CERAMIC RESONATOR (CERALOCK®)

APPLICATION MANUAL

muRata *Innovator in Electronics*

**Murata
Manufacturing Co., Ltd.**

Introduction

CERALOCK® is the trade mark of Murata's ceramic resonators. These components are made of high stability piezoelectric ceramics that function as a mechanical resonator.
This device has been developed to function as a reference signal generator and the frequency is primary adjusted by the size and thickness of the ceramic element.

With the advance of the IC technology, various equipment may be controlled by a single LSI integrated circuit, such as the one-chip microprocessor. CERALOCK® can be used as the timing element in most microprocessor based equipment.

In the future, more and more application will use CERALOCK® because of its high stability non-adjustment performance, miniature size and cost savings. Typical application includes TVs, VCRs, automotive electronic devices, telephones, copiers, cameras, voice synthesizers, communication equipment, remote controls and toys.

This manual describes CERALOCK® and will assist you in applying it effectively.

CONTENTS

1 Characteristics and Types of CERALOCK®

1. General Characteristics of CERALOCK®

Ceramic resonators use the mechanical resonance of piezoelectric ceramics. (Generally, lead zirconium titanate : PZT.)
The oscillation mode varies with resonant frequency. The table on the right shows this relationship.
As a resonator device, quartz crystal is well-known. RC oscillation circuits and LC oscillation circuits are also used to produce electrical resonance. The following are the characteristics of CERALOCK®.
① High stability of oscillation frequency
Oscillation frequency stability is between that of the quartz crystal and LC or RC oscillation circuits. The temperature coefficient of quartz crystal is $10^{-6}/°C$ maximum and approximately 10^{-3} to $10^{-4}/°C$ for LC or RC oscillation circuits. Compared with these, it is $10^{-5}/°C$ at -20 to $+80°C$ for ceramic resonators.
② Small configuration and light weight
The ceramic resonator is half the size of popular quartz crystals.
③ Low price, non-adjustment
CERALOCK® is mass produced, resulting in low cost and high stability.
Unlike RC or LC circuits, ceramic resonators use mechanical resonance. This means it is not basically effected by external circuits or by the fluctuation of the supply voltage.
Highly stable oscillation circuits can therefore be made without the need of adjustment.
The table briefly describes the characteristics of various oscillator elements.

■**Vibration Mode and Frequency Range**

Vibration Mode \ Frequency(Hz)		1k	10k	100k	1M	10M	100M	1G
1 Flexure Vibration		▅	▅					
2 Length-wise Vibration				▅				
3 Area Vibration					▅			
4 Radius Vibration					▅			
5 Thickness Vibration						▅		
6 Trapped Vibration						▅	▅	
7 Surface Acoustic Wave							▅	▅

[Note] : ←—→ show the direction of vibration

■**Characteristics of Various Oscillator Elements**

Name	Symbol	Price	Size	Adjust-ment	Oscillation Frequency Initial Tolerance	Long-term Stability
LC		Inexpen-sive	Big	Required	±2.0%	Fair
CR		Inexpen-sive	Small	Required	±2.0%	Fair
Quartz Crystal		Expen-sive	Big	Not required	±0.001%	Excellent
Ceramic Resonator		Inexpen-sive	Small	Not required	±0.5%	Excellent

2. Types of CERALOCK®

kHz Band CERALOCK® (CSB Series)
The CSB series uses are a vibration mode of the piezoelectric ceramic element. The dimensions of this element vary with frequency. The ceramic element is sealed in a plastic case and the size of the case also varies with the frequency band. Washable products are available in all the frequencies ; However, three standard products (375 to 699kHz) are also made in less expensive non-washable models.

■Part Numbering

(1) CSB Series (Except CSB□J Type)

(Ex.) | CSB | 455 | E | 1 | |
❶ ❷ ❸ ❹ ❺

❶Series CSB : kHz band CERALOCK®
❷Oscillation Frequency
❸Type (indicates vibration mode with different dimensions.)
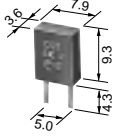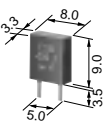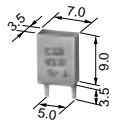❹Custom Specifications
❺Magazine
   CSB : -CA01 (Magazine)

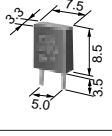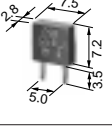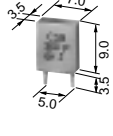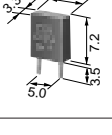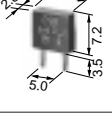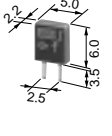## Characteristics and Types of CERALOCK® 1

(2) CSB☐J Type

(Ex.) | CSB | 1000 | J(R) | 1 | 00 | ☐ | ☐ |
| ❶ | ❷ | ❸ | ❹ | ❺ | ❻ | ❼ |

❶Series CSB : kHz band CERALOCK®
❷Oscillation Frequency
❸Type (indicates vibration mode with different dimensions.)
❹Frequency Tolerance
  0 : ±0.5%, 1 : ±0.3%, 2 : ±0.2%, 5 : ±2kHz,
  6 : ±1kHz, 7 : ±0.7%, 8 : ±1.0%, 9 : others
❺Individual Specifications (for different ICs, reliability, etc.)
❻Terminal Shapes, etc.
❼Magazine
  CSB : -CA01 (Magazine)
• When ❹ and ❺ are "000", omit these numbers in case of standard products.

■**Part Numbers and Dimensions of kHz Band CERALOCK® (CSB Series) (Standard Products)**

Washable			Non-Washable			
Part Number	Frequency (kHz)	Dimensions (in mm)	Part Number	Frequency (kHz)	Ultrasonic-Wash	Dimensions (in mm)
CSB☐P	375–429		CSB☐J	375–429	APPLICABLE*	
CSB☐E	430–509		CSB☐J	430–519	APPLICABLE*	
			CSB☐J	520–575	APPLICABLE*	
CSB☐P	510–699		CSB☐JR	576–655	APPLICABLE*	
			CSB☐J	656–699	APPLICABLE*	
———	———	———	CSB☐J	700–1250	APPLICABLE*	

∗Please consult Murata regarding ultrasonic cleaning conditions to avoid possible damage during ultrasonic cleaning.

1 **Characteristics and Types of CERALOCK®**

1

MHz Band CERALOCK® (CSA Series)

Because CSA series uses the thickness vibration mode of piezoelectric ceramic element, there is little difference of dimensions over the whole frequency band.
This type, by being completely dipped in epoxy resin, is washable.
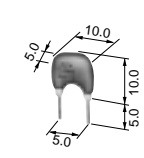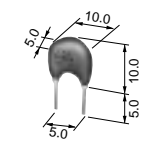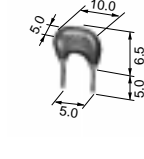
■Part Numbering

(Ex.) | CSA | 33.86 | MXZ | 1 | 40 | | |
❶ ❷ ❸ ❹ ❺ ❻ ❼

❶Series
   CSA : MHz band CERALOCK®
❷Oscillation Frequency
❸Type (indicates vibration mode with different dimensions.)
   MTZ : Thickness longitudinal vibration
   MXZ : Thickness longitudinal vibration
                      (3rd Overtone)
❹Frequency Tolerance
   0 : ±0.5%, 1 : ±0.3%, 2 : ±0.2%,
   7 : ±0.7%, 8 : ±1.0%, 9 : others
❺Individual Specifications (for different ICs, reliability, etc.)
❻Terminal Shapes, etc.
❼Taping
   CSA Series :
   -TF01 (Radial taping in flat package (standard))
   -TR01 (Radial taping on reel package)
 • When ❹ and ❺ are "000", omit these numbers in case of standard products.

■Part Numbers and Dimensions of MHz Band
  CERALOCK® (CSA Series)

Part Number	Frequency (MHz)	Dimensions (in mm)
CSA☐MTZ	10.01–13.00	
CSA☐MXZ	13.01–32.99	
CSA☐MXZ	33.00–60.00	

4

Characteristics and Types of CERALOCK® **1**

■**Specifications of Taped Products of MHz Band CERALOCK® (CSA Series)**
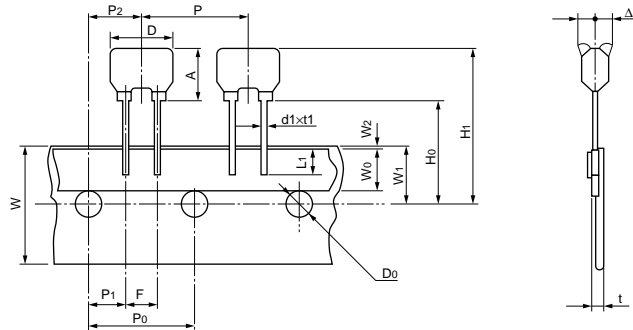
(in mm)

Item	Code	CSA☐MTZ/MXZ-TR01/TF01 Nominal Value	Allowable Value	CSA☐MTZ/MXZ-TR/TF Nominal Value	Allowable Value
Width of Diameter	D	10.0max.	–	10.0max.	–
Height of Resonator	A	10.0max.	–	10.0max.	–
Dimension of Terminal	$d_1 \times t_1$	0.5×0.4	±0.1	0.5×0.4	±0.1
Adhered Terminal Shape	L_1	3.0min.	–	3.0min.	–
Taping Pitch	P	12.7	±0.5	12.7	±0.5
Guide Pitch	P_0	12.7	±0.2	12.7	±0.2
Feed Hole Position to Resonator Terminal	P_1	3.85	±0.5	3.85	±0.5
Feed Hole Position to Resonator Body	P_2	6.35	±0.5	6.35	±0.5
Terminal Spacing	F	5.0	+0.5 −0.2	5.0	+0.5 −0.2
Deviation across Tape	Δh	0	±1.0	0	±1.0
Width of Base Tape	W	18.0	±0.5	18.0	±0.5
Width of Adhesive Tape	W_0	6.0min.	–	6.0min.	–
Half of Base Tape Width	W_1	9.0	±0.5	9.0	±0.5
Margin between Both Tape	W_2	0	+0.5 −0	0	+0.5 −0
Height of Terminal Stopper	H_0	18.0	±0.5	16.0	±0.5
Total Height of Resonator	H_1	28.5max.	–	26.5max.	–
Diameter of Feed Hole	D_0	ϕ4.0	±0.2	ϕ4.0	±0.2
Total Thickness of Tape	t	0.6	±0.2	0.6	±0.2

• The difference between -TR and -TR01 (-TF and -TF01) is only dimension of H_0 (16mm or 18mm).
• -TF01 is standard.
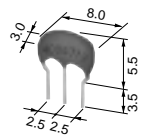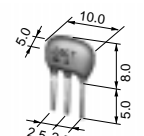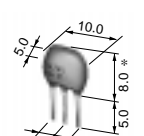• CST series is also available on tape.

