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Assessment of Harmonic Distortion Sources in Power Networks with Capacitor Banks

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Abstract. The identification of distortion sources in a power system is a topic unsolved. The problem has a difficult solution because there are elements in the system that do not produce harmonic but amplifies the existing in the electrical network. The most common of those elements is the capacitor, very used to compensate power factor at fundamental frequency. The capacitor behaviour makes that the indices proposed up now to identify distorsion indices fail in the presence of this element. In this paper, a new one is presented: the load characterization index. Besides using an extended equivalent circuit to represent the load, this index calculates the distortion introduced by the load, evaluating, besides the current distortion at its input, the voltage distortion at its terminals. The introduction of voltage assesing makes the index suitable to identify the linear and non-linear loads in the power system even in the presence of capacitors.

Key words

Power Quality, Harmonic, Distortion Source, Distortion Assessment, Distribution Networks, Non-Linear Loads.

1. Introduction

In a liberalized electricity market, the electric power quality, EPQ, in the grid can be a critical competitive parameter and may represent a key to supply contracts. Both, measures and assessing consumers contribution to the EPQ are becoming increasingly important [1]-[8]. Harmonic distortion is one of the main aspects of power quality and it is the fastest growing in importance in recent years because of the proliferation of nonlinear and time-varing loads in power systems, which absorb nonsinusoidal currents.

In the thecnical papers there have been many proposals to establish the responsibility of each agent in the harmonic distortion of power distribution networks, [1]-[8]. One of the most relevant is the based on the harmonic active power sign, [2]-[3]. Other relevant group of proposal is the based on the current decomposition, [4]-[7].

All those procedures have their advantages and disadvantages. However, non of them are able to identify the true distortion sources on systems with the presence of capacitors, [8]-[11]. Indeed, it should be noted that while the loads that produce harmonics are undoubtedly non linear loads which introduce distortion in the system, other elements may have an important role in the propagation of harmonics in the networks, although they can not be listed as distortion sources. The capacitor is the most important one. It is widely used in power systems to compensate for low power factor of inductive loads. However, its performance is optimal only if the network operates in steady state sinusoidal conditions. In another case, the capacitor may cause serious problems, [8]-[11]. This is mainly due to its harmonic impedance, which decreases as frequency increases, and besides, it increases the distortion of the current that load consumes. In fact, on high harmonic order, capacitive impedances are really low and current is almost completely non active. So, for example, on high order of harmonic in presence of capacitor the determination of the active power sign is really difficult.

In this regard, a new procedure is presented in this paper that evaluates the distortion introduced by each load connected to a point of common connection, PCC. Besides, it takes into account the presence of capacitors to compensate the power factor at fundamental frequency and its behavior at high frequency. This procedure, which results in the so-called Load Characterization Index (LCI), could be implemented in commercial network analyzers to carry out the analysis of the responsibility of each load on the total distortion power system.

The behabiour of the index has been checked by simulation and experimental tests, based on industral applications where some problems have been detected.