Optimized Solutions for Competitive Resonant Appliances

The Next Generation RC-H5 IGBT Optimized for Induction Cooking and Resonant Applications

Inverterization is growing rapidly especially in the field of switched mode power supplies and consumer drive applications due to the demand for more efficient products. Discrete IGBTs are used as the preferred power switch covering most of these applications from 60W to 3.6kW. Interest in home appliances using IGBTs in resonant switching conditions is also increasing for the same reason.

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Today's appliances like inverterized induction cooking stoves, microwave ovens, rice-cookers and continuous flow water heaters are more popular than ever before. These products not only offer the consumer improved energy efficiency, but also offer convenient features like fast heating times and quick, variable temperature control. These application examples require specific optimized power devices in place of the standardized IGBTs used in hard-switched drives applications.

With a new family of IGBTs Infineon introduces the next generation of reverse conduction IGBTs, RC-H5. This new series for single-switch and half-bridge topologies is further optimized for usage under resonant or soft-switching conditions. The IGBT portfolio is complemented by the new generation of EiceDRIVER™ driver ICs with the 1EDL compact series for general usage as a low-side switch and the 2EDL series for half-bridge applications. The portfolio of the IGBT and the matching driver IC is shown in Table 1.

Continuous Collector Current At T=100 °	600V/650V	1100V	1200V	1350V	1600V
IGBT and Diode			IHW15N120R3		
20A	IHW20N65R5*		IHW20N120R3 IHW20N120R5*	IHW20N135R3 IHW20N135R5*	
30A		IHW30N110R3	IHW30N120R3	IHW30N135R3	IHW30N160R2
40A	IHW40N60R IHW40N60RF IHW40N65R5*		IHW40N120R3	IHW40N135R3	
50A	IHW50N65R5*				
EiceDRIVER™	1EDL compact* (2EDL compact)	1EDL compact*	1EDL compact*	1EDL compact*	1EDL compact*

*NEW

Table 1: Infineon's IGBT and driver portfolio for resonant applications

The main focus of the new 1200V/1350V RC-H5 family is on single-switch induction cooking appliances with the benefit of a well-balanced cost/performance trade-off, which results in an overall system cost optimization for the designer. The new series allows the reduction of the bill-of-material (BOM) by savings in the passive components, such as the amount of copper used in the chokes by decreasing the inductance value. It is also possible to increase the coil diameter with less turns to allow a significant increase of the system-efficiency due to less resistive losses. The increase in efficiency is due to 30% reduction of switching losses compared to the previous version. Through the combination of these two optimizations, the best cost/performance balance can be achieved. The highest efficiency standards can be reached without increasing the material cost, and it might even be lowered. A sample topology where the IGBT is used as a single-switch inverter is depicted in Figure 1.

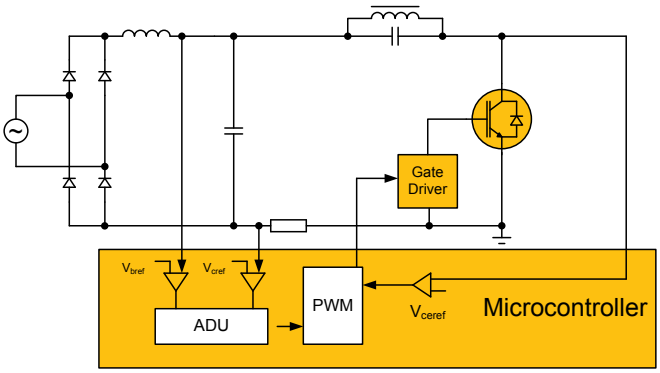

Figure 1: Quasi-Resonant Inverter (single-switch) that is used for Single-Ended induction cooking hobs

The new single-switch RC-H5 family offers the system not only cost/performance savings, but also a simpler handling of the power device. One important aspect of the chip design was to optimize the IGBT to improve the EMI behavior of the system. As an example the chip's

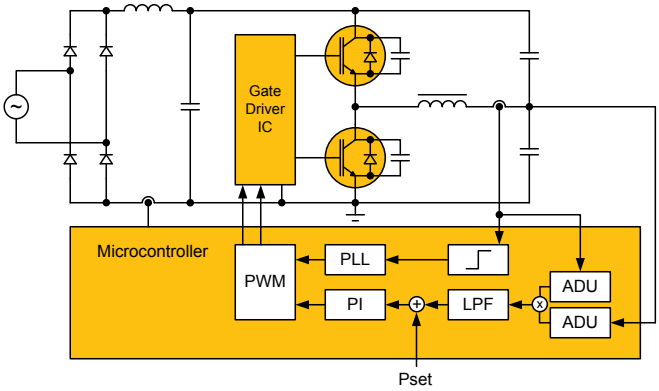

Figure 2: Half-Bridge Inverter that is used in Half-Bridge based induction cooking hobs

current electrical behavior results in a low tail current in combination with a soft di/dt ($t_{d,off}$). The system result is an EMI behavior that comes with less effort in the filtering at the input stage.

