A Diagnostic Kicker System as a Versatile Tool for Storage Ring Characterisations

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Motivation

- Beam excitation in any transverse direction
- Deflection up to aperture limits
- Excitation amplitude - precisely defined and reproducible

Challenge

- Simultaneous pulsing of both systems
- High amplitude stability up to 10Hz repetition rate
- Timing stability by pulse synchronisation

Requirements

- Two separate diagnostic kicker systems
Technical Realisation

Pinger System Design Parameters

<table>
<thead>
<tr>
<th>Description</th>
<th>Horizontal</th>
<th>Vertical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deflection angle</td>
<td>5.3 mrad</td>
<td>2.1 mrad</td>
</tr>
<tr>
<td>Kick strength</td>
<td>19.3 mTm</td>
<td>13.2 mTm</td>
</tr>
<tr>
<td>Pulse length</td>
<td>1.5 µs</td>
<td>1.5 µs</td>
</tr>
<tr>
<td>Magnet aperture</td>
<td>93 mm x 50 mm</td>
<td>85 mm x 52 mm</td>
</tr>
<tr>
<td>Magnet length</td>
<td>240 mm</td>
<td>300 mm</td>
</tr>
</tbody>
</table>

Technical Realisation of the two Diagnostic Kicker Systems

- Two lumped inductance magnets, designed as ferrite window frame magnets
- Magnets around a ceramic beam pipe
  - Titanium sputtered with 5 µm thickness,
    No considerable field reduction
- Pulser circuits directly attached
- Half-sinusoidal pulse shape with max. pulse length of 1.5 µs

Constrains for the Mech. Design were:
- Available mechanical length of 690 mm
- High magnetic flux density
- Integration into the storage ring with least interference to continuous user operation.
Exploded View of the Kicker Magnet Assembly

- Ferrites (CMD 5005)
- Ceramic beam pipe (titanium sputtered)
- Connectors
- Symmetrical half-coils
- Insulation parts
- Copper enclosure
- Mounting screws
- Base plate
- Stand

- Horizontal kicker magnet
- Vertical kicker magnet

Diagnostic Kicker System / Olaf Dressler / EPAC'06
Magnet in Reality

Horizontal kicker magnet

Vertical kicker magnet

Half-coil of vertical kicker magnet

Picture of the assembled magnets from above
Design of Pulser Circuit

- **Low shift** of ignition timing vs. trigger
  - Thyratron as main switch

- Realisation in-house by utilising commercially available components

- Pulser boxes adjacent to the magnets
  - Low inductance

- Charging power supply with high stability ($2 \times 10^{-4}$)

- Three dimensional layout
  - High voltage prove and low inner inductance

- Wrap connections
  - Interchangeable polarity
Pulse Current on Horizontal Magnet from 3 to 15 kV
Magnetic Field Measurements

**Integral Magnetic Field Measurement**

- Magnet yoke
- Direction of measurement
- Integral pickup coil
- Magnetic flux measurement

**Measured Integral Field vs. Pulse Current**

- **Linearity** over the **whole range**
  - No saturation of the core was observed!

- Measurements with current amplitudes up to **4.5 kA** vertical and **3.9 kA** horizontal
Both systems can be run simultaneously and synchronized in:

- **Continuous operation mode** with 10 Hz repetition rate
- **Single shot mode** where a gate signal is given by CAN-bus for **synchronous start trigger**
- **Synchronized** with the **1.25 MHz revolution frequency** and **50 Hz line beat** for **coincident** beam excitation and measurement
Charging Voltage on Horizontal Kicker vs. Horizontal Beam Deflection

Methodology

- The system is continuously pinging horizontally at 10 Hz.
- Determination of the excitation amplitude by a moveable aperture limit - a horizontal scraper.
- Increasing excitation of the circulating electron beam up to nearly zero lifetime.
- Measurement identifies the linearity between charging voltage vs. deflection amplitude.
Conclusion

- This Diagnostic Kicker System was integrated into the BESSY II storage ring 6 years ago.
- Since then a variety of measurements have been successfully performed, e.g.: Frequency map measurements, dynamic aperture measurements, ...
- Very reliable equipment with only little maintenance.
Acknowledgements

- To the excellent cooperation of different work groups at BESSY
- Especially to Peter Kuske, who established the system by his frequency map measurements
- Continuous support and guidance of Jens-Olaf Kuszynski for the Labview control programs
Control Rack with Local Control Electronics

Control units made by DESY

F.u.G. power supplies

Self made heating control
General Survey

- CAN control unit
  - Can bus cable
- VME unit for start trigger
  - Continuous and synchronised trigger signal

- Pulser control unit
- Heating control unit
- HV power supply

Cables connections:
- Trigger
- Control pulser
- Heating
- HV supply

3.70 Service area

Accelerator tunnel

- Magnet
- Pulser
- HV trigger unit

Main power circuit
- HV trigger unit for grid 1 and 2
Labview program – front panel and flow diagram for frequency map acquisition

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Labview program – front panel and flow diagram for frequency map acquisition

Flow Diagram:

1. Start
2. Read init file
3. Preset scope
4. Open EPICS PV’s
5. Create array of setpoints for kicker & masterclock
6. Check current low:
   - Yes: Sextupole on
   - No: Next kicker value
7. Set back masterclock
8. Start injection
9. Check enough current:
   - Yes: Stop injection
   - No: Next kicker value
10. Sextupole off
11. Shift PV m’clock value
12. Write PV kicker value
13. Write PV kicker gate
14. Acquire data
15. Data to file
16. Check enough current:
   - Yes: Next kicker value
   - No: Close EPICS PV’s
17. Set back machine
18. Stop

Front Panel:

- Frequency Map Acquisition
- Trigger variable: Trigger mode, Current min, Current max
- New injection: Kickers
- Y1 min, Y1 max: Number of steps
- Y2 min, Y2 max: Number of steps
- RHOD: RHOD
- RHOD: RHOD

Data plot (X,Y) with grid and markers

Stop
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