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Installation, Commissioning and Performance of Phase Reference Line for LCLS-II

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Any cavity controller for a distributed system needs a Phase Reference Line (PRL) signal from which to define phases of a cavity field measurement. The LCLS-II PRL system at SLAC provides bidirectional (forward and reverse) phase references at 1300 MHz to each rack of the LLRF system. The PRL controller embedded with the Master Oscillator (MO) locks the average phase of the two directions to the MO itself. Phase-averaging tracking loop is applied in firmware which supports the feature of cancelling the phase drift caused by changes in PRL cable length. FPGA logic moves the phase of digital LO to get zero average phase of the two PRL signals. This same LO is used for processing cavity pickup signals, thus establishing a stable reference phase for critical cavity RF measurements. At low frequencies, open-loop PRL noise relative to the LO distribution includes a strong environment and $1/f$ components, but the closed-loop noise approaches the noise floor of the DSP. The implication is that the close-in phase noise of the cavities will be dominated by the chassis DAQ noise. The final out-of-loop phase noise relevant to machine operations is that of the cavity field relative to the beam.

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