THE CASCADE INTERFERENCE SWITCH COMPRISING A TRANSMISSION RESONATOR*

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Abstract

The new concept of microwave interference switches is reported. Interference switch is based on series of H-plane T-junctions (cascade switch) in the view of decreasing switched power at Off state and comprises irises in both its own input and output arms. At On state the irises act as a transmission resonator localizing the nodes of the standing wave at the junctions. Such distribution is expected to decrease the plasma losses. It was shown with a simulation that the cascade switch with additional irises increases the efficiency of the active microwave compressors. The simulation was made with CST studio and COMSOL.

INTRODUCTION

The most effective way to boost microwave power feeding linear particle accelerator is usage of microwave resonant compressors. The compressor accumulates microwave energy into its cavity and rapidly discharges accumulated energy towards the load.

There are two types of resonant compressors. Passive compressors keep resonant characteristics of their resonant cavities. Passive SLED system increases an input power in factor of 4 or 9 under a condition of synchronous phase shift of a supplying generator. An active resonant compressor changes Q-factor of its resonant cavity while emitting stored energy. The ratio of Q-factors at accumulating regime and discharging regime determines amplification factor of active compressors.

The level of accumulated energy is comparable for both active and passive compressors. Active compressors have an operating power less though. The reason of it is a switching element having limited dialectical strength. Moreover, the switch has significant losses up to 3 dB.

The most frequent type of the switch is a microwave interference switch. Such switch is based on H-plane T-junction which has one direct arm coupled with a cavity and other arm short circuited. The last arm is connected to the load. A discharge gap is placed at quarter wavelength from a shorting plane. When plasma is broken down running waves from the cavity and the shorted arm add constructively and the microwave power leaves towards the load. The interference switch is simple and effective. Though, power handling capability is limited by cross-section of a waveguide. Moreover, a gas-discharger and its inner elements such as a quartz tube decrease the handling power.

To enhance the operating power a cascade interference switch was suggested [1, 2, 3]. The cascade switch divides the switching power among discharge gaps. This method allows decreasing the switching power as much as $1/2^N$, where N is number of H-tees. However, interaction between the switching wave and gas plasma discharge keeps large amount of losses.

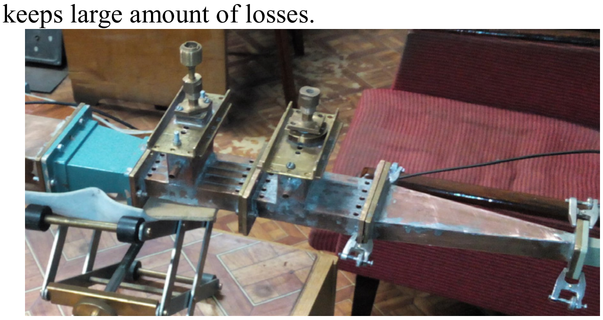

Figure 1: Overmoded cascade interference switch.

The work [4, 5, 6] proposed an overmoded microwave interference switch (Fig. 1) having enhanced handling power. Such switch has two variants of implementation an overmoded waveguide and a package of regular waveguides with a mutual side arm (Fig. 2). The cascade switch based on overmoded T-junctions brought about further enhancement of the operating power. However, interaction between plasma and the switching waves had still stood the same.

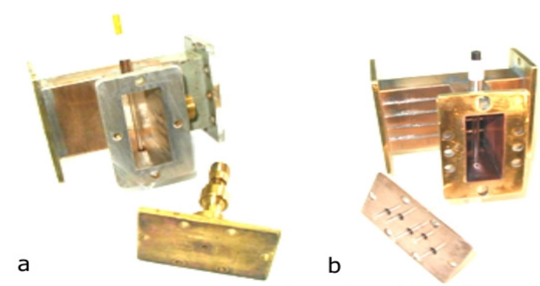

Figure 2: Overmoded interference switches (a – a switch based on overmoded waveguide; b – a package of singlemoded waveguides with a mutual side arm).

This paper concerns a method to increase the operating efficiency of the gas-discharge switches.

RESULTS OF SIMULATION AND ANALYSIS

Overmoded Cascade Switch

The singlemoded cascade switch has an interesting regularity in its act [3]. As one can see from a simulation a behavior of the overmoded cascade switch is quiet similar to the singlemoded cascade switch. Nodes of the

*The work was supported by the Program on Competitiveness Enhancement of the National Research Tomsk Polytechnic University and by Russian Foundation for Basic Research (Grant №15-08-01853).

