

BODAS Controller

RC10-10 Series 31

RE 95206

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- ▶ For closed- and open-loop control of hydraulic components

Features

- ▶ High performance thanks to 32-bit TriCore technology with 270 MHz
- ▶ Component of the BODAS system for mobile applications
- ▶ Robust and compact design meeting specifications for mobile applications
- ▶ High Electromagnetic Compatibility (EMC)
- ▶ Inputs and outputs with fault detection
- ▶ Central output deactivation
- ▶ Pulse-Width-Modulated (PWM) solenoid currents for minimal hysteresis
- ▶ Closed-loop control of solenoid currents, i.e. not dependent on supply voltage and temperature

Main components

- ▶ 20 power outputs, 10 of which current-controlled
- ▶ 9 low power signal outputs
- ▶ 46 multi-functional input pins
- ▶ Program sequence monitoring with watchdog
- ▶ Two independent sensor voltage supplies
- ▶ Four independent CAN bus interfaces (one of which useable for ISOBUS and one with wake-up function)
- ▶ One LIN interface

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Ordering code

01	02	03
RC	10-10	/ 31

Type

01	BODAS controller	RC
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Version

02	1 st number: number of proportional power outputs ¹⁾ 2 nd number: number of power switching outputs	10-10
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Series

03	Series 3, index 1	31
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Notes:

- ▶ The BODAS controllers are not functional without software.
- ▶ In order to use the BODAS controllers, you also need:
 - BODAS standard software or
 - application-specific software
- ▶ If there is a sample label on the name plate, it is a prototype or sample, i.e., components not released for series production.

Possible sample labels are:

- SC: A
- SC: B
- SC: C
- SC: S (prototype software)

Optional accessories

▶ BODAS-design software

The windows-based PC software BODAS-design (see data sheet 95112) can be used for programming this BODAS RC controller. All graphical and textual programming languages specified according to IEC 61131-3 are available. Restrictions regarding the languages apply for safety related applications (see safety-relevant project planning instruction).

▶ BODAS-service software

The windows-based PC software BODAS-service (see data sheet 95086) is used for displaying functions, errors and system variables as well as for setting parameters via a PC. It is also used for flashing programs from a PC onto the controller.

▶ C programming interface C-API

The programming interface C-API (see data sheet 95115) can be used for programming this BODAS RC controller in the programming language C. All required functions that are needed for the configuration and the reading of the inputs, the control of the outputs, the use of the communication interfaces and the creation of the diagnostics information for BODAS-service are available to the user in the form of a software library.

Additionally, the user needs a C Compiler, with which the created program is translated into a machine code that is readable for the BODAS controller.

▶ BODAS measuring adapter MA8

The BODAS measuring adapter MA8 (see data sheet 95090) facilitates measuring all electrical signals at the inputs, outputs and interfaces of the BODAS controller. For testing purposes, it is connected in series between the RC controller and the vehicle or device wiring.

▶ BODAS TB3 test box

The BODAS test box TB3 is used for simulation of vehicle and device functions for development and testing purposes with BODAS controllers. The BODAS TB3 test box is connected to the controller via an adapter cable. A stencil provides channel designations specific for this controller. For details see data sheet 95092.

All products mentioned here are available from Bosch Rexroth.

Further information can be found on the internet at:
www.boschrexroth.com/mobile-electronics

¹⁾ Includes Low-side proportional outputs that must be used in combination with High-side outputs.

Description

The BODAS controller RC10-10/31 is designed as a universal controller for mobile working machines. State-of-the-art 32-bit TriCore technology, a clock frequency of 270 MHz and numerous I/O functions account for a controller with high power density in a compact housing. The controller is used for the programmable control of proportional and switching solenoids as well as additional electrical switching functions. Typical applications are electrohydraulically actuated work functions, travel drives and transmission controls.

Internally the BODAS controller RC10-10 series 31 contains a powerful 32-bit TriCore microprocessor TC1793, all input and output circuitry and a power supply unit for operation with 12 or 24 volt nominal supply voltages.

With 20 power outputs, 9 small signal outputs, a total of 51 input channels, two constant voltage sources and four CAN buses for communication in the vehicle, the RC10-10/31 controllers form a powerful platform for controlling mobile working machines.

The ten current-controlled, pulse-width-modulated (PWM) outputs are used in particular for controlling proportional solenoids. Current control guarantees the set-point current even if the supply voltage or the temperature of the solenoid changes and it is characterized by minimal hysteresis. The PWM outputs match the electrical proportional control of Rexroth axial piston units and valves. 10 switching outputs can be used for switching solenoids, relays or other electrical consumers.

Up to 12 inputs may be used to measure frequency signals. Eight of these inputs are configured for active frequency sensors and six of these can read in Rexroth DSM1-10 speed sensors with integrated diagnosis function.

Four resistance inputs are used, for example, to directly connect temperature sensors and may be used to acquire frequency signals alternatively.

Eight inputs can be used for connecting sensor via the SAE J2716 SENT interface.

The other inputs can be used for measuring analog voltages or as switching inputs.

The inputs are protected against overvoltage and electrical interference. The voltage inputs can be monitored to detect cable breaks or short circuits.

CAN bus interfaces are available with all BODAS controllers RC for exchanging data with other bus users or electronic systems (e.g. controller RC, I/O extension module, joystick, engine control unit, display).

Four independent CAN bus interfaces, each of which can be operated with various protocols, are available in the RC10-10/31 BODAS controller. One of these CAN interfaces can be used to wake up the controller. Another one features ISOBUS termination. Communication with a service tool is also conducted via a CAN interface. The RC10-10/31 controller is supported as standard by the Rexroth tool BODAS-service.

An application interface in the form of a C-API is available for programming the controller in high level language C. This allows the software developer to concentrate on the important functions of the machine without having to become immersed in the details of the TriCore technology and the hardware of the controller.

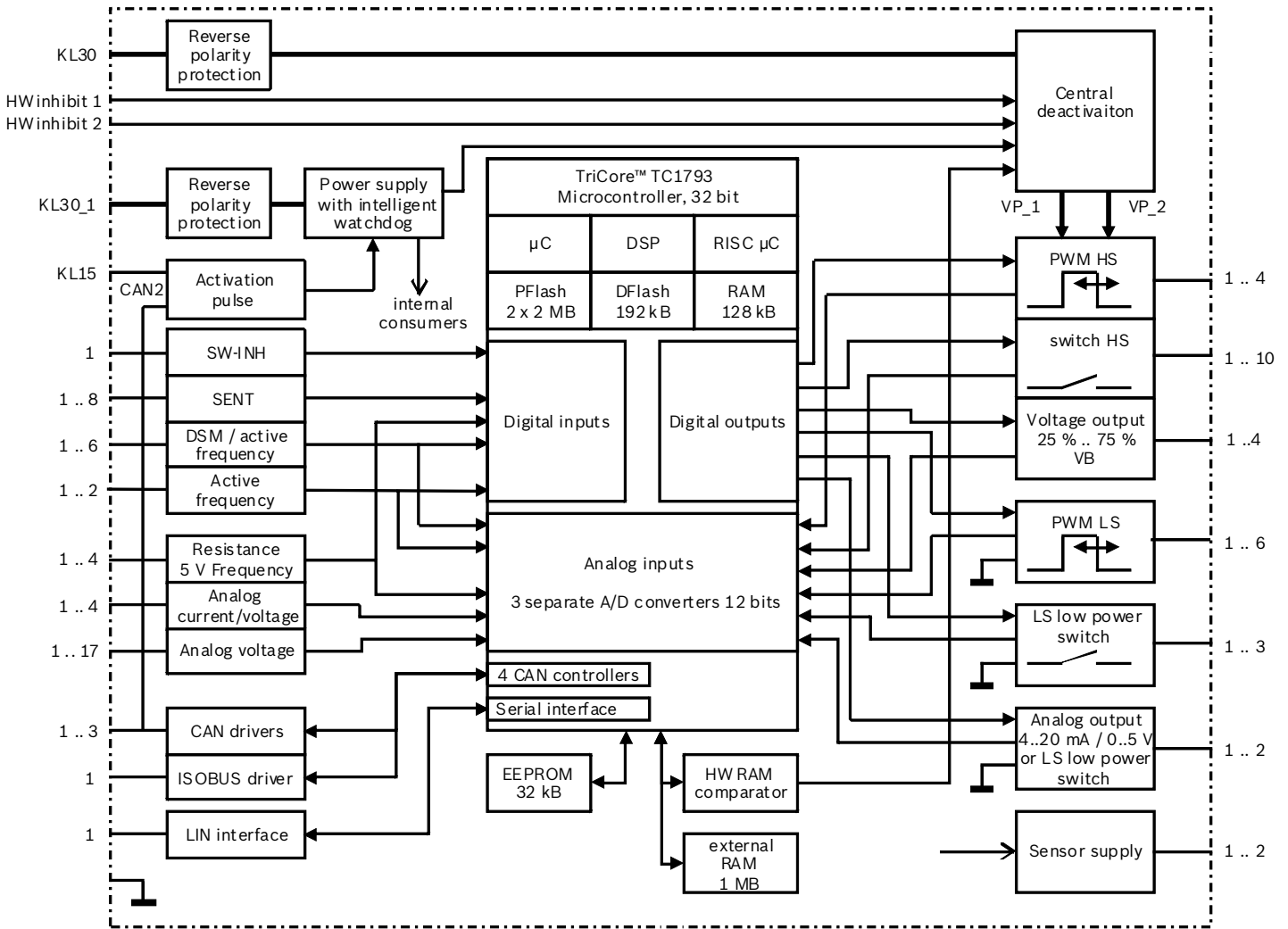
Simple and flexible programming of the BODAS controller according to the industry standard IEC 61131-3, which enables a very convenient and rapid introduction to the programming of the RC10-10/31, is possible with the BODAS-design software. Comprehensive and complex applications can be conveniently developed and clearly represented with BODAS-design.

