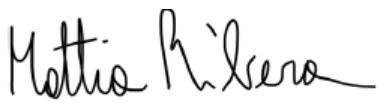
**PhD in Information Technology and Electrical Engineering**
**Università degli Studi di Napoli Federico II**

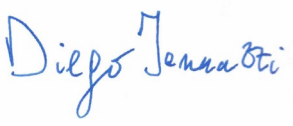
# PhD Student: Mattia Ribera

**Cycle:** **XXXVIII**

## Training and Research Activities Report

## Year: First





**Tutor: Prof. Diego Iannuzzi**

**Date: October xx , 2020**

# Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

**Cycle:** XXXVIII **Author: Mattia Ribera**

## 1. Information:

- **PhD student:** Mattia Ribera
- **DR number:** DR996625
- **Date of birth:** 02/11/1993
- **Master Science degree: Automation Engineering University: Università degli Studi di Napoli "Federico II"**
- **Doctoral Cycle: XXXVIII**
- **Scholarship type:** *UNINA*
- **Tutor: prof. Diego Iannuzzi**

## 2. Study and training activities:

| Activity | Type[1] | Hours | Credits | Dates | Organizer | Certificate[2] |
|---|---|---|---|---|---|---|
| Reti Elettriche Intelligenti - Generatori, convertitori e dispositivi di accumulo | Course | 48 | 6 | From 25/09/2022 To 16/12/2022 | Prof. Diego Iannuzzi | Y |
| MATLAB Campus-Wide License per la formazione nelle discipline STEM | Seminar | 1 | 0.2 | 26/10/2022 | Alessio Conte, Federico Seri (MATLAB) | Y |
| Industry 4.0 Fundamentals in Bosh Applications | Seminar | 8 | 2 | From 23/01/2023 To 26/01/2023 | Eng. Martino Bruni, Prof. Mariagrazia Dotoli | Y |
| Accurate and Efficient Numerical Modeling Methods for Superconducting Circuit Quantum Information Processing Devices | Seminar | 1 | 0.2 | 3/04/2023 | Prof. Thomas E. Roth | Y |
| Analysis and Control of Functional Brain Networks | Seminar | 1 | 0.2 | 9/03/2023 | Prof. Fabio Pasqualetti | N |
| Evolution of the 3D chromatin architecture in acute leukemia | Seminar | 1 | 0.2 | 24/3/2023 | Prof. Aristotelis Tsirigos | Y |

| | | | | | | |
|---|---|---|---|---|---|---|
| **How to Publish Under the CARE-CRUI Open Access Agreement with IEEE** | **Seminar** | **1.5** | **0.3** | **5/4/2023** | **Prof. Nino Grizzuti, Eszter Lukacs, Prof. Stefano Bianco** | **Y** |
| **Learning gene association networks using single-cell RNA-seq data: a graphical model approach** | **Seminar** | **1** | **0.2** | **31/3/2023** | **Prof. Davide Risso** | **Y** |
| **The right ST sensor for you condition monitoring applications** | **Seminar** | **1** | **0.2** | **18/04/2023** | **Pasi Myllymaki, Vladimir Janousek** | **N** |
| **Statistical data analysis for science and engineering research** | **Course** | **12** | **4** | **From 06/02/2023 To 16/02/2023** | **Prof. Roberto Pietrantuono** | **Y** |
| **La mobilità del future: sostenibile, sicura e connessa** | **Seminar** | **4** | **0.8** | **09/05/2023** | **Ing. Marco Toro** | **Y** |
| **Ensuring SESIP L3 security for low-power, high-performance Bluetooth LE 5.3 solutions** | **Seminar** | **1** | **0.2** | **10/05/2023** | **STMicroelectronics** | **N** |
| **Controllo di posizione di un PMSM con Simulink e Microchip 32-bit MCUs** | **Seminar** | **1** | **0.2** | **13/07/2023** | **Mathwork Team** | **Y** |
| **Webinar STM Give your edge AI model a performance boost with the NVIDIA TAO Toolkit and STM32 AI solutions** | **Seminar** | **1** | **0.2** | **29/08/2023** | **STMicroelectronics** | **N** |
| **Modeling Phased Array Systems with MATLAB** | **Seminar** | **1** | **0.2** | **30/08/2023** | **Mathwork Team** | **Y** |
| **Research in Energy Storage Systems for Automotive, Aerospace and Grid-connected Systems at The Ohio State University Center for Automotive Research** | **Seminar** | **2** | **0.4** | **15/09/2023** | **Prof. Ciro Attaianese Dr. Luigi Pio Di Noia** | **Y** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Electric And Hybrid Vehicles** | **Course** | **48** | **6** | **From 08/03/2023 To 04/06/2023** | **Prof. Diego Iannuzzi** | **Y** |
| **Percorso per il rafforzamento delle competenze sulla progettazione europea** | **Course** | **11** | **2.2** | **From 14/09/2023 To 26/10/2023** | **Dr. Tommaso Foglia, Dr. Federico Porcedda, Dr. Veronica Rocco** | **N** |

