

Audible Alarm Basics

Everything you wanted to know, but were afraid to ask

by Dan O'Brien, Sales Engineer, Mallory Sonalert Products, Inc.

From smoke detectors to automobiles, audible alarms (also known to be called buzzers) have become a part of our everyday life. Some of the uses of these alarms are innocuous such as in a microwave oven. However, in some applications such as in a smoke detector or medical equipment, a person's life may depend upon the audible warning sound. In all cases, the equipment designer should consider the desired characteristics of the audible alarm at the initial design planning phase to obtain satisfactory performance and avoid costly redesign. The first characteristic for a designer to consider is the type of sound such as a continuous, intermittent, or specialty sound. Other critical criteria include sound level, frequency, current draw, quality, mounting configuration, cost, and availability.

Electromagnetic vs Piezoelectric

Two main types of audible alarms are the electromagnetic type and the piezoelectric type. Figure I shows a summary of each type along with the different packages available. The

electromagnetic buzzer generally consists of a plastic housing with a metal diaphragm that is flexed by an electromagnet. The main benefit of this design is the ability to obtain low frequencies in a small package. Drawbacks include mechanical wear, electrical noise, lower sound output, and large power consumption.

The piezoelectric type avoids electro-mechanical contacts by using a piezoelectric transducer. The transducer consists of a polarized ceramic material bonded to a metal disc. A voltage applied to the transducer will cause it to flex. A voltage that is applied and released at an appropriate rate or frequency will produce a continuous audible sound. Piezoelectric audible alarms offer no mechanical wear, an absence of electrical noise, low power consumption, and a clear penetrating sound. Advances in transducer design have allowed these devices to shrink in size and lower the sound frequency enabling them to move into applications traditionally serviced by electromagnetic devices.

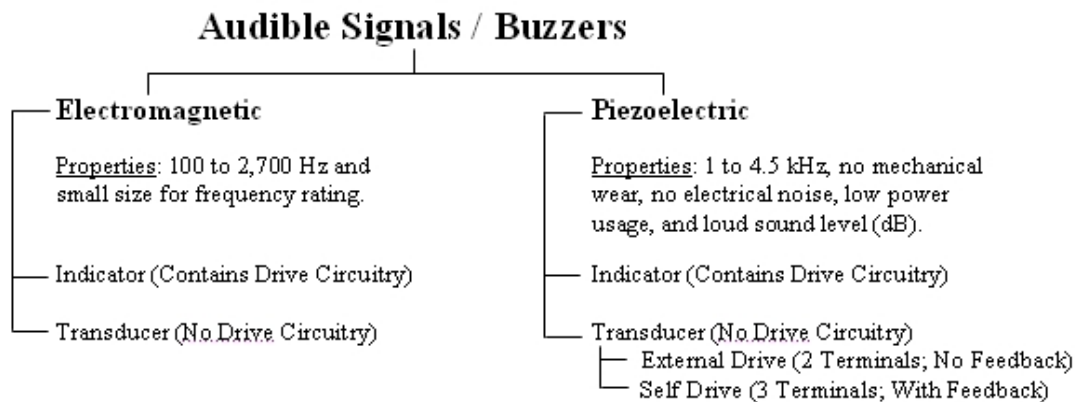


FIGURE I

Indicator vs. Transducer

Piezoelectric audible alarms are available in two packages: with a driving circuit (indicator) and without a driving circuit (transducer). Transducer devices do not have a circuit included, so the user must supply the drive signal to the device to generate the audible sound. The drive signal is typically a sine or square wave applied at the rated frequency of the particular transducer model. A transducer device has two package options: self-drive (with feedback) and external-drive (no feedback). An external-drive package will have only two external terminals on the device. The user must provide a full square or sine wave to the device to generate an audible sound. A self-drive package option has a third terminal that provides a feedback signal that is 180 degrees out of phase with the drive signal. A simple oscillation circuit can be used with the self-drive package that greatly reduces the component count (and cost). Schematics of electronic circuits that will provide drive signals for both the external-drive and self-drive types of transducer devices are available from the manufacturer of these devices.

