CONTENTS

1. Introduction

During the past several years, development in ultrasonic ceramic transducers and in the applications of these transducers have led to the popularization of both remote control systems for television receivers or slide projectors and proximity switches such as burglar alarms, parking meters, and conveyer-type monitoring.
When used for the remote control systems or proximity switches, a frequency of about 40 kHz is utilized from the view points of low noise and high efficiency. Both a transducer for generating ultrasonic sounds and a transducer for receiving ultrasonic sounds are needed in these equipment. For such transducers, the ultrasonic ceramic microphones developed by Matsushita Electric are recommendable. With the trend toward miniaturization and increased reliability in ultrasonic transducers, it is expected that a great acceptance of our ultrasonic ceramic microphone will occur. This presentation will include a explanation of the ultrasonic ceramic microphone and its applications to remote controls and proximity switches.

Type A

Type T

Type C and D

Type S and U

2. FEATURES

- High sensitivity over –67 db/V/μbar
- Superb temperature and humidity durability
- Stable electrical and mechanical characteristics
- Small in size, especially in type S and T.
- An unparalleled broad variety of shapes.

3. OPERATION PRINCIPLE

The ultrasonic ceramic microphone is a device for transforming acoustic energy to mechanial energy and then to electrical energy or vice versa. The ultrasonic ceramic microphones which have been developed by Matsushita employ unique construction featuring higher sensitivity, wider bandwidth and smaller size as compared to conventional.

As shown in Fig 1, our transducer utilizesa compound vibrater, that is, a conical aluminium resonator with a connector bonded at the center of the piezoelectric elements of the bimorph type, consisting of oppositely polarized material in a sandwich construction.

When an ultrasonic signal is applied to the compound vibrator, the conical resonator begins to vibrate effectively because of its shape and drive the piezoelectric resonator at its central part according to the frequency of the signal.

As a result, the compound resonator generates a high electrical signal from the piezoelectric resonator. Furthermore, the formation of standing waves inside the case results in a higher electrical voltage.

If the resonant frequency of this compound resonator corresponds to the frequency of the ultrasonic wave applied, the electrical voltage generated from the piezoelectric resonator is at a maximum.

Our ultrasonic ceramic microphone is thus designed with consideration to the resonance of the standing wave formed in the case as well as the resonance of the compound resonator, so that it functions as a higher sensitivity transducer.

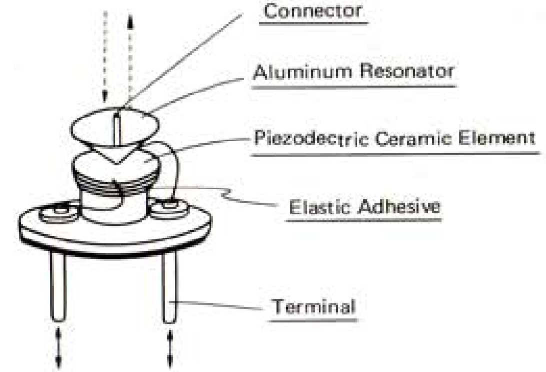


Fig. 1 Fundamental costruction

4. PART NUMBER CODE

E F R – □ □ □ □ □ □ □

Common Code | Applications | Type | Construction of Element | Center Frequency | Suffix

Applications:

R	For reception use
O	For transmission use

Type:

A	w/sealed terminal
C	Thin type
D	New thin type
S	Compact type
T	Compact type w/sealed terminal
U	New compact type

Construction of Element:

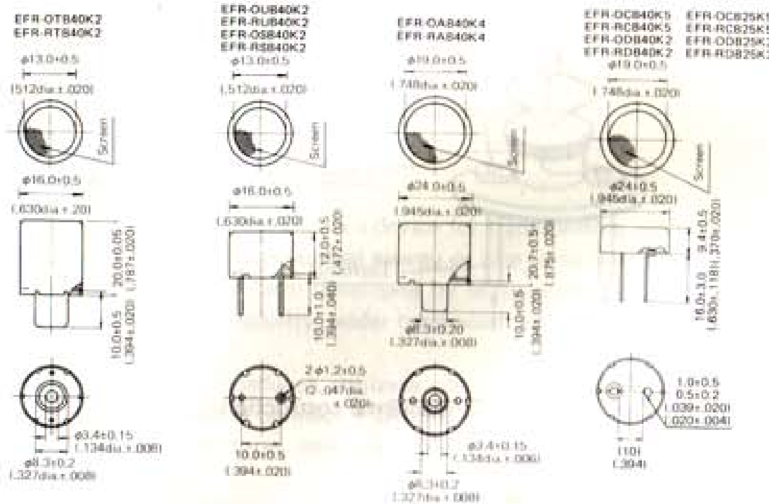
B	Composite type

Center Frequency:

40K	40kHz
25K	25kHz

5. SPECIFICATIONS

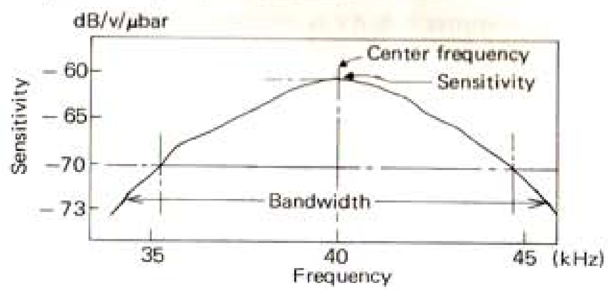
5-1. Dimensions



5-2. Definition of Terms

Center Frequency	Center frequency of bandwidth which is obtained when sensitivity is −70dB/V/μBar measured in accordance with specified measuring circuit.
Sensitivity	Sensitivity at center frequency when measured in accordance with specified measuring circuit
Bandwidth	Bandwidth at frequency where sensitivity is −73dB/V/μBar when measured in accordance with the specified measuring circuit

Response Frequency Characteristics



5-3. Specifications

Item \ Type / Part No.	Type T	Type S	Type A	Type C	
Part No.	*EFR-OTB40K2 EFR-RTB40K2	EFR-OUB40K2 EFR-RUB40K2 *EFR-OSB40K2 EFR-RSB40K2	*EFR-OAB40K4 EFR-RAB40K4	*EFR-OCB40K5 EFR-RCB40K5 *EFR-ODB40K2 EFR-RDB40K2	*EFR-OCB25K5 EFR-RCB25K5 *EFR-ODB25K2 EFR-RDB25K2
Max. Input Voltage (Vrms)	20				
Center Frequency (kHz)	*41.0±1.0 40.0±1.0			*41.0±1.0 40.0±1.0	*26.0±1.0 25.0±1.0
Sensitivity (dB/v/μbar)	−70 min.	−67 min.			−65 min.
Bandwidth (kHz)	4.0 min.		3.5 min.		3.0 min.
Application	*Transmitter Receiver			*Transmitter Receiver	

5-4. Ratings

Item	Test Method	Requirement
Temperrature Characteristics	Specimen shall be stored at −20°C (−4°F) and +60°C (140°F) for 30 minutes respectively and measured right after it is taken from the constant temperature chamber. The readings shall then be compared with that at +23°C (73.4°F).	Change of center frequency: 3.0kHz max. Sensitivity drop: 10.0dB max.
Humidity	Specimen shall be stored at 40±2°C (104±3.6°F), 90~95%RH for 100 hours and then kept at normal temperature and humidity for 24 hours before measurement.	Sensitivity Drop: 3.0dB max.
Shock	Specimen shall be measured after impact of 50G is applied as follows: Direction 3 mutually perpendicular directions Cycle 3 times per direction	Sensitivity drop: 3.0dB max. Bandwidth: To meet the specified value
Vibration	Measurement shall be conducted after the following vibration is applied to specimen. Total excursion 1.5mm Vivration frequency 10 ~ 55 Hz Sweep period 1 minute Direction 3 mutually pependicular directions Time 1 hour per direction	Sensitivity drop: 3.0dB max. Bandwidth: To meet the specified value

6. MEASUREMENT

6-1. Measuring method for Response Frequency Characteristics

The frequency characteristics show how the sensitivity or the sound pressure level varies with frequency.
When used as a microphone, the transducer has, due to its piezoelectric construction, high sensitivity at a certain frequency and a lower sensitivity at others. The frequency characteristic, therefore, around the resonant frequency is important in the case of general microphones, and good sensitivity over a wide range of frequencies is necessary. The measurement is conducted by reading how much voltage is generated across the open electric terminals when a unit of sound pressure (1 μbar of which equals a pressure of 0.1 Newton per square meter) is applied to an ultrasonic ceramic microphone.
There is the following relation:

$S = E/\overline{P}$

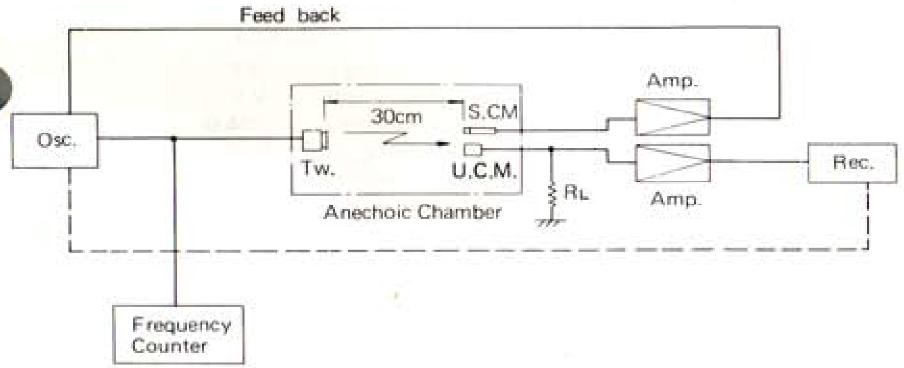
S: Sensitivity
$\overline{P}$: Sound pressure (μbar)
E: Output voltage (V)

