Inverters 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 grid and thus transferred even over greater distances and made available in a different location.

Due to the reduction of primary energy consumption, DC substations equipped with the Sitras® PCI type of self-commutated IGBT inverters crucially contribute toward reducing CO₂ and saving energy costs.

**Features**
- Existing substations can be retrofitted by installing a Sitras PCI
- Possibility of remote parameterization, control and diagnosis via standardized communication interface
- Use of tried and tested IGBT technology from Siemens rail vehicle construction

Flow of energy from the vehicle via the inverter to the medium-voltage power grid
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 design is suitable for use in systems with nominal voltages of 750 V DC and 1,500 V DC.

Cubicle design

The inverter components are housed in a panel group of several cubicles. The system can therefore be easily integrated into existing substations.

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 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.

Main components (see example below)

- **Converter modules** (1) for highly efficient conversion of DC to AC with the aid of railway-compatible IGBTs
- **DC choking coils** (3) for limiting the common-mode currents between the two converter modules and for decoupling from the DC traction power grid
- **DC circuit-breaker** (2) and **precharging unit** (4) for safe shutdown of the Sitras PCI and for charging the converter unit's link capacitors
- **Momentary overvoltage limiters** (6) enable limiting of transient overvoltage on the inverter to admissible values
- **AC circuit-breaker** (10) and **DC disconnector** (5) for protection purposes and for insulation of the Sitras PCI
- **AC choking coil** (7) for reducing harmonics at the power grid end and for reducing equalizing currents between the inverters
- **AC filters** (8) are defined by the local power supply company’s connection conditions and reduce the harmonics induced by the pulsing
- **Touch panel** (11) for operating and control

Example: Design of Sitras PCI (large type) with two inverter panels and adjacent DC panel
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 grid 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 is endeavored to avoid transmission losses. In standard cases, Sitras PCI can be run with power factor 1.

Current harmonics in the three-phase medium-voltage grid can be reduced by means of the combination of AC choking coil 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 choking coil.

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 grid and discharging in the event of a fault

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 autotransformer 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 autotransformer is needed for adaptation of the voltage level in the event of connection to the rectifier transformer.

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.

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, returned energy, temperatures, currents and voltages (App)

Autonomous inverter  Additional inverter  Reversible converter
Security information

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.

References

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

- Stuttgartter Straßenbahnen AG, Germany: 1
- Riyadh Public Transport Project, Saudi Arabia: 16

Operator control and monitoring via the Simatic HMI TP900 touch panel

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Technical data

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1) in preparation  2) other values on request