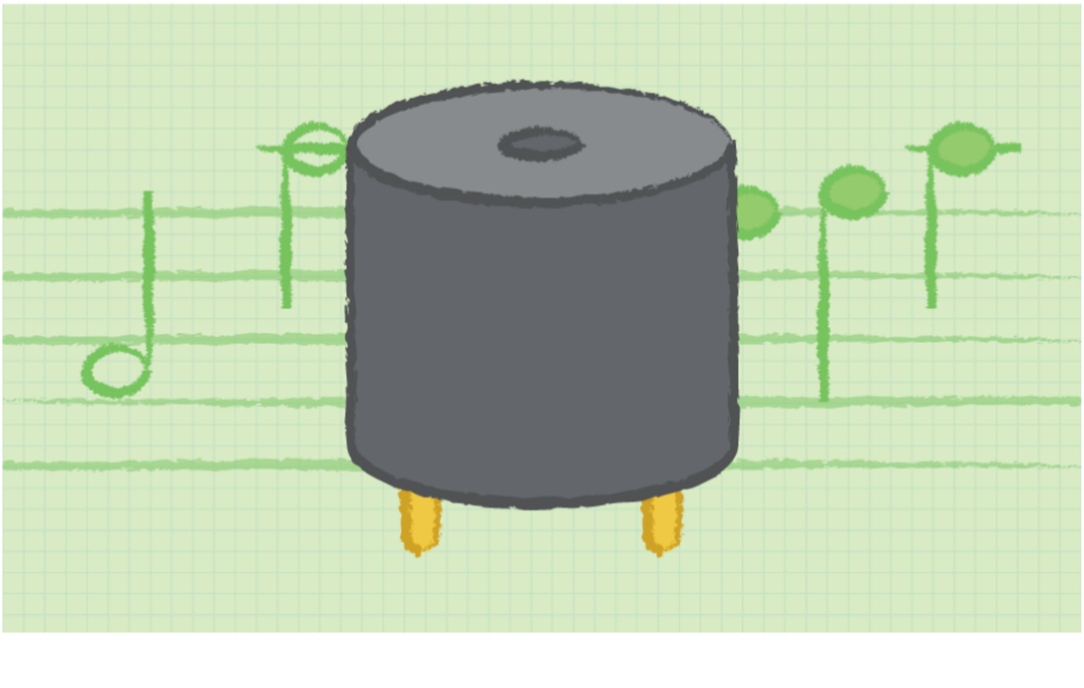
Buzzer Basics - Technologies, Tones, and Drive Circuits

By Bruce Rose



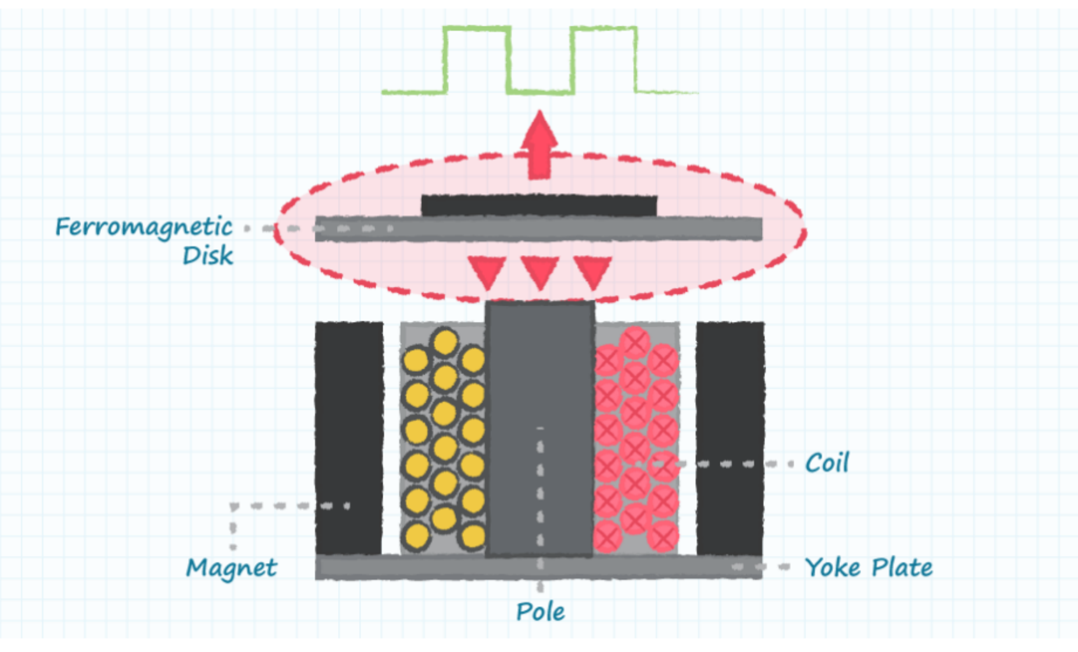
In This Post...

There are many choices for communicating information between a product and the user. One of the most common choices for audio communication is a buzzer. Understanding some of the technologies and configurations of buzzers is useful during the design process, so in this blog post we will describe typical configurations, provide example buzzer tones, and present common drive circuit options.

Magnetic and Piezo Buzzers

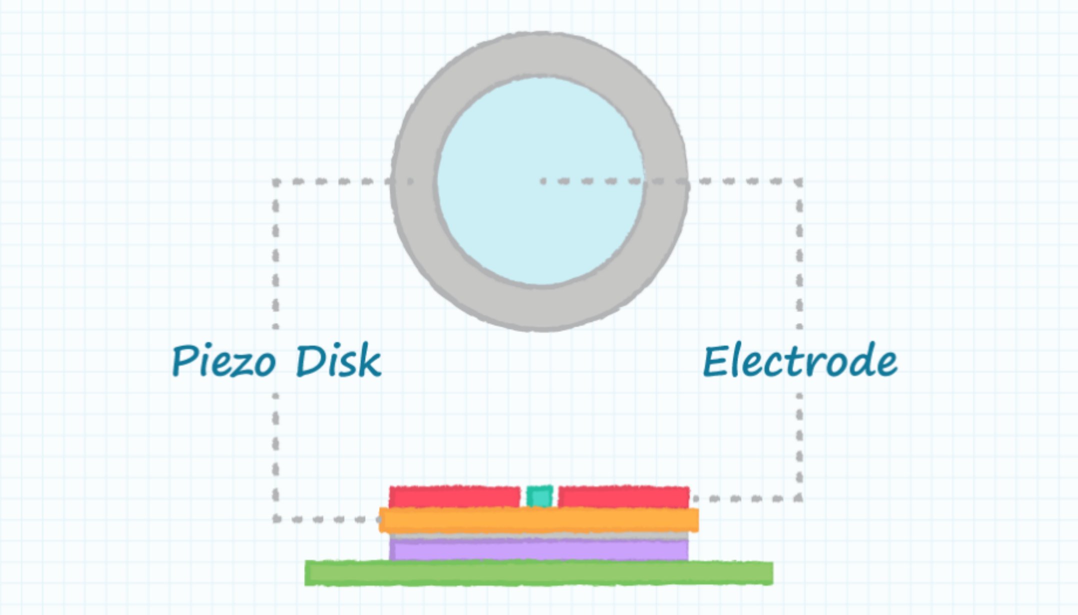
The two most common technologies used in buzzer designs are magnetic and piezo. Many applications use either a magnetic or a piezo buzzer, but the decision regarding which of the two technologies to use is based upon many different constraints. Magnetic buzzers operate at lower voltages and higher currents (1.5~12 V, > 20 mA) compared to piezo buzzers (12~220 V, < 20 mA), while piezo buzzers often have greater maximum sound pressure level (SPL) capability than magnetic buzzers. However, it should be noted that the greater SPL available from piezo buzzers requires larger footprints.

