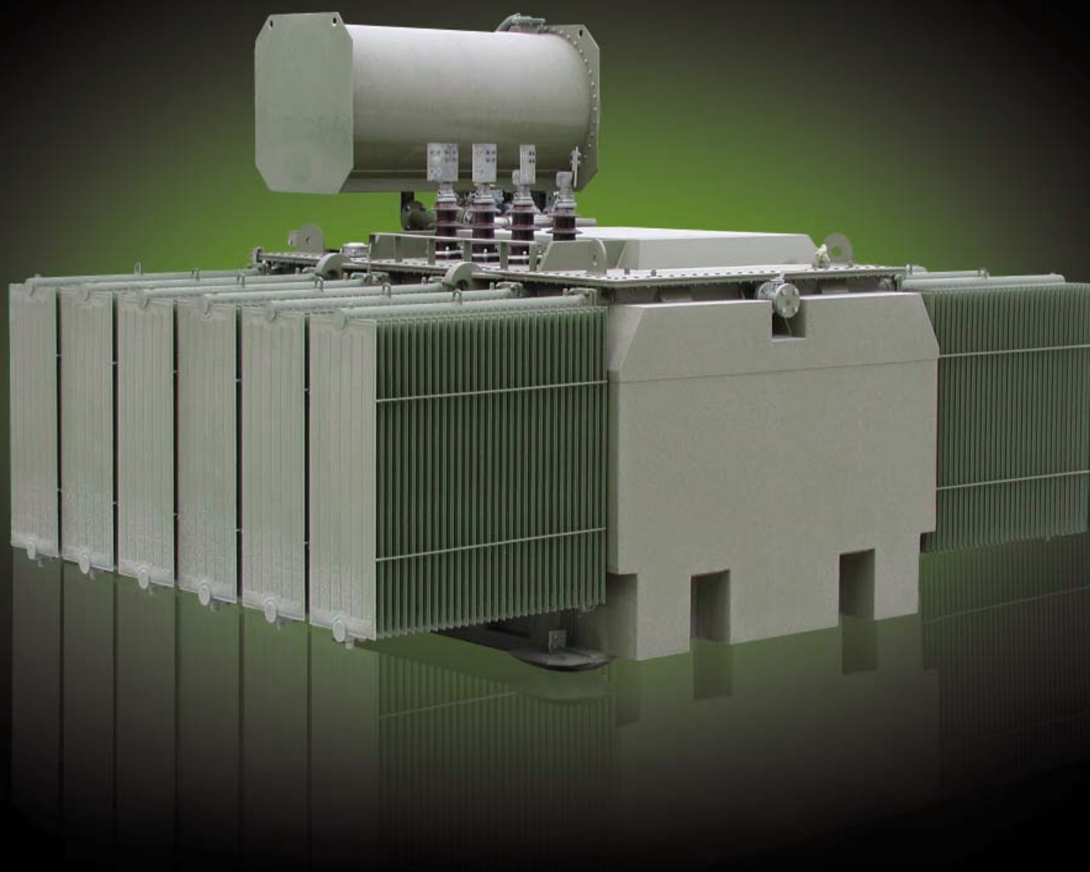


Transformers

Special transformers
Reactors products

Power and productivity
for a better world™

Reactors – Custom designed, custom built

ABB Oy Transformers has extensive experience and numerous references from different reactor applications, having the global product responsibility within the ABB group for special transformers and small and medium-size reactors.

Our compact and low-weight transformers and reactors fully comply with the customers' specifications. The products are developed involving customers and ABB system engineering know-how ensuring that the special requirements are always met. The high quality of our reliable products provides an outstanding capacity to withstand short circuits, harmonics, as well as fast and large load fluctuations.

Special and type tests and quality control ensure realible and safe operation, while ABB's product support and global service network with fast response maximize the availability.

