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Recent Progress of LLRF System for SACLA

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The X-ray free-electron laser, SACLA, at SPring-8 emits a steady laser with an intensity of 300 uJ at 10 keV, which strongly supported by a highly accurate and stable LLRF system. This LLRF system realizes about a 20 fs short-term temporal stability. However, SACLA still requires operator trimming once a 30 minutes to the rf phase and amplitude of injector cavities. Hence the long-term stability of the laser is not sufficiently stable. The target long-term stability must be within about 300 fs at least, which calculated by simulation. One of causes of the drifts is a temperature movement of +/- 0.1 K around enclosures, where LLRF instruments like in-phase/quadrant (IQ) modulator/demodulators are installed. This temperature movement also affects the optical length of phase-stabilized fibers. A temporal value corresponding to this length change is about several-hundred fs ~ several ps for the 1 km optical fiber. To mitigate these kinds of the effects, we installed precise temperature controllers with a temperature stability of 0.01 K for the injector enclosures and are presently installing optical fiber length controllers. This precise temperature controllers use heaters and the pulse width modulation (PWM) method to manipulated an AC heater current for realizing a 0.01 K stability. The optical fiber length controller uses Michelson interferometory to stabilize the whole fiber length by feedback control. The precise temperature controller greatly helps to increase laser intensities from 300 uJ to over 400 uJ and its stability. The installation of the fiber length control system will be finished around the end of this year. We expect this system also reduces the drift. This presentation describes recent progress of our LLRF system development including the improvements mentioned above.

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