Macroscopic systems and Electrical energy conversion

Electrical energy management is a main society topic considering the development of **renewable energy**. Unlike energy production, energy conversion to electric energy is still on a development stage. Optimal energy management is generally based on non-dissipative, smart and simple to use **semi-conductor components**in order to propose innovative and performing conversion structures.

Our team main activities are related to **power devices design**, their integration in electrical power converters taking into consideration operational constraints and their reliability. Our work contributes to **effective management of the electrical energy** while respecting constraints (high voltage, high temperature, compactness and limitation of electromagnetic pollution sources).

Renewable energies and power quality: new generation of converters

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Our team works on the development of hardware and software tools to estimate and improve the **efficiency of the energy conversion chain** for **household photovoltaic** (PV) applications.

Figure 1 : key elements reminder of a grid connected photovoltaic system.

Our research team works on every link in the PV chain. An example of achievement in relation with inverters is described below.

We have recently developed a new mixed 5-level inverter to limit earth leakage currents, while at the same time generating adequate robustness and cost-effectiveness of the system. This kind of topology (see Figure 2) is based on the mixture between a 2-level H-Bridge converter and a 3-level NPC structure. A comparative simulation analysis between a 5-level NPC inverter and the new mixed 5-level converter is introduced to get a better understanding of the differences between the two topologies.

The results show that the new inverter proposed enables to reduce the voltage stress across the semiconductor switches and to improve the output signal quality. In particular, the THD, which has approximately the same value as a 5-level NPC inverter, is divided by four compared to the well-known H-Bridge structure. The number of power devices and input capacities are reduced compared to the NPC topology one (10 even 9 power switches and 2 input capacitances for the new mixed 5-level inverter compared to 14 semiconductor devices and 4 input capacitances for the 5-level NPC topology). Thus, the robustness of the converter could be improved. Many experimental measurements are helpful to validate the operation of the new mixed 5-level inverter. The first results allow confirming the limitation of earth leakage currents and the increase of the robustness of this converter to improve the energy efficiency of domestic photovoltaic systems.

Figure 2 : new mixed 5-level inverter for 3 kW household photovoltaic applications.

CPL transmission

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Nowadays, PLC (Power Line Communication) systems manufacturer ensures theoretical bandwidth that is rarely achieved in a real environment. This bandwidth depends on the electrical network diversity and the quality of the electrical installation inside the buildings. The main objective of our work consists in characterizing the elements of an electrical installation, so that we can deduct the modeling parameters. This approach has led to the development of diagnosis tools for an electricity network. It allows to know the real performances of the PLC transmission.

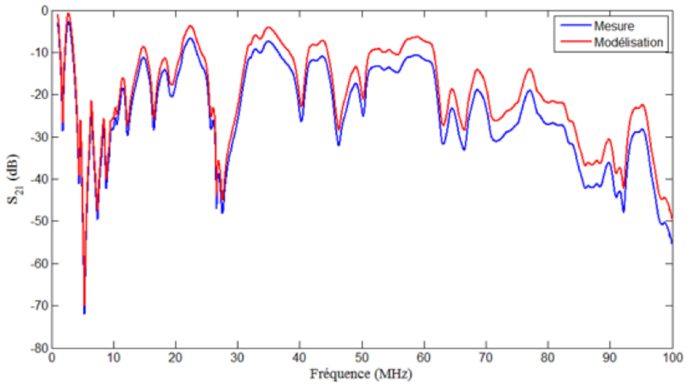

Figure: Transfer function comparison between the modelling of an identified network and the measurement.