

# CERAMIC FILTER (CERAFIL®)



## *Application Manual*

**murata** *Innovator  
in Electronics*

**Murata  
Manufacturing Co., Ltd.**

## **Introduction**

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Ceramic filters (CERAFIL®\*) have now become an indispensable component in a multitude of electronic equipment.

The IC, developed in military and space applications, has found wide use in the field of commercial equipment, such as stereo systems, TV sets, automotive radios, etc. For this reason, new high-performance miniature integrated filters. extremely desirable for use in IF circuits.

Moreover, radio wave disturbance due to the remarkable sophistication of communication networks and the rapid progress of data transmitting rates have become significant problems. As a result, the demand for filters with high selectivity and wide pass bandwidth has increased.

The IC application of the active elements will continue to progress, increasing the demand for highly selective, non-adjustable, miniature and wide pass bandwidth IF circuits.

Accordingly, CERAFIL® is the most suitable component for a broad range of product. However, there is very little reference literature on application and design features. This CERAFIL® Application Manual has been compiled to help you design with the superior characteristics of CERAFIL®, to utilize them more efficiently and without any problem. This edition explains the CERAFIL® principle, the features and the specific criteria for the application of CERAFIL®. We intend to assist you to utilize all of these features effectively by matching the purpose with the application.

\*CERAFIL® is the brand name of the MURATA product.

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## 1 Types of CERAFIL®

## 2 Filter

## 3 Operating Principles of CERAFIL®

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## 5 Discriminator

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## 7 Features of CERAFIL®


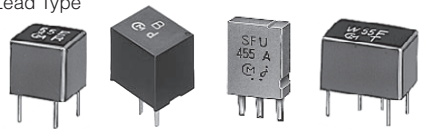




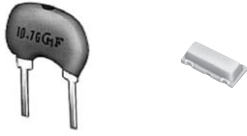

## 8 How to Use CERAFIL®

## 9 Ceramic Discriminator Application

## 10 Appendix

# 1 Types of CERAFIL®

Types of CERAFIL® and applicable markets

	Types of CERAFIL®	Typical Center Frequency	Hi-Fi Audio	Portable Audio	Car Audio	TV / VCR	RKE / TPMS	Wireless Data Communication	Mobile Phone	Cordless Phone	Radio Communication Equipment
Ceramic Filter	SMD Type 	450kHz 455kHz	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	Lead Type 		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	SMD Type 	10.7MHz	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
	Lead Type 		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
		4.5MHz 5.5MHz 6.0MHz 6.5MHz				<input type="radio"/>					
Ceramic Discriminator		450kHz 455kHz					<input type="radio"/>	<input type="radio"/>			<input type="radio"/>
		10.7MHz	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>			
Ceramic Trap		4.5MHz 5.5MHz 6.0MHz 6.5MHz				<input type="radio"/>					

1

# 2 Filter

## 1. Filter

An electrical component which has a function of passing, or stopping, a specific frequency.

## 2. Operating Principles and Features of Filters

The filters have different names depending on the structures and the materials used. The types, the principles and the features of the filters which are currently used are shown in table 1.

2

■Table 1. Operating Principle and feature of each filter.

Filter Groups	The Range of Applicable Frequency	Function	Operating Principle	Feature
Ceramic Filter	10kHz to 100MHz	B.P. B.E.	Utilizing piezoelectrical ceramics as an electrical-mechanical transducer and as a mechanical resonator, a specific characteristic is obtained by simultaneously providing electrical and mechanical system within a single system.	The dimensions are smaller than the LC filter. The frequency is fixed for both IF circuit and FM detector circuit, and high selectivity is obtained. The frequency stability is inferior to the crystal filter. It has some spurious response by mechanical vibration.
LC Filter	100Hz to 150MHz	L.P. H.P. B.P. B.E.	A specific characteristic is obtained by merging the positive and negative reactances of the coil (L) and the capacitor (C).	The acceptable degree of vibration for choosing the center frequency, the pass band, the amplitude characteristic or delay characteristic is normally great. On the other hand, the dimensions are often larger compared with the vibrating type of filter and the shape factor is inferior.
Crystal Filter	3kHz to 200MHz	L.P. H.P. B.P. B.E.	A specific characteristic is obtained by merging both series and parallel resonant frequency by using frequency characteristics near the resonant point of the crystal resonator.	The loss is extremely small, the cut-off characteristic is very steep and the stability is great. It is hard to get the wide band because of a high Q.
Mechanical Filter	100Hz to 800kHz	B.P.	It consists of 3 portions of mechanically vibrating filter sections which have certain frequency characteristics: The mechanical electrical transducer section and the matching section which connects with the external electronic circuit. It converts energy by adhering the piezoelectric ceramics on the metallic resonant element.	The loss is small, the cut-off characteristic is steep and the stability is great. The structure is rather complicated. It also has a spurious characteristic. The dimensions are large.
Active Filter	100Hz to 80kHz	L.P. H.P. B.P. B.E.	Although the operating principle differs by the type, each of them generally utilizes the characteristics of the OP-Amp., and it operates the circuit by corresponding the merging circuit of both the OP-Amp. and the RC to the transfer function. A hybrid IC is used because a respectively high accuracy is required for the RC.	The characteristics of any filters are available with this type. Compared with both the LC and mechanical filter, a miniature and light-weight filter is available in the low frequency range. It has strong vibration and shock resistance. It requires a power source.

L.P. : Low Pass Filter, B.P. : Band Pass Filter, H.P. : High Pass Filter, B.E. : Band Eliminate Filter

Fig.2-1 graphically shows the relations between the applicable frequency range and the bandwidth of each filter.

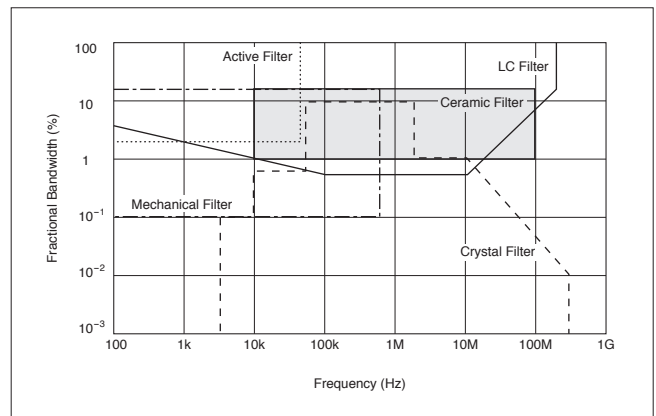


Fig. 2-1 The relations between the Applicable Frequency Range and the Bandwidth of Each Filter Type

# 3 Operating Principles of CERAFIL®

CERAFIL® (ceramic filter) is a filter which uses a piezoelectric ceramics (barium titanate ceramics, lead-zirconate-titanate ceramics, etc.) as an electrical-mechanical transducer and as a mechanical resonator. It provides the electrical and the mechanical system simultaneously within a single element.

## 1. What is Piezoelectric Effect?

Distortion takes place in the crystal lattice when a stress is applied upon it, and the crystal group which has no symmetric center causes a polarization in addition to the distortion.

This phenomenon was found by the Curie brothers in 1880 and is called the piezoelectric direct effect (or Curie's Effect). In other words, it means that the mechanical force (stress) can be converted into an electrical signal (an electrical field) or the electrical signal into the mechanical force. These two phenomena are collectively called the piezoelectric effect, and any substance which has this nature is called piezoelectric ceramics.

The crystal group, the symmetry of which is inferior among all crystals having the characteristic of piezoelectricity, has a native limited volume of polarization before some electric field or stress is applied. This is called spontaneous polarization. The crystal is distorted by a phenomenon like the thermal vibration of atoms according to the temperature change. The degree of spontaneous polarization also changes according to the distortion of crystal and its variation appears as a potential difference. This is called the phenomenon of pyroelectricity.

On the other hand, when such a crystal is applied with an electric field, a distortion or a stress occurs. It is called the piezoelectric inverse effect (or Lippman's Effect).

Also, among the crystals which have a spontaneous polarization, those which can reverse their direction by the external electrical field are called ferroelectric substances. The relations among these effects may be expressed as Fig. 3-1.