With the BODAS-service software, the programs can be quickly and simply downloaded to the controller via the Flash module. Extensive service functions, such as diagnostics, parameter setting or display of process variables are available via the graphical Windows interface of BODAS-service. This enables simple parameter setting and diagnostics in order to place the machine in service rapidly and safely.

The BODAS controllers RC were developed specifically for use in mobile working machines and satisfy corresponding protection requirements regarding ambient temperatures, water and dust ingress, shock and vibration as well as electromagnetic compatibility (EMC). BODAS controllers RC and corresponding software in combination with pumps, motors, valves, sensors, input devices and actuators from Rexroth make for complete system solutions.

The RC10-10/31 controller can be used for safety functions according to ISO 25119 or EN ISO 13849. Safety-relevant project planning instructions have to be observed if such safety functions shall be implemented or the two-channel stop function shall be used. These instructions are available on request.

Block circuit diagram



Abbreviations	
μC	Microcontroller
DSP	Digital signal processor
RISC	Reduced instruction set computer
PFlash	program flash
DFlash	Data flash
RAM	Random Access Memory

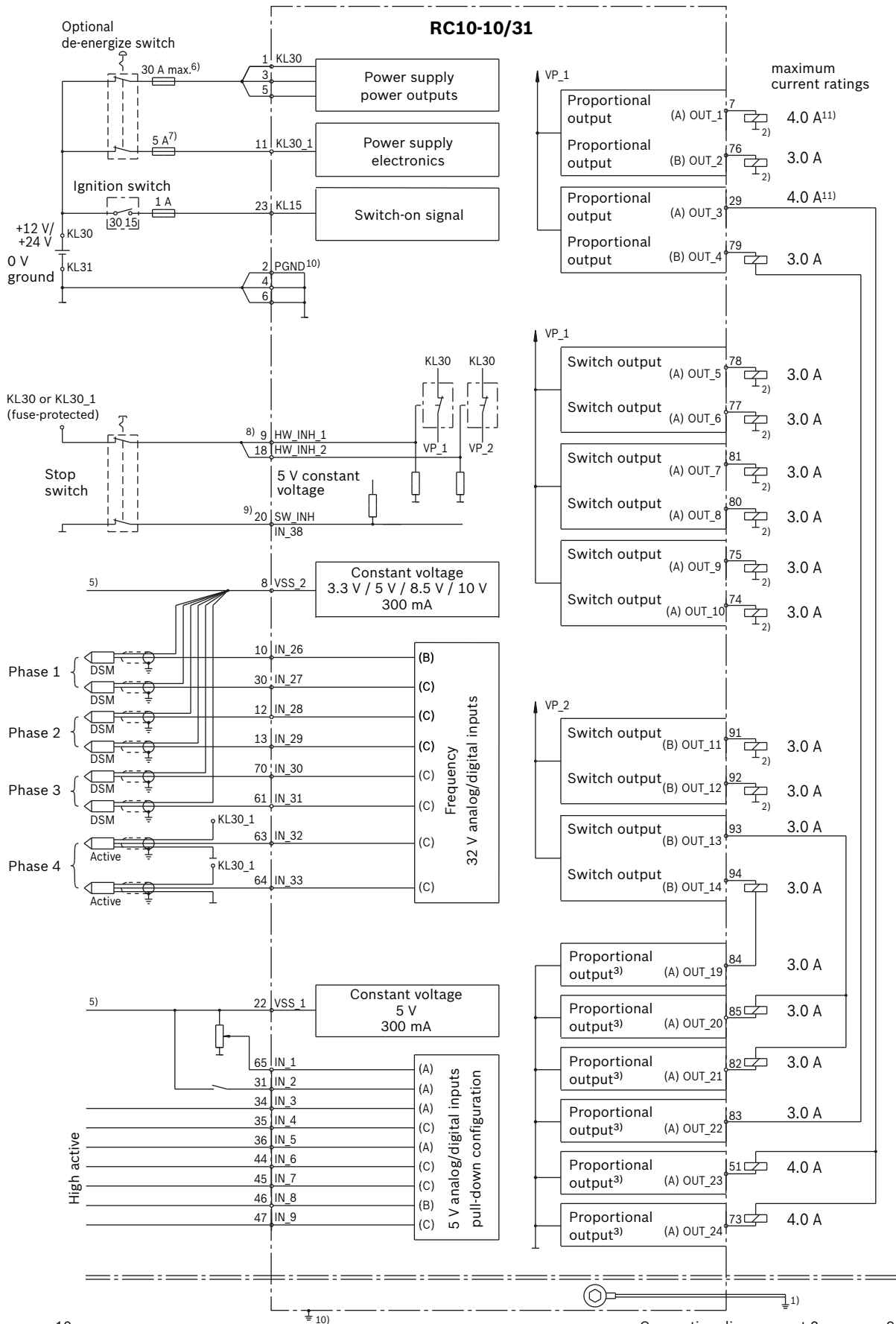
Technical data

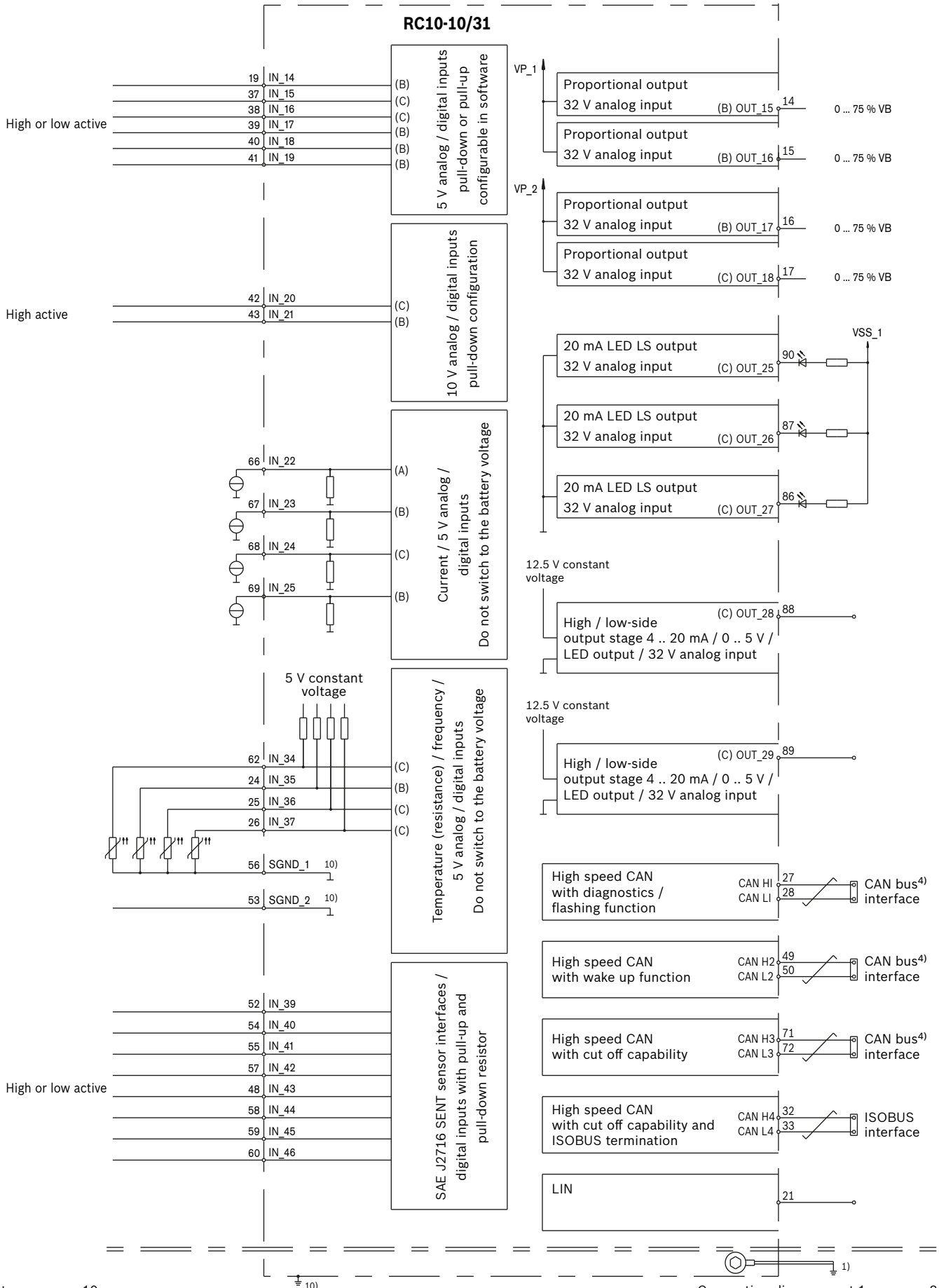
BODAS Controller		RC10-10 Series 31
Supply voltage		
Nominal		12 V DC and 24 V DC
Permissible range		8 V DC to 32 V DC
Current consumption		
Standby current		<1 mA at 32 V
Without load, in the 12 V vehicle electrical system, approx.		280 mA
Without load, in the 24 V vehicle electrical system, approx.		210 mA
Fuses		
Internal		–
External in supply path for power outputs		max. 30 A
External in supply path for internal electronics		5 A
Constant voltage sources, total		2
300 mA	5 V ± 2.5 %	1
300 mA	3.3 V, 5 V, 8.5 V, 10 V ±10 %	1
Analog voltage inputs, total (can be used as digital inputs, partially provided as alternative function)		42
0 to 5 V		23
0 to 10 V		2
0 to 32 V		17
Digital voltage inputs, total (alternative function of other inputs)		51
Analog input with digital evaluation in software (see above)		42
SENT inputs used as digital inputs		8
Software inhibit input used as digital input		1
Resistance inputs		
Measurable resistance range	0 Ω to 50 kΩ	4
Frequency inputs, total		12
Active sensors	typical 0 Hz .. 20 kHz	2
DSM (can be used as active speed sensor input alternatively)	typical 0 Hz .. 20 kHz	6
5 V frequency inputs (alternative function of resistance inputs)	typical 0 Hz .. 20 kHz	4
Analog outputs, total		6
0 .. 5 V or 4 .. 20 mA		2
25 % .. 75 % V_{bat}		4
Digital sensor interfaces		
SAE J2716 SENT		8
Low current switch outputs (typically used for LED), total		5
Low side switch output (up to 20 mA)		3
Low side switch output as alternative function of 5 V / 20 mA analog outputs (see above)		2
Proportional solenoid output, total		10
Current-controlled high-side PWM output stage	0 .. 3 A, PWM up to 250 Hz	2
	0 .. 4 A, PWM up to 250 Hz	2
Current-controlled low-side PWM output stage	0 .. 3 A, PWM up to 1 kHz	4
Use with loads powered from high-side outputs	0 .. 4 A, PWM up to 1 kHz	2
Digital power output stages		
Switch output stage	max. 3 A	10
Can be used to power loads with current control on the low-side		

BODAS Controller	RC10-10 Series 31
Communication interfaces, total	5
CAN 2.0 B	3
ISOBUS	1
LIN	1
Fault detection in the event of cable break and short circuit	
Inputs (dependent on pull-up / pull-down resistor)	●
Outputs	●
LIN	●
CAN	●
Protection against short circuits to supply voltage and ground (Requirement: controller is powered and running, i.e. KL_30, KL30_1 and KL15 connected to VB, ground pins connected to vehicle ground, processor runs valid software)	
Inputs	●
Outputs	●
LIN	●
CAN	●
Reverse polarity protection	
Power supply power outputs	●
Power supply electronics	●
Microcontroller	SAK-TC1793
Clock frequency	
Processor clock	270 MHz
Internal memory capacity in microcontroller	
SRAM	128 kB
DFlash	192 kB
