

Digital Low Level RF control for Advanced Light Source

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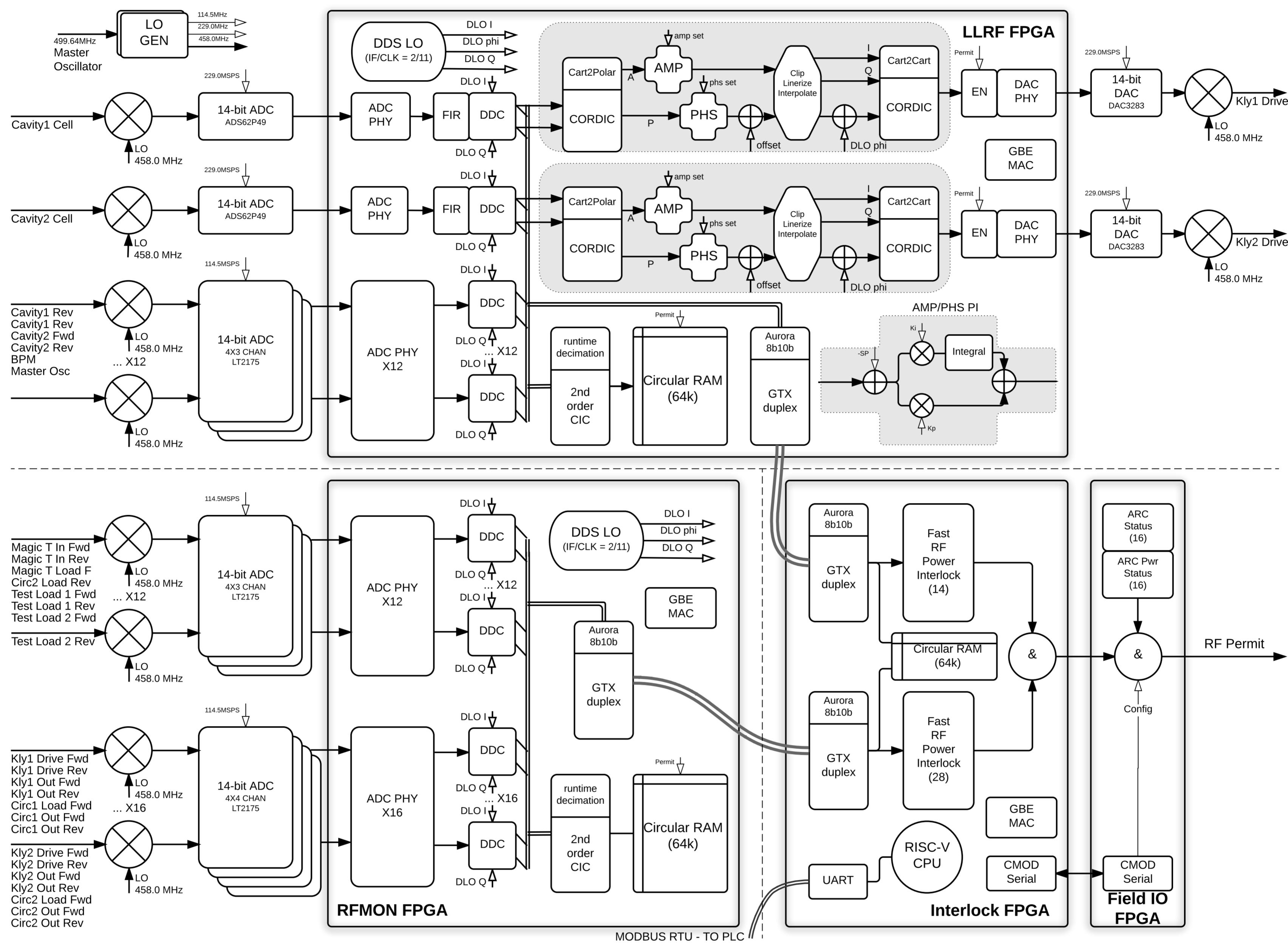
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Abstract

A digital LLRF control system has been built and installed as part of the Storage Ring RF system upgrade project at Advanced Light Source in LBNL. In order to enable a configurable two klystrons driving two cavities operation, the system implements low-noise RF front-end, non-IQ digital receiver/digitizer, double rate feedback control loop, and 42 channels distributed RF monitor with integrated fast interlock across multiple chassis and subsystems. Chassis level test shows > 78 dB isolation between feedback channels, and 128 fs RMS time jitter [10Hz, 50MHz] at Klystron drive ports. Preliminary test result shows RF field stability of 0.01% in amplitude and 0.01° in phase at 499.654 MHz for the band above 1 Hz (no beam).

