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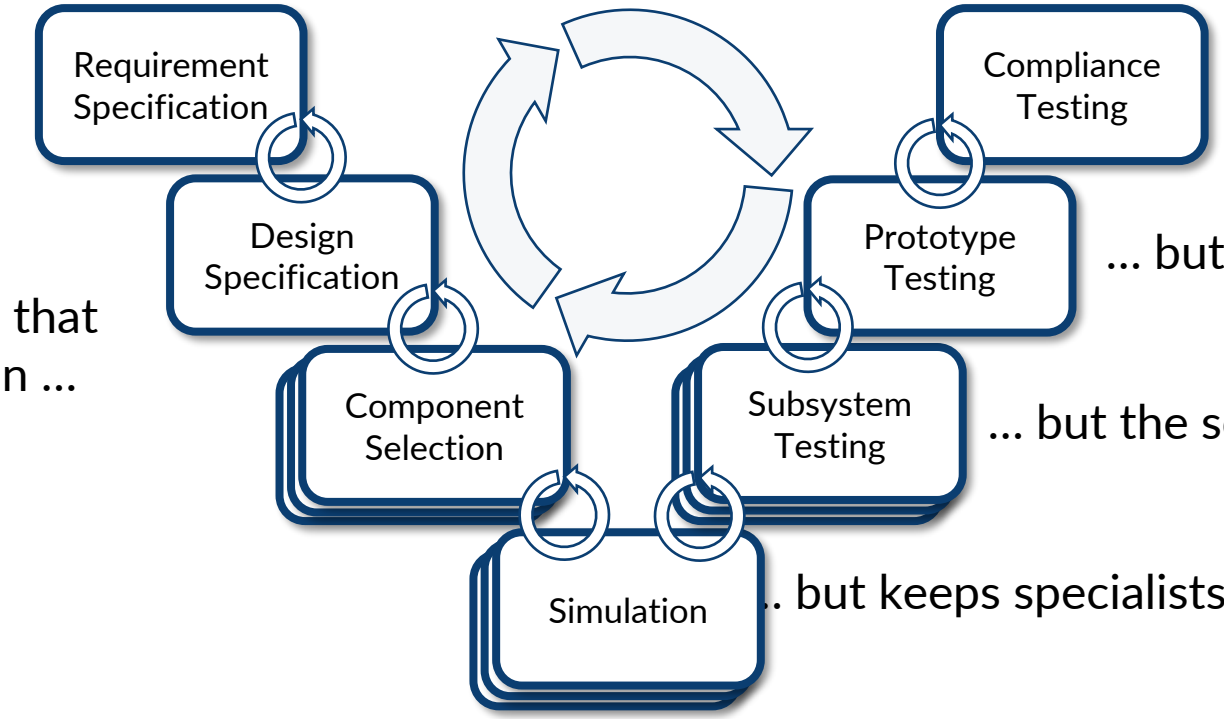
Current Power Electronics Design Process

Iterative design process, that always leads to a solution ...



... but is very cost-intensive.

... but is very time consuming.

... but the solution is never optimal.

... but keeps specialists unnecessarily engaged.

... but customers' requirements might be unsatisfied.

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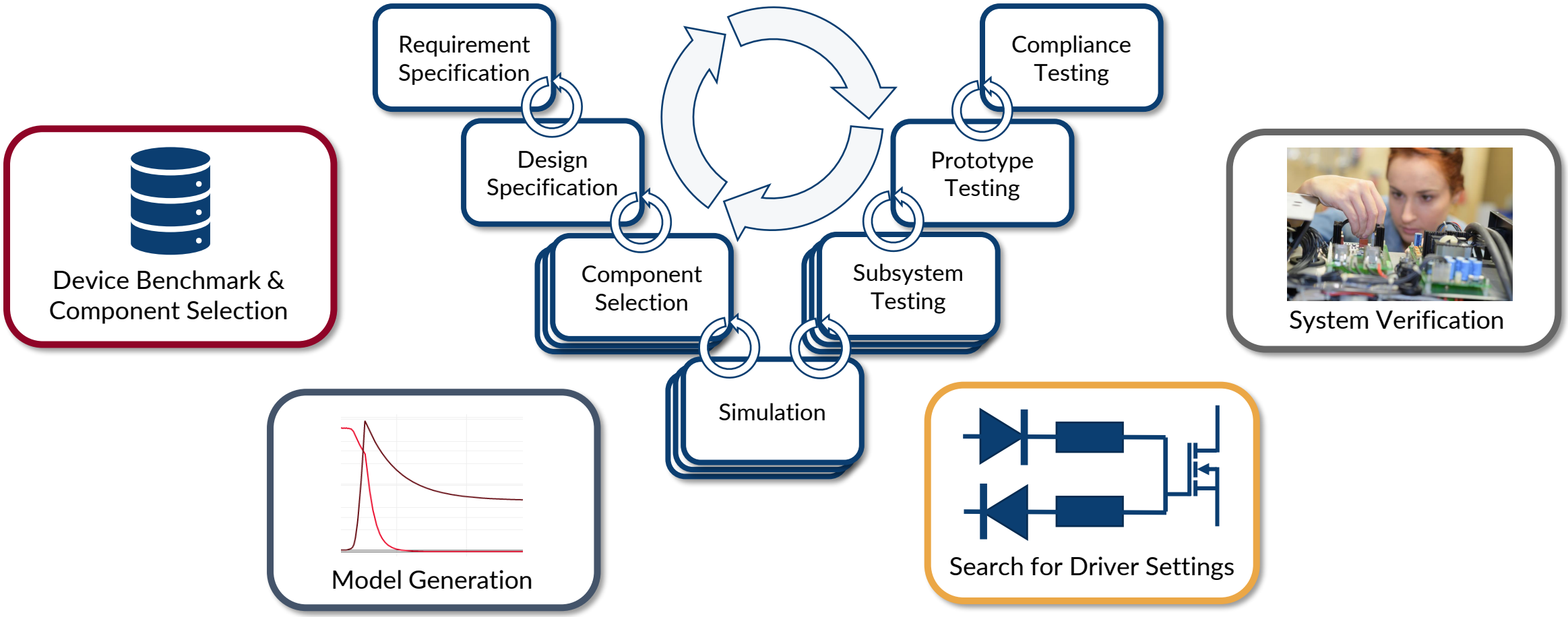
Role of Measurement



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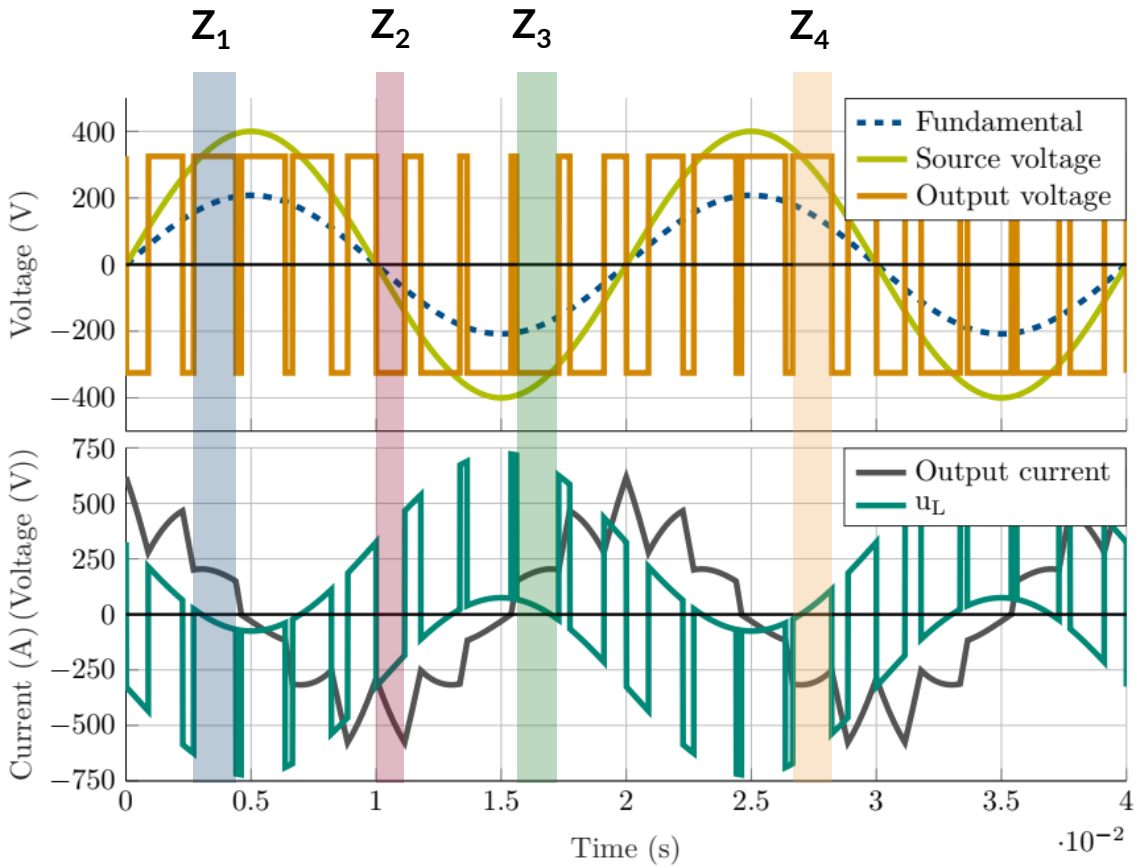
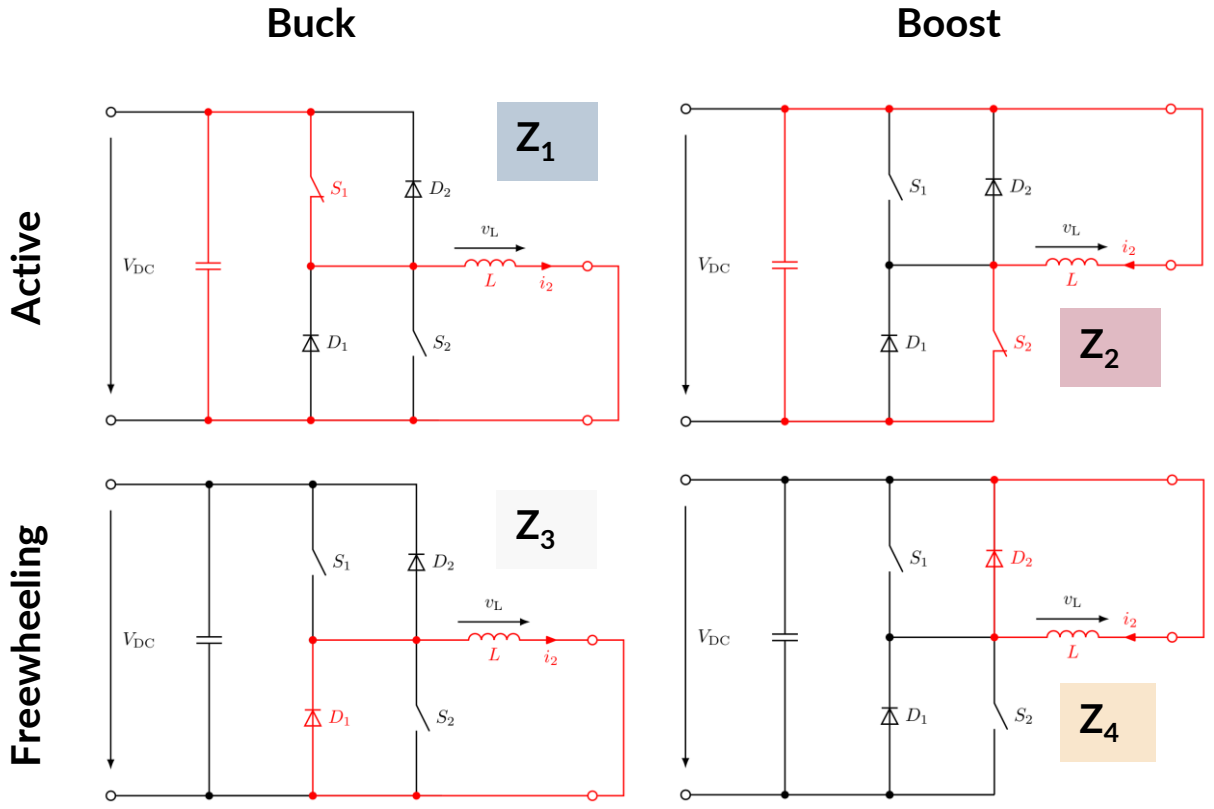
Switching Losses