PFlash with ECC Check C-API or BODAS-design manual for the use of the 2 nd PFlash area	organized in two separate address areas 2 x 2 MB
External memory capacity in RC controller	
RAM with CRC	1 MB
EEPROM	32 kB
Software installation	
Download in PFlash	●

BODAS Controller		RC10-10 Series 31
Durability testing		
Simulated field use of 10 years with 10,000 operating hours		●
Electromagnetic compatibility		
Spurious interference (ISO 11452-2)		150 V _{RMS} /m
Spurious interference (ISO 11452-4)		BCI: 100 mA
Load dump with 12 V battery voltage		●
Load dump with 24 V battery voltage		●
Electrostatic Discharge ESD (according to ISO 10605)		
Direct contact unpowered / powered up		8 kV / 8 kV
Air discharge unpowered / powered up		15 kV / 15 kV
Maximum power dissipation		
Internal Electronics		4 W to 6 W
Output stages		45 W (32 V, 30 A)
Operating temperature, housing		
With mounting point on cooling surface		-40 to +85 °C (-40 to +185 °F)
Temperature of cooling surface		+60 °C (140 °F)
Storage temperature, housing		
Maximum permissible housing temperature momentary, passive:		-40 to +105 °C (-40 to +221 °F)
Vibration resistance, broadband noise oscillations (ISO 16750-3)		
57.9 m/s ² , 10 to 1000 Hz, 32 h per axis		●
10 Hz: 18 (m/s ²) ² /Hz		●
20 Hz: 36 (m/s ²) ² /Hz		●
30 Hz: 36 (m/s ²) ² /Hz		●
180 Hz: 1 (m/s ²) ² /Hz		●
2000 Hz: 1 (m/s ²) ² /Hz		●
Shock resistance		
Transport shock (IEC 60068-2-27)		a = 30 m/s ² ; t = 18 ms 1000 times per spatial axis x, y, z and in each direction (pos./neg.)
Moisture resistance (IEC 60068-2-11 Db version 2)		
90–96 % (+25 °C to +55 °C)		●
Salt spray resistance (DIN EN 60068-2-11 Ka)		
NaCl 5%		●
pH value 6.5 – 7.2		●
144 h 35 °C		●
Type of protection (ISO 20653)		
With installed mating connector including wire seals and dummy plugs		IP65
Housing material		
Cover		Die-cast aluminium
Base		Deep-drawn sheet metal
Weight		640 g ±5%
Outer dimensions		
Without mating connector		
Length		203 ±1 mm
Width		167.3 mm
Height		37.9 mm
Mating connector		
One connector chamber		94 male pins

Connection diagram





Footnotes for the connection diagram

- 1) Short, low-resistance connection from a case screw to the vehicle ground.
- 2) Own ground connection to battery (chassis possible).
- 3) Loads connected to low side outputs must be powered from high side outputs of the same controller. Stand-alone operation of low side outputs is not permissible.
Deviations from that rule require additional measures. Please contact Bosch Rexroth.
Combinations between high side and low side outputs different from the ones shown are possible. These are examples only. For more information see safout() function in the API manual.
- 4) CAN bus: 120 Ω termination resistor and twisted line necessary.
- 5) Constant voltage sources can be used as sensor supply or switching voltage for switches/push-buttons.
- 6) Can be adjusted to the actual current consumption of the consumers and must be adjusted to the permissible loading of the lines and pins.
- 7) If deactivated during operation, data will not be saved in the non-volatile memory and there will be no after run.
- 8) First deactivation channel: deactivation with level < 4 V (open / cable break); activation with level > 7 V (switch to terminal 30 or 30_1). When deactivated the respective main switch VP_x is off.
The main switches can be deactivated together (as shown) or separately.
- 9) Second deactivation channel: deactivation with level > 3 V (open / cable break); activation with level < 0.4 V (switch to ground). The second deactivation channel shuts of output stage control via the processor's emergency stop function.
For more information on deactivation channels please see the respective programming manual and safety-relevant project planning instructions.
- 10) Terminal 31 (PGND) and sensor grounds (SGND_x) are joined at a star point in the controller and are connected to the housing.
SGND_1 shall be used for the ground connection of analog sensors and SGND_2 shall be used for the ground connection of digital sensors.
- 11) The total current out of OUT_1 and OUT_2 must not exceed 6 A.
The total current out of OUT_3 and OUT_4 must not exceed 6 A.

