Discrete solution in HA

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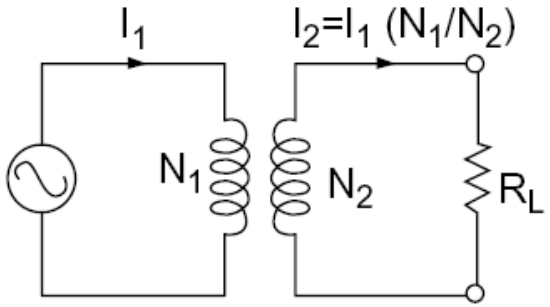
IFCN IPC SMD AP AE

Never stop thinking

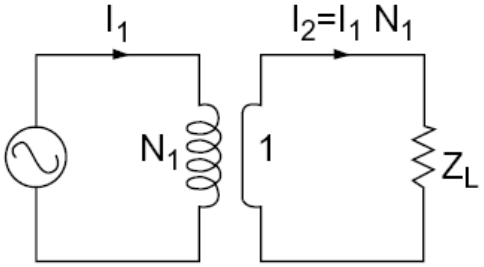
- **Induction heating application**
  - Single-end Quasi-resonant Type Converter
  - Half-bridge Series Resonant Type
- **Microwave oven**
- **Inverter home appliance**

Induction Heating Basics

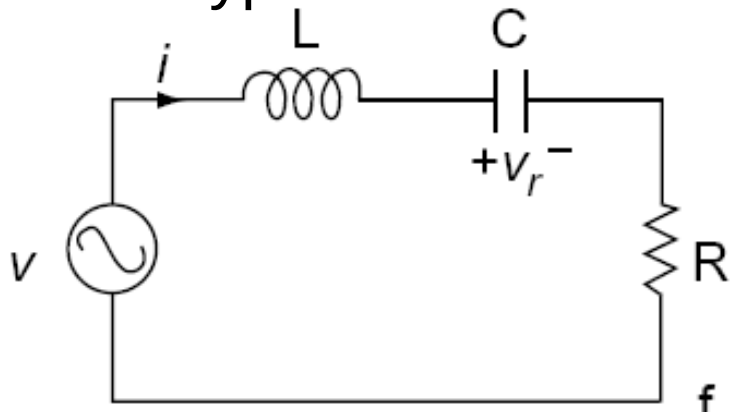
- Equivalent circuit of transformer



- Equivalent circuit of IH cooker →secondary shorted

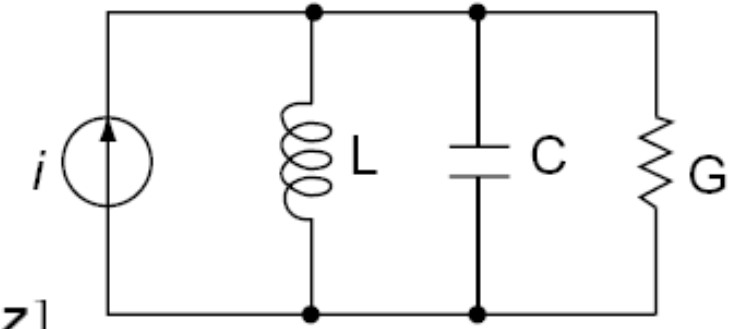


- Two Types of Resonant Converter



$$f_o = \frac{1}{2\pi\sqrt{LC}}[\text{Hz}]$$

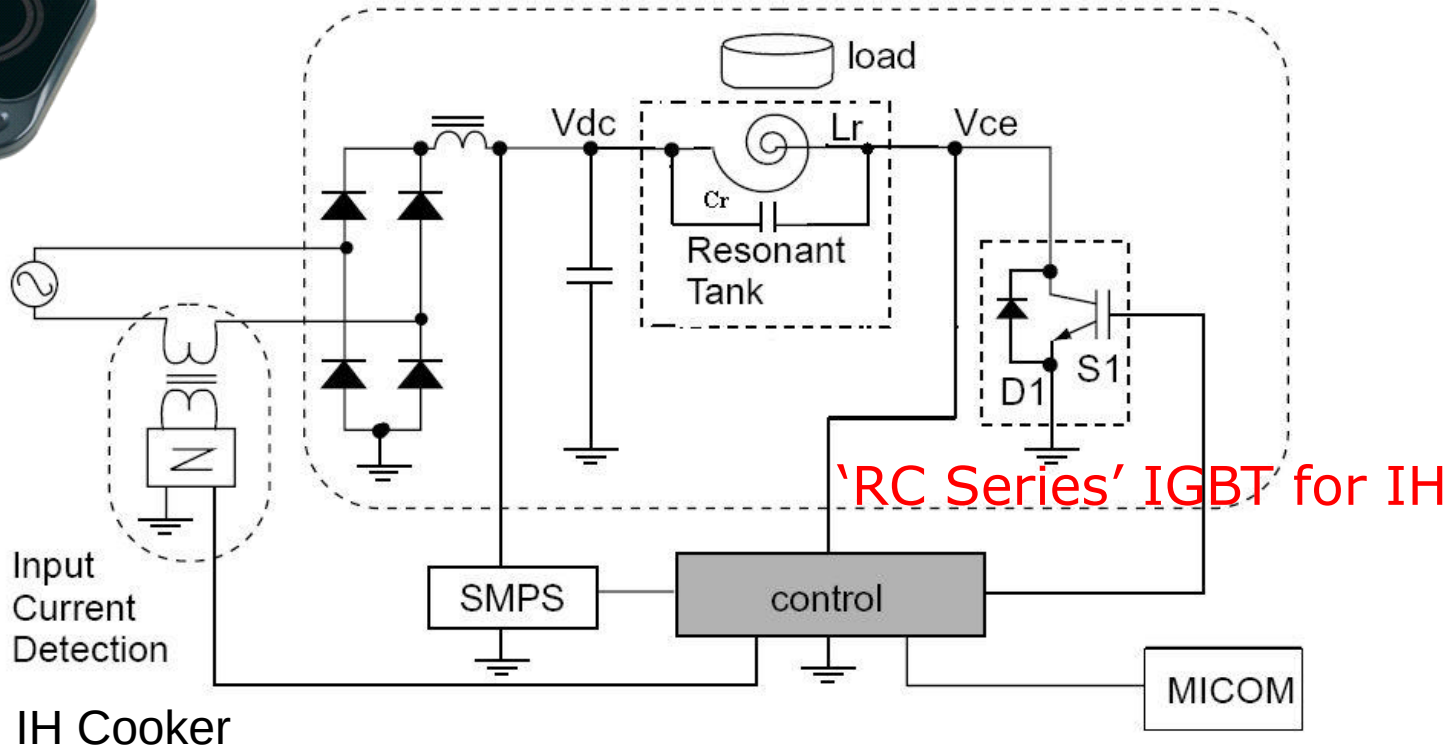
(a) Series resonant



(b) Parallel resonant

Quasi-resonant Type Converter

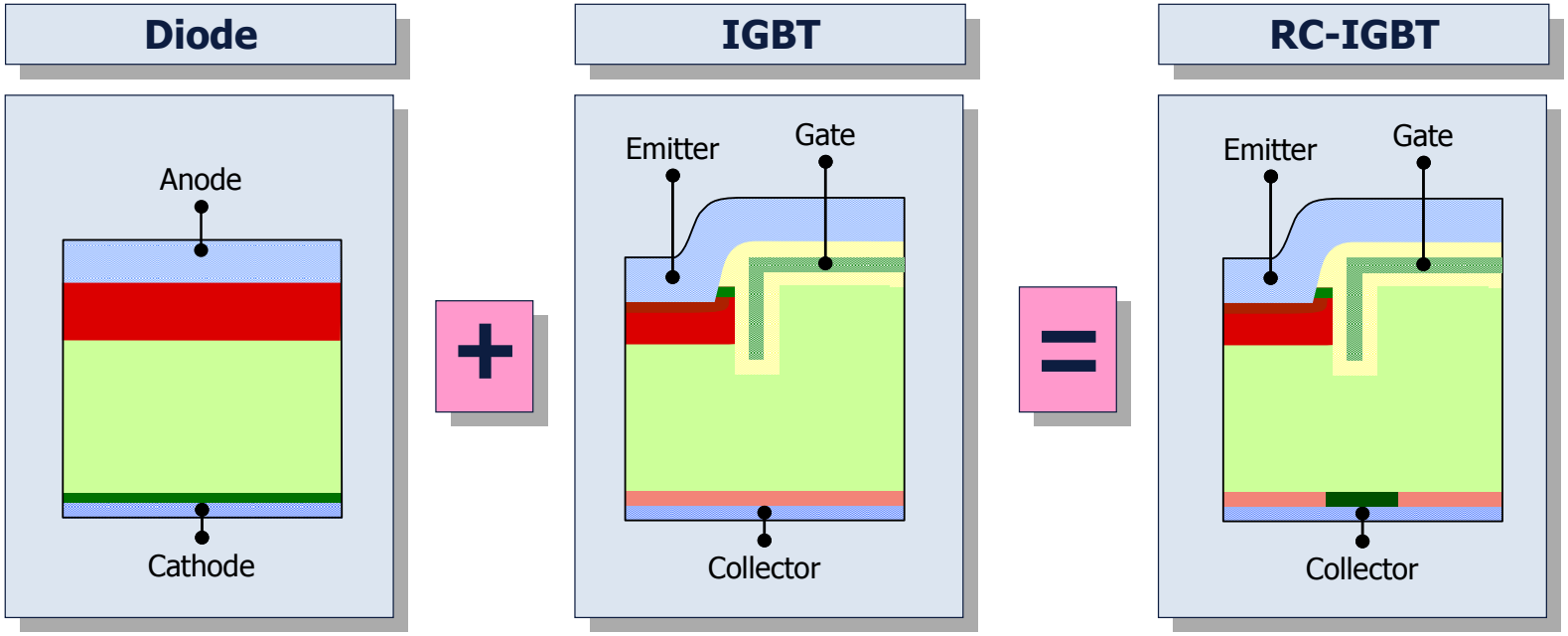
- Single-end Quasi-resonant converter main circuit



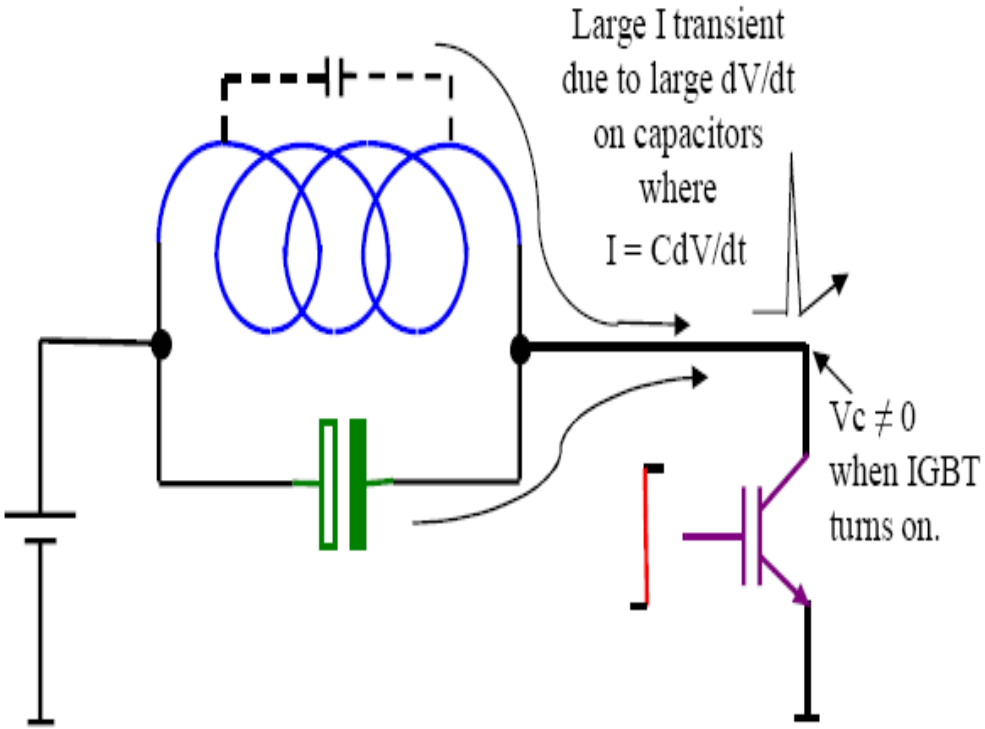
- Single-ended IH Cooker
  - Quasi-resonant Converter
  - Low Cost Solution

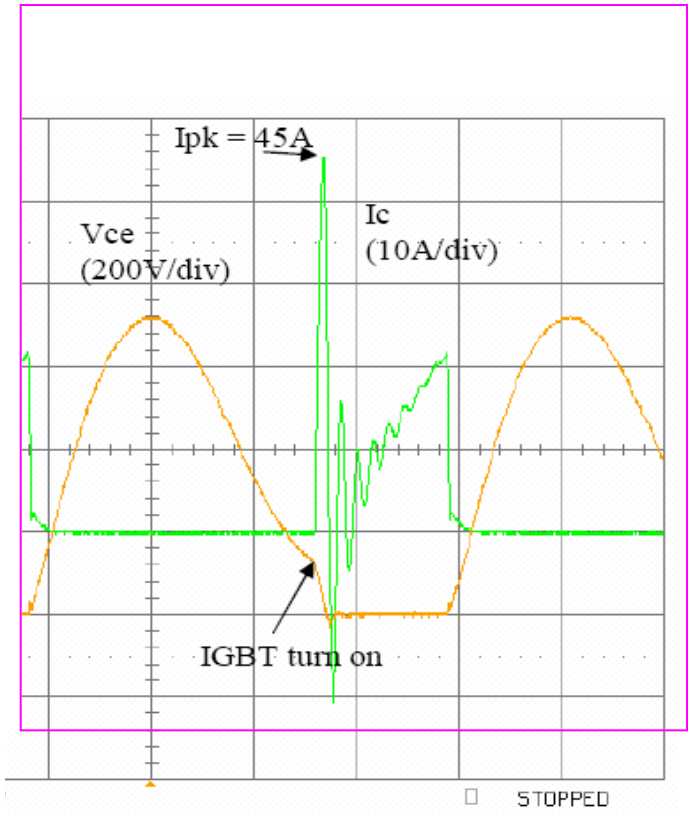
RC3-IGBT - The Monolithic Solution of IGBT & Diode

- The RC3 is based on the latest technology of TrenchStop™ IGBT. In addition the **R**everse **C**onducting diode is integrated into the IGBT.
- Your Benefit is an tailor-made single solution just optimized for **I**nduction **H**eating (**IH**). This improves the performance and reduces the losses even more than previous generations.



