SMART METERING TO ASSESS THE PERFORMANCE OF AN INDUSTRIAL USER CONNECTED TO THE POWER NETWORK

CONTORIZARE INTELIGENTĂ (SMART METERING) PENTRU ANALIZA PERFORMANTELOR UNUI UTILIZATOR INDUSTRIAL CONECTAT LA REȚEAUA ELECTRICĂ

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Abstract: *The experimental study of the energy behavior of an industrial user allows highlighting its energetic performance, the practical ways to improve the way in which power is used, as well as the validation of the theoretical hypotheses formulated in order to assess this user. The assessment of the power quality supplied in the public system and observing the quality indicators to fit in the standard permitted limits play an important role in order to establish the optimal functioning parameters for this industrial power user. In this paper, the results of the experimental study achieved at a large-scale≠ industrial power user are exposed, along with the problems that emerged from this research. Moreover, solutions for solving these kind of problems are indicated.*

Keywords: experimental study, industrial power user, power quality supplied.

Rezumat: *Studiul experimental al comportamentului energetic a unui utilizator industrial permite puterea în evidenţă a performanţelor sale energetice, posibilitățile practice de îmbunătăţire a modului de utilizare a energiei electrice precum şi validarea ipotezelor teoretice care au stat la baza evaluării utilizatorului. Un rol important în stabilirea parametrilor optimi de funcţionarea îl are evaluarea calităţii energiei elecrtice furnizate din sistemul public şi încadrarea indicatorilor de calitate în limitele admise. În cadrul lucrării sunt indicate rezultate ale studiului experimental efectuate la un mare utilizator de energie electrică, problemele care au fost puse în evidenţă şi sunt indicate unele soluţii pentru depăşirea acestora.*

Cuvinte cheie: studiului experimental, mare utilizator, calitatea energiei electrice.

1. Introduction

The analyzed user is powered at a 110 kV, and it is feeds through a 110/20

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kV transformer, users which are directly connected to 20 kV, and a number of users connected to low voltage from 20/0.4 kV transformers.

In order to obtain the necessary information for the user's energy assessment, it has been equipped with an intelligent measurement system (smart metering) comprising electronic meters that allow the measurement of the energy, the storage of the measured data, the transfer of data to the SCADA system, the two-way transfer of information as well as the carrying out of simple processing (determining the load graph, indicating the maximum values, etc.).

2. The monitoring scheme used

Figure 1 shows the main scheme of the analysed user.

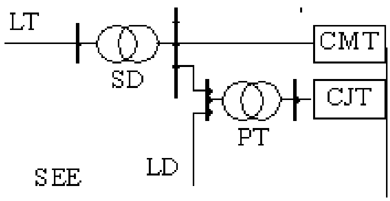

Figure 1. The main scheme of the analysed user.

In the diagram in Figure 1, CMT models the users which are connected to medium voltage, CJT – users that are connected to low voltage, PT corresponds to the transformer stations, SD – IT/MT power transformer in the SEE power system, LD – distribution line in the user's premises.

Once and for the increase of the number of modern receivers, which are equipped with frequency converters and other nonlinear receivers, the user was confronted with effects of non-sinusoidal and non-symmetrical regimes, and frequency fluctuation phenomena (flicker phenomenon).

The measurements were performed on all power system bars at an interval of 5 seconds to determine the flows of electrical energy within the company.

The voltage at the user's 110 kV power bars varies between 110.72 and 111.56 kV, values which fall within the limits imposed by the standards in force (must fall within the limits of 110,10% and 99 kV) [1].

The data in Figure 2 highlight the user's concern for virtually equal loading of the three phases, with a similar allure of load graphs, leading to a unbalance of line voltages within the permissible limits (about 0.75%). It can also be observed that during the study, the voltage at the 20 kV bars was within the permissible limits of variation (about 0.9%).