1 Characteristics and Types of CERALOCK®

1

CERALOCK® with Built-in Load Capacitance (CST/CSTS Series)

As CST/CSTS series does not require externally mounted capacitors, the number of components can be reduced, allowing circuits to be made more compact. The table shows the frequency range and appearance of the 3-terminal CERALOCK® with built-in load capacitance.

■Part Numbering

(1) CST Series

(Ex.) | CST | 33.86 | MXW | 1 | 40 | | |
❶ ❷ ❸ ❹ ❺ ❻ ❼

❶Series
   CST : MHz band CERALOCK® with
         built-in load capacitance
❷Oscillation Frequency
❸Type (indicates vibration mode)
   MG : Thickness shear vibration
   MTW : Thickness longitudinal vibration
   MXW : Thickness longitudinal vibration
                        (3rd Overtone)
❹Frequency Tolerance
   0 : ±0.5%, 1 : ±0.3%, 2 : ±0.2%,
   7 : ±0.7%, 8 : ±1.0%, 9 : others
❺Individual Specifications (for different ICs, reliability, etc.)
❻Terminal Shapes, etc.
❼Taping
   CST Series :
   -TF01 (Radial taping in flat package (standard))
   -TR01 (Radial taping on reel package)
• When ❹ and ❺ are "000", omit these numbers in case of standard products.

(2) CSTS Series

(Ex.) | CSTS | 0400 | MG | 0 | 3 | | | |
❶ ❷ ❸ ❹ ❺ ❻ ❼ ❽

❶Series
   CSTS : MHz band CERALOCK® with
           built-in load capacitance and round terminals.
❷Oscillation Frequency
❸Type (indicates vibration mode)
   MG : Thickness shear vibration
❹Frequency Tolerance
   0 : ±0.5%, 1 : ±0.3%, 2 : ±0.2%,
   7 : ±0.7%, 8 : ±1.0%, 9 : others
❺Built-in Load Capacitance Value
   3 : 15pF, 6 : 47pF
❻Individual Specification (for different ICs, reliability, etc.)
❼Terminal Shapes, etc.
❽Taping
   -T2 (Radial taping in flat package (standard))
• When ❹, ❺and ❻ are "000", omit these numbers in case of standard products.

■Part Numbers and Dimensions of CERALOCK® with Built-in Load Capacitance (CST/CSTS Series)

Part Number	Frequency	Dimensions (in mm)
CSTS☐☐MG	2.00–10.00MHz	
CST☐☐MTW	10.01–13.0MHz	
CST☐☐MXW	13.01–60.00MHz	

∗13.01–14.99MHz : 9.0, 33.00–60.00MHz : 7.0

6

1

Reflow Solderable kHz Band CERALOCK® (CSBF Series)
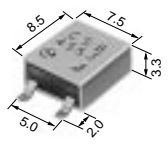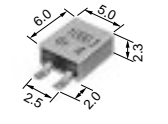
Reflow solderable kHz band CERALOCK® (CSBF series) have been developed to meet down sizing and S.M.T. (Surface Mount Technology) requirements.

■Part Numbering

(Ex.) | CSBF | 500 | J | 1 | 00 | | |
❶ ❷ ❸ ❹ ❺ ❻ ❼
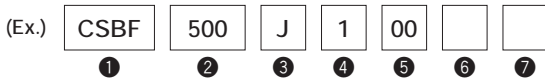
❶Series
   CSBF : kHz band reflow solderable CERALOCK®
❷Oscillation Frequency
❸Type (indicates vibration mode with different dimensions.)
❹Frequency Tolerance
   0 : ±0.5%, 1 : ±0.3%, 2 : ±0.2%, 5 : ±2kHz,
   6 : ±1kHz, 7 : ±0.7%, 8 : ±1.0%, 9 : others
❺Individual Specifications (for different ICs, reliability, etc.)
❻Terminal Shapes, etc.
❼Taping
   CSBF Series : -TC01 (Emboss taping on reel package)
• When ❹ and ❺ are "000", omit these numbers in case of standard products.

■Dimensions of Reflow Solderable CERALOCK® (CSBF Series)

Part Number*1	Frequency (kHz)	Dimensions (in mm)
CSBF☐J	430–519	
CSBF☐J	700–1250*2	

*1 Please consult Murata regarding Ultrasonic cleaning conditions to avoid possible damage during Ultrasonic cleaning.
*2 Not available for certain frequencies.

■Dimensions of Carrier Tape for CSBF Series (430 to 519kHz Type)

• Different Dimensions of carrier tape in 700 to 1250kHz.
(in mm)

1　Characteristics and Types of CERALOCK®

1
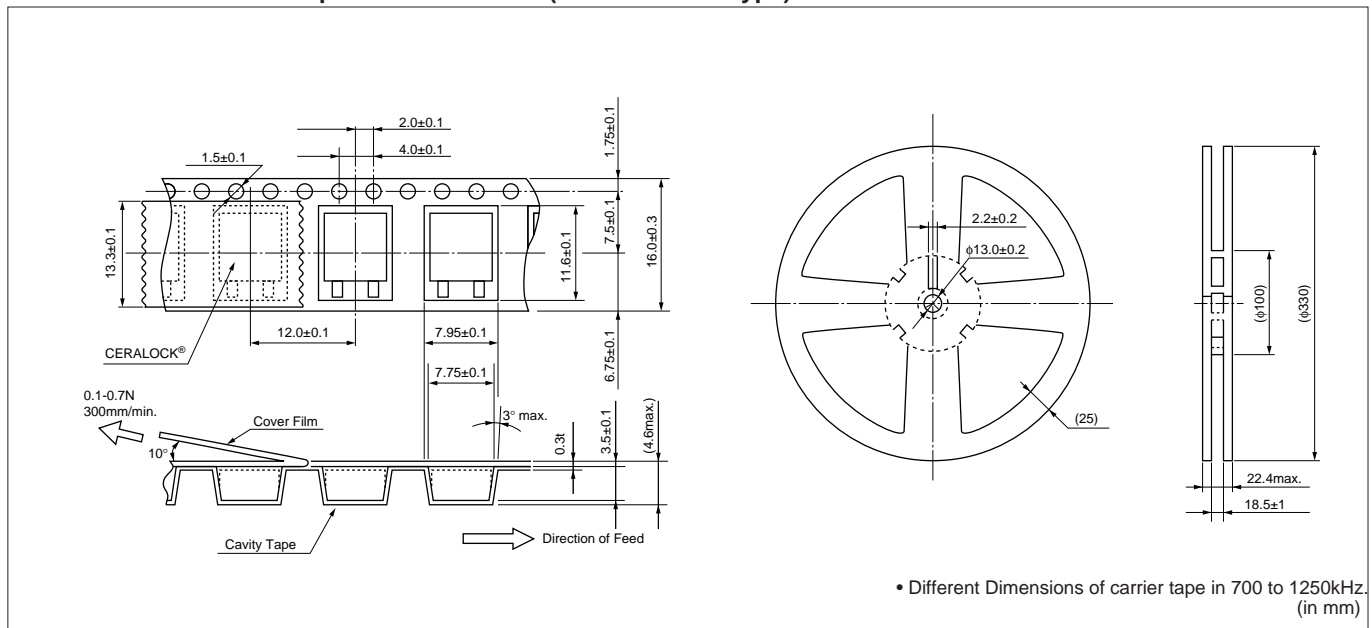
MHz Band Chip CERALOCK®

The MHz band Chip CERALOCK® has a wide frequency range and small footprint to meet further down sizing and high-density mounting requirements.
The table shows the dimensions and two-terminals standard land patterns of the CERALOCK® CSACV/CSACW series.
The second table shows the dimensions and three-terminals standard land patterns of CSTCC/CSTCV/CSTCW series chip resonator (built-in load capacitance type). And the carrier tape dimensions of CSTCC series are shown in next page.

■Part Numbering

(1) CSACV/CSTCC/CSTCV Series

(Ex.) | CSTCC | 4.00 | MG | 1 | 00 | | |
❶ ❷ ❸ ❹ ❺ ❻ ❼

❶Series
　CSACV : MHz band chip CERALOCK®
　CSTCC/CSTCV : MHz band chip CERALOCK®
　　　　　　　　 with built-in load capacitance
❷Oscillation Frequency
❸Type (indicates vibration mode)
　MK : Shear vibration
　MG : Thickness shear vibration
　MTJ : Thickness longitudinal vibration
　MXJ : Thickness longitudinal vibration (3rd Overtone)
❹Frequency Tolerance
　0 : ±0.5%, 1 : ±0.3%, 2 : ±0.2%,
　7 : ±0.7%, 8 : ±1.0%, 9 : others
❺Individual Specifications (for different ICs, reliability, etc.)
❻Terminal Shapes, etc.
❼Taping
　CSTCC : -TC (Emboss taping)
　CSACV/CSTCV : -TC20 (Emboss taping)
• When ❹ and ❺ are "000", omit these numbers in case of standard products.

(2) CSACW/CSTCW Series

(Ex.) | CSTCW | 3386 | MX | 0 | 1 | | | |
❶ ❷ ❸ ❹ ❺ ❻ ❼ ❽

❶Series
　CSACW : MHz band chip CERALOCK®
　CSTCW : MHz band chip CERALOCK®
　　　　　 with built-in load capacitance
❷Oscillation Frequency
❸Type (indicates vibration mode)
　MX : Thickness longitudinal vibration (3rd Overtone)
❹Frequency Tolerance
　0 : ±0.5%, 1 : ±0.3%, 2 : ±0.2%,
　7 : ±0.7%, 8 : ±1.0%, 9 : others
❺Load capacitance value
　(In case of CSTCW, load capacitance is built-in)
❻Individual Specifications (for different ICs, reliability, etc.)
❼Terminal Shapes, etc.
❽Taping
　-T (Emboss taping)
• When ❹, ❺ and ❻ are "000", omit these numbers in case of standard products.