The designations (A), (B), (C) indicate the respective ADC channel used for this input or current feedback.

Overview of functions

Pin	Description	Main function	Alternative functions
1, 3, 5	Voltage supply VB (terminal 30)	Power supply for output stages Nominal 12 V DC or 24 V DC Operating range 8 V DC to 32 V DC	
11	Voltage supply VB (terminal 30_1)	Power supply for internal electronics Nominal 12 V DC or 24 V DC Operating range 8 V DC to 32 V DC A wire with 0.75 mm ² cross section must be used for this pin	
23	Ignition key (terminal 15)	Switch-on signal power up with VB	
2, 4, 6	Power ground PGND	Power supply ground Internally connected to each other and to pins 56 and 53	
56	Sensor ground SGND_1	Sensor ground for analog sensors	
53	Sensor ground SGND_2	Sensor ground for digital sensors	
9	Hardware Inhibit HW_INH_1 Pull-Down resistor 261 kΩ to GND	Primary activation input for VP_1¹⁾ main switch Activation level > 7 V (switch to terminal 30 or 30_1) Deactivation level < 4 V (open / cable break)	
18	Hardware Inhibit HW_INH_2 Pull-Down resistor 261 kΩ to GND	Primary activation input for VP_2¹⁾ main switch Activation level > 7 V (switch to terminal 30 or 30_1) Deactivation level < 4 V (open / cable break)	
20	SW_INH / IN_38 Pull-up resistor 10 kΩ to 5 V	Secondary activation input SW_INH Activation level < 0.4 V (switch to ground) Deactivation level > 3 V (open / cable break)	Digital input IN_38 Active low
65, 31, 34, 35, 36, 44, 45, 46, 47	IN_1 to IN_9 Pull-Down resistor 118 kΩ to GND	Analog voltage input Measuring range nominal 0 to 5 V Resolution 12 bits Resolution 1.44 mV / bit Accuracy ± 3 % at 5 V Filter limit frequency 224 Hz	Digital input Switching threshold configurable in software (max. 5 V)

Pin	Description	Main function	Alternative functions
19, 37, 38, 39, 40, 41	<p>IN_14 to IN_19</p> <p>Pull-down configuration: 6.9 kΩ pull-down to GND (default after reset) Pull-up configuration: 118 kΩ pull-down to GND and 7.4 kΩ pull-up to 5 V Open pin voltage 4.7 V</p>	<p>Analog voltage input</p> <p>Measuring range nominal 0 to 5 V Resolution 12 bits ▶ in pull-down configuration 1.40 mV/bit ▶ in pull-up configuration 1.44 mV/bit Accuracy ± 3 % at 5 V Filter limit frequency: ▶ in pull-down configuration 264 Hz ▶ in pull-up configuration 224 Hz</p>	<p>Digital input</p> <p>Switching threshold configurable in software (max. 5 V)</p>
42, 43	<p>IN_20, IN_21</p> <p>Pull-Down resistor 78 kΩ to GND</p>	<p>Analog voltage input</p> <p>Measuring range nominal 0 to 10 V Resolution 12 bits Resolution 3.01 mV / bit Accuracy ± 5 % at 10 V Filter limit frequency 180 Hz</p>	<p>Digital input</p> <p>Switching threshold configurable in software (max. 10 V)</p>
66, 67, 68, 69	<p>IN_22 to IN_25</p> <p>Pull-Down resistor 14.4 kΩ to GND if used as analog voltage input</p> <p>Do not switch to battery voltage!</p>	<p>Analog current input</p> <p>Measuring range nominal 4 to 20 mA Accuracy ± 6.5 % at 20 mA</p> <p>Load in current measurement mode 244 Ω</p>	<p>Analog voltage input</p> <p>Measuring range nominal 0 to 5 V Resolution 12 bits Resolution 1.44 mV / bit Accuracy ± 3 % at 5 V Filter limit frequency 224 Hz</p> <p>Digital input</p> <p>Switching threshold configurable in software (max. 5 V)</p>
62, 24, 25, 26	<p>IN_34 to IN_37</p> <p>Pull-down resistor 29 kΩ to GND and Pull-up resistor 1.2 kΩ to 5 V Open pin voltage 4.8 V</p> <p>Do not switch to battery voltage!</p>	<p>Resistance input</p> <p>Measuring range 0 .. 50 kΩ</p> <p>Temperature input</p> <p>Measuring range -50 .. 150 °C</p> <p>Can be used with Bosch Rexroth TSA or TSF (PTC) temperature sensors or Bosch NTC temperature sensors. For details see API manual.</p>	<p>Analog voltage input</p> <p>Measuring range nominal 0 to 5 V Resolution 12 bits Resolution 1.44 mV / bit Accuracy ± 3 % at 5 V Filter limit frequency 1647 kHz</p> <p>Digital input</p> <p>Switching threshold configurable in software (max. 5 V)</p> <p>Frequency input</p> <p>For frequency sensors that switch between typically 0 V and 5 V (e.g. Bosch DG23i) Low level < 1.7 V / high level > 3.5 V Measurable range up to 20 kHz ▶ minimal pulse length 25 μs ▶ the lower frequency limit depends on the period used in software for the frequency acquisition</p> <p>Do not use for active frequency sensors that switch or pull-up to battery voltage!</p>

Pin	Description	Main function	Alternative functions
52, 54, 55, 57, 48, 58, 59, 60	<p>IN_39 to IN_46</p> <p>50 kΩ pull-down to GND and 15 kΩ pull-up to 5 V Open pin voltage 3.9 V Input capacitance typical 168 pF</p>	<p>SAE J2716 SENT (Single Edge Nibble Transmission) sensor signal input</p> <p>For sensor supply use VSS_x with 5 V For sensor ground use SGND_2 Filter limit frequency 140.8 kHz</p> <p>Check API manual for SENT signal evaluation.</p>	<p>Digital input</p> <p>Low Level < 1.6 V High Level > 3 V</p> <p>(max. 5 V)</p>
10, 30, 12, 13, 70, 61	<p>IN_26 to IN_31</p> <p>Only in DSM configuration: Pull down resistor 196 Ω to GND</p> <p>Active frequency sensor input or analog input configuration: Pull-down resistor 11.2 kΩ to GND</p>	<p>Frequency input for Bosch Rexroth DSM speed sensors</p> <p>The DSM signal includes frequency, direction and diagnosis information Low Level < 8.4 mA High Level > 11.2 mA Measurable range 0 .. 10 kHz (relates to 5 kHz tooth frequency due to duplication of frequency by DSM) DSM standstill detection can be used Filter limit frequency 26.2 kHz</p>	<p>Frequency input for active speed sensors that switch to high level</p> <p>Low Level < 1.7 V High Level > 2 V Measurable range up to 20 kHz ► minimal pulse length 25 μs ► the lower frequency limit depends on the period used in software for the frequency acquisition Filter limit frequency 26.2 kHz The phase between two frequency inputs can be used to acquire the direction Phase 1: IN_26 / IN_27 Phase 2: IN_28 / IN_29 Phase 3: IN_30 / IN_31</p> <p>Analog voltage input</p> <p>Measuring range nominal 0 to 32 V Resolution 12 bits Resolution 8.78 mV / bit Accuracy ± 6 % at 32 V Filter limit frequency 700 Hz</p> <p>Digital input</p> <p>Switching threshold configurable in software (max. 32 V)</p>
63, 64	<p>IN_32 to IN_33</p> <p>Pull-down resistor 40 kΩ to GND and Pull-up resistor 6.8 kΩ to 5 V Open pin voltage 3.6 V</p>	<p>Frequency input for active speed sensors that switch to low level</p> <p>Low Level < 1.3 V High Level > 3.5 V Filter limit frequency 28.5 kHz Measurable range up to 20 kHz ► minimal pulse length 25 μs ► the lower frequency limit depends on the period used in software for the frequency acquisition The phase between these two frequency inputs can be used to acquire the direction Phase 4: IN_32 / IN_33</p>	<p>Analog voltage input</p> <p>Measuring range nominal 0 to 32 V Resolution 12 bits Resolution 8.78 mV / bit Accuracy ± 6 % at 32 V Filter limit frequency 700 Hz</p> <p>Digital input</p> <p>Switching threshold configurable in software (max. 32 V)</p>

