Trained to fit

A transformer for a train that will go anywhere

Joel Vauchel, Harry Zueger

ABB offers a broad palette of products to the rail sector. The company produces power supply systems for rail networks as well as most of the electrics for locomotives. Notably, ABB is the global market leader for traction transformers. Currently, such a transformer is being elaborated, that makes the new AGC trains of the French Railway Company (SNCF) fully versatile – the same train will be able to draw its power from the overhead line regardless of the different voltage levels provided, or from a diesel generator where no such line is available. Such a train will be able to use France's entire rail network flexibly and seamlessly.

The achievement is especially remarkable, as the train was developed from a platform that was specified to permit certain combinations of the three power supply systems (two electrification voltages and diesel power), but not all three on the same vehicle. Consequently, the transformer was designed to fit in the same space on the train as the generator, making the two modes mutually exclusive. But when a three-system train was called for, ABB jumped to the challenge and showed it could be done.

At the beginning of the 20th Century, most electric railways used a DC power supply with voltages in the range of 600 V to 3 kV. These relatively low voltages could be fed directly to the traction motors, so keeping the construction of locomotives simple. However, the currents required to deliver the necessary power were very high (often in the order of several thousand Amperes over prolonged periods), calling for either a third rail or a heavy catenary[1)].

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Starting from the early years of the 20th Century, and increasingly during the 1920ies to 1950ies, higher transmission voltages were implemented (notably in the US but also Germany and France). These permitted lower currents and consequently reductions in both the weight and the cost of the catenary or the elimination of the third rail. Modern state-of-the-art railway networks use high voltage AC systems in which the catenary voltage ranges from 15 kV/16.7 Hz (in Switzerland, Germany, Austria, Sweden and Norway) to 25 kV 50/60 Hz (in many other countries). The lighter catenary construction not only saves costs but also permits faster running. Speeds above 250 km/h would not be feasible without an AC system.

Besides the lighter catenary, the major advantage of the higher voltage lies in the reduction of the number of feeding substations required (typically every 20 to 25 km at 15 kV and 50 km for 25 kV, instead of every 10 km at 1.5 kV DC).

On board the locomotive, however, the catenary voltage must be adapted to a voltage level suitable for the propulsion system – typically between 1000 and 2000 V. This requires a traction transformer.

Fifty percent market share

The Geneva plant of ABB Sécheron Ltd. has been manufacturing traction transformers since the introduction of AC supply systems. Six years ago, the Geneva plant concentrated its transformer activity on traction applications – a sector where it already leads with a fifty-percent share of the world market. Today, the company has strategic alliance contracts with the rolling stock manufacturers Stadler Rail, Bombardier, Siemens, and Alstom.

A traction transformer must meet key performance criteria such as:

- It is a single transfer point for energy between catenary and motors, imposing the highest reliability demands as any transformer breakdown stops the train.
- Smallest size, as space is at a premium.
- Lowest weight as the axle weight limit may not typically exceed 22.5 t. The restraint is even tougher for high speed or narrow gauge trains.
- Multiple low-voltage output levels are required to deliver power, not only to the traction system but also to auxiliary systems (air conditioning, lighting, signaling, information systems) and safety systems (brakes, battery chargers).

Key rolling stock manufacturers such as Bombardier are launching versatile train "platforms" permitting diesel and/or electrically powered variants to be easily derived from a common design. The new AGC (autorail à grande capacité) family of trains 1 being delivered to the French National Railway Company (SNCF) is an example of such a design Factbox.

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Designed for diesel and electric operations

When deliveries are complete, more than 500 AGC trains will be in service. These trains will be used throughout the 29,500 km SNCF network, of which 15,800 km is not electrified, 5,800 km is electrified at 1.5 kV DC and 7,900 km at 25 kV AC. Bombardier is supplying diesel, diesel/DC and AC/DC variants of the AGC. ABB is delivering the traction motors for all units, the generators for diesel operation, and the traction transformers for AC operations.

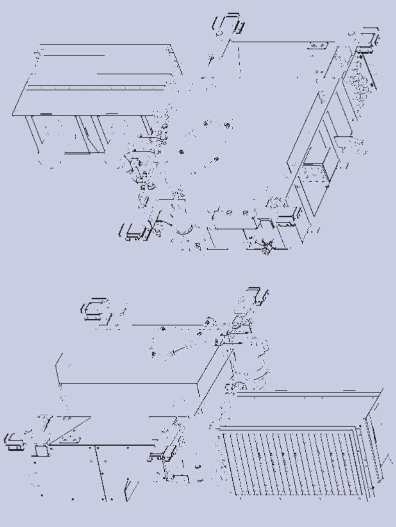
In order to meet these requirements, ABB had to design a small, sturdy and reliable traction transformer for mounting in the same volume and location as the diesel engine/generator power pack. This allowed Bombardier to manufacture the same body, irrespective of the propulsion system.