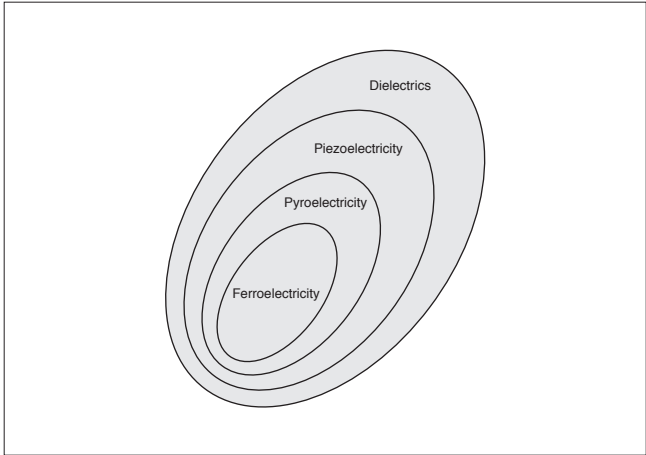


Fig. 3-1 Relations Among Piezoelectricity, Pyroelectricity, and Ferroelectricity.

**2. What is Piezoelectric Ceramics?**

Some piezoelectric crystals can be calcined into polycrystal ceramics, though there is a spontaneous polarization in each of the fine crystals in the piezoelectric ceramics which is cancelled as a whole and shows no piezoelectricity. But when a high D.C. voltage is applied to such ceramics, the directions of the spontaneous polarizations are brought to a uniformity and a ferroelectricity ceramics is attained. With some additives, the material with extremely stable frequency, temperature and aging characteristics is being used by MURATA for CERAFIL®. Compared with the single crystal, the piezoelectric ceramics has various advantageous features as follows ;


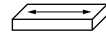

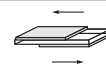

1. Can be mass-produced at low cost.
2. Can be formed into any desirable shape.
3. The direction of the polarization is easily attainable.
4. Chemically and physically stable.
5. Easy for fabrication.

**3. Electrical-Mechanical Transducer and its Equivalent Circuit**

**1. Vibrating Mode**

Since the ceramic resonator with which the polarization has been oriented is piezoelectric, as described earlier, it vibrates in a vibrating mode when the electrodes are provided with the ceramic resonator, as a sine wave is applied across the both polarities and then excited. Table 2 shows the typical vibrating modes, the shapes and the applicable frequencies of such ceramic resonators.

■ Table 2. The Vibrating Modes and the Applicable Frequency Band

Vibrating mode		Frequency (Hz)						
		1k	10k	100k	1M	10M	100M	1G
Flexural mode		█						
Length mode				█				
Area expansion mode				█				
Thickness shear mode					█			
Thickness expander mode					█			

Note : Arrows signifies the directions of the vibrations.

### 3 Operating Principle of CERAFIL®

#### 2. Symbols in the Electrical Circuit of the Electrical-Mechanical Transducer and the Equivalent Circuit

The symbols as shown in Fig. 3-2 are used for the electrical-mechanical transducer in an electrical circuit. The equivalent circuit with two-terminal type transducer near the resonating point is shown in Fig. 3-3 even if the vibrating mode used is different. Each parameter can be considered as spring-pendulum shown in Fig. 3-4.

- C<sub>0</sub>: the capacitance between the electrodes is called the parallel equivalent capacitance.
- C<sub>1</sub>: mechanically corresponds to the flexibility of rubber or a spring, and it is called the equivalent compliance.
- L<sub>1</sub>: mechanically corresponds to the inertia (mass or moment) and is called the equivalent mass (or equivalent inductance).
- R<sub>1</sub>: is a friction resistance, and is called the equivalent resistance.

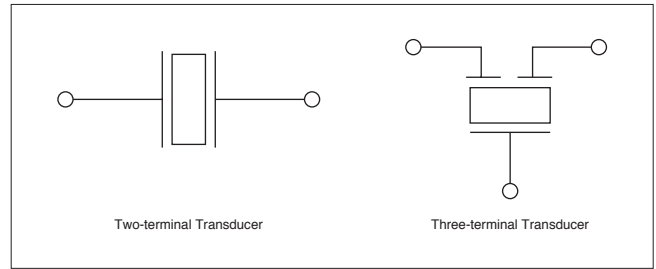


Fig. 3-2 Symbols in the Electrical Circuit for the Transducer

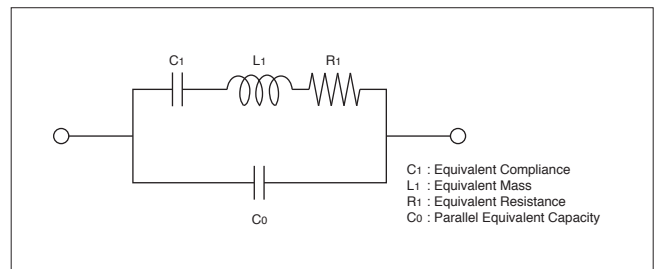


Fig. 3-3 Two-terminal Type Equivalent Circuit

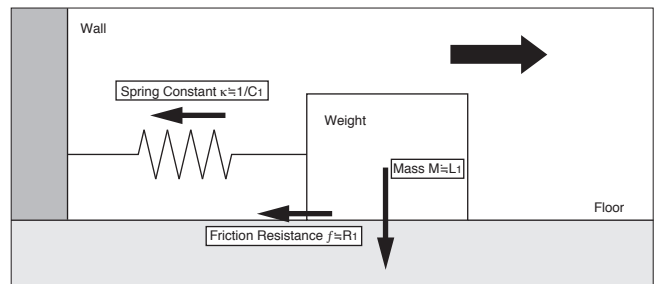


Fig. 3-4 Relations Between Spring-Pendulum and Electrical-Mechanical Transducer

In an ideal electrical-mechanical transducer, the impedance change takes place as shown in Fig. 3-5, and each constant of these and each constant of the equivalent circuit in Fig. 3-3 are in the following relation of equations shown in Fig. 3-5.

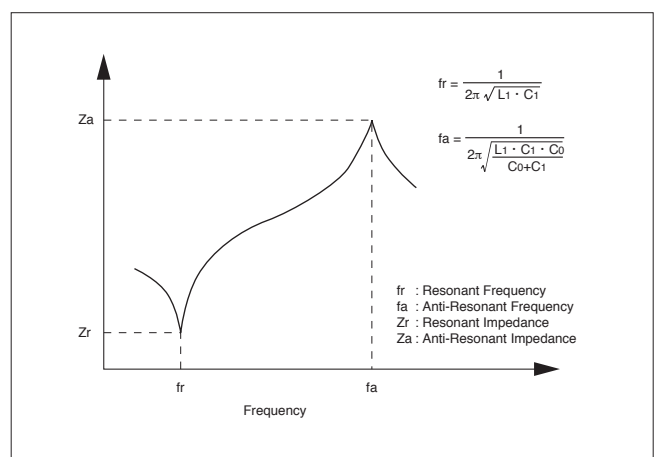


Fig. 3-5 Impedance Characteristic of the 2-terminal Type



## Operating Principle of CERAFIL® 3

### 4. CERAFIL®

When the piezoelectric ceramics described above is polarized by providing a pair of electrodes so that it can be excited in a prescribed vibrating mode, and if a suitable matching impedance is applied to operate it, a CERAFIL® is completed. A model example of 455 kHz CERAFIL® for AM is shown in Fig. 3-6.

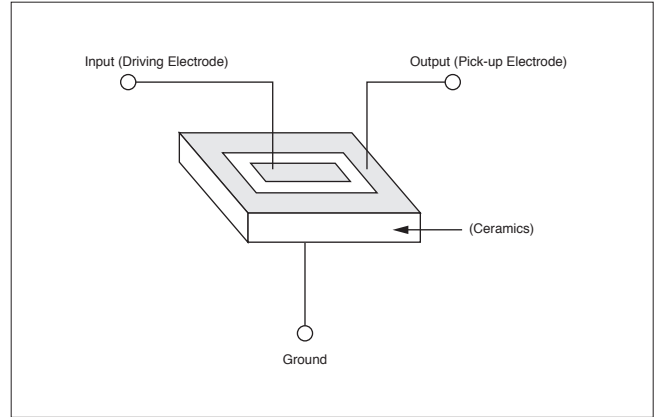


Fig.3-6 Model of the 455 kHz CERAFIL® for AM

# 4 Technical Terms of CERAFIL®

Some specific terms are used with CERAFIL®. Let us explain those terms in this paragraph.

## 1. Frequency Characteristics of CERAFIL® and Related Terminologies

Refer to the frequency characteristic graph (Fig. 4-1) with particulars (Table 3).

