Basic and Important Needs for Series Connection of Semiconductor Devices (IGBTs)

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Abstract:Semiconductor devices like MOSFET, IGBT are used as an electronic switch for some specific voltage rating of that device. There is a requirement of higher voltage rating few kilo volts to hundred kilo volts. So, by connecting semiconductors device in series for providing high voltage rating.

When semiconductors device is connected in series there is some important requirement i.e, control circuit for each semiconductor device to turn ON and OFF, voltage sharing at each semiconductor device. This paper describes the basic needs for series connection of semiconductor device.

I. INTRODUCTION

There is demand of high voltage to some application where large capacity of power equipments used by power system in industrial plant.There are different types of semiconductors devices are available in market with different voltage rating (around some few kV), but some application which require high voltage (some kV to hundred kV). Series connection of Semiconductor devices (IGBTs) are used to provide such a high voltage, but there is some limitation to achieve the series connection. This article describes how to get high voltage series connection of IGBT successfully without any damage of IGBT.

II. IGBT OVER OTHER SEMICONDUCTOR DEVICE

BJTs (Bipolar Junction Transistors), MOSFETs (Metal Oxide Semiconductor Filed Effect Transistors) are available with different rating, but there is some limitation in it which not satisfied user requirements.BJTs have high voltage and high current available, but their switching speeds are slow, even if that power MOSFETs have high switching speeds, but high voltage and high current devices are costly and very difficult to achieve .So there is require another semiconductor device which includes both the characteristic of BJT and MOSFET and also easy to control it.

IGBT (Insulate Gate Bipolar Transistor) takes the best parts of both types of transistors, high switching speed of a MOSFET with low saturation voltage bipolar transistor, and combines them together to produce a different type of transistor switching device that is able to handle large currents collector-emitter. IGBT is unidirectional semiconductor device and it simply turn ON or OFF by activating and deactivating the gate terminal of it.

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III. FACTORS AFFECTED IN SERIES CONNECTION

When IGBTs are connected in series there are many factors which are affected i.e, which type of IGBTs used and IGBTs characteristics.

The IGBT manufacturing process is very complex, including oxide growth, deposition, diffusion, and many other procedures. However, IGBTs have same type, design and manufactured at same time, but there will be small difference between them.

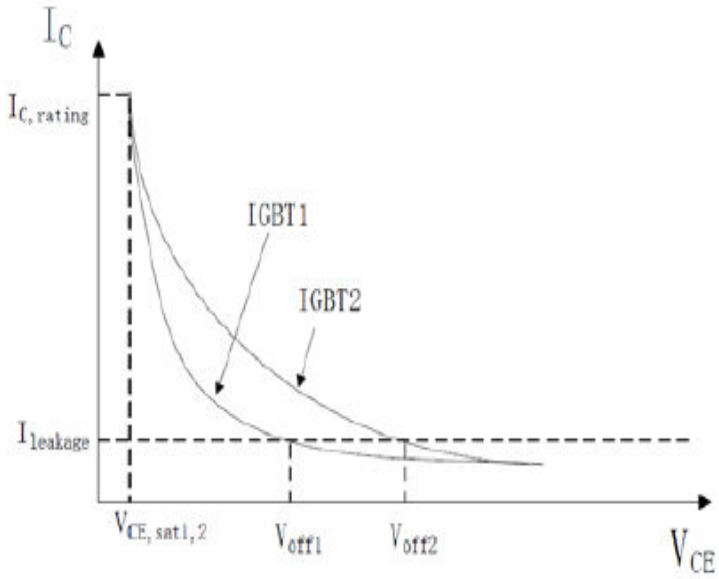

Figure 1: Two same type ofIGBTs V-I Characteristics Comparison

Two same type of IGBTs V-I Characteristic comparison is shown in Figure 1. This figure tells that even though IGBTs are same type there V-I characteristics is little bit different with each other.When IGBT1 and IGBT2 are connected in series, the current flowing through them will be the same, but the voltage in each device is very different. So voltage sharing between two IGBTs are not equal.

In this configuration gate control voltage signalplays important role. The delay between the signalsfrom control circuit to gate terminal as small as possible. As well as the synchronization of each gate signal to other gate signal should me very small (approximately few neno seconds). If IGBTs are connected in series and all IGBTs are turn OFF at same time expect one IGBT which turn OFF after some few seconds. Thus, there is voltage unbalance across series connection of IGBT. So this one IGBT seen high voltage than its voltage rating and there is a chance that this IGBT may damage.

IV. REQUIRE SOLUTION FOR SERIES CONNECTION

Series connection of IGBTs required some solution for provide protection against the fault condition i.e, over voltage or over current and also required that semiconductor devices are not damage when voltage is unbalance across IGBTs.

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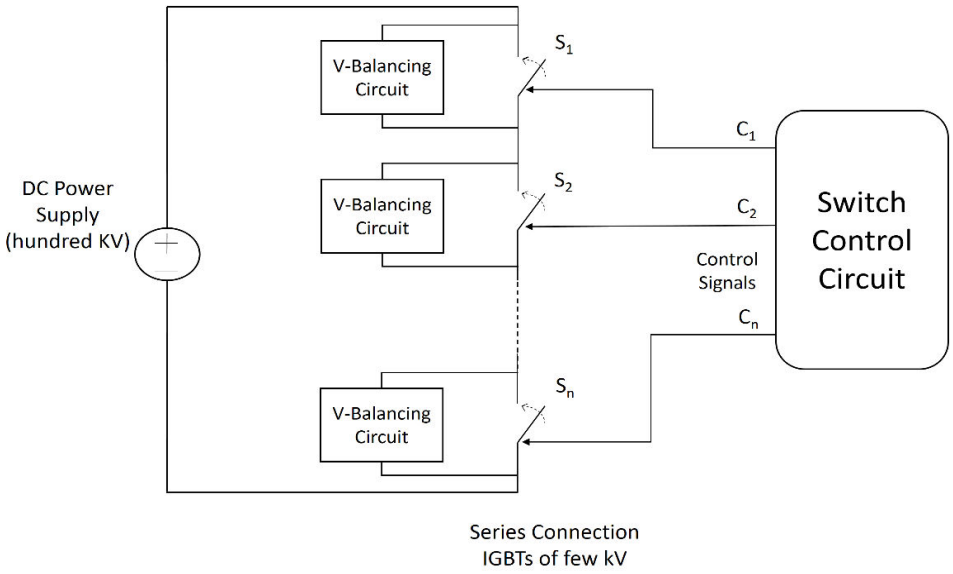

Figure 2: Series Connection of IGBT

Two or more IGBTs of few kV rating are connected in series with high voltage DC power supply (hundred kV) as shown in Figure 2. Here, there is requirement of control circuit which turn OFF the IGBT switch when over voltage is detected. So, this control circuit provide the control signal (gate voltage) to gate terminal of IGBT switch according to the sensing device which measure the over voltage and over current condition. When the voltage is remain under specified value then control circuit provide the high voltage signal to turn ON the IGBT switch and when the over voltage is detected then it provides the low voltage signal to turn OFF the IGBT.

When IGBT is turn ON at different time then last IGBT seen high voltage the others. So voltage balancing circuit is connected across each IGBT for voltage balancing purpose

V. CONCLUSION

The main requirement of series connection of IGBTs are control circuit which provide control signal to each IGBT to trigger them and voltage balancing circuit for provide equal voltage sharing across each IGBT to prevent the damage of IGBT.

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