Pin	Description	Main function	Alternative functions
7, 29	<p>OUT_1, OUT_3</p> <p>Pull-up resistor 21.5 kΩ to supply voltage Free-wheeling diode included for inductive loads Power supply centrally switchable via VP_1 Open pin voltage 7.5 V with $V_{bat} = 12\text{ V}$</p> <p>The total current out of OUT_1 and OUT_2 must not exceed 6 A. The total current out of OUT_3 and OUT_4 must not exceed 6 A.</p>	<p>Proportional high-side output stage Maximum current 4 A</p> <p>Current control range 0.1 .. 4 A PWM frequency 50 .. 250 Hz Closed loop current control with current measurement over shunt resistor Software controllable duty cycle for open loop current control</p>	<p>Switching high-side output stage Maximum current 4 A</p> <p>100 % duty cycle</p>
76, 79	<p>OUT_2, OUT_4</p> <p>Pull-up resistor 21.5 kΩ to supply voltage Free-wheeling diode included for inductive loads Power supply centrally switchable via VP_1 Open pin voltage 7.5 V with $V_{bat} = 12\text{ V}$</p> <p>The total current out of OUT_1 and OUT_2 must not exceed 6 A. The total current out of OUT_3 and OUT_4 must not exceed 6 A.</p>	<p>Proportional high-side output stage Maximum current 3 A</p> <p>Current control range 0.1 .. 3 A PWM frequency 50 .. 250 Hz Closed loop current control with current measurement over shunt resistor Software controllable duty cycle for open loop current control</p>	<p>Switching high-side output stage Maximum current 3 A</p> <p>100 % duty cycle</p>
78, 77, 81, 80, 75, 74,	<p>OUT_5 to OUT_10</p> <p>Pull-up resistor 21.5 kΩ to supply voltage Free-wheeling diode included for inductive loads Power supply centrally switchable via VP_1 Open pin voltage 7.5 V with $V_{bat} = 12\text{ V}$</p>	<p>Switching high-side output stage Maximum current 3 A</p> <p>100 % duty cycle</p>	
91, 92, 93, 94	<p>OUT_11 to OUT_14</p> <p>Pull-up resistor 21.5 kΩ to supply voltage Free-wheeling diode included for inductive loads Power supply centrally switchable via VP_2 Open pin voltage 7.5 V with $V_{bat} = 12\text{ V}$</p>	<p>Switching high-side output stage Maximum current 3 A</p> <p>100 % duty cycle</p>	

Pin	Description	Main function	Alternative functions
84, 85, 82, 83	OUT_19 to OUT_22 Pull-down resistor 146 kΩ to GND Free-wheeling diode included for inductive loads	Proportional low-side output stage Maximum current 3 A Current control range 0.1 .. 3 A PWM frequency 100 .. 1000 Hz Closed loop current control with current measurement over shunt resistor Software controllable duty cycle for open loop current control	Switching low-side output stage Maximum current 3 A 100 % duty cycle
51, 73	OUT_23, OUT_24 Pull-down resistor 146 kΩ to GND Free-wheeling diode included for inductive loads	Proportional low-side output stage Maximum current 4 A Current control range 0.1 .. 4 A PWM frequency 100 .. 1000 Hz Closed loop current control with current measurement over shunt resistor Software controllable duty cycle for open loop current control	Switching low-side output stage Maximum current 4 A 100 % duty cycle
14, 15	OUT_15, OUT_16 Pull-down resistor 55 kΩ to GND Power supply centrally switchable via VP_1	PWM control signal output Output voltage 0 % .. 75 % VB Output resistance 3.6 kΩ Minimal external capacitor 100 μF Maximum PWM frequency 5 kHz	Analog voltage input Measuring range nominal 0 to 32 V Resolution 12 bits Resolution 8.09 mV / bit Accuracy ± 6 % at 32 V Filter limit frequency 483 kHz Digital input Switching threshold configurable in software (max. 32 V)
16, 17	OUT_17, OUT_18 Pull-down resistor 55 kΩ to GND Power supply centrally switchable via VP_2	PWM control signal output Output voltage 0 % .. 75 % VB Output resistance 3.6 kΩ Minimal external capacitor 100 μF Maximum PWM frequency 5 kHz	Analog voltage input Measuring range nominal 0 to 32 V Resolution 12 bits Resolution 8.09 mV / bit Accuracy ± 6 % at 32 V Filter limit frequency 483 kHz Digital input Switching threshold configurable in software (max. 32 V)
90, 87, 86	OUT_25 to OUT_27 Pull-down resistor 55 kΩ to GND	Low-side switch Maximum permissible nominal current 20 mA For LED output use serial resistor Maximum voltage at connector pin 5 V if used as Low-side switch	Analog voltage input Measuring range nominal 0 to 32 V Resolution 12 bits Resolution 8.09 mV / bit Accuracy ± 6 % at 32 V Filter limit frequency 483 kHz Digital input Switching threshold configurable in software (max. 32 V)

