A new Generation of SpaceFibre Test and Development Equipment

SpaceFibre, Short Paper

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***Abstract*— SpaceFibre is a new technology for use onboard spacecraft that provides point-to-point and networked interconnections at Gigabit rates with in-built Quality of Service and Fault Detection, Isolation and Recovery. The SpaceFibre standard is virtually finished, with the ECSS standardisation activity to be ended this year.**

There is a need for equipment to support the development and testing of applications of the entire protocol stack. This paper describes the new generation of SpaceFibre equipment designed for this purpose. They provide users with several options for platforms and connectors, such as FMC, USB 3.0, cPCI, PXI, PXIe and SpaceVPX. The number of platforms supported and the flexibility of the equipment provides the end user with a broad range of options to include SpaceFibre in their current system design. This helps to promote the adoption of SpaceFibre technology.

A number of designs using the equipment here described is currently available or under development. They include the SUNRISE SpaceFibre Router and the Multilane SpaceFibre interface, among others. When combined, these new boards and designs offer a powerful and rich set of tools to help with SpaceFibre designs.

***Index Terms*— SpaceFibre, RTG4, USB, cPCI, PXI, PXIe, SpaceVPX, EGSE, FMC**

I. Introduction

SpaceFibre (SpFi) will be released as an ECSS standard later this year [1]. With the addition of the network and multilaning layers the standard is virtually finished. STAR-Dundee released a few years ago the STAR Fire unit [2] to help with the SpFi implementation and adoption in the initial stages of the protocol. However, a new generation of Electronic Ground Support Equipment (EGSE) products is required to provide users with suitable hardware to implement and test the whole SpFi protocol stack. Furthermore, there is a need for demonstrators with space-qualified components to increase SpFi maturity. In this article a new family of products specifically designed to provide a platform to support SpFi adoption is presented.

II. STAR Fire Mk3

The STAR Fire Mk3 is the evolution of the initial STAR Fire device [2]. It shares with the old version some of its features. It has two SpFi and two SpaceWire (SpW) interfaces, two MICTOR connectors for connecting a Logic Analyser, and four SMB connectors. Three of those are external input triggers, and one is an external output trigger. Fig. 1 illustrates the block diagram of the STAR Fire Mk3 design. Fig. 2 shows the STAR Fire Mk3 unit.

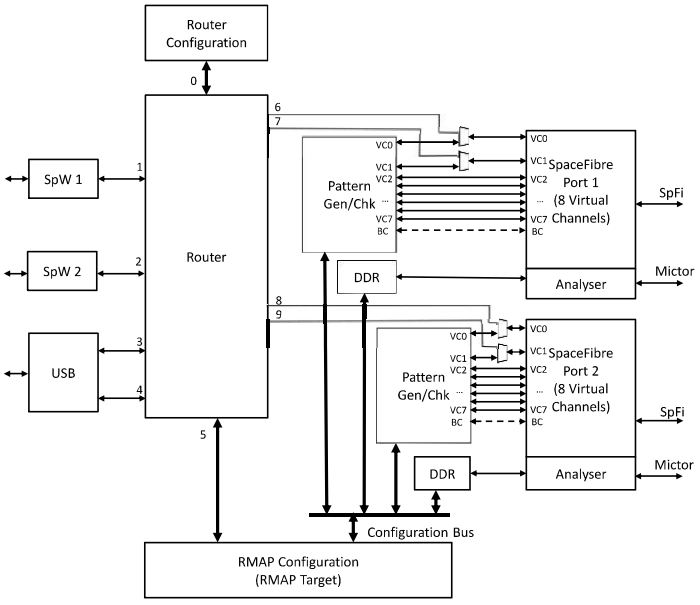

Figure 1. STAR Fire Mk3 architecture

The new STAR Fire unit can operate as a SpFi link analyser, SpFi interface and as a bridge between SpFi and SpW, among others. It has embedded pattern data generators and checkers. The Mk3 version features a USB 3.0 micro B interface, which provides communications with a much higher

data rate with the host PC. This means that the SpFi link can be directly interfaced from a computer at very high data rates. The old version can only use instead basic internal data generators and checkers for this purpose.

A bigger FPGA has also allowed an upgrade of the internal data generators and checkers to emulate realistic instruments. Specifically, this new unit features some of its Virtual Channels connected to advanced data generator and checkers. These provide with complex data generation capabilities, thus allowing more realistic data streams automatically generated and checked by the STAR Fire unit without the need for computer intervention. Some of the capabilities of these new data generators and checkers are:

- The type of data pattern can be selected among different options: random pattern, incrementing pattern, fixed word value, alternating word values, left or right circularly rotating four byte pattern
- Data value/seed is configurable
- Data pattern and packet lengths are configurable
- Length of data bursts and data rate can be configured
- EEP can be inserted in a specific position
- The initial four words of each packet can be configured

The capabilities of the embedded Analyser have also been improved. Now it is possible to trigger on any given data or control word received and also to select the Virtual Channel when triggering in data frames. Finally, a DDR memory is used instead of the internal FPGA memory to store the captured values, resulting in greater recording capabilities.

