AN1176 – Design Considerations for Driving Piezoelectric Buzzers

Alex Jarvis, Applications Engineer, Diodes Incorporated

This document discusses the case for using piezoelectric buzzers and piezoelectric buzzer drivers

Note: Piezoelectric buzzers can also be referred to as piezoelectric horns or sounders, in this document they will be referred to as buzzers.

Piezoelectric Buzzers

Figure 1: Piezoelectric Buzzer

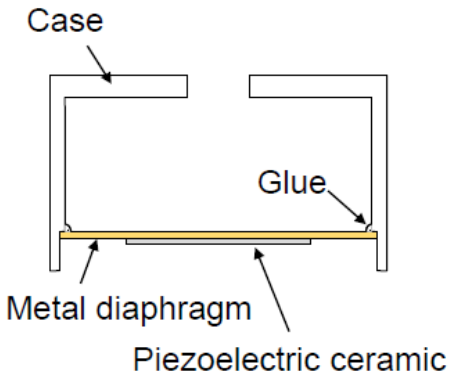

Figure 2: Cross Section of a Piezoelectric Buzzer

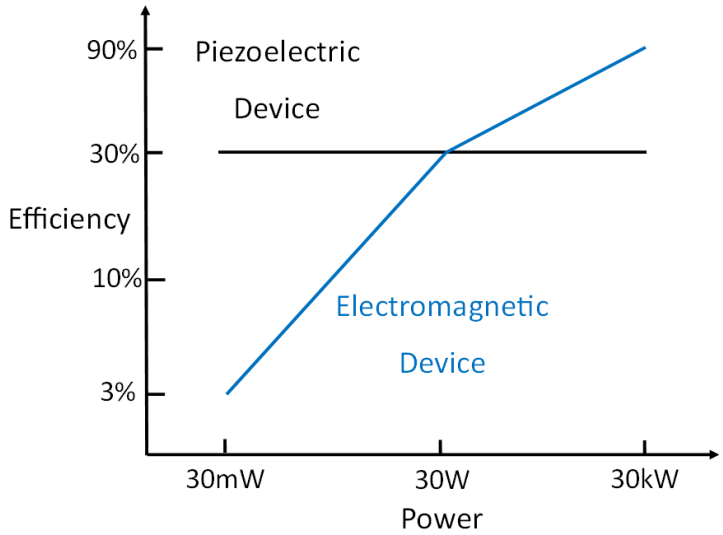

Figure 3: Efficiency of a Piezoelectric Buzzer Vs an Electromagnetic Buzzer

A piezoelectric buzzer is a small, low profile and lightweight electronic device that produces sound when it is subjected to an alternating field of electricity. Piezoelectric buzzers are a low cost, reliable alternative to a magnetic buzzer, that can offer louder sound outputs whilst consuming less power as they are more efficient in the <30W power range. Low power consumption makes the piezoelectric buzzer ideal in battery powered applications. A key advantage of piezoelectric buzzers is that, unlike inductive speakers, they can operate in damp conditions.

Piezoelectric buzzers are regularly used to produce audible signals in alarms and warning devices. Piezoelectric buzzers are available in a wide range of frequencies, including audible and ultrasonic. The sound pressure level (SPL) output of a piezoelectric buzzer depends on the magnitude of the voltage applied to it and the frequency of excitation. The SPL is greatest when a piezoelectric buzzer is excited at its resonant frequency.

Typical Applications of Piezoelectric Buzzers

- Smoke, Gas and Water Alarms
- Industrial Security Alarms
- Security Devices
- Bluetooth or Wireless Location Trackers
- Air Humidifiers
- Ultrasonic Applications
- Home Appliances
- Haptic Feedback
- Alarm Clocks
- Health Care Systems
- Automotive Alarms and Security Devices
- Dashboard Audio
- Vehicle Approach Warning

