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Electric charging:

Charging systems and
their power supply



Introduction

A survey among customers revealed that problems may arise when charging electric vehicles. In this document we shall discuss these problems and their causes. We will also discuss the solutions which EREA Energy Engineering can offer.

The charging system

Before the charging system starts to charge an electric vehicle it carries out a number of checks on the power supply from the grid. It will not be possible to charge the vehicle unless certain conditions are met. One common precondition is the presence of a neutral conductor, which may only have a limited voltage difference with reference to network earth. Many charging systems will refuse to charge the vehicle unless a clean neutral conductor is detected.

Incoming electrical supply

Two types of electricity grid are in use in Belgium, 3x230V and 3x400V. The 3x400V system is far and away the most common in Europe. Charging systems for electric vehicles are therefore designed for this type of supply. Problems will therefore rarely arise when a 3x400V network is used.

3x230V supplies are, however, also in use in Belgium and a number of other European countries. These grids have a totally different configuration, and problems can therefore arise during charging, even with charging stations in a building or home with a single-phase supply.

3 x 230 Volt networks

Figure 1 shows a 3x230V network with both a single-phase and a three-phase building connected.

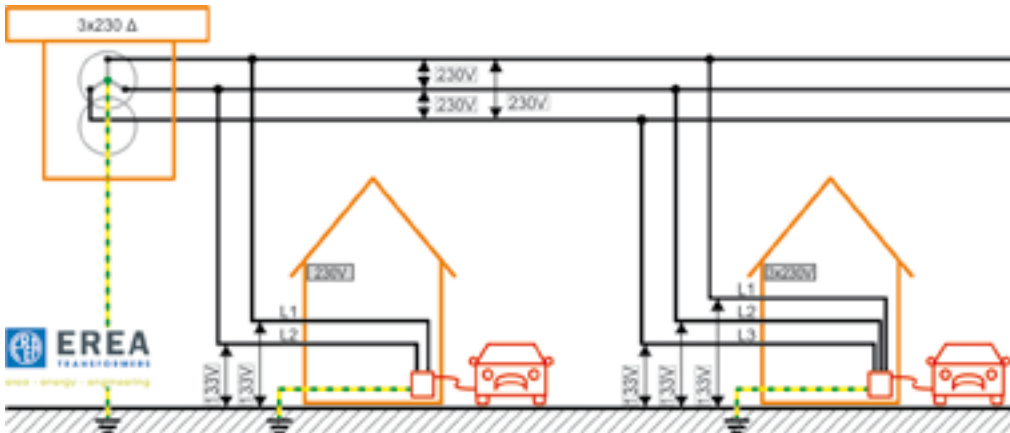


Figure 1: A 3 x 230V network with a single-phase and a three-phase connection.

The neutral point is earthed in the transformer substation. The voltage between this neutral point and the lines (referred to hereinafter as the phase voltage) in this type of supply is 133V. Because a voltage of 133V has no application there is no point in dividing the neutral conductor. The consumers are, after all, connected in delta between the 3 lines.

This means that the three lines each lie at around 133V on the earth, and that, unlike a 3x400V grid, a three-phase 3x230V network has no connection at all to the earth potential.

The electric vehicle charging system will detect this and several systems, both single and three phase, will, in these circumstances, refuse to charge the vehicle on a 3x230V network.

An additional problem for three-phase charging systems is that they are generally designed only for a 3x400V network, so that the voltage in a three-phase 3x230V network is simply too low.

The problem of the absence of a neutral conductor in this type of network can be resolved with the use of an isolating transformer. The isolating transformer results in an electrically separated network, fully floating with reference to the primary network and earth. A neutral conductor can be provided by earthing one of the conductors.

This solution is shown in Figure 2.

