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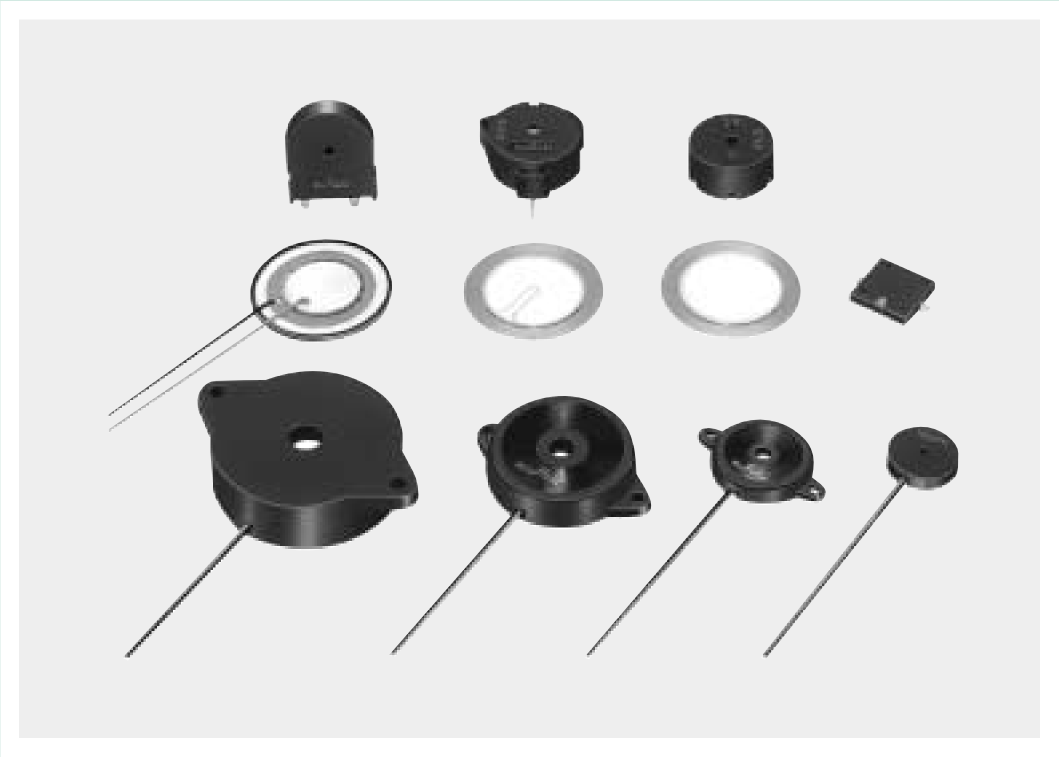


PIEZOELECTRIC SOUND COMPONENTS

APPLICATION MANUAL

Innovator in Electronics

Murata
Manufacturing Co., Ltd.

Introduction

Murata is active in R&D of new electronic components, seeking infinite possibility of ceramic materials. Particularly, as a pioneer in the development of piezoelectric ceramics, Murata has met the needs of technical revolution in electronics with original products.
Our ceramic resonators (CERALOCK®), ceramic filters (CERAFIL®), piezo buzzers and various ultrasonic transducers have been contributed to the development of electronics.
The "Piezoelectric sound components" introduced herein operates on an innovative principle utilizing natural oscillation of piezoelectric ceramics. Today, piezoelectric sound components are used in many ways such as home appliances, OA equipments, audio equipments and telephones etc. And they are applicated widely, for examples, alarms, speakers, telephone ringers, receivers, transmitters and beep sounds etc.
This manual is made for customers to use piezoelectric sound components efficiently and with no trouble. It is recommended that the manual be read while referring to the catalog.

