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The Thyristor is etensively used in High Power Applications

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Introduction

A Gate Turn-Off thyristor (GTO) is a special type of thyristor, which is a high-power 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 third lead, the gate lead. Although the thyristor is extensively used in high power applications, it always suffered from being a semi-controlled device. Even though it could be switched ON by applying a gate signal, it has to be turned OFF by interrupting the main current using a commutation circuit. In case of DC to DC and DC to AC conversion circuits, this becomes a serious deficiency with thyristor due to the absence of natural current zero (as in case of AC circuits). Hence, the development of Gate Turn off Thyristor (GTO) addresses the major problem of the thyristor by ensuring the turn OFF mechanism through the gate terminal. A Gate Turn off Thyristor or GTO is a three terminal, bipolar (current controlled minority carrier) semiconductor switching device. Similar to conventional thyristor, the terminals are anode, cathode and gate as shown in figure below. As the name indicates, it has gate turn off capability. These are capable not only to turn ON the main current with a gate drive circuit, but also to turn it OFF. A small positive gate current triggers the GTO into conduction mode and also by a negative pulse on the gate; it is capable of being turned off. Observe in below figure that the gate has double arrows on it which distinguish the GTO from normal thyristor. This indicates the bidirectional current flow through the gate terminal. The junction between the P+ anode and N base is called anode junction. A heavily doped P+ anode region is required to obtain the higher efficiency anode junction so that a good turn ON properties is achieved. However, the turn OFF capabilities are affected with such GTOs. This problem can be solved by introducing heavily doped N+ layers at regular intervals in P+ anode layer as shown in figure. So this N+ layer makes a direct contact with N layer at junction J1. This cause the electrons to travel from base N region directly to anode metal contact without causing hole injection from P+ anode. This is called as a anode shorted GTO structure. Due to these anode shorts, the reverse blocking capacity of the GTO is reduced to the reverse breakdown voltage of junction j3 and hence speeds up the turn OFF mechanism. However, with a large number of anode shorts, the efficiency of the anode junction reduces and hence the turn ON performance of the GTO degrades. Therefore, careful considerations have to be taken about the density of these anode shorts for a good turn ON and OFF performance. During the turn ON, GTO is similar to thyristor in its operates. So the first quadrant characteristics are similar to the thyristor. When the anode is made positive with respect to cathode, the device operates in forward blocking mode. By the application of positive gate signal triggers the GTO into conduction state. The latching current and forward leakage currents are considerably higher in GTO compared to the thyristor as shown in figure. The gate drive can be removed if the anode current is above the holding current level.

But it is recommended not to remove the positive gate drive during conduction and to hold at value more than the maximum critical gate current. This is because the cathode is subdivided into small finger elements as discussed above to assist the turn OFF process. This causes the anode current dips below the holding current level transiently, which forces a high anode current at a high rate back into the GTO. This can be potentially destructive. Therefore, some manufacturers recommend the continuous gate signal during the conduction state. The GTO can be turned OFF by the application of reverse gate current which can be either step or ramp drive. The GTO can be turned OFF without reversing anode voltage. The dashed line in the figure shows i-v trajectory during the turn OFF for an inductive load. It should be noted that during the turn OFF, GTO can block a rated forward voltage only. To avoid dv/dt triggering and protect the device during turn OFF, either a recommended value of resistance must be connected between the gate and cathode or a small reverse bias voltage (typically -2V) must be maintained on the gate terminal. This prevents the gate cathode junction to become forward biased and hence the GTO sustains during the turn OFF state. In reverse biased condition of GTO, the blocking capability is depends on the type of GTO. A symmetric GTO has a high reverse blocking capability while asymmetric GTO has a small reverse blocking capability as shown in figure. It is observed that, during reverse biased condition, after a small reverse voltage (20 V to 30 V) GTO starts conducting in reverse direction due to the anode short structure. This mode of operation does not destroy the device provided that the gate is negatively biased and the time of this operation should be small.