

A New Gate Driver IC Family that Fits All

Infineon Technologies presents the new EiceDRIVER™ Compact family, a single channel gate driver IC for general purpose. The different variants of the family are intended to support discrete IGBTs, IGBT modules and MOS transistors, but also SiC and GaN switches. **Oliver Hellmund, Heiko Rettinger and Michael Wendt, Infineon Technologies, Germany**

Ranging from 0.5A up to 6A output current, the available devices allow gate driving of IGBTs and MOS transistors with different power classes. The DSO-8 package of the EiceDRIVER™ Compact ensures a small footprint and higher power density. Additionally, the reduced complexity facilitates the integration into system designs. The coreless transformer isolation technology ensures an undisturbed operation at offset voltages up to ± 1200 V and a common mode transient immunity (CMTI) of more than 100 kV/ μ s. This is a significant improvement in robustness and a new milestone when it comes to galvanically isolated drivers.

The 1EDI20N12AF and 1EDI60N12AF are intended to drive MOSFETs, SiC, and GaN switches. The output current to drive the gate is set at a minimum of 2 A or 6 A. Both devices have a separate charge and discharge output to adapt the turn on and turn off phase to the application by using different resistor values. With the propagation delay below 105 ns and the input filter time of only 40 ns the device can be used up to 4 MHz for high switching frequency applications as SMPS. Both types are optimized for utilization with power semiconductors based on the CoolMOS™ technology. The undervoltage

threshold UVLO is fitting to proper MOS transistors operation. The EiceDRIVER Compact in conjunction with the new CoolMOS C7 device in a 4 pin package enables an additional gain in efficiency of 0.5 %. Besides SMPS these drivers are recommended for applications such as PFC, server, telecom, solar, buck/boost converter and PC power.

The 1EDI05I12AF, 1EDI20I12AF, 1EDI40I12AF and 1EDI60I12AF are intended to drive discrete IGBTs and IGBT modules with a gate output current from at least 0.5 A to 6 A. The four variants also have separate outputs for charging and discharging the gate, similar to the 1EDI20N12AF and 1EDI60N12AF. The drivers are designed with a large built in input filter of 230 ns for robust PWM operation in harsh environments. As a result, these driver ICs are characterized by an enlarged propagation delay of 300 ns. The delay time is trimmed for better matching of the switching behavior of different devices. Typical applications are drives, solar inverters, welding or inductive cooking.

Also belonging to the EiceDRIVER Compact family, the 1EDI10I12MF, 1EDI20I12MF and 1EDI30I12MF feature an Active Miller Clamp instead of the separated charge/discharge outputs. This

solution keeps the transistor turned off at high dV/dt across the IGBT even with an unipolar power supply. Details of the Compact family are shown in Table 1.

Coreless Transformer

Compared to previous designs the coreless transformer technology enables higher output currents and therefore higher power density while the same compact DSO-8 package can be used.

Fast switching of the power stage can have a major impact on the system functionality if the driver is not designed for such an application environment. The robust design of the new coreless transformer ensures a high CMTI at a dV/dt operation of more than 100 kV/ μ s, as tested in an application circuit with CoolMOS transistors [1].

The internal input noise filter will cancel any noise up to a pulse duration of $T_{MININ} \pm 40$ ns for MOSFET and $T_{MININ} \pm 240$ ns for IGBT variants. Thus, no external filter is needed in standard applications.

The input logic was designed for a wide operating range while the input threshold voltage levels are always linked to the positive input supply voltage. The integrated under voltage lockout circuit will activate the chip at 3 V and, from this level onward, the input high threshold

