PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Pasquale Franzese

XXIX Cycle

Training and Research Activities Report – Third Year

Pasquale Franzese

Tutor: prof. Diego Iannuzzi

Diego Iannuzzi

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UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

1. Information:

- **PhD student:** Pasquale Franzese
- **DR number:** 993624
- **Date of birth:** 14/07/1994
- **Master Science degree:** Master's degree in Automation Engineering (cum laude)
  University: Università di Napoli Federico II
- **Doctoral Cycle:** XXXIV
- **Scholarship type:** No scholarship
- **Tutor:** Prof. Diego Ianuzzi

2. Study and training activities:

Activity	Type[1]	Hours	Credits	Dates	Organizer	Certificate[2]
Statistical data analysis for science and engineering research	Courses	32	4	04/21	DIETI (UNINA) Prof. Roberto Pietrantuono	Y
Scientific Programming and Visualization with Python	Courses	24	3	8/03/21-11/03/21	DIETI (UNINA) Prof. Iunio Iervolino	Y

2.1.Study and training activities - credits earned

	Courses	Seminars	Research	Tutorship	Total
First Year	**24,2**	**6,6**	**25**	**0**	**55,8**
Second Year	**33**	**6,8**	**34**	**1**	**74,8**
Bimonth 1	**0**	**0**	**6**	**8**	**34**
Bimonth 2	**0**	**0**	**5**	**0**	**5**
Bimonth 3	**7**	**0**	**7**	**4**	**18**
Bimonth 4	**0**	**0**	**7**	**4**	**11**
Bimonth 5	**0**	**0**	**6**	**0**	**6**
Bimonth 6	**0**	**0**	**7**	**0**	**7**
Three mounths extention	**0**	**0**	**5**	**0**	**5**
Total	**64.2**	**13.5**	**102**	**16**	**216.6**
Expected	**30 - 70**	**10 - 30**	**80 - 140**	**0 – 4.8**	**>180**

3. Research activity:

MULTIPLE EV PARKING SLOTS OF ULTRA-FAST CHARGING STATION:

The number of Plug-in Electric Vehicles (PEVs) available on the car market is continuously growing. The electrification of the mobility is definitely related to the diffusion of the

charging infrastructures widely distributed on the territory. Indeed, PEV owners request for charging stations able to offer features adequate to the expectations. They are expected to be able to recharge vehicle's on-board battery in a ten of minutes. In my research activity, Ultra-Fast Charging Stations (UFCSs) are investigated. The stations are discussed in terms of electric schemes and modalities of control. I focused on components, systems, state variable and security level. Moreover, the UFCS prototype realized at the University of Naples Federico II is discussed in terms of configuration and rated values. The results of some numerical tests are carried out. They point out both the main features of the charging slots and the requirements of load emulators for UFCS.

OPTIMAL POWER SCHEDULING MULTIPLE SLOTS UFCS:

The paper focuses on a scheduling strategy for multislot Ultra-Fast Charging Stations (UFCSs) for Electrical Vehicles (EVs), equipped with a Battery Energy Storage System (BESS). The scheduling strategy allows the energy management of charging simultaneously more EVs, while both optimizing the charging time and levelling the power supplied by the distribution grid (i.e., peak-shaving). The output of the scheduling strategy is the EV charging power profile as a function of UFCS power and energy, EV power requirements, State of Charge (SoC), power converters and BESS's conversion efficiency. The scheduling strategy is detailed for the UFCS infrastructure realized at the University of Naples Federico II, equipped with two charging slots of 160 kW rated power and a grid-tied power converter of 50 kW. The emulations are carried out to assess the behavior of the infrastructure by using the experimental charging results carried out on two real commercial EVs. The strategy is proposed with two different scheduling algorithms, which define modes of managing the infrastructure's charging slots. They are the FCBS ('First Come Best Served') and RR ('Round Robin') algorithms. A comparison analysis points out the most relevant features of the obtained results.