CONTENTS

1 Type of piezoelectric sound components and Oscillating system

1. Type of piezoelectric sound components

TYPE	DRIVING PROCEDURES			STANDARD PARTS
	EXTERNAL DRIVE	SELF DRIVE	BUILT IN CIRCUIT	
PIEZOELECTRIC DIAPHRAGM	○	○		7BB-27-3R5
PIEZOELECTRIC SOUNDER	○	○		PKM22EPT-2001-B0
PIEZOELECTRIC BUZZER		○	○	PKB24SPC-3601-B0
PIEZOELECTRIC SPEAKER	○			VSB35EW-0701B

2. Oscillating system

Basically, sound source of a piezoelectric sound component is a piezoelectric diaphragm. A piezoelectric diaphragm consists of a piezoelectric ceramic plate which have electrodes on both sides and a metal plate (brass or stainless steel etc).
A piezoelectric ceramic plate is attached to a metal plate with adhesives. Fig. 2 shows the oscillating system of a piezoelectric diaphragms.
Applying D. C. voltage between electrodes of a piezoelectric diaphragm causes mechanical distortion due to the piezoelectric effect. For a disshaped piezoelectric element, the distortion of the piezoelectric element expands in radial direction. And the piezoelectric diaphragm bends toward the direction shown in Fig.2 (a). The metal plate bonded to the piezoelectric element does not expand. Conversely, when the piezoelectric element shrinks, the piezoelectric diaphragm bends in the direction shown in Fig.2 (b). Thus, when AC voltage is applied across electrodes, the bending shown in Fig.2 (a) and Fig.2 (b) is repeated as shown in Fig.2 (c), producing sound waves in the air.

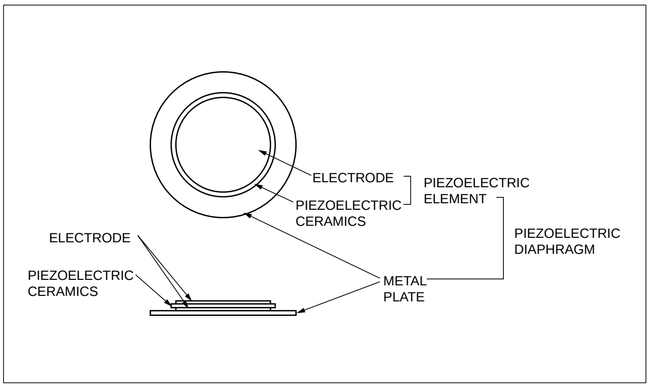


Fig. 1 Structure of piezoelectric diaphragm

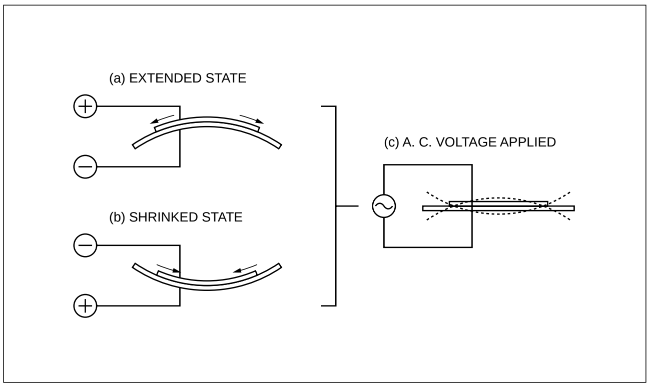


Fig. 2 Oscillation system

2 Procedures

1. Soldering procedures

A lead wire is needed to apply voltage to the piezoelectric diaphragm. When using a soldering iron, the optimum temperature for soldering a lead wire to a metal plate is 300℃ for a few seconds and the same temperature for the ceramic silver electrode for 0.5 second or less. The lead wire should be as fine as possible, as it works as a load restricting oscillation of the piezoelectric diaphragm. (Example: AWG32)

2. Design procedure

In general, man's audible frequency range is about 20 Hz to 20kHz. Frequency range of 2kHz to 4kHz are most easily heard. For this reason, most piezoelectric sound components are used in this frequency range, and the resonant frequency (f_0) is generally selected in the same range too. As shown in Fig. 3, the resonant frequency depends on methods used to support the piezoelectric diaphragm. If piezoelectric diaphragms are of the same, shape, their values will become smaller in the order of (a), (b) and (c). In general, the piezoelectric diaphragm is installed in a cavity to produce high sound pressure (Fig. 4). The resonant frequency (fcav) of the cavity in Fig. 4 is obtained from Formula (1) (Helmholtz's Formula). Since the piezoelectric diaphragm and cavity have proper resonant frequencies, (f_0) and (fcav) respectively, sound pressure in specific frequencies can be increased and a specific band width can be provided by controlling the both positions.

