Powder Level Sensors

Piezoelectric type

LTS(3-terminal type self-oscillation formula) series
TSP(2-terminal type separate excitation oscillation formula) series

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Powder Level Sensors
LTS, TSP Series

TDK's piezo-type level sensor, which uses a sensor element consisting of a piezoelectric ceramic, was developed originally by TDK.
The sensor detects the presence of powder when the sensor element, which a built-in oscillating circuit causes to vibrate, comes into contact with powder and the vibrational conditions are altered.
The TSP series, which employs an external source of oscillation based on a custom chip, offers even better operational stability.

FEATURES

- This is a unique sensor that employs a piezoelectric ceramic sensor element.
- The exterior has a die cast finish which makes the sensor highly resistant to effects caused by external vibrations and provide stable detection characteristics.
- The sensor can detect both magnetic and non-magnetic powders.
- The sensor can be easily mounted to a wide range of locations.
- Two output types are available: ON/OFF digital output (D type) and continuously variable analog type (A type).
- Compact size and low cost.

APPLICATIONS

- Toner detectors for copiers, laser printers, etc.
- Detectors for coffee and other powders in automatic beverage vending machines.
- Detectors for other types of powders.

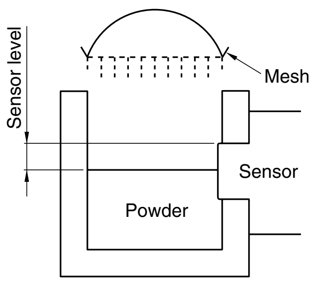
PRODUCT IDENTIFICATION

TSP	1	5	D	10	C -	01
(1)	(2)	(3)	(4)	(5)	(6)	(7)

(1) Types of toner sensors
LTS: 3-terminal type self-oscillation formula
TSP: 2-terminal type separate excitation oscillation formula
(2) Sensor diameter
1 : 11mm dia.
(3) Operational voltage
5 : DC.5V
(4) Output type
D : Digital
A : Analog
(5) Shape of case
(6) Output terminal type
C : Directly attached connector
None : Lead lines
(7) Identifying control number

SENSOR LEVEL EVALUATION METHOD

Position the sensor as indicated in the drawing below. The sensor level is determined as the level at which the sensor detects powder when powder is supplied from above.

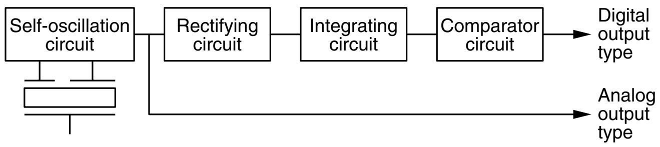


• All specifications are subject to change without notice.

3-TERMINAL TYPE SELF-OSCILLATION FORMULA, LTS SERIES

PRINCIPLES OF OPERATION

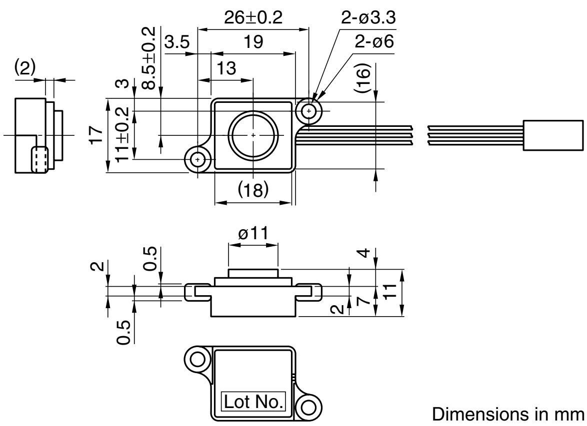
A vibrator, comprising a piezoelectric element attached to a metallic diaphragm, is supported by a die cast case. The vibrator is driven by a self-oscillation circuit.
When the vibrator comes into contact with powder, the vibrator's oscillation is impeded, causing the vibrator to stop and hence the powder to be detected.
Two types of outputs are available: The analog output type (direct output of oscillation waveform) and the digital type (output of high-low levels after passing the oscillation waveform through rectifying, integrating, and comparator circuits).



