RF Terminator: compact RF load from SiC

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HG2018, Shanghai, June 2018
MOTIVATION

In the CLIC klystron-based solution, each module comprises 8 hybrids. Each hybrid has to be equipped with a load which, in case of arcing, will absorb part of the power traveling back to the klystron.

PRELIMINARY CONSIDERATIONS:

- The load has to withstand peak power in the order of tens of MW
- If installed on the 4th port of an hybrid, very low average power will be dissipated
- The RF design should be easily scalable in order to handle higher average power
RF DESIGN

- 2 EKasicP cones are placed in a standard rectangular waveguide.
- A water cooling channel is machined in the holding plate.

This design can be easily scaled. For example, if we intend to double the power we can move to a double-height rectangular waveguide.

![Electric field distribution](image)
MATERIAL PROPERTY

EkasicP material has been chosen as absorbing material.

Relative permittivity for CerasicB1, EkasicF and EkasicP measured with the transmission method.

Black circles: real part; blue circles: imaginary part.

EkasicP Material Properties

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>$f_0$</td>
<td>12</td>
<td>GHz</td>
</tr>
<tr>
<td>$\text{Re}{\varepsilon_r}$</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>$\tan\delta$</td>
<td>0.2</td>
<td></td>
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</table>
- Compact design
- Just 6 pieces
- Shrink fit cones technology
- Brazing/shrink fit in the same operation
- Simplified cooling
HEAT LOAD

Ansys HFSS simulation with 150w RF load

Power loss density

Power for 1 structure (2 loads)
Static Thermal simulation for 150 W average input power

Max T: 446 degree C

Power loss density

Ansys HFSS imported load
Static Structural simulation

Max. Deformation: 50um

Max. stress: ~20MPa
Schrink fit test samples

2 samples:
- 1 with cones «MICROPIERRE» supplier
- 1 with cones «CERATEC» supplier

Tungstène mass

Tooling for shrink fit
Results of the shrik fit test- OK

No breaks on cones!
4 prototypes manufacturing steps

Metrology body/cone

Brazing/shrink fit (815°C/5 min.)

EB welding vacuum cap
4 prototypes manufactured

«MICROPIERRE» supplier

«CERATEC» supplier
RF COLD TESTS

Load no. 1

Load no. 2

Load no. 3

Load no. 4

RF Terminators in the lab for the measurements. Each load is labelled

<table>
<thead>
<tr>
<th>Load no.</th>
<th>$S_{11} @ f_0$ [dB]</th>
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<tbody>
<tr>
<td>1</td>
<td>-40.4</td>
</tr>
<tr>
<td>2</td>
<td>-39.1</td>
</tr>
<tr>
<td>3</td>
<td>-41.9</td>
</tr>
<tr>
<td>4</td>
<td>-45.6</td>
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</tbody>
</table>
COMPARISON

Magnitude (dB)

Frequency (Hz)

Load1
Load2
Load3
Load4

HFSS

\times 10^{10}
DOUBLE-HEIGHT WAVEGUIDE DESIGN

In order to double the power handling capability, the height of the waveguide can be simply doubled to host 4 cones.

**STANDARD WR90**

**DOUBLE-HEIGHT WR90**

- Diameter of the base has been reduced to fit in the copper holder.
- Diameter of the tip has not been changed.
- Length of the cones has not been changed.
DOUBLE-HEIGHT WAVEGUIDE DESIGN

Electric field distribution

**Bandwidth**

-62.78
A circular waveguide will host 6 cones.

A mode conversion, from $\text{TE}_{10}$ (rectangular wg) to rotating $\text{TE}_{11}$ (circular wg), is necessary to get a more uniform distribution of the fields.

A section of elliptical waveguide will be used to get the mode conversion.
NOVEL RF DESIGN

BANDWIDTH

-40.69
CONCLUSION

- 4 RF terminators (with 2 EkasicP cones) have been built and measured successfully.

- High power tests shall be performed to prove the power handling capability of the RF terminators.