TABLE 8 – PhD Programme INDUSTRIAL AND INFORMATION ENGINEERING

THE PhD PROGRAMME	
Administrative location	University of Udine, Polytechnic Department of Engineering and Architecture (DPIA) - via delle Scienze 206, 33100 Udine, ITALY (tel. +39 0432 558253)
Associated location	Institut National Polytechnique de Grenoble (France)
Location for training, teaching and research activity	Teaching and other training activities will take place primarily at the administrative programme location or in other locations of the University of Udine. The research program will be mainly developed, depending on the scholarship (see art. 11 of the Call) and/or on the supervisor assigned, at one of these locations: administrative location, associated location, financial supporter's location (if the financial supporter is an external institution).
Coordinator	Prof. David Esseni (david.essendi@uniud.it)
Programme duration	3 years
Curricula	1. New management paradigms and fabrication technologies for competitive enterprises with low environmental impact; 2. Information and communication technology for the inclusive society; 3. Design of innovative thermo-electro-mechanical systems and development of advanced methods for the assessment of structural damage and reliability for energy saving; 4. Mechanical technologies and electronic devices for domotics, medical diagnostic and safety.
Programme website	https://www.uniud.it/it/ateneo-uniud/ateneo-uniud-organizzazione/dipartimenti/dpia http://phd.diegm.uniud.it/iie-phd/

ADMISSION REQUIREMENTS	
Required degree	Italian Laurea (before DM 509/99) or Italian Laurea specialistica/magistrale (ex DM 509/1999 and DM 270/04). Foreign degrees and titles: refer to art. 3 and 4 of the Call.
Knowledge of the following foreign language	English

DOCUMENTS AND QUALIFICATIONS TO BE ATTACHED TO THE APPLICATION FOR ADMISSION	
Compulsory documents (art. 5 of the Call)	1. Certification or self-certification (refer to art. 5 paragraph 5 of the Call) of the academic title needed for admission to the PhD programme and list of the exams (with grades) passed during the Italian first level (bachelor) and the Laurea Specialistica/Magistrale programmess or during the Italian programmes before D.M. 509/99 or during the foreign academic programmes; 2. Curriculum vitae et studiorum, dated and signed; 3. Copy of a valid identity document (citizens of countries not belonging to the European Union a copy of a valid passport, comprehensive of the pages containing the holder's photo, personal details, passport number, date and place of issue, date of expiry); 4. A research project, dated and signed, developed in accordance with the description of the research topic of interest, which highlights the contribution that the applicant can offer to the development of the same topic (approximate limit 10,000 characters, spaces included).
Optional documents (art. 5 of the Call)	1. Master thesis ("Tesi di Laurea") associated to the degree/title providing access to the PhD programme. Applicants who are not graduated on the expiration date of this Call can submit an extended abstract in place of the complete thesis, in Italian or English language, signed by themselves and by their thesis Supervisor (approximate limit: 25.000 characters, including spaces); 2. Motivational letter by which the applicant explains the reasons for admission to the PhD programme, dated and signed (approximate limit: 2.500 characters, including spaces); 3. Publications (max 2); 4. Letters of reference (max 2), from university professors, scientific researchers or other experts in the field (art. 6 of the Call).

SELECTION COMMITTEE	
Appointed members	Antonio Affanni – Assistant Professor – University of Udine Roberto Petrella – Associate Professor – University of Udine Lauro Snidaro – Associate Professor – University of Udine Ruben Specogna – Associate Professor – University of Udine
Substitute members	Roberto Rinaldo – Full Professor – University of Udine David Esseni – Full Professor – University of Udine

ADMISSION

GENERAL COMPETITION (art. 8 of the Call for Applications)

