Transforming suburban transport

ABB traction transformers helping to move millions of commuters

CÉCILE FÉLON, HARRY ZÜGER – A train speeds out of a calm suburb and into the bustling city, opens its doors and releases hundreds of passengers onto the platform. Soon the doors close and power once again flows to the train through overhead lines allowing it to accelerate rapidly to 60 km/h in a few seconds. Within a few kilometers the train decelerates and glides into yet another station to unload still more commuters. These events are repeated hour after hour, day after day, year after year. In cities around the world commuters rely on the high-performance of ABB traction transformers to reliably power their travel, quietly, and efficiently, while they prepare for another day at work.

Unlike regional rail systems, which operate between towns and cities, commuter rail services usually connect city centers to outlying suburbs within a range of around 60 km. These suburban railway networks carry large numbers of passengers under demanding conditions.

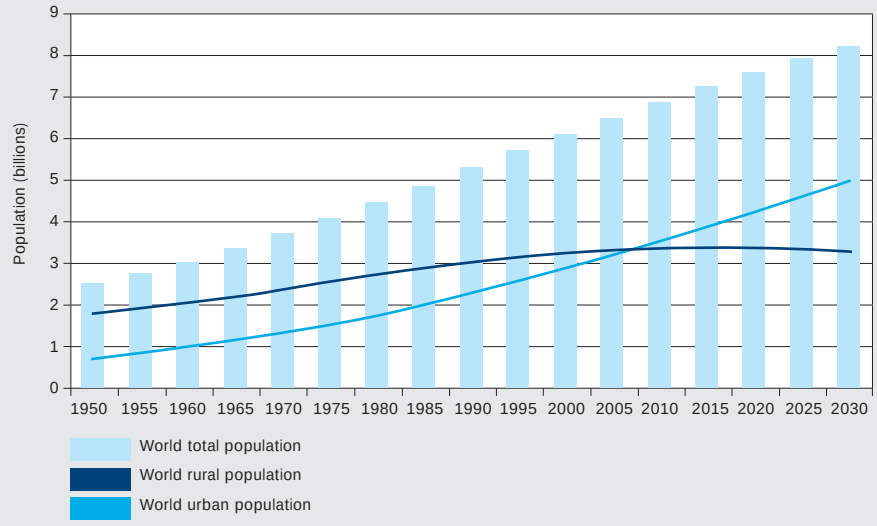
Commuter trains are expected to stop frequently, and decelerate and accelerate rapidly, placing severe strain on components. Despite these harsh operating conditions, the train is expected to perform reliably and provide a dependable service, no matter the environmental conditions.

ABB is a leading supplier of compact, lightweight, reliable traction transformers tailored to suit the specific requirements of the commuter train manufacturers and operators. ABB has an unrivaled track record, having manufactured several thousand traction transformers that are in operation around the world today. Now more than ever, ABB can provide a level of technical experience that facilitates the delivery of traction transformer technology regardless of the constraints faced by commuter train suppliers.

ABB's traction transformer improves urban quality of life

2008 represented a landmark year in global urbanization with more than half of the world's population living within urban areas for the first time. Forecasters predict that 60 percent of the global population will live in urban neighborhoods by 2030, and that the trend is set to continue. By 2015, it is estimated that 560 cities across the globe will have a population in excess of one million people ➔ 1.

1 The urban and rural population of the world, 1950 to 2030



This urban expansion is placing considerable strain on existing transportation infrastructure, with unprecedented levels of congestion becoming widespread in many urban areas. Evidence of this pressure can be seen in cities around the world, ranging from those in Germany, where commuters spend an average of 65 minutes each day travelling to work, to China, where this figure rises to 83 minutes a day. Not only does this level of congestion impact upon the quality of life of those subjected to it, but it also generates high levels of air pollution locally. In order to satisfy the increasingly critical need for a solution to this problem, cities are moving to expand the reach and capacity of their public transport networks.

As a leader in propulsion technologies, ABB is helping cities in this battle against congestion and pollution by contributing several key technologies to the electric multiple units (EMUs) used by many modern commuter network operators around the world. These vehicles display significantly higher levels of energy-efficiency when compared to diesel trains and buses and require relatively little space to transport large passenger numbers. By some estimates, convincing a commuter to switch from car to train will reduce CO_2 emissions by 50g / km [1]

To encourage passengers to use rail, mass transport operators must offer an affordable, reliable, and pleasant transport experience. Often rail operators collaborate closely with rolling stock manufacturers to ensure this.

ABB's long and extensive track record in commuter trains

ABB provides traction transformers for suppliers of commuter rail rolling stock around the globe. The effective implementation of innovative ideas and the ability to serve the world-wide market have helped ABB establish itself as a leading supplier of cutting-edge traction transformers.

