Design and Test Results of Kicker Units for the Positron Accumulator Ring at the APS

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Overview

- What is a kicker?
- Why do synchrotrons need them?
- Kickers at the APS
- Positron vs. Electron Kicker

Kicker prototype at the APS [1]
**What is a kicker magnet?**

- A strong field is used to ‘kick’ the beam in another direction.

- Kickers redirect the beam
  - Injection
  - Extraction

- Coiled wire
  - used to create magnets

\[ F = q(E + v \times B) \]

\[ F = (BlI)n \]
Why do synchrotrons need kickers?
Kickers at the APS

- Three main components to kicker system:
  - Magnets
  - Pulse Forming Network
  - Power Supply

Circuit diagram of the kicker unit [1]
Window-frame Magnets

- CMD5005 ferrite
- \( L = 844.8 \text{ nH (coils)} \)
  - Based on geometry
  - Inductance too high for specifications
- Coils are divided to reduce \( L \)
  - Half turn & longitudinally
  - 4 magnet sections

\[
T_r = \frac{\pi \sqrt{L_{1/2}C}}{8}
\]
Pulse Forming Network (PFN)

- Triaxial cables AA7949
  - $Z_0 = 14 \ \Omega$
  - $v_p = 0.16 \ m/\text{ns}$
  - 8/9 m long
    - trimmed during testing
- $C = 1.72 \ nF$
  - Rated for 50 kV
  - Chosen first because industry limited
  - Each half turn magnet divided into sections by lumped capacitors
**Test Results**

### Prototype Issues

- Rise and fall time of magnetic field too long.

- Inductance of connections greater than expected.

- Magnetic coupling between adjacent magnet sections.

### Solutions

- **Rise time:**
  - Added capacitor, \( C_t = 4.7\, \text{nF} \)
  - Shortened PFN cables (8m)

- **Fall time:**
  - Capacitor value at output of magnet tripled

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**Prototype Issues**

**Solutions**

- Rise time:
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- Fall time:
  - Capacitor value at output of magnet tripled

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![Magnetic field of extraction kicker [1]](image1)

![Magnetic field of injection kicker [1]](image2)
### Final Results

<table>
<thead>
<tr>
<th>Simulation Specifications</th>
<th>Test Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prototype</td>
</tr>
<tr>
<td>Rise time</td>
<td>0 – 100%</td>
</tr>
<tr>
<td></td>
<td>20 – 100%</td>
</tr>
<tr>
<td>Fall time</td>
<td>94 – 50%</td>
</tr>
<tr>
<td>Flat top</td>
<td>3% flat</td>
</tr>
<tr>
<td>Ringing</td>
<td>% of peak</td>
</tr>
<tr>
<td>Field strength</td>
<td>283/435 G</td>
</tr>
</tbody>
</table>

Rise time: 0 – 100% < 190 ns 120 ns 160 ns 142 ns 120 ns 160 ns 142 ns 98 ns 88 ns 98 ns 88 ns 98 ns 88 ns 98 ns 88 ns 98 ns 88 ns

Fall time: 94 – 50% <70 ns 200 ns 70 ns n/a 200 ns 70 ns n/a 200 ns 70 ns n/a 200 ns 70 ns n/a 200 ns 70 ns n/a 200 ns 70 ns n/a

Flat top: 3% flat >35 ns 60 ns 46 ns 60 ns 46 ns 60 ns 46 ns 60 ns 46 ns 60 ns 46 ns 60 ns 46 ns 60 ns 46 ns 60 ns 46 ns 60 ns 46 ns

Ringing: % of peak <30% ns 26% n/a 26% n/a 26% n/a 26% n/a 26% n/a 26% n/a 26% n/a 26% n/a 26% n/a 26% n/a 26% n/a 26% n/a 26% n/a 26% n/a 26% n/a 26% n/a

Field strength: 283/435 G ~450 G ~500

Simulation Specifications | Test Results
--- | ---
Rise time | Prototype | Injection | Extraction
--- | --- | --- | ---
0 – 100% | < 190 ns | 120 ns | 160 ns | 142 ns
20 – 100% | <100 ns | 98 ns | 88 ns |
Fall time | 94 – 50% | <70 ns | 200 ns | 70 ns | n/a
Flat top | 3% flat | >35 ns | 60 ns | 46 ns |
Ringing | % of peak | <30% ns | 26% | n/a |
Field strength | 283/435 G | ~450 G | ~500 |
Positron vs. Electron kickers

- Positron (+)
- Electron (-)

- Need to switch direction of B/I
- Switch leads on magnets

http://www.physbot.co.uk/magnetic-fields-and-induction.html
References


thank you!