1-1-1995

A High-Power Current Pulse-Generator Using An Insulated-Gate Bipolar-Transistor

Kijun Park
University of Central Florida

Jin J. Kim
University of Central Florida

Find similar works at: <https://stars.library.ucf.edu/facultybib1990>
University of Central Florida Libraries <http://library.ucf.edu>

This Note is brought to you for free and open access by the Faculty Bibliography at STARS. It has been accepted for inclusion in Faculty Bibliography 1990s by an authorized administrator of STARS. For more information, please contact STARS@ucf.edu.

Recommended Citation

Park, Kijun and Kim, Jin J., "A High-Power Current Pulse-Generator Using An Insulated-Gate Bipolar-Transistor" (1995). *Faculty Bibliography 1990s*. 1431.
<https://stars.library.ucf.edu/facultybib1990/1431>

A high power current pulse generator using an insulated-gate bipolar transistor

Cite as: Review of Scientific Instruments **66**, 3713 (1995); <https://doi.org/10.1063/1.1145427>
Submitted: 21 March 1994 . Accepted: 27 February 1995 . Published Online: 09 September 1998

Kijun Park, and Jin J. Kim

View Online

Export Citation

ARTICLES YOU MAY BE INTERESTED IN

[A high current pulse generator for magnetizing thin magnetic films](#)

Review of Scientific Instruments **67**, 3948 (1996); <https://doi.org/10.1063/1.1147296>

[A Portable Pulse Generator](#)

Review of Scientific Instruments **18**, 639 (1947); <https://doi.org/10.1063/1.1741018>

[Subnanosecond high-voltage pulse generator](#)

Review of Scientific Instruments **58**, 1523 (1987); <https://doi.org/10.1063/1.1139392>

Challenge us.

What are your needs for periodic
signal detection?

Zurich
Instruments

A high power current pulse generator using an insulated-gate bipolar transistor

Kijun Park^{a)} and Jin J. Kim^{b)}

Center for Research and Education in Optics and Lasers (CREOL), University of Central Florida, Orlando, Florida 32816-2700

(Received 21 March 1994; accepted for publication 27 February 1995)

A simple and reliable high power current pulse generator using a commercially available insulated gate bipolar transistor has been designed and constructed. This device generates current pulses up to 650 A at up to 990 V with the pulse length adjustable over 0.6 μ s—1 ms with a rise time <0.5 μ s. © 1995 American Institute of Physics.

A number of pulse power applications require pulses of adjustable width $>1 \mu$ s at a kilovolt range with a current of a few hundred amperes. For example, square current pulses of 100–400 A at several hundred volts (~ 2 kV/cm) are necessary for pumping far-infrared semiconductor lasers whose impedance is less than an ohm during pumping the lasers.¹ It is also required to generate current pulses of rise time faster than 1 μ s with adjustable pulse width (1–10 μ s) at low repetition rate (<50 Hz) to operate the lasers under optimum conditions. In this note we describe a simple and reliable high power current pulse generator using an insulated-gate bipolar transistor (IGBT) which is used for our far-infrared semiconductor laser. LC pulse forming circuits or usual capacitor discharging circuits are not suitable for pumping such a laser because the pulses generated by them are not very easy to adjust for laser pumping and the long oscillating tail of the current pulse due to an impedance mismatch contributes to heating the sample, thereby reducing the efficiency of the laser.² The pulse generator can be readily constructed in a research laboratory at low cost. This device can be scaled up by using higher rated IGBTs or by connecting multiple IGBTs to generate higher power pulses than that described in this note.^{3–5} Although the pulse generator is exclusively used for laser pumping in our work, such a device should be useful for other applications.

To meet the requirements of laser pumping with active power devices, we chose an IGBT as the switching element.^{6,7} The IGBT (Q1) (Fuji Electric, IGBT model 1MBI300L120) is used as a high side switch between the load and the charging capacitor (C1) as shown schematically in Fig. 1. The use of an IGBT significantly simplifies the design and construction of the circuit since it is a voltage controlled device. The IGBT is a monolithic cascaded Bi-MOS in which a *pnp* bipolar transistor and a power MOS-FET are Darlington-connected to achieve a high input impedance. The gate driving voltage should be less than 20 V to avoid a gate breakdown as specified by the manufacturer. To further simplify the circuit design we used a hybrid IGBT driver (U1) (Fuji Electric, model EXB841). The driver requires an isolated 20 V power supply to generate +15 and –5 V gate driving voltage pulses. These pulses are produced

by a built-in circuit within the driver. The isolated 20 V power supply (P.S. 2) is made of a separate transformer and rectifier ICs. The hybrid driver is directly connected to a programmable delay generator (Stanford Research Systems, model DG535). The input of the driver (pins 14 and 15) is isolated by a built-in high-speed photocoupler.⁴ It also has an overcurrent protection circuit which is useful when the IGBT is operated at its maximum current rating. The overcurrent detection output (pins 4 and 5) of the driver is not used in our application.

