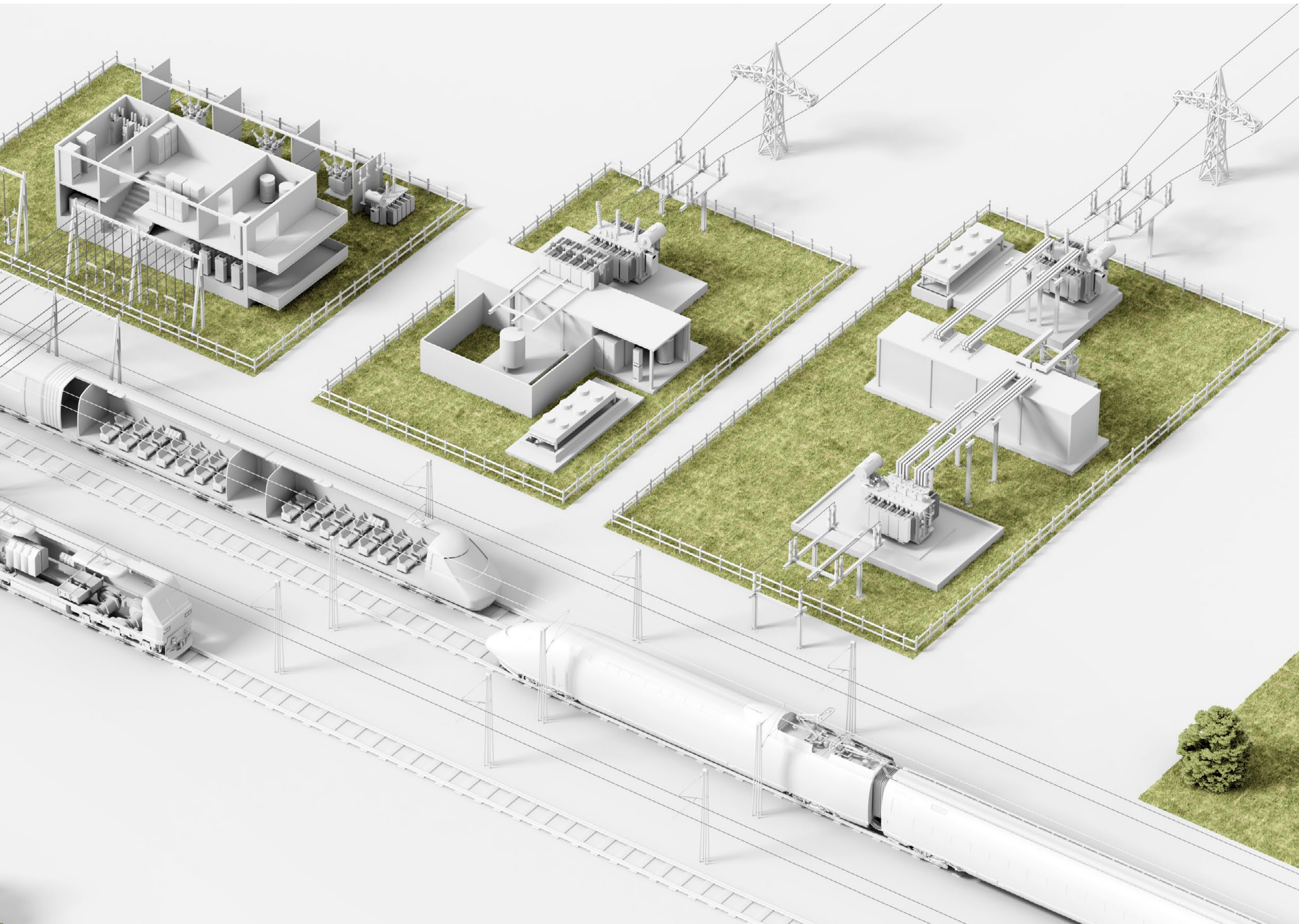
PRODUCT NOTE

More power for railway lines
Dynamic shunt compensation and static frequency conversion for the 50 Hertz (Hz) traction power supply



ABB’s shunt compensation and static frequency conversion solutions ensure grid compatibility of traction power supplies, while optimizing performance of railway corridors.

Benefits

- Optimized energy costs and reduced operating expenditure
- Improved compliance to meet utility regulations
- Simplified connection agreement and minimized project lead time
- High efficiency over entire power range
- Increased power feeding distance
- Ensured power quality
- Comprehensive life-cycle management services

ABB offers a range of solutions for maintaining power quality in railway grids and for providing efficient railway grid interconnections.
Dynamic shunt compensation devices based on SVC or STATCOM technology uses power semiconductors to control reactive power.
The cycle-by-cycle controllability of the devices enables them to counteract even the most rapid voltage transients and protect the grid from serious voltage variations. Additionally, they can control the grid’s voltage profile and raise its stability limit, enhancing grid capacity while making it more robust, flexible and predictable.

Much of the electric energy used by railways is drawn from national grids. However, for historical reasons, the frequencies used for railway electrification often differ from these grids. The state-of-the-art solution is static frequency converters (SFCs) using proven power electronics. The standardization of these power electronic modules delivers substantial advantages in terms of cost and quality. With many SFCs sold worldwide this converter has an unbeatable track record of high reliability and availability.

Load balancing solutions

Increased traffic on existing tracks, combined with new high-speed rail projects, means that rail traction is fast becoming an important load on electrical supply grids. This has turned the focus on power quality. Trains powered from the catenary require stable supply voltages that do not sag.

Modern traction systems present demanding challenges to supply grids. Usually, the single-phase railway supply is connected between two of the three phases of the public grid. This can cause substantial imbalance in a network not originally built to operate this way.