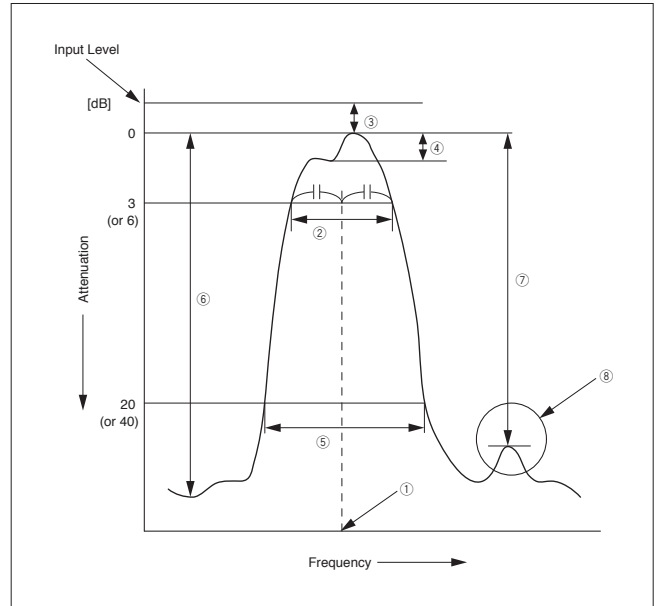


Fig. 4-1 An example of CERAFIL® frequency characteristic

■Table 3. Terminologies

Numbers in Fig.4-1	Terminology	Symbol	Unit	Explanation of the Term
①	Center Frequency	$f_0$	Hz	Signifies the frequency in the center of the pass bandwidth. However, the center frequency for some product is expressed at the point where the loss is minimum.
②	Pass Bandwidth	(3dB) B.W.	Hz	Signifies a difference between the two frequencies where the attenuation becomes 3dB from the level of the minimum loss point.
③	Insertion Loss	Loss	dB	Expressed in the input and output level ratio at the point of minimum loss in dB. (The insertion loss for some product is expressed in the input and output level ratio at the center frequency.)
④	Ripple	—	dB	If there are peaks and valleys in a pass bandwidth, the ripple expresses the level difference of voltage between the maximum peak and minimum valley and it is expressed in dB.
⑤	Attenuation Bandwidth (dB bandwidth)	(20dB) B.W.	Hz	Signifies a difference between the two frequencies where the attenuation becomes the specified values (dB) from the level of minimum loss. (Example: Expressed at a point where the attenuation becomes 20 dB in case of 10.7 MHz filter.)
⑥	Selectivity	—	dB	Expressed as the attenuation of the detuning point from the center frequency. (Example: The attenuation that $\pm 9$ kHz was detuned from the center frequency in case of 455 kHz filter.)
⑦	Spurious Response	sp	dB	Expressed as the difference of voltage ratio between minimum attenuation point in the stop band range and minimum loss point in the pass bandwidth by using dB (the stopped range is specified with each filter).
⑧	Spurious	—	—	Signifies the frequency response based on the parasitic (unwanted) vibration against the frequency except the fundamental vibration.
Other	Bottom Level	—	dB	Signifies the minimum or average attenuation without both main response and spurious within the specified frequency range.
	Shape Factor	—	—	One of the ways expressing selectivity, which is expressed as [Attenuation Bandwidth/Pass Bandwidth]. The selectivity becomes steeper as the resultant value comes closer to value 1.

## 2. Other Terminologies

### 1. Input/Output Impedance

Signifies the internal impedance value of the input and output side at the center frequency of CERAFIL®, and it is expressed in  $\Omega$ . It causes no problem even if the input and the output are used in reverse with CERAFIL®, since the input and the output impedance are in a symmetry of substantially the same value.

### 2. Impedance Matching

When connecting one electric circuit to another, or a component to another, or one electric circuit to a component, the electric energy is supplied most efficiently from the signal source to the load if the signal source impedance and the load impedance are the same. If these impedances are mismatched, electric energy escapes in the form of a reflection. To match the signal source impedance and the load impedance is called the impedance matching. This is very important for CERAFIL®, as an improper impedance matching may cause various problems (refer to the advised points in chapter 8-1).

### 3. dB (Decibel)

Decibel is the logarithmic ratio value by comparing the two levels. It is also used with CERAFIL® when expressing the frequency characteristics, the insertion loss, the spurious response, etc.

dB is defined and calculated by the ratio of the electric power, the voltage and the current, as follows:

$$\text{Electric Power Ratio dB} = 10\log_{10}P_2/P_1$$

(electric power at two points as  $P_1$  and  $P_2$ )

$$\text{Voltage Ratio dB} = 20\log_{10}E_2/E_1$$

(voltage at two points as  $E_1$  and  $E_2$ )

$$\text{Current Ratio dB} = 20\log_{10}I_2/I_1$$

(current at two points as  $I_1$  and  $I_2$ )

#### The merit of using the decibel:

- (1) As exemplified above, the decibel is expressed as a logarithm.
- (2) The amplitude, attenuation, etc. are simply calculated by merely adding or subtracting.

## 4 Technical terms of CERAFILE®

### 4. dBμ

The dB has been used only for comparing the two volumes such as the electric power ratio, voltage ratio, current ratio, etc. In addition dB may be also used for expressing electric power or voltage by deciding on some reference values. In CERAFILE®, dBμ is used for expressing voltage value such as the input level. Here the reference value is 0 dBμ = 1 μV. In other words, the volume that represents a level of 60 dBμ equals 1 mV. It is important to clearly distinguish dB from dBμ.

The decibel for expressing other levels:

**dBm** : The voltage or current level to obtain the power of 1 mW in the load of 600 Ω is specified a 0 dBm.

(Voltage : 0 dBm =  $\sqrt{600 \times 1 \times 10^{-3}} = 0.775 \text{ Vrms}$ )

**dBs** : Reference values is 1 Vrms = 0 dBsw

### 5. Group Delay Time Characteristic

One of the most important characteristics of a transmitting element is to transmit a signal with the lowest distortion. This distortion occurs when the phase shifting of a signal which passes through a certain transmitting path is nonlinear to the frequency. For convenience the GDT characteristic is used for the purpose of expressing the non-linearity against the frequency of phase shifting and it is calculated by the following formula : TD (GDT),  $\phi$ , (phase difference between input and output) and  $\omega$  (angular frequency).

$$T_D = \frac{d\phi}{d\omega}$$

The above formula shows that the phase slope was differentiated by the frequency. That is to say, when the GDT is constant, a signal is transmitted correctly without distortion.

Recent trends in quality FM receiver and other equipment emphasizing the distortion factor characteristic are also stressing the phase linearity in the pass band. In other words, they need a flat GDT characteristic with high selectivity.

In principle the GDT characteristic and the amplitude characteristic are related to each other. The amplitude characteristic with a flat top is called the Butterworth Characteristic, while the amplitude characteristic resembling a sine wave is called a Gaussian Characteristic as shown in Fig. 4-2.

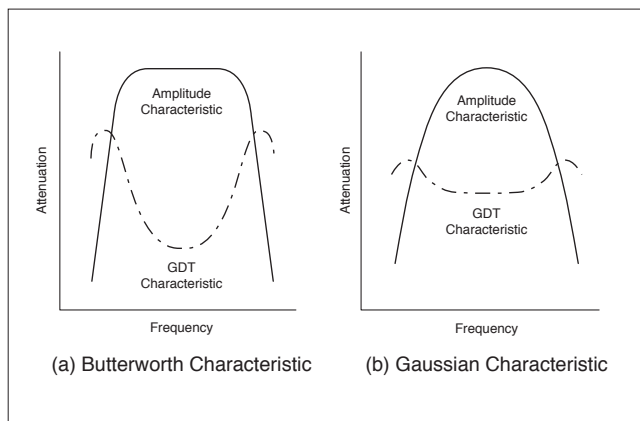


Fig. 4-2 Relationship between Amplitude and GDT Characteristic

# 5 Discriminator

In the preceding chapter, we explained filtering characteristics and their principles. We have ceramic discriminators which convert the changes in frequency into an audio signal via the various detection methods based on the impedance or phase characteristics of CERAFIL®.

## 1. Discriminator

The detection of FM waves is made through the circuit in which the relation between the frequency and the output voltage is linear. The discriminator functions to convert the change of frequency into audio frequency, a unique system of detection only used for FM broadcasting. FM wave detection methods, such as ratio detection, Foster-Seeley detection, quadrature detection, differential peak detection, etc. are known.

## 5 Discriminator

### 2. Detection methods

#### 1. Ratio Detection

Ratio detection is the most popular method in use at present. Let us introduce its simple operating principle as shown in Fig. 5-1. The voltage  $e_1$  and  $e_2$  applied to the diode  $D_1$  and  $D_2$  are composed of both the primary voltage  $V_1$  and a half of the secondary voltage  $V_2$ . The voltage  $e_1$  and  $e_2$  are expressed in the equations as shown in Fig. 5-1 (b). By this high frequency voltage, the rectified current  $I_1$  of diode  $D_1$  has voltage  $E_1$  generated at both ends of  $C_3$ , and voltage  $E_2$  as well as  $E_1$  occurs at both ends of  $C_4$ . Moreover, the voltage of both ends of  $R_3$  and  $R_4$  becomes  $(E_1+E_2)/2$  since the voltage  $(E_1+E_2)$  takes place at both ends of  $R_3$  and  $R_4$  by the current  $I_1$  and  $I_2$ .

