A SpaceWire Active Backplane Specification for Space Systems

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Short Paper

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Abstract

This paper introduces a SpaceWire Active Backplane (SpWAB) specification that is based on a design developed for the Modular Architecture for Robust Computing (MARC) project demonstration system [1]. The specification is based upon a modular architecture and incorporates facilities to support “Hot swapping” and “Plug and Play” system integration and test approaches.

The paper details the network and power architecture, the electrical interfaces and the potential connector design that will carry the high speed SpaceWire signals with controlled impedance between modules.

The developments required to permit realisation of the standard within a space environment are identified as well as a suggested physical configuration for the system Modules.

1 Introduction

The SpWAB specification [2] offers a communication and power distribution backplane interface that permits spacecraft units to be built from “Modules”. The modules may include functions such as control processors, mass memory and Input/Output modules, potentially from different suppliers, that have a high level of capability. An example system is shown in Figure 1 which shows a reference distributed Data Handling and processing architecture [3].

The SpWAB interface to the module is comprised of redundant SpW interfaces and switched power. The module SpW interfaces are connected together via SpW routers that are part of the SpWAB, this configuration has the advantage that the network architecture is decoupled from the module design and the SpW connectivity is maintained even if individual modules have failed or have been intentionally powered off. The switched power interface permits any module to be turned off when not required, conserving power and increasing the module reliability.

The SpWAB permits a decentralised architecture system based on a SpaceWire network as a communication medium. It is anticipated that this decentralised architecture will allow efficient resource sharing (e.g. computing, signal processing, mass memory, etc.) among spacecraft payload and platform functions.

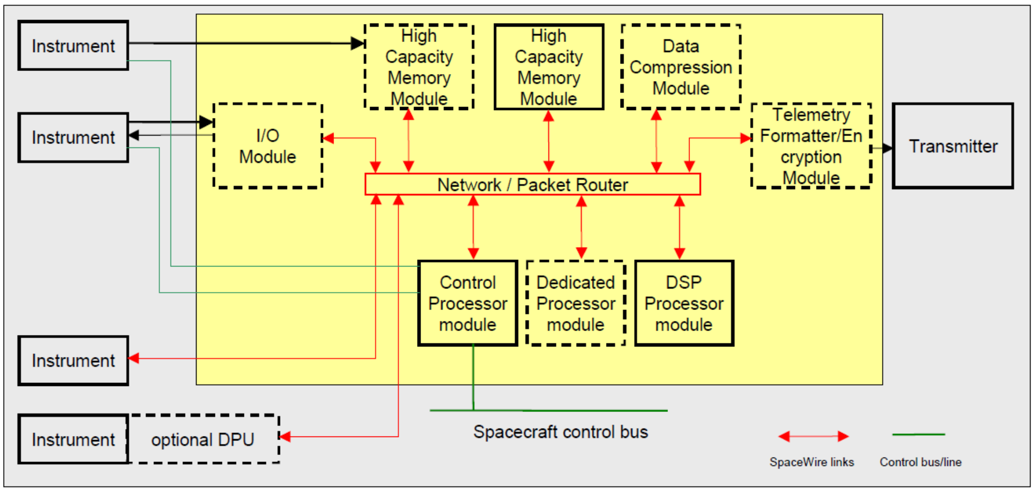

Figure 1: Distributed data handling and processing architecture

2 SpWAB Network and Power Architecture

The context of the SpWAB is shown in Figure 2. Power is supplied to the SpWAB and the Modules from nominal and redundant Power Supplies. Modules "1 to N" have identical interfaces to the backplane, while two master Reconfiguration Modules incorporate additional signal lines for power switch control.

