Telemetry over TETRA Network

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Abstract: Many applications are suitable for wireless data telemetry. This paper presents a solution for a public alarming and temperature supervision telemetry system using TETRA network as a platform. The telemetry system includes a control centre, a pilot TETRA network, and a telemetry unit consisting of a telemetry server, a microcomputer, an alarming device and a temperature sensor. The described application will be implemented in near future into the new integrated information and communication technology platform for civil protection and disaster relief in the Republic of Slovenia.

Key-Words: Wireless Telemetry System, TETRA, Short Data Service, Microcomputer, MPIC

1 Introduction

Traditionally, telemetry systems have been used for remote data acquisition and control.

System devices are usually placed on different remote locations away from a control centre. To connect individual elements of the system, wired or wireless communication links are used.

There are many distributed control systems suitable for wireless telemetry such as automated systems in factories, building access, remote monitoring, security and alarm systems, health care applications and inventory management systems. For a reliable and secure communication between distributed measurement and control devices and a centralized control centre, professional digital communication system offers adequate solution.

In this paper, telemetry systems and the digital wireless communication system TETRA are briefly described at the beginning. The paper continuous with the presentation of a telemetry system which is capable to control remote alarm devices and transmit temperature measurement data from the remote sensor device to the control centre using pilot TETRA network consisting of a digital exchange, two base stations, and mobile terminals.

TETRA is a global standard for professional radio communications with distinct features such as fast call setup, group call, call priority, direct mode operation, etc. TETRA was developed to meet the needs of the most demanding professional radio users like police, fire and rescue teams, army, etc.

TETRA is the only European standard for digital Professional Mobile Radio (PMR).

2 Wireless Telemetry

A typical wireless telemetry system [1] includes three basic processes:

- data acquisition; a process where physical data stream is sampled and the required parameters are measured,
- wireless data transmission; deals with packaging and wireless data transmission,
- data storage and analysis; deals with storing and analyzing of received data in the control centre.

A telemetry unit and a control centre are two basic components of a classical telemetry system. The telemetry unit is placed on a remote location. It is usually connected by a wireless radio link to the control centre. The telemetry unit collects measurement data from external sensors and transmits them to the central control centre over the wireless network. The received data in the control centre are processed by a special telemetry application program. Based on the results of the analysis, control information is transmitted back to the telemetry unit over the same wireless network. According to the received commands, the telemetry unit controls external appliances such as relays, valves, motors and pumps.

In our application the professional mobile radio network TETRA was chosen for transmission of measurement and control data between the remote telemetry unit and the control centre. In the TETRA network status service, Short Data Service and IP packet data service are used for data exchange.

Wireless network is simple to install, low in cost and widely accessible.

2.1 Benefits

Compared to wired telemetry, wireless telemetry has several advantages such as improved mobility, simple installation, easier extension and reconfiguration.

Data processing is typically handled by a centralized data acquisition and control application, which leads to the fact that the telemetry units are less complicated and consequently cheaper. This is especially important for systems with great number of telemetry stations.

Besides that, elements of wireless telemetry system can be implemented also in moving vehicles.

2.2 Applications

Application areas for wireless telemetry and control are diverse. In an industrial environment, telemetry is used to measure and control temperature, pressure, humidity or liquid level. In transportation, telemetry enables traffic control, fleet management, traffic measurement and variation of message signs. Telemetry can be used for environmental monitoring such as weather monitoring, seismic monitoring, flood prevention, irrigation control and remote supervision of fire. It can be used also for heating, ventilation and air conditioning control. Emerging telemetry applications in energy management are reducing electricity, water and gas consumption. Other important applications are related to life safety monitoring and health care.

3 TETRA

Terrestrial Trunked Radio (TETRA) [2, 3] is a digital trunked mobile radio standard developed by the European Telecommunications Standards Institute (ETSI).

The TETRA standard has been developed to meet the needs of wide variety of traditional PMR user organisations. It has a scaleable architecture, allowing economic network deployments ranging from single site local area coverage to multiple site wide area national coverage.

The performance specifications are optimised for operation between 150 MHz and 900 MHz.

The spacing between TETRA carriers is 25 kHz. Each carrier provides four independent physical channels by use of Time Division Multiple Access (TDMA) technique, which divides carrier into four time slots. The $\pi/4$-DQPSK modulation scheme was chosen to support a gross bit rate of 36 kbit/s, which means that net data rates up to 28.8 kbit/s can be supported for some data applications.

The TETRA system was designed for reliable, spectral efficient and safe voice communications and data transmission.

In the TETRA Release 1.3 standard, two operating modes are defined:

- Voice and Data (V+D); enables basic Trunked Mode Operation (TMO),
- Direct Mode Operation (DMO); enables direct communication between radio terminals.

