

Discrete IGBTs in trench-gate field-stop technology

Induction heating applications



650V Discrete IGBTs

Discover the ST's discrete IGBT series, tailored to target a large range of industrial applications, with a particular focus on induction heating applications.

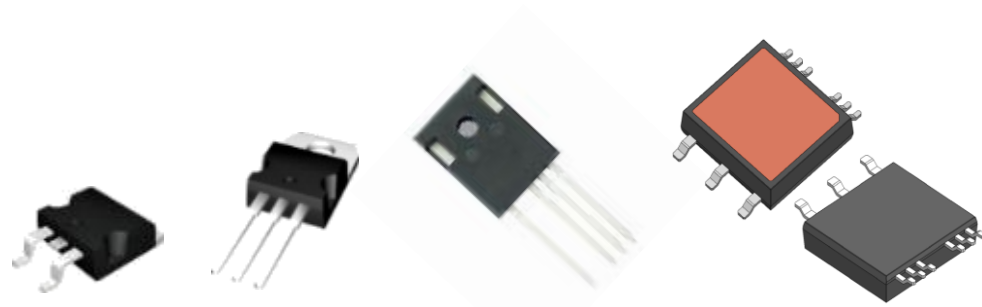
You will learn:

- Overview of our discrete IGBT series
- Induction heating phenomenon
- Common topologies for induction heating
- New IH series of IGBTs, dedicated to induction heating applications
- Benchmarks between new IH and HB series and against competitors
- Support material dedicated to our IGBTs

IGBT & IPM

Power Product Portfolio

From Discrete to Intelligent Power Modules, ST leads the innovation



Discrete IGBTs

Typical power: 10 W to 5 kW and even more



SLLIMM™ IPM

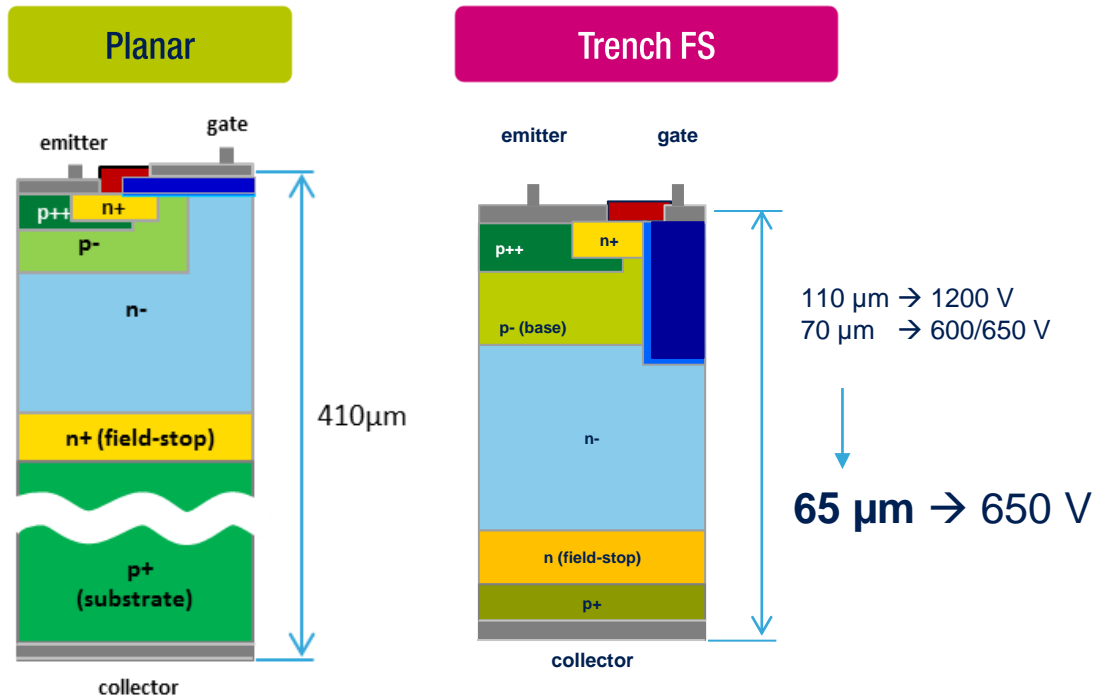
Typical power: 20 W to 3 kW



Trench-gate field-stop IGBTs

Technology milestones and features

Technology structures



Technology Features & Benefits

- Implanted Back Emitter
- Implanted Field Stop
- Optimized P-N-P BJT

- Lower E_{OFF} due to improved minority carrier recombination

- Trench Gate
- Thin wafer thickness

- High switching robustness (Large RBSOA)
- Lower $V_{CE(sat)}$
- Lower R_{TH}



Robustness and reliability

The Increasing up to 175°C of the max Junction Temperature $T_j(max)$, Ensures an higher lifetime



Energy saving

Extremely low switching-off combined with a low conduction losses.

IGBT Trench Technology

Breakdown Voltage

600 V	650 V	1200 V	1250 V
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Current

5 to 20 A	20 to 80 A	4 to 200 A	20 to 80 A	40 A	40 A, 50 A	15 to 75 A	8 to 75 A	15 to 40 A	20 A, 30 A
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Switching frequency

8 to 30 kHz	50 to 100 kHz	2 to 20 kHz	16 to 60 kHz	Up to 8 kHz	2 to 20 kHz	20 to 100 kHz	16 to 60 kHz
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IGBT series

H	V	M	HB	HB2*	IH*	S	M	H	IH
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Focus Applications

Home appliances (fans, pumps, washing machines and dryers)	Welding, high frequency converters, PFC, solar, UPS, charger	Industrial motor control, automotive traction inverter, GPI, Air-Con	High frequency converters, PFC, solar, UPS, charger, welding and induction heating	Induction heating and soft switching	Industrial motor control, GPI, Air-Con	PFC, welding, high frequency converters, solar, UPS, charger	Induction heating, microwave and soft switching
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* Enlargement in development



IGBT products

Nomenclature



Available packages

- A = D³PAK*
- B = D²PAK
- D = DPAK
- F = TO-220FP
- FW = TO-3PF
- P = TO-220
- W = TO-247
- WA=TO-247 long Leads
- W ... - 4 = TO-247-4
- WT = TO-3P
- YA = Max247 long Leads

*) investigation on-going

Nominal device current
@ T_c = 100° C

Technology generation

F = Trench gate field stop technology

Diode Options

- D = Very fast recovery
- DH = Half-rated diode
- DL = Low forward voltage(*)

