

Transformers to power Indian Railways

Indian Railways has ambitious electrification targets and has found that ABB's comprehensive range of transformers provides an ideal and eco-efficient means not only to power trains, trackside and stations but also to boost rolling stock speed and performance.

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Indian Railways have 64,000 km of routes, but around 60 % is not yet electrified, so the goal is to electrify the entire network at an average rate of around 10 km per day

Figure 1. Indian Railways have an ambitious electrification program both in the national and metro networks. Shown here is a Lucknow Metro train

With approximately 200,000 employees and a rail network that encompasses over 64,000 km of routes, Indian Railways is one of the biggest public-sector enterprises in the world. Of this 64,000 km, around 60 percent is not yet electrified. Indian Railways have a goal to electrify the entire network, at an average rate of around 10 km per day (5,000 km is the 2018-19 target), in order to improve passenger experience and freight handling, reduce carbon emissions from diesel locomotives and save on fuel costs, Figures 1 and 2. The company also looks to employ equipment that reduces overall carbon footprint and improves energy efficiency.

To meet electrification goals, Indian Railways will have to acquire more rolling stock and more of the trackside transformers that supply the 25 kV overhead lines. ABB already supplies locomotive transformers to Indian Railways' original equipment manufacturers (OEMs), like Chittaranjan Locomotive Works (CLW) and Diesel Locomotive works (DLW). In fact, 40 percent of Indian Railways' high-speed trains, like the "Rajdhani" and "Shatabdi" passenger trains, are powered by ABB traction transformers. ABB's 30.24 MVA, trackside transformers, with a low-loss design, are also helping Indian Railways and their engineering, procurement, and construction (EPC) partners in their mission, Figures 3 and 4.



The traction transformer market is also driven by measures being taken to combat the rapid urbanization taking place in India, where metro cities and other B-class cities are facing serious traffic jams and vehicle pollution. The Indian Ministry of Housing and Urban Affairs has approved a policy to commission environmentally friendly metro railways in cities having a population of more than one million. This will help to decongest, and reduce pollution levels in cities and make commuting easier. In support of the Ministry's vision, ABB electric multiple unit (EMU) technology for traction transformers are helping to develop the Metro network in cities like Delhi, Lucknow, Kochi and Mumbai. ABB traction transformers produced in India are suitable for local conditions and are well accepted by Delhi Metro Rail Corporation

(DMRC), a central agency for approval of metro equipment.

India's metro networks also have many stations that require distribution auxiliary and rectifier transformers. Here, ABB's latest vacuum-cast-type technology on dry-type distribution transformers is helping metro EPCs to supply auxiliary loads and third-rail systems.

ABB traction transformers for Indian rolling stock

Traction transformers have two main purposes in trains. Firstly, they convert single-phase, high-voltage (normally ranging from 15 to 25 kV) from the overhead catenary lines to levels (400 V – 1.8 kV) that are usable by the power converters in the train's traction chain.

Secondly, traction transformers provide galvanic insulation for safety and protection purposes.

The key specific technical product challenges in India are:

- Harsh environmental conditions: ambient temperature, shock, vibration, flooding, humidity and aridity.
- India Railways' maximum temperature limits (which are 20°C lower than international standards) for transformer components combined with the high ambient temperatures makes it difficult to cool a contained traction transformer effectively and still maintain a reasonable weight and size.

One of the vital factors for success in India is the ability to manufacture locally –





Figure 2. Indian Railways has a route length of over 64,000 km, with running track length of 87,000 km. The total trackage including yards, sidings, etc., exceeds 113,000 km.

New ABB transformers allow freight trains to increase their speed from 60 to 90 km/h



Figure 3. ABB trackside transformer.

a fact understood by ABB at the end the 1990s when local production of traction transformers for WAP passenger and WAG freight locomotives was started up. ABB has developed its portfolio to cover almost all local rolling stock and propulsion system makers – for example, CLW, DLW, Bombardier, Siemens, Alstom and Medha.

Recently, ABB had its Indian premiere of compact, lightweight transformers that use an ester as cooling fluid. These provide a safer and biodegradable alternative to traditional transformers. The metro in Lucknow was an early recipient of one such (1 MVA, 25 kV / 50 Hz) transformer, equipped with one auxiliary and two traction windings. With an inductor included in the tank plus a cooling system, the total transformer weight is just 3,100 kg. This project was the first one awarded by Alstom India to ABB India and all manufacturing is local. The ABB global team delivered to Alstom's satisfaction, which paved the way for the Madhepura Century Project – a very large order – being awarded in 2016 to ABB India by Alstom for 1,600 traction transformers to be delivered over a period of 11 years.