We will consider the tuning frequency of discriminator as  $f_0$  and the input frequency as  $f$ .

(1) For  $f=f_0$ ,  $E_0$  becomes zero owing to  $E_1=E_2$

(2) For  $f < f_0$ ,  $E_0$  becomes  $E_0 = \frac{E_1+E_2}{2} - E_1 = \frac{1}{2}(E_2-E_1)$   
 because  $I_1 < I_2$  ( $I_1+I_2=\text{constant}$ )

(3) For  $f > f_0$ ,  $E_0$  becomes  $E_0 = \frac{E_1+E_2}{2} - E_2 = \frac{1}{2}(E_1-E_2)$   
 due to  $I_1 > I_2$

Also, the frequency characteristics becomes an S-shaped curve as shown Fig. 5-1 (c). We can see that if the impedance characteristic of a ceramic resonator is designed into the circuit, then a coil as a detector is unnecessary. Perhaps more interesting is the fact that adjustment is eliminated.

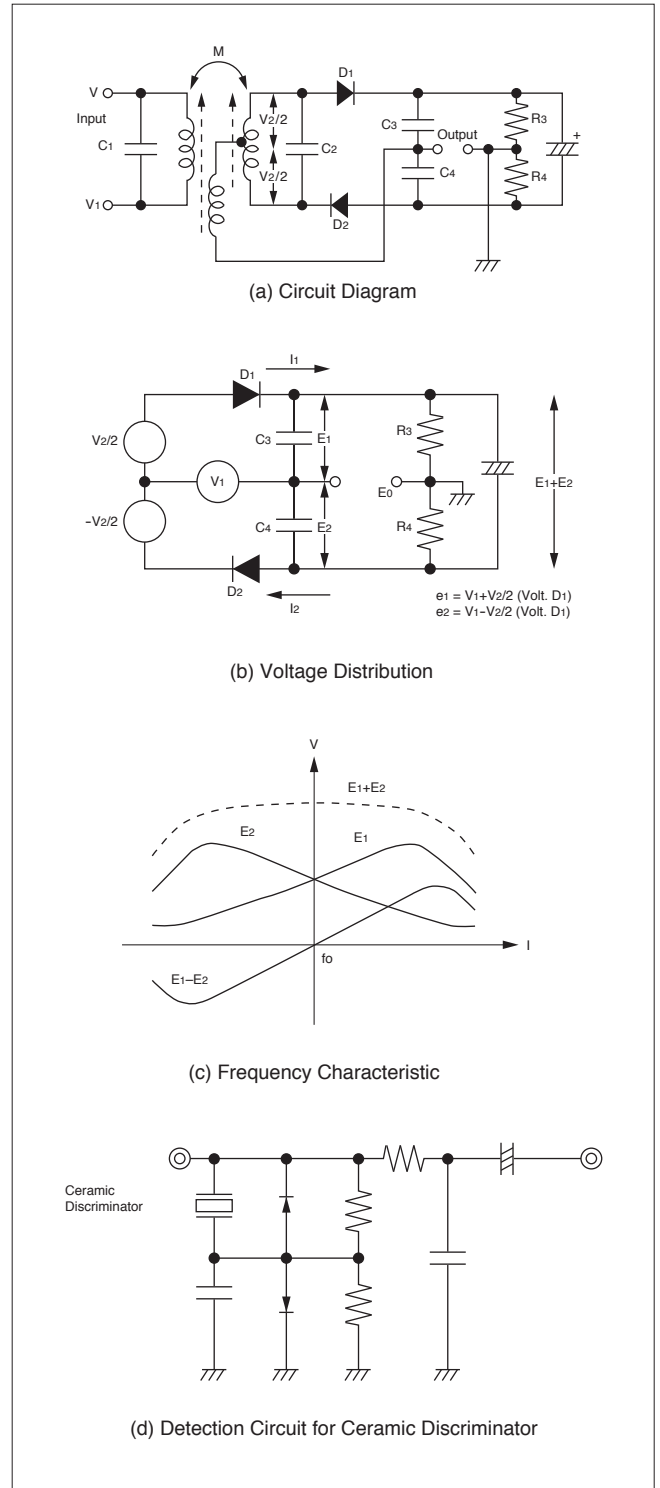
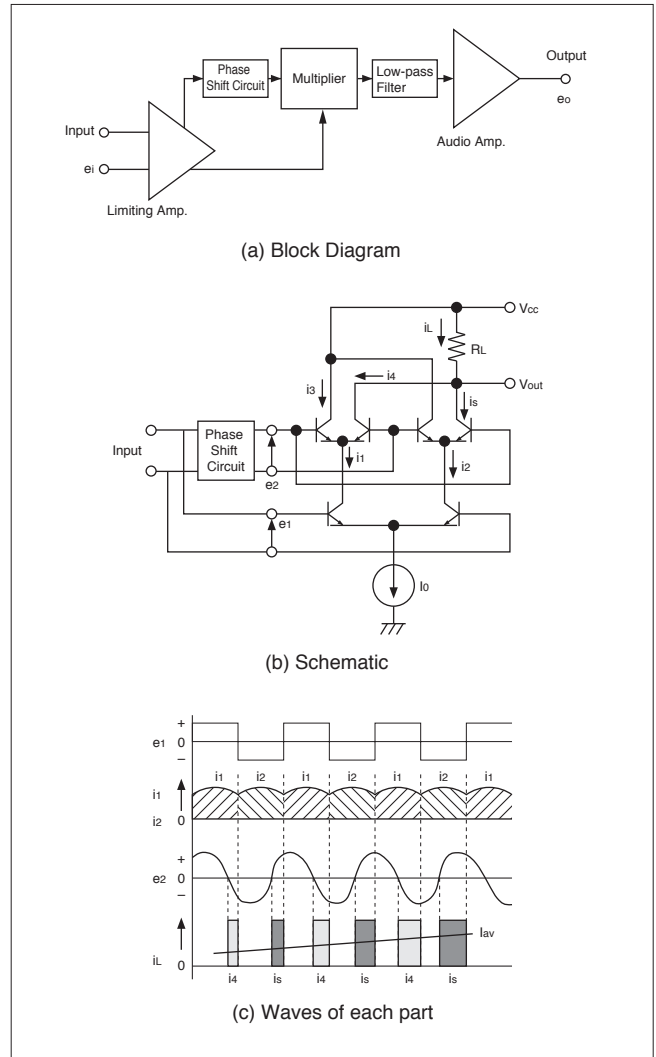


Fig. 5-1 Ratio Detector

**2. Quadrature Detection**

This detection method was originally developed as a sound detector for TV sets, but recently it has become popular in the consumer market (FM tuners, car radios, etc.). The fundamental circuit composition is illustrated in Fig. 5-2 (a) and the operating principle in Fig. 5-2 (b) and (c). This detection method utilizes the phase characteristic. An FM signal is supplied directly to one side of the multiplier's input with an IC to the other side of the multiplier's input. An FM-IF signal, which is passed through the phase shifting circuit mainly composed of a tank circuit tuned to FM-IF, is applied. According to the phase difference between  $e_1$  and  $e_2$  (passed through the phase shifter). As shown in Fig. 5-2 (b) and (c), the pulse width of output  $i_L$  changes, and by passing it through the low pass filter the average value of the output-pulse changes and the phase detection is performed. Up to this time a coil has been used as a phase shifter. Again, by taking advantage of the phase characteristic of the ceramic resonator as a ceramic discriminator, we can eliminate adjustment of the FM-IF circuit.



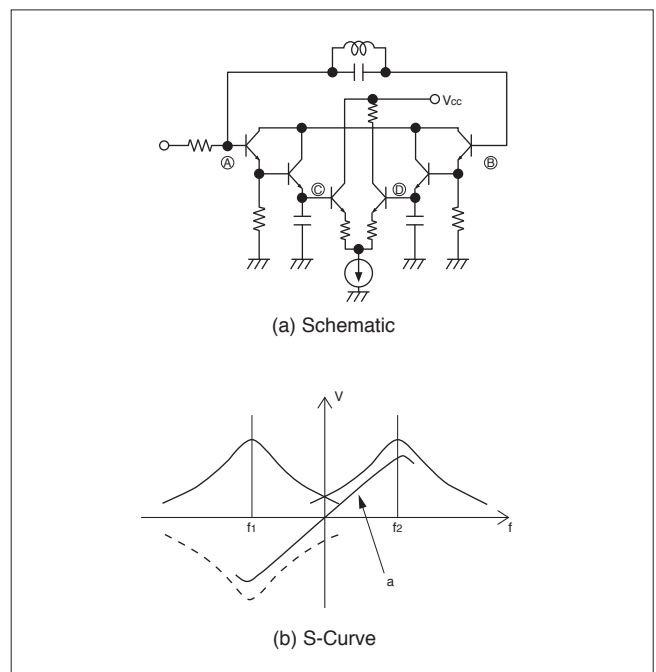
**Fig. 5-2 Quadrature Detector**

**3. Differential Peak Detection**

This detection method was developed by RCA as a sound detector for TV sets. The method has the following features.