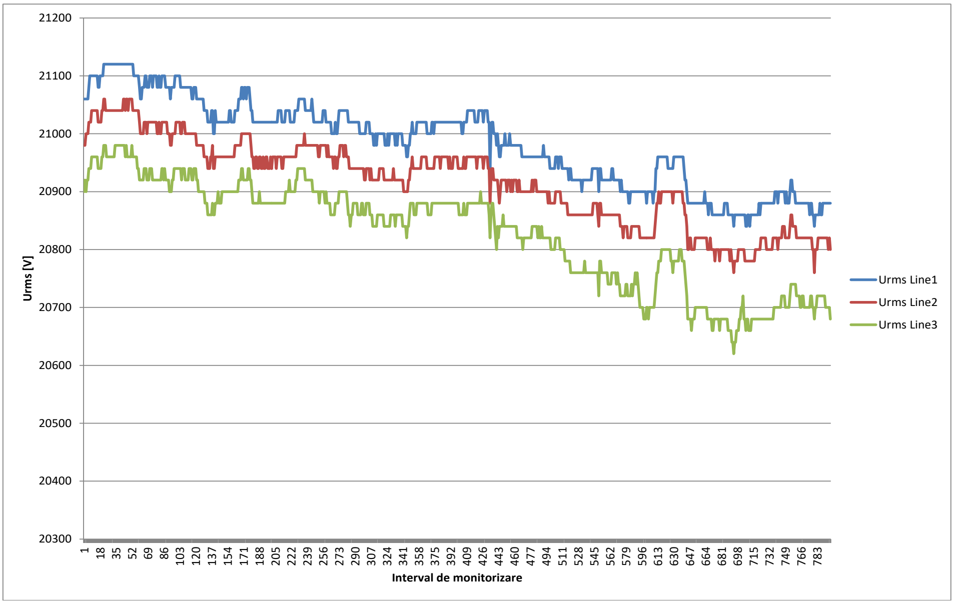

Figure 2. Voltages variation on the 20 kV power bar during the study carried out.

The user operates with the medium voltage network with the neutral point of the system connected to earth via a low value resistor. Under these conditions, the way in which the phase-earth voltage of the system varies is also of interest (figure 3).

The analysis of the data in Figure 3 reveals a unbalance factor of about 5%, which indicates the existence of single-phase users connected in the low-voltage network, unevenly on the three phases, leading to different voltage falls over the three phases.

It is important that the unbalance of the voltages between phases has values within the accepted limits so that the three-phase motors connected in the triangle in the low voltage network are not affected by the unbalance of the power voltages. Connecting the three-phase motors to the star could lead to a reduction in their operating performance [2].

Variation of the measured values of the negative unbalance factor V_{unb} determined as the ratio between the negative sequence component U^{-} of the voltage curve and the positive sequence component U^{+} of the voltage curve

$$V_{unb} = \frac{U^{-}}{U^{+}} \ , \tag{1}$$

is indicated in figure 4.

Special power schemes have been proposed to achieve symmetrization of electric currents in the analyzed network [3].

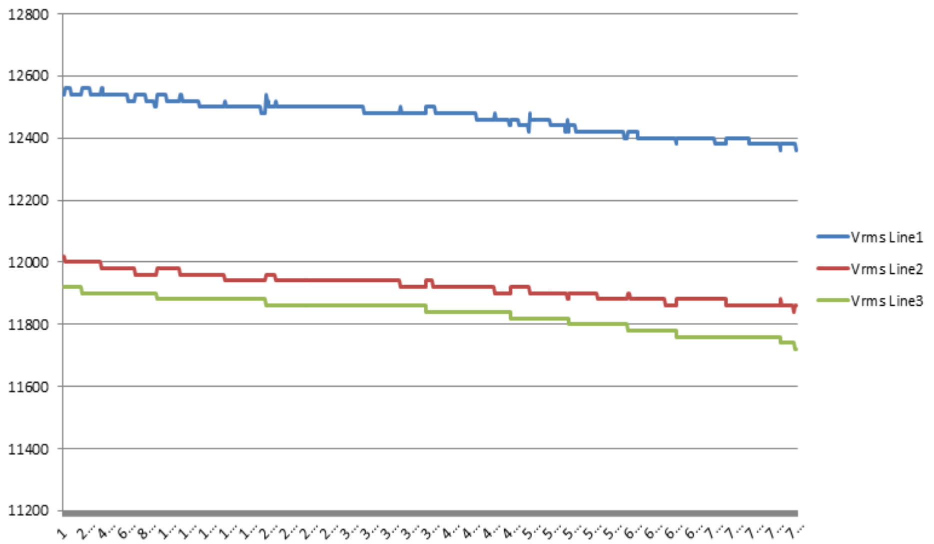

Figure 3. Variation of phase-to-earth voltages in the 20 kV system of the studied user.