Piezoelectric audible alarms that include a driving circuit are called indicators. For these devices, the user needs only to supply an appropriate voltage to produce the audible sound. Indicator models are available that operate over various voltage ranges from 1 to 250 volts AC or DC. Advantages to the designer of

indicator audible alarms include ease of use and the confidence that the design has been thoroughly tested over the entire operating temperature range and environmental conditions.

While a transducer type audible alarm will have a lower part cost since no electronic circuitry is included, the user will incur significant circuit design time and testing costs to ensure the operating reliability of their circuit design over the entire temperature range and environmental conditions. If the application using the audible alarm has significant sales volume and the design and testing resources are available, then the cost savings of using a transducer type audible alarm may be justified. Most designers will find, however, that the value added by an indicator model will more than justify its higher cost.

Sound Level

After deciding upon the type of sound needed such as a continuous tone, intermittent tone, or specialty sound, the designer must choose the sound level desired. The sound level is the size or amplitude of the air pressure fluctuations produced by the audible alarm. A useful scale for this purpose is the decibel or dB scale. This relative scale ranges from the threshold of hearing (0 dB) to the threshold of pain (130 dB). For an audible alarm to be useful, it must be at least 10 dB above the ambient background noise in order to be easily heard. As Figure II shows, the ambient background noise can vary widely from 30 dB at a library

Decibels	
130	Threshold of Pain
120	Rock Concert
110	Jet Take-off
100	
90	Heavy Truck
80	
70	Loud Singing
60	Conversation
50	
40	
30	Library
20	Quiet Whisper
10	
0	Hearing Threshold

Figure II

to 90 dB near a heavy truck. If a designer is not able to determine the ambient background noise where the audible alarm will be used, then the designer must rely on the experience of the audible alarm supplier to determine the needed sound level for the audible warning device. As a general rule of thumb, the following suggestions can be a starting point:

Application: Outside/Heavy Industrial
Use: Loud/Extra Loud Audible Alarm

Application: Light Industrial
Use: Medium Level Audible Alarm

Application: Office/Elevator
Use: Soft Level Audible Alarm

When comparing audible alarm sound level specifications from one manufacture to another, it is important for the designer to note whether or not the sound level specifications are listed as minimums or typical readings. Some buzzer manufacturers will strictly rate their parts to a guaranteed minimum dB level while others will be much looser in their promises and show typical values.

Another key to comparing sound level readings is to note the distance the sound level reading is specified at. Sound level will fall off 6 dB every time the distance traveled doubles, so the distance at which the measurement is made is critical. Unfortunately, there are no set distance standards for the industry, but an informal standard for the North American industry is a 2 foot measurement distance. Other common distances for sound level readings are 10cm, 30cm, and 100cm. A chart in Appendix I is attached to help convert sound level readings from different distances.

Finally, it must be noted that audible alarm providers must associate the rated dB level to an input voltage. For example, an indicator could have the following sound level specifications:

70 dB min. @ 2 ft. @ 6 Vdc.
85 dB min. @ 2 ft. @ 16 Vdc.

The first line above reads 70 decibels minimum at 2 feet at 6 Volts DC. As this example shows, the sound level increases from 70 dB to 85 dB as the voltage varies from 6 Vdc to 16 Vdc. This voltage versus sound level effect is related to the operation of the piezoelectric transducer. A larger voltage across the transducer will produce a greater physical deflection that will be heard as a louder sound.

A word must also be said about the method used by manufacturers to rate the dB level of their audible alarms. To avoid sound reflections and outside noise, and anechoic sound chamber should be used. This anechoic chamber is typically a box or a room lined with sound dampening material to ensure that the sound level readings are untainted. Not all manufacturers use anechoic chambers when rating their buzzers, so care must be taken when comparing one manufacturer's specifications with another's.

Frequency Rating

The next important characteristic to consider for an audible alarm is the rated frequency (also known musically as pitch). The number of pressure variations per second is the frequency of the sound, and it is measured in Hertz (Hz). The rumble of distant thunder has

a low frequency while a whistle has a relatively high frequency. The normal hearing range for a healthy young person is 20 Hz to 20,000 Hz (20 kHz), but as a person ages, they tend to lose their high frequency hearing capability.

