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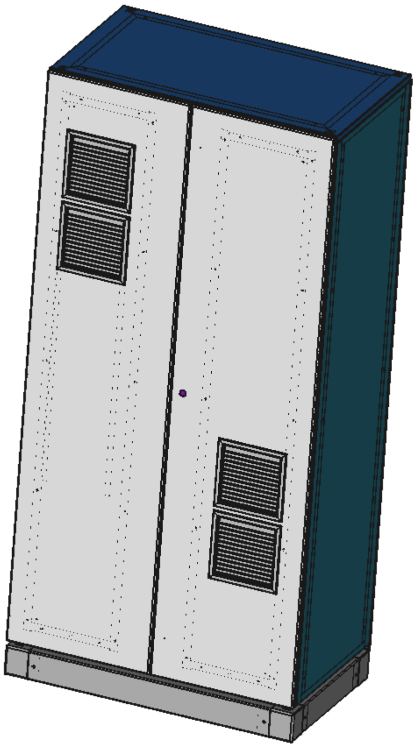
Technical specifications

DCS 19

DC/DC CONVERTER
CHARGING OF ELECTRIC BUSES FROM OVERHEAD LINES



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Obsah:

1 Introduction

The **DCS 19** converter is designed for charging (fast charging) the traction battery of an electric bus.

The power supply, i.e. the input voltage to the converter, is supplied from a tram or trolleybus overhead line with a nominal value **of 600 Vdc**.

At its galvanically isolated output, the step-up converter provides **a stabilised voltage** of up to **750 Vdc** and an output current, with a limit, of up to **250 A**.

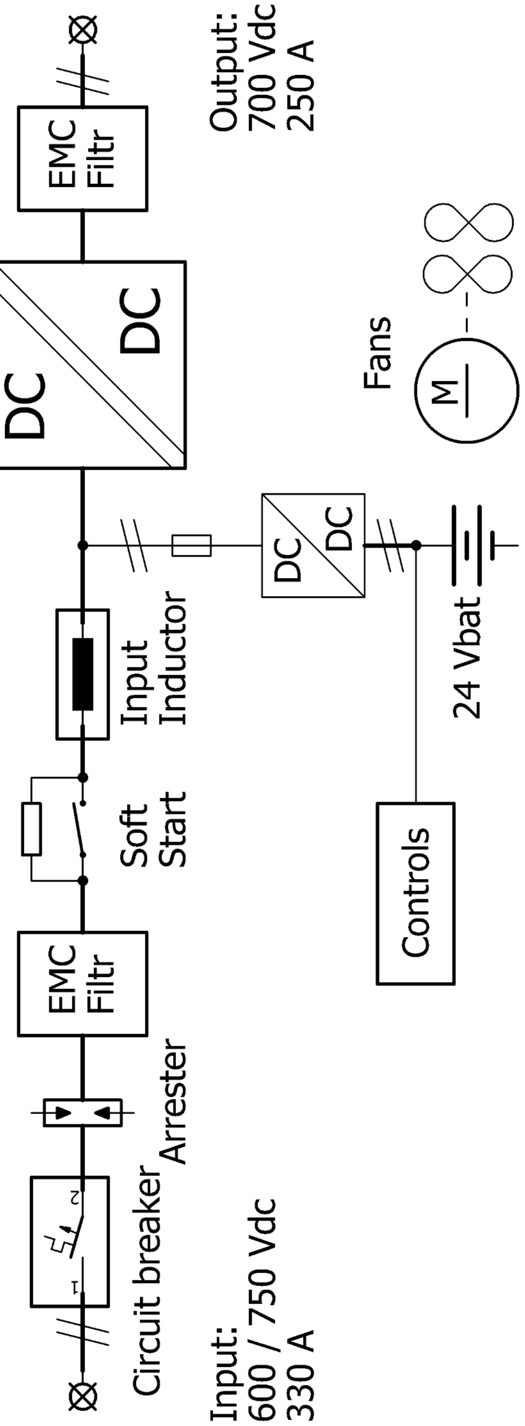
The device is based on a step-up DC/DC converter with galvanic isolation of the input from the output via a high-frequency transformer.