In a magnetic buzzer, a current is driven through a coil of wire which produces a magnetic field. A flexible ferromagnetic disk is attracted to the coil when the current is present and returns to a "rest" position when the current is not flowing through the coil. The sound from a magnetic buzzer is produced by the movement of the ferromagnetic disk in a similar manner to how the cone in a speaker produces sound. A magnetic buzzer is a current driven device, but the power source is typically a voltage. The current through the coil is determined by the applied voltage and the impedance of the coil.



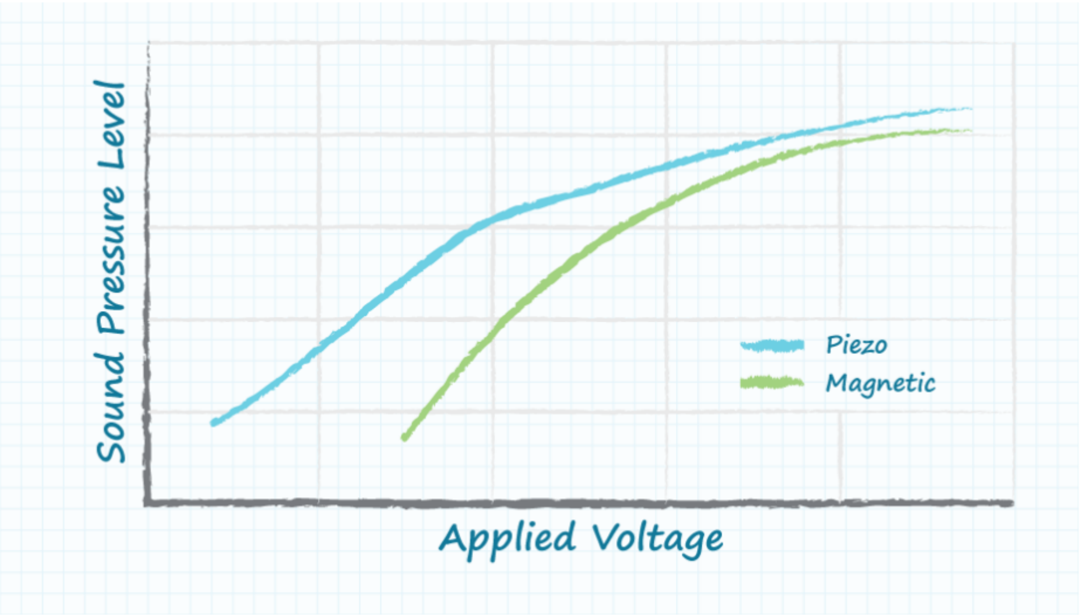
Construction of a typical magnetic buzzer

Piezo buzzers are used in similar applications as magnetic buzzers. Piezo buzzers are constructed by placing electrical contacts on the two faces of a disk of piezoelectric material and then supporting the disk at the edges in an enclosure. When a voltage is applied across the two electrodes, the piezoelectric material mechanically deforms due to the applied voltage. This movement of the piezo disk within the buzzer creates sound in a similar manner as the movement of the ferromagnetic disk in a magnetic buzzer or the speaker cone mentioned above.



Construction of a typical piezo buzzer

A piezo buzzer differs from a magnetic buzzer in that it is driven by a voltage rather than a current. A piezo buzzer is modeled as a capacitor while a magnetic buzzer is modeled as a coil in series with a resistor. The frequency of the sound produced by both magnetic and piezo buzzers can be controlled over a wide range by the frequency of the signal driving the buzzer. A piezo buzzer exhibits a reasonably linear relationship between the input drive signal strength and the output audio power while a magnetic buzzer's audio output declines rapidly with a decreasing input drive signal.



Graph showing the relationship between drive signal and audio output in piezo and magnetic buzzers

Transducers and Indicators

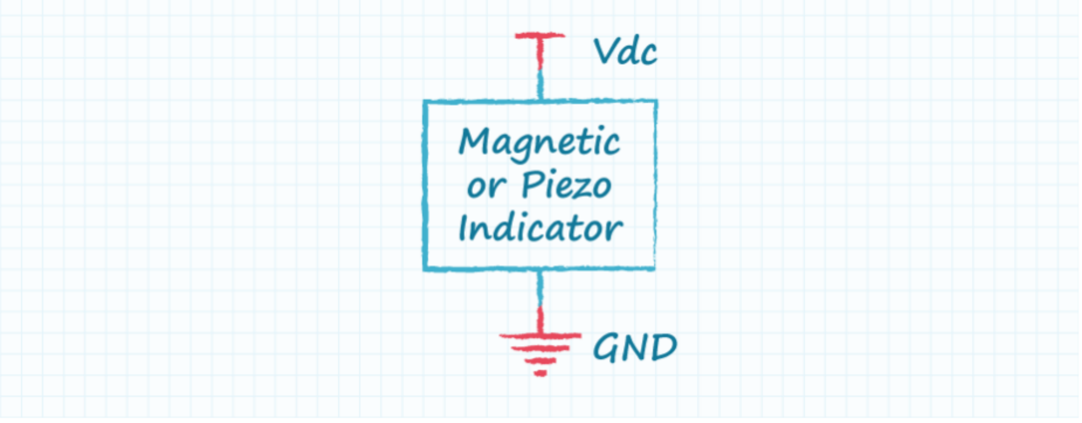
The following are some examples of the sounds that buzzers are able to create. The continuous tone and slow/fast pulse sounds can be produced by either an indicator or a transducer.

- Continuous (Feedback/ Warning Signal)
  - Indicator Vdc: continuously on
  - Transducer excitation waveform: continuous fixed frequency
- Slow/Fast Pulse (Feedback/ Warning Signal)
  - Indicator Vdc: switched on and off
  - Transducer excitation waveform: pulsed fixed frequency

The high/low tone, siren and chime sounds can be produced only by a transducer and the associated support circuitry due to the multiple frequencies of the signal.

