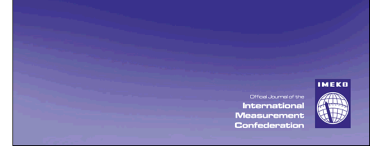

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On-Line Fault Detection Technique for Voltage Transformers

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Abstract — Conventional voltage transformers (CVTs) are still widely used as transducers in the power network, thanks to their high reliability, insulation capability, low drift over time and temperature. Their rugged construction is very often used as justification for skipping periodical tests and calibrations, that require putting them off-line, thus avoiding a time-consuming and expensive procedure. For this reason, in the last years, a growing interest has been addressed towards the study of online diagnostic and calibration procedures. The typical approach is based on the frequency response analysis that permits, under sinusoidal conditions, to detect possible deterioration of the behavior of CVT. Anyway, the real interest is to check the CVT fleet already installed and operating on the grid without requiring their disconnection from the grid. As well known, distribution grid voltage features a non negligible harmonic distortion, which may allow the online evaluation of the frequency response of the transformer, by simply connecting a reference transducer. Unfortunately, being the harmonics much lower than the fundamental, this approach cannot be employed in a straightforward way because of the nonlinear behavior of the CVT. This paper proposes an innovative condition monitoring technique of CVTs based on a nonlinear simplified Volterra model. This opens the way to a new approach to the on-site characterization of CVTs, exploiting the actual voltage of the grid and thus not requiring its disconnection.

Keywords—*voltage transformer; Volterra model; harmonic monitoring; frequency response; diagnostic.*

I. INTRODUCTION

Nowadays, along with the concept of sustainable development, most renewable power generators, such as solar panels and wind turbines, are connected to the grid by means of switch-mode interface converters. On the other hand, many electrical loads use a power electronics input stage. Since these generators and converters are nonlinear devices, harmonic distortion in the grid has noticeably increased in the last years. Harmonics should be monitored since they may be responsible for increasing energy losses, overheating in power transformers and malfunction of electronic switches. Consequently, the transducers installed in the grid have to guarantee a proper measurement accuracy not only at the mains frequency, but also over a suitable frequency bandwidth.

Another mandatory prerequisite of the transducers is high reliability and negligible drift over time of their measurement accuracy. Any replacement and/or off-line calibration of these devices imply interruption of the grid service, thus having great economic impact.

Despite the availability of a new generation of non-conventional instrument transformers (NCITs), based on electronics, optical technologies, etc., the CIT, based on the law of induction, is still the most widely used device for current and voltage measurement in medium and high voltage systems. In a overall evaluation, their robustness, passive working principle and long-term stability are features very often preferred to the wider bandwidth, higher linearity and smaller size of NCITs.

As a consequence, the CVTs are also used for voltage harmonic monitoring. In order to guarantee proper performances, it is necessary to characterize their accuracy in the frequency band of interest. The conventional approach is to evaluate the ratio and the phase error versus frequency, by applying a sinusoidal frequency sweep. In the last years, many researches have been addressed to exploit the knowledge of CVT frequency response for improving the performances. In particular, the target was to extend and improve the bandwidth of the device with real-time frequency