Applications

Reactors manufactured by ABB include:

- Shunt reactors
- Series reactors, such as
  - Current limiting reactors
  - Neutral / earthing reactors
  - Motor starting reactor
  - Arc furnace series reactors
  - Duplex reactors
- Earthing transformers

Standards

The following standard governs the reactor and the applications: IEC 60076-6 Part 6: Reactors, published 2007. This new standard gives more specif c def nitions of the types of reactor and also more specif c demands for testing reactors compared to the previous standard IEC 60289.

Testing

Extensive and heavy type testing programs have been performed for the verification of the design platform used for the reactors. The project specific type and special tests can be performed if specified by the customer. Routine tests stated in the standards are always performed for each reactor unit.

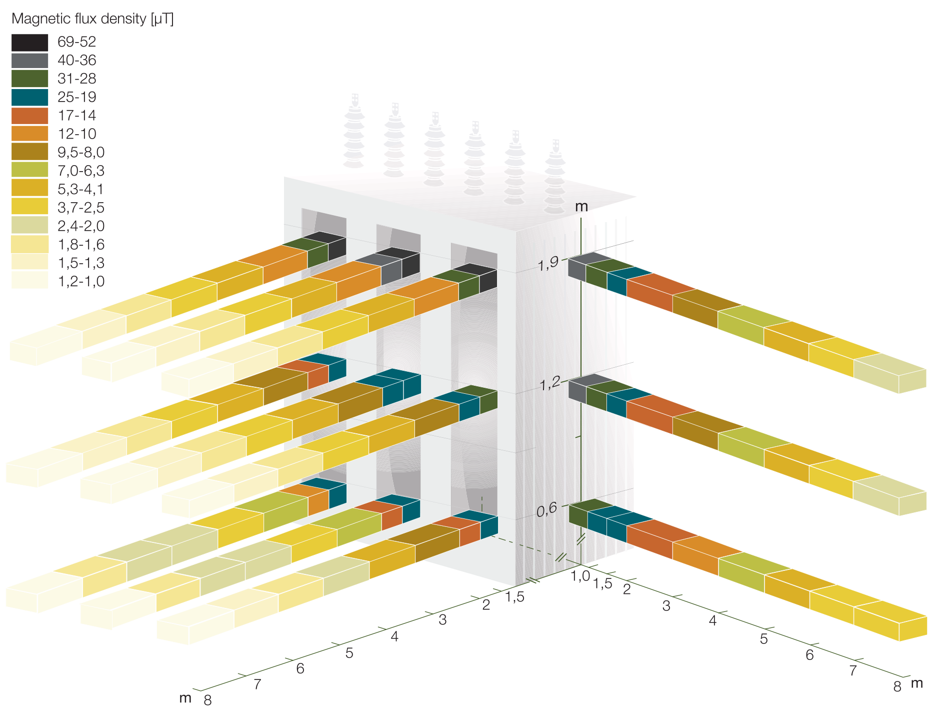
Design

The ABB reactor design is generally based on the magnetically shielded air core or gapped-core concepts. The selection of the design type depends on the reactance needed and requirement for the linearity.

The magnetically shielded air core is generally most commonly used in different reactor applications. This type reactor is designed without any ferromagnetic material inside the winding, but incorporating a magnetic shield outside the winding for flux control purposes. The magnetically shielded air core is used in applications when the inductance is small and linearity area is wide. The reactance is almost linear as winding turns generates most of the inductance. It is also safe to use, the shielding around the winding collect the flux to stay inside, it doesn't spread into surroundings of the reactor.

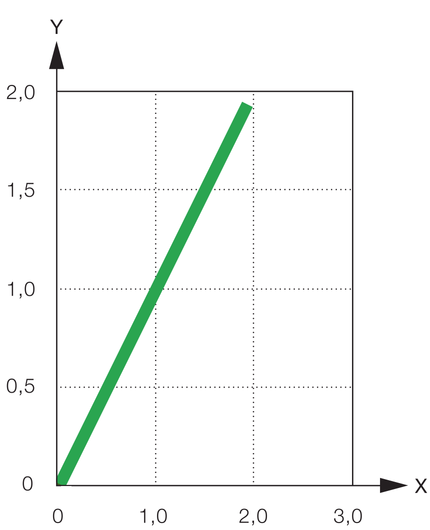
The gapped-core reactors are designed with a gapped ferromagnetic core inside the winding. The gapped-core concept gives a compact design with low losses and low total mass. It is used with higher reactance values, meaning high voltages or small power. The reactance is not linear as most of the inductance is generated by core steel, which saturates with excessive currents.