ELECTRICAL CHARACTERISTICS

Item	Standard
Operating input voltage	5V±0.5V
Input current	20mA max.
Operating temperature range	0 to 50°C
Sensor level	5mm±3mm
Output voltage HIGH	4.5V min.
Output voltage LOW	0.5V max.

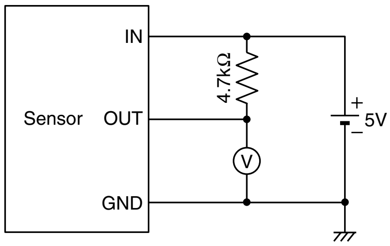
SHAPES AND DIMENSIONS



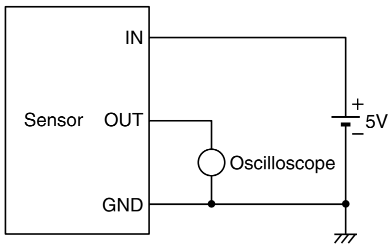
Dimensions in mm

CIRCUIT DIAGRAMS

Digital output type



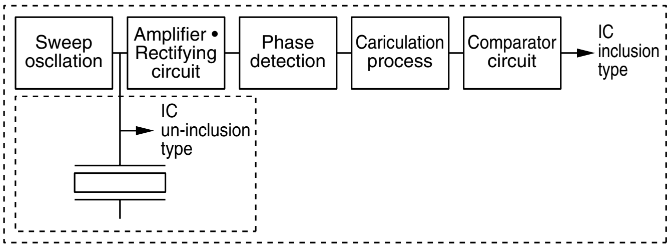
Analog output type



2-TERMINAL TYPE SEPARATE EXCITATION OSCILLATION FORMULA, TSP SERIES

PRINCIPLES OF OPERATION

A vibrator, comprising a piezoelectric element attached to a metallic diaphragm, is supported by a die cast case. The vibrator is driven by an external excitation oscillation circuit.
When the vibrator comes into contact with powder, the vibrator's oscillation is impeded, causing the vibrator to stop and hence the powder to be detected.
The external excitation oscillator circuit and phase comparator circuit etc. are driven by a TDK custom chip.
These products are available in two types: The "External chip" type in which all the circuitry is provided in a separate chip and the sensor consists only of the vibrator element, and the "Internal chip" type in which the signal processing is performed inside the sensor to provide a binary output of high/low levels.

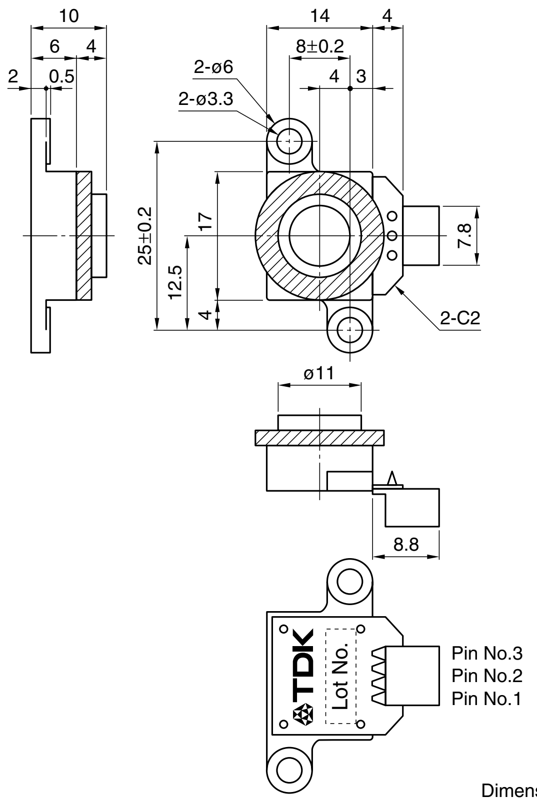


ELECTRICAL CHARACTERISTICS

Item	Standard
Operating input voltage	5V±0.5V
Input current	20mA max.
Operating temperature range	0 to 50°C
Sensor level	5mm±3mm
Output voltage HIGH	4.5V min.
Output voltage LOW	0.5V max.

