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# PERFORMANCE OF A COMPACT LLRF SYSTEM USING ANALOG RF BACKPLANE IN MTCA.4 *

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*Abstract*

In order to increase system compactness, mitigate cabling problems, increase rack space, minimize points of failure in the system and reduce digital distortion leakage into the sensitive analog signals, the concept of the RF backplane located in the rear section of the MTCA.4 crate has been introduced. Besides signal distribution, the concept includes a signal generation module and backplane management module. The generation and splitting of the analog signals is taking place in slots 15 and 14 on the rear side in the micro LO generation module (DRTM-LOG1300). This module generates the local oscillator signal, the clocks and feeds through the master reference signal over the RF backplane to the slots. In this paper we present the recent results of such system.


## INTRODUCTION

Interconnection between modules in high density, modular systems represent an engineering challenge because, by definition, the number of interconnects per given area is maximized. At the same time, the quality of these interconnects is crucial for high quality instrumentation.

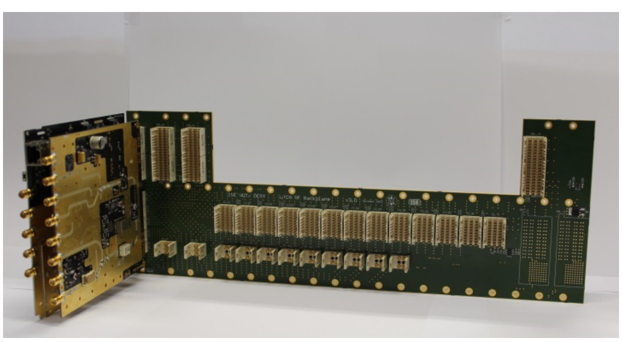

Figure 1: Picture of the assembled LO/CLK generation module and uRFB.

The MTCA.4 environment offers a very compact and efficient architecture for high-speed, high-throughput digital data links; however support for RF signals was not foreseen. The concept presented in this paper extends the MTCA.4 distribution of precise timing signals with the distribution of high fidelity RF signals. In order to decouple the highly sensitive RF signals from the digital signals, routed on the AMC backplane, the RF signals are routed in the rear of a standard MTCA.4 crate, on a dedicated backplane – MicroTCA.4 RF-Backplane (uRFB) [1-3].

This concept also includes board-management that follows the same principles as the MTCA.4 compliant board-management used for front modules. This concept will be handled by the new backplane management module (MCH-RTM-BM) together with the management module located in front [4].

## SYSTEM DESCRIPTION

The system is composed of the RF signal and CLK generator (DRTM-LOG1300) that splits the input reference signal (REF) into 9 RF outputs which are fed to the uRFB over RADIALL multi-coax connectors (R694.252.107) [5]. The same architecture is also used for the pilot (CAL) signal and the LO signal. The module also serves as a fan-out for 22 LVPECL CLK signals that are fed the uRFB over ERNI ADF [6] connectors (ERmetZD-10x3P-FEM). Besides high quality signals, the RF-Backplane also hosts digital communication channels (e.g. SPI for data transfer between the DRTM-LOG1300 to the backplane manager board). The RESET signal is generated on the timing board and its correspondent rear module (X2 timer in slot 2) then distributed to the reset circuit on DRTM-LOG1300 for resetting the CLK dividers. The payload power (+12 V) and management power (+3.3V) are also distributed over the RF-Backplane and can be supplied from either a RTM Power Module (RTM-PM) or from the front MCH over the MCH-RTM-BM module. Fig. 2 shows a block diagram of the systems involved.

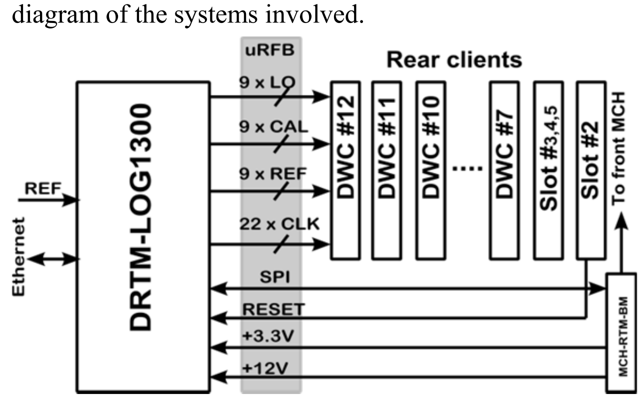


Figure 2: Block diagram of the distribution of RF signals over the RFBackplane.

