SEPHY: An Ethernet Physical Layer Transceiver for Space

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Abstract

Since its development, Ethernet has experienced an impressive growth and has become the dominant technology for wired local area networks. It has also more recently expanded beyond computer networks to cover also industrial and automotive networks. This adoption is driven by the lower costs enabled by reusing existing technology. For critical applications, Ethernet has to be extended to ensure timely and reliable delivery of frames. A number of technologies that can solve the reliability and real time issues have been proposed, for example Time Triggered Ethernet (TTE). Space systems are an example of critical applications and Ethernet has been used in some missions like NASA´s Orion and in launchers. However, there is an additional problem in space applications that has so far prevented a wider adoption of Ethernet. Electronic circuits that operate in space are exposed to radiation that causes errors and make most commercial devices not suitable for space missions. This means that special components have to be designed for space use. For Ethernet, most components like switches or Medium Access Controllers (MACs) are purely digital. There is however one exception, the physical layer transceivers (PHYs) that are by nature mixed-signal devices. The availability of rad-hard Ethernet PHYs qualified for space use is crucial to enable the widespread adoption of Ethernet in space. This paper presents the options for a space Ethernet PHY and the SEPHY project that is currently developing a 10/100 Mb/s European Ethernet transceiver for space.

I. OPTIONS FOR A SPACE ETHERNET PHY

The IEEE 802.3 standard defines many PHYs covering different transmission media and speeds. The most commonly used media in Ethernet are Unshielded Twisted Pairs (UTP). Assuming that the space PHY will use UTP, the IEEE 802.3 standard provides several alternatives. The most relevant ones are: 10BASE-T defined in IEEE 802.3i , 100BASE-TX defined in IEEE 802.3u, 1000BASE-T defined in IEEE 802.3ab and 10GBASE-T defined in IEEE 802.3an. Each of those standards provides a 10x speed increase over the previous one, starting with the 10 Mb/s of 10BASE-T. From a performance point of view, the best would be to select the highest speed PHY for rad-hard implementation. However, there are other factors that should be considered when making a decision. As the speed increases, so does the complexity of the PHY. For example, 10GBASE-T PHYs are currently manufactured in 40 or 28 nm technologies and consume several watts. Implementing that PHY on the older nodes qualified for space use will most likely not be feasible. The development cost also increases with speed. Therefore, the selection of the PHY standards to implement for the space market needs shall weight both the speed and the cost/complexity.

The first standards (10BASE-T and 100BASE-TX) use only two pairs in half duplex mode. Therefore, there is no echo and no far-end crosstalk. This greatly simplifies the transceiver design. For 100BASE-TX the speed increase is achieved by using a larger transmission frequency and number of levels. In any case both standards can be implemented with a moderate cost on an old technology node. On the other hand, the 1000BASE-T and 10GBASE-T standards use the four pairs in full duplex. This means that the receiver on each pair needs to cancel the echo and the crosstalk from the other three pairs. Additionally, these two standards incorporate a more sophisticated coding scheme (Trellis Code Modulation in the first case and Multilevel Coset Coding in the second) that need complex decoders. This makes the implementation of the transceiver a challenging task.

II. A European Ethernet transceiver for space: SEPHY

The Space Ethernet PHYsical layer transceiver (SEPHY) project funded by the European Union Horizon 2020 research program, is currently developing a radiation hardened PHY. The availability of a European PHY is key to ensure that access to the PHY is not restricted by the United States International Traffic in Arms Regulation (ITAR) and the Export Administration Regulation (EAR), and as a consequence, the non-dependence for the European space industry is guaranteed. The goal of the project is to deliver a production-worth PHY in 2017.

The technology selected to implement the SEPHY device is Atmel´s 150 nm Silicon On Insulator (SOI), as it provides a sufficient level of radiation tolerance that qualifies it for space applications. It is also the same technology for which other European Ethernet components are being developed in the FLPP3 Time-trigered Ethernet Space ASIC project.

The project consortium is formed by different European companies and research centers led by Arquimea that will develop the analog components. IHP will focus on the digital design and Universidad Antonio de Nebrija on the verification. Atmel will be in charge of the fabrication of the integrated circuits. Finally, TTTech and Thales Alenia Space Spain will integrate and test the silicon prototypes on a network and perform also radiation testing.

The project targets the implementation of the 10BASE-T and 100BASE-TX standards. This will provide 10Mb/s and 100Mb/s connectivity in space systems. This compares to the solutions currently used in the space domain like the Mil-Std-1553B (low data rate, large cable length) or SpaceWire (high data rate, short cable length). The proposed transceiver will meet the cable length (100m) and data transfer (100Mbps) requirements not only for launchers applications where cable length is the main constraint but also for the onboard communication requirements where high data rate is required. Those standards can be likewise implemented with a reasonable cost and provide a solution to the industry needs in the short term. The development of a 1000BASE-T PHY would imply much larger cost, time and risk and could jeopardize the adoption of Ethernet. Additionally, starting with lower speeds gives the opportunity to the new standards being developed to mature potentially providing more choices for the second generation of SEPHY. In fact, the project also includes a roadmap activity to identify the best alternative for a second generation of SEPHYs. This will target at least 1Gb/s and its feasibility will also be studied and linked to the future technology nodes planned for space devices.

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