

Gate turn-off thyristor

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A gate turn-off thyristor (GTO) is a special type of thyristor, which is a high-power (e.g. 1200V AC) semiconductor device. It was invented by General Electric. GTOs, as opposed to normal thyristors, are fully controllable switches which can be turned on and off by their gate lead.

Turn on is accomplished by a positive current pulse between the gate and cathode terminals. As the gate-cathode behaves like PN junction, there will be some relatively small voltage between the terminals. The turn-on phenomenon in GTO is, however, not as reliable as an SCR (thyristor), and a small positive gate current must be maintained even after turn on to improve reliability.

Turn off is accomplished by a negative voltage pulse between the gate and cathode terminals. Some of the forward current (about one-third to one-fifth) is stolen and used to induce a cathode-gate voltage, which in turn causes the forward current to fall, and the GTO will switch off (transitioning to the blocking state).

GTO thyristors suffer from long switch-off times, whereby after the forward current falls, there is a long tail time where residual current continues to flow until all remaining charge from the device is taken away. This restricts the maximum switching frequency to about 1kHz. It may be noted, however, that the turn-off time of a GTO is approximately ten times faster than that of a comparable SCR.

A distributed buffer gate turn-off thyristor (DB-GTO) is a thyristor with additional PN layers in the drift region to reshape the field profile and increase the voltage blocked in the off state. Compared to a typical PNP structure of a conventional thyristor, the DB-GTO thyristor has a PN-PN-PN structure.

GTO thyristors are available with or without reverse blocking capability. Reverse blocking capability adds to the forward voltage drop because of the need to have a long, low-doped P1 region.

GTO thyristors capable of blocking reverse voltage are known as Symmetrical GTO thyristors, abbreviated S-GTO. Usually, the reverse blocking voltage rating and forward blocking voltage rating are the same. The typical application for symmetrical GTO thyristors is in the current source inverter.

GTO thyristors incapable of blocking reverse voltage are known as asymmetrical GTO thyristors, abbreviated A-GTO, and are generally more common than Symmetrical GTO thyristors. They typically have a reverse breakdown rating in the tens of volts. A-GTO thyristors are used where either a reverse conducting diode is applied in parallel (for example, in voltage source inverters) or where reverse voltage would never occur (for example, in switching power supplies or DC traction choppers).

Unlike the insulated gate bipolar transistor (IGBT), the GTO thyristor requires external devices (snubber circuits) to shape the turn-on and turn-off currents to prevent device destruction.

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During turn off, the forward voltage of the device must be limited until the current tails off. The limit is usually around 20% of the forward-blocking voltage rating. If the voltage rises too fast at turn off, not all of the device will turn off, and the GTO will fail, often explosively, due to the high voltage and current focus on a small portion of the device. Substantial snubber circuits are added around the device to limit the rise of voltage at turn off. Resetting the snubber circuit usually places a minimum on-time requirement on GTO-based circuits.

The minimum on- and off-time is handled in DC motor chopper circuits by using a variable switching frequency at the lowest and highest duty cycle. This is observable in traction applications where the frequency will ramp up as the motor starts, then the frequency stays constant over most of the speed ranges, then the frequency drops back down to zero at full speed.

The main applications are in variable-speed motor drives, high-power inverters, and traction. GTOs are increasingly being replaced by integrated gate-commutated thyristors (IGCT), which are an evolutionary development of the GTO, and insulated-gate bipolar transistors (IGBT), which are members of the transistor family.

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