Magnetic flux density

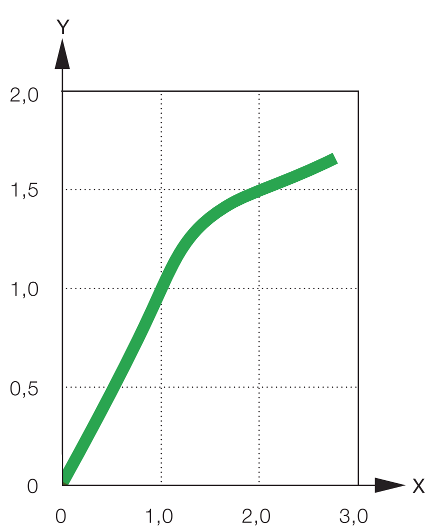


The test results of magnetic flux density measurement done by Tampere University of Technology. The flux is according to the standards, and it does not limit the location of the other equipment.

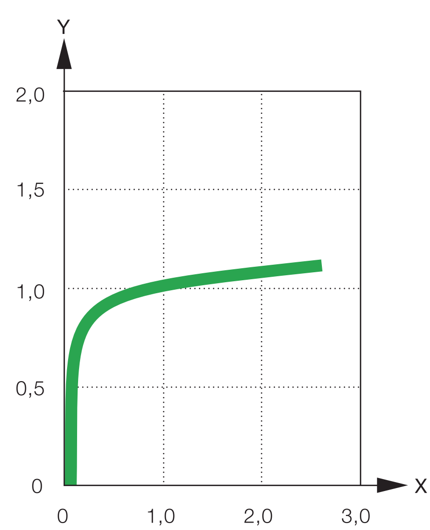
Linear



Non-Linear



Saturated



Reactors – Custom designed, custom built

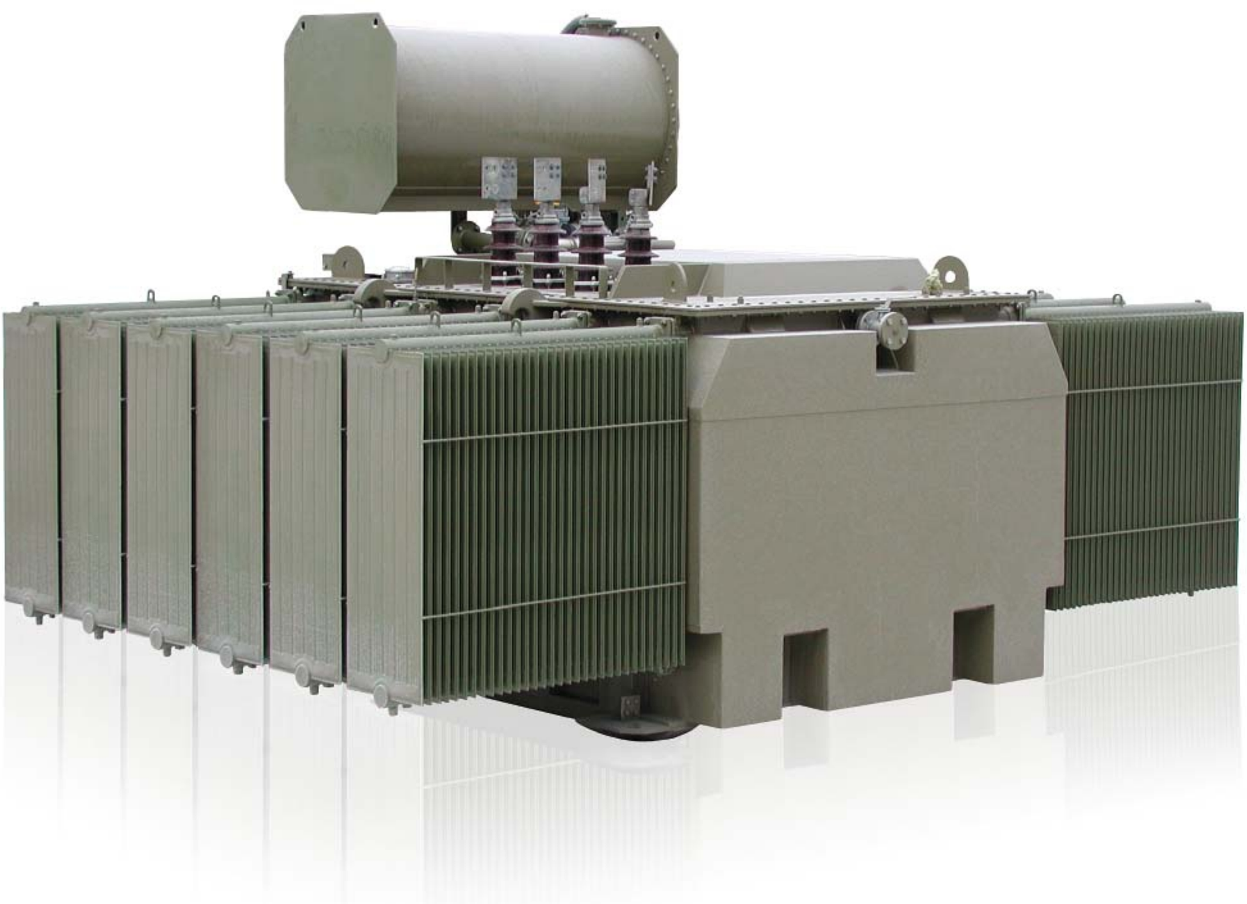
Shunt reactors

Cost efficiency in power transmission
Shunt reactors are a vital part of the efficient operation of long transmission high voltage power lines.

The shunt reactor compensates the capacitive generation on power lines to avoid non-controlled voltage rise especially on lightly loaded lines. The simple design and robust build-up makes the shunt reactor the most cost efficient mean to compensate the capacitive generation.

According to the IEC 60076-6 standard the shunt reactor is connected from the phase to the earth, from the phase to the neutral or between the phases in a power system to compensate for capacitive current.

Shunt reactors are often installed in the stations at the end of the line. In this way the voltage difference between the ends of the line is reduced both amplitude and in phase angle. Shunt reactors may also be connected to the power system at junctures where several lines meet or to the tertiary windings of transformers.
Transmission cables have much higher capacitance to earth than the overhead lines. Long submarine cables for system of 100 kV and more need shunt reactors. The same goes for the large urban networks to prevent excessive



voltage rise when a high load suddenly falls out due to a failure.

Shunt reactor construction

The shunt reactor construction is like a transformer, except that air gaps are installed on the core limbs. The core limbs can be constructed with radially or flat stacked limbs.

The ABB shunt reactors designs are based on the magnetically shielded air core and capped-core concepts. The outer frame gives a low reluctance path for the main flux and in normal operation it acts like the side limbs in a five-limbed transformer core. It has also the advantage of flux patterns in the individual limbs independent of the fluxes in the adjacent limbs.

The operating characteristics of a reactor make it necessary to supply full power to the reactor during the tests. In comparison to transformer testing the manufacture needs additional special test facilities to safely verify the integrity of the reactor.