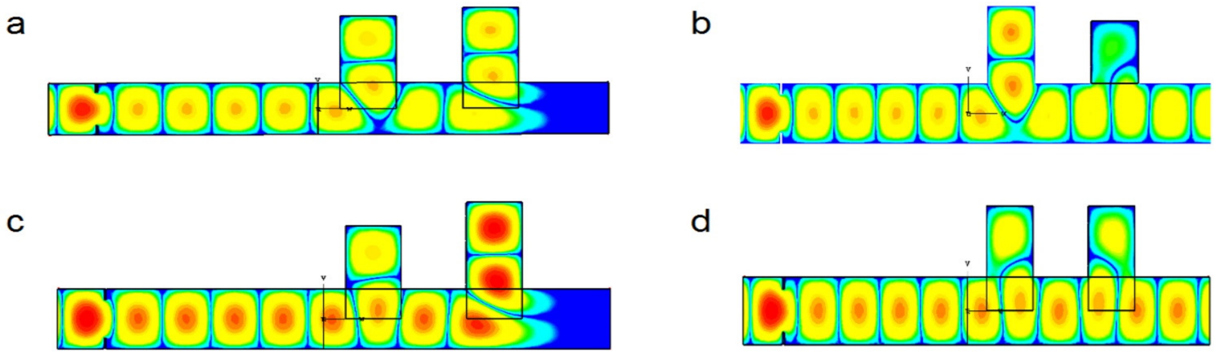

Figure 3: Field patterns of the overmoded cascade interference switch at different regimes (a – Off-state; b – the second H-tee is switched on; c – the first H-tee is switched on; c – On-state).

standing wave locate close to junctions of switched H-tees (Fig. 3 b, c) and wave amplitudes of unswitched H-tees are increasing. Such effect could locally decreases plasma losses. When the last switch is switched on a standing wave turns into a running wave (Fig. 3 d). A transmission resonator should supply a standing wave regime during all switching process.

Transmission Resonator Comprised in an Interference Switch

A regular switch with a transmission resonator was simulated (Fig. 4). This switch was switched by a wire with a low conductivity. The conductivity was chosen thus losses were equal to a half of input power for the regular switch without a transmission resonator. Such level of losses fits losses of plasma broken down in nitrogen medium.

A node of a standing wave appeared at the center of the junction when irises were connected to input and output ports at half-wave distance from the junction. Hence, a transmission coefficient became equal to ~1.

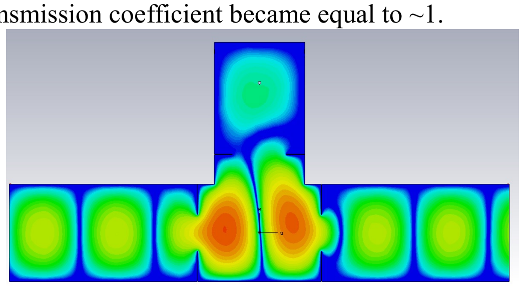

Figure 4: Field pattern in the regular interference switch comprising a transmission resonator.

There are two problems that occur when the transmission resonator is used. The first one is an increase of wave amplitudes in the discharge gaps and the second is the termination of the output pulse length. The length has to be greater than the excitation time of the transmission resonator. Long output pulses could be supplied by the compact active compressors with a variable geometry [7].

As it was estimated the electric field strength in the transmission resonator is much greater than in the regular switch at accumulating regime. Dividing accumulated energy among few H-tees (Fig. 5) one can decrease the field strength in the switch area. A distance between neighboring H-tees of the cascade switch is not equal to a half wavelength that leads to the impossibility to put wave nodes at the junctions correctly. Nevertheless, the increase of the efficiency is supposed to be significant.

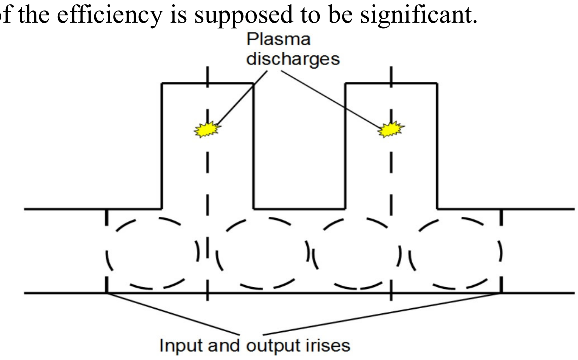

Figure 5: Scheme of the cascade interference switch with transmission resonator.

CONCLUSION

The cascade switch allows increasing the operating power at Off state and the transmission resonator allows decreasing losses at On state. So that, the switch can afford to have the greater efficiency than a conventional interference gas-discharge switch.

ACKNOWLEDGMENT

This research was performed with partial financial support from the National Research Tomsk Polytechnic University Competitiveness Programme and with support of the Russian Foundation for Basic Research (Grant No.15-08-01853a).

Authors are glad to thank Dr. Yushkov and Dr. Chumerin for supporting and helpful advises.

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ISBN 978-3-95450-181-6

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ISBN 978-3-95450-181-6