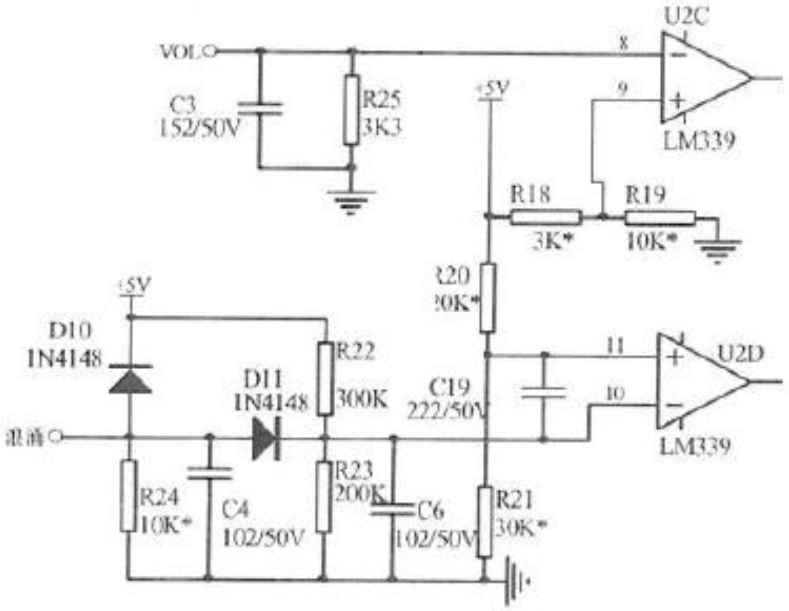
Device Stress During Operation

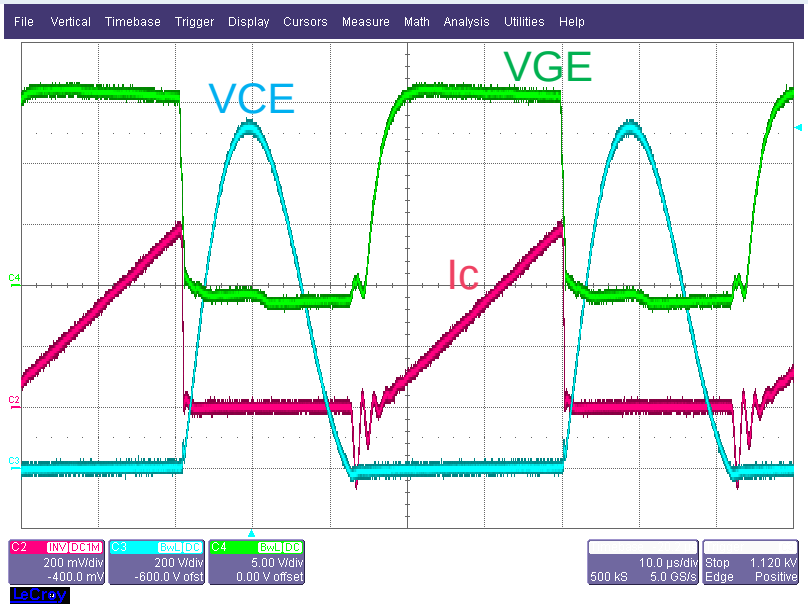




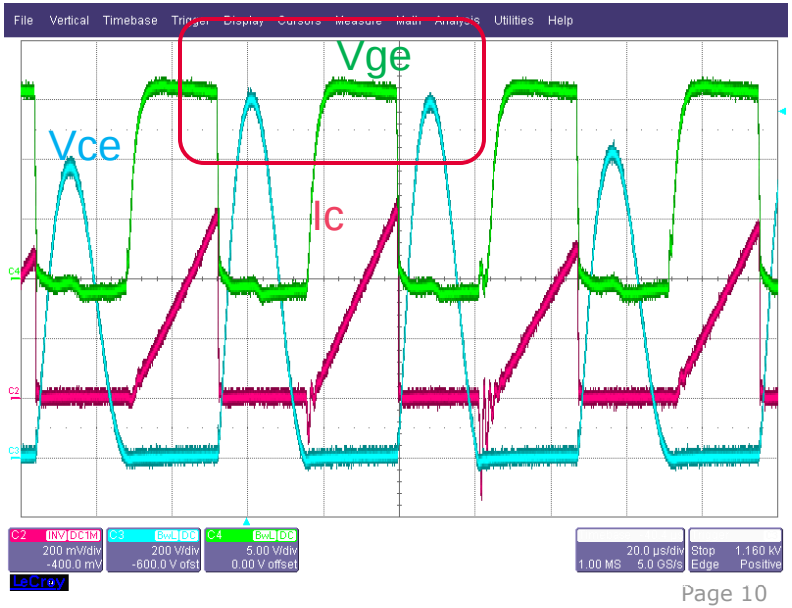
Device Stress During Operation

- High Power Operation Stage



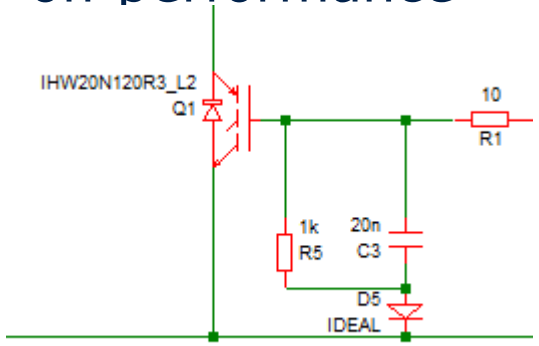


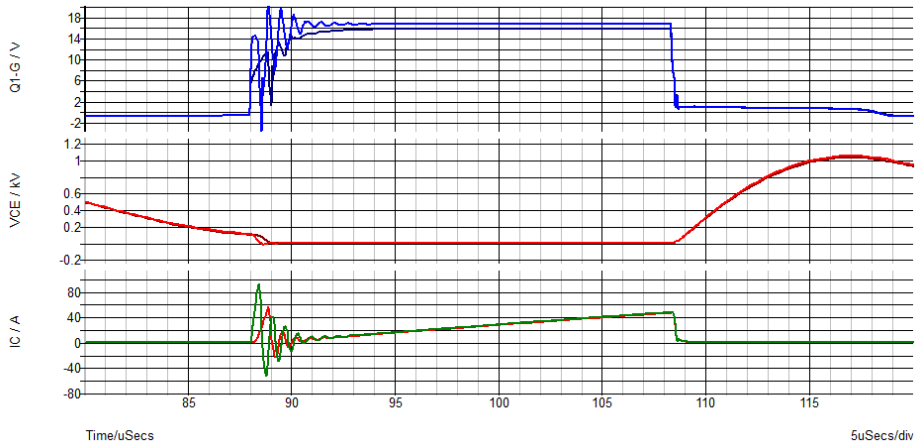
- Operation Stage When Surge Happen



New patented peak pulse reduction

- Reducing the turn-on time without loosing turn-off performance



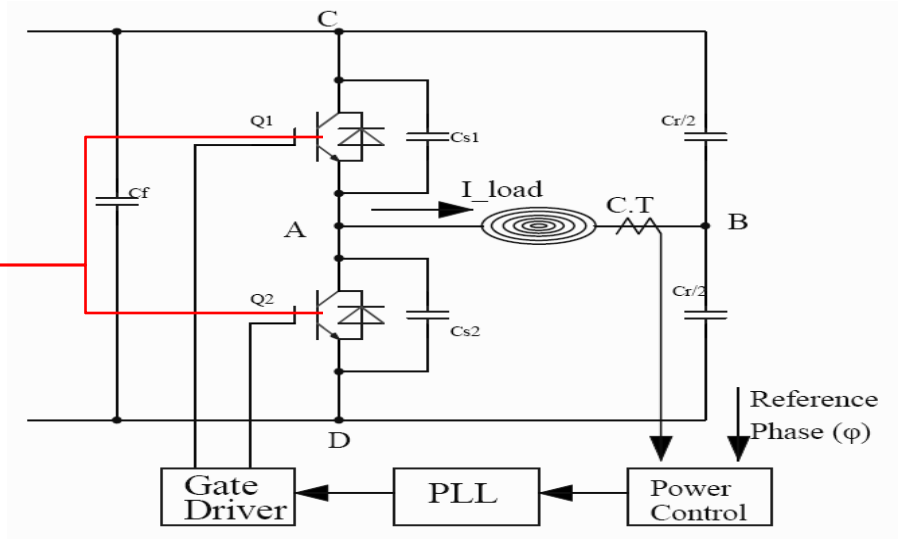


- **Induction heating application**
  - Single-end Quasi-resonant Type Converter
  - Half-bridge Series Resonant Type
- **Microwave oven**
- **Inverter home appliance**

Half-bridge Series Resonant Type

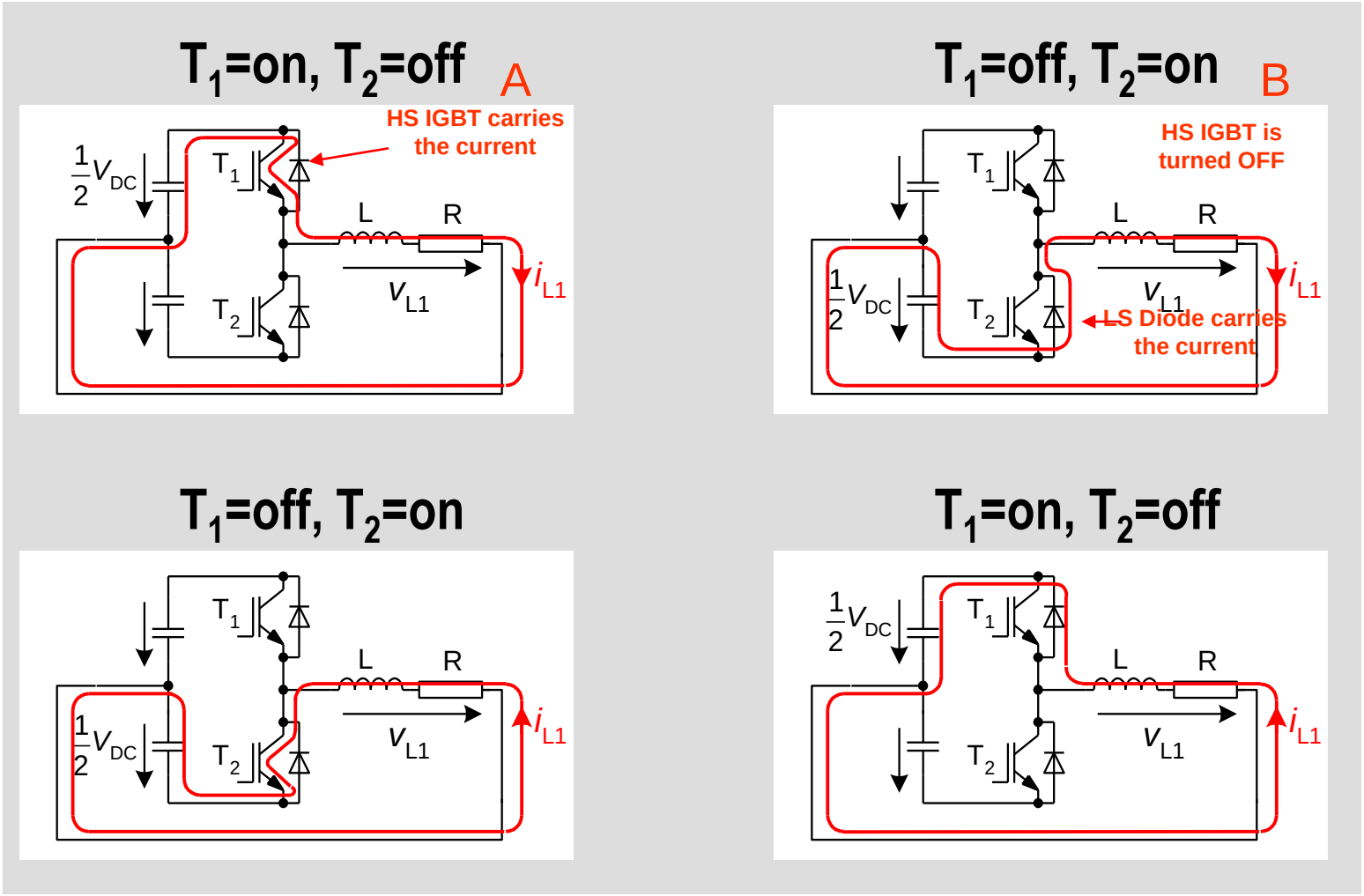
- Circuit Topology → Half-bridge Series Resonant Type
- Operating Mode → Inductive Mode
- Power Device: Discrete IGBT

hard” or “soft” switching



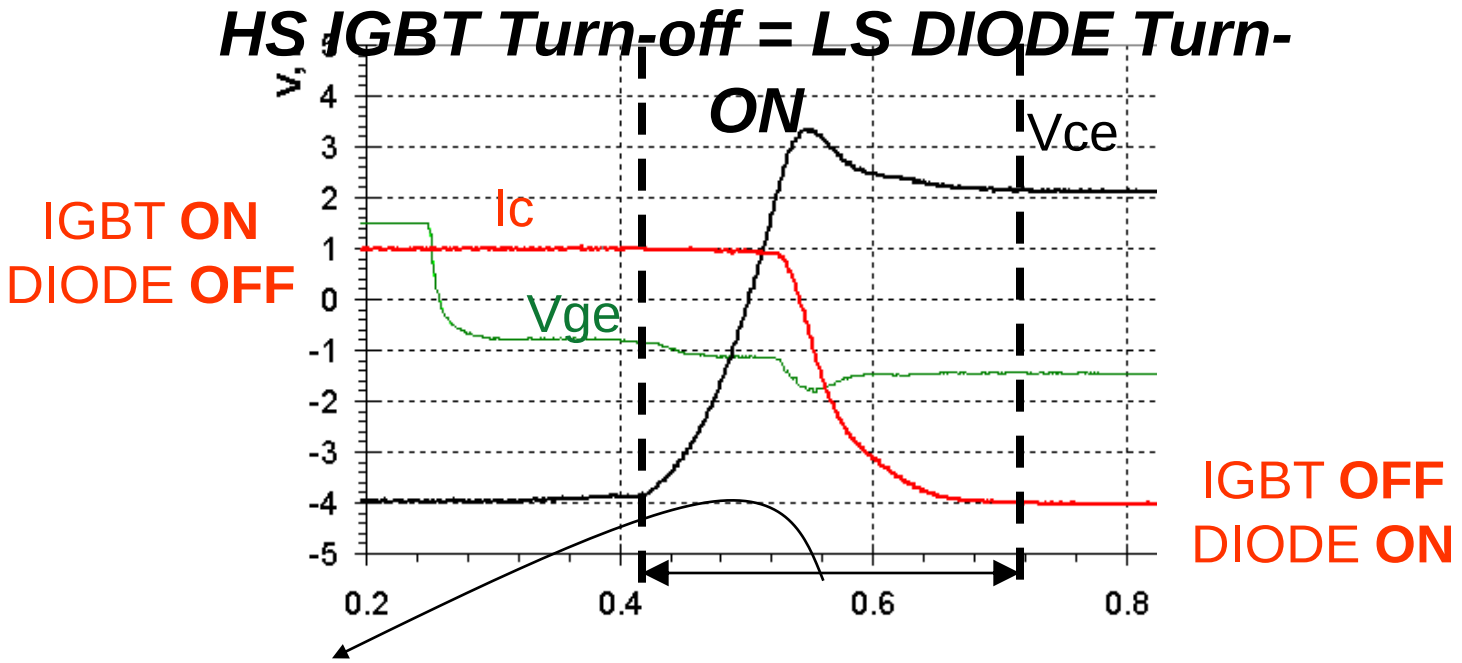
Example of Hard Switching – Inductive Load

- Switching pattern of Half Bridge Circuit with **Inductive Load,** typical in **Motor Drive**



Example of Hard Switching – Inductive Load

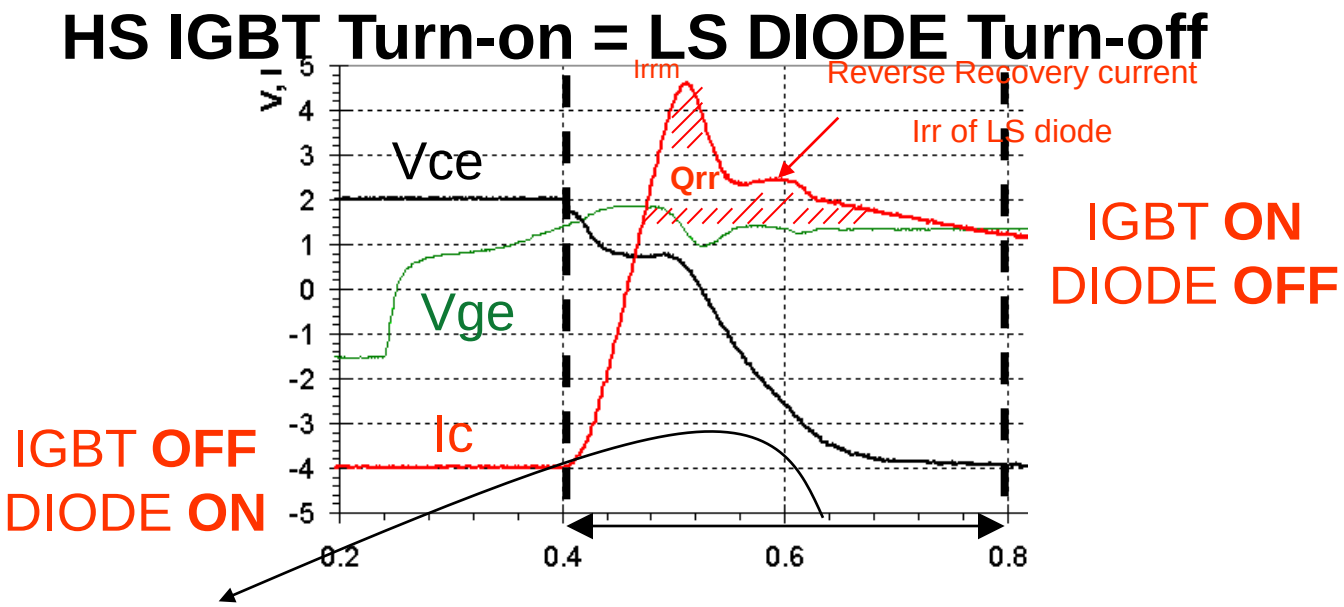
- What happens in the transition from **A** to **B** ?
- The current has to be commutated from the IGBT to the Diode => IGBT Turns OFF and Diode Turns ON.



- In this interval V **and** I are > 0 ➔ there is a power loss P=V x I in the IGBT.
- Large dI/dt and dV/dt are preferred to reduce power loss ➔ EMI issues

Example of Hard Switching – Inductive Load

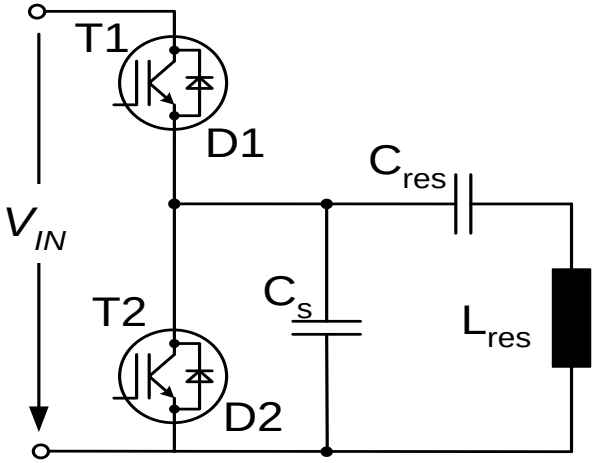
- What happens in the transition from **B** to **A** ?
- The current has to be commutated from the Diode to the IGBT => Diode Turns OFF and IGBT Turns ON.



