Intercom Systems in Combat Vehicles (R)evolution

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Abstract. The paper deals with the intercommunication system in combat vehicles. First of all is shown the basic definition of these intercoms and the characterization of the vast majority intercoms' features. Further is defined the VETRONICS concept. The main part of the paper deals with the design and complete simulation of the new concept of VETRONICS Interoperability Intercom System for combat vehicles called VI2C which interconnects a soldier system and other systems with the communication gateway of the vehicle (this gateway includes intercom and data services). Complete system is based on only one multifunctional unit. This unit can be configured by its firmware to fulfill the needs of the latest combat vehicles allowing the number of crewmen and radios, functionality and adaptability to be tailored to the required environment. VI2C provides vehicle diagnostic connection, access to public telephone lines for voice/data connectivity and integration with a wide range of data terminals, battle managements systems, tactical radio, local area networks, sensors, navigation systems as well as video and audio ancillaries (voice recording, alarms, etc.). The main idea of that next generation system, the basic unit and its selected functions are going to be briefly described in this paper.

Keywords: CAN; Combat Vehicle; Data Bus; Data Communication; Ethernet; FlexRay; Intercom; VETRONICS.

1 Introduction

Intercom (Inter Communication system) used to be a stand-alone voice communication system that operated independently of any other communication network. It is a device designed for voice and lately also for data communication used by a crew of combat vehicle. The task of intercoms used in combat vehicles is to ensure rapid, safe and clear communication inside and outside of such vehicle. Intercom system consists of various types of boxes (units) and accessories accessible to crew members.

Original intercom systems for voice transmissions inside combat vehicles were only analog without possibility of additional data transfers. Later, these analog systems were replaced by digital ones, which are able to transport both a digitized voice and data. Currently, the data throughput of digital intercoms is usually limited to a maximum of 64 kbit/s, which is fully sufficient for clear digitized voice

communication, however for the transmission of additional data means considerably limiting factor (additional data can include information or warning signals, commands, video, data from sensors, location information, etc.). Table 1 summaries the main communication features of the vast majority intercoms.

Table 1. Summarization of analyzed intercoms features.

Features / Intercom	Digital voice transmission	Communication record	Data transmissions	Data transmissions above 16 kbit/s	Data transmissions above 64 kbit/s	IP / Ethernet	Interoperable	VETRONICS compatible
R-120/124/174	✗	✗	✗	✗	✗	✗	✗	✗
AN/VIC-1, AN/VIC-2	✗	✗	✗	✗	✗	✗	✗	✗
BCC 600	✗	✗	✗	✗	✗	✗	✗	✗
VIC-3 (ROVIS, AN/VIC-3)	✓	✗	✓	✗	✗	✗	✗	✗
LV2	✓	✗	✓	✗	✗	✗	✗	✗
VIC-5 (TacG2, G2, AN/VIC-5)	✓	✓	✓	✓	✓	✓	✓	✗
SOTAS M2	✓	✓	✓	✓	✓	✓	✓	✗
FONET	✓	✓	✓	✓	✓	✗	✗	✗
RF-7800I	✓	✓	✓	✓	✓	✓	✓	✗
ICC-201, ICC-251	✓	✓	✓	✓	✓	✓	✗	✗
TADIRAN VIC-500	✓	✓	✓	✓	✗	✗	✗	✗
WiSPR	✓	✓	✓	✓	✓	✓	✓	✗
VICM 100	✓	✓	✓	✓	✗	✗	✗	✗
VICM 200 Combat	✓	✓	✓	✓	✓	✓	✓	✗
VI2C	✓	✓	✓	✓	✓	✓	✓	✓

Combat vehicle systems process huge amount of data that can be provided to each other or this data can be also stored in the board system memory, which is assessed after the end of a combat action. Modern communication devices (intercoms) inside combat vehicles are a part of the whole system of electronics, part of on-board system architecture specified by the principles of VETRONICS (Vehicle Electronics Systems). The multimedia transmission network is built in the vehicle within this architecture. This network should be capable of transmitting audio, video or other

data signals to the crewmen and it enables efficient driving and conducting combat operations. The partial aim of the research is to design data communication through suitable data buses such as Ethernet, CAN and FlexRay, MOST, respectively RS-232 – this system is named VI2C (VETRONICS Interoperability Intercom).

VI2C is designed as fully programmable digital communication system that incorporates a new philosophy in vehicle and inter-vehicle communication. The VI2C forms a fully scalable voice and data communication platform, offering voice for inter-vehicular communication, data information exchange services over standard physical interfaces as well as flexible control of external communication with interfaces to external tactical, public and automotive networks.

2 Vehicle Electronics System (VETRONICS)

Military vehicles include numerous electrical and electronic systems that are controlled and monitored by the crewmen. In current vehicles voice communication, system control and monitoring are facilitated by standalone user interfaces that are specific to an individual subsystem. As vehicles became more complex, the number of standalone controls and displays has increased. Combat vehicles also include a variety of optical systems, which are used by the crew for driving, local situational awareness, surveillance and for target acquisition. Furthermore, recent net-enabled operations allow a considerable amount of information in relation to the crew's environment (for example own vehicle position, system status, contact detection, etc.) to be available through both internal and external sources. Net enabled operations also allow information to be available to dismounted crew, other nearby vehicles, and the Command and Control (C2) system [1], [2]. Modern vehicle systems integration (VETRONICS) is based on distributed control, network sensors and communication systems which provide the ability to integrate all vehicle functions through a common Operator Machine Interface. This interface is also exploited to support other combat functions including communication, commands and control.

