Modules as an Instrument for Low Inductive System Designs

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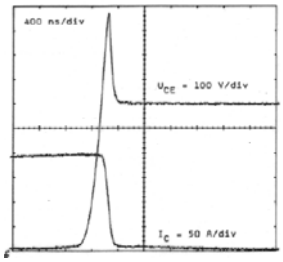
Parasitic inductance in fast switching applications causes over voltage and increased switch off losses in the semiconductor. A intelligent module concept is the key for a low system inductance.

Theory [1]:

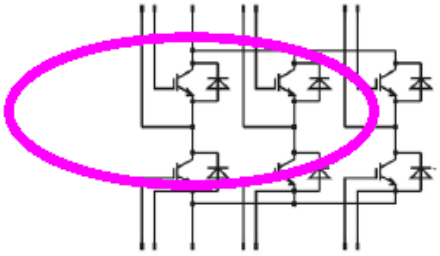
Switching-off the IGBT results in a current change and this causes an over voltage spike by the current change in the parasitic inductances according to $V_{CE}(peak) = V_{CE} + L \times di/dt$



To avoid parasitic inductance in the power circuit, the layout of the circuit becomes important. The parasitic inductance rises with the area encircled by the electric current. With overlap of the tracks of positive and negative voltage the area becomes minimal, capacitors are used to shorten these loops in order to reduce the encircled area.

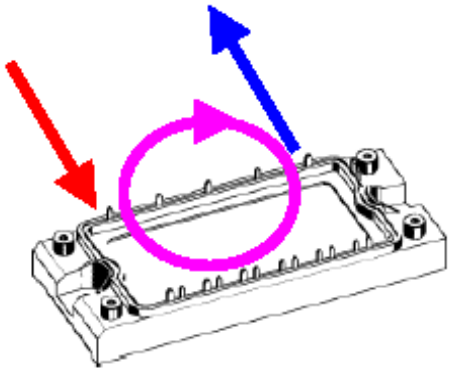
Influence of Power Modules on the System Inductance

The power module is a key component regarding the parasitic inductance. There is the internal inductance of the module but more important is how pinning and structure influence the inductance of the PCB layout. The target in bridge configurations is the short cut of the encircled area of the DC input as small as possible with a capacitor.



The distance between DC+ and DC- contact and the accessibility of these contacts will influence the system inductance and the switch off losses.

Here a example for a inverter module causing a high system inductance.

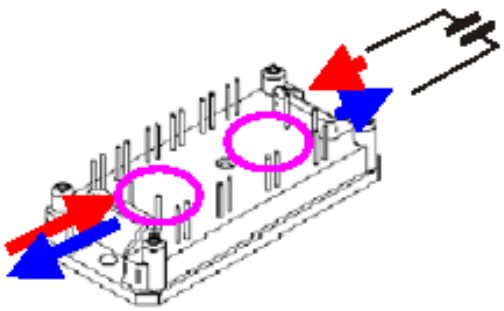


The target is to avoid inductive loops in the DC-Link with a capacitive overlap of positive and negative DC-Tracks and to compensate the remaining inductance.

To fulfill these requirements it is necessary to provide a module structure and pining, which is corresponding to the needs. Solutions are module designs supporting the connection of external snubber capacitors close to the module or the integration of fast capacitors to shorten the high frequency in smallest loops, with lowest inductance.

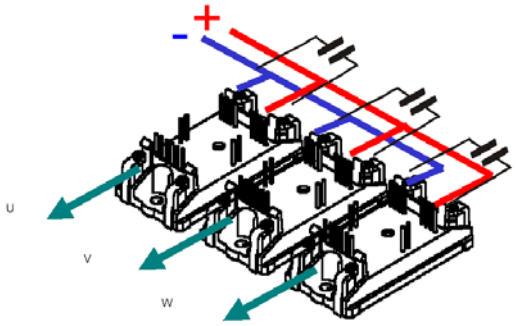
Low Inductance Examples

A module structure and the pinning of modules have to be designed referring to the targets of parasitic inductance reduction. If considered prior to the module design this goal is achievable without any disadvantage and additional cost. For motor drive applications often the 3-phase bridge topology in a single module is used. Here inductance reduction is possible with an external capacitor connected to additional contacts for the DC+ and DC-. The capacitor divides the inductive loop in half.



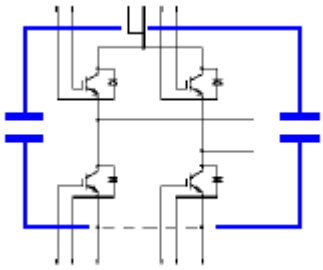
A division of the 3-phase inverter bridge into 3 half-bridge modules offers the opportunity to

shorten the inductive loop individually for each module.

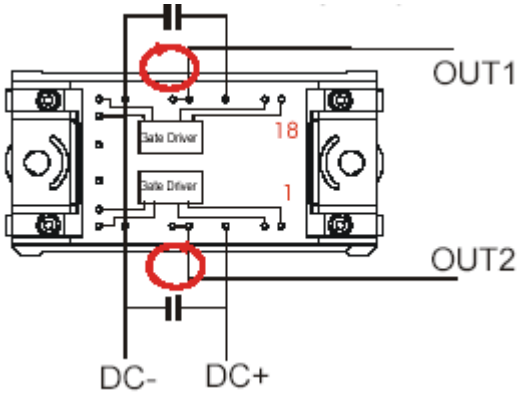


For motor drives, working at a PWM frequency up to 20kHz the reduction of switching losses is important, for power supplies and welders using 100kHz PWM frequency, the avoidance of parasitic inductance is a must.

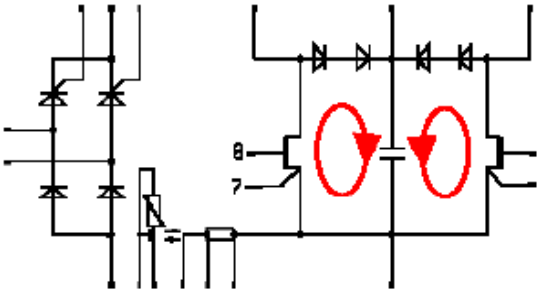
In this example supports the modul pinning the connection of external snubber capacitors.



The inductuve loop is closed with a minimal inductance.



Active power factor correction is now required in many applications. Size reduction of the passive components is achievable with increased switching frequency up to 500kHz. The switching losses are dominant in such applications and the reduction can improve the performance significantly. The switch off losses are influenced by the parasitic inductance at the output, the ideal solution is to shorten the high frequency at its origin, inside the active component.



The integrated capacitor shortens the high frequency inside the module. Such advantages are only possible with module technology.

Modules are the ideal platform to improve the dynamic behavior of power systems with intelligent pinning and a module structure conforming to the needs.