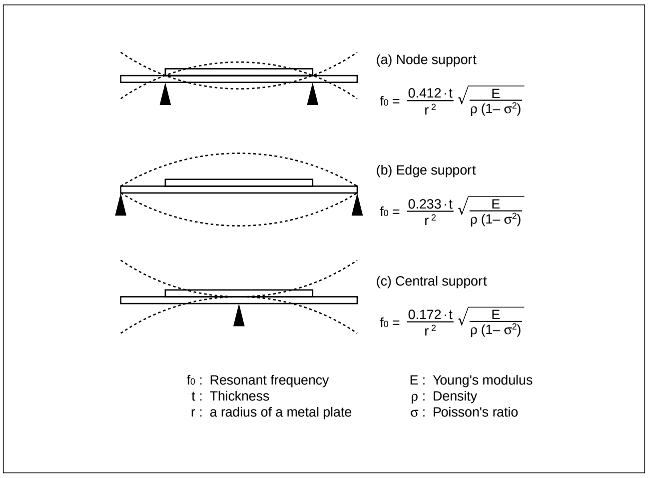


Fig. 3 Supporting method

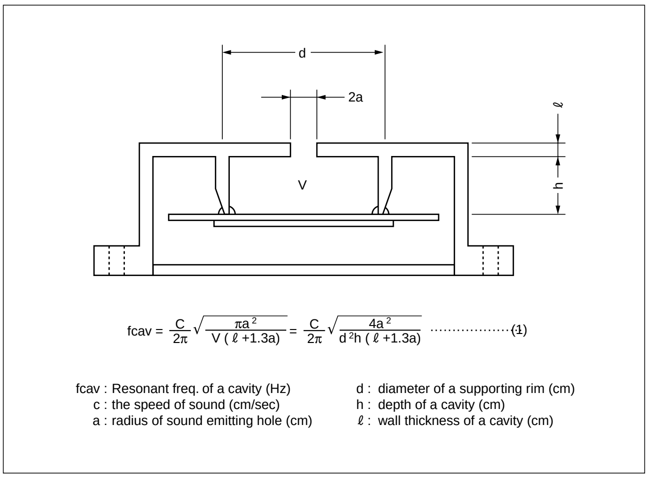


Fig. 4 Sectional view of a cavity

3. Drive procedure

Drive procedures for piezoelectric sound components include (a) external drive method and (b) self drive method as shown in Fig. 5.