Switching losses are dependent on many parameters

→ Testing close to application

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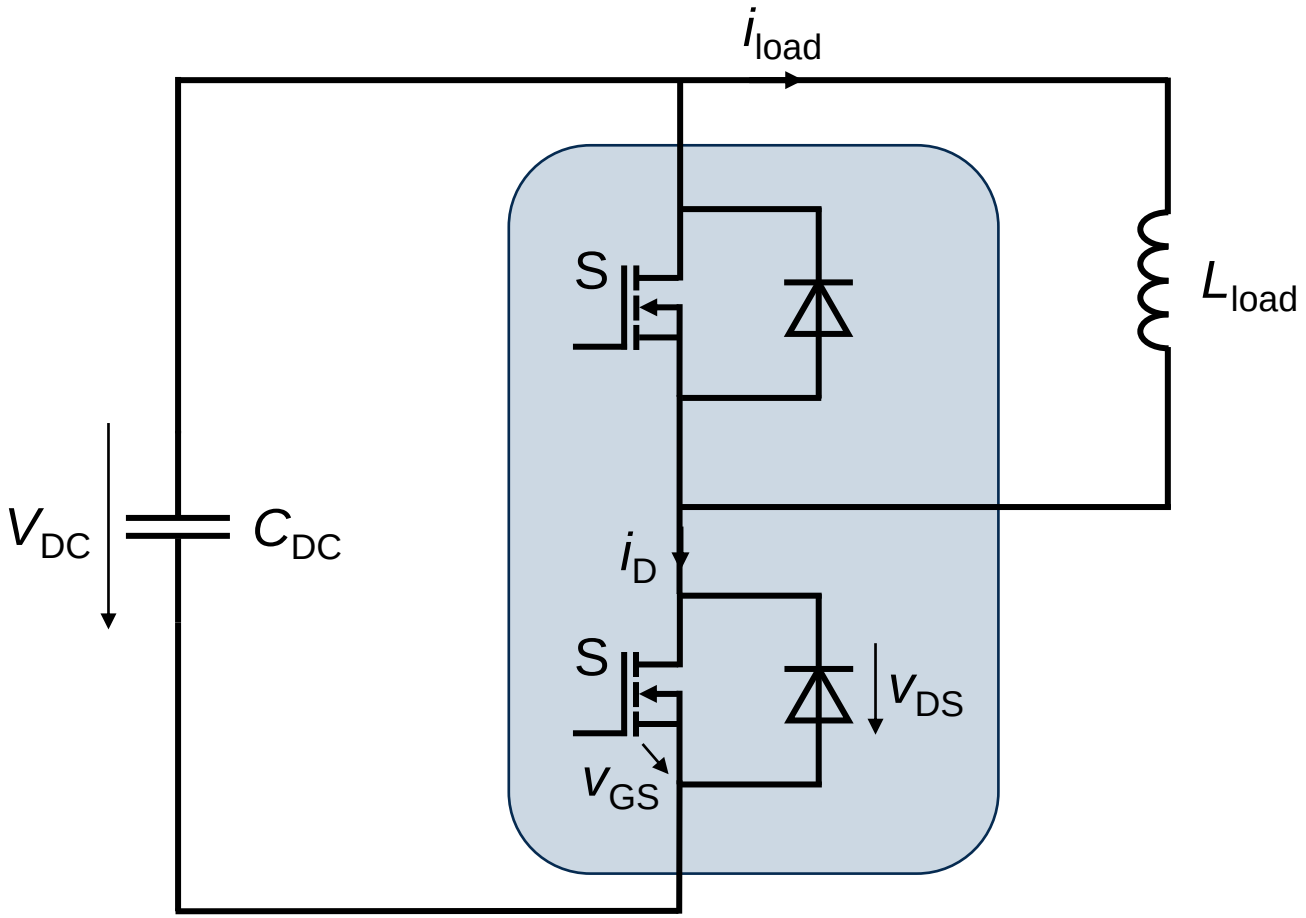
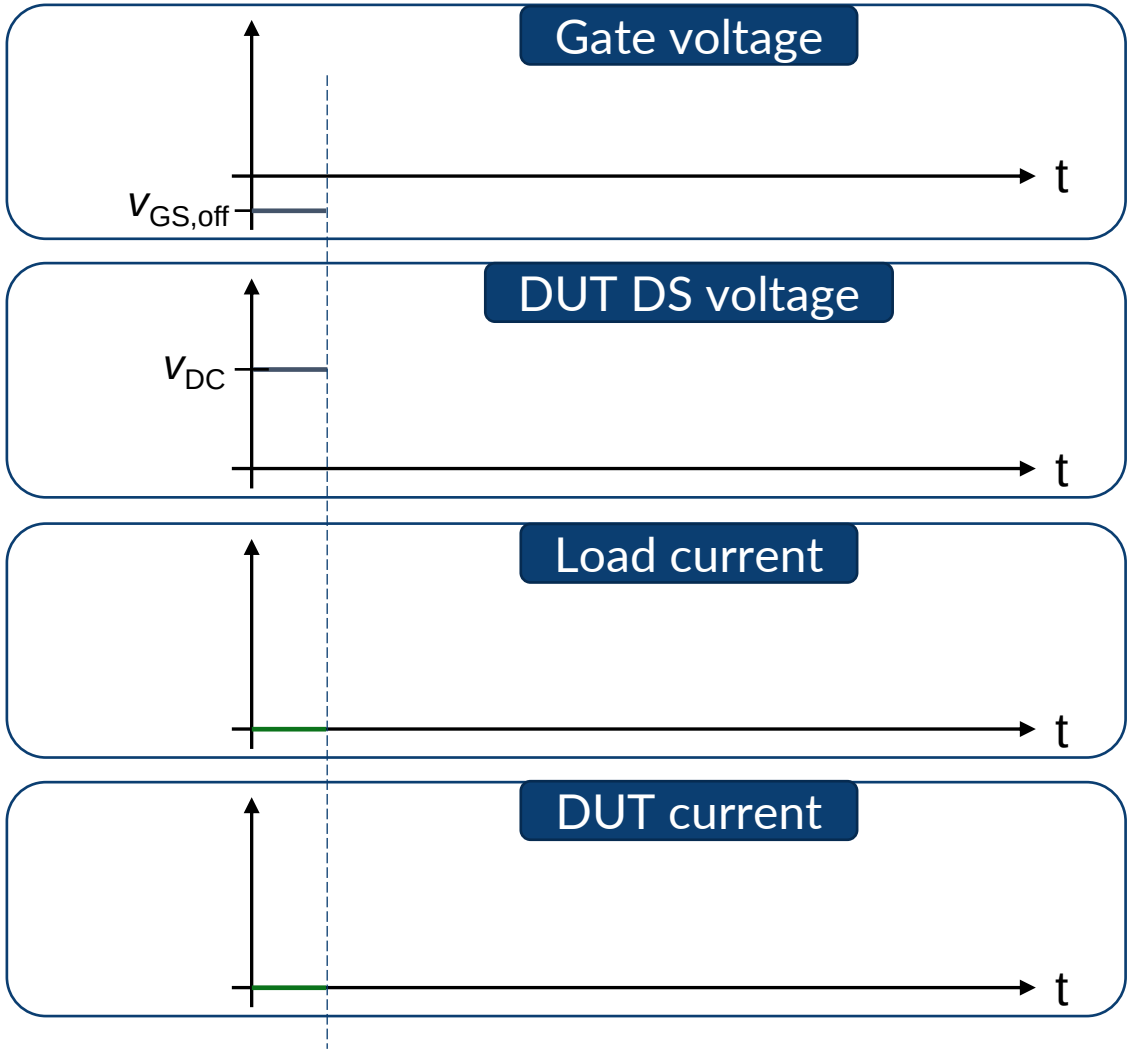
Testing of Inductive Switching





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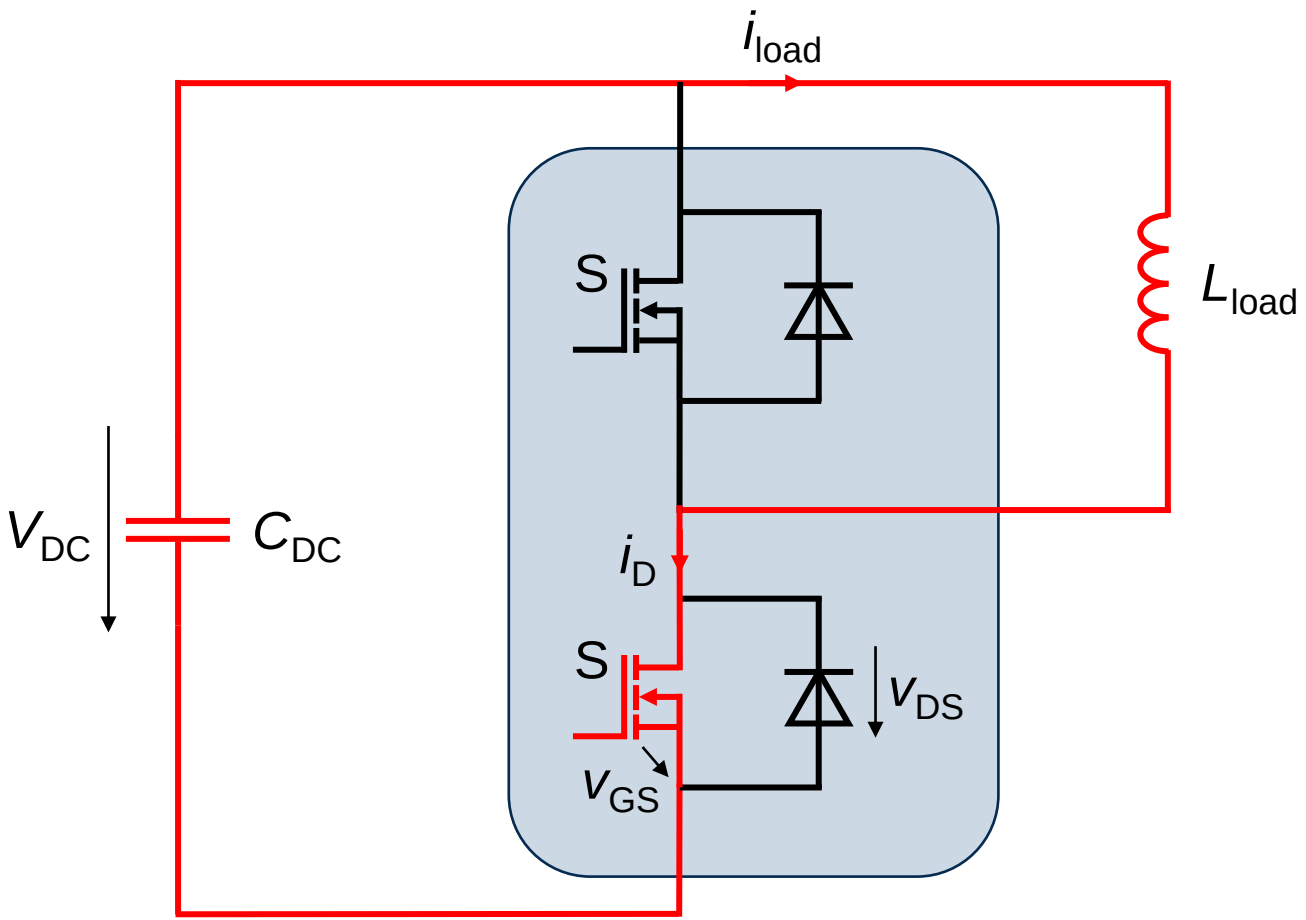
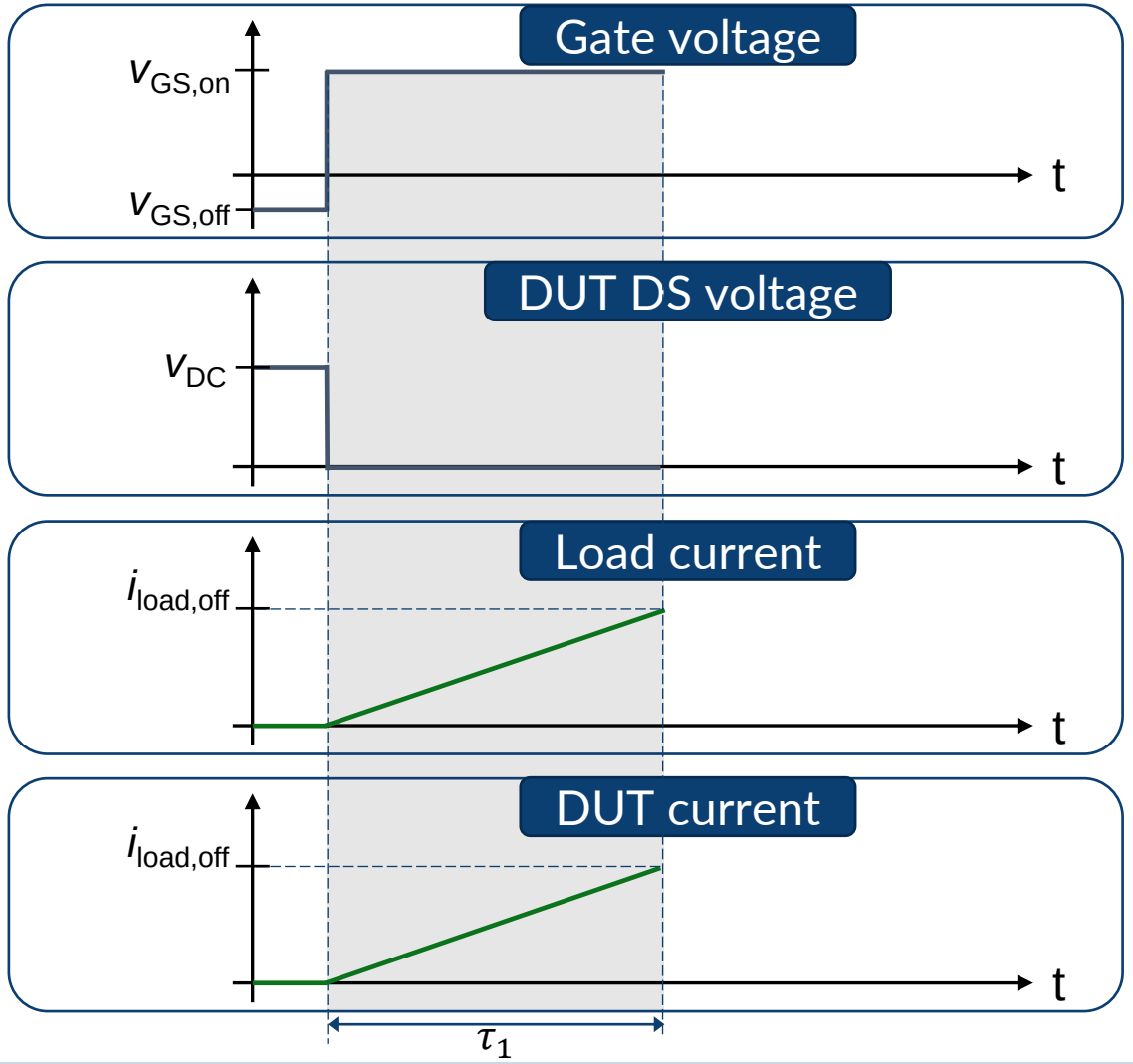
Testing of Inductive Switching