The output voltage and current values of the converter, together with **the vehicle's integrated fast charger**, are regulated according to the requirements of the vehicle's traction battery management system (BMS). The vehicle communicates with the DC/DC charging converter via Wi-Fi and Powerline wireless systems.

The enclosure itself is a metal structure suspended from a catenary pole. It contains aluminium heat sinks, chokes and transformers. The insulation materials used, i.e. conductors and insulators, are halogen-free, non-flammable and non-toxic.

The internal power supply, including its backup, is provided by a 24V battery recharged by an integrated low-power DC/DC converter.

2 Block diagram – power section



3 Device description – power section

3.1 Parameters of the DCS19 DC/DC converter

Parameters		Conditions, notes
DC input voltage: - rated - range	 600 Vdc 400 – 800 Vdc	trolley
DC input current: - rated	 330 A DC	
Output voltage	*500 – 750 Vdc	depending on the vehicle's traction battery and the condition of the overhead contact line
Maximum output current	250 A	
Communication input/output:	Wi-Fi	
Cooling: - flow - fan	forced air 1000 m³/h max.	
Noise level	< 60 dB	
Protection	IP 54	
Operating conditions: - operating temperature range - storage and transport - Altitude	 –25°C to +40°C –40°C to +55°C 1200 m	 max.
Flammability class of insulation materials:	UL 94 - V0	
External dimensions:	1010 × 610 × 2100 mm	W × D × H
Weight:	550 kg	

* Precise current and voltage regulation is performed by the vehicle's integrated fast-charging unit

3.2 Description of input circuits

A 600 V DC voltage from the overhead line system is supplied to the circuit breaker’s input terminals.

The circuit breaker is remotely controlled by a servomotor. It can be switched on and off using the integrated servomotor, either via the control system or from the control panel. In addition, this circuit breaker can be tripped via its quick-release mechanism, either by the control system or from the control panel using the “Emergency STOP” button.

The main circuit breaker’s quick-release mechanism is designed such that, in the event of a 24Vdc control voltage failure, it is automatically activated, causing the input circuit breaker to trip.

The input circuit breaker can also be operated manually.

After lifting the protective plexiglass cover, moving the control lever from the AUTO position to the MANUAL position opens the slot for inserting the green handle, which is otherwise located on the left-hand side of the circuit breaker. The circuit breaker can be operated by turning the handle clockwise (as indicated by the arrow).

Please note that if the control lever is in the MANUAL position, the remote control via the servomotor will not work. You must therefore ensure that it is returned to the AUTO position once manual operation is complete.

The colour in the window next to the control opening indicates the status of the circuit breaker:

Red – circuit breaker on
Green – circuit breaker off
White – intermediate position

Note
The input circuit breaker is tripped when the cabinet door is opened.

3.3 Input circuit breaker parameters

Parameters		Conditions, notes
Operating voltage: - rated Ue - insulation Ui	 1000 Vdc 1000 V	
Rated impulse withstand voltage Uimp	8 kV	
Rated short-circuit breaking capacity Icu	36 kA	1000 Vdc
Rated operational short-circuit breaking capacity Ics	36 kA	1000 Vdc
Rated short-circuit closing capacity Icm	76 kA	1000 Vdc
Rated current	350 A	
Adjustable overcurrent trip	(0.8–0.9–1) × In	
Instantaneous short-circuit trip, adjustable	(5–6–7–8–9–10) × In	
Overvoltage category	III	
Maximum switching frequency	60 switching cycles per hour	
Terminals:	M10 bolts	
Terminal tightening torque:	70 Nm	
Busbar width	30 mm	

When the input circuit breaker is closed, a voltage of 600 V DC is fed to the surge arrester.

3.4 Surge arrester parameters

Parameters		Conditions, notes
Operating (continuous) voltage Uc	850 Vdc	max.
Max. impulse discharge current Imax	10 kA	8/20 µs
Impulse current Ihc	100 kA max.	4/10 µs
Energy withstand	10.5 kJ/kV	
Short-circuit current	20 kA DC	for 0.2 s

From the surge arrester, the input voltage is routed to the input EMC filter and then to the soft-start circuit. This circuit, by slowly pre-charging the converter capacitor via a pre-charge resistor, prevents the overcurrent and overvoltage spikes that occur when the input circuit breaker is switched on, i.e. the spikes caused by the direct application of the overhead line voltage to the converter.