### *RF-Backplane*

The RF-Backplane is mechanically compatible with a standard 12-slot MTCA.4 chassis offered by the two main industry chassis manufacturers [7-8]. The signals are

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compactly routed over a 14-layer backplane made of low-loss, low-temperature-coefficient dielectric PCB material. It has been designed to offer good performance over a wide frequency range up to 6 GHz. The measured reflection coefficients on the RADIALL connectors are close to -20 dB at 1.3 GHz and close to -10 dB at 6 GHz. The measured losses are -3 dB at 1.3 GHz and app. -10 dB at 6 GHz. The next revision of the RF-Backplane will solve the issues regarding losses and the reflection coefficient at frequencies above 1.3 GHz. A redesign of the RADIALL connector and optimization of its PCB layout will help improving the isolation between channels.

Fig. 3 shows a practical implementation of the uRFB.

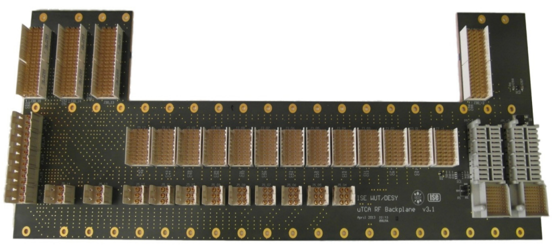

Figure 3: RF-Backplane picture.

### *DRTM-LOG1300*

The DRTM-LOG1300 (Fig. 6) is located in slot 15 in the rear-side of the standard MTCA.4, 12-slot crate and generates the required RF and CLK signals that are then distributed over the uRFB. It is composed of exchangeable RF splitting sections, exchangeable RF mezzanine module, exchangeable DC/DC mezzanine, temperature controller mezzanine and the carrier board (see Fig. 5) which hosts all the sub-modules. The RF mezzanine module (see Fig. 4) design emphasizes low residual-phase-noise (LO; 3 fs [100Hz – 1MHz]), high channel-to-channel isolation (<-90 dBc up to 7 GHz), low spectral content of non-linear components (< -90dBc up to 7 GHz). The matching of internal and external RF interconnections is -20 dB. The LO channel provides +31 dBm of RF continuous-wave power at 1.354 GHz before splitting. The power consumption of the module is 24 W without the temperature regulation.

The module also includes independent temperature control of 3 Peltier elements which regulate the temperatures of RF sections. In order to achieve long-term stability of the RF parameters the temperature control of the PID loop is optimized for the operating conditions that are expected in the rack/crate environment.

The DRTM-LOG1300 can be operated remotely and includes an ARM7TDMI micro-controller for on-board application related activities.

Fig. 5 shows a 3D model of the assembled DRTM-LOG1300 module. The front connectors are interconnected by means of rigid RF cables.

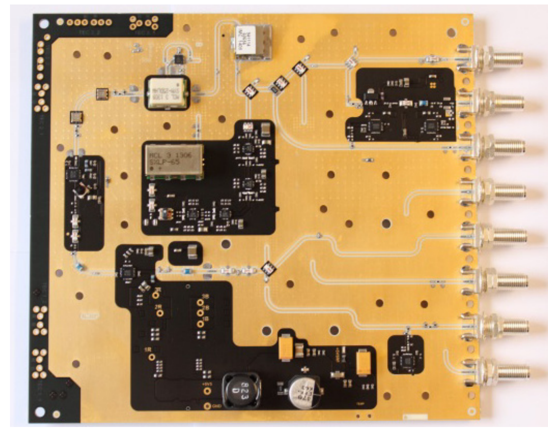

Figure 4: Picture of the RF mezzanine on the DRTM-LOG1300.

