SPACEFIBRE

Session: SpaceWire Standardisation

Short Paper

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ABSTRACT

SpaceFibre [1] is a very high-speed serial communications link being designed for use on spacecraft. It is designed to operate at speeds of 2 Gbits/s or higher depending on the specific driver/receiver technology used. Copper or fibre optic physical layers can be used. SpaceFibre is designed to interoperate with a SpaceWire network with a single SpaceFibre link being able to carry data from many SpaceWire links.

This paper provides a brief introduction to SpaceFibre and outlines the results of several SpaceFibre prototypes. It then considers how quality of service (QoS) will be implemented in SpaceFibre. The application of SpaceFibre in instruments, mass memory and processing systems is then described. The paper concludes with an overview of the current state of the SpaceFibre specification.

1 INTRODUCTION

SpaceWire [2] provides point-to-point and networked payload communication services for use on board spacecraft. It connects instruments to mass memory units and processing systems and provides the connection from the mass memory to the downlink telemetry system. SpaceWire uses bi-directional data links that operate up to 200 Mbits/s using current radiation tolerant components and micro-miniature D-type connectors. Higher speed operation is possible when matched impedance connectors are used. SpaceWire is being used on many space missions across the world. This success is due to many factors including standardisation, simplicity of implementation, performance and flexibility.

Several instruments, including synthetic aperture radar and multi-spectral imagers, require higher data rates to the mass memory unit. Downlink telemetry systems are being designed that can support Gbit/s data transfer leading to the need for similar data rates to transfer the data from the mass memory unit. There is a growing requirement for a data communication link with an order of magnitude higher performance than SpaceWire. Standardisation, simplicity of implementation and flexibility are also import characteristics that need to be provided for a new data link technology to be successful.

The University of Dundee have been working on a Gbit/s data link technology for several years [3]. Trade-offs of ground data link technologies that could possibly be used as the basis for a new spacecraft Gbit/s data link have been carried out. An outline specification for SpaceFibre has been written and prototype implementations have been implemented and tested. Extensive work has been carried out for ESA on the physical layer and fibre optic components by Patria Oy, VTT, Fibre Pulse, INO and Gore [4][5]. Components have been selected and tested for flight applications.

2 SpaceFibre CODEC

The SpaceFibre CODEC [3] is responsible for the encoding and decoding of the data being sent over the communications link. A block diagram of the SpaceFibre CODEC is illustrated in Figure 1.

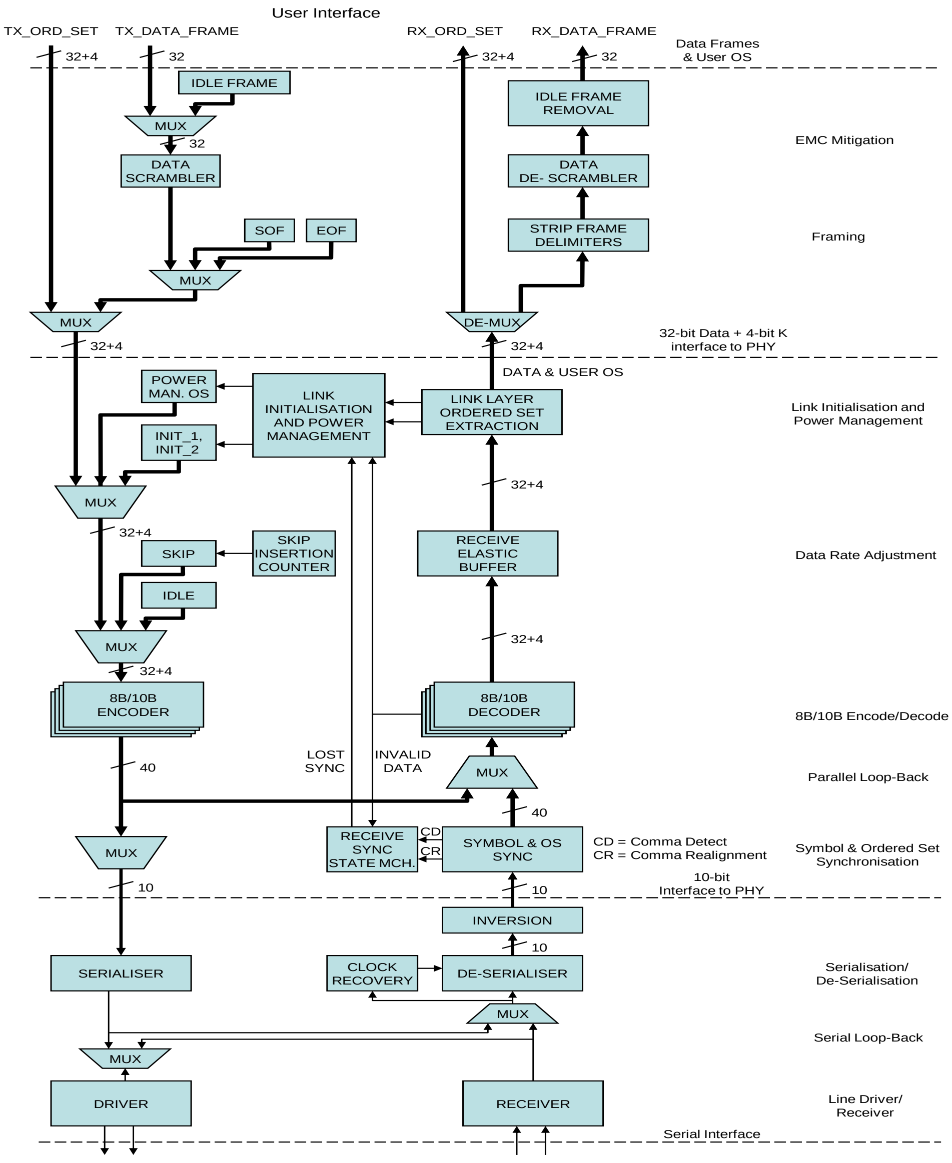

Figure 1: SpaceFibre CODEC Block Diagram

3 Prototype Implementations

Several SpaceFibre CODEC prototypes have been implemented by various organisations.