When the voltage across the converter's input capacitors reaches a value close to the overhead line voltage, the contactor's main contact closes and the DC/DC converter is ready to start operation.

The individual components of the electrical circuits in the input section, which are at the trolley voltage potential, have double insulation against the chassis and the enclosure.

3.5 Auxiliary converter 600/28 Vdc.

The converter stabilises the output voltage to 27.5 V; the exact value is adjustable. The power supply can be controlled by a signal and provides status feedback at 24 V.

The auxiliary converter is mounted on an aluminium base which is fitted to a common heat sink.

The base carries a fully isolated DC/DC converter for charging the battery and the entire 24 V system.

The auxiliary converter is designed with double (semiconductor elements) and reinforced (transformer) insulation.

Parameters		Conditions, notes
Input voltage: - rated	 600 Vdc	 400–800 V
Output current: - rated - maximum	 50 A DC 50 A DC	
Output voltage: - rated	 28 Vdc	regulated, adjustable
Input current: - rated - maximum	 2.5 A DC 3.3 A DC	
Efficiency:	94.0%	50 Adc
Max. test voltage: - input — output, base - base — output	 4,000 VAC 2,100 VAC	50 Hz, 1 min.

3.5.1 24 V DC mains supply – PELF system

The stand’s operation is powered by a 24Vdc auxiliary power supply. This power supply is based on a maintenance-free 24V 20Ah battery (two 12V traction batteries connected in series).

This battery is charged from the overhead line voltage via a charger integrated into the converter cabinet.

The 24V DC voltage is fed from the battery to the switchboard at the front of the stand, which is accessible upon opening the door. A contactor is located at the switchboard input, allowing all 24V circuits to be switched off, except for the 24V make circuit and the 600V main circuit breaker trip circuits. These circuits, which are permanently live, are protected by automotive fuses located next to the batteries, together with 50 A fuses – the 24V main fuse – and 40 A fuses – the 24V charging fuse. The other 24V circuits are protected by glass fuses in Wago terminals located in the switchboard.

3.6 Description of the main DC/DC converter

The power section of the main DC/DC converter consists of four main parts:

- Inverter voltage stabiliser
- Inverter on the primary side of the converter’s transformer
- Power transformer
- Output rectifiers on the secondary side of the transformer with a smoothing filter

On the primary side of the converter, i.e. the side supplied by the overhead line voltage, other essential components are connected, such as a 600/28 Vdc auxiliary converter for charging the backup battery and the entire 24 V system, and a temperature control circuit.

The inverter is based on two transistor modules, two half-bridges, which form the resulting H-bridge for controlling the voltage and current of the transformer’s primary winding and thus the entire converter. The inverter operates at a frequency of 75 kHz, which allows the use of relatively small, relative to the power output, wound inductive components, i.e. transformers and chokes. The voltage at the inverter output, and thus at the transformer primary, is **unregulated**. The pulses are in resonance with the transformer itself.

The transistor modules used are designed for mounting on a heat sink. The permissible insulation test voltage between the electrical circuits and the base (heat sink) is 4 kV AC for 1 minute.

The switching of individual transistors is provided by drivers powered and controlled by the control unit – the regulator.

The switching transistors of the modules require a smoothing capacitor located in the immediate vicinity of these switching elements to function. The smoothing capacitor itself in this case consists of four individual capacitors. The rated voltage of the capacitors is selected so as to prevent breakdown of their insulation even during the expected input network overvoltages frequently occurring on the traction line.

A discharge resistor is an essential component of a converter with capacitors. It ensures that the voltage drops to a safe level when the input overhead line voltage to the equipment is switched off. The time taken for the capacitor to discharge to a safe voltage level is **60 seconds**.

Information on the input voltage, provided by CU4/5_ type voltage sensors, is required to regulate the system. These sensors galvanically isolate the main circuits from the control circuits and provide information on the magnitude of the input voltage at their output in the form of a current in mA.

The inverter’s electrical circuits have double insulation against the chassis and the enclosure.