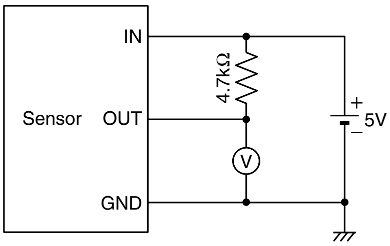
BUILT-IN IC TYPE

SHAPES AND DIMENSIONS



Dimensions in mm

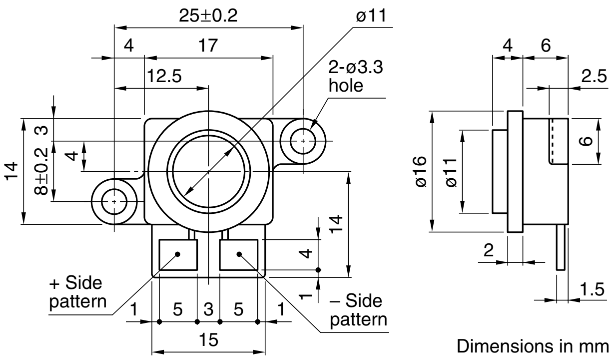
CIRCUIT DIAGRAM



IC SEPARATED TYPE

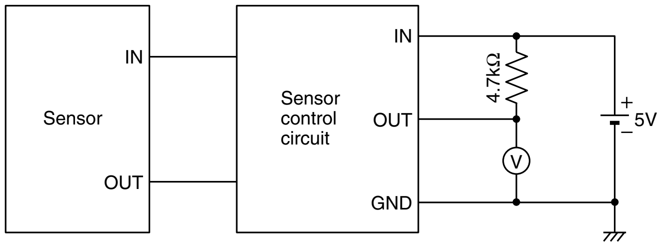
SHAPES AND DIMENSIONS

SENSOR

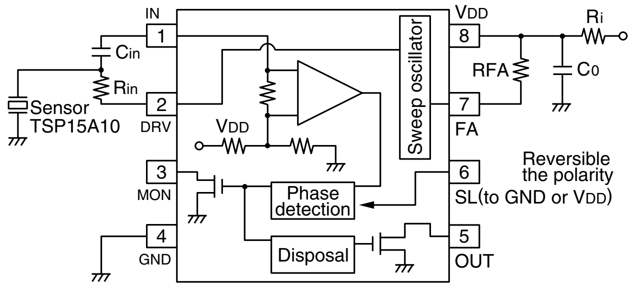


Dimensions in mm

CIRCUIT DIAGRAM



CUSTOM IC CIRCUIT



Co : 10µF
Cin : 1000pF
Rin : 240kΩ
Ri : 10Ω
RFA : 18kΩ

IC SEPARATED TYPE PRECAUTIONS

- Shorten the connection distance between the sensor and IC block as much as possible. This distance must not exceed 250mm.
- Observe the polarity of the sensor block.
- Consult with TDK when using this product.

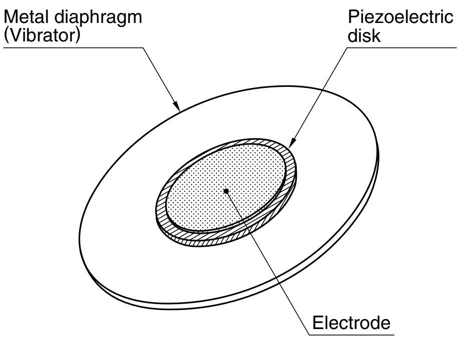
PIEZO-TYPE LEVEL SENSORS

BASIC PRINCIPLES OF OPERATION

The basic structure and principles of operation of a piezoelectric vibration type sensor are the same as those of a piezoelectric sounder.

The most generally used vibrator "unimorph" structure comprises a thin piezoelectric disk, which has electrodes formed on both surfaces, attached to a thin metal diaphragm (Fig.1).