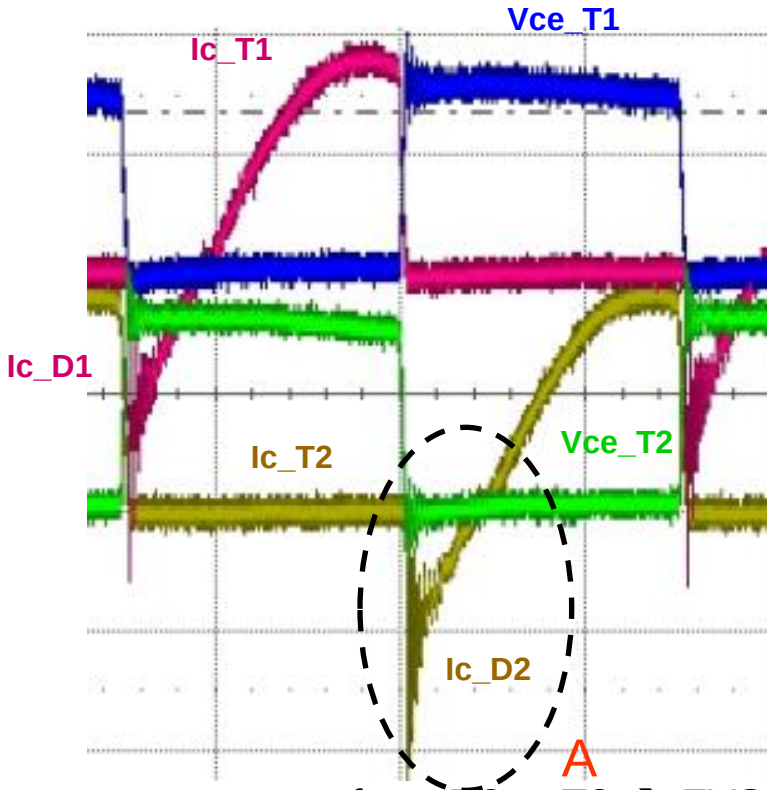
- In this interval V **and** I are > 0, hence there is a power loss P=V x I in the IGBT and DIODE.
- The Higher the charge Qrr the higher the power dissipated ➔ A diode with **FAST RECOVERY** (Low Qrr) IS NEEDED !!!
- Large dI/dt and dV/dt are preferred to reduce power loss ➔ EMI issues

Example of Soft Switching – Resonant Half bridge

- Half Bridge Circuit with series **LC Resonant Load,** typical in **Induction Cooking**



(from BSH Induction cooker)



- What happen to Low side switch T2 / D2:
- **A**: Diode D2 is conducting (Voltage is low), current commutates from D2 to T2 ➔ ZVS (Zero Voltage Switching) at turn-on for T2
- **The Diode MUST HAVE LOW Vf, NOT LOW Qrr !!!. Reverse Recovery can be „slow“.**

IHW Series Portfolio
600V, 1100V, 1200V, 1350V and 1600V!

Induction Cookers – MWO – Rice Cooker – Multi-function Printers

TO-247

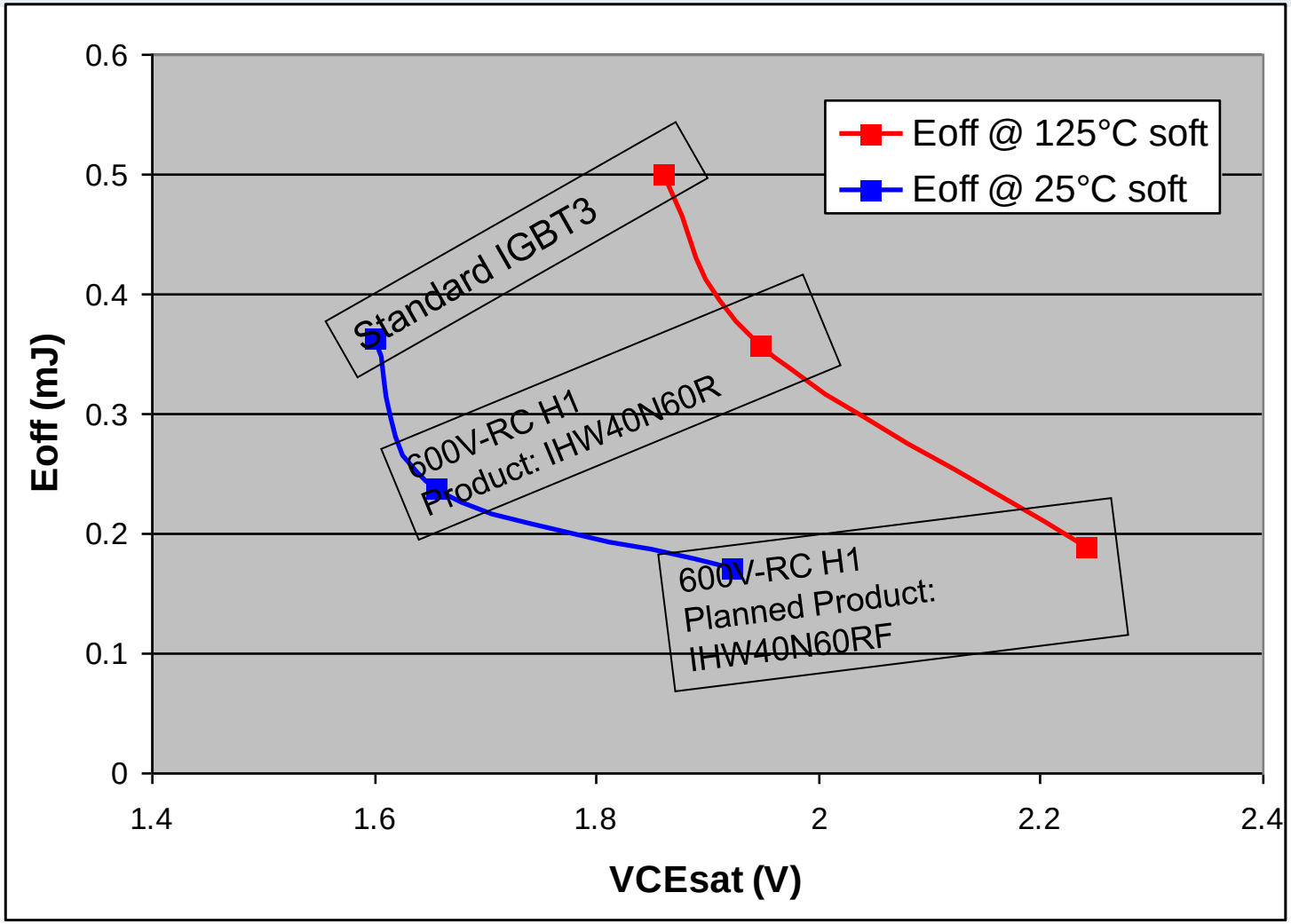
Continuous Collector current at T_C =100° C

$$T_C = T_{j\max} - V_{CEsat\max@T_{j\max}} \bullet I_{cnom} \bullet R_{thjc}$$

IGBT +Diode	600V	1100V	1200V	1350V	1600V
15A			IHW15N120R3		
20A			IHW20N120R3	IHW20N135R3	
25A			IHW25N120R2		
30A		IHW30N110R3	IHW30N120R2		IHW30N160R2
40A	IHW40N60R IHW40N60RF		IHW40T120		

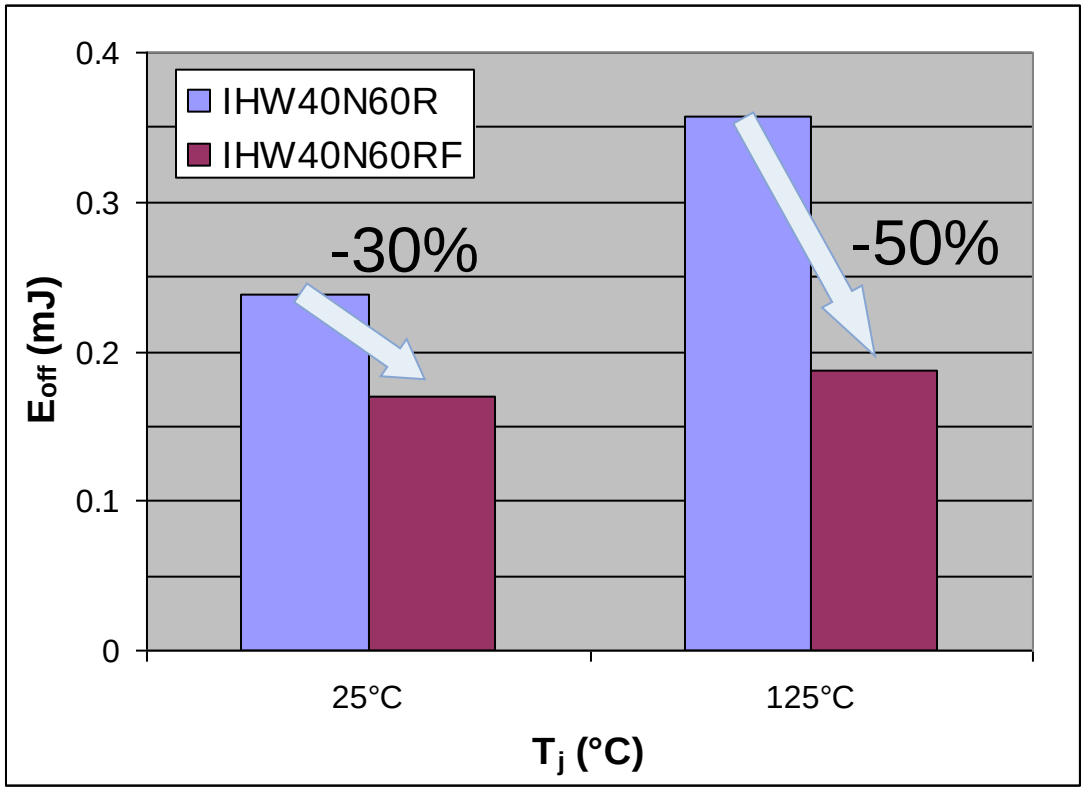
Comprehensive portfolio for all soft switching applications

Trade-off curve for soft-switching 600V IGBT3: 1kV/µs, 40A, 10 Ohm, VCE=400V



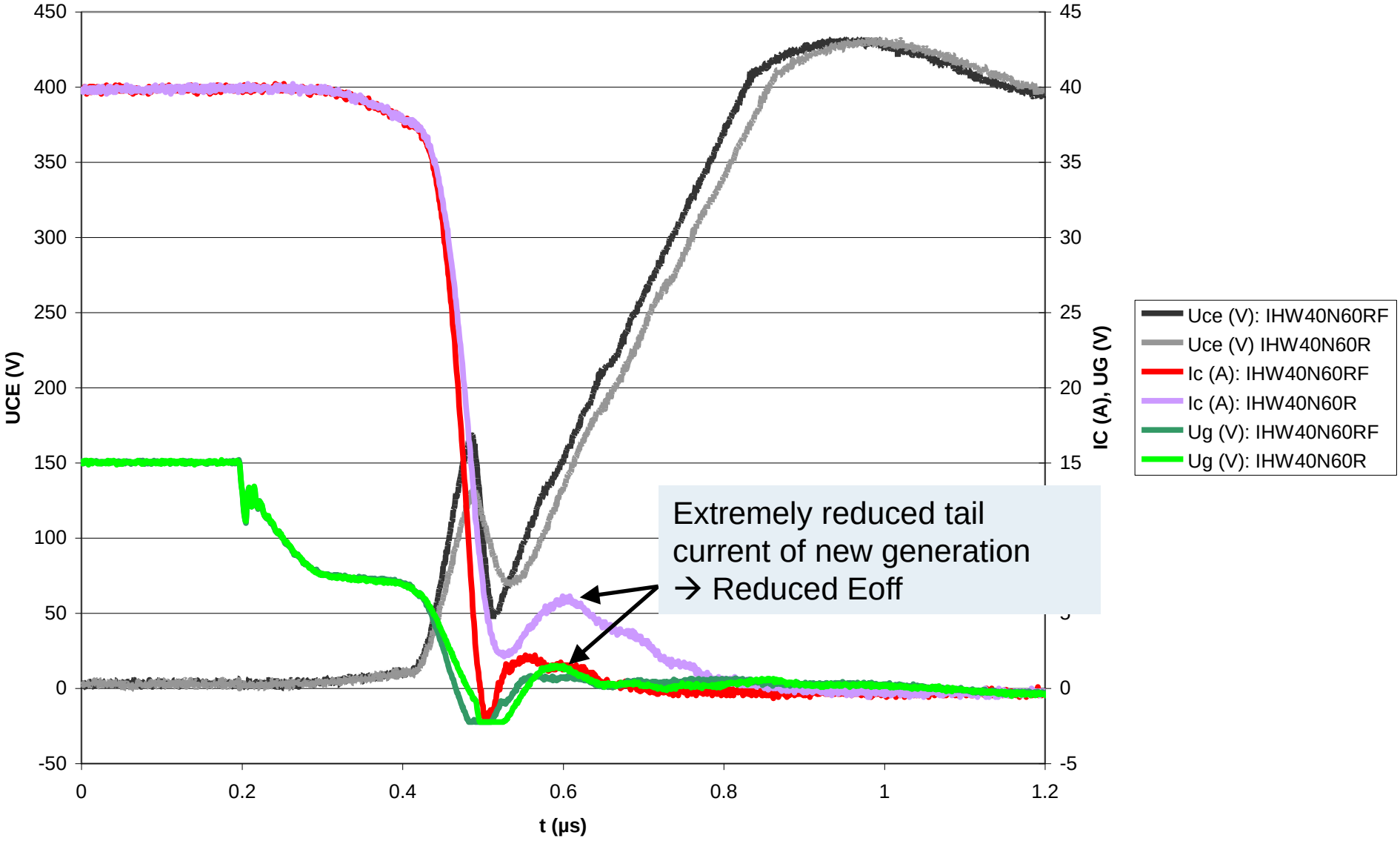
Infineon Technologies offer a product spectrum covering the whole trade-off curve!

Soft-switching: 40A, 10 Ohm



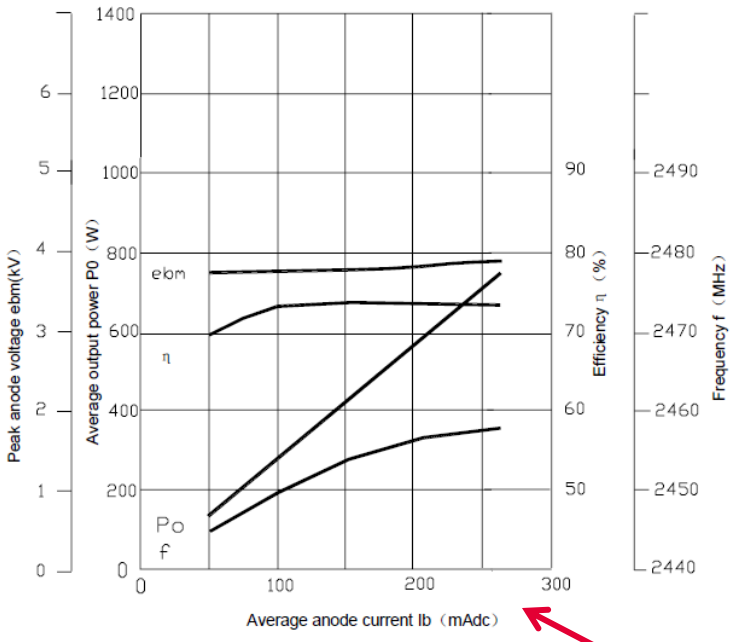
- The switching losses and are significantly reduced as compared to IHW40N60R (previous generation).
- The switching losses of the IHW40N60RF show a very small dependence on temperature.

