

# Powering the world's metro and tram systems

**ABB is a leading supplier of power and automation products and systems for the railway industry, with a comprehensive offering for traction power supply, rolling stock and service.**

**In traction power supply, ABB's FACTS (flexible AC transmission system) devices help maintain stability and power quality in both the traction network and the surrounding grid. Our high- and medium-voltage switchgear, frequency converters and transformers convert and supply power to the railway's catenaries, and our control and monitoring systems (including substation control and operation centers) permit the optimal operation and utilization of these assets.**

**In rolling stock, ABB is a market-leading manufacturer of traction transformers, traction motors and converters that supply the vehicle's traction and auxiliary power. Our portfolio includes low- and medium-voltage products as well as semiconductors and surge arresters. For diesel trains, we are a leading supplier of turbochargers.**

**ABB technologies and equipment serve a range of rail applications, including high-speed and suburban railways, metros, trams, trolleybuses and freight trains. ABB also provides service, maintenance, refurbishment and retrofit solutions.**

**We present a sample of some of the products and solutions that we have supplied in recent years to metro and light rail systems around the world.**

## India

India is experiencing a rapid rate of urbanization. Of the various public transport options available, high-capacity rail-based metro systems are ideally suited to serve the country's densely populated urban areas. Delhi and Kolkata are the two cities with existing rapid transit rail systems in operation, both of which are being expanded. New metro systems are at various stages of implementation in Bangalore, Mumbai, Chennai and Hyderabad.

Delhi Metro Rail Corporation (DMRC) is the first independent metro operator in India, and its metro system is the national benchmark for on-time project execution and efficiency. ABB has been partnering DMRC since 2002, and has provided an extensive array of products and systems for the metro's traction power supply and rolling stock. These include traction, receiving and auxiliary substations, overhead electrification, integrated building and asset management solutions, traction transformers and motors, and SCADA (supervisory control and data acquisition) systems.



ABB technologies help Delhi Metro Rail Corporation (DMRC) to reduce traffic congestion, pollution and road accidents

Delhi's metro system has 213 km of track and 148 stations along elevated and underground sections. The ABB SCADA system monitors and controls the metro network, connecting the stations - as well as the receiving and traction substations - to a central and backup control center.

For phase 1 of the Bangalore metro system, ABB is providing a turnkey traction power supply solution consisting of four 66/33 kV main receiving substations, as well as 38 auxiliary and 27 traction substations. When phase 1 is fully operational in 2012, an ABB SCADA system will monitor and control the 41 stations and 42 km of elevated and underground track.

ABB is also supplying the SCADA systems for the Mumbai and Kolkata metros.

### Middle East

ABB is playing a key role in the emerging metro and urban transportation network of the Middle East. The new driverless and fully automated Dubai Metro is the first urban rail network in the Arabian Peninsula. The Red Line is almost fully operational and the Green Line is set to start running later this year. When completed the two lines will comprise 47 underground and outdoor stations along 70 km of track, and have a capacity of 23,000 passengers an hour in each direction.



ABB technologies ensure that metro trains in Dubai run reliably and efficiently

To ensure reliable and high quality power to the metro, ABB was selected by Dubai Electricity and Water Authority (DEWA) to supply substation control and monitoring systems for the three 132/33 kV gas insulated substations that power the two lines. The systems improve reliability and energy efficiency of the electrical network by using a powerful set of tools to monitor and manage power quality. The substations also feature fault recorders and tariff metering systems that carefully monitor performance and ensure smooth operation. On the low voltage side, ABB supplied the main distribution boards that feed the power distribution, lighting and HVAC (heating, ventilation and air conditioning) systems at each of the 47 metro stations.

Another significant project in the Arabian Peninsula is the region's first electric rapid transit system in the Saudi Arabian capital, Riyadh. The system will enable an emission-free transport zone within the grounds of the newly built King Saud University for Health

Sciences. Scheduled for completion in 2011, the system comprises 24 stations over a five sq km campus. ABB is supplying a SCADA control and monitoring system for the entire rapid transit system, as well as a broad range of electrical equipment for the three traction substations. In addition to the transformers, rectifiers, switchgear, low voltage equipment and uninterruptible power supplies, ABB is also responsible for design, engineering, testing, commissioning and installation.



ABB is supplying electrical and SCADA equipment for King Saud University's rapid transit system

### Europe

In Europe, ABB is playing a pivotal role in many of the region's electric urban transportation systems, including the huge metropolitan areas of London and Paris as well as major cities like Vienna, Zurich, Stockholm and Rome.

#### London

For London Underground, the world's second longest metro system after Shanghai, ABB has delivered several solutions that ensure the reliability and quality of the extensive traction power supply system. London Underground has 402 km of track, 270 stations and supports more than one billion passenger journeys a year. It is also the world's oldest rapid transit system, the first section of which dates back to 1863.

