EREA
TRANSFORMERS

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QUALITY PRODUCT
MADE IN BELGIUM

Dimensioning line protection for a transformer.

Dimensioning line protection for a transformer.

The connection between inrush current and line protection

The **inrush current** is frequently underestimated when selecting the line protection for a transformer. The entire iron core is magnetised the moment the transformer is energised. During this process (which lasts for only a fraction of a second) the transformer will draw a peak current from the electricity grid. This inrush current may be up to 25 times the current during normal operation, even if the transformer is not under load.

LINE PROTECTION: automatic protection fuse(s) at the supply end of the line which protect it against overcurrent due to overload or a short circuit.

In **smaller installations**, for example in domestic premises, the safety device at the supply end of the installation will determine what inrush currents can be handled. When selecting a transformer it is therefore crucial to determine at the outset whether the installation will be able to handle it without problems. If that isn't the case you can find solutions **from EREA** in the form of low inrush current transformers and inrush current limiters.

This is rarely a problem in **industrial applications** where the capacity of the electricity grid is generously dimensioned. So, almost always, the line protection can be optimally dimensioned in such settings. However it remains necessary to consider the issue carefully.

Level of the inrush current

The level of the inrush current depends on a number of factors.

- **The frame size of the transformer**
  The inrush current, of course, increases with the size of the transformer`s frame. This is because the volume of iron to be magnetised increases.

- **The work induction of the transformer**
  This design parameter determines the weight, dimensions, zero-load current and also the inrush current. We must therefore seek a compromise here. With IRC transformers a low inrush current is more critical than with an industrial transformer (e.g. one from the SPT or ATT series).

- **The impedance of the electricity grid**
  The greater the impedance the more the network will suppress the inrush current. Where a building is located in a rural area there is a high probability that the electricity is supplied by a cable several kilometres long. The impedance caused by this cable will have a substantial impact on the inrush current. The ris k of problems from inrush current is therefore small. In an industrial building, by contrast, the transformer will be connected to the medium-voltage substation by a short, thick cable. The inrush current will be at a maximum in these circumstances.

- **The moment of connection**
  The instantaneous voltage of the electricity grid varies sinsuoidally with time. If the connection is exactly simultaneous with the zero crossing of the mains supply the inrush current will be maximal. As the moment of connection can vary each time, there is a random element. It may happen that connection takes place without problems a number of times, until that one occasion when the connection is made just at the zero crossing of the sine wave.

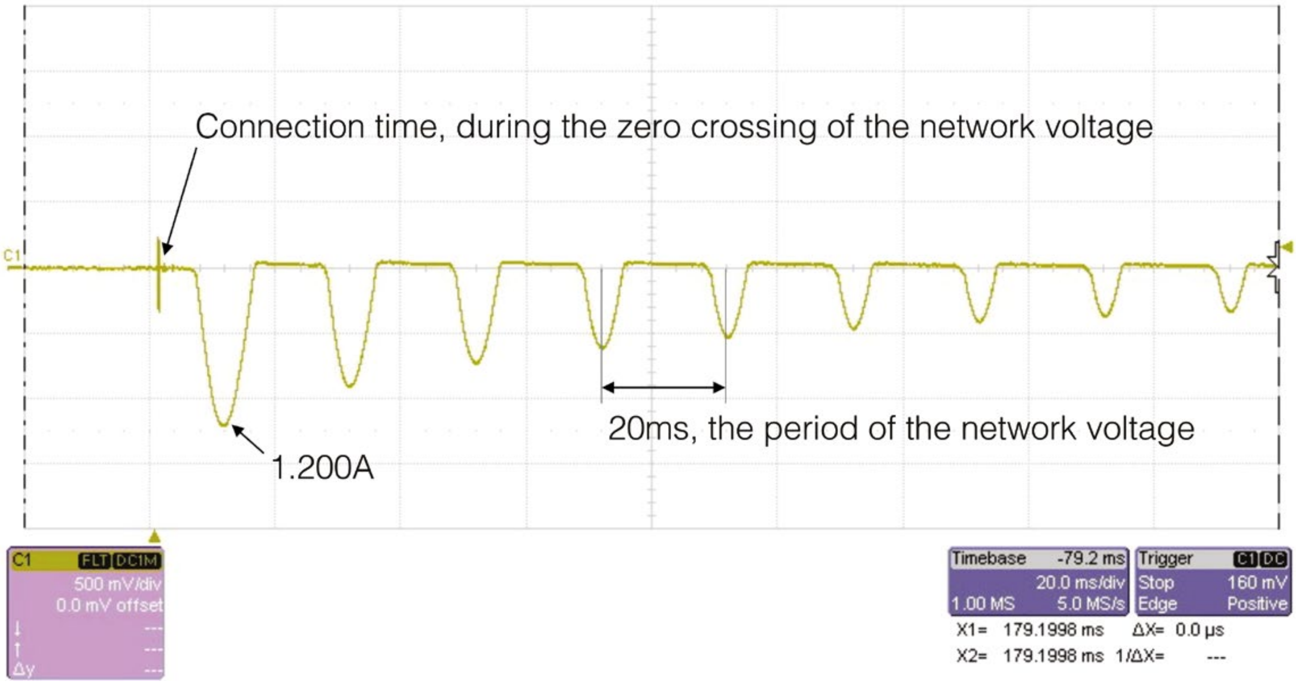
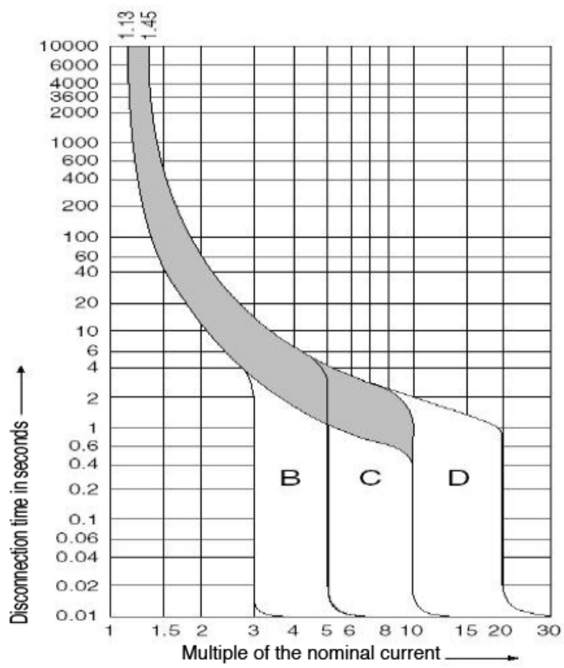


