LLRF Performance Results in Fermi@Elettra

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The LLRF system is designed to control the phase and amplitude of the RF system, ensuring stable and repeatable operation of the FEL. The LLRF firmware developments focus on improving the resolution and stability of the residual phase measurement, with the phase and amplitude stability within the specs for both systems (LLRF4: 0.069º, 0.082%; AD Board: 0.07%) and with very similar values.

**LLRF Test Results**

- **Phase Loop**: The resolution of the residual phase (RefPhase – CavPhase) is improved by a factor of 6 when the phase loop is enabled. The measured phase error is around 0.04º rms, much lower than the requirements (0.1º rms).

- **Cable Calibration Loop**: The cable calibration loop is meant to compensate the elongation of the cables going from the tunnel to the LLRF chassis, improving the long term stability of the phase measurements.

- **Amplitude Loop**: Similar resolution in open and close loop if small periods of data analyzed, but better long term stability observed. The amplitude stability when the amplitude loop is off is around 0.05% rms and around 0.03% when the amplitude loop is enabled.

**Next Steps**

- **Hardware**: At present, there is a LLRF System installed per klystron (14 Systems). The 1st AD prototype board has been successfully tested. The series production of the board will start next month, to upgrade LLRF HW in 2012.

- **LLRF Firmware Developments**
  - Real-time communications between master and slave AD boards and loop developments.
  - Intrapulse feedback loop.
  - Reflected power interlock implementation in through LLRF.
  - Study connection of LLRF controllers through high-speed serial links to a central controller (Matrix).
  - Integration of LLRF and timing firmware in same hardware platform (if required).
  - Investigate iterative learning possibilities.