Technical features

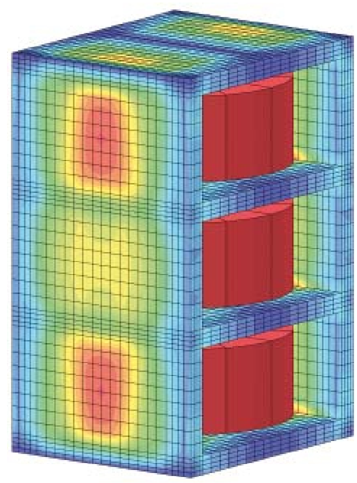
- Rating and voltage range of the design platform for the products covered in this brochure is up to 45 MVAr and 145 kV
- Due to the parallel connection, the load is usually continuously 100% loading

(NOTE: ABB offers a full range of reactors up to highest levels and ratings. See the brochure “Shunt reactors” 1ZSE 954001EN-11.)

Shunt reactors with on-load tap changers, OLTC

Shunt reactors equipped with an OLTC are intended to allow adjustment of the reactive compensation depending on the load condition of the line/ network. During light loading, the maximum reactive compensation at the tap with a minimum number of turns is used, and for full load conditions the reactor is switched to the tap with the maximum number of the turns. A typical tapping range allows a reduction in the reactive power from 100 % to about 50 %.

Magnetic flux distribution in the shield

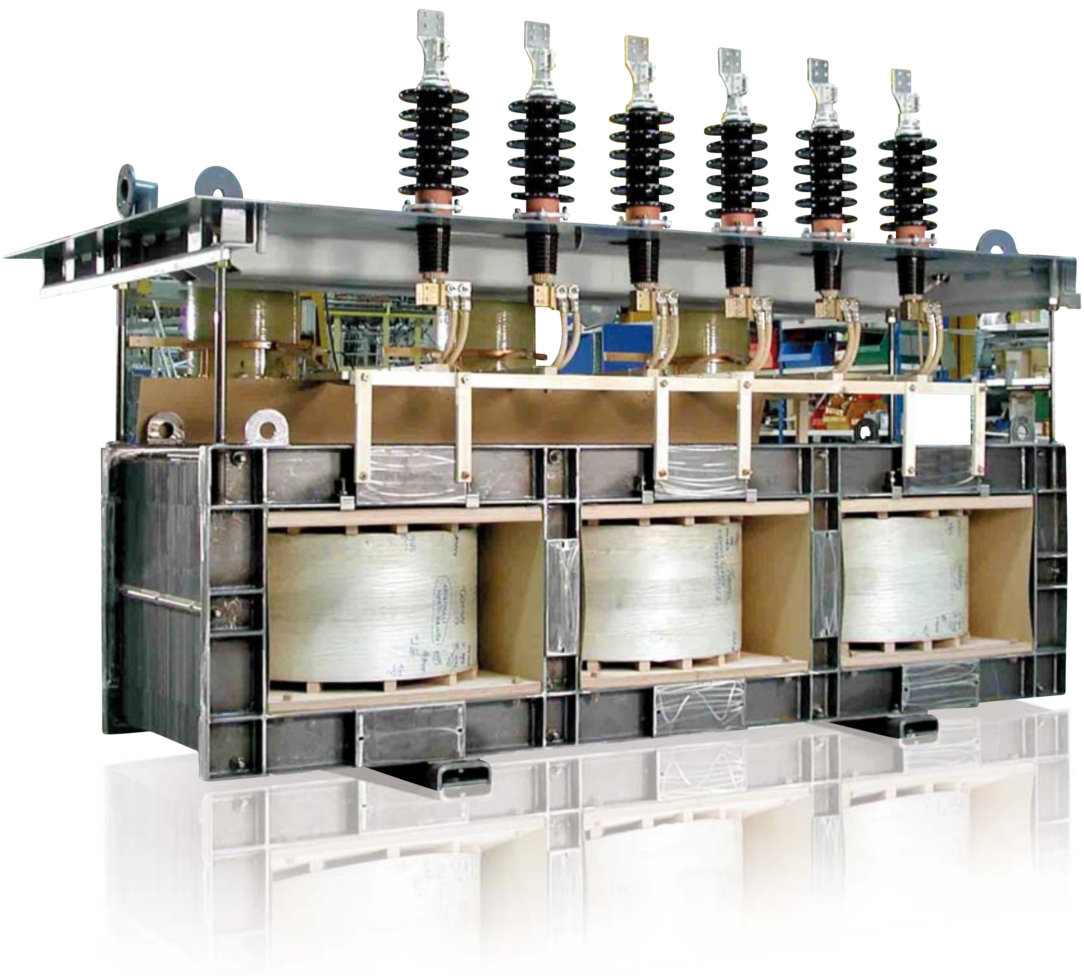


Magnetic flux distribution in the shield simulated for 30 MVAr reactor. ABB is using the most advanced tools in design process.