A typical range of frequencies for audible alarms is as follows:

- Low Frequency: 1 to 2 kHz
- Medium Frequency: 2 to 3.5 kHz
- High Frequency: 3.5 to 4.5 kHz

While a piano will range from 27.5 Hz to 4,186 Hz, the human ear is most sensitive to sounds between 2 kHz and 5 kHz. Experiments have been run to understand how the sound level heard by the human ear is affected by frequency. It turns out that the human ear is not a perfect microphone. Low frequency sounds must have a higher sound level in order to “sound” as equally loud to the human ear as higher frequency sounds. To compensate for this facet of human hearing, the measurement of the sound level should be adjusted so that it reflects how the ear hears the sound. A recognized standard for this adjustment

is the A-Weighting curve shown in Figure III. When this curve is used to measure the sound level of an audible sound, the readings will be given in units of dBA showing that an A-Weighting curve was applied. An audible alarm user, therefore, should expect sound level readings specified in units of dBA such as:

90 dBA @ 10cm @ 6 Vdc.

The above statement reads: 90 decibels A-weighted at 10 centimeters at 6 Volts DC.

Power Consumption

As product design requirements move toward lower voltage levels and battery powered systems, the power consumption of all electronic components has become an important issue. Audible alarms require anywhere from tens of milliamps (mA) to 80+ mA to operate. Audible alarm circuit designs using inductors or transformers will typically require greater current (40+ mA) while designs utilizing discrete components or IC’s will typically use less than 20mA. Electromagnetic type audible alarms require greater current because they utilize an electromagnetic in their construction. If power consumption or electronic noise is an important consideration for the application, then electromagnetic devices and audible indicators that utilize inductors or transformers should be avoided.

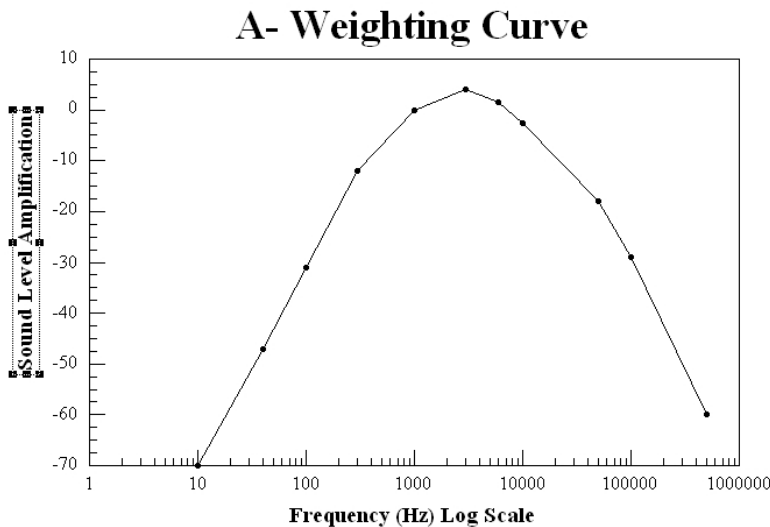


FIGURE III

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Construction Quality

Because of the critical role audible warning devices can play in an application, the quality of the buzzer should be an important consideration. Circuit designers often have the misconception that an audible alarm is a single component, whereas in reality, an audible alarm is a complicated assembly. While two different manufacturer's audible alarm devices may look and sound the same on the outside, the internal construction quality may be at two very different levels. When evaluating a particular audible alarm model, a tear-down of the unit should be standard practice. Peeling down the case of the audible alarm with side cutters will expose the circuit board and the transducer. Questions that can be answered by a tear-down include:

- Is the housing of sufficient strength?
- Is the circuit board relatively clean of excess flux?
- Do the solder joints have a good appearance?
- Is the circuit board well laid out without the use of jumpers?
- If the transducer is mounted to the housing using a silicone adhesive, is the adhesive bead clean, and does it have adequate adhesion strength?

