Feasibility study of a Medium Voltage DC/DC Converter adopting WBG devices

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Research context and motivation
- Research activity is based on the TransPod Project. The main Project topic is about the design of an innovative Ultra-high speed vacuum tube train. The TransPod vehicle (Pod) is built like an airline jet fuselage, containing rows of seats inside.
- One of the partner of the project is IKOS. IKOS company leader of Railway engineering, with more than 650 engineering consultants working on projects around the world. The aim of the research is the design an high power density DC/DC Converter.
- The DC/DC converter will be designed in a collaboration between IKOS and the energy department of Politecnico di Torino. The goal is to use Wide band gap (WBG) devices in the design.

Adopted methodologies
- **AUXILIARY CIRCUIT FOR A QUASI-ZERO VOLTAGE SWITCHING**
  - To reduce the switching losses a LC circuit has been designed. This allow to reach a quasi zero voltage during the turn-on of the Mosfet.

Addressed research questions/problems
- The state of the art in High power converter is based on devices as IGBT or thyristors (IGCT,GTO). These components are able to switch at some hundred of Hz. Converters structures are based on the multilevel concept. New medium voltage SiC mosfet prototype made by cree and new mid power GaN (vertical fet) can change the concept of the Multilevel. New technologies are pushing in the direction to increase the break-down voltage of the single switch. Currently, SiC and GaN components are able to carry few current than Si devices. On the other side, is easier to connect in parallel in order to reach the same power of the Si technology based converter in the medium voltage range.
- The driver circuit of the high voltage SiC transistors.
- Comparison between hard and soft switching technique using High Voltage SiC Mosfet.
- Evaluation of the parasitic element in a high frequency transformer in order to define the equivalent electric circuit. This is useful to define the resonant frequency of the device, thus define the switching frequency range of the converter.

Novel contributions
- The first innovation step is given by the use a high voltage SiC MOSFET in a two level buck converter with a Dc-link voltage rate of some kV. The integration and the packaging of the High voltage WBG chips is innovative too.
- From the control point of view, the innovation is the direct commutation approach. The idea is to control of the peak current that pass through the power switch. This is relatively easy in a single leg based converter. For a multiphase converter the peak current control and, at the same time, the shifting of the current in order to reduce the output current ripple is the new aim.

Future work
- Test the peak current phase shift (PCPS) control in a low voltage hardware system.
- Define the equivalent electric circuit of the high frequency transformer using the measurement on a real component.
- Test and evaluate the simulation result on the soft switching circuitry.
- Design and test the DC/DC Converter using HV SiC components.

List of attended classes
- 02LWHRV – Communication (15/02/18, 5h, SS)
- 01PJMVRV – Elia informatica (14/03/18, 20h, SS)
- 08IXTRVR – Project management (15/02/18, 5h, SS)
- 01RISRV – Public speaking (15/02/18, 5h, SS)
- 02RHRV – The new Internet Society (13/03/18, 5h, SS)
- 01SRGRV – Magnetic materials for electrical energy (23/11/17, 20h, HS)
- 01RGRV – Optimization methods for engineering problems (13/06/18, 20h, HS)
- 01SRFVRV – Programmazione scientifica avanzata in matlab (13/04/18, 20h, HS)
- Summer Course on Power Electronics and Applications (06/07/18, 30h, HS, Rome)
- European PhD School Power Electronics, Electrical Machines, Energy Control and Power Systems (21/05/18, 30h, HS, Gaeta)