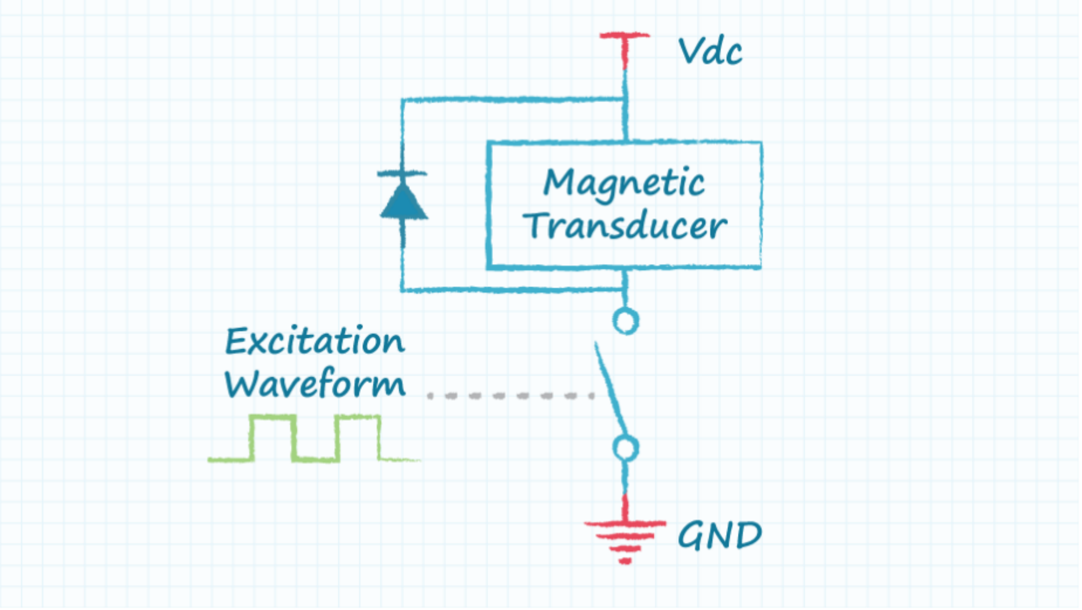
- High/Low Tone (Warning Signal)
  - Transducer excitation waveform: rapidly alternating between two frequencies
- Siren (Alarm)
  - Transducer excitation waveform: periodic ramping of frequency from low to high
- Chime (Door Bell)
  - Transducer excitation waveform: single slow cycle between high and low frequencies

Application Circuit for Magnetic or Piezo Indicator



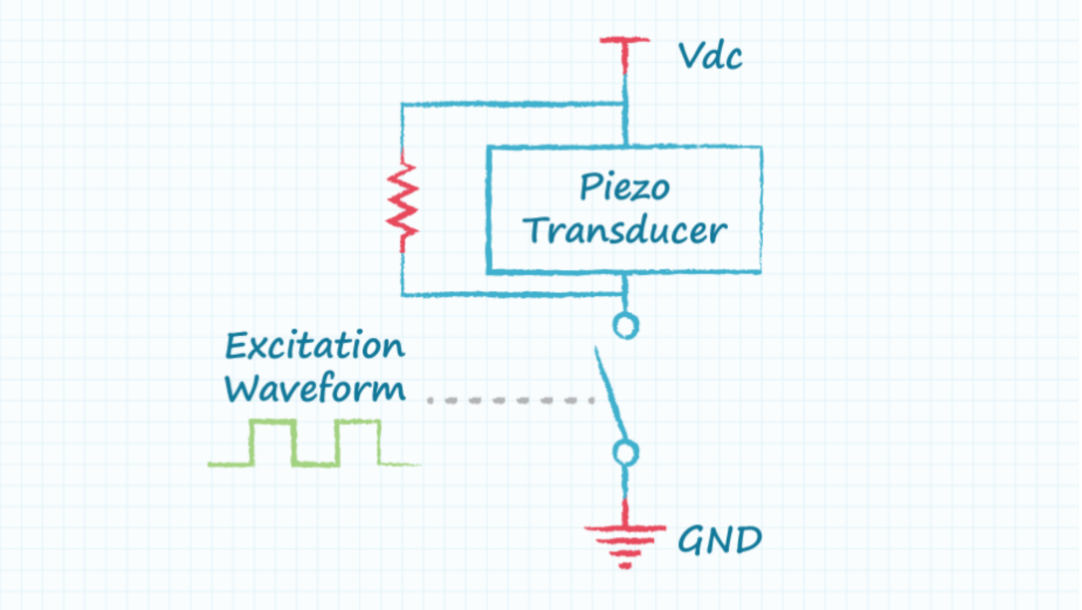
An indicator requires only a dc voltage to operate and sound is produced whenever the voltage is present.

Application Circuit for Magnetic Transducer



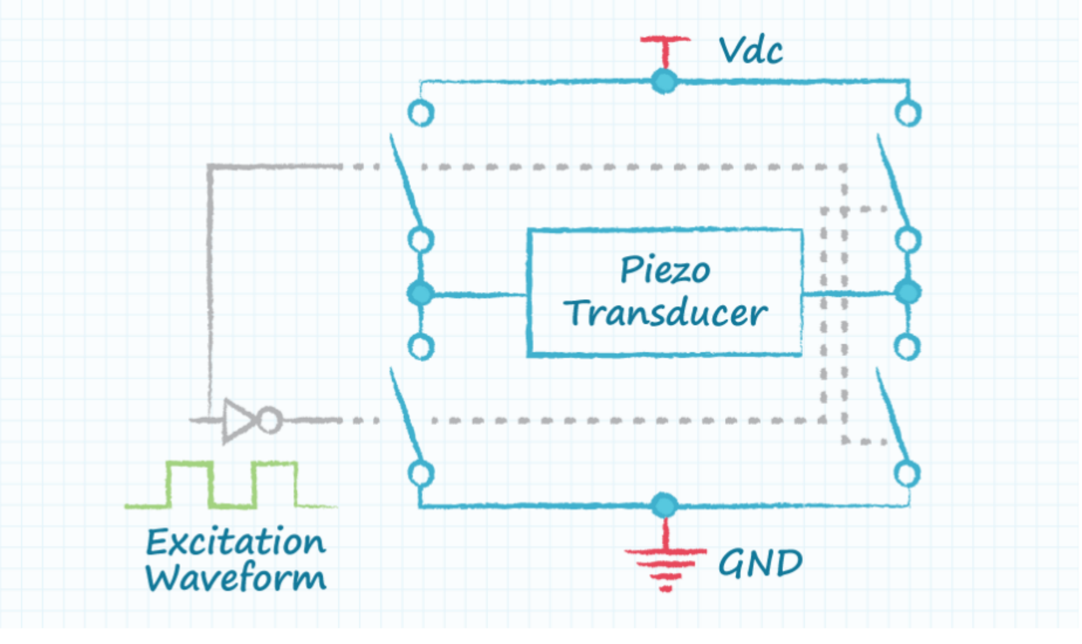
A magnetic transducer requires an excitation waveform to drive the buzzer. Arbitrary wave shapes and a wide range of frequencies can be used for the excitation waveform. The switch in the schematic is used to amplify the excitation waveform and is typically either a BJT or a FET. The diode is required to clamp the fly-back voltage created when the switch (transistor) is shut off quickly.