■Dimensions and Standard land Pattern of Chip CERALOCK® (CSAC/CSACV/CSACW Series)

Part Number	Frequency (MHz)	Dimensions Standard Land Pattern (mm)
CSACV☐MTJ	10.01–13.49	
CSACV☐MXJ	13.50–20.00	
CSACW☐MX	20.01–70.00	

∗1 Thickness varies with frequency.

■Dimensions and Standard land Pattern of Chip CERALOCK® (CSTCC/CSTCV/CSTCW Series)

Part Number	Frequency (MHz)	Dimensions Standard Land Pattern (mm)
CSTCC☐MG	2.00–10.00	
CSTCV☐MTJ	10.01–13.49	
CSTCV☐MXJ	13.50–20.00	
CSTCW☐MX*4	20.01–70.00	

*1 Thickness varies with frequency.
*2 Thickness varies with frequency.
*3 The electrode pattern changes according to the built-in capacitance.
*4 Conformal coating or washing to the components is not acceptable.
　Because it is not hermetically sealed.

■Dimensions of Carrier Tape for Chip CERALOCK®

CSTCC Series
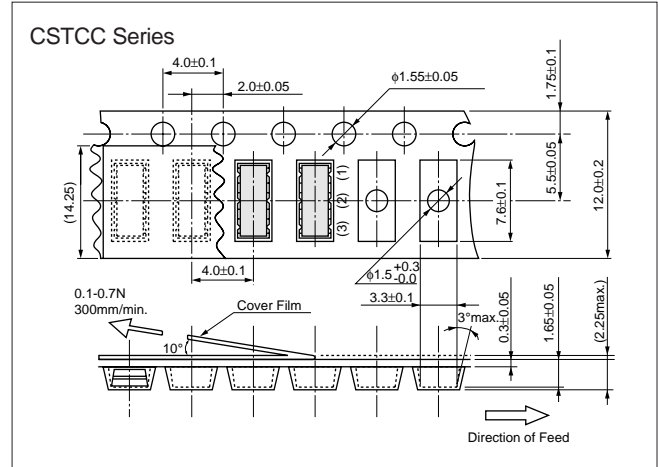
2 **Principles of CERALOCK®**

1. Equivalent Circuit Constants

Fig.2-1 shows the symbol for a ceramic resonator. The impedance and phase characteristics measured between the terminals are shown in Fig.2-2. This illustrates that the resonator becomes inductive in the frequency zone between the frequency Fr (resonant frequency), which provides the minimum impedance, and the frequency Fa (anti-resonant frequency), which provides the maximum impedance.

It becomes capacitive in other frequency zones. This means that the mechanical vibration of a two-terminal resonator can be replaced equivalently with a combination of series and parallel resonant circuits consisting of an inductor : L, a capacitor : C, and a resistor : R. In the vicinity of the specific frequency (Refer to Note 1 on page 12.), the equivalent circuit can be expressed as shown in Fig.2-3.

Fr and Fa frequencies are determined by the piezoelectric ceramic material and the physical parameters. The equivalent circuit constants can be determined from the following formulas. (Refer to Note 2 on page 12.)

$$Fr=1/2\pi \sqrt{L_1C_1} \quad\text{————————(2-1)}$$
$$Fa=1/2\pi \sqrt{L_1C_1C_0/(C_1+C_0)}=Fr \sqrt{1+C_1/C_0} \quad\text{———(2-2)}$$
$$Qm=1/2\pi FrC_1R_1 \quad\text{————————(2-3)}$$
(Qm : Mechanical Q)

Considering the limited frequency range of Fr≦F≦Fa, the impedance is given as Z=Re+jωLe (Le≧0) as shown in Fig.2-4, and CERALOCK® should work as an inductance Le (H) having the loss Re (Ω).

Symbol○

Impedance between Two Terminals Z=R+jx
(R : Real Component, X : Impedance Component)
Phase ϕ =tan⁻¹X/R

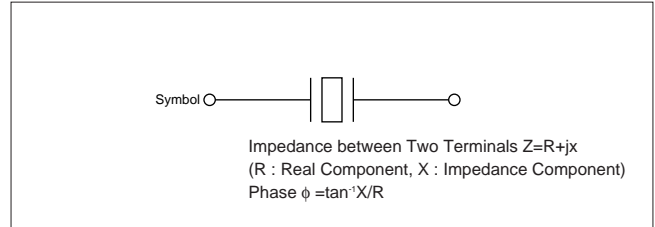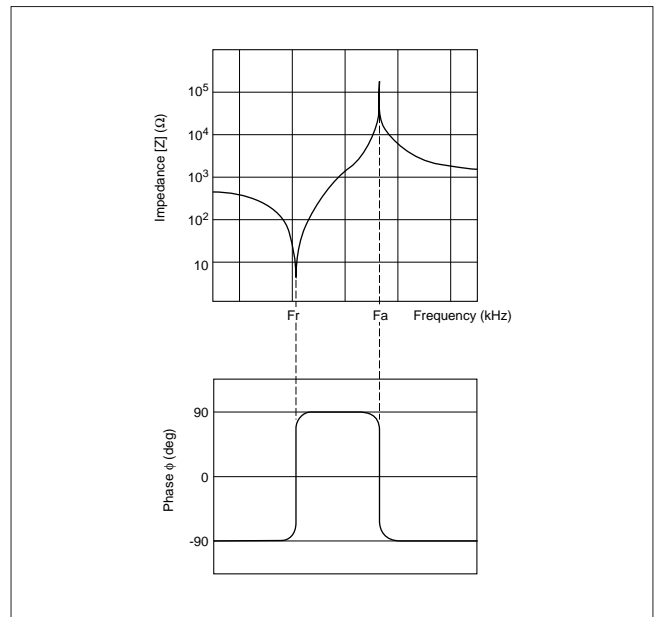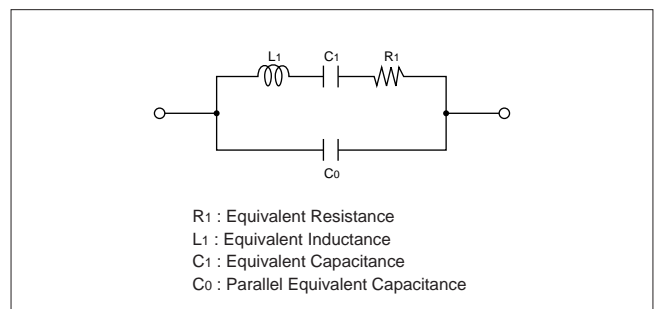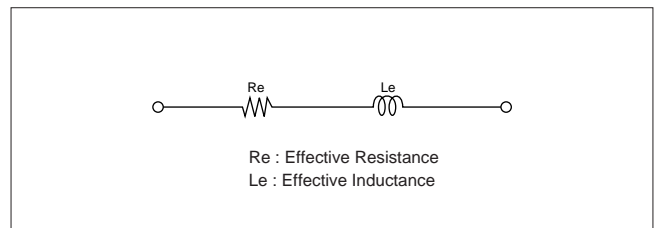Fig.2-1 Symbol of the 2-Terminal CERALOCK®

Fig.2-2 Impedance and Phase Characteristics of CERALOCK®

R₁ : Equivalent Resistance
L₁ : Equivalent Inductance
C₁ : Equivalent Capacitance
C₀ : Parallel Equivalent Capacitance

Fig.2-3 Electrical Equivalent Circuit of CERALOCK®

Re : Effective Resistance
Le : Effective Inductance

Fig.2-4 Equivalent Circuit of CERALOCK®
in the Frequency Band Fr≦F≦Fa

Principles of CERALOCK® 2

The table on this page shows comparison for the equivalent constants between CERALOCK® and quartz crystal oscillator.

In comparison, there is a large difference in capacitance and Qm, which results in the difference of oscillating conditions, when actually operated.

The table in the appendix shows the standard values of equivalent circuit constant for each type of CERALOCK®. Furthermore, other higher harmonic modes exist, other than the desired oscillation mode. These other oscillation modes exist because the ceramic resonator uses mechanical resonance.

Fig.2-5 shows those characteristics.
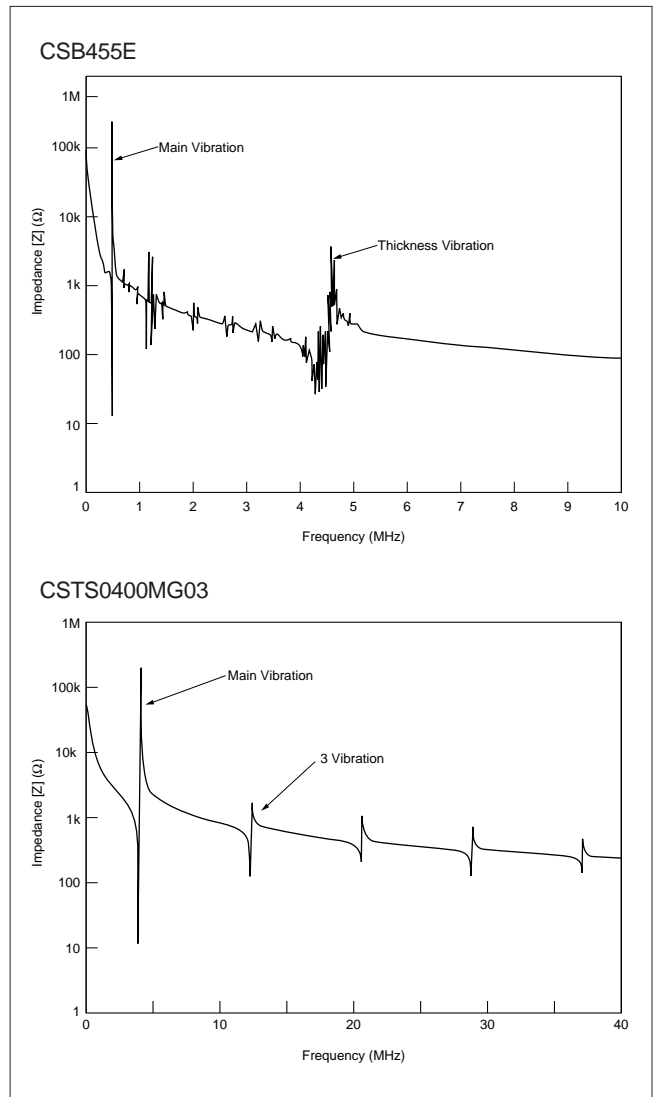
Fig.2-5 Spurious Characteristics of CERALOCK®

■**Comparison of Equivalent Circuits of CERALOCK® and Crystal Oscillator**

Resonator	Oscillation Frequency	L_1 (μH)	C_1 (pF)	C_0 (pF)	R_1 (Ω)	Qm	ΔF (kHz)
CERALOCK®	455kHz	7.68×10^3	16.7	272.8	10.1	2136	13
	2.50MHz	0.8×10^3	5.9	36.8	17.9	643	184
	4.00MHz	0.46×10^3	3.8	19.8	9.0	1220	351
	8.00MHz	0.13×10^3	3.5	19.9	8.0	775	642
Crystal	453.5kHz	8.6×10^6	0.015	5.15	1060	23000	0.6
	2.457MHz	7.2×10^5	0.005	2.39	37.0	298869	3
	4.00MHz	2.1×10^5	0.007	2.39	22.1	240986	6
	8.00MHz	1.4×10^4	0.027	5.57	8.0	88677	19

2 **Principles of CERALOCK**®

Notes

(Note 1)
The relationship between the size of the resonator
and the resonant frequency is described as follows.
For example, the frequency doubles if the thickness
doubles, when thickness vibration is used.
The following relationship is obtained when the
length of the resonators is ℓ , the resonance
frequency is Fr, the speed of sound waves travelling
through piezoelectric ceramics, and the wavelength
is λ.

$$\begin{cases} Fr\cdot \ell = Const. \\ \text{(frequency constant, Fr·t for the thickness)} \\ \lambda = 2\ell \\ C = Fr\cdot\lambda = 2Fr\cdot \ell \end{cases}$$

As seen in the above formula, the frequency
constant determines the size of the resonator.

