

THE WAVEGUIDE COMPONENTS DEVELOPMENT FOR THE CLIC PETS ON/OFF OPERATION

A. Cappelletti, CERN, Geneva, Switzerland

Abstract

One of the important operational PETS specifications is the capability to reduce the output power from individual PETS in the case of local breakdown in the adjusted accelerating structure, or the PETS itself [1]. In the present base-line design, the produced power is controlled by detuning the structure via progressively inserting wedges into the damping slots [2]; however, this technique requires rather complicated and thus expensive mechanical devices. Recently the possibility to use the external and compact RF waveguide devices combined with inside PETS recirculation was explored [3]. The special RF devices necessary to implement this have been developed and are presented.

INTRODUCTION

The CLIC Power Extraction and Transfer Structure (PETS) is a passive microwave device which should generate RF power for the CLIC main linac accelerating structure [4]. To provide the accelerating structure recovery after the RF breakdown, ideally, one would need to regulate the power transmission from the PETS through the controlled waveguide circuit in such a way that it acts like a variable attenuator. Moreover, the RF power deflected in this process can be recombined with the generated RF power directly inside the PETS. With the proper choice of RF phases between the two, this can help to suppress the RF power flow itself (see [3] for more details). Here we will present the two types of RF devices which allow for such an operation. Throughout the system design, special care was given to minimize the surface electric field at any status of its operation.

THE CHOKE-BASED TUNABLE REFLECTOR

The basic element for both designs is a classical waveguide choke configuration. Here, a circular waveguide operates at its fundamental mode and communicates with an external coaxial line. In this device, the power transmission through the waveguide can be regulated simply by the linear displacement of the short circuit position at the end of the coaxial line. The surface electric field plots for the two extreme cases of the short circuit position are shown in Fig. 1, as simulated with HFSS [5]. In order to obtain a feasible design and to provide the mechanical tuning of the device type 1, we have developed the RF contact-free configuration of the coaxial short circuit plug. It represents the coaxial filter, where the filter period, shape and total length were designed to ensure full reflection and to minimize (< -40 dB) the RF power transmission through the filter. The device comprises five periods. The plug profile was

optimized to reduce the electric field in the gap. The general view of the device together with its performance is shown in Fig. 2a-c.

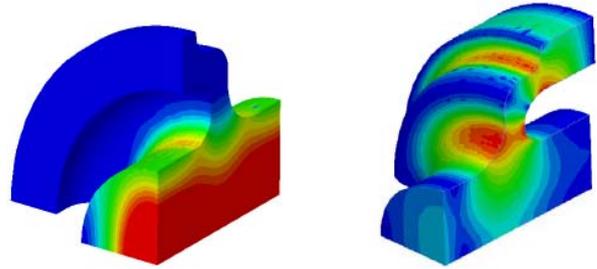


Figure 1: The choke reflector.

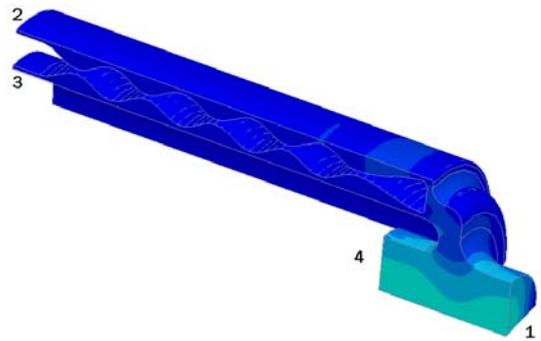


Figure 2a: Choke with coaxial plug.

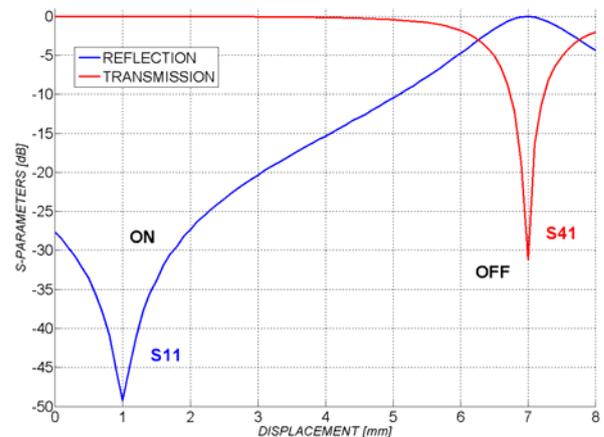


Figure 2b: Choke transmission/reflection performance.