Application Circuit for Piezo Transducer



A piezo transducer can be driven with a circuit similar to a magnetic transducer. The diode across the piezo transducer is not required because the inductance of a piezo transducer is small, but a resistor is required to reset the voltage when the switch is open. This circuit is not normally used to drive a piezo transducer because the resistor dissipates power. Other circuits can be used to increase the sound level from a piezo transducer by increasing the peak to peak voltage applied to the transducer.

Full Bridge Circuit for Piezo Transducers

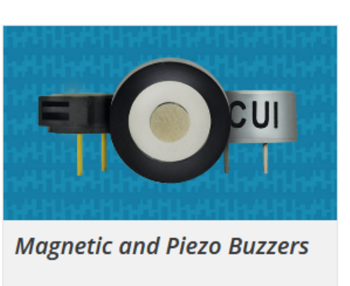


A full bridge circuit is often used for driving piezo transducers. The advantage of using the full bridge comprised of four switches is the peak-to-peak voltage applied across the transducer is twice as large as the available supply voltage. The use of a full bridge driver will cause a resultant increase in the sound volume of about 6 dB due to the doubling of the voltage applied to the transducer.

Conclusion

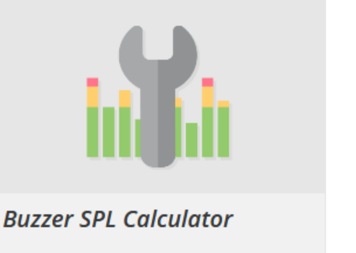
Buzzers are a simple and inexpensive means of providing communication between electronic products and the user. Piezo and magnetic buzzers are used in similar applications with the primary differences being that magnetic buzzers operate from lower voltages and higher currents than their piezo buzzer counterparts, while piezo buzzers offer users higher SPLs in generally larger footprints. Buzzers configured as indicators require only a dc voltage to operate but are limited to a single audio frequency of operation, whereas transducers require external circuitry, but provide a wider range of audio frequencies.

Additional Resources

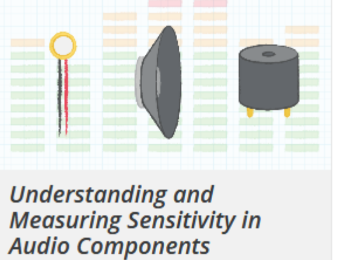


Magnetic and Piezo Buzzers
Featured Products

Buzzers and Their Working Principles
Product Spotlight



Buzzer SPL Calculator
Featured Resource



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Bruce Rose
Technical Contributor

During his many years in the electronics industry working in design, sales, and marketing, Bruce Rose has focused on analog circuits and power delivery. His range of work experience includes organizing and chairing international workshops, publishing and presenting in more than 40 technical conferences and journals, and having been awarded seven patents. While he enjoys his time at work, Bruce further enjoys the time he is able to spend with his family hiking, biking, and canoeing as well as pursuing his passion of full scale and model aviation.

PRODUCT SPOTLIGHT: PIEZO AND MAGNETIC BUZZERS

Introduction

Welcome to the CUI Devices Product Spotlight on piezo and magnetic buzzers. Learn about CUI Devices' buzzer product line, including a description of the main technologies used, their working principles, key specifications and possible applications.

Objectives

- Introduce the two main buzzer technologies and their working principles
- Introduce the two major circuit types and their working principles
- Introduce various options among CUI Devices' buzzer line, including available sound effects and mounting types
- Define common specifications
- Introduce typical applications

Searching for buzzers? Check out CUI Devices' portfolio of magnetic and piezo buzzers ▸

Piezo vs. Magnetic Buzzers

CUI Devices' buzzer line utilizes two main technologies. Each technology has specific advantages and tradeoffs that must be taken into consideration depending on the application requirements.

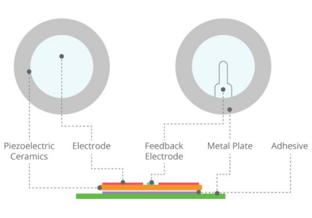
Piezo Buzzer Characteristics

- Wide operating voltage: 3~250 V
- Lower current consumption: less than 30 mA higher rated frequency
- Larger footprint
- Higher sound pressure level

Magnetic Buzzer Characteristics

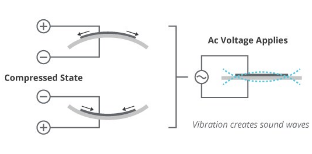
- Narrow operating voltage: 1~16 V
- Higher current consumption: 30~100 mA
- Lower rated frequency
- Smaller footprint
- Lower sound pressure level

Piezoceramic Element Structure



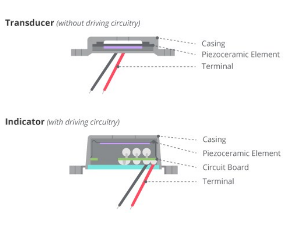
At the heart of all piezo-type buzzers is the piezoelectric element. The piezoelectric element is composed of a piezoelectric ceramic and a metal plate held together with adhesive. Both sides of the piezoelectric ceramic plate contain an electrode for electrical conduction. Piezo materials exhibit a specific phenomenon known as the piezoelectric effect and the reverse piezoelectric effect. Exposure to mechanical strain will cause the material to develop an electric field, and vice versa.

Working Principle of Piezo Buzzers



When an alternating voltage is applied to the piezoceramic element, the element extends and shrinks diametrically. This characteristic of piezoelectric material is utilized to make the ceramic plate vibrate rapidly to generate sound waves.

Piezo Buzzer Structure



There are two types of piezo buzzers - transducers and indicators. Transducers consist of a casing, a piezoceramic element and a terminal. In order to operate a transducer, the user must send a square wave signal to the buzzer. Indicators consist of a casing, a piezoceramic element, a circuit board and a terminal. In order to operate an indicator, the user must send the buzzer a specified dc voltage.

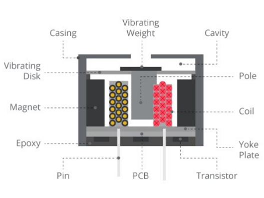
Piezo Buzzer Feedback

Some CUI Devices piezo buzzers include a feedback line. Driving circuits for buzzers with feedback tend to be simpler than those circuits without. Feedback is accomplished by dividing the piezo element into two, electrically isolated pieces. When the main piezo element is actuated it squeezes the feedback portion, creating a voltage on the feedback line. A simple way to use feedback is to have the feedback line connected to the base of a transistor. As the piezo element oscillates, the feedback signal will oscillate and the transistor will alternately block or allow current to flow.