Figure 1: *Type of current during connection of an SPT 31500/BTE to a 400V network a few metres from a medium-voltage substation. In less favourable circumstances the transformer cannot be connected. The maximal peak current at connection would then amount to almost 1200A or 25x the nominal primary current for this transformer.*

Dimensioning the line protection

As it is difficult in practice to estimate the actual net impedance, it is usual to err on the side of **safety**. The transformer is primarily protected with a Type D circuit breaker for high inrush currents or with a Type aM fuse with a current value of 1.5 to 2x the nominal primary current of the transformer.

Figure 2: *Characteristics of various circuit breakers. A D80 circuit breaker, for example, can handle inrush currents of 1200A (15 x 80A). A D80 circuit breaker is therefore adequate for the situation sketched out in Figure 1.*



While the (slower) Type D circuit breakers or an aM fuse are preferred you can also opt for **a (faster) Type-C circuit breaker or a gG-class fuse**. These have a smaller ratio between the permitted peak current and the nominal current. In order to allow the transformer to be connected each time without problems, the nominal current of the protective device(s) must be higher. On the one hand this means that the supply cable to the transformer must be thicker, on the other hand the overdimensioned line protection will offer less effective protection against overload. Additionally there is a possibility that the entire network will require upgrading because of the higher nominal value of the fuse.

The **transformer** only affects the choice of the current and the curve of the device serving as line protection. Other parameters such as the short-circuit current of the circuit breaker and the dimensioning of a suitable earth leakage device are determined as with any other circuit, and not by the characteristics of the transformer.

The recommended protective devices for each standard transformer **can be found in our technical documentation and on our website**. These values are calculated to allow a transformer to be connected without problems on every occasion. For critical (often industrial) applications where the electrical circuits are very robust (low impedance) a Type D circuit breaker (or an aM fuse) is preferred. In less difficult circumstances you can also opt for a Type C circuit breaker or a gG fuse.

In some cases the recommended circuit breakers **are not feasible in a particular installation**, for example in a domestic setting where the circuit breaker at the supply end of the installation is already more sensitive than the recommended circuit breaker for the transformer.

The most straightforward solution is to select the **highest achievable protection**. With medium or high grid impedance it can happen that the circuit breaker doesn't trip, or that it trips only sporadically. Bear in mind that the inrush current occurs at the moment of connection. Once the transformer is under constant voltage the risk of tripping only exists in the event of an occasional interruption of the supply voltage. The uncertainty does, however, mean that this stopgap solution is far from optimal.

Low inrush current transformers

EREA have developed various specific solutions to allow more reliable installations to be built.