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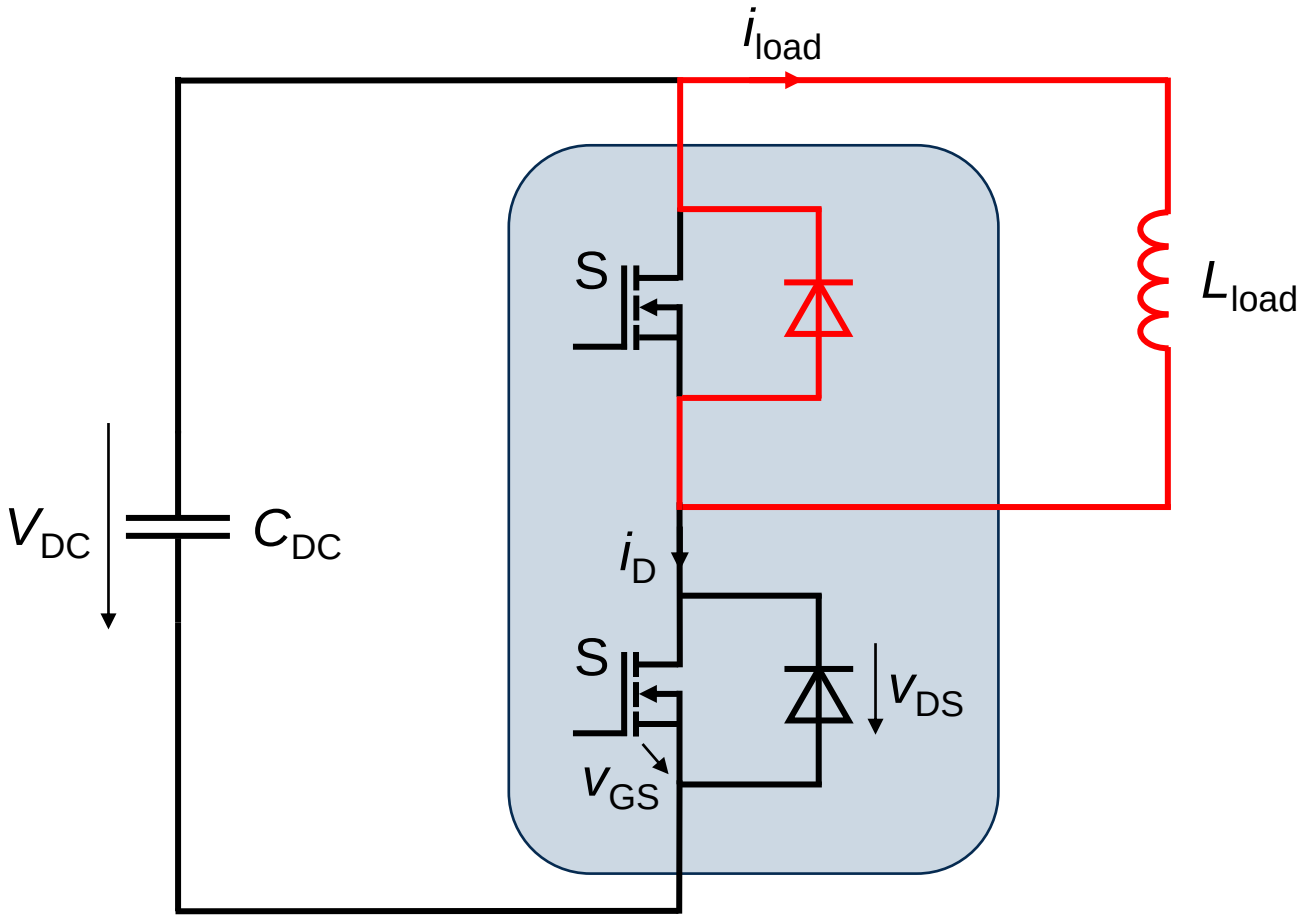
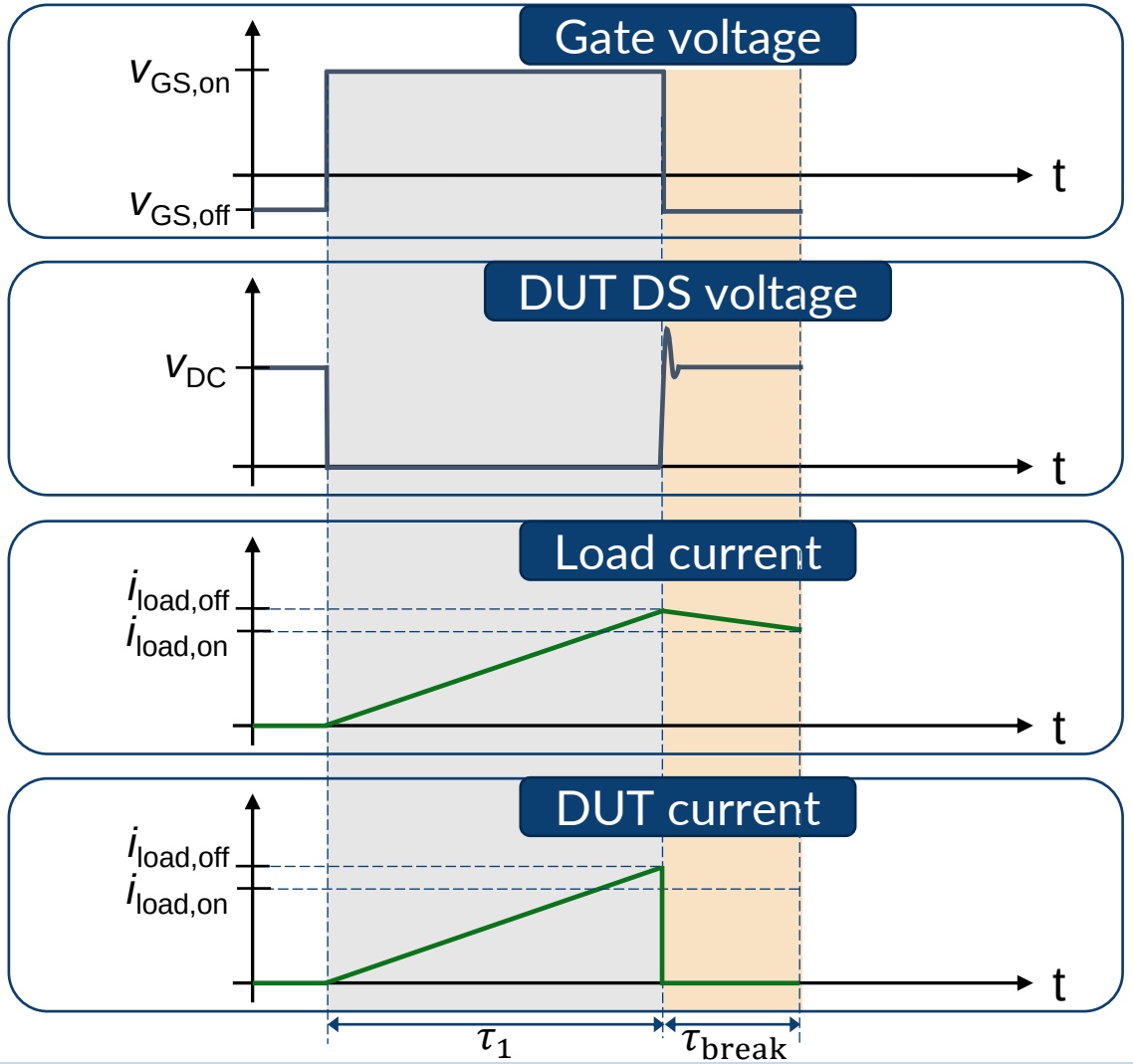
Testing of Inductive Switching





