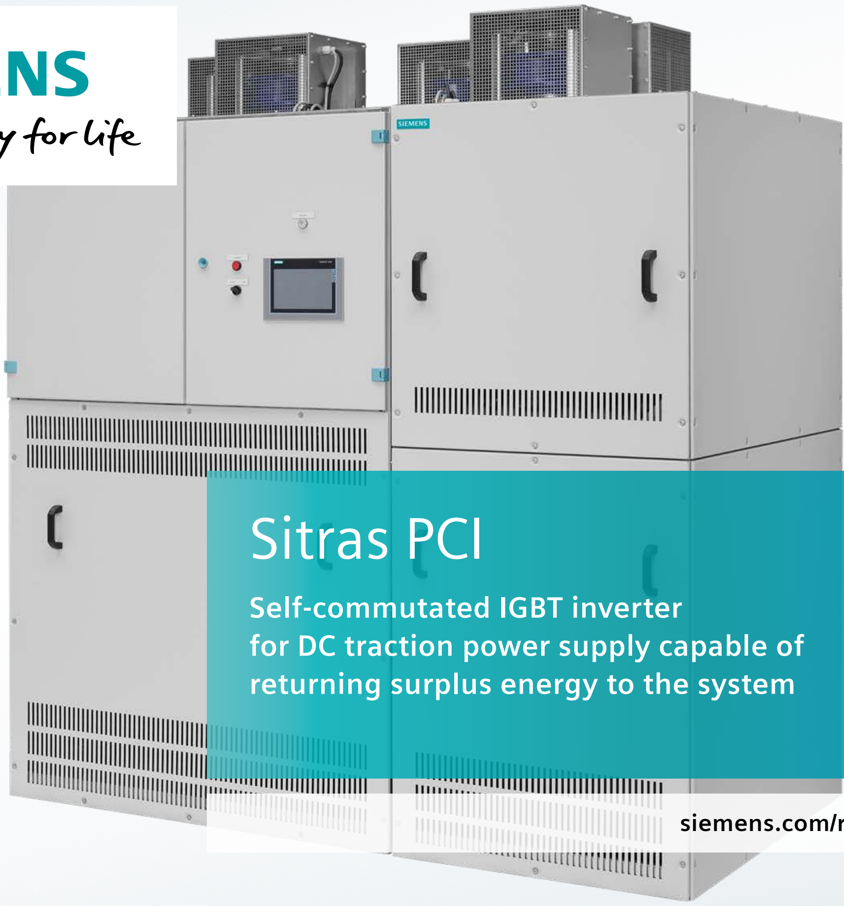


Sitras PCI

Self-commutated IGBT inverter for DC traction power supply capable of returning surplus energy to the system

siemens.com/rail-electrification

Self-commutated IGBT inverters of type Sitras® PCI are for the most part used at those points at which the transfer of energy between vehicles is frequently incomplete. Via the inverter, the vehicles' braking energy can be fed at any time into the constantly receptive medium-voltage power network and thus transferred even over greater distances and made available in a different location.

In addition to energy recovery, the Sitras PCI can also generate reactive power for the three-phase power network. The reactive power can be capacitive in order to maintain the voltage in the three-phase power network or inductive in order to compensate a capacitive cable network.

Features

- Braking energy recovery up to 1 000 MWh/year**
- Operation cost savings up to 150 000 €/year** with electricity costs of 15 ct/kWh and through reactive power compensation
- Reduction of CO2-emissions* up to 468 t/year**
- Heat reduction in tunnels by braking energy recovery and saving braking resistances on the vehicles when complete braking energy recovery

*) German energy mix 2018
**) per inverter unit Sitras PCI

Design

The panels of the Sitras PCI inverters are installed in steel cubicles and are designed for indoor installation.

All of the main components are easily accessible from the front and can therefore be replaced with ease. This type of construction is suitable for mounting against a wall.

The Sitras PCI inverter is designed for the use of 750 V and 1 500 V.