Fig.1: Structure of 3-terminal piezoelectric unimorph vibrator



The piezoelectric ceramic undergoes polarization treatment in the direction perpendicular to the disk surface. As shown in Fig. 2, when an external voltage is applied, the disk expands and contracts in the direction of the polarization as well as in a perpendicular direction relative to the direction of polarization. In the unimorph structure, a metal diaphragm that does not expand-contract when an electric field is applied is attached to one side of the disk. Therefore this metal diaphragm is flexed by expansion-contraction of the piezoelectric ceramic as shown in Fig.3. The unimorph structure vibrates due to repeated flexure when an AC signal is used as the applied voltage.

Fig.2: Movement of the piezoelectric element

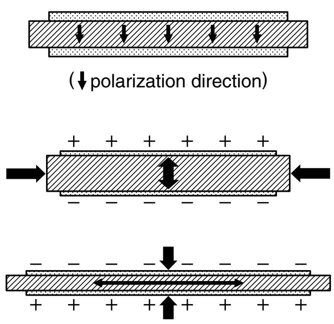
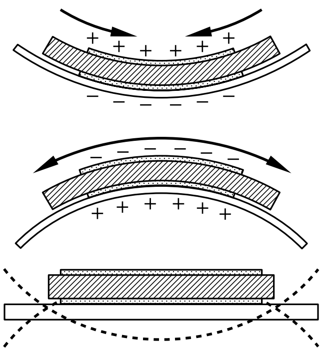


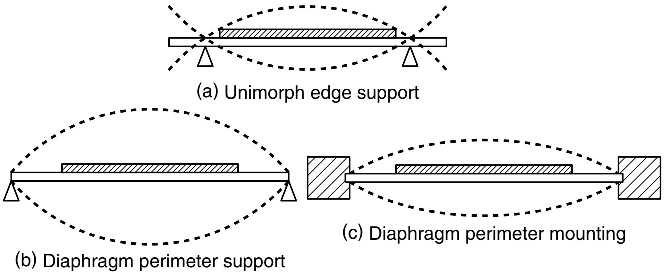
Fig.3: Flexing vibration



Since the sensing diaphragm surface will be exposed to powder and must be wiped periodically, the piezoelectric vibration sensor must be constructed in such a way that the surface of the sensing diaphragm is flat and is located at the very front of the sensor.

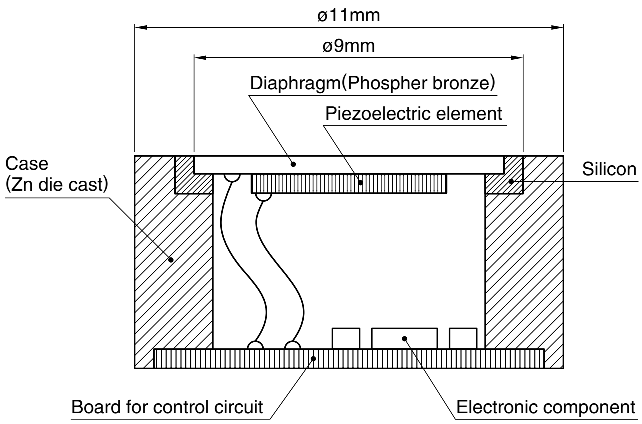
In order to fulfill these conditions, the bond between the unimorph structure and the case is located at the diaphragm perimeter, not at the unimorph edge. The diaphragm perimeter is connected to the case (diaphragm perimeter mounting in Fig.4).

Fig.4.Unimorph mounting/support methods



Since sensor detection characteristics are greatly affected by changes in the diaphragm perimeter support, various methods are required to avoid this source of variance. These methods include use of elastic silicone to attach the diaphragm, use of a fixed attachment area / thickness, etc. (Fig.5)

Fig.5: Structure of piezoelectric vibrator type sensor



3-TERMINAL TYPE POWDER LEVEL SENSORS

PRINCIPLES OF OPERATION

The three-terminal type powder level sensor is equipped with a primary electrode and an output electrode on the piezoelectric ceramic. The self-oscillation method is used to vibrate the perimeter-supported unimorph at its innate vibration frequency.
The unimorph structure utilized for this is shown in Fig.6.
Self-oscillation is carried out using a drive circuit such as that of Fig.7.

