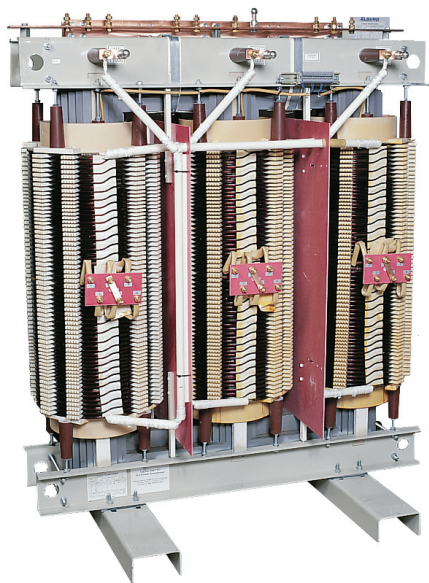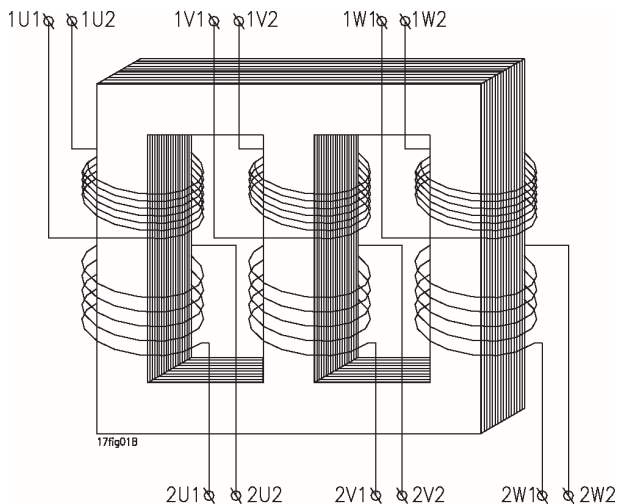# The three-phase transformer

Dry-type three-phase transformer from Noratel.

In theory a three-phase transformer works like three separate single-phase transformers with shared limbs in which the magnetic circuit for the outer limbs is longer than for the centre limb. The voltage transformation is determined by the ratio between the number of turns on the primary and secondary sides assuming what are known as even connections, Yy, Dd and Zz.

Schematic diagram of a three-phase transformer

In the three-phase transformer we can change the transformation by going from star to delta connection. This gives us mixed connections. In the case of mixed connections the ratio between the main voltages on the primary and secondary sides is not equal to the ratio between the number of turns. The transformation ratio is calcu-lated as equal to the ratio between the main primary and secondary voltages with no load independently of the ratio between the numbers of turns.

Three-phase connections

Three-phase transformers can have their windings connected in various ways: star, delta or zigzag connection. The connection type must be specified on the transformer's rating plate.

Star, delta or zigzag connection is indicated by the letters Y, D and Z for the side with the highest voltage and y, d and z for the side with the lowest voltage. If the neutral point is connected to separate terminals, the code should be YN or ZN for the high-voltage side and yn or zn for the low-voltage side.

Common to all the connection types is that the transformer's phase terminals are marked 1U, 1V and 1W on the high-voltage side and 2U, 2V and 2W on the low-voltage side. Any connection point which represents the windings' neutral point is marked 1N or 2N.
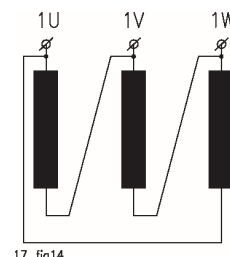
Star connection

In the case of star connection the three windings are connected together at their end points. The connection point represents the windings' neutral point. Star connection is indicated by Y on the high-voltage side and y on the low-voltage side. This connection type is used for both low and high voltages and for low currents.
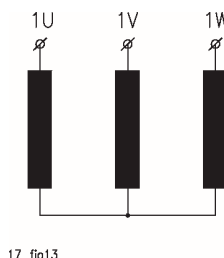

Delta connection

In the case of delta connection the ends of the windings are connected together as shown in the diagram. We can see that both the ends are connected together. Delta connection is indicated by D or d. This connection type is used mainly for high rated currents and low voltages.

