Operating Principle of Magnetic Transducer

The operating principle of a magnetic transducer is herein described, based on this Fig 1.

**Fig. 1 Cross-section of Magnetic Transducer:**

The magnetic flux from a magnet produces a bias magnetic field at the tip of the iron core, drawing a diaphragm toward itself by a suitable force. If electric signals (for example, rectangular shaped voltage with a frequency of 3.2 KHz and 1.5 Vp-p) coming intermittently at a fixed frequency from an external oscillating circuit are input, an electric current will intermittently flow through the coil, generating an intermittent magnetic field at the tip of the iron core.

The magnetic field drives the diaphragm up and down, generating the sound pressure corresponding to the amplitude of the diaphragm. This sound pressure is further multiplied by the resonance effect of the resonator installed on the case. Each product is designed and adjusted based on resonance frequency (fo) and resonance frequency (fv), so that excellent performance is obtained at the standard frequency. Accordingly, the functional composition of a magnetic transducer can be divided into the magnetic circuit unit, and the resonance unit.
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Measuring Circuit

We at Flezon input electric signals of a specific frequency to a magnetic transducer, using the measuring circuit shown in Fig. 2, to measure the characteristics of the acoustic components. Please use this information in measuring your acoustic components and arranging driving circuits.

Fig. 2 Magnetic Transducer Driving Circuit:

Frequency Characteristics

A magnetic transducer emits sound based on the frequency of the electric signals input, and it is the frequency characteristics that determine what degree of sound is caused in relation to input frequency. Frequency characteristics are generally shown as a graph that indicates results of measurement at the sound pressure level (SPL) 10 cm in front of the magnetic transducer, while changing the frequency of input signals from 500 Hz to 10 KHz at the rated voltage. They are referred to as sound pressure level frequency characteristics. Use these values for product selection to match the purpose and input conditions for use, while nothing their difference.
Reverse Connection

There is polarity in magnetic transducer input. Even if a reverse polarity connection is made, sound is produced, but it is not certain that sound pressure specifications will be satisfied. In the case of a reverse connection, the operating direction of the magnetic field will change (attraction ⇔ repulsion), and resonance frequency (fo) will alter, so it is possible that sound pressure at the standard frequency will decline or deviation will become larger.

Frequency Characteristics Caused by Voltage Changes

There may be cases in which a magnetic transducer is used at voltages other than the rated voltage. Note that frequency characteristics stated in the catalog are those at the time of the rated voltage. Frequency characteristics during input at voltage other than the rated voltage changes as shown in Fig. 3. As input voltage becomes lower, resonance frequency (fo) of the magnetic transducer rises; as input voltage becomes higher, fo reduces. Because resonance frequency (fv) of the resonator does not change in relation to voltage, the frequency band becomes narrow when voltage is low, while the band widens to the low frequency side when voltage is high. If voltage is too low, fo may rise above the standard frequency, causing a substantial reduction of sound pressure.

Fig.3 Frequency characteristics during input at voltage other than the rated voltage changes:

![Graph showing frequency characteristics during input at voltage other than the rated voltage changes.](image-url)
Average Consumption Current

The average consumption current (mA), is described in the form of MAX.xx. This means that, if the rated voltage is applied without limiting electric current, the average current value will not surpass xx mA. Be careful, as it is not meant that electric current exceeding xx mA must not be applied to the product. In reality, maximum current 2 to 3 times higher than the average current is required as peak current. Therefore, a driving current that can supply sufficient current should be provided. If the peak current is restricted, there can be a case in which sound pressure will not be output as specified.

(Example) In the case of FZ111A, whose average current is MAX. 10mA, prepare a driving circuit that can supply the peak current of at least 30mA.

Cross Structure of Magnetic Transducer
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Cross-section of Magnetic Transducer (Pin Type without epoxy) *FZ111

Cross-section of Magnetic Transducer (SMD Type without epoxy) *PWT

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 dB and Phon

Sound pressure level is referred to as Sound Output and rated in dB (decibel). DB is defined as the sound pressure level in logarithmic ratio to a sound pressure on the basis of the minimal sound pressure (20µPa) whose 1KHz sound that a person in good condition can hear out. The sound pressure level is calculated as shown below in measuring an unspecified sound pressure P (µPa).

\[
\text{Sound pressure level (dB)} = 20\log \left( \frac{P}{20} \right) \left( \frac{P}{0.0002} \right)
\]

The term phon is a unit which describes loudness level as is the case of the decibel. Generally, even the sound level being equal, it is hard for us to hear out the sound clearly due to frequencies. "Loudness contour" (Fig.4) is a statistically calculated collection comprising sounds of the same loudness with every frequency based on the 1 KHz sound. The phon is formed through corrections of the sound pressure levels, basing the contour. For measurement of the sound pressure, the sound level meter possessing the A weighting is employed, which shows relatively corrected values in accordance with the loudness contour. This way the term dB is considered to be phon in specifications.

