# ABB's transformers for special applications meet special needs

## Designed to be flexible, compact, and adaptable, ABB's specialized transformers are available in a broad range of voltage levels and power ratings; units for subsea or mobile substations and data centers operate with reduced losses.

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For complex applications or harsh conditions standard transformer products might not be feasible. Drawing on 100 years of experience and a global footprint, ABB has developed special application transformers with this in mind. High quality materials for core and winding, improved components and perfected connection technologies allow ABB to develop transformers to suit the end user; the result is reduced

Figure 1. Data centers count on reliable power, which ABB's TVRT makes possible.

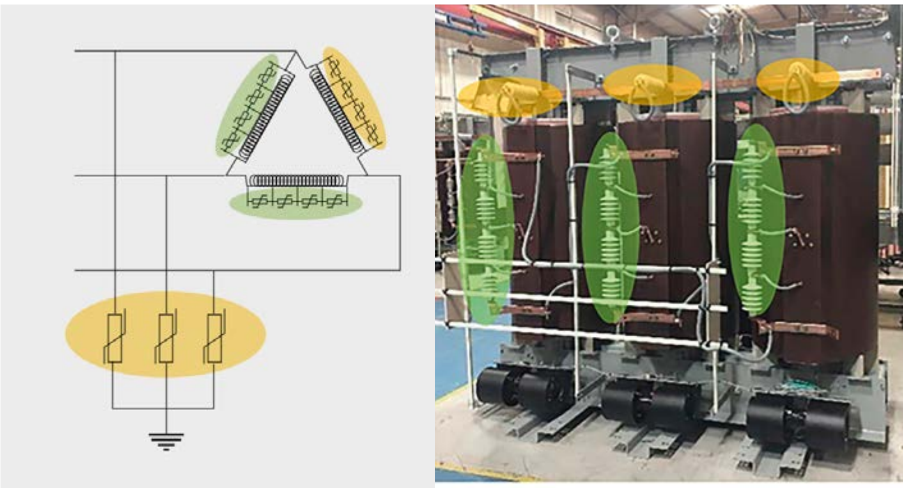

Figure 2. TVRT is designed specifically to resist load-bank switching operations.

**ABB's specialized transformers are used for complex applications or in harsh conditions, and are available in a broad range of voltage levels and power ratings**

power losses and extended product lifetime. In this way, ABB meets customers' technological demands while reducing investment time.

## Data centers

Data center technology is dynamic and continually expanding – ABB ensures safe, reliable, and efficient operation of these invaluable information fortresses, Figure 1. Building on its background in supplying mission critical power and automation technologies, ABB has developed a transformer that can operate safely with fast-acting breakers to provide reliable commissioning and load-bank switching operations.

Switching of fast-acting breakers, such as vacuum and SF6 breakers, can produce fast transient overvoltages inside transformer windings; some of which lead to failures, with subsequent downtime and irreparable equipment; both of which are incredibly costly to network managers. ABB's Transient Voltage Resistant™ Transformer (TVRT™) provides complete peace of mind during network switching operations, Figure 2. The TVRT functions in any electrical network because it is the only solution that controls transient voltages. All its components are oil-free, which greatly reduces installation costs and removes the risk of fires or spills; this is the safest solution for people, property and the environment.

The development of the TVRT by ABB engineers led to the knowledge that switching transients are generated inside of the windings, unlike lightening voltage transients. Furthermore, overvoltages caused by high frequency re-ignitions are the source of the major voltage stress, not amplification of voltage due to resonance inside the transformer, as was previously thought. With that insight, ABB's engineers addressed the problem and provided a simple solution: varistors are placed strategically along the windings in proprietary arrangements to limit transient overvoltages for re-ignitions that may occur inside of the breaker as well as for any amplified voltages from harmonic resonance inside of the transformer. Combined with advanced winding design, this engineered technology controls peak voltages that might occur without the need to know the characteristics of the connected system.

The TVRT technology also eliminates the risk and maintenance associated with oil-filled capacitors. This is particularly important for data centers that rely on dry-type transformers to


Figure 3. ABB's rugged subsea power transformers deliver the power that makes subsea exploration by the oil and gas industry feasible.

**ABB's subsea transformers are designed to operate at great depth and extreme atmospheric pressure**

lower the need for maintenance and reduce the risk of fire.

## Subsea applications

ABB delivered the world's first commercial subsea transformers in 1998 – a pioneering achievement. Robust, maintenance-free and exceptionally reliable, transformers are routinely used nowadays to power the field equipment of the oil and gas industry that is located on the seabed: boosters, pumps, compressors, pipeline heating systems and frequency converters, Figure 3. In the near future, subsea transformers and reactors will be used for grid connections of wave power, tidal turbines and offshore wind parks.