Soft-switching @ 125° C, 40A, 10 Ohm

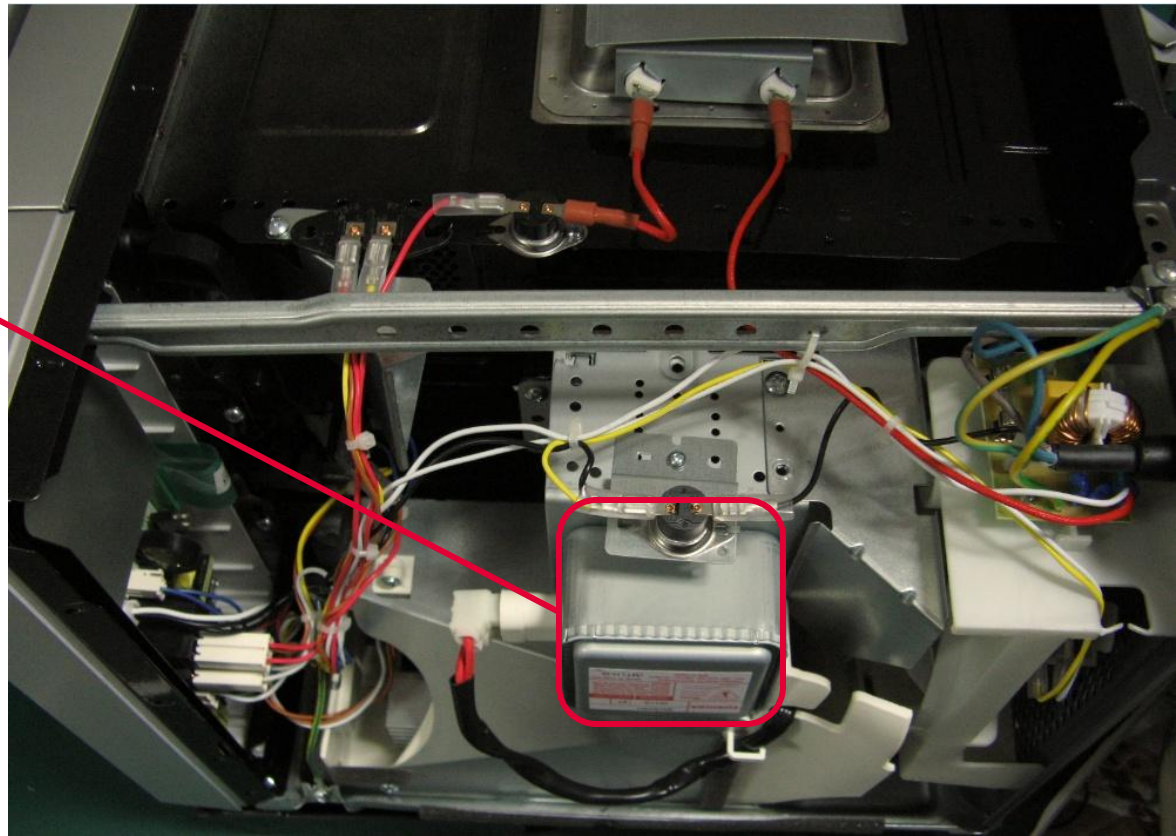


- Induction heating application
- **Microwave oven**
- Inverter home appliance

Performance of MAGNETRON

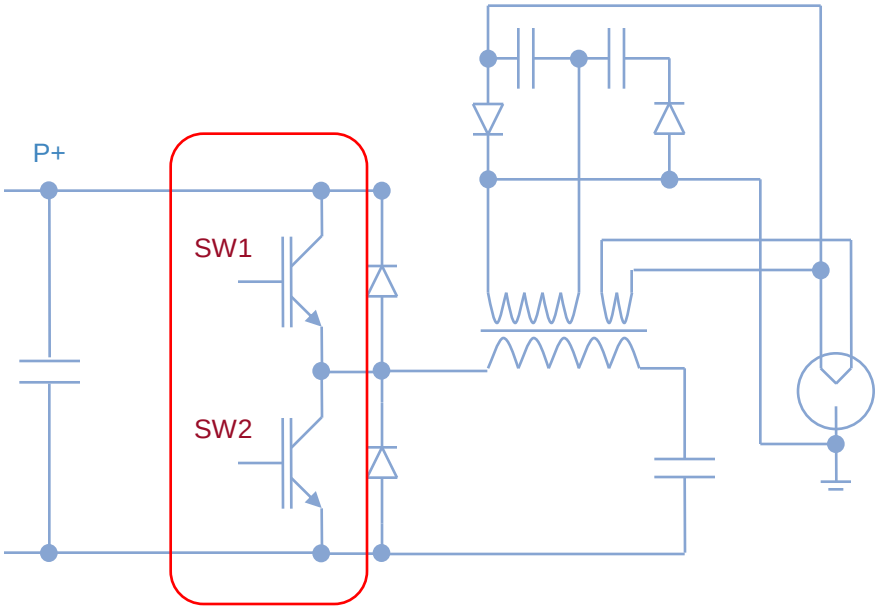


Operating conditions:
Power supply: Single phase full wave recited without filter

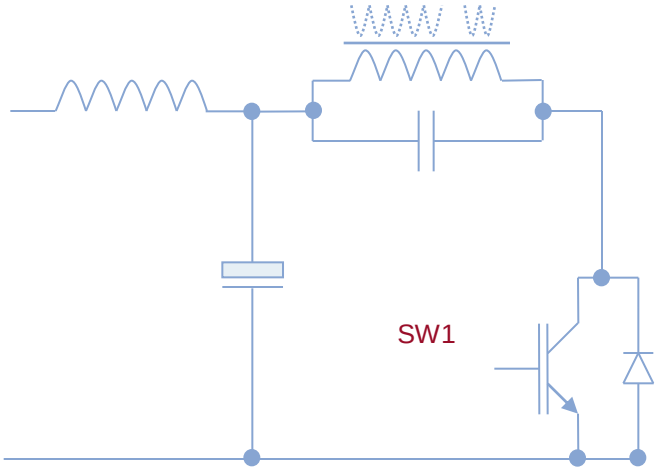


IGBT for Microwave Oven

600V: Half-Bridge Topology



1200V: Single Ended Topology



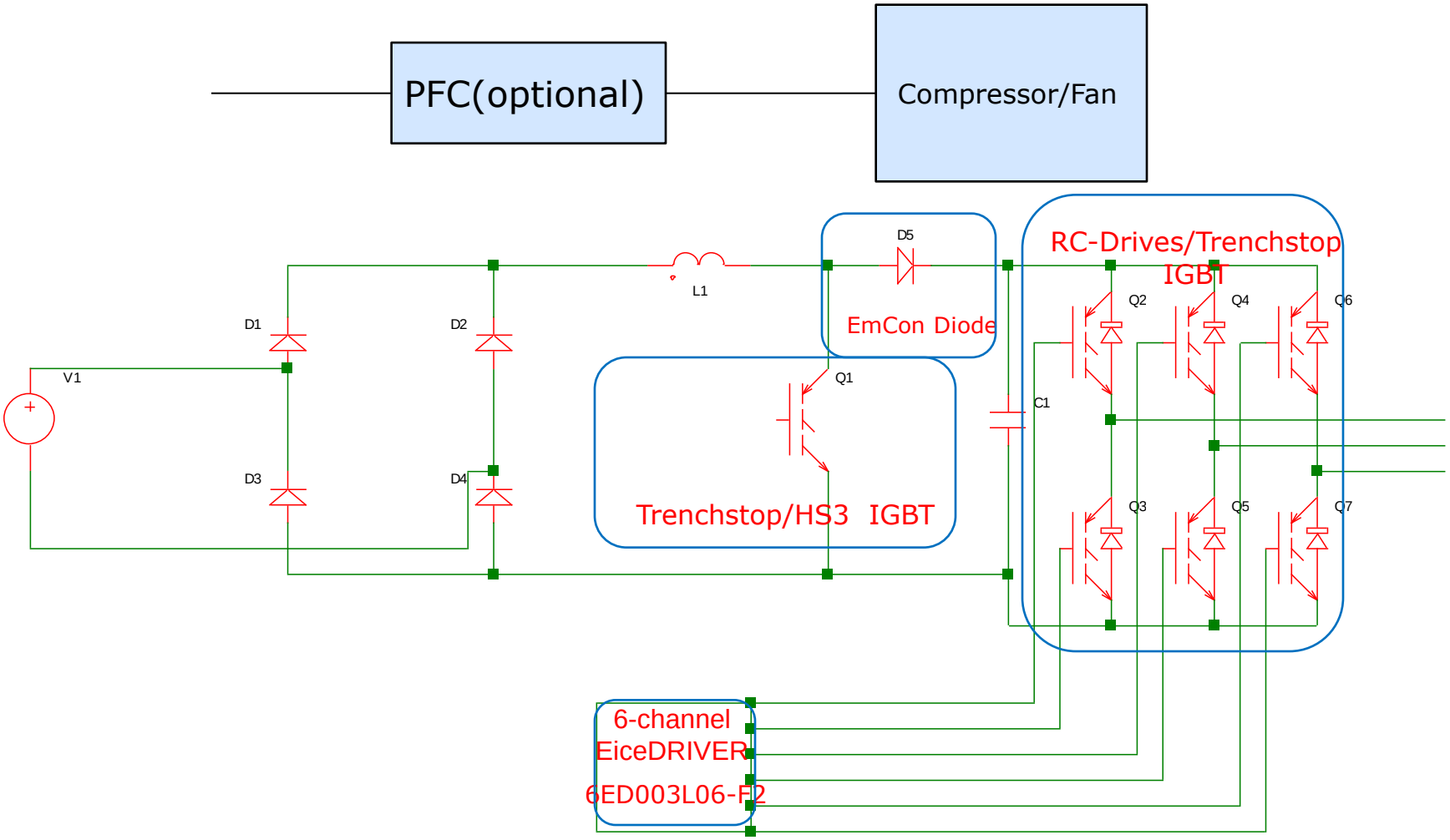
‘hard’ or ‘soft’ switching

IGBT in ***TrenchStop Reverse Conducting*** technology
Switching frequency 20kHz

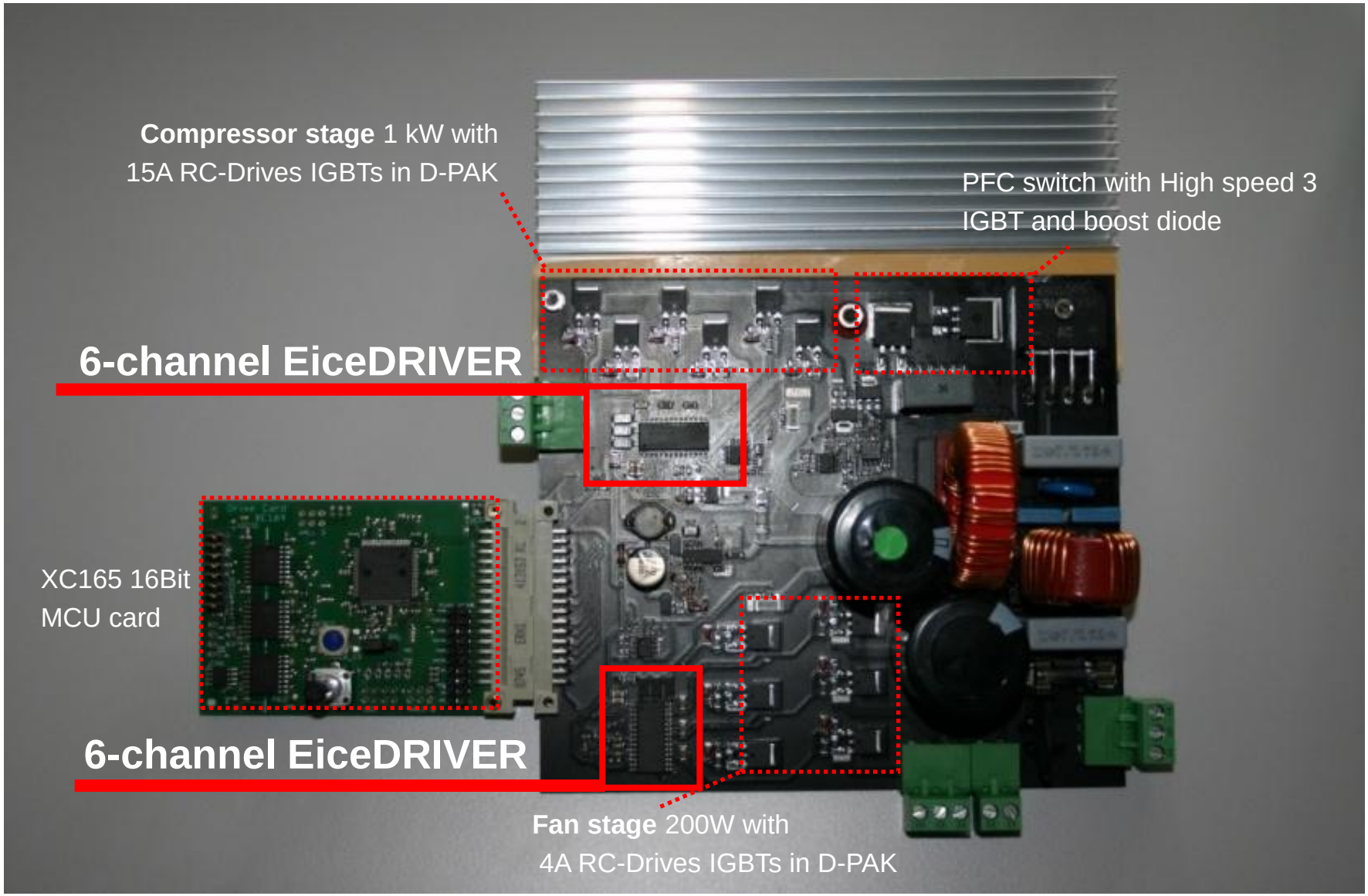
e.g. 600V/40A IGBT IHW40N60R/IHW40N60RF
e.g. 1200V/20A IGBT IHW20N120R3

- Induction heating application
- Microwave oven
- **Inverter home appliance**

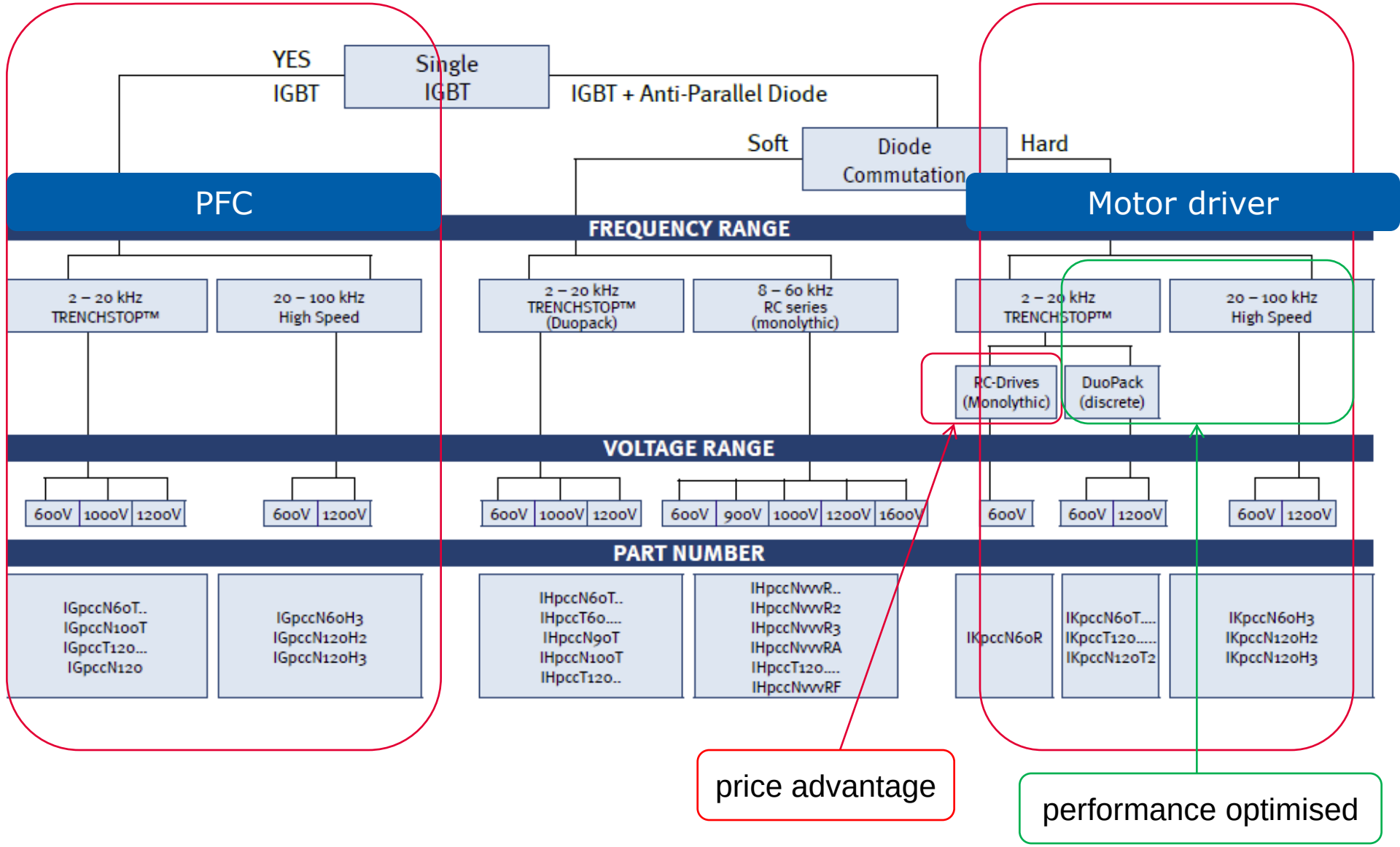
System configuration for inverterized HA