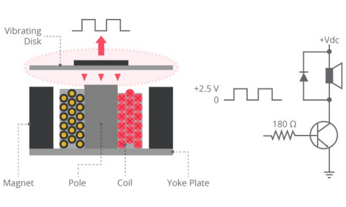
- The feedback line provides a voltage that is proportional to the strain on the main piezo element
- This voltage can be used to create a simple, self-oscillating circuit

Magnetic Buzzer Structure

This illustration highlights the structure of a typical magnetic buzzer. Like piezo technology, magnetic buzzers are available in transducer and indicator configurations. In a magnetic buzzer, the transistor acts as the driving circuit. Indicators include the transistor, creating a tone when a dc voltage is applied. Transducers lack this transistor, requiring a square wave signal to operate properly.



Working Principle of Magnetic Buzzers



The vibrating disk in a magnetic buzzer is attracted to the pole by the magnetic field. When an oscillating signal is moved through the coil, it produces a fluctuating magnetic field which vibrates the disk at a frequency equal to that of the drive signal.

Indicators vs. Transducers

As mentioned earlier in the presentation, piezo and magnetic indicators have the driving circuitry built into the design, creating a "plug and play" solution. Because of this, engineers do not need to worry about building a complex circuit to drive the buzzer. The disadvantage, however, is that indicators operate on a fixed frequency, reducing the flexibility offered to achieve an alternate frequency as application requirements change. Transducers, on the other hand, do not have the driving circuit built-in, so engineers are offered a greater range of flexibility when designing their circuit. The downside comes in the fact that transducers do require an external driving signal to operate properly, potentially adding complexity and time to the design cycle.

Indicator Characteristics

- Built-in driving circuit (frequency generator)
- Simple to design-in
- Fixed frequency (function)

Transducer Characteristics

- External driving circuit required
- Complex to design-in
- User-selected frequencies or multiple frequencies

Key Buzzer Specifications

Frequency Response

How efficiently a buzzer produces sound at a given frequency.

Sound Pressure Level (Unit: dB Pa)

Sound pressure level, SPL, is the deviation from atmospheric pressure caused by the soundwave expressed in decibel Pascals. It is generally proportional to input voltage and decays by 6 dB's when doubling the distance from the buzzer.

Resonant Frequency (Unit: F0 Hz)

All things have a specific frequency at which they tend to vibrate. This frequency is called the resonant frequency. For buzzers, the resonant frequency is the frequency at which they will be the loudest.

Impedance (Unit: ohm)

Electrical impedance is the ratio of applied voltage to current. The electrical impedance varies with frequency.

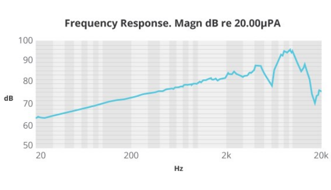
dB's

$$L_p = 10\log_{10}(Prms/Pref) = 20\log_{10}(Vrms/Vref)$$

A decibel is the scaled logarithm of the ratio of a measured value with respect to a reference value. Decibels are useful because they can show a huge range of values in a small space. For instance a sound pressure scale going from 0-120 dB can represent sound pressures from 20 μPa (micro-pascals) to 20,000,000,000,000 μPa. This roughly represents the lowest SPL a human can hear all the way up to uncomfortably loud sounds. Note: The generally accepted value for "Pref" in the formula above is 20 μPa.

- dB stands for decibel
- It is not a unit, but rather a ratio
- Values increase exponentially, instead of linearly as in counting numbers
- Expressed in "normal" numbers, 20 dB is ten times the power of 10 dB
- Allows for a huge range of values to be expressed in relatively little space

Frequency Response



In a perfect world all devices would recreate every frequency at the exact same amplitude. In real life every device will have frequencies which it may amplify and frequencies which it will tend to reduce or attenuate. Frequency response curves show how a particular device responds to each frequency. SPL is plotted against frequency to indicate how the device will handle certain frequencies. Note: frequency is plotted on an exponential basis, similar to dB's, it allows the full range of human hearing to be fit in a compact space.

The Human Ear and A-Weighting

Comparison of Different SPL's		
Jet engine at 30 m	632 Pa	150 dB
Threshold of pain	63.2 Pa	130 dB
Hearing damage (possible)	20 Pa	Approx. 120 dB
Jet at 100 m	6.32-200 Pa	110-140 dB
Jack hammer at 1 m	2 Pa	Approx. 100 dB
Traffic on a busy roadway at 10 m	$2x10^{-1}$-$6.32x10^{-1}$ Pa	80-90 dB
Passenger car at 10 m	$2x10^{-2}$-210^{-1} Pa	60-80 dB
Normal conversation at 1 m	$2x10^{-3}$-$2x10^{-2}$ Pa	40-60 dB
Very calm room	$2x10^{-4}$-$6.32x10^{-4}$ Pa	20-30 dB
Auditory threshold at 1 kHz	$2x10^{-5}$ Pa (RMS)	0 dB

20 Hz to 20 kHz tends to be the general range for human ears. This range is reduced with age, especially in males. In older males 13 kHz tends to be the upper end of the audible range. The human ear does not have a flat frequency response over the audible range. Certain frequencies tend to be attenuated while others are magnified. A-weighting attempts to compensate for this by discounting frequencies which the human ear is less sensitive to. It places priority on sounds between 1 kHz and 7 kHz.

- Generally, most humans can perceive frequencies from 20 Hz ~ 20,000 Hz
- However, the human ear is more sensitive to some frequencies than others
- A-weighting places more value on frequencies which the human ear is more sensitive to
- Some CUI Devices buzzers specify SPL using the A-weight system, i.e. dBA

Resonant Frequency

The classic experiment showing that a crystal wine glass can be shattered when excited by a sound that matches its resonant frequency

Every system has a particular frequency that it tends to vibrate at. For instance, if you pluck a string on a guitar that string will vibrate very near, or at, its resonant frequency. By driving a system at its resonant frequency, very large displacements, relative to the input signal strength can be achieved. Driving a buzzer with an input signal which has the same frequency as the buzzer's resonant frequency, will create the greatest SPL with the least input power.

- Resonant frequency is the natural frequency a system tends to oscillate at
- Driving a system at its resonant frequency will create the largest amplitudes with the smallest input
- Buzzers are loudest when driven at their resonant frequency

SPL Calculator

CUI Devices has developed an SPL calculator to allow users to convert a buzzer's specified SPL on the datasheet to different real-world conditions, or to compare SPLs between two devices with different specified parameters. This tool makes it quick and easy for designers to specify the proper buzzer for their application.