Traditional production facilities, without subsea electric machinery, must cope with the constant decrease of the pressure of the reservoir and a shortened economic lifetime of the field. Typically, subsea booster pumps increase the pressure of oil flow and water pumps raise the oil by injecting water into the reservoir, thereby increasing the lifetime and productivity of the wells. Compressors raise the pressure of the gas and increase the flow from the seabed to shore along the gas pipeline. Subsea high-voltage (HV) transformers allow pumps and compressors to be placed farther away from the existing power generation and supply point.

Electric motors located on production facilities, controlled by topside drive these pumps and compressors. Long HV cables supply power from the topside drives to the subsea machinery situated apart from the topside installation. Step-down subsea transformers are then installed at the seabed nearby to adapt the supplied high voltage to the operation voltage of the machinery. Higher transmission voltage reduces the load current and therefore the size and weight of the cables and the voltage drop in the cable.

Dedicated subsea power distribution grids can be constructed with constant voltage and frequency (50 / 60 / 16.7 Hz) with a main subsea transformer and a subsea power distribution grid on its low voltage side. Recently, ABB has successfully conducted underwater tests of a drive unit that includes an integrated subsea transformer; this demonstrates that power transformers up to 100 MVA can be manufactured and operated.

ABB's subsea transformers are designed to operate at great depth and extreme atmospheric pressure. The devices are liquid-filled and pressure-compensated to keep the internal pressure near that of the external water.

ABB uses high-quality insulating oil with a low expansion coefficient and high compatibility with other components in the transformer. Because the transformer is housed in a solid corrosion-proof tank that cannot expand, even when hot, the oil is degassed before installation and the tank is provided with a patented pressure compensating system, thereby ensuring safe operations.

Once installed on the seabed, the scope for repairs is limited. ABB has


Figure 4. Polytransformers rely on a multi-voltage approach and are compact; they can be shipped and installed in any substation.

invested in resources to ensure that its transformers are maintenance-free and all components are of the highest quality. Rigorous testing enables these transformers to enjoy a long, maintenance-free operating life.

## ABB's HV mobile transformers for planning

Nowadays, utilities are asked to prepare detailed contingency plans, to efficiently manage partial grid unavailability in case of a power transformer failure. If failure occurs at a critical substation, with approximately 500 MVA rated power, revenue losses can reach up to $0.3 million per day, before consideration of financial losses caused by damage to reputation. Two main strategies exist to meet these challenges: replace the failed unit with a local spare unit within the same substation (i.e., the traditional N+1 spare approach), or use adaptable transformers that are compact, rapidly deployable multi-voltage solutions. The latter approach is dominant today: a single design with outstanding flexibility that leads to lower investment costs.

The use of HV Mobile transformers, Figure 4, can significantly reduce reaction time – i.e., a compact single phase unit can be transported and put into operation in just a few days. It would take weeks or even months to mobilize a large, spare, standard three-phase transformer.

Ten years ago, ABB manufactured the world's first HV mobile transformer using the robust shell technology to give utilities a flexible and fast recovery solution. Thanks to research on materials and winding configurations, this solution has been recently improved: it is more compact, with a higher-rated power and a higher number of voltage ratios; polyvalent transformers can be easily transported to any desired substation rapidly, thereby optimizing grid operation.

Multi-voltage configurations must allow rapid adaptation to different grid voltage levels, to allow full working capabilities. The latest Shell HV mobile units solves these challenges. Successfully tested in its Córdoba, Spain facility in early 2018, ABB could then design and manufacture a 550 MVA three-phase bank composed of modular hybrid single-phase units, with multi-voltage capacity for different voltage ratio configurations by means of 400-220 / 220-138-66 / 33-20 kV rated voltages, Figure 5. These are the world's first mobile single-phase transformer units operating at 420 kV with full voltage range and capacity OLTC in HV. Now, emergency conditions will not impact the operation of these mobile units.