> Ester oil displays excellent performance characteristics at the high temperature frequently experienced when these vehicles undergo periods of heavy acceleration. Such innovations maintain transformer efficiency while providing the client with a readily biodegradable product.

Within the last five years, the dramatic growth of commuter rail networks has helped ABB strengthen this reputation further. The company has delivered transformers to serve dozens of cities in Europe, India, and even to new markets such as North America and Africa.

New Jersey

In North America, the NJ (New Jersey) Transit system is a commuter rail network that serves the New Jersey suburbs of New York City, Newark, Trenton and Philadelphia. NJ Transit is the fourth busiest commuter rail network in North America, carrying approximately 252,000 passengers every weekday. Unlike many commuter trains in Europe, the trains that operate on this system use electric locomotives rather than EMUs. Bombardier is the supplier of the ALP 46 (American Locomotive Passenger) locomotive fleet to the NJ Transit system. These locomotives are required to be able to transition from zero to full throttle instantaneously, a practice that is commonly called for on North American rail systems. Instantaneous acceleration generates a violent thermal shock as the equipment undergoes a rapid temperature rise, a situation heightened under cold weather conditions. Bombardier chose ABB to supply transformers for these locomotives, supporting their reliability under these challenging conditions → 2.

Paris and suburbs

ABB has also supplied Bombardier with traction transformers for use on their SPACIUM EMUs in France. These trains

2 ABB traction transformer for Bombardier's ALP 46 locomotive

3 The last generation of traction transformer for Alstom's Porteur Polyvalent platform

are to be operated by SNCF (the French National Railway Company) in and around Paris, as part of an overall plan to extensively renew the countries regional rail network. These new EMU's were derived from Bombardier's AGC (Autorail à Grande Capacité) family of trains. ABB had already delivered traction transformers for the standard AGC platform and the AGC XBiBi versatile version. Drawing on these experiences, the most significant challenge facing ABB engineers on this SPACIUM project was to produce transformers with minimal noise emissions. ABB installed roof mounted, silent running traction transformers, as well as cooling systems that ensure lower noise emissions. The commuter and regional services operating in and around Paris account for around 1 billion trips per year, or 80 percent of national rail usage. This figure highlights the importance of suburban rail networks and their potential to improve efficient and reliable mass transport. In the case of Paris the development of the RER (Regional Express Network) has successfully combined existing rail infrastructure with the Paris Metro system so that the city centre and the surrounding suburban areas are connected providing an efficient and fully integrated transport system.

French regional

Further renewal of French suburban rail networks has led to investments in Alstom's Coradia Polyvalent trains named Régiolis by their French operator. The prime consideration for Alstom in the design of this single level modular train was to reduce the weight as much as possible. ABB won the contract to supply traction transformers to power these trains and worked closely with the client to produce a transformer, with DC line filter reactors and an auxiliary converter inductor with a total weight of only 2,650 kg → 3.

Switzerland

Switzerland has some of the worlds most highly integrated and efficient public transport systems. Although annual passenger numbers only total approximately 360 million, Switzerland's reliance on rail systems on a per capita basis is huge, with each citizen taking an average of 49 rail journeys per year representing the highest per capita usage of rail services for any European country.

Within the last six years, ABB has supplied a large number of traction transformers for the Swiss railway market. ABB won an order from Stadler Rail in 2003 to equip its FLIRT (Fast Light Innovative Regional Train) initially built for Switzerland → 4. Drawing on this successful project, ABB won repeat orders in the following years to equip further trains of the FLIRT platform for use in many other countries including Germany, Hungary, Algeria, Finland, and Norway. Today, almost 800 traction transformers have been delivered to Stadler Rail and in the year 2009, the total number of transformers ordered for the FLIRT platform surpassed 1000 units.

Based on their successful long term partnership, Stadler Rail again chose ABB as supplier for the traction systems

2008 represented a landmark year in global urbanization with more than half of the world's population living within urban areas. With forecasters predicting 60 percent of the global population will live in urban neighborhoods by 2030, it is widely accepted that this global trend is set to continue.

4 ABB has received orders for more than 1,000 traction transformers for Stadler Rail's FLIRT trains.

5 ABB traction transformer for Siemen's Desiro train

of its new generation of double-decker multiple-unit train (DOSTO) for use on Zurich's S-Bahn network. There are already follow-up orders for this type of double-deck EMU from Switzerland, Austria, and Germany. The DOSTO collaboration is likely to repeat the FLIRT success story.

India

In 2004, ABB was awarded a contract from Siemens Mobility to supply transformers for 172 EMUs intended to service the Mumbai commuter rail system. This project presented specific challenges for ABB's engineers with the transformers being required to function in India's high tropical temperatures. The traction transformers were designed to provide increased energy efficiency at higher temperatures. The Mumbai system is one of the most intensively utilized public transportation networks in the world and the Mumbai Suburban Railway alone carries more than 6.1 million commuters daily.

