, checking 24

**I**

Installation  
    electrical 18  
    mechanical 17  
Intended use 9  
Introduction 7  
IP degree of protection 13

**M**

Maintenance 25  
Manuals  
    Source 5

Mechanical installation 17  
Mounting distances 17

## O

Overview 19

## P

Pollution degree 13

## Q

Qualification of personnel 9

## S

Service 25  
Service address 25  
Shipping 26  
Source  
    Manuals 5  
Storage 26

## T

Technical data 13  
Terms 29

## U

Units and conversion tables 27

## V

Ventilation 17  
Voltage reduction 23