POWER CONTROL STRATEGY OF PHOTOVOLTAIC CASCADED H-BRIDGE CONVERTER:

The activity deals with the power control of a delta connected Cascaded H-Bridge (CHB) converter equipped with photovoltaic (PV) modules. A hierarchical architecture of energy management is proposed: a "Module level" controller performs a Maximum Power Point Tracking (MPPT) algorithm to achieve the optimal utilization of each PV module; a "Leg level" controller manages the power flow control within the modules of a single CHB phase leg, and a "System" level controller manages the active power flow between the three CHB phases and the reactive power generation towards the grid. The active power control is aimed at the compensation of the mismatches between the different PV-powered modules, which may come from partial shadowing phenomena. A power unbalance compensation between cascaded modules is implemented through the Pulse Width Modulation (PWM) algorithm, while the unbalance compensation between the phases is implemented through the phase currents control. To compensate the active power unbalance due to PV module mismatches, the obtained effect is equivalent to the injection of a zero sequence current. A reactive power control has been implemented to perform a

power factor (PF) correction, too. A set of numerical simulations validate the effectiveness of the algorithm, which can simultaneously achieve the desired active power generation from all the PV panels and the desired PF control towards the grid.

OPTIMIZATED CONTROL STRATEGY FOR SINGLE-PHASE MULTILEVEL CASCADED CONVERTER IN A DISTRIBUTED PV-BESS SYSTEM:

This activity focuses on an energy management of single-phase PV-BESS hybrid distributed system sized for residential units' applications, using CHB converter topology as grid interface. A hierarchical architecture of energy management based on the implementation of concentrated and distributed control layers has been proposed. The supervision for the references generation of each control layer is demanded to the implementation of optimized control algorithm. It provides to minimize the reactive supplied by each PV and BESS modules in order to maximize the PV sources production and active power exchange with grid taking into account voltage and current constraints. Some other constraints regard the power provided by the batteries for different values of SoC, the mismatch between the voltage of battery modules, the partial shadowing phenomenon and the results of the MPPT algorithm. Numerical analysis and simulation results are carried out in order to validate the optimal algorithm in typical operating conditions and to assess the effectiveness of the whole control strategy.

3.1. Research products:

Pubblications:

- **Published:** P. Franzese, A. Di Pasquale, D. Iannuzzi and M. Pagano, "Electric Ultra-Fast Charging Stations: a Real Case Study," 2021 AEIT International Annual Conference (AEIT), 2021, pp. 1-6, doi: 10.23919/AEIT53387.2021.9626929
- **Published:** P. Franzese, A. Cervone and D. Iannuzzi, "Power Control Strategy of a Delta-Connected Photovoltaic Cascaded H-Bridge Converter for Low Voltage Distribution Networks in Energy Community," 2021 IEEE 6th International Forum on Research and Technology for Society and Industry (RTSI), 2021, pp. 346-351, doi: 10.1109/RTSI50628.2021.9597305.
- **Pending:** Ciro Attaianese, Antonio Di Pasquale, Pasquale Franzese, Diego Iannuzzi and Mario Pagano, "An Optimal Power Scheduling for Multiple EV Parking Slots of Ultra-Fast Charging Station"
- **Pending:** Pasquale Franzese, Marino Coppola, Diego Iannuzzi, Santolo Meo, "Optimal design of a 3kW DAB converter to minimize the power losses and the size"
- **Pending:** Pasquale Franzese, Andrea Cervone, Diego Iannuzzi, "Optimizated Control Strategy for Single-phase Multilevel Cascaded Converter in a Distributed PV-BESS System"

5. Conferences and seminars attended

I attended following conferences where I presented papers:

Università degli Studi di Napoli Federico II

- *2021 AEIT International Annual Conference (AEIT)*
- *2021 IEEE 6th International Forum on Research and Technology for Society and Industry (RTSI)*

6. Tutorship

I took an active part in teaching in various forms. I participated in the preparation of the exercises for the course of "Generators, converters and storage devices" taught by my tutor Diego Iannuzzi for students in the electrical engineering graduation class, as well as in the days of promotion of research activities on the topic of Ultra-Fast charging. I carried out the tutoring activity at DIETI for the courses of Physics I and Physics II, for a total of 100 hours. I actively followed the internship of master's degree students and I was co-supervisor of their theses.