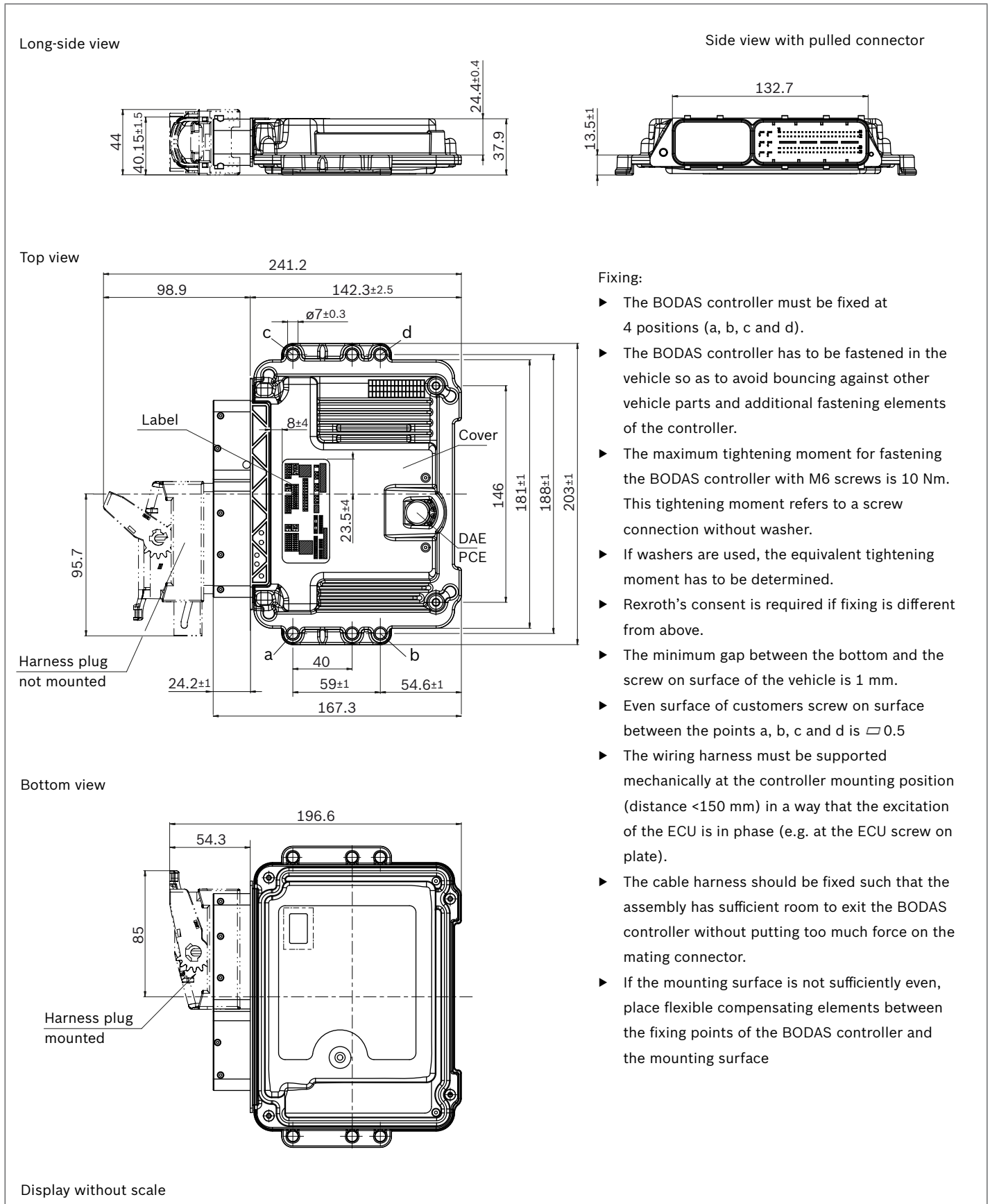
Pin	Description	Main function	Alternative functions
88, 89	OUT_28 to OUT_29 Pull-down resistor 37 kΩ to GND	High-side switch for analog output Current output 4 .. 20 mA Accuracy in steady state: ± 3 % at 20 mA Voltage output 0 .. 5 V Accuracy in steady state: ± 3 % at 5 V with 200 Ω external ohmic resistance	Low-side switch Maximum permissible nominal current 20 mA. For LED output use serial resistor Maximum voltage at connector pin 5 V if used as Low-side switch Analog voltage input Measuring range nominal 0 to 32 V Resolution 12 bits Resolution 8.09 mV / bit Accuracy ± 6 % at 32 V Filter limit frequency 483 Hz Digital input Switching threshold configurable in software (max. 32 V)
22	VSS_1	Sensor supply output voltage Nominal on-voltage 5 V Accuracy ± 2.5 % Voltage off < 0.5 V Maximum output current 300 mA Maximum external capacity 100 μF Output voltage ratiometric to ADC reference voltage	
8	VSS_2 Do not switch on VSS_2 in software if no load is connected. A minimal current of 5 mA / μF is required if a load is connected to VSS_2 to avoid diagnosis errors.	Sensor supply output voltage Nominal on-voltage software configurable as 3.3 V, 5 V, 8.5 V, 10 V Accuracy ± 10 % Voltage off < 0.5 V Maximum output current 300 mA Maximum external capacity 100 μF	
21	LIN Pull-up resistor 1 kΩ to V _{bat}	Local Interconnect Network (LIN) Single wire bus interface Physical layer according to ISO 9141 Maximum transfer rate 20 kBaud	
27, 28	CAN1_H, CAN1_L	CAN interface 2.0 B high speed CAN interface according to ISO 11898 Maximum transfer rate 500 kBaud for vehicle use (1 MBaud selectable with limited EMC characteristic, e.g. for flashing)	Diagnosis interface Flashing interface
49, 50	CAN2_H, CAN2_L	CAN interface 2.0 B high speed CAN interface according to ISO 11898 Maximum transfer rate 500 kBaud for vehicle use (1 MBaud selectable with limited EMC characteristic)	Wake-up Any CAN traffic can wake up the RC in silence mode Shut off capability CAN transceiver can be switched off

Pin	Description	Main function	Alternative functions
71, 72	CAN3_H, CAN3_L¹⁾	CAN interface 2.0 B high speed CAN interface according to ISO 11898 Maximum transfer rate 500 kBaud for vehicle use (1 MBaud selectable with limited EMC characteristic)	Shut off capability CAN transceiver can be switched off
32, 33	CAN4_H, CAN4_L¹⁾	CAN interface 2.0 B high speed CAN interface according to ISO 11898 Maximum transfer rate 500 kBaud for vehicle use (1 MBaud selectable with limited EMC characteristic) Due to the ISOBUS termination CAN_4 can only be used as the first or last device on a CAN bus. External 120 Ω termination must not be applied.	ISOBUS interface Active bus termination to 2.5 V based on ISO 11783 standard (full compliance not claimed) Termination supply derived from RC power supply Resistance approx. 2 kΩ between CAN4_H and CAN4_L Analog voltage input Measuring range nominal 0 to 32 V for CAN_4 diagnosis only. 55 kΩ Pull-Down resistor included. Do not use as analog input. Shut off capability CAN transceiver can be switched off

Pin numbers in **bold** are for contact type BDK 2.8
 Pin numbers in *italic* are for contact type MQS 1.5 CB
 All other pins are for contact type BCB 0.6

1) The activation of a main switch requires the testing of switch off paths within the RC control unit. During this test both main switches, CAN_3 and CAN_4 are switched off shortly several times even if one main switch has been activated already. Please take note of this behavior especially if the main switches are not activated at the same point in time.

Dimensions

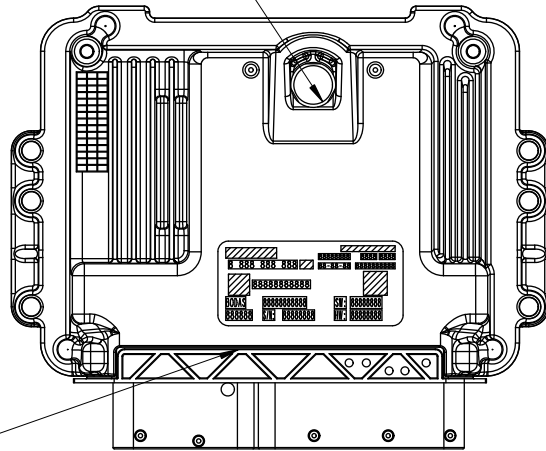
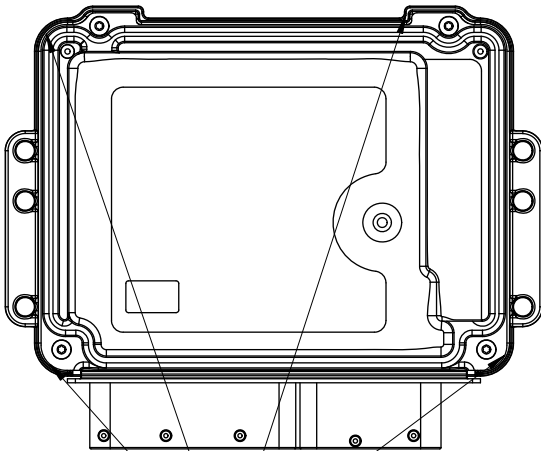
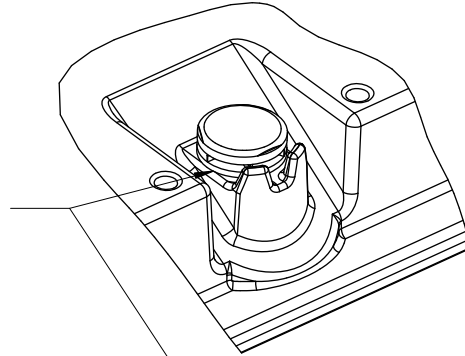


Fixing:

- ▶ The BODAS controller must be fixed at 4 positions (a, b, c and d).
- ▶ The BODAS controller has to be fastened in the vehicle so as to avoid bouncing against other vehicle parts and additional fastening elements of the controller.
- ▶ The maximum tightening moment for fastening the BODAS controller with M6 screws is 10 Nm. This tightening moment refers to a screw connection without washer.
- ▶ If washers are used, the equivalent tightening moment has to be determined.
- ▶ Rexroth's consent is required if fixing is different from above.
- ▶ The minimum gap between the bottom and the screw on surface of the vehicle is 1 mm.
- ▶ Even surface of customers screw on surface between the points a, b, c and d is $\square 0.5$
- ▶ The wiring harness must be supported mechanically at the controller mounting position (distance <150 mm) in a way that the excitation of the ECU is in phase (e.g. at the ECU screw on plate).
- ▶ The cable harness should be fixed such that the assembly has sufficient room to exit the BODAS controller without putting too much force on the mating connector.
- ▶ If the mounting surface is not sufficiently even, place flexible compensating elements between the fixing points of the BODAS controller and the mounting surface

Installation position

No standing or permanently running water allowed in the sealing area of the pressure equalizing element. Install accordingly.