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Positions available: 4						
Detailed description	***N.***	***Funding***	***Annual gross amount***	***Period abroad***	***Period in enterprise (indentified by the Univ. of Udine)***	***Research Topic***
Positions WITH SCHOLARSHIP: 4	**1**	National Operational Program (PON) Research and Innovation 2014-2020 "Education and research for recovery – REACT-EU (M.D. 1061/2021) and University of Udine	€ 15.343,28	max 6 months optional	min 6 - max 12 months mandatory	1.1 Green Topic "Optimization of mechanical processing for sustainability" (PON RI 2014/2020 Axis IV Action IV.5)
	1	National Operational Program (PON) Research and Innovation 2014-2020 "Education and research for recovery – REACT-EU (M.D. 1061/2021) and University of Udine	€ 15.343,28	-	min 6 - max 12 months mandatory	1.2 Green Topic "Automatic measurement of the acceptability of driving simulators by drivers through the realization of wearable biosensors and implementation of machine learning algorithms." (PON RI 2014/2020 Axis IV Action IV.5)
	1	National Operational Program (PON) Research and Innovation 2014-2020 "Education and research for recovery – REACT-EU (M.D. 1061/2021) and University of Udine	€ 15.343,28	-	min 6 - max 12 months mandatory	1.3 Green Topic "Digital twins models and innovative electromagnetic sensors for the zero waste steel production" (PON RI 2014/2020 Axis IV Action IV.5)
	1	National Operational Program (PON) Research and Innovation 2014-2020 "Education and research for recovery – REACT-EU (M.D. 1061/2021) and University of Udine	€ 15.343,28	max 6 months optional	min 6 - max 12 months mandatory	1.4 Green Topic "High-power electrical energy conversion systems for reduced-impact industrial production" (PON RI 2014/2020 Axis IV Action IV.5)

Competition procedure and test schedule		
Evaluation of qualifications and oral examination. For the evaluation of applicants' attitude for scientific research and their knowledge to develop the topic of interest, the Selection Committee can attribute up to 100 points to each applicant: max 30 points to the qualifications and max 70 points to the oral examination. The applicant is admitted to the interview if his/her qualifications receive at least 16 points. The oral examination is passed with at least 49 points. The applicant is eligible to the PhD programme if he/she passes the oral examination. Only for eligible applicants, the points attained in in the oral examination will be added to the points of the qualifications. Scholarships are assigned according to the provisions of art. 10 of the Call. **DATE FOR THE PUBLICATION OF THE ADMITTED APPLICANTS TO THE INTERVIEW: within November 2, 2021** **DATE FOR THE PUBLICATION OF THE FINAL RANKING LIST: within November 11, 2021**		
Foreign language that can be used for examination	Italian or English	
Evaluation Criteria of qualifications *During the preliminary meeting the Selection Committee may establish sub-criteria for the evaluation*	Curriculum vitae et studiorum + research project	*15*
	Scientific publications	*5*
	Thesis/Abstract	*2*
	Letters of reference	*4*
	Motivational letter for admission to the PhD programme	*4*
Oral examination	The oral examination consists of an individual interview of about 15 minutes aiming to assess the applicant flair to undertake a research doctorate and to carry out the research tasks in the areas of interest for the doctorate.	

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	The interview will be assessed considering the following criteria: a) technical and scientific competence in the topics of the doctorate; b) knowledge of the state of the art for the doctorate curricula, c) mastery of English language.	
Calendar of the oral examination	**Date**	**November 3, 2021**
	Time	09:30 am
	How to conduct the examination	The oral examination will be held online (MS Teams).
	Based on the number of applicants, the oral examination may take place in more than one day. Applicants must exhibit a valid ID.	