Characteristics of Piezoelectric Buzzers

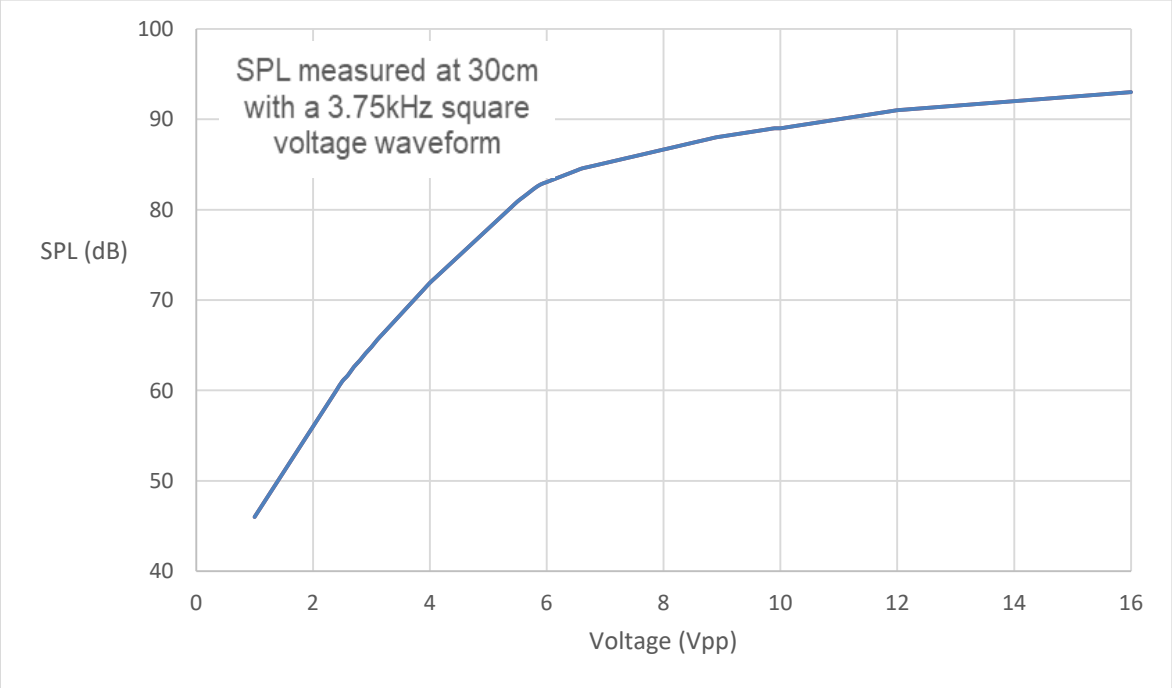

Figure 4: SPL vs. Voltage

Figure 4 is a graph of SPL vs. voltage for a specific piezoelectric buzzer at a fixed frequency of 3.75kHz. The SPL output of the piezoelectric buzzer increases with the voltage applied.

