Application Note

Smoke Alarm Sounder Using the DRV8220 and MSPM0G350x Microcontroller

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ABSTRACT

Many current designs for smoke alarm sounders are implemented with discrete circuits and can require multiple sounding elements to produce different tones depending on the application, leading to increased power and design cost. In this application note, a three-chip design is presented to obtain a cost and power optimized smoke alarm sounder sub system that provides dual frequency output as well as audio playback using the DRV8220 low voltage H-bridge motor driver with low power sleep mode and the MSPM0G350x Mixed-Signal Microcontroller with Arm® 32-bit Cortex®-M0+ CPU. The presented design satisfies SPL requirements for smoke alarms and provides a wide output frequency range with a single piezo element with an approximately flat response over the range.

Table of Contents

1 Introduction....2
2 Demo Hardware....2
3 Test Results....4
4 Summary....5
5 References....5

Trademarks

1 Introduction

Smoke alarms provide a standard 3kHz signal, which is proven effective in alerting people to danger when they are awake. However, this frequency is proven not to be the most effective one regarding the occupants that are asleep or people who are hearing impaired. The 2010 edition of the NFPA 72 National Fire Alarm and Signaling Code introduced the term *low frequency sounders*, which are proven to have the most significant effect in terms of alarming people in *sleeping areas*, people who have hearing impairment, and individuals under the influence of drugs or chemicals. Areas such as hotels, lodging houses, dormitories, apartment buildings, daycare facilities and hospitals are marked as *sleeping areas* where low frequency sounders show the best results in terms of waking effectiveness. The frequency of 520Hz square wave signal is proved to be the most effective in terms of waking up the high-risks groups in the event of a fire compared to the standard 3kHz signal. Including the 520Hz frequency signal is typically associated with higher cost since the low frequency requires more power to produce. This generally requires a different sounder element and driver circuit. The smoke alarm can have a single sounder element and driving circuit with alarm tone selected by firmware for an optimized cost design.

2 Demo Hardware

The block diagram for the demo smoke alarm setup based on the MSPM0G3507 and DRV8220 is shown in the Figure 2-1. The introduced setup consists of an MSPM0G3507 LaunchPad™ development kit to which two additional TI evaluation boards are connected. Evaluation module TLV61046AEVM-833 is used to provide an appropriate voltage rail for the driver module DRV8220EVM and piezo element. This arrangement supports either a single ended PWM (for alarm tone generation) or a differential PWM (such as BD modulation) to drive the piezo speaker. *BD Modulation* is used in this demo to accommodate both audio playback and alarm tone generation.

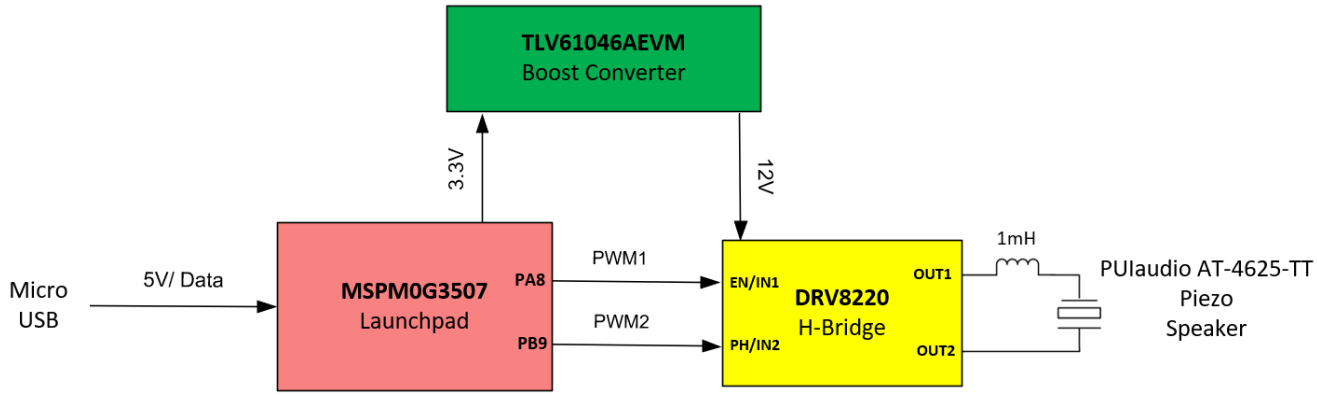

Figure 2-1. Smoke Alarm Sounder With the DRV8220 and MSPM0G Hardware Block Diagram

