Self Powered Digital Audio MP3 Speaker

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2006-2007 Academic Year
Introduction:

The first practical sound reproduction device was patented by Thomas Edison in 1878. Ever since then people have been inventing new ways to reproduce audio. Designers always have one major problem; eliminating sound quality loss that arises in the sound reproduction chain. In analog audio, sound quality loss is present from the many stages that are required to boost the signal to a high wattage and to the tone control circuitry used to boost bass and treble. Once the audio is in digital form, its quality does not degrade unless it is switched back into analog form.

My proposal is to create a self-powered speaker that plays mp3 encoded audio. The project takes a digital input source, decodes it and sends the information out through a digital amplifier to the speaker. Thus, eliminating loss that is associated with analog audio. The power supply, amplifier and controller units will all be housed inside of a normal speaker box. All that the end user will need to do is plug the speaker into the wall, plug in the source and push play.

Microcontroller:

The controlling mechanism behind this project is FreeScale’s MC9S12DP512 16-bit microcontroller (MCU). The MCU (U1 on sheet 1-A) is connected to a +5 Volt regulator from the power supply at VSSA, VSS1, and VSS2 referenced from VDDA, VDD1, and VDD2. +5V is also connected to VREGEN, VDDX, VDDR referenced from VSSX and VSSR. The MCU has many multipurpose I/O pins that are used to handle user input (SW1-SW6), reset to the MP3 decoder (U2), the PWM chip (U1 on sheet 1-B), and the digital amplifier (U4). It also controls shut down, SD, and over temperature warning,
OTW, from the digital amplifier, and MUTE from the PWM. All connections from the MP3 decoder, PWM, and digital amplifier are active low signals. The mute signal should be held low during power up, and shut down or reset.

For control of the MP3 decoder and PWM I²C transmission is used. To ensure that the chips are not receiving the same data instructions over I²C, a switching circuit is needed. SDA and SCL are connected to the switch, and the output of the switch is connected to the PWM and MP3 decoder. The bit enable pins (BE0-BE3) on the switch (U9) are active low and connected to PTM0-PTM3. To receive data from USBWiz OEM Board (U7) and to send raw MP3 data to the decoder, SPI ports 0 and 1 are utilized. For both the I²C and SPI, the MCU is always configured as the master device. To accomplish this, the slave select pins (SPI0 and SPI1) are tied to +5V.

**USBWiz OEM Board:**

USBWiz OEM Board (U7) is connected to +5V and +3.3V regulators. The +5V is used for the USB connection (J2) and the +3.3V is used to power the IC’s that are on the board. This board provides a USB host as well as handles the file system for the thumb drive. USBWiz sends the MP3 files over SPI to the MCU. The MCU will only retrieve the data when the SPI_RDY pin is high. If the pin is low then all incoming commands from the MCU will be ignored. To make the device a slave over the SPI port, SPI_SSEL (pin 8) is tied to ground. MODE1 and MODE0 pins are left unconnected because this tells the board to operate in SPI mode.
User Interface:

The user interface is comprised of input buttons, connected to PB0-PB5 on the MCU, and an LCD screen connected to PTA0-PTA7 and PK0-PK2. The buttons, 6 in total, are each connected to the 5V supply, and I/O pins on port B through 1k pull-down resistors. This allows for active high operation. The debouncing for each button is handled in software. The buttons are mounted on the front of the case for easy access from the user. They are labeled ‘PLAY’, ‘+’, ‘-’, ‘NEXT’, ‘PREV’, and ‘STOP’. The ‘PLAY’ (SW1) button will allow the user to either select a directory to view if selecting directories, or play a song if a directory has been entered. The ‘+’ and ‘-‘ (SW2 and SW3 respectively) buttons control the volume during any stage of the process. ‘NEXT’ and ‘PREV’ (SW4 and SW5 respectively) allow the user to cycle through directories or songs and the ‘STOP’ (SW6) button will allow the user to discontinue audio playback at any time.

The LCD screen will be used to display directory information, song information, and which song is currently playing. The circuitry connected to the module sets the contrast of the display through a divider network (R14, and R15) and eliminates noise through C33.

Power Supply:

The power supply is an OEM supply that receives a 120Vac signal and outputs 48Vdc and 12Vdc. The 12V line, rated at 500 mA, is used to supply the gates of the FET’s on the digital amplifier and it also goes into 2 different regulators. The first is a +5V regulator (U6) that will supply the MCU and USBWiz with power. The second regulator is +3.3V (U7) and is used to power the MP3 decoder, PWM, and the IC’s on the
USBWiz OEM Board. Each regulator is rated for 500 mA, so they will not be overloaded by the 12V line. The 48V line is used to power the amplifier rails and draws a maximum of 2.6A.

There are two grounds on the supply, digital ground and analog ground, separated by a 1 Ohm resistor. The digital ground is connected to; the USBWiz, MP3 decoder, PWM, digital amplifier, and MCU. Analog ground is connected to the digital amplifier and the regulators.

**PWM:**

The pulse width modulator (U1 on schematic 1-B) requires a +3.3V supply and draws its input serially from the MP3 decoder. Once the information is processed it is output to the digital amplifier in PWM form. PWM_M_1 goes to PWM_B on the digital amplifier, and PWM_P_1 goes to PWM_A on the amp. To control Left and Right, a LRCLK is connected to LRCLK on the amplifier. To control the device, I2C is used and is connected through an analog switch (U9) along with the MP3 decoder. The switch is used so that the MCU doesn’t talk to both chips at the same time. The master clock on the PWM is set by OCLK on the MP3 decoder to ensure synchronization of the input data and LRCLK.

**Digital Amplifier:**

The digital amplifier (U4) requires two supplies, a 12V and 48V, for operation. The 12V line drives the FET gates and internal logic while the 48V is used to set the rails that drive the output signal. The amplifier takes two different PWM inputs, PWM_A and
PWM_B, which come from the PWM chip (U3). PWM_A is associated with the + terminal of the speaker, while PWM_B is associated with the – terminal.

**MP3 Decoder:**

The MP3 decoder receives the raw MP3 data from the MCU. It is supplied from the +3.3V regulator. The decoder asks for data from the MCU when the data request pin outputs a high signal. Once that signal goes high, the MCU will input data into the decoder until the signal returns low. Since the decoder’s logic level is not compatible with the MCU’s 5V level, a converter (U10) is needed. The data request line enters into A and B on the converter and is output, +5V for a logic high from Y to the MCU.

After the MP3 data has been decoded, it is then sent to the PWM.