3.1 ESA/University of Dundee

University of Dundee have implemented several SpaceFibre prototypes. One of these, built for ESA, was integrated with the Fibre optic components provided by Patria and successful tests made at 2 Gbits/s over 100 m fibre optic cable.

3.2 NASA GSFC

NASA Goddard Space Flight Center (GSFC) implemented a SpaceFibre prototype and demonstrated it on the Max Launch Abort System (MLAS) [6].

3.3 JAXA

JAXA have also implemented a SpaceFibre prototype. This uses the "Wizard link" technology from Texas Instruments which provides 8B/10B encoding/decoding and serialisation/de-serialisation.

3.4 Interoperability Testing

Interoperability testing between the JAXA prototype and the University of Dundee prototype revealed some problems which are believed to be related to the use of the Wizard link device. The SpaceFibre specification will be altered to permit the use of the Wizard link as the lower level of the CODEC, as this is technology is available in a radiation tolerant device. Further interoperability testing is planned for later in 2010.

4 SpaceFibre Quality of Service

The SpaceFibre CODEC provides the basic means of transferring data over a SpaceFibre link, with data frames being used as a means of multiplexing several different data streams over the one physical link. To support several data streams running over the one link, virtual channels are provided as illustrated in Figure 2.

Data to sent over the SpaceFibre link is written into one of the virtual channel transmit buffers (VC TX Buffer). There is a separate virtual channel for each "stream" of data being sent over the network. The "stream" may contain individual commands, packets of data, or continuous data streams. The local system may use several virtual channels to send different types of data over the SpaceFibre network. There may be data waiting to be sent in several of the VC TX Buffers. The medium access controller (MAC) determines which VC TX Buffer will be allowed to send data when the current data frame has finished being sent. To be allowed to send data there must be data in the VC TX Buffer to be sent and there must be room in the corresponding VC TX buffer at the other end of the SpaceFibre link. Flow control information is passed from the VC RX Buffers at one end of the link to the MAC at the other end of the link so that the MAC knows which VC RX Buffer can accept data. If there is more than one VC TX Buffer with data to send with room in the corresponding VC RX Buffer, then a medium access policy will determine which of the VC TX Buffers is allowed to send data. SpaceFibre will support several QoS classes which drive the medium access policy. These QoS classes include priority, bandwidth reservation and scheduled data transfer. A data retry mechanism is provided for each virtual channel which can be used to support reliable data transfer.

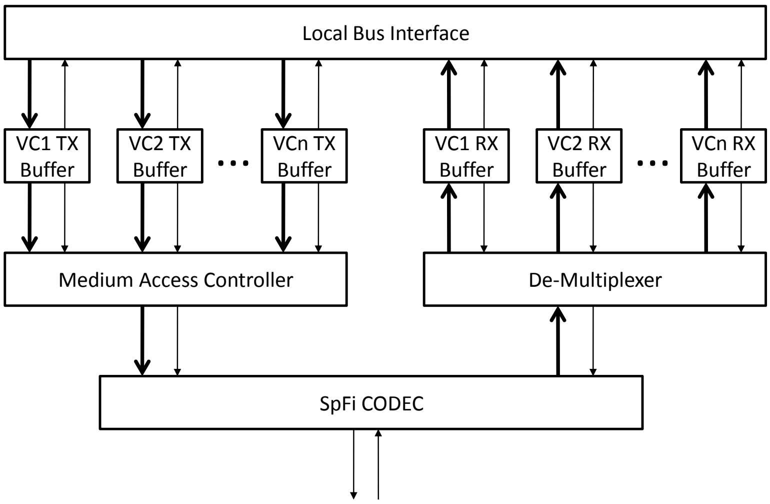

Figure 2: SpaceFibre Virtual Channels

When a VC TX Buffer is given permission to send data it passes a data frame of up to 256 bytes to the SpaceFibre CODEC for sending across the SpaceFibre link. The data is received at the other end of the link and passed via a data frame de-multiplexer to the appropriate VC RX Buffer. Data in the VC RX Buffers can be read by the local system.

5 SPACEFIBRE APPLICATIONS

SpaceFibre is being developed to support a wide range of spacecraft applications where high data rates are required. Specific applications include the interconnection of high data rate instruments to mass memory units, the transfer of data from the mass memory unit to the downlink telemetry system, and the multiplexing of data from several SpaceWire links over a single SpaceFibre backbone to reduce mass and power consumption.

6 SPACEFIBRE CURRENT STATE

The lower levels of SpaceFibre have been specified by the University of Dundee and a prototype SpaceFibre interface developed and tested. NASA have developed a prototype SpaceFibre system to this specification and tested it on the MAX Launch Abort System (MLAS) test vehicle. JAXA have also developed a prototype SpaceFibre system. QoS mechanisms for SpaceFibre are currently being defined and prototyped to provide a comprehensive capability set for future space missions. SpaceFibre is now being defined for use in several onboard applications including mass memory devices and DSP processors. SpaceFibre fills a growing gap in onboard communications links for spacecraft, which is being widened by the high data-rate demands of new instruments.

7 REFERENCES

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