In addition to voice communication services, TETRA V+D mode provides three different data transmission services:

- Short Data Service (SDS),
- Packet Mode Data,
- Circuit Mode Data.

Short Data Service provides point-to-point and point to multi-point connections for sending short data messages which are 2, 4, 8 or 256 bytes long. This service is suitable for low data rate applications such as telemetry [4]. Short messages comprise status messages with predefined meanings, and user data messages carrying arbitrary user-defined data. This service is supported on the TETRA control channel.

Packet Mode Data Service is a fully featured packet data service suitable for IP traffic. It supports packet data transmission in either Connection Oriented or Connection-less configurations. The single channel gross bit rate is 7.2 kbit/s while the net bit rate is about 3-4.5 kbit/s, which is sufficient for applications like Automatic Vehicle Location (AVL), WAP and e-mail. For more demanding applications such as image transmission and slow-rate video, compression algorithms must be used. To increase the transmission rate, multiple-slot Packet Data service can be used, which has some drawbacks such as increased power consumption of mobile devices and reduced availability of resources for voice communication.

In the case of the Circuit Mode Data service, a fixed data communication channel is established between two points. The data rate depends on the level of error protection coding as shown in Table 1. Up to four time slots can be assigned to a single data connection. Since data transmission is normally bursty by its very nature, this mode can be quite inefficient from the channel usage viewpoint.

Table 1: Data rates for Circuit Mode Data Service

error protection	transmission rate [kbit/s]			
	1 slot	2 slot	3 slot	4slot
high	2,4	4,8	7,2	9,6
medium	4,8	9,4	14,4	19,2
low	7,2	14,4	21,6	28,8

To increase data rates, ETSI defined TETRA Enhanced Data Service (TEDS) as a part of TETRA Release 2 standard which contains specifications for improved air interface, speech coding, interworking, roaming and development of the USIM module. TEDS offers higher data rates up to 150 kbit/s, however it needs significantly more radio spectrum and wider channels than TETRA V+D.

TEDS is particularly suitable for telemetry applications such as delivery of medical telemetry from the patient to the hospital and for vehicular telemetry. It is also convenient for general file transfer, transfer of photographs, maps, images and video.

4 Pilot Wireless Telemetry System

A pilot wireless telemetry system that can be used for civil protection and disaster relief applications is shown in Figure 1. It consists of three parts, namely a control unit, a TETRA network and a telemetry unit.

The purpose of the presented telemetry system is to demonstrate and validate two telemetry functions. The first one is wireless transmission of temperature measurement data from a sensor device over the TETRA network to the control centre where they are stored and analysed. The second function is to send warning danger messages to activate the public alarming system. The warning system corresponds to the type of threat. Recently, the Slovenian government introduced new unified alarm signals for the danger of high water levels, fire, and environmental or other disasters.

Activation and deactivation of the alarm device in the telemetry unit is controlled from the control centre. The control signals are sent over the TETRA network.

The telemetry unit consists of a communication modem, a personal computer with a program application, and a simple MPIC microcomputer with a proper program application for sensor device and alarm system operation.

4.1 TETRA Network

The pilot TETRA network which is used in our telemetry system consists of one digital exchange, one mobile and one fixed base station, one dispatcher workstation and several mobile stations.

In the TETRA network, Short Data Service is used for the transmission of measurement and control data. Particularly, the SDS type 4 service is used, which allows user defined data with a variable length of up to 2047 bits. Short Data Service – Transport Layer (SDS-TL) service is a derivative of the SDS type 4 service and is particularly suitable because it ensures interoperability between various applications.

The mobile terminal on the remote site serves as a modem and presents a link between the TETRA network and the telemetry unit, composed of a personal computer and a microcomputer. The telemetry unit receives data from the control centre over the TETRA network and sends measurement data from the sensor to the control centre.

The microcomputer and the TETRA mobile station are connected to the application computer via serial RS232 interfaces.