Zigzag connection

Each phase consists of two equal windings on unequal limbs. There will therefore be parts of two phases on each limb, with one winding on each limb being connected together at the end points. Zigzag connection is indicated by Z or z. This connection type requires 15.5% more windings than star or delta connection, resulting in a larger and more expensive transformer. It is mainly used where load unbalance can occur between the phases and neutral.
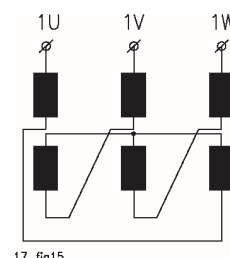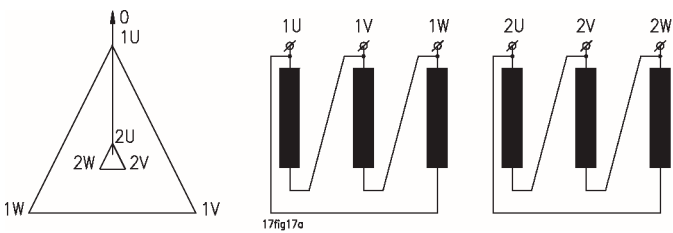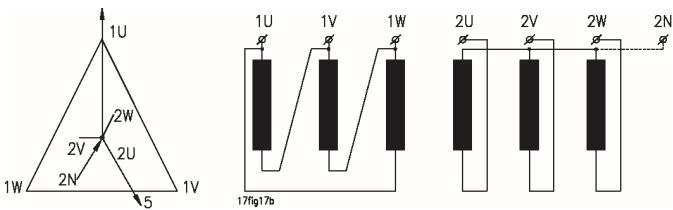
Vector groups

The connection of all the windings in a three-phase transformer is indicated by a vector group symbol. This symbol indicates the winding con-nections and their relative phase displacement by means of a numerical index (e.g. Dny11). The "clock method" is used to produce the numerical index of the vector group, with each hour representing 30 electrical degrees. The numerical index of the vector group comes from the clock hour figure the phase voltage hand (2U) is at when the phase voltage hand of the high-voltage winding (1U) is at 12 o'clock. The system's phase sequence should be 1U, 1V, 1W, or R, S and T. The following are common three-phase connections:
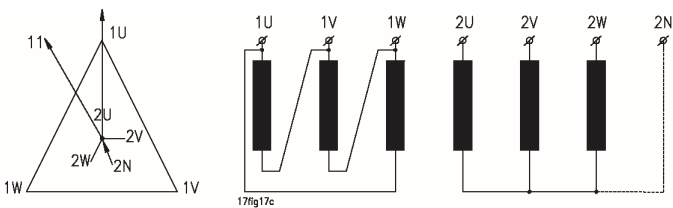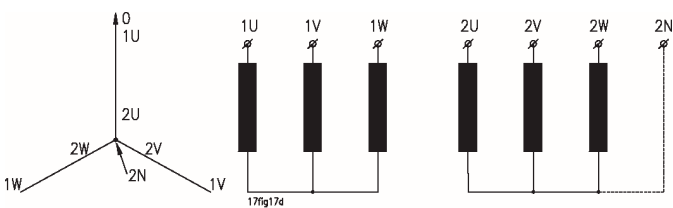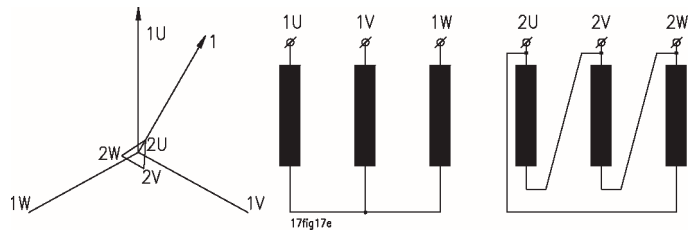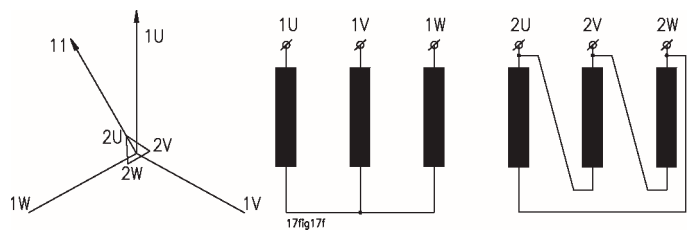
Dd0

17fig17a

Dyn5

17fig17b

Dyn11

17fig17c

Yyn0

17fig17d

Yd1

17fig17e

Yd11

17fig17f

Dz0

17fig17g

Yz1

17fig17h

Yz11

17fig17i