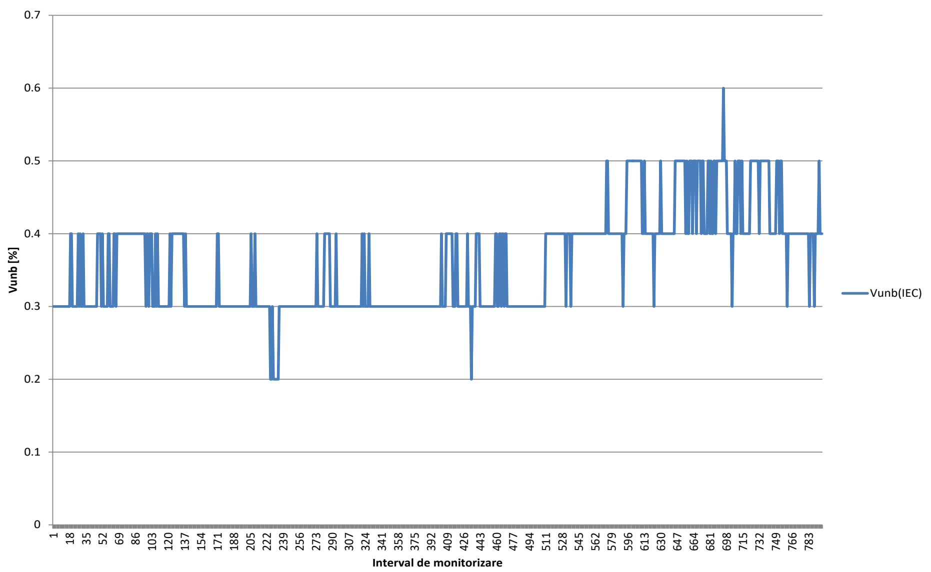

Figure 4. Variation of voltage unbalance the low voltage bars of the user.

Although the user includes several non-linear sources (frequency converters, controlled rectifiers, etc.) the user has taken effective measures to limit the distortions of electric current curves so that the voltage distortion factor k_{dU} , determined as the ratio between the residual voltage U_d and the fundamental harmonica $U_1$of the tension at the bars of 0.4 kV

$$k_{dU} = \frac{U_d}{U_1}\,, \tag{2}$$

within the limits allowed by the current regulations (figure 5), with values not exceeding 1 % (compared to 8% allowed in the standards) [4]. Figure 6 shows the result of the monitoring of electric currents, from the point of view of their distortion.

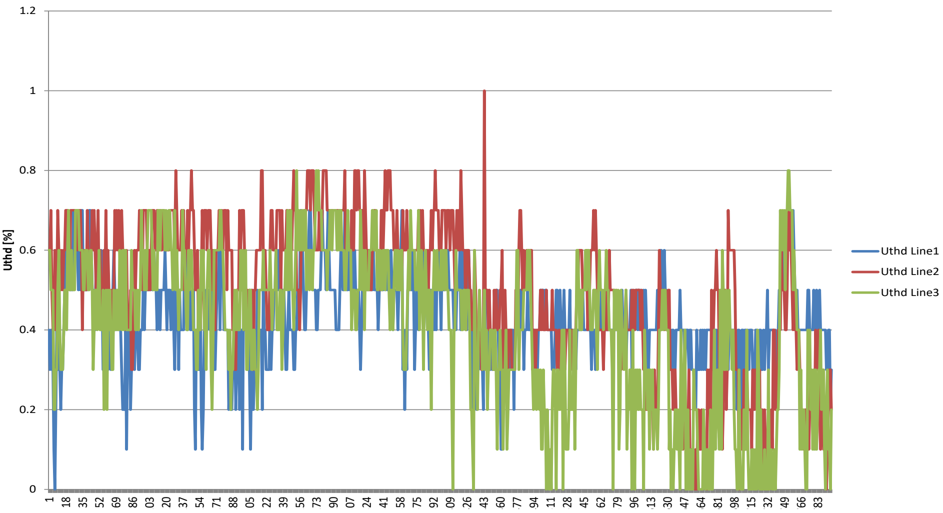

Figure 5. Variation of voltage unbalance at voltage bars of the user on all monetarised period.