1. Low inrush current transformer

One reliable option is to choose a **low inrush current transformer**. With this type the core is less strongly magnetised. We refer to these as 'low induction transformers'. These transformers intrinsically have a lower inrush current and can be protected with a Type C circuit breaker, which need not be overdimensioned. The disadvantage of such transformers is that more core material and/or more copper windings are required to carry the same output. This makes them larger and more expensive than standard transformers.

EREA currently carry two series of IRC transformers. Both of these series have been developed for specific purposes, but they can be deployed universally:

- Our standard EC and ECT series currently include 3 single-phase low inrush current (EC) transformers and 3 three-phase (ECT) models). The capacity range of these transformers is primarily geared to the charging of electric vehicles.
- In our standard PVT series we offer 10 3-phase (PVT) transformers. These range from 6kVA to 70kVA and are primarily intended for the connection of convertors for photovoltaic installations or to connect heat pumps.

Find the perfect, problem-free transformer for every project. Thanks to our speedy selection cards you can find what you need in no time.

Need a low inrush current transformer for your vehicle charging station? Download the speedy selection card, which will take you straight to the product you need.




Need a low inrush current transformer for your solar panel or heat pump installation?
Our speedy selection card will guide you seamlessly to the right transformer solution for you.




A low inrush current variant of **any of our transformers** can be manufactured on request.

A number of low inrush current transformers are available for the charging of electric vehicles. Click here for further information on our website.

Single-phase **Three-phase**

2. Inrush current limiters (IRCs).

An inrush current limiter is an alternative solution.

These devices are placed upstream of the transformer. They ensure that the impedance of the grid is briefly increased during connection. This allows a more gentle magnetisation of the core. This is possible with transformers with a primary current up to 25A. For three-phase transformers 3 IRCs are provided.

Connection diagram for single-phase transformer

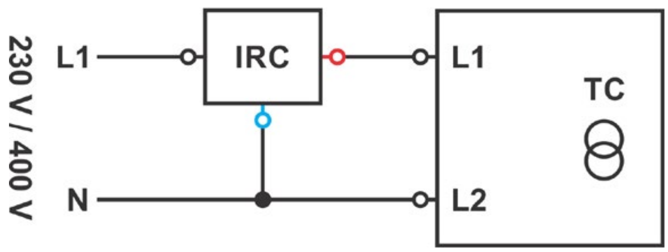


Figure 3: *Connection diagram for an inrush current limiter for a single-phase transformer*

Connection diagram for a three-phase transformer

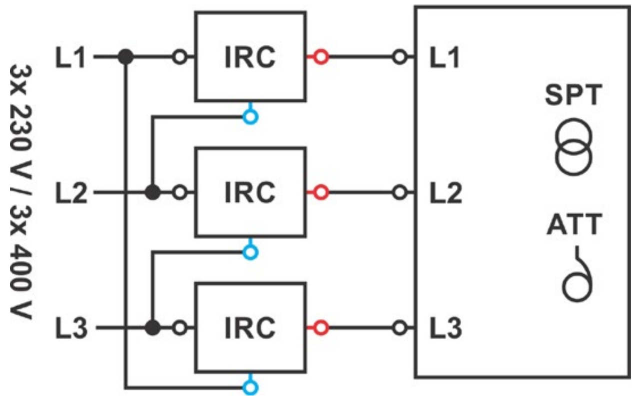


Figure 4: *Connection diagram for an inrush current limiter for use with a three-phase transformer fed by a 3 x 230V or 3 x 400V supply without a neutral conductor.*

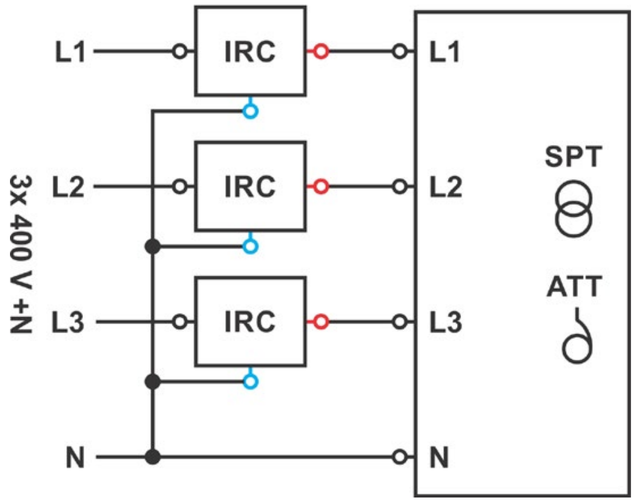


Figure 5: *Connection diagram for an inrush current limiter for use with a three-phase transformer fed by a 3 x 400V supply with a neutral conductor.*

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Need advice with the design of your project?
Our committed and experienced staff
stand ready to assist.

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Edition 2022-05-03

Transforming since 1933