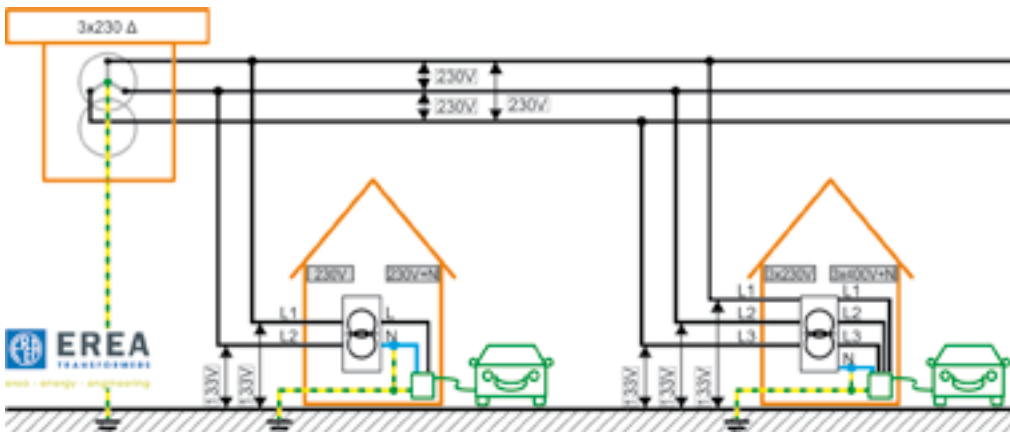


Figure 2: Creating a neutral conductor in a 3 x 230V network (using our EC series for single-phase systems and our ECT series for three-phase systems).

With a single-phase supply a single-phase isolating transformer can be placed between the incoming supply and the charging system, with one of the terminals of the transformer placed as a secondary on the earth. This connection is then referred to as the neutral conductor.

In the case of three-phase installations a three-phase isolating transformer can be placed between the incoming lines and the charging system, not only providing separation but also converting the 3x230V supply to 3x400V with a neutral conductor. The neutral point, to which the neutral conductor is connected, can be earthed, thus providing the charging system with both a neutral conductor (at earth potential) and a higher voltage (3x400V).

ERE A Energy Engineering has developed the EC series (single-phase systems) and the ECT series (three-phase systems) specifically for this application.

These transformers have certain characteristics making them ideal for this application:

- Capacities selected on the basis of charging systems currently in use.
→ Single phase or three phase, 16A, 32A, 50A, 63A.
- Low inrush current for use in domestic and tertiary electrical installations.
→ Primary safety devices with fuse rating equivalent to the nominal current type D.
- Lower losses than standard transformers (both loaded and unloaded).
→ Energy-efficient transformers in line with our BTE series.
- Additional terminal for the neutral conductor on the secondary (EC series only).
→ Connection is straightforward.

3 x 400 Volt networks

Figure 3 shows a single-phase and a three-phase connection to a 3x400V network with neutral conductor.

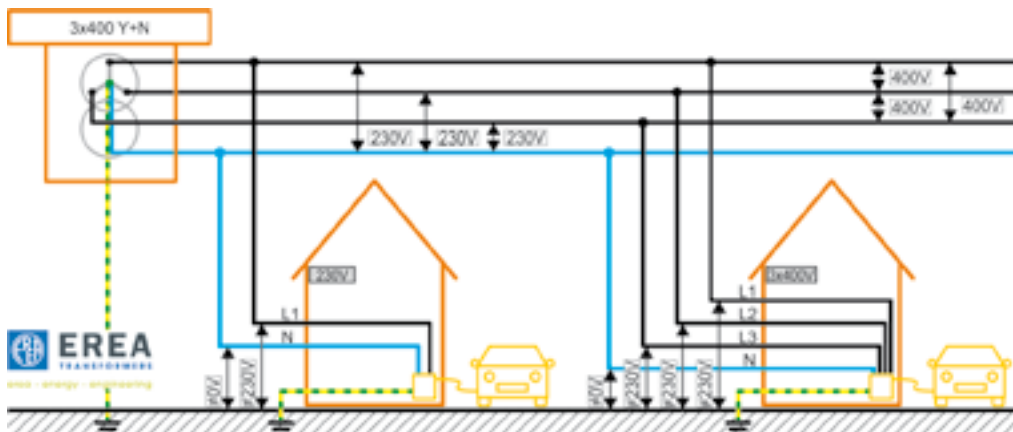


Figure 3:
3x400V + N Infrastructure

The neutral conductor is also earthed in the transformer station with this type of supply. With this type of supply we have 230V between the neutral conductor and the phases. The neutral conductor is, of course, distributed in this case.