(*) for soft-switching applications only

Breakdown Voltage ÷ 10

IGBT SERIES

- H = 600V, Medium speed (8 ÷ 30 kHz)
- H...B(2) = High speed (16 ÷ 60 kHz)
- HP...B(2) = H...B(2) with protection diode
- V = Very high speed (50 ÷ 100 kHz)
- M = Low loss (2 ÷ 20 kHz)
- S = Low drop (up to 8 kHz)
- H = 1200V, High speed (20 ÷ 100 kHz)
- IH = soft switching (16 ÷ 60 kHz)

650 V HB series IGBTs

For hard switching circuitries up to 60 kHz

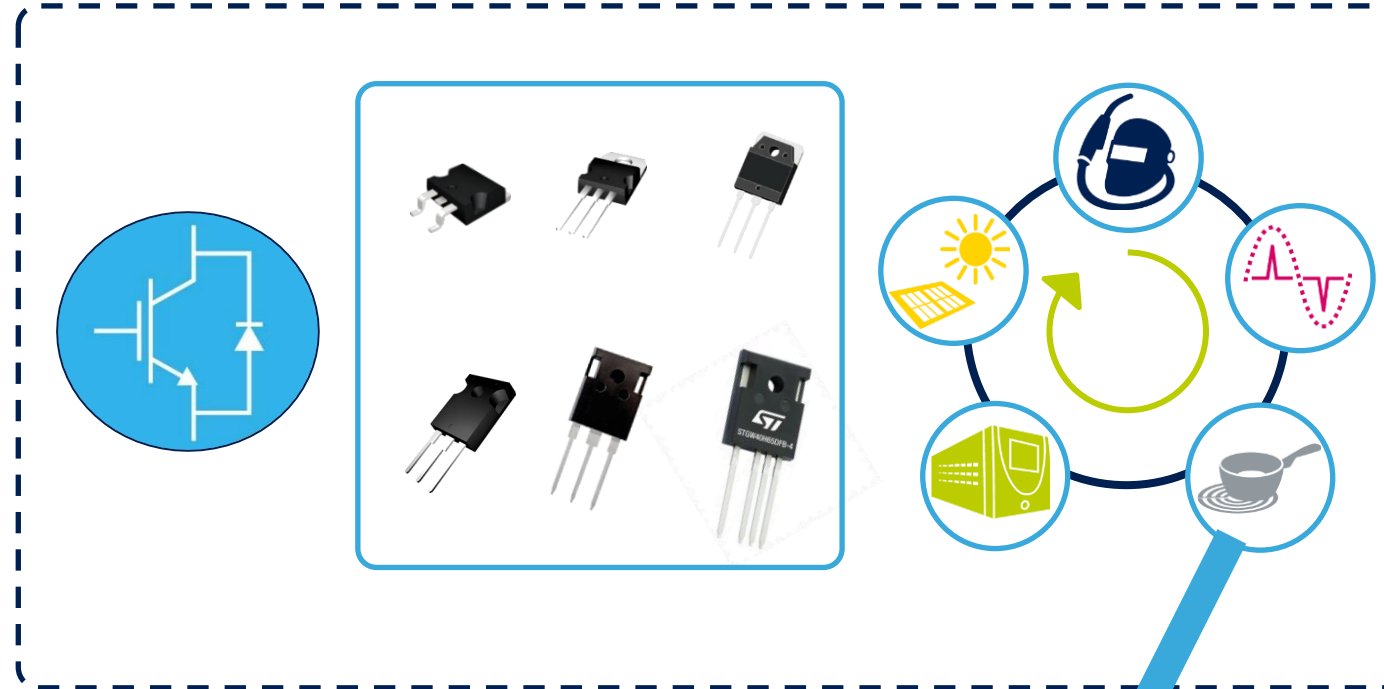
$V_{CESAT} = 1.55 \text{ V up to } 1.6 \text{ V}$

Current size of 20 A, 30 A, 40 A, 60 A, and 80 A

Up to 60 kHz

Three diode options: very fast recovery diode, protection diode, and low-drop diode

Available in D2PAK, TO-220, TO-3P, TO-247, TO-247 Long Leads and TO247-4 Leads



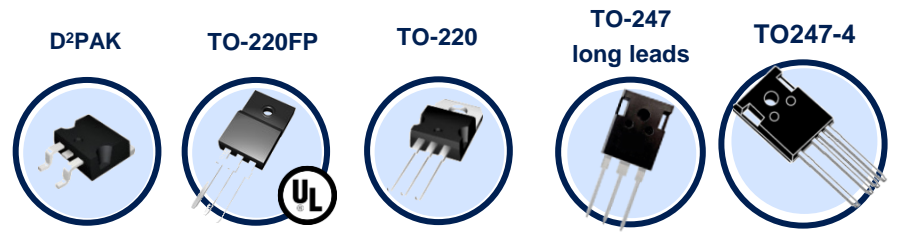
600 V HB series with low-drop diode optimized for induction heating

NEW

650 V HB2 Series IGBTs for Higher Efficiency



- Lower Qg compared to HB series
- Wide current offer from 15 to 100 A
- Several package options
- Three diode options: D, DH and for Protection
- Automotive eligible (AEC-Q101 rev.D)



* Preliminary data

Induction Heating Principle

Main applications

Industrial

- Hard (Silver) Brazing
- Tin Soldering
- Melting Applications

Domestic

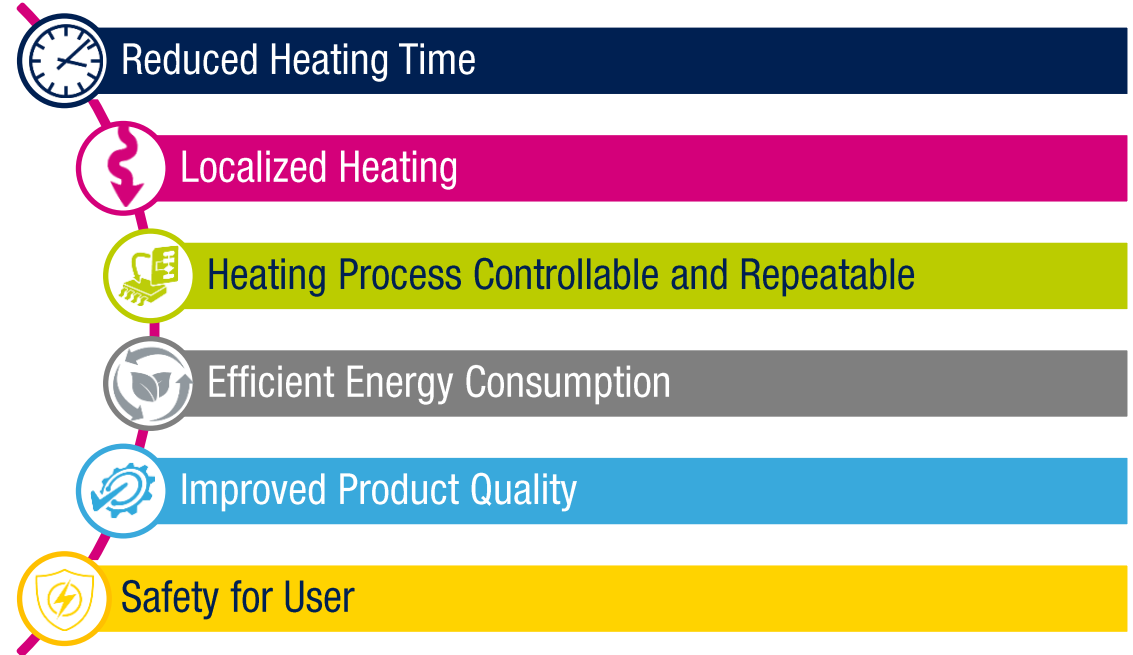
- IH appliances (cookers, microwave ovens, etc.)