So, VETRONICS is the integration of all electronic components and subsystems architectures inside combat vehicles. This is a combination of several layers of electronic systems (weapon systems, fire control system, reconnaissance equipment, protective systems, navigation, communication system, etc.) through a single data bus (as a backbone bus is recommended Ethernet).

3 Military Vehicle Internal Communication System

An internal communication system (an intercom) inside combat vehicle used to be stand-alone voice communication system that operates independently of any other communication network. Nowadays, it is a device designed for voice and data communication among vehicle crewmen and other combat sections. A purpose of intercom system used in combat vehicles is to ensure safe and clear communication inside and outside of such vehicle. Current intercom systems consist of different types of units and accessories.

The modest intercom system should be a part of the whole system of vehicle electronics, part of complex airborne system architecture specified by the principles of VETRONICS. Within this architecture a multimedia transmission network should be built in combat vehicle, it should be used to transfer text, audio, video and other data signals to enable effective management of crewmen and vehicle combat operations. The basis of all modern combat vehicles is ensuring reliable communication and data transfer between the modules, units, devices and subsystems. It is possible through the data buses. There are numbers of buses used in combat vehicles.

For that huge system, like multimedia network inside combat vehicle, it is suitable to use an existing local area network (LAN) architecture based on Ethernet bus. However, the internal communication device should be able to stand separately in the system – for example, when it is incorporated into an older vehicle without implemented LAN architecture in case of partial modernization [3]. When the intercom is a part of vehicle electronics it is also profitable to use other buses than Ethernet – almost every modern combat vehicle is equipped by CAN bus, eventually FlexRay bus [4]. These buses can be used for direct communication through them or as a reserve solution when the primary bus is broken. They can be also used for automotive diagnostic purposes.

Presented system of internal communication VI2C (Fig. 1) is a part of VETRONICS. The system is based on only one universal unit. As a primary bus is used Ethernet, reserved buses are CAN and FlexRay. For data radio connection is used serial RS-232 interface.

3.1 Designed and Simulated Intercom

The whole intercom system VI2C was simulated in the software CANoe (from Vector Informatik GmbH). CANoe supports three phases of the development process, ranging from simulation of the entire network and remaining bus simulation to analysis of a real network. This requires all control units in the network to be integrated as network nodes in the simulation setup. The bus communication is defined via integrated databases (for example DBC, XML) [5], [6]. In CANoe different options are available and they may be used in any combination for the different bus systems – it supports all needed buses like CAN, FlexRay, MOST and Ethernet, respectively RS-232. The VI2C network topology was specified and the design was refined down to the level of the network nodes. All functions of intercom are represented by nodes connected to the desired network.

The emphasis in modeling lies in the description of the node‘s bus behavior (in CAPL language). It is also very useful to create “graphic panels” for both inputs and outputs from/to the buses. These inputs/outputs were interconnected with corresponding bus‘s messages to visual and analyze them. In addition to the voice (realized by VoIP) and data communication among crew members the designed intercom system is able to process signals originated by BMS (Battle Management System connected through Ethernet) and generate warning audio messages, it is also able to process OBD-II (On-Board Diagnostics) signals generated by vehicle electronics (connected through CAN bus) and generate appropriate audio warning

messages. The system is also able to forward the data to the other bus through implemented gateway.

Intercom unit allows data communication over Ethernet (primary and secondary network interface), CAN bus, FlexRay bus and serial RS-232 interface (additionally also MOST interface). The default method of communication is through Ethernet 1, but the user (or VI2C system automatically) can also choose a different offered data communication. The intercom system processes, manages and presents massive amount of data arriving from various sources like BMS, sensors, automotive diagnostic etc. into a user-friendly format (audio messages).

VI2C system is designed to support architectures and topologies scalable from a simple intercom system to a fully digitized voice and data communications platform with wireless and telephony extension, adaptable to any configuration and role required by combat vehicle, communication nodes and reconnaissance operations. The system's open architecture and flexible design allow expansion of VI2C system configuration and/or provisioning of additional services by software upgrades (or by simple addition of a new unit), without intervention in the previous hardware configuration.

Fig. 1. Design of a new intercom system

4 Conclusion

As results of this research are the design, simulation and implementation of a new concept of intercom system VI2C with higher data throughput incorporated into the VETRONICS. VI2C architecture requires no central unit and introduces an innovative decentralization mechanism of both control and switching operations,

increasing system availability. Based on modular and software-controlled design, the system can be configured in accordance to special combat vehicle requirements and allows the addition of various subsystems in a “plug and play” manner.

This software defined system uses digital audio signals to enhance speech quality and intelligibility (it converts analog voice and PTT from the radio to VOIP packets and conversely). The system also serves as an Ethernet switch to exchange IP frames between the soldier system, the radio, the other crew boxes, the vehicle interface (like BMS) and other communication buses – CAN, FlexRay and MOST. The system follows the principles of VETRONICS and it can also supply HUMS (Health and Usage Monitoring Systems) – due to the connection to above mentioned buses it can analyze measured parameters from various sensors through their signals and messages. Based on preset boundaries for measured parameters VI2C is able to play audio warning messages. VI2C can also partially replace whole BMS.

The aim of this paper was to show the first step in the design of that complex system – full / partial simulation. The modern intercom system is not just a device for voice communication inside combat vehicle among crew members. That system can be used as the central device inside combat vehicle which is able to integrate and manage all voice, video and other data communication inside and outside the vehicle, communicate with other combat vehicles and coalition forces, utilize or replace BMS or HUMS and collaborate with other elements of VETRONICS. The goal is to elevate the intercom system into the system capable of exchange any type of data.

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