In practice it is customary to express sensitivity as sensitivity in dB and not as sensitivity in volts per microbar.
Therefore, the following equation is obtained:

$$20 \log_{10} (E\,[v] / \overline{P}\,[\mu bar] / 1\,[v] / 1\,[\mu bar])$$
$$= 20 \log_{10} E/\overline{P}\ [dB/V/\mu bar]$$

6-2. Measuring circuit

Fig 3 shows the measuring circuit for response frequency characteristics.
The standard measuring circuit is operated, by placing a standard microphone (Bruel & Kjæ r, type 4135) with a flat frequency response in a suitable position in the sound field near the ceramic microphone under test. Continuous response curves can be recorded by the Bruel & Kjær equipment.

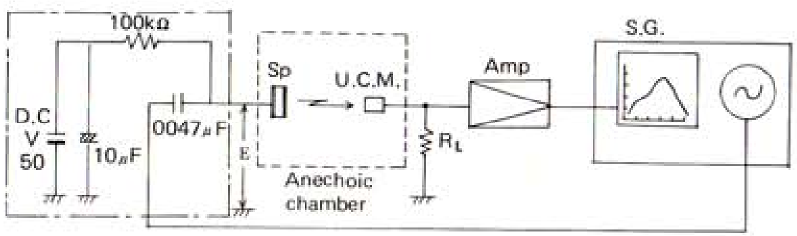


RL:	3.9kΩ	Osc.:	Oscillator
U.C.M.:	Ultrasonic Ceramic Microphone	Rec.:	Recorder
S.C.M.:	Standard Condenser Microphone	Tw.:	Tweeter
Amp.:	Amplifier		

Fig. 3 Measuring circuit

Following semi-standard measuring method is recommended in place of standard measuring method of Fig.3 which requires some time.

Fig 4 shows the semi-standard measuring circuit which mainly consists of a sweep generator, an anechoic chamber, and a bias network for a standard speaker with a flat frequency response. First, the generator is calibrated from the semi-standard transducer measured by the use of the standard measuring circuit. The next procedure is to substitiute the microphone under test for the semi-standard transducer. By setting the oscillator to feed an appropriate sound signal, a continuous frequency response curve of the microphone under test is automatically produced on sweep generator readout.

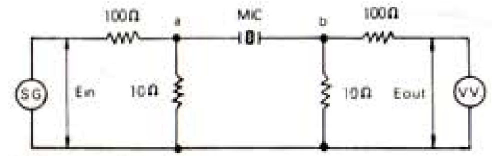


RL	:	3.9 kΩ	Amp	:	Amplifier
SP	:	Standard condenser speaker	S.G	:	Sweep generator
U.C.M.	:	Ultrasonic ceramic microphone	E	:	Signal voltage 1.0 Vrms

Fig. 4 Semi-standard measuring circuit

6-3 Measuring Method for Admittance Characteristics

Fig 5 shows the measuring circuit for the admittance of the ultrasonic ceramic microphone.



S.G. : Signal generator
V.V. : High impedance volt meter
MIC : Ultrasonic ceramic microphone
Ein should be adjusted so as to make Eout 50mV
When a-b terminals are shorted.

Fig. 5 Measuring circuit

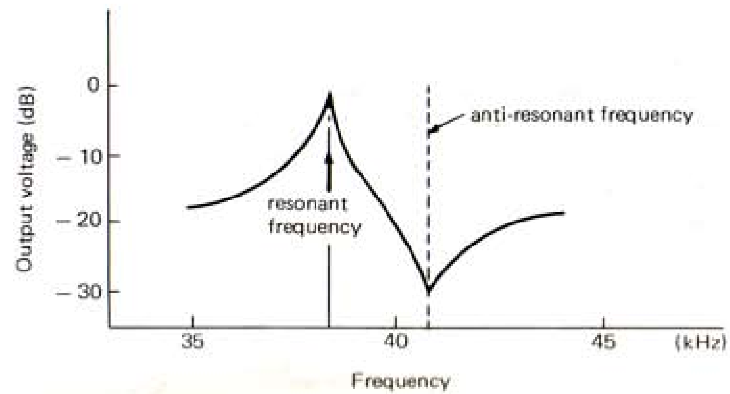


Fig. 6 Admittance characteristics

7. GENERAL CHARACTERISTICS

7-1. Response Frequency Characteristics

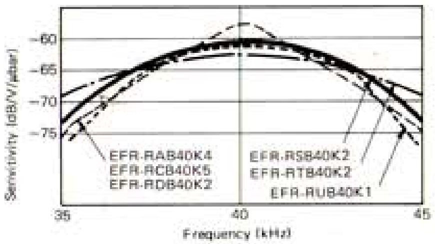


Fig. 7(a)