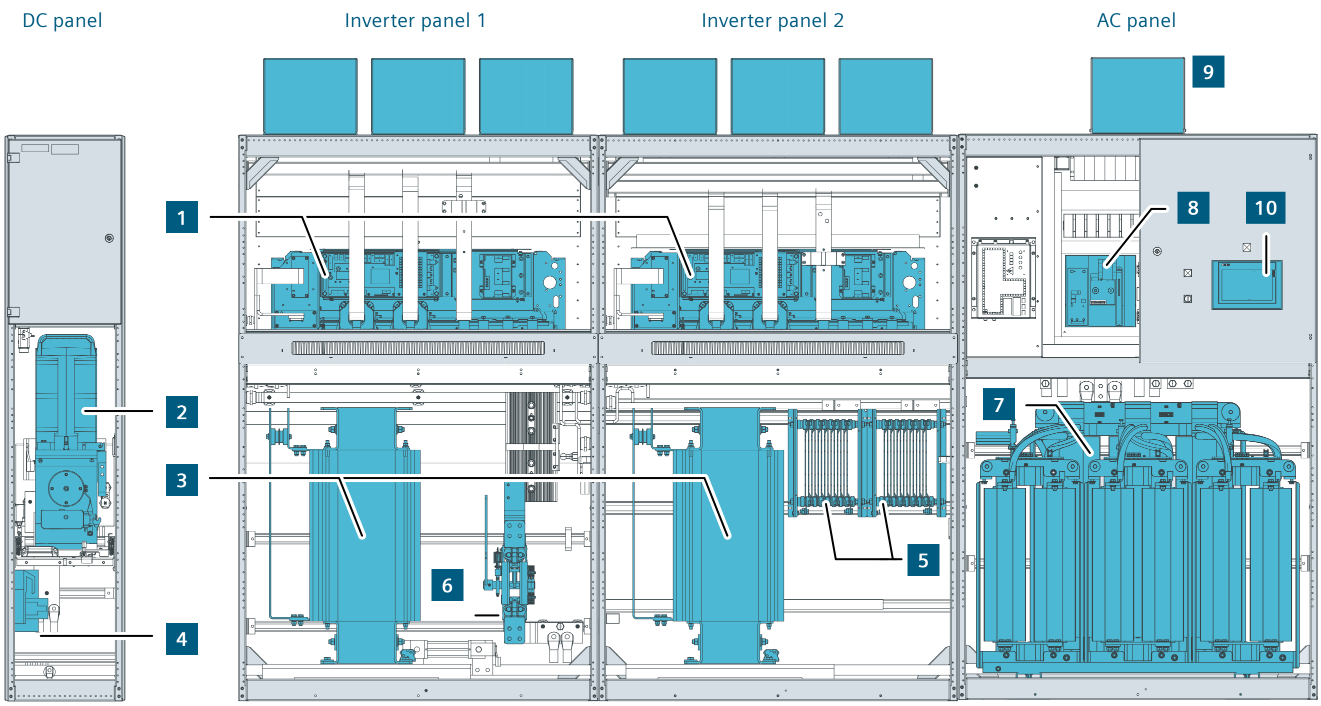
Cubicle design

The inverter components are housed in a panel group of several cubicles. The system can therefore be easily integrated into existing substations. The cubicle design varies between the 750 V and 1 500 V applications.

Depending on the system design, the modular Sitras PCI comprises one or two inverter panels, one AC panel and one DC panel. The DC panel can be installed physically separately and is mainly separately integrated into the DC switchgear. The precharging unit is integrated into the DC panel.

The 1 500 V version comprises one or two inverter panels and one AC panel, depending on the power variant. In the 1 500 V version, the DC panel is not part of the supply scope. Here, precharging takes place in the AC panel.

The inverter panels and the AC panel possess forced-air ventilation consisting of speed-controlled **fans (9)** that suck the defined air flows through the compartments to be cooled.



1 Converter module
2 DC circuit-breaker
3 DC inductor
4 Precharging unit
5 Momentary overvoltage limiter
6 DC disconnector
7 AC reactor
8 AC circuit-breaker
9 Fan
10 Touch panel

Example 1: Design of Sitras PCI 750 V with two inverter panels and adjacent DC panel

Main components (see example below for 750 V und 1 500 V)

Converter modules (1)
for highly efficient conversion of DC to AC with the aid of railway-compatible IGBTs.

DC circuit-breaker (2)
for safe shutdown of the Sitras PCI.

