Indonesian Journal of Electrical Engineering and Computer Science
Vol. 9, No. 2, February 2018, pp. 249~252
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v9.i2.pp249-252

Design and Implementation of Smart Non-Invasive Bone Conduction Ear-Plug System

G. Ravichandran[1], M. Krishnamurthy[2]
[1] Research Scholar, Department of Information Technology, AMET University, Chennai
[2] Department of Information Technology, KCG college of Engineering and Technology, Chennai

Article Info

Article history:

Received Oct 9, 2017
Revised Dec 25, 2017
Accepted Jan 10, 2018

Keywords:

ARM
Atollic
Cortex-M4
Music Player
STM32

ABSTRACT

The project aim is to design a smart earplug system integrated with non-invasive bone conduction technique which is capable of doing some advanced audio processing to provide voice enhancing, noise filtered audio for the hearing impaired people [2]. The system is also designed to work as an embedded music player, a life activity tracker and a Smartphone companion. It can even read the SMS that is just received on your smartphone into your ear. This project needs a very low power microcontroller but with high-performance signal processing requirements. STM32L476 from STMicroelectronics meets this needs and thus chosen as the main MCU. It is an ultra-low power ARM Cortex-M4 based microcontroller that can run up to 80MHz. It has got 1MB of Flash memory and 128 KB RAM.

Corresponding Author:

G. Ravichandran.,
Research Scholar, Department of Information Technology,
AMET University,
Chennai.

1. INTRODUCTION

A transducer is any gadget used to change over vitality starting with one shape then onto the next; ordinarily when changing over information vitality into yield energy. For transduction to happen, a change from one type of energy should likewise occur, for example, a transformation from mechanical to electrical vitality or the other way around. The employments of transducers are across the board, affecting us from numerous points of view. A typical case is an amplifier, which changes the info vitality, the sound waves created by voice or instrument, to yield energy, the electrical motivations as opened up sound [1]-[2]. The yield of bone-conduction help is, at last, a vibration flag. The system uses advanced digital filtering techniques to remove high-frequency noise from the audio input and allows the only the low-frequency content to pass through. Human voice lies in this lower frequency spectrum of audio, and thus the digital filter enhances the clarity of the voice heard.

The microcontroller collects multiple samples of the sensor output, stores in a buffer and then process all in one go. The whole process is interrupt-driven and double-buffered for performance. In this project, FIR filter is used to provide a stable operation without any phase distortion. Implementing digital filters for a high-speed stream of data tend to be computationally intensive and make heavy use of multiply-accumulate operations. ARM Cortex-M4 microcontroller has single cycle MAC instructions that make them excellent for digital signal processing as shown in Figure 1. In this case, CMSIS DSP libraries from ARM are used for these processing needs. The active noise filter is not the default mode of the device. The user is allowed to cancel this mode by simply touching a button so that the original input audio can be heard, which is nothing but the surrounding ambient sound. In this paper describes that the energy efficient based networks [3].

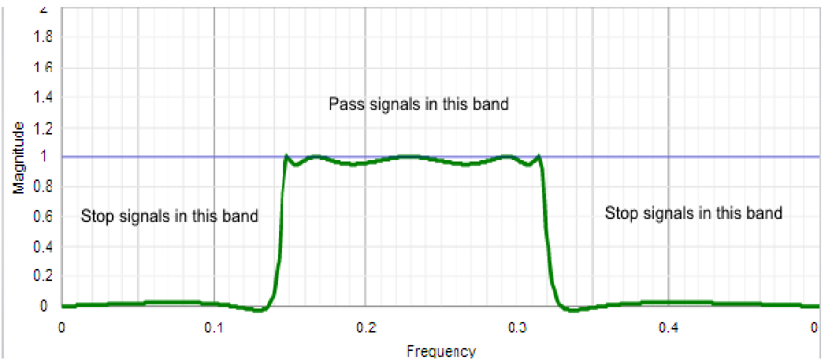

Figure 1. Digital Audio Signal processing

Design of a Single Input Fuzzy Logic Controller Based SVC for Dynamic Performance Enhancement of Power Systems is described in [4]. In this paper [5] illustrates that the An Efficient Self-Reconfiguration and Route Selection for Wireless Sensor Networks. Networks are excellent things of communication is presented in this paper [6]-[7].