- (1) Can output at high levels.
  - (2) Can function with only 1 synchronous coil.
- The principle is shown in Fig. 5-3. The circuit resonates  $f_1$  at point B and  $f_2$  at point A due to its own impedance change.

Non-linearities of synchronous characteristics compensate each other by applying rectified intermediate frequency voltage. As a results, linearity like line "a" shown in Fig. 5-3 can be obtained.



**Fig. 5-3 Differential Peak Detector**

# 6 Trap

## 1. Trap

As mentioned above, ceramic filters pass only a particular frequency. However a Band Eliminate Filter (B. E. F.), which blocks or attenuates a particular frequency, is called a trap. A sound trap for TV set is one famous example of B. E. F.

In a TV set, a video signal is used in picture amplitude circuit after a video signal detection block; a ceramic resonator is insert here and a trap circuit is formed in order to eliminate the sound signal involved in the video signal.

## 2. Ceramic Trap

### Three-Terminal Ceramic Trap

A three-terminal ceramic trap has a monolith structure formed from 2 ceramic resonators. Fig. 6-1 shows a measurement circuit of a three-terminal ceramic trap (TPSRA4M50C00-B0) that is inserted in parallel with S. S. G. The characteristic of a three-terminal ceramic trap equals two two-terminal ceramic traps.

A three-terminal ceramic trap attenuates the signal at 4.5 MHz around 50 dB from 0 Hz point shown as Fig. 6-2. Though a three-terminal ceramic trap needs an additional coil shown as Fig. 6-1, it is used in Color TV sets and VCRs due to its high attenuation.

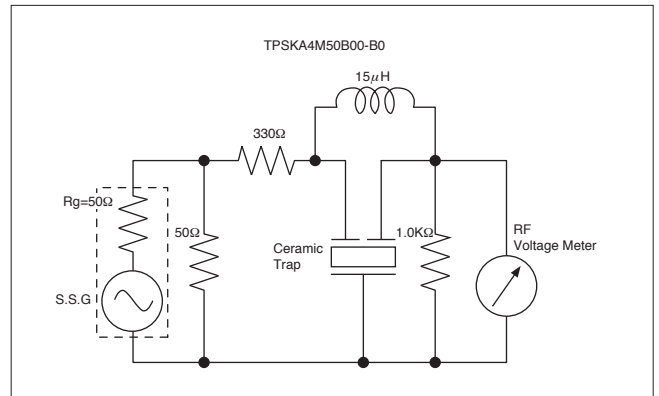


Fig. 6-1 Measurement Circuit Diagram of Three-Terminal Ceramic Trap

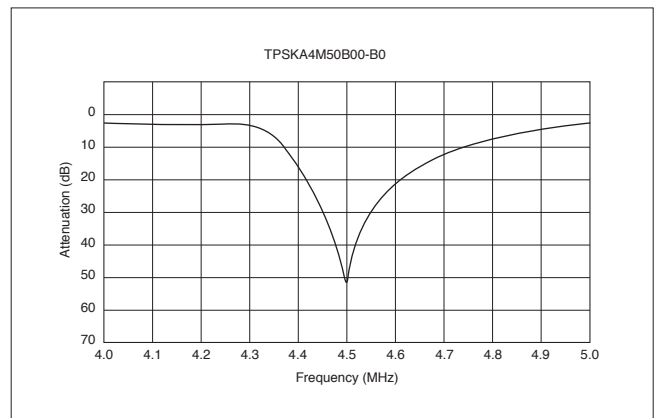


Fig. 6-2 Frequency Characteristic of Three-Terminal Ceramic Trap



# 7 Features of CERAFIL®

## 1. Ease of Highly Selective-Design

By virtue of employing a mechanical vibration means, CERAFIL® has a high Q compared with IFT, and therefore, a high selectivity is obtained. Just one CERAFIL® equals the selectivity available with 2 or 3 IFTs. It also has a remarkable frequency temperature coefficient, high selectivity and high stability.

## 2. No Peaking Needed

Because CERAFIL® is employing a mechanical resonance, it is almost unaffected by the surrounding circuits: its characteristics do not deviate when it is implanted in the printed circuit and no adjustment is required.

## 3. A Very Suitable Component for Miniaturization

CERAFIL® is available in various forms for many applications. CERAFIL® facilitates space savings and a low profile in your products.

## 4. A Very Suitable Component for Integrated Filters

There is a growing need for integrating the selective elements because the gain per stage is greater when IC is used in the amplifier. When building the integrated filter by LC, at least 5 to 8 stages will be required depending on the selectivity, and consequently, a large size integrated LC filter will be required and the adjustments become extremely complicated when taking into consideration such factors as the adjustments for each stage, dispersions and temperature characteristics. In this respect, CERAFIL® can easily be integrated in compact form and for simple high selectivity.

## 5. Optimum Component for Solid State Application

Nowadays, electronics are represented by the IC, and deal with electrons in the solid state, heading in the direction of a solid-state application where the functions cannot be separated.

CERAFIL® utilizes the electrons in the piezoelectric ceramics, and unlike the conventional IFT, it cannot be disassembled into components like a coil or capacitor. It is, therefore, most suitable in IC circuits and will become popular with IC growth.

# 8 How to Use CERAFIL®

As mentioned earlier, CERAFIL® abounds with many features in comparison with the IFT, but there are points of caution to be observed in the use of CERAFIL®. Let us explain these points here. The CERAFIL® must be thoroughly understood, and when used at its optimum performance, it operates without problems.

## 1. Impedance Matching

It is imperative to match the impedance properly whenever any circuit is connected to another circuit, any component to another component or any circuit to another component.

This is also the basic requirement for CERAFIL®. The characteristics as described in the catalog are applicable as long as proper impedance matching is met. Impedance matching required for CERAFIL® is not difficult since the resistance values giving proper input/output impedance for optimum frequency characteristics are shown in our catalog or specifications. One only has to match the signal source impedance and the load impedance, so the values meet the ones specified.

Fig. 8-1 shows the changes of the frequency characteristics with changes of the resistance values with SFECF10M7HA00-R0.

If the input/output impedance ( $R_1$ ) and ( $R_2$ ) are connected to lower values than those specified, the center frequency shifts toward the low side and the ripples increase as shown Fig. 8-1. On the other hand, if ( $R_1$ ) and ( $R_2$ ) are connected to higher values than those specified, the center frequency shifts toward the high side and the ripples increase as shown.

However, the characteristic shift caused by the mismatching is not such a serious problem. The matching impedance can be within the range of  $\pm 50\%$  of the values specified, though the accuracy for the impedance matching depends on the required performance of the model.

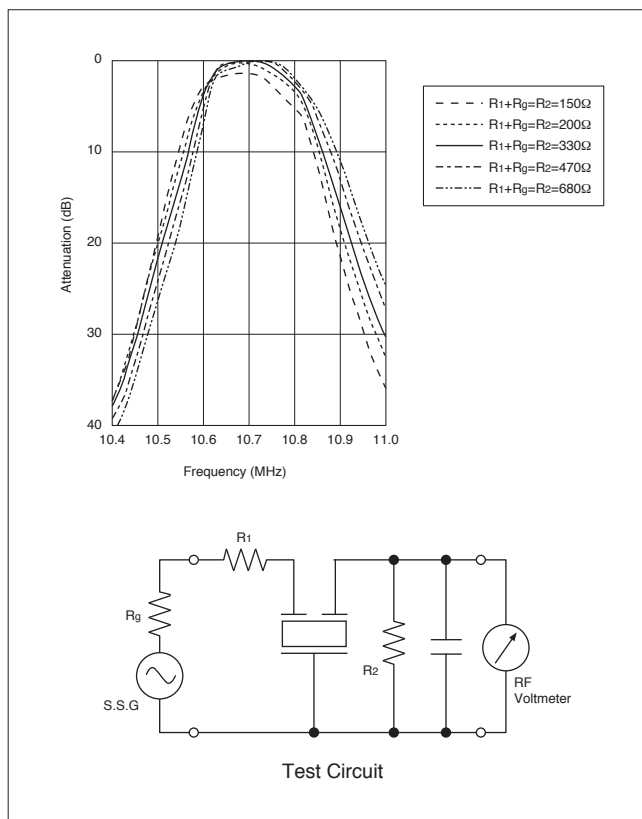


Fig. 8-1 SFECF10M7HA00 Impedance Characteristic (Input & Output resistive termination)

## 8 How to Use CERAFIL®

### 2. Countermeasure for Spurious Response

The question of spurious response arises by the fact that resonance occurs under alien vibrating mode or overtone except the basic vibration, because CERAFIL® uses mechanical vibration mode. With ceramic filter such as 10.7 MHz, 4.5 MHz, etc., the spurious is not great enough to cause serious a problem since these types use a trapped energy vibration mode. But a countermeasure against the spurious is required for the 455 kHz filter.