Medical

- Non-invasive therapy
- Instrument sterilization

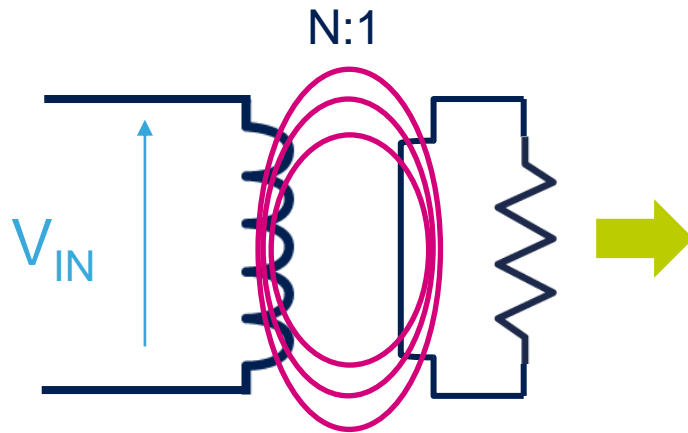


Benefits



Induction is a **flame-free, no-contact heating method** that exploits the well-known electromagnetic induction phenomenon

Eddy currents generated within the metal and its resistance leads to Joule heating and also generates losses due to the hysteresis of the magnetic material



The system can be approximated by an electric transformer, where the primary is the copper coil into the induction cooker and the secondary the bottom layer of the pot.

An induction cooker consists of a coil of copper wire, placed underneath the cooking pot.

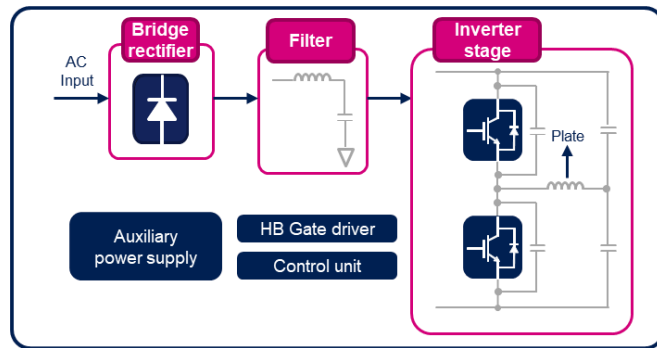
An alternating electric current flows through the coil, producing an oscillating magnetic field, that in turn induces an electric current in the pot.

Current flowing in the metal pot produces resistive heating which heats the food.

Most Suitable Topologies for IH Market

ZVS resonant converters are commonly adopted to minimize the switching losses and improve the heat conversion efficiency

HALF BRIDGE SERIES RESONANT



≈ 4 kW

600V IGBT

650V IGBT

HB

IH

STGx30H60DLFB
STGx40H60DLFB
STGx60H60DLFB

STGx40IH65DF
STGx50IH65DF

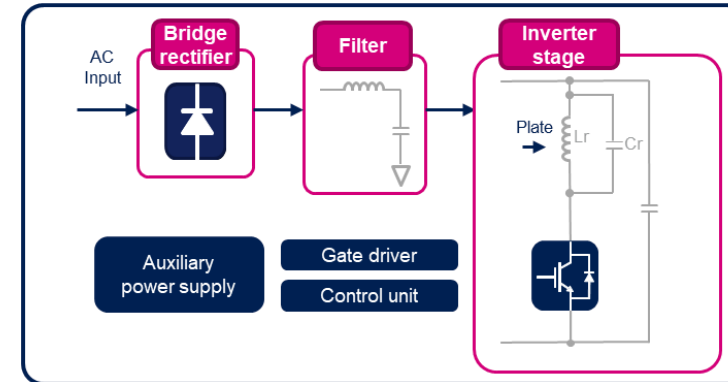
Advantages

- ❖ Lower voltage across the switch, enabling to manage higher power rating
- ❖ Robustness
- ❖ Higher power factor at full load

Drawbacks

- ❖ Two switches are required
- ❖ Higher component count
- ❖ More complex design and driving stage

SINGLE SWITCH QUASI RESONANT



≈ 2.5 kW

1250V IGBT

IH

STGx20IH125DF
STGx28IH125DF

Advantages

- ❖ One single switch needed
- ❖ Easy/economic design of heatsink and PCB
- ❖ Simple driving stage

Drawbacks

- ❖ High breakdown voltage required to the switch
- ❖ Limited power range

NEW

Induction Heating series IGBTs

Dedicated for soft-switching

12

650V IH series IGBTs

- Very low $V_{CE(sat)} = 1.5\text{ V} (@I_{CN})$
- Very low switching losses
- Low thermal resistance
- Improved efficiency in final application

Product portfolio

STGWA40IH65DF

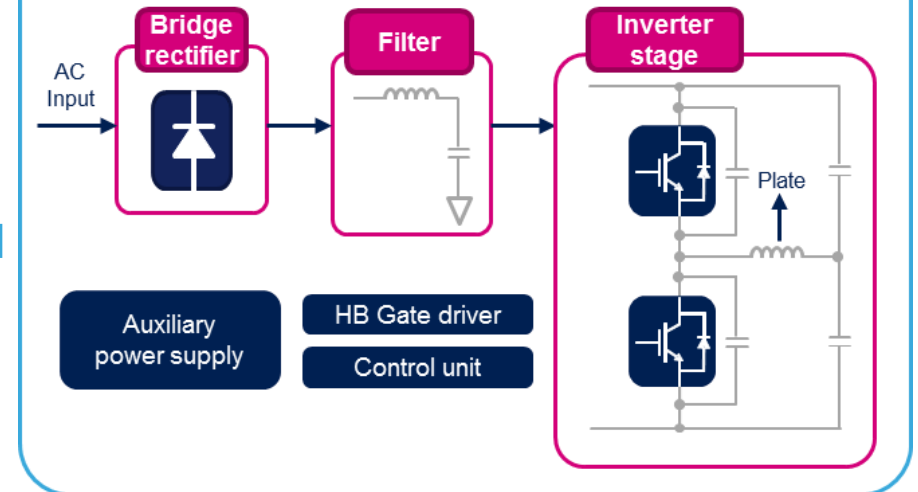
$V_{CE(sat)}=1.5\text{V}, E_{off} = 0.19\text{ mJ}^1)$

