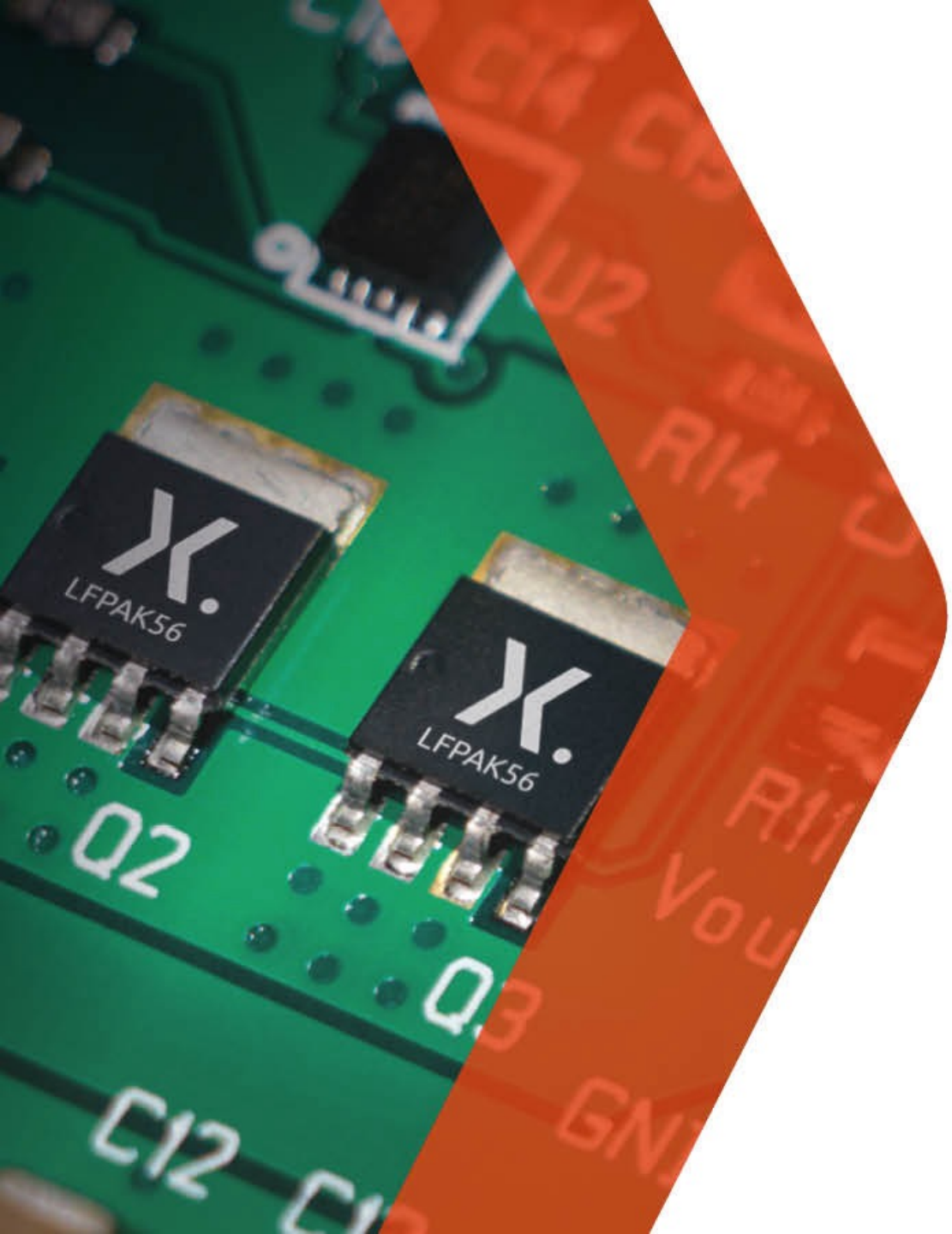


nexperia

Electrothermal MOSFET Models

Rapid Prototyping of Automotive Electronic Systems

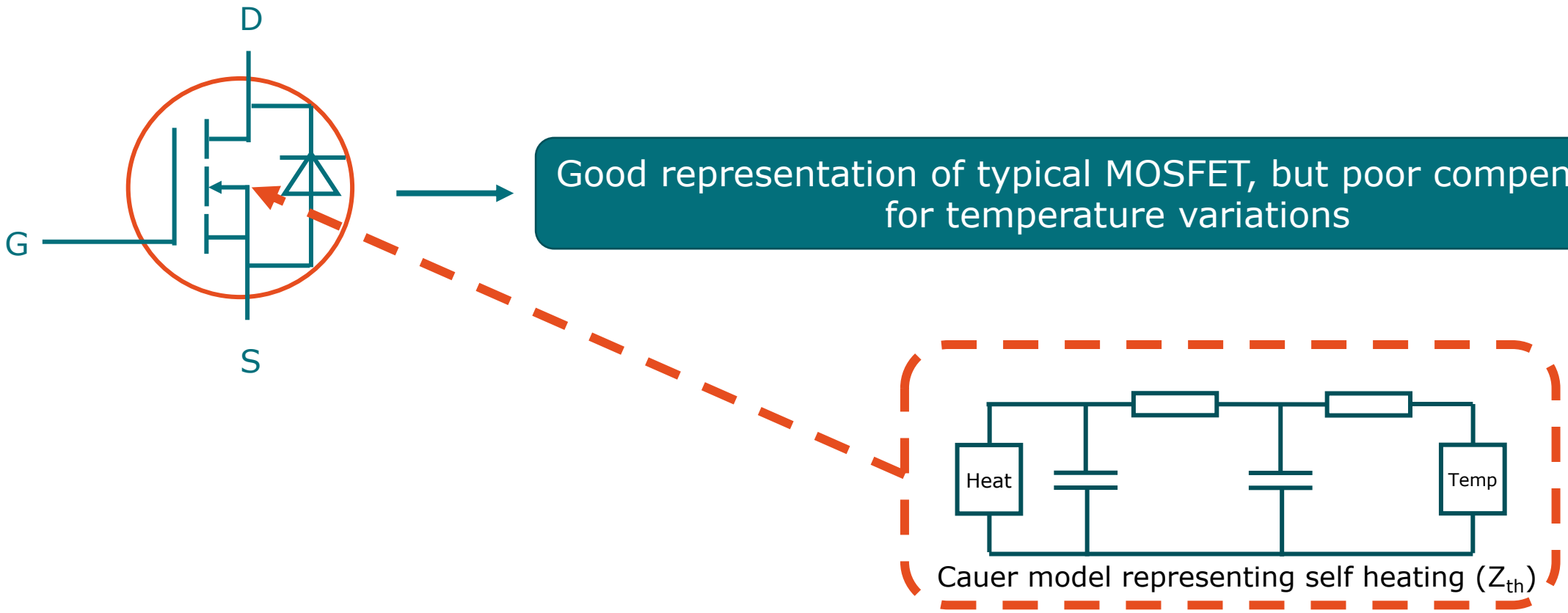
