# ASSEGNO DI RICERCA

**Titolo**: Onboard and Offboard Power Converters for Electric Vehicle Chargers

**Durata**: 12 mesi, rinnovabile
**Tutor**: Prof. Gabriele Grandi – DEI, UNIBO

## Progetto di Ricerca e Piano di Attività

### Research project

The project aims to provide technical advancements in the field of electric vehicle charging, employing the most recent technologies while meeting relevant design constraints like high power density, reduced cost, high efficiency, and low harmonic pollution. A preliminary investigation of the most popular converters employed in onboard and offboard chargers is carried out with a look at both active front-end rectifying stage and isolated/non-isolated dc/dc back-end for single- and three-phase grid connections. Specifically, modular configurations that guarantee a granular power scaling while optimizing efficiency in low-power operations are investigated. Furthermore, high-frequency isolated power converters using wideband gap devices like SiC and GaN are the core of the converter. To ensure grid-to-vehicle, vehicle-to-grid, and vehicle-to-vehicle operations, bidirectional topologies and configurations are employed in all the power stages. Uncommon, multipurpose, and highly integrated topologies are expected to be developed for achieving design targets like weight optimization and cost minimization. Novel modulation techniques employing variable switching frequency, interleaving action, and advanced phase shift are crucial elements for the filtering stage optimization to improve power quality and volume utilization.

The main targets are:

1) Development of scaled-down converters with or without high-frequency isolation. Testing in load conditions similar to the one experienced by the actual system during electric vehicle charging. Validation of bidirectional power routing capabilities in single- and three-phase connections.
2) Development and simulation of a full-scale converter using wideband gap devices on realistic voltage and current charging profiles. Efficiency calculation at all power levels and for both grid-to-vehicle and vehicle-to-grid modes.
3) Definition and implementation of novel modulation strategies to achieve filtering stage and cooling system design optimization specific for the convert topologies under study.

### Activity plan

The activity will be developed in three main stages.

1) The first stage is the project definition. It includes a literature overview of already developed techniques that can be used for the current project. Furthermore, the determination of requirements and standards must be fulfilled during the implementation process. Finally, the calculation of fundamental parameters of the system model together with a feasibility study confirms the desired outcome.

2) The second stage includes the hardware development of optimal topologies for the ac/dc active front-end and the dc/dc back-end. In addition, software definition and optimization

of modulation strategies are carried out in this stage. A scaled-down prototype should accompany a full-scale numerical system.

3) The third stage covers performance tests and their evaluation. Firstly, numerical results of the whole system are drawn. Secondly, hardware in the loop testing of the novel modulation strategies and closed-loop controls is performed. Lastly, the topology and its related control are validated on a scaled-down prototype.