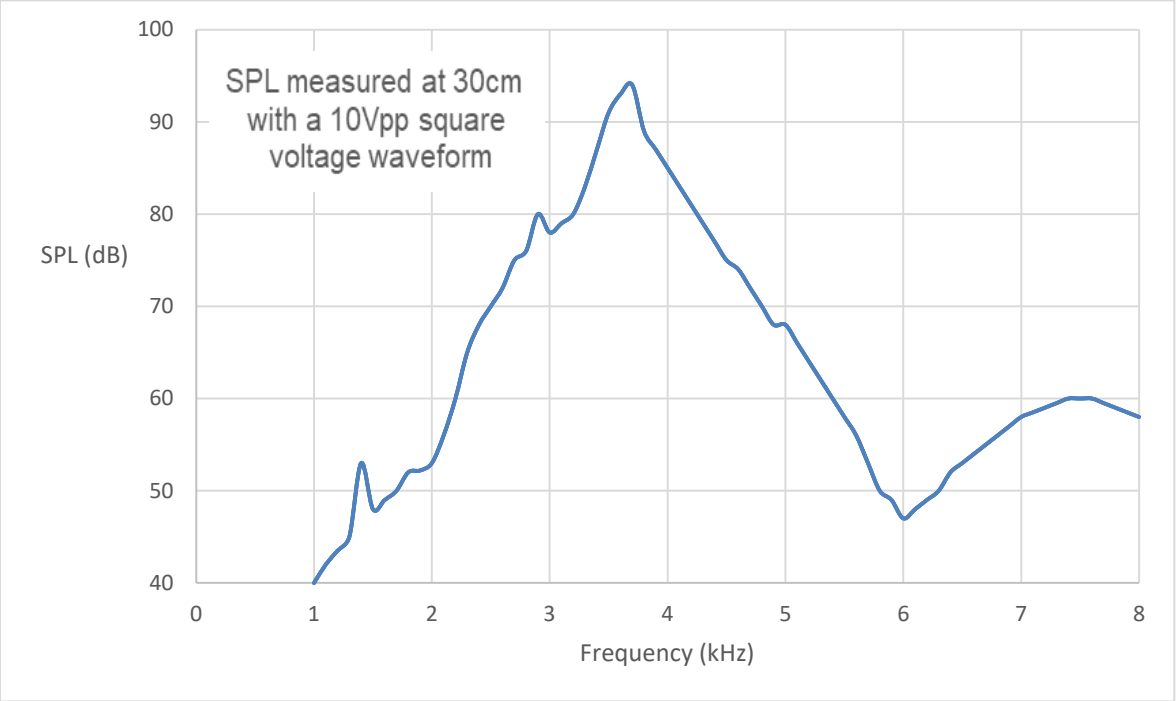

Figure 5: SPL vs Frequency

Figure 5 is a graph of SPL vs. frequency for a specific piezoelectric buzzer at a fixed voltage of 10Vpp. The SPL output of the piezoelectric buzzer varies with the driving frequency. A particular piezoelectric buzzer may have one or more resonant frequency peaks where SPL is at its greatest.

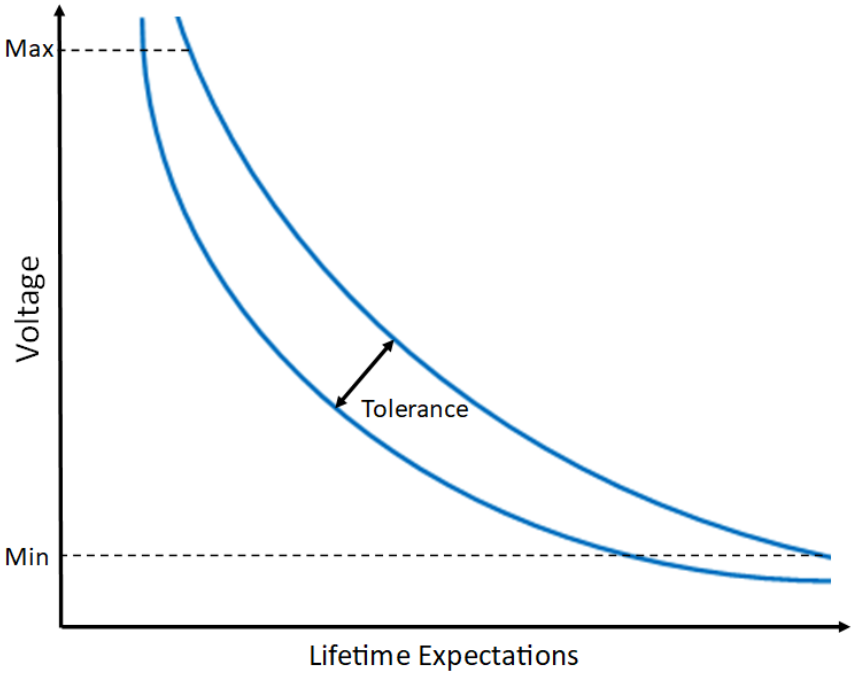

Figure 6: Expected Lifetime of a Piezoelectric Buzzer

Figure 6 is a graph of voltage vs. lifetime for a piezoelectric buzzer. The expected lifetime of the piezoelectric buzzer is inversely proportional to the voltage applied to buzzer. If a high SPL is required, it is preferable to choose a piezoelectric buzzer with a high SPL at the specified frequency. It may be desirable to apply the minimum possible voltage to maximize the expected lifetime.