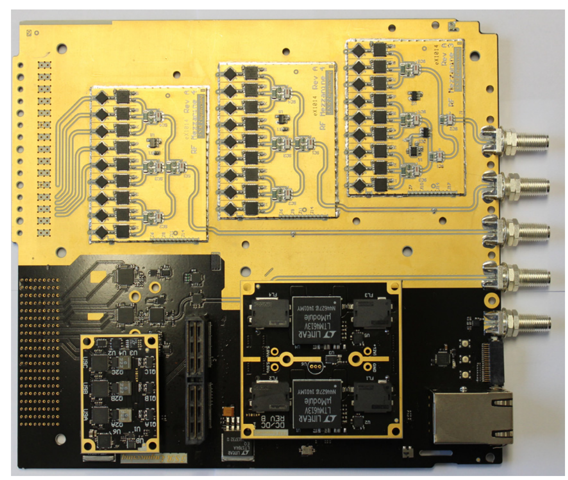

Figure 5: Picture of the RF mezzanine on the DRTM-LOG1300.

### *Integrated System*

Fig. 7 shows a picture of the DRTM-LOG1300 providing RF and CLK signals to 6 down-converters over the RF-Backplane. The power for the DRTM-LOG1300 module is provided by standard MTCA.4 power module also sitting in the rear side of crate.

Full operation of 6 down-converters was achieved in such configuration. The presented architecture can support up to +15 dBm of LO input power (remotely adjustable) to each client and up to +13 dBm of REF power to the required channels in slot 3,4 and 5. Residual noise measurements show that CLK and LO, provided over the backplane, show no degradation compared to the same signals provided by an external 19” LO and CLK generation unit.

## SUMMARY

The main concept of the signal distribution over the uRFB has been proven to achieve comparable performance to 19” modules. The achieved high

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compactness of the concept substantially reduces the number of cables that are needed. The architecture includes MTCA.4-based board-management.

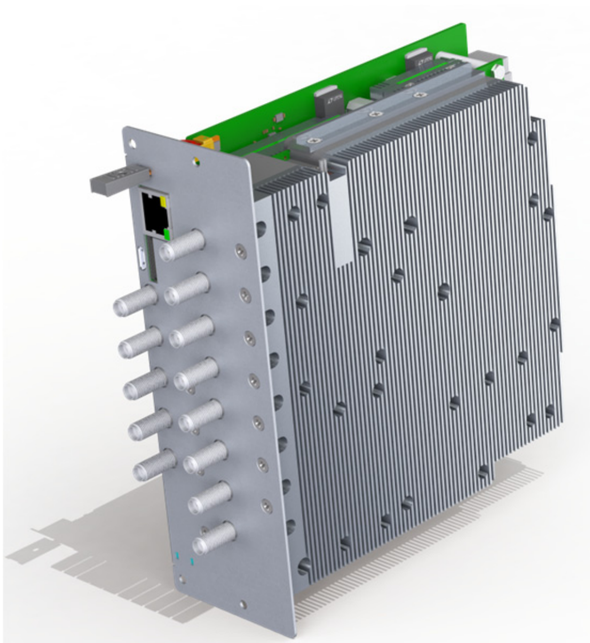

Figure 6: Picture of the DRTM-LOG1300.

Other features, like reset of the CLK signals and optimization of the PID temperature controller loop, have to be checked and finalized. The final operation in connection with the MCH-RTM-BM module is foreseen in the near future.

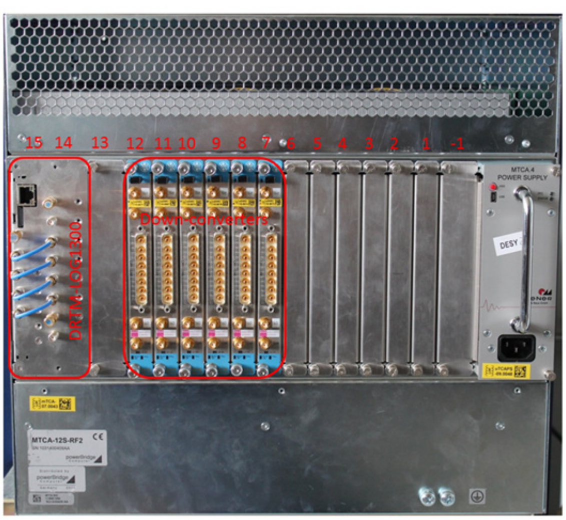


Figure 7: Picture of the rear side of the integrated system.

## ACKNOWLEDGEMENTS

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