RF-Backplane Management for the MicroTCA.4 Control System

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***Abstract*—To transport low-noise Radio Frequency (RF) signals within a MicroTCA.4 Crate a new RTM backplane is invented as an optional extension to the 9U crate standard. The RTM backplane is equipped with links for high precision RF and Clock signals for the µRTM, therefore it is also called an RF-Backplane. In combination with this backplane new extended RTMs (eRTM) and RTM Power Modules (RTM-PM) can be operated. Up to four 6 HP wide eRTMs can be installed behind the front Power Modules and the MCH Modules. The RTM-PMs deliver managed low-noise separated analog bipolar power (+VV, -VV) for the RTMs and unipolar power for the eRTMs. This paper covers one of the eRTMs which is a Backplane Management module for the rear side (MCH-RTM-BM) designed to manage these new features. The MCH-RTM-BM will manage the RTM backplane connectivity for up to 12 µRTMs, 3 eRTMs and 2 RTM-PMs. For this purpose the MCH-RTM-BM is working together with the already existing NAT-MCH-PHYS. In addition the MCH-RTM-BM is connected to the eRTMs via LVDS links. These links can be user defined and are managed with a User Logic on the Backplane Management Module. This User Logic consists of a microcontroller with an FPGA.**

***Index Terms*—MicroTCA.4, doocs system, management, power control**

I. Introduction

DESY and Warsaw University of Technology have introduced an RF-Backplane [1] [2] for low noise clock and RF signal distribution to µRTM boards in MicroTCA.4 crates. It increases the operating reliability and maintainability of the MicroTCA.4 system, reduces the cabling and the performance limitations due to external components. It is an optional capability extension and fully compatible with the existing 9U crates of the MicroTCA.4 Standard. It is a passive Rear Transition Module backplane (RTM backplane) which is located behind the Advanced Mezzanine Card backplane (AMC backplane [3]). After first verification of the RTM backplane operation and performance, the concept was finalized by adding extended RTMs, Rear Power Modules and a management card, submitted for publication [4]. First results of analog performance tests of this new RTM backplane prototype at frequency of 1.3 GHz were described in [5]. The high-frequency signal distribution network operates from DC to the 6 GHz band. Further content of this paper is focused on the RTM backplane extensions and management concept.

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II. RTM Backplane Related MicroTCA.4 Extensions

Together with the backplane three additional types of RTMs have been specified:

1) Extended RTM (eRTM)
The eRTM is a special RTM using space behind front power and MCH modules, designed to operate with the RTM backplane without corresponding AMC. There can be up to three double-width, full-size (6HP) eRTMs.
2) RTM Power Module (RTM-PM)
The RTM-PM is a special Power Module for all RTMs connected to the RTM backplane. It can be installed on the rear side of the crate behind the front PMs. The functionality is not specified in MicroTCA.4 Specification yet.
3) µRTM with connection to the RTM backplane
The µRTM can get additional power from the RTM-PM, if the µRTM has a connector to the RTM backplane. It can get also RF and clock signals with extra connectors to the RTM backplane. The µRTMs which are plugged to the RTM backplane still comply to the MicroTCA.4 Specifications [6].

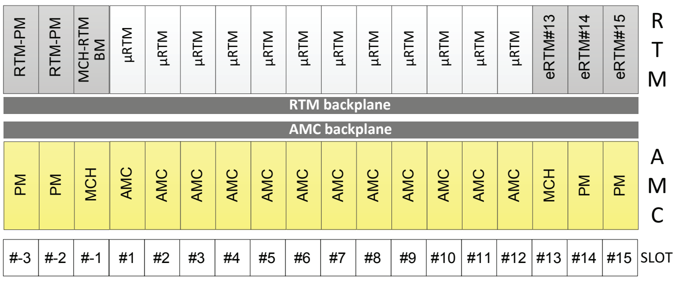

Fig. 1. Top view of a MicroTCA.4 Crate with RTM backplane.

Schematic top view of a MicroTCA.4 12 slot crate is shown in Figure 1. The eRTMs are located behind the Power Modules on the right side and behind the MicroTCA Carrier Hubs (MCHs) of the front view. The RTM-PM are behind the front left Power Modules. All new rear modules are marked in grey, the RTM and AMC backplane are in the middle in dark grey.

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The front of the crate with the AMC backplane is a standard MicroTCA.4 design.