In recent years ABB has installed a total of six static var compensators (SVCs) and 10 standalone harmonic filters at critical points in the metro's 22 kV and 11 kV power distribution networks. This has made it possible for London Underground to close an aging 180 MW power plant, and instead draw power from the public grid without affecting power quality for millions of other consumers in the capital. Space constraints and the proximity of large numbers of people in the stations meant the SVC installations had to be compact and completed in such a way as to confine noise and magnetic fields.

In 2009, ABB was awarded another large contract to build a new bulk supply point substation to power the underground rail system. The solution is part of a

plan to upgrade power supply to the underground railway lines and support the introduction of new rolling stock. ABB was responsible for the design, supply, installation and commissioning of the substation. In addition, ABB is supplying 27 hi-T Plus dry-type transformers for traction power supply. These uniquely robust transformers can operate at much higher temperatures (hence, hi-T Plus) and have a longer service life than other transformers, thanks to the use of materials with class H thermal insulation (the highest). This enables them to withstand strong overloads, high harmonic distortions and high temperatures.



ABB's hi-T Plus vacuum cast coil dry-type transformer

Controlling and managing the power distribution system of this vast and complex rail network is an ABB SCADA system. The solution manages train motive power as well as low voltage supplies for lighting, lifts, escalators, ticket barriers, communication systems, and control systems throughout the network. The solution replaced five different multi-vendor SCADA systems. ABB performed the switchover from the old systems to the new solution without disrupting the normal train schedules. Installation work was carried out during a short cleaning and maintenance window each night, with commissioning taking place in phases to ensure that passengers would not be stranded or delayed by shutdowns.

### **Switzerland**

Switzerland has the highest frequency of train services in the world. ABB is not only providing power solutions for two of the country's most important rail projects of all time – the new Gotthard and Lötschberg base tunnels for high-speed trains – but is also a major supplier for the urban rail transportation systems in three of the country's largest cities: Zurich, Bern and Lucerne.

In Zurich ABB has provided the entire power supply

system for a new 12.7 km extension that links towns and municipalities in the Glattal area with Zurich's tram network. ABB was responsible for the design, supply, installation and commissioning of eight rectifier substations that supply the contact line with 600 V DC, and for the low voltage main distribution system that supplies all 22 stops with power for the ticket vending machines, information boards and track switches. ABB also installed the lighting, ventilation and fire alarm systems in the rectifier stations.

To meet the increasing demand for public transportation, the Swiss capital, Bern, has opted for trams instead of the trolleybuses used to date. Two new tram lines are set to open in 2012. ABB is providing five rectifier substations that will supply the tram lines with 600 V DC, and is also supplying remote protection for the contact line system. The remote system will connect the rectifier substations to the higher level control system operated by the local utility.

And in Lucerne, ABB is revamping the rectifier substations that power the city's network of trolleybus lines.

### **Other European metropolises**

For the Paris Metro, ABB is currently carrying out the complete refurbishment of two gas insulated bulk supply substations at the Denfert and Lamarck metro stations. When completed in 2011 the substations will feed the DC injection points of the suburban rail and metro lines, ensuring a reliable and efficient supply of power to the city's rail system.

In Vienna, ABB has supplied the traction power supply and distribution systems for recent extensions to two of the city's metro lines. To reduce traffic congestion and connect an additional 90,000 residents to the subway system, Wiener Linien added five stations and 4.6 km of track to the U1 line, and 11 stations and 9 km of track to the U2 line. ABB was responsible for the design, supply, erection and commissioning of eight DC traction substations, as well as power distribution for 17 stations. ABB's ability to provide service and maintenance for the equipment was a key component in the contract.

For network control, ABB has supplied SCADA solutions for metro systems all over the world. Besides London, two of the most notable in Europe are those for Stockholm and Rome. In the Swedish capital, an ABB SCADA system monitors and controls the metropolitan rail network, which consists of three underground and three light rail lines. The solution has improved operational security, made maintenance more efficient by integrating the whole network into a single system, and improved data transmission capacity. The solution for Rome has



achieved similar results. By integrating all power supply functions into a single system – power, escalators, CCTV, lighting, firefighting, PA (public address), tunnel ventilation, etc - the solution has improved the quality, safety and performance of the entire Rome Metro power system.

And in Spain, ABB has supplied around 370 vacuum cast coil dry-type transformers for the metro systems of Spain's two largest cities, Madrid and Barcelona. These robust and environmentally friendly transformers can operate in heavily dust-polluted environments, and are explosion-proof, self-extinguishing and fume-free.