The following countermeasures are available.

- (1) It is recommended to use supplementary IFT together with CERAFIL® for suppression of spurious.
- (2) Arranging 2 or more CERAFIL® for mutual cancellation of spurious.
- (3) To provide low pass or high pass filter of the fixed LC for suppression of spurious.

Among the countermeasures itemized above, the most common approach is method (1). The spurious responses are shown in Fig. 8-2 with only SFULA450KU2B-B0 and Fig. 8-3 with SFULA450KU2B-B0 + IFT. This arrangement for suppression is sufficient.

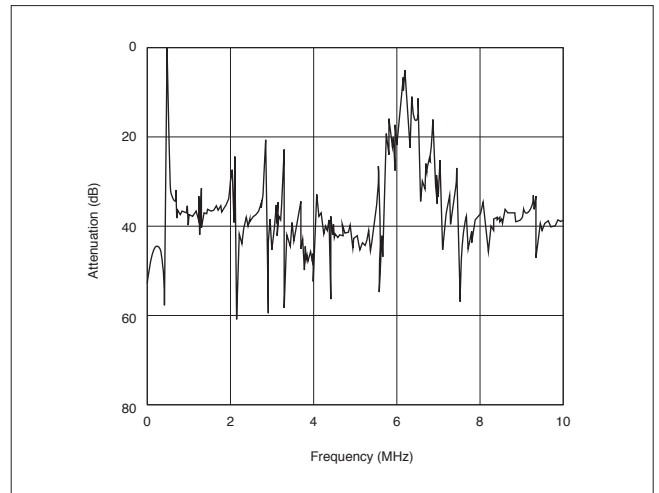


Fig. 8-2 Spurious Response with SFULA450KU2B-B0

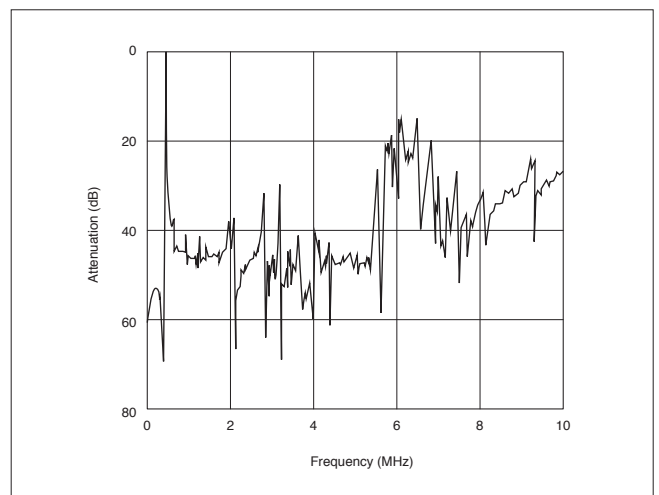


Fig. 8-3 Spurious Response with SFULA450KU2B-B0+IFT

### 3. Consideration for Gain Distribution

The impedance of both input and output is symmetric and small; it is necessary to consider the distribution in the circuit. A resistor is used for the impedance matching (as described in section 8.1.) and a certain D.C. loss is caused by the resistors, which reduces the gain. This sometimes creates a problem if the set has no allowance for this loss. The following countermeasures are available.

Countermeasures

- (1) Using CERAFIL® in the amplifier stage instead of using it in the interstage, design the amplifier for the gain performance consideration.
- (2) Use in combination with IFT for minimizing both matching loss and D.C. loss. In this case, regard the IFT merely as a matching transformer and rely on CERAFIL® for the selectivity.

## 4. Bias Circuit

Although a bias is required to drive the transistor, CERAFIL® does not pass D.C. This means that the bias circuit is required. But since CERAFIL® requires matching resistance, the matching resistor can play a double role as both matching and bias resistor. (Refer to Fig. 8-4,)

In this case, check the impedance of the transistor's side from CERAFIL® side, and always take the parallel circuit of both the bias resistance and the transistor's internal resistance into consideration to meet the resistance value with one of the specification because the internal resistance of the transistor is changed by the bias resistance.

When using IC, there is no need for additionally providing any bias circuit since IC has a bias circuit within itself. However, considering that CERAFIL® does not pass D.C. and that the conversion gain cannot be sufficiently obtained since the input impedance of CERAFIL® is low; the general approach is to use IFT when coupling with MIX stage. (Refer to Fig. 8-5,)

