JOB DESCRIPTION

(START DATE : 01/09/23)
(END DATE : 01/09/26)

TOPIC : DC/AC CONVERTERS FOR MEDIUM VOLTAGE PHOTOVOLTAICS

CEA (SOLAR DEPT) – LAPLACE (TOULOUSE)

Le bourget du lac (73370), 22/02/2023. France

Job title

PhD offer in medium voltage power electronics for photovoltaics.

Location

French Alternative Energies and Atomic Energy Commission, Le bourget du lac (73370), Savoie, France.

Description of the institute

CEA is the French Alternative Energies and Atomic Energy Commission, a public body established in October 1945. CEA is the largest technology research and development provider in France, whose role is to transfer this know-how to the industry. CEA has staff of about 16000 people, a budget of 4.3 billion Euros per year, and has filed more than 650 priority patents.
The CEA operates ten research centres in France, each specializing in specific fields.

CEA is operating today more than 350 people at INES, the French institute of solar energy, which has started operations in 2005. After a strong phase of growth, today ten CEA-labs at INES cover the complete value chain of photovoltaics: material, cells, modules, solar systems, and storage systems. Furthermore, three labs deal with energy in buildings. As a technological research centre, CEA focuses on R&D activities from TRL 4 to TRL 7, with the objective of transferring innovations to French and European industrial partners. Over 200 industrial partners, SME's, medium, French and International groups are permanently in contract with CEA to develop innovations.

With the aim to maximize the penetration of solar system in the electricity network, research efforts are made on smartgrids, energy management, demand response and grid coupled storage systems. These efforts are demonstrated on the INES campus, which has benefited from large investments, for example a megawatt scale multi microgrid platform with a PV system. Another demonstration example is the solar mobility station, where our energy management system assures the solar charging of electric vehicles and the minimization of the resulting grid impact.
The power electronics group of the lab for photovoltaic systems participates in this project. It deals with the development of advanced power electronics for PV systems and battery systems based on latest semiconductors available (SiC, GaN) in a MV/MW range. The lab has been at the origin of technology transfer to industrial partners as well as the creation of start-ups.

Context

The market for photovoltaic (PV) systems is moving towards increasingly powerful PV power plants. There are already about ten PV power plants built whose power exceeds 1 GW. The continuous increase in power of power plants naturally leads to reflections around the optimal voltage level for the operation of PV power plants up to the point of injection of the electrical power (LV/MV transformer). The construction of PV strings is guided by obtaining a maximum installed power per string (wherein the serialization of PV modules is limited by the low voltage level). This leads to a technical and economic optimum for the construction of PV power plants where 1500 V_{DC} has therefore become standardised. The low voltage involved (1500 V_{DC} PV strings and injection of electrical energy under 550 V-3~AC) in PV power plants limits the maximum power of nowadays DC/AC converters. The CEA's solar technology department (DTS) has research infrastructures including 3 kV_{DC} PV strings based on specifically designed and instrumented PV modules since 2016. Commercial glass-glass PV modules are also studied at the DTS for these applications. . It is in this technological context that the DTS continues researches on the feasibility of increasing the voltage of PV power plants beyond 1500V_{DC} and with an injection voltage at least equal to 3.3 kV-3~AC. Future technological innovations should allow an increase in the power of DC/AC converters, continuity of production in the event of damage, a reduction in the quantity of metals and semiconductors installed in a PV plant.

Work description

The objective of this thesis work will be to evaluate the performance of medium voltage DC/AC converters (including an MPPT input stage) whose power exceeds 10MW using Si and/or SiC power semiconductor switches produced massively.

In parallel with this central study on DC/AC converters, additional investigations will focus on:
-Dielectric strength of PV modules / possibility of implementing longer PV module strings
-Sizing and configuration of MV/20kV transformers
-Converter cooling

The thesis will consist of several steps:
-Bibliographic studies
-Simulations of innovative medium voltage conversion structures
-Experiments: a functional model including protection devices will be sized and produced for operation at real voltage, at full power or at split power
-Comparative LCA studies (LV PV plant Vs MV PV plant) can be outsourced from data produced in this doctoral thesis

Education / Skills / Experience

Completed university degree (Master/Diploma/PhD) in electrical engineering, power electronics, physics or a comparable subject. Experience analog electronics; knowledge of the physics of semiconductor components and their characterization is suitable.

Skills required : static converters, Electrical engineering, Power electronics, Regulation of electrical systems, digital control to FPGA, Working knowledge of experimental converter implementations, Dielectric materials (optional).

Contacts (please send a detailed curriculum vitae and a cover letter to apply)

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