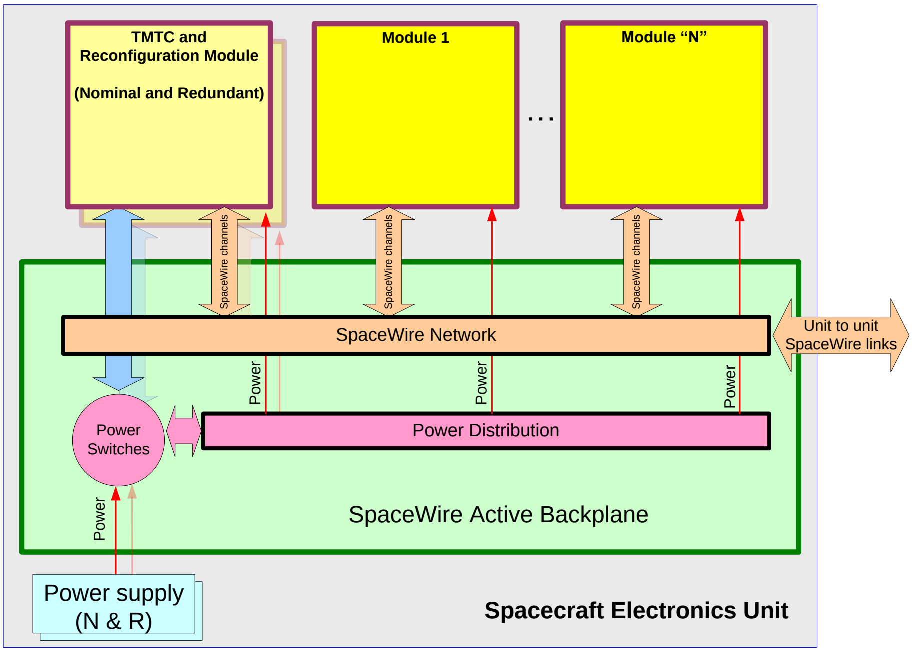

Figure 2: SpWAB context within an example Spacecraft Electronics Unit

The master Modules each incorporate a hardware based Reconfiguration Controller that handles the highest level of Failure Detection Isolation and Recovery (FDIR) within the unit. The Reconfiguration Controller performs autonomous power switching in response to an internal system watchdog timeout. In a normally operating system the system watchdog is held off by SpW health (heartbeat) messages from one or more Modules. It is anticipated that the master Modules will incorporate either a Telemetry and Telecommand (TMTC) interface or an interface to a unit that is at a higher level in the spacecraft system FDIR hierarchy.

2.1 Network Architecture

The SpWAB network architecture is based on a Cluster (Figure 3) that incorporates two 8 port SpW routers to provide a simple network building block with built in path redundancy. The regularity of the network architecture simplifies the network discovery process needed to support a "Plug and Play" system. The Modules are identified based on the router ports that they are connected to and the Cluster number. This identification convention means that the network paths between two modules can be easily deduced. This SpWAB network can be expanded to support any number of Modules by increasing the Cluster count and it provides expansion port connections to other Spacecraft units or to Electrical Ground Support Equipment during testing.