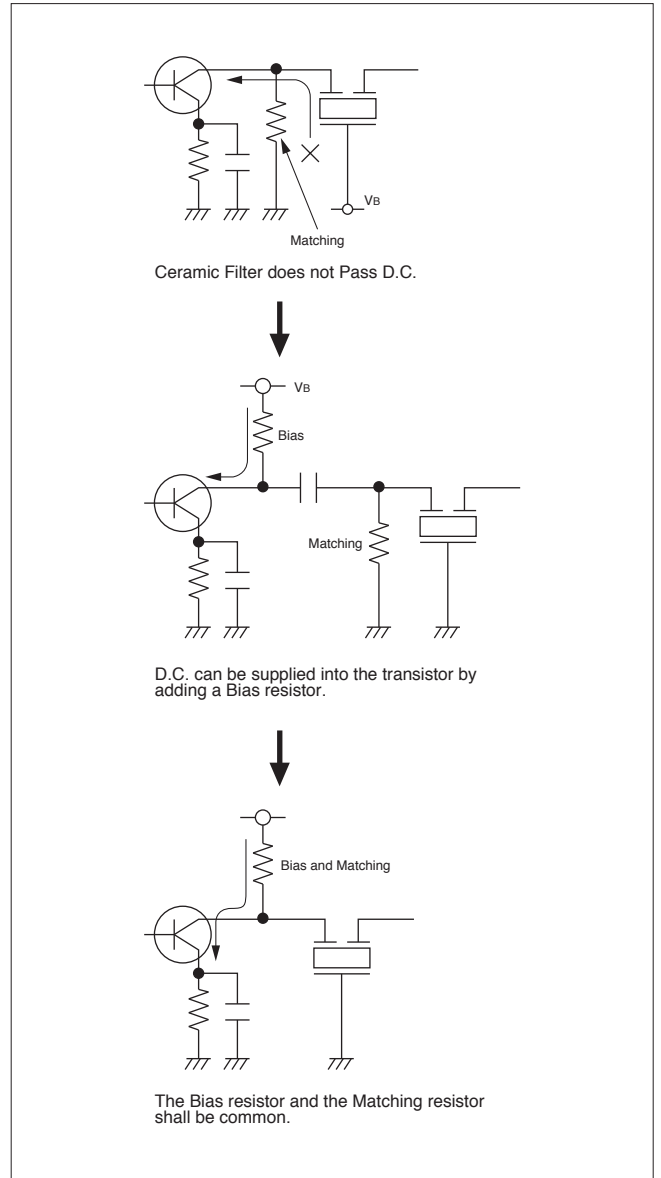


Fig. 8-4 Coupling with a transistor

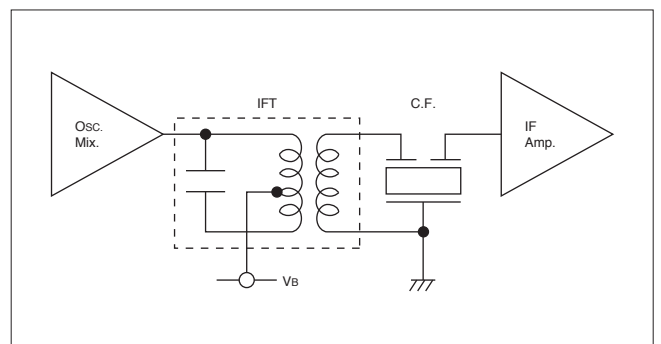


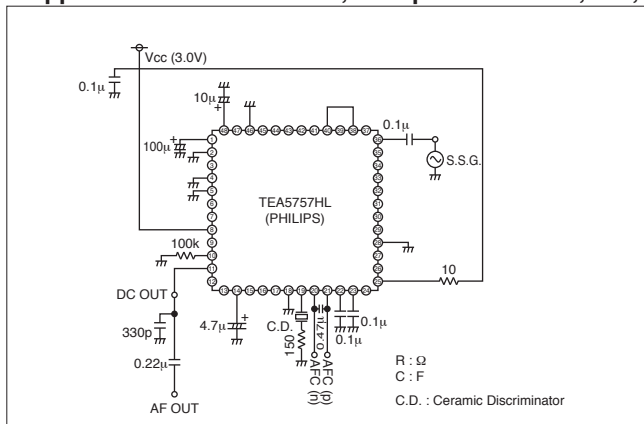
Fig. 8-5 Coupling with MIX stage

# 9 Ceramic Discriminator Application

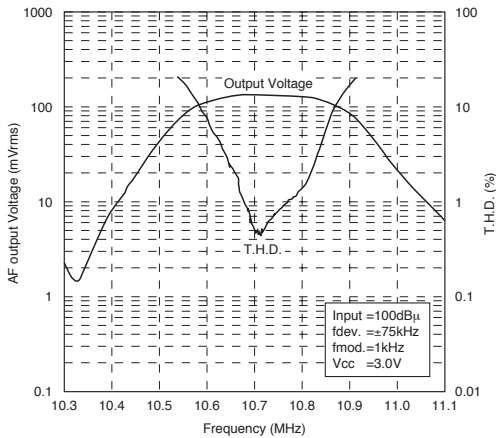
In this chapter, we will illustrate four applied circuits using our ceramic discriminator and their characteristic data. They will be useful as circuits in small radios, VICS, RKE and so forth. The advantage to this is that adjustment is not required in the IF stage, including the detection stage. Our Murata's Product Manager will be happy to recommend the appropriate ceramic discriminator for use with your chosen IC.

## ■CDSCB10M7GA105A-R0

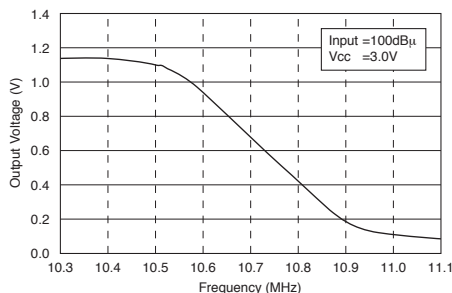
Applications : Small Radios, Headphone Stereos, etc.,



TEA5757HL Type IC Test Circuit



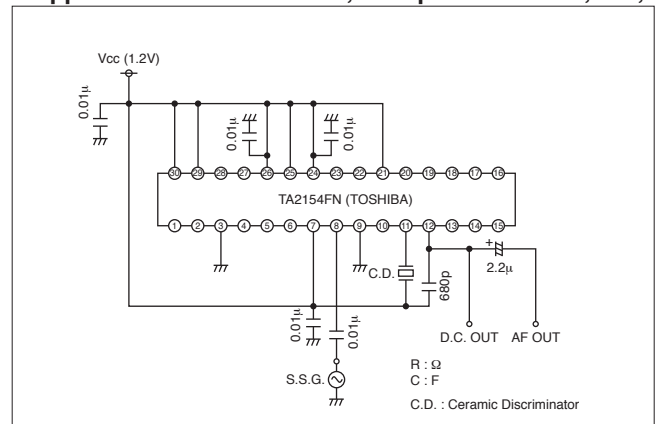
Recovered Audio Frequency Voltage & Total Harmonic Distortion vs. IF Input Frequency



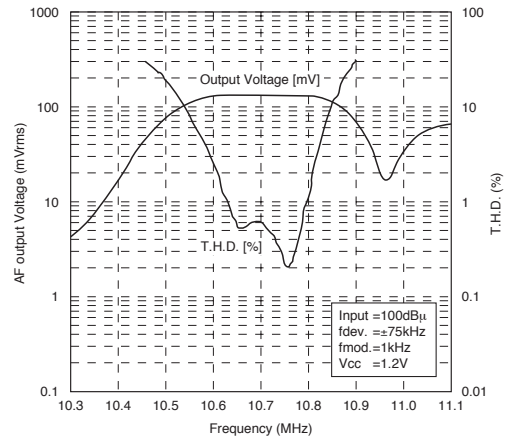
Output D.C. Voltage vs. IF Input Frequency

## ■CDSCB10M7GA113-R0

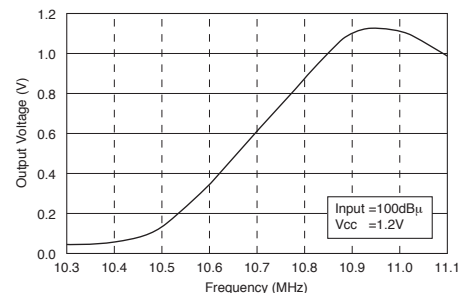
Applications : Small Radios, Headphone Stereos, etc.,



TA2154FN Type IC Test Circuit



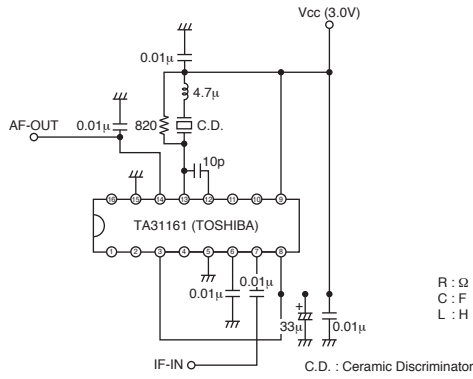
Recovered Audio Frequency Voltage & Total Harmonic Distortion vs. IF Input Frequency



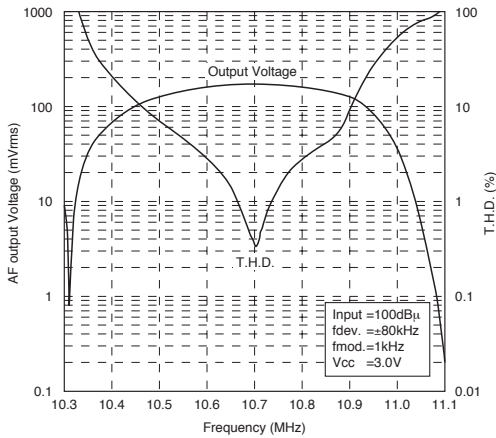
Output D.C. Voltage vs. IF Input Frequency

# Ceramic Discriminator Application **9**

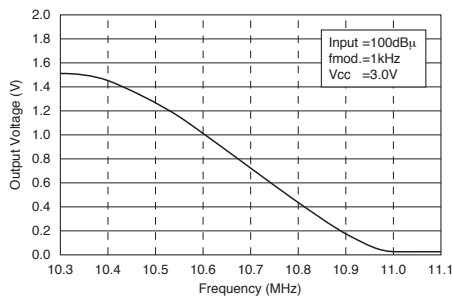
## ■CDSCB10M7GF072-R0 Applications : VICS, etc.,



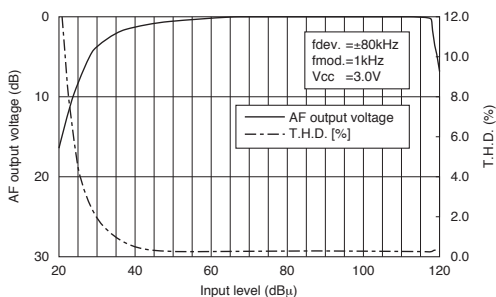
TA31161 Type IC Test Circuit



Recovered Audio Frequency Voltage & Total Harmonic Distortion vs. IF Input Frequency