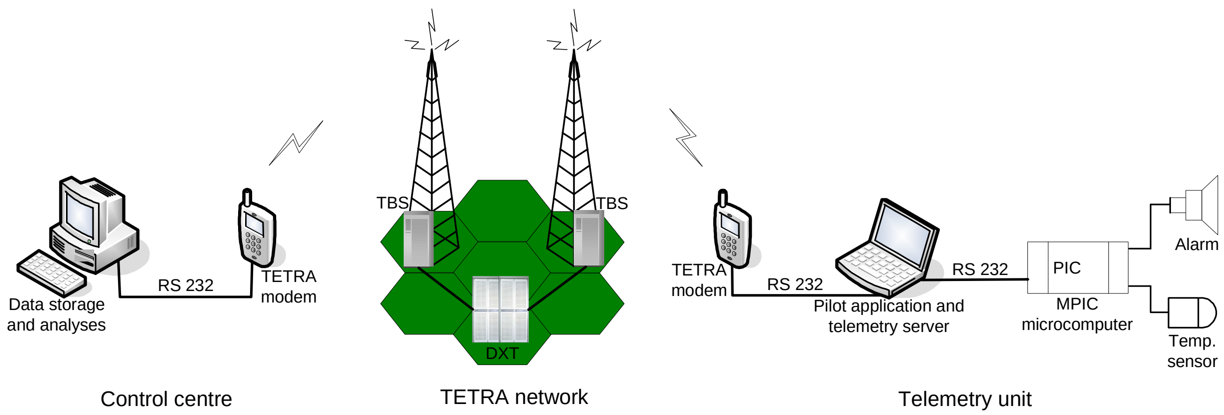

Fig. 1: Pilot wireless telemetry system

4.2 Pilot application

The pilot application is running on the personal computer although it could be implemented directly on the microcomputer.

The user interface of the pilot application is written in Visual Basic and is shown in Fig. 2. The pilot application performs two tasks:

- triggering the alarm for a predefined duration of time, which is demonstrated by turning on and off a LED connected to a microcomputer output,
- temperature measurement and transmission of measured values on demand, or automatically in the case that the threshold values are exceeded.

Temperature measurements and alarm control signals are initiated by predefined keywords that are sent as SDS messages from the control centre.

In case of alarming situations, various warning or danger signal are sent from the control unit to the alarm device. The signals are predefined and may cause longer or shorter steady or variable siren tones.

When the temperature threshold value is exceeded, an SDS message is automatically sent to the control centre. During the high temperature interval SDS messages are periodically sent, and at the end of the interval an SDS message denoting normalization of the temperature is sent to the control unit.

Thus, the personal computer performs local control and acts as a telemetry server. All the actions and measurement values are stored locally and are accessible on demand from remote locations over the TETRA network using the TCP/IP protocol. The same values and actions could also be stored on the computer in the control unit.

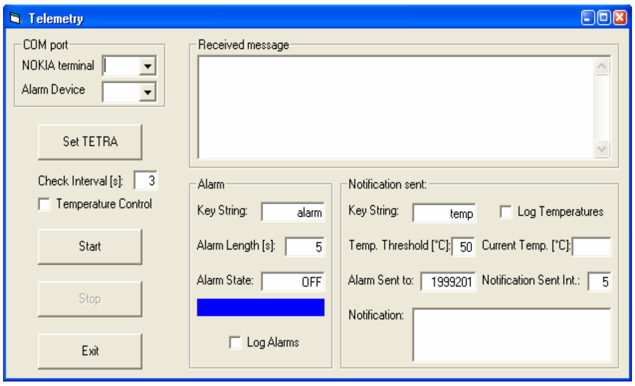

Fig. 2: Pilot application - user interface

4.3 MPIC development system

A microcomputer system, MPIC, has been developed to perform and control temperature measurements and simulate alarm signals used in the public alarming system.

The core of the development system is motherboard with a microcontroller PIC16F877A [5]. The block diagram of the microcomputer system is shown in Fig. 3. The development system includes also an RS232 module between the microcomputer and the personal computer, a module for

