High Level RF for PXIE

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PIP-II Tuesday technical meeting
14 July 2015
Sigmaphi ad for IPAC 14
PXIE RFQ
RF installation at CMTF
RF Block Diagram

128-600 Watt Modules Combined to make 75kW
One of the missing PEM nuts. On one of the slices, we opened the top panel and found the nut straddling the input Wilkinson.

This photo of the spare slice. Three screws were missing, but no nuts found in the chassis. make 75kW

A dangerous place for metal to be floating around.
The RF input coax as found on spare slice left, after we moved it, right. We are also concerned about the bias coax, tan lines, that also lay over the Wilkinson splitter.
Initially the amp would not run above this power level because our Temperature sensor would provide an external fault for a step in power. Just one of several interface issues to combat.
CW test at 45 KW for approximately 30 minutes. Top network analyzer magnitude and phase, bottom forward power and water temperature out.

-7 dBm drive from NA

Red arrow shows time synchrony

Left bay water temp warning at 84.3F
Right bay water temp warning at 85.3 F

Red water temp F
Green forward power watts
SN01 output harmonics at 75 kW coupling value at 325 MHz is 6 dB higher so subtract from marker 2 second harmonic is -31.32 dB
NA Power sweep, 0.5 dB/ div and 5 deg/div

REFERENCE VALUE
25.194 dB

Gain = 76.8 dB

74 Kw

73 Kw = 78.6 dBm
SN01 Efficiency

SN01 gain dB
Circulator performance vs Input Water Temperature = 68.6 F
Circulator performance vs Input Water Temperature = 74.5 °F
Circulator performance vs Input Water Temperature = 80.4 F
Circulator performance vs Input Water Temperature = 85 F
Circulator Performance

Input Water Temperature = 85 F, red is the difference between input and output water temp yellow is the forward power out of the amplifier. Water flow is 4.1 GPM. At 60 kW, the delta T is approximately 6 deg F. The thermal impedance between the water channels and the ferrite disc requires this lower operating water temperature.
Measurement of reflected power as a function of the set point on the water skid at 65 kW amp power **50 ohm load**. Blue is 85 F, magenta is 84 F, yellow is 82.5 F and the sweet spot. This is with only one amp running and the LEBT energized. As more loads are added, the temperature at the circulators may vary and adjustments made.
Running at 74 kw (yellow), temperature of transistors in C (blue), radiated power dBm into room antenna (red), cooling water temperature (green). Abrupt turn off of power to see time constant, about ten minutes to stabilize transistor temp, six minutes for the water loop.
Buncher cavity conditioning setup (June-July, 2015)

Comark amplifier (3kW 162.5MHz)  Directional coupler  Tuner

Pickup loop
MEBT Cavity

Cavity is conditioned up to 1720 W (in the cavity). Operate at this power level for 3 days (8 hours/day).
Reflected power: ~ 5 W
Vacuum: ~1.2 E -8 torr
Cooling water $\Delta T$ ($T_{out} - T_{in}$) is 2.1 F (Stem), 0.7 F (Body) at 1720 W level, flow rate: ~ 3.8 – 4 GPM
Resonant Frequency shift: ~ -17 kHz
COMARK

Low Input

VIEW HISTORY

<table>
<thead>
<tr>
<th>DATE</th>
<th>TIME</th>
<th>EVENT</th>
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<tbody>
<tr>
<td>29-Apr-2015</td>
<td>2:31 PM</td>
<td>Low Input</td>
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<td>2:30 PM</td>
<td>Carrier Off</td>
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<td>2:16 PM</td>
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<td>29-Apr-2015</td>
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<tr>
<td>29-Apr-2015</td>
<td>12:03 PM</td>
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CLEAR HISTORY

BACK TO MAIN

FWD (Volts) RFL (Volts) TEMP (°C) DC (Volts) ATTEN MODE
0        0        26        47        0 MAN
2:35PM   29-Apr-2015

COMARK

COMPREHENSIVE 0 Watt 1
PHASE 0 Watt 0
TEMPERATURE 25 °C
SCHNED 39 50 49 48 47 46 45 44 43 42 41 40 39
Comark 162.5 MHz 3 kW CW amplifier

• Observed issues delaying delivery of the balance of units.
  • History feature does not show events in chronological order
  • Forward power readback poor below 500 watts
  • No air filters
  • Water flow meter readback is “flakey” varying between 2-24 liters/min
  • Control interface connection required bypass capacitors for stable operation.
  • Interface optical couplers unable to sink adequate current.
Comark 162.5 MHz 3 kW CW amplifier

<table>
<thead>
<tr>
<th>external calibrated f.w.d power</th>
<th>Amplifier Internal f.w.d power</th>
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<tbody>
<tr>
<td>100</td>
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<td>200</td>
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<td>2500</td>
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<td>3000 trips</td>
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![Graph showing the relationship between external calibrated f.w.d power and Amplifier Internal f.w.d power.](graph.png)
Comark 162.5 MHz 3 kW CW amplifier

1 dB bandwidth @ 2 kW is 17 MHz
Summary

- **High** Level RF has been tested extensively in CW mode
- When water returns both the RFQ and MEBT amplifier will be tested in pulse mode
- Rigid coax on site is being cleaned at CMTF
- 6” flex coax fully tested to 75kW CW
- Will need to procure only a few sections of 6” rigid coax for the RFQ, with delivery a week to ten days after order.
- A source of connectors has been found for the Cablewaves 1-5/8” coax. There are almost 2000 feet on sight that could be used for PXIE MEBT, HWR, SSR1. Connectors are approximately $350 each.