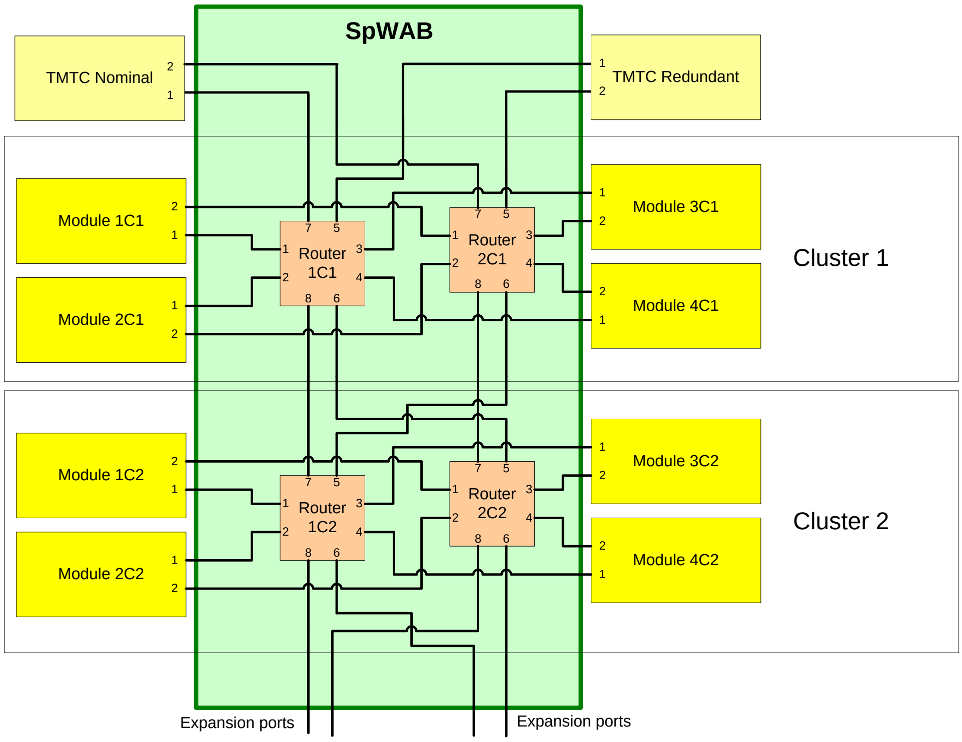

Figure 3: SpWAB network architecture

2.2 Power Architecture

Each Module is powered from both the Nominal and Redundant DC power rails which are combined via series/parallel diodes plus a Latching Current Limiter (LCL) for failure protection (Figure 4). The SpWAB routers are not shown in the diagram for clarity but each one is powered via a Point of Load DC-DC converter and may be switched on/off individually via LCLs.

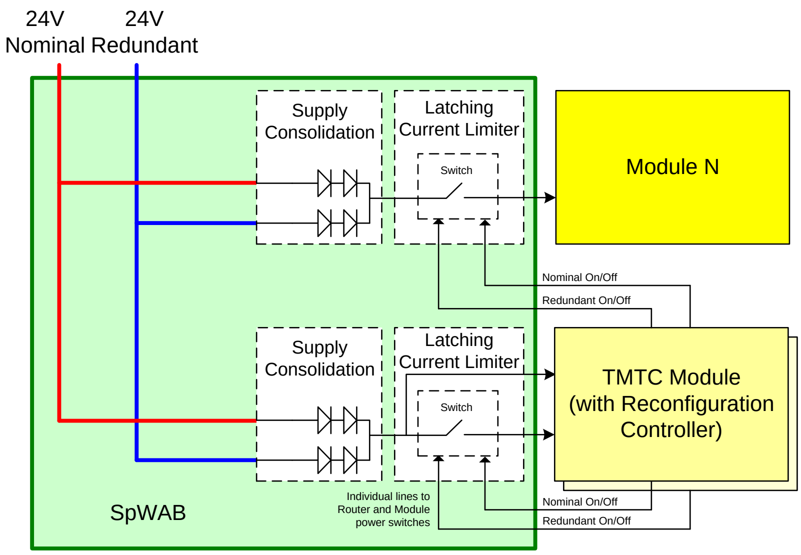

Figure 4: SpWAB Module power switching architecture

2.3 Module Interfaces

Each Module is connected via 2 SpW ports to the SpWAB. No discrete signal lines are provided thus all module communication is via the SpW network. A module may have further interfaces, for example at the front panel, however these are not routed via the SpWAB.

Two SpW interfaces are required for redundancy reasons so the full functionality and performance of a module must be available if one of the SpW ports to the network fails. The module must be designed to prevent propagation of failures through the SpW interfaces by, for example, providing over-voltage protection on the internal power supply rails [4]. The Module should be compatible with the RMAP protocol for health monitoring and any basic control functions. To permit control by multiple users each RMAP control function should be accessed via atomic read/modify/write operations. To facilitate “Plug and Play” the module should map identification information into a fixed area of address space.

The module receives a single Latching Current Limiter protected rail. It is anticipated that the supplied voltage will be in the range 12V to 24V, with the lower voltage being preferred to simplify the design of low output voltage the Point of Load DC-DC converters accommodated on the Module.

3 SpWAB Connectors

Currently there are no space approved backplane connectors that provide a controlled impedance interface. Options are to either, characterise an existing connector and incorporate appropriate compensation components or, to design a new connector using controlled impedance contacts. The proposed solution for the SpWAB is to develop a new pair of mating connectors in co-operation with Hypertac, the connectors being based on existing Twinax contacts and built in a Hypertac HPH form factor connector body. The Twinax contacts can operate at data rates in excess of 1Gbps and hence can handle the higher data rates that will be required for future space applications. A portion of the proposed connector contains standard contacts for power and control signal distribution. Support for "Hot swapping" could be provided by incorporating different length pins to force removal of power upon card extraction and to ensure that the ground connection breaks last.