September 2021

Introduction

- Andy Berry
- Principal Application Engineer

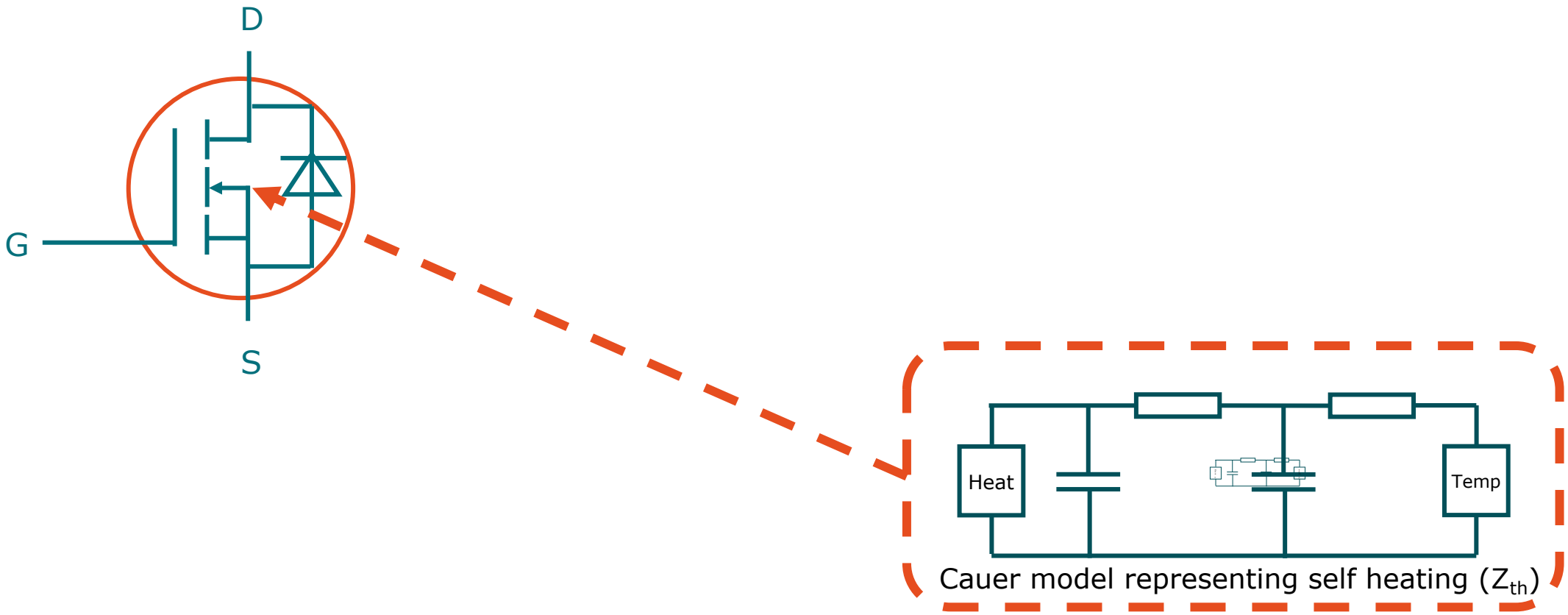
- Norman Stapelberg
- Senior International Product Marketing Manager

