# Multifunction Board Unit for Public Transport Vehicle

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*Abstract:* A discussed multifunction board unit is being developed for an use in public transport vehicles. It features multichannel acoustic outputs, RS-485 bus interface, IBIS interface, short-range 2.4 GHz communication, data/voice communication at frequency band of 160 MHz, ability to receive commands from sightless people transmitters, FLASH memory disk for data storage, inductive modem for automatic contact-less switch control and several inputs/outputs for generic use. The paper deals with software conception of designed unit based on single high performance signal microprocessor.

*Key-Words:* Multifunction board unit, Public transport vehicle, Inductive modem, FLASH disk, Short-range data communication, Radiomodem, Public transport board information system.

## 1 Introduction

The multifunction board unit is optimized for use in public transport vehicles equipped with information system that is controlled by a board computer by means of a RS-485 bus or an IBIS bus. Designed multifunction board unit extends such vehicle information system by following features:

- triple bus-stop independent digital announcement with special type of MPEG 2 compression,
- speech synthesizer,
- mobile radio equipment controller,
- 1200 Baud FFSK radiomodem,
- control unit for inductive modem,
- FLASH memory disk for generic data storage,
- short-range 2.4 GHz data communication,
- receiving of signalization from sightless people.

Fig. 1 shows the interconnection of the MBU with vehicle information system.

The core of the MBU unit is represented by single powerful digital signal microprocessor with instruction rate up to 700 MIPS.

The MBU is equipped with 128MB FLASH memory, which, besides other, serves as FLASH disk. The FLASH disk can be used by other vehicle devices for generic data storage. Primarily it is designed for possibility of FW update of board information devices, a board computer for example.

A 2.4 GHz communication module is used for short range communication. This communication enables wireless monitoring and configuring vehicle devices during vehicle parking in depot for example.

As plenty of public transport companies use for voice communication broadcast radios, the MBU unit implements software FFSK 1200 bps radiomodem that enables data communication using existing radios.

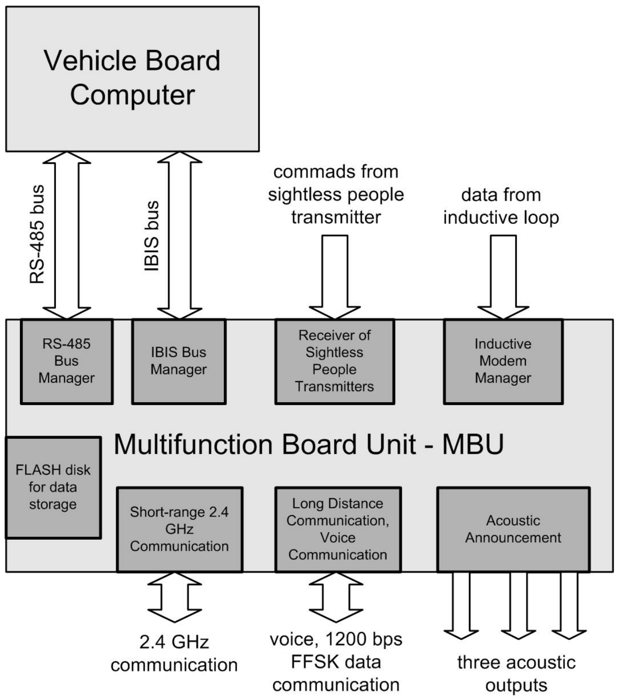


Fig. 1 Multifunction Board Unit features

The MBU supports communication via inductive loop. The inductive data transmission offers use for an accurate identification of position of municipal transport vehicle, for example.

Acoustic unit feature is used for bus-stop announcement inside vehicle and on demand announcement for outside sightless passengers. It performs signal reconstruction from compression speech signals for limited bandwidth channels from 50 Hz to 10 kHz. Now we use for high end quality announcement two method of speech compression:

- adaptive differential pulse code modulation (ADPCM) with 88 kbps bit stream or
- MPEG (near CD-ROM quality) with 45 kbps bit stream.

The implementation of ADPCM is based on the ITU recommendation G.721. Both methods have input speech parameters that are organized into 20-millisecond frames.

## 2 Software structure

Software solution of the MBU unit is based on multitasking RTOS (Real-time Operating System). Individual tasks in designed application are shown in Fig. 2 where they are called as "managers".

A software kernel has to use RTOS features as task's scheduling, priority system, memory and resource sharing and so on.

### 2.1 RS-485 Bus Manager

This task control communication over serial RS-485 interface. By means of this bus the MBU unit can communicate with other devices of vehicle information system. RS-485 bus manager uses (and is used by) other managers. For example, if the board computer wants to store data in MBU FLASH disk, the RS-485 manager control the communication with the board computer and obtained data shares with the FLASH manager that manages their storing.