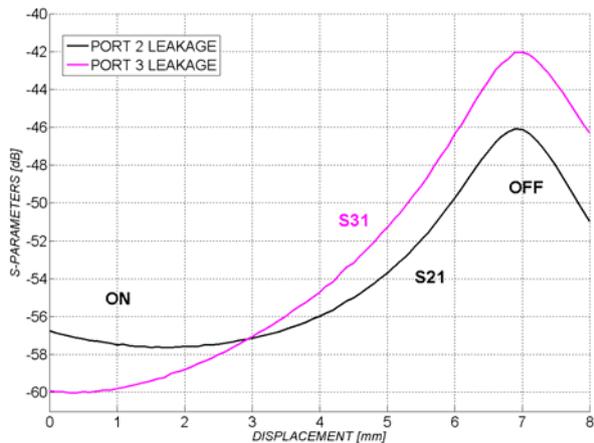


Figure 2c: Choke leakage performance.

THE WAVEGUIDE CIRCUIT TYPE 1

The basic idea behind the two designs is to use the polarization properties of the circular to elliptical transition waveguide (see [6] for more details). The device type 1 comprises four waveguide circuits. The first one is a dual polarization mode launcher; the second is the circular to elliptical transition waveguide, where the ellipse's major axis is rotated by 45 degrees with respect to the input rectangular waveguide; the third is the choke reflector, described above in details and finally the fourth is the 90 degrees rotated second circular to elliptical transition waveguide together with circular to rectangular waveguide taper; these complete the device.

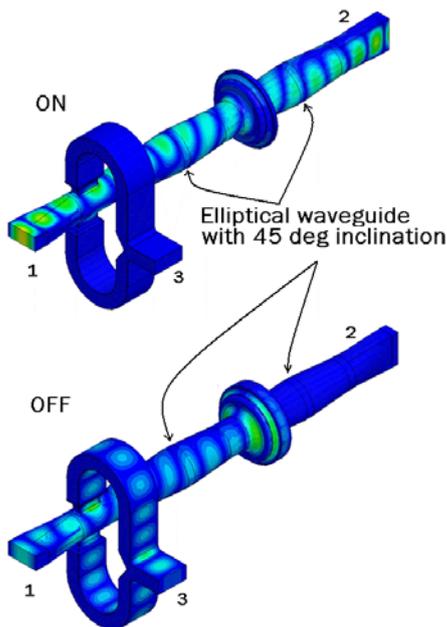


Figure 3: The waveguide circuit type 1, illustration.

Through the operation, when the choke is tuned to the full transmission, the incident wave from port one only experiences a 90 degrees wave polarization rotation

towards port two (see Fig. 3, upper picture). On the contrary, with the full reflection (see Fig. 3 lower picture) the reflected wave fully recombines back into port three.

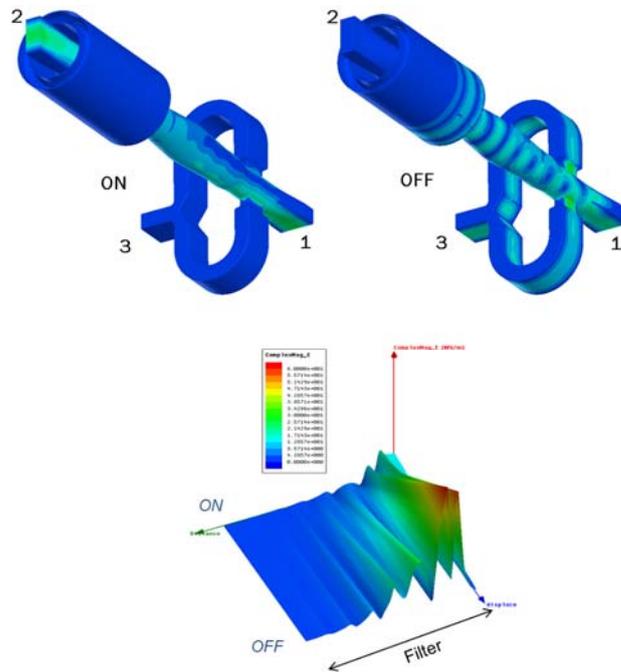


Figure 4: The waveguide circuit type 1, design.

The overall view of the complete device with tuneable coaxial plug is shown in Fig. 4 for the two extreme plug positions. In addition, the rotating wave polarization reduces the maximal electrical surface field in the choke by about 40%. The surface electric field plot for the different plug position along the choke and coaxial filter is also shown in Fig.4. In the present design, the 60 MV/m in the choke and 18 MW/m at maximum on the coaxial plug surface are expected for the nominal CLIC RF power of 65 MW per accelerating structure.