Figure 2. STAR Fire Mk3 unit

III. SpaceFibre PXI Board

PXI (PCI eXtensions for Instrumentation) is an industry standard widely used as a platform for electronic instrumentation in automated test systems [3]. It is currently used in many industry areas, including aerospace. PXI uses PCI in the communication backplane.

PXI Express (PXIe) uses the same PXI form factor but features PCI Express (PCIe) as backplane communication protocol. Switching from PCI to PCIe allows multiplying the available bandwidth from 132 MB/s up to 12 GB/s [4].

The SpaceFibre PXI board has been developed to implement a range of SpW and SpFi devices. The board is a 3U compatible with PXI, Compact PCI (cPCI) or PXIe racks. It can also be provided with the PXIe interconnection if required.

The board offers DDR memory and programmable clock sources to provide the end user with a very flexible architecture to implement multiple designs. It features a novel set of front panel interconnects. There is a set of flexible interface connectors that can be used to customise the board, such as SpFi, SpW, external triggers, etc. Thus, the board can be easily modified to accommodate different designs. This allows using the same PXI board to implement many different products.

Several designs have already been implemented using the PXI Board, such as the SUNRISE 8-port SpFi Router (Fig. 3), the STAR Fire design (Fig. 1), a 4-port SpFi interface, a Multilane (up to 4 lanes) SpFi interface, or a SpW to SpFi bridge.

Figure 3. *PXI Board configured as SpaceFibre Router. The front panel has 8 SpFi ports and 4 SpW ports*

A. The SUNRISE SpaceFibre Router

The SUNRISE router is the first implementation of a SpFi routing switch. Fig. 4 depicts the router block diagram. It features 8 SpFi interfaces with 4 Virtual Channels each, plus 4 SpW interfaces tied to a ninth SpFi port. All of them are accessible over the front panel, as shown in Fig 3. There is also an internal configuration port (Port 0).

This router implements path and logical addressing, group adaptive routing, virtual networks, time distribution and message broadcast. It also fully supports the Quality of Service (QoS) and Fault Detection Isolation and Recovery (FDIR) capabilities native to SpFi.

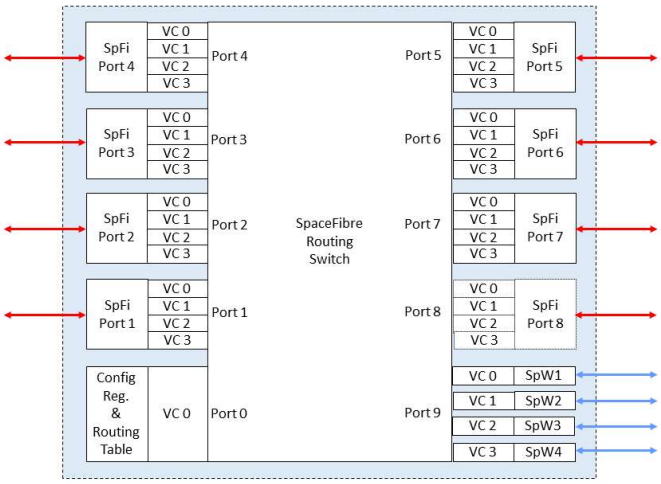

Figure 4. *SUNRISE SpaceFibre Router Block Diagram*

IV. SpaceFibre RTG4 PXIe Board

The SpaceFibre RTG4 PXIe board is a variation of the standard PXI board. This board is a 3U featuring a Microsemi RTG4 PROTO FPGA instead of a Spartan 6. This allows implementing designs with multiple SpFi and SpW interfaces in radiation-hardened technology.

Like the standard PXI, this board offers two banks of DDR memory, and a PXIe interface. It also offers the same set of flexible interfaces connectors as the PXI card. Up to 8 SpFi interfaces are supported. Furthermore, various front panel options are offered, also with an option for a custom front panel to support custom applications.

Current designs with this board include a multilane SpFi interface. Others designs planned for the near future include a 10-port SpFi router or an 8 lane-SpFi interface.

