Enhance the Protection Capability of Intentional Electromagnetic Interference with Inductive Gas Discharge Tube

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Abstract— A proposed inductive gas discharge tube (IGDT) including two electrodes and one hollow insulator ring is studied. The insulating ring of a GDT has spinal metal outside with inductive characteristics. In comparison to the conventional design, the proposed IGDT can provide early triggering capability during fast IEMI introduced and results a smaller residual surge current.

1. INTRODUCTION

When the microelectronic devices are connected to outdoor antennas, their exposure probabilities to transient current or voltage from direct electromagnetic induction are increased. The coupled transient phenomena, i.e., electromagnetic pulse (EMP) [1], can be induced by lightning (LEMP) which possess slow rise time in microsecond grade, or intentional electromagnetic interference (IEMI) [2–4] and nuclear electromagnetic pulse(NEMP) [5–7] which possess fast rise time in nanosecond grade. In these microelectronic circuits, Gas Discharge Tubes (GDT) were frequently adopted as energy absorbers, in the front end to provide over current/voltage dissipation path to connecting them to ground, so that the back end microelectronic devices are protected from the induced power damage. Therefore, GDT should be capable of handling multiple transient phenomena; rapid response and self-recovery with low residue current or voltage, and which are its essential properties [8]. At present, GDTs are widely used to protect for the telecommunications, data communications, audio, video equipment, welding equipment, electronic ignitions, construction safety, and military applications [9, 10].

Electromagnetic interference has the property that most of the high power and energy cluster around low frequency band. Conventional GDT alone has the difficulty to eliminate the energy. This study proposes a GDT with a sputtered inductive layer for overvoltage or overcurrent protection. We will discuss a method that will simultaneously reduce the low frequency power by inductive gas discharge tube (IGDT).

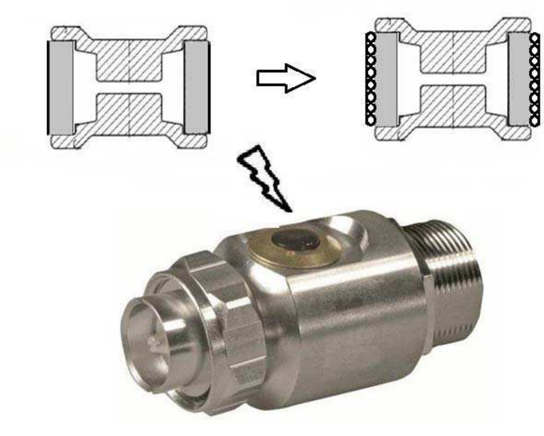

Figure 1: The conventional GDT and proposed IGDT with shunt inductor; and its container.

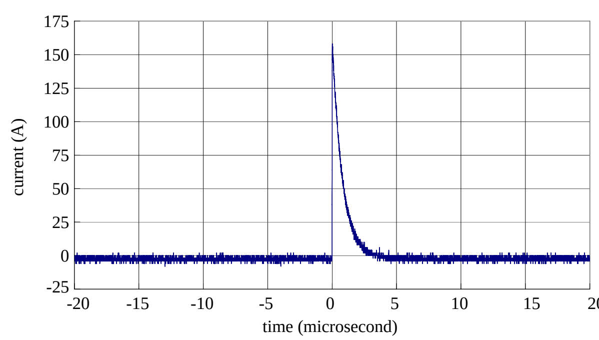

Figure 2: Source has a 20 nanoseconds rise time, 2 microseconds fall time, with peak current 164 Amperes. The source input impedance is 60 ohm.

2. GAS DISCHARGE TUBES AND TEST SOURCE

The structure of GDT includes two end electrodes with a hollow cylindrical insulator. The insulator layer consists of materials such as ceramic, polymer, or glass. Typically the insulator layer of GDT is welded to the electrodes, and under ambient temperature and one atmosphere the tube is sealed with a particular gas inside. In addition, an annular protective coating is applied to the outside part of the ceramic insulator. As shown in Figure 1, a conventional GDT includes two electrodes; each electrode comprises a concave base and at least one hollow cylindrical insulator. The insulator is welded or glued to the base electrode. We also show the proposed inductive gas discharge tube (IGDT) with a spinal inductor shunt to ground.

The source used to test the DGT has a 20 nanosecond rise time, 2 microsecond fall time. The input peak current is shown here to be 164 Ampere The source has input impedance of 60 ohm as shown in Figure 2.

3. RESULTS

The test is performed by inserting the GDT between the source and 50 ohm load. The source acts as an interference transient current and voltage. During an IEMI invasion, when voltage rise is faster than one nanosecond per kilovolt, the residual after the conventional GDT protection is still greater than 20 A (Figure 3). Under such result, the communication system or other electronic equipment still has a chance to cause some damage. To solve this problem, we add a spinal inductor shunt to ground to the GDT, which is chosen to have a high pass characteristic with 3 dB corner frequency at 500 MHz.