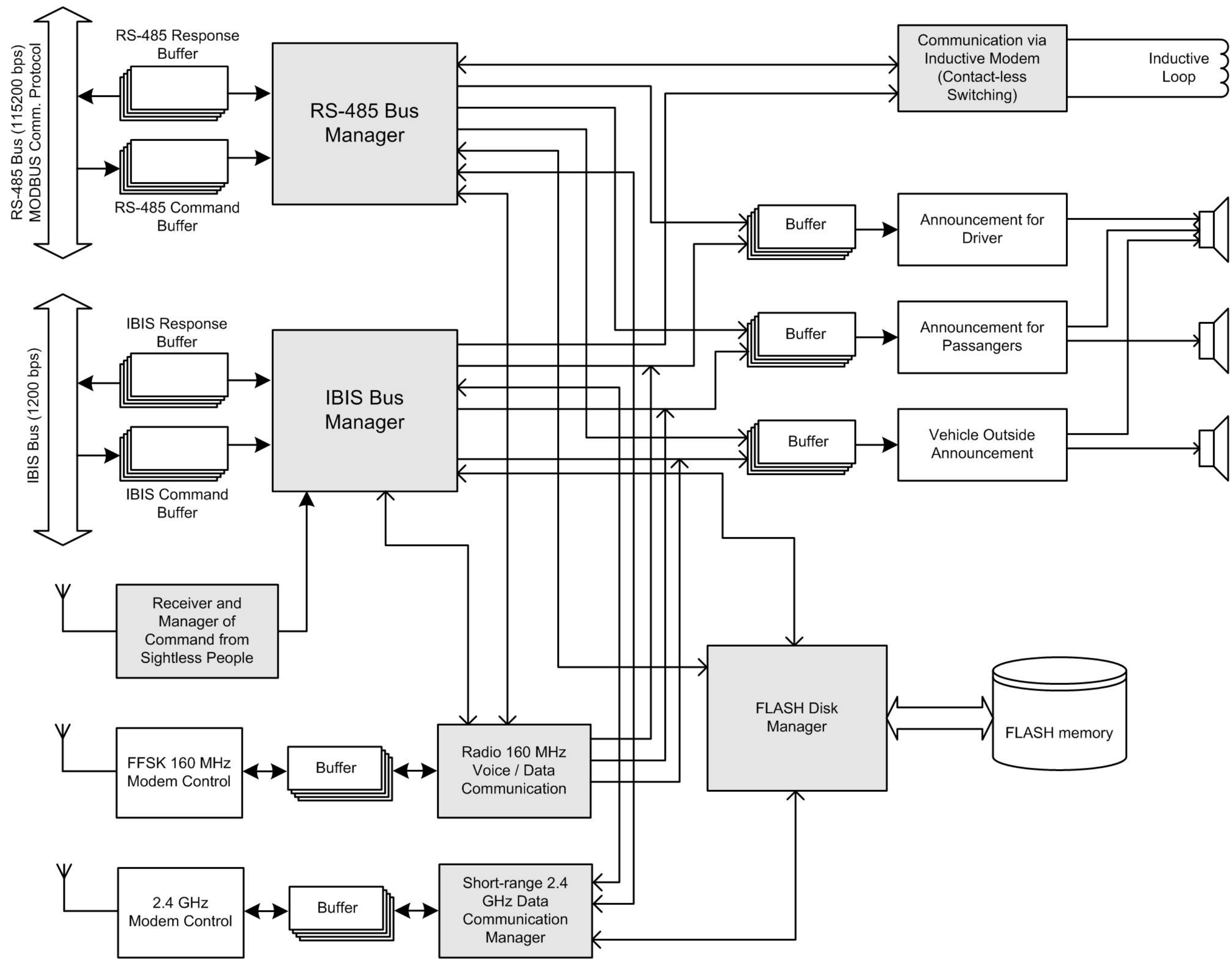


Fig. 2 MBU software block scheme

## 2.2 IBIS Bus Manager

It manages communication over serial IBIS vehicle bus and by way of other SW managers processes received commands, acoustic announcement, for example.

## 2.3 FLASH Disk Manager

The FLASH disk manager controls write and read operation to/from implemented FLASH memory. The manager offers to the other software parts functions for operation with files, such as create file, write and read file, delete and so on.

File manager is based on Intel Virtual Small Block File Manager (Intel VFM). It divides 64K words FLASH memory pages into 256 blocks, each consists of 256K words (Virtual Small Blocks) and provides numbered logical blocks, which are possible to allocate, write, read and release independently on their physical placing. It also must ensure recovery after system reset. Each disk partition can be formatted so it consists of up to 2048 blocks, it means 1MB.

A file system driver operates over VFM manager. A file is formed from a chain of virtual blocks. 6 words from each block represent file system overhead. One word is reserved for file name. (It is not possible to use classical 8+3 chars file name). It is possible to move in file word by word in read mode. In write mode the data can be appended to the file end only.