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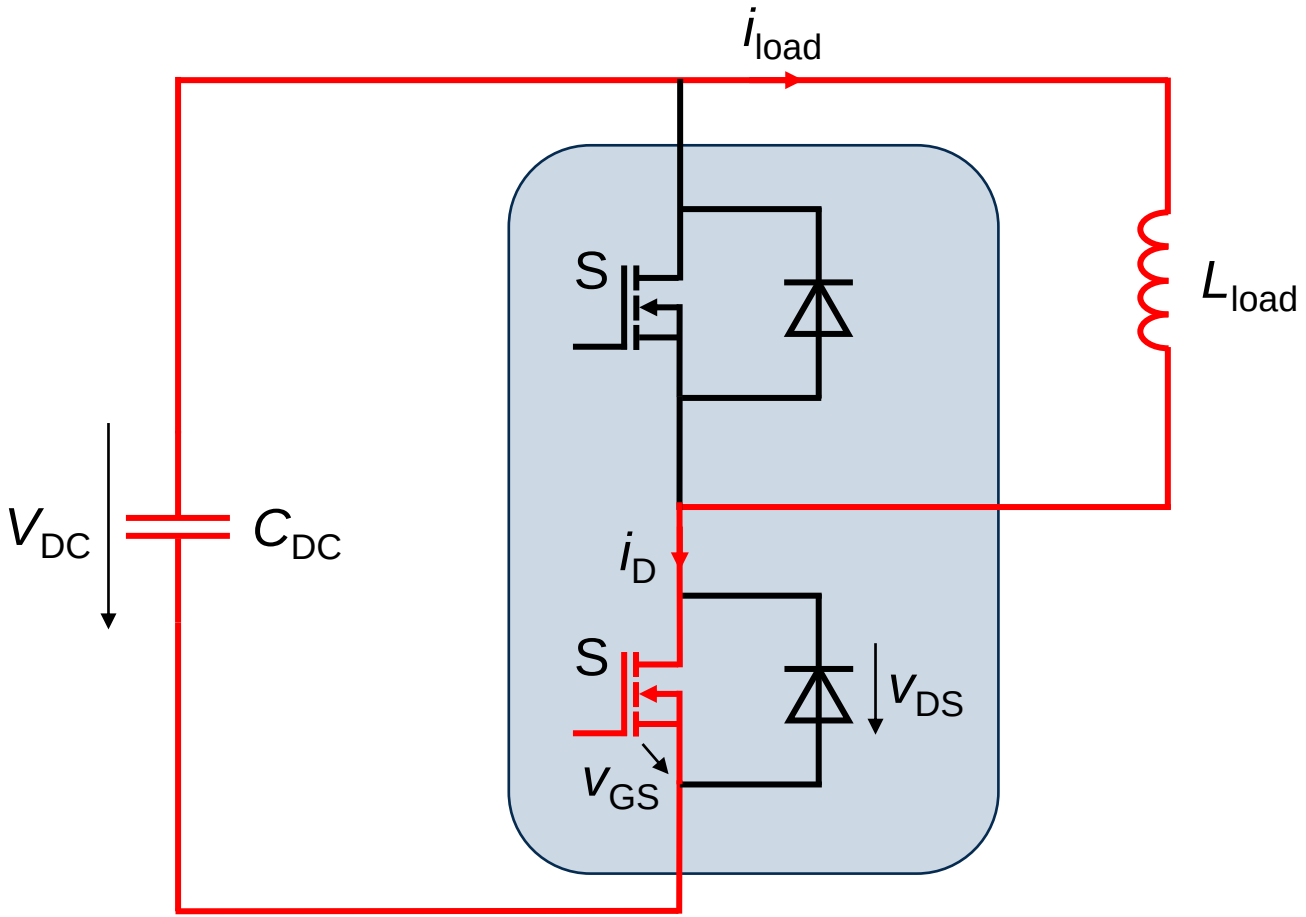
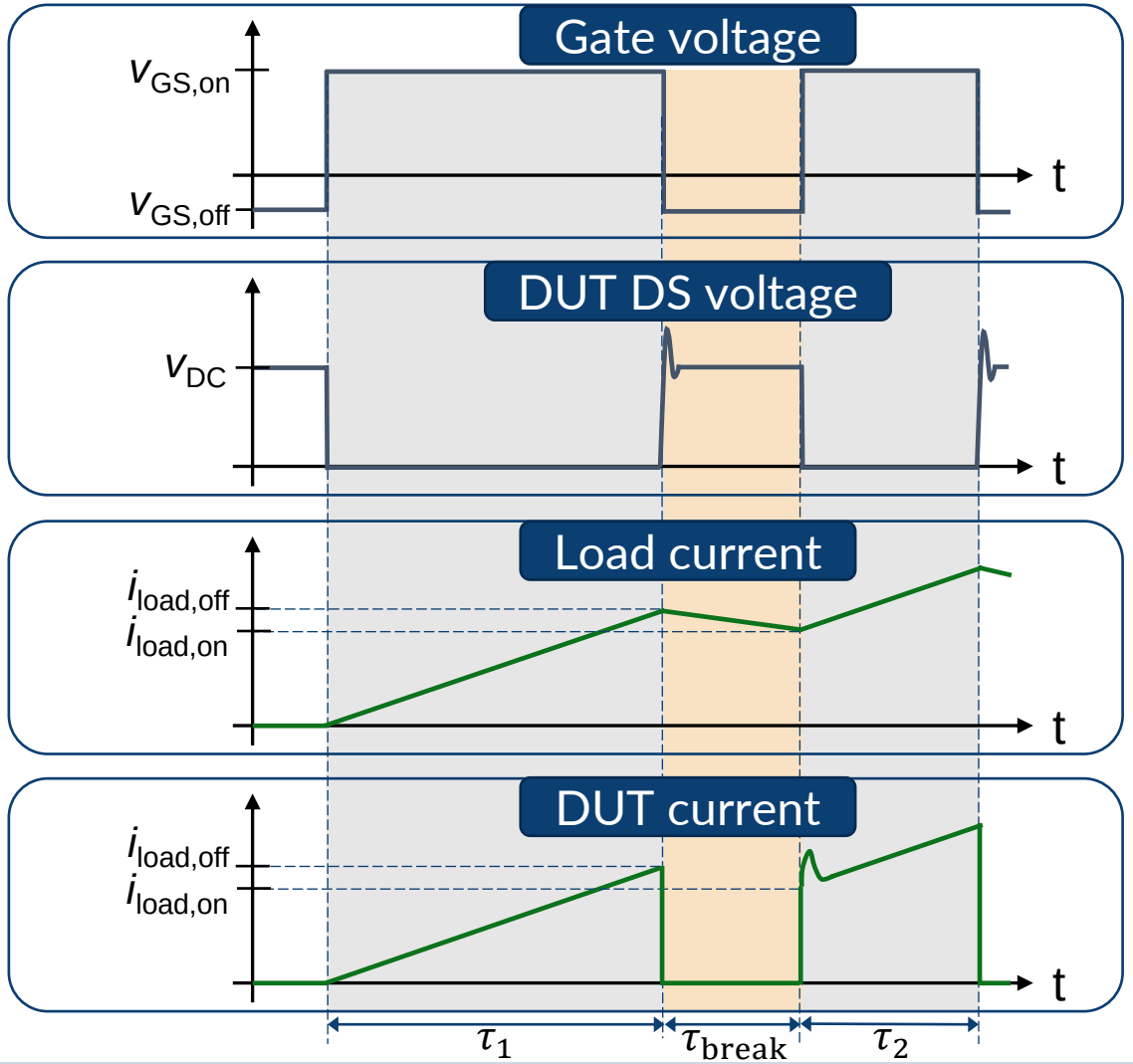
Testing of Inductive Switching





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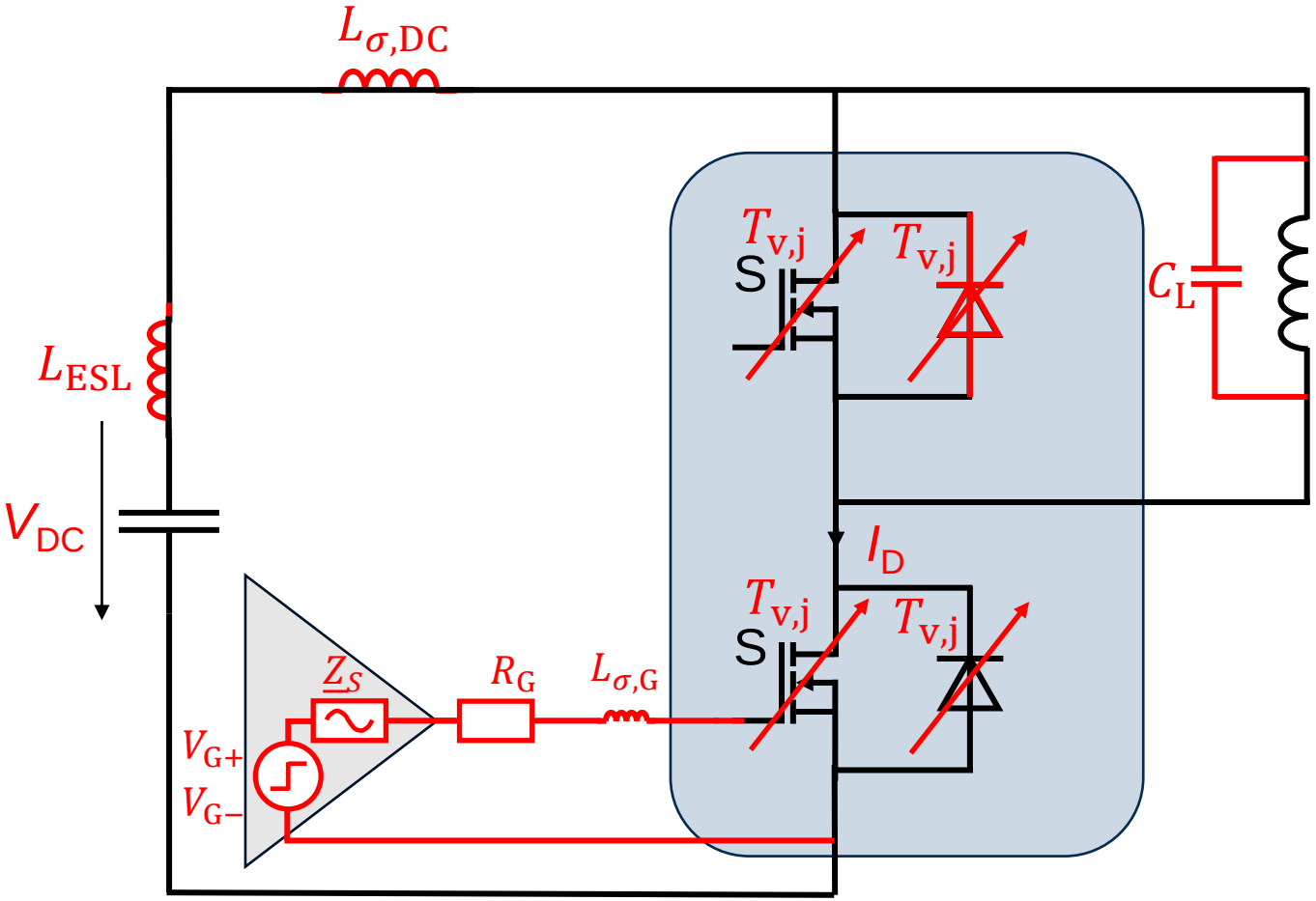
Influencing Factors



1. Stray capacitance load inductor C_{L}
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9. Load current I_{D}
10. DC-voltage V_{DC}

