Innovative semiconductor devices for power electronics applications

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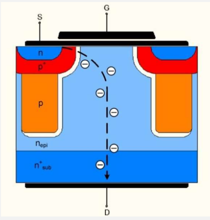
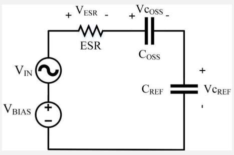
Dottorato di Ricerca in
Ingegneria dei Sistemi, Energetica,
Informatica e delle Telecomunicazioni
XXXIII Ciclo

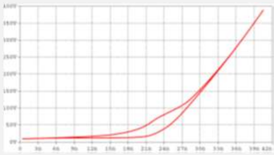
Superjunction MOSFET



Proposed circuits models



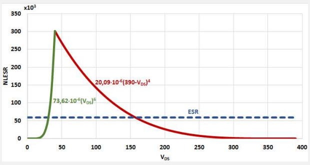
The off-state and the optimization problem are used to estimate the parasitic resistances through a genetic algorithm



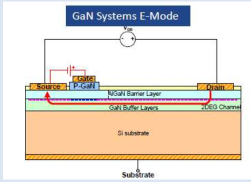
$$NLESR = \begin{cases} a\, v_{DS}^{n} & v_{DS} \in [0; V_{R\max}] \\ b\,(V_{DS\max} - v_{DS})^{m} & v_{DS} \in [V_{R\max}; V_{DS\max}] \end{cases}$$

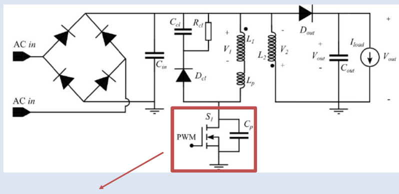
$$OF = \left| E_{LM} - E_{LS}(Rdg, Rds) \right|$$

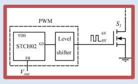
$$0 \le Rdg \le R_{m1}$$
$$0 \le Rds \le R_{m2}$$



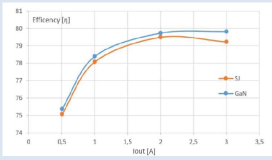
GaN Power Device





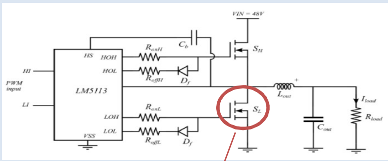


Si and GaN Devices in Quasi Resonant Flyback converters for Wall Charger Applications

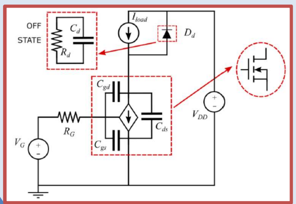


Efficiency of the QR flyback.

The performance of a GaN prototype STGT120 and a SJ MOSFET STF8N65M5 have been compared. The experimental results confirm the increasing of the whole system efficiency with a GaN device even if the converter design is optimized for a SJ MOSFET



Efficiency of state-of-the-art GaN devices in a synchronous-rectifier buck converter



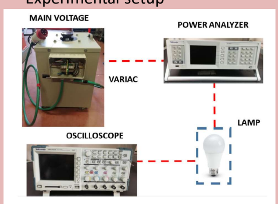
Equivalent circuit model. All the electrical components have been represented, both for turn on and turn off transient.

$$\frac{E_{t,GaN}}{E_{t,Si}} \approx \frac{(1-\eta_{GaN})}{(1-\eta_{Si})}\frac{P_{in,GaN}}{P_{in,Si}}$$

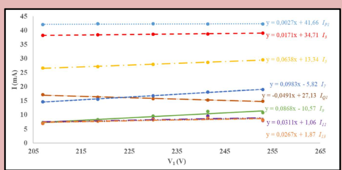
The proposed model is able to estimate the ratio of the energy with a low computational effort

Modeling of energy saving lamps

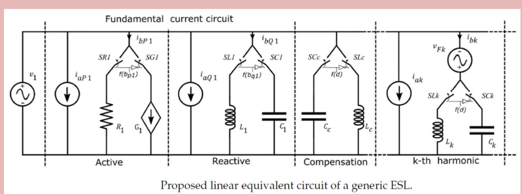
Experimental setup



$$I_{P1} \stackrel{\text{def}}{=} I_{P1}(V_1) = a_{P1} + b_{P1}V_1$$
$$I_{Q1} \stackrel{\text{def}}{=} I_{Q1}(V_1) = a_{Q1} + b_{Q1}V_1$$
$$I_k \stackrel{\text{def}}{=} I_k(V_1) = a_k + b_kV_1$$
$$k = 2, 3, \ldots K$$

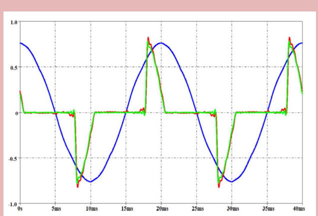


A polynomial function representing each current harmonic as a function of Vrms can be obtained by interpolation of the measured currents amplitudes.

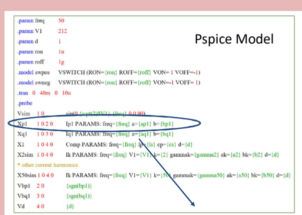


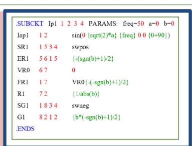
Proposed linear equivalent circuit of a generic ESL.

The circuit model is able to foresee the overall current distortion of different lamp configurations. This feature is useful in the optimal design of lighting systems when a key target is the mitigation of the current distortion.



Measured voltage on the mains (blue waveform, rms 212 V), measured current (green waveform) and simulated current (red waveform) for a LED. Per-unit system: base voltage 400 V, base current 250 mA

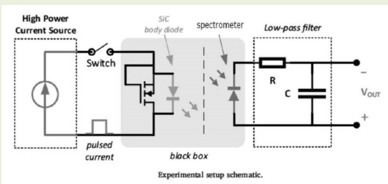




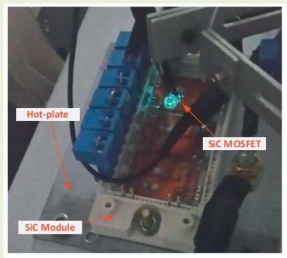
SiC module reliability

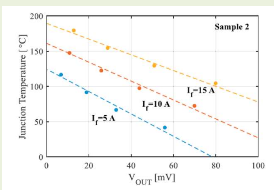
The light emission of SiC MOSFETs during reverse conduction, caused by the Light Emission Diode (LED)-like behaviour of the body diode will be studied and investigated.

SiC MOSFET body diode's light emission is a temperature sensitive electrical parameter



Experimental setup schematic.





The photodiode current is proportional to the sensed light. A current pulse was supplied to the body-diode by a current source. The values of pulsed current were 5, 10 and 15 A, and the pulse durations were in the range 1÷2 s.