Cavity Frequency Measurement and Initial Tuning at FLASH

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Goals

- Remote cavity tuning at FLASH and test stands
  - Remote and simultaneous frequency measurement of all cavities (no need to go into the tunnel)
  - Make use of standard RF distribution system, klystron, LLRF system, Master Oscillator etc.
- Check tuner step motors under warm conditions to exclude mistakes of connectors, wires and software
- Tuning of the cavities at the 1.3 GHz after cool down
- Relax the cavities to initial frequencies before warming up
- Test of the procedure with warm SC cavity
  - Low power from klystron
  - Checking the frequency range and resolution
- FLASH commissioning in March/April 2010
  - Check of tuner motors
  - Tuning of the cold cavities
# Measurement conditions

<table>
<thead>
<tr>
<th></th>
<th>Warm</th>
<th>Cold</th>
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<tbody>
<tr>
<td>Quality Factor</td>
<td>1.0e4</td>
<td>3.0e6</td>
</tr>
<tr>
<td>Frequency range [MHz]</td>
<td>1298.0 +/-0.4</td>
<td>1300.0 +/-0.4</td>
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<tr>
<td>Frequency step from pulse to pulse [kHz]</td>
<td>10</td>
<td>0.5</td>
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<tr>
<td>Measurement points (RF pulses)</td>
<td>80</td>
<td>1600</td>
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<tr>
<td>Frequency sensitivity [kHz]</td>
<td>25</td>
<td>1</td>
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</table>
Requirements for the Frequency Sweeping System

- Sweeping with constant reference frequency – 1.3GHz from Master Oscillator
- Frequency range from -2.4 MHz to +0.4 MHz relative to 1.3GHz
- Frequency resolution at least 0.5 kHz
- Standard methods for field detection by diagnostic ADCs using DOOCs
Schematic of the RF Station
Hardware and Software of the Measurement Setup
Measurements: Warm SC Cavity on a Table

Frequency sweep (-2MHz; -20MHz) with step 10kHz
Measurements: Warm SC Cavity on a Table

Frequency sweep (-2MHz; -10MHz) with step 10kHz

Matlab interface

DOOCS panel
Integration with LLRF Control System

- New version of firmware for frequency sweeping
- Created DOOCS frequency sweeping procedure server
- Operator Interface
- Automated data logging
FLASH Commissioning: ACC1

- Cavities 3 & 4 no change of frequency
- Motor current needs to be raised 40%

First RF on ACC1 after cavity tuning, 07.04.2010
FLASH Commissioning: ACC23

The frequencies are mirrored with respect to 1.3GHz (i.e. wrong sign)

ACC23 spectrum, initial sweep

Frequency spread range: 74kHz - 430kHz
FLASH Commissioning: ACC45

- ACC4 is OK
- ACC5: cavities 2 & 8 no changes on frequency
- Motor current needs to be raised 50%

ACC45 spectrum, initial sweep

First RF on ACC5 after cavity tuning, 09.04.2010
FLASH Commissioning: ACC67

- ACC6 is OK
- ACC7: bad signals, wrong cabling
- ACC7: cavity 3 and cavity 6 are interchanged

ACC67 spectrum before tuning

ACC67 spectrum after fine adjustment
Documentation

- Complete and detailed commissioning documentation has been done
- Excel document with links to FLASH logbook
Conclusions

- Automated and simultaneous scan of many cavities speed up setup of FLASH, and modules where commissioned within two days including software debugging.

- Developed important procedure for large scale machines like XFEL & ILC.

- Cavity characterization in wide range of frequency ±20 MHz with high resolution 0.1 kHz.

- Safe solution for warm cavities – possible measurement of very small field gradient (only 10kW forward power per cavity at CHECHIA and CMTB).

- No need for hardware change for the sweeping procedure (RF reference signal from MO).
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