Traditional MOSFET Models



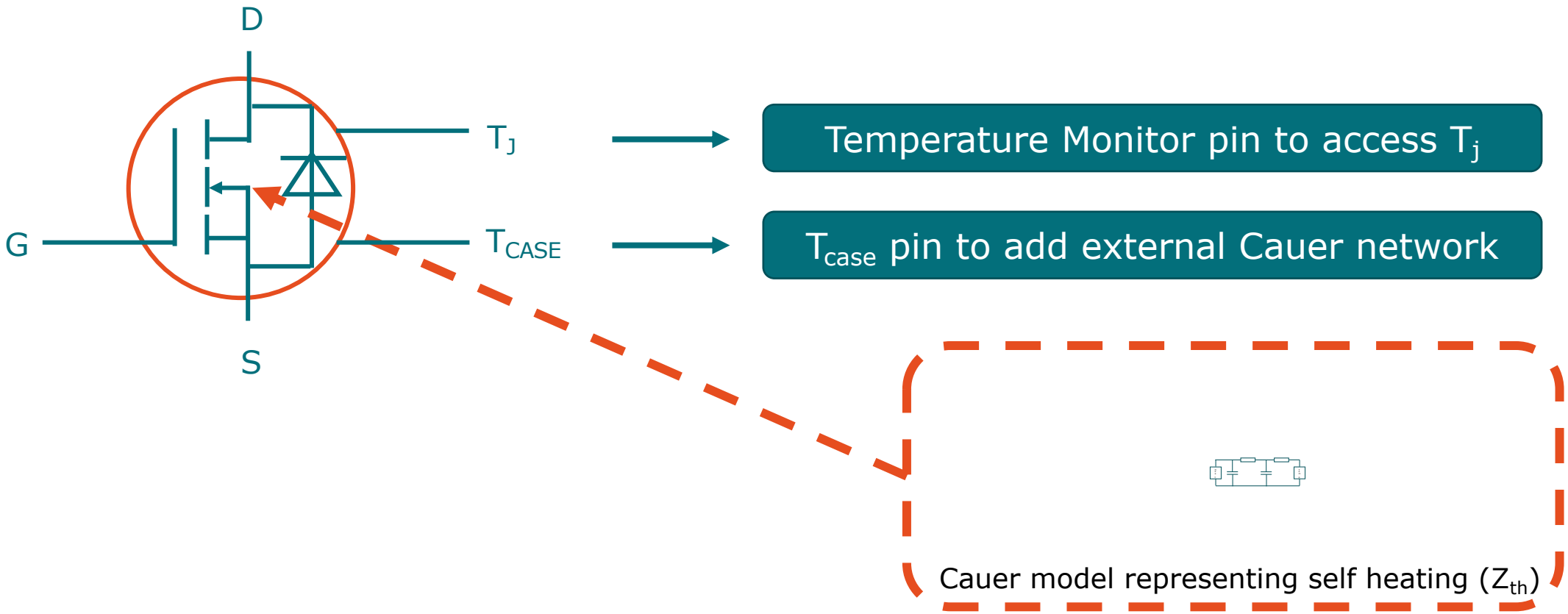
Good representation of typical MOSFET, but poor compensation for temperature variations