Fig.6: Electrode structure of 3-terminal piezoelectric vibrator

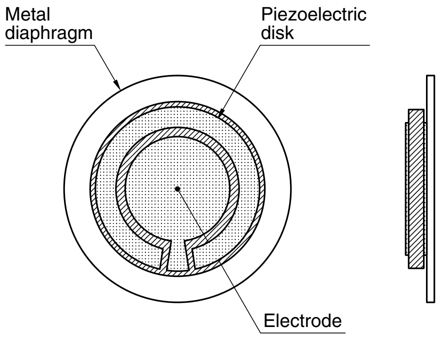
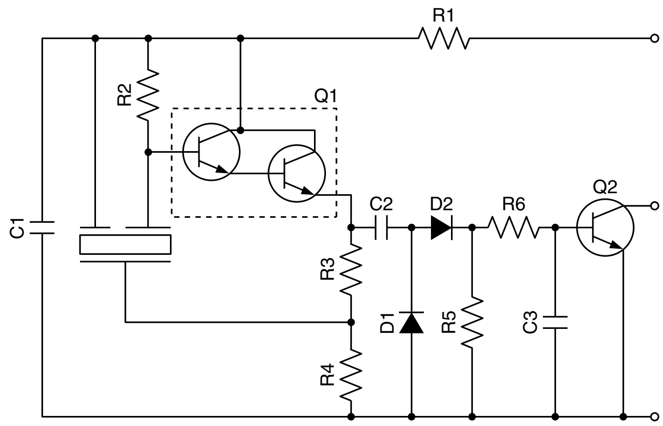


Fig.7: Self-oscillation formula drive circuit with 3-terminal piezoelectric vibrator



Vibration characteristics are shown in Fig.8, as loading is gradually increased starting from a non-loaded state with no powder contacting the sensor diaphragm surface. Vibration can be maintained since gain from the main electrode to the output electrode is high in the non-loaded state. As the loading of the sensor diaphragm surface increases (Fig.9), this gain decreases, and the gain needed to maintain vibration can no longer be maintained as a threshold loading value is exceeded. Then vibration stops.
The presence or absence of powder is detected by determining whether a vibration occurs and then outputting the result.

Fig.8: Frequency characteristics of gain and phase change with a contact load to be applied to piezoelectric vibrator surface

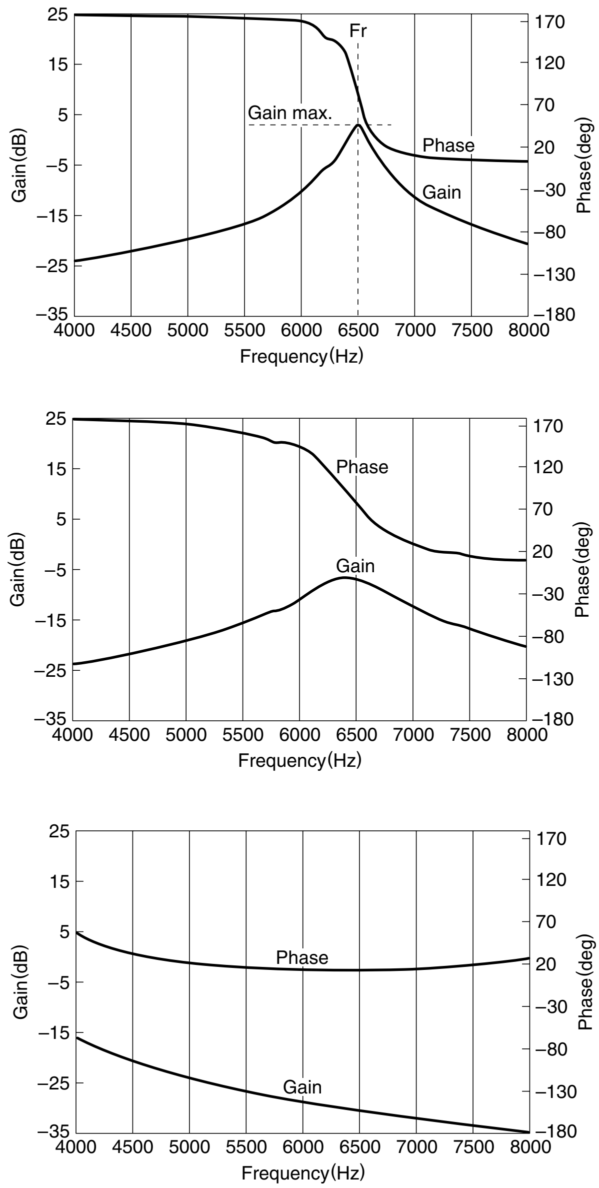
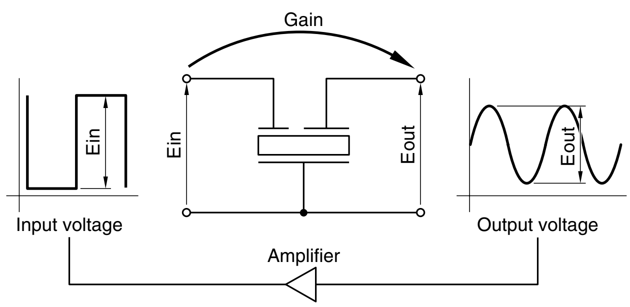


