Ultra Low-Power Acoustic Detector Applicable in Ambient Assistance Living Systems

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Summary: Ambient Assisted Living (AAL) includes methods, concepts, systems, devices as well as services, which provide unobtrusive support for daily life based on the context and situation of the assisted person. The technologies applied for AAL are user-centric, i.e. oriented towards the needs and capabilities of the particular user. They are also integrated into the immediate personal environment of the user. As a consequence, the technology is adapting to the user rather than the other way around. The in-house monitoring of elderly or disabled people (hard of hearing, deaf, with limited movement ability), using intelligent sensors is a very desirable service that may potentially increase the user's autonomy and independence while minimizing the risks of living alone. The described ultra low-power acoustic detector allows upgrade of the presented warning systems. It features long-term autonomy and possibility to use it as an element of the wireless personal area network (WPAN).

Keywords: Ambient assisted living, Home-care assistive system, WPAN.

1. INTRODUCTION

Monitoring people's activities and providing automated services that improve safety and quality of life is a very attractive proposition for elderly and disabled people who are living alone. Although the problem was considered for many years, it has only recently begun to become more relevant for two main reasons. First, many studies together with the rising costs of healthcare point out that the taking care of elderly and disabled people who live alone at home is going to become a challenge in the next few years [10, 11, 12, 13, 14]. The second, and more positive development is that communications, sensing and processing technologies are rapidly maturing to the point that make automated services possible both in terms of cost and technology. In terms of technology uses, the so called "independent living" or "assisted living" domain today comprises a heterogeneous field of applications ranging from quite simple devices such as intelligent medication dispensers, fall sensors or bed sensors to complex systems such as networked homes and interactive services. Some are relatively mature and some are still under development.

Ambient Assisted Living (AAL) [1] is an initiative from the European Union to emphasize the importance of addressing the needs of the ageing European population by reducing innovation barriers on ICT with the goal to lower social security costs in the future. The program intends to extend the time the elderly and disabled people can live in their home environment by increasing the autonomy of people and assisting them in carrying out their daily activities. Assisted Living solutions using ambient intelligence technology can help to cope with this trend, by providing some proactive and situation-aware assistance to sustain the autonomy and increase the quality of life. The goal is to enable elderly people to live longer in their preferred environment, to enhance the quality of their lives and to reduce costs for society and public health systems.

Research activity in AAL has not reached its peak yet, however, it is envisaged to do so in the forthcoming years since the European Union has just launched the 1st call for proposals under the Ambient Assisted Living Joint Programme [2].

Next presented projects cover the area of AAL.

In the Gator Tech House [4], a work carried out by Florida University, a whole flat is instrumented with an assortment of coordinated, through an central server, assistive smart objects such as a smart mailbox, which notifies of letter arrival, a smart front door which enables to check who is outside the door and to remotely open it, or a smart bathroom with a toilet paper sensor, a flush detector or a temperature regulating shower. The overall goal is to define a set of smart objects and services, which populate an assistive home for elderly and/or disabled people.

The PAUL (Personal Assistant Unit for Living) system from the University of Kaiserslautern [3] collects signals from motion detectors, wall switches or body signals, and interprets them to assist the users in their daily life but also to monitor their health condition and safeguard them. The data is interpreted using fuzzy logic, automata, pattern recognition and neural networks. It is a good example of an application of artificial intelligence to create proactive assistive environments.

Some relevant projects funded by EU 6FP that cover areas of AAL are PERSONA [5], CAALYX [6], NETCARITY [7], and SOPRANO [8].

The herewith described acoustic detector is a part of an upgraded assistive system presented in a previous work of the author [9]. The system is directed to support the daily activities and give assistance to disabled people – hard of hearing, deaf, elderly, with limited movements ability, etc. The system architecture is presented on Fig. 1. It is based on three different modules, namely Sensor Module (Door bell, Fire/smoke alarm, etc.), Intermediate Node (IN) and Warning Light Indicator (WLI). A Wireless Personal Area Network (WPAN) is realized by using of wireless (Bluetooth) communication between different modules.

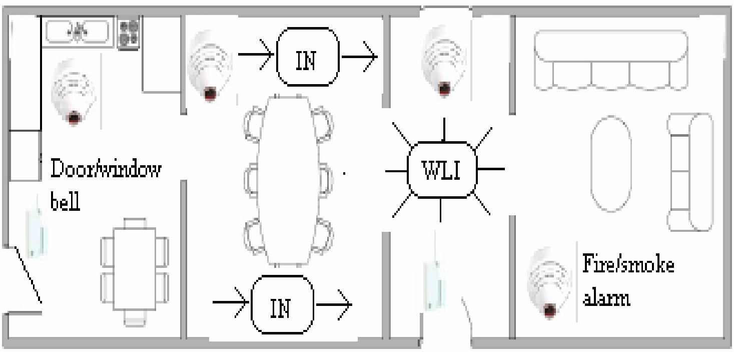

Fig. 1 Architecture of wireless warning system: IN – intermediate node; WLI – warning light indicator

