SPACEWIRE STANDARD EVOLUTION

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Short Paper

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1 ABSTRACT

This papers lists and describes the modifications to the SpaceWire standard which have been proposed to be included in the next update of the standard. The discussion within the SpaceWire Working Group on the details of the updates will be started next year. Suggestions for updates beyond what is described in this paper are welcome and can still be considered.

2 INTRODUCTION

SpaceWire has been standardised within ECSS in ECSS-E-50-12A and the standard was first published in 2003 [1]. Since then many groups worked on the development of SpaceWire links, nodes, routers and networks and on the application of this technology in space systems. In the past years the standardisation effort aimed at the definition of higher level protocols such as RMAP which is awaiting its standardisation within ECSS as ECSS-E-ST-50-11C - SpaceWire Protocols. In parallel the SpaceWire Working Group is discussing new concepts and additional protocols like SpW PnP and SpW-RT.

Partially through the experience gained with the implementation of real systems and partially through the development of new concepts several issues have been identified to be considered for the update of the ECSS-E-50-12A standard. Among those are the specification of SpaceWire cables and connectors, the introduction of interrupts using the same side channelling mechanism as Time-Codes and the introduction of a configuration port 0 also for nodes. All these issues will be introduced in the next update of the SpaceWire standard which will aim to maintain backwards compatibility. In the following the identified items are discussed per level.

3 PHYSICAL LEVEL

During the past years a number of suggestions have been made to modify the specification of the physical level.

3.1 CABLES

The standard provides a very detailed and rigid specification on the construction of the cable. It specifies e.g. wire type and size of the conductors but also of the shield, filler, binder and jacket material. This kind of specification can be directly given to a cable manufacturer who can based on this produce a cable compliant to the standard, which is able to transmit the signal over a length of 10 m and support a data rate of 200 Mbps. The disadvantage is that this cable may be too heavy and rigid for some short connections and too lossy for distances beyond 10 m. Some different cable constructions have been proposed in the past. The idea for the update of the standard is to specify not the construction but some physical and electrical parameters. These could comprise parameters like Differential Impedance, Signal Skew, Return Loss, Insertion Loss, Near-end Crosstalk (NEXT) and Far-end Crosstalk (FEXT) [2], [3], [4], [5], [6].

3.2 CONNECTORS

A nine-pin micro-miniature D-type is specified as the SpaceWire connector. It is compact and available for space use. The differential impedance of the D-type connectors does not match the 100 Ω of the cables and the termination. Still in practice the distortion introduced by it is acceptable in most cases. Other connectors like a 4-way twinax connector [2][3][4] or circular 13 pin 38999 Series II connector [6] have been proposed and investigated. It should be discussed if and which additional connector types should be included in the standard.

3.3 CABLE ASSEMBLY

The micro-miniature D-type connector has nine signal contacts. Eight are used for the 4 twisted pair cables and one is used to terminate the inner shields at end of the cable from which the signals are being driven. The inner shields are isolated from one another. This feature can be useful to prevent loops in the grounding design and the symmetrical arrangement avoids the problem of having to know which end of the cable is which during installation.

A problem occurs when the cable is broken into several parts due to bulk head connectors which are often used in larger structures. This leads to the situation that the inner shields on both sides of the bulkhead are not connected to the ground of either side. A connection of the inner shield on both sides with the possibility to implement a controlled capacitive decoupling on one side behind the plug could be investigated as a solution.

3.4 BACKPLANE

SpaceWire links are often used within a unit or electronic box. The current SpaceWire standard contains some requirements on PCB and backplane tracking but no requirements on backplane connectors or backplane construction.

4 CHARACTER LEVEL

The time control codes are defined as an ESC character followed by a single data character. Six bits of time information are held in the least significant six bits of the Time-Code (T0-T5) and the two most significant bits (T6, T7) contain control flags which are distributed isochronously with the Time-Code. The two control flags are reserved for future use and both are set to zero. Since the issue of the SpaceWire standard a number of proposals have been made on how a good use could be made of the three reserved states of the control flags.

4.1 Distributed Interrupts

The first proposal is to use one of the reserved states to distribute interrupts through the SpaceWire network using the same side channel mechanism as for Time-Codes. The available bits allow defining 32 Interrupts Codes and 32 Interrupt-Acknowledge Codes. Routers and nodes only propagate the interrupts when they receive it for the first time. At this point a timer is started to reset this lock. It is also reset when the corresponding Interrupt-Acknowledge Code is received [7], [8].

4.2 Multi-Time-Code Mechanism

Only one node in a SpaceWire network should provide the active TICK_IN signal which triggers the broadcast of the Time-Codes. This is to avoid collisions of Time-Codes within the network. For fail safety and redundancy reasons it can be useful to have simultaneous Time-Codes from different time masters in a system. This could be implemented by using the two remaining reserved states of the control flags [9].

5 Exchange Level

The exchange level is responsible for making a connection and for managing the flow of data across the link.

5.1 SpaceWire State Transitions

During the implementation of the SpaceWire codec some inconsistencies in the transitions described in the state diagram have been identified [10].

a) The transition from Started to ErrorReset is impossible when gotNULL condition is set.

b) The transition from Connecting to Run shall be applied only after sending FCT to channel.

These inconsistencies will have to be corrected by making some slight modifications of the standard text and state diagrams.

5.2 Simplex Link Operation

For many high speed payload data applications only a simplex connection from the instrument to the memory is required. In these cases the back channel provided by SpaceWire is often seen as unnecessary complexity and cable mass. It has been proposed to modify the SpaceWire codec and the state machine to support simplex operation [11], [12]. Also the possibility of a half-duplex SpaceWire implementation has been suggested [13].

It remains to be investigated what consequences these changes will have for the backwards compatibility of SpaceWire and if they should be included in the update of the standard.

6 Network Level

The network level is the highest level specified in the standard.

During the development of higher layer protocols a number of issues and clarifications where identified.

6.1 Configuration Port in Nodes

Every SpaceWire routing switch has one internal configuration port with address zero. It can be used to configure the routing switch and to obtain status information. This is an important feature for network discovery and PnP. It showed to be a problem that this port zero is only present in routing switches and not in nodes. The update of the definition will align the SpaceWire Node addressing with the SpaceWire Routing Switch addressing. An internal configuration port with address 0 will be introduced for nodes but normal SpaceWire packets starting with a logical address (32 – 254) will be passed to the next layer as before.

6.2 Router Function in Nodes

What has been described before corresponds to a very simple router with one external port, one internal configuration port and one node internal port. This concept can be extended to several external ports by introducing path addressing and a routing table. This would not only fulfil the needs of network discovery but would also enable an elegant cross strapping method for redundancy switching and easy packet routing through the end nodes.

6.3 Router Timeout

If a router stops receiving data due to an internal failure the packet is stuck and can block some paths in the network. It is difficult to detect and recover this situation from outside the routers. An effective method to recover from this failure condition is to introduce a timeout inside the routing switches which removes the stuck packet from the link after a certain period of time.

7 Conclusion

A non exhaustive list of proposed modifications to the SpaceWire standard has been provided in this paper. Additional proposals are welcome and can still be submitted to the author. The different options will be discussed and consolidated within the SpaceWire working group. In many cases breadboard implementations exist already. Based on the results of the discussion the modifications may be included in the next update of the SpaceWire standard.

8 References

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