Research Topics Description
Research Topic 1.1: Optimization of mechanical processing for sustainability European manufacturing is in a moment of very important change with objectives of reducing the environmental impact of industrial and Agile production. These productions are focused on energy saving and waste reduction, also going beyond the Zero Defects paradigm and moving towards the Zero Waste paradigm, also through virtuous circular economy models that transform waste into a resource for new production cycles. The typical scenario is that of a mechanical surface with cracks or other micro-scale surface defects that need to be removed by milling or other mechanical processing (Figures 1 and 2). The research object of the proposed project is aimed at the study of a system that by acquiring the images of the defect before and after processing, in addition to data from the machine tool is able to modify the parameters of the machine itself with the aim of eliminate the defect at the lowest possible energy cost and also minimizing waste. Consumption optimization is a fundamental aspect to embrace the European Green Deal, with a view to reducing the impact on the environment of all production activities in a short time. Objectives and expected results, proposed research activity, methodologies and contents: Goals: The research object of the proposed project is aimed at the study of a system based on the analysis of images coming from video sensors for the evaluation of defects present in the production of mechanical parts. The goal is to be able to estimate the thickness of the defects in order to minimize the intervention (e.g. milling, grinding) by machine tools for the removal of the defect, with the consequent energy saving and reduction of material waste. Proposed research activity: The proposed research activity should include the following phases: - Analysis of the state of the art on automatic defect detection in the industrial sector - Study in detail of the processes for determining thickness using video sensors (e.g., lighting, sensor positioning, type of sensors) - Analysis of image datasets - Development of Artificial Intelligence models for identifying defects and estimating their thickness - Verification of the models developed on test images - Verification of the models on a robotic system in a controlled pilot environment - Possible verification of the models in an industrial production environment Methods and contents: Quality control of products in industry is often still done manually by experienced operators. This is often found to be inefficient, time consuming and error prone. Therefore, automated approaches have been introduced to assist the operator in this task. Generally, automated inspection systems consist of the following modules: image acquisition, image processing, feature extraction and decision making. The automated approach can be based on classic computer vision methods, but these are often based on fixed rules and therefore not easily adaptable to new data or scenarios. Industrial interest in machine learning applications has exploded since 2005 and the growing trend is evident. Furthermore, neural networks (especially deep architectures) have been important from 2012 onwards, thanks to their versatility and excellent quality of results. The research that the PhD student should develop should combine consolidated Signal / Image Processing techniques for filtering input data from video sensors, the most modern Machine Learning and Deep Learning approaches for the identification and segmentation of defects on the surface of products. The innovative use of Data Fusion techniques is also envisaged to include the parameters of the machine tool in the process of detecting defects and calculating their thickness in order to improve the accuracy of the estimate. In particular, it is expected that the learning of the models could be done through Reinforcement Learning, that has a natural use in the field of robotic systems that interact with the real world. Research activity to be carried out in the company and its degree of involvement in the definition of the training path: In the field of mechanics a topic in which the company intends to invest is the modelling of surface machining processes for the elimination of defects. To create systems that rework mechanical parts with the aim of reducing the energy consumption necessary to eliminate the defect. The research activity to be carried out in the company concerns the piloting activity on a real robotic system set up for the milling of surfaces of non-ferrous metal components (aluminum, brass, etc.), mechanical artifacts of arbitrary sizes and shapes. Joint research with the company's internal research team, validation of the developed models. **Research Topic 1.2: Automatic measurement of the acceptability of driving simulators by drivers through the realization of wearable biosensors and implementation of machine learning algorithms.** During the last decade, scientific research aimed at recognition of psychophysical wellbeing growed exponentially; thanks to the development of new wearable sensors able to communicate with smartphones or laptops, it is possible to acquire a wide variety of biophysical signals which can provide an indication of the psychophysical wellbeing of individuals. In this field, the majority of scientific literature is directed to the stress measurement during driving; during the last 12 months, about 31000 scientific articles aimed at measuring the stress on drivers have been published.

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In the recent past, the DPIA signed several research contracts with a company (leader in the driving simulators production) to design and realize a wearable sensor able to acquire 3 ECG channels and 2 EDA channels, with the aim of realizing a commercial device able to collect biosignals from the driver and send them to the local network in order to correlate them with vehicle telemetry.
The proposed research activity aims at automatically recognizing the mental wellbeing of the driver on board the driving simulator; to do this, new wearable sensors will be developed ad hoc; a measurement campaign will take place on a professional driving simulator testing several individuals, in order to acquire an adequate dataset of biosignals and, finally, machine learning algorithms will be trained in order to automatically measure the stress of the driver.