For the µRTMs and eRTMs the RTM backplane provides some functionality which is not contained in the MicroTCA.4 Specification. The functions are:

- power supply distribution
- electronic keying (e-keying) for clock and RF signals distribution

Electronic keying means to get information about the compatibility of the modules before starting them up. The information is processed by the management which decides to activate the module totally, partial or not.

Simplified RTM backplane layout is shown in Figure 2. There are connector zones specified for the RTM backplane. The Zone 3 connectors provide power supply and the communication to the management for the eRTMs. The Zone 2 connector is the new rear power supply for the µRTMs and for the backplane management. Furthermore RTM backplane specific clocks come via Zone 2 from eRTM in slot #15. Zone 1 covers special multi-pin coaxial connectors for the RF signals, which are fed from the local oscillator generator [7] in slot #15 in the DESY system.

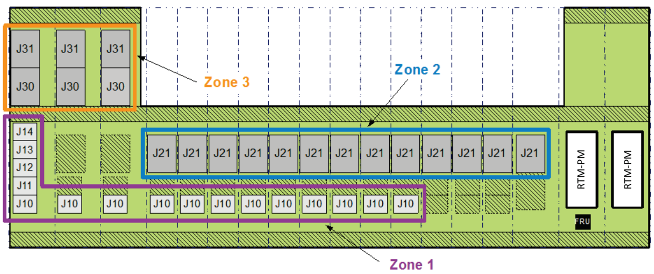

Fig. 2. The different connectors on the zones of the RTM backplane [2].

These new features, connections and modules require a management. The functions of this management, like communication and power management, will be described in the following section.

III. The Management

In a original MicroTCA.4 crate the management has to handle all the connections to the different component like Power Modules, Cooling Unit, AMCs and µRTMs [3]. The main communications are over IMPI [8] or I^{2}C [9]. This connections will be handled also by the management of the RTM backplane.

With the RTM backplane the AMCs and µRTMs are still managed by the already existing MCH of the front, while the eRTMs and RTM-PMs require an additional management module, the RTM Backplane Management (MCH-RTM-BM). The MCH-RTM-BM is mounted back-to-back with the left MCH [10] of the AMC side, to which it is connected via the MicroTCA Zone 3 connector. The benefit of this is, that the rear side can take advantage of the already existing management functions of the front MCH. The option of a redundant management was not used by DESYs current crate design. The MCH-RTM-BM can support up to 12 µRTMs, 3 eRTMs and 2 redundant RTM-PMs.

The management can be divided in three main components:

1) MCH of the AMC side
2) Expander (MCH-RTM-BM)
3) User Logic (MCH-RTM-BM)

This paper focuses on the management which is not supervised by the front MCH. It describes the management of the power which is distributed from the RTM-PMs to the µRTMs and the eRTMs over the RTM backplane. Furthermore it is described how the eRTMs communicate with each other and how they are managed.

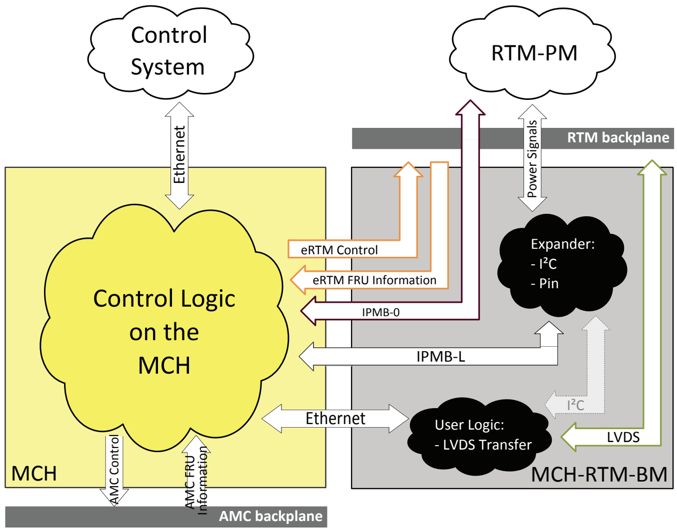

Fig. 3. Communication Block Diagram of the RTM Backplane Management.

