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# AVR298: USB Audio Demonstration with ATmega32(16)U4

## Features

- Runs with ATmega32U4 Microcontrollers at 8MHz
- USB Low Power Bus Powered Device (less than 100mA)
- Supported by any PC running Windows® (98SE or later), Linux® or Mac OS®.
- Less than 14Kbytes of Code Required
- USB device with audio speaker and audio microphone

## 1. Introduction

This document describes a simple audio project. It allows to quickly test USB hardware using the ATmega32U4 without any driver installation.

The reader should be familiar with *USB Software Library for AT90USBxxx Microcontrollers* (doc 7675, included in the CD-ROM & Atmel website) and the AUDIO specification ([http://www.usb.org/developers/devclass\\_docs/audio10.pdf](http://www.usb.org/developers/devclass_docs/audio10.pdf)).



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8-bit **AVR**<sup>®</sup>  
Microcontrollers

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Application Note

## 2. Hardware Requirements

The USB audio application requires the following hardware:

- AVR USB evaluation board (ATEVK527)
- AVR USB microcontroller
- USB cable (Standard A to Mini B)
- PC running on Windows® (98SE, ME, 2000, XP), Linux® or MAC® OS with an USB 1.1 or 2.0 host
- headset

## 3. In-System programming and Device Firmware Upgrade

To program the device you can use the following methods:

- The JTAG interface using the JTAGICE mkII
- The SPI interface using the AVRISP mkII and JTAGICE mkII
- The USB interface thanks to the factory DFU bootloader and FLIP<sup>(1)</sup> software
- The parallel programming using the STK®500 or STK®600

Please refer to the hardware user guide of the board you are using to see how to program the device using these different methods.

Please refer to FLIP<sup>(1)</sup> help content to see how to install the USB driver and program the device through the USB interface.

Note: 1. FLIP is software provided by atmel to allow the user to program the Atmel devices through the USB interface (No external hardware required) thanks to the factory DFU bootloader.

## 4. Quick Start

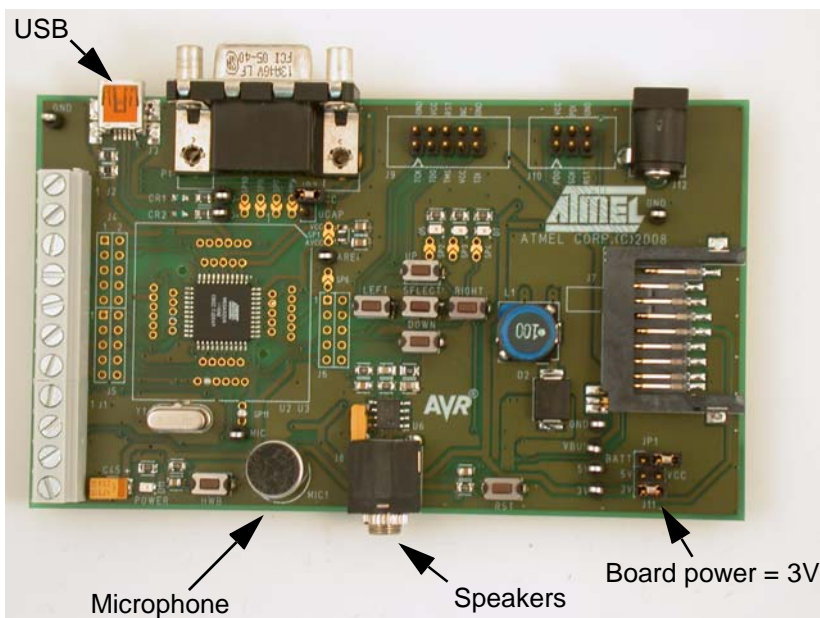
Once your device is programmed with *EVK527-ATMega32U4-usbdevice\_audio.a90* or *EVK527-ATMega32U4-usbdevice\_audio.hex* file, you can start the audio demonstration. Check that your device is enumerated as an audio controller (see figure 11), then you can use the kit as an audio speaker and audio microphone.