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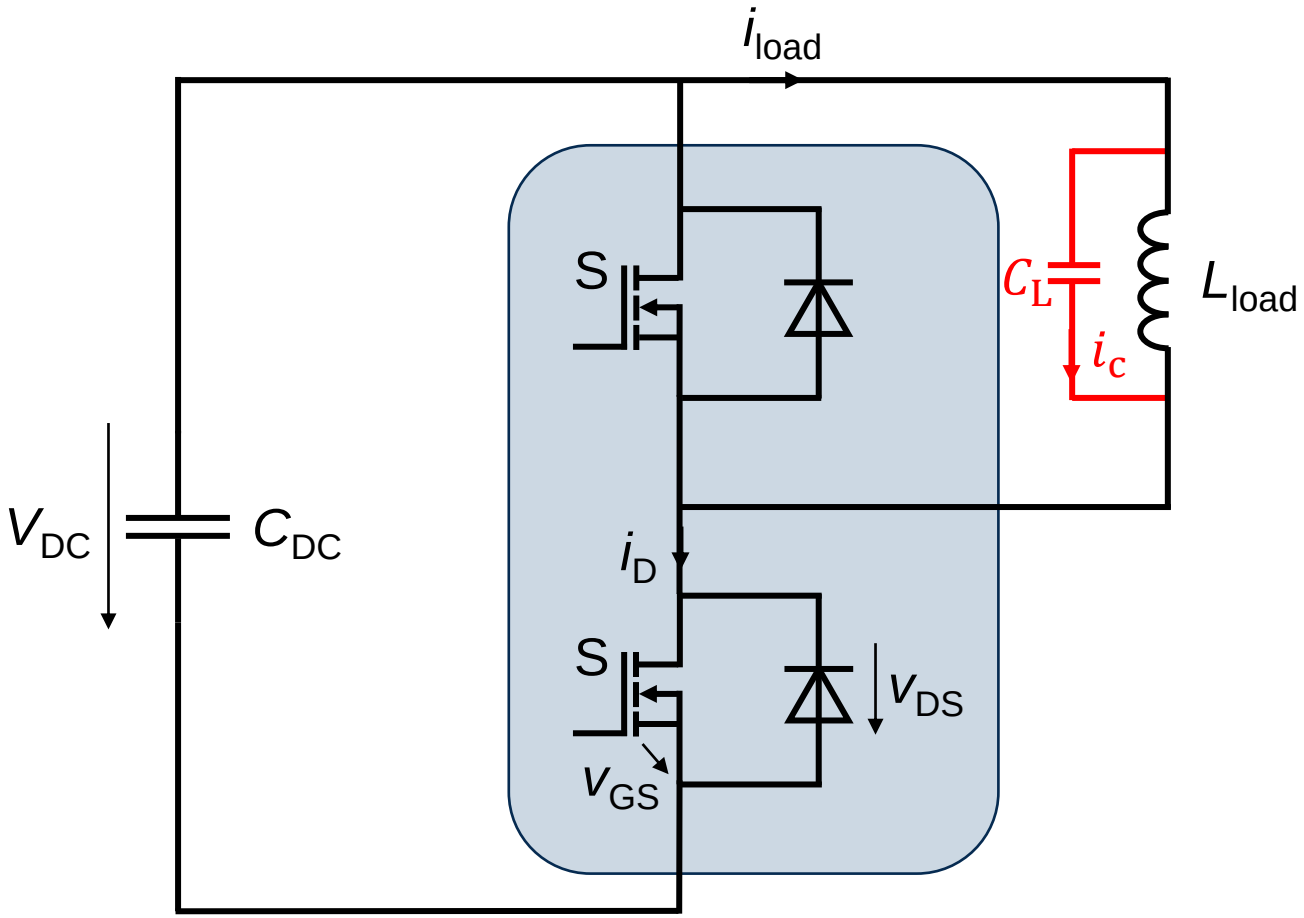
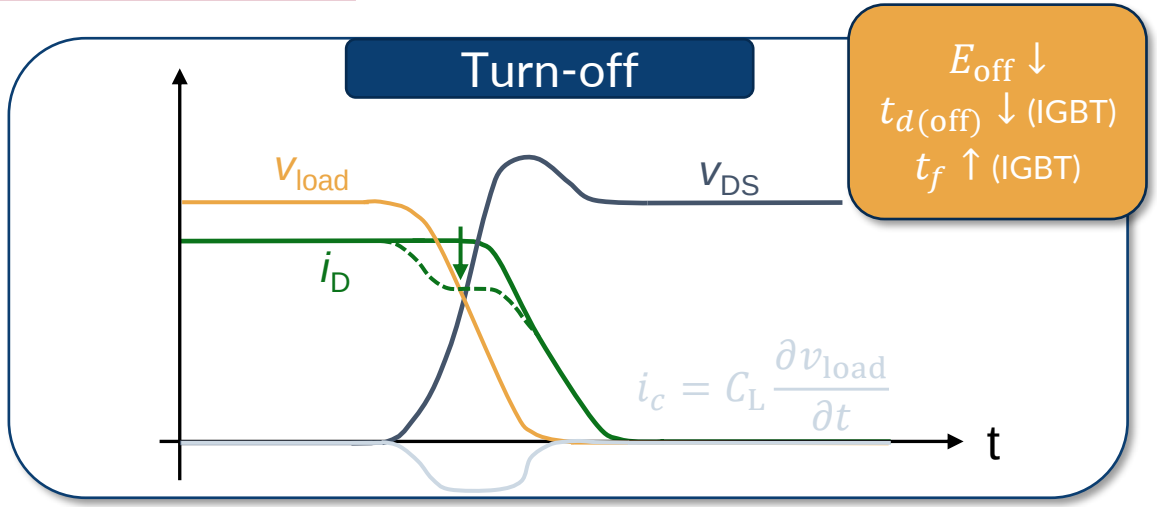
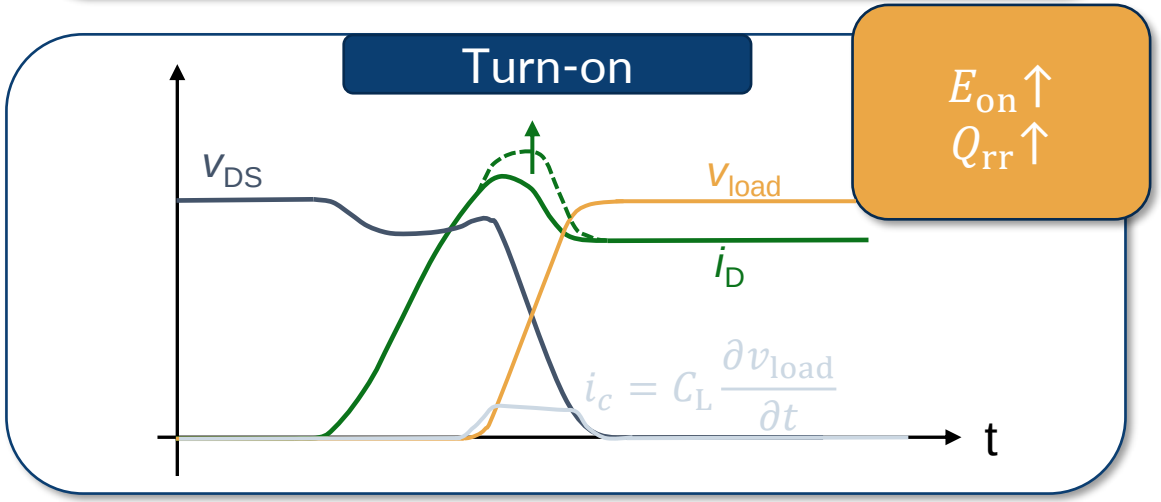
Load Inductor Stray Capacitance







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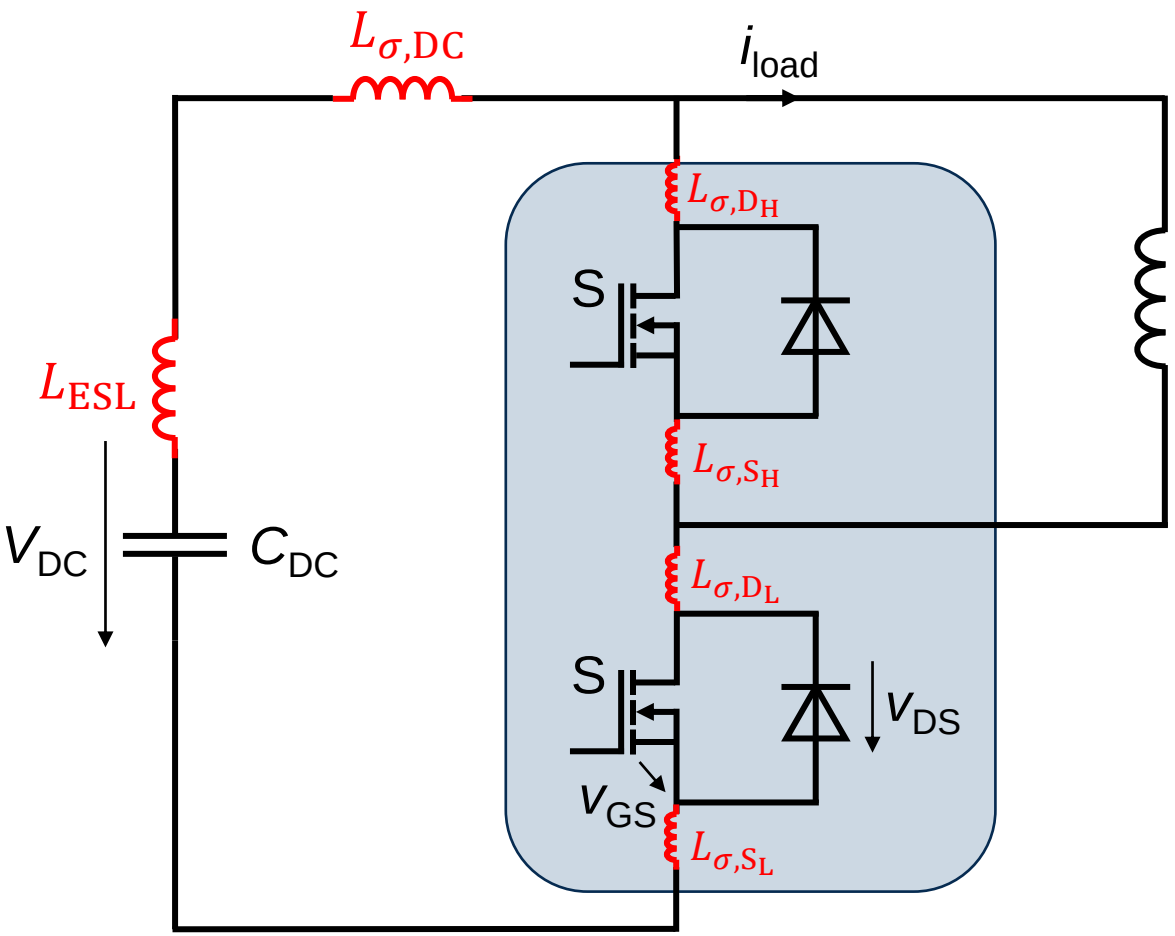
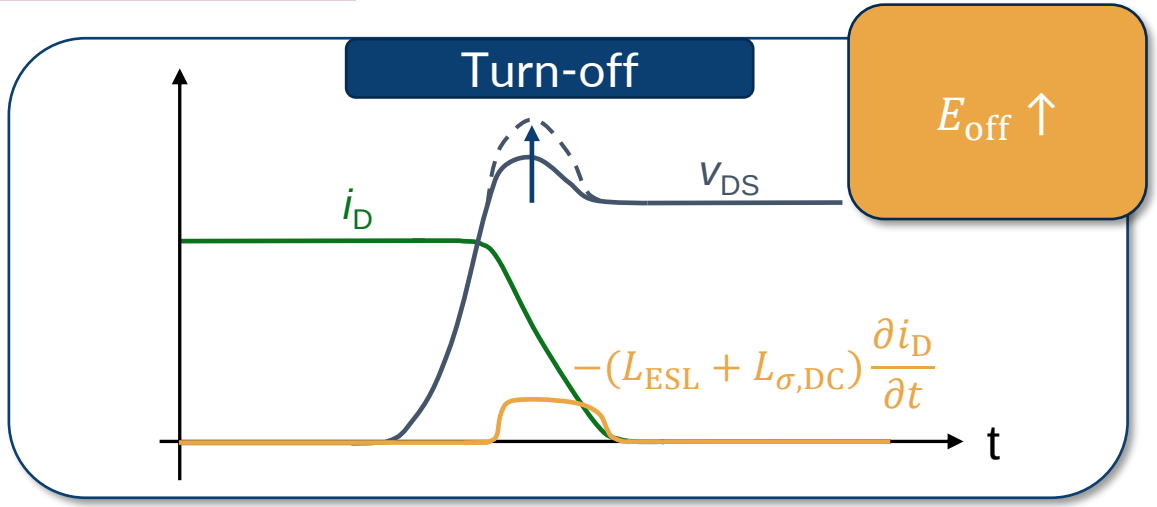
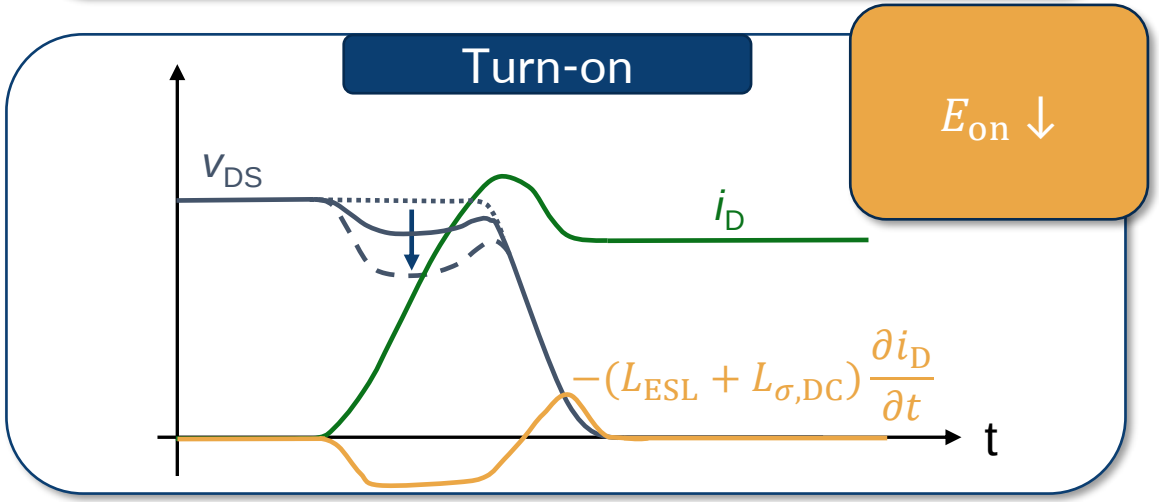
DC-Link Stray Inductance