One application question that is sometimes asked is whether the transducer metal type is important. Piezoelectric transducers are typically made of either brass or stainless steel. The advantage of brass is that it is cheaper and it is easier to process and therefore more reliable in the field. The only advantage of using stainless steel is

that it does not need to be coated with a protective coating for harsh salt water applications. For 99.9% of the applications (i.e. not subjected to harsh salt water), brass is the preferred transducer choice. For those other 0.1%, either a stainless steel or a brass transducer with a protective coating can be used.

Environmental Testing

For most applications, it is also important to note the environmental and electrical testing methods the audible alarm manufacturer uses to ensure their products are qualified. Testing should include: reverse voltage, surge voltage, vibration, shock, salt spray, thermal shock, hot and cold life & storage tests, and intermittent voltage life tests. This kind of data should be able to be provided upon demand.

Some production processes or application environments may also dictate whether the audible alarm should be completely sealed or open to the outside air. Manufacturers of audible alarms typically offer both sealed and unsealed units. Sealed units will often be back-filled in the housing with an epoxy compound. Unsealed units will often have a snap-in type cover. Sealed units may cost slightly more than unsealed units, and they may also be a little taller in height to provide additional room for the epoxy back-fill.

A similar processing issue is whether a wash label is needed to cover the sound emission hole during the circuit board cleaning process. If water penetrates inside the audible alarm during cleaning, the audible alarm may be either temporarily or permanently damaged by

the water intrusion. After the audible alarm makes it through the circuit board cleaning process, the wash label must be removed by hand for the audible alarm to function correctly. If the audible alarm will be seeing a wash type process, then a wash label is needed.

Market Trends

Several trends have emerged in the audible alarm market in the last few years. While the market will continue to steadily grow for large panel mount industrial units, the demand for smaller and louder pc board mount units has maintained its strong upward pace. The product offering of surface mount audible alarms has also increased to stay up with the ever growing demand for this type package.

Another challenge for audible alarm manufacturers is to provide audible alarms with lower frequencies. As we age, our higher frequency hearing capability tends to decline. With the aging of the baby boomers, there is a greater need to provide end products containing audible alarms with these lower frequency sounds. This need along with the demand for smaller and louder audible alarms results in conflicting design requirements for audible alarm designers. Due to the way a transducer operates, a lower frequency dictates a larger, not smaller, transducer size. This effect can also be seen with stereo speakers that use a large bass speaker to produce the low frequency music sounds and a small tweeter speaker for the high frequency music sounds.

Another trend with audible alarms is to provide specialty sounds. As audible

warning sounds have become more commonplace, using a specialty sound has emerged as a new way to catch someone's attention. Specialty sounds include chimes, chirps, warbles, and sirens. Advances in technology has enabled siren sounds to be placed on pc board mountable audible alarms measuring only 23 mm diameter by 10.5 mm high.



Board Mountable Siren Models
23mm dia x 10.5 mm height

For more information, contact:
Mallory Sonalert Products, Inc.
4411 S. High School Rd.
Indianapolis, IN 46241
317-612-1000 (ph)
info@mallory-sonalert.com (email)
www.mallory-sonalert.com (website)

Appendix I

Sound Level vs Distance

	Distance			
	1 Meter (3 feet)	60 cm (2 feet)	30 cm (1 foot)	10 cm
91	102	105	111	120
90	101	104	110	119
89	100	103	109	118
88	99	102	108	117
87	98	101	107	116
86	97	100	106	115
85	96	99	105	114
84	95	98	104	113
83	94	97	103	112
82	93	96	102	111
81	92	95	101	110
80	91	94	100	109
79	90	93	99	108
78	89	92	98	107
77	88	91	97	106
76	87	90	96	105
75	86	89	95	104
74	85	88	94	103
73	84	87	93	102
72	83	86	92	101
71	82	85	91	100
70	81	84	90	99
69	80	83	89	98
68	79	82	88	97
67	78	81	87	96
66	77	80	86	95

Sound Level (dB)

Examples:

1. An audible signal that is specified at 100dB at 2 feet would be equivalent to 115dB at 10cm.
2. 90dB at 1 Meter = 99dB at 1 foot.
3. 110dB @ 10cm = 81dB @ 10 feet.