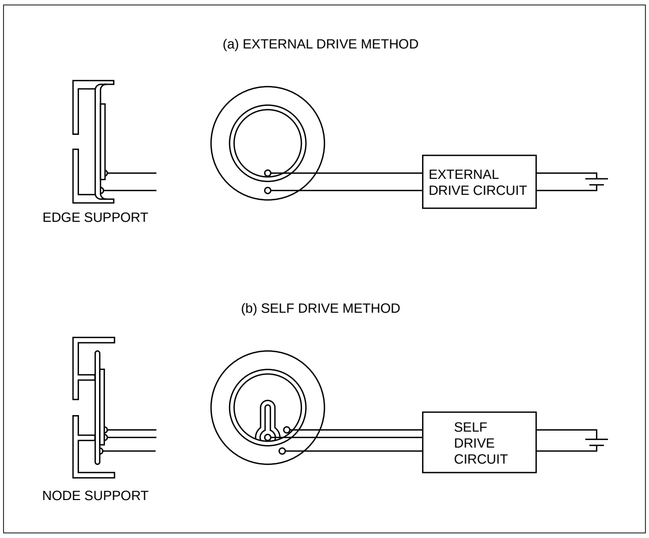


Fig. 5 Drive procedure

External drive method

This method produces sound by driving the piezoelectric diaphragm with electric signals supplied from an external oscillating circuit such as a multivibrator. Using this method, the piezoelectric buzzer can work as a speaker. In this method, a mechanical oscillation Qm of the piezoelectric diaphragm is damped properly to provide a wider frequency band of the sound pressure. This is applied to a switching sounds of home electric appliances, key-in sounds of OA equipments, alarm sounds of digital watches and the multiple sounds like those used in electronic games. This method is also applied to the ringers, transmitters, receivers of telephone sets, tweeters, card radios and speakers of crystal TV's. Fig. 6 shows the examples of the circuit to which the external drive method is applied.
(i) represents a circuit in which output signals of the unstable multivibrator are boosted through the coil and transistors. (ii) represents a circuit using 2 NAND gates, which is oscillated or stopped by ON / OFF operations of the input signal. (iii) and (iv) represent example of the piezoelectric diaphragm connected to telephone tone ringer IC.

