PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Pasquale De Falco

XXX Cycle

Training and Research Activities Report – First Year

Tutor: Guido Carpinelli

1. Information

Pasquale De Falco obtained his Master's Degree in Electrical Engineering (110/110 cum laude) at University of Naples "Federico II". He is now a XXX cycle ITEE PhD student, with fellowship financed by Ministero dell'Istruzione, dell'Università e della Ricerca. His tutor is prof. Guido Carpinelli.

2. Study and Training activities

In the first year of PhD course, Pasquale De Falco attended the following modules, seminars and PhD schools:

Modules

- Modelli, metodi e software per l'ottimizzazione. Prof. Sforza.
- Designing and writing scientific manuscripts for publication in english language scholarly journals. Prof. Parker (Pfeiffer University, USA).
- Fondamenti di analisi funzionale. Prof. Fiorenza (attended only).
- Gestione razionale dell'energia elettrica. Prof. Bracale.

Seminars

- Fault location using sparse estimation methods. Lecturer: prof. Abur (Northeastern University, USA), organizer: prof. Carpinelli.
- Fundamentals of semiconductor power modules reliability. Lecturer: prof. Castellazzi (University of Nottingham, UK), organizer: prof. Irace.
- Advanced power module thermal management and design for lifetime extension. Lecturer: prof. Castellazzi (University of Nottingham, UK), organizer: prof. Irace.
- Power module on-board health monitoring. Lecturer: prof. Castellazzi (University of Nottingham, UK), organizer: prof. Irace.
- Partial possibilistic regression path modeling. Lecturer: prof. Romano (Università della Calabria, Italy), organizer: prof. Rinaldi.
- L'esperienza maturata in ambito Terna riguardo alla programmazione delle indisponibilità degli elementi di rete, con particolare riferimento ai problemi di impatto degli impianti di produzione con la rete elettrica. Lecturer: ing. Principe (Terna S.p.A.), organizer: prof. Carpinelli.
- Regularization of two-fold bifurcations in planar piecewise-smooth systems. Lecturer: prof. Hogan (University of Bristol, UK), organizer: prof. Di Bernardo.
- Semantic technology made in Italy. Lecturer: ing. Masucci (Expert System), organizer: prof. Corazza.
- On the complexity of temporal equilibrium logic. Lecturer: prof. Bozzelli (Universidad Politecnica de Madrid, Spain), organizer: prof. Peron.
- Domanda attiva (webinar). Lecturers: prof. Mancarella (University of Manchester, UK) and prof. Vicino (Università di Siena, Italy), organizer: EnSiEl.
- La Ricerca nel Settore Scientifico Disciplinare della Elettrotecnica negli ultimi decenni. Lecturer: prof. Salerno (Università di Roma Tor Vergata, Italy), organizer: prof. Martone.

PhD Schools

- European PhD School, 16th edition, Gaeta 2015.

In the following table, the CFUs acquired for the above-reported activities during each of the six two-months periods are reported. The CFUs provided by the module “Fondamenti di analisi funzionale” will be acquired during the second year of PhD course.

	Credits year 1							
		1	2	3	4	5	6	
	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary
Modules	20	0	0	0	10	6	0	16
Seminars	5	0	0.2	1.6	0.8	0	1.4	4
Research	35	6	6	6	8	6	8	40
	60	6	6.2	7.6	19	12	9.4	60

3. Research activity

In recent years, the new concept of smart grids (SGs) has been developed, and it is expected that future electrical distribution systems will be characterized by the simultaneous presence of different distributed resources, such as renewable energy sources, storage systems, and loads that actively contribute to the operation of such systems, along with an increasingly complex and performing ICT relevant infrastructure. In some countries electric grids no longer deliver energy in a one-way flow from large power plants to end users, and this tendency is expected to further increase and to spread worldwide; producers and consumers will continuously interact at different voltage levels to determine in advance the requests of electrical loads and to flexibly and efficiently adapt the production and demand for electricity. A flow of information will characterize such systems and act to ensure optimized operation of the network and management of distributed generation resources (including storage units), allowing SGs to operate with a two-way flow of both electricity and information. In this context, new technologies and services are being introduced in power systems to render the electrical networks more reliable, efficient, secure, and environmentally-friendly. Moreover, an intelligent and rational operation of all the elements of the electrical system is required for different horizon times and taking into account two different aspects: the minimization of operative costs and the fulfillment of Power Quality (PQ) levels [1-6].

Then, tools that allow the SG operators to make decisions for a certain interval of the day, such as purchasing power, generating power, switching loads and shedding loads, also furnishing external services to the distribution grid (i.e., reactive power support, etc.) and simultaneously being competitive in liberalized energy markets, have been provided in relevant literature [5-8]. On the other hand, the massive penetration of non-linear elements in power systems, mainly power electronics converters, increased the sensitivity to PQ issues and their related economic consequences [9,10]. Among the disturbances that affect PQ, waveform distortions, unbalances and voltage fluctuations are of growing interest due to the detrimental effects they cause; a good remedy to the presence of such PQ disturbances in SGs is the use of distributed energy resources as active compensators [11,12]. A vast amount of research has been conducted in order to provide appropriate real-time control tools for the compensation of disturbances at different harmonic orders [13-16].

However, all these tools are always subject to the intrinsic uncertainties of some input variables, i.e., the availability of renewable energy sources and the randomness of the energy demand of electrical loads are a concerning issue for the optimal scheduling of power profiles, while voltage and current harmonic disturbances are usually unknown in the real-time control and must be properly estimated in order to be compensated.