This is, therefore, the most suitable grid connection for both single-phase and three-phase charging systems.

In exceptional cases it may still be that the vehicle can't be charged, despite these apparently ideal circumstances. Where there is a large distance to the transformer station and the load is unbalanced, the current in the neutral conductor will result in a difference in potential with reference to earth, tripping the charging system.

This can also be resolved by installing isolating transformers to create an electrically separated network and placing the neutral conductor on earth potential again (Figure 4).

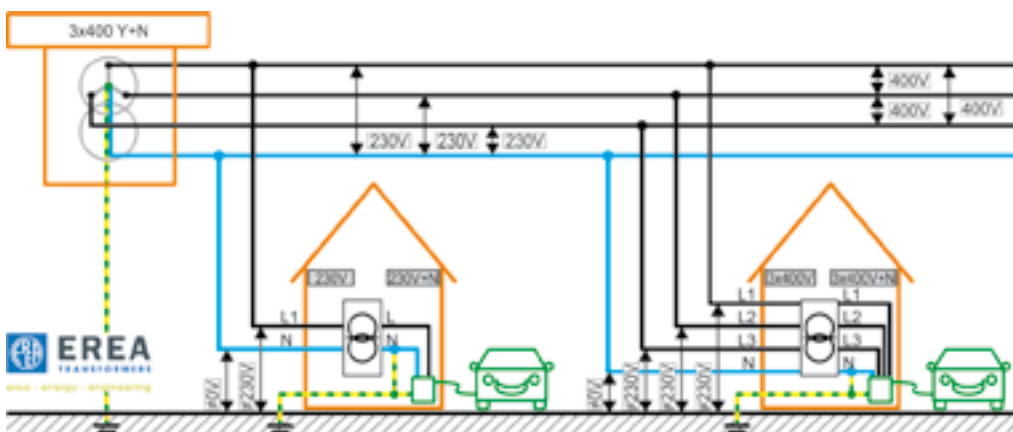


Figure 4: Re-earthing a neutral conductor in a 3 x 400V + N (using our EC series transformer for single-phase systems and our ECT series for three-phase systems).



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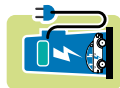
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Charging station type	Type der Ladestation
Transformer type	Transformator type
Transformer code	Transformator-Code
Power	Leistung
U primary	U Primär
U secondary	U Sekundär
I primary (230V Δ)	I Primär (230V Δ)
I primary (400V Y+N)	I Primär (400V Y+N)
I Sec (1ph: 230V / 3ph: 400V Y+N) Sec (1ph: 230V / 3ph: 400V Y+N)	
Protection primary	Primärschutz
Protection secondary	Sekundärschutz
No-load losses - P _{Fe} (W)	Leerlaufverluste - P _{Fe} (W)
Full-load losses - P _{cu} (W)	Vollastverluste - P _{cu} (W)
Efficiency - (%)	Wirkungsgrad - (%)
Voltage drop - ΔU(%)	Spannungsabfall - ΔU(%)
Dimensions:	Abmessungen:
mm Length - A	mm Länge - A
mm Width - B	mm Breite - B
mm Height - C	mm Höhe - C
mm Distance between holes - D	mm Lochabstand - D
mm Distance between holes - E	mm Lochabstand - E
mm Hole diameter - Ø	mm Lochdurchmesser - Ø
kg Weight	kg Gewicht
Type of enclosure IP20	Gehäusotyp IP20
Code	Code
mm Dimensions A x B x C	mm Abmessungen A x B x C
kg Weight	kg Gewicht
Type of enclosure IP23	Gehäusotyp IP23
Code	Code
mm Dimensions A x B x C	mm Abmessungen A x B x C
kg Weight	kg Gewicht
Type Silentblock	Typ Schwingungsdämpfer
Code	Code