Traditional MOSFET Models



Advanced MOSFET Models

Electrothermal Models for Rapid Prototyping of Automotive Electronic Systems



Advanced MOSFET Models

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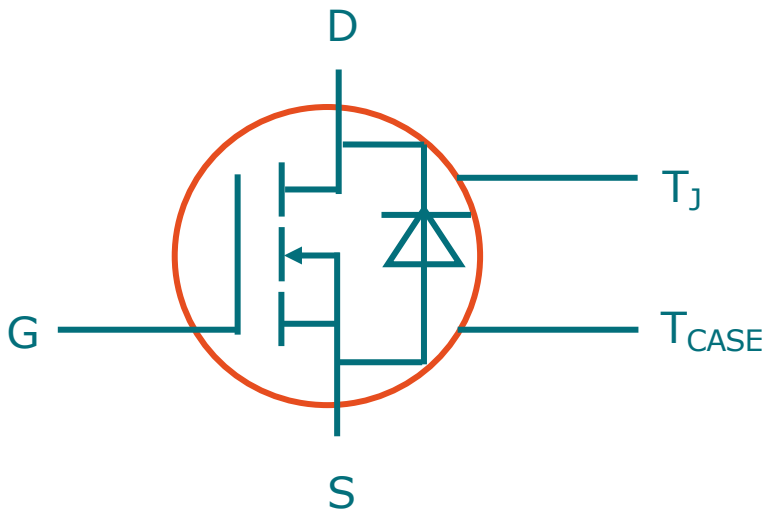


Temperature Monitor pin to access T_j

T_{case} pin to add external Cauer network

Increase in power dissipation

Increase in Tj

MOSFET characteristics change

Thermally compensated MOSFET models

Thermal inter-dependency of all device characteristics

Application Overview

R_{DSon} and Forward Diode Temperature Behavior

Motor Control Applications

Reverse Battery Protection Applications

Conduction losses: the device heats up

R_{DSon} and diode forward current I_S increase with temperature

MOSFET conduction losses have great impact on the operating temperature of the PCB

Temperature behaviour is key to model the application thermal performance

Application Overview

Breakdown Voltage Temperature Behaviour Modelling

Short Circuit Conditions : high current , low inductance scenarios

Low inductance: rise of current only limited by the wire inductance!

↓

MOSFET must withstand short and very high current pulses

↓

Possibility of avalanche: critical condition in MOSFET behaviour

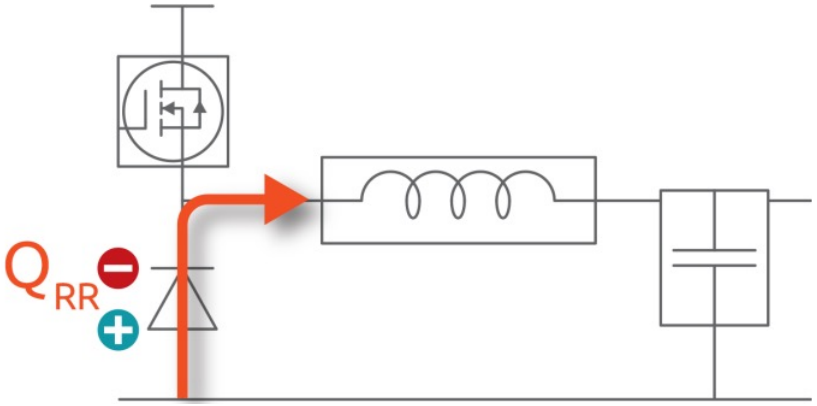
Accurate break-down modelling is key to accurate computation of avalanche energy

Application Overview

Body Diode Reverse Recovery Modelling

Motor Control Applications

During dead-time both MOSFETS are off: free-wheel current flows in the low side body diode