Figure 4-1. Audio Enumeration



The figure below shows the ATEVK527 used for the demo:

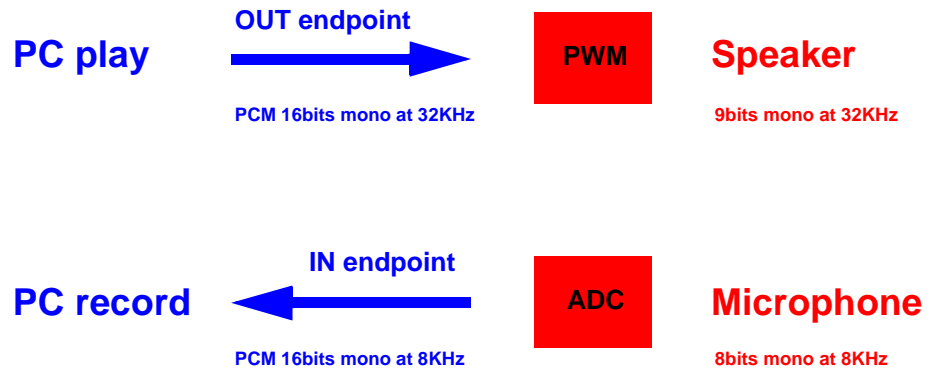
Figure 4-2. Demonstration Board



## 5. Application Overview

The USB audio application manages the data exchange between the PC and the PWM hardware (speaker) and ADC hardware (microphone). When a sound is played on the PC, the USB device receives a periodic unsynchronized OUT endpoints, and when the record microphone is running then the USB device receives a periodic unsynchronized IN endpoints.

**Figure 5-1.** Application data exchange

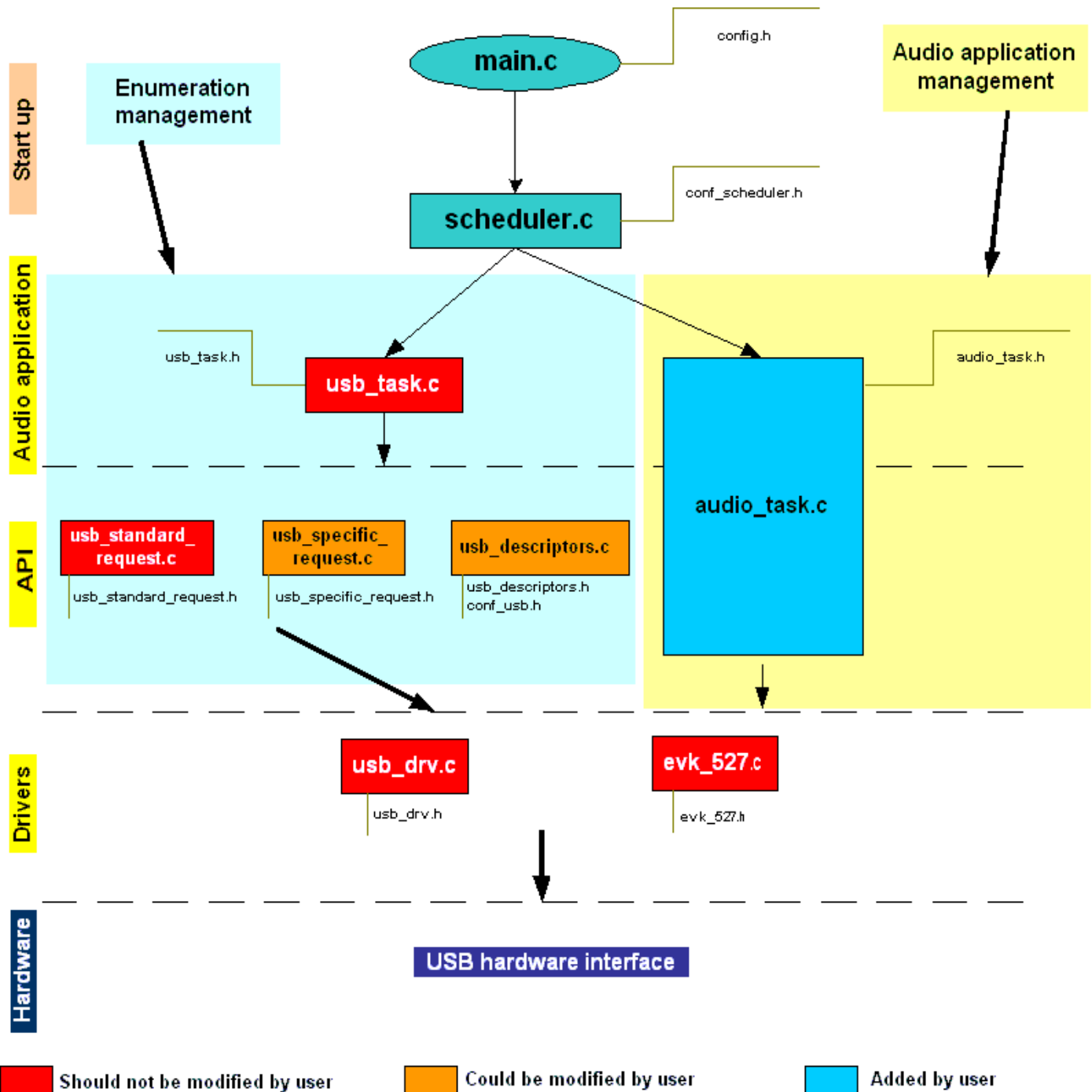


During the USB enumeration, the USB device describes the frequency and the formats of the audio data. In the demo, the data format used is the PCM, the speaker uses 16-bit mono at 32KHz, and the microphone uses 16-bit mono at 8KHz.