The 5.8 MVA, 25 kV / 50 Hz Madhepura transformers have one filter and four traction windings, one three-phase transformer included in the tank and



Figure 4. An array of four ABB trackside transformers installed by Indian Railways.

two heat exchangers. The total weight is 7,500 kg. This new transformer allows freight trains to increase their speed from 60 to 90 km/h.

ABB liquid-filled trackside transformers support the greener goals of Indian Railways

Since 2002, ABB has supported Indian train line electrification by providing a variety of single-phase, liquid-filled 21.6 / 30.24 MVA trackside transformers to connect power systems at 66, 110, 132 and even 220 kV to the 27 kV catenaries that supply power to the electric locomotives. Reliability of the units has been proven by extensive short-circuit tests performed at the Central Power Research Laboratory (CPRI), the accredited testing laboratory with bases in Bangalore and Bhopal.

ABB is currently the largest single supplier of railway trackside transformers to Indian Railways. The transformers are designed to withstand frequent and severe overloads – of up to 200 percent of the nominal load – to support heavy freight and passenger traffic even during the hottest days, when ambient temperatures can exceed 50°C. The units are equipped with fiber-optic sensors to

In 2016 ABB India got a very large order of 1,600 traction transformers to be delivered over a period of 11 years to Alstom for the Madhepura Century Project

monitor working conditions and thus optimize their lifetime. Conventional oil filtration units and no-load or on-load tap-changers are used to reduce maintenance intervals and substation personnel levels.

The compact and lightweight design guarantees efficiencies that go well beyond the customer's minimum efficiency requirements to ensure a low total cost of ownership and a greater reduction of carbon footprint during operation. ABB transformers have excellent global references and more than 250 of these units have been manufactured locally – with an excellent history of on-time delivery and short lead time – and installed in the Indian Railways power network.

Dry-type transformers for mass rapid transit systems in India

The self-extinguishing nature of dry-type transformers makes them the ideal choice for installations in busy

metro stations, Figure 5. These transformers are mostly installed indoors, for example, in underground or above ground metro stations. Because of the tight dimensions in these locations, most of the transformers are supplied with fully removable enclosures that allow for them to be reassembled at the installation site. These enclosures are modular, so their assembly is simple. The light weight and easy handling of aluminum-wound, dry-type transformers has encouraged most metros networks to migrate to them from copper-wound, dry-type transformers. Dry-type transformers in metro stations are used primarily in 24 kV AC systems, third-rail DC systems and monorails.

Auxiliary dry-type transformers in the Metro

Auxiliary dry-type transformers, usually three-phase, are widely used to power heating, ventilation and air-condition-



Figure 5. Dry-type transformers are ideal for underground or enclosed applications.

ABB is currently the largest Indian Railways' single supplier of railway trackside transformers, which are designed to withstand frequent and severe overloads – of up to 200 % of the nominal load

ing systems at metro stations – as well as the lighting loads of various associated shops and malls. Normally, transformers with ratings from 1,600 kVA to 3,150 kVA are used in underground metro stations, while lower ratings are used above ground. ABB has supplied auxiliary dry-type transformers to various metros in India, e.g., Delhi Metro Rail Corporation, Ghaziabad Metro, Noida – Greater Noida Metro, Lucknow Metro, Navi- Mumbai Metro, Chennai Metro and, most recently, Ahmedabad Metro.

Predominantly, oil-immersed transformers are used for supplying overhead railway lines of 24 kV AC systems. Recently, ABB successfully commissioned a dry-type, single-phase transformer having a voltage ratio of 33 / 24 kV

(Noida – Greater Noida metro) for this task.

ABB has supplied 12-pulse rectifier, dry-type transformers along with two six-pulse rectifiers for a third-rail DC system. Third-rail DC systems are used as they provide a smoother operation than 24 kV AC systems, though the latter system has a lower initial investment. Reference locations for this application are Kochi Metro Rail Corporation, Kolkata Metro Rail Corporation and, outside of India, Bangkok Metro. ABB has also supplied 12-pulse rectifier, dry-type transformers along with two six-pulse rectifiers for a monorail system. These transformers were additionally equipped with a surge arrester protection system to help the transformer withstand fast transients gener-

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ated by vacuum circuit breakers during the switching operations. This solution is known as ABB's Transient Voltage Resistant™ Transformer (TVRT) and is specifically designed to withstand voltage transients generated from switching. The reference location for this application is Mumbai Monorail.

On the fast track

ABB, as a technology leader in infrastructure and transportation and with its portfolio of transformers for locomotives and trackside, is helping Indian Railways in their mission to electrify their network. ABB technologies are also helping Indian Railways to provide more powerful freight locomotives, increasing their average speed to 90 km/hr. This increased performance is enabling Indian Railways to haul more freight, increase revenue, shift freight from road to rail, decongest roads and reduce air pollution. And with the introduction of more eco-efficient, ester-filled transformers, fire safety is promoted and environmental impact reduced.



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