The power transformer transmits the full power of the fast-charging converter and provides galvanic isolation of the secondary side from the overhead line circuits. The transformer output is not earthed; it is isolated (IT system).

The secondary winding of the transformer consists of two identical windings, which are then fed into the rectifier blocks.

The operating frequency of the power transformer is relatively high and lies above the audible range, i.e. the range of human hearing.

The AC voltage from the transformer’s secondary winding is converted to DC output voltage using diode rectifiers.

The rectifiers, configured in a bridge circuit, are connected in parallel.

A discharge resistor is connected in parallel to the output capacitors to ensure the voltage drops to a safe level when the converter is switched off or the voltage is disconnected from the battery-powered vehicle.

The converter’s power output (750 V DC, max. 250 A) is routed via a noise filter outside the enclosure to a device that connects the converter output to the electrical bus.

The exact value of the output (charging) current is measured by a current sensor. Together with the sensor on the primary side of the inverter and **the vehicle section of the fast charger**, they ensure the limitation **of the** maximum **output current and voltage**.

The output voltage of the entire DC/DC converter is measured by a voltage sensor.

Based on the information from the sensors, the controller is able to detect, among other non-standard conditions, a short circuit at the converter output and shut down the device.

In consultation with the user, conditions and parameters can be set for the potential restart of the system following a fault.

3.6.1 Control section – Controller

The **RTK** series controller is designed to control modern converters, ranging from simple to complex systems, including the control of trolleybus and electric bus drive systems using IGBT and SiC transistors.

All system control functions are performed by a 32-bit processor based on software. Signals from current and voltage sensors with current outputs, galvanically isolated from the trolleybus voltage, are converted by the processor's high-speed A/D converters into digital data and subsequently processed together with other input signals using the software contained within the processor. The fast current outputs are used to control the drivers of the power converters, along with other outputs that determine circuit configuration and so on. In addition to basic control functions, the program performs drive diagnostics, sets emergency modes, etc.

By connecting a laptop to the controller's programming port, the internal processor communicates with the software on the PC (laptop), which allows for very easy configuration of the device's parameters and modification of the control program; this also provides feedback on the current system status, or on the type and number of recorded fault conditions.

The software can be supplemented with additional functions, depending on the requirements of the specific operator, e.g. a transport company.

The controller can be connected to CAN and ETHERNET communication buses, and via these interfaces, remote access to the controller's functions and parameters—including diagnostics of the entire controlled system—is possible.

High system reliability is achieved by processing all control signal inputs in a single processor and on a single control board, as well as through the use of connectors, terminals and entire terminal blocks that are spring-loaded (i.e. screwless), making them suitable for environments subject to vibration. The low power dissipation within the enclosed housing, resulting in low temperatures of critical components, contributes significantly to the high reliability of the control regulator.

During the design of the control system and the development of the software, great emphasis was placed on the simplicity and clarity of operation of both the controller itself and the entire drive, in order to keep operational requirements to a minimum and to minimise the technical equipment and qualifications required of maintenance personnel.

The controller system consists of individual units, each of which performs a specific function. The units are interconnected via connectors, which allow them to be disconnected and each unit to be operated independently. The separation of the individual units – inputs, outputs and power supplies – makes it possible, if necessary, to replace relatively inexpensive peripheral components very easily. The units are arranged side by side on a common insulating base plate, which can be secured to the base as a single unit using four M6 screw holes. An overview of the device with dimensions is provided in the appendix.

The inputs and outputs of electrical signals, routed via WAGO connectors, are located around the perimeter of the controller.

The control regulator is operated by signals from the 24Vb on-board network, via analogue or binary levels.

The controller outputs, individually protected against overvoltage, short-circuit and overcurrent, allow the connection of standard contactors or other inductive loads up to 2.5A without the need for additional protection.

LED indicators on the individual units are visible once the cover is removed and provide simple visual information on the operating and fault states of the entire drive and the controller itself.

3.6.2 Control panel

Devices such as relays, converters, insulation testers, etc., which are necessary to ensure all internal functions of the DCS_ rapid charger, are concentrated on the panel and accessible upon opening the front door.

