FLASH II Project: LLRF Options and Tests

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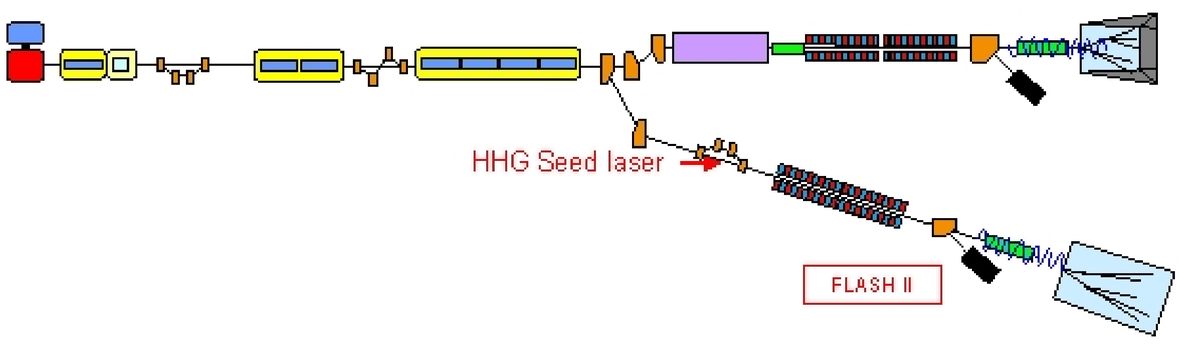
Abstract

There will be a major extension of the FLASH facility during next three years. The modifications include a new experimental hall to double the number of user stations and an additional variable-gap undulator in a separate tunnel to be able to deliver two largely independent wavelengths to two different user stations simultaneously. The electron beam is switched between the present fixed-gap undulator line of FLASH and the new variable gap undulator FLASH2. The LLRF system will be capable to control RF field stability according to new requirements like RF amplitude and phase change from pulse to pulse and intra-pulse, different beam loading for different beam lines, ability of independent LLRF parameter adjustment and tuning for FLASH and FLASH2.

Schematic Layout of the FLASH Facility



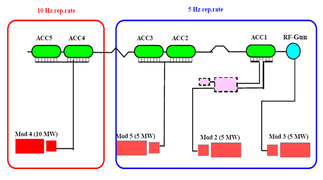
The electron gun is on the left, the experimental hall on the right. Behind the last accelerating module, the beam is switched between FLASH I, which is the present undulator line, and FLASH II, which is the upgrade.

Requirements

- RF amplitude and phase change within pulse
- RF amplitude and phase change from pulse to pulse
- Different beam loading for FLASH and FLASH2 (including arbitrary pulse patterns)
- Ability of gradient tuning of ACC45 and ACC67 (for wavelength scans FLASH)
- Ability of phase tuning of Gun, ACC1, ACC39 (for variation in compression FLASH and FLASH2)
- Ability of independent LLRF parameter adjustment for FLASH and FLASH2

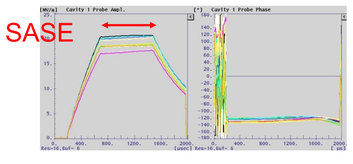
High gradient ramp must be set up so that an adjustment to the lower ramp does not affect the high gradient ramp
This is for adjusting all LLRF parameters in FLASH without worrying to disturb the operation in FLASH2

Two Ramp Modes: First Experiment in 2006

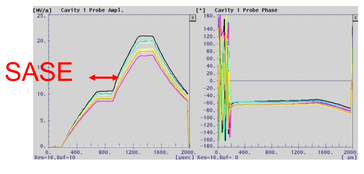


Established the possibility of operating the cavities with two gradient levels (pulse to pulse and intra pulse) so that they can be run at a high gradient along with (during) SASE operation.

