

A HARMONIC IMPEDANCE MEASUREMENT SYSTEM FOR REDUCTION OF HARMONICS IN THE ELECTRICITY GRID

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ABSTRACT

This paper describes the development of a Complex Harmonic Impedance Measurement system, called the CHIME-system. This system performs on-line impedance measurements in the electricity grid and will be designed for implementation in Digital Signal Processor (DSP) control systems of grid-connected electronic power converters, like photovoltaic inverters. This system could be used to estimate the potential of harmonic voltage distortion in low voltage distribution systems, due to large scale photovoltaic implementations.

The CHIME-system estimates the complex small signal network impedance for a range of harmonic frequencies up to the 40th. To avoid disturbances in the grid, the injected stimulus for the measurement should be small enough to let the system comply with the standard for current emission of home appliances. This implicates that the system must be able to extract the complex network impedance from very small signals, often lower than noise levels. The CHIME-system can comply with these demanding specifications and works with the combination of a Lock-in system and Discrete Fourier Transformation (DFT).

This paper discusses the principle of the CHIME-system and give results from computer simulations and laboratory measurements. These results show that the

CHIME-system can work well by injecting a very low measurement current, lower than the allowed emission of a small home appliance. Beside that, the CHIME-system is capable of operating under a strong polluted grid voltage.

Later this system will be implemented as an ancillary service, in a grid-connected power electronic converter.

1 INTRODUCTION

Because today's modern home appliances and small inverters for DER bring in more and more capacitances to the grid, the effect on the total grid impedance in the low voltage distribution grid is significant. It is the Electro Magnetic Interference (EMI) filter that brings this capacitive load to the grid. Although these capacitances are small, because of the large and still increasing numbers, the total capacitive load in distribution grids can rise to a high level. Capacitive loads and inductive grid impedances can come into resonance. This resonance can let the impedance around the resonance frequency, rise to a much higher level. In this way harmonic currents that lie in the same frequency range can be transferred into problematic high harmonic voltages. Therefore these resonances are a real threat for power quality [1].

In today's practice the EMI filter capacitances of DER inverters are much higher than those of modern home appliances of comparable power size. Installing a DER inverter of 2kW or more in a dwelling, can triple the total capacitance at the Point of Connection (PoC). Beside the resonance phenomenon, an inverter can reduce the damping of this resonance and with that respond strongly on pollution of the grid voltage [2].

The Chime-system is developed, to locate these possible resonances, to make it possible to take measures on beforehand by using this harmonic impedance information [3].

For this purpose, the measurement system must be able to estimate the complex small signal grid impedance for a range of harmonic frequencies up to the 40th. The injected stimulus for the measurement, is a current waveform which contains a number of frequency components. These components are located close to harmonic frequencies of the grid voltage. Due to the integration of the measurement system into a small grid-connected power electronic converter, this injected current must be small enough to let the system comply with the standard for current emission of home appliances [4]. This implicates that the system must be able to extract the complex network impedance from very small signals, often lower than noise levels. One method that can comply with these demanding specifications is based on a Lock-in method [5]. However a disadvantage of this method is that it outputs only one frequency component at the time. A Discrete Fourier Transformation (DFT) system however, can give the same result with a whole spectrum as output. The results of both systems are comparable, because the basis of the DFT and the Lock-in system is the same. This paper compares the two systems and discusses a solution in the combination of the two for the CHIME-system.