PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Domenico Perna

XXIX Cycle

Training and Research Activities Report – Second Year

I Information

I.1Name Surname

Domenico Perna , Electrical Engineer – University of Naples " Federico II "

I.2PhD Cycle and University

XXIX Cycle – ITEE University of Naples " Federico II "

I.3Fellowship type

Scholarship supported by Hitachi Rail Italy (ex Ansaldo Breda S.p.A.).

I.4Tutors

Andrea Del Pizzo from D.I.E.T.I. - University of Naples " Federico II"

Luigi Fratelli from Hitachi Rail Italy – a Hitachi Group

Roberta Schiavo from Hitachi Rail Italy – a Hitachi Group

II Study and Training activities

II.1 Courses

- From Ad-hoc Modules : Followed 21 hours of English course FIRST CAMBRIDGE

II.2 Seminar

- "Mathematical Modelling of Atomic force Microscopes" - Dr. Martin Homer
- "Regularization of two-fold bifurcations in planar piecewise-smooth systems" - Prof. John Hogan
- "Semantic Technology Made in Italy" - Dr. Vincenzo Masucci
- "On the complexity of Temporal Equilibrium Logic" - Dr. Laura Bozzelli
- "Beyond the data: how to achieve actionable insights with machine learning" - Dr. Matteo Santoro
- "On motion planning, motion representation and its orbital stabilization for mechanical system" - Prof. Anton Shiriaev
- "Model based and pattern based GUI testing - Part 1" - Prof. Ana Paiva
- "Model based and pattern based GUI testing - Part 2" - Prof. Ana Paiva
- "The evolution of Railway signaling systems" - Ing. Giovanni Bergellini , Ing. Giovanni Trezza

II.3 External Course

- 16th Edition of the European Ph.D. School : Power Electronics, Electrical Machines, Energy Control & Power Systems .

- Didactics: 32 hours for sixteen laboratory sessions – Electrical Machines and Power Converters – Lecturer : Ivan Spina

III Research Activity

III .1 Title

"Improvement of efficiency and reliability in Light Railway Vehicles through estimation algorithms based on multitechnology integration "

III .2 Study

With reference to Light Railway Transportation Vehicles, the attention has been focused on how the introduction of new technologies may improve efficiency and reliability. First of all, taking into account on board integration of energy storage systems and then comparing from energetic point of view vehicles equipped either with Induction Motor (I.M.) or Permanent Magnet Synchronous Motor Drive (P.M.S.M.).

Furthermore, the estimations and optimizations of control parameters in I.M. traction drives, such as, induction motor parameter or rotor speed signal, have been investigated to improve control performance and reliability.

At following, the list of references :

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[2] Gunselmann, W.: "Technologies for increased energy efficiency in railway systems," Power Electronics and Applications, 2005 European Conference on, pp.10÷15, 2005.

[3] Barrero, R.; Tackoen, X.; Van Mierlo J.: "Improving Energy Efficiency in Public Transport: Stationary supercapacitor based energy storage systems for a metro-network", Proc. of Vehicle Power and Propulsion Conf. VPPC'08, Harbin, China, pp. 1÷8, Sept. 2008.

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III .3 Research description

Activity 1:

Modern light railways vehicles, equipped with supercapacitors energy storage system, are able to achieve several goals, such as: energy saving, power supply optimization and catenary free operation. In detail, streetcars very often are requested to operate for some distance in catenary-free mode for two main requirements: 1) safety, for moving vehicles to a station in case of catenary line fault ; 2) conservation of old town , avoiding the presence of catenary in the historical places.

A methodology was proposed for sizing a supercapacitor energy storage system as a function of assigned length and slope of track for a tram operating in catenary-free mode. In order to properly size the supercapacitors bank avoiding its expensive oversizing, a set of experimental measurements were carried out in line-disconnected mode on an experimental tram. The results of these tests were widely discussed, especially with reference to the losses in the different sections of the vehicle and to the power required by the traction drive and by on-board auxiliary loads.

The values of capacitance, weight and dimensions of supercapacitors seem compatible with the considered vehicle, also for more than one thousand meters with lowered pantograph.

PUBLISHED PAPER :

" A method for "design to range" energy storage systems in catenary free operation of light railway vehicles" - 5th *I*nternational *C*onference on *C*lean *E*lectrical *P*ower Renewable Energy Resources Impact 16-18 June 2015 – Taormina, Italy.

Activity 2:

Energy consumption is a big deal of the last years in word wide. It is strictly connected to the increase of released CO_2 so has become crucial and received even more attention . Nonetheless, traffic congestion is a real issue in major cities and this has led the increase of time costs in urban travel. Light Railway systems, are more efficient and less emissive compared to other ways of urban transportation. Combining the advantages of time costs reduction and environment safeguard, they are a solution that fits the above issues

In the context of light railway traction systems, a typical route for urban travel have speed profile more similar to triangular then trapezoidal. Therefore, two vehicles equipped with IM and PMSM have been compared from the energetic point of view by focusing our attention to a deceleration part of speed time diagram consisting of inertial phase and breaking phase because either allow energy saving.

