NLC - The Next Linear Collider Project

Damping Ring Kicker Development

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May 1999
SLAC has embarked on a kicker development program to meet the NLC requirements for Damping Ring kickers

Currently:
• kicker conceptual design developed
• development prototype manufactured to explore concepts
• IGBT-based modulator is being considered
• low power prototype modulator was developed

This is a new design -- but we are confident that the specifications will be met with a high-reliability magnet
Technical Motivation

Each ring requires two kicker systems,
• injection and extraction kickers have similar specifications
• positron pre-damping ring requires stronger kicker with larger free aperture
• short rise-fall times (60 ns)
• stable, flat top (250 ns)
• low impedance to stored beam

Kicker and modulator development effort is joint effort between NLC and SPEAR3. Initial phases of design effort address similar requirements
## Specifications

<table>
<thead>
<tr>
<th></th>
<th>Kicker</th>
<th>DR</th>
<th>Pre-DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise/Fall Time</td>
<td>60</td>
<td>100</td>
<td>ns</td>
</tr>
<tr>
<td>Flattop</td>
<td>260</td>
<td>260</td>
<td>ns</td>
</tr>
<tr>
<td>Repetition rate</td>
<td>120</td>
<td>120</td>
<td>Hz</td>
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<tr>
<td>Beam Energy</td>
<td>2.0</td>
<td>2.0</td>
<td>GeV</td>
</tr>
<tr>
<td>Kick angle</td>
<td>2.5</td>
<td>8.0</td>
<td>mr</td>
</tr>
<tr>
<td>Length</td>
<td>1.2</td>
<td>1.8</td>
<td>m</td>
</tr>
<tr>
<td>Field</td>
<td>140</td>
<td>310</td>
<td>gauss</td>
</tr>
<tr>
<td>Field uniformity</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Injection tols</td>
<td>± 3.5x10^{-3}</td>
<td>± 10.x10^{-3}</td>
<td>stability</td>
</tr>
<tr>
<td>Extraction tols</td>
<td>± 0.5x10^{-3}</td>
<td>± 1.6x10^{-3}</td>
<td>stability</td>
</tr>
</tbody>
</table>

(*) Specifications have not been finalized
Program Goals

The SLC (SLAC) damping ring kickers at the have been a major operational problem. Kicker and modulator lifetimes, stability, radiation susceptibility, and vacuum failures present risks to the program we would like to eliminate for the NLC.

The NLC damping ring design requires lower field kickers and has allocated additional beamline space.

The main damping ring kickers are installed in pairs to reduce modulator jitter sensitivity.

The DR kickers must:

- meet the operational requirements
- meet the project availability requirements
- not place other systems at risk (e.g.: vacuum failures)
R&D Motivation

A set of R&D projects are proposed to meet the kicker requirements.

Modulator:
- New modulator design using commercial IGBT transistors designed for traction motor control
- Key technology
- Develop modulator to verify expected performance and establish baseline reliability

Kicker
- Stripline kicker avoids most of the SLC operational problems
- Key technology
- Develop kicker to gain confidence in design and establish baseline reliability
Prototype Design

Modulator
• stacked IGBT design

Kicker
• shorted strip-line design
• balanced drive currents do not require ceramic beamline gaps
• similar kicker used in DELTA at Dortmund
• flat top, short rise/fall time requirements make this a unique kicker. (Synchrotron light sources are not interested in orbit variations of extracted beam)
Dortmund Kicker
Probable cross-section

- the magnet will require a controlled impedance
- water cooling is not allowed in the prototype
- vacuum considerations have not been formally addressed
Engineering Challenges

There is no such thing as a free lunch. The stripline kicker design has a number of engineering challenges we believe can be overcome to produce a high quality kicker for the NLC damping rings and other storage rings.

- Kicker must not present resonance disruption of beam
- Is beam impedance acceptable?
- Impedance match to modulator
- Vacuum feedthrough of modulator drive cables
- Mechanical tolerance requirements of kicker strips
- Water cooling
- Manufacturability and reliability of design
- Rise/fall time of modulator -- beam physics
- Stability
- Higher modes in magnetic field quality
Development Strategies

Existing prototype validates model and expectation for magnetic performance, but fails beam impedance measurements (3GHz resonance)

Develop IGBT modulator (key technology). Rise time, stability, performance expected to meet specifications. Test into existing prototype or into shorted load cables.

Develop DR vacuum kicker. Test model for vacuum stability, electrical impedance, effective stripline length, other concerns

Design Pre-DR kicker with understanding of modulator capabilities. Evaluate need of ferrite materials inside vacuum enclosure
Schedule

Q3FY99-Q4FY99  Impedance optimizations of existing prototype
Q3FY99-Q3FY00  Development of IGBT modulator
Q2FY00-Q3FY02  Engineering and production of DR vacuum magnet
Q3FY00-         Initial design for Pre DR kicker