Demand for electricity is growing and this trend will continue in the future and it is estimated at 1.2% per year. Overall capacity of renewable energy sources (RES) is still growing and replacing potentially harmful and obsolete technologies. However, increasing introduction of more RES into the complex power distribution system poses new challenges related to maintaining, stable operation and correct management of whole system. Interaction of such power system with the increasing number of distributed RES and loads reveals problems with energy quality and reliable delivery assurance. Poor power quality is caused by constant and periodical voltage distortions like dips, sags, spikes, imbalances, symmetrical and unsymmetrical higher harmonics content. Also grid may be weak due to high and variable over time grid impedance (due to different loads and connection and disconnection of energy sources) what may result in additional distortions. In such case grid connected devices may not work properly what is revealed by increased energy losses, shortening their life time and failure. This leads to increased unnecessary costs associated with additional energy production, devices servicing, replacement or production downtime.

Currently, this state of power system is being gradually improved from both: source and demand side by application of power electronics converters (PECs) used as interconnection device to coupling distributed energy sources, storage systems and active loads. The PEC applications are only possible way to proper adjusting of generated electrical or consumed energy parameters according to grid standards (grid codes).

For selected topology of PEC, a dedicated current control strategy mainly responsible for operation stability and robustness is used, which determines the converter output voltage. Known from literature current control strategies has strongly limited control band and application range. It means, that every current control strategy is dedicated to a particular PEC topology and has control band limited only to fundamental current harmonic. Hence, many unpredictable in time and character grid voltage distortion may cause improper operation, stability lost or failure of PEC, because applied control technique will not be able to response adequately. To overcome that it is possible to expand control band by adding additional control blocs in aim to remove unwanted distortion, what allows to fully utilize the benefits given by PEC converter and what is one of the most frequently discussed topics in power electronics field over the years. However, some of aforementioned additional control blocks can not only compensate unwanted distortion but also affect operation of other control blocks in control band, and as result positively or negatively interact with them in scope of compensation or amplification of distortion for which it was not intended to. Hence, in spite of many publications devoted to this problem there is clear lack of one ideal solution and thus there is still a strong need to develop a simple, universal current control strategy combined of fundamental current control and a single additional control block, which will be resistant to own and grid voltage distortions and able to maintain stable and accurate operation of grid connected converter under strongly distorted grid voltage conditions.

Novel scientific methodology will bases mainly on the solid, comprehensive analysis and mathematical decomposition to the symmetrical components of different types of grid voltage distortions and disturbances introduced by the converter and methods of their compensation for low and high sampling/switching frequency will be conducted. The results of the analysis supported with simulation results are intended to provide detailed information on the nature and frequency band of the specified distortion and how known methods of their compensation reject them. Such, complex and comprehensive analysis of entire set of distortions with exact explanation of its behaviour in multi-domain systems have not yet been made (e.g. whether the particular control system in wide range of switching/sampling frequency is able to cope with the compensation of the selected distortion; whether the current control algorithm positively or negatively interact with many compensation algorithms applied at the same time). Hence a strong need emerges for a thorough analysis of all kinds of distortions, whose results gives detailed description and guidelines to elaborate single and simple distortion compensation structure applicable in wide range topologies of grid connected VSCs. Comparative analysis of the compiled results will be the basis for development of universal current control algorithms resistant to converter own and grid voltage distortions.

As a part of the work will be designed simulation models of AC/DC PEC, single and multiphase, for low (5-10 kHz) and high (100 kHz) sampling frequency. Next will be carried out complex analysis of different type of voltage distortions and methods of their compensations. Based on this be designed novel and comprehensive compensation block which will be resistant to own and grid voltage distortions and able to maintain stable and accurate operation of grid connected converter under strongly distorted grid voltage conditions. Next simulation of new current control method at different grid voltage distortions be conducted as well as comparison with well-known control methods – they should be characterized by not worse current quality as well as dynamic response. Finally experimental results at various voltage distortion be conducted on constructed during a project laboratory setup. This task be concentrated mainly on results analysis and verification of developed control algorithms.