## China

China is developing its rail and light rail infrastructure at a rapid pace. ABB technologies are making a key contribution and helping to transform the country's rail network to set new global standards. In the urban rail transportation segment, ABB power products like traction transformers, medium voltage switchgear, low harmonic drives and dry-type transformers ensure that the metro and light rail networks of major Chinese cities operate reliably and efficiently, including those of Beijing, Shanghai, Guangzhou, Shenzhen, Nanjing, Tianjin and Changchun.

One example is the Shanghai Metro, which is a combined metro and light rail system that serves China's largest city. The Shanghai Metro comprises 12 metro lines, 273 stations and more than 430 km of track, making it the longest network in the world. ABB has supplied several traction and power supply solutions over the years. In one such case, ABB has provided power supply solutions for six lines and extensions, including 14 bays of 110 kV gas insulated switchgear, 16 units of 110 kV transformers and 256 sets of 35 kV gas insulated switchgear.

ABB has also supplied an innovative solution that improves the network's power quality, while optimizing power consumption. The solution consists of around 200 active harmonic filters and reactive power compensation devices that eliminate harmonic distortion, stabilize the power network and help reduce the metro's power consumption. Significantly, the solution enables power inverters to be installed in the 400 V power distribution network to reduce energy consumption. Inverters generate harmonics, which ABB's solution eliminates with minimal power usage, thus providing Shanghai Metro with a cost-effective and energy-efficient solution that improves power quality and network stability.

ABB has recently established a new manufacturing unit in Guangzhou that provides advanced metro traction solutions for the Chinese market. The facility is equipped with state-of-the-art technology for the manufacture of key traction components like

propulsion converters, auxiliary converters and traction motors. Among the first orders delivered by the factory are rolling stock solutions for the Shenzhen Metro. ABB is also setting up a global converter R&D center at the facility.



ABB's custom-built traction converter system helps ensure the efficient and reliable operation of the Shenzhen Metro

## Turkey

In Turkey, ABB has provided power traction solutions for several of the country's metro and light rail systems, including Istanbul, Eskisehir, Adana and Izmir.

In Istanbul, ABB was selected by metro line contractor Avrasya Metro Group (AMG) to provide an electrification solution for the traction and power distribution systems in the new Kadikoy-Kartal metro line, which is currently under construction and scheduled to open in late 2011. The Kadikoy-Kartal metro line is one of the most important ongoing infrastructure projects in the city. The line will run on the Anatolian side of Istanbul and link up with the Marmaray rail tunnel under the Bosphorus strait, which will be the first rail link to connect the European and Asian sides of the city. With 16 stations, 21.75 kilometers of double track, and eight-car trains passing in each direction every 90 seconds and carrying up to one million passengers a day, reliability of the line's power supply is critical to metro operations and public safety.

ABB's solution, which includes 176 UniGear medium voltage switchgear panels and 86 vacuum cast coil dry-type transformers, was chosen by both AMG and the end user, Istanbul Metropolitan Municipality, for its outstanding reliability and performance record in similar rail and metro projects worldwide.

UniGear is among the world's most popular medium voltage switchgear. Its modular, robust and compact features with arc protection and segregated compartments for safety have made it a preferred choice for the most demanding environments and applications worldwide. 86 distribution transformers support the substation and traction power supply,

and include a range of ABB's hi-T Plus dry-type transformers, designed to withstand overloads, harmonic distortion and high temperatures.

ABB has also supplied vacuum cast coil transformers for the Kirazli-Olimpiyat metro line on the European side of the city, the 14-km Adana underground and elevated metro system in Adana, the three-line tram system in Eskisehir, and the metro system in Izmir.

### **Brazil**

Sao Paulo, one of the largest cities in the southern hemisphere, has the seventh largest metropolitan area in the world and an estimated population of 11 million. Companhia Paulista de Trens Metropolitanos (CPTM) operates six commuter rail lines that serve 22 of the 39 municipalities that make up the Sao Paulo Metropolitan Region. The network has 93 stations, 260 km of track and carries 2.1 million passengers a day and is integrated with the city's metro system.

CPTM has plans to double capacity by upgrading lines, constructing and refurbishing stations and other infrastructure, and by expanding its fleet of rolling stock. As part of the plan, CPTM has selected ABB to deliver power products and systems that will support the expansion and enhance system reliability. ABB is already supplying rectifier substations (138 kV, 88 kV and 34.5 kV), as well as a 3 kV DC supply to power the trains, and is facilitating the upgrade of two existing 34.5 kV substations.

### **Australia**

Yarra Trams is the trading name of the Melbourne tram network, and is considered the largest tram networks in the world with 249 km of double track, 28 tram routes, 1,770 tram stops and around 160 million passenger trips a year. Each week Yarra Trams operates 31,400 scheduled tram services, which requires many of the trams to operate for up to 20 hours a day.

When Yarra Trams decided to upgrade the traction substations serving this huge network, a key requirement was to keep the services running during installation and commissioning. They wanted an experienced partner, with the ability to execute the project under challenging conditions, and with the products and solutions to ensure operational reliability. They also wanted a company with local resources and expertise, as well as full service support. Yarra Trams chose ABB.

ABB's solution included five turnkey 6.6 /11 kV 600 V DC traction substations with medium voltage switchgear, transformers, rectifiers, DC switchgear and a SCADA system. The solution provides Yarra

Trams with the reliability to achieve 99.4 percent service delivery and meet high punctuality.

### **Worldwide**

Of the many rolling stock and infrastructure products and systems that ABB supplies for public transportation systems, four deserve special mention in 2011: DC rectifiers, modular traction motors, traction converters and ABB's new high-speed DC circuit breaker.

### ***DC rectifiers***

Traction power supply links the AC medium voltage supply system and the DC supply line (catenary or third rail) of the traction vehicles. For applications in DC electric traction the naturally cooled silicon diode rectifiers are the most suitable because they combine simple design, low maintenance, high overload capacity and a long operating life.

ABB has extensive experience of designing and manufacturing traction rectifiers, supported by many prestigious references all over the world, including London Underground and municipal transport systems in Belarus and Algeria. In Poland alone, ABB has supplied more than 1,000 rectifiers to the railway and rapid transit system networks.

One of the most impressive is the rectifier solution for the Sao Paulo Metro in Brazil, which ABB designed to enable surplus power from the metro to be converted from DC to AC power and returned to the local grid.

### ***Modular traction motors***

Traditionally, traction motors are among the many custom-made components required by train manufacturers. These motors are intensely engineered, which impacts their cost, lead time and ease of maintenance. ABB's 'one platform, multiple designs' concept overcomes these obstacles by meeting customers' varying requirements from a single modular platform. The motors are built to customer specifications by combining a set of standard components into a vast number of possible product configurations.

Following its recent launch, ABB's new and pioneering concept of modular traction motors is creating widespread interest in the rail industry. First orders were received in 2010 from Tranelec for installation on subway trains, and for a train project in China. A third order is for modular medium power traction motors for 30 subway trains for the new Kadikoy-Kartal metro line in Istanbul. The customer is the Spanish train car builder Construcciones y Auxiliar de Ferrocarriles (CAF). In addition to the new contracts, ABB has received a large number of requests for quotation from train manufacturers and OEMs in Europe, the U.S., South America and Asia.



An ABB traction motor for the new Kadikoy-Kartal metro line in Istanbul

Over the past two decades ABB has supplied around 3,000 high power density traction motors for the light rail vehicles operating on the metro systems and tramways of Europe. These exceptionally reliable motors offer a high degree of design flexibility and optimization to meet the space requirements of low-floor vehicles. Among the many metro and tram systems using them are Milan (Italy), Oporto (Portugal), Vitoria-Gasteiz (Spain), Edinburgh (Scotland) and Strasbourg (France). For instance, more than 1,400 of these motors are installed in the Strasbourg Eurotram, the largest light rail network in France, where they have been powering the Bombardier trams efficiently and reliably since the 1990s.

#### ***Traction converters***

For their rolling stock, many of Europe's tram operators have chosen ABB's roof-mounted BORDLINE® traction converters, which are renowned for their energy efficiency, reliability, compactness and service friendliness. These complete and highly integrated power electronics subsystems consist of two motor inverters, two auxiliary converter outputs, a battery charger, a braking chopper and all control electronics. Suitable for use on trams and narrow-gauge regional trains at line voltages of between 600 and 1,500 V DC, the converters are characterized by their very low weight, small dimensions and adaptable mechanical, electrical and logical interfaces to the vehicle. Public transport operators that have selected roof-mounted BORDLINE converters include those in Switzerland (Basel, Berne-Solothurn, the Lucerne region and the greater Zurich area), Germany (Bochum, Mainz, Munich, Nuremberg and Potsdam), Austria (Graz), France (Lyon) and Norway (Bergen).



ABB's roof-mounted highly integrated BORDLINE compact converters for light rail vehicles (BORDLINE CC400)

#### ***High-speed DC circuit breaker***

The ABB high-speed DC circuit breaker is the successful result of an R&D initiative by the Group to develop a new generation of onboard DC circuit breaker for metros, trams and trolley buses. ABB has registered five patents to make this successful innovation a reality.

Exceptionally compact and lightweight, the new DC breaker needs only half the space and is two-thirds the weight of other circuit breakers currently available in the market place. It results in optimum adaptation to customers' space constraints, greater portability and easier installation. Cadmium-free, it is considered to be one of the most environmentally friendly DC circuit breaker of the market.

#### **For more information:**

ABB Railway portal: [www.abb.com/railway](http://www.abb.com/railway)

ABB Review special edition on railways and transportation: [www.abb.com/review](http://www.abb.com/review)