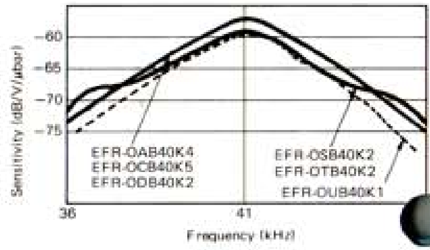


Fig. 7 (b)

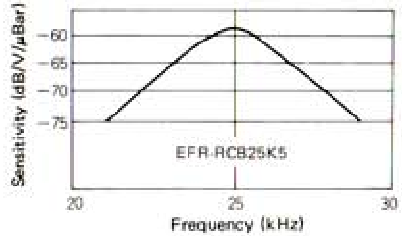


Fig. 7 (c)

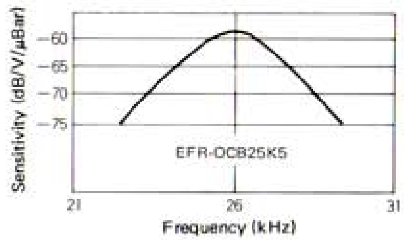


Fig. 7 (d)

Even microphones for transmitting are specified by the response frequency characteristics under the case of being used as receiving transducers.
Therefore, the center frequency is adjusted to be 1.0 kHz higher as compared with the receiving transducer so that its output sound pressure level reaches a maximum around 40 kHz.

Transmitter

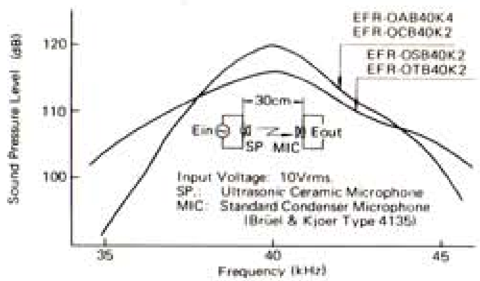


Fig. 8

7-2. Directivity

The directional characteristics can be shown as a series of response curves at different angles of incidence. The characteristic varies according to the shape and the size of the compound resonator, the case dimensions, and the position of the resonator. Such a microphone having little directivity, as shown in Fig. 9(b), is suited for use in remote controls. On the contrary, for a proximity detector which requires good directivity, it is strengthened by connecting a waveguide with an ultrasonic ceramic microphone.

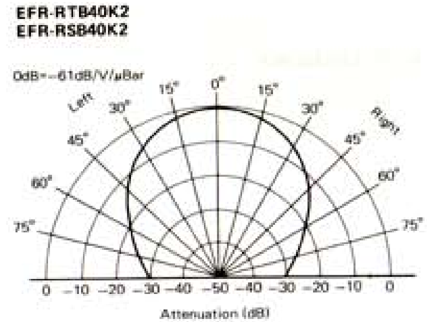


Fig. 9(a)

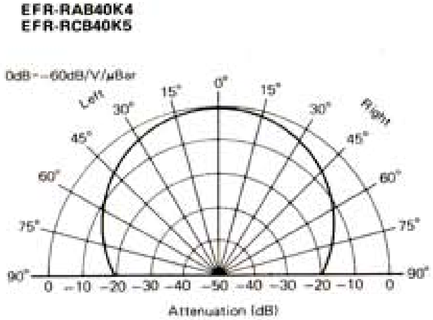


Fig. 9(b)

7-3. Admittance Characteristics

Fig. 10 shows the admittance characteristics of ultrasonic ceramic microphone as a function of frequency.

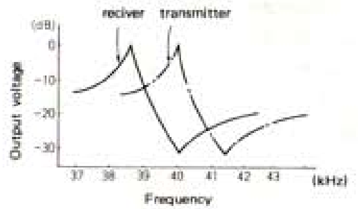


Fig. 10

7-4. Generated Voltage as a Function of Distance

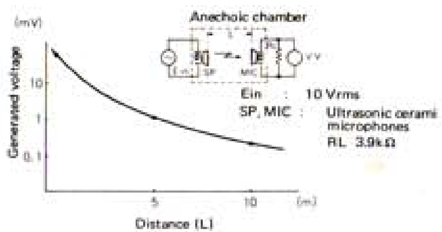


Fig. 11 Generated voltage as a function of distance

7-5 Characteristic Change due to Application Conditions

The characteristics of the ultrasonic ceramic microphone vary with the changes of impedance applied and the input signal voltage. Because the electrical impedance of the ultrasonic microphone is about 4 kΩ, it is advisable that the output impedance of the applied circuit match this value.
The following figures, Fig 12 ~ 13 show the interrelationship between the characteristics of the ultrasonic microphones and the above mentioned conditions.