Sales Code	1EDI60N12AF	1EDI20N12AF	1EDI60I12AF	1EDI40I12AF	1EDI20I12AF	1EDI05I12AF	1EDI30I12MF	1EDI20I12MF	1EDI10I12MF
Package	DSO-8 (150mil)		DSO-8 (150mil)				DSO-8 (150mil)		
Applications	SMPS, PFC, telecom, server, solar, buck/boost converter, PC power		General purpose inverter (GPI), drives (general purpose & servo), welding, IH industrial and cooking, solar inverter, UPS				General purpose inverter (GPI), industrial drives, welding, IH industrial, solar inverter, UPS		
Voltage class	up to 1200V		up to 1200V				up to 1200V		
Output Current	6 A / -6 A	2 A / -2 A	6 A / -6 A	4 A / -4 A	2 A / -2 A	0.5 A / -0.5 A	3 A / -3 A	2 A / -2 A	1 A / -1 A
Separate source / sink output	✓	✓	✓	✓	✓	✓	-	-	-
Active miller clamp	-	-	-	-	-	-	✓	✓	✓
UVLO	MOSFET		IGBT				IGBT		
Propagation delay	105ns	105ns	300ns				300ns		
Max. switching frequency	4 MHz	4 MHz	1 MHz				1 MHz		
Recommendation	CoolMOS™ C7, CP		All 650V and 1200V IGBT modules				All 650V and 1200V IGBT modules		

Table 1: Product overview of the new EiceDRIVER™ 1EDI Compact family

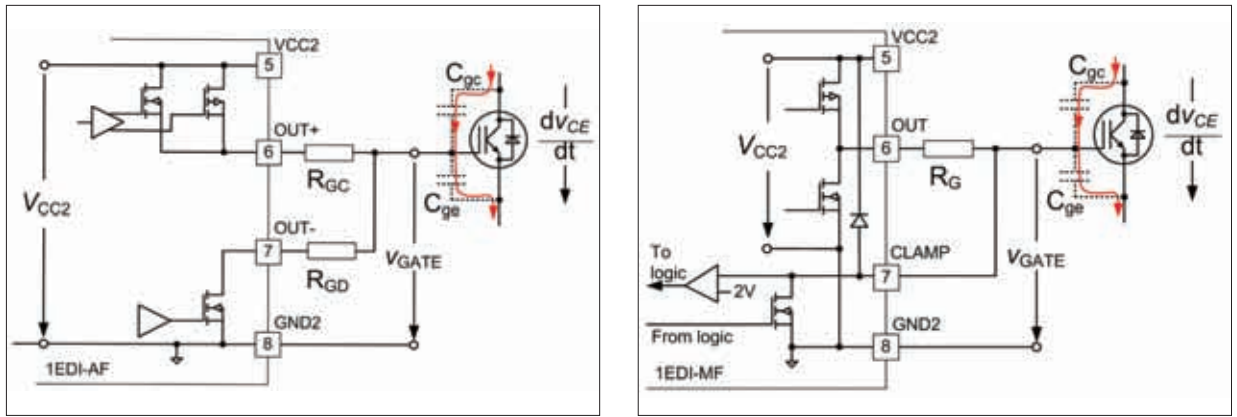


Figure 1: Output block diagram (left: separate output variant; right: CLAMP variant)

voltage will always be at $V_{IN+}=0.7 \cdot V_{CC1}$. The input low threshold voltage is set at $V_{INL}=0.3 \cdot V_{CC1}$ accordingly. This linear scaling allows for operations directly from a 3.3 V digital signal processor but is also capable of accepting output signals from a 12 V PFC controller to boost its signal. The maximum input voltage rating is $V_{CC1,max}=17$ V.

Inverting and Non-Inverting Input

The new 1EDI Compact family members provide the option to use two input signals, one inverting and one non-inverting. These inputs can be utilized in various combinations depending on the application needs. For example, the non inverting input can be used as PWM input while the inverting input can operate as kind of enable signal or vice versa. Another example is the inverted driving of the input, $IN+$ is high while $IN-$ is low. This can be useful for safety reasons.

If two devices are used to drive IGBTs or MOS transistors in a half bridge configuration, the $IN+$ signal of the High Side Driver can be connected to the $IN-$ signal of the Low Side Driver and vice versa. In such a configuration a cross conduction is avoided.