The frequency domain performance of the device, for its ON and OFF configuration, is shown in Fig. 5a and 5b respectively.

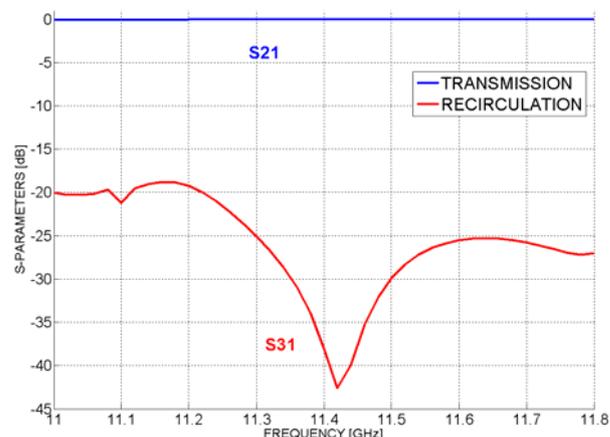


Figure 5a: Frequency domain performance for device type 1 at its ON configuration.

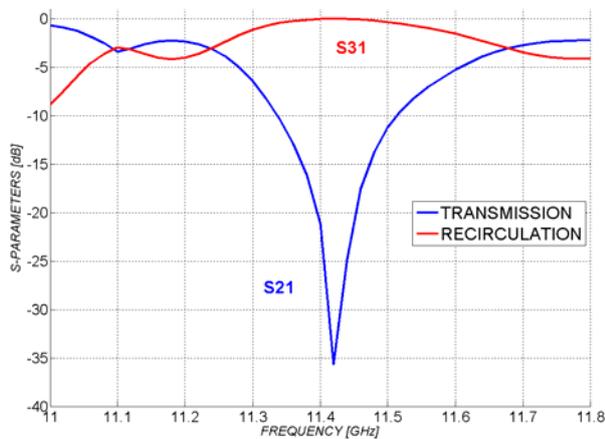


Figure 5b: Frequency domain performance for device type 1 at its OFF configuration.

The optimal operating point is seen to be in correspondence with 11.424 GHz, as it was designed to be.

THE WAVEGUIDE CIRCUIT TYPE 2

In this circuit, another solution substitutes a rotary movement for the linear one previously discussed. When the elliptical section's major axis (see Fig. 6 upper picture) is not rotated with respect to the input/output rectangular waveguides orientation, the whole system provides full transmission between port one and port two. After being rotated by 45 degrees (see Fig. 6 lower picture) the incident wave is rotated enough to be recombined completely into port three. In this design, the choke mode flanges act as RF contact-free joints.

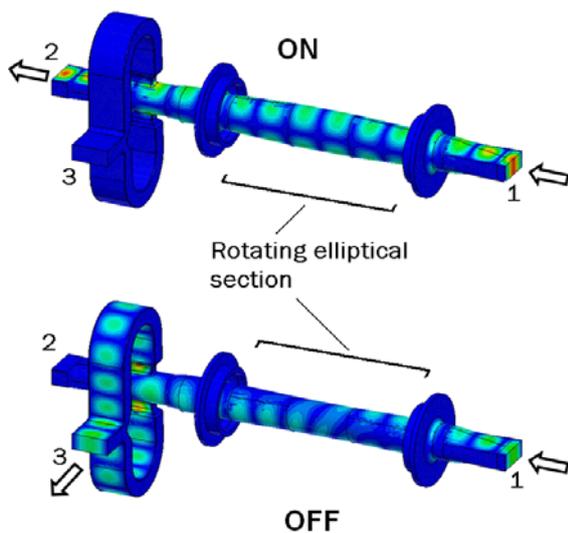


Figure 3: The waveguide circuit type 2.

Comparing the two approaches, the circuit type two provides wider frequency bandwidth (more accurate analysis are currently being performed) and lower (by

about 15%) electric field enchantment during the operation; however, translating the fast rotation into the vacuum seems to be technically more complicated than the linear movement in circuit type one.

SUMMARY

In this paper, the two designs of the compact devices which allow for high power control in the RF waveguide circuits have been presented. The RF design has been finished. Next, the mechanical design and fabrication of the 11.424 GHz mechanically controlled prototypes are scheduled. We are planning to be ready for the high RF power tests at SLAC by autumn 2009. The choke mode flange similar to that being proposed for the circuit type two has already been fabricated at CERN. It will be high power tested at SLAC in early 2009.

If successful, these devices can also be used in any other facilities as compact RF power attenuators/splitters.

REFERENCES

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