Try the SPL calculator now ▸

Buzzer Sound Samples

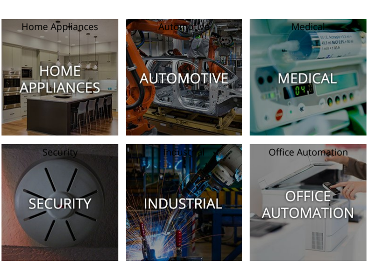
Buzzers are implemented across many applications, usually to act as a warning signal. Click on the sound icons to sample common sound effects available in the CUI Devices buzzer line.

Sound Effects

- Continuous (Feedback/ Warning Signal)
- High/Low Tone (Warning Signal)
- Slow/Fast Pulse (Feedback/ Warning Signal)
- Siren (Alarm)
- Chime (Door Bell)

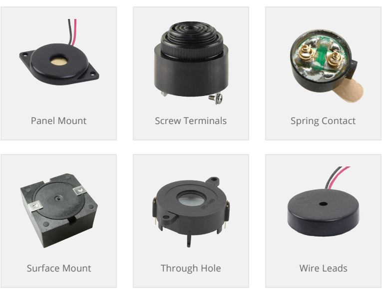
Applications

Buzzers are typically used for identification and alarm purposes across many major industries. The major application categories that utilize buzzers for indication or alert purposes include: home appliances, automotive electronics, medical, safety and security, industrial, and office automation.



Mounting Configurations

CUI Devices' buzzers are available in various mounting configurations depending on the application need, including SMT, PCB pin, wire lead, snap-in, vertical mount and panel mount.



Quickly find and compare models based on your key specifications ▸

Summary

CUI Devices' buzzer line utilizes two main technologies, magnetic and piezoelectric. And their available mounting configurations allow for consumers to utilize CUI Devices' broad product line depending on the application need.

Search CUI Devices' Buzzers

Contact Us

CUI DEVICES
6405 SW Rosewood St, Ste C
Lake Oswego, OR 97035
1-877-323-3576

PIEZO PASSIVE BUZZER - VERTICAL

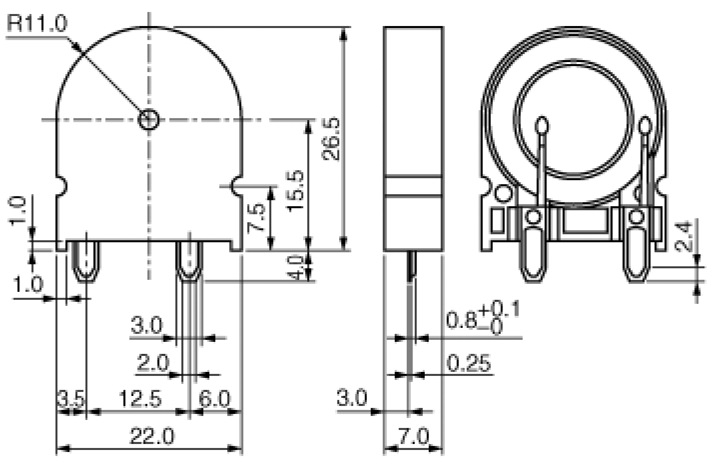
Externally driven piezoelectric sounders are used in washing machines, keyboard, timer, digital watches, electronic calculators, telephones and other consumer equipment. They are driven by a signal (ex.: 2048Hz or 4096Hz) from an LSI/MCU and provide melodious sound. Also, if the source is like a melody IC, you can also sound melody. Equivalent to Murata PKM22EPTH2001-B0.

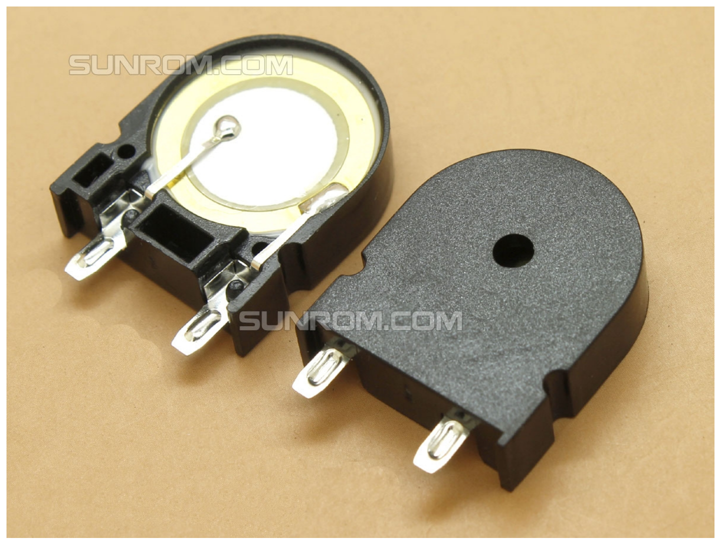
Features

1. Low power consumption
2. No noise and high reliability
3. No electric noise and little influence on peripheral circuits
4. It complies with the JEITA standard (RC - 8180A)

DIMENSIONS

PCB Holes we suggest of 3.2mm dia. with 12.5mm space apart





Tol.: ±0.5
(in mm)

SPECIFICATIONS

Size	22.0×7.0×26.5 mm
Frequency	2 kHZ
Sound Pressure Level	70dB (min.)
Measure Condition of Sound Pressure Level	[3.0Vp-p,2.0kHz,square wave,10cm]
Capacitance	19nF
Capacitance Tolerance	±30%
Measurement Condition of Capacitance	[120Hz]
Maximum input voltage	±12.5Vo-p max. or 25.0Vo-p max
Operating Temperature Range	-20°C to 70°C
Storage Temperature Range	-40°C to 80°C
Shape	Lead
Lead Shape	Pin Type
Lead length	Lead length:4.0mm
Drive Type	External Drive
EIAJ Part Number	PS-RP2-V27-20

CHARTS

Figure 1 Frequency Characteristics (sine wave)

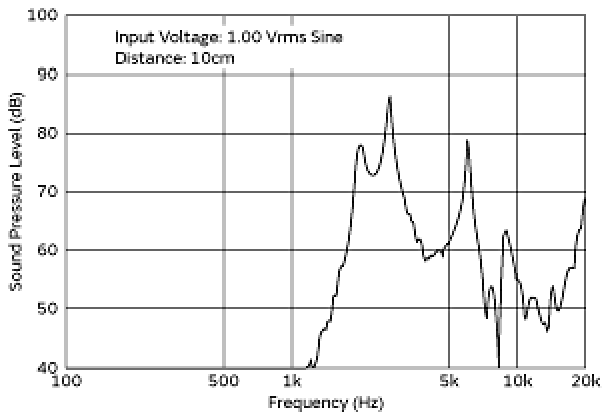


Figure 2 Frequency Characteristics (square wave)