IFX discrete solution with 2x 6ED inside: Dual motor kit for 1 kW Aircon Split systems



IGBT selection guide for inverterized HA



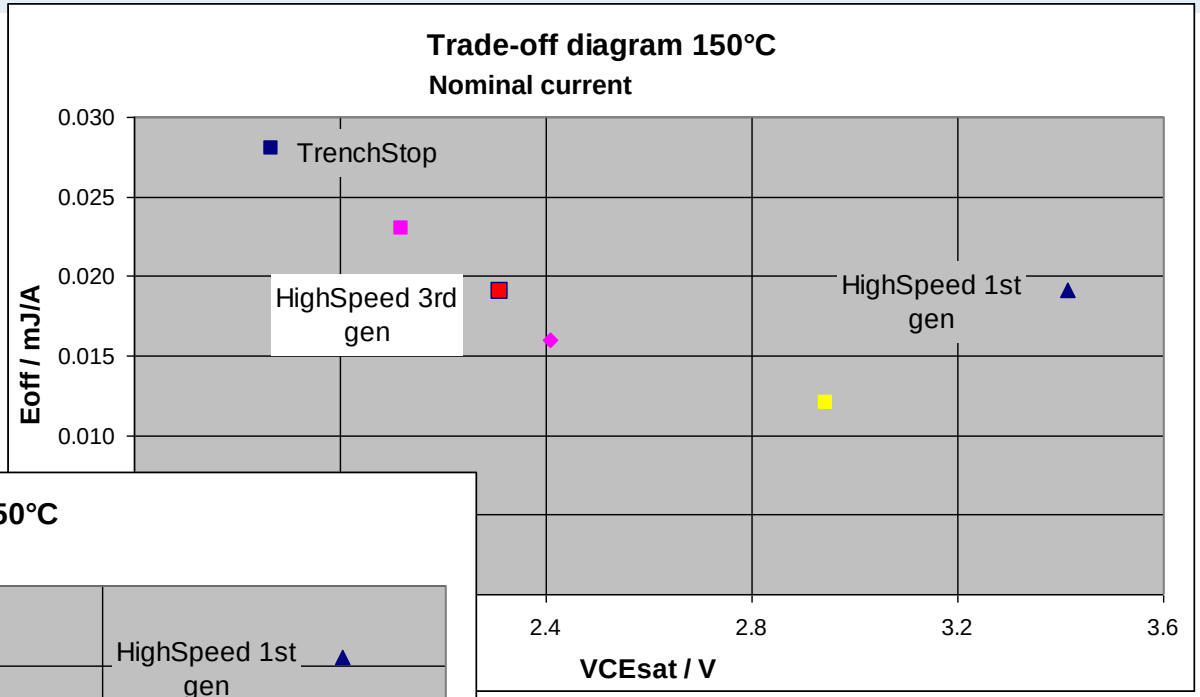
- Induction heating application
- Microwave oven
- **Inverter home appliance**
  - PFC IGBT + Diode
  - Motor driver

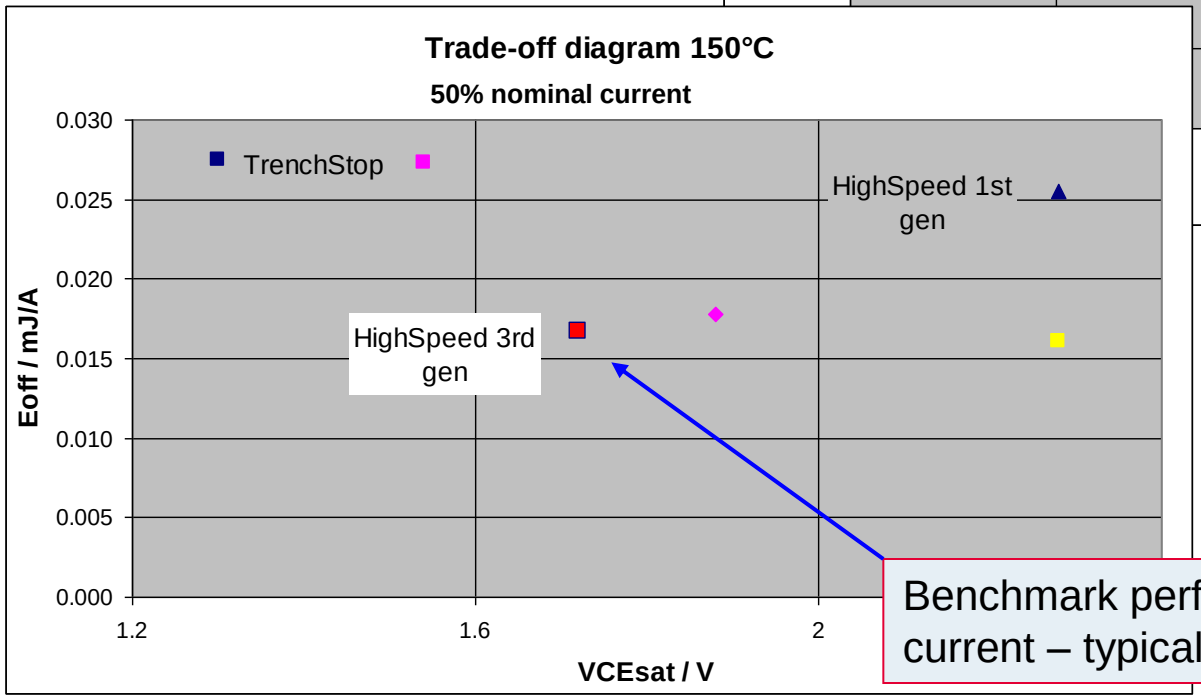
IGBT Competitor Landscape

IFX

Competitor A

Competitor B





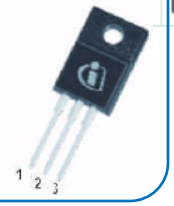
Switching conditions:
400V bus voltage
gate voltage 15V -> 0V
nominal gate resistor

Benchmark performance at partial load current – typical in the application

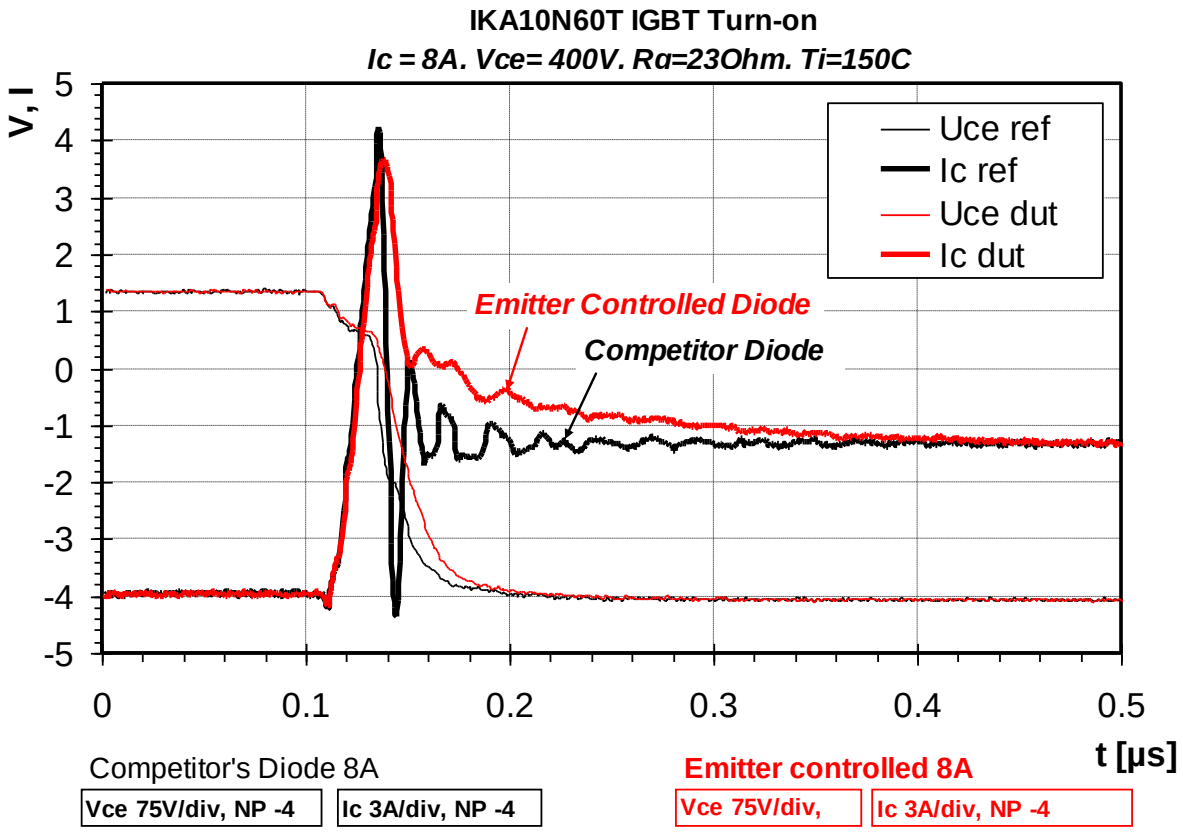
Sing IGBT
600V TO247/TO220Fullpak Portfolio

$$T_C = T_{j\max} - V_{CEsat\max@T_{j\max}} \bullet I_{cnom} \bullet R_{thjc}$$

Continuous collector current at T_C =100° C

Product Type	Product Status	Order Online	Green	Switching Frequency	Package	V_{CE} (max)	$I_{C(max)}$ @ 25°	$I_{C(max)}$ @ 100°
IGW30N60T	in production	Request	RoHS	TRENCHSTOP™ 2-20kHz	TO-247	600.0 V	60.0 A	30.0 A
IGW50N60T	TO247 	Request	RoHS	TRENCHSTOP™ 2-20kHz	TO-247	600.0 V	100.0 A	50.0 A
IGW75N60T		Request	RoHS	TRENCHSTOP™ 2-20kHz	TO-247	600.0 V	150.0 A	75.0 A
IGW20N60H3		Request	RoHS	HighSpeed3 20-100kHz	TO-247	600.0 V	40.0 A	20.0 A
IGW30N60H3		Request	RoHS	HighSpeed3 20-100kHz	TO-247	600.0 V	60.0 A	30.0 A
IGW40N60H3		Request	RoHS	HighSpeed3 20-100kHz	TO-247	600.0 V	80.0 A	40.0 A
IGW50N60H3	in production	Request	RoHS	HighSpeed3 20-100kHz	TO-247	600.0 V	100.0 A	50.0 A
IGW75N60H3	in production	Request	RoHS	HighSpeed3 20-100kHz	TO-247	600.0 V	140.0 A	75.0 A
IGA30N60H3	TO220 FullPAK 	Request	RoHS	HighSpeed3 20-100kHz	TO220-3 FP	600.0 V	18.0 A	11.0 A

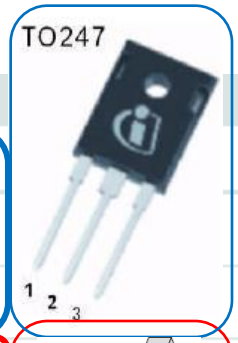
Discrete Emitter Controlled Diodes
Your Soft Alternative

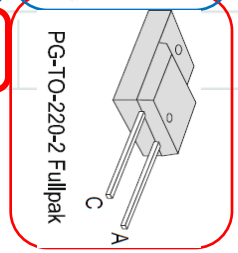


Your Advantage:

- The Emitter controlled technology improves the IGBT turn-on by reducing current and voltage oscillations.
- Gate resistor Rg can be reduced, reducing IGBT turn-on losses

Discrete Emitter Controlled Diodes
600V TO247/TO220Fullpak Portfolio





Product Type	Order Online	Packages	Green	I_F (typ)	I_F (max)	$I_{F,SM}$ (max)	V_F (typ)	I_R (max)
IDW30E60	Request			75.0 A	120.0 A	150.0 A	1.65 V	40.0 µA
IDW75E60	Request	PG-TO247-3	RoHS	75.0 A	120.0 A	220.0 A	1.65 V	40.0 µA
IDW100E60	Request	PG-TO247-3	RoHS	100.0 A	150.0 A	400.0 A	1.65 V	40.0 µA
IDV30E60C	Request	PG-TO220-2	RoHS	12.0 A	21.0 A	-	1.65 V	40.0 µA

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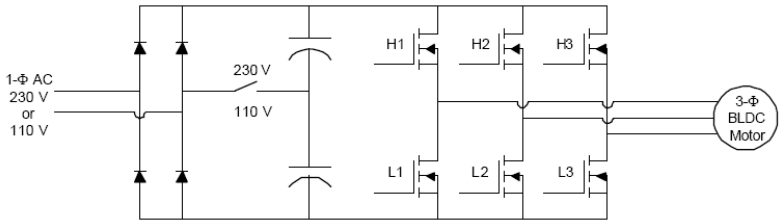
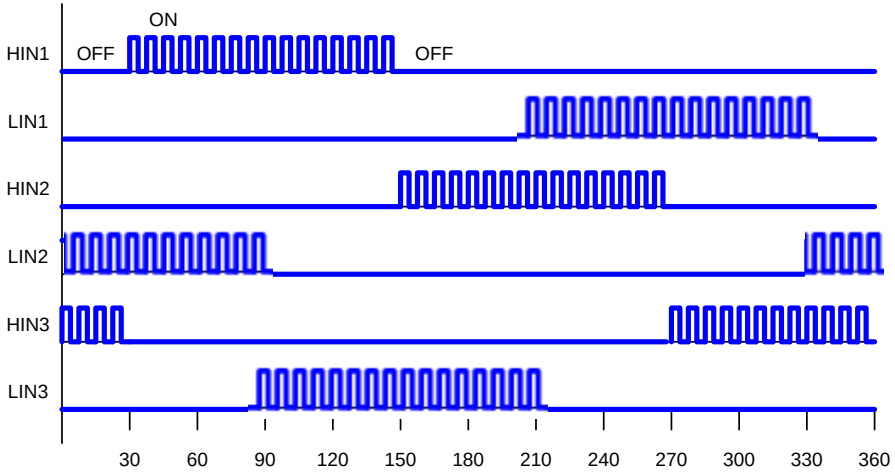
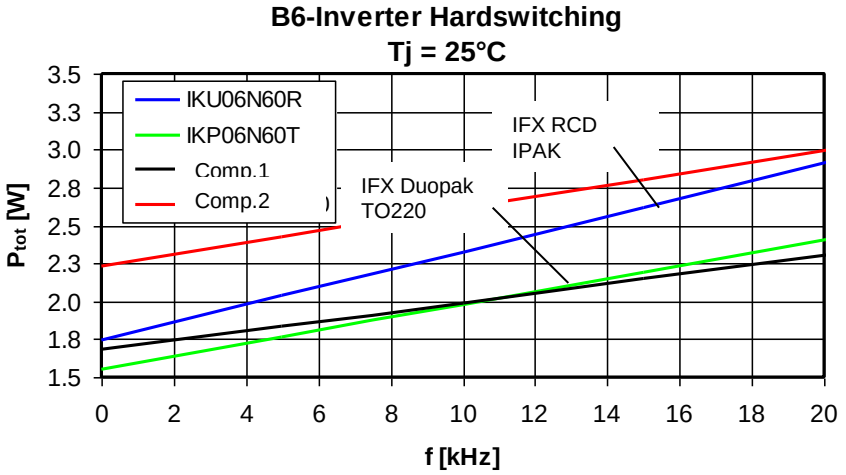
Loss estimation vs switching frequency

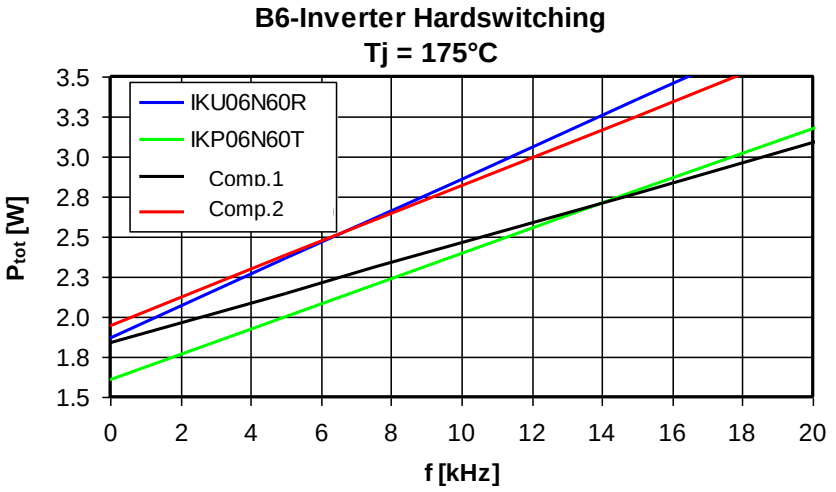
- BLDC Motor, Vcc=400V, Rg=24 Ohm, Iout=6A. **Hard Switching**



