New KFA45 tuning summary at B867

N. Ayala, A. Ferrero, T. Kramer
KFA45 5\textsuperscript{th} generator layout overview

New generator elements
- MS G1-G2 triggering system
- TX cables – CLP52
- New magnet + magnet entry box

Tunable elements
- MS connection box ferrites
- MS common mode ferrites
- Magnet connection box ferrites
- Magnet connection box RC filters
KFA45 5th measurement setup overview
KFA45 5th tuning – Reference measurements

No RC filter
No magnet connection box ferrites
MS ferrites (1 + 5) configuration (same as in 2018 operation)
Reservoir voltage 5v (a bit low)

January 2019

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Trise [ns]</th>
<th>Tfall [ns]</th>
<th>Flat top ripple</th>
<th>Post pulse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic config - 0xW721 + No RC+ MagCB 0mm + MSCB(1+5)</td>
<td>152</td>
<td>123</td>
<td>106.5%</td>
<td>NOK</td>
</tr>
</tbody>
</table>
KFA45 5th tuning – RC filters

- RC filters – They generate over or undershoot after any sudden $dI/dt$ change.
  - Good for shaping the rising/falling edge
  - The post-pulse gets boosted as well
  - Need to be the right capacitance value, too much slows down the overall $dI/dt$
KFA45 5th tuning – Ferrites (Magnet entry box)

- Saturating ferrites – Rising edge compression and post pulse damping
  - Strong tendency to create ringing (either after rising or falling edge)

---

![KFA45 magnetic field tuning measurements. Module 4. -- October 2019 --](image-url)

- Reference waveform (No ferrite, No filter)
- 7xW721 + RC 12Ω/150pF + MagCB 0mm + MSCB(1+5)
- 7xW721 + RC 12Ω/150pF + MagCB 30mm + MSCB(1+5)
- 7xW721 + RC 12Ω/150pF + MagCB 50mm + MSCB(1+5)

---

![KFA45 magnetic field tuning measurements. Module 4. -- October 2019 --](image-url)

- Reference waveform (No ferrite, No filter)
- 7xW721 + RC 12Ω/150pF + MagCB 0mm + MSCB(1+5)
- 7xW721 + RC 12Ω/150pF + MagCB 30mm + MSCB(1+5)
- 7xW721 + RC 12Ω/150pF + MagCB 50mm + MSCB(1+5)
KFA45 5th tuning – Ferrites (MS connection box)

- Saturating ferrites – Rising edge compression and post pulse damping
  - Strong tendency to create ringing (after rise/fall time)
KFA45 5th tuning – MS cathode stray capacitance
KFA45 5th tuning – MS cathode stray capacitance

New electronics
+ New oil with higher $\varepsilon_r$
= More cathode stray capacitance
KFA45 5th tuning – MS cathode stray capacitance

MS common mode ferrites (VAC Vitroperm 500F - W721)
KFA45 5\textsuperscript{th} tuning – MS cathode stray capacitance

- Good suppression of the flat top bump
- Strong degradation of rise and fall time
- No available tools to decrease $t_{fall}$ and $t_{rise}$ afterwards

+85ns!!!

+28ns!!!
KFA45 5th tuning – MS cathode stray capacitance

- Configuration 67xW721 is very aggressive despite of the good flat top bump rejection.
- Rise and fall time impossible to be reduced with more RC filters of magnetic compression.

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Trise [ns]</th>
<th>Tfall [ns]</th>
<th>Flat top ripple</th>
<th>Post pulse</th>
</tr>
</thead>
<tbody>
<tr>
<td>67xW721 + RC 12/150pF- 400/470pF + MagCB 50mm + MSCB(0+8)</td>
<td>174</td>
<td>125</td>
<td>102.7%</td>
<td>OK</td>
</tr>
<tr>
<td>3xW721 + RC 12/150pF + MagCB 50mm + MSCB(0+8)</td>
<td>97</td>
<td>97</td>
<td>106%</td>
<td>NOK</td>
</tr>
</tbody>
</table>

- Reduction of the stray capacitance would be needed in order to meet the ±2% flat to stability.
KFA45 5\textsuperscript{th} tuning – MS cathode stray capacitance

- MS partially filled with oil. Test performed to assess the impact of the oil dielectric permittivity on the MS performance. (From $\varepsilon_r=3.2$ to something close to $\varepsilon_r=1$).
- At 20kV Flat top bump reduced by 36%.

- Using Shell Diala oil ($\varepsilon_r=2.2$), bump could be reduced by ~15%.

- MS geometry + all new electronics play a significant role in terms of flat top bump amplitude.

![KFA45 magnetic field. Module 4. -- January 2020 -- @20kV](image-url)
Higher reservoir $\rightarrow$ Higher thyatron $dV/dt$ $\rightarrow$ More ringing, less rise time
KFA45 5th tuning – Proposed final configuration
KFA45 5th tuning – Final configurations

- Based on all presented tuning tools and through an iterative process of test & measurement supported by Pspice and educated guess (based on observations), a tuning configuration is proposed to meet KFA45 LUI requirements.

19xW721 + RC 12/150pF + MagCB 30mm + MSCB(1+8) – Vres 5.5
KFA45 5\textsuperscript{th} tuning – Proposed final configuration

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Trise [ns]</th>
<th>Tfall [ns]</th>
<th>Flat top ripple</th>
<th>Post pulse</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd Injection BCMS</td>
<td>82</td>
<td>103</td>
<td>104.6%</td>
<td>OK</td>
</tr>
<tr>
<td>2nd Injection LCH standard</td>
<td>82</td>
<td>101</td>
<td>104.9%</td>
<td>OK</td>
</tr>
<tr>
<td>1st Injection</td>
<td>132</td>
<td>121</td>
<td>103.8%</td>
<td>OK</td>
</tr>
</tbody>
</table>
Conclusions

• Summary of all KFA45 tuning tools presented.
  • RC filter.
  • Ferrites at magnet entry box, MS and common mode ferrites.
• Due to the new trigger system + Midel 7131 oil ($\varepsilon_r = 3.2$) the stray capacitance on the cathode has bigger impact on the flat top ripple.
  • Ferrite mitigation improves the situation but with a negative impact on the rise/fall time.
  • Further mitigation need the reduction of the stray capacitance.
  • Test on the MS partially filled with oil showed a 36% flat top bump reduction.
• The MS reservoir need to be kept under control for optimal generator performance.

• A lot of tuning done at the pulse generator. A generator tuned configuration has been proposed. The performance need to be checked under the emittance point of view.
KFA45 5\textsuperscript{th} tuning – MS cathode stray capacitance

KFA45 magnetic field. Module 4. -- November 2019 --

![Diagram showing KFA45 magnetic field](image)

- Normalized field [%] vs Time [ns]
- Line chart comparing theoretical and simulated results

Recovery Time: T_{rec}
Time Delay: T_{ delay}

KFA45 5th tuning – Flat top ramp

- Measurement artefact
  - Ground loop between probe and oscilloscope → Discarded
  - Pick up coupling with the magnet HV conductor → Discarded
- Cable attenuation → Almost discarded. (more measurements needed)
- MS stray capacitance RLC charge → More measurements needed

+0.7% per 1us