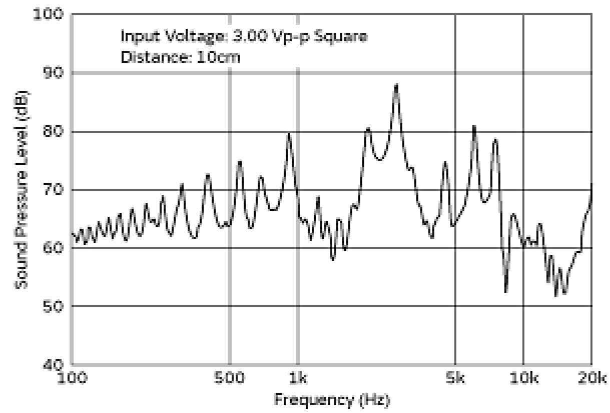
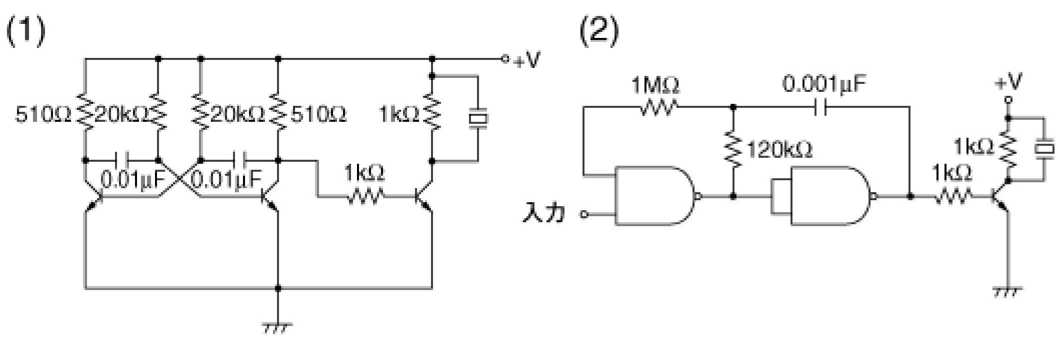


Figure 3 Typical Externally Driving circuit, Astable, NAND, Inverter gates



NOTES

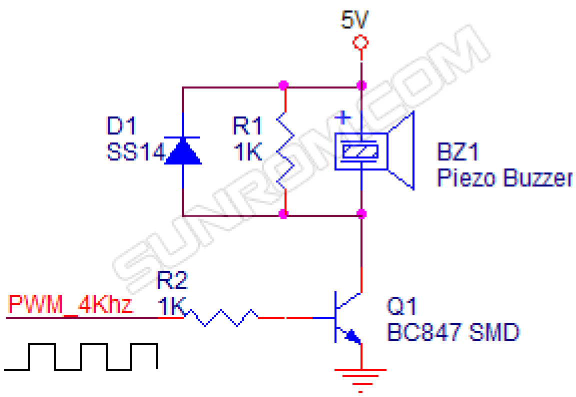
Please note, Unlike electromagnetic types which has coil, This buzzer does not contains internal driving circuit, so do not expect to just power on and hear something. It needs square wave of 4Khz to drive. The black case provides cavity for resonance and protection. You can vary its frequency to create tones just like you hear from microwave or washing machine.

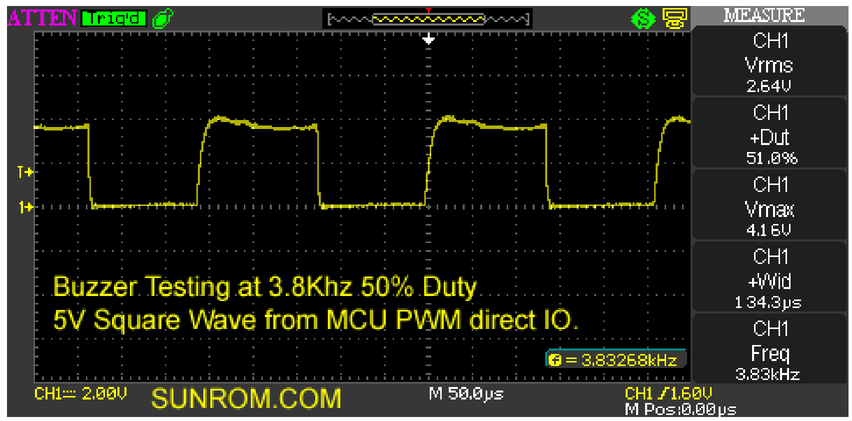
When compared to low cost electromagnetic type buzzer this piezo consumes only 2-3mA, while coil type can take upto 100mA. Low current consumption makes it ideal for battery operation. While electromagnetic type is high on EMI, this piezo's emi noise is very neglible.

Buzzer Comparison

Parameter	**Piezo Buzzer This model**	**Other Electromagnetic Coil Type**
Current	2-3mA	150-200mA
Moisture	Proof	Sensitive to moisture
Operation Life	Long, No moving parts	Coil heats and life is around 2 years
Operation Temp	High upto 150 deg C	approx 50 deg C
Noise	Does not emit	Emit high EMI noise over driving voltage
Technology	Piezo Vibration	Coil Oscillation
Frequency	Variable 1-10Khz	Fixed

You can use frequency from 1 Khz to 10 Khz but highest amplitude you will get around 4 Khz. Please see graph of frequency response above.
This is how we use it in our designs at Sunrom.





ORDERING DETAILS

Sunrom Part#	Ordering Page
5288	http://www.sunrom.com/m/5288

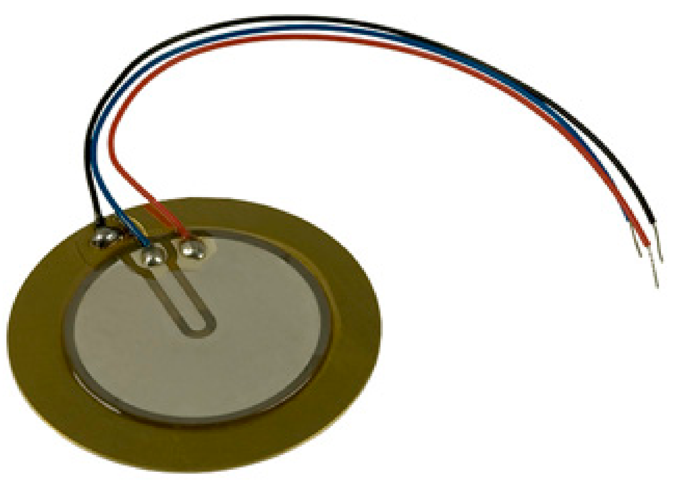
What's the third wire on a piezo buzzer?

Ask Question

Asked 8 years, 10 months ago Active 3 years, 1 month ago Viewed 41k times

44

Most piezos I've seen have just two connections, but this type has three.