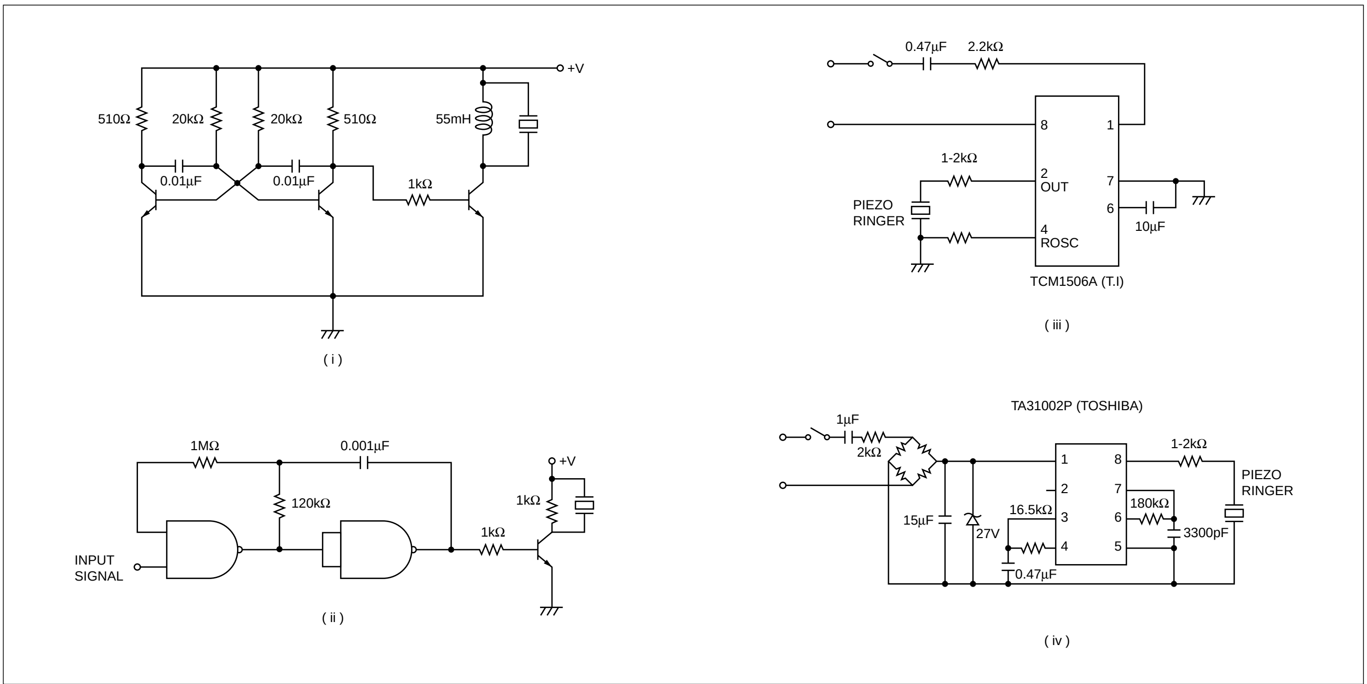


Fig. 6 Example's of the external drive circuit

Notice (handling) in using external drive circuit

1) Electric charges accumulated in the piezoelectric diaphragm due to thermal and mechanical shock may cause high voltage which may destroy LSI. Use the method using a Zener diode as shown in Fig. 7 to prevent this.
2) Applying D. C. voltage to the piezoelectric diaphragm in the environment of high humidity causes Ag migration. Therefore, design a circuit which does not require D. C. voltage be applied for a long time.
3) Consider the following points in connecting a piezo ringer and tone ringer IC.
   i) For external capacitors and resisters; especially, when the ringing frequency is changed by adjusting variable resister, tone may be distorted.
   ii) Ringer ICs; ringer ICs are produced by many manufactures have different characteristics. When using a ringer IC, consult us or its manufacturer for operating procedures.
   iii) If tone is distorted as discribed in Fig. 8 (a), place a resister in series to vary resistance as described in (b) and select a resistance with which the distortion can be eliminated. The recommended resistance is in a range between lkohms to 2kohms. Alternatively, it is recommended to place a diode in parallel with the piezo ringer.