The panel inside the cabinet features several control elements and is therefore referred to as **the control panel**.

Description of the control panel:

Buttons and indicator lights:

ON Switches on the input circuit breaker; simultaneously, a green indicator light signals that the device is de-energised (600 V DC)

OFF Switch off the main circuit breaker; simultaneously, the red indicator light signals the presence of 600 V DC voltage in the cabinet

24V ON Switching on the 24V DC auxiliary voltage contactor

Emergency STOP Quick-trip of the input contactor followed by disconnection of the 24Vdc

FAULT Indicator light specifying the type of fault based on the number of flashes

Description of the control and signalling functions of the stand control panel:

Control functions:

The main button is the yellow **24V ON** button. This button is used to start the stand. When this button is pressed, the stand's control system takes control of the system and keeps the 24V input contactor in the ON state.

The **ON** and **OFF** buttons can be used to switch the 600Vdc input circuit breaker on and off via its servomotor.

The **Emergency Stop** button allows the equipment to be switched off quickly in an emergency.

Signalling functions:

The **ON** button has a built-in green indicator LED. This LED indicates that the input circuit breaker is off; therefore, if this green light is on, the device is de-energised except for the input terminals of this circuit breaker (F2).

The **OFF** button has a built-in red indicator LED. This LED indicates that the input circuit breaker is on; therefore, if this red indicator is lit, the device is connected to the 600 V DC trolley network.

The **FAULT** indicator flashes to signal certain faults. The nature of the fault can be identified by the number of flashes. In addition to the fault being indicated by the number of flashes of the **FAULT** indicator, it is also displayed as a numerical code on the electric bus driver's panel. The indicator therefore serves primarily to distinguish faults with lower numerical codes.

3.6.2 Insulation Status Monitor

The HIST-1 continuously monitors the condition of the basic and supplementary insulation of the device's electrical circuits and signals any deterioration below the permitted limits.

The meter enables measurement of the overall insulation condition as well as individual insulation in all types of traction networks – insulated symmetrical, insulated asymmetrical, earthed and combined.

The monitor is designed as a digital meter with microprocessor control and a memory for evaluated limit values.

All adjustable parameters necessary for the correct operation of the device and the measured limit values are stored in three memory blocks, which retain data even in the event of a power failure.

The monitor is housed in a single all-plastic enclosure (230 x 200 x 95 mm) with a transparent door, behind which is a front panel featuring LED indicators, two buttons and instrument sockets.