Alternate SASE, standard mode of operation



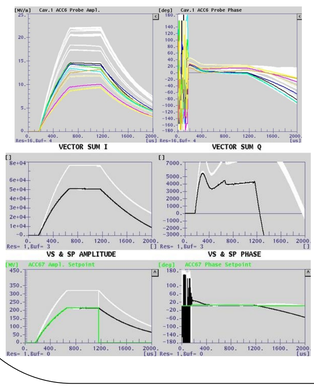
Ramp with two levels, 1st for SASE
Variable RF pulse length

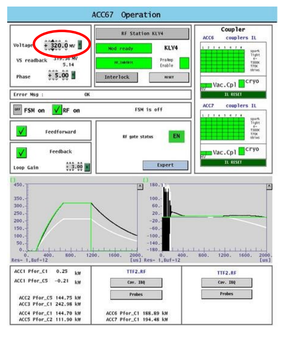


V.Ayvazyan, H.Edwards, G.Petrosyan, K.Rehlich, S.Simrock, E.Vogel, “Alternating Gradient Operation of Accelerating Modules at FLASH”, Proc. EPAC’08, p. 1523.

Bi-level Accelerating Gradient Test - from Pulse to Pulse

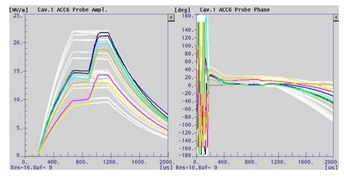
- (12.05.2011) Tested the possibility of operating the cavities with two gradient levels (from pulse to pulse) at ACC67 so that they can be run with low and high gradient for FLASH and FLASH2
- 10 Hz rep rate (gradient levels aren't synchronized with beam)

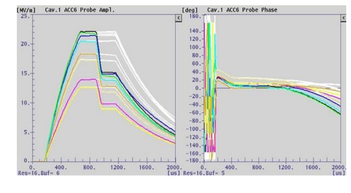


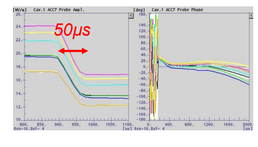


Bi-level Accelerating Gradient Test - Intrapulse

- Tested the possibility of operating the cavities with two gradient levels (intra pulse) at ACC67 so that they can be run with high and low gradient for FLASH and FLASH2
- 10 Hz rep rate (gradient levels aren't synchronized with beam)

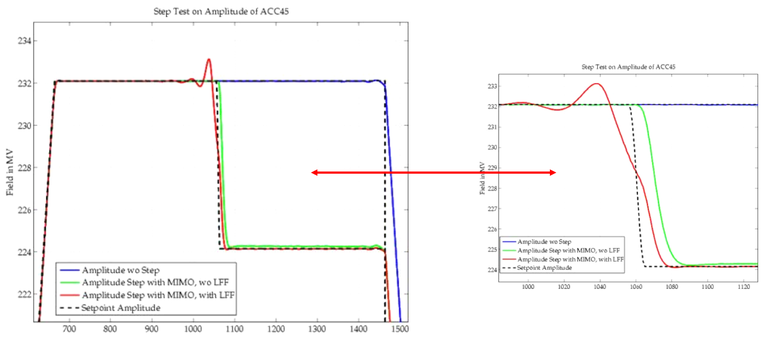






Bi-level Accelerating Gradient Test - with Learning Feed Forward

- Step test of 4% change from amplitude set point
- Phase is unchanged during this excitation

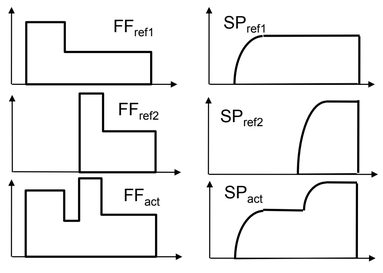


Possible Implementation of LLRF Control Tables for Bi-level Operation

- Controller server creates two reference sets of tables for FLASH and FLASH2 pulses
- Actual tables are superposition of both reference tables

$SP_{act} = \max(SP_{ref1}, SP_{ref2})$

$FF_{act} = \max(FF_{ref1}, FF_{ref2})$



- Export entire software into new hardware platform (µTCA based)
- Controller firmware and software implementation with two sets of tables (FF,SP, BLC etc.)
- Timing & synchronization
- Algorithm development: connection between feed-forward tables and set-point tables
- 2 x learning feed-forward
- Two beam modes (DDD/JDDD panels, histories, etc.)