![Fig.4 Loudness contour](image-url)
Sound Pressure and Distance

As there are differences in the measuring distances when manufacturers make the measurement of sound pressure, the following formula is recommended for calculation on occasions when a buzzer itself is tested or compared with a planned finished product. However, as for as the calculated is concerned, it is a theoretical one and therefore subject to change, depending upon circumstances and conditions.

\[ B = A + 20 \log \left( \frac{L_a}{L_b} \right) \]

A: sound pressure value at distance \( L_a \)

B: sound pressure value at distance \( L_b \)

The table below is to shape up relations between the measuring distance variation and the sound pressure variation for reference. (Fig.5)

<table>
<thead>
<tr>
<th>Measuring distance variation</th>
<th>2times</th>
<th>3times</th>
<th>4times</th>
<th>5times</th>
<th>6times</th>
<th>7times</th>
<th>8times</th>
<th>9times</th>
<th>10times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound pressure variation(db)</td>
<td>-6.02</td>
<td>-9.54</td>
<td>-12.04</td>
<td>-13.98</td>
<td>-15.56</td>
<td>-16.90</td>
<td>-18.06</td>
<td>-19.08</td>
<td>-20.00</td>
</tr>
</tbody>
</table>

**Fig.5 Measuring distance variation and the sound pressure variation :**

Example: 10cm : 80dB → 30cm : 80 - 9.54 = 70.46(dB)
Tone

The tone output, generated by buzzers, is essential in product design. A recommended way of selecting a desired tone is by listening to the different tones produced by the different buzzer. Additionally, FFT analysis is usable for visual tone selection method. The sound is not an oscillation of a single frequency, but as a collected body of individual frequencies. The analysis is to diagnose the ratio of constituent frequencies. The following is a sample analysis of our typical buzzer.

- Magnetic buzzer

Magnetic Buzzer and Transducer Fig. 6 shows how the peep sound is composed of a collected body of the fundamental frequency and its integer fold frequencies. This sound composed of integer fold frequencies is generally referred to as a single sound which has a clearer tone than the low pitched buzzers have.

Fig.6 Magnetic Buzzer FFT analysis:
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- Pezoelectric buzzer

The buzzer produces the peep sound closer to the pure sound, which is composed of almost the fundamental frequency. Compared with the transducer, it is likely to sound relatively less mellow. (Fig. 7)

![Piezo buzzer FFT analysis](image)

**Resonance Effect of Helmholtz**

Magnetic transducer are usually built into equipment and used in that state. At that time, users may have various needs, such as "raising sound pressure" or "widening the frequency band." By installing a resonator on the case in which the magnetic transducer is contained, etc., it is possible to make sound characteristics closer to these requirements. On this occasion, the "resonance effect of Helmholtz," which can be used for reference purposes, is hereby introduced. To improve the characteristics, it is possible to widen the frequency band or to raise the sound pressure of the standard frequency or desired frequency by setting the resonance frequency (fv) of the external resonator for the magnetic transducer use at a level slightly higher than double the standard frequency, a desired frequency close to it, or the consonance frequency (fo) of the sounder. The resonance effect formula of Helmholtz shown in Fig. 8 represents a theoretical formula that demonstrates the relationship between fv of the external resonator and the size of the resonator. Because the effect of the resonator incorporated in the magnetic transducer is not included, it is necessary to take the acoustic combination with the resonator of the magnetic transducer in actual setting. The usual method is to incorporate the magnetic transducer in the real body of the external resonator and adjust its sound emission hole, etc., while considering the value, calculated through the formula, and to seek optimization.
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**Fig. 8** The resonance effect formula of Helmholtz:

\[
fv = \frac{CD}{4} \sqrt{\frac{1}{\pi V(L+0.75D)}}
\]

Where
- \(fv\): resonant frequency of resonator [Hz]
- \(V\): volume of resonance chamber [mm³]
- \(D\): diameter of sound emission hole [mm]
- \(L\): depth of sound emission hole [mm]
- \(C\): speed of sound = approx. 344000 [mm/sec]