The $IN+$ terminal is internally pulled down to favor off state and the $IN-$ terminal is pulled up respectively. This setup also ensures an off state in all other configurations where an input signal might be connected to a high impedance output, a weak solder joint or a wire break.

Various Output Configurations

The 1EDI Compact family targets a broad range of applications. Different variants are offered to support individual requirements.

The devices with separate output for source and sink are useful to adapt the application circuit for turned on and off switching behavior. This is made possible by implementing separate gate charge

and discharge resistors without the need of an additional external diode. Details are shown in Figure 1, left hand side. The supply voltage can be up to $V_{CC2}=35$ V. The IC can be used with unipolar power supply for bipolar gate voltages. As a result, the driving circuit can be simplified with less PCB space and minimized parasitics in the gate loop leading to a better performance.

Another output configuration is shown in Figure 1, right hand side. Here, a common charge/discharge path is combined with an Active Miller Clamp. The advantage of this setup is that the transistor is turned off even with high dV/dt . In this solution the bipolar supply can be avoided to reduce the circuit efforts and PCB space. The driver IC supports unipolar supply of up to $V_{CC2}=20$ V which is sufficient for most of the applications.

Due to the low quiescent current of the driver, a simplified supply voltage generation with bootstrap circuit can be used. The driver supports a high modulation index without the need of being equipped with a huge bootstrap capacitor.

An additional benefit of the Active Miller Clamp variant is the integrated diode which clamps the pin CLAMP to V_{CC2} . Since this pin is directly connected to the gate of the power switch there is no

additional resistive path compared to the body diode of the general gate output and gate resistor path – normally to be found in similar configurations. Thus, space is saved for another external diode on the PCB. The CLAMP function itself has the same current capability as the output. The 1EDI30I12MF has a minimum peak current of $I_{OUT}=3$ A. The CLAMP circuit becomes active at turn off when the voltage at the CLAMP pin drops below $V_{GATE}=2$ V. At the next turn on the CLAMP circuit is switched into a tri-state mode.

Thermal Performance

The dual chip design of the EiceDRIVER Compact family creates two independent sections of power loss within the package. The input section has been evaluated on its own to exclude effects from the output chip. In the second step of the evaluation the input and output operation have been combined as described in Figure 2.

The temperature increase of a 1EDI60N12AF as a function of input switching frequency of up to 5 MHz and the supply voltage of up to $V_{CC1}=17$ V was tested. The driver IC shows a temperature increase in the area of the input chip of up to 5.5 K at $V_{CC1}=5$ V and of up to 14 K at $V_{CC1}=17$ V.

