High Power CW RF Sources for Booster and Ring in SSRF

Shenjie Zhao, On behalf of SSRF RF Group
Outline

1. Status of Klystrons
2. Some Trips or problems
3. Upgrades
### Four Sets of CW Klystron Type Transmitters in SSRF

<table>
<thead>
<tr>
<th></th>
<th>NO0</th>
<th>NO1</th>
<th>NO2</th>
<th>NO3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Booster</td>
<td>Ring</td>
<td>Ring</td>
<td>Ring</td>
</tr>
<tr>
<td>Klystron Type (Thales)</td>
<td>TH2161</td>
<td>TH2161B</td>
<td>TH2161B</td>
<td>TH2161B</td>
</tr>
<tr>
<td>Serial No</td>
<td>616002</td>
<td>161010</td>
<td>161012</td>
<td>161015 (161013 before Oct, 17)</td>
</tr>
<tr>
<td>Max Power (kW)</td>
<td>180</td>
<td>300</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Power mode now (kW)</td>
<td>130</td>
<td>220</td>
<td>220</td>
<td>220</td>
</tr>
<tr>
<td>Used Power now (kW)</td>
<td>60 (pulse)</td>
<td>145</td>
<td>145</td>
<td>145</td>
</tr>
<tr>
<td>Fil Time (h)</td>
<td>81000</td>
<td>75000</td>
<td>71300</td>
<td>3700</td>
</tr>
<tr>
<td>HVPS Time (h)</td>
<td>79000</td>
<td>73000</td>
<td>69000</td>
<td>3600</td>
</tr>
<tr>
<td>PSU (Ampegon)</td>
<td>46kV/7.5A</td>
<td>55kV/12A</td>
<td>55kV/12A</td>
<td>55kV/12A</td>
</tr>
<tr>
<td>PSM modules</td>
<td>68</td>
<td>86</td>
<td>86</td>
<td>86</td>
</tr>
</tbody>
</table>

Three 300kW transmitters in Ring for three SRF cavities

One 180kW transmitter in Booster for two 5-cell NC cavities
Heating Curves-No0

- Cathode not degraded;
- Filament a little thinner.
Heating Curves-No1

- Cathode and filament not degraded;

No1 Heating Curve@220kW mode (I_k vs I_F)

No1 Filament (V_F vs I_F)
Heating Curves-No2

- Cathode and filament not degraded;
Gain Jump of Original No3 Klystron

- The gain jump around 67~76kW of old No3 klystron start from 2010;
- Retune of the cavities of the klystron only make the gain jump power point changed a little;
Gain Jump of Original No3 Klystron

- 20161129 80kW to 90kW jump was observed in pulse condition. This jump lead to cavity’s pick-up arc at 201707192108;
- The check or test of this old klystron in Thales will cost ~50,000 EUR, without not any maintenance guarantee.

Gain jump of original No3 klystron

20170103 new No3 Klystron

Gain Jump of Original No3 Klystron

20170103～15 3days high voltage condition on new No3 klystron

Ion pump current

201707192108 No3 klystron gain jump lead to the pick up arc of cavity when beam injection in Ring
100Hz Noise on Forward Power

- A burn connect of No71 module lead to the 100Hz noise;
- 100Hz noise always comes from one abnormal module.

201303280820#3KLY 100Hz noise
AC coupling, 1M input resistor.
Ch1-HVPS:I，Ch2-HVPS:V，Ch3-FIL:I，Ch4-CO1:Pki
Transformer Current Interlock from PSU0

- During normal running (MOD Voltage On), sometimes (2016/02/25, 2016/02/27) Transformer over current trip from P2 (measuring the 3 phase current of T2).
- Frequently happen if try to close the step-start (AUX ON->Standby). Most from P2 (L1, L2, I>>), one time from P1 (L1, I>>)

- During test there is a serious trip.
  - P1 shows ~2000A when trip!
  - We can't turn on the KSU anyway.

- Set the time relay for step-start P10 to 0.5S (original 0.5S, and 2S from 2015/03/31) from comment of Ampegon engineer
- We can close the step-start without any problem
Isolated Transformer Spark-over

- Isolated transformer spark-over often lead to damage of many cards!
- After 2013, a new type domestic isolated transformer was adopted, the tolerant voltage is 100kV.
Trips From Humidity

Some trips happened from high humidity:
- Discharge from HV feedthrough for Ion pumps
- Spark from HV power supply of klystron
- Damaged relay contacts of PSU0 in Booster

Solutions:
- Add dryer surrounding the HV feedthroughs;
- Turn on the fan inside the HV klystron power supply during machine shutting down;
- RF hall Isolating and extra dehumidifiers make the humidity of RF hall decreased from 65% to 55% during raining season.

26 June 2018
There are many auxiliary power failures, focus power, 24V power, filament power, anode power, ion pump power etc;

Now we exchange them periodically.

201510162026 trip. Anode voltage drop lead to beam dump
Upgrade of No0 PSU

- The PSU0 was delivered in 2000, and was a very old version;
- Upgrade the control system means Booster and Ring can share the same spare parts;
- The upgraded parts include: PSMC, ICS, IOC, and EPICS.
Upgrade of the PSMC of No1~3 PSU

- The low frequency noise was suspected from RF PWM;
- On 2016 Summer, we upgraded the PSMC in ring, which make the PWM frequency adjustable.
- The light noise was verified from PWM of the PSUs.
Conclusion

- After more than 70,000 hours running, 3 of 4 high power CW klystrons work well and keep health;
- The old No3 klystron was exchanged because of big gain jump;
- 100 Hz noise always come from one abnormal PSM module;
- Humidity is a enemy for the transmitters especially for all high voltage powers;
- We exchange auxiliary power periodically;
- We upgraded the control system of PSU0 to make all the PSUs can share the same spare parts;
- The PSMC of PSU1~3 was upgraded to make the PWM frequency adjustable.
Thanks for attention!