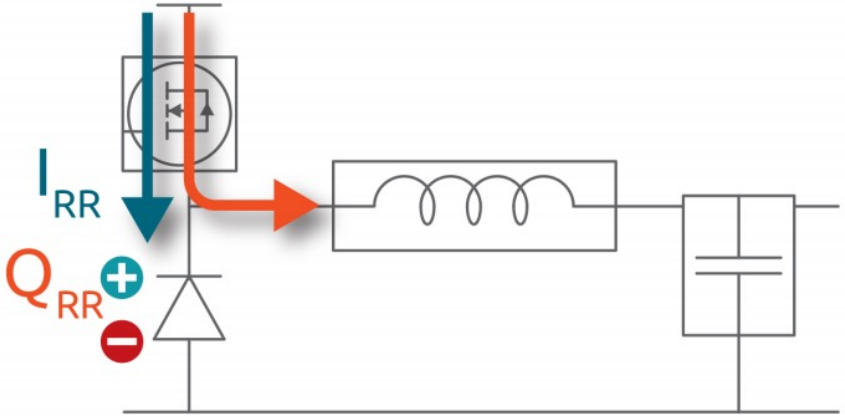
Q_{RR} ACCUMULATES

Application Overview

Body Diode Reverse Recovery Modelling

Motor Control Applications

High-side turns on: a current peak occurs and flows until Q_{RR} is removed from the low-side



HIGH-SPEED CURRET PULSE

EM emissions

Application Overview

Body Diode Reverse Recovery Modelling

Motor Control Applications

The reverse recovery pulse I_{RR} interacts with MOSFET lead frame and board parasitics

↓

Resonance due to MOSFET non-ideal switching behaviour has great impact on EM emission

↓

EMC performances and optimisation is a key design requirement for customers

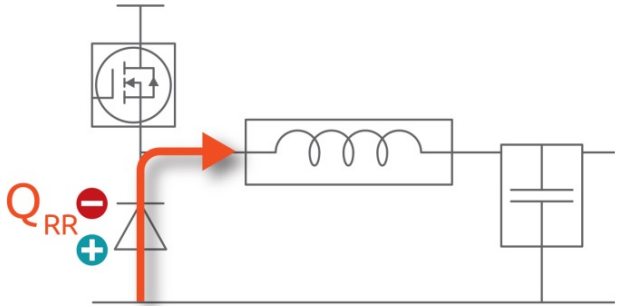
Accurate modelling of reverse recovery behaviour is key for EMC considerations

