CAN bus solutions for Data Handling Space Systems

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Introduction

This paper presents the on-going activities and solutions related to the development, research and standardization processes of the CAN Bus solutions carried out in European Space projects and studies where Thales Alenia Space Italy (TAS-I) is leading the industrial activities in collaboration with the European Space Agency. The goal of these activities is to improve the design and the implementation of the on-board Data Handling System by a modular satellite architecture based on Controller Area Network (CAN) providing in such a way an effective improvement with respect to the currently adopted communication buses.
The CAN communication bus has been successfully used for many years in automotive industry and its usage in space is being assessed and one implementation is already the baseline in the EXOMARS (Entry Descent & Landing and Rover Modules) avionics architecture.
The improvements and application to other Space systems such as Telecom Satellites have been studied and are under definition in the frame of ESA study and in Thales Alenia Space R&D activities.
Further, CAN bus for Space Applications is in the process of being standardized in a specific ECSS standard.

Spacecraft Command and Control Bus

Conventional space borne controls are based on Centralized Control systems where a single central control unit is responsible of controlling the application tasks and performing data management, resulting often in high performance requirements for the CPU.

Another downside of the current systems is the physical concentration of I/O interfaces which often results in a great amount of wiring and connectors with the associated impact on reliability, tests and maintenance.

Currently serial communication standards used for space are mainly based on MIL-STD-1553B and RS-485 which provide a communication paradigm based on Master/Slave or Client/Server configuration. In the case of MIL-STD-1553 the master/slave paradigm makes more complicated to handle the redundancy mechanisms as it is prohibited to have more than one master on the bus.
Also, in applications where power is a scarce resource (e.g. rovers) MIL-STD-1553 is a poor solution with a minimum power consumption of 2W per interface.

CAN is a vehicle bus standard designed to allow microcontrollers and devices to communicate with each other within a vehicle without a host computer. CAN is a message based protocol, designed specifically for automotive applications but also used in other areas such as industrial automation and medical equipment.
In Space CAN would allow scalable bus architectures with reduced power consumption, wiring harness and engineering effort and would also increased functionality, reliability, observability and controllability.

CAN solution for Space

The solutions based on CAN bus technology have been widely experienced already in the ESA ExoMars program, facing and solving issues which have not been treated before in and European project and allowed TAS-I to acquire a great competence in this technology and to lead studies and internal R&D aimed at extending the applicability to other space applications.
The activities performed have covered all levels of engineering, from the most abstract layers (design of CAN applications for space vehicles, identification of CAN mission requirements) to the lowest ones (study of RS485 transceivers performances, implementation and testing of the designed solutions), spacing from Hardware (specification of the CCIPC core and support to its development and test, integration of the core in AMBA SoC) to Software (TM/TC exchange procedures, first CAN real-time applications through RASTA boards). Although these activities have always been treated as separated they have been affected each other, by using the progressive outputs of each activity to tune the current results of the other ones.
In the frame of ExoMars program, the first steps of the CAN integration have dealt with the collection of the mission requirements for the Rover/EDM modules and their harmonization with the capabilities offered by the CAN technology, together to the CANopen protocol. It has to be underlined that the CAN integration has been performed for both platform and payload buses, which have shown very different characteristics in terms of type of data exchange and bus load. However, the wide range of CANopen functionalities has allowed covering the demands of both buses.
Concurrently, the CAN development environment has been setup and the first designed CAN solutions were implemented in order to verify their feasibility. The development tools available from the automotive industry have demonstrated flexibility to be adapted to specific space application features like the ExoMars redundancy management scheme (two redundant RS485 transceivers + one CAN controller) which has been implemented in both fully SW and HW-in-the-loop simulations.
The design phase regarded also with the identification and specification of the TM/TC protocol exchanged over CAN bus, verifying the proposed solutions in the CAN development environment. This specification has taken into account also of the results coming from a preliminary analysis of two commercial CANopen SW stacks, which were ported under the RTEMS real-time operating system and tested via RASTA boards. The CPU performances vs CANopen functions trade-off has been crucial to prefer some CAN solutions compared to other ones. Parallel to the CAN requirement refinement, TAS-I has faced the development of the CANopen Controller IP Core (CCIPC) which implements in Hardware all the ExoMars CANopen functions. This IP core has been developed in collaboration with SITAEL Aerospace which has been designated to develop the VHDL code of the core.

The experiences gained with the ExoMars program have been very useful for SATCOM applications in the frame of the CABCOM study (currently ongoing in TAS-I). The objective of this activity is the development of a ‘CAN solution’ to be used in platform and payload avionics of telecom satellites. The proposed CAN solution covers all the aspects related to the introduction of the CAN bus in telecom satellites, from the physical and protocol layer definition up to the test and validation procedure definition. A breadboard system fully representative of the electrical architecture proposed for CAN, with both RS-485 and ISO transceivers, representative redundancy, data traffic, noise and faults injection capability will be developed allowing pre-qualification of the CAN solution proposed. At the end of this study, the achieved results will represent the technical proof that a CAN SATCOM solution is feasible and it will be able to lead to money and time savings, bringing benefits in all engineering steps of the DH system development from design, integration up to verification.

Conclusions

The CAN study, development and validation activities performed in TAS-I have demonstrated that the CAN bus is an effective solution for the implementation of a European, low power and reliable, platform and payload serial data line for both scientific and SATCOM mission.

This result is taken into account by ESA and drives the standardization process which will result in ECSS-E-ST-50-15C and will contain all services and recommendations to cover the peculiarities of our specific applications. TAS-I is in fact active member of the ECSS-E-ST-50-15C working group since 2009 and, with its competencies in CANopen development for space applications, is responsible of the standard section dedicated to the protocol specification. Several other initiatives have been planned by ESA to complete in 2014 the standardization of the CAN bus and in particular of a space qualified ISO11898 transceiver.