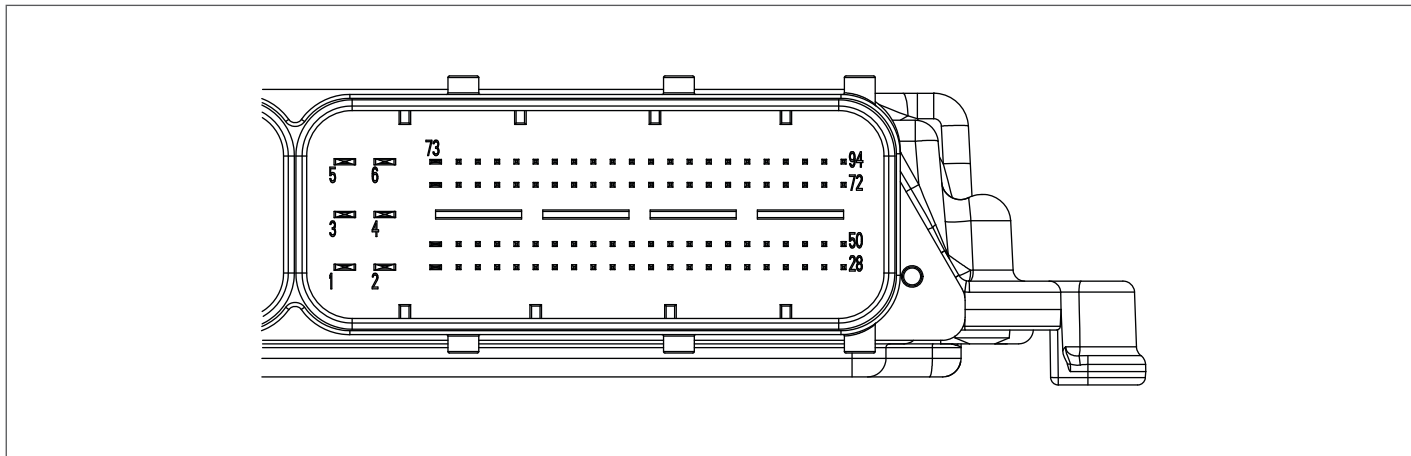
No standing or permanently running water allowed in the revolving groove area (cover-bottom-connector). Install accordingly

Mating connector

The 154-way plug connector is divided in 2 modules (94- and 60-way). Only the 94-pin module is used. The 60-pin module is closed and unused. The 1 928 xxx numbers stated below are Bosch designations. Technical details about these documents and part numbers are available at www.bosch-connectors.com. The numbers prefixed with "TE" are designations of TE connectivity (previously Tyco Electronics). Visit www.te.com for information on these items.

Assembly instruction	1 928 A01 09M
Technical customer documentation	1 928 A01 00T
Offer drawing (assembly)	1 928 A00 325
Offer drawing (carrier)	1 928 A00 326
Final check instruction	1 928 A00 05E

View of connector strip



Terminal designation

Contact BCB 0.6	Contact MQS 1.5 CB	Contact BDK 2.8
Row 1: Pins 8 to 28	Row 1: Pin 7	Pins 1 to 6
Row 2: Pins 30 to 50	Row 2: Pin 29	
Row 3: Pins 52 to 72	Row 3: Pin 51	
Row 4: Pins 74 to 94	Row 4: Pin 73	

Tools

Contact Type	Line cross section in mm ²	Hand Crimping		Automatic crimping	Extraction tool	Process specification
		Hand Tool	Profile of insert			
BCB 0.6	0.35 to 0.5	TE 0-539635-1	TE 0-539683-2	TE 9-878 439-2	1 928 496 755	1 928 A00 70M
BCB 0.6	0.75	TE 0-539635-1	TE 0-539683-2	TE 9-878 591-2	1 928 496 755	1 928 A00 70M
MQS 1.5 CB	0.75 to 1.5	TE 539635-1	TE 539692-2	TE 541662	TE 6-1579007-0	TE 114-18286
BDK 2.8	0.5 to 1.0	1 928 498 161 (with die)		1 928 498 163	1 928 498 167	1 928 F00 025
BDK 2.8	1.5 to 2.5	1 928 498 162 (with die)		1 928 498 164	1 928 498 167	928 F00 025

Cables

Use FLKr Type "B" cables.

Connector components

The following parts are required for assembling a wiring harness connector. Alternatives are listed if applicable.

Designation	Version	Part number	Manufacturer	Number
Contact carrier, Code C		1 928 405 063	Bosch	1
Cover	Outlet up	1 928 405 247	Bosch	1
	Outlet left	1 928 405 071	Bosch	
	Outlet right	1 928 405 069	Bosch	
Secondary lock power		1 928 405 074	Bosch	1
Secondary lock signal		1 928 405 073	Bosch	1
Holding plate		1 928 405 067	Bosch	1
Fixing strap		1 928 401 713	Bosch	1
Contact BCB 0.6	Line cross section in mm ² 0.35 - 0.5 Insulation diameter in mm 1.2 - 1.6 Not allowed for pin 11 (KL30_1)	1 928 492 555	Bosch	up to 84
	Line cross section in mm ² 0.75 Insulation diameter in mm 1.7 - 1.9	1 928 492 556	Bosch	
Contact MQS 1.5 CB	Line cross section in mm ² 0.75 - 1.5 Insulation diameter in mm 1.7 - 2.4	TE 1 241 608-1	TE connectivity	up to 4
Contact BDK 2.8	Line cross section in mm ² 0.5 - 1.0 Insulation diameter in mm 1.2 - 2.1	1 928 498 056	Bosch	up to 6
	Line cross section in mm ² 1.5 - 2.5 Insulation diameter in mm 2.2 - 3.0	1 928 498 057	Bosch	
Dummy contact BCB 0.6		1 928 405 077	Bosch	1) ¹⁾
Dummy contact MQS 1.5-CB		1 928 405 076	Bosch	1) ¹⁾
Single wire seal for BDK 2.8	For insulation diameter in mm 1.2 - 2.1 (blue)	1 928 300 599	Bosch	up to 6
Single wire seal for BDK 2.8	For insulation diameter in mm 2.2 - 3.0 (white)	1 928 300 600	Bosch	up to 6
Cavity / dummy plug BDK 2.8	(clear)	1 928 300 601	Bosch	1) ¹⁾

1) Free contact chambers are to be sealed with dummy contacts to ensure water tightness.

Connector Kit

Mating connector sets with the following content are available under Rexroth part number R917010843 for the manual assembly of wiring harness connectors for laboratory or small-series requirements. Machined assembly is recommended for larger quantities.

Designation	Version	Part number	Manufacturer	Number
Contact carrier, Code C		1 928 405 063	Bosch	1
Cover	Outlet right	1 928 405 069	Bosch	1
Secondary lock power		1 928 405 074	Bosch	1
Secondary lock signal		1 928 405 073	Bosch	1
Holding plate		1 928 405 067	Bosch	1
Fixing strap		1 928 401 713	Bosch	1
Contact BCB 0.6	Line cross section in mm ² 0.75 Insulation diameter in mm 1.7 – 1.9	1 928 492 556	Bosch	84
Contact MQS 1.5 CB	Line cross section in mm ² 0.75 – 1.5 Insulation diameter in mm 1.7 – 2.4	TE 1 241 608-1	TE connectivity	6
Contact BDK 2.8	Line cross section in mm ² 1.5 – 2.5 Insulation diameter in mm 2.2 – 3.0	1 928 498 057	Bosch	8
Dummy contact BCB 0.6		1 928 405 077	Bosch	60 ¹⁾
Dummy contact MQS 1.5-CB		1 928 405 076	Bosch	6 ¹⁾
Single wire seal for BDK 2.8	For insulation diameter in mm 2.2 – 3.0 (white)	1 928 300 600	Bosch	6
Cavity / dummy plug BDK 2.8	(clear)	1 928 300 601	Bosch	4 ¹⁾

Delivered loose in a PE bag. Not suitable for processing by a machine.

1) Free contact chambers are to be sealed with dummy contacts to ensure water tightness.