1) Courses, Seminar, Doctoral School, Research, Tutorship
2) Choose: Y or N

### 2.1.Study and training activities - credits earned

| | Courses | Seminars | Research | Tutorship | Total |
|---|---|---|---|---|---|
| Bimonth 1 | **6** | **0.2** | **7** | | **13.2** |
| Bimonth 2 | | **2** | **5** | | **7** |
| Bimonth 3 | | **1.3** | **5** | | **6.3** |
| Bimonth 4 | **4** | **1.3** | **5** | | **10.3** |
| Bimonth 5 | | **0.6** | **3** | | **3.6** |
| Bimonth 6 | **8.2** | **0.4** | **4** | | **12.6** |
| **Total** | **18.2** | **5.8** | **29** | | **53** |
| **Expected** | **30 - 70** | **10 - 30** | **80 - 140** | **0 – 4.8** | |

## 3. Research activity:

My research activity is related to modelling techniques for electrochemical energy storage systems and different applications of them. The energy storage systems (ESS) refer to the technology used to store and distribute energy from various sources. In particular, they are widely integrated with renewable energy sources into power grid, as it enables the smooth distribution of energy and reduces the need of fossil fuel-based power generation. Other improvements are reliability and stability of the power grid and provide backup power during power outages. The electrochemical technology is commonly applied to e-mobility systems (Electric Vehicles and Fast Charge Infrastructures), smart-grid, railway and aircraft. Lithium batteries are the most widely used due to their optimal energy and power densities for the applications just defined. However, the lifetime is limited to thousands cycle of using and hardly to predict. For these reasons, research activities have been directed toward appropriate lithium battery modeling and alternatives for existing applications to extend the lifetime of actual Battery Energy Storage Systems (BESS).

### 3.1. LiFePo battery modelling and State of Health (SOH) estimation

This technology presents a high number of non-linearities, dependent on operating and environmental conditions. Thus, the focus of this activity was to assess a right modelling strategy to characterize a lithium cell, useful for state of health estimation algorithm implemented in BMSs (Battery Management Systems). The FAAM company provided the physical LFP cells and evaluated data from its laboratories. Within the facilities of the FAAM company, the batteries were subjected to an aging cycle involving continuous charging and discharging. This was facilitated by an industrial battery cycler, and a climate-controlled chamber was employed to maintain a stable environmental temperature throughout the process. Meanwhile, at the DIETI electrical laboratory, our research team developed a fully controllable battery cycler by utilizing a bidirectional power supply and a sophisticated data acquisition system, all managed through a complex MATLAB script. To ensure precise thermal control of the battery under test, Peltier modules and related sensors and controllers were employed. Our in-house battery cycler offered several advantages, including a high data sample rate, superior temperature control of the battery cell, and exceptional accuracy in tracking current profiles during both aging and identification cycles. To construct our battery models, both FAAM and UNINA devices applied a series of current pulses at various states of health, capturing voltage responses critical to the modeling process. The intention was to linearize the battery behaviour using the ARMAX models at known states of charge and states of health and store the identified models in a polynomial database to use for SOH estimation purposes. The first estimation algorithm and results were presented at the ESARS conference but ongoing investigations have led us to recognize the need for a new experimental design to attain a more robust SOH estimation model. In this regard, collaborative research with the electrical research group at Politecnico di Milano yielded a lightweight and tested open circuit voltage model of LFP batteries. The next research activities steps will focus on:

- Continue the investigation of the presented battery models;
- Apply the acquired techniques to define battery model with different technology;
- Given the multitude of influencing factors, we will explore the potential of efficient neural networks to aid in our research objectives.

### 3.2.Benefits of Hibrid Energy Storage System for Battery based Ultra Fast Charging Station

The University of Naples Federico II's UFCS installation boasts remarkable power performance, thanks to the integration of a Battery Energy Storage System (BESS) within its infrastructure. Consequently, this allows the grid and the BESS to jointly supply the charging energy, with the battery module's size aligned with the high power demands of electric vehicles. However, the BESS faces early aging due to the substantial demands of high currents and deep discharge. The I-STENTORE European Project is a collaborative effort involving UNINA research groups and industrial companies, all committed to devising innovative energy storage solutions for charging electric vehicles and ensuring optimal lifespan management of energy modules, while reducing stress on the existing BESS. The primary goal of UNINA's research teams is to introduce an additional energy storage module that places less strain on the

current BESS and presents an economically viable solution for future battery-based charging infrastructure. The research initiative commences with the development of an aging model for the NMC Battery (a lithium technology used in the BESS under examination). This model serves to provide an accurate estimation of the battery's lifecycle during charging routines. Subsequently, this model will be integrated into an upgraded UFCS simulation with the new Hybrid Energy Storage System (ESS).The next phase will focus on determining an optimal energy management strategy for the new charging station. As the research activity progresses, the enhanced UFCS will undergo practical testing. Additionally, this year has seen an expansion of my technical skills, encompassing the management of the installed station and electrical power devices in the lab, which will be crucial for the planned upgrades and safer prototyping testing.

## 4. Research products:

D. Iannuzzi; M. Ribera; P. Satariano; E. Fedele; F. Pagliarini; P. Cennamo; F. Orsini; L. Petrazzuoli; M. Spinelli
*"Capacity Fade Estimation of LiFePo Cells Based on Improved Impulse Response Method: Experimental Results"*
2023 IEEE International Conference on Electrical Systems for Aircraft, Railway, Ship Propulsion and Road Vehicles & International Transportation Electrification Conference (ESARS-ITEC), Venice, Italy, March 2023

P. Franzese; M. Ribera; D. Iannuzzi
*"Design Comparative Analysis Of Distributed and Concentrated Electrical Power Conversion Systems for Multi-Slot Ultra-Fast Chargers"*
7th E-Mobility Power System Integration Symposium, Copenhagen, Denmark, September 2023

S. Barcellona; S. Colnago; E. Fedele; D. Iannuzzi; L. Piegari; M. Ribera
*"Cycle Aging Effect on the Open Circuit Voltage of a LiFePO4 Battery"*
2023 IEEE Vehicle Power and Propulsion (IEEE VPPC 2023), Milan, Italy, October 2023

## 5. Conferences and seminars attended

*Conferences:*

- 2023 IEEE International Conference on Electrical Systems for Aircraft, Railway, Ship Propulsion and Road Vehicles & International Transportation Electrification Conference (ESARS-ITEC), Venice, Italy
  *I attended this conference as presenting author.*
- 2023 IEEE Vehicle Power and Propulsion (IEEE VPPC 2023), Milan, Italy
  *I attended virtually this conference as presenting author*

## 6. Activity abroad:

## 7. Tutorship