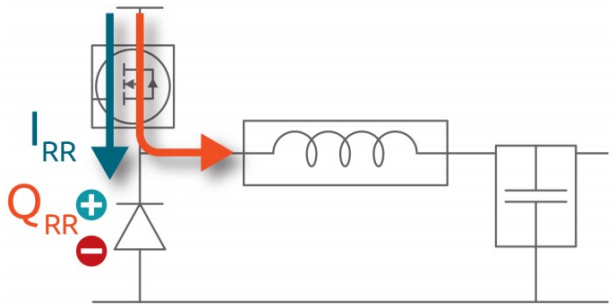
Application Overview

Gate Charge and Voltage Dependent Capacitances

Motor Control Applications

Turn-on and Turn-off transient behaviour is critical for applications modelling

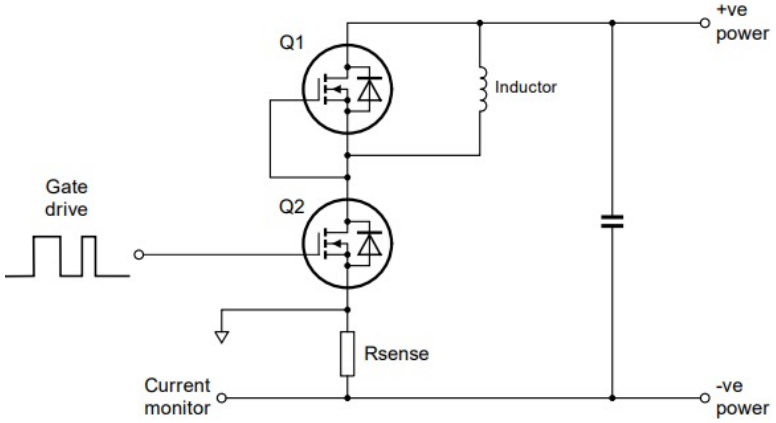


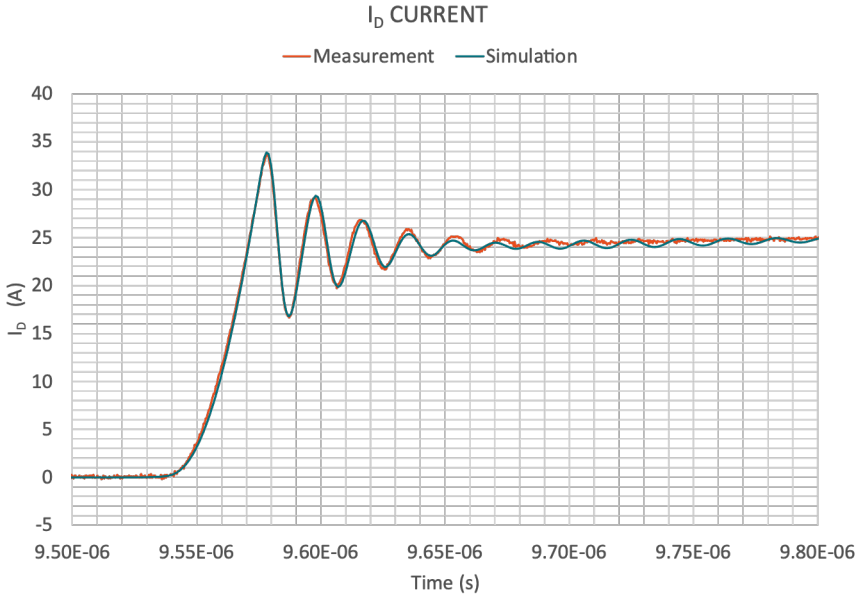


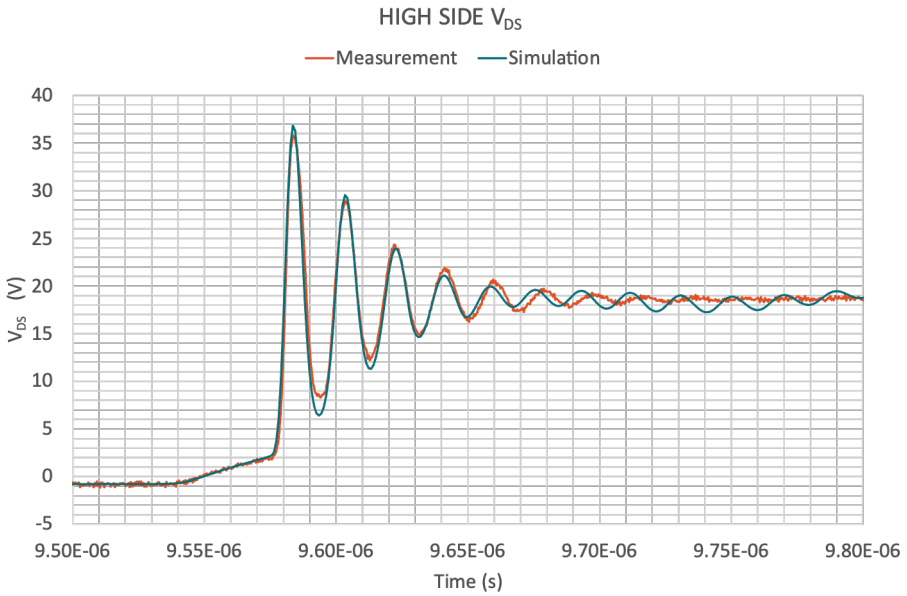
Accurate modelling of the dynamic characteristics is key for accurate modelling of transient behaviour