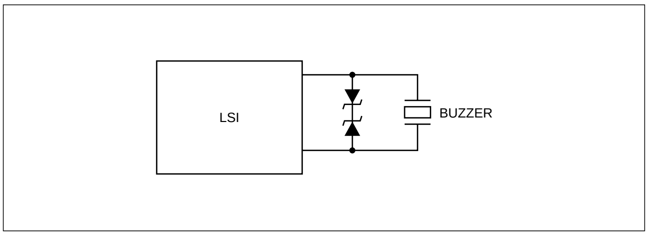


Fig. 7 Protect circuit

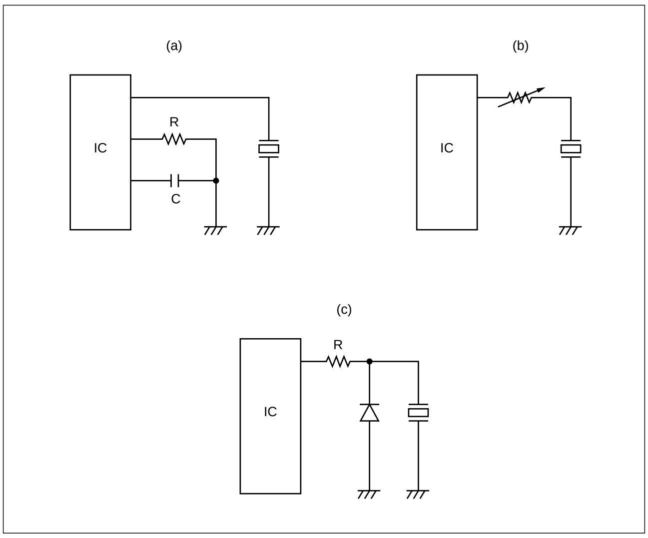


Fig. 8 Circuits for piezo ringer

Self drive method

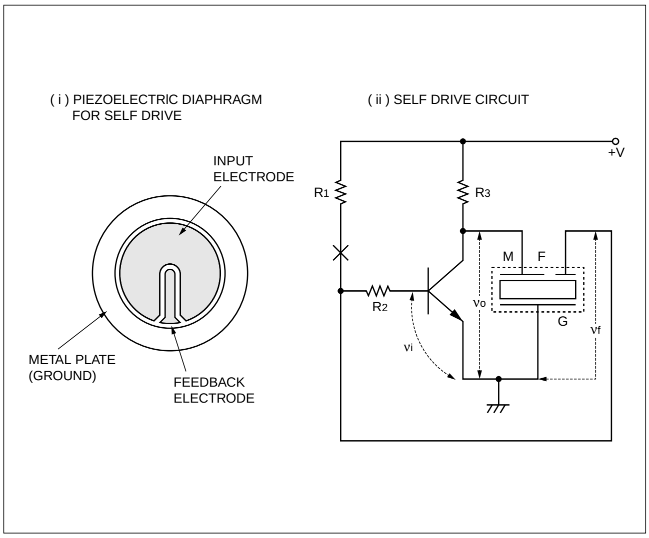
Fig. 9 shows a typical application of the self drive method. The piezoelectric diaphragm provided with feedback electrode shown in Fig.9 (i) is involved in the closed loop of a hartley types oscillation circuit. When the frequency is closed to the resonant frequency, the circuit satisfies oscillating 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.
Basic oscillating conditions of this circuit are shown below.

a. Phase difference between v_o and v_f shown in Fig. 9 must be 180 degrees.
b. The following conditions must be satisfied:

$$v_f / v_o \geqq \frac{R_2+h_{ie}}{h_{fe} \cdot R_3}$$

where;
h_{ie}: Input impedance of transistor
h_{fe}: Current amplification

c. Set R_1 so that the D. C. bias point of transistor, VCE is half of supply voltage.
d. Adjust R_2 so that spurious oscillation is not applied to oscillating waves.

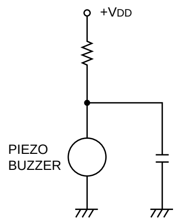


Fin. 9 Self drive circuit

2 Procedures

Notice (handling) in using self drive method

1) When the piezoelectric buzzer is set to produce intermittent sounds, sound may be heard continuously even when the self drive circuit is turned ON / OFF at the "X" point shown in Fig. 9. It is because of the failure of turning off the feedback voltage.
2) Builed up a circuit of the piezoelectric sounder exactly as per the recommended circuit shown in the catalog. h_{fe} of the transistor and circuit constants are designed to ensure stable oscillation of the piezoelectric sounder.
3) Design switching which ensures direct power switching.
4) The self drive circuit is already contained in the piezoelectric buzzer. So there is no need to prepare an another circuit to drive the piezoelectric buzzer.
5) Rated voltage (3.0 to 20Vdc) must be kept. Products which can operate with voltage higher than 20Vdc are also available.
6) Do not place resistors in series with the power source, as this may cause abnormal oscillation. If a resistor is essential to adjust sound pressure, place a capacitor (about 1μF) in parallel with the piezo buzzer.



7) Do not close the sound emmitting hole on the front side of casing.
8) Carefully install the piezo buzzer so that no obstacle is placed within 15mm from the sound release hole on the front side of the casing.

3 Characteristics and measuring method

1. Characteristics

TYPE	RESONANT FREQUENCY	RESONANT IMPEDANCE	CAPACITANCE	SOUND PRESSURE LEVEL	OSCILLATING FREQUENCY	CURRENT CONSUMPTION	INPUT VOLTAGE	OPERATING VOLTAGE
PIEZOELECTRIC DIAPHRAGM	○	○	○					
PIEZOELECTRIC SOUNDER (EXTERNAL DRIVE)			○	○			○	
PIEZOELECTRIC SOUNDER (SELF DRIVE)				○	○	○		○
PIEZOELECTRIC BUZZER				○	○	○		○
PIEZOELECTRIC SPEAKER			○	○			○	
REMARKS	COMMON CONDITIONS: OPERATING TEMP. RANGE / STORAGE TEMP. RANGE MEASUREMENT INSTRUMENTS: LCR METER (CAPACITANCE) / FREQ. COUNTER (OSCILLATING FREQ.) MULTI METER (CURRENT CONSUMPTION)							

2. Measuring Procedure

Measurement of resonant frequency and resonant impedance

When the piezoelectric diaphragm oscillates freely in air, the node does not move as shown in Fig. 10. With this point held with a measuring terminal, the resonant frequency (f_0) and resonant impedance (R_0) are measured in the constant-current circuit.