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**Example of Execution (Experiment)**

The degree of improvement in the characteristics attained through the addition of a resonator to the outside of the magnetic transducer is explained, using the results of an experiment employing the magnetic transducer FZ105 Series. The standard frequency of this product is 2,048 Hz, while sound pressure specification for the product as a signal unit is min 70 dB (typical 77 dB) in terms of sound pressure at 10 cm. (Fig. 9)

**Fig. 9** Frequency response without additional resonator:

Because this magnetic transducer has only a small space in front of the diaphragm, it does not have resonance frequency (fv). Therefore, it was considered that, even if it is incorporated, little effect will arise on the external resonator, because its space capacity is small. Dimensional conditions for the external resonator, shall be in accordance with Fig 10.
Expansion of the band

In order to widen the frequency band to be used to 2,048 Hz - 2,700 Hz, it is considered to set $f_v$ for the external resonator in Fig. 6 at around 2,700 Hz. The theoretical diameter of the sound release hole, obtained by solving the relational expression in Fig. 8, is: $D = 1.7\text{mm}$. If the value is slightly reduced to $D = 1.5\text{mm}$, for subsequent fine adjustment, the theoretical $f_v$ based on the relational expression becomes 2,460 Hz. The $f_v$ value resulting from real measurement arises at 1,700 Hz because of the effect of the signal-unit characteristics of the magnetic transducer. The actual measurement value will be equal to the characteristics shown in Fig. 11. Thus, compared with the signal unit case, the frequency band will be expanded.

Fig.11 Frequency response with resonator (Design 1) :
Raising the sound pressure

To increase the sound pressure of the standard frequency of 2,048 Hz above that of the single unit, \( f_v \) for the external resonator in Fig. 10 is assumed to be set at 4,100 Hz, which is twice the standard frequency. If \( D=3.3 \) is assumed, the theoretical \( f_v \) based on the relational expression 4,270 Hz. The \( f_v \) value resulting from real measurement, however, will generate at around 4,000 Hz due to the single-unit effect, etc., of the sounder. The real measurement value proves to be as shown in Fig. 12, and it is clear that the sound pressure level at 2,048 Hz is higher than for the single unit. In this case, however, the sound is audibly high-pitched, because the second harmonic portion will increase.

Points of Attention in Setting an External Resonator

Based on the aforementioned experimental example, the resonance effect of Helmholtz and its significance are believed to be understood. Points of attention in setting an external resonator are as follows. 1) if the sounder has a resonator of its own, there is a possibility that the theoretical value of the relational expression in Fig. 8 and the real measurement value will be substantially different, as the resonator or the sounder and the external resonator combine acoustically. In this case, it is necessary to adjust the actual equipment of the external resonator, attaining optimization. 2) To ensure the resonance effect of the resonator, it is necessary to reduce the sound resistance of the sound emission hole. If the sound emission hole of the external resonator is reduced too much, however, it is possible that no satisfactory outcome will be produced, even if the same frequency is set.
Soldering and Washing

- **Soldering**
  
  The sealed miniature sound transducers by Star should not be exposed to extremely high temperatures for prolonged periods of time. As excessive heat will degrade the sealing performance of the unit, soldering should be conducted as quickly as possible.

  Recommended temperature and for soldering:
  - 250°C ........ within 5 seconds
  - 350°C ........ within 1.5 seconds

- **Dip soldering**
  
  Dip soldering may be conducted only in the case of washable products. As for non-washable products, dip soldering should not be implemented.

- **Washing**
  
  (1) **Washable type transducers.**
  
  Along with other electronic components, these transducers may be washed with cleaning solvents after the soldering process.

  (2) **Non-washable type transducers.**
  
  Subsequent mounting is recommended to avoid being washed. If it is inevitable to wash a transducer, take necessary measures to prevent washing fluid from entering into the transducer. And it is also required to ensure well ventilation to avoid any undesirable effects by the component substances of the flux that may otherwise remain in the atmosphere.
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Flux Removing Solvents

In view of the recent requirement for total elimination of ozone-depleting chemicals, we have decided to recommend our customers to use deionized water for their cleaning process at the conditions given below, instead of CFC that was conventionally used.

Conditions for cleaning :

- Cleaning solvent .......... Deionized water
- Solvent temperature ......... 55 ± 5°C
- Immersion time ............ 5 ± 0.5 minutes

For further details, feel free to ask us directly or any of our distributors.

Recommend Temperature Profile for Lead-Free Solder

![Graph showing temperature profile]