Advanced MOSFET Models

Electrothermal Models for Rapid Prototyping of Automotive Electronic Systems





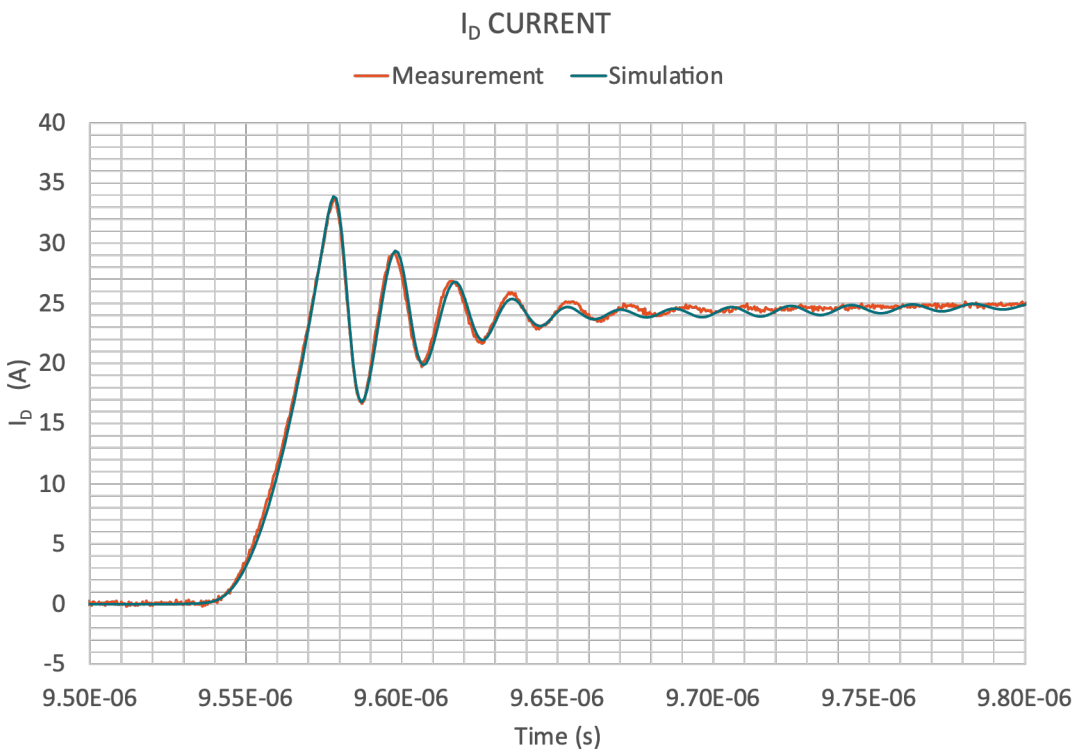


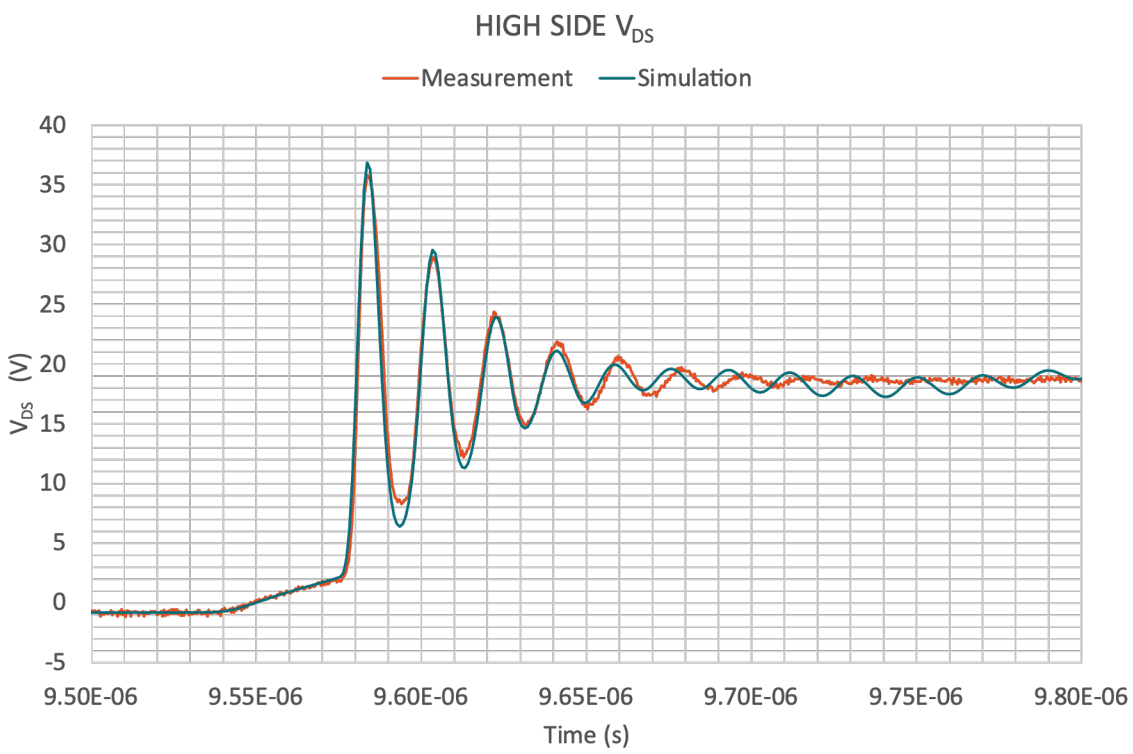
Accurate modelling of static & dynamic characteristics