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EC and ECT series - EC und ECT Serien

Isolating transformers for coupling Charging stations - Low inrush current
Trenntransformatoren zum Kopplung von Ladestationen - Einschaltstrombegrenst



Single phase - 16A		Single phase - 32A		Single phase - 48A		Three-phase - 16A		Three-phase - 32A		Three-phase - 63A	
Monophase - 16A		Monophase - 32A		Monophase - 48A		Dreiphasen - 16A		Dreiphasen - 32A		Dreiphasen - 63A	
230EC 3700 /IRC	11536	230EC 7400 /IRC	11537	230EC 11000 /IRC	11580	ECT 11000 /IRC	11538	ECT 22000 /IRC	11539	ECT 44000 /IRC	11582
3.7 kVA		7.4 kVA		11 kVA		11 kVA		22 kVA		44 kVA	
230V/245V		230V/245V		230V/245V		230V Δ/400V Y+N		230V Δ/400V Y+N		230V Δ/400V Y+N	
230V+N		230V+N		230V+N		400V Y+N		400V Y+N		400V Y+N	
16.5A		32.9A		49A		28.6A		57.2A		112A	
						16.5A		33A		64.7A	
16A		32A		48A		16A		32A		63A	
16A type C		32A type C		50A type C		230V Δ - 32A type C		230V Δ - 63A type C		230V Δ - 125A type C	
						400V Y - 16A type C		400V Y - 32A type C		400V Y - 63A type C	
16A type C		32A type C		50A type C		16A type C		32A type C		63A type C	
42		45		40		58		75		114	
78		152		190		222		578		858	
96.9		97.4		98.0		97.5		97.2		97.8	
2.1		2.1		1.7		2.0		2.6		2.0	
240		280		320		420		480		640	
200		230		260		270		270		390	
225		365		415		365		415		500	
200		180		210		280		320		400	
177		178		220		223		240		245	
11		11.5		11.5		11		11		11	
45		76		107		121		168		314	
K20EC/030		K20EC/035		K20EC/045		K20ECT/040		K20ECT/050		K20ECT/060	
11540		11541		11581		11542		11543		11583	
270 x 250 x 240		307 x 268 x 420		350 x 355 x 470		460 x 320 x 420		530 x 320 x 470		660 x 470 x 560	
3.3		5.6		8.6		8.3		9.0		15.2	
K23EC/030		K23EC/035		K23EC/045		K23ECT/040		K23ECT/050		K23ECT/060	
11544		11545		11603		11546		11547		11604	
290 x 353 x 240		325 x 370 x 420		370 x 460 x 470		480 x 435 x 420		550 x 420 x 470		680 x 570 x 560	
5.7		8.4		12.5		12.7		14		20	
SILENT BLOCK 50		SILENT BLOCK 50		SILENT BLOCK 50		SILENT BLOCK 50		SILENT BLOCK 50		SILENT BLOCK 120	
11483		11483		11483		11483		11483		11484	

Transforming since 1933

Figure 5:
Speedy selection
card - an overview of
the standard trans-
formers available for
charging



Figure 6: Models in our EC and ECT series.

The most significant difference between these transformers and standard transformers is the **low inrush current (IRC)**. Most standard transformers have a peak inrush current of 15 to 20x the nominal current at full load. These transformers are intended primarily for industrial applications, where the use of a type D circuit breaker is unproblematical. In domestic applications this is not possible and the inrush current can cause problems with larger transformers.

In designing the transformers in the EC and ECT series, the inrush current has therefore been chosen so as to avoid any need for **overdimensioning of the primary safety device**. A normal circuit breaker with a C curve is adequate, and the fuse rating can be determined on the basis of the nominal current of the transformer under full load.



Recommended options

ERE A Energy Engineering can provide housings for all these transformers. IP20 and IP23 models are available as standard. Higher IP ratings are also available on request.

