

## GUIDE FOR ASSESSING THE NETWORK HARMONIC IMPEDANCE

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## 1 INTRODUCTION

WG CC02 (CIGRE 36.05/ CTRSD 2) has published recommendations for the connection of harmonic producing loads in MV and HV power systems which have been an important input for the new EMC Technical Report 1000-3-C "Assessment of emission limits for disturbing loads in MV and HV power systems" (1996). The aim of this Basic EMC Publication is to limit the harmonic currents and voltages in the network to avoid disturbances to sensitive equipment.

Non-linear loads are generally characterized by harmonic currents, and therefore, it is often preferred to express the emission limits in terms of currents rather than voltages. In order to translate the injected harmonic currents into harmonic voltages though, one needs to know the harmonic impedance of the system.

However, assessing the network harmonic impedance is a very complex and difficult task. There is no inexpensive, simple and universal measurement or computational method available, powerful computer programs may be used, but a full knowledge of the network characteristics is lacking. Moreover, the impedance is continuously changing with loads, network elements and system conditions.

The objective of this report is to provide practical guidance for assessing the system harmonic impedance, taking into account the considered network (L.V., MV or HV), the disturbing load importance (small or great contribution to the network pollution), the analytical and computational tools available.

Due to space limitations, we only present an extensive summary of the paper here. The full paper, with all references and appendices, may be obtained on request at the CTRSD Secretariat<sup>3</sup>. It may also be found in ELECTRA, No. 167, August 1996, 96-111.

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## 2 CHOICE OF REPRESENTATIVE NETWORK CONDITIONS

For most studies, it will be sufficient to consider normal operating conditions.

However, in particular cases, e.g. when studying the connection of a big disturbing load bringing some risk that the resulting total harmonic voltages could exceed the planning limits, also reasonable emergency conditions (i.e. a N-1 configuration) should be considered.

In both cases, at least heavy- and light-load conditions should be taken into account.

## 3 MEASUREMENT METHODS

## 3.1 General principles

The basic principle is to make use of (inter)harmonic currents  $I_h$  injected at the point where the (inter)harmonic impedance  $Z_h$  is to be measured, then using Ohm's law,

$$Z_h = \frac{U_h}{I_h} \quad (1)$$

assuming that no (inter)harmonic voltage was present in the network prior to the current injection (Fig. 1). In cases where this assumption is not valid,  $U_h$  and  $I_h$  should be replaced by  $\Delta U_h$  and  $\Delta I_h$ .



Fig. 1: Basic principle of measurement methods

N.B.  $Z_h$ ,  $U_h$  and  $I_h$  are obviously complex quantities but, in order to simplify the notation, the symbols have not been underlined.

In practice however, the power system is 3-phase and is not symmetrical. Furthermore, in most cases, the injected harmonic currents are far from symmetrical. Thus, even if we assume the system is symmetrical (more correct in MV than in LHV), we have to study the practicability of

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