

Fig. 2 (c) I_c , V_{ce} , I_g , V_{ge} waveforms for IXGH40N60A under ZCS conditions

At time $t=t_0$, the DUT and the switch S are turned on simultaneously, this first phase (I) corresponds to on-state operating device.

At $t=t_1$, the switch is opened, resulting the remove of current through the DUT. Device current abruptly falls to zero, but the DUT is in its on-state. This second phase (II) corresponds to zero current regime. At $t=t_2$, the DUT is turned off and still in the ZCS regime. After that and exactly at time t_3 the third phase (III) begins and corresponds to the close of the switch again, the inductor force current to flow through the snubber capacitors, leading to a rise in the device voltage and a tail current is observed (see Fig. 9). The last phase (IV) corresponds to the drop off of current when most of charge has decayed in a recombination dominated [2]-[5].

Also simulation results shows a rather dramatic drop between the first phase I and the second phase II, where carriers are also decaying due to recombination.

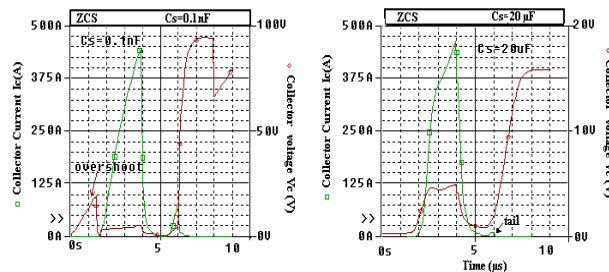


Fig. 3 (a) I_c , V_{ce} waveforms for IXGH40N60A under ZCS condition for different values of C_s

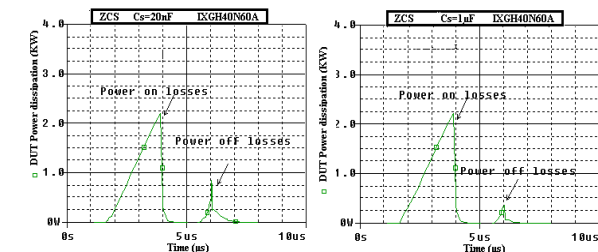


Fig. 3 (b) DUT power dissipation characteristics under ZCS condition for IXGH40N60A at $C_s=1\mu F$ and $C_s=20nF$

As there is a huge power loss within the device during ZCS operating condition, the inductor, the snubber capacitor and

the temperature are expected to have a significant impact on the device characteristics [6]-[9]. Thus, the choice of C_s , inductance L and the temperature have a similar influence on the turn-off performance under ZCS. Hence, ZCS turn-off involves charge removal from the drift region during the no current regime. On the other hand, ZCS turn-off involves a significant time interval of no external current. During this phase, charges are being removed from the drift region. Furthermore, DUT is turned off; carriers are also flushed out through the channel [7], [8].

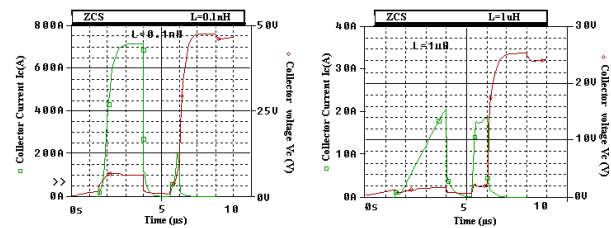


Fig. 4 (a) I_c , V_{ce} waveforms for IXGH40N60A under ZCS condition for different values of L

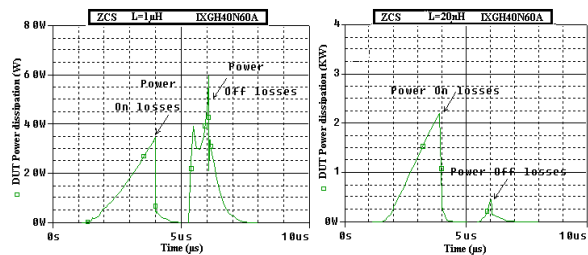


Fig. 4 (b) DUT power dissipation characteristics under ZCS condition for IXGH40N60A at $L=1\mu H$ and $L=20nH$

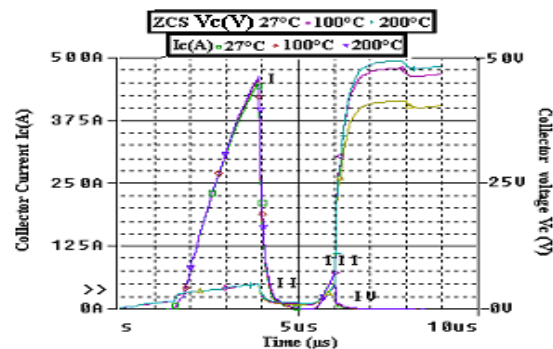


Fig. 5 (a) I_c , V_{ce} waveforms for IXGH40N60A under ZCS condition for different values of temperature

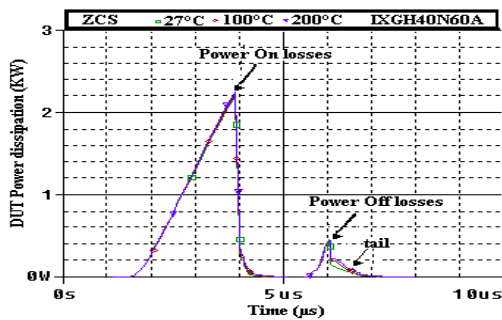


Fig. 5 (b) DUT power dissipation characteristics under ZCS condition for IXGH40N60A at 27°C, 100°C, and 200°C

III. CONCLUSION

In this paper a detailed comparative numerical study performance for actual PT-IGBTs for IXYS in soft switching conditions ZCS conditions. It has also been demonstrated that, the inductance L , the snubber capacitors, and the temperature have a strong influence on IGBT turn-off characteristics.

The main conclusions, which can be made from the present study, are:

- It was found that with increasing C_s , L and Temperature, the ΔI_c (initial drop) collector current decreases, hence turn-off time increase. These affect greatly the switching speed of the device. Then if we select an appropriate values of C_s , L and even temperature, the turn-off time can be reduced to the smallest values.
- In increasing temperature, the current of PNP transistor increase. This leads to higher concentration excess trapped charge and hence to a reduction in dV/dt capability.
- The power losses under ZCS can also been influenced by circuit in construction with varying of inductance. In this paper, we are verified and clarified that the construction with large inductance is suggested. This would support switching –off.

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