RF BACKPLANE FOR MTCA.4 BASED CONTROL SYSTEMS

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Abstract

The Low Level RF (LLRF) control system developed for linear accelerator based Free Electron Lasers (FEL) require real-time processing of thousands RF signals with very challenging RF field detection precision. To provide a reliable, maintainable and scalable system a new development of the LLRF control based on MTCA.4 architecture was started in DESY for FLASH and European-XFEL. In contrast to standard RF control systems realized in 19" modules, we could demonstrate setup with field detection, RF generation, RF distribution, DAQ system and the high-speed real-time processing entirely embedded in the MTCA.4 crate system. This unique scheme embeds ultra-high precision analog electronics for detection on the Rear Transition Module (RTM) with powerful digital processing units on the Advanced Mezzanine Card (AMC). To increase system reliability, maintainability and reduce performance limitations by RF cabling network, we developed and embedded in the MTCA.4 crate an unique RF Backplane (uRFB) for RTM cards. This backplane is used for distribution of high-performance Local Oscillator (LO), RF and low-jitter clock signals together with low-noise analog power supply to analog RTM cards in the system. In this paper we present the architecture of the MTCA.4 crate with the uRFB, the RF Backplane design and successful laboratory test results of the LLRF control system demonstrating the performance of our development.

MTCA.4 BASED LLRF CONTROL SYSTEM

- Digital subsystems located in front of the crate (AMC boards)
- High-speed data transmission over the AMC backplane
- High-precision RF subsystems in RTM format
- RTM boards require tens of high-performance RF and CLK interconnections

Figure 1: MTCA crate equipped with LLRF control system modules

RF BACKPLANE CONCEPT

Figure 2: RF Backplane position in the crate (crosssection)

- The RF Backplane was placed in parallel to the AMC Backplane, on the RTM side
- It provides RF and clock interconnections for RTMs
- No MTCA standard violation: standard (non RF Backplane compatible) RTMs can be directly used in the crate

RF Backplane was designed to distribute:

- 1354 MHz Local Oscillator signal (8 single-ended lines)
- 1300 MHz Master Oscillator reference signal (3 single-ended lines)
- high precision clocks to uRTMs (18 differential 81 MHz CLK)
- high performance analog power supply (+/- 7V) for uRTMs (9 slots)

Figure 3: Simplified block diagram of the RF Backplane

RF BACKPLANE DESIGN

- 10-layer RF board design
- Hybrid construction – main board + uRFB shield
- Edge plating for further shielding against AMC Backplane distortions
- ERNI (3x10 diff pair) for CLK signals
- 6-in-1 coaxial connector for LO and MO signals

Figure 4: PCB design concept

Figure 5: RF Backplane installed in the MTCA crate.

PERFORMANCE TESTS

- Laboratory tests demonstrated low RF loss and crosstalks meeting design requirements
- During MTCA crate tests investigated were crate and RF Backplane influence on distributed signal jitter
- Tests were performed:
 - with crate turned off
 - after subsequently switching on fans and digital subsystems
 - with crate half loaded with digital and RF cards
- LLRF signals recorded with fast ADCs and compared to signals recorded without the RF Backplane

Figure 6: Phase noise of the LO signal distributed over the RF Backplane with and without activating digital subsystems

CONCLUSIONS

- Tests demonstrated high performance RF signal distribution over the RF Backplane
- No significant jitter and phase noise degradation from crate and digital subsystems was detected
- LLRF signals recorded by the digitizers exhibit parameters comparable to ones achieved without the RF Backplane, with signals distributed by RF coax cables
- The RF backplane allows to reduce external cabling of the MTCA crate, improves reliability and maintainability and finally leads to system compactness

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