RF Backplane For MTCA.4 Based Control System

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Internal LLRF System RF Signal Distribution in Fully Equipped MTCA Crate

AMC Cards (front)  uRTM Cards (back)

Controller

Vector Modulator

10-CH
ADC

ADC

10-CH
ADC

LO Generator Module

8x
1.3 GHz RF signals

9x 1.3 GHz Master Oscillator

8x 1.3 GHz CAL

10x
54 MHz IF signals

1.3 GHz modulated output

10x
1.354 GHz LO

18 x 81 MHz clocks

8x 1.3 GHz CAL

LO Generator Module
In Practice Crate Surrounding Would Look Like That…

Cable management is a fundamental problem for many applications
What about hiding „internal” LLRF connections inside of the crate?

RF Backplane Solution
AMC-RTM Pair – Side View

AMC

RTM

AMC Backplane

Zone 3
AMC-RTM Pair – RF Backplane Location

Abbreviation **uRFB** - **uTCA RF Backplane**

![Diagram showing the location of AMC and RTM backplanes with ADF Connector and Multipin RF Coaxial Connector.](image-url)
AMC-RTM Pair – RF Backplane Connectors

Abbreviation uRFB - uTCA RF Backplane

ERMET ZD, 3x10 diff. pairs

Radiall Coaxipack 2 6-pin, 6GHz RF connectors
Advantages of the RF Backplane Concept

System with signals distributed outside the crate

- Improved cable management
- Higher reliability
- Space reduction

System with RF Backplane
Up to 4 extended RTMs (eRTM)
Slots, eRTMs and Rear Power Supply Modules

1 or 2 Rear Power Supply Modules

Rear View

Cooling Unit

Zone 3 Area

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 -1 -2 -3

eRTM15 eRTM eRTM uRTM uRTM uRTM uRTM uRTM uRTM uRTM uRTM uRTM uRTM uRTM MCH-RTM eRTM/Rear Power Module Rear Power Module

Cooling Unit
uRFB – Final Concept Highlights

- **Fully compatible to the standard.** No mechanical collision with standard RTM boards. Supported by crate manufacturers.

- **Hot swap functionality for RF signals.** IPMI extension for uRFB worked out with N.A.T.

- uRFB fully passive. All intelligence in modules -> great flexibility for users.

- Developed a concept of extended RTM (eRTM) boards.

- **Redundant high performance rear power supply** for analog applications.
eRTMs

- Offer system designers additional space (note that eRTMs are wider (6HE) than uRTMs (4HE))
- Designers can use 2 or even 3 slots for one module if necessary
  - eRTMs can be used for applications requiring significant space for components like filters or precise temperature stabilization
- uRFB provides management, power supply and data links for eRTMs
- Slot 15 was assigned for RF signal entry. See uLOG poster by T. Rohlev as an example input board design
uRFB Management and Power Supply

- An MCH-RTM board in slot #1 will manage the uRFB
- Connected to MCH via Zone 3
- Standard (AMC) management „mirrored” to the RTM side will be used to reduce development cost and time

- eRTM and uRTM FRUs will contain information about required connectivity and power supply
- Rear Power Module can supply 4 x +12V to all eRTMs and 12x +/- 7V to uRTMs
- uRTM designer can decide to use +/-7V from uRFB or standard _12V from AMC
- Economy use case: power supply for eRTM in slot #15 from MCH-RTM (no Rear PM) but limited to max 25W
• 27 RF signals (optimized for 1.3 GHz but can work up to 6 GHz)
• Hot-swap for RF signals
• 22 CLK signals
• „Analog“ power supply: +/-7 V for RTMs and +12 V for eRTMs
• Management and communication
Project Status
Project Status: Tested uRFB PCB Prototype and Fixed Crate Extensions

- Boards developed to test interconnections and prove feasibility of the uRFB concept
- Crate manufacturers worked out solutions for additional slots and cooling capacity