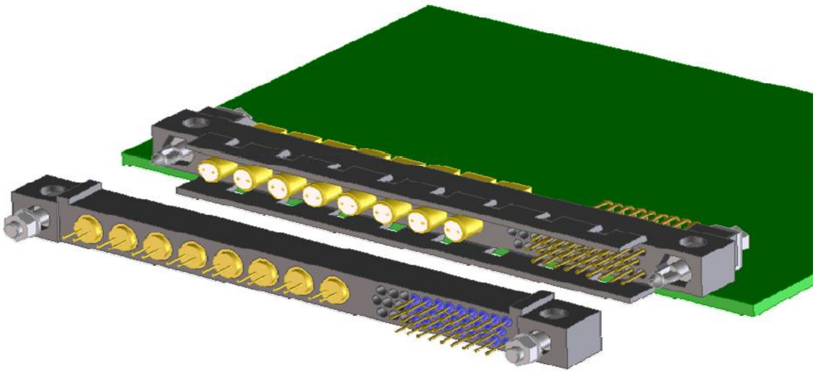

Figure 5: Proposed design of the SpWAB to Module connectors

4 MODULE PHYSICAL CHARACTERISTICS

There are no "standard" sizes for electronics circuit boards used in space applications. Spacecraft unit suppliers tend to optimise the board size for each application and produce a unit as a cube shaped box for structural, thermal and mass efficiency reasons. Clearly if Modules from different suppliers are to be integrated together within a unit then a standardised packaging scheme is required and the SpWAB specification needs to incorporate physical as well as functional and electrical interface constraints on the Module.

Eurocard board sizes are commonly used in the development of ground based electronic systems and card frames are readily available. The "Single Eurocard" size (100mm x 160mm) is considered too small to accommodate the components are required for a processor card based on the typical IC packages available in the space domain. The "Double Eurocard" (233mm x 160mm) is a more practical size but the aspect ratio leads to tall units compared to the depth. In consideration of these factors the "Extended Double Eurocard" (233mm x 220mm) is the selected card size for the SpWAB module specification.

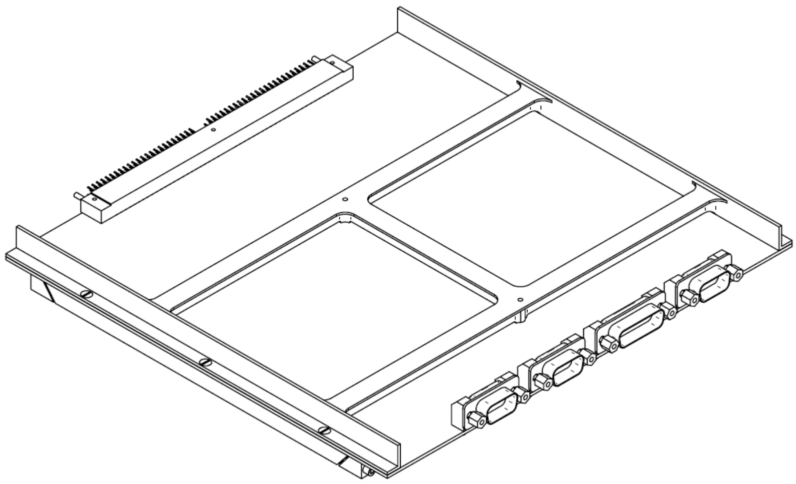

Figure 5: Example module design based on Extended Double Eurocard size

5 REQUIRED DEVELOPMENTS

To build the SpWAB as envisaged to a flight standard and permit the required components to be accommodated efficiently on the backplane three principal developments need to be undertaken:

1. Development of compact Point of Load converters incorporating over-voltage protection.

2. Develop small Latching Current Limiters with isolated redundant switch controls and possible means to monitor the current.

3. Develop a connector with a mix of controlled impedance and standard contacts that can support at least two SpW links and possibly facilities for “Hot Plugging”.

6 REFERENCES

1. A. Senior, W. Gasti, O. Emam, T. Jorden, R. Knowelden, S. Fowell, “Modular Architecture for Robust Computation”, International SpaceWire Conference 2008.

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4. F. Tonicello, M. Triggianese, "Points of Load Converters and distributed power architecture approach", ESA Technology Innovation Day, February 2010.