LLRF Operation and Performance at the European XFEL.


Abstract

The European X-ray Free-Electron Laser (XFEL) [1] at Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany is a user facility providing ultra-short and soft X-ray flashes with a high brilliance. All LLRF stations of the injector, covering the normal conducting RF (gun, A1; 8.3 GHz superconducting cavities (SCCs)) and A11 (8.3 GHz SCCs), were successfully commissioned by the end of 2015. The progress in the acceleration part (six 9.2 GHz SCCs each) in the XFEL accelerator tunnel (XTL) was concluded in June 2017. SAS-1 light was produced in SAS-1 undulator section S4A1 and delivered to the first users in September 2017, marking the beginning of regular user operation. The current status of the LLRF systems, the experience gained during operation and the performance achieved in terms of stability and energy reach are presented.

RF Stations and Sections of the European XFEL

Overview

- Soft-and-hard X-ray light experiments
- 400 TESLA type cavities
- Resonance frequency 1.3 GHz
- 80 cavities per XTL RF station
- Design energy 1.5 GeV
- Pulsed operation 10 Hz

Advanced commissioning

- All XTL stations are one continuous ring plant
- Commissioning up to operating (CS) 8-4-25 RF stations
- First users September 2017

Maximal Electron Energy after CS8 Commissioning

Efforts In Order To Increase The Maximal Possible Electron Beam Energy

Maximal Energy During Investigations

LLRF Status

Stability

- LLRF sync stability
- Intra pulse RMS value, w/ beam operation
- XTL specification: 64 x 0.01%/s, 64 x 0.1 deg.

- Pulse-to-pulse stability at same order of magnitude

Electron beam energy stability

- Measured up to 28 MV/m, 17.5 GeV
- Relative energy stability as measured by the energy servers. Shown is the standard deviation on the energy of the first bunch over 100 shots, divided by the beam energy. It contains some contribution of BPM noise.
- Electron beam energy stability requirement: 1.4E-4

Conclusions & Outlook

The basic commissioning of the LLRF systems at the European XFEL went very smoothly and was finished up to RF station A25. RF stations A24 and A25 will follow around May 2018. The advanced LLRF commissioning is on-going. The operation during user runs in 2017 yielded a SASE brilliance at 19.9 MV/m, which is 20% above the requirement. It is believed that after system improvements the requirements will be met. The maximal design energy of 17.5 GeV has not been reached yet. In order to further improve the performance some contribution of BPM and Beam-Loading Compensation (BLC) will help to reach the goal of 17.5 GeV.

References & Contact

[2] J. Branlard, LLRF Commissioning and operation. Talk at TESLA Technology Collaboration (TTC) meeting, Milan, 2018
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