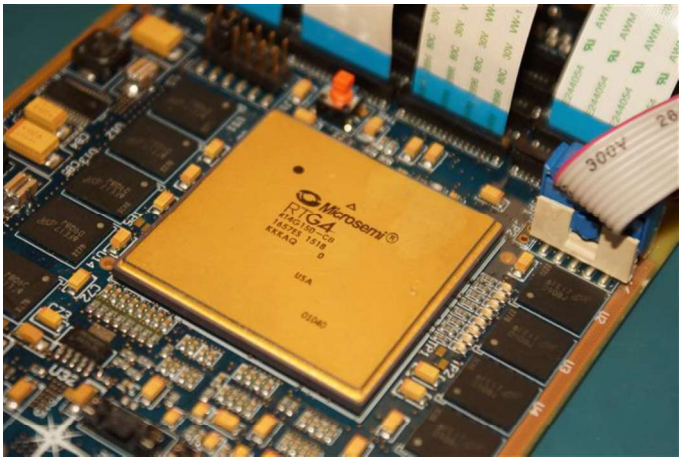

Figure 5. *SpaceFibre RTG4 PXIe board*

V. SpaceVPX-RTG4 Lite Board

SpaceVPX (also known as VITA 78) [6] uses the OpenVPX (VITA 65) backplane standard [5] adding features required for space to the VPX standard. They include important aspects in space, such as single-point failure tolerance, fault detection on critical configuration signals, robust system diagnostics, etc. Moreover, SpaceVPX offers the possibility of using SpW and SpFi for control and data planes.

A SpaceVPX Lite board will be made available in the coming months. Similar to the aforementioned PXIe-RTG4 board, this is a 3U unit with a Microsemi RTG4 PROTO silicon and a SpaceVPX [6] interface supporting a SpW control plane and a SpFi data plane along with standard management functions. In the front panel there are available two SpW and two SpFi connectors for user access.

An FMC daughterboard connector is available, with a family of daughter boards planned. Among them, a dual 3 GSamples/s ADC FMC board will be released with the board.

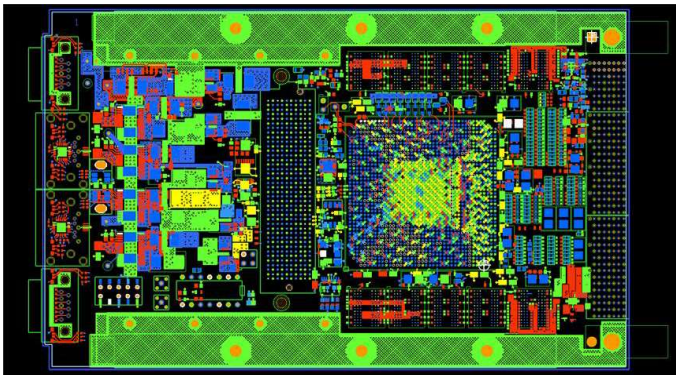

Figure 6. *SpaceVPX-RTG4 PCB design*

VI. FMC SpaceWire/SpaceFibre Board

The FMC-SpaceWire/SpaceFibre board (Fig. 7) is an FPGA Mezzanine Card (FMC) which is designed to extend the capabilities of an FPGA development board by adding support for SpW and SpFi interfaces. The board features a standard FMC High Pin Count (HPC) connector and has four SpW ports with accompanying tri-colour status LEDs, and two SpFi ports. The SpW signals are connected via LVDS buffers, and all SpFi signals are AC coupled. This adds protection preventing damage to the FPGA in case of signals levels being out of specifications.

There is an on-board 125 MHz oscillator that can be used as a reference clock inside the FPGA. Also, two SMA connectors provide with the option of using an external differential clock input instead of the on-board oscillator. 20 GPIO pins are available to the user.

Two sets of switches are used to set different connections of the SpW and SpFi signals on the FMC connector. The FMC board can be configured using the switches to work with a number of FPGA development kits including but not limited to:

- Microsemi RTG4 Development Kit - HPC1 and HPC2
- SmartFusion2 Adv Dev Kit - HPC and LPC
- Xilinx VC707/VC709 Board

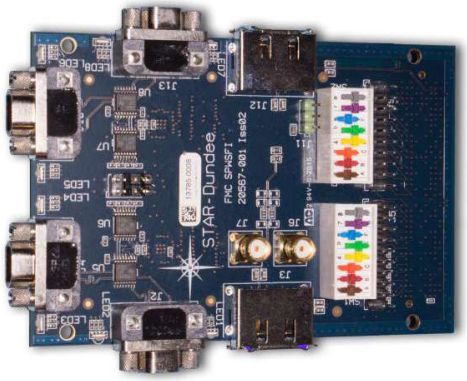

Figure 7. FMC-SpaceWire/SpaceFibre board

VII. Conclusion

The SpaceFibre standard is now basically complete. There is a growing number of space applications that can benefit from the SpFi features, namely, multi-Gbps data rate and in-built QoS and FDIR. Consequently, there is a growing interest on SpFi. A new set of products to support its adoption is required.

In this article a new generation of SpFi test and development equipment has been described. The equipment is flexible and supports popular platforms and connectors such as FMC, USB 3.0, cPCI, PXI, PXIe and SpaceVPX. Furthermore, a number of designs using this equipment is ready or under development and will be also made available by STAR-Dundee. These include the SUNRISE SpFi Router, Multilane or Multiport SpFi interfaces, etc. When combined, these new boards and designs offer a powerful and rich set of tools to help with SpFi designs.

References

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