2. EXISTING SYSTEM

People with hearing loss problem, often use low-quality analogue hearing aids, which are nothing but a simple analogue audio amplifier or a passive audio reinforcement system. They are less flexible and are just designed to gather sound energy and direct it into the ear canal at higher volumes.But with the availability of miniature microphone sensors and extremely low-power digital signal processors, hearing aids can be constructed with audiometric and cognitive intelligence that matches the hearing loss, physical features and lifestyle of the wearer, thus delivering more value and benefit for the hearing impaired person.

3. OVERALL SYSTEM DESIGN AND ITS FEATURES

The Overall System Design for hear-clear as shown in Figure 2(b).

3.1. Audio DAC and MEMS Microphone

A stereo Audio DAC is controlled and communicated by the main MCU using I2C and SAI protocol interface respectively. The sound output of this DAC goes to the audio amplifier circuitry to drive the bone conducting transducer. The audio input may come from a MEMS microphone (live sound), or it could be the recorded audio files (pre-recorded audio). An Omni-directional MEMS audio sensor digital microphone provides a digital signal in PSM format to the microcontroller.

3.2. Bone Conducting Transducer

The sound is nothing but vibration. Bone conduction is our body's natural ability to transfer sound through a bone [8]. The sound processor converts sound into vibrations which are sent through the skull bone, directly to the inner ear. A bone conduction transducer is a special type of speaker that has a metal rod wrapped with the voice coil. When currently is pulsed through the coil, the magnetic field causes a piece of metal to expand and contract – creating a speaker when pressed against a flat surface [9]-[10]. The transducer is pressed up against the jaw or ear bone to turn the skull into a speaker cavity. An audio amplifier circuitry is needed to drive this speaker as shown in Figure 2.

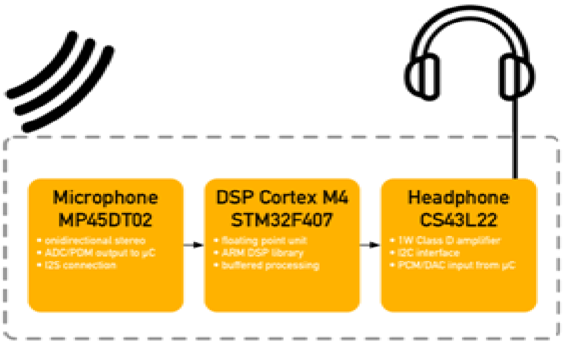

Figure 2. Design of Bone Conducting Transducer

3.3. Audio Amplification

Over the course of time, the user may have degrading hearing levels, and it might be important to increase the volume level to balance that. The device allows the user to change the audio amplifier gain on the fly using input buttons.

3.4. Onboard File Storage

The device has a built-in Quad-SPI flash memory, used to store the audio files. Here WAV type audio file format is used to store the digital audio content.

