PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Pasquale Franzese

XXXIV Cycle

Training and Research Activities Report – First Year

Tutor: Diego Iannuzzi

1. Information

PhD candidate:	Pasquale Franzese (mat. DR993624)
Date of birth:	14/07/1994
Master Science title:	Master's degree in Automation Engineering (cum laude) on 29/10/2018, Università di Napoli Federico II
Master Thesis title:	Experimental validation of wireless power transfer for E-bike charging station
Doctoral Cycle:	XXXIV
Fellowship type:	financed by CRIAT (Centro di Ricerca Interuniversitario su Azionamenti per Trazione Aerea, Terrestre e Marittima) of Università di Napoli Federico II
Tutor:	Prof. Diego Ianuzzi
Year:	First

2. Study and Training activities

In the first year of PhD program, I attended the following seminars and courses:

Activity	Type	Lecturer	Provider	Bimonthly	Credits
Parallel and Distributed computing with MATLAB	Seminar	Stefano Marrone	DIETI (UNINA)	1°	0,4
How to publish a scientific paper	Seminar	E.Magistrelli, Aliaksandr Birukou	DIETI (UNINA)	1°	0,4
L'Accademia delle Startup - Le Startup dell'Accademia	Seminar	Lucia D'Arienzo, Daniela Pasquali, Massimo Varrone	Campania NewSteel	1°	1,6
Elettromagnetismo e Relatività	Ad hoc module	Prof. Amedeo Capozzoli	DIETI (UNINA)	1° / 2°	5
Data Science and Optimization	Ad hoc module	Manilo Gaudioso, Laura Palagi, Enza Messina	DIETI (UNINA)	2°	1,2
Big Data	Ad hoc module	Prof. Antonio Picariello, Giancarlo Sperlì	DIETI (UNINA)	2° / 3°	3
Misure e collaudo su machine ed impianti elettrici	Ms.Sc. module	Prof. Annalisa Liccardo	DIETI (UNINA)	3° / 4°	6

Misure per la compatibilità elettromagnetica	Ms.Sc. module	Prof. Nicola Pasquino	DIETI (UNINA)	3° / 4°	9
Sensori e trasduttori di misura	Ms.Sc. module	Prof. Rosario Schiano Lo Moriello	DIETI (UNINA)	3° / 4°	0 (9) [2]
Presentazione ADI: vittorie, sfide, obiettivi	Seminar	Lorenzo Fattori	DIETI (UNINA)	4°	0,2
Development Trend of Si and WB Devices – What is required by the Application	Seminar	Prof. Leo Lorenz	European PhD School PEEMECPS[1]	4°	0,4
General Properties, Scaling Laws & Inherent Limitations of Energy Electronics	Seminar	Prof. Johann Walter Kolar	European PhD School PEEMECPS[1]	4°	0,4
Medium Frequency Trasformer Design Optimisation for Solid State Trasformers	Seminar	Drazen Dujic	European PhD School PEEMECPS[1]	4°	0,4
Modelling, prototyping, testing of power electronics and electrical drives systems	Seminar	Bernd Neuner	European PhD School PEEMECPS[1]	4°	0,4
Insulation Coordination in Power electronics	Seminar	Ilknur Colak	European PhD School PEEMECPS[1]	4°	0,4
Outlook on electric mobility and power electronics	Seminar	Samuel Araujo	European PhD School PEEMECPS[1]	4°	0,4
Electrification of Road Transportation and Impact of Electric Vehicle Charging on Distribution Networks	Seminar	Sasa Djokic	European PhD School PEEMECPS[1]	4°	0,4
Electrochemical Energy Storage Systems for Stationary and Dynamic Applications	Seminar	Marcello Canova	European PhD School PEEMECPS[1]	4°	0,4
Silicon Carbide Power Devices: Technologies and Applications	Seminar	Mario Saggio	European PhD School PEEMECPS[1]	4°	0,4
Fuel Cell Technology for Automotive applications	Seminar	Fei Gao, Elena Breaz	European PhD School PEEMECPS[1]	4°	0,4
Ingegneria del software	Ms.Sc. Module	Prof. Anna Rita Fasolino	DIETI (UNINA)	6°	0 (9) [2]

