162.5 MHz Coupler for RFQ

Mechanical design
162.5 MHz Coupler for RFQ

The PXIE RFQ power coupler includes all components necessary to transport up to 75kW (each) of RF power from a 50Ω source into the RFQ vacuum while maintaining the RFQ vacuum integrity.

**Main features:**
- Air cooled non grounded coupling loop
- HV bias
- Single Water cooled Ceramic window
- Compact design

According to Functional Requirement Specification for PXIE RFQ Coupler, clearance between the RFQ body and enclosure wall is 1.6 m on the shortest side. 1 m of space for is reserved for egress and 0.2m for RFQ component protection railings.
RFQ to Coupler interface

Most of the RF port dimensions are on sheet 3 of 27J052 Rev.A. See Sheet 3, Section G-G and zones B4 and B7 for port dimensions.

Will change to 76.9

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162.5 MHz Coupler for RFQ

3 Variants
162.5 MHz Coupler for RFQ

3 Variants
Variant 1 Coupler on RFQ
Variant 2 Coupler on RFQ
Variant 3 Coupler on RFQ
Coupler, variant 2 on RFQ

Variant 2 Coupler will use 322 mm. Shortest 90 degree coaxial 3 1/8 elbow is 4”. Distance from RFQ body to the side of the elbow attached to the coupler will be 490 mm. Can we use thinner railing? This variant provide better flexibility for coaxial line connection.
According to Functional Requirement Specification PXIE RFQ Coupler, Clearance between the RFQ body and enclosure wall is 1.6m on the shortest side. We will need 1m of space for egress and 0.2m for RFQ component protection railings. Variant 3 Coupler will use 299 mm. This variant is more compact.
162.5 MHz Coupler for RFQ Variant 2
Main components

- Instrumentation Box
- Inner Conductor
- Outer Conductor Extension
- Inner T-junction
- Copper coated bellow
- Outer T-junction
- Capacitor
- Straight Outer Conductor
- PTFE Support Rings
- Ceramic window assembly
- Viton O-ring
- RF seal
162.5 MHz Coupler for RFQ Variant 3
Main components

- Instrumentation Box
- Outer Conductor Extension
- Inner Conductor
- Capacitor
- Straight Outer Conductor
- Inner T-junction
- Outer T-junction
- Copper coated bellow
- PTFE Support Rings
- Ceramic window assembly
- Viton O-ring
- RF seal

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Ceramic window assembly

- 3 1/8 Fixed coaxial flange
- Al2O3 ceramic disc
- Copper sleeves
- Custom Rotatable Flange SS316
- Viton O-ring
- RF seal Beryllium Copper C175 Alloy 10 (Bal Seal Spring)
- Copper 101 Tube OD 3.5” ID 3” wall 0.25”
- Copper 101 Tube OD .25”

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Ceramic window assembly

1/4" Size Water Cooling Tube (Actual tube OD 3/8”)

#10-24 Threaded hole

Solder-Joint Copper Tube Fitting for Water Male Adapter for 1/4" Tube Size, 1/4" NPT.

Air inlet

Venting holes

Air outlet holes
Depth=3*Diameter
162.5 MHz Coupler for RFQ
Ceramic joint protection
162.5 MHz Coupler for RFQ
Inner T-junction installation

#10-24 Screw
162.5 MHz Coupler for RFQ, Variant 2
Inner T-junction installation

- Copper coated bellow will protect ceramic window
- Notch on inner conductor and special PTFE support will isolate bellow during coaxial line installation
162.5 MHz coupler for RFQ Capacitor

Copper ring

Kapton® polyimide Insulating Tape
162.5 MHz coupler for RFQ
Cooling air flow

Air cooled non grounded coupling loop
162.5 MHz coupler for RFQ
Cooling air flow
To verify air cooling and modal calculations we designed and ordered test coupler. Expected delivery – end of May from VMS.
Preliminary design of Test Stand for RFQ Couplers
# Al2O3 Ceramic Properties Standard

![CoorsTek Logo](image)