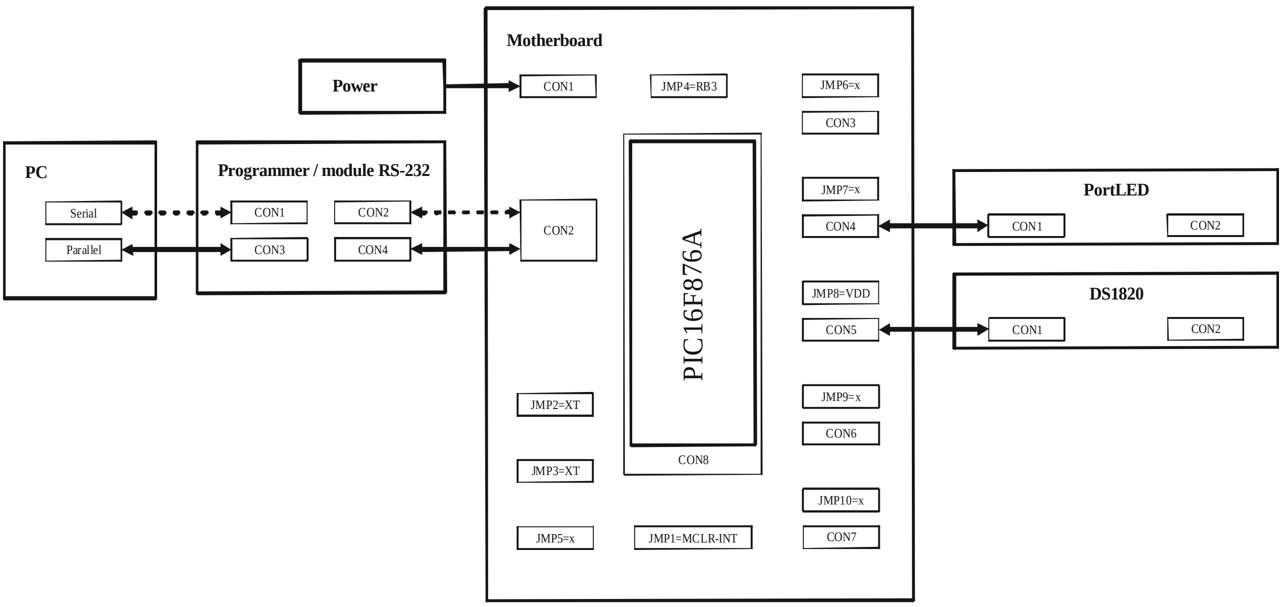

Fig. 3: Microcomputer system - block scheme

visualisation of the alarm signal (PortLED) and a module with a temperature sensor DS1820, performing temperature measurements.

Block diagram of the pilot application that is running on the MPIC microcomputer is shown in Fig. 4. After the microcomputer start-up or reset, directions of the in/out pins are defined and the temperature sensor is initilized. From this moment on, the program runs in an infinite loop, waiting for commands for appropriate actions that come over the serial RS232 module from the personal computer.

The pilot application program distinguishes three types of commands; namely *ain* and *aif*, which are used for turning on and off the alarm, and *tim* for temperature measurement initiation. After receiving one of these commands from the pilot application that is running on the personal computer, the microcomputer takes an appropriate action. When the *ain* command is received, the microcomputer sets appropriate pins to the high level, which turns on the LEDs on the PortLED module, and responds by sending back the confirmation command *acn*. The command *aif* turns off the visual alarm and is confirmed with the *acf* command. Received command *tim* initiates temperature measurement and is confirmed by the command *tcm*. When the measurement is finished the command *tom* is sent back to the computer following the measured data. After each procedure the command *wnc* is sent to the computer indicating that the microcomputer is in the ready state waiting to receive the next command.

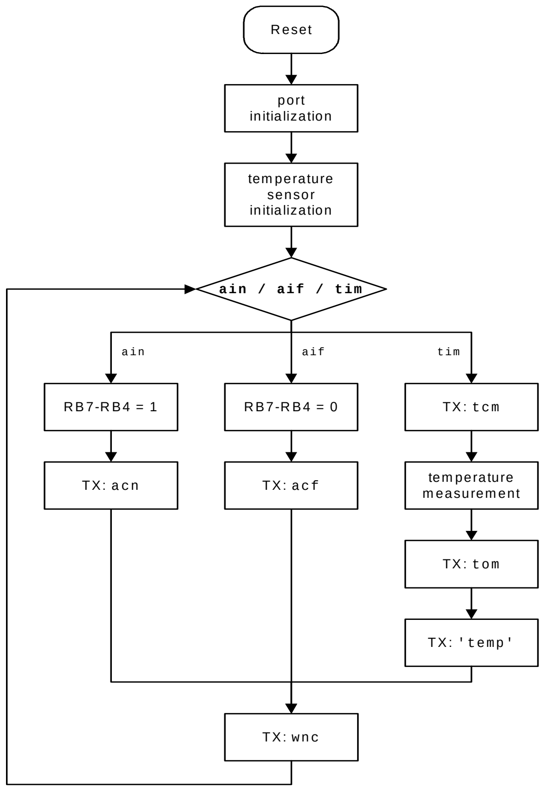

Fig. 4: Block diagram of the microcomputer application

5 Conclusion

A pilot wireless telemetry application for public alarming and remote measurement and control of temperature has been developed and tested using Short Data Service for data transmission over a TETRA network.

The pilot application could work also without the personal computer in the telemetry unit if the application program was implemented in the microcomputer.

The presented telemetry application can be further improved and extended to other telemetry applications for public safety and environmental monitoring based on the new national TETRA communication network which is controlled by the Ministry of Defence, Administration of the Republic of Slovenia for Civil Protection and Disaster Relief.

References:

[1] F. Carden, R. Jedlicka, R. Henry, *Telemetry Systems Engineering*, Artech House Publisher, 2002.

[2] J. Dunlop, D. Girma, J. Irvine, Digital mobile communications and the TETRA system, John Wiley & Sons, 1999.

[3] http://www.tetramou.com/

[4] I. Ozimek, G. Kandus, SCADA system using TETRA communication network, *Recent advances in computers, computing and communications*, WSEAS, 2002, pp. 164-166

[5] M. Smolnikar, *MPIC development system - Common development system for PIC microcontroller family*, http://mpicds.googlepages.com/, Nov. 2006.