Fig.9: Input and output waveform of piezoelectric vibrator

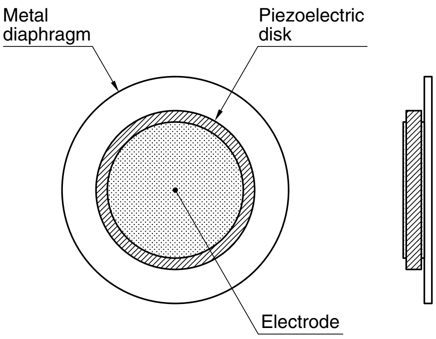


2-TERMINAL TYPE POWDER LEVEL SENSORS

PRINCIPLES OF OPERATION

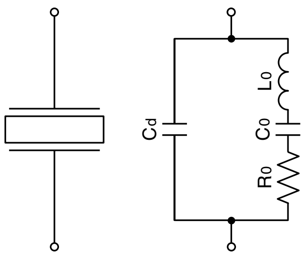
The two-terminal type powder level sensor comprises a piezoelectric ceramic equipped with electrodes on both sides. The sensor is operated by applying an external AC signal to the electrodes on both sides (Fig. 10).

Fig.10: Structure of 2-terminal piezoelectric unimorph vibrator



In contrast to the three-terminal type powder level sensor, the vibration does not stop even after a load is applied since the vibration is caused by an external AC signal. The changes in unimorph characteristics are used to distinguish whether or not a load is applied to the sensor diaphragm surface. In the equivalent circuit diagram shown in Fig.11, C_d denotes electrostatic capacitance, L_0 denotes equivalent mass, C_0 denotes the inverse number of the equivalent stiffness and R_0 denotes equivalent mechanical resistance. The frequency at the impedance minimum in Fig.12 is the series resonance point of L_0, C_0, and R_0.