**CoorsTek**

*Amazing Solutions*

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<table>
<thead>
<tr>
<th>Properties*</th>
<th>Units</th>
<th>Test</th>
<th>(\text{Min. (99.9%) Al}_2\text{O}_3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>(\text{gm/cc})</td>
<td>ASTM-C20</td>
<td>3.92</td>
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<tr>
<td>Crystal Size</td>
<td>(\text{MICRONS})</td>
<td>THIN-SECTION</td>
<td>6</td>
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<tr>
<td>Water Absorption</td>
<td>%</td>
<td>ASTM-373</td>
<td>0</td>
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<tr>
<td>Gas Permeability</td>
<td>–</td>
<td>–</td>
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<tr>
<td>Color</td>
<td>–</td>
<td>IVORY</td>
<td>0</td>
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<tr>
<td>Flexural Strength (MOR)</td>
<td>(\text{MPa (psi \times 10^9)})</td>
<td>ASTM-F117</td>
<td>3.75 (54)</td>
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<tr>
<td>Elastic Modulus</td>
<td>(\text{GPa (psi \times 10^9)})</td>
<td>ASTM-C394</td>
<td>370 (54)</td>
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<tr>
<td>Poisson’s Ratio</td>
<td>–</td>
<td>ASTM-C394</td>
<td>0.22</td>
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<tr>
<td>Compressive Strength</td>
<td>(\text{MPa (psi \times 10^9)})</td>
<td>ASTM-C773</td>
<td>2500 (163)</td>
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<tr>
<td>Hardness</td>
<td>(\text{HRA (kg/mm²)})</td>
<td>MARVIN - 1000 gm</td>
<td>14.1 (1440)</td>
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<tr>
<td>Tensile Strength</td>
<td>(\text{MPa (psi \times 10^9)})</td>
<td>ROCKWELL 45 N</td>
<td>83</td>
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<tr>
<td>Fracture Toughness</td>
<td>(\text{Mpa m}^{1/2})</td>
<td>ACMA TEST #4</td>
<td>248 (96)</td>
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<tr>
<td>Thermal Conductivity</td>
<td>(\text{W/m K})</td>
<td>ASTM-C48</td>
<td>3.0</td>
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<tr>
<td>Coefficient of Thermal Expansion</td>
<td>(1 \times 10^{-6}/\text{°C})</td>
<td>ASTM-C372</td>
<td>8.2</td>
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<tr>
<td>Specific Heat</td>
<td>(\text{J/kg K})</td>
<td>ASTM-E1340</td>
<td>880</td>
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<tr>
<td>Thermal Shock Resistance</td>
<td>(\Delta T_c)</td>
<td>–</td>
<td>200</td>
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<tr>
<td>Maximum Use Temperature</td>
<td>(\text{°C})</td>
<td>NO-LOAD COND.</td>
<td>1750</td>
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<tr>
<td>Dielectric Strength</td>
<td>(6.35\text{mm ac-V/mm (ac V/m)})</td>
<td>ASTM-0116</td>
<td>8.7 (220)</td>
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<tr>
<td>Dielectric Constant</td>
<td>1 (\text{MHz})</td>
<td>ASTM-0150</td>
<td>9.8</td>
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<td>Dielectric Loss (tan delta)</td>
<td>1 (\text{MHz})</td>
<td>ASTM-D50</td>
<td>&lt; 0.0001</td>
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<tr>
<td>Volume Resistivity</td>
<td>25 (\text{°C})</td>
<td>ASTM-01829</td>
<td>(&gt; 10^{14})</td>
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<tr>
<td></td>
<td>500 (\text{°C})</td>
<td>ASTM-01829</td>
<td>(2 \times 10^{13})</td>
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<tr>
<td></td>
<td>1000 (\text{°C})</td>
<td>ASTM-01829</td>
<td>(2 \times 10^{13})</td>
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<td>Impingement</td>
<td>–</td>
<td>–</td>
<td>0.47</td>
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<tr>
<td>Rubbing</td>
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5/21/2013

Oleg Pronitchev

![Fermilab Logo](image)
<table>
<thead>
<tr>
<th>ITEMS</th>
<th>UNIT</th>
<th>CUSTOMER'S REQUEST</th>
<th>PROPOSED CERAMIC MATERIAL</th>
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<tr>
<td>KYOCERA MATERIAL No.</td>
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<td>RF EQUIPMENT</td>
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<td>METALLIZATION</td>
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<td>Mo/Mn + Ni Plating</td>
<td>Mo/Mn+ Ni Plating</td>
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<td>N2/H2 VACUUM</td>
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<tr>
<td>BRAZING MATERIAL</td>
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<td>Ag-Cu / Cu / Au-Cu</td>
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<tr>
<td>Al2O3 PURITY</td>
<td>%</td>
<td>99.5MIN.</td>
<td>99.8</td>
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<td>SEE Coefficient (Max.)</td>
<td>–</td>
<td>NO REQUEST</td>
<td>11.5</td>
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<tr>
<td>FLEXUAL STRENGTH</td>
<td>MPa</td>
<td>NO REQUEST</td>
<td>300</td>
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<td>YOUNG'S MODULUS</td>
<td>GPa</td>
<td>NO REQUEST</td>
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<tr>
<td>POISSON'S RATIO</td>
<td>–</td>
<td>NO REQUEST</td>
<td>0.23</td>
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<tr>
<td>VOLUME RESISTIVITY</td>
<td>Ohm*cm</td>
<td>NO REQUEST</td>
<td>&gt;10¹⁴</td>
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<tr>
<td>DIELECTRIC CONSTANT (1 MHz)</td>
<td>–</td>
<td>9.8 +0.2/-0.4</td>
<td>9.9</td>
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<tr>
<td>Tan Delta ( @1MHz )</td>
<td>(×10⁴)</td>
<td>&lt;10⁴ at R.oom Temperature</td>
<td>0.4 (@8GHz) circular cavity</td>
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<tr>
<td>CTE</td>
<td>×10⁶/deg C</td>
<td>NO REQUEST</td>
<td>7</td>
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<tr>
<td>THERMAL CONDUCTIVITY</td>
<td>W/(mK)</td>
<td>NO REQUEST</td>
<td>29</td>
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</table>

SEE Coefficient: Secondary Electron Emission Coefficient
These are reference value taken from material measurement data.
The failure mode in brazing process is ceramic crack.
Tensile strength for Ag(72%)-Cu(28%) material itself: 32-40kgf/mm2. Bonding strength after brazing: 10-15kgf/mm2
Summary of RFQ Coupler Design Status

✓ Engineering design nearly complete, see F10003120.
✓ Thermal, stress, deflection and modal analysis complete
✓ Test coupler designed, fabrication drawings released to procurement, expected delivery end of May 2013 from VMS

Remaining Tasks and Plans

– Make groove mock-up of Coupler to RFQ flange to test the groove/spring fit
– Fabrication drawings
– Procurement of RFQ Coupler
– Finish Design and order Coupler Test Stand
– Design and order Coupler Support