

Precision Low-Level RF System for Short-Pulse X-Ray in the APS Upgrade

A precision digital Low-level RF control system(LLRF) with embedded drift calibration loops has been developed for The Short-Pulse X-ray R & D (SPX0) in the Advanced Photon Source Upgrade (APS-U) at Argonne National Laboratory. As a major capability in APS-U, SPX/SPX0 imposes a set of stringent requirements on the rf stability in the deflecting cavities, among which the is the very tight differential phase error budget of a total 0.077-degree RMS for the differential phase between the two deflecting cavities in two sectors. The solution to meet this challenge is a joint-system of the Low-level RF and a Timing-synchronization, and the development of this system has been a collaborative effort between Argonne National Laboratory and Lawrence Berkeley National Laboratory. In this joint-system of LLRF and Timing, the cavity rf field is stabilized by a rf feedback loop of the digital LLRF controller with respect to the rf phase reference distributed to the Sync-head at the cryo-module in Storage Ring tunnel by the Timing-synchronization system via. Fiber optics. While the Timing-synchronization system monitors and calibrates the phase drifts along the fiber cables, the LLRF controller monitors and calibrates the phase drifts along the rf signal transmission coaxial cables between the sync-head and the LLRF controllers. The key electronics technology for this system is the advanced implementation of a four-frequency digital receiver on which the critical functionality of a simultaneous rf cable phase drift calibration with a rf pilot-tone (Calibration loop) as well as the fiber optics drift calibration with an interferometer beat signal is realized. At this time, the developed LLRF system has successfully gone through a number of field tests, and supported high-power SRF test programs. The great deal of key LLRF technology gained from SPX0 will not only enable the targeted application - SPX, but also will greatly benefit other APS accelerator upgrade projects in future.

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