A 200 μ F capacitor (C1) is charged by using an external dc power supply (KEPCO, BHK-1000-0.2 M) through a current limiting resistor (R1). The IGBT (Q1) used in the circuit has a specified maximum voltage of 1200 V. The continuous current is 300 A as specified by the manufacturer. We operated the IGBT in the range of 0–1000 V depending on the desired voltage level. Limiting the operating voltage to 1000 V also helps avoid an IGBT breakdown due to switching surge voltages induced in the main circuit by a changing collector current at turn-off. To generate a current pulse, an external voltage pulse (+4 V) from the delay generator is applied to the input of the hybrid IGBT driver. Shortening and twisting of the gate wires reduce the driver-to-gate circuit inductance.⁴ When the input voltage is high (+4 V), the driver produces +15 V to the IGBT gate, thereby turning on the IGBT, and the capacitor (C1) is discharged to the load through a 0.5 Ω current limiting resistor (R2). The current is shut off when a negative voltage (–5 V) is applied to the IGBT gate, which is achieved when the input voltage to the hybrid driver becomes low (0 V). Therefore the pulse length of the current can be readily adjusted by varying the length of the delay pulse to the hybrid IGBT driver. We have tested this pulser up to 650 A at 990 V with a 2 μ s pulse width at the repetition rate of 50 Hz. The rated peak current for a 1 ms long pulse is 600 A.⁴

When the IGBT is turned off, a switching voltage is induced in the main circuit due to a stray inductance. Therefore minimizing the circuit inductance is important. The capacitor (C2) and the diode (D2)–resistor (R3) connected in parallel across the IGBT collector to emitter form an over-voltage protection snubber circuit for the IGBT. Also, a metal oxide varistor (V1) is connected in parallel for additional protection from overvoltage spikes. Zener diodes (D4,5) are connected to the IGBT gate and emitter for protection from overvoltages. Although our application is lim-

^{a)}Also at the Department of Electrical and Computer Engineering.

^{b)}Also at the Departments of Physics and Electrical and Computer Engineering.

FIG. 1. The circuit for the current pulse generator using an IGBT module and a hybrid IGBT driver.

ited to low duty cycles ($<10 \mu\text{s}$ pulse duration at $<50 \text{ Hz}$), this device can be operated at much higher repetition rates by adding a large capacitor and a high current power supply.

The current pulses generated by the device with a Ga-doped $p\text{-Ge}$ load ($3.9 \times 4.9 \times 15.5 \text{ mm}^3$) at 11 K are shown in Fig. 2. These pulses were applied in the 3.9 mm direction through ohmic contacts on the $4.9 \text{ mm} \times 15.5 \text{ mm}$ sides. Trace A shows the shortest pulse generated by the circuit which is the same as the delay generator pulse length ($0.6 \mu\text{s}$). Trace B is generated by a $1.0 \mu\text{s}$ pulse from the delay generator. The rise times (10%–90%) of the two current pulses are 0.27 and $0.45 \mu\text{s}$, respectively. The width of each pulse is slightly larger than that of the input pulse owing to the delays of the driver and IGBT switching. The tails of the current pulses shown in the figure are attributed to the induction of the main circuit and the IGBT turn-off delay. We note that the voltage slightly decreases during the pulse. We be-

FIG. 2. Current (top) and voltage (bottom) pulses generated by the device with a $p\text{-Ge}$ load at 11 K. Trace A shows a minimum pulse width of $0.6 \mu\text{s}$ generated by the circuit at the input of the IGBT driver; trace B shows a $1.0 \mu\text{s}$ pulse width at the input of the IGBT driver.

lieve that this is caused by the decreasing impedance of the sample during the current pulse and the corresponding increase in voltage drop across the 0.5Ω resistor (R1) connected in series with the $200 \mu\text{F}$ capacitor.

LIST OF PARTS

C1	200 μF , 2000 V
C2	0.003 μF MICA, 2000 V
C3 and C4	47 μF , 33 V
D1	P600M, 1000 V, 6 A
D2	FF1510, fast recovery type, 1000 V, $I_{\text{FSM}}=30 \text{ A}$
D3	ERA34-10, fast recovery type, 1000 V, 1 A
D4 and D5	16 V Zener
D6	MUR8100, ultrafast recovery type, 1000 V, $I_{\text{FSM}}=100 \text{ A}$
Q1	IGBT, 1MBI300L-120, 1200 V, 300 A
Q2	2N2222A
R1	10 k Ω , 5 W
R2	0.5 Ω , 10 W
R3	50 Ω , 5 W
R4	100 Ω , 5 W
R5	0.01 Ω , 10 W
R6	3.3 Ω , 0.5 W
R7	470 Ω , 0.5 W
R8	100 Ω , 0.5 W
U1	EXB841, high-speed IGBT driver
V1	V660LA100B, MOV

¹V. N. Shastin, *Opt. Quantum Electron.* **23**, S111 (1991).

²S. Komiyama and S. Kuroda, *Solid State Commun.* **59**, 167 (1986).

³Data Power Modules SIMOPAC and IGBT Book 1991/1992 (Siemens AG, Munchen, 1991).

⁴Fuji Electric Co. IGBT Data Book, 1992 (Imported and distributed by Collmer Semiconductor, Inc., Dallas, TX).

⁵D. Chatroux and J. Muary, "IGBT: A solid state switch," *Proc. SPIE* **1859**, 145 (1993).

⁶M. H. Rashid, *Power Electronics*, 2nd ed. (Prentice-Hall, Englewood Cliffs, NJ, 1993).

⁷B. K. Bose, *IEEE Trans. Power Electron.* **7**, 2 (1992).