Hard Switching Modulation

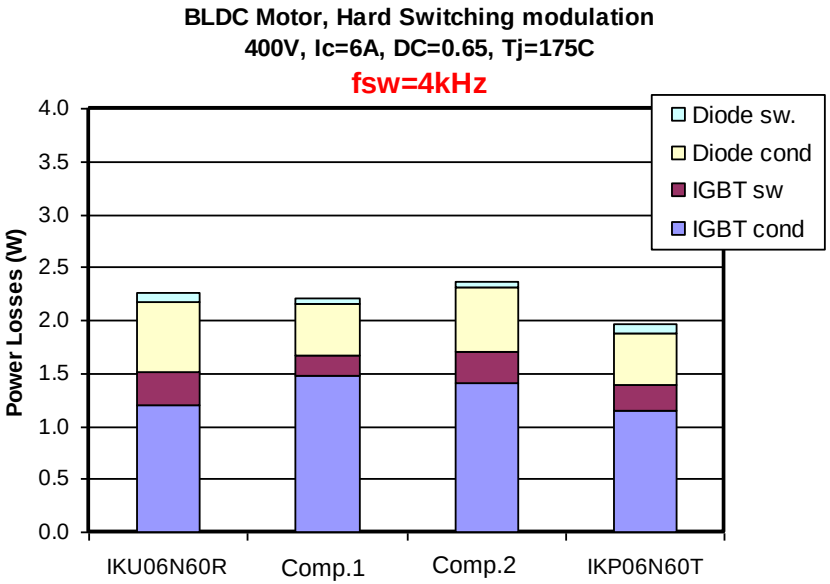


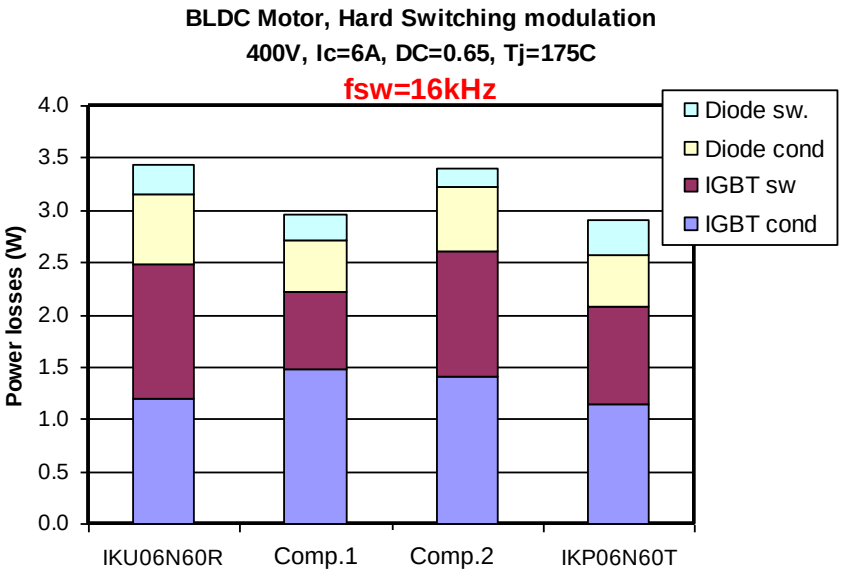




Conduction Losses versus Switching Losses

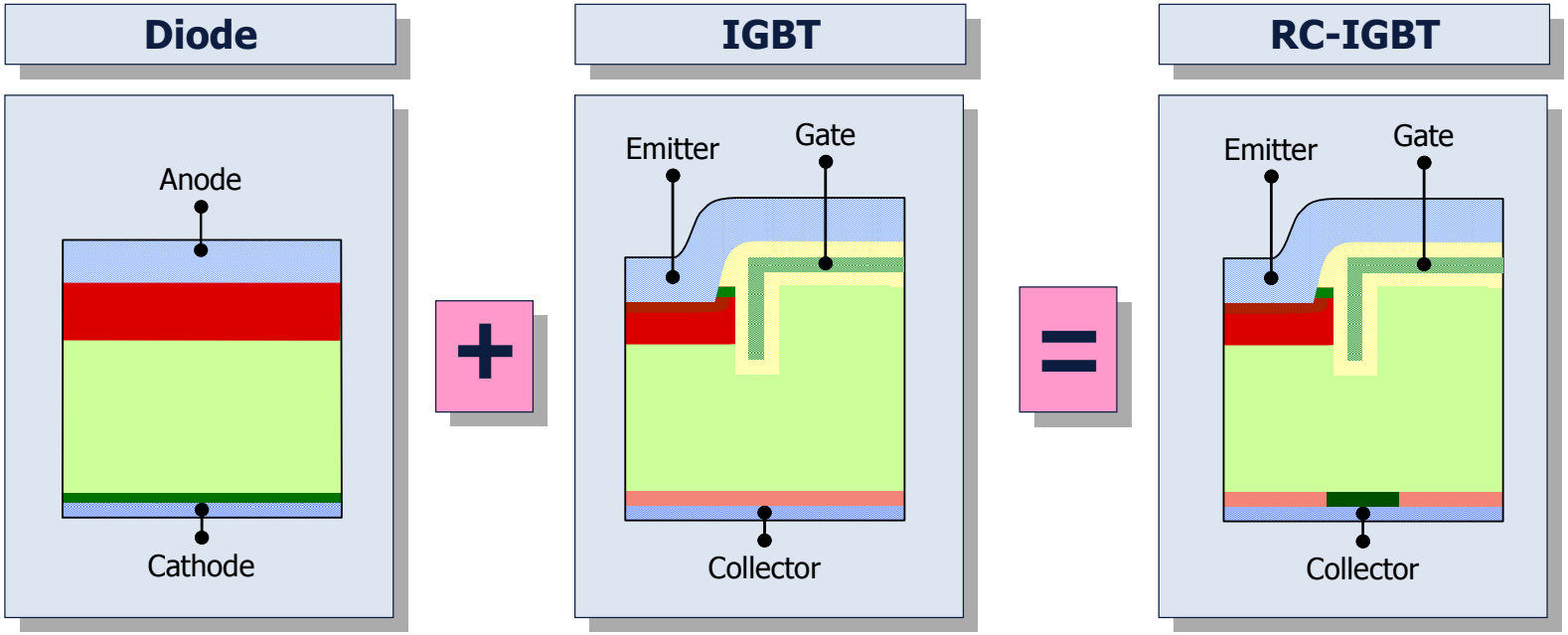
- Conduction losses are the predominant loss meaning low Vce(sat) is the most relevant parameter





Infineon IGBTs offer the lowest Vce(sat) in the low cost consumer market

RC-Drives
Reverse Conduction IGBT for Drives



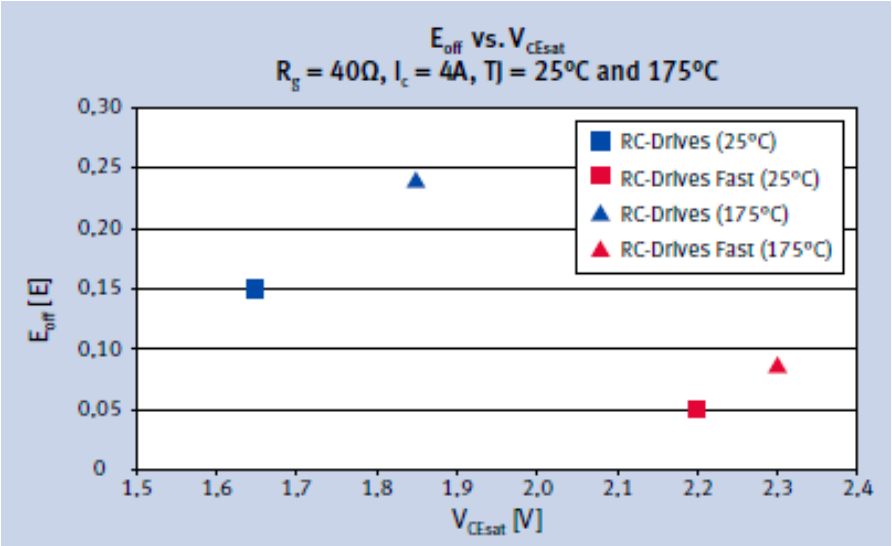
- **RC-D**: Infineon now offers the free wheeling diode monolithically integrated into the TRENCHSTOP IGBT-die for hard switching applications (**R**everse **C**onducting for **D**rives)
- Same DC current rating of diode and IGBT
- This leads to current classes [<15A] being available in new package classes.

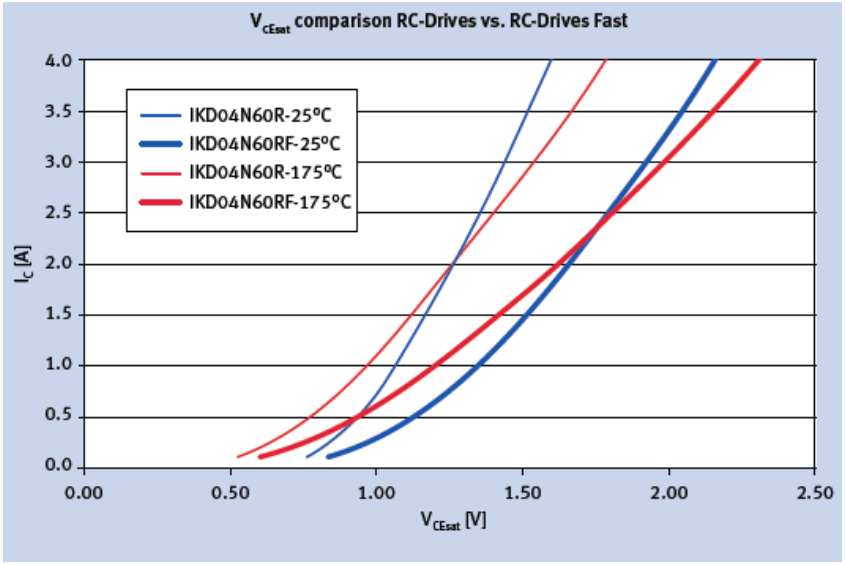
RC-Drives Product Portfolio

Product Portfolio

Inverter Output power [W]	Switching frequency	B_{Vces} [V]	I_c @ 25°C [A]	I_c @ 100°C [A]	V_{CEsat} @ 175°C	DPAK	IPAK
100	4~30kHz	600	5	2,5		IKD03N60RF	
200	4~30kHz	600	8	4		IKD04N60RF	
200	≤4kHz	600	8	4	[illegible]	IKD04N60R	IKU04N60R
600	≤4kHz	600	12	6	[illegible],85	IKD06N60R	IKU06N60R
1000	≤8kHz	600	20	10	1,85	IKD10N60R	IKU10N60R
1500	≤8kHz	600	30	15	1,85	IKD15N60R	IKU15N60R

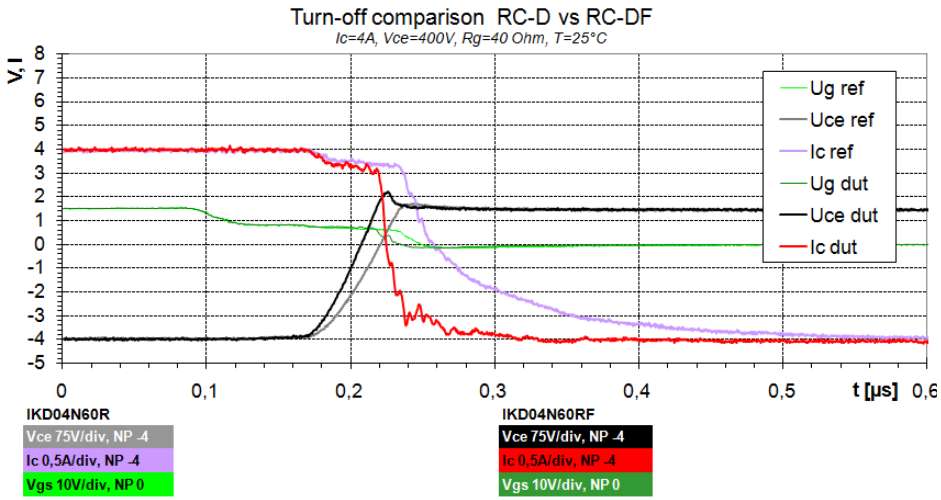
NEW RC-DF



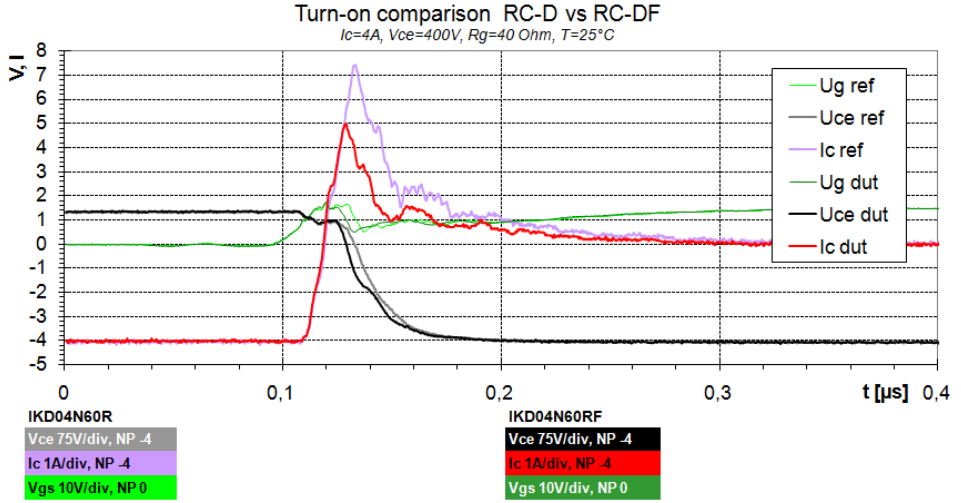


Switching comparison RC-D vs RC-DF

Turn-off



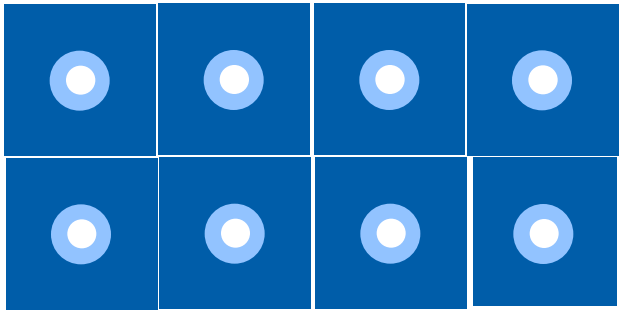
Turn-on IGBT

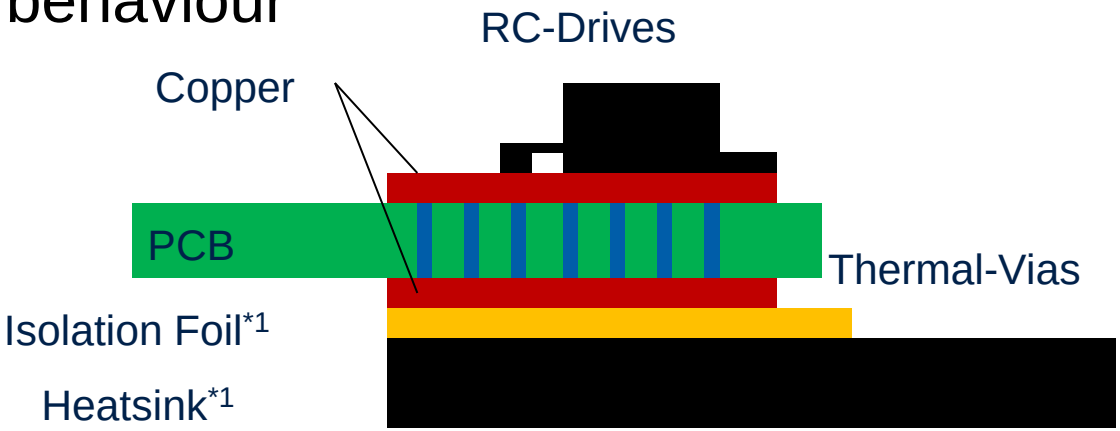


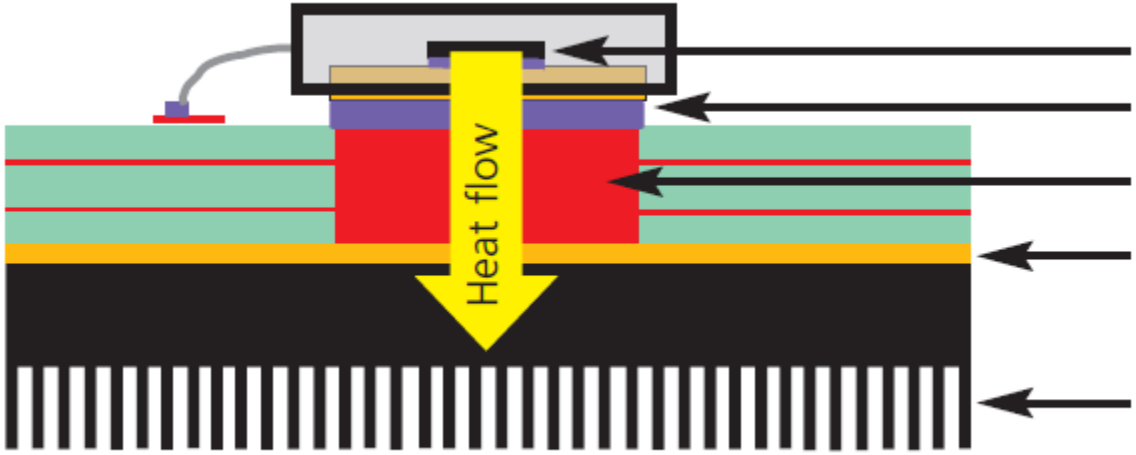
- Due to the simultaneous optmization of IGBT and integrated diode for fast switching, both IGBT turn-off and turn-on are showing reduced power losses and still smooth switching behavior