Driving a Piezoelectric Buzzer

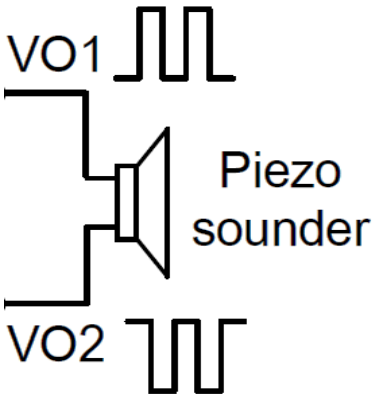

Figure 7: Differential Configuration Driving Waveform

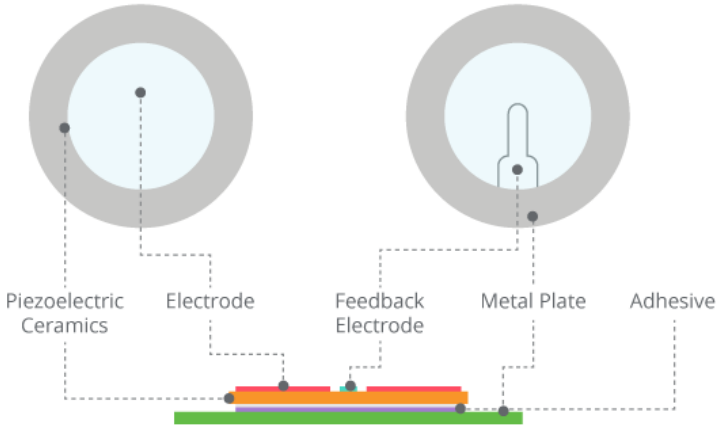

Figure 8: Types of Piezoelectric Buzzers

To drive a piezoelectric buzzer, in a differential configuration, alternating square waves are applied to the positive and negative terminals. This can be seen in in figure 7. Piezoelectric buzzers can also be setup in a single-ended configuration where one of the positive or negative terminals is tied to ground and a square waveform is applied to the opposite terminal. The differential configuration is preferred for higher SPL as the peak-to-peak voltage across the piezoelectric buzzer is twice as much as it would be in the single ended configuration.

There are two different types of piezoelectric buzzer as depicted in figure 8. The standard piezoelectric buzzer has two terminals, a positive and a negative terminal. However, there is a self-excitation variant which has three terminals, a positive and a negative plus an additional feedback electrode. The signal from the feedback electrode can be fed back to the driver allowing the buzzer to self-excite at its resonant frequency.

Piezoelectric Buzzer Drivers

	PAM8904E	PAM8904Q	PAM8906	PAM8907
Boost Method	Charge Pump	Charge Pump	Inductive	Inductive
Supply Voltage Range	1.5 – 5.5V	2.3 – 5V	2.1 – 5.5V	1.8 – 5.5V
Output Voltage	1x, 2x or 3x Supply Voltage Selectable	1x, 2x or 3x Supply Voltage Selectable	10V,12V and 18V Variants Available	11V or 15.6V Selectable
Buzzer Type	Standard Two Terminals	Standard Two Terminals	Standard Two Terminals or Self-exciting Three Terminals	Standard Two Terminals
Automotive Compliant	No	Yes	No	No
External Components Required	4 Capacitors	4 Capacitors	6 Capacitors 2 Resistors 1 Inductor 1 Optional Switching Diode	5 Capacitors 1 Inductor 1 Optional Switching Diode

Table 1: Comparison of Diodes' Piezoelectric Buzzer Driver Range

Table 1 is a comparison of Diodes' Piezoelectric buzzer driver range. The PAM8904E, PAM8906 and PAM8907 are piezoelectric buzzer drivers with integrated boost converters for a higher SPL. The PAM8904Q is an automotive qualified version of the PAM8904E. These drivers can operate from a supply voltage as low as 1.5V and up to 5.5V. All of these drivers include protection features such as thermal shutdown, overcurrent protection, overvoltage protection and undervoltage lockout. The drivers also have built-in automatic shutdown and wakeup. Current consumption during shutdown is less than 1µA.