Safety instructions

General instructions

- ▶ Reliable operation cannot be guaranteed if samples or prototypes are used in series production machines.
- ▶ The proposed circuits do not imply any technical liability for the system on the part of Bosch Rexroth.
- ▶ Incorrect connections could cause unexpected signals at the outputs of the controller.
- ▶ Incorrect programming or parameter settings on the controller may create potential hazards while the machine is in operation. It is the responsibility of the machine manufacturer to identify hazards of this type in a hazard analysis and to bring them to the attention of the end user. Rexroth assumes no liability for dangers of this type.
- ▶ The component firmware/software must be installed and removed by Bosch Rexroth or by the authorized partner concerned in order to uphold the warranty.
- ▶ It is not permissible to open the controller or to modify or repair the controller. Modification or repairs to the wiring could result in dangerous malfunctions. Repairs to the controller may only be performed by Bosch Rexroth or by an authorized partner.
- ▶ To switch off the system in emergencies, the stop switch (two-channel stop function) or the optional de-energize switch may be used. The switch must be in an easily accessible position for the operator. The system must be designed in such a way that safe braking is ensured when the outputs are switched off.
- ▶ When the electronics is not energized no pins must be connected to a voltage source. Thus, when the current supply is switched off, the supply for the electronics, the power outputs and the external sensor supply have to be switched off together.
- ▶ Make sure that the controller's configuration does not lead to safety-critical malfunctions of the complete system in the event of failure or malfunction. This type of system behavior may lead to danger to life and/or cause much damage to property.
- ▶ System developments, installations and commissioning of electronic systems for controlling hydraulic drives must only be carried out by trained and experienced specialists who are sufficiently familiar with both the components used and the complete system.
- ▶ While commissioning and maintenance the controller (with BODAS Tools) the machine may pose unforeseen hazards. Before commissioning the system, you must therefore ensure that the vehicle and the hydraulic system are in a safe condition.
- ▶ Make sure that nobody is in the machine's danger zone.
- ▶ No defective or incorrectly functioning components may be used. If the components should fail or demonstrate faulty operation, repairs must be performed immediately.
- ▶ Controllers used to develop software may only be installed in series production machines if it can be guaranteed that these controllers have not been flash-programmed with new software more than 500 times. Controllers that have been programmed more than 1000 times are not to be installed in series production machines!

Notes on the installation point and position

- ▶ Do not install the controller close to parts that generate considerable heat (e.g. exhaust).
- ▶ Radio transmitting equipment and mobile telephones must not be used in the driver's cab without a suitable antenna or near the control electronics.
- ▶ A sufficiently large distance to radio transmitting systems must be maintained.
- ▶ All connectors must be unplugged from the electronics during electrical welding and painting operations.
- ▶ Cables/wires must be sealed individually to prevent water from entering the device.
- ▶ The controller must not be electrostatically charged, e.g. during painting operations.
- ▶ The controller will heat up beyond normal ambient temperature during operation. To avoid danger caused by high temperatures, it should be protected against contact.
- ▶ Install the control unit in such a way that the electrical plug is not facing upwards. This ensures that any condensation water that may form can flow out.
- ▶ Standing and permanently running water are not permitted anywhere near the circumferential groove (lid/base connector) or the pressure balance element (DAE).
- ▶ The case must be wired to vehicle ground in order to comply with EMC guidelines. Metallic screws are used to create a connection to vehicle ground.

Notes on transport and storage

- ▶ If it is dropped, the controller must not be used any longer as invisible damage could have a negative impact on reliability.
- ▶ Control units must be stored with a mean relative humidity of 60% and at a temperature between -10 °C and +30 °C. Storage temperatures between -20 °C and +40 °C are briefly permissible, for up to 100 hours.
- ▶ After a storage time of more than 5 years, the controller must be examined by the manufacturer.

Notes on wiring and circuitry

- ▶ The electronics and the power outputs of a controller must be fed from the same power source.
- ▶ When wiring the output stages, the maximum cumulative output current for each output stage group should be noted. The cumulative output current means a permanent, simultaneous actuation of the output stages.
- ▶ Lines to the speed sensors shall be as short as possible and shielded. The shielding must be connected to the electronics on one side or to the machine or vehicle ground via a low-resistance connection.
- ▶ The product may only be wired when it is de-energized.
- ▶ Lines to the electronics must not be routed close to other power-conducting lines in the machine or vehicle.
- ▶ The wiring harness should be fixated mechanically in the area in which the controller is installed (spacing < 150 mm). The wiring harness should be fixated so that in-phase excitation with the controller occurs (e.g. at the controller bolting point).
- ▶ If possible, lines should be routed in the vehicle interior. If the lines are routed outside the vehicle, make sure that they are securely fixed.
- ▶ Lines must not be kinked or twisted, must not rub against edges and must not be routed through sharp-edged ducts without protection.
- ▶ Lines are to be routed with sufficient spacing to hot or moving vehicle parts.
- ▶ PWM outputs must not be linked or bridged.
- ▶ PMW outputs with current measurement (OUT_1 to OUT_4 and OUT_19 to OUT_24) must not be used to power bulbs.
- ▶ The sensor supplies can be „pulled up“ by an external connection, e.g. the application of a higher voltage, because they operate only as a voltage source but not as a voltage sink. Pulling up a sensor supply may result in unexpected malfunctions and damage of the controller in lasting operation.
- ▶ The „high side“ outputs may not be externally connected to battery.

- ▶ If the stop function is used in an application, the contacts 9 and 18 (HW_INH_1, HW_INH_2) of the controller must be connected to the stop switch in the vehicle. For a dual channel switch off function the contact 20 (SW_INH) has to be connected to the stop switch, too. Refer to the connection diagram.

Note on proportional and switching solenoids and other wired inductive consumers

- ▶ The proportional solenoids must not be wired with free-wheeling diodes.
- ▶ Switching solenoids at the outputs of the control unit do not need to be connected to free-wheeling diodes.
- ▶ The electronics may only be tested with the proportional solenoids connected.
- ▶ Other inductive loads that are in the system but not connected to the controller must be connected to free-wheeling diodes. This applies to relays (e.g. for de-energizing the controller) that have the same supply as the controller, too.

Intended use

- ▶ The controller is designed for use in mobile working machines provided no limitations / restrictions are made to certain application areas in this data sheet.
- ▶ Operation of the controller must generally occur within the operating ranges specified and released in this data sheet, particularly with regard to voltage, current, temperature, vibration, shock and other described environmental influences.
- ▶ Use outside of the specified and released boundary conditions may result in danger to life and/or cause damage to components which could result in consequential damage to the mobile working machine.

Improper use

- ▶ Any use of the controller other than that described in chapter „Intended use“ is considered to be improper.
- ▶ Use in explosive areas is not permissible.
- ▶ Damage resulting from improper use and/or from unauthorized interference in the component not described in this data sheet render all warranty and liability claims void with respect to the manufacturer.

Use in functions relevant to safety

- ▶ The customer is responsible for performing a risk analysis of the mobile working machine and determining the possible safety-related functions.
- ▶ In safety-related applications, the customer is responsible for taking suitable measures for ensuring safety (sensor redundancy, plausibility check, emergency switch, etc.)
- ▶ For example, a suitable assignment of input variables (e.g. by connecting the acceleration pedal signal to two independent analog inputs) can be used to detect faults and to activate specially programmed reactions.
- ▶ Special measures may be initiated if the plausibility check shows deviations between the set-point values and the values read back by the microcontroller.
- ▶ Product data that is necessary to assess the safety of the machine can be provided on request or are listed in this data sheet.
- ▶ For all control units, the notes found in the API description, in the online help section of BODAS design and in the „safety- relevant project planning instructions“ must be observed

Safety features in the BODAS controller

- ▶ The input circuits for speed and analog signals partially feature electrically independent circuits. Faults can be detected by the microcontroller using software diagnostic functions if appropriate input pins are used.
- ▶ Faults in the supply voltage are detected by internal monitoring.
- ▶ All output signals can be monitored by the microcontroller with the appropriate software.
- ▶ The controllers can be operated with all power outputs de-energized for service purposes.
- ▶ The internal watchdog module switches off the power supply of proportional and switched outputs centrally when there are malfunctions in the program run.

Further information

- ▶ In addition, the application-specific documents (connection diagrams, software descriptions, etc.) are to be observed.
- ▶ More detailed information on BODAS controllers may be found at www.boschrexroth.com/mobile-electronics.

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