2. HARDWARE SOLUTION OF WIRELESS ACOUSTIC DETECTOR

The detector presented below is developed, taking into account the following requirements:

- compatibility with multiple contemporary detectors and alarm devices, used in practice (door bell, fire, smoke, gas, open window, etc.);
- possibility for embodiment in WPAN;
- long-term (minimum 1 year) autonomy;

Wireless communication is based on Bluetooth communication set ABM-600 (Air Logic). ABM-600-2.0EDR is a Class2 surface mountable Bluetooth® module, fully compliant system for data and voice communications. Physical interface to host (UART, USB) can support full Bluetooth data rate 723.2kbps. The consumption in 'inquiry' mode is up to 40mA, and in 'connected' mode is about 15mA. A drive logic circuit is developed, allowing switch on Bluetooth interface, for short time, only when an event is detected. As a result, the total power consumption minimized. In fact, low power is just as important as the reliability of the communications itself. Before the advent of wireless sensor communications, low power was synonymous with low current consumption.

Most of the warning detectors used in practice react with an acoustic alarm (loud) signal, when the corresponding event is detected. For this reason, a decision of drive logic, based on the acoustic principle, is realized. The electrical diagram of the detector is presented on Fig. 2. The circuit consists of two parts. In the acoustic part, a piezoelectric buzzer is used as a microphone. To cover the extreme requirements of the consumption, the detector is realized, using ultra low-power amplifiers and logical elements. Two dual, micro-power rail-to-rail CMOS amplifiers LMC6462 (National Semiconductor) with supply current of 20μA/Amp are chosen.

The piezoelectric element is connected to the power supply via a resistor of 100kΩ and the total consumption of the acoustic part is less than 100 μA.

To further reduce power consumption, the device was turned off when it did not need to communicate, and was awakened when an alarm situation was raised or a periodic status update was called for duty cycling. The circuit configuration initializing awake procedure (in predetermined time period) plays the role of a watchdog timer. In the proposed solution this circuit is realized using ultra low-power dual amplifier TS942 (Semiconductor Technology) and Dual D-type flip-flop HEF4013B. Supply currents are: 2µA/Amp; 2µA/flip-flop, which determines consumption of watchdog – less than 10µA. The period between awakenings (when no event is detected) depends on the time-forming group R1;C1 and reference voltage level formed by the group R21;R22. The pointed values of elements determine a period of about 3 minutes between awakenings (the capacitor's DC leakage current about 5 µA is taken into account). Once awaken, the Bluetooth module measures the battery level and if it exceeds a certain level, the module turns off. If a low-battery is recognized, the Bluetooth module includes itself into the network and sends an alarm signal. The described test procedure requires about 100µAh.

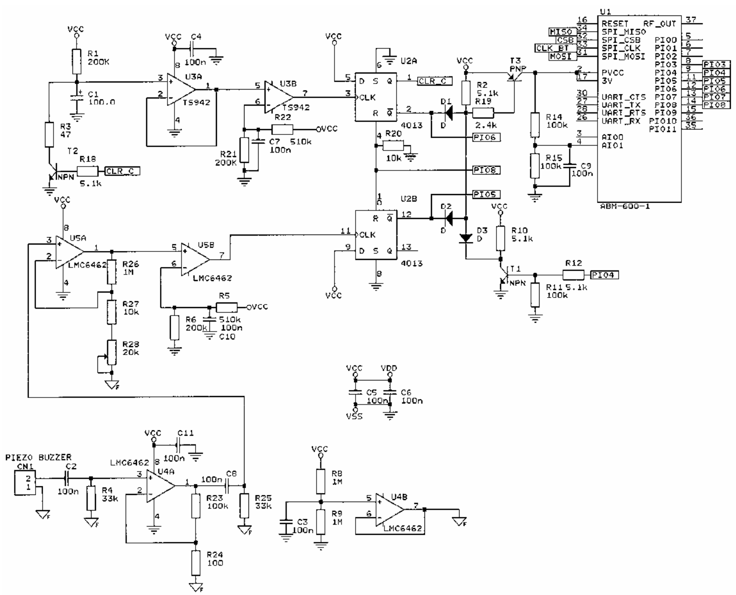

Fig. 2 Electrical diagram of the ultra low-power acoustic detector with Bluetooth wireless interface

3. CONCLUSION

The main advantage of the described ultra low-power acoustic detector is full compatibility with different alarm detectors, acting with an acoustic alarm signal when they identify a corresponding event. The solution allows to implement new WPAN-s and optimize those used in live supporting system for elderly and disabled people.

The benefits pointed above are related to the low power consumption, the warranted detectors' autonomy (with lithium AA battery 2400mAh) for more than 24 months in a stand-by mode, and for more than 18 months if the detector activates on a daily basis, 4-5 times per day. The proposed solution, based on the contemporary wireless Bluetooth EDR 2.0 system, allows development and embodiment of specific software algorithms for acoustic signal analysis, resulting in higher noise immunity.

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