More in detail, is possible to identify two kinds of inertial slow down to achieve coasting phase, that is:

- Case 1: reference torque produced by control strategy is set to zero while the devices of inverter are controlled;
- Case 2 : reference torque produced by control strategy is set to zero and the devices of inverter are open.

To reach this goal, have been implemented simulation algorithms in SIMULINK and the results achieved at present show that:

- As expected, if switches of inverter are uncontrolled is possible to eliminate energy consumption due to switching and motor losses where in PMSM are less than IM unit;
- Furthermore, in case 2, PMSM unit is regenerative so this could be more interesting for vehicles using on board storage systems for energy saving goals;
- The optimization of coasting phase, according to the time constraints of route profile may increase energy efficiency of Railway Transportation System.

ACCEPTED PAPER - " Energetical comparative analysis of I.M. and P.M. brushless drives in Light Railway Transportation Systems " - *23th International Symposium on Power Electronics, Electrical Drives, Automation and Motion 22-24 June 2016*

Activity 3:

Railway transportation field is a multidisciplinary area of interest with many different and complex perspective. The need to introduce new technologies that can improve efficiency, reliability and security among various subsystems of the railway vehicles, is mandatory to fulfill the challenges from market also in terms of reducing costs.

Traction architecture, that is the interface between electrical and mechanical energy, represent the core of system and induction machine (IM) drives are widely used for the advantages of simple construction, reliability, robustness and low cost.

Vector control is usually adopted in railway systems thanks to the better dynamic performance and more stability compared to the others controls, but also in this case speed sensors are utilized and this may involve problems in terms of reliability and so on.

An application of speed sensorless vector control for a real vehicle has been presented, by considering how an indirect knowledge of speed signal, delivered on modern high speed train network could be beneficial in some typical traction applications**.**

At this purpose, have been developed simulation algorithms in SIMULINK and the results achieved at present show the practicability of solution and the benefits would result of his adoption.

IV Credits Summary

	Credits year 1								Credits year 2								Credits year 3									
		1	2	3	4	5	6			1	2	3	4	5	6			1	2	3	4	5	6			
	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Total	Check
Modules	21	0	3	9	6	6	0	**24**	15	0	7	0	0	0	0	**7**	0							**0**	**31**	30-70
Seminars	5	0	0	0	0	0	0,4	**0,4**	5	0,2	0,2	0	0,6	2,8	0	**3,8**	5,8							**0**	**4,2**	10-30
Research	34	10	7	1	4	4	9,6	**36**	40	9,8	2,8	10	9,4	7,2	10	**49**	54,2							**0**	**85**	80-140
	60	10	10	10	10	10	10	**60**	60	10	10	10	10	10	10	**60**	60	0	0	0	0	0	0	**0**	**120**	180

Year	Lecture/Activity	Type	Credits	Certification
1	Europrogettazione	Ad hoc module	3	x
1	Misure per l'Ingegneria dei Materiali	MS Module	9	x
1	Elettronica Industriale di Potenza	MS Module	6	x
1	15th Edition of European PhD School	External Course	3ECTS	x
1	State of the art in Power Converters for High Voltage DC Transmission Systems	Seminar	0,4	x
2	Corso di Inglese FIRST CAMBRIDGE	Ad hoc module	4	x
2	16th Edition of European PhD School PEEMEC	External Course	3ECTS	x
2	"Mathematical Modelling of Atomic force Microscopes" - Dr. Martin Homer	Seminar	0,2	x
2	"Regularization of two-fold bifurcations in planar piecewise-smooth systems" - Prof. John Hogan	Seminar	0,2	x
2	Semantic Technology Made in Italy - Dr. Vincenzo Masucci	Seminar	0,4	x
2	On the complexity of Temporal Equilibrium Logic - Dr. Laura Bozzelli	Seminar	0,2	x
2	Beyond the data: how to achieve actionable insights with machine learning - Dr. Matteo Santoro	Seminar	0,4	x
2	On motion planning, motion representation and its orbital stabilization for mechanical system - Prof. Anton Shiriaev	Seminar	0,2	x

Year	Lecture/Activity	Type	Credits	Certification
2	Model based and pattern based GUI testing - Parte 1 - Prof. Ana Paiva	Seminar	0,8	x
2	Model based and pattern based GUI testing - Parte 2 - Prof. Ana Paiva	Seminar	0,8	x
2	The evolution of Railway signaling systems - Ing. Giovanni Bergellini , Ing. Giovanni Trezza	Seminar	0,6	x