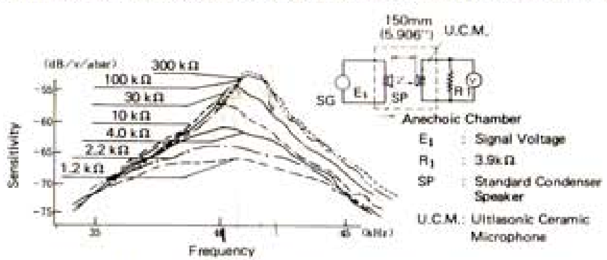


Fig. 12(a) Characteristic change due to load resistance

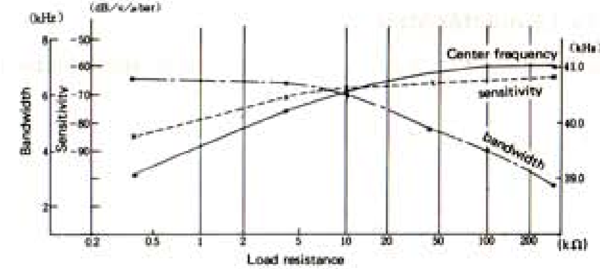


Fig. 12(b) Characteristic change due to load resistance

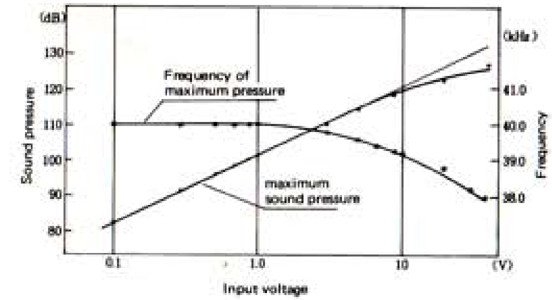


Fig. 13 Characteristic change due to input voltage

8. CHARACTERISTIC CHANGE DUE TO ENVIRONMENTAL CONDITIONS AND LIFE

8-1. Temperature Characteristics

Fig. 14 (a) and (b) show the temperature characteristics of the ultrasonic ceramic microphone.

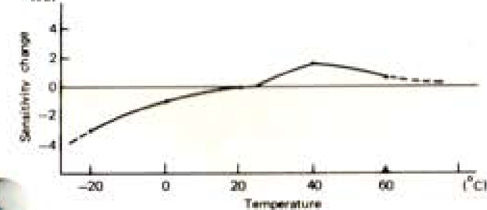


Fig. 14 (a)

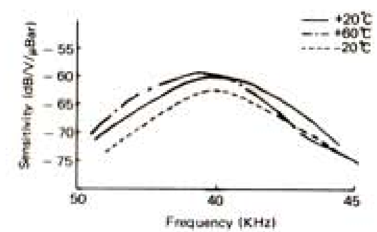


Fig. 14 (b)

8-2. Humidity Characteristics

Fig. 15 (a) and (b) show the humidity characteristic changes under the following conditions:

Humidity	90 ~ 95% RH
Temperature	40 ± 2°C (104 ± 3.60°F)
Time	100 hours

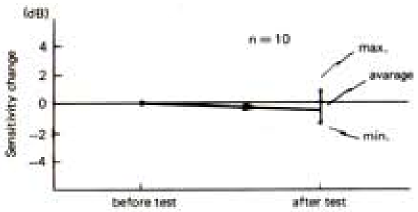


Fig. 15 (a)

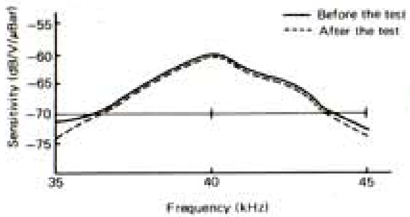


Fig. 15 (b)

Since a moisture treatment is efficiently conducted, all ultrasonic ceramic microphones manufactured by Matsushita Electronic Components are excellent in durability against moisture.