STGWA50IH65DF

$V_{CE(sat)}=1.5\text{V}, E_{off} = 0.28\text{ mJ}^1)$

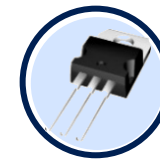
In plan

Half-bridge topology



STGx20IH65DF
STGx30IH65DF

TO-220



TO-247
long leads



MAX $T_J=175^{\circ}\text{C}$

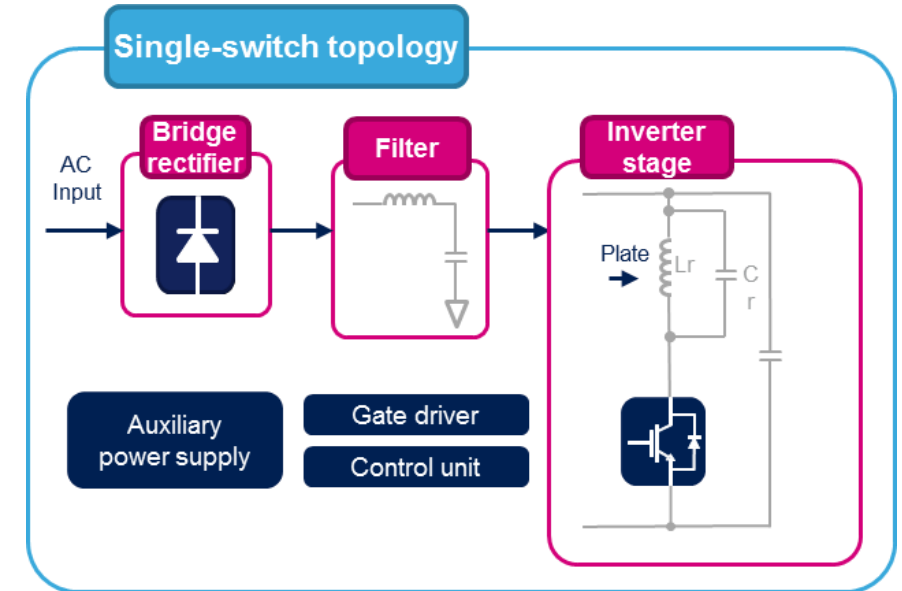
Induction Heating series IGBTs

Dedicated for soft-switching

13

1250V IH series IGBTs

- $V_{CE(sat)} = 2\text{V} (@I_{CN})$
- Low switching losses
- Low thermal resistance
- Improved efficiency in final application



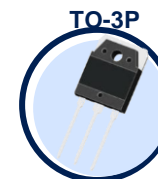
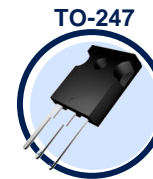
Product portfolio

STGx20IH125DF

$V_{CE(sat)} = 2\text{V}$

STGx28IH125DF

$V_{CE(sat)} = 2\text{V}$





650V IH Series IGBTs

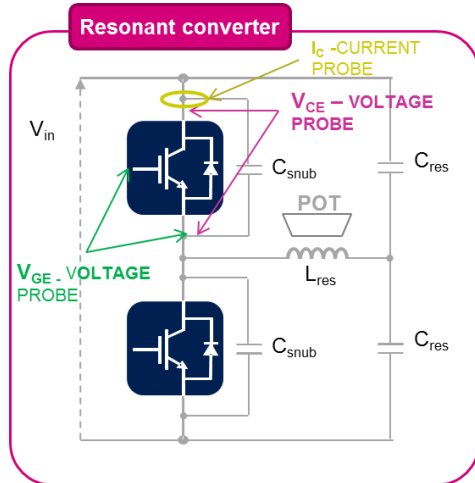
Benchmarks

40A IH vs 40A HB Comparison

in a 2.5 kW in Std Condition in Half-bridge Topology for IH

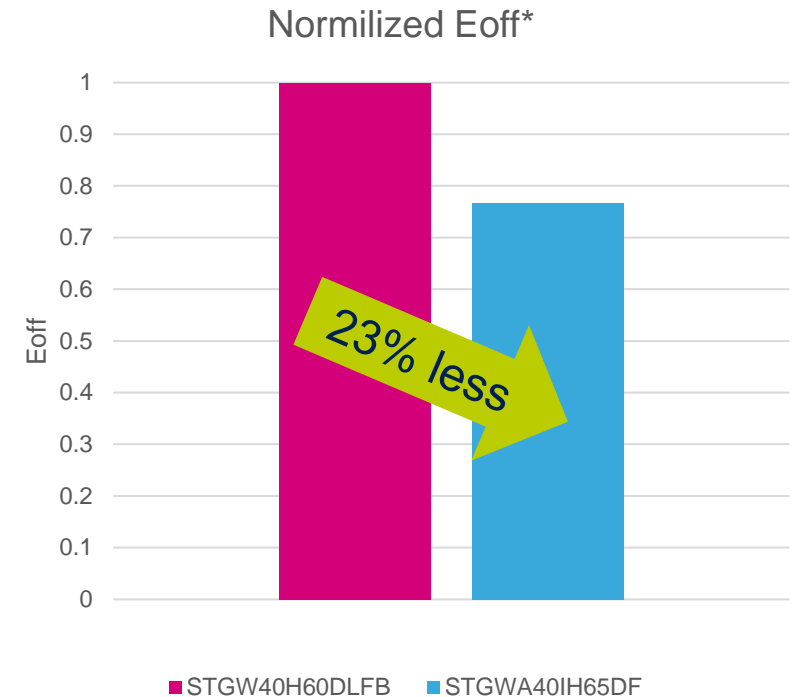
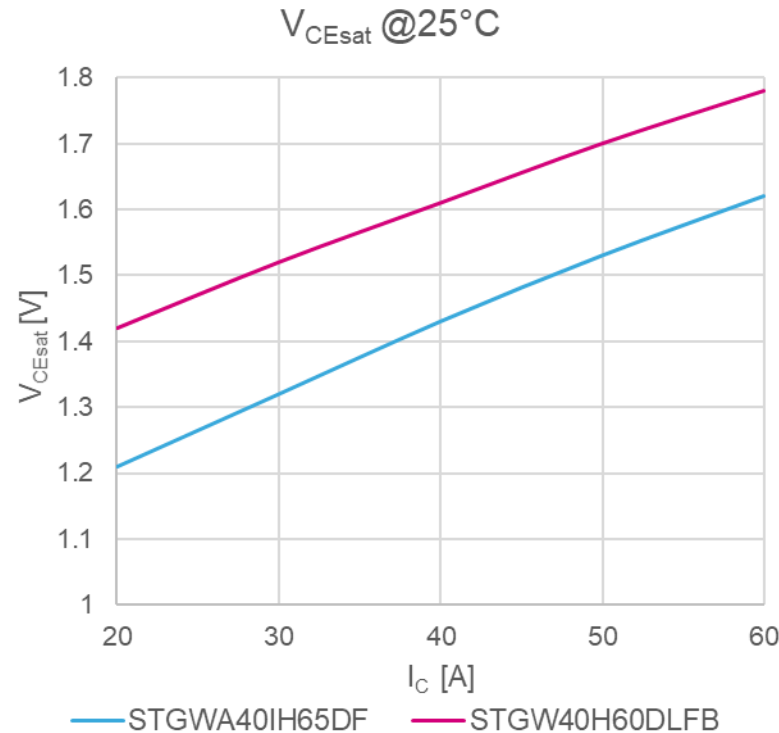
Test conditions