## 6. Firmware

As explained in the *USB Software Library for AT90USBxxx Microcontrollers* document (doc 7675) all USB firmware packages are based on the same architecture. This section is dedicated to the audio module only. The customization of the files described hereafter allows the user to build his own audio application.

Figure 6-1. USB Audio Firmware Architecture



## 6.1 audio\_task.c

This file contains :

- timers initialization
- timers interrupts
- routines which collect and put audio data

### Speaker

The main audio task gets the audio samples from endpoint OUT and put it in the RAM buffer. The OSC value tolerance doesn't allow to have an exact 32KHz frequency for the speaker, so the main loop adjusts the timer 1 interrupt to avoid losing a sample or underrun.

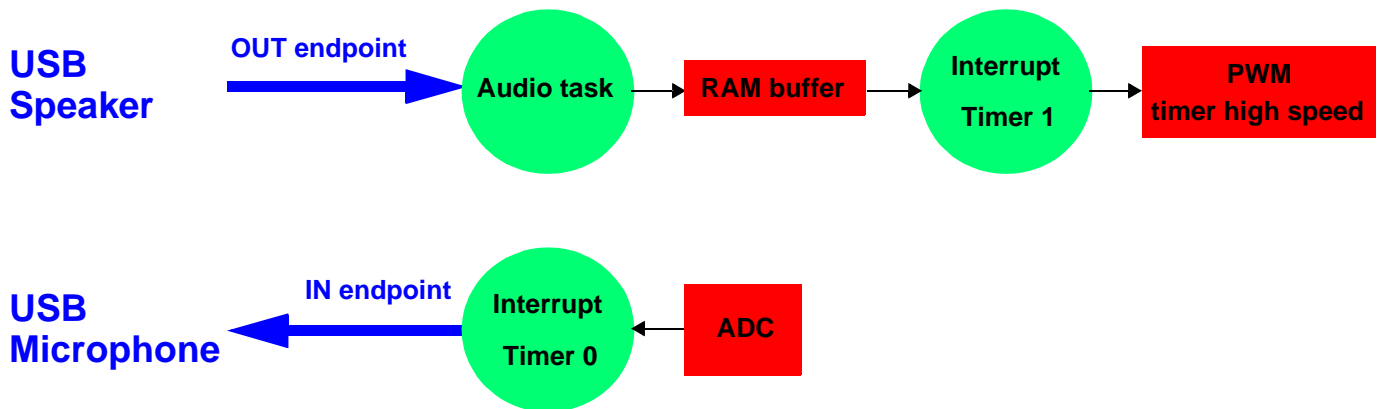
Timer 1 interrupt transfers the audio data from RAM to PWM (high speed timer). Timer 1 is responsible for adjusting data flow with PWM bits resolution and volume requested by USB host.

Note: We use only 9 bits out of the 10 bits from PWM to avoid saturation of Operational Amplifier.

### Microphone

Timer 0 interrupt is used to get the ADC value each 125 $\mu$ s (8KHz) and if the "endpoint IN" is requested by the USB host, the value is put in this endpoint.

Figure 6-2. Application data exchange



## 6.2 evk\_527.c.

This file contains all the routines to manage the EVK527 board resources (Joystick, LEDs...). The user should not modify this file when using the EVK527 board. Otherwise, he has to build his own hardware management file.

