XFEL Pulser

• Specification of Pulser
• Dump pulser with a Belhke switch
• Dump pulser form the FID company
• Dump pulser with Mosfet
• Flat top pulser
### Specification of Pulser

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Fast single bunch kicker (for beam dump)</th>
<th>Flat top kicker (for beam distribution)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse Form</td>
<td>Burst</td>
<td>Flat top</td>
</tr>
<tr>
<td>Repetition Rate [Hz]</td>
<td>$5 \times 10^6$</td>
<td>10</td>
</tr>
<tr>
<td>Max. Pulse Width [s]</td>
<td>$200 \times 10^{-9}$</td>
<td>$300 \times 10^{-6}$</td>
</tr>
<tr>
<td>Rise/Fall Time [s]</td>
<td>$&lt; 100 \times 10^{-9}$</td>
<td>$\approx 20 \times 10^{-6}$</td>
</tr>
<tr>
<td>Rel. Amplitude Stability</td>
<td>0.01</td>
<td>$3 \times 10^{-4}$</td>
</tr>
<tr>
<td>Relative Residual Ripple</td>
<td>$3 \times 10^{-4}$</td>
<td>$3 \times 10^{-4}$</td>
</tr>
<tr>
<td>Kick angle [mrad]</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Max. int. Field Strength [mT×m]</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>Min. full aperture [mm]</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Max. system length [m]</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Pulser Voltage [kV]</td>
<td>8</td>
<td>0.3</td>
</tr>
<tr>
<td>Pulse Current [A]</td>
<td>100</td>
<td>300</td>
</tr>
<tr>
<td>Max. Power [kW]</td>
<td>40</td>
<td>0.27</td>
</tr>
<tr>
<td>Average Power [W]</td>
<td>260</td>
<td>270</td>
</tr>
</tbody>
</table>
Generation of pulse with a pulse length of 12ns

- A principle setup of the pulser
- A Behlke switch in Mosfet technology
- Generate max. 1000 single pulses with 1μs spacing

**Behlke switch data:**
- Type: HTS 80-12UF
- Pulse voltage: 8kV
- Pulse current: 120A (tp<50ns)
- Frequency: 3kHz
- Jitter: 100ps
- Rise time (10-90%): 2ns

**Pulser data:**
- Voltage: \( U = 6.5kV \)
- Pulse current: \( I = 73.6A \)
- Frequency (burst): \( f = 1MHz \)
- Number of pulses: 1000
- Pulse length: \( t = 12ns \)
Measurement of the ripple

Switch HTS 80-12-UF $t_{on}=10\,\text{ns}$

- 2.3% ripple at 40\,\text{ns}
- 0.68% ripple at 200\,\text{ns}

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Measurement of the timing jitter

Channel 1 Trigger (Delay - Trigger generator) Channel 4
Pulse current with a Jitter of 200ps (Behlke Data: Typical Turn-on Jitter of 100ps)

F. Obier / DESY
Measurement at TTF 2 (March 2005)

Data:
Voltage \( U = 7.0kV \)
Pulse current \( I = 61A \)
Pulse length \( t = 12\)ns

- Equipment test
- Measure the kicker strength
- Measure kicker amplitude stability
- Scan the kicker pulse with a step width of 0.5ns and taking 20 pulses for each data point.

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Measurement on kicker 'flat' top to investigate influence of timing jitter. Standard deviations of unkicked / kicked bunch (eposx1/eposx2) are given below as well as relative error. **Smallest error as low as 0.5 %** at certain delay, relative error increases with distance from 'flat' top. Kicker HV = 7kV.

Increase Kicker HV, we expect eventually to see a clipping at larger kicker amplitudes. **Kicker HV = 7.64 kV**.
Relative error for 2 points within anyhow present beam jitter of 50-60 micron.

- scan the kicker pulse with a step width of 0.5ns and take 100 pulses for each data point.
Pulser with a burst frequency of 3MHz

Pulser data:
- Voltage: $U = 6.5kV$
- Pulse current: $I = 73.6A$
- Frequency (burst): $f = 3MHz$
- Number of pulses: 3000
- Pulse length: $t = 12ns$

- A principle set up of the pulser
- A Behlke switch in Mosfet technology
- Generate max. 3000 single pulses with 330ns spacing

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In this measurement you can see identical pulse amplitudes, we have calibrated it with individual resistors. Power supply voltage of 6.5kV

**Pulser data:**
- Voltage: U = 6.5kV
- Pulse current: I = 51.3A
- Frequency (burst): f = 5MHz
- Number of pulses: 5000
- Pulse length: t = 12ns
Measurement of first prototype of the dark current pulser from the FID Company

**Speciation:**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>f=1-9MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltages</td>
<td>U=700V</td>
</tr>
<tr>
<td>Current</td>
<td>I= 50A</td>
</tr>
<tr>
<td>Rise time</td>
<td>t=5ns</td>
</tr>
<tr>
<td>Pulse length</td>
<td>t=40-940ns</td>
</tr>
<tr>
<td>Burst</td>
<td>1000 Pulse</td>
</tr>
</tbody>
</table>

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Mosfet pulser module

Pulser module data:
- Voltage: \( U = 1000 \text{V} \)
- Pulse current: \( I = 80 \text{A} \)
- Frequency (burst): \( f = 2 \text{ MHz} \)

Next steps:
- We want to integrate a new optical fiber in the circuit. So we can operate with a frequency of 5 MHz and we can reduce the jitter.
- After this we want to build a pulser with a stack of modules.

Optical fiber data:
- Input: +5V into 50Ω
- Output: 1mW
- Jitter RMS: 10ps
- Rise time: 100ps
- Bandwidth: 180 MHz
Flat top pulser

- Pulse current of 100A
- Pulse length of 300µs

Pulser data:
- Voltage: U = 200V
- Pulse current: I = 400A
- Frequency: f = 10Hz
- Pulse length: t = 300µs
Pulse stability measurement of the PETRA III Injection Kicker

We need a method to measure the amplitude stability and the similarity of the pulse shape. We have two identical pulser and kicker. We give the pulse current into a Pearson monitor and measure the difference between currents. You can see that the Stability is 0.2 per mill. The begin and the end differences come from the timing jitter (Behkle switch 1ns).

F. Obier / DESY
Summary:

• For the XFEL Dump pulser we can use a Behlke switch. The pulse stability is good. The main problem is the ripple after the pulse. We could compensate it with a corrector magnet, but this will be very complicated.

• For the FID Pulser we must make the same measurements about ripple, stability, jitter and so on.

• For the Mosfet module we want to integrate a new optical fiber in the circuit. So, we can operate with a frequency of 5 MHz and we can reduce the jitter.

• For the flat top pulser we want to make the difference measurement.