Harmonic analysis of voltage curves has highlighted the presence in particular of rank 5 and 7 harmonics that can cause damage in the operation of some users (Table 1). The harmonics with a multiple rank of three, although they appeared in the voltage curve, are of low values, so it is no longer necessary to limit these harmonics in the triangle winding of the transformer 110/20 kV, which allowed the use of star winding at this transformer, with important economic advantages for the user

Table 4.1 - *The impact of the deformant regime on receivers*

Distortion factor of the voltage curve	The consequences of long-term exposure
$k_{du} \leq 5\%$	In the most cases there are no problems
$5\% < k_{du} \leq 7\%$	Problems may arise in highly sensitive equipment
$7\% < k_{du} \leq 10\%$	Problems may also occur in robust elements
$k_{du} > 10\%$	Damage may occur

In order to limit the harmonic content in the user scheme, solutions have been proposed related to the proper connection of converters that power electrical machines operating at adaptable speed [4].

The data in Figure 6 indicate that the electrical current distortion factor, at some points in the technological process, can reach relatively high values. The reduced internal impedance of the power supply system shall cause the level of voltage harmonics at the power bars (figure 5) not to exceed the limits permitted by the standards in force.

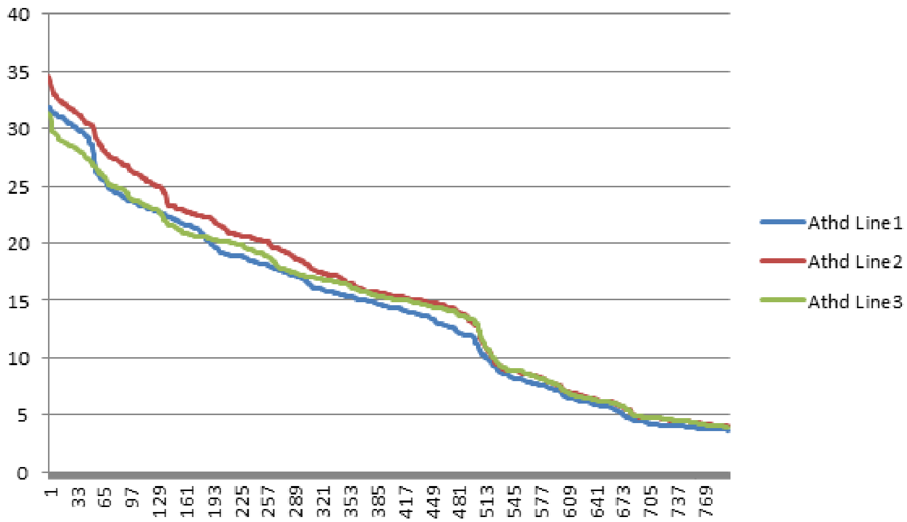

Figure 6. Variation of the total harmonic distortion factor of the electric current curves on the analyzed circuit.

Harmonics with a rank above 50 were not analyzed having insignificant values.

A particular attention was paid to monitoring the values of electrical currents in the supply circuits to determine both their demands and the level of losses in the user's electrical circuits. Figure 7 shows the recorded values of electric currents in the form of ranked curves.

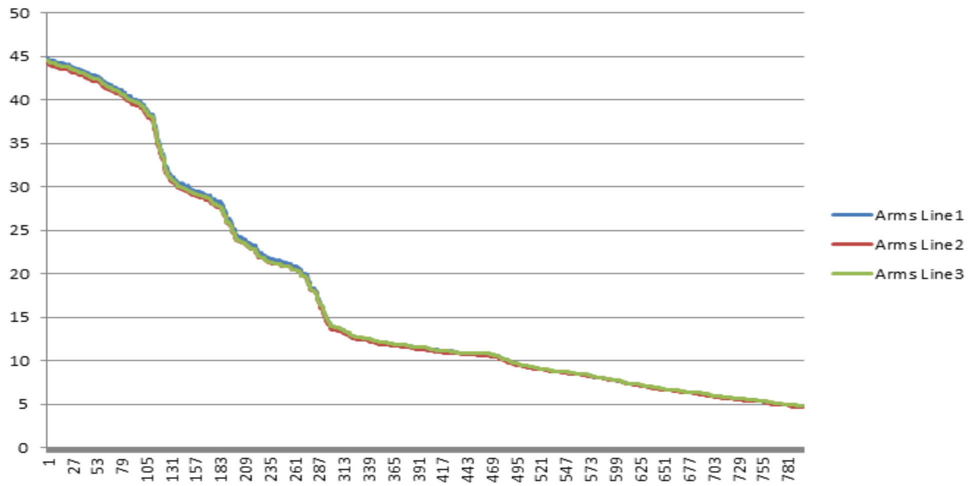

Figure 7. Ranked curves of electrical currents during monitorization.