Fig.11: Equivalent circuit of 2-terminal piezoelectric unimorph vibrator



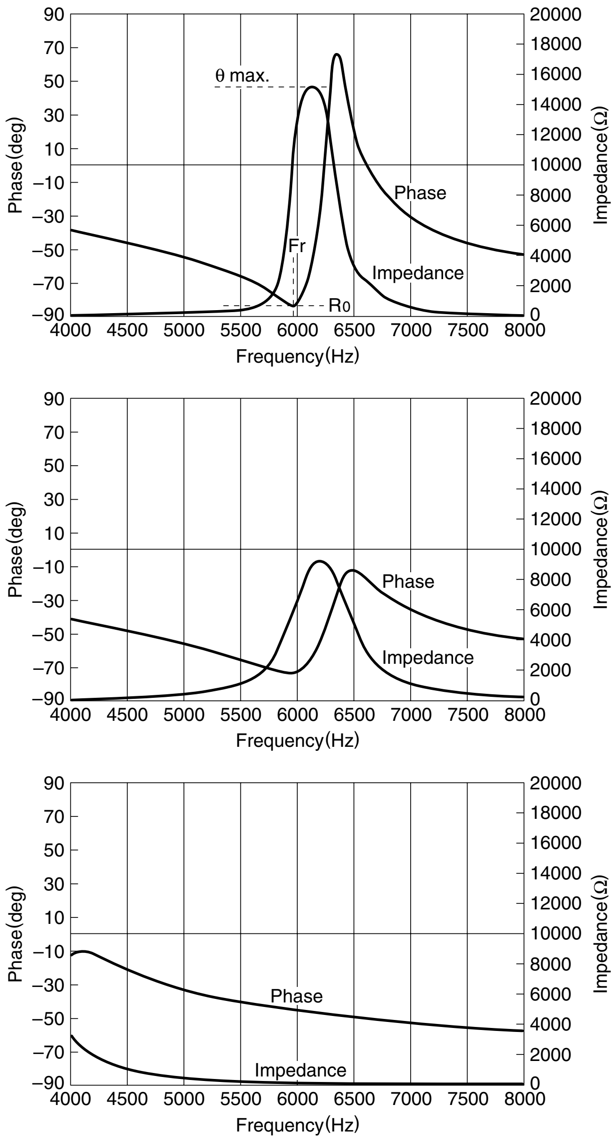
The unimorph of the two-terminal type sensor becomes inductive in the vicinity of the resonance point when unloaded and exhibits a capacitance at other times. However as the load upon the sensor diaphragm surface increases, the phase characteristics gradually change, and the sensor exhibits a capacitance over the entire frequency range as the load is increased above a certain value(Fig.12).

Using this characteristic, the loading is determined by detecting the phase in the vicinity of the unimorph resonance point and determining whether the sensor exhibits inductance (no load is applied to the sensor diaphragm surface) or capacitance (load is applied to the sensor diaphragm surface). This in turn allows the sensor to detect the presence or absence of powder on the sensor diaphragm surface.

TDK has built a special chip into this two-terminal type sensor to realize stable driving and detection characteristics. The special chip includes a sweep oscillator circuit, waveform shaping/amplification circuit, phase detector circuit and digital control circuit.

Since the resonance frequency for the toner sensor is centered in the vicinity of 6kHz, a frequency sweep from 4 to 8kHz is performed to determine whether the signal from the sensor is inductive or capacitive within this frequency range. If the piezoelectric element is detected to be inductive during a sweep, a primary signal output indicates the "non-loaded" condition. If piezoelectric element inductance is not detected during a sweep, the primary signal output indicates the "loaded" condition. Although the presence or absence of toner can be detected simply based on this output signal, a counter is provided that improves sensor accuracy by averaging out output chattering (frequent alternating toner loaded / non-loaded indications from the sensor diaphragm surface). Toner detection is stabilized by providing final sensor output as a secondary output passing through this counter.

Fig.12: Frequency characteristics of impedance and phase change with contact load to be applied to piezoelectric vibrator surface



PRECAUTIONS

[ALL TYPES]

- An extremely thin metal sheet and piezoelectric element are used for the toner sensor detector surface. Therefore the sensor detector surface must be handled carefully to make sure that it is not subjected to mechanical stress.
- Grounding and other measures must be considered because the sensor circuitry and piezoelectric element can be damaged by surges and static electricity.

[3-TERMINAL TYPE]

- A ground should be connected to the case of the LTS type during operation to prevent the case from changing potential.

[2-TERMINAL TYPE]

- Make sure that the OFF time of the sensor's power supply is at least 1msec to prevent an internal logic error.
- The length of wiring connections must be no longer that 250mm when a separate chip is used to operate the sensor.
- Please consult with TDK when using a separate chip.

RELIABILITY TESTING

Temperature storage test
The sensor must operate properly after being placed for 240 hours in a +60°C environment.
Low temperature storage test
The sensor must operate properly after being placed for 240 hours in a –20°C environment.
Humidity endurance test
The sensor must operate properly after being placed for 240 hours in a +30°C, 25% relative humidity environment.
Humidity endurance test
The sensor must operate properly after being placed for 240 hours in a +40°C, 95% relative humidity environment.
Vibration test
The sensor must operate properly after being subjected to vibration cycles in directions x, y and z for two hours in each direction; a single cycle consisting of 10 to 55Hz vibrations with an amplitude of 0.7mm for one minute.