$\ell = \lambda / 2$

Amplitude
Range of
Standing
Wave

×

(Min.Amplitude) (Max.Amplitude)
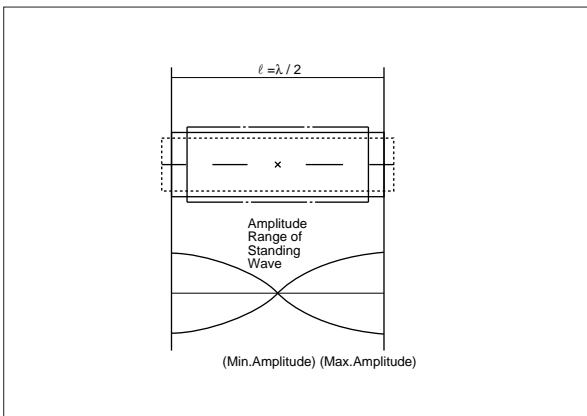
Fig. Ⅰ

(Note 2)
In Fig.2-3, when resistance R_1 is omitted for
simplification, the impedance $Z(\omega)$ between 2
terminals is expressed by the following formula.

$$Z(\omega) = \frac{\dfrac{1}{j\omega C_0}\left(j\omega L_1 + \dfrac{1}{j\omega C_1}\right)}{\dfrac{1}{j\omega C_0} + \left(j\omega L_1 + \dfrac{1}{j\omega C_1}\right)}$$

$$= \frac{j\left(\omega L_1 - \dfrac{1}{\omega C_1}\right)}{1 + \dfrac{C_0}{C_1} - \omega^2\, C_0 L_1}$$

When $\omega = \dfrac{1}{\sqrt{L_1 C_1}} = \omega r$, $Z(\omega r) = 0$

When $\omega = \dfrac{1}{\sqrt{C_0 C_1 L_1/(C_0 + C_1)}} = \omega a$, $Z(\omega a) = \infty$

Therefore from $\omega = 2\pi F$,

$$Fr = \omega r/2\pi = \frac{1}{2\pi\sqrt{L_1 C_1}}$$

$$Fa = \omega a/2\pi = \frac{1}{2\pi\sqrt{C_0 C_1 L_1/(C_0 + C_1)}} = Fr\sqrt{1 + \frac{C_1}{C_0}}$$

L_1 C_1

C_0

Fig. Ⅱ

2. Basic Oscillation Circuits

Generally, basic oscillation circuits can be grouped into the following 3 categories.
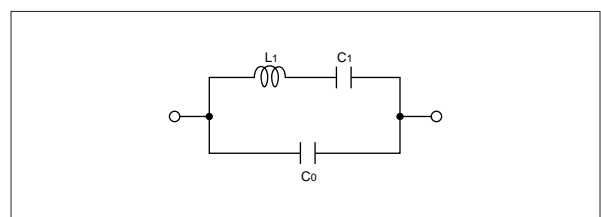① Use of positive Feedback
② Use of negative resistance element
③ Use of delay in transfer time or phase
In the case of ceramic resonators, quarts crystal oscillators, and LC oscillators, positive feedback is the circuit of choice.
Among the positive feedback oscillation circuit using an LC, the tuning type anti-coupling oscillation circuit, Colpitts and Hartley circuits are typically used.
See Fig.2-6.

In Fig.2-6, a transistor, which is the most basic amplifier, is used.
The oscillation frequencies are approximately the same as the resonance frequency of the circuit consisting of L, C_{L1} and C_{L2} in the Colpitts circuit or consisting of L_1 and L_2 in the Hartley circuit. These frequencies can be represented by the following formulas. (Refer to Note 3 on page 15.)

(Colpitts Circuit)

$$\text{fosc.} \fallingdotseq \frac{1}{2\pi \sqrt{L \cdot \dfrac{C_{L1} \cdot C_{L2}}{C_{L1} + C_{L2}}}} \quad\quad\quad (2\text{-}4)$$

(Hartley Circuit)

$$\text{fosc.} \fallingdotseq \frac{1}{2\pi \sqrt{C \, (L_1+L_2)}} \quad\quad\quad (2\text{-}5)$$

In an LC network, the inductor is replaced by a ceramic resonator, taking advantage of the fact that the resonator becomes inductive between resonant and anti-resonant frequencies.
This is most commonly used in the Colpitts circuit.
The operating principle of these oscillation circuits can be seen in Fig.2-7. Oscillation occurs when the following conditions are satisfied.

$$\begin{cases} \text{Loop Gain } G = \alpha \cdot \beta \geqq 1 \\ \text{Phase Amount} \quad\quad\quad\quad\quad\quad (2\text{-}6) \\ \quad\quad \theta = \theta_1 + \theta_2 = 360°\times n \ (n = 1, 2, \cdots) \end{cases}$$

In Colpitts circuit, an inverter of $\theta_1 = 180°$ is used, and it is inverted more than $\theta_2 = 180°$ with L and C in the feedback circuit. The operation with a ceramic resonator can be considered the same.
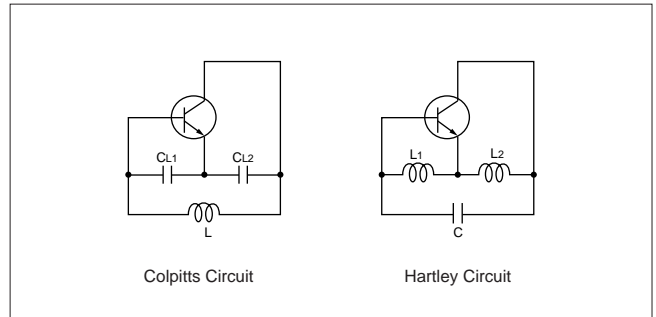

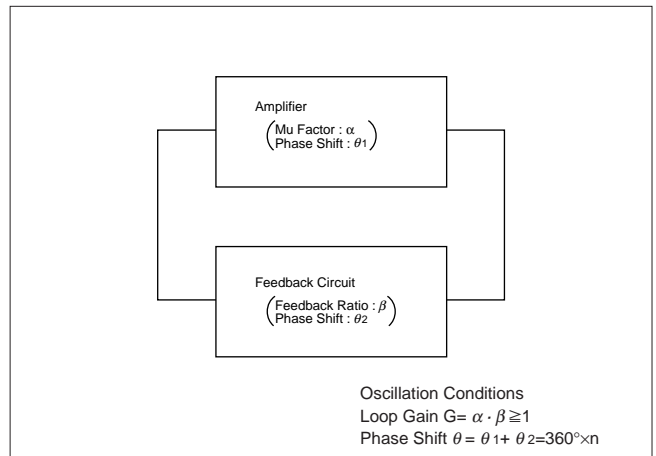Fig.2-6 Basic Configuration of LC Oscillation Circuit

Fig.2-7 Principle of Oscillation

2 **Principles of CERALOCK®**

It is general and simple to utilize inverter for Colpitts circuit with CERALOCK®.

Fig.2-8 shows the basic oscillation circuit with inverter. In open loop circuit by cutting at Ⓐ point, it is possible to measure loop gain G and phase shift θ.

Fig.2-9 shows the actual measuring circuit, and the example of measuring result is shown in Fig.2-10.
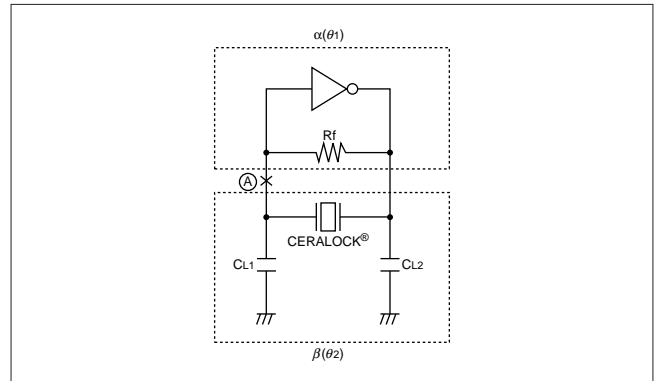
Fig.2-8 Basic Oscillation Circuit with inverters

Loop Gain : $G = \alpha \cdot \beta$
Phase Shift : $\theta_1 + \theta_2$
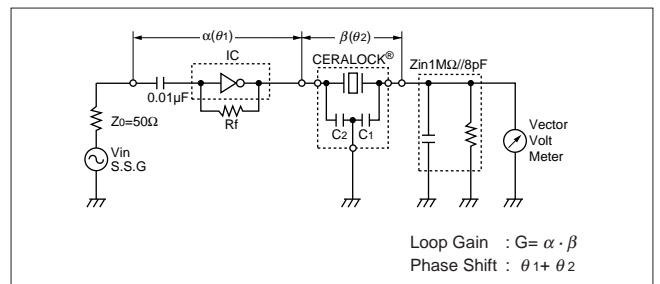
Fig.2-9 Measuring Circuit Network of Loop Gain and Phase Shift

CERALOCK®
CSTS0400MG03
$V_{DD}=+5V$
$C_{L1}=C_{L2}=15pF$
IC : TC4069UBP

CERALOCK®
CSTS0400MG03
$V_{DD}=+2.0V$
$C_{L1}=C_{L2}=15pF$
IC : TC4069UBP

Fig.2-10 Measured Results of Loop Gain and Phase Shift

14

2

Notes

(Note 3)

Fig. Ⅲ shows the equivalent circuit of an emitter grounding type transistor circuit. In the figure, Ri stands for input impedance , R_0 stands for output impedance and β stands for current amplification rate.