Therefore, the research activity performed during the first year of PhD course is in the field of SGs and, in particular, aims to provide advanced short-time forecasting tools and dynamic harmonic state estimators of electrical variables that can be used for the optimal operation of SGs.

With reference to advanced short-time forecasting tools, probabilistic Bayesian methods based on Monte Carlo Markov Chain simulation were proposed for photovoltaic and wind generators power forecasting. The choice of probabilistic methods, instead of classical deterministic methods, was motivated by the need of information about the unavoidable uncertainties of renewable power production; deterministic forecasts do not meet some operational needs, such as risk-related power system operating conditions, where an evaluation of the reliability of the forecast is essential to make decisions. In the proposed Bayesian-based methods, the characterization of available data series was performed through ARIMA models, while the probabilistic characterization of the random variable was performed selecting appropriate probability distribution functions. Evaluations of the goodness and of the reliability of the probabilistic forecasts were made through consolidated indices and also considering the economical value of the forecasts. In fact, since electrical energy has an economic value on liberalized markets that vary depending on the hours of the day, on the day of the week and on the month of the year, also the unitary power forecasting error has different economic impact. Therefore, some deterministic and probabilistic cost-based indices were proposed by taking into account not only the quality of the forecasts, but also their value.

With reference to dynamic harmonic state estimators, first studies were focused on the application of Kalman Filters to provide real-time estimation of harmonic current disturbances in AC/DC hybrid microgrids. An appropriate model was selected in order to represent the non-linear behavior of the electrical system under study. Moreover, a comparison between different methods for the optimal placement of measurement units was performed in order to select the most appropriate measurements needed as input.

The research activity has been performed in collaboration with the following Universities:

- Università di Napoli “Parthenope”
- Politecnico di Torino

In the next year of PhD course, the research activity will be mainly focused on: (i) advanced probabilistic methods for the probabilistic forecasting of photovoltaic, wind and load powers; (ii) the characterization of extreme values of wind speed, from both mechanical and electrical reliability point of view; (iii) new non-linear approaches for the dynamic harmonic state estimation in SGs.

References

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[4] N. Hatziargyriou, H. Asano, R. Iravani, C. Marnay, "Microgrids", IEEE Power and Energy Magazine, Vol.5, No.4, pp.78-94, 2007

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[6] E. Planas, A. Gil-de-Muro, J. Andreu, I. Kortabarria, I. M. de Alegría: "General aspects, hierarchical controls and droop methods in micro-retes: A review", Renewable and Sustainable Energy Reviews, Vol. 17, January 2013, Pages 147-159

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[9] M. McGranaghan, B. Roettger, "Economic evaluation of power quality," IEEE Power Eng. Rev., vol. 22, pp. 8-12, 2000.

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[13] A. Griffo, et al., "An optimal control strategy for power quality enhancement in a competitive environment," International Journal of Electrical Power & Energy Systems, vol. 29, no. 7, pp. 514-525, 2007.

[14] R. de Araujo, et al., "A robust adaptive control strategy of active power filters for power-factor correction, harmonic compensation, and balancing of nonlinear loads," IEEE Transactions on Power Electronics, vol. 27, no. 2, pp. 718-730, 2012.

[15] N. Mariun, et al., "Review of control strategies for power quality conditioners," in Proceedings of IEEE Power and Energy Conference, PECon 2004.

[16] M. Monfared, S. Golestan, "Control strategies for single-phase grid integration of small-scale renewable energy sources: A review," Renewable and Sustainable Energy Reviews, vol. 16, no. 7, pp. 4982-4993, 2012.

4. Products

In the first year of PhD course, Pasquale De Falco was co-author of the following papers:

Journal papers

- A. Bracale, P. De Falco. "An Advanced Bayesian Method for Short-Term Probabilistic Forecasting of the Generation of Wind Power", Special Issue on Forecasting Methods and Measurements of Forecasting Errors for Renewable Energy Sources, Energies, vol. 8, 2015.

Conference papers

- L. Alfieri, A. Bracale, P. De Falco, M. Aprea. "On the comparison among optimal measurement placement methods for a hybrid micro grid harmonic state estimation. Part I: theoretical aspect", 3rd International Symposium on Energy Challenges and Mechanics, Aberdeen, UK, 7-9 July, 2015.
- L. Alfieri, A. Bracale, P. De Falco, M. Aprea. "On the comparison among optimal measurement placement methods for a hybrid micro grid harmonic state estimation. Part II:

numerical applications", 3rd International Symposium on Energy Challenges and Mechanics, Aberdeen, UK, 7-9 July, 2015.

Papers in preparation or waiting for approval

- A. Bracale, G. Carpinelli, P. De Falco, R. Rizzo, A. Russo. "New Advanced Method and Cost-based Indices Applied to Probabilistic Forecasting of Photovoltaic Generation".
- A. Bracale, G. Carpinelli, P. De Falco. "A Bayesian-based approach for the short-term forecasting of electrical loads in power systems".

5. Conferences and Seminars

Pasquale De Falco attended the following conferences and seminars:

- European PhD School, 16th edition, Gaeta, 25-29 May 2015.

Pasquale De Falco was co-author of works presented at the following conferences and seminars:

- 3rd International Symposium on Energy Challenges and Mechanics, Aberdeen, UK, 7-9 July, 2015.

6. Activity abroad

No activity abroad has been carried out during the first year of PhD course.

7. Tutorship

Pasquale De Falco was involved in tutorship activities for a duration of 10 hours for the preparation of a Ms. Sc. thesis.