## 2.4 Short-range Data Communication

The wireless data transmission (between a vehicle and some kind of base station - BS) is practically realized with using of low-power consumption and low-cost transceivers, which operate in the 2.4 GHz licence-free frequency band. Data rate between the BS and the vehicle is given by used transceivers. We will assume the effective data rate of 115200 bps (the real data rate of the radio interface is severalfold greater).

All base stations and mobile stations (vehicles) use only one data channel. The communication is a Server-Client architecture. Communication is possible between a Server and a Client but not between a Client and Client or Server and Server. In our network the base stations are Servers and the vehicles are Clients.

The short-range data communications can be used for following tasks:

– Data transmission to vehicle: database of vehicle's time table, FW update of vehicle information system devices (including board computer), database of indicator panels.
– Data transmission from vehicle: information of vehicle day statistic, monitoring of actual vehicle device configuration, monitoring of number of vehicles in individual park depots.

## 2.5 Long Distance FFSK Data Transmission

The mobile radio station modem use for modulation the Fast Frequency Shift Keying (FFSK). The coding modulation scheme is software implemented. FFSK modem is especially suited for software decision encoding and decoding algorithms. The communication protocol multiplexes control information and errors protect data by the cyclic redundancy check (CRC). This protocol (MPT 1317/1327) is described in [7]. This modem is designed for the semi-duplex mode in operation. Control information are use as digital selective and group calling and for exchange state message. Generating polynomial is:

$$x^{15} + x^{14} + x^{13} + x^{11} + x^4 + x^2 + 1$$

Then it takes the 15-bit remainder from the polynomial divider, inverts the last bit and ap-pends en even parity bit generated from the initial 48 bits and the 15 bit remainder (with the last bit inverted). This 16-bit word is used as the "checksum".

The system can work as private mobile radio (PMR) [8]. The digital signal processing do, amount others, following:

– Integrated sub-audio tone filter by Continuous Tone Controlled Squelch Systems (CTCSS).
– Emergency tone for passengers and dispatcher.
– SW implemented correction of signal.

## 2.6 Inductive Method Communication

Inductive wireless data communication is primarily designed for the transmission of short protected data messages between a moving vehicle and a stationary device using the inductive method in the frequency band from 65 to 135 kHz. The data transmission operates on the basis of electromagnetic induction.

In the proposed inductive transmission system we have used the synchronous data transmission organized into short data frames. The data frames have to preserve the following criterions in order to obtain the reliable data transmission in mobile applications between a vehicle in motion and the stationary device:

– Each frame starts with a 8bit synchronizing sequence of "01010101b" that serves for bit synchronization of the transmitting modulator and the receiving demodulator.
– An 8 bit start mark "01111110b" follows the synchronizing sequence. The start mark serves as unique identification of the frame start.

- The data transmitter ensures a bit transparency that prevents the presence of the start mark “01111110b” inside the frame.
- The frames are as short as possible, consisting of the necessary number of information bits and protection bits.
- Data protection of information bits is at least 12 bits (CRC12) generated by polynomial $x^{11} + x^4 + x^3 + x^2 + 1$, it has no ability to correct error bits (self-correcting code causes unacceptable redundancy).
- The frames are transmitted in fast succession; there is no time delay between the frames.

It is sufficient to transfer 36 information bits in our tested experimental application, so the structure of this frame is shown in following Fig. 3.

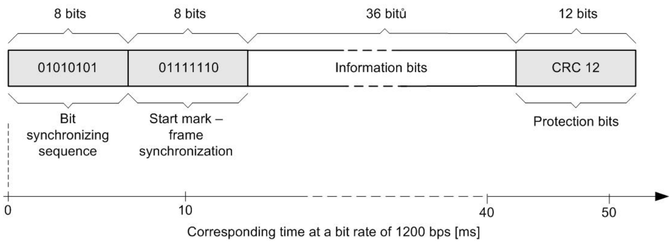


Fig. 3 Example of suitable structure of the data frame

The inductive data transmission offers use for an accurate identification of position of municipal transport vehicle or it can be the basis of the contact-less point setting., for example.

## 3 Conclusion

Designed multifunction board unit integrates features that rapidly extend functions of vehicle board information system. Enables wireless communications with vehicle and manages acoustic announcements for inside and outside passengers. At present time we have done functional prototype powered by ADSP Blackfin535 powerful microprocessor and we are going to do optimization of individual communication parts.

We want to design communication protocol for massive data transmission via short-range 2.4 GHz interface to be able to reprogram many vehicles staying in depot simultaneously.

Generally speaking, a product design was constrained by more of the following key design goals, not necessarily with equal importance:

- Power consumption (green solution).
- Upgradeability and flexibility (longer product cycles).
- Cost of product (multiple nodes of operation).
- Cost of design (was designed universal hardware).

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