Economia ed organizzazione aziendale	Ms.Sc. Module	Prof. Corrado Lo Storto	DIETI (UNINA)	6°	0 (6) [2]

[1] European PhD School Power Electronics, Electrical Machines, Energy Control and Power Systems 20th edition, Gaeta, Italy

[2] Credits not yet obtained

	Credits year 1								
		1	2	3	4	5	6		
	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Check
Modules	20	0	6,2	3	0	9	6	**24**	30-70
Seminars	8	2,4	0	0	4,2	0	0	**6,6**	10-30
Research	36	5	6,5	8	7	7	9	**43**	80-140
	64	7,4	13	11	11	16	15	**73**	180

3. Research activity

My fellowship is associated with a project "*ELECTRIC ULTRA FAST CHARGING STATION (E-UFCS)*" presented for "POR FESR CAMPANIA 2014/2020- O.S. 1.1" that is a collaboration between *CRIAT (Centro di Ricerca Interuniversitario su Azionamenti per Trazione Aerea, Terrestre e Marittima) of Università di Napoli Federico II* and *Samso s.p.a*, so part of my research deal with charging stations for electrical vehicles.

For the diffusion of electric vehicles, the most important bottleneck regards autonomy and recharge time. I undertook my research activity to acquire skills on charging electric vehicles and to be able to help overcome the technological limits on recharge times in the future. Given these premises, I am studying towards two different and complementary directions:

- Ultra-Fast charge is intended to maximize the charging capacity of the vehicle's batteries in order to make the time of refueling comparable with that of vehicles with a combustion engine. On the charging stations it is planned to use large amounts of power to push the energy from the network to the vehicle (G2V).
- In Wireless charge the tendency is totally different, it intends to provide a widespread branching of recharging points that can exempt drivers from the act of recharging the vehicle. This charging method is much slower than the previous one but has the advantage of being convenient and functional, especially in the city and for vehicles used for car sharing.

Simplified scheme of wireless power charge is in following figure:

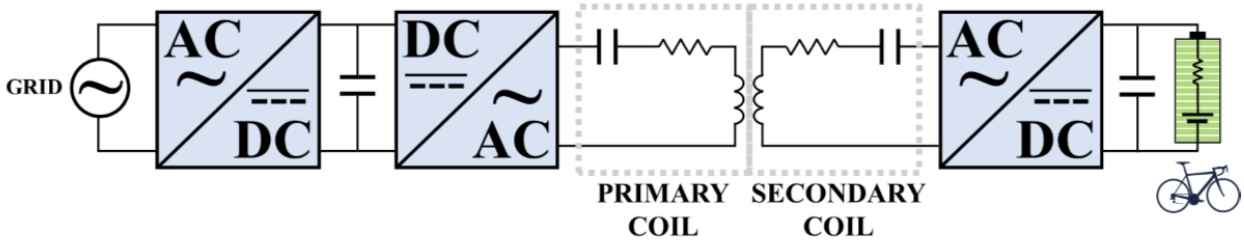

Fig.1 - Simplified scheme of wireless power charge

A device with this topology is already made for a service of bike sharing in my department, but it is not completely finished and operational.

Simplified scheme of ultrafast charge according to project (above mentioned) is in following figure:

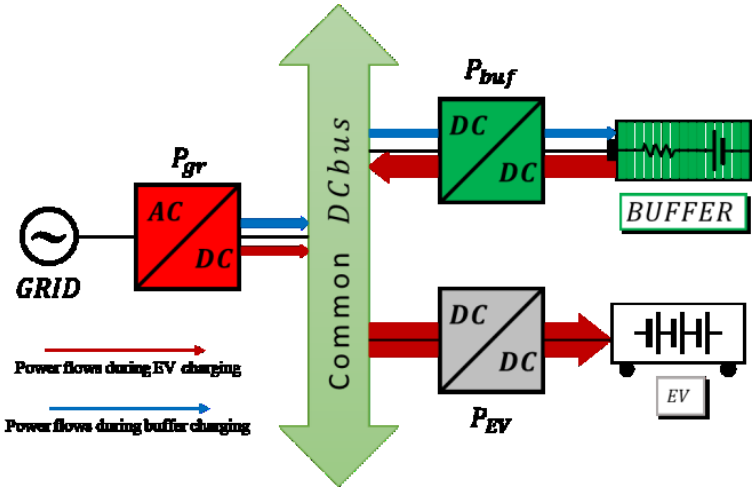

Fig.2 - Simplified scheme of ultrafast charge

The aim for the project (above mentioned) is to design an ultrafast charge station, two vehicles can charge simultaneously, the time target to charge two vehicles of 40kWh is 10 min. Since the grid is not able to provide the amount of power to observe the time target, a BESS (battery energy storage system), named Buffer in *Fig.2*, is used to help the grid.

In my first reserch activity, to approach the study on charging of batteries, I studyed about types of rechargeable batteries commercial used for electric traction. They include lead–acid ("flooded", deep-cycle, and VRLA), NiCd, nickel–metal hydride, lithium-ion, Li-ion polymer, and, less commonly, zinc–air and molten-salt batteries. The most common battery type in modern electric cars are lithium-ion and Lithium polymer battery, because of their high energy density compared to their weight.

I studied on modelling Li-ion batteries and characterize them from data on datasheets. Although there are the different mathematical models offered in the literature, it is not easy to associate the quantities supplied by producers with those requested in the models.
Several producers offer diffent types of Li-ion batteries in commercial solutions, but they are not always willing to share their detailed product data, so there are not many research papers on testing of them.
To study on batteries modelling and to analize their charge and discharge cycles need in both above types of charge to choose right references during the charge for the controllers, but they need also to size the BESS. Basic models were used to sizing battery pack according to energy and power balancing based on 'Load Levelling' and 'Load Shiftng' techniques.
Thanks to the project, the idea is to buy the battery pack choosen to study about SoC (state of charge) and SoH (state of health) estimation using different mathematical models and to test experimentally for our case of use. Furthermore, integration with renewable sources is envisaged to guarantee a sustainable diffusion of electric vehicles.
Control of converters ultrafast charge is designed and simulated, next steps are to implement the control algorithm on a simulation platform to simulate *hardware in the loop* (dSPACE expantion box) and then on a microcontroller. Control of converters design has been also based on study of n-degrees averaged modelling of converters.
The device for wireless power charge is almost ready to work, there were mistakes along the way. A sensorless control was design to lighten the part of device mounted on board of vehicle, it was simulated and it is implementig on control board of the device.

4. Products

Pubblications:

- **Published:** Diego Iannuzzi, Pasquale Franzese. "Preliminary Design of Ultrafast Charging Station for Electrical Vehicles" in *ELECTRIMACS2019* Salerno, *IMASC-IEEE*
- **Published:** Pasquale Franzese, Diego Iannuzzi. "Wireless Battery Charger based on Sensorless Control for E-bike Station" in *EPE'19 ECCE Europe*, *IEEE*
- **To be published:** Diego Iannuzzi, Pasquale Franzese. "Ultrafast Charging Station for Electrical Vehicles: Dynamic Modelling, Design and Control Strategy", *Mathematics and Computers in Simulation 2020*

5. Conferences and Seminars

- ELECTRIMACS 2019, Salerno, Italy 21-23 May 2019 (1 paper in oral session)
- European PHD School - Power Electronics Electrical Machines Energy Control and Power Systems 20th edition 20-24 May 2019 (presentation of research activities in poster session)
- EPE'19 ECCE Europe, Genova, Italy 2-5 September 2019 (1 paper in poster session)

6. Tutorship

The only experiences are support to a master thesis students and teaching support for the course of “Macchine ed azionamenti elettrici”.

31 October 2019

PhD student, **Pasquale Franzese**

Tutor, **Diego Iannuzzi**