When the oscillation circuit in Fig.2-6 is expressed by using the equivalent circuit in Fig. Ⅲ, it becomes like Fig. Ⅳ. Z_1, Z_2 and Z are as shown in the table for each Hartley type and Colpitts type circuit. The following 3 formulas are obtained based on Fig. Ⅳ.

Fig. Ⅲ

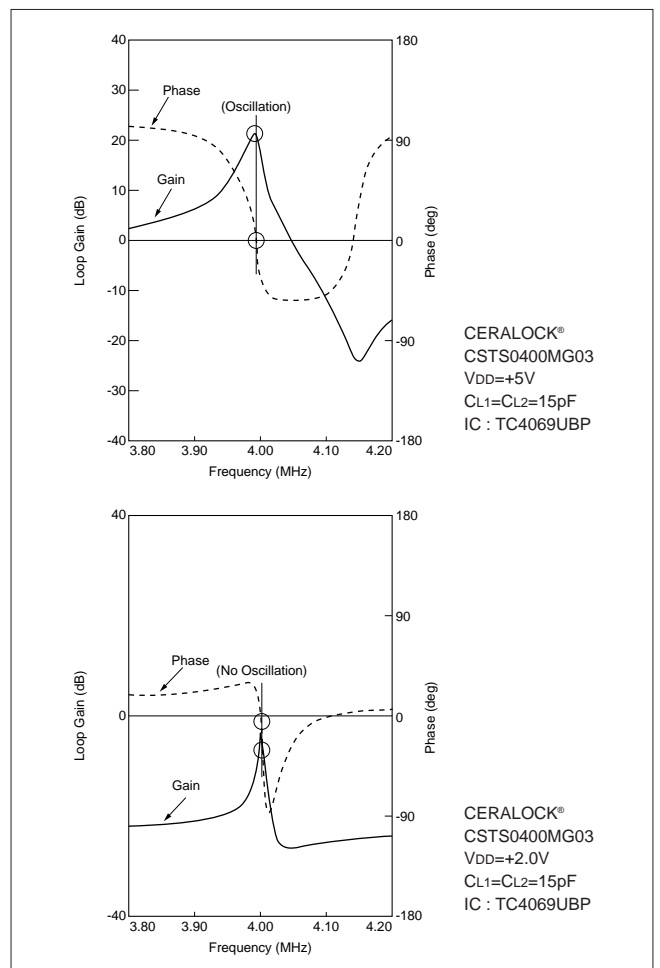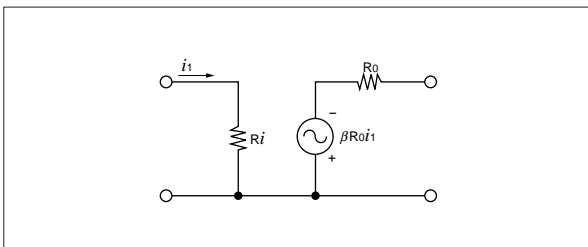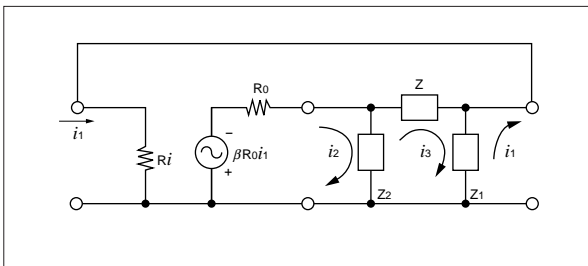|	Hartley Type	Colpitts Type
Z_1	$j\omega L_1$	$1 / j\omega C_{L1}$
Z_2	$j\omega L_2$	$1 / j\omega C_{L2}$
Z	$1 / j\omega C$	$j\omega L$

Fig. Ⅳ Hartley/Colpitts Type LC Oscillation Circuits

$$\begin{cases} \beta R_0 i_1 + (R_0 + Z_2)\, i_2 - Z_2 i_3 = 0 & \cdots\cdots\cdots\cdots(1) \\ Z_1 i_1 + Z_2 i_2 - (Z_2 + Z + Z_1)\, i_3 = 0 & \cdots\cdots\cdots\cdots(2) \\ (Z_1 + Ri)\, i_1 - Z_1 i_3 = 0 & \cdots\cdots\cdots\cdots(3) \end{cases}$$

As $i_1 \neq 0$, $i_2 \neq 0$, $i_3 \neq 0$ are required for continuous oscillation, the following conditional formula can be performed by solving the formulas of (1), (2) and (3) on the current.

$$\begin{cases} \beta R_0 Z_1 Z_2 = (Z_1 + Ri)Z_2^2 - \{Z_1(Z_2 + Z) + \\ \qquad (Z_2 + Z + Z_1)Ri\}(Z_2 + R_0) & \cdots\cdots\cdots\cdots(4) \end{cases}$$

Then, as Z_1, Z_2 and Z are all imaginary numbers, the following conditional formula is obtained by dividing the formula (4) into the real number part and the imaginary number part.

$$\begin{cases} \text{(Imaginary number part)} \\ \quad Z_1 Z_2 Z + (Z_1 + Z_2 + Z)Ri R_0 = 0 & \cdots\cdots\cdots(5) \\ \text{(Real number part)} \\ \quad \beta R_0 Z_1 Z_2 + Z_1(Z + Z_2)R_0 + \\ \quad Z_2(Z + Z_1)Ri = 0 & \cdots\cdots\cdots\cdots(6) \end{cases}$$

Formula (5) represents the phase condition and formula (6) represents the power condition. Oscillation frequency can be obtained by applying the elements shown in the aforementioned table to Z_1 Z_2 and Z solving it for angular frequency ω.

(Hartley Type)

$$\omega^2 osc = (2\pi\, fosc.)^2 = \cfrac{1}{(L_1 L_2)\, C\left\{1 + \cfrac{L_1 \cdot L_2}{(L_1 + L_2)\, CRi R_0}\right\}}$$
$$\cdots\cdots\cdots\cdots(7)$$

(Colpitts Type)

$$\omega^2 osc = (2\pi\, fosc.)^2 = \cfrac{1}{L\cfrac{C_{L1}\cdot C_{L2}}{C_{L1} + C_{L2}}} \cdot \left\{1 + \cfrac{L}{(C_{L1} + C_{L2})\, Ri R_0}\right\}$$
$$\cdots\cdots\cdots\cdots(8)$$

In either circuit, the term in brackets will be 1 as long as Ri and R_0 is large enough. Therefore oscillation frequency can be obtained by the following formula.

(Hartley Type)　$fosc. \fallingdotseq \cfrac{1}{2\pi\,\sqrt{(L_1 + L_2)\, C}}$　$\cdots\cdots(9)$

(Colpitts Type)　$fosc. \fallingdotseq \cfrac{1}{2\pi\,\sqrt{L \cdot \cfrac{C_{L1}\cdot C_{L2}}{C_{L1} + C_{L2}}}}$　$\cdots\cdots(10)$

3 Specifications of CERALOCK®

1. Electrical Specifications

The frequency stability of CERALOCK® is between that of crystal and LC or RC oscillators. Temperature stability is ±0.3 to ±0.5% against initial values within -20 to +80°C. The initial frequency precision is ±0.5% for standard products. The frequency of the standard CERALOCK® is adjusted by the standard measuring circuit, but the oscillation frequency may shift when used in the actual IC circuit. Usually, if the frequency precision needed for clock signal of a 1 chip microcomputer is approximately ±2 to 3% under working conditions, CERALOCK® standard type can be used in most cases. If exact oscillation frequency is required for a special purpose, Murata can manufacture the ceramic resonator for the desired frequency. The following are the general electrical specifications of CERALOCK®. (As for the standard measuring circuit of oscillation frequency, please refer to the next chapter "Application to Typical Oscillation Circuit".)
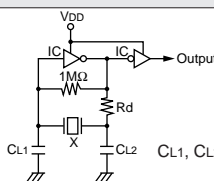
Electrical Specifications of kHz Band CSB Series

Electrical specifications of CSB series are shown in the tables. The value of load capacitance (C_{L1}, C_{L2}) and damping resistance (Rd) depend on the frequency. (The initial frequency tolerance of standard CSB☐J/JR type is ±0.5% max.)

■**Resonant Impedance Specifications of CSB Series**

Frequency Range (kHz)	Resonant Impedance (Ω max.)
375– 450	20
451– 504	30
505– 799	40
800– 899	60
900–1099	100
1100–1250	120

■**Frequency Specifications of CSB Series**

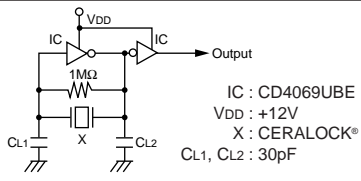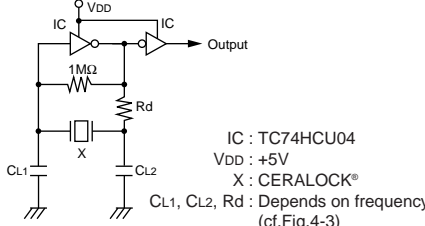| Item / Part Number	Frequency (kHz)	Initial Tolerance of Oscillation Frequency	Temperature Stability of Oscillation Frequency (-20 to +80°C)	Aging (at room temperature 10 years)	Standard Circuit for Oscillation Frequency
CSB Series (with MOS IC)	375–699	±2kHz	±0.3%	±0.3%	IC : CD4069UBE (MOS) : TC74HCU04 (H-CMOS) V_{DD} : +5V X : CERALOCK® C_{L1}, C_{L2}, Rd : Depends on frequency (cf.Fig.4-2,4-3)
CSB☐40 Series (with H-CMOS IC)	700–1250	±0.5%			

Specifications of CERALOCK® **3**

Electrical Specifications of MHz Band CSA/CSTS Series

Electrical specifications of CSA/CSTS series are shown in the tables. Please note that oscillation frequency measuring circuit constants of the CSA□040 series (with H-CMOS IC) depends on frequency.