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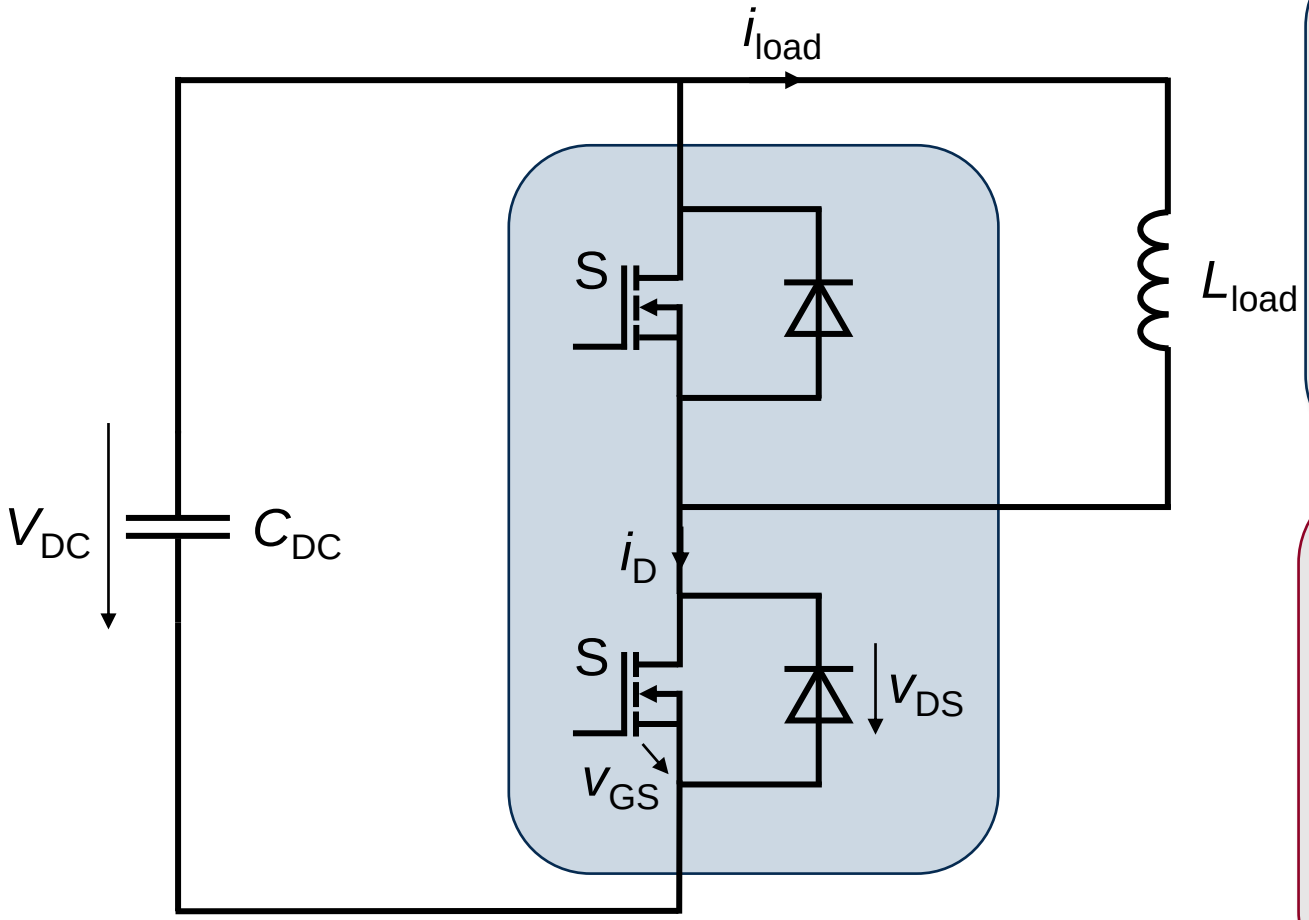
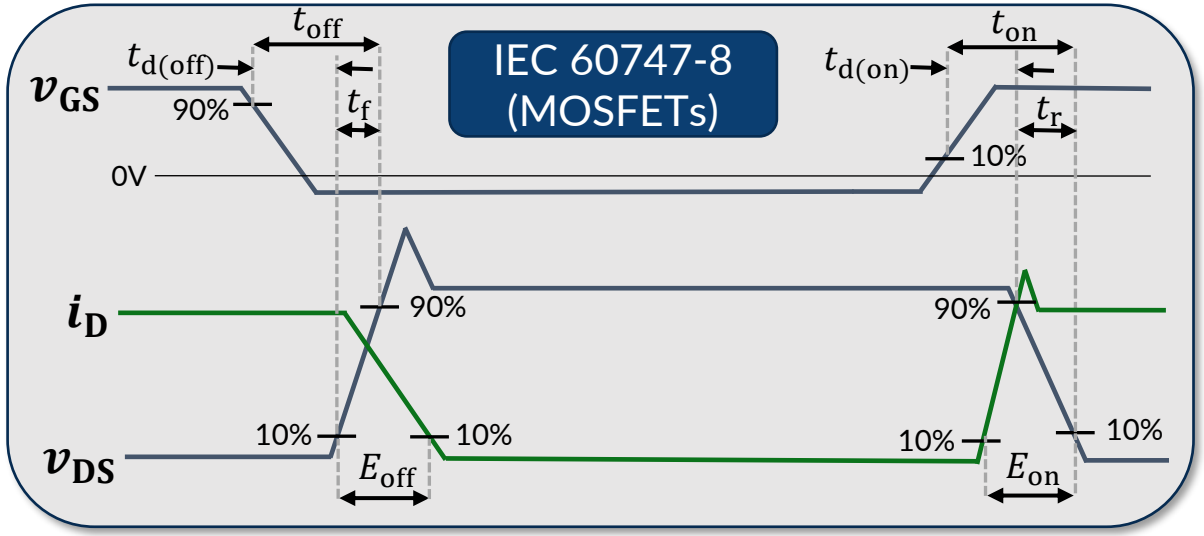
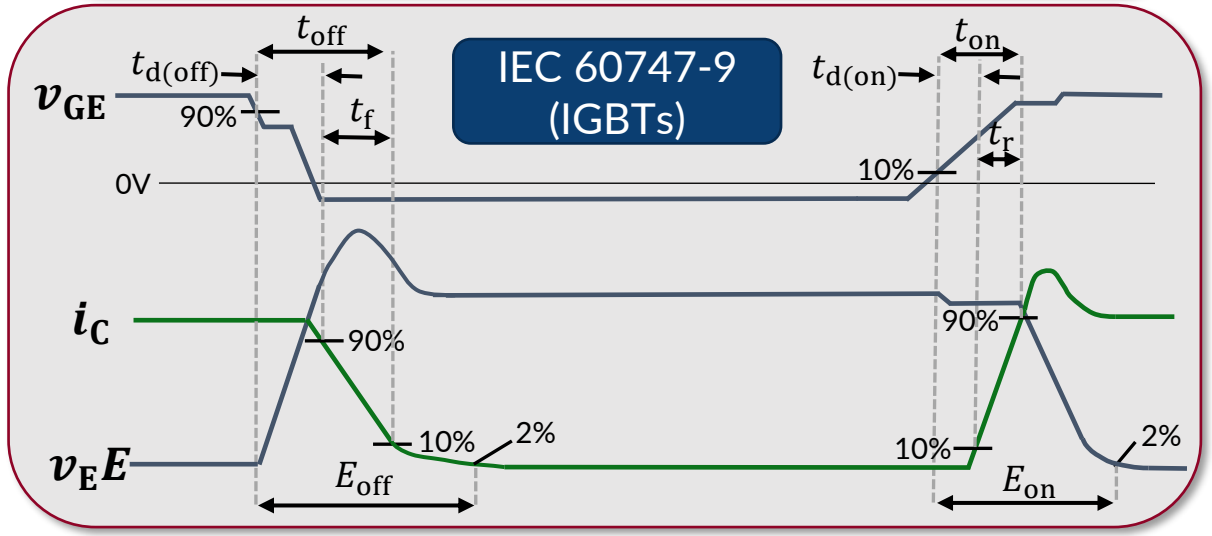
Testing of Inductive Switching - Standard







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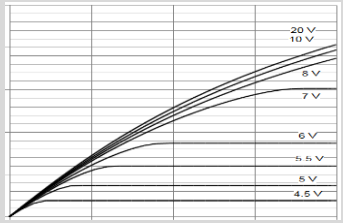
Parameters of Interest

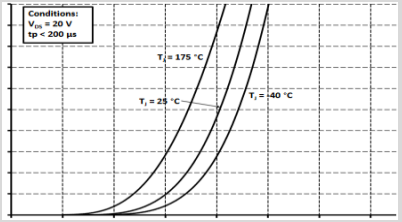
Parameter	Symbol
Turn-on energy	E_{on}
Turn-off energy	E_{off}
Turn-on delay time	$t_{d(on)}$
Turn-off delay time	$t_{d(off)}$
Rise time	t_r
Fall time	t_f
Maximum peak voltage during turn-off	U_{max}
Maximum peak current during turn-on	I_{max}
Reverse recovery charge	Q_{rr}
Reverse recovery current	I_{rr}
Reverse recovery energy	E_{rr}
Reverse recovery time	t_{rr}
Rate of change of current for turn-on and turn-off	di/dt
Rate of change of voltage for turn-on and turn-off	du/dt

Parameter	Symbol
Gate Charge	Q_g (Q_{Gate})
Short circuit collector current	$I_{C(sc)}$
DC body diode forward current	I_{SD}
Pulsed body diode current	$I_{SDpulse}$
Dynamic on resistance	R_{DSON}
Module stray inductance	L_σ

Static characteristics



Output characteristic



Transfer characteristic

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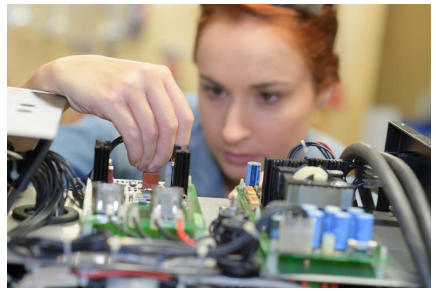
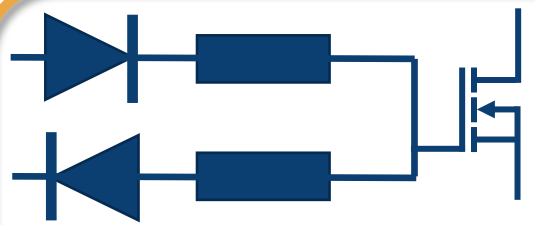
Double Pulse Test – Use Cases

Device Benchmark & Component Selection

Automatic Model Generation



System Verification



Search for Driver Settings

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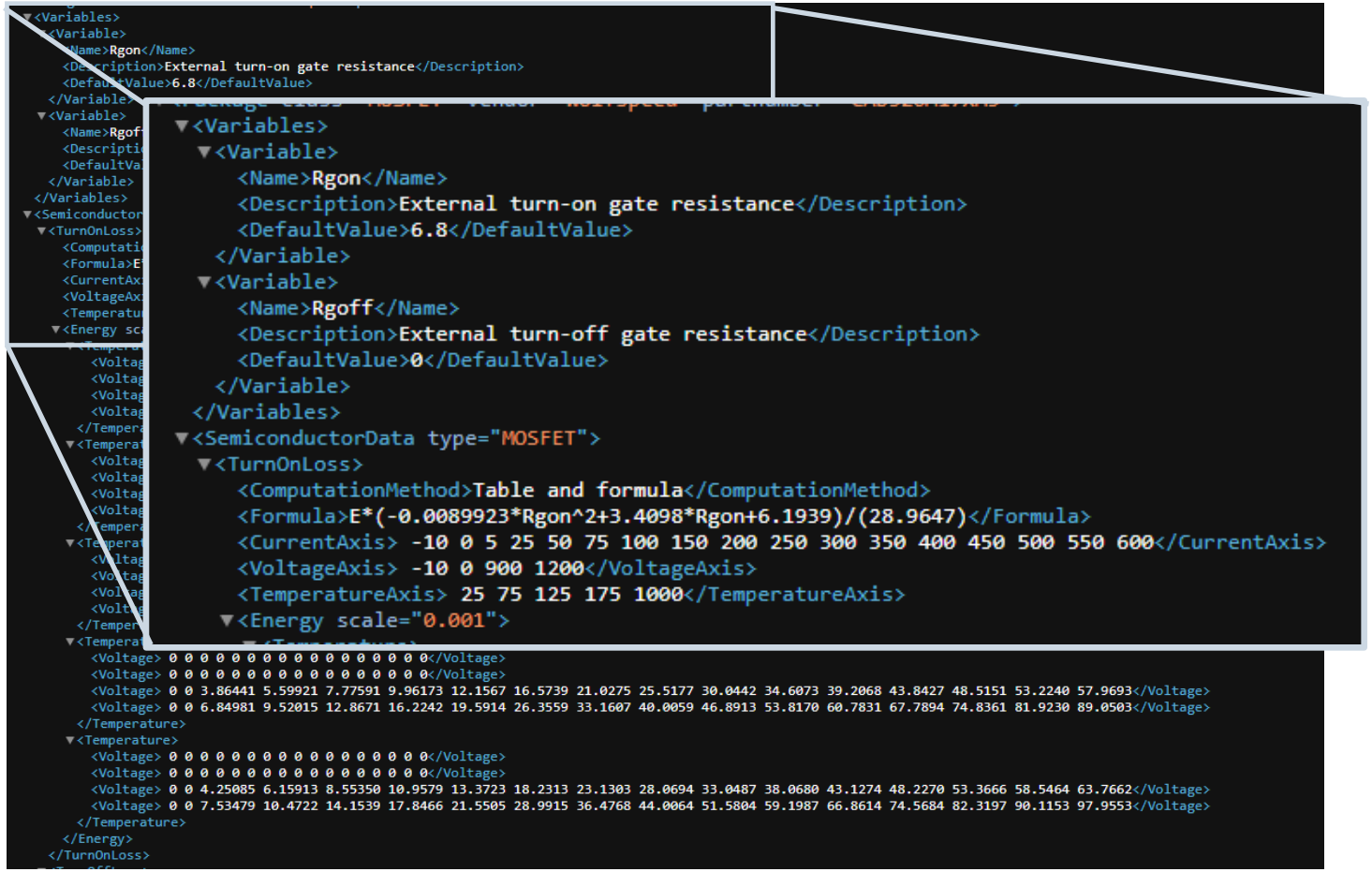
Influencing Factors