The MSPM0G350x family of microcontrollers are ultra-low-power MCU's which operate with a supply voltage ranging from 1.62V to 3.6V. The LaunchPad™ presented in this demo is powered via USB cable plugged into a PC and provides an input voltage rail of 5V. The MSPM0G3507 LaunchPad includes an LDO which provides the 3.3V rail for powering the MCU and the boost converter input. The DRV8220 H-Bridge features an operating voltage range of 4.5V to 18V. This demo uses the default 12V output from the TLV61046AEVM for the piezo drive voltage, however, this voltage is adjustable on the EVM. The DRV8220 motor driver was chosen for this application because of the low power dissipation and low cost. The H-bridge design in the DRV82xx family is also capable of driving capacitive loads which is also an important consideration in this application.

The hardware demo connections are shown in Figure 2-2 and detailed in the following:

- MSPM0G 3.3V is connected to TLV61046A VIN
- MSPM0G GND is connected to TLV61046A GND
- TLV61046A VOUT is connected to DRV8220 VM
- TLV61046A GND is connected to DRV8220 GND
- MSPM0G PA8 is connected to DRV8220 IN1
- MSPM0G PA9 is connected to DRV8220 IN2
- DRV8220 OUT1 is connected to PCT-4546E Piezo

- DRV8220 OUT2 is connected to PCT-4546E Piezo
- USB cable is connected from PC to MSPM0G Launchpad