Maintenance on site conditions. Changing CT ratio by tap link. Victor mines, Canada.

Basic key design input information for shunt Reactors:
Standard parameters like frequency, cooling, ambient conditions, etc.
Rated power (with rated voltage)
Rated voltage U_N is the base for design, guaranteed values and tests
Maximum operating voltage U_{max}. The maximum continuous voltage, which is the base for thermal design
S= $U2_{max}$ / X (110% voltage results in 121% power)

Reactors – Custom designed, custom built



Series reactors

Series reactors are mostly used to limit the current and to increase the impedance. They are designed for different purposes, such as current limiting, neutral / earthing, motor starting, arc furnace series reactors, and duplex reactors. ABB series reactors are usually the magnetically shielded air core design. Series reactors may also be equipped with OLTC.

Basic key design input information for Series Reactors
Standard parameters such as frequency, insulation class, cooling, ambient conditions
Rated continuous current, if any
Rated reactance
Rated short-time current
Rated short-time current duration
The required LI level across the reactor can be relevant with higher voltages

Current limiting reactors

Current limiting reactors are connected in series in a power system to limit the current under system fault conditions. In normal operation, the continuous current flows through the reactor. The magnetically shielded air core design is usually applied, due to the linearity requirement and the high short-time currents. The electro dynamic forces are also easier to handle in this type of design. Usually reactance is rather low, which makes the air core more economical solution.

Neutral earthing reactors

The application of neutral earthing reactors increases the impedance in the neutral point of a transformer or a shunt reactor. During single-phase faults, the reactor limits the fault current in the neutral and the restoration of the power line is improved.

According to the IEC 60076-6 standard, the neutral-earthing reactor is connected between the neutral of a power system and earth to limit the line-to-earth current under system earth fault conditions to a desired value.

The losses in the reactor are without economic importance. The designed current density in the winding is determined by the reactor's ability to withstand the mechanical forces due to the short-time fault current.

Motor starting reactors

Motor starting reactors are connected in series with a motor to limit the inrush current during the motor starting operation. Usually for short-time duty only.

Arc-furnace series reactors

An arc-furnace series reactor is connected in series with an arc-furnace to increase the eff ciency of the metal melting operation and reduce voltage variation in the power system. The reactor is usually connected on the HV side of the furnace transformer. It creates additional reactance to the circuit to stabilize the arc, which is adjustable by tap-changer (on-load or off-circuit). Currents will be limited up to few kAs; the limiting factor is usually OLTC.

Duplex reactors

Duplex reactor is a series reactor for making a mutual coupling between two branches of a system.

Series reactor with on-load tap changers, OLTC

Earthing transformers

Earthing transformers are classified as reactors as standard. An earthing transformer (neutral coupler) is a three-phase transformer connected to the power system to provide a neutral connection for earthing, either directly or via impedance. The earthing transformers may in addition supply a local auxiliary load.

The earthing transformer creates a neutral point for a network. ZN connection is usually applied. Z connection provides linear and specified zero sequence impedance. YN+d can also be applied.

Basic key design input information for Earthing Transformers
Standard parameters such as frequency, insulation class, cooling, ambient conditions, etc.
Rated continuous neutral current, if any
Rated zero sequence reactance
Rated short-time neutral current
Rated short-time current duration
Auxiliary winding, if any (voltage, power)

Contact us

ABB Oy
Transformers
P.O. Box 688
FI-65101
Phone: +358 (0)10 22 11
Fax: +358 (0)10 22 41 291
E-Mail: firstname.surname@fi.abb.com

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