The data in Figure 7 show that in the analyzed circuit the electric currents on three phases have virtually equal values, but with an important variation in the values determined by the specifics of the technological process corresponding to the analyzed circuit.

Taking into consideration the existence of electrical welding processes in the analyzed unit, voltage fluctuations on low voltage bars were monitored to assess the flicker effect and possible physiological embarrassment effects on the health of the staff in the enterprise. The recorded data did not reveal any exceedances in the form of a flicker.

The ranked curves of the active and reactive power required by the user (figure 8 and figure 9) as well as the analysis of the variation of the power factor (figure 10).

The curves in Figure 9 indicate that over a significant period of time, the user absorbs capacitive reactive power. Bassed on the data in Figure 10, it is noted that the capacitive power factor values are within the limits accepted by the regulations in force. In order to ensure the control of reactive power in the capacitive area and the limitation of unwanted increases in voltage in this range, concrete solutions for limiting the capacitive regime have been analyzed.

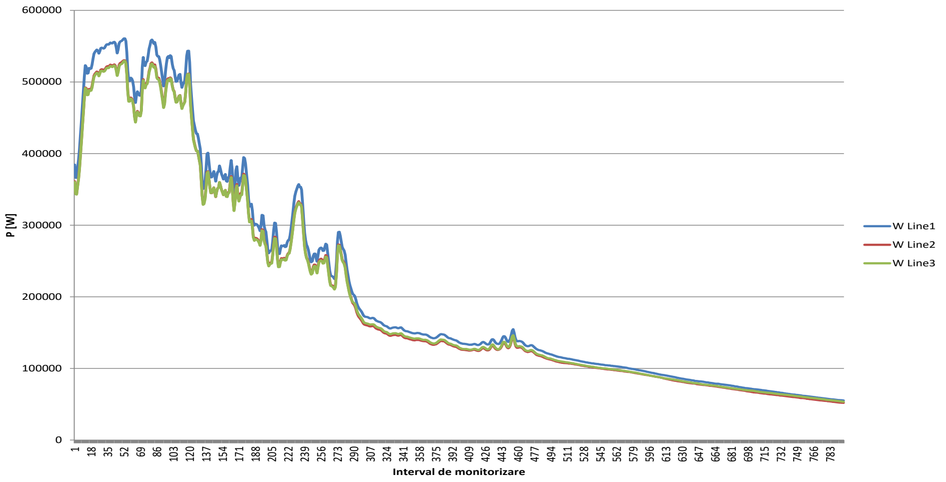

Figure 8. The ranked curves of the active powers for the three phases of the analysed electrical circuit.

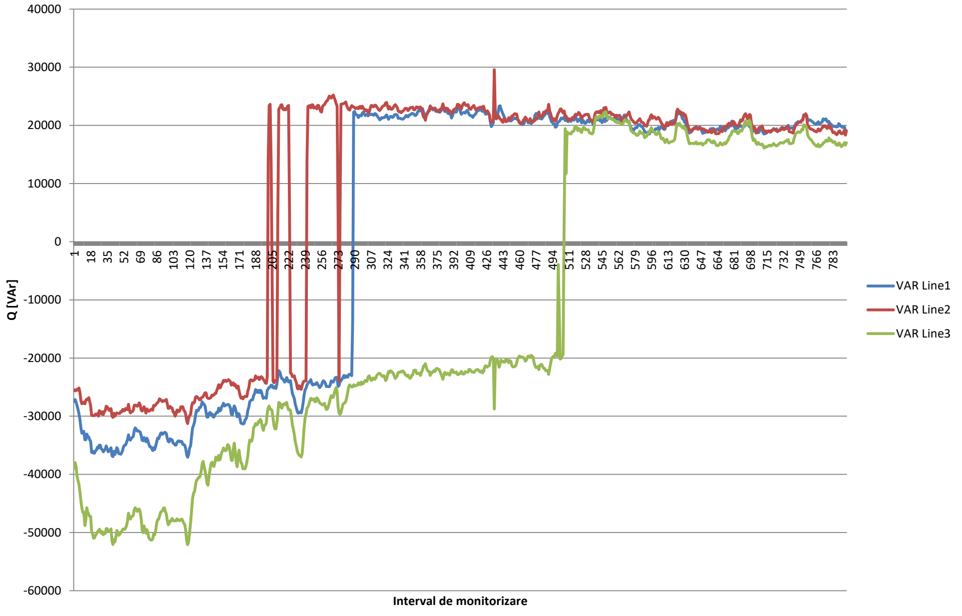

Figure 9. Variation of reactive powers during the time of monitoring.