8-3. Stability against Shock and Vibration

Fig. 16 (a) and (b) show stability against shock under the following conditions:

Acceleration:	100G
Direction:	3 mutually perpendicular directions
Cycles:	3 times per direction (9 times in total)

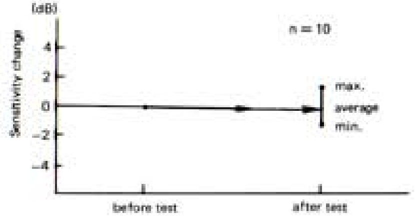


Fig. 16 (a)

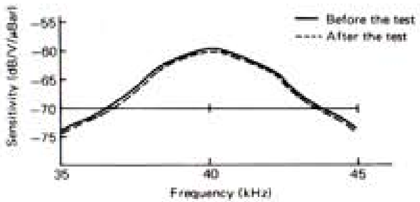


Fig. 16 (b)

Fig. 17 (a) and (b) show the stability against vibration under the following conditions:

Vibration frequency:	10 ~ 55 Hz
Sweep period:	1 min.
Total excursion:	1.5 mm
Direction:	3 mutually perpendicular directions
Time:	1 hour per direction (3 hours in total)

Fig. 17 (a)

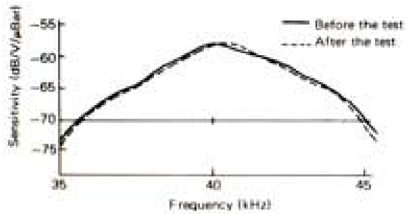


Fig. 17 (b)

8-4. Life

Fig. 18 shows the results of a continuous operating test under the following conditions:

Input voltage: 20 Vrms
Input frequency: 40 kHz
At room temperature

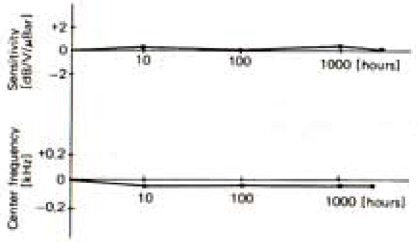


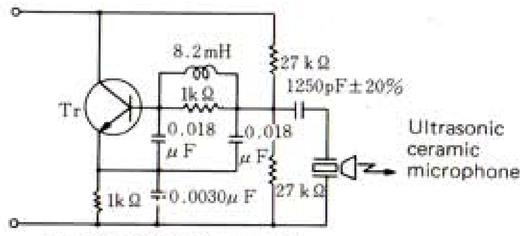
Fig. 18

The input voltage of 20 Vrms is several times the voltage ordinarilly used. No deterioration of the characteristics shall be found during the test.

9 CIRCUIT EXAMPLES

9-1. Transmitter

Fig. 19 shows an example of an oscillating circuit whose arrangement produces an ultrasonic wave of 40 kHz.



Tr : 2SC538A (Matsushita)

Fig. 19

Another example of an oscillating circuit is shown in Fig. 20.

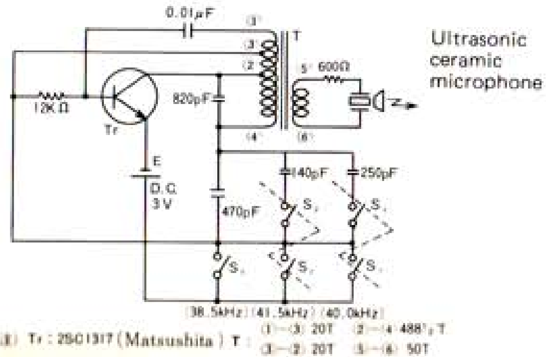


Fig. 20

Fig. 21 is an oscillating circuit by means of a multivibrator.

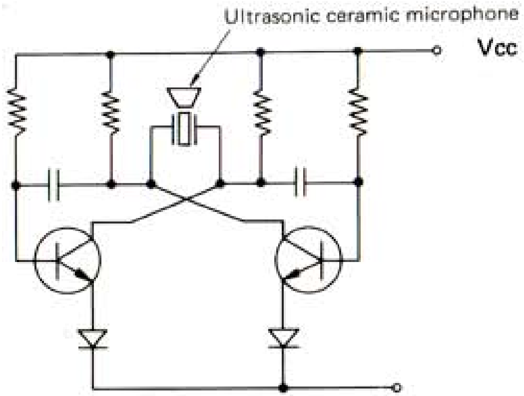


Fig. 21

The diode in the emitter circuits of the transistors suppress the reverse voltage occurring between the base and emitter. At low voltages there is no need for such diodes.

9-2. Receiver

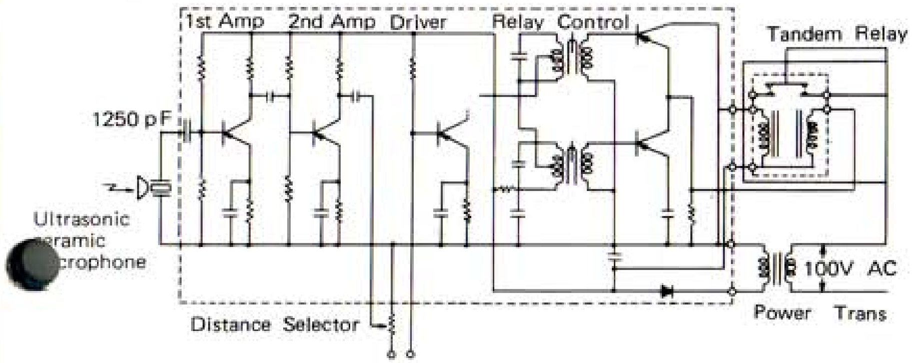


Fig. 22

Fig. 22 shows an example of the receiver circuit for a television remote control system.