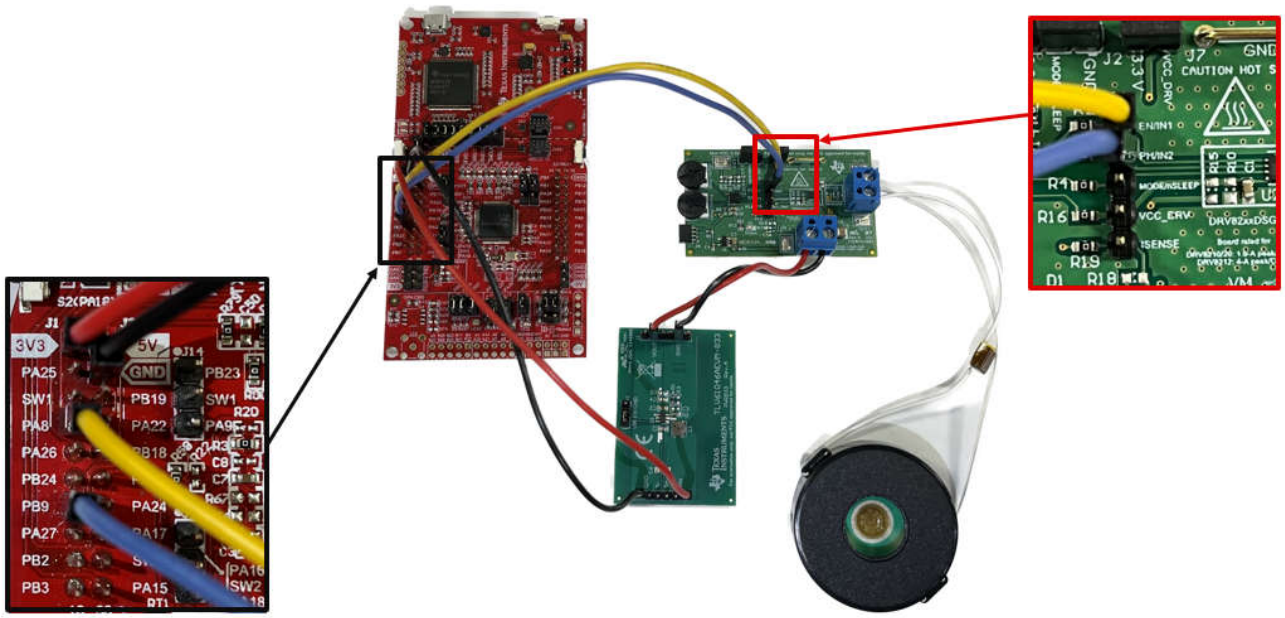

Figure 2-2. Hardware Demo Connections

The MSPM0G350x microcontrollers (MCUs) are part of the MSP highly integrated, ultra-low-power 32bit MCU family based on the enhanced Arm® Cortex®-M0+ 32bit core platform operating at up to 80MHz frequency. High-performance integrated analog peripherals simplify the supply chain and optimize the cost. MSPM0G350x integrates two 12bit 4Msps ADCs, configurable internal shared voltage reference, one 12bit 1Msps DAC, three high speed comparators with built-in reference DACs, two zero-drift zero-crossover op-amps with programmable gain, and one general-purpose amplifier. Moreover, the MSPM0G350x incorporates intelligent digital peripherals, such as seven timers which supports up to 22PWM channels. MSPM0 MCU platform combines the Arm Cortex-M0+ platform with a holistic ultra-low-power system architecture, allowing increased performance while reducing energy consumption, which is especially crucial with application as smoke alarm which require more power to produce low frequency tone.

The DRV8220 is an integrated motor driver with four N-channel power FETs, charge pump regulator, and protection circuitry. The triple charge pump architecture allows reduction of design size and 100% duty cycle operation with operating supply voltage range between 4.5V to 18V. The DRV8220 H-Bridge Motor Driver supports multiple control interface modes: PWM, phase/enable, independent half-bridge and parallel half -bridge and within those each supports a low-power sleep mode to make sure ultra-low quiescent current draw. The DRV8220 is part of a family of devices which come in pin-to-pin scalable RDS(on) and supply voltage options to support various loads and supply rails with minimal design changes.

The TLV61046A is a highly-integrated boost converter, that integrates a 30V power switch, an input to output isolation switch, and a rectifier diode. TLV61046A can output up to 28V from input of a Li+ battery or two alkaline batteries in series. TLV61046A implements output short circuit protection, output overvoltage protection, and thermal shutdown. Within this application internal default 12V output voltage setting by connecting the FB pin to the VIN pin is used.

The piezoelectric sounder AT-4625-TT-HT-R used in this hardware demo has a wide range of operating voltage from 3Vp-p to 30Vp-p with a current draw ≤80mA. The minimum SPL is rated at 120/100dBA for 10cm/1m, with the ability to create more than 90dBA output at 3 meters. Perhaps more importantly for this application is that AT-4625-TT-HT-R exhibits a relatively flat response over a wide range of frequencies as opposed to the more typical selective frequency response.

3 Test Results

The demo hardware was tested for SPL performance using the setup shown in Figure 3-1. A Radio Shack SPL meter evaluated the sound values at the distance of 1 meter from piezoelectric sounder.

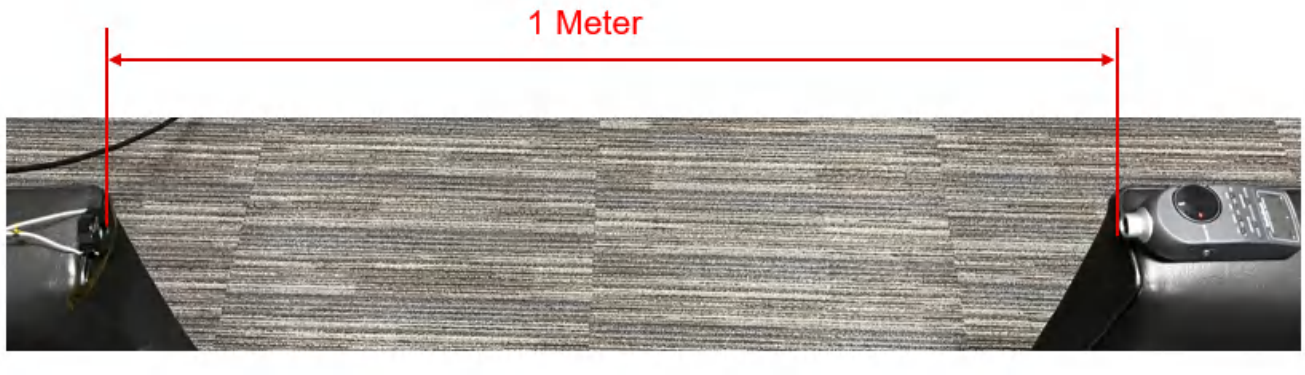

Figure 3-1. SPL Test Setup Performed with Radio Shack SPL Meter

Within the SPL measurement, the frequency was swept between 100Hz and 4.1kHz for evaluation. The results are shown in Figure 3-2. As can be seen, the SPL range of this demo over the described frequency range is 80 to 100dB. More importantly, the SPL at frequencies ≥ 520Hz is at least 88dB. These results show the ability of this demo to produce a wide range of sound frequencies at acceptable SPL levels for playback of audio and different alarm tones with a single piezo speaker element and fixed circuit design.