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9. Load current I_{D}
10. DC-voltage V_{DC}

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Influencing Factors

```
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  <Package class="MOSFET" vendor="UnitedSiC" partnumber="UF3C120040K4S">
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        <VoltageAxis>0 800.0</VoltageAxis>
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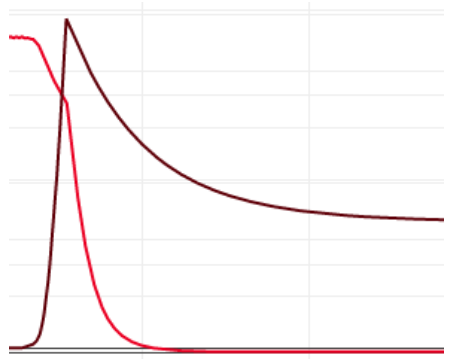
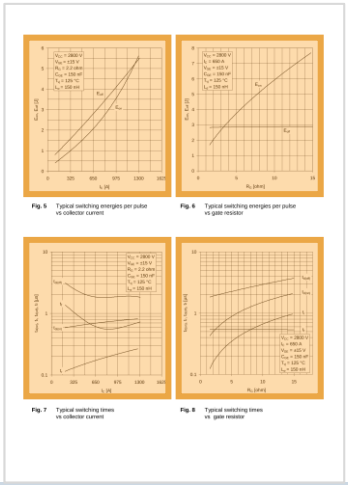
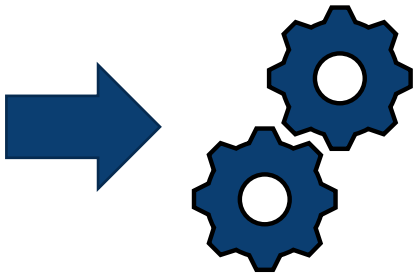
Use Case – Model Generation

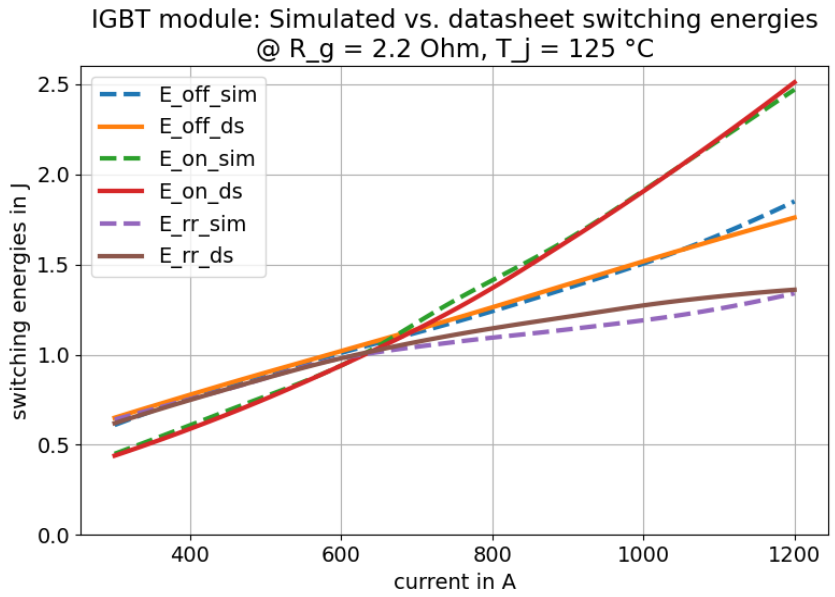
- Accurate measurements allow better device models
- Automatic generation possible
- Quality metrices can be developed and applied (accuracy information)





Static information can be obtained with DataSheetVision





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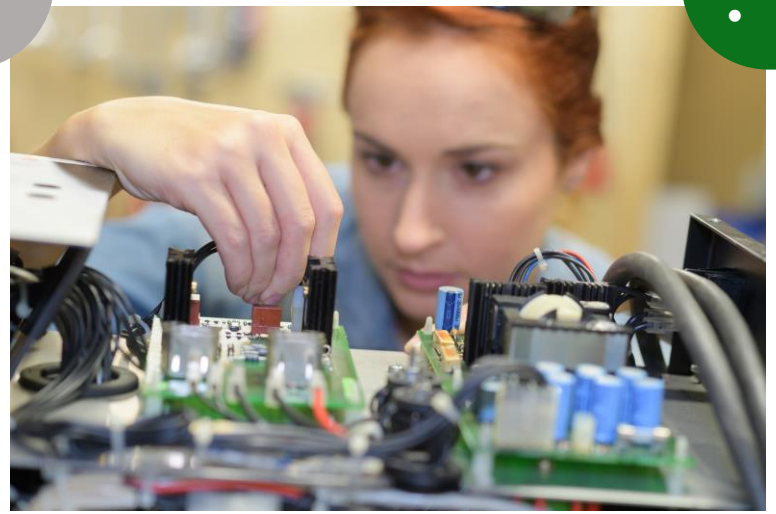
Use Case – Design Verification

- Measurements on real setup for verification purposes
- Allow further optimization but in the region of model uncertainty
- Close of “control loop” points out shortcomings in modelling
- Shortcomings can be adressed and models become better



- For design of controller’s circuit simulations are quite simple (ideal switch and look-up table)
- The commonly used look-up tables described in XML files can be generated according to operation parameters
- Improved accuracy

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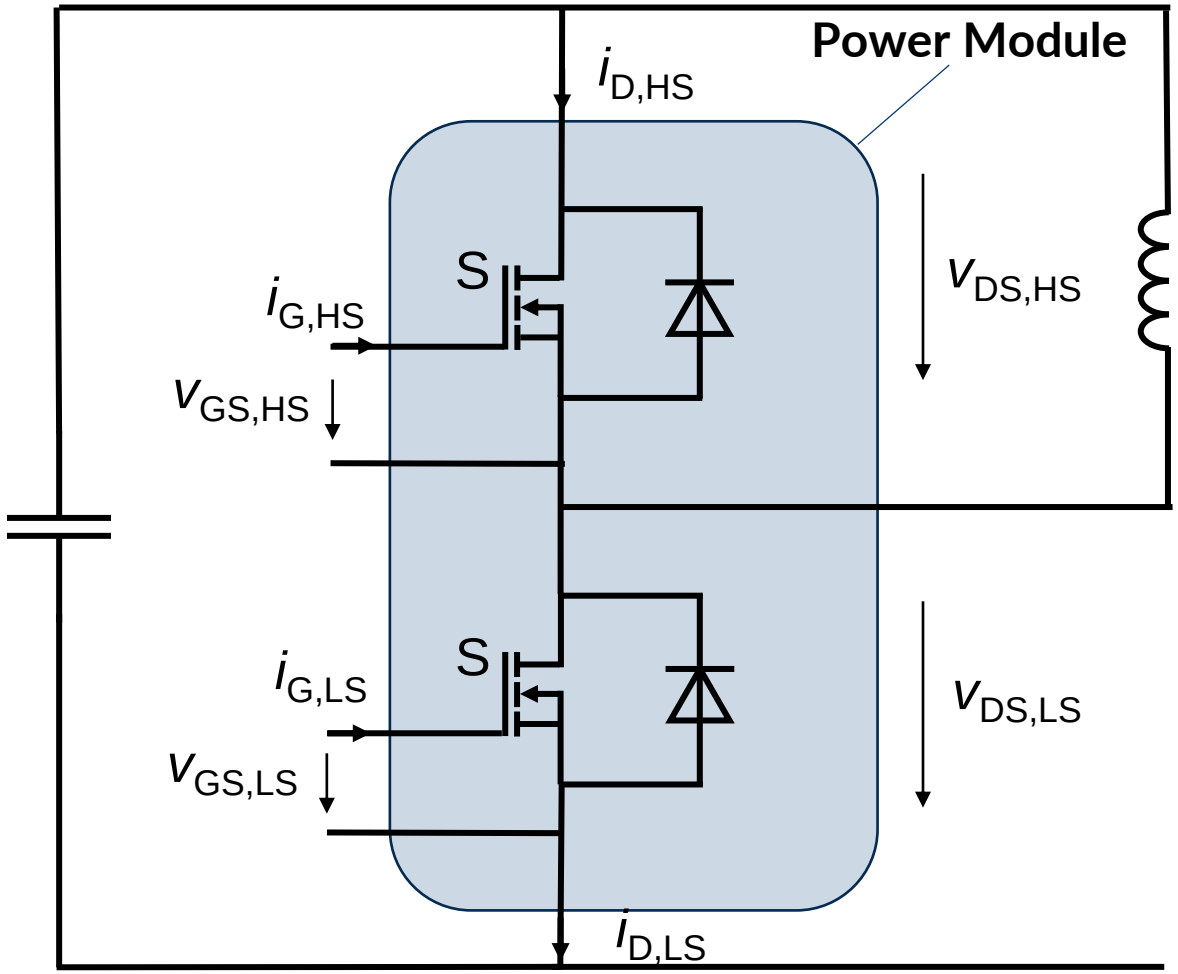