Switching frequency 24.9 kHz ;
Snubber capacitors, $C_{\text{SNUBBER}} = 2 \times 15 \text{ nF}$;
Resonant capacitors, $C_{\text{RESONANT}} = 2 \times 470 \text{ nF}$;
Resonant inductor, $L_{\text{RESONANT}} = 58 \text{ }\mu\text{H}$;
 $I_{\text{OFF}} = 36 \text{ A}$
 $I_{\text{PK}} = 62 \text{ A}$
 $V_{\text{FAN}} = 8 \text{ V}$
 $T_{\text{AMB}} = 25 \text{ }^\circ\text{C} (\pm 2^\circ\text{C})$



All the test results refer to a generic pot for IH cooker used in an ST lab

Static & dynamic performance



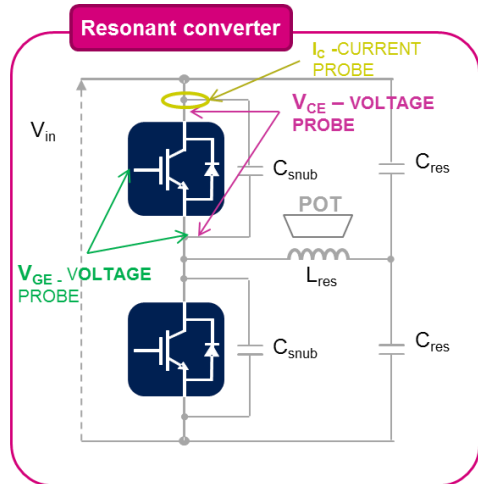
The 40A IH series outperforms the 40A HB series, lowering both saturation voltage and turn-off energy

40A IH vs 40A HB Comparison

in a 2.5 kW in Std Condition in Half-bridge Topology for IH

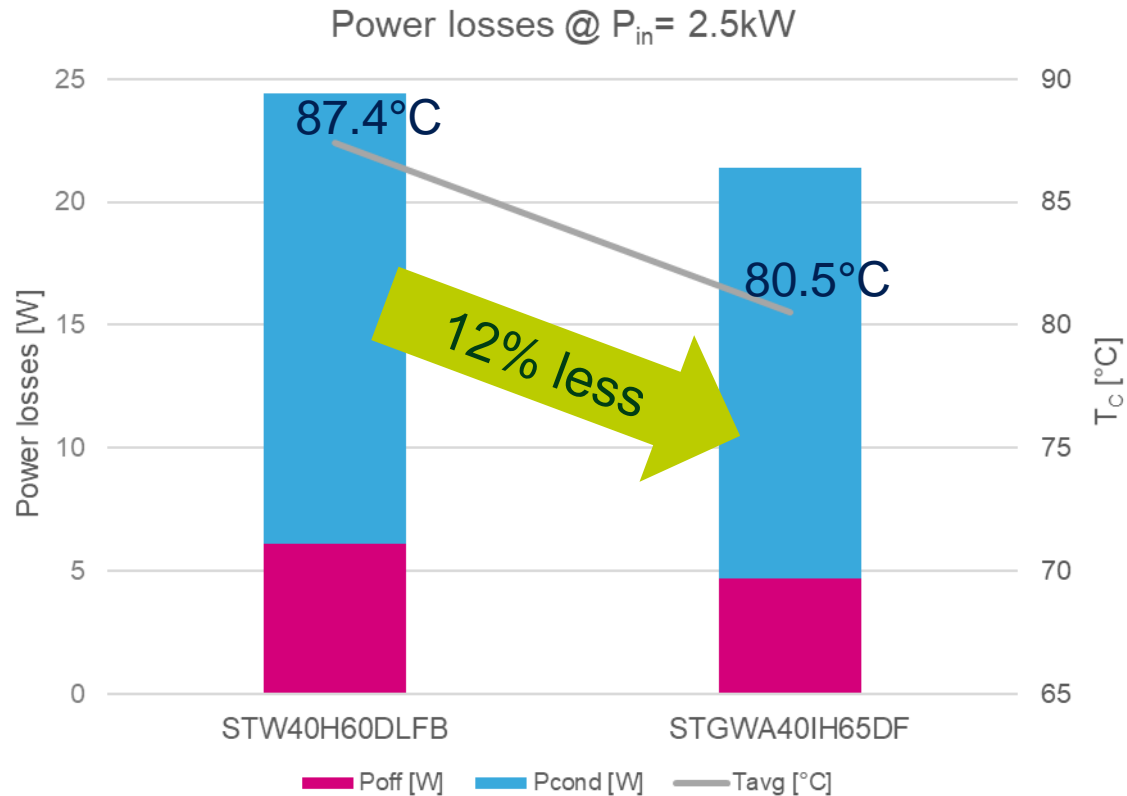
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Estimated power loss and thermal performance



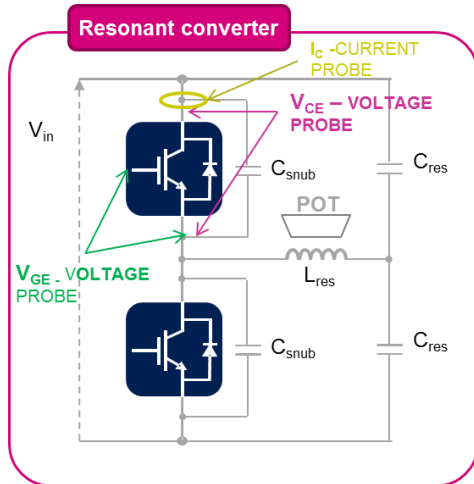
IH series guarantees **12% less** of total power loss compared to the HB series and an average case temperature **7°C less**.