A block diagram of the communication of the MCH-RTM-BM is shown in Figure 3. An Ethernet connection to the front MCH allows external access, for instance from a Control System. The IPMI-0 connection from the RTM-PMs will be forwarded through the MCH-RTM-BM directly to the front MCH. In the same way the I^{2}C buses of the eRTMs will be managed. Furthermore the I^{2}C bus reading out the FRU Information of the RTM backplane will get also forwarded via the MCH-RTM-BM. This gives the operator the information about the connectivity of the rear side of the crate. The microcontroller on the MCH-RTM-BM is acting as an expander to forward all other incoming signals, for example power resets or present signals, over an I^{2}C bus to the MCH of the front side. The Expander is also working on outgoing signals to the RTM backplane, like for example Geographical Addresses or power resets. All this includes to manage the querying of the rear sides connectivity data. On the MCH-RTM-BM is, there in addition to the Expander, also an other microcontroller with FPGA which is called here User Logic. This User Logic manage three Low Voltage Differential Signaling (LVDS) lines to each eRTM, because they do not have a connection to the AMC backplane for data transfer. These User Logic can be implemented individually to fit to the users crate configuration. Each eRTM shall have a special record in their FRU Information how to handle their individual LVDS lines. These required information will be provided by the front MCH via the Ethernet connection to the User Logic.

The e-keying of the RTM backplane will be managed from the front MCH in the same way as it handles the AMC backplane.

The management can control two different system configurations. One configuration has no RTM-PM and only the eRTM in slot #15 is plugged in, all µRTMs are still managed and powered over the AMC with Zone 3 connector. Both configurations are described in the two following subsections.

A. Power Management with RTM Power Module

If there is at least one RTM-PM connected to the RTM backplane, the control of the power budget is an important task. Due to the backplane management the front MCH has a connection to the RTM-PMs, this allows the MCH to control individually the power supply for each module in the whole crate. Furthermore, the MCH or external control has the possibility to shut off the power for any RTM if needed. In addition the connection between front MCH and MCH-RTM-BM provides the possibility of monitoring all power capabilities. PMs management and control procedures are described in the PICMG MicroTCA.0 Specification [3].

With the new RTM backplane the µRTMs have the option to get low-noise separated analog bipolar power (+VV, -VV). DESY is needing +7 and -7 volt especially for DESY's down converter [11] or vector modulator [12]. For this purpose a special RTM Power Module will be developed [13]. Each µRTM stores in their FRU information a record about their power needs. There are two types of µRTM with are connected to the RTM backplane: the ones which need only the power from the RTM backplane and the other ones that need both inputs. The µRTMs which needs both inputs have two possibilities: managed power supply or self managed power supply. It is called external and internal switching.

External switching means, that the MCH-RTM-BM takes care of the power switching. That means, that the FRU stores the information about the preferred power supply and the MCH-RTM-BM together with the front MCH take care of the input via the AMC or the RTM backplane. Furthermore the designer of a µRTM has to take care of the power handling on the µRTM. DESY developers are using diodes to make sure that only one power supply can be forwarded to the sensitive analog circuits.

Internal switching means, that the management have a connection to an internal switch on the µRTM. On Figure 4 is this the I/O expander. The MCH reads the records of the FRU, which is inside the microcontroller. The microcontroller emulates the EEPROM with the FRU Information.This information contains a special record which is read out over the I^{2}C bus via Zone 3 to the AMC and further to the front MCH, as usual in a standard MicroTCA.4 system [6]. This records contain the power requirements of the module. But the handle

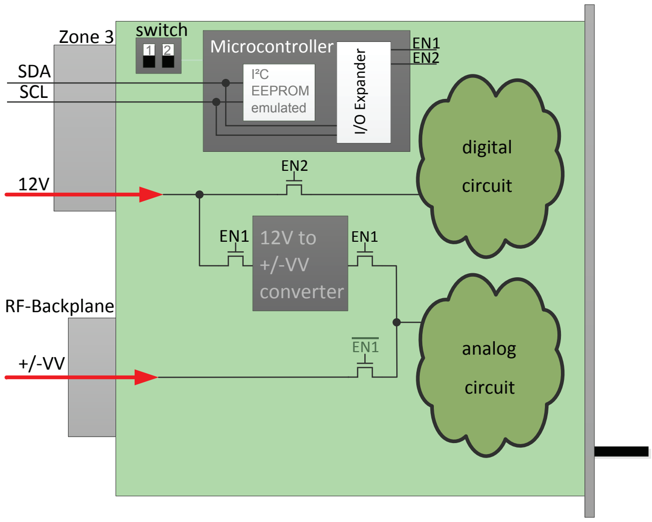

Fig. 4. Internal switching mode of µRTMs.

of the module depends on the configuration of the system, if it is a system with RTM-PM or not. With all this e-keying informations the MCH can then switch the enable pins of the expander on the module for the right power supply via the I^{2}C bus. The Table I shows the different constellations of the enable signals.