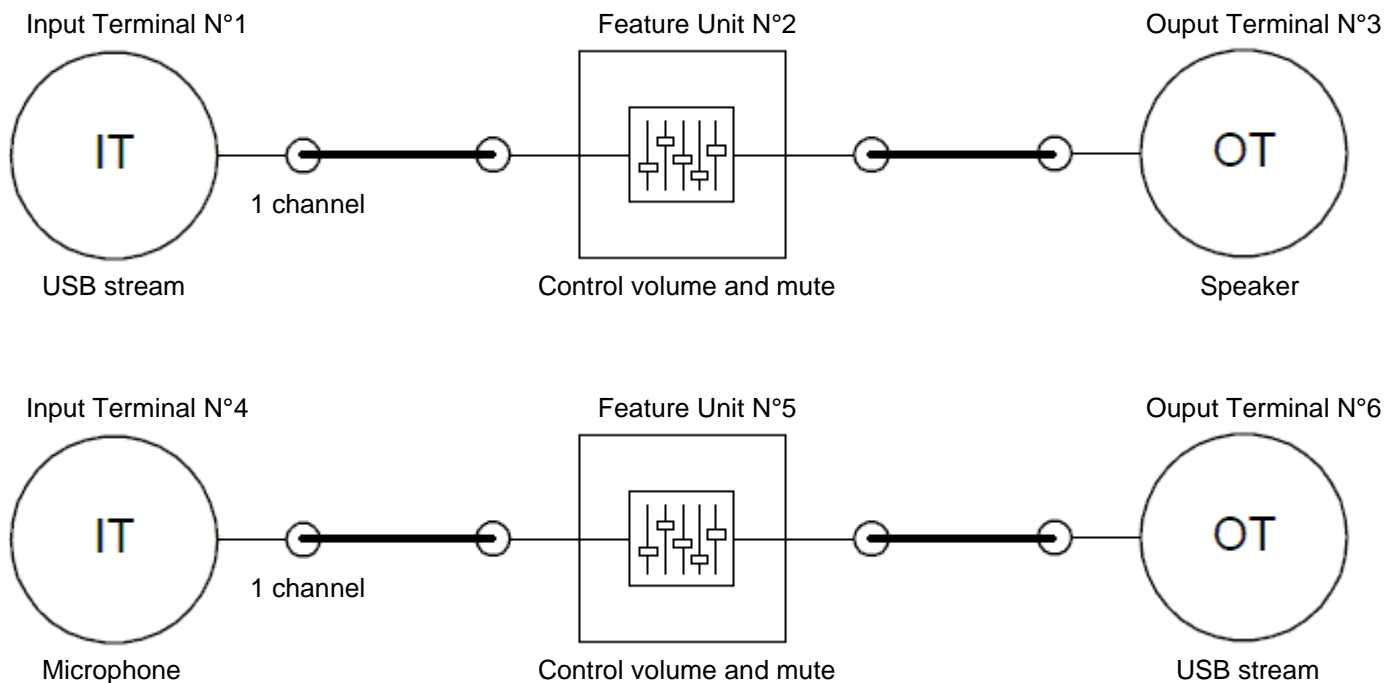
## 6.3 usb\_specific\_request.c

This file contains the routine which receives the audio control requests, like volume level and mute control.

## 6.4 usb\_descriptor.c

The audio topology, which is put in USB descriptor, is explained in the AUDIO specification ([http://www.usb.org/developers/devclass\\_docs/audio10.pdf](http://www.usb.org/developers/devclass_docs/audio10.pdf)). The audio topology chose for this demo is described in the following figure.

**Figure 6-3.** Audio Function Topology from demo



## 7. PC Software

The USB audio application does not require any PC software. Under Windows®, you can use the standard recorder “Sound Recorder” to try the microphone feature.

## 8. Limitations

If the speaker is running at 32KHz then recording and playback can't be running at same time, due to limited CPU bandwidth when clocked at 8MHz.

## 9. Related Documents

AVR USB Datasheet (doc 7766)

USB Software Library for AT90USBxxx Microcontrollers (doc 7675)

USB Audio class specification ([www.usb.org](http://www.usb.org))



## Headquarters

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**Atmel Corporation**  
2325 Orchard Parkway  
San Jose, CA 95131  
USA  
Tel: 1(408) 441-0311  
Fax: 1(408) 487-2600

## International

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**Atmel Asia**  
Room 1219  
Chinachem Golden Plaza  
77 Mody Road Tsimshatsui  
East Kowloon  
Hong Kong  
Tel: (852) 2721-9778  
Fax: (852) 2722-1369

**Atmel Europe**  
Le Krebs  
8, Rue Jean-Pierre Timbaud  
BP 309  
78054 Saint-Quentin-en-  
Yvelines Cedex  
France  
Tel: (33) 1-30-60-70-00  
Fax: (33) 1-30-60-71-11

**Atmel Japan**  
9F, Tonetsu Shinkawa Bldg.  
1-24-8 Shinkawa  
Chuo-ku, Tokyo 104-0033  
Japan  
Tel: (81) 3-3523-3551  
Fax: (81) 3-3523-7581

## Product Contact

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**Web Site**  
[www.atmel.com](http://www.atmel.com)

**Technical Support**  
[avr@atmel.com](mailto:avr@atmel.com)

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