DC inductor (3)
for limiting the common-mode currents between the two converter modules and for decoupling from the DC traction power network.

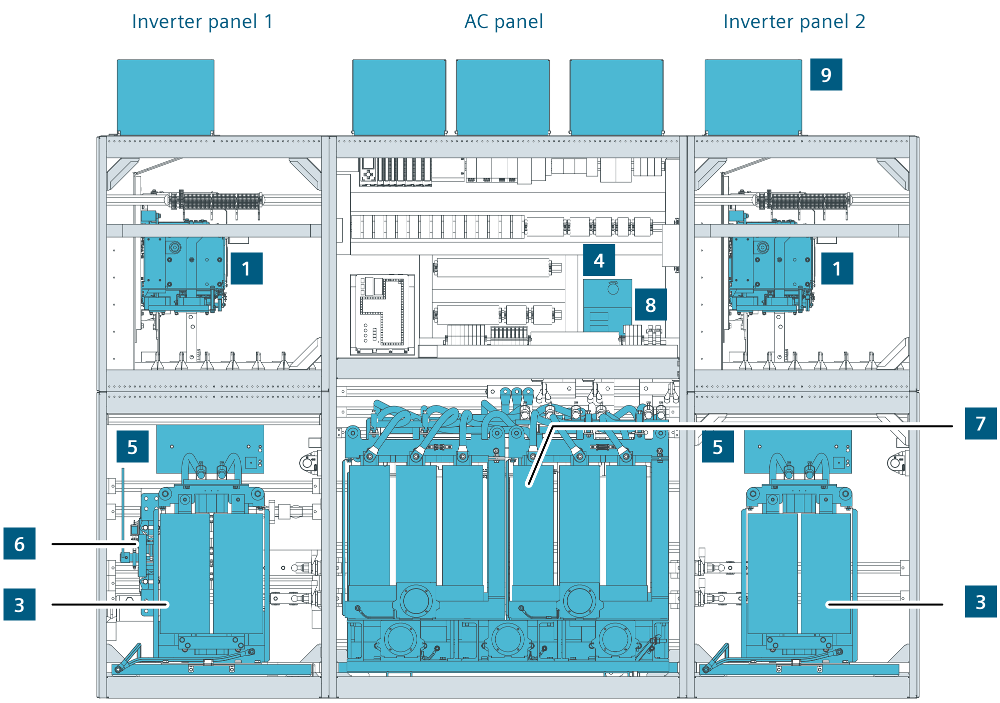
Precharging unit (4)
for charging the converter unit's link capacitors at 750 V in the DC panel, at 1 500 V in the AC panel.

Momentary overvoltage limiters (5)
enable limiting of transient overvoltage on the inverter to admissible values.

AC circuit-breaker (8) and **DC disconnector (6)**
for protection purposes and for insulation of the Sitras PCI.

AC reactor (7)
for reducing harmonics at the power network end and for reducing equalizing currents between the inverters.

Touch panel (10)
for operating and control.



1 Converter module
2 DC circuit-breaker*
3 DC inductor
4 Precharging unit*
5 Momentary overvoltage limiter
6 DC disconnector
7 AC reactor
8 AC circuit-breaker
9 Fan
10 Touch panel*

*) not shown

Example 2: Design of Sitras PCI 1 500 V with two inverter panels

Design variants

Sitras PCI 750 V

with one inverter panel

with two inverter panels

Sitras PCI 1 500 V

with one inverter panel

with two inverter panels

Function

Control

The self-commutated two-point inverter generates a pulse pattern, that simulates a three-phase fundamental frequency. It is necessary to have an inductance between the three-phase network and the inverter which makes it possible to control the current. The desired power flow is achieved by means of current control.

Power quality

In power supply systems, as high a power factor as possible should be used in order to avoid transmission losses. In standard cases, Sitras PCI can be run with power factor 1.

If required, reactive power compensation can be set by means of fixed value specification, external specifications of the energy supplier, or the power factor.

Current harmonics in the three-phase medium-voltage network can be reduced by means of the combination of AC reactor and AC filter, that the demanded limit values can be met. At the DC voltage end, voltage harmonics are reduced by use of a DC inductor.