Transformer mounted under-floor

This transformer is mounted under-floor just behind the front bogie – the rest of the train is fully low-floor,

2 The under-floor transformer for the AGC

rated power	1800 kVA
primary	25 kV / 72 A
secondaries	932 V / 484 A
filter winding	1 x 110 kVA, 1000 V / 110A
overload	2750 kVA
thermal class	A (H for wire)
dimensions	2951 x 2583 x 842 mm
weight	3040 kg
impedance	28 percent (1.72 mH)
tank material	steel
standards	IEC 60310 NFF 16-101,2,3 NFF 65101



1 Modularity permits both diesel a and electric b variants of the AGC railcar for SNCF (French Railways). ABB is supplying the generators, transformers and traction motors.

3 The transformer for the AGC XBiBi

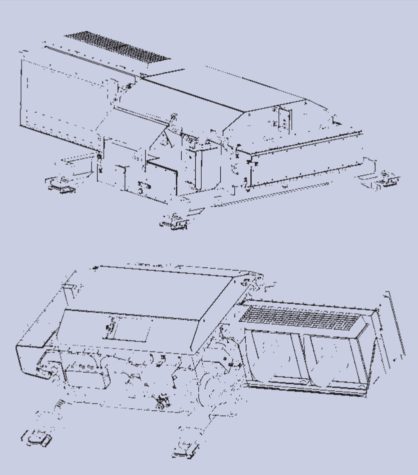
Factbox Key parameters of AGC trains for SNCF (French Railways)

	Diesel			Electric 25kV & 1.5 kV			Diesel & 1.5kV	
Number of cars	2	3	4	2	3	4	3	4
Bogies	Bo' 2' 2'	Bo' 2' 2' Bo'	Bo' 2' 2' 2' Bo'	Bo' 2' Bo'	Bo' 2' 2' Bo'	Bo' 2' 2' 2' Bo'	Bo' 2' 2' Bo'	Bo' 2' 2' 2' Bo'
Max speed (km/h)	140	160	140	160	160	160	160	160
Motor Power (kW)	622	2×622	2×622	1300	1300	1300	2×622/1300	2×622/1300
Acceleration (m/s²) 0-50km/h	0.45	0.66	0.52	1	0.82	0.67	0.81	0.66
capacity (seated/standing)	144/130	208/200	272/251	144/130	208/200	272/251	208/200	272/251
Mass (t)	92.6	130.6	158.5	94.6	121.6	149.5	131.6	159.9

providing easier access for disabled passengers, passengers traveling with bicycles, baby-carriages etc. Low floor also enables shorter dwelling times at stations, permitting faster services and better utilization of line capacity.

The transformer module 2 integrates the oil expansion tank and the cooling system. This means that the oil circuit no longer has to be completed after the mounting of the transformer on the train. Supervision and protection devices such as fast fuses and current transformers are also mounted inside the terminal box. The cooler is equipped with two-speed motors and is over-dimensioned in order to offer more surface reserve than usual – this makes the transformer more robust under heavy service conditions. The under-floor resilient mounting minimizes structure-borne noise.

4 The roof-mounted transformer for the AGC XBiBi – electrical properties are the same as for the under-floor variant 2, but dimensions are 3216 × 2382 × 860 mm



Fully versatile – the train that will go anywhere

Shortly after the delivery of the first transformers by ABB, SNCF expressed the intention of obtaining fully versatile trains being able to run on all three power supply options. In other words: the dream train capable of running everywhere in France from Dunkirk to Nice and Brest to Strasbourg.

This new "model", called AGC XBiBi (bi-mode and dual voltage) was not included in the original AGC concept – the traction transformer and diesel engine were mutually exclusive because they occupied the same position. ABB met the challenge by elaborating a solution with minimal cost, short delivery time and a high modularity impact that did not affect the overall AGC design. The low floor construction had to be retained and modification of the diesel coach was also no option.

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Roof mounted traction transformer for AGC XBiBi

Drawing on its past experience with roof-mounted traction transformers as delivered for Bombardier's NINA trains, but also for Stadler's FLIRT[2)] and Alstom's X60, ABB designed a flat roof-mounted traction transformer 3, electrically identical to the under-floor one 2. This enabled its application without requiring adaptation of the propulsion or control system.

The key parameters of AGC XBiBi traction transformer are identical to the standard AGC under-floor transformer electrically. Mechanically the dimensions were modified to 3,216 × 2,382 × 860 mm 4. Both transformer models are layer types in order to minimize vibrations.

On the right track

Today, the notion of "platform" is being promoted by all train manufacturers. It is therefore important to investigate all possible solutions at an early stage so as to minimize subsequent time-consuming engineering efforts for product adaptation.

Besides the transformers presented here, ABB Sécheron also offers a broad range of state-of-the-art traction transformer technologies. The company has developed weight-saving solutions for the integration of the DC line-filter and chopper reactor functions inside the transformer's active part. These are used on Bombardier's latest multi-system locomotives (TRAXX family) and on high speed trains.

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Footnotes

1) Catenary is the structure of the overhead line.

2) See also "The compact converter" on page 52 of this edition of ABB Review.