STGWA40IH65DF vs 40A Competitors

in a 2.5kW in Std Condition in Half-bridge Topology for IH

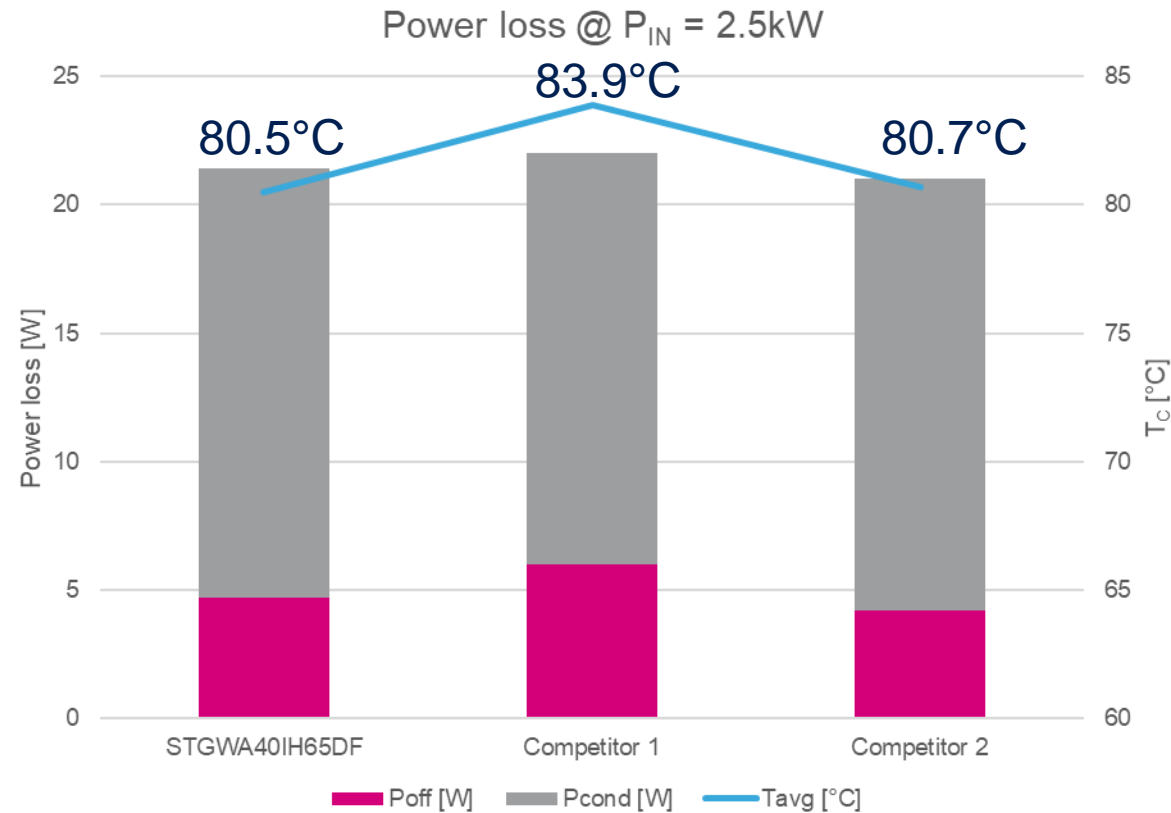
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Estimated power loss and thermal performance



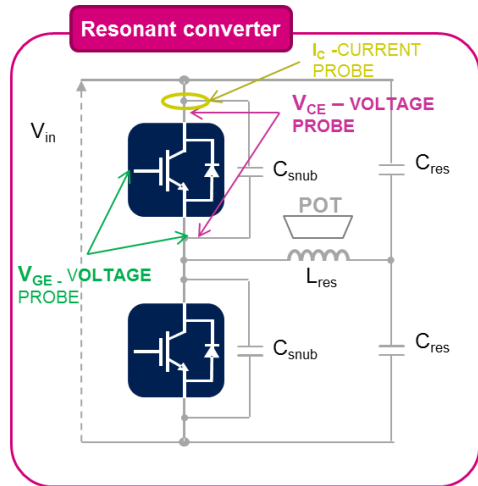
STGWA40IH65DF is aligned in power loss to the major competitors, but keeping a lower case temperature

50A IH vs 60A HB Comparison

in a 3.3kW in Std Condition in Half-bridge Topology for IH

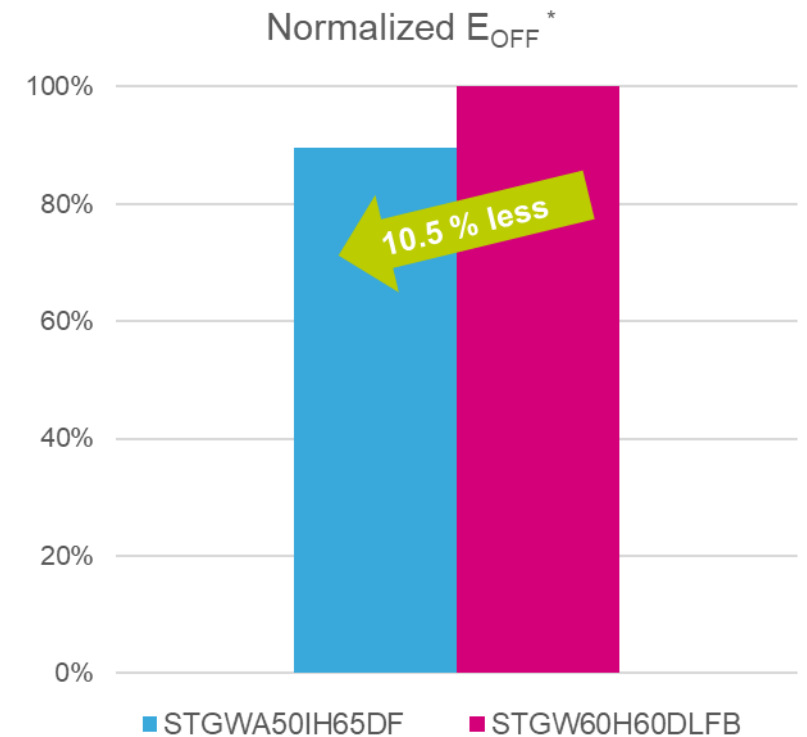
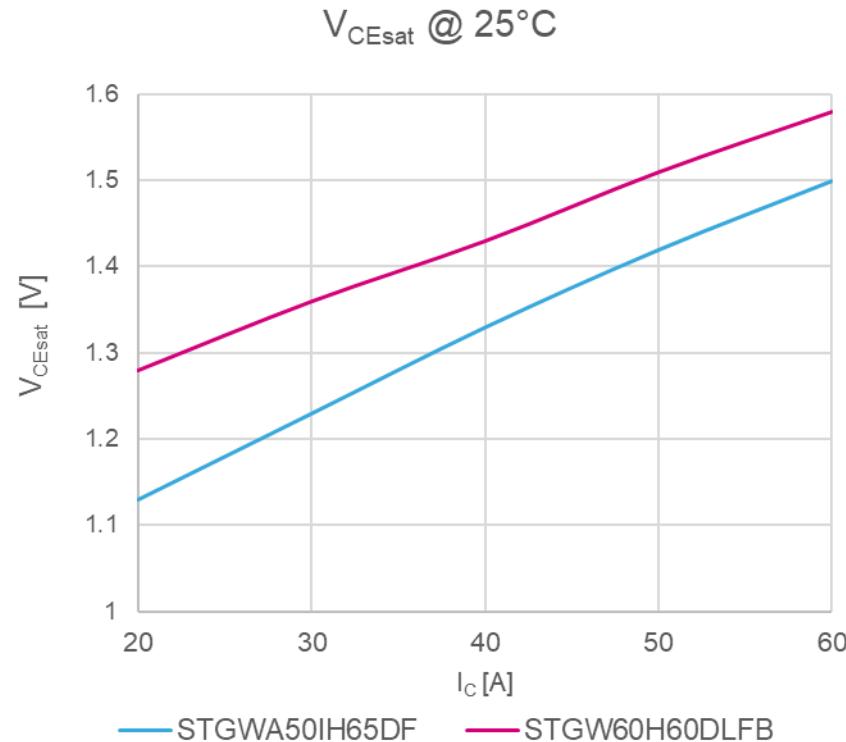
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All the test results refer to a generic pot for IH cooker used in an ST lab