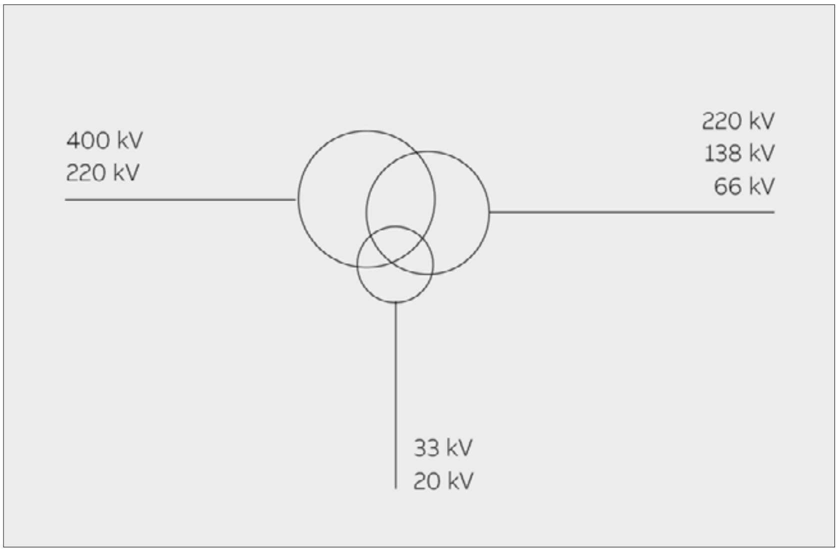


Figure 5. Simplified diagram shows the possible HV levels, LV levels and tertiary voltage levels that can be adjusted.

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Conceived to provide emergency support for up to fourteen substations spread over an approximate 1000 km² area, end users can now count on an optimized spare fleet instead of turning to the typical N+1 approach. This single adaptable modular design solution therefore results in a significant reduction in investment.

Additionally, the newest HV mobile unit's limit weight is below 100 tons, and shipping height is less than 3.5 meters to ensure short and easy transit. Nevertheless, the transformer must still operate properly once it reaches the substation. By adapting to the existing system voltage levels at each new location, ABB's mobile solution achieves the greatest voltage ratios available for a HV mobile unit in the industry today. The HV level can be adapted either to 400 kV or 220 kV, LV level can be adjusted to 220 kV, 138 kV or 66 kV, and tertiary voltage can be selected from 33 kV to 20 kV, Figure 5. The main voltage can be altered after arrival, and additional minor voltage levels on-load adaptations can be provided by the permanently installed OLTC HV side during operation.

Overall, ABB's shell HV mobile transformers help utilities to deal with emergency contingency plans, thanks to mechanical robustness, compactness and ease of transit, straightforward voltage tap adaptations, and reliability.

## Mobile substations and multi-functional modules

During contingent events (e.g., interim grid connections) utilities still need to provide for power, but how? Enter ABB's Power Transformers for Mobile Substations (MoSS), Figure 6a and Multi-Functional Modules (MFM),


Figure 6. Power transformers for mobile substations can be easily arranged in many configurations, mounted for air, rail and road transportation and installed almost anywhere.

Figure 6a shows power transformers at 27 MVA 150 / 8.4 kV for MFM "Lean-type", used in the ACEA Substation, Salisano, Italy. The MFM's are skid-mounted and were installed on existing foundations.

Figure 6b. Generator step-up power transformers at 30 / 40 / 60 MVA 11.5 / 220 kV for MFM, to be coupled with gas turbine-generating units. The MFMs are installed on trailers for road transportation in Algeria.

**Power transformers for mobile substations can be easily arranged in many configurations, mounted for air, rail, and road transportation and installed almost anywhere**

Figure 6. These devices enable: power to be supplied during emergency or planned outages, loads to be moved and the integration of distributed or renewable power and generation.

Completely assembled, these units are mobile and ready-to-connect. Designed to comply with any grid codes, these power transformers are invaluable for the demands of special substations.

Available for various voltages and power ratings, the transformers are reliable – supplying high- quality energy to many different substation configurations and applications:

- Dispersed and unpredictable generation sites
- Generation from renewable sources
- Fast-recovery plan due to aging of the existing plant
- Skid mounted arrangement to limit civil works
- Fully relocatable modularized switchyard
- Power supply to facilitate projects by providing an alternative temporary supply in substations
- Emergency installations in adverse environmental conditions

Most recently, ABB moved the first generator step-up (GSU) 60 MVA and 220 kV power transformer on a single trailer in combination with the high-voltage hybrid switchgear PASS module (Plug and Switch System) – forming a fully assembled MFM – to the energy grid in Algeria, Figure 6b. In cooperation with Energy Services Inc. (ESI), a Pratt & Whitney affiliated engineering group, this concept has been developed for the power supply through their MOBILEPAC® self- contained gas turbine-powered electric generating units, which feed the GSU power transformers rated at 30 / 40 / 60 MVA, 11.5 / 220 kV, BIL 1050 kV.

This special power transformer is designed with three cooling stages and is integrated to the PASS through oil-SF6 bushings. The MFM's are then equipped with synchronizing relays for the generator gas turbine and digital relays for control, protection and metering. The compact design of these GSU power transformers for MFM and the MOBILEPAC® power supply system allow energy to be supplied less than one day after arrival. Currently, in operation in four different locations in Algeria, these units guarantee flexibility and adaptability to customers, who count on ABB to meet the unique demands in the transformer market.

"ESI chose ABB's MFM solution on account of its compact design, speed of delivery as well as ABB's commitment to supply products as per stringent technical specifications, thereby paving the way for this important collaboration." stated Larry Pitts.

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