■Resonant Impedance Specifications of CSA/CSTS Series

Type	Frequency Range (MHz)	Resonant Impedance (Ω max.)
CSTS□MG	2.00— 2.99	100
	3.00— 3.99	50
	4.00— 7.99	30
	8.00—10.00	25
CSA□MTZ	10.01—13.00	25
CSA□MXZ	13.01—60.00	40

3

■Frequency Specifications of CSA Series

Item		Frequency Range (MHz)	Initial Tolerance Of Oscillation Frequency	Temperature Stability of Oscillation Frequency (-20 to +80°C)	Aging (at room temperature 10 years)	Standard Circuit for Oscillation Frequency
with MOS IC	CSA□MTZ	10.01—13.00	±0.5%	±0.5%	±0.5%	IC : CD4069UBE V_{DD} : +12V X : CERALOCK® C_{L1}, C_{L2} : 30pF
with H-CMOS IC	CSA□MTZ040	10.01—13.00	±0.5%	±0.5%	±0.5%	IC : TC74HCU04 V_{DD} : +5V X : CERALOCK® C_{L1}, C_{L2}, Rd : Depends on frequency (cf.Fig.4-3)
	CSA□MXZ040	13.01—60.00		±0.3%	±0.3%	

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3 **Specifications of CERALOCK**®

Electrical Specifications of CST/CSTS Series with Built-in Load Capacitance

MHz band 3-terminal CERALOCK® (CST/CSTS) series
is built-in load capacitance.
Fig3-1 shows the electrical equivalent circuit.
The table shows the general specifications of the CST
and CSTS series. Input and output terminals of the 3-
terminal CERALOCK® are shown in the table titled
Dimensions of CERALOCK® CST/CSTS series in
Chapter 1 on page 6.
But connecting reverse, the oscillating characteristics
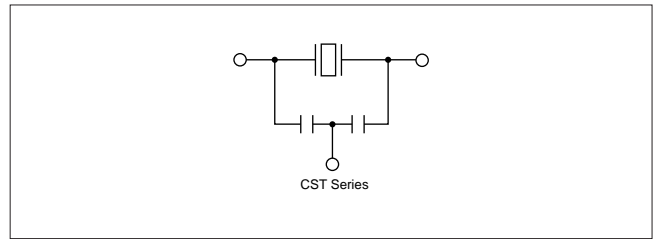are not effected except that the frequency has slight lag.

CST Series

Fig.3-1 Symbol of the 3-terminal CERALOCK®

■General Standard of Specifications of 3-terminal CERALOCK® (CST/CSTS Series)

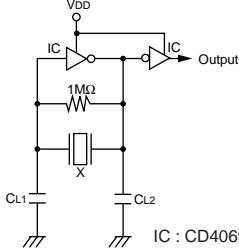| Item / Part Number		Frequency Range (MHz)	Initial Tolerance Of Oscillation Frequency	Temperature Stability of Oscillation Frequency (-20 to +80°C)	Aging (at room temperature 10 years)	Standard Circuit for Oscillation Frequency
CST(S) Series	CSTS☐MG03/06	2.00—10.00	±0.5%	±0.2%*1	±0.2%	
	CST☐MTW	10.01—13.00	±0.5%	±0.4%	±0.3%	
	CST☐MXW040	13.01—60.00	±0.5%	±0.3%	±0.3%	

*1 This value varies for built-in Capacitance
*2 If connected conversely, there may occur a little frequency lag.
*3 MG06/MXW040 series:TC74HCU04, MG03 series:TC4069UBP
*4 This resistance value applies to the CSTS☐MG06 series.

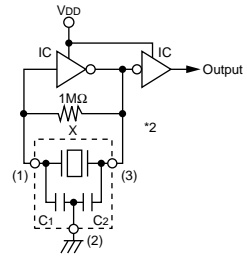## Electrical Specifications of MHz Band Chip CERALOCK® (CSACV/CSACW Series) (CSTCC/CSTCV/CSTCW Series)

General specifications of chip CERALOCK®
(CSACV/CSACW series) (CSTCC/CSTCV/CSTCW
series) are shown in the tables respectively.

■General Specifications of CSACV/CSACW Series

Item / Part Number	Frequency Range (MHz)	Initial Tolerance of Oscillation Frequency	Temperature Stability of Oscillation Frequency (-20 to +80°C)	Aging (at room temperature 10 years)	Standard Circuit for Oscillation Frequency
CSACV□MTJ	10.01—13.49	±0.5%	±0.5%	±0.5%	
CSACV□MXJ040	13.50—15.99	±0.5%	±0.3%	±0.3%	
CSACW□MX03	16.00—24.99	±0.5%	±0.2%	±0.1%	
CSACW□MX01	25.00—70.00	±0.5%	±0.2%	±0.1%	

IC : CD4069UBE*
V_{DD} : +5V(MTJ Type:+12V)
X : Chip CERALOCK®
C_{L1}, C_{L2} : This value varies for frequency.

∗MXJ040/MX03/M01 Series(except 60.01—70.00MHz);TC74HCU04, MX Series(60.01—70.00MHz);SN74AHCU04

■General Specifications of CSTCC/CSTCV/CSTCW Series

Item / Part Number	Frequency Range (MHz)	Initial Tolerance of Oscillation Frequency	Temperature Stability of Oscillation Frequency (-20 to +80°C)	Aging (at room temperature 10 years)	Standard Circuit for Oscillation Frequency
CSTCC□MG	2.00—10.00	±0.5%	±0.3%	±0.3%	
CSTCV□MTJ	10.01—13.49	±0.5%	±0.4%	±0.3%	
CSTCV□MXJ040	13.50—15.99	±0.5%	±0.3%	±0.3%	
CSTCW□MX03	16.00—24.99	±0.5%	±0.2%	±0.1%	
CSTCW□MX01	25.00—70.00	±0.5%	±0.2%	±0.1%	

IC : CD4069UBE*1
V_{DD} : +5V(MTJ Type:+12V)
X : Chip CERALOCK®

∗1 MXJ040/MX03/MX01 Series(except 60.01—70.00MHz);TC74HCU04, MX Series (60.01—70.00MHz);SN74AHCU04
∗2 If connected with wrong direction, above specification may not be guaranteed.

3   Specifications of CERALOCK®

2. Mechanical and Environmental Specifications of CERALOCK®

The tables show the standard test conditions of mechanical strength and environmental specifications of CERALOCK®.
Fig.3-2 shows the changes of oscillation frequency in each test, the table on the next page shows the criteria after the tests, and Fig.3-3 shows the reflow soldering profile.

■Test Conditions for Standard Reliability of CERALOCK®

Item	Conditions
1. Shock Resistance	Measure after dropping from a height of [a] cm to [b] floor surface 3 times.
2. Soldering Heat Resistance	Lead terminals are immersed up to 2.0 mm from the resonator's body in solder bath of [c], and then the resonator shall be measured after being placed in natural condition for 1 hour.[*1] Reflow profile show in Fig.3-5 of heat stress is applied to the resonator, then being placed in natural condition for 1 hour, the resonator shall be measured.[*2]
3. Vibration Resistance	Measure after applying vibration of 10 to 55Hz amplitude of 2 mm to each of 3 directions, X, Y, Z.
4. Humidity Resistance	Keep in a chamber with temperature of [d] and humidity of 90 to 95% for [e] hours. Leave for 1 hour before measurement.
5. Storage at High Temperature	Keep in a chamber at 85±2°C for [e] hours. Leave for 1 hour before measurement.
6. Storage at Low Temperature	Keep in a chamber at [f] °C for [e] hours. Leave for 1 hour before measurement.
7. Temperature Cycling	Keep in a chamber at -55°C for 30 minutes. After leaving at room temperature for 15 minutes, keep in a chamber at +85°C for 30 minutes, and then room temperature for 15 minutes. After 10 cycles of above, measure at room temperature.
8. Terminal Strength	Apply 1 kg of static load vertically to each terminal and measure.[*3]

∗1 applies to CSB series, CSA/CST(S) series. ∗2 applies to CSACV(W) series, CSTCC/CSTCV(W) series.
∗3 applies to CSB series, CSA/CST(S) series.

1. CSB Series

Type	fosc.	a	b	c	d	e	f
J(R)	375—1250kHz	100	concrete	350±10°C	60±2°C	1000	−55±2°C
P, E, F	375— 699kHz	75	concrete	350±10°C	40±2°C	500	−25±2°C

2. CSA/CST(S) Series

Type	fosc.	a	b	c	d	e	f
MG	2.00—10.00MHz	100	concrete	350±10°C	60±2°C	1000	−55±2°C
MTZ/MTW	10.01—13.00MHz	100	concrete	350±10°C	60±2°C	1000	−55±2°C
MXZ/MXW	13.01—60.00MHz	100	concrete	350±10°C	60±2°C	1000	−55±2°C

3. CSACV(W) Series

Type	fosc.	a	b	c	d	e	f
MTJ	10.01—13.49MHz	100	wooden plate	—	60±2°C	1000	−55±2°C
MX(J)	13.50—70.00MHz	100	wooden plate	—	60±2°C	1000	−55±2°C

4. CSTC(C)(V)(W) Series

Type	fosc.	a	b	c	d	e	f
MG	2.00—10.00MHz	100	wooden plate	—	60±2°C	1000	−55±2°C
MTJ	10.01—13.49MHz	100	wooden plate	—	60±2°C	1000	−55±2°C
MX(J)	13.50—70.00MHz	100	wooden plate	—	60±2°C	1000	−55±2°C