System setup: LLRF controller + RF monitors + Fast RF interlock



Digital LLRF chassis

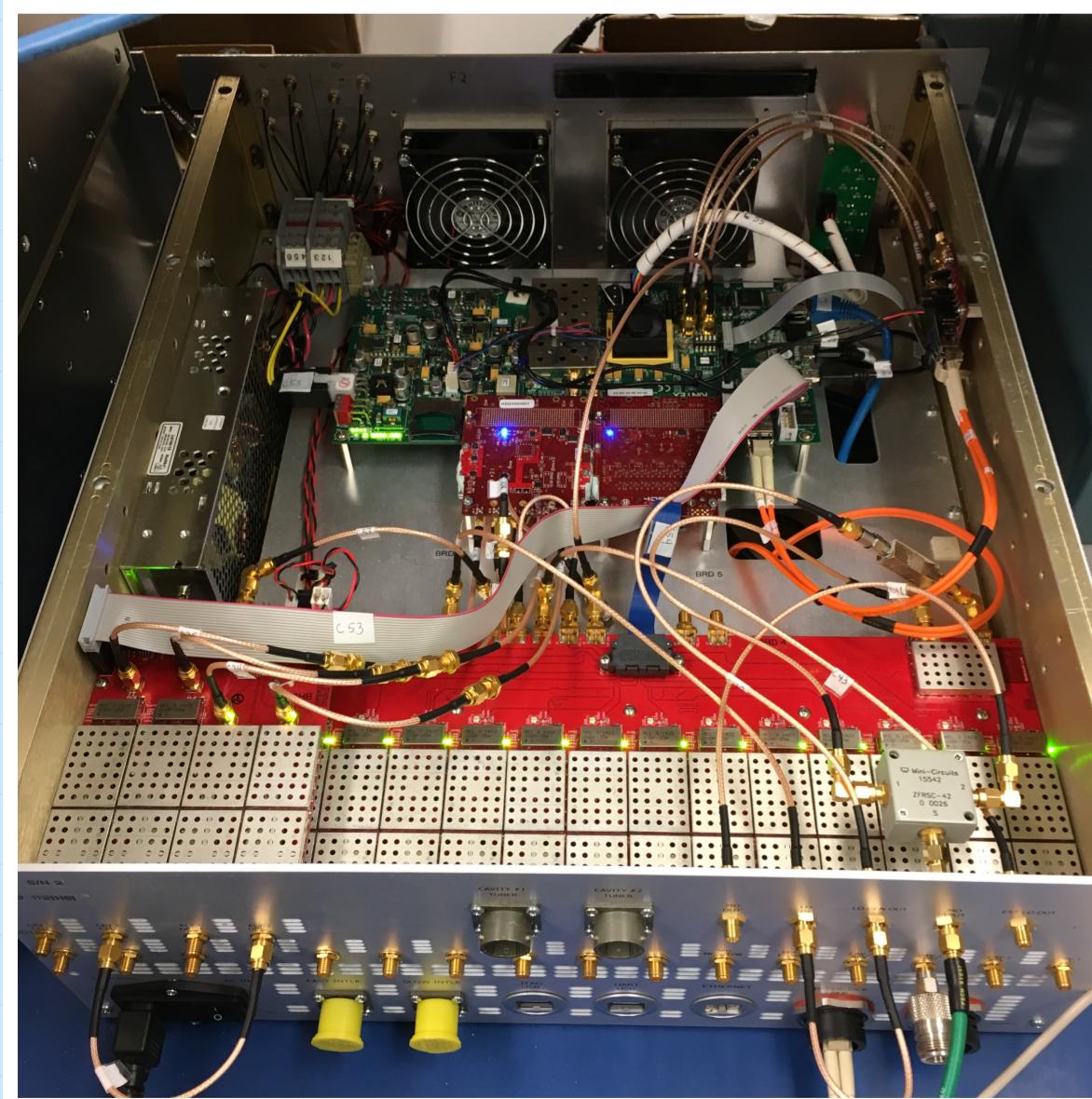
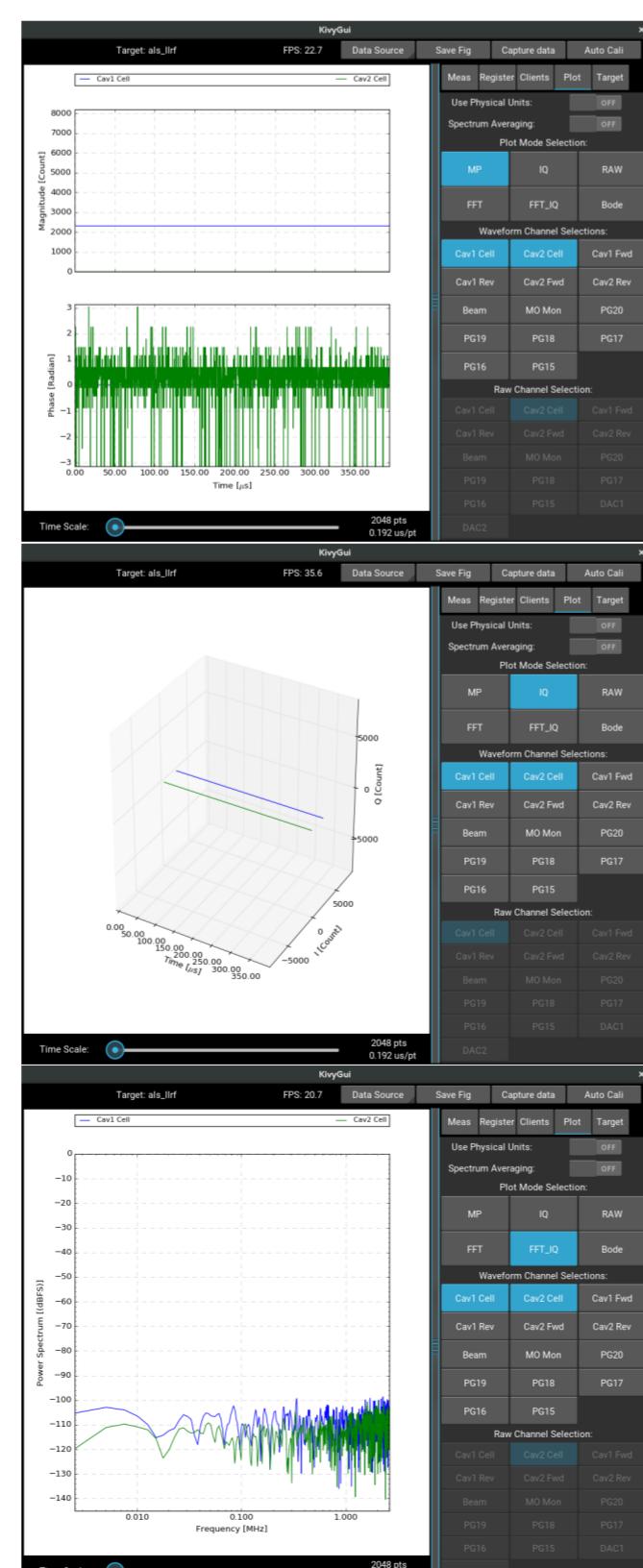


Figure: LLRF chassis assembly



Features

- > 74.3 dBFS signal-noise ratio on feedback channels, 72.1 dBFS on monitor channels;
- > 78 dB channel isolation between feedback channels;
- 128 fs RMS time jitter [10Hz, 50MHz] at Klystron Drive ports;
- < 3.4 microsecond total feedback group delay;
- < 0.01% amplitude and phase stability (preliminary);
- 42 channels distributed synchronous digital oscilloscope with deterministic latency;
- 1.45 microsecond maximum RF power interlock latency;
- Programmable feedback and interlock configurations with respect to operation modes;
- Non-OS, Non-Ethernet, direct hardware integration with high power RF and personnel safety interlocks;
- EPICS and various diagnostic software support;
- Fully open source from hardware, gateware, firmware to software design;

Status

As part of ALS Storage Ring RF System upgrade project, the digital LLRF control system was commissioned in March 2017 and enabled nominal operation with desired preliminary performance. Further optimization is planned together with additional upgrades in the FY 2018.