The PF power factor was determined by the base of the recorded energy values over a specified time interval:

$$PF = \frac{W_{trifazat}^{P}}{W_{trifazat}^{S}}, \qquad (3)$$

The PF value, although widely used in the practical applications, provides accurate information on the energy behavior of the consumer only in the case of a constant consumption over the period in which the power factor assessment is made.

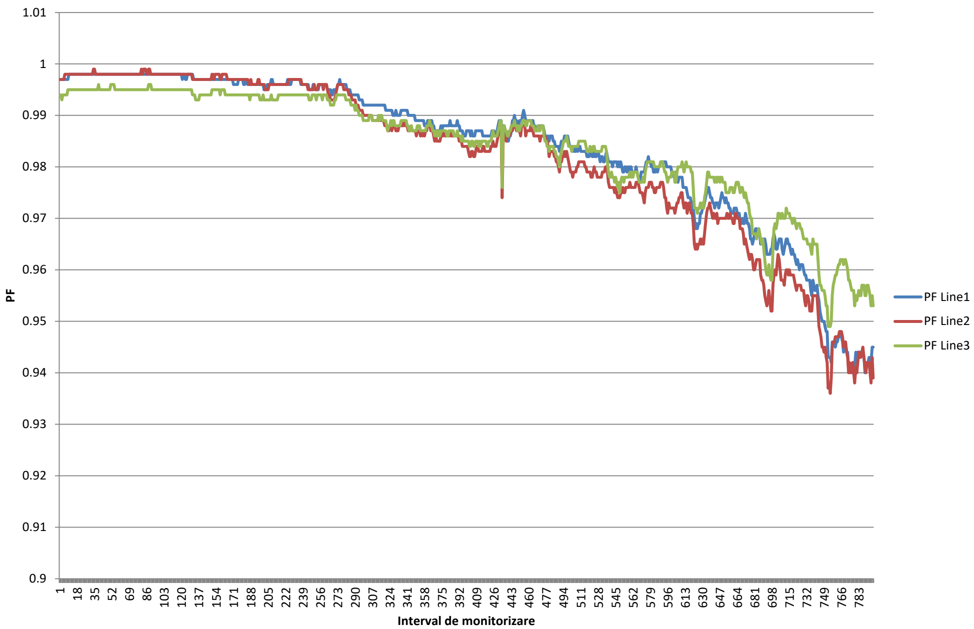

Figure 10. The variation of the power factor in the monitored range.

3. Conclusions

The monitoring of voltage curves at the power bars represents an important interest in determining of the quality of electricity, supplied by the local electricity distributor. Monitoring of current curves is important for assessing user-driven disturbances transmitted to the distributor's circuits.

The presence of a modern monitoring system in the analyzed user allows the obtaining of the most important information on its energy behavior, but also it limits the electromagnetic disturbances generated by the technological process and the adoption of intelligent measures to increase the user's performance.

Obtaining an accurate information about the evolution of sizes in the medium and high voltage circuits requires replacing the current electromagnetic transformers with a narrow frequency band with modern transducers (optical effect) to achieve a response with a frequency band up to at least 10 kHz

R E F E R E N C E S

[1] *** *Voltage characteristics of electricity supplied by public distribution systems*, Standard EN 50160:2009.
[2] *** *Electromagnetic compatibility* (EMC) – Part 3-13: *Limits – Assessment of emission for the connection of unbalanced installationa to* MV, HV *and* EHV *power systems*, Standard IEC/TR 61000-3-13.
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[4] *** *Electromagnetic compatibility* (EMC) – Part 3-6: *Limits – Assessment of emission limits for the connection of distorting installations* to MV, HV *and* EHV *power systems*, Standard IEC/TR 61000-3-6.