Measuring procedure

1) Connect the switch to side "a", and adjust frequency of the oscillator to read the frequency and the voltage when the voltmeter indicates a minimum value.
2) Then connect the switch to side "b", and vary the variable resistor to have the same voltage as in 1). Then, read the value of the resistor.
3) The resonant frequency (f_0) can be obtained from 1) and the resonant impedance (R_0) from 2).

* : Actual measurement are performed using a measuring unit in accordance with the above principle.

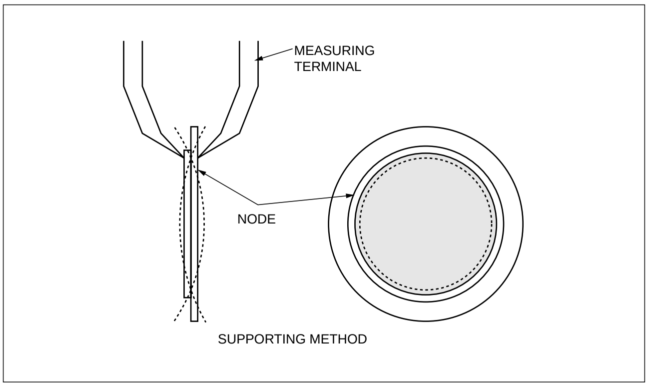


Fig. 10 Measurement of piezoelectric diaphragm

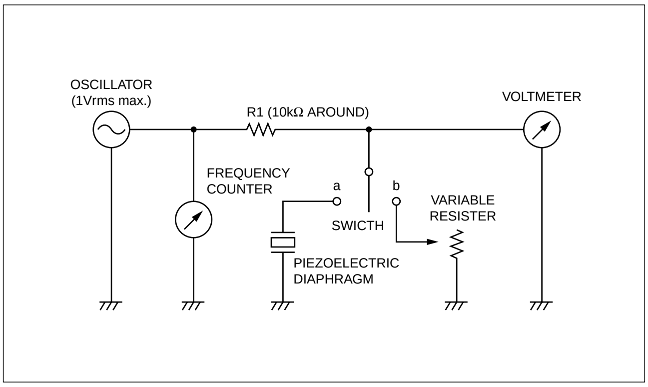


Fig. 11 Measurement set up of resonant freq. and resonant impedance

3 Characteristics and measuring method

Measurement of sound pressure level (S. P. L.)

The sound pressure level is measured with a sound pressure level meter as shown in Fig. 12 (Fig. 12 shows an example of the self drive piezoelectric sounder).

* : The relation between sound pressure level and distance, between sound pressure level and voltage can be expressed with Formula (2). The value of the sound pressure level under different operating conditions can be easily calculated using values specified in the catalog.

S. P. L.(dB) [under actual operating conditions]
= S. P. L.(dB) [value specified in catalog]
-20 log A/B(dB) ··(2)

In case of relation with distance:
A; Actual distance
B; Distance specified in catalog

In case of relation with voltage:
A; Voltage specified in catalog
B; Actual operating voltage

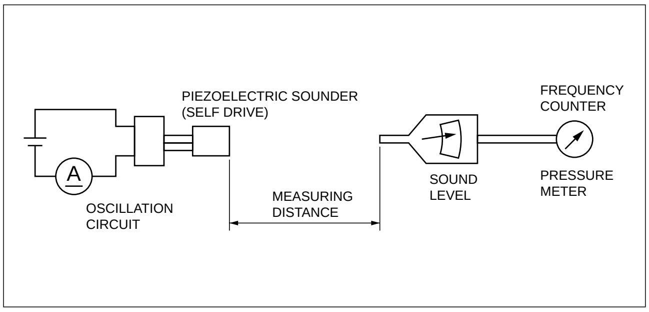


Fig. 12 Measurement set up of S. P. L.