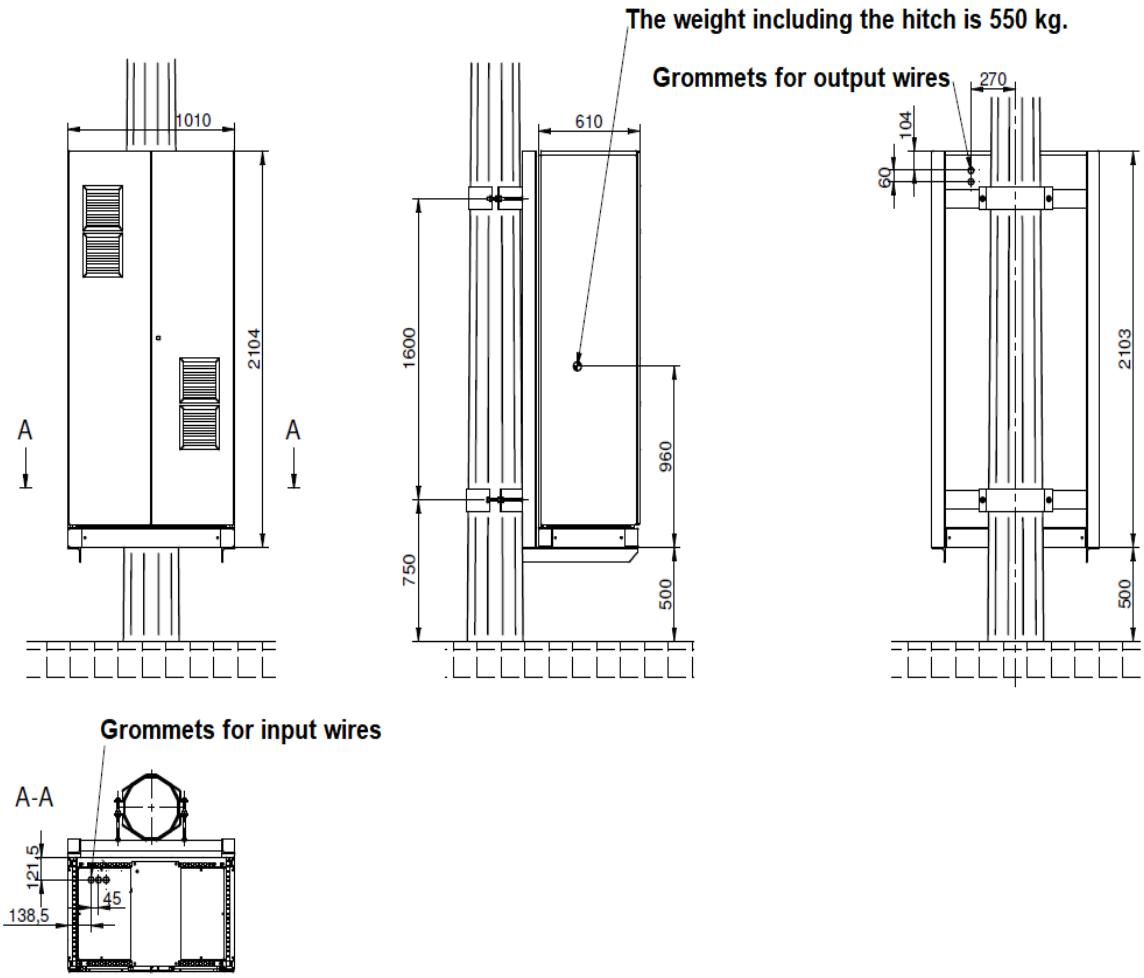
The terminals are connected to the non-live parts and the electrical centres of the live parts, which, when the monitor is switched off, allows the resistance of the individual insulation layers to be measured directly at these points (e.g. using a Megmet), or, when the monitor is switched on, enables reduced insulation conditions to be simulated.

4 DC/DC converter enclosure

4.1 Enclosure design description

The entire DC/DC converter and auxiliary converters are enclosed in a steel enclosure with an opening front door. The entire enclosure is secured to the mast by brackets on the rear of the enclosure.

Power inputs **from below** and outputs **from above** are routed into the interior of the enclosure through a cable gland and connected to the designated terminal via a cable lug.



Forced cooling is provided by two brushless fans powered by a 24V supply. Air drawn in from the front of the enclosure is blown by the fans exclusively into the heat sinks, with strict separation of the clean space containing the power and other components. Fan speeds are controlled independently according to the measured temperatures in the main or auxiliary converter compartments.

The interior of the cabinet is divided into compartments, each of which is cooled in a different way. Hazardous areas are protected by removable metal or plastic covers.

Limit switches trip the input circuit breaker when the door is opened, thereby cutting off the overhead line voltage supply, and the controller ensures that the voltage is disconnected from the vehicle side.

During the design of the transistor circuitry, strict care is taken to ensure that no environmentally harmful materials are used. Non-flammable and flame-retardant materials are also used.

The insulation materials used comply with flammability category/class V0, according to UL 94.

5 Diagnostics of inverters and drive

Basic, simple diagnostics of the drive can be performed via LEDs after opening the converter covers or, where applicable, after removing the RTK controller cover.

Diagnostic access to stored data in the inverter's processor control is via the CAN bus and Ethernet. In addition to monitoring the current status, this method allows access to the event history and, if necessary, enables changes to control parameters.

Another option, offering full programming capabilities, is direct connection to the control electronics via the **PPA** programming device.

The "Dmon" software application has been developed for this system monitoring via PC.

Conformity documents:

• Fixed railway installations	ČSN EN 50122-1
	ČSN EN 50328
	ČSN EN 50163
• Electromagnetic compatibility	ČSN EN 50121-5
• Halogen-free materials	ČSN EN 60754-1
• No toxic gases	ČSN EN 50305 (NES 02-713, NFC 20-454)

Note