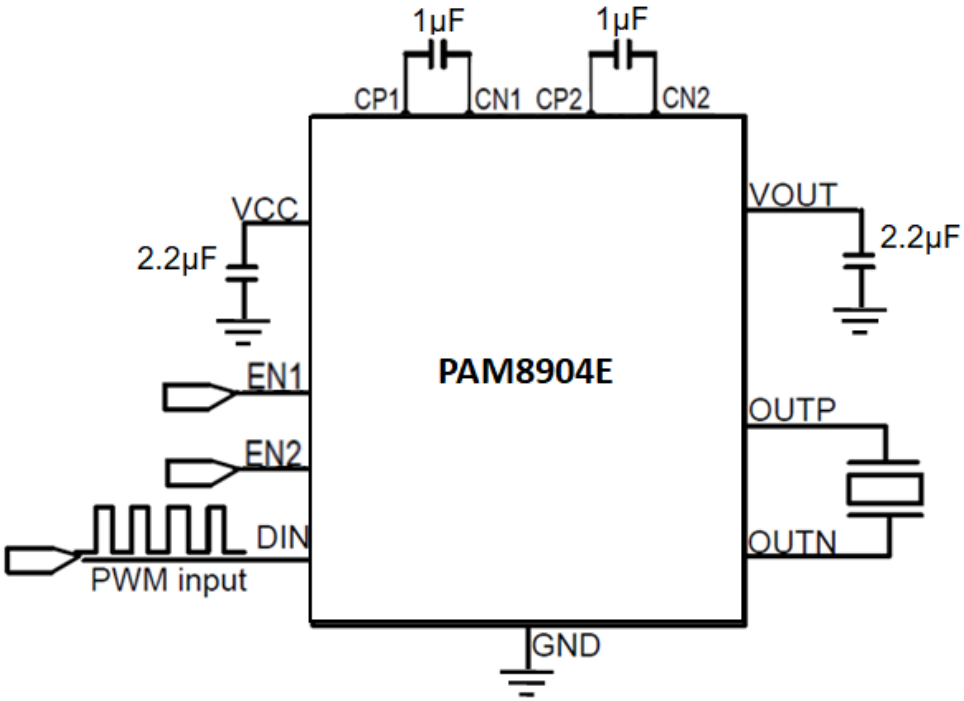

Figure 9: PAM8904E Typical Application Circuit

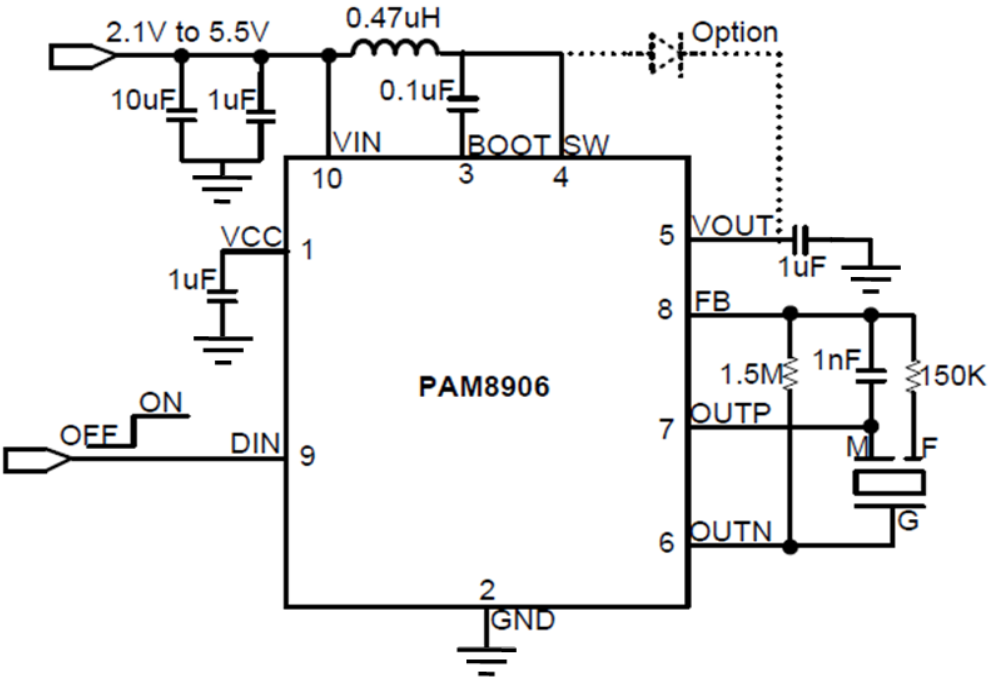

Figure 10: PAM8906 Typical Application Circuit

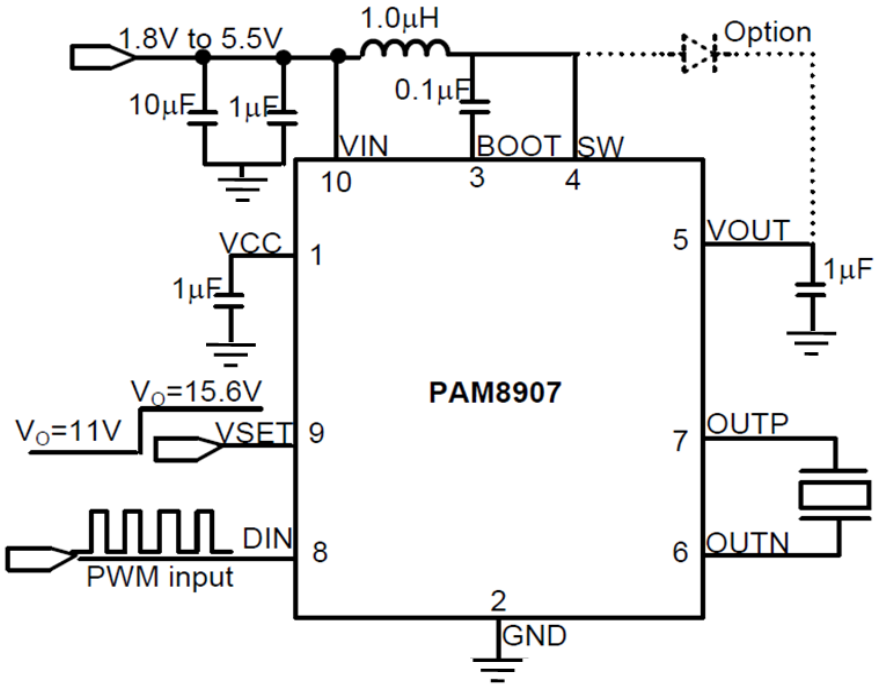

Figure 11: PAM8907 Typical Application Circuit

Figures 9-11 show typical applications of the PAM8904E, PAM8906 and PAM8907. The PAM8904E uses a charge pump which can operate in either 1x, 2x or 3x mode, while the PAM8906 and PAM8907 both use an inductive boost. The PAM8906 and PAM8907 will continue to provide a fixed output voltage as the battery becomes more resistive. However, the output voltage level of the PAM8904E is proportional to the input. Therefore, in battery powered systems the output voltage will reduce proportionally with the battery voltage. An optional switching diode can be included with both the PAM8906 and PAM8907. Including a switching diode in the circuit reduces the power consumption by approximately 20%. If the designer chooses to include this component, a 20V Schottky with a current rating of 1A is recommended.

Pulse Width Modulated (PWM) Input vs. Self-Exciting Piezoelectric Buzzers

The PAM8906 includes a feedback (FB) pin which is used when driving a three terminal piezoelectric buzzer in a self-exciting mode of operation. However, instead the PAM8907 includes a VSET pin which is used to select the output voltage of the boost converter, from either 11V or 15.6V. The designer must decide between a self-exciting piezoelectric buzzer circuit or a PWM input excited one.

The advantage of using a self-exciting piezoelectric circuit is that the piezoelectric buzzer will excite at its resonant frequency, where SPL is greatest, and there is no need to provide a PWM signal, just an enable signal. Alternatively, the designer can choose to supply a PWM data signal to drive a two-terminal piezoelectric buzzer. The advantage of doing this is that the sound frequency is defined by the frequency of the PWM signal. So, an exact sound frequency can be selected and there is the option to have multiple tone outputs. However, the SPL at the additional frequencies may not be optimized.

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