PCB Designer: T. Leśniak, K. Czuba, P. Kownacki
Project Status: eRTM Templates

Will be available on the MTCA webpage
Project Status: eRTM and uRTM Test Boards

Input test board (eRTM15)

Output test board (RTM)

PCB Designer: B. Gąsowski
PCB Designer: J. Dobosz
Project Status: uRFB Measurements

- Developed automated teststand
- Measurements in laboratory and in the crate filled with digital boards
- No detectable signal spectrum degradation – in range 9kHz – 6 GHz (no spectral lines at level above instrument noise floor of -75 dBm)
- Excellent isolation from digital side of the MTCA crate

Table I: Measurement Results of The Attenuation and Reflection Coefficients of the uRFB at Frequency 1.300 GHz for REF and CAL and 1.354 GHz for LO Lines

| Slot | $A_{REF}$ [dB] | $|\Gamma_{REF}|$ [dB] | $A_{LO}$ [dB] | $|\Gamma_{LO}|$ [dB] | $A_{CAL}$ [dB] | $|\Gamma_{CAL}|$ [dB] |
|------|----------------|-----------------------|--------------|---------------------|----------------|---------------------|
| 4    | 3.4            | -16.2                 | 3.5          | -16.5               | 3.1            | -18.5               |
| 5    | 2.8            | -15.4                 | 3.3          | -16.8               | 4.3            | -18.2               |
| 6    | 3.3            | -15.6                 | 4.7          | -17.1               | 3.2            | -19.0               |
| 7    | 2.3            | -15.4                 | 2.6          | -16.2               | 2.6            | -17.9               |
| 8    | 2.1            | -15.2                 | 2.9          | -16.7               | 4.1            | -17.6               |
| 9    | 3.4            | -15.1                 | 3.4          | -16.7               | 3.3            | -18.3               |
| 10   | 1.5            | -15.4                 | 2.3          | -16.7               | 2.0            | -18.0               |
| 11   | 1.4            | -15.5                 | 2.5          | -16.8               | 1.9            | -18.4               |
| 12   | 1.9            | -15.2                 | 1.2          | -16.7               | 2.6            | -18.4               |
Current Activities
Current Activities: RF Performance Optimization for up to 6GHz

- The HVF project requires operation in frequency range 0.1- 6GHz (so far PCB was optimized for 1.3 GHz)
- Difficulties with precise calibration (lack of cal kit with multicoax connectors) -> special calibration boards under development
- Still good results up to ~2.5GHz
- Matching problems above 2.5GHz due to PCB layout around coax connector
- 3D EM simulations done to identify problem sources and optimize layout
- New PCB version ready for manufacturing this week
Example of 3D EM Simulations: Influence of a Via Stub

- Simulations and optimization performed also for other issues of connector layout
- So far simulations well match measurement results

Courtesy of: T. Leśniak, Ł. Kowalczyk
Current Activities: Management, Power Modules and Drifts

• **The MCH-RTM** (uRFB management) board is under development. Expected in Nov. 2013.

• **Rear Power Modules** under development. Expected by end of 2013

• **RF signal phase drifts measurements**: important for long term LLRF system performance
  
  • Set of test adapters and drift teststand are under development. Phase drifts will be characterized with temperature and humidity changes
Future Plans

- **EMI tests**: investigation of uRFB influence on the MTCA crate performance.
- **Reliability tests**: after having the final design frozen (expected Q1 of 2014)
- **Industry licensing**: companies are interested to offer MTCA crates with uRFB option
- **RF Backplane for small form factor crates**
Summary

- Compact solution integrated with the crate
- No collision with standard MTCA cards
- Reduces number of cable connections and improves reliability and maintainability
- Hot-swap for RF signals up to 6 GHz
- Allows using high-performance power supplies (managed) for RTMs
eRTMs to increase number and size of modules
- Developed and tested successfully
- No significant signal spectrum and jitter degradation
- Management and power supply under development
- Extensive performance tests prepared
Thank you for attention!