Protection concept

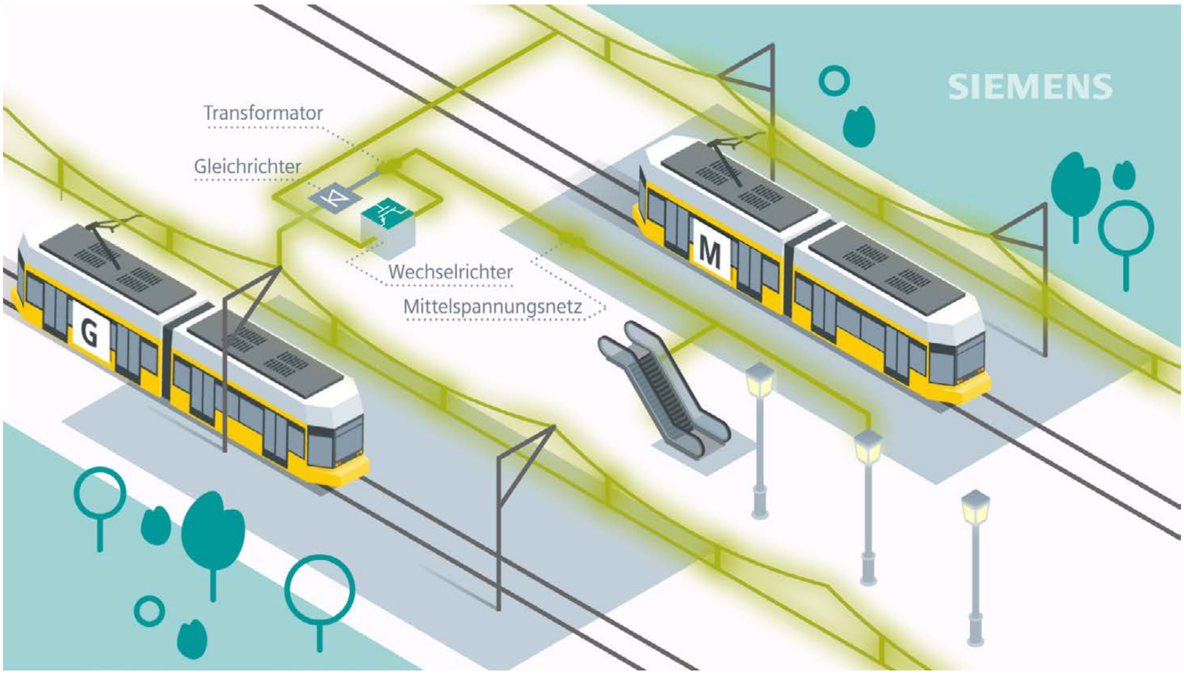
The protection concept comprises the following functionality:
- Automatic control of all necessary processes such as power-on and off sequences
- Diverse monitoring functions such as voltage and current monitoring, internal short-circuit detection, fan functions, temperature sensing
- Automatic isolation from the power network and discharging in the event of a fault.

Operator control and monitoring

The S7 controller, HMI (Human Machine Interface) and MCU (Multipoint Control Unit) components communicate via PROFINET IO. PROFINET communication takes place in real time via Industrial Ethernet.
Connection to the substation automation system in accordance with IEC 61850 is possible.

Local operation and remote access to all HMI functions for operator control and monitoring is possible. In addition, it is optionally possible to inform about operating states and measured values in real time via smartphone app. This offers diverse possibilities such as:

- Monitoring operating states (App)
- Switching on and off, setting new parameters
- Access to the message archive for fault messages and warnings (App)
- Detecting all measured values like operating hours (App), returned energy (App), temperatures (App), currents and voltages



Flow of energy from the vehicle via the inverter to the medium-voltage power network

System integration

The Sitras PCI pulse-controlled inverter can be used as an autonomous inverter, as an additional inverter or as a reversible converter.