Measurement equipment



MXO5

MXO4

RTO6

one or two

All with B6 Option

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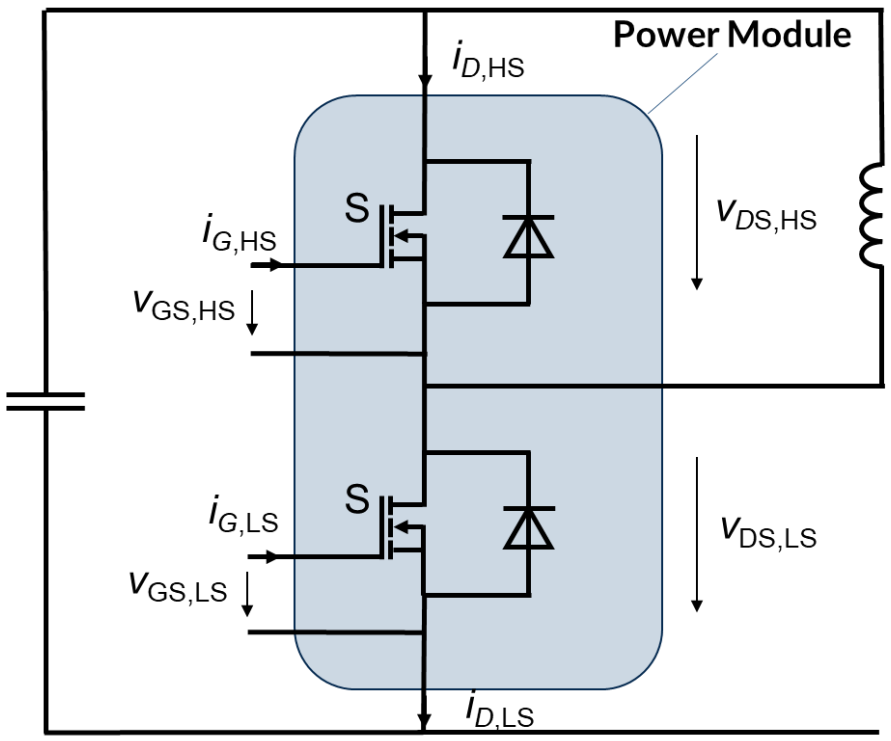
Probing



Signal	Probe
$v_{GS,HS}$	ZHD
$i_{G,HS}$	Rogowski / Infinity Sensor / Shunt + ZHD
$v_{DS,HS}$	ZHD
$i_{D,HS}$	Rogowski / Shunt + ZHD
$v_{GS,LS}$	ZD10 / Any passive
$i_{G,LS}$	ZD10 + Shunt
$v_{DS,LS}$	ZH10/11
$i_{D,LS}$	Rogowski / Infinity Sensor / Shunt + ZD10

Further options possible
Selection depends on DUT (configuration and performance)

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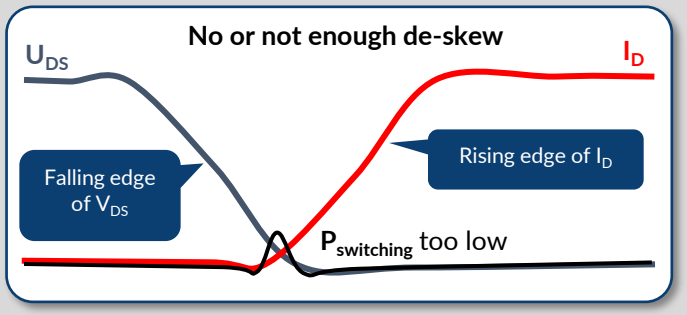
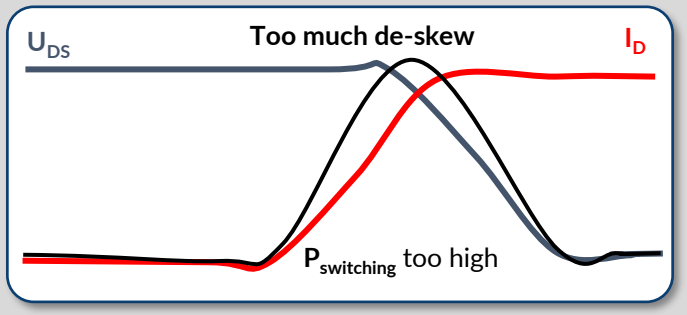
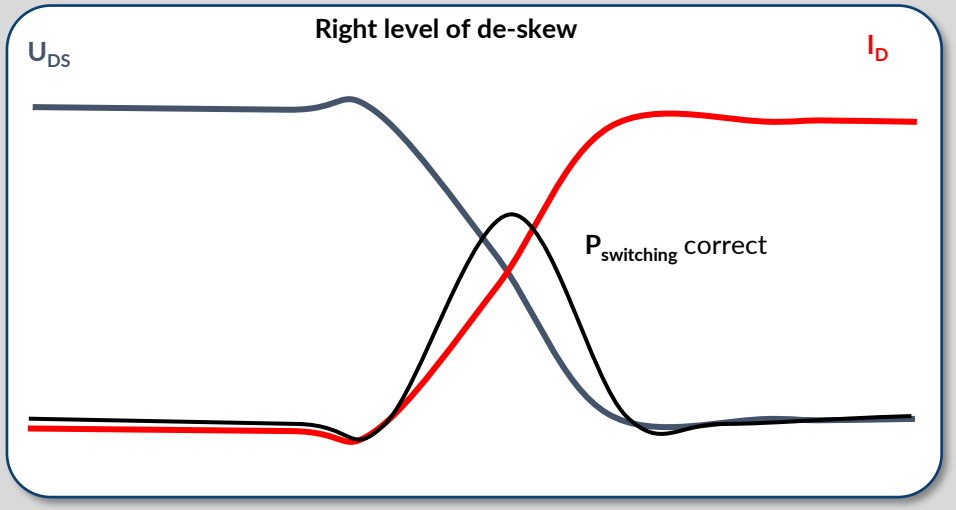
Automatic De-Skew

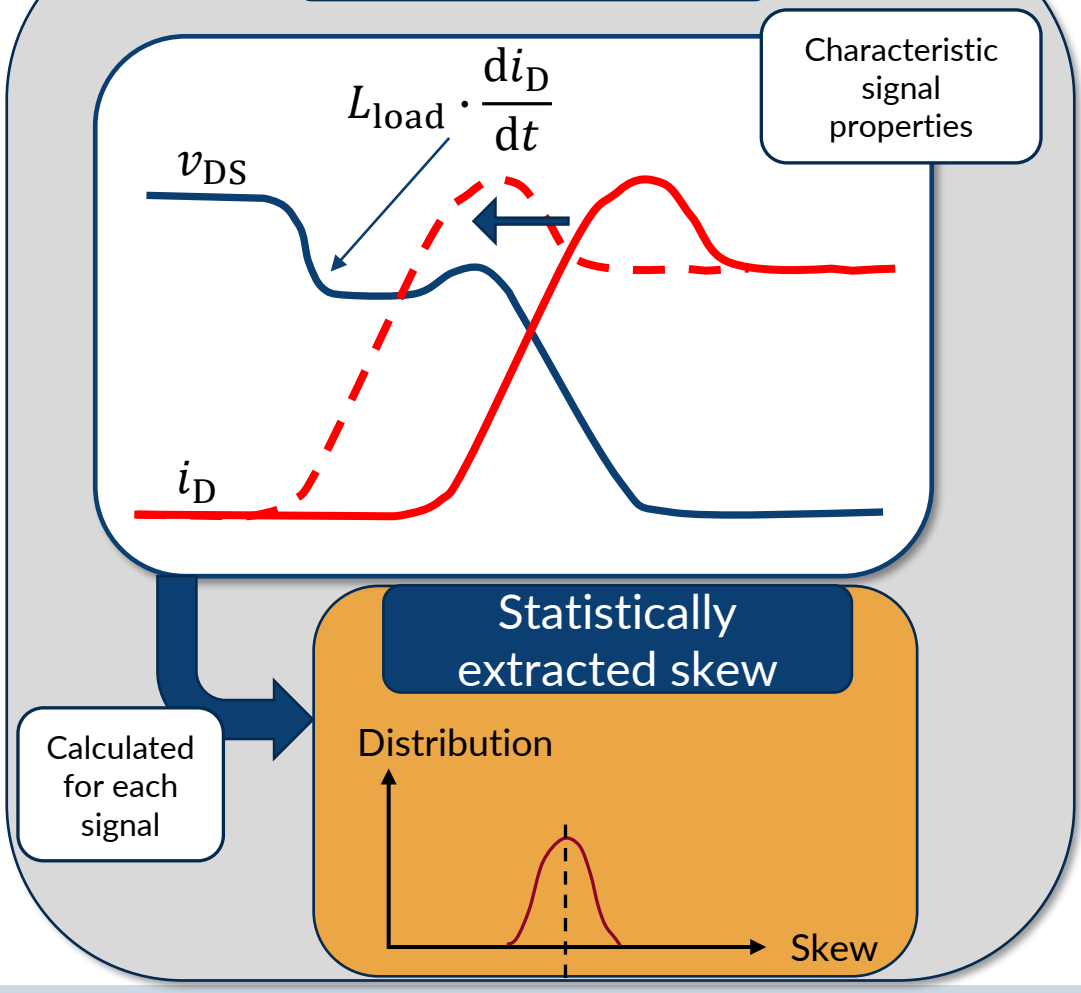
De-skew issue







Automatic de-skew



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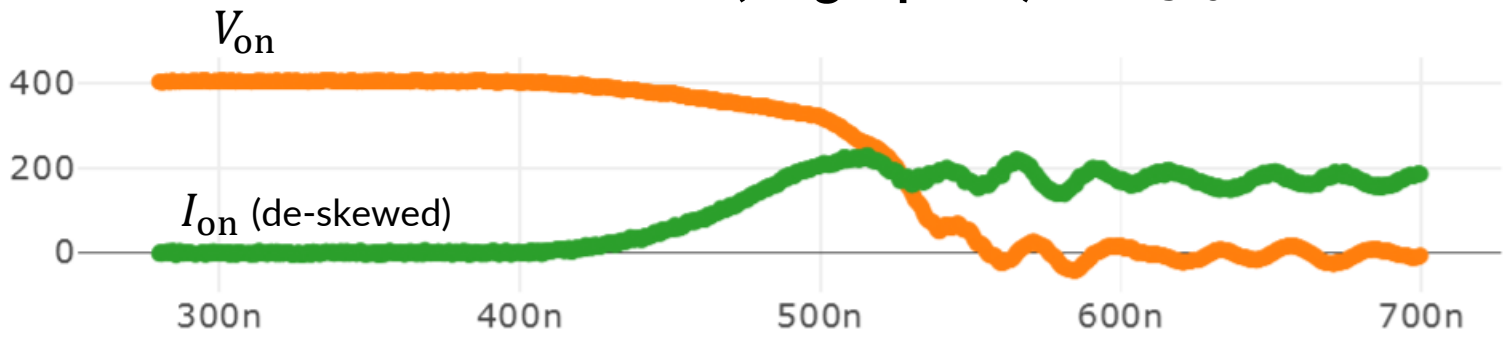
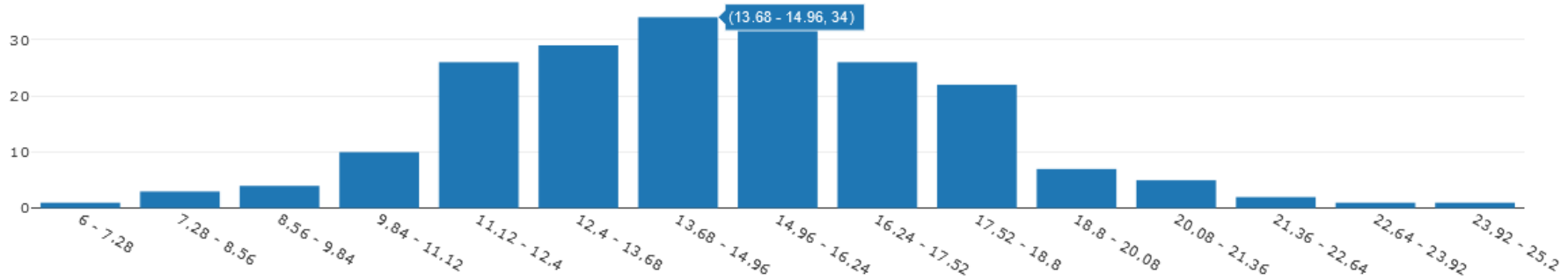
Automatic De-Skew Realization

Result (single point): Δt_{skew}: 13.4 ns



Statistic de-skew: Δt_{skew}: 14.92 ns



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Summary

Key Take-aways

1) Measurements will help you speed up and improve your design process

2) Measurements lead to a more solid design with less uncertainty

3) Measurement automation can greatly reduce measurement effort

Outlook

- Accurate data & models allow to use simulations for model synthesis

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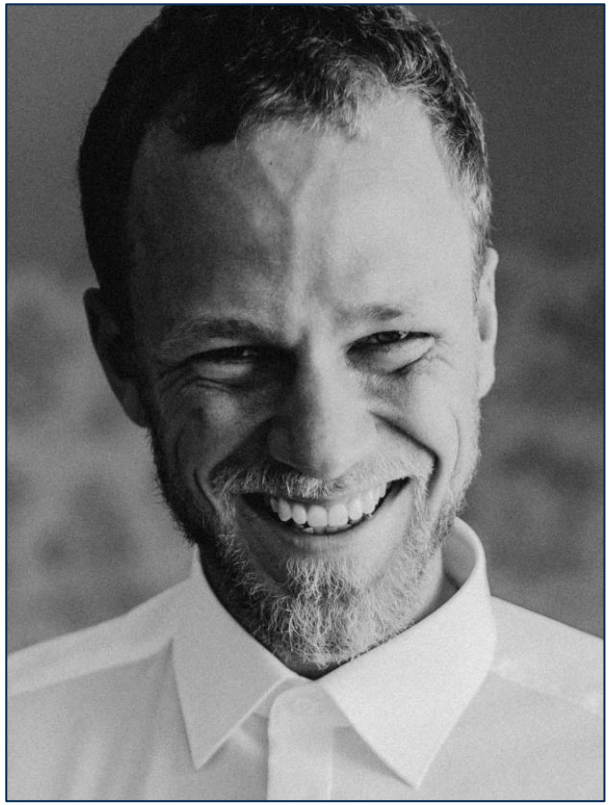
Contact



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