TABLE I
ENABLE MODES OF INTERNAL SWITCHING

EN1	EN2	
0	0	Enables only the power from the RTM backplane for the analog circuit.
0	1	Enables the power from the AMC and the RTM backplane for the digital and the analog circuit.
1	0	Enables only the power from the AMC and the converter manages the right +/-VV for the analog circuit.
1	1	Enables only the power from the AMC, but for the digital and the analog circuit.

If an front MCH is inserted in the system which can not interpret the special records for the power supply in the emulated EEPROM (FRU), the MCH will not handle the power supply at all for this module. For this purpose a dip switch should be on the board to manual switch the power supply. The dip switch has two dips, one is for the local or MCH control the other one is for choosing the power input. The dip switch number 1 is for the switching of local control (down) or controlled by the MCH (up). The switch number 2 is setting if 12V (down) or +/-VV (up) shall be used.

The power for the eRTMs are provided by the RTM-PMs and are managed by the front MCH. The power can be up to 120W for MCH-RTM-BM and up to 80W for other eRTMs.

The power supply is new in a MicroTCA.4 system. Now the µRTMs can get power supply from two different Power Modules, the one of the front or from the RTM-PMs. In addition with the new power supply from the RTM backplane they do not need a converter anymore on the module. The +VV and -VV power is directly provided by the RTM Power Module.

Furthermore, the possibility to chose the power supply leads also to the option of choosing both supplies together. Now also the space in the rear side of the crate can be filled with the new eRTMs which get their power from the RTM-PMs over the RTM backplane.

B. *Power Management without RTM Power Module*

For simple systems operating without RTM-PM the MCH-RTM-BM provides the Management Power (MP) and the Payload Power (PP) only to eRTM#15 via the Zone 3 from the front MCH. In the DESY design a module which is dedicated for RF signal generation and distribution will be plugged in slot #15. It acts as an RF transmitter for the entire RTM backplane. If this module gets the power from the front the PP is limited to 30W.

The µRTMs get their power from the front AMC like in a standard MicroTCA.4 Crate without RTM backplane. But now they get the additional clock and RF signals distributed from the DESY MicroLOG [7] .

C. *Communication*

As written before the eRTMs have no connection to the AMC backplane via AMCs like the µRTMs. They need special links on the RTM backplane to communicate with each other, but also to give information or send/receive data to/from the control system which can not be send over the IPMI bus, for example a firmware update of the eRTMs. Therefor is the User Logic a part of the MCH-RTM-BM, which is implemented inside a SoC (System on Chip) integrated ARM Microcontroller and FPGA (Xilinx ZYNQ series [14]). This logic is a special ZYNQ with transceiver channels to enable an Ethernet connection from the User Logic to the front MCH and further to the control system. With this Ethernet connection and the SMS (System Management Software) on the User Logic it can read out the SEL (System Event Log) of the MCH via the Remote Management Control Protocol (RMCP). In the SEL there are events for insertion and hot swap of eRTMs. Further more the User Logic provides also to other logic on the MCH-RTM-BM the Ethernet connection to the front MCH.

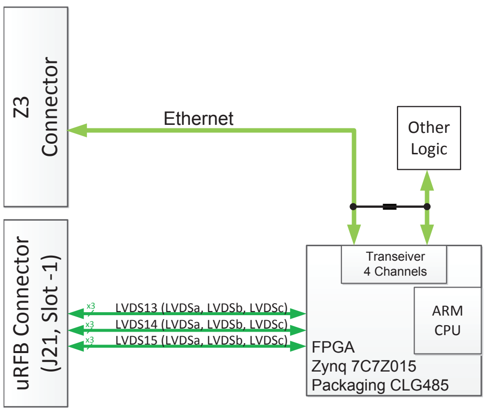

Fig. 5. Connections of the User Logic on the MCH-RTM-BM.

In addition the User Logic manages the LVDS links for communication between the eRTMs. These connections are shown in Figure 5.

IV. Conclusion

The advantage of these optional extensions are the higher quality of RF and Clock signals, the cabling is reduced and with the eRTMs are now space for 6HP wide boards. Also the use of external components can be reduced due to the eRTMs. Furthermore the RTM Power Modules deliver managed low-noise separated analog bipolar power (+/- 7V for DESY applications) for the µRTMs and in addition up to 80W unipolar 12V power for the eRTMs and the special MCH-RTM-BM can get up to 120W. This gives the option to install powerful boards, for example a multiple core CPU. And all this is managed by the MCH-RTM-BM and the front MCH.

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