What's the third wire for?

piezo-buzzer

share improve this question follow

asked Aug 14 '11 at 10:54
Federico Russo
9,108 • 13 • 59 • 112

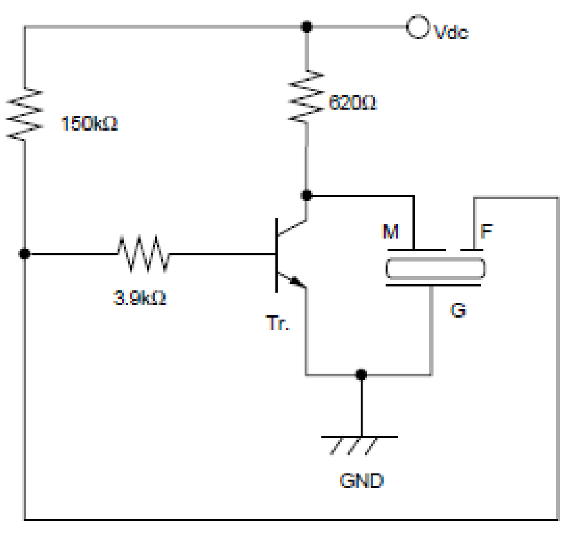
2 I accepted stevenvh's answer because it makes it clear to me. Don't let this stop you from posting other answers, however, possibly giving more detail. I might change my mind :-) – Federico Russo Aug 14 '11 at 14:10

It's a good answer. Nice and clear and to the point. – Russell McMahon ♦ Aug 15 '11 at 8:03

add a comment

50

They're called **self drive** types, and they're meant to be used as part of the oscillator:



The piezo effect works both ways: if you apply a voltage the piezo stretches, but also if it stretches it creates a voltage. This principle is used to create a feedback signal which drives the oscillator.
The advantage of the self drive is that it will automagically work at its **resonance frequency**, where it produces the loudest sound. In 2-wire circuits the oscillator's frequency is independent of the piezo's resonance frequency, and it's the designer who has to make that they're close.

For the piezo of your picture:

> "G" = black

(I guess `M`, `F` and `G` stand for `Main`, `Feedback` and `Ground`, resp. CMIIW)

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edited Aug 15 '11 at 11:50

answered Aug 14 '11 at 11:01
stevenvh
139k • 19 • 435 • 648

3 I found a 3 pin piezo puzzer in a smoke detector and was wondering how it works (and why it's there). Now that you say it allows to produce the loudest sound, it makes sense... – tigrou May 2 '15 at 16:18

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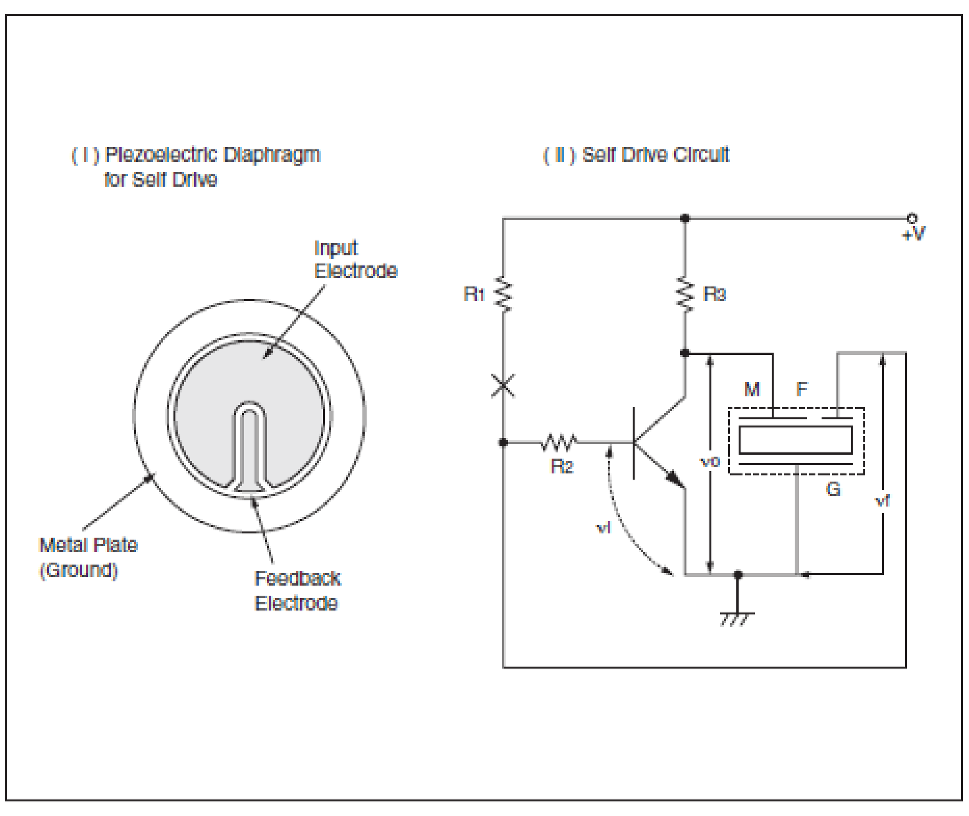
9

Here is a good in-depth explanation of buzzers including self-driven ones + some usefull schematics: [Piezoelectric Sound Components Application Manual](#) (812kb).

Excerpt (from p.5):

> **Self Drive**
>
> Method Fig. 9 shows a typical application of the self drive method. The piezoelectric diaphragm provided with feedback electrode shown in Fig. 9 (i) is involved in the closed loop of a Hartley types oscillation circuit. When the frequency is closed to the resonant frequency, the circuit satisfies oscillating conditions, and the piezoelectric diaphragm is driven with the oscillating frequency. Fig. 9 (ii) shows a simple oscillating circuit consisting of one transistor and three resistors. In general, the node support shown in Fig. 3 (a) is popular in the self drive method. Proper resonance of the piezoelectric diaphragm by the node support provides stable oscillation with high mechanical Qm of vibration but also a single high pressure tone.
>
> 
>
>
> **Fig. 9 Self Drive Circuit**

share improve this answer follow

edited Jun 2 '17 at 12:40
Community ♦
1

answered Mar 23 '14 at 19:13
hurufu
191 • 2 • 3

1 I agree, it does, but linking to a pdf with all the information makes for a bad answer. Please include some of the relevant information in your answer text. – Passerby Mar 23 '14 at 19:36

1 @hurufu Welcome to EE.SE. There is a slight problem with answers, which primarily consists of link to an external page (so called *link-only answer*). If that page moves in the future, then the link dies, and the answer becomes largely useless. So, include an abstract (or excerpt, or synopsis) along with the link.
– Nick Alexeev ♦ Mar 23 '14 at 19:44

this helps a lot to me and make this circuit clear~ – lukeluck Oct 12 '19 at 1:14

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