Autonomous inverter

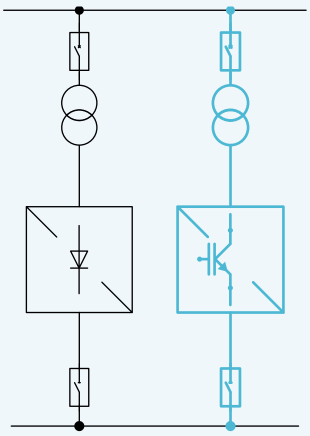
During planning / construction of new substations, it is advantageous to connect the Sitras PCI inverter directly to the medium-voltage switchgear in parallel with the diode rectifier. A separate transformer is connected in front of the rectifier to adapt the voltage.

Additional inverter

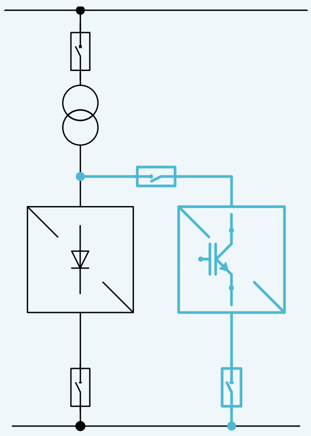
The design as an additional inverter represents a very compact and therefore space-saving solution that is especially suitable, for example, for retrofitting in existing substations.
An additional transformer is needed for adaptation of the voltage level in the event of connection to the rectifier transformer.

Reversible converter

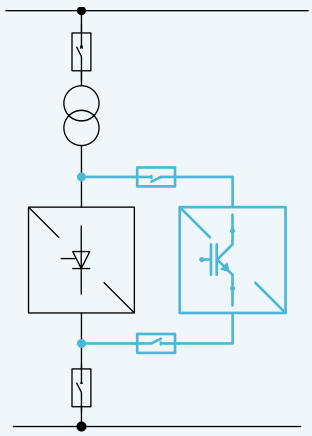
Reversible converters are regenerative, controlled converters. Thus, they unite the functions of controlled rectifiers with those of inverters.
An additional transformer is needed for adaptation of the voltage level in the event of connection to the rectifier transformer.



Autonomous inverter



Additional inverter



Reversible converter

References

Since market introduction in 2016 the inverter Sitras PCI has been used in the following projects:

Sitras PCI with energy recovery

Stuttgarter Straßenbahnen AG, Germany
750 V - 2.5 MW: 1 pc. (operation 2016-2019)

Stuttgarter Straßenbahnen AG, Germany
750 V - 1.25 MW: 2 pcs. (operation since 2020)

Gujarat Metro Rail Corporation, India
750 V - 2.5 MW: 2 pcs. (under construction)

Wiener Linien, Austria
750 V: 2 pcs. (under construction)

Sitras PCI with feeds back power and reactive power compensation

Wendelsteinbahn, Germany
1 500 V - 2.5 MW / 1.6 MVar: 1pc. (operation since 2020)

Wendelsteinbahn, Germany

Technical data

Type	[V]	750	750	1500 [1]	1500
Number of inverter panels		1	2	1	2
Energy recovery (DC end)					
Power (max.)	[MW]	1.25	2.5	1.25	2.5
Current (max)[2]	[A]	1500	3000	750	1500
Example of duty cycle: • für 20 s	[A]	1400	2800	700	1400
• für 80 s	[A]	0	0	0	0
Reactive power[3] (AC end)					
Power (continuous)	[MVar]	()[2]	()[2]	≤0,8	≤1,6
Current (continuous)	[A]	()[2]	()[2]	442	886
Efficiency acc. to EN 50328	[%]	>96	>96	>96	>96
Auxiliary voltage	[Hz]	50 / 60	50 / 60	50 / 60	50 / 60
	[V AC]	400	400	400	400
additionally (optional)	[V DC]	110	110	110	110
Width (without DC panel)	[mm]	2800	4200	2300	3200
Height (with ventilation)	[mm]	2500	2500	2500	2500
Depth	[mm]	1400	1400	1400	1400
Total weight (without inductor and reactor and DC panel)	[kg]	ca. 1340	ca. 2100	ca. 1170	ca. 1740
Max. ambient temperature	[°C]	+40	+40	+40	+40
Degree of protection acc. to IEC 60529[2]		IP20	IP20	IP20	IP20

[1] in preparation
[2] values on request
[3] maximum values without simultaneous feeds back

Industrial Security

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

For more information about industrial security, please visit:
http://www.siemens.com/industrialsecurity.

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