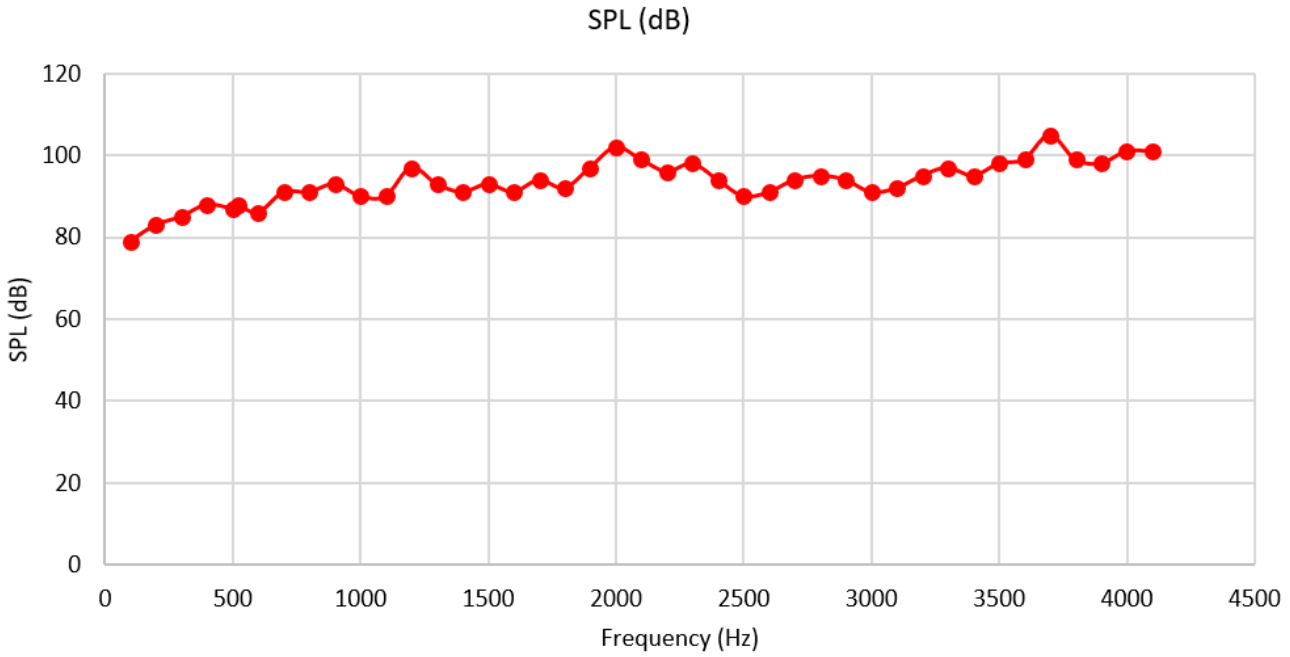

Figure 3-2. SPL Measurement Test Results on the Smoke Alarm Demo With the DRV8220 and MSPM0G Performed With Radio Shack SPL Meter at the Distance of 1m From the Piezo Sounder

4 Summary

This application note provides a low-power and cost-efficient design for smoke alarm sounders that is capable of meeting NFPA 72 requirements and provides two output frequencies of 500Hz and 3kHz, which are proved to be the most effective designs within placement in sleeping areas. Additionally, audio playback is possible with this same hardware design through firmware. Use of an H-bridge driver over discrete implementations introduces several advantages, such as low power dissipation, and high SPL output due to differential drive of the piezo without expensive auto-transformer magnetics.

While not described in detail in this application note, an alternate design is possible for smoke alarms which use the TPS8802 analog AFE. The TPS8802 includes an H-bridge horn driver (selectable for either 2-terminal or self-resonant 3-terminal piezo drive) and a boost converter. In this case, the TLV61046A and DRV8220 shown in this demo are replaced by the functionality included in the TPS8802.

5 References

- Texas Instruments, *Piezo Speaker Strobe Notification Reference Design*.
- Texas Instruments, *Class-D LC Filter Design*. application note.

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