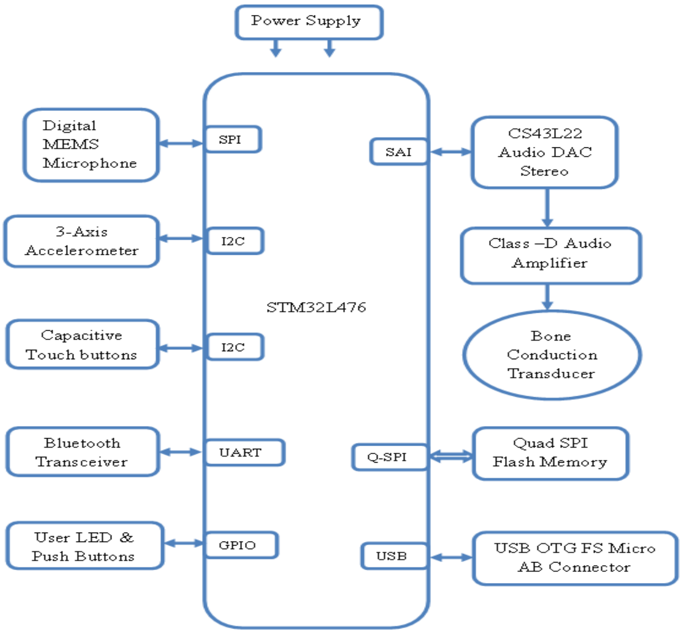

Figure 3. Overall System Design

3.5. Embedded Music Player

The device acts as a standalone music player that can play music directly into the ear. Favourite tracks can be permanently stored in the onboard memory and can be played back whenever the user presses the music player button.

3.6. File Transfer over USB

The device is equipped with USB connectivity to facilitate file transfers between the device and a PC/Laptop. The microcontroller supports USB OTG full speed communication via a USB connector and acts as a USB device when connected to the host computer.

3.7. Activity Tracking

The device can actively monitor the user movements using a 3D accelerometer and can show the activity/inactivity ratio on the smartphone app. This extends the device into fitness usage purposes.

3.8. Capacitive Touch Control

A set of capacitive touch buttons on the surface of the instrument allows the user to enter the input using simple touch gestures. A capacitive touch keypad controller scans the input electrodes and upon recognizing a user button press event, informs it to the main microcontroller.

4. CONCLUSION

We proposed this system based on an extensive study considering several speeches and music signals and also different feedback paths. It has been designed a smart earplug system integrated with non-invasive bone conduction technique which is capable of doing some advanced audio processing to provide voice enhancing and noise filtered audio for the hearing impaired people. The results show an excellent performance regarding entrainment prevention and adaptation speed. The system has a strong practical relevance because of the acceptable computational complexity and the ability to perform very satisfactorily under a large variety of audio signals and acoustic feedback scenarios.

REFERENCES

[1] Moonen M., "Acoustic feedback control: State of the art and future challenges," *Proceedings of the IEEE,* vol/issue: 99(2), pp. 288–327, 2011.
[2] Agnew J. and Thornton J. M., "Just noticeable and objectionable group delays in digital hearing aids," *Journal of the American Academy of Audiology*, vol/issue: 11(6), pp. 330-336, 2000.
[3] A. Salh, *et al.*, "Maximizing Energy Efficiency for Consumption Circuit Power in Downlink Massive MIMO Wireless Networks," *International Journal of Electrical and Computer Engineering*, vol/issue: 7(6), pp. 2977-2985, 2017.
[4] Subramanian D. D. P., "Design of a Single Input Fuzzy Logic Controller Based SVC for Dynamic Performance Enhancement of Power Systems."
[5] M. A. Manivasagam and T. Ananthan, "An Efficient Self-Reconfiguration and Route Selection for Wireless Sensor Networks," *IJMSR,* vol/issue: 9(2), pp. 192-199, 2017.
[6] M. Anwar, *et al.*, "Wireless Body Area Networks for Healthcare Applications: An Overview," *TELKOMNIKA (Telecommunication Computing Electronics and Control)*, vol/issue: 15(3), 2017.
[7] M. Mekki and O. Abdallah, "Development of a Wireless Sensors Network for Greenhouse Monitoring and Control," *Indonesian Journal of Electrical Engineering and Informatics (IJEEI)*, vol/issue: 5(3), 2017.
[8] Siqueira M. G. and A. Alwan, "Steady-state analysis of continuous adaptation in acoustic feedback reduction systems for hearing-aids," *IEEE Transactions on Speech and Audio Processing*, vol/issue: 8(4), pp. 443-453, 2000.
[9] Liuni M., *et al.*, "Automatic adaptation of the time-frequency resolution for sound analysis and re-synthesis," *IEEE Transactions on Audio, Speech, and Language Processing*, vol/issue: 21(5), pp. 959-970, 2013.
[10] Gil-Cacho J. M., *et al.*, "Transform domain prediction error method for improved acoustic echo and feedback cancellation," in *Signal Processing Conference (EUSIPCO)*, pp. 2422-2426, 2012.