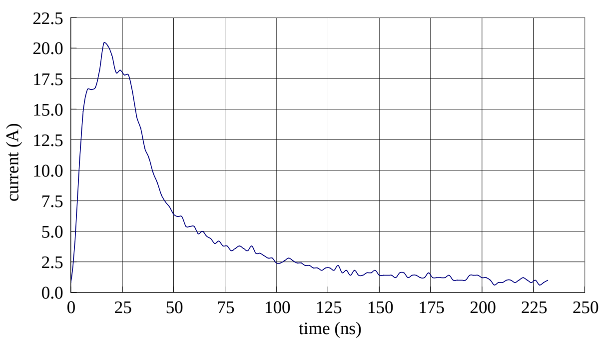

Figure 3: After the conventional GDT, the response has a residue peak current 20 A.

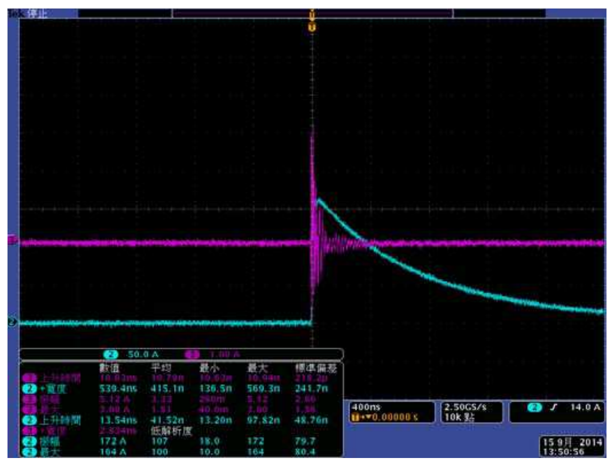

Figure 4: IGDT after input surge has an initial peak current of 164 A, and the output current is reduced to 3 A peak value. The x-axis is time, y-axis is current. Input and output are on different current scales.

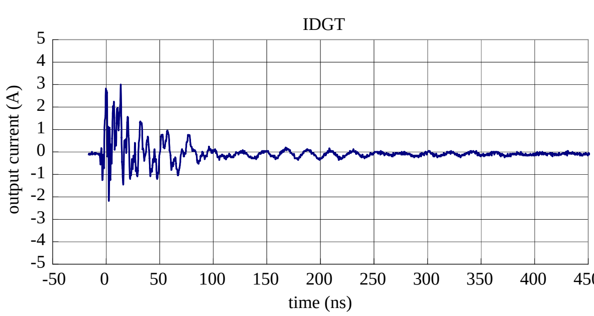

Figure 5: IDGT output characteristic. The output current is reduced to 3 A peak value with some minor ringing phenomenon.

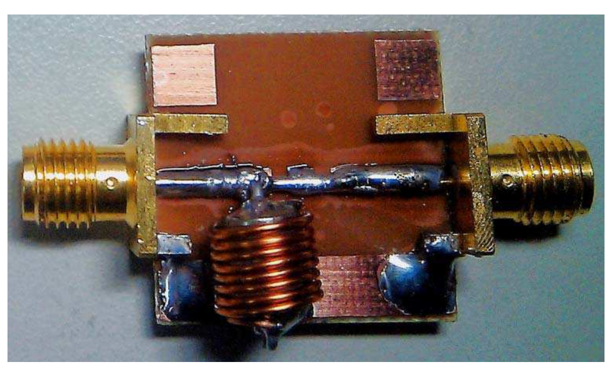

Figure 6: Another version of IGDT, it shows the same response property.

Figure 4 shows the inductive gas discharge tube (IGDT) subjected to 20 nanosecond rise time, 2 microsecond pulse with 50 ohm load. The input peak current is shown here to be 164 A. The output peak current, after the IDGT, is reduced to 3 Ampere maximum.

Figure 5 shows the same configuration as in Figure 4, but only IDGT output was plotted. The output current is shown to reduce to 3 A peak value with some minor ringing phenomenon. The high energy fast pulse peak current of GDT was transferred to slower time with ringing of IDGT. The pulse width is drastically reduced to 70 ns. Another version of IDGT in Figure 6 is tested and still shows the same properties.

4. CONCLUSION

The spinal inductor added to the DGT has a high pass filter response. The filter is intentionally adjusted to 500 MHz cutoff frequency. It can filter out the high power parts of interference from the lightning and low frequency threat. Chose the suitable cutoff frequency can protect the electronics from particular elctromagnetic interference from the terrorist attack (IEMI), or the state of an artificial malicious attack (NEMP), the above can effectively reduce the residual current and improve the survival of the system.

ACKNOWLEDGMENT

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