10. APPLICATIONS

10-1. Remote Control

Important applications of ultrasonic ceramic microphones are, for instance, remote control of television receivers, slide projectors, garage door openers, and cranes. Many television receivers have provision for remote operation in changing channels, varying the volume, and turning the set on or off.
Operating principles of multi-channel remote controls are classified mainly in two according to their signal transmitting methods.

A) Frequency method
Fig. 23 shows a typical block diagram of a separate frequency remote control, in which different functions can be accomplished by using specific frequencies for each. The transmitter produces four frequencies for the following four functions.

38.0 kHz	Turn set on or off and vary volume
41.0 kHz	Sound on or off (muting)
39.0 kHz	Turn channel selector clockwise (cw)
40.0 kHz	Turn channel selector counterclockwise (ccw)

A transducer at the receiver intercepts the ultrasonic waves, converting them to electric signals for the remote control. These electric signals are amplified to a level that can operate the relays. Separated relays generate signals to operate the switching mechanism.

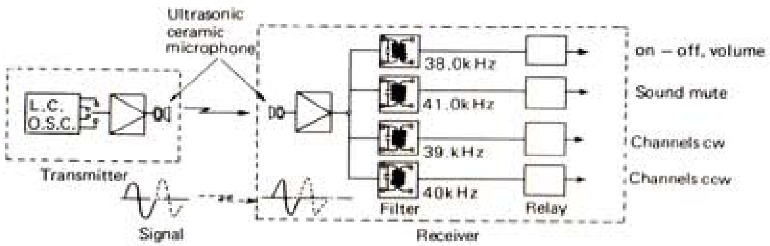


Fig. 23

B) Pulse code method
Fig. 24 and 25 show typical block diagrams of transmitter and receiver. The message signal is arranged in a 4-bit binary pulse code.

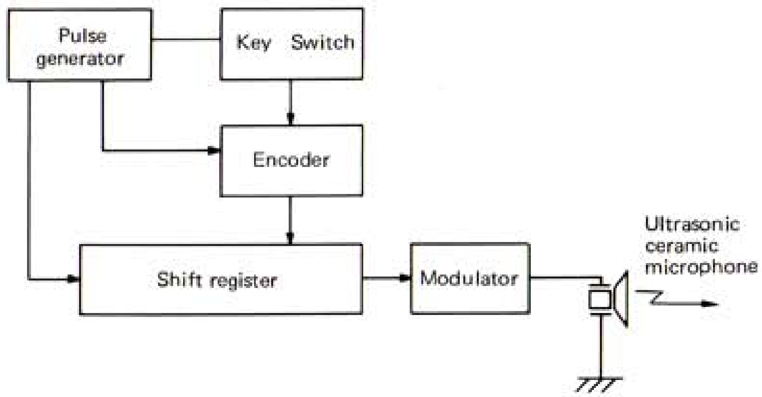


Fig. 24 Transmitter

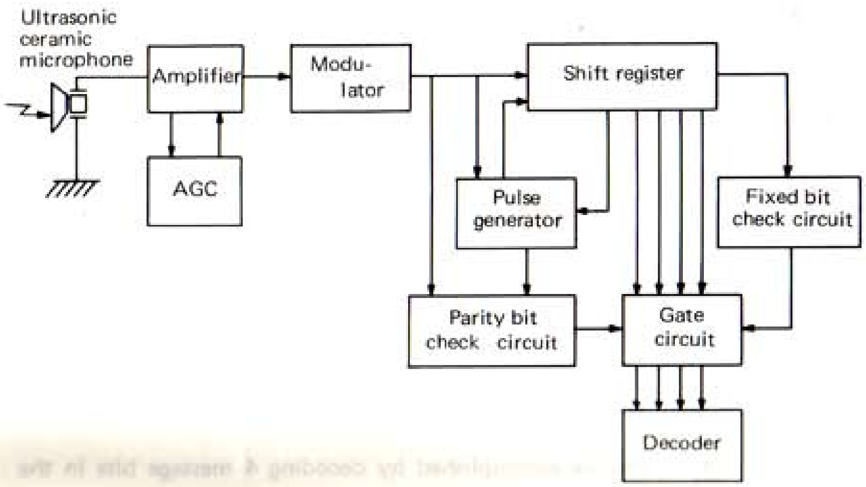


Fig. 25 Receiver

Signals in binary encoded form which contain 4 message bits and a parity bit are applied to an 8-bit parallel-in, serial-out shift register. Three fixed bits are also coupled to the register. Both clock pulse and clear pulse are generated by the pulse generator.
Fig. 26 shows an output signal waveform from the shift register.

