High Power High Efficiency Klystron

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Jan.20, 2021
Outline

◆ R&D status
  • 1st klystron prototype
  • High efficiency klystron (2nd klystron)
  • MBK (Multi-beam klystron)

◆ Future plan
1st klystron prototype
Milestone

◆ Oct. 2017 Design report
◆ May. 2018 Mechanical design review
◆ Oct. 2019 Parts processing
◆ Nov. 2019 Baking out
◆ Dec. 2019 Delivery to IHEP
◆ Mar. 2020 High power test (400kW CW and 800kW pulsed)
◆ Sep. 2020 High power test (490kW CW)
Parts processing

- Cavity part
- Cavity
- Cold test
- Collector brazing
- Gun processing
- Vacuum Assy assembly
- Coil&Gird
Baking out

Prototype installation

Top view
Delivery to IHEP

Before delivery

Packing

Loading

Arrived IHEP

In place at test stand
High power test status

◆ Phase I:

◆ 400 kW CW test and 800kW pulsed conditioning from Jan.3-Mar.9 2020

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Design</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating frequency (MHz)</td>
<td>650</td>
<td>650</td>
</tr>
<tr>
<td>Beam Voltage (kV)</td>
<td>81.5</td>
<td>80</td>
</tr>
<tr>
<td>Beam Perveance (μA/V$^{3/2}$)</td>
<td>0.65</td>
<td>0.7</td>
</tr>
<tr>
<td>Efficiency(%)</td>
<td>65</td>
<td>62</td>
</tr>
<tr>
<td>Saturation Gain(dB)</td>
<td>≥45</td>
<td>47</td>
</tr>
<tr>
<td>Output power(kW)</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>1 dB Bandwidth(MHz)</td>
<td>≥1</td>
<td>1.8</td>
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</tbody>
</table>
High power test status

◆ Phase II:
  a) Phase II test is started from Aug. 24 2020, CW power is up to 490kW on Sep.1 2020.

Cold test for waveguide system  Test stand  800kW Load
High power test status

◆ Phase II:
  b) Arc happened on load at CW 490kW On Sep. 2 2020

1) Temp. at load end is more than 140 degree C.
2) Arc happened on 2 load branches.
3) The RF conditioning is stopped on Sep. 2 morning.
High power test status

◆ Phase II:
  c) RF Load is sent back Germany on Sep.18 2020.
  d) Repaired load is delivered to China on Dec.30 2020, but there are still many cracked ferrite pics, so it can not be used for high power test. It will be send back Germany again.
High efficiency klystron

(2\textsuperscript{nd} klystron)
High efficiency design (final)

AJDISK(1D) EFF: 84.5%

EMSYS(2.5D) EFF: 79.3%

CST(3D) EFF: 77%
High efficiency design (final)

Gain(3D): 48.3dB
Bandwidth(2.5D): ≥ 0.8MHz
Frequency tolerance: f1, f2, f7 ± 0.2MHz, others ± 0.5MHz
Mechanical design review meeting was held on Dec. 1 2020.
The experts provide several views and recommendations.
Mechanical drawing

Components mechanical drawing

Cavity

Gun
Components fabrication is in progress

Cavity part
Multi-beam klystron
Multi-beam klystron

1) Design Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>Value</th>
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<tbody>
<tr>
<td>Gun Voltage</td>
<td>kV</td>
<td>54</td>
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<tr>
<td>Beam number</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Beam perveance</td>
<td>μP</td>
<td>0.2</td>
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<tr>
<td>Output power</td>
<td>kW</td>
<td>800</td>
</tr>
<tr>
<td>1dB bandwidth (3-D simulation)</td>
<td>MHz</td>
<td>±0.75</td>
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<tr>
<td>Efficiency (3-D simulation)</td>
<td>%</td>
<td>80.5</td>
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</table>

The MBK design is finished, including the interactive cavity, electron gun, focusing solenoid, window and collector.
Multi-beam klystron

2) Design of electron gun and focusing solenoid is also finished.
3) MBK window prototype will be constructed and tested.
Multi-beam klystron

4) Mechanical design and drawing are also in progress
Future plan

① We are waiting for 800kW load sent back for 1st klystron prototype high power test (>500kW, 800kW CW?)
② Take efforts to push manufacture of 2nd klystron.
③ Start to MBK parts manufacture after completing mechanical design and drawing.
Thanks for your attention!