Plasma Cell Loaded Transmission Line Technologies for Broadband Applications

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Several cold plasma-based variable RF technologies have been presented recently, many of which leverage gas discharge tube (GDT) technology. These encapsulated two-terminal devices filled with low-pressure inert gas are available commercially as reusable high-current surge arrestors. Applications including switches and limiters have been offered. However, most designs have focused on resonant structures loaded with GDTs with many advantages in terms of RF performance, lifetime, and response time. This paper investigates broadband designs utilizing the technique of loading broadband microwave structures with GDTs.

Consider a GDT as a shunt element in various transmission line topologies such as microstrip line, coplanar waveguide (CPW), or substrate integrated waveguide (SIW). These structures offer broadband operation while the GDT element controls the propagation of electromagnetic waves. In the presence of sufficient incident power, a GDT will behave in a quasi-absorptive mode, both reflecting and absorbing some of the incident power, thereby modifying transmission through the structure. This mechanism permits control of the transmission via control of the plasma discharge in the GDT. There are inherent benefits associated with cold plasma based technologies such as realization of devices that have demonstrated high power handling. Additionally, plasma ignition has a rapid response time on the order of tens of nanoseconds. Furthermore, plasma cell loaded devices offer strong linearity possibilities since the non-ignited plasma is simply low-pressure gas with negligible leakage, while ignited plasma enables the aforementioned absorption and reflection. An example SIW structure loaded with a shunt GDT fabricated for L-band operation demonstrated a 3dB decrease in transmission with energized plasma as compared to without energized plasma at an incident power level of 51dBm. Such plasma devices clearly have high power handling capacity. Using loaded transmission line circuits, devices such as switches, limiters, or attenuators can be implemented and achieve broadband performance. Preliminary results demonstrate high power handling of loaded transmission line topologies, and microstrip line or CPW implementations can offer improvements in both the broadband operation and the degree of attenuation or isolation as compared to the SIW results. This is possible due to the limited single-mode bandwidth of SIWs, and because the fields are concentrated in a smaller space as compared to an SIW structure. This property will enable the plasma cell to interact with a larger portion of the fields which in turn should produce stronger decreases in transmission.