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Broadband system to increase bitrate in train communication networks

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A B S T R A C T

MVB (Multifunction Vehicle Bus), defined in IEC 61375, has been broadly adopted as the communication standard between embedded control systems on-board modern trains. In this work a new method to take advantage of the full bandwidth of the channel using an OFDM technique is described. With this new method it is possible to share the physical medium between standard MVB traffic and new OFDM traffic. A 90 Mbps theoretical bitrate can be achieved. The results of this work have been validated in a test bench including standard MVB nodes transmitting on a line similar to a real vehicle bus.

Contents

1. Introduction

Several factors drive the installation of new communication systems on-board trains: investment by companies and governments facilitates the development of new systems; furthermore, the rapid advances of the technology, the social adoption of the information and communication technologies (ICT) and the demand for new services by users in the railway sector have led to the installation or redesign of new on-board communications systems.

In recent decades, railway operators planned to develop a modern and versatile communication system on-board trains. The objective was to allow the interchange of information between different sets of equipment embedded in a train. In addition, it was necessary to unify an interface between devices, so that vehicles developed by different manufactures could interact in the same network.

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Table 1
Comparison of industrial buses

Bus	Bitrate [Mbps]	Physical medium	Audio/video	Advantages	Disadvantages
LonWorks (ANSI/EIA-709)	0.078	Twisted pair	No	Established. It is used by NYCT and others	Low speed. No audio. No video.
TCN (IEC 61375)	1 1.5	Twisted pair Optical fibre	Low bitrate audio	Promoted by Siemens and Adtranz	Not extensible. No audio. No video.
AS-5370	5 1.25	Twisted pair Optical fibre	Audio	Derivate of LonWorks	Requires a license
E1 PDH (UIT G.732)	2.048	Twisted pair	Audio	Established. It is used by NYCT	Not extendible
WorldFIP (EN50170-3)	2.5	Twisted pair Optical fibre	Audio	Promoted by Alstom	Proprietary components
Ethernet (IEEE 802.3)	10	Coaxial Twisted pair	Video	Difunded	Requires couplers. Not deterministic
Profibus (IEC 61158)	12	Twisted pair Optical fibre	Audio and video	Very fast	Requires couplers

At the end of 1988, the International Electrotechnical Commission (IEC) and the Union Internationale des Chemins de fer (UIC) began to develop an international standard detailing all requirements for the communication process of all on-board equipment. The major requirements of this development are:

- Interoperability at train level to allow communication between railway vehicles of different countries.
- Interoperability at vehicle level to allow communication between devices of different manufacturers.
- Improvement in the operation and introduction of new services.
- Support for configuration and maintenance and a general cost reduction in the life-time of products.

After ten years of work, the IEC 61375-1 or Train Communication Network (TCN) was obtained [1]. Different European projects for its validation and standardization have been carried out around TCN. ROSIN (96-99) (Railway Open System Interconnection Network) [2,3], TrainCom (00-04) (Integrated Communication System for Intelligent Train Applications) [4,5] and EuRoMain (02-05) (European Railway Open Maintenance System) [6,7]. Finally, in October 1999, in Kyoto (Japan), TCN achieved the state of International Standard as IEC 61375-1. Later, the IEEE Vehicular Society included TCN in its IEEE Standard for Communications Protocol Onboard Trains, as P1473-T.

In spite of the increasing use of TCN in communications on-board trains, there are other communication standards that perform the same functions, like LonWorks (ANSI/EIA 709) [8] and Profibus (IEC 61158-3) [9]. Table 1 [10] shows others industrial communication fieldbuses used for interconnecting embedded systems on-board trains.

In recent years, the limitations of TCN have been detected. This bus was designed as a real time bus for control and supervision purposes. These applications typically require a low bandwidth, so that the bus was designed with a bitrate of 1.5 Mbps. But today, the users and operators of railway systems are demanding new services, like new embedded control systems, digital audio, video-surveillance and user information, with more bandwidth requirements. The solution, a priori, is the installation of new wiring for these new systems. Nevertheless, the installation and maintenance costs grow rapidly. This paper presents an approach using a similar solution to others sharing techniques like PLC or ADSL. The solution shares the physical wire used by TCN with a high frequency channel using an OFDM technique. Bitrate increases to several Megabits per second.

The paper is organized in four sections. After this introduction, Section 2 briefly reviews the norm IEC 61375 on Train Communication Network and other standards used in train networks. The following section describes the communication system proposed, introducing the OFDM architecture. Section 4 describes the prototype used for system validation. Finally, the last two sections present results and the conclusions.

2. Standards discussion

This section describes several industrial fieldbus standards used to support broadband communication between electronic embedded systems in train vehicles. In addition, Table 1 synthesizes and compares these and others standards.

2.1. EIA-709 (LonWorks)

EIA-709 and IEEE 1473-L, known as LonWorks, specifies the physical layer LON (Local Operating Network) and the LonTalk communications protocol. This standard supports control systems by means of a point to point network in a hierarchical structure (master-slave). Interoperability is allowed between different manufactures and good results are obtained. Nevertheless, maintenance and modification are expensive and difficult in these networks.

LonWorks is used in multiple industrial applications, for example in Amtrak's Acela Express [11]. The main disadvantages of this network are the low bitrate of some kbps, and the fact that it is a non-deterministic network, which does not allow the system to function in real time.

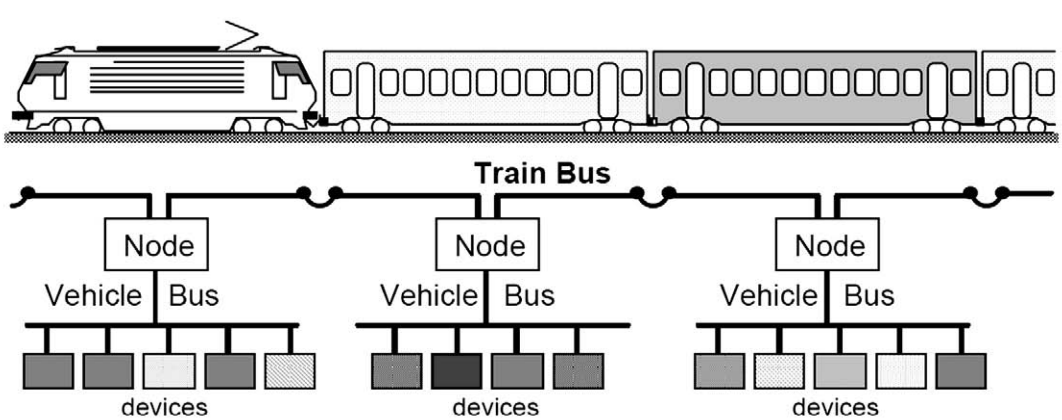

Fig. 1. TCN buses architecture.