4 Environmental Characteristics

Various environmental changes such as change in room temperature and atmosphere and vibration should be considered at storage instllation and actual operation of the piezoelectric buzzer. Typical voltage and temperature characteristics and environmental tests are shown using the piezoelectric sounder PKM24SP-3805 as an example.

1. Voltage and temperature characteristics

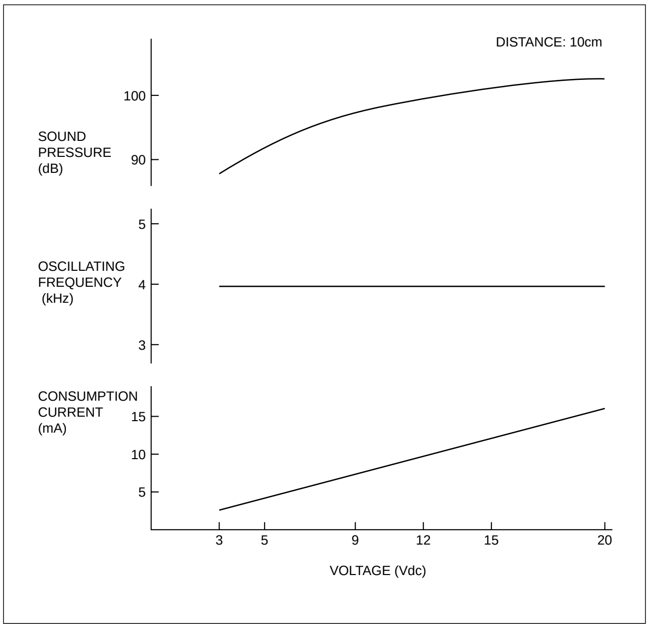


Fig. 13 Voltage characteristics

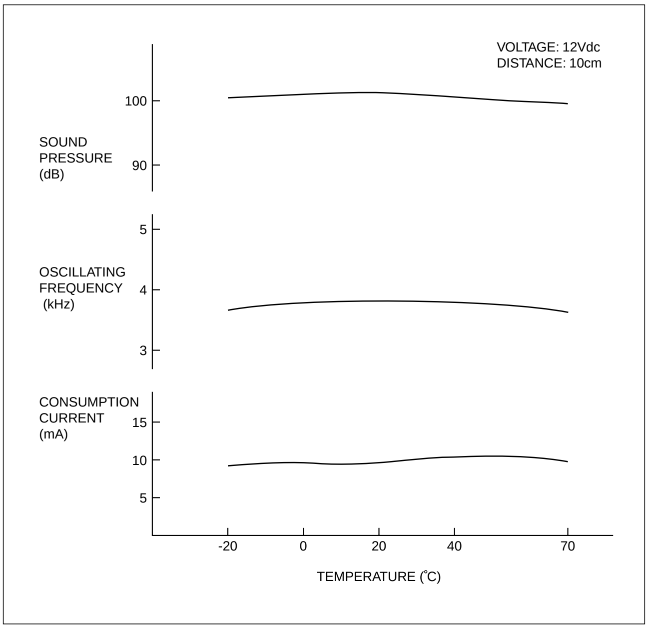


Fig. 14 Temperature characteristics

2. Environmental test

No	ITEM	CONDITION	DEVIATIONS
1	High temperature	+85±2℃, 240Hrs	S. P. L. : Initial value ±10dB Oscillating freq. : Initial value ±10% Consumption current : Initial value ±10%
2	Low temperature	-40±2℃, 240Hrs	
3	Humidity	+60±2℃, R.H. 90-95%, 240Hrs	
4	Temperature cycle	Following cycle 5times; -40±2℃(30min.) → +20℃(15min.) → +85±2℃(30min.) → +20℃(15min.)	
5	Vibration	10 to 55Hz (1 cycle, 1 min.) Amplitude 1.5 mm 2 Hrs for each three mutually perpendicular directions	
6	Shock	+100G sine wave 3 times for each three mutually perpendicular direction	

After following test, samples should be left at natural condition (Temp.; 25°C) for more than 4 hours.

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