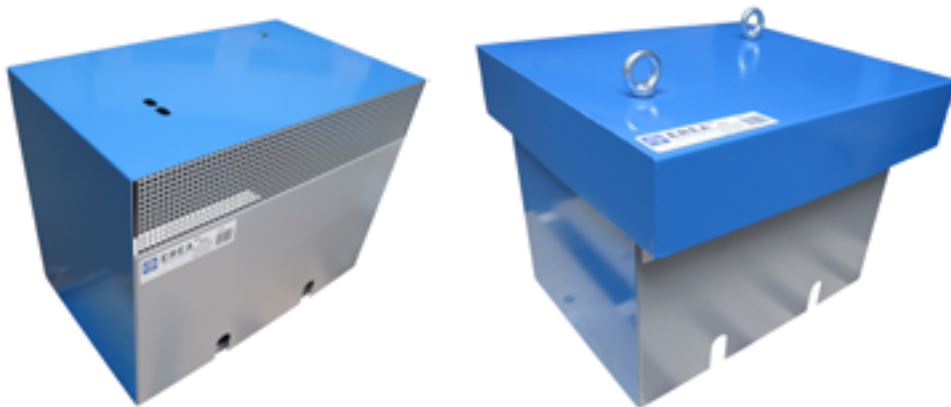


Figure 7: An IP20 cabinet (left) and an IP23 cabinet (right). Higher IP ratings are available on request.

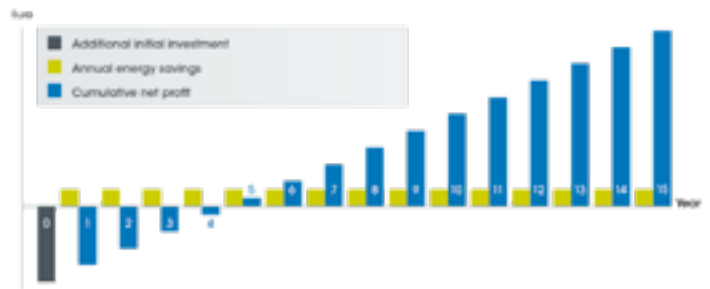
The transformers that we design for charging systems feature low magnetic induction. As well as the benefits already discussed in this article these transformers therefore produce very little noise, in contrast to their industrial counterparts. An important point, particularly in a residential setting. There may, however, be an audible hum where the substrate on which the transformer rests is sensitive to acoustic resonance, for example with hollow timber structures. In this case it can be helpful to install vibration dampers below the transformer.



Figure 8: Vibration damper. The rubber construction ensures that the acoustic vibration generated by the transformer is not transmitted to the substrate, where it may be amplified.

Total Cost of Ownership - TCO

In order to achieve this low inrush current, the EC and ECT transformers contain more iron and more copper than the equivalent standard transformers. This obviously increases the initial purchase cost somewhat. Against this, however, the losses are significantly lower, so that the additional cost of purchase will, over the years, be recovered via energy savings. The Total Cost of Ownership (TCO) of an EC or ECT charging station transformer is appreciably lower than that of a standard transformer.



Choice of protection on the primary or secondary side.

Protection devices

The transformers must be adequately protected on both the primary and secondary side.

Both the primary and secondary windings of transformers in the EC and ECT series must be protected with a type C circuit breaker on the basis of their nominal current. You can easily find the exact ratings for the recommended safety devices using our speedy selection card. (See above (figure 5) or consult our website www.erea.be under 'documents' for the complete PDF speedy selection card for charging station transformers).

Differential circuit breaker - type B

Isolating transformers create a complete new network, fully separated from the supply network. Any isolation faults will therefore not be detected by a circuit breaker positioned ahead of the transformer. The charging of electric vehicles can also cause a DC fault current. This will not be detected by a normal type A residual current device. Where the charging system lacks a built-in safety device for this purpose a type B circuit breaker, which is capable of detecting both AC and DC fault currents, must be installed.





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Like to know more about charging systems
and their power supply? Our dedicated,
enthusiastic and experienced staff staff
will be glad to help you.

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Transforming

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