Injecting Digital into Power Electronics: Programmable Digital Gate Driver IC for Power Transistors

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***Abstract*— A gate driver IC is an important circuit bridging the voltage gap between control ICs operating at less than 5 V and the power electronics operating above 30 V. The conventional gate driver IC, however, just turns on/off the power transistors and shows the trade-off between the switching loss and the switching noise of the power transistors. In addition, the conventional gate driver IC need to be customized for a large variety of power transistors. To solve the problems, we proposed a programmable general-purpose digital gate driver IC, which dynamically changes the gate drive current during the turn-on/off transient with digital control bits. In the developed gate driver IC fabricated with 40 V, 0.18 µm BCD process, the 6-bit gate control signals with four 160-ns time steps are globally optimized using a simulated annealing algorithm, reducing the switching noise by 37 % and the switching loss by 47 % at the double pulse test of 300 V, 50 A insulated gate bipolar transistor (IGBT).**

Keywords—Gate driver, Power transistor, IGBT, Switching loss, Switching noise

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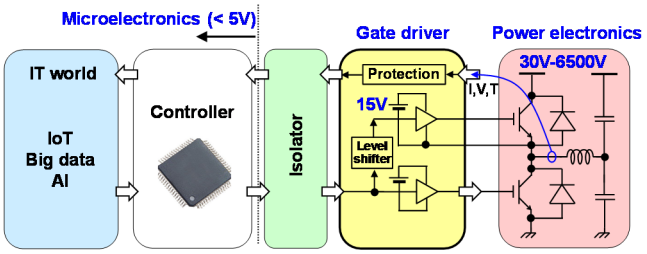

Fig. 1. Function of gate driver in power electronics. Gate driver is interface between microelectronics and power electronics.

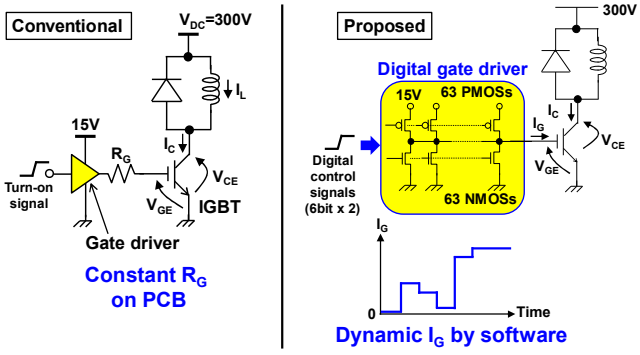

Fig. 2. Conventional gate driver with fixed gate resistance (R_G) and proposed programmable digital gate driver.

REFERENCES

[1] K. Miyazaki, S. Abe, M. Tsukuda, I. Omura, K. Wada, M. Takamiya, and T. Sakurai, "General-Purpose Clocked Gate Driver IC With Programmable 63-Level Drivability to Optimize Overshoot and Energy Loss in Switching by a Simulated Annealing Algorithm," IEEE Transactions on Industry Applications, Vol.53, No.3, pp. 2350 - 2357, May/June 2017.

[2] T. Sai, K. Miyazaki, H. Obara, T. Mannen, K. Wada, I. Omura, M. Takamiya, and T. Sakurai, "Load Current and Temperature Dependent Optimization of Active Gate Driving Vectors," IEEE Energy Conversion Congress & Exposition, pp. 3292-3297, Sep. 2019.

[3] T. Sai, K. Miyazaki, H. Obara, T. Mannen, K. Wada, I. Omura, T. Sakurai, and M. Takamiya, "Stop-and-Go Gate Drive Minimizing Test Cost to Find Optimum Gate Driving Vectors in Digital Gate Drivers," IEEE Applied Power Electronics Conference and Exposition, pp. 3096-3101, March 2020.

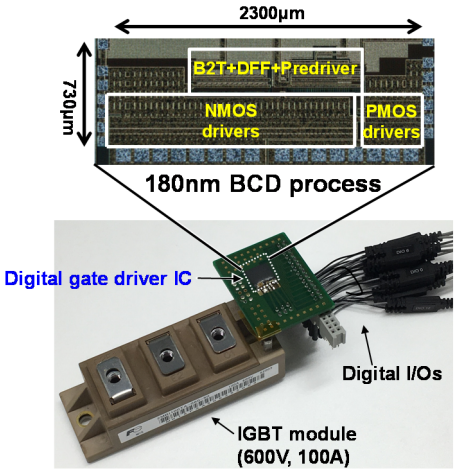

Fig. 3. Developed digital gate driver IC mounted on commercially available IGBT module.

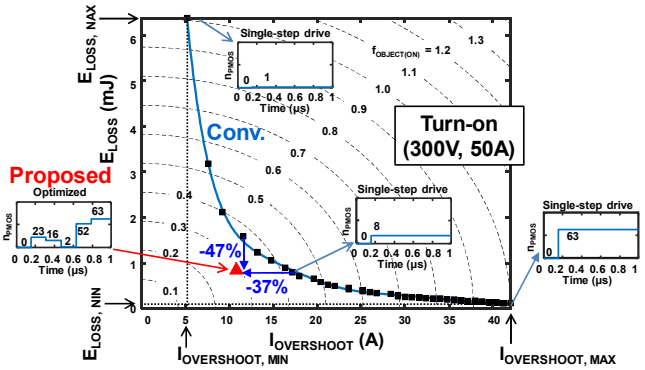

Fig. 4. Measured switching loss (E_{LOSS}) and collector current overshoot ($I_{OVERSHOOT}$) at turn-on of IGBT in conventional gate drive and proposed gate drive using digital gate driver IC. E_{LOSS} is reduced by 47 % at same $I_{OVERSHOOT}$. $I_{OVERSHOOT}$ is reduced by 37 % at same E_{LOSS}.