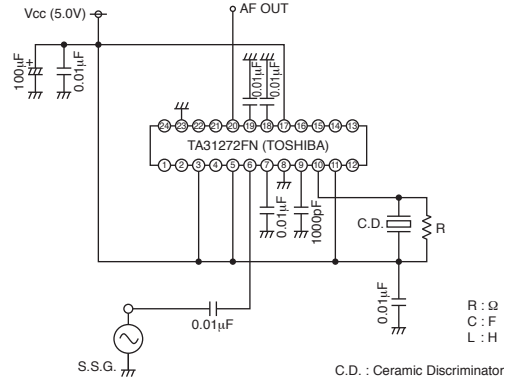


Output DC Voltage vs. IF Input Frequency

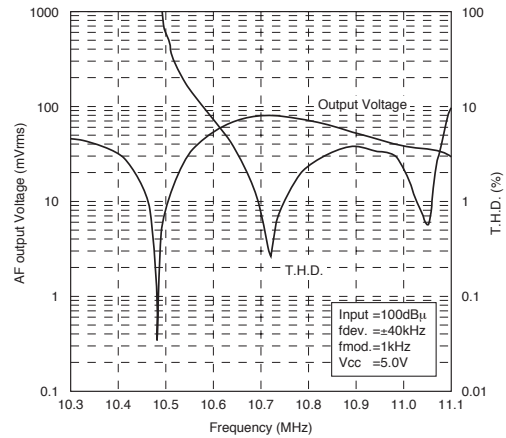


AF Output Voltage & T.H.D. vs. Input Level

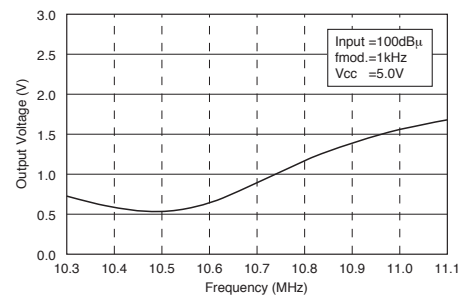
## ■CDSCB10M7GF107-R0 Applications : RKE, TPMS, etc.,



TA31272FN Type IC Test Circuit



Recovered Audio Frequency Voltage & Total Harmonic Distortion vs. IF Input Frequency



Output D.C. Voltage vs. IF Input Frequency

# 10 Appendix

## 1. Correct Use of Ceramic Discriminator

Accurate circuit values are required to obtain specified electrical characteristic. In the case of input/output impedance mismatching or application to unsuitable IC, it may cause characteristic shift. To determine the appropriate ceramic discriminator and circuit condition for your specific application, we recommend you contact a Murata product specialist to help develop the circuit design.

## 2. Applied IC Reference Table for Ceramic Discriminator

Example : **CDSCB 10M7 GA 027 - R0**

①      ②      ③      ④      ⑤

① Product ID

CDSCB : SMD Type  
 CDALF : Lead Type

② Nominal Center Frequency

10M7 : 10.7 MHz

③ Type and Frequency Rank Code

④ Applied IC Code

ex.) 027 : CXA1238 (SONY)  
 100 : TA2149N (TOSHIBA)

\*Please see the following table for reference applied IC.  
 If you cannot find the IC part number you seek, please contact our sales representative.

⑤ Packaging

Code	Packaging
-B0	Bulk
-A0	Radial Taping H0=18 mm
-R0	Embossed Taping φ=180 mm

Radial taping is applied to lead type and embossed taping to chip type.

IC Manufacturer	IC Part Number	④ Suffix Number
ATMEL	U4313B	081
	U4490B	034V
Infineon	TDA1576T	051
	TDA6160X	038
Panasonic	AN7004	011
	AN7232	053
Freescale	MC13156	049
	MC13158	073
Renesas	μPC1391M	056
NXP	NE604	020
	SA605	042
	SA626	047
	SA636DK	096
	SA639	085
	TDA1596T	120
	TEA5710	040
	TEA5757HL	105A
	TEA5762 / 5757	061
	UAA3220TS	098
ROHM	BA1448	060
	BA4230AF	005
	BA4234L	004
SAMSUNG	S1A0903	118A
SANYO	LA1225M	108A
	LA1814M	115
	LA1823	101
	LA1827M	083
	LA1831	043
	LA1832/M	046
	LA1833	086
	LA1835/M	048
	LA1838/M	079
	LA7770	023
	LV23000M	114
	LV23100V	121

IC Manufacturer	IC Part Number	④ Suffix Number
SONY	CX1691M	078
	CX-20029	001
	CXA1111	093
	CXA1238	027
	CXA1238N	027N
	CXA1343M	032
	CXA1376AM	054
	CXA1538M/N/S	069
	CXA1611	075
	CXA3067M	076
T.I.	TRF6901	119
TOKO	TK14570L	122
	TK14583V	112
	TK14588V	109
TOSHIBA	TA2003	031
	TA2007N	033
	TA2008A/AN	045
	TA2022	050
	TA2057	057
	TA2099N	082
	TA2104AFN	080
	TA2104F	080A
	TA2111N/F/FN	077
	TA2132	092
	TA2132BP	092D
	TA2142FN	102
	TA2149AN	100A
	TA2149N	100
	TA2154FN	113
	TA2159F	116
	TA31161	072
	TA31272F	107
	TA7303P	008
	TA7640AP	006
TA8122AN/AF	016	
TA8132AN/AF	018	



# 10 Appendix

## Intermediate Frequency of Television System Worldwide

Area / Country		Frequency [MHz]						System
		AP	S	C	P	AS	P-S	
Asia	Japan	52.75	54.25	55.17	58.75	60.25	4.5	NTSC
	Korea	39.75	41.25	42.17	45.75	47.25	4.5	NTSC
	Taiwan	39.75	41.25	42.17	45.75	47.25	4.5	NTSC
	Hong Kong	31.50	33.50	35.07	39.50	41.50	6.0	PAL
	China	30.00	31.50	33.57	38.00	39.50	6.5	PAL
	India	31.50	33.50	35.07	39.50	41.50	6.0	PAL
ASEAN	Philippine	39.75	41.25	42.17	45.75	47.25	4.5	NTSC
	Malaysia	31.50	33.50	35.07	39.50	41.50	6.0	PAL
North and South America	Canada	39.75	41.25	42.17	45.75	47.25	4.5	NTSC
	U.S.A.	39.75	41.25	42.17	45.75	47.25	4.5	NTSC
	Mexico	39.75	41.25	42.17	45.75	47.25	4.5	NTSC
	Brazil	39.75	41.25	42.17	45.75	47.25	4.5	PAL
Europe	Germany	31.90	33.40	34.47	38.90	40.40	5.5	PAL
	U.K.	31.50	33.50	35.07	39.50	41.50	6.0	PAL
	France	40.70	39.20	37.10	32.70	31.20	6.5	SECAM
	Russia	30.00	31.50	35.57	38.00	39.50	6.5	SECAM
Other Area	Australia	29.875	31.375	37.445	36.875	38.375	5.5	PAL
	New Zealand	31.90	33.40	34.47	38.90	40.40	5.5	PAL
	Nigeria	29.875	33.40	34.47	38.90	40.40	5.5	PAL
	Saudi Arabia	31.90	33.40	34.47	38.90	40.40	5.5	SECAM

### Remarks

P : Picture Signal

C : Chromatic Signal

S : Sound Signal

AP : Adjacent Channel Picture Signal

AS : Adjacent Channel Sound Signal

**⚠Note:**

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No Murata products should be used or sold, through any channels, for use in the design, development, production, utilization, maintenance or operation of, or otherwise contribution to (1) any weapons (Weapons of Mass Destruction [nuclear, chemical or biological weapons or missiles] or conventional weapons) or (2) goods or systems specially designed or intended for military end-use or utilization by military end-users.

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2. Please contact our sales representatives or product engineers before using the products in this catalog for the applications listed below, which require especially high reliability for the prevention of defects which might directly damage a third party's life, body or property, or when one of our products is intended for use in applications other than those specified in this catalog.

- |                             |  |
|-----------------------------|--|
| ① Aircraft equipment        | ② Aerospace equipment  |
| ③ Undersea equipment        | ④ Power plant equipment  |
| ⑤ Medical equipment         | ⑥ Transportation equipment (vehicles, trains, ships, etc.)   |
| ⑦ Traffic signal equipment  | ⑧ Disaster prevention / crime prevention equipment   |
| ⑨ Data-processing equipment | ⑩ Application of similar complexity and/or reliability requirements to the applications listed above |

3. Product specifications in this catalog are as of November 2010. They are subject to change or our products in it may be discontinued without advance notice. Please check with our sales representatives or product engineers before ordering. If there are any questions, please contact our sales representatives or product engineers.

4. Please read rating and ⚠CAUTION (for storage, operating, rating, soldering, mounting and handling) in this catalog to prevent smoking and/or burning, etc.

5. This catalog has only typical specifications because there is no space for detailed specifications. Therefore, please review our product specifications or consult the approval sheet for product specifications before ordering.

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**Head Office**

1-10-1, Higashi Kotari, Nagaokakyo-shi, Kyoto 617-8555, Japan  
Phone: 81-75-951-9111

**International Division**

3-29-12, Shibuya, Shibuya-ku, Tokyo 150-0002, Japan  
Phone: 81-3-5469-6123 Fax: 81-3-5469-6155 E-mail: intl@murata.co.jp