Load balancing principle
Voltage and current imbalances between phases of AC supply systems must be confined in magnitude and prevented from spreading through the grid to other parts of the system. Voltage fluctuations and harmonics need to be controlled if they are to stay within the limits specified by the grid owner/operator.

Nowadays, traction loads, P_{load}, tend to be relatively large. If the fault level of the grid is represented by S_{ssc}, the imbalance, $U_{imbalance}$, is equal to

$$U_{imbalance} = \frac{P_{load}}{S_{ssc}}$$

A common requirement is that the negative phase sequence voltage resulting from an unbalanced load should not exceed one percent. In many cases the traction system is relatively weak high-voltage transmission lines, while weaker sub-transmission lines may run somewhere in the vicinity of the rail. These lines can be used to supply the rail in case the imbalance caused by the traction load can be eliminated.
To tackle these challenges, ABB's load balancer portfolio offers static synchronous compensators (STATCOM) with a power range up to +/- 360 megavolt-ampere reactive (Mvar) per unit through to its static Var compensator (SVC) exceeding 1000 Mvar.

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Dynamic load balancer at Evron in France ensuring stable supply voltages to an existing railway line whiloe enabling an increase in traffic

SFC solutions

The SFC is well-established for railway systems operating at 16.7 Hertz (Hz) and 25 Hz.

Although the 50 Hz or 60 Hz conventional power supply using single-phase transformers connected to the three-phase domestic grid appears straightforward, there are several disadvantages. These include unbalanced loading of the three-phase grid and harmonic current injection from the railway into the grid. However, these can all be eliminated when employing a SFC.

Using a SFC within the traction power supply reduces installation, operation and maintenance costs, while increasing overall system efficiency and reliability.

SFC principle
Using SFCs within feeder stations to interconnect same frequency three-phase public grids to single-phase railway grids, brings several advantages.

SFCs draw symmetrical loads from three-phase public grids, eliminating any load imbalance. The SFC, therefore, can be connected to a lower voltage node in the public grid with lower short-circuit capacity.

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SFC station at Wolkramshausen in Germany ensuring a reliable power supply to the Deutsche Bahn (DB)

SFCs freely control the voltage levels, angles and frequencies on the railway grid, which means the public grid and the railway grid can be totally decoupled. Hence, adjacent rail sections can be synchronized and connected to each other to realize a meshed grid, thereby eliminating neutral sections.

Peak load consumption at individual connection points on the public grid can be reduced. SFC active power flow control allows a more efficient use of the train’s regenerative energy over a longer catenary line. Also, reactive power can be controlled independently on the public and railway sides. Train efficiency can be improved with a higher catenary voltage level.

Generally, SFCs enable the distance between feeding points to be extended, thereby reducing their number. SFCs have a fixed harmonic spectrum towards to public three-phase grid which means harmonic distortions from the rolling stock are mitigated.

ABB's complete (AC and DC) shunt compensation and SFC portfolio for railways and urban transports

	50 / 60 Hz Railway connections	16.7 / 25 Hz Railway connections	DC Railway connections	
SFC	**Grid interconnection 3ph to 1ph (10 to 120 MVA)** • Full decoupling of grids • Indopondont, fast control of froquency, voltage, active and reactive power on both sides • Connection to weak grids	**Grid interconntion 3ph to 1ph (10 to 120 MVA)** • Tull decoupling of grids • Independent, fast control of frequency, voltage, active and reactive power on both sides • Connection to weak grids		**Frequency conversion**
SVC	**SVC Classic (exceeding 1000 Mvar)** • Voltage stability improvement • Power quality improve-ment Load balancing		**SVC Classic (exceed-ing 1000 Mvar)** • Voltage stability improvement • Power quality improvement • Power factor improvement	**Dynamic shunt compensation**
Hybrid (SVC + STATCOM)	• Voltage stability improvement Power quality improvement • Optimized performance • Load balancing • Thyristor-switched reactors and capacitors are operated in parallel Connection to weak grids		• Voltage stability improvement • Power quality improvement • Active harmonic filtering • Connection to weak grids	
STATCOM	**PCS 6000 (up to +/-38 Mvar) or SVC Light (up to +/-360 Mvar)** • Voltage stability improvement • Power quality improve-ment Load balancing • Active harmonic filtering • Connection to weak grids		**PCS 6000 (up to +/-38 Mvar) or SVC Light (up to +/-360 Mvar)** • Voltage stability improvement • Power quality improvement • Active harmonic filtering • Connection to weak grids	

Selected SFC and load balancer references

SFC station for Queensland Rail at Wulkuraka in Australia

Customer challenges
- Increased energy demand for the Brisbane Rosewood Line and for a new rolling stock maintenance depot nearby
- Conversion of country's three-phase 50 Hz grid to single-phase 50 Hz railway meshed grid without imbalance effects to the supplying grid

ABB solution
- Turnkey solution incorporating a 20 MVA SFC
- Transformers, switchgear, control and cooling systems
- Design, engineering, installation, commissioning and civil works

Customer benefits
- Stronger railway corridor performance
- Higher power supply without fault current rating increase

Load balancer for High Speed One (HS1) in UK

Customer challenges
- Elimination of voltage imbalance due to large single-phase traction load (60 MVA)
- Voltage drops across long traction feeders at large traction loads

ABB solution
- 1 load balancer: 80 Mvar inductive to 170 Mvar capacitive
- 6 single-phase SVCs: 5 Mvar inductive to 40 Mvar capacitive

Customer benefits
- Load balancer to restore symmetrical voltage
- Single-phase SVCs on feeder / catenary system for voltage support and harmonic reduction

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SFC station at Wolkramshausen in Germany ensuring a reliable power supply to the Deutsche Bahn (DB)

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Load balancer for High Speed One (HS1) in UK

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3BHS987050 E02 Rev A

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