The single-switch RC-H5 series is complemented with a new generation of IGBTs, the half-bridge RC-H5 series. The half-bridge RC-H5 is optimized for induction stoves and can easily cover the full power range from 300W to 3.6kW, without the need of going into a burst mode where the system has to go into a pulsed turn-on turn-off behavior. The topology of this application is depicted in Figure 2.

The new half bridge RC-H5 series has enormous advantages compared to older 600V RC-IGBT technologies. The new devices combine the superior features of low conduction losses and low switching losses given by the high speed characteristics. The reduced total losses can increase the system efficiency by 30% in a 40kHz resonant-switching-design. This IGBT family is now even more flexible because it can also be used in hard-switching conditions. The power losses when turning on the devices have been reduced significantly by reducing the effect of a high Q_{rr} and a dependency of the V_F to the applied gate-voltage as shown in Figure 3. The significantly reduced Q_{rr} while turning on the IGBT allows the resonant system to be operated across a wider range even when not operating in over-resonant conditions.

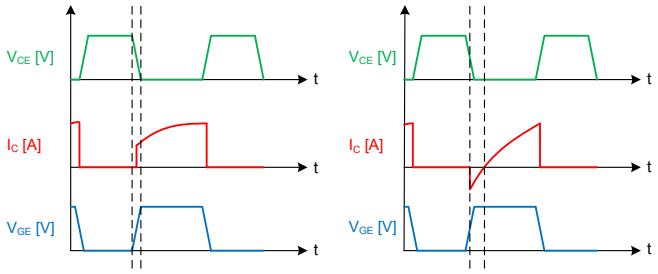

Figure 3: New RC-H family in 650V shows hard-switching capability (left) and a low dependency of the V_{GE} vs. V_F (right)

Furthermore, because of its superior loss behavior the new family can easily be used to get more output power by directly replacing a previous generation, due to the same package and similar EMI-behavior. The portfolio in 1200V/1350V and 650V offers 20A devices for utilization in inverterized microwave ovens or smaller induction heaters with output power below 1.8kW. The 40A and 50A versions of the 650V IGBT family are suitable for systems with higher output power.

The optimal design of the new family makes these devices suitable not only for purely soft-switching applications, but also allows them to be used in applications where the IGBT can run into some hard-switching conditions. As an example these conditions can appear at the turn-on phase of the system during duty-cycle variation.

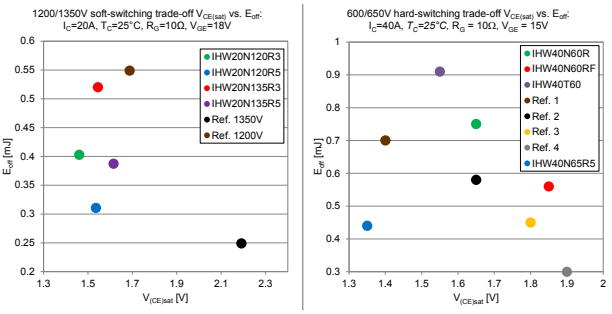

Figure 4: Trade-off diagrams 1200V/1350V (left) and 600V/650V (right) for resonant application VCE(sat) vs Eoff

The diagrams in Figure 4 show the superior electrical performance trade-off of the RC-H5. This curve defines the IGBT power losses related to the $V_{CE(sat)}$ and the E_{off}. The resulting junction temperature in combination with the used R_{thj-c} and the R_{thc-a} will result in low values. The resulting temperature of the T_j (junction temperature) is a key issue for the reliability of the IGBT. The optimization of the chip-size and the active area of the IGBT-cells of the monolithically integrated IGBT/diode combination are highly tuned to allow low temperatures in high power and low power conditions. The combination of advanced soldering processes with the perfect fit of the TO-247 package, offers a component that is ideally suited for resonant circuits. This reduces the size of the heatsink and the effort of the fan needed to cool the power semiconductors. The new series gives designers superior thermal behavior in the application and keeps the overall ambient, heatsink, and case-temperature low.

Reliability is a key issue for home appliances where the RC-H5 series stands out. The 1200V/1350V IGBTs show less current spikes during capacitive charging during the turn-on. The value has been reduced by 10%. Furthermore new processes in the chip allow the device to handle external stress moments like lighting surges better than ever. For the new 650V version the blocking voltage and the resulting breakdown voltage were increased by 50V without any sacrifice in the conduction and switching behavior. It also offers these improvements in 1200V as it is the highest performance device in the family; it ideally fits in systems that can handle the surges by advanced control algorithms. With an eye on reliability the new family thus provides outstanding values and helps to design a system protected from outside disturbances.

Infineon's new power switches are targeted specifically for the needs of each application, and the RC-H5 is the next step in this optimization for home appliances. Ideal system solutions are also available by combining with the compact EiceDRIVER™ Compact family and the industry optimized XMC1000/XMC4000 ARM® Cortex™-M microcontroller technology.

For further information on the complete portfolio, including product briefs, selection guides, datasheets and application notes please visit: www.infineon.com/igbt, for specific material on the new RC-H5 series: www.infineon.com/rch5 Information on the EiceDRIVER™ compact family and the XMC family can be found here: www.infineon.com/eicedriver and www.infineon.com/xmc

Literature:

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