Goals:
The goals of future research are oriented to automatically recognize the driver's wellbeing integrating the existing commercial device with new wearable sensors designed ad hoc (e.g. electroencefalograph), and implementing machine learning algorithms able to process all the acquired biosignals with the aim of providing an estimation on acceptability for the driver of the simulated vehicle and/or the simulator itself. It is well known in fact that driving simulators may give rise to the "motion sickness" phenomenon which is in general undesirable.
As a direct consequence, the system can have the capability of measuring the driver wellbeing when different car set-ups (in terms of mass distribution, suspensions, ...) are under test, or when autonomous driving algorithms are under test, or when Advanced Driver Assistance Systems (ADAS) algorithms are under test.
Estimating the acceptability for the driver of a vehicle on the simulator (before that the physical prototype is realized) is of paramount importance in terms of energy saving and emissions reduction.
The proposed research activity spans over several fields of Information Engineering: from the wearable sensors design (hardware and firmware), to the advanced biosignal processing, to extraction of objective and significant features able to detect the driver stress, to the implementation of machine learning algorithms for the automatic measurement of wellbeing on the driving simulator.
During the research activity, a measurement campaign will be organized with an adequate number of drivers where the acquired biosignals (with the developed sensors) will be used to extract an optimized model for the measurement of the stress in individuals while driving on a professional driving simulator.
The PhD student during the internship period in the company will cooperate with the R&D team in order to integrate the new developed wearable sensors with the ECG+EDA sensor commercialized by the company. Moreover, the PhD student will organize the measurement campaign in order to collect biophysical signals from several drivers with the aim of training machine learning algorithms to detect the stress automatically.

Research Topic 1.3: Digital twins models and innovative electromagnetic sensors for the zero waste steel production
Digital twins are virtual (or digital) models of devices, systems or processes belonging to the physical world. These models can be used to study production systems before investments in physical prototypes are made. This avoids the production and transport of unnecessary physical prototypes, reducing the use of raw materials and the carbon footprint. In addition, production systems can be optimized using virtual prototyping in order to reduce the environmental impact, particularly reducing energy consumption and the presence of processing waste. This can also be done through the research and development of innovative sensors and control systems, as advocated by the "smart factory" specialization area, by "key enabling technologies" (KETs) and by issues relating to industry 4.0.
Objectives
The objectives, results and research and development of methodologies and prototypes can be summarized in the following list:
1. Research and implementation of new efficient systems for virtual prototyping and creation of digital twins models of electromagnetic phenomena, in particular concerning induced currents and electromagnetic propagation. These models are an enabling technology for the project because, in order to be useful for the application, a simulation speed is required that cannot be obtained with the software available on the market. In fact, with commercial software it would not be possible to carry out the project as the solution of a single problem also requires a couple of days of simulation. Therefore, specific theoretical innovations are needed that drastically reduce the simulation time (by a factor of several thousand). Only in this case can digital twins models be used effectively for the optimization of production processes in order to obtain zero waste production. In fact, in this case it is possible in real time to adjust the casting or extrusion parameters to lead back to an optimal production. The result of the research will therefore be highly innovative simulation methodologies with heavy implications both theoretical and from the point of view of the applications where they can be used.
2. The control of steel production takes place through specific sensors based on electromagnetic induction. It is planned to develop new inductive sensors capable of providing useful information for adjusting the casting parameters. These sensors will be developed and optimized through virtual prototyping. Only the optimized version will actually be produced and its effectiveness will be evaluated by inserting the sensor into a real steel production line.
3. Another family of electromagnetic sensors that are planned to be developed are those that allow you to perform a two-dimensional or three-dimensional tomography of the steel in the billet or during extrusion. These techniques provide as a fundamental requirement even during their operation to have digital twins models available (and not only during their design phase) and are crucial to ensuring the quality of the steel produced. These sensors also require a theoretical study of the various techniques for the solution of the so-called inverse problem, which allows us to reconstruct an image of the steel section. Electromagnetic techniques are far cheaper, safer and more environmentally friendly than those based on X-ray tomography. We will focus in particular on two techniques: magnetic impedance tomography (MIT) and electrical impedance tomography (EIT). The solution of the inverse problem, which makes it possible to obtain the image of the steel section, can take place through iterative techniques, non-iterative techniques based on the Shannon principle of monotonicity or by methods related to artificial intelligence. The information on the section is expected to be of great importance for optimizing the plant from the point of view of energy and production quality.
4. Research and development with the virtual prototyping of innovative electromagnetic sensors for the on-line verification of the quality of continuous casting products and the absence of defects (short and long) is envisaged, always with a view to changing the casting parameters to avoid waste. Apart from the defects (i.e. voids or inclusions within the cast or extruded product), we would also like to determine the liquid section and the semi-solid fraction within the product being solidified.
5. Optimization from an energy and performance point of view for the reduction of waste is of fundamental importance. Since sensors and devices will be characterized by many variables, it will also be necessary to achieve specific innovations in the theory concerning the exploration of the design space and in the development of virtual assistants for design based on artificial intelligence (in particular machine learning).