Static & dynamic performance



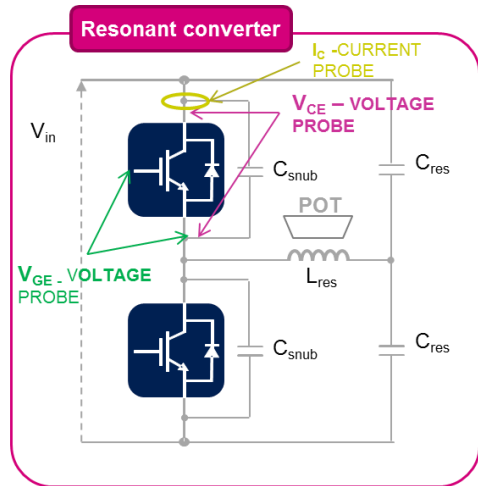
The 50A IH series outperforms the 60A HB series, lowering both saturation voltage and turn-off energy

50A IH vs 60A HB Comparison

in a 3.3kW in Std Condition in Half-bridge Topology for IH

Test conditions

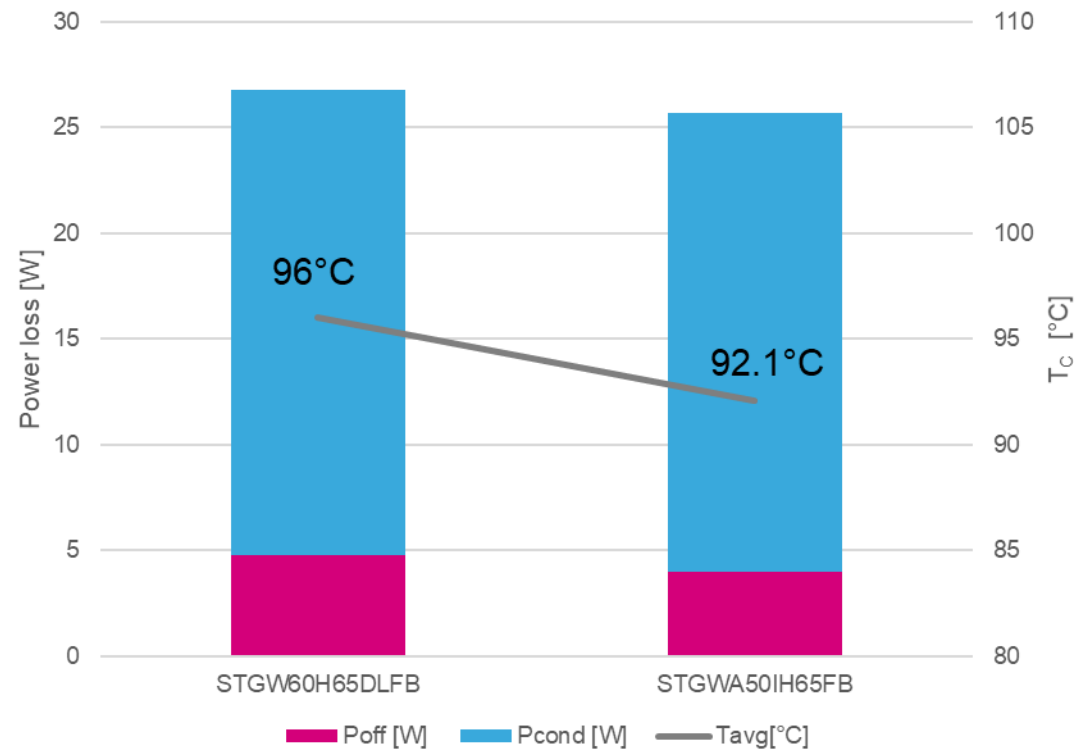
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All the test results refer to a generic pot for IH cooker used in an ST lab

Estimated power loss and thermal performance

Power loss @ $P_{\text{IN}} = 3.3\text{kW}$



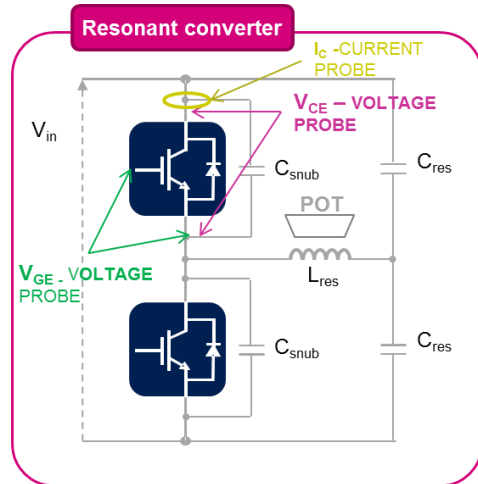
STGWA50IH65DF guarantees **lower total power loss** compared to the STGW60H60DLFB and an average case temperature **4°C less**.