RC-Drives
Thermal Concept

- Infineon recommend the small drill hole concepts since it‘s the most cost effective solution due to easy production and adequate thermal behaviour





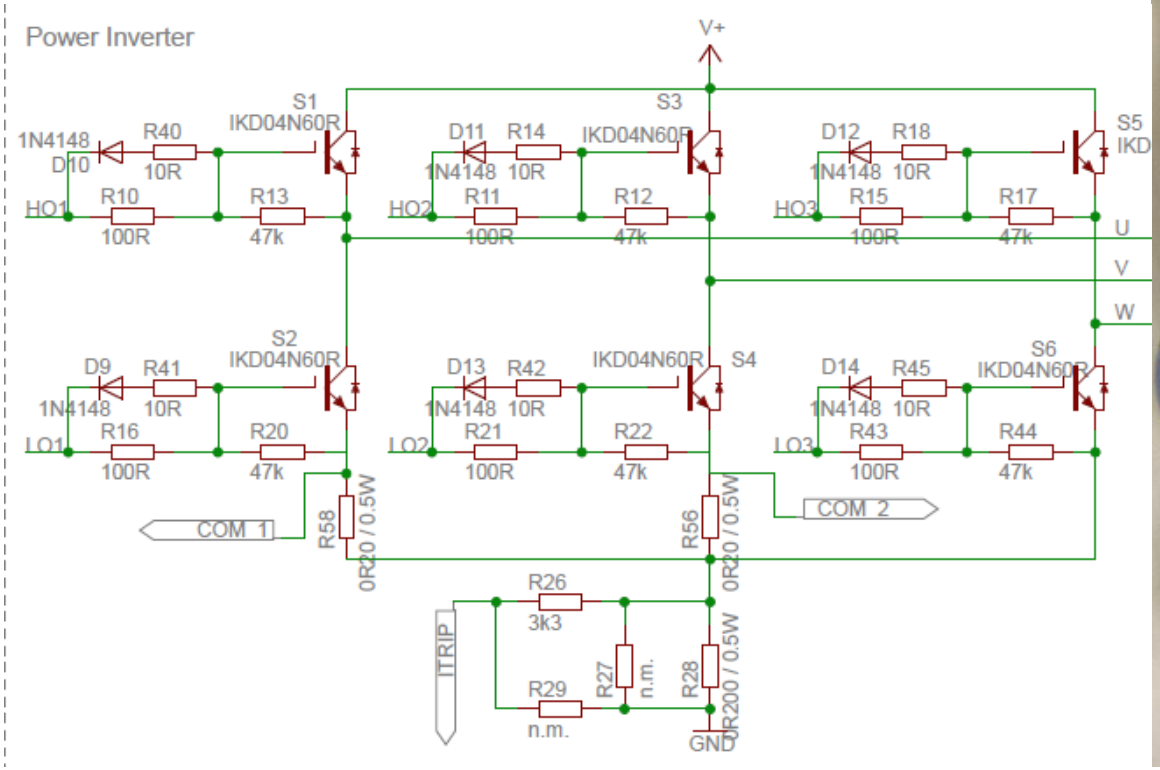


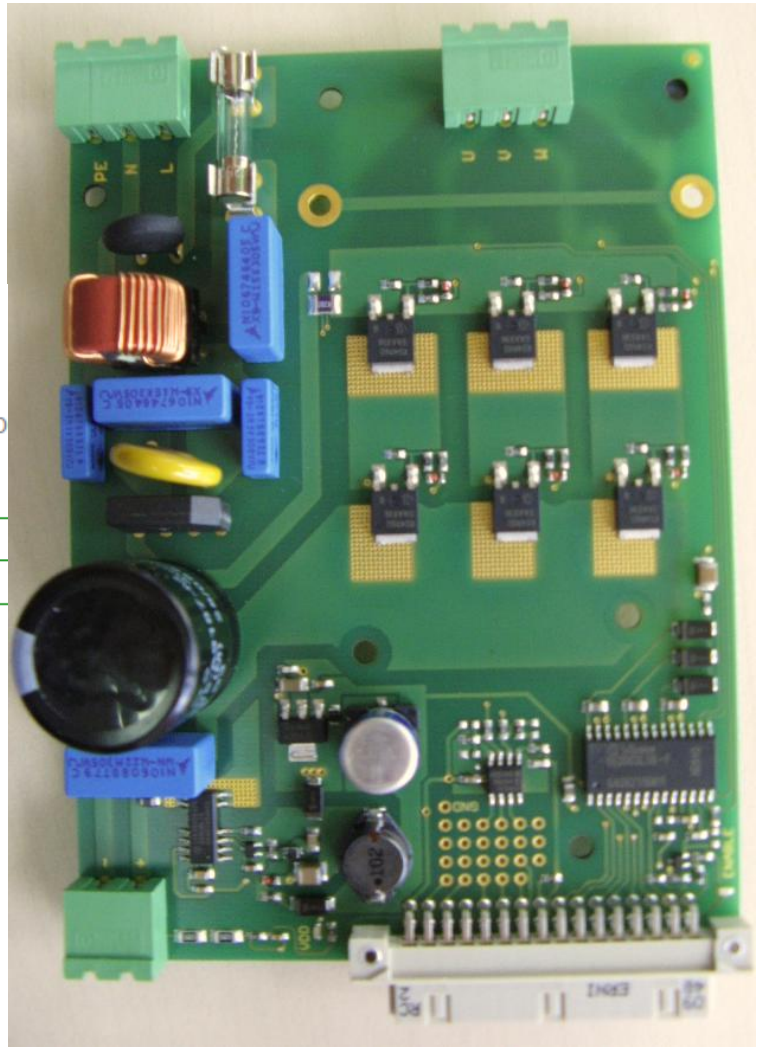
*1) optional

Application Test Setup (1)

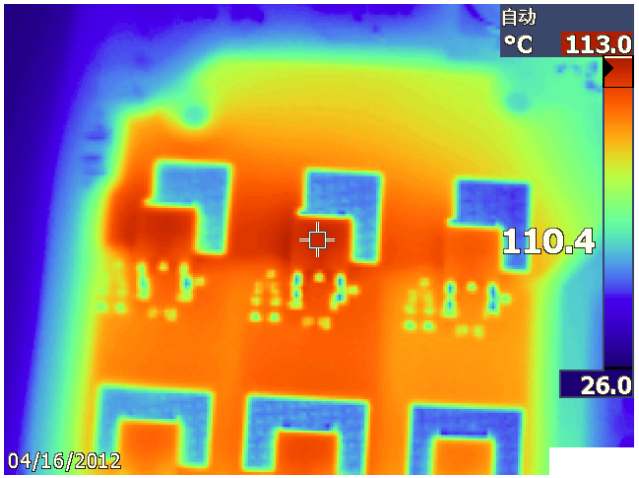
Test condition:

- Input voltage: 231Vac
- Inverter switching frequency : 15Khz
- Ambient temperature: 23˚C (±2˚C)
- Stand-by time: 0.5hour / measurement

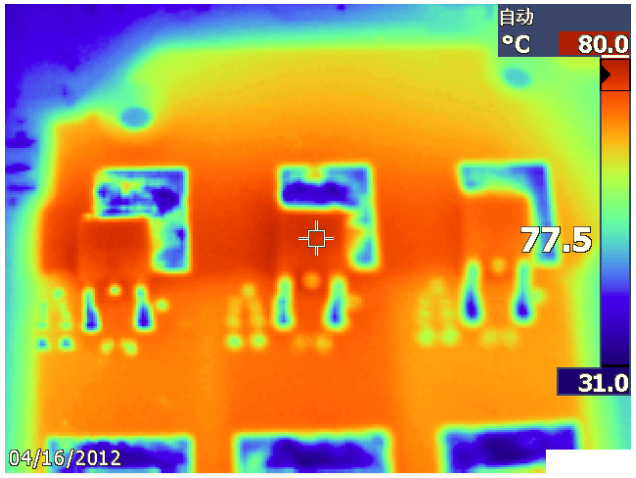




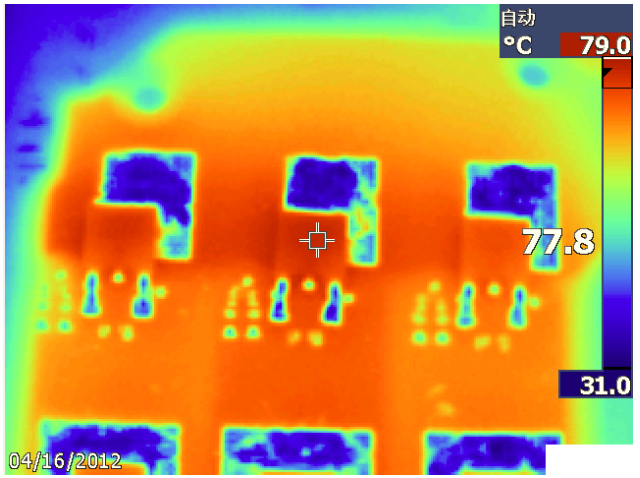
Meaurements in the application
Input power 102W



IKD04N60R



IKD04N60RF

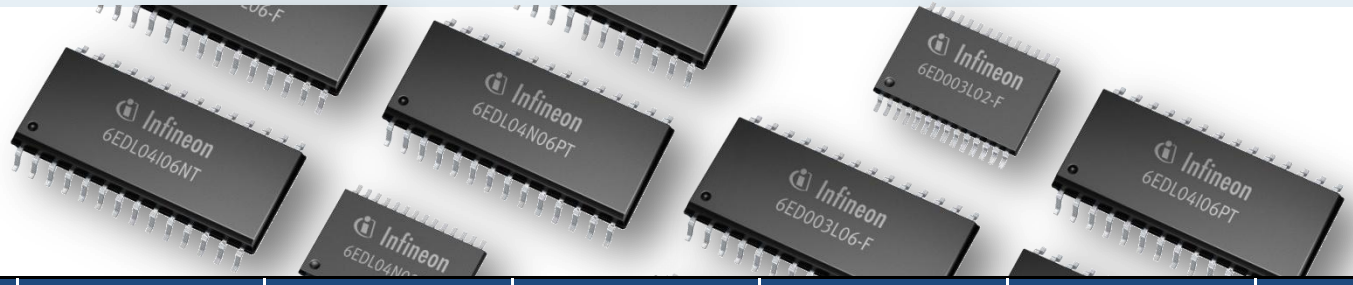


IKD03N60RF

Input condition	IKD04N60R	IKD04N60RF	IKD03N60RF
231Vac, 102W	113℃	80℃	79℃

- The package temperature (T_{case}) of IKD04N60R, IKD04N60RF & IKD03N60RF were measured at input power=102W

EiceDRIVER™ - **6ED 2nd** Generation Driver IC Portfolio of for IGBTs and MOSFETs



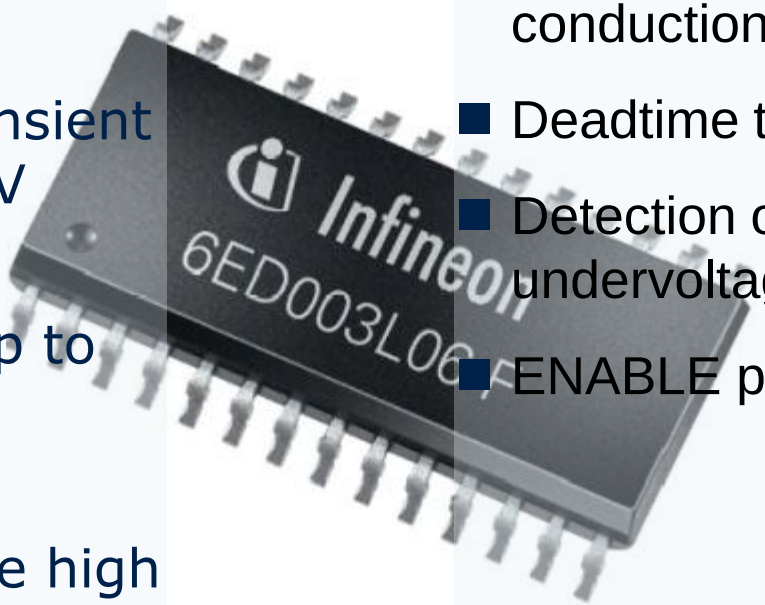
Sales Code	6ED003L02-F2	6EDL04N02PR	6ED003L06-F2	6EDL04I06NT	6EDL04I06PT	6EDL04N06PT
SP - ordering code	SP000919390	SP000926072	SP000929928	SP000926082	SP000926088	SP000926102
Status	coming soon	coming soon	coming soon	coming soon	coming soon	coming soon
Blocking Voltage	200V	200V	600V	600V	600V	600V
Input Logic	negative	positive New!	negative	negative	positive New!	positive New!
Integr. Bootstrap Function	no	yes New!	no	yes New!	yes New!	yes New!
Optimized for	IGBT	MOSFET New!	IGBT	IGBT	IGBT	MOSFET New!
Package	PG-TSSOP-28	PG-TSSOP-28	PG-DSO-28	PG-DSO-28	PG-DSO-28	PG-DSO-28
ES	available	-	available	-	-	-
QS	Aug'11	Sept'11	Aug'11	Sept'11	Sept'11	Sept'11
MP	Nov'11	Nov'11	Nov'11	Nov'11	Nov'11	Nov'11
Replacement	6ED003L02-F	new	6ED003L06-F	new	new	new
PCN for today's customers	Oct'11		Oct'11			

Recommendation for new designs:
Shift from 6ED003L02-F to 6ED003L02-F2 (1by1 solution)
Shift from 6ED003L06-F to 6ED003L06-F2 (1by1 solution)
Or check our new additional variants

6ED003L06-F2 - Premium quality gate driver

Technology & Device Features:

- SOI-technology: robust again latch up
- Insensitivity to transient voltages up to -50V
- Full functionality up to +600V
- Power supply of the high side drivers via bootstrap



Protection Features:

- Signal interlocking of every phase to prevent cross-conduction
- Deadtime typ. 310 ns
- Detection of overcurrent and undervoltage supply
- ENABLE pin

EiceDRIVER™ - 6ED003L06-F2
Block diagram

Inputs:

Schmitt trigger,

Pre-biase,

Noise filter,

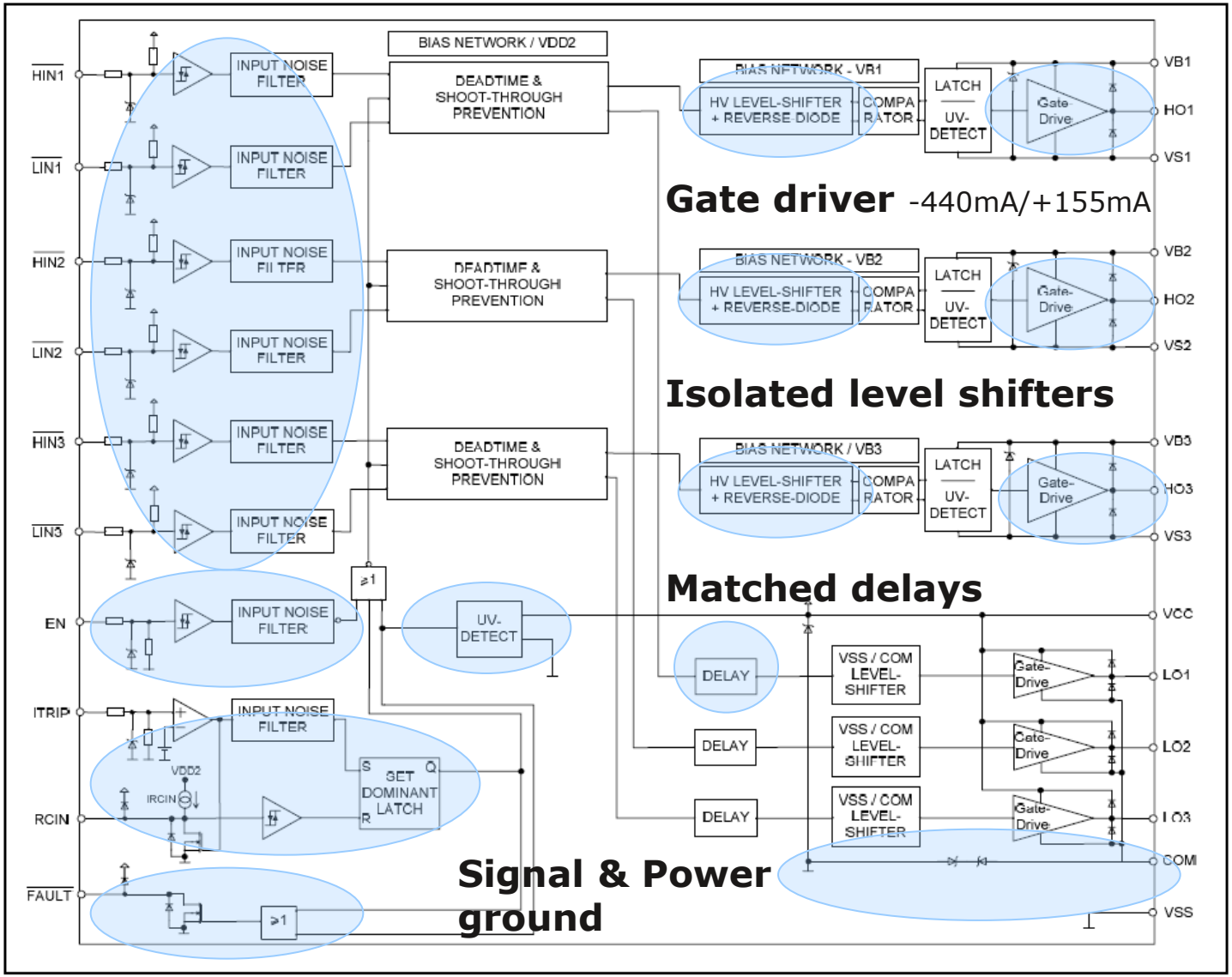
Interlocking

Enable

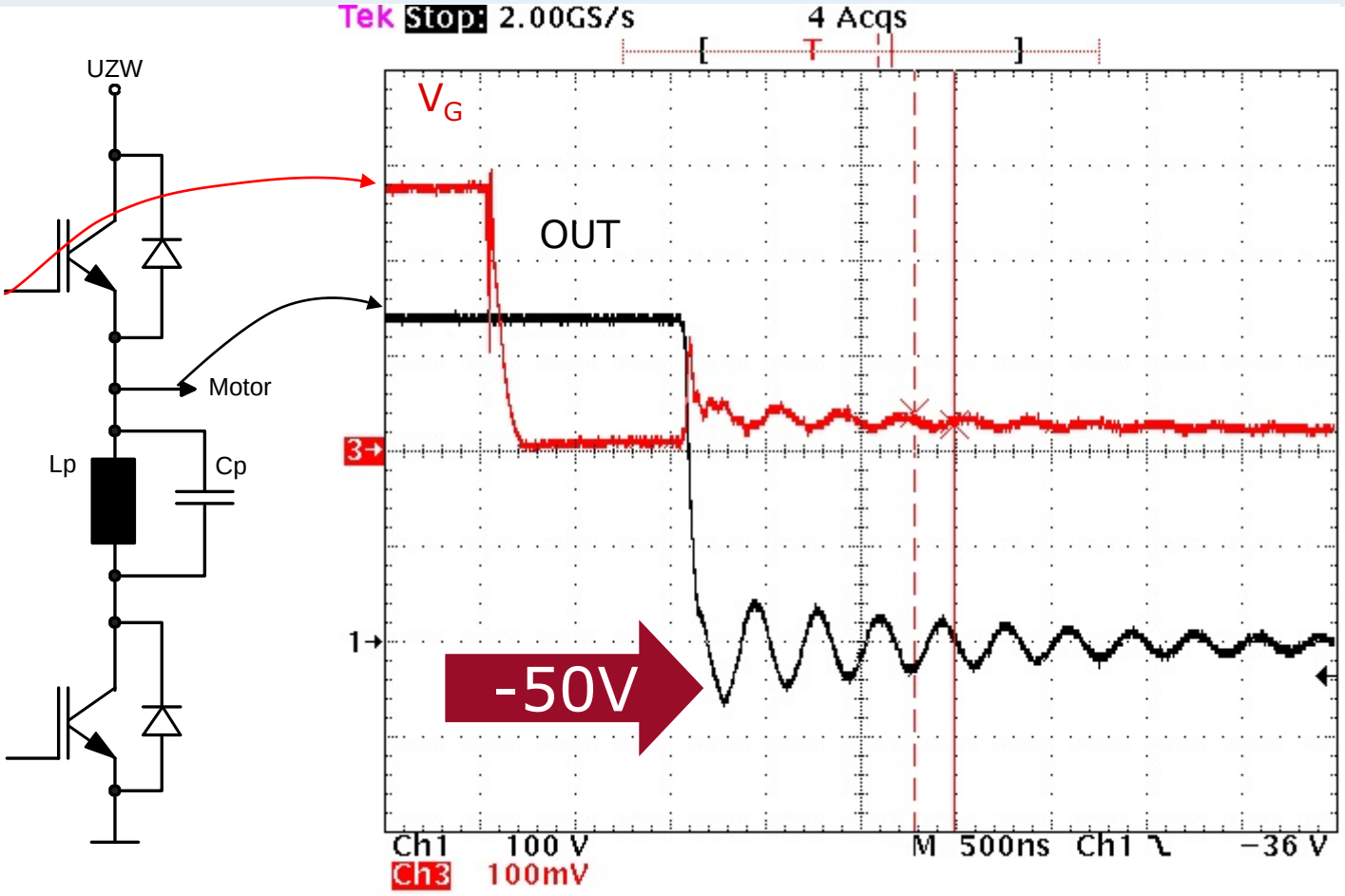
Undervoltage lock-out

Overcurrent protection

Fault feedback



Performance with physical parasitic Elements

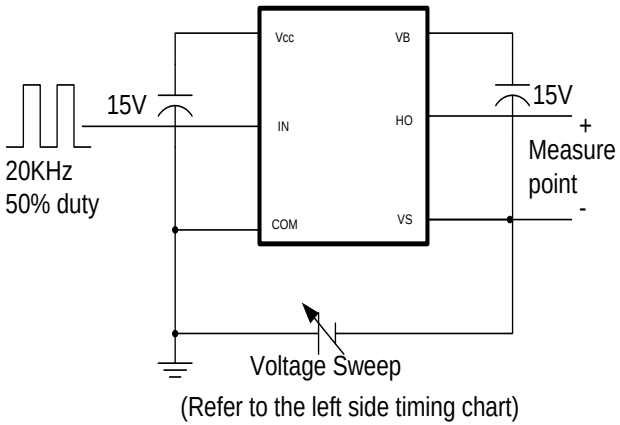


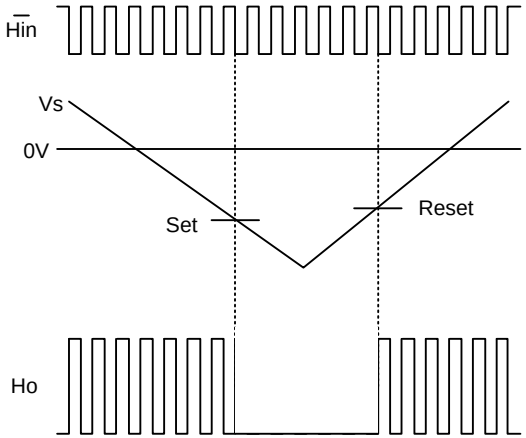
3-phase Fullbridge in motor operation with physical parasitic components (Lp, Cp) at DC-bus voltage of 320V (Motor in Y-connection , without mechanical Load)

Safe operation without latch even with transients down to -50V

Testing neg. VS voltage

- Purpose is to identify ignored level of input gating in HVIC when Vs falls to under 0V.
- Test Method & circuit



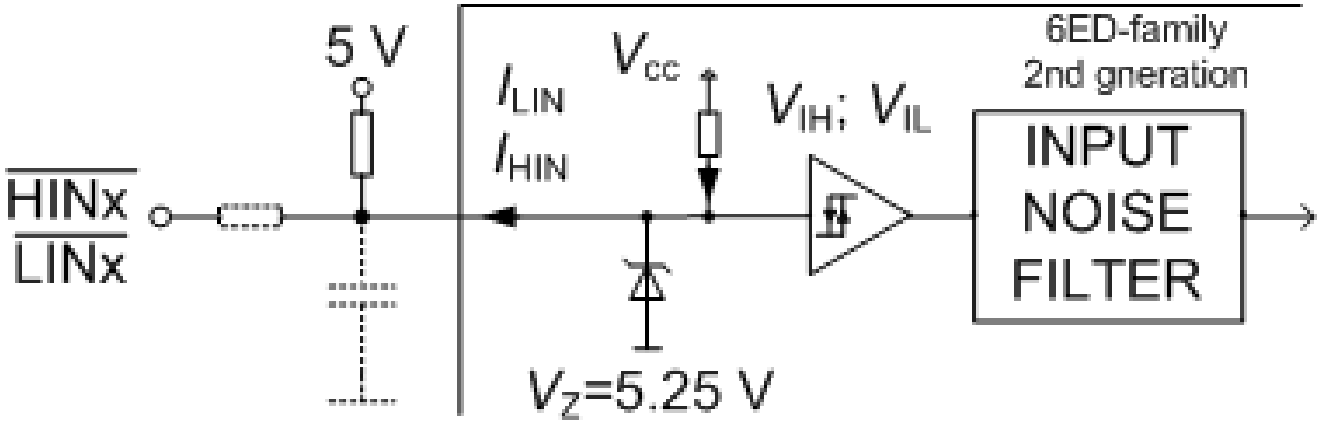


DUT	Set[V]	Reset[V]
6ED family – 2nd generation	−12.4	−10.6
Comp I	−6.5	−6.3

- Test result : Regarding -Vs identified level, 6ED is better than Comp I

/HIN, /LIN control pins

- Integrated pull up resistors of approx. 70 kΩ
- Integrated zener clamping < 5.8 V
- ext. pull up resistors are recommended
- RC filter (100 Ω, 1nF) may be necessary in noisy environment

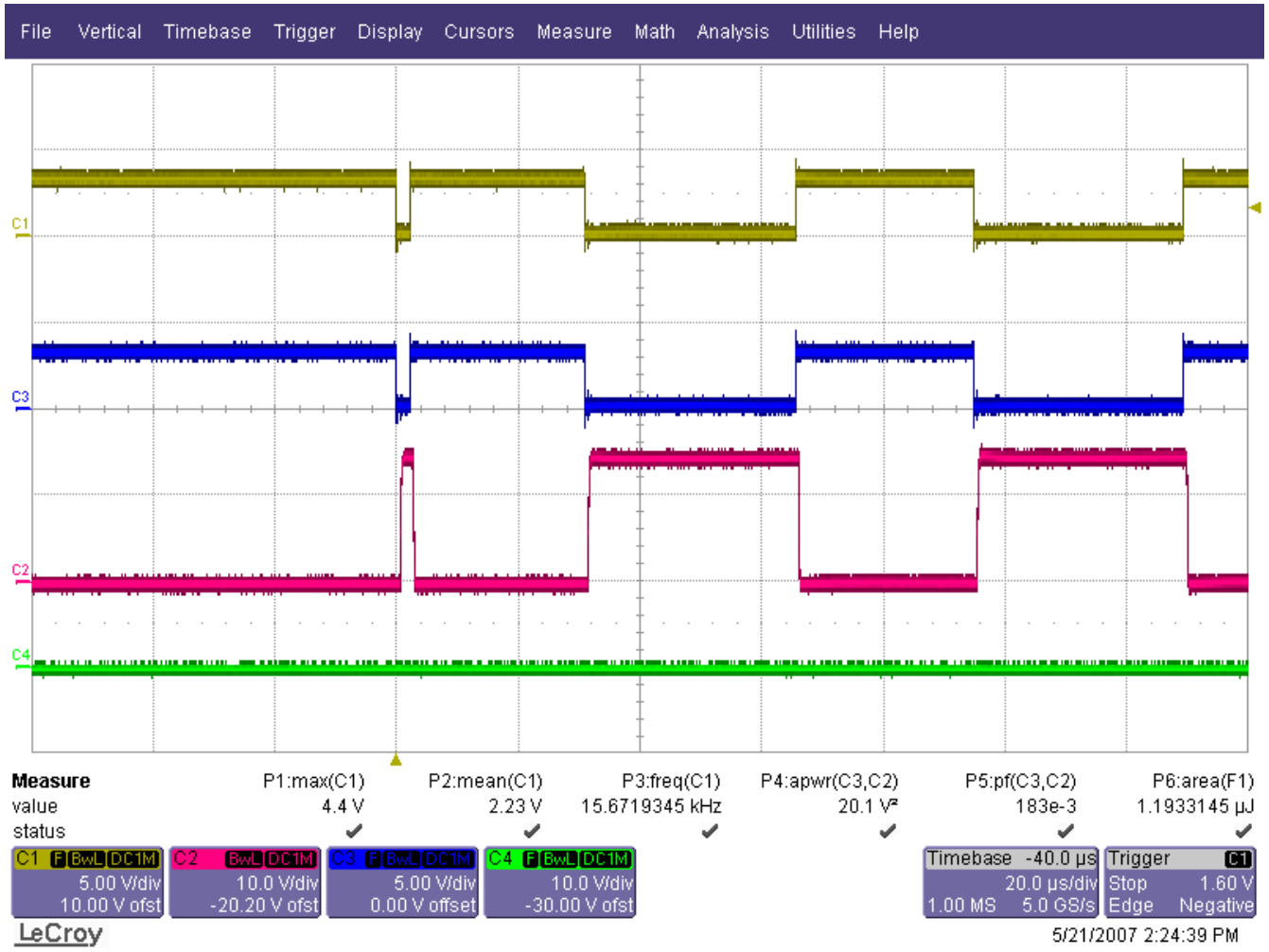


Interlocking

- Philosophy of interlock function
  - Avoid any short circuit of any half bridge
  - The first incoming turn-on signal rules the output
  - The second incoming turn-on signal is neglected
  - Second turn-on signal is processed, when active turn-on signal vanishes, i.e. when interlock condition vanishes

6ED family -2nd generation: Interlocking (1)

- Synchronous turn-on of /HIN and /LIN



CH1: /LIN

CH3: /HIN

CH2: LO

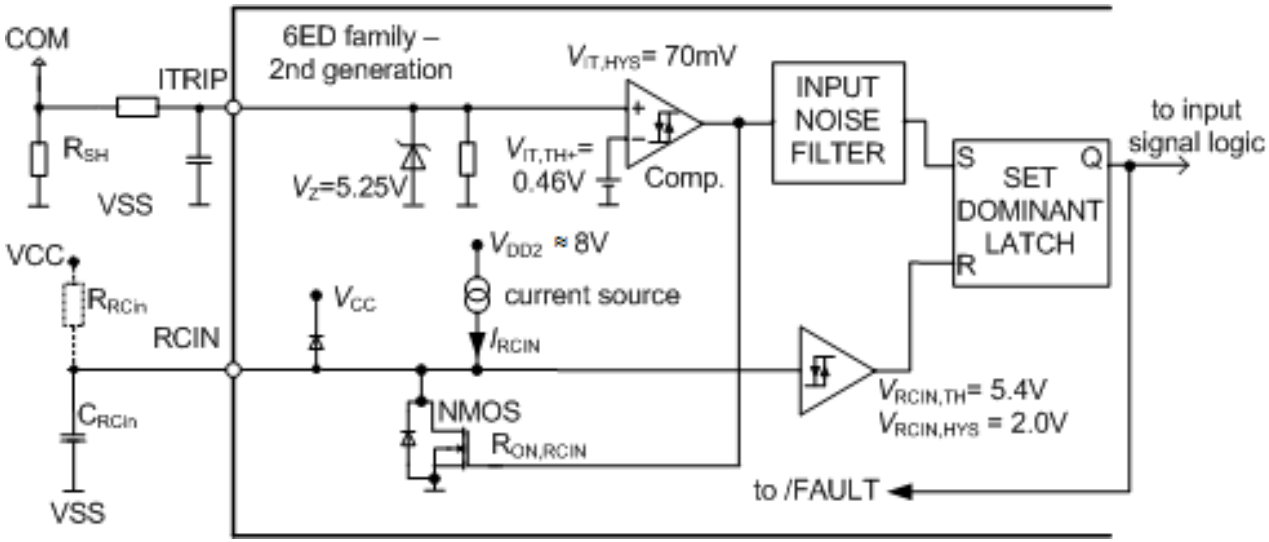
CH4: HO

Low side output is active, high side output disabled

Interlocking inhibits shoot through at any time

Overcurrent protection (ITRIP)

- Comparator threshold of 0.46 mV and hysteresis of 70 mV triggers RCin circuit
- Direct connection of shunt via RC-filter
- Short pulse suppression avoids wrong trigger of flip-flop
- RS-flip-flop triggers fault signal



RCin programming

- RCin capacitor is recommended in the range < 10nF
- A good choice is 2.2 nF
- A large capacitor may be discharged only partially without reaching the restart threshold
- IC is released after filter time
- Intermitting SC / overcurrent is possible

ENERGY EFFICIENCY
MOBILITY
SECURITY

Innovative semiconductor solutions for energy efficiency, mobility and security.