Specifications of CERALOCK® **3**

3

1. Shock Resistance
2. Solder Heat Resistance
3. Vibration Resistance
4. Humidity Resistance
5. Storage at High Temperature
6. Storage at Low Temperature
7. Temperature Cycling
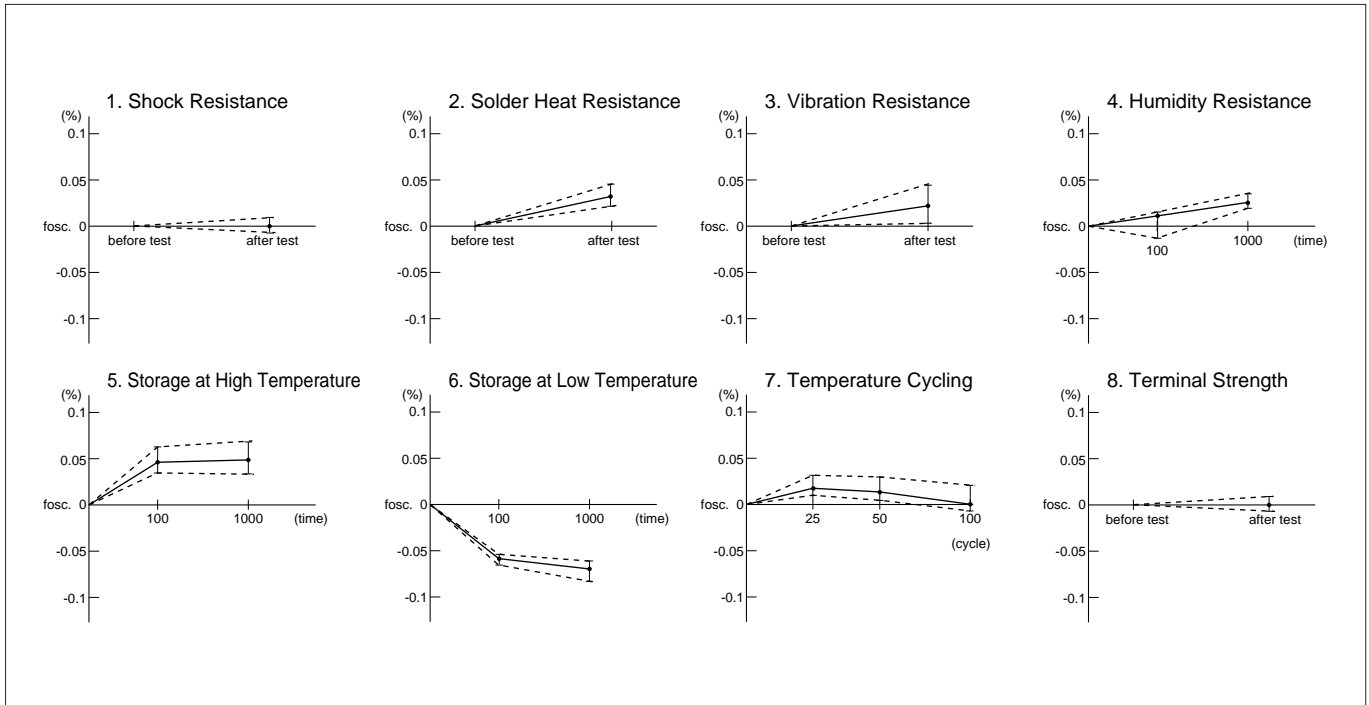### 8. Terminal Strength

Fig.3-2 General Changes of Oscillation Frequency in Each Reliability Test (CSA4.00MG)

■**Deviation after Reliability Test**

Item Type	Oscillation Frequency	Others
CSB Series	within±0.2%(for the initial value)	Meets the individual specification of each product.
CSA(CV)□MT(Z)(J)	within±0.3%(for the initial value)	
CSA(CV)(CW)□MX(Z)(J)	within±0.2%(for the initial value)	
CST(S)(CC)□MG	within±0.2%(for the initial value)	
CST(CV)□MT(W)(J)	within±0.2%(for the initial value)	
CST(CV)(CW)□MX(W)(J)	within±0.2%(for the initial value)	

1. Pre-heating conditions shall be 140 to 160°C for 60 to 120 seconds
Ascending time up to 150°C shall be longer than 30 seconds.
2. Heating conditions shall be within 20 seconds at 230°C min., but peak temperature shall be lower than 240°C.
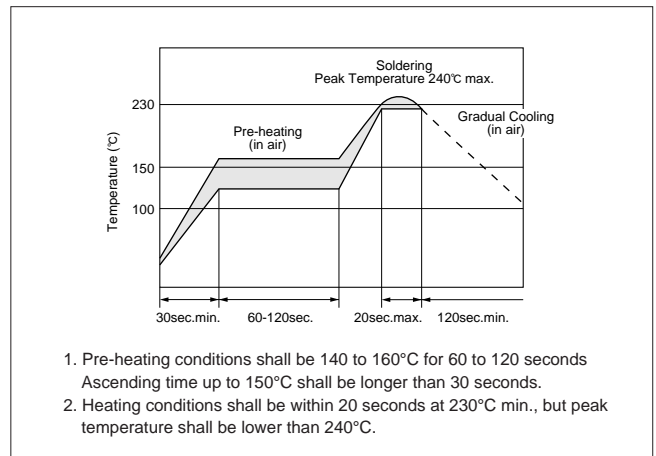
Fig.3-3 Reflow Soldering Profile

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4 Application to Typical Oscillation Circuit

As described in Chapter 2, the most common oscillation circuit with CERALOCK® is to replace L of a Colpitts circuit with CERALOCK®. The design of the circuit varies with the application and the IC being used, etc. Although the basic configuration of the circuit is the same as that of a quartz crystal, the difference in mechanical Q results in the difference of the circuit constant.

This chapter briefly describes the characteristics of the oscillation circuit and gives some typical examples.

1. Cautions for Designing Oscillation Circuits

It is becoming more common to configure the oscillation circuit with a digital IC, and simplest way to use an inverter gate.

Fig.4-1 shows the configuration of a basic oscillation circuit with a C-MOS inverter.

INV. 1 works as an inverter amplifier of the oscillation circuit. INV. 2 acts to shape the waveform and also acts as a buffer for the connection of a frequency counter. The feedback resistance Rf provides negative feedback around the inverter in order to put it in the linear region, so the oscillation will start, when power is applied.

If the value of Rf is too large, and if the insulation resistance of the input inverter is accidentally decreased, oscillation will stop due to the loss of loop gain. Also, if Rf is too great, noise from other circuits can be introduced into the oscillation circuit.

Obviously, if Rf is too small, loop gain will be low. An Rf of 1MΩ is generally used with a ceramic resonator.

Damping resistor Rd provides loose coupling between the inverter and the feedback circuit and decreases the loading on the inverter, thus saving energy.

In addition, the damping resistor stabilizes the phase of the feedback circuit and provides a means of reducing the gain in the high frequency area, thus preventing the possibility of spurious oscillation.

Load capacitance C_{L1} and C_{L2} provide the phase lag of 180°.

The proper selected value depends on the application, the IC used, and the frequency. If C_{L1} and C_{L2} values are too low, the loop gain in the high frequency is increased, which in turn increases the probability of spurious oscillation.

This is particularly likely around 4 to 5 MHz, where the thickness vibration mode lies, as shown in Fig.2-5 when using kHz band resonator.
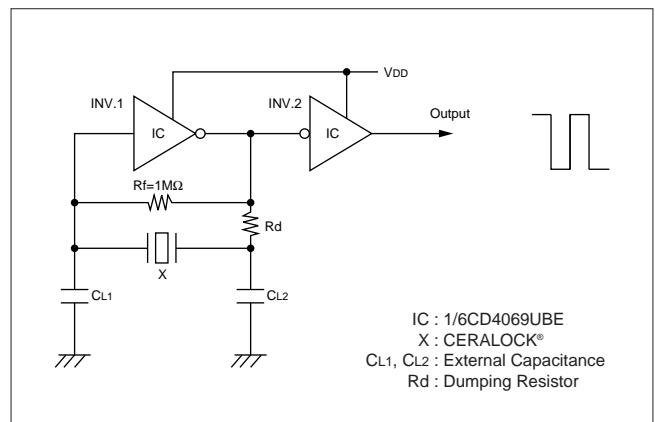

Fig.4-1 Basic Oscillation Circuit with C-MOS Inverter

Oscillation frequency fosc. in this circuit is expressed approximately by the following equation.

$$fosc. = Fr \sqrt{1 + \frac{C_1}{C_0 + C_L}} \qquad\qquad (4\text{-}1)$$

Where, Fr=Resonance frequency of CERALOCK®

C_1 : Equivalent series capacitance of CERALOCK®

C_0 : Equivalent parallel capacitance of CERALOCK®

$$C_L = \frac{C_{L1} \cdot C_{L2}}{C_{L1} + C_{L2}}$$

This clearly shows that the oscillation frequency is influenced by the loading capacitance. And caution should be paid in defining its value when a tight tolerance of oscillation frequency is required.

2. Application to Various Oscillation Circuits

Application to C-MOS Inverter

For the C-MOS inverting amplifier, the one-stage 4069 C-MOS group is best suited.

The C-MOS 4049 type is not used, because the three-stage buffer type has excessive gain, which causes RC oscillation and ringing.

Murata employs the RCA(HARRIS) CD4069UBE as a C-MOS standard circuit. This circuit is shown in Fig.4-2. The oscillation frequency of the standard CERALOCK® (C-MOS specifications) is adjusted by the circuit in Fig.4-2.

CERALOCK®	Frequency Rage	V_{DD}	Circuit Constant			
			C_{L1}	C_{L2}	Rf	Rd
CSB Series	375— 429kHz	+5V	120pF	470pF	1MΩ	0
	430— 699kHz		100pF	100pF	1MΩ	0
	700—1250kHz		100pF	100pF	1MΩ	5.6kΩ
CSTS□MG03	2.00—10.00MHz	+5V	(15pF)	(15pF)	1MΩ	0
CSA□MTZ	6.31—13.00MHz	+12V	30pF	30pF	1MΩ	0

*MG03 series : TC4069UBP
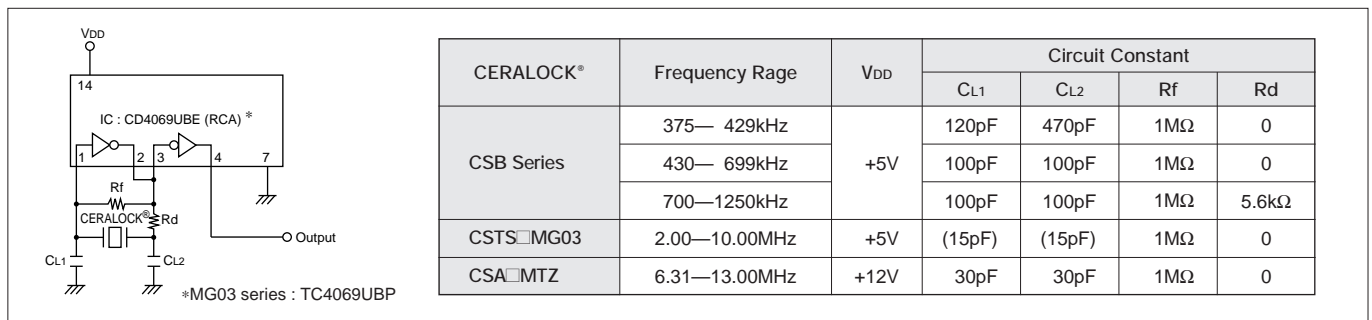
Fig.4-2 C-MOS Standard Circuit

4 Application to Typical Oscillation Circuit

Application to H-MOS Inverter

Recently, high speed C-MOS (H-CMOS) have been used more frequently for oscillation circuit allowing high speed and energy saving control for the microprocessor. There are two types of H-CMOS inverters : the un-buffered 74HCU series and the 74HC series with buffers.