STGWA50IH65DF vs 60A Competitors

in a 3.3kW in Std Condition in Half-bridge Topology for IH

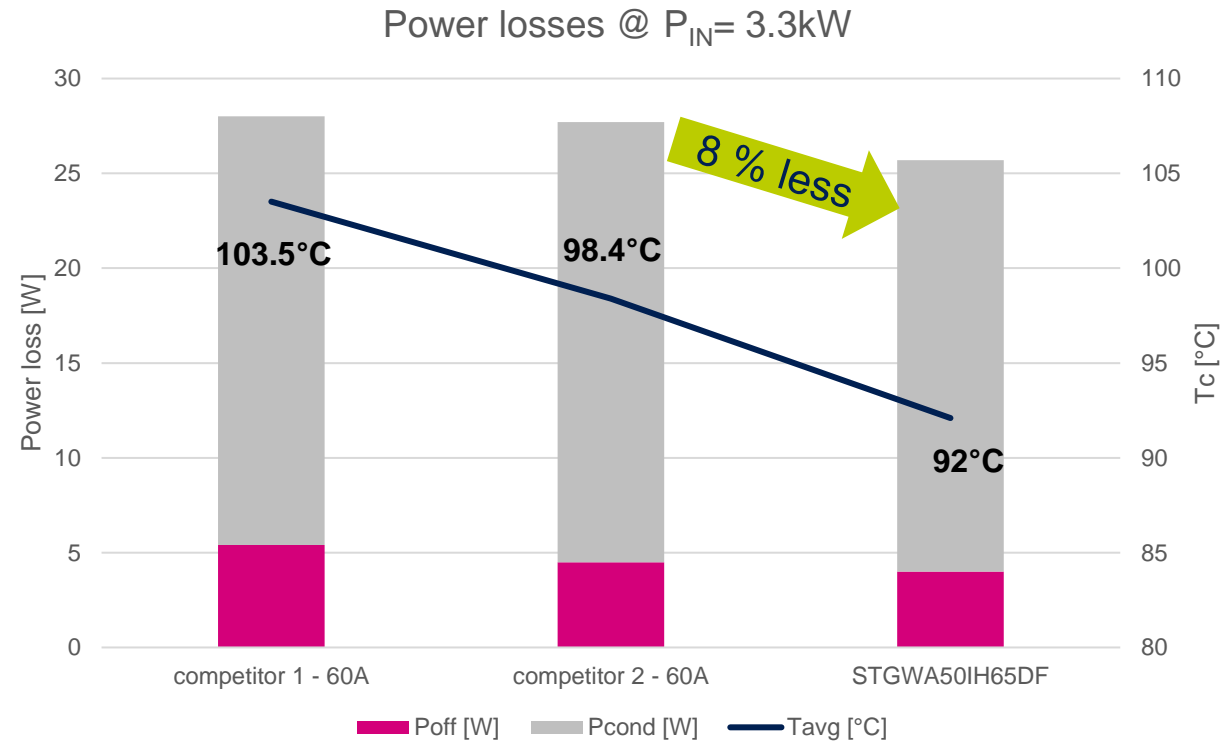
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All the test results refer to a generic pot for IH cooker used in an ST lab

Estimated power loss and thermal performances



STGWA50IH65DF saves about 8% of power loss than Competitor 3 (600 V, 60 A) and Competitor 1 (650 V, 60 A), ensuring a lower case temperature.

IGBT Support material

Trench gate field-stop IGBT
1200V M series



New M series IGBTs increase energy efficiency in UPS and industrial power applications

Based on the third generation of 1200V for IGBTs in ST's proprietary trench gate field-stop technology, the M series increases the efficiency of UPS, solar, welding and industrial drive applications. Working up to 20 kHz in hard-switching topologies thanks to the optimal trade-off between on state conduction and switching performance, these devices also offers outstanding robustness and EMI characteristics.

KEY FEATURES

- 10 us minimum delay capability at start-up
- 175 °C maximum temperature (T_j)
- The lowest overall I_{CE} to 20 kHz

KEY BENEFITS

- M series is tailored efficiency of target
- Longer lifetime
- Safe paralleling
- Soft and fast recovery antiparallel diode
- High robustness



650V HB series IGBTs
Innovative 4-lead package



Boosts application efficiency with turn-on switching energy

ST's HB series of high-speed 650V IGBTs offers increased ruggedness and enhanced reliability for applications working at switching frequencies between 16 and 60 kHz. In addition to maintaining a wide safe operating area (SOA), the maximum junction temperature of 175 °C and the extremely good V_{CE(sat)} vs E_{sw} tradeoff, the new 4-lead package significantly decreases turn-on switching energy and ensures a very good impact on system efficiency.

KEY FEATURES

- Maximum 175 °C
- Very low V_{CE(sat)}
- Very good E_{sw}
- Very high V_{CE(sat)}
- Proven thermal

ADVANCED PACKAGING

- 4-lead package
- Switching 16 - 60 kHz
- Power 40A, 60A

650V IH series IGBTs
The best choice for induction heating



Maximize efficiency in induction heating systems as well as resonant and soft switching applications

Specifically designed for induction heating applications, ST's 650V IH series in trench gate field-stop (TFS) IGBT technology offers very low V_{CE(sat)}, thermal resistance and switching losses.

Thanks to the fast and soft recovery free-wheeling co-packed diode, the 650V IH series ensure superior performance and high efficiency in induction heating applications (half-bridge topology) and in resonant and soft switching circuits in a wide switching frequency range from 16 to 60 kHz. Available in current capability of 40 A and 60 A in TO-247 long-lead package, the series will be enlarged with 20 A and 30 A devices in TO-247 long-lead and in TO-220 package.

KEY FEATURES

- Wide frequency range from 16 to 60 kHz
- Very low V_{CE(sat)} (1.5 V typ)
- Low thermal resistance
- Maximum operating T_j of 175 °C
- 650 V very fast and soft recovery free-wheeling co-packed diode

TARGET APPLICATIONS

- Half-bridge induction heating
- Microwave ovens
- Resonant converters




AN4713 Application note

Induction cooking: IGBTs in resonant converters

HB and V series

Luigi Abbatelli, Giuseppe Catalisano, Rosario Gulino, Maurizio Melito



AN4638 Application note

Welding machines: V and HB series IGBTs on two-switch forward converters

Anselmo Liberti, Rosario Gulino

HB series



AN5277

Application note

Introduction to the new fast 650 V HB2 IGBT series on a two-switch forward welding equipment

HB2 series

IGBT finder





For additional information,
please visit www.st.com