For the evaluation of the output section, the input was supplied with a

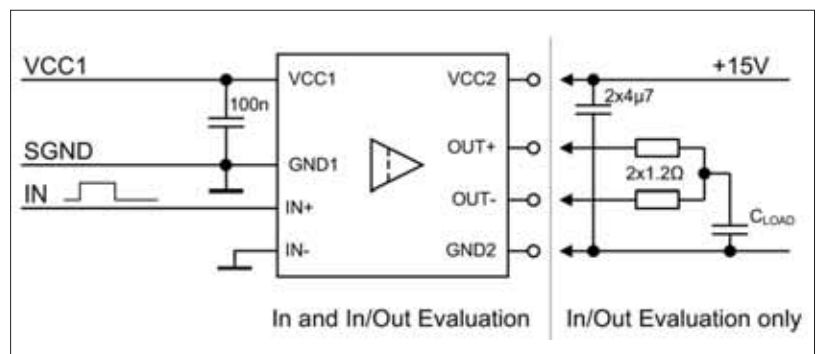


Figure 2: Application usage of logic input

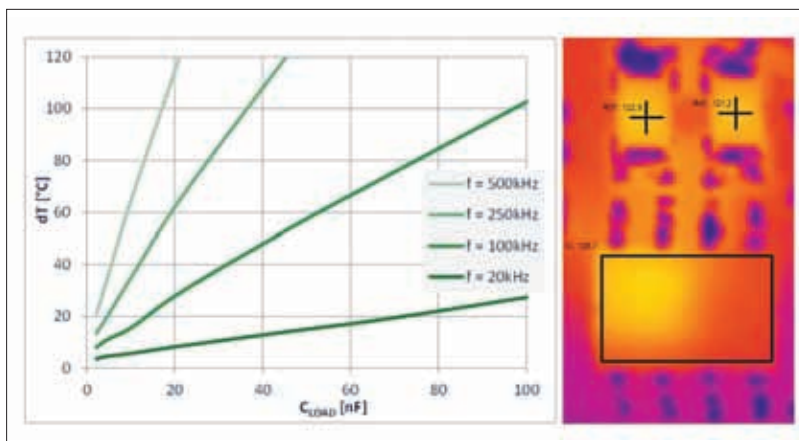


Figure 3: Overall temperature evaluation over capacitive load at various switching frequencies

constant voltage of $V_{CC1}=5$ V. However the influence of the input chip is minor compared to the power loss in the output chip at $V_{CC2}=15$ V and 50 % duty cycle. The thermal effects of capacitive load (C_{LOAD}) variation and different switching frequencies are recorded in Figure 3. The power loss was shared between the driver output stage and the two external gate resistors of 1.2Ω each.

Output Current Capability

The output current is one of the most important parameters of a driver IC. The strongest driver ICs of the family, 1EDI60112AF and 1EDI60N12AF, are rated with a minimum peak current of $I_{gate}=6$ A at $V_{DS}=15$ V across the output device. This rating is valid over the whole temperature range, so typical values nearly double during a dynamic short circuit test without external gate resistors. Therefore, the additional booster circuit common to older designs is not needed anymore for many applications. Since the driver can deliver the output voltage up to the supply voltage in on state and down to GND in off state, the disadvantage of the reduced output

voltage of a simple boost circuit can be avoided.

Switching Results

The driver 1EDI60N12AF was evaluated in a test circuit by using the CoolMOS IPZ65R095C7 as load for the driver in a boost configuration running at 50 % duty cycle and switching frequency $f_{sw}=1$ MHz. The typical total gate charge of the transistor is 45 nC [3]. In this test circuit the power supply voltage was 50 V and the gate driver supply voltage was $V_{CC2}=12$ V. The gate charge resistance and the gate discharge resistance was 1.2Ω . The output load current was 0.5 A and the supply current of the driver was 56 mA.

With this operation conditions the maximum temperature at the CoolMOS was $T_{CM}=81^\circ\text{C}$ and at the driver with $T_{DN}=64^\circ\text{C}$. For this reason, the capacity of the 1EDI Compact is more than sufficient to drive the CoolMOS C7. Even at high switching frequencies the driver shows proper behavior.

Conclusion

The EiceDRIVER Compact family was developed to be operated with a wide

range of discrete IGBT, MOS, modules, SiC and GaN switches. One example of the thermal performance in a test circuit and one typical application circuit were shown and discussed, both proofing the outstanding performance of the new driver family. Due to its innovative design the efforts for the application circuit can be reduced. Wide input supply range and flexible input signal configurations minimize external circuit requirements, complexity and PCB space. The strong driver output and high switching frequency capability eliminates the need for booster stages which, again, saves PCB space and increases overall power density. Several output current / gate current classes and configurations of the driver family guarantee for an optimized system design in terms of layout, performance and cost. With the integrated features and the smart solution of the driver it's easy to use. Thus, the device family matches the requirements of the applications in a cost-driven, high performance and high power density markets. Further details are available at [4].

Literature

- [1] H. Rettinger, "1ED Compact – A new high performance, cost efficient, high voltage gate driver IC family", PCIM 2014, Germany
- [2] J. Hancock, F. Stückler, E. Vecino, "C7 CoolMOS™: Mastering the Art of Quickness", Application Note AN 2012-11 V1.0, Infineon Technologies
- [3] Datasheet IPZ65R095C7
- [4] <http://www.infineon.com/eicedriver-compact>