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Research Topic 1.4: High-power electrical energy conversion systems for reduced-impact industrial production

The research topic is within the field of electrical drives and power electronic converters. Considering industrial applications, and in particular those of medium-high power, it is believed that the improvements in terms of energy efficiency, cost and/or functionality can have a significant effect on the environmental impact of the production of goods and services. The study will therefore analyze and propose innovative solutions in the field of power electronic converters and their applications (e.g. in the control of electric motors, integration of renewable sources and power exchange with storage systems) and strategies aimed at globally improving the efficiency of energy utilization. Among the possible contributions, it is expected that the main ones should concern alternative converter topologies, control and management methods, introduction of innovative semiconductor devices and system reliability. Many of the considerations and results obtained for a specific application (e.g. industrial) can be extended by analogy to different applications (e.g. related to electric/hybrid mobility or traction in general).

Objectives and expected results, research activity, methodologies and contents:

The proposed research activity concerns the electrical power conversion for applications in the industrial field, in particular those of medium-high power, from which a greater impact is expected on energy consumption and the environment.

One of the main objectives is to propose innovations and strategies able to globally improve the efficiency of energy conversion. Moreover, the possibility to introduce new functionalities or to improve the controllability of these systems could then be an enabling element for the optimization of some production processes, such as those in the steel industry.

In addition, a contribution to the development of power systems that do not currently exist or are not very widespread is expected, with the aim of improving the exploitation of energy from renewable sources and/or the recovery of energy otherwise dispersed (especially at local grid level), reducing the transport of power over long distances through the power grid (where possible). One of the topics of greatest interest and wide application is that of DC converters for renewable source integration and storage systems. These needs also emerge both for electric/hybrid vehicles in order to be used in support of the grid ("Vehicle to Grid", V2G), as well as for systems based on renewable energy at the local level and on the grid in general. Currently, for high power (in the order of MW), relatively few viable solutions are available in the literature.

Other aspects that can be considered are innovative inverter topologies (e.g. multi-level) and their control, the use of high performance "wide bandgap" semiconductor devices, and the evaluation of reliability and robustness of the system. Further, a recently introduced interesting aspect is the physical integration of measurement and protection sensors (in particular for the current) inside power modules, a topic that could see the collaboration with foreign research centers that are engaged in this topic (e.g. Silicon Austria Labs in Austria, with which Prof. Roberto PETRELLA already collaborates).

From the methodological point of view, the evaluation should take into account (in a preliminary way) the potential of significant environmental impact. Subsequently, the typical tools of industrial research will be applied, which include a thorough study of the problem and any existing solutions (including through the scientific and technical literature available), the construction of analytical models and the development of innovative solutions at the conceptual level, the simulation of dynamical models representing the system with adequate level of detail, the possible design of a prototype.

Activities to be developed in the company and its level of involvement in the definition of the educational training:

The activities that are expected to be carried out at the selected company can include the collection of data and information on the field of application considered (steel industry), advanced-stage development/design, and experimental validation.

The company has identified some issues of specific interest in the field of electrical and electro-mechanical power conversion, e.g. the use of innovative topologies of high-power converters for industrial applications, use of "wide bandgap" semiconductors, the evaluation of reliability and strategies for the improvement of the trade-off between reliability, resilience and cost. Thus, the company will be able to provide guidance, expressing an experienced point of view on the subject.

During the period carried out at the company, the student is expected to carry out some practical activities, including experimental ones, also using equipment, test systems and measurement facilities, provided by the company.

The company will also be involved in periodic discussions on the progress of the research. Also, a close interaction with the company staff is expected in the crucial moments of the planned activities.