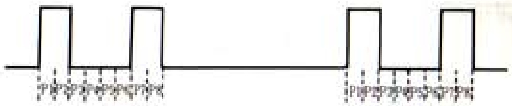


Fig. 26 Output signal waveform

The modulator circuit accomplishes the function of modulating the signal from the shift register and amplifying the modulated signal for driving a ceramic transducer to produce inaudible sound waves transmitted to the receiver.
The amplifier serves to amplify the signal from the ceramic transducer to a level that can be easily demodulated. The AGC circuit is coupled to this amplifier in order to eliminate undesired r.f. pick-up or other high level noise sources.
The signal recovered in the demodulator output together with the clock pulse and the clear pulse from the pulse generator is coupled to an 8-bit serial-in, parallel-out shift register.
Eight clock periods later, a parallel-output signal will appear at the output of the shift register.
By making use of the 3 fixed bits, it is possible to determine if the signal has been transmitted correctly.
A parity check is made before 4 message bits are coupled to the decoder through the gate circuit.
If the check is satisfactory, 4 message bits are coupled to the decoder. If, however, the check shows the parity to be incorrect, nothing passes through the gate circuit.
15 different functions can be accomplished by decoding 4 message bits in the decoder.

10-2.Proximity Switch

Other important applications of the ultrasonic ceramic microphones are proximity switches. They include burglar alarms, conveyer-type monitoring and level detectors. The burglar alarms operate by either an amplitude variation of an ultrasonic signal caused by an intruder, or more commonly, they are based on sensing Doppler signals caused by the intruder.
Fig. 27 shows an typical block diagram of the burglar alarm whose operation is based on the Doppler effect.

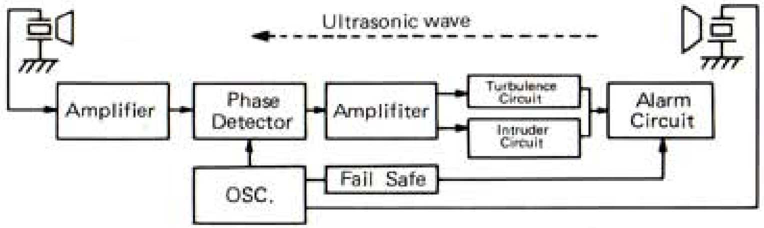


Fig. 27 Typical block diagram of burglar alarm

The conveyer-type monitoring includes a variety of applications. Ultrasonic switches are available that count, sort, position, or control other functions associated with a conveyer-line operation.
Ultrasonic beams are broken or reflected from an object to be detected, such as a box carton. Either the loss of signal in a broken beam or receipt of an echo by a receiving transducer is used to operate a relay, counter, or other devices as the operation requires. Detection range is up to about 10m.
Measurement of a liquid level can be accomplished. This measurement usually is based upon the time required for a pulse of ultrasonic energy to travel from a transmitter to a free surface, reflect from the surface, and return to a receiver.

11. SUGGESTIONS FOR HANDLING

1. Characteristics change owing to load impedance
   Center frequency and sensitivity change in accordance with load impedance. Therefore, the load characteristics chart should be taken into consideration in circuit designing.
2. Transmitting transducer
   Specifications of transmitting transducer are prescribed in convenience on the assumption that they are used as receivers, but its characteristics are different from those for receivers. Thereby they should be used as transmitters only.
3. Directivity
   Please be careful in deciding the facing position of microphone because of directivity.
4. Terminal connection
   The microphone is sealed after connecting a metal case and a ground terminal. Full attention should be paid to the terminal, polarity and connecting method.
5. Usage Range
   Because the microphone is designed for use in the air, it can not be used, for instance, under the water or others.
6. Apply of D.C. voltage
   A high d.c. voltage might deteriorate insulation resistance. So, it is advisable that capacitors should be inserted into the circuit to eliminate d.c. voltage applying.
   (Recommendable capacitance value : 1250 pF ±20%)
7. It is advisable to cover the case by means of a rubber sheet or other cushions.
8. When used as a transmitter, it is recommendable to reduce the Q factor of the transmitter circuit by adding the resistor in the circuit or to set the oscillating frequency at a certain frequency point of the microphone which is a little bit far from its series resonant frequency to avoid much power consumption.
   Please note the resonant resistance is very low, about 500 Ω.

MEMO