The 74HCU system is optimum for the CERALOCK® oscillation circuit.

Fig.4-3 shows our standard H-CMOS circuit.

Since H-CMOS has high gain, especially in the high frequency area, greater loading capacitor (C_L) and damping resistor (Rd) should be employed to stabilize oscillation performance. As a standard circuit, we recommend Toshiba's TC74CU04, but any 74HCU04 inverter from other manufacturers may be used.

The oscillation frequency of CSA□040 series and CSB□40 series for H-CMOS specifications is adjusted by the circuit in Fig.4-3.
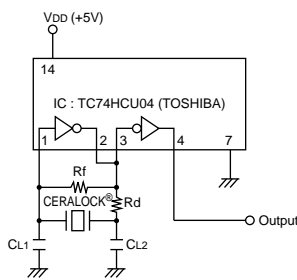
CERALOCK®	Frequency Rage	Circuit Constant			
		C_{L1}	C_{L2}	Rf	Rd
CSB□40	375— 429kHz	330pF	330pF	1MΩ	5.6kΩ
	430— 699kHz	220pF	220pF	1MΩ	5.6kΩ
	700— 999kHz	150pF	150pF	1MΩ	5.6kΩ
	1000—1250kHz	100pF	100pF	1MΩ	5.6kΩ
CSTS□MG06	2.00— 3.39MHz	(47pF)	(47pF)	1MΩ	1.0kΩ
	3.40—10.00MHz	(47pF)	(47pF)	1MΩ	680Ω
CSA□MTZ040	10.01—13.00MHz	100pF	100pF	1MΩ	220Ω
CSA□MXZ040	13.01—19.99MHz	30pF	30pF	1MΩ	0
	20.00—25.99MHz	15pF	15pF	1MΩ	0
	26.00—60.00MHz	5pF	5pF	1MΩ	0

Fig.4-3 H-CMOS Standard Circuit

Application to Typical Oscillation Circuit 4

Application to Transistors and Comparators

Fig.4-4 shows examples of the configuration for a Colpitts type oscillation circuit with a transistor. Load capacitance used is larger than in the case of a MOS inverter.

Fig.4-5 shows an example with a comparator IC. The oscillation circuit is configured by using the invert input side. Loading capacitance and feedback resistance are almost the same as those for a MOS-IC.
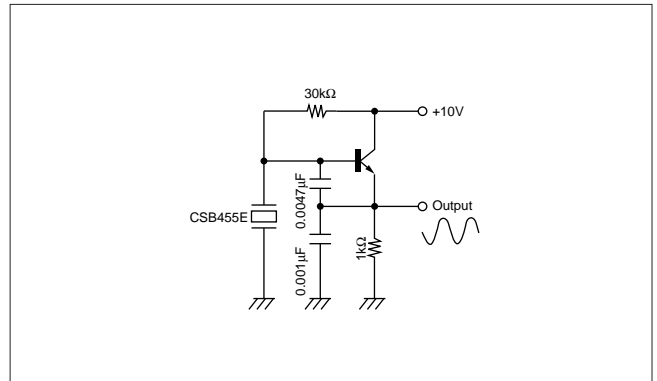
Fig.4-4 Examples Oscillation Circuit with a Transistor

Ex.	CERALOCK®	C_1	C_2
	CSB400P	120pF	120pF
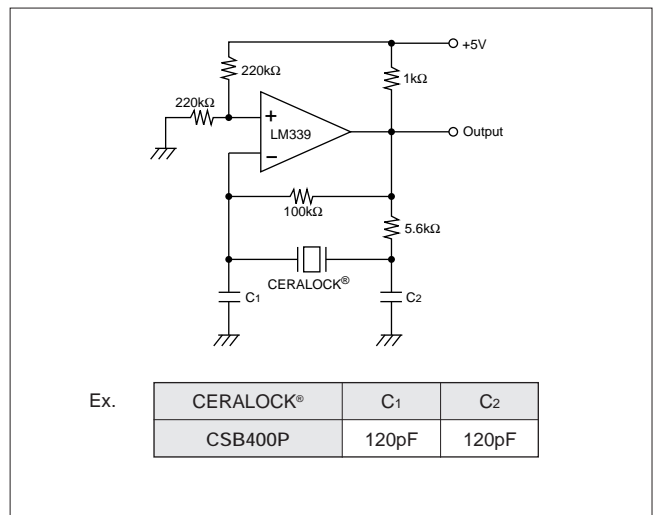
Fig.4-5 Example of Application to a Comparator

5 Characteristics of CERALOCK® Oscillation Circuit

This chapter describes the general characteristics of the basic oscillation of Fig.4-1(P.22). Contact Murata for detailed characteristics of oscillation with specific kinds of ICs and LSIs.

1. Stability of Oscillation Frequency

Fig.5-1 shows examples of actual measurements for stability of the oscillation frequency.
The stability versus temperature change is ±0.1 to 0.5% within a range of -20 to +80°C, although varies slightly depending on the ceramic material.
Influence of load capacitance (C_{L1}, C_{L2}) on the oscillation frequency is relatively high, as seen in formula (4-1) (P.23).
It varies approximately ±0.05% for a capacitance deviation of ±10%. The stability versus supply voltage is normally within ±0.05% in the working voltage range, although it varies with the characteristics of the IC.
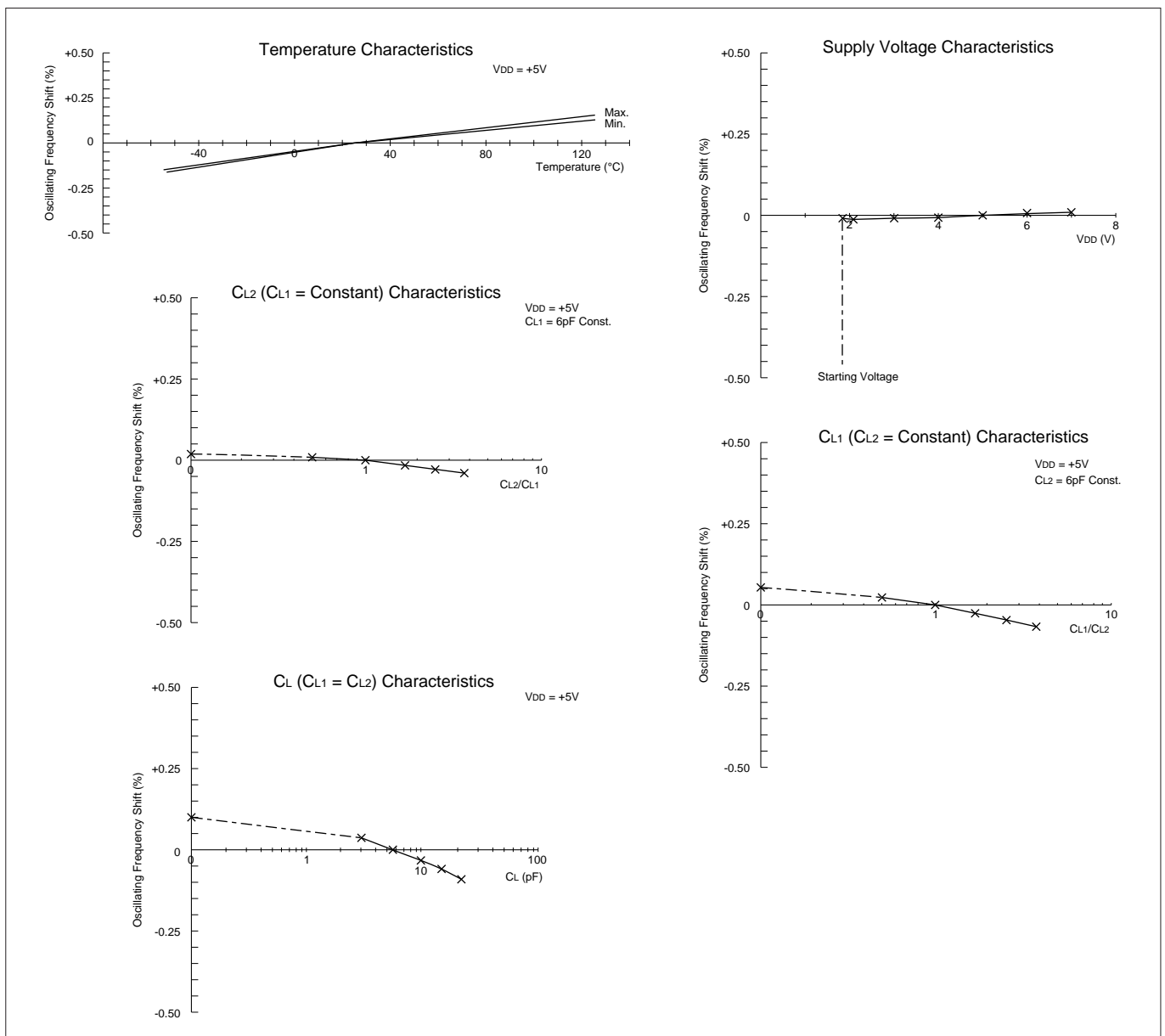
Fig.5-1 Examples of Actual Measurement for the Stability of Oscillation Frequency (IC:TC74HCU04, CERALOCK®:CSACW3386MX01)

Characteristics of CERALOCK® Oscillation Circuit **5**

2. Characteristics of the Oscillation Level

The Fig.5-2 shows examples of actual measurements of the oscillation level versus temperature, supply voltage and load capacitance (C_{L1}, C_{L2}). The oscillating amplitude is required to be stable over a wide temperature range, and temperature characteristics should be as flat as possible. The graph titled Supply Voltage Characteristics in Fig.5-2 shows that the amplitude varies linearly with supply voltage, unless the IC has an internal power supply voltage regulator.