Accurate modelling of reverse recovery behaviour

→ Early debugging of EMI issues

Measured Data vs. Simulated Data

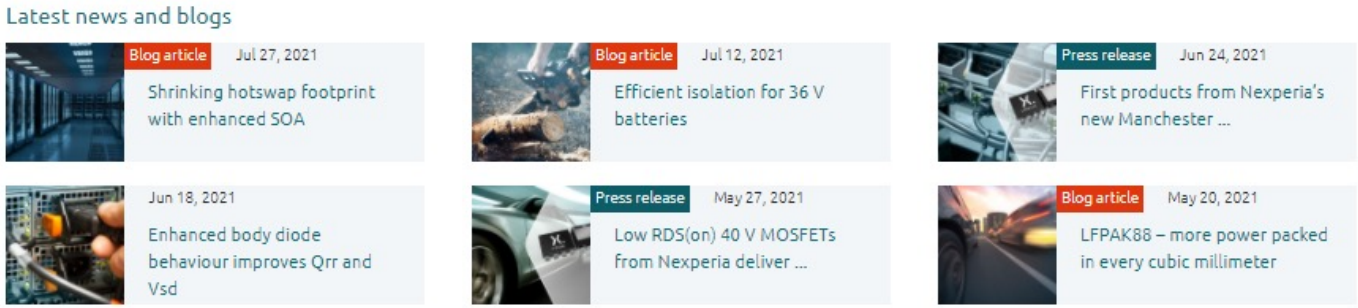


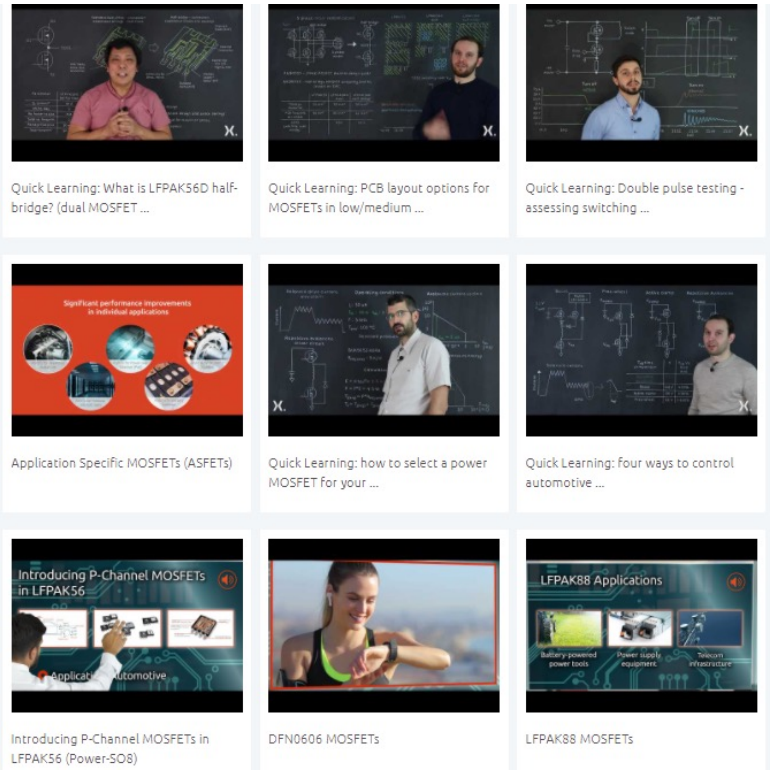


	I_D Peak (A)	t_{rr} (ns)	V_{DS} 1st Peak 1 (V)	V_{DS} 2nd Peak (V)	V_{DS} 3rd Peak (V)
Measurement	33.7	11.3	35.63	28.65	24.35
Simulation	33.9	11.2	36.8	29.5	23.9
Error (%)	0.59%	0.88%	3.28%	2.97%	1.85%

Nexperia Resources

- Models coming soon and will be available on our website
- Please visit nexperia.com/mosfets





public

Please share your questions and insights

EFFICIENCY WINS.