Within the last six years, ABB has supplied a large number of traction transformers for FLIRT trains for Switzerland, Germany, Hungary, Algeria, Finland, Norway and other countries.

Scotland

In another project with Siemens Mobility, ABB was contracted to supply traction transformers for trains destined for the Scottish railway franchise Scotrail. Siemens required environmentally-friendly, highly efficient mono-system transformers for use on a new generation Desiro commuter train ➔ 5. ABB responded to this challenge by producing transformers that used ester oil rather than conventional mineral oil as coolant. Ester oil displays excellent performance characteristics at the high temperature frequently experienced when these vehicles undergo periods of heavy acceleration. Such innovations maintain transformer efficiency while providing the client with a readily biodegradable product that makes its ultimate decommissioning more cost effective, and presenting fewer adverse environmental implications throughout the product's working life. Further benefits include the oil's high fire point, which allows it to meet the UK safety requirements for operation in tunnels. These new trains will be used by Scotrail to serve Glasgow's metropolitan area.

Algeria

In 2006, Algerian State Railways placed an order for 64 new FLIRT trains from Stadler (with ABB traction transformers) for use on local services around the capital Alger (Algiers). These trains are notable because they are designed to carry high passenger densities of up to 10 per m^2, in searing temperatures up to 55 °C.

This project illustrates the strengths of standardization. The cooling of the FLIRT transformer was designed for 15 kV. The Algerian FLIRT, however, uses the same system at 25 kV, providing a greater cooling reserve and so making the train suitable for either higher ambient temperatures or higher power.

South Africa

In South Africa, ABB traction technologies will power the Gautrain, an 80-kilometer rapid mass transit railway linking Johannesburg and Pretoria to Tambo International Airport. The Gauteng province is at the heart of South Africa's economy. It creates one-third of South Africa's gross domestic product and is home to around 10 million people, one-fifth of the population. ABB is playing a vital role in this project providing traction solutions for the 24 electric train sets that will operate at speeds of up to 160 km/h ➔ 6.

The Gautrain is a variant of Bombardier's award-winning Electrostar train, which is widely used in the United Kingdom and is powered by ABB traction transformers.

Modifications were made to ABB's standardized transformer design for the Electrostar to meet Gautrain's specific re-

6 The Bombardier's Gautrain train with ABB traction transformers

quirements for fast acceleration, low noise emissions and adaptability to the African climate. These adaptations have enabled ABB to offer high-class traction solutions at an unbeatable quality to price ratio. Chief among these modifications is a huge increase in power of around 40 percent to boost the train's acceleration.

ABB, the irrefutable leader

ABB has worked closely with leading suppliers in the rail industry, providing traction transformers for numerous commuter trains. These transformers have accrued a high number of operation hours worldwide and enabled millions of trips to work and leisure in the world's cities.

> The SPACIUM EMUs were derived from the AGC (Autorail a Grande Capacite). ABB delivered traction transformers for both AGC and SPACIUM.

Reducing weight of traction transformers

ABB Sécheron factory in Geneva, the Group's global "Centre of Excellence" for traction transformers

Building on several decades of experience in the traction transformer business, ABB has worked tirelessly to reduce the weight of its transformers, while continuing to provide the best possible performance.

The driving force for the efforts to reduce weight was and remains the commuter- and high-speed train market, where each kilogram has a material impact on operating costs and speed.

Weight is a primary consideration from the very beginning of the design process for ABB transformers. Once the target weight has been established, the transformer is designed using the best available technology to achieve the goal. ABB's team of engineers works closely with industry research and development partners to ensure the best insulation components are used to minimize weight, without compromising the dielectric capacity.

A transformer's design must accommodate load cycles, as specified by the customer, using the minimum weight of copper required to avoid any risk of overheating. Transposed wires are used to minimize harmonic losses and additional weight reduction can be achieved, in some cases, by integrating the converter's reactors into the transformer's housing, where they benefit from hydraulic cooling. Finally, software is used to establish the minimum distance between the transformer's winding and its tank. This ensures that the transformer is as compact as possible, without exceeding the external levels of magnetic flux specified by the customer.

The weight of a transformer's tank, whether made of steel or aluminum, is optimized using the finite element method (FEM) to ensure mechanical robustness while minimizing weight. In most transformers of this type, one or more cooling units are incorporated into the tank in order to simplify the hydraulic circuits and make each transformer an independent, self-cooling unit. Such cooling systems are compact and highly effective with low-noise (< 93dB) motor fans.

Cécile Félon
Harry Züger
ABB Power Products
Genève, Switzerland
cecile.felon@ch.abb.com
harry.zueger@ch.abb.com

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