Importance of measuring parasitic capacitance in isolated gate drive applications

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Galvanic isolation techniques

- Inductive (Magnetic) Coupling
- Capacitive Coupling
- Optical Coupling
High DC-link voltages lead to longer exposure to dV/dt stress

- Isolated gate drivers are used in state-of-the-art in systems with IGBT in half bridge configurations and a DC voltage up to 900 V.
- Modern power transistors (high speed IGBT, SiC) allow very high dV/dt.
- The times, in which dV/dt can act, are long in systems with high DC voltage.
- Noise which is generated by dV/dt overrides isolated signal transfer due to coupling capacitances.
- Analyses of capacitive behavior is required for:
  - PCB layout
  - Gate driver ICs
  - Transformers for secondary side supply of gate driver ICs
CMTI and $C_{\text{IO}}$ specification are performance parameters for gate driver ICs

- Disturbances via the input-to-output capacitance $C_{\text{IO}}$ may limit the reliability of power electronics, e.g. by unintended turn-on of a gate driver output and potentially damaging the power stage.

- Therefore $C_{\text{IO}}$ and common mode transient immunity (CMTI) of gate driver ICs are important parameters for gate drivers to meet systems performance targets.

- Galvanic isolation standards for magnetic couplers such as VDE0884 define $C_{\text{IO}}$ and CMTI measurement methods.
Are gate drivers the real source of \( \frac{dV}{dt} \) coupling effects?

› The physical realization of electronic components can bring parasitic capacitive coupling effects from the power side to the control side.

› The size of isolation structures for magnetic and capacitive couplers are in the same order of magnitude.
The windings of discrete transformers can have a considerable capacitive coupling

- The physical realization of electronic components can bring parasitic capacitive coupling effects from the power side to the control side.

- A measurement of magnetic couplers and transformers is required.

- Note: Transformers of SMPS have usually a larger physical size and coupling capacitance.
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1. Why is capacitive coupling important in high voltage (HV) applications?

2. Measurement results
Various measurement techniques can be used for measuring small capacitances

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The test setup at a glance

› LCR analyzer: Agilent 4285A
› Test fixture: Agilent 16047A
› Test PCBs for various gate driver ICs in different packages
Compensation of influences originating from the test setup is mandatory

- Compensation test setup including adapter for DUT
  - \( R_S \) and \( L_S \) -> \( Z_S \) by SHORT
  - \( C_P \) and \( G_P \) -> \( Y_P \) by OPEN

The measurement results can now be corrected by the known influence of \( Z_S \) and \( Y_P \)

\[
Z_S = R_S + j \omega L_S \quad \text{for} \quad Z_S \gg Z_{\text{SHORT}}
\]

\[
Y_P = G_P + j \omega C_P \quad \text{for} \quad Z_S \ll \frac{R_S + j \omega L_S}{Y_P}
\]
The capacitances of the power supply XFMR are 10x larger than those of gate driver ICs.
Summary

› All power electronics contain switched nodes. Parasitic capacitances can therefore easily inject currents into signals and references (GND).

› The capacitive coupling of gate driver ICs is around 1 pF. Small coupling capacitances are a key factor for good CMTI – benefits include robust operation and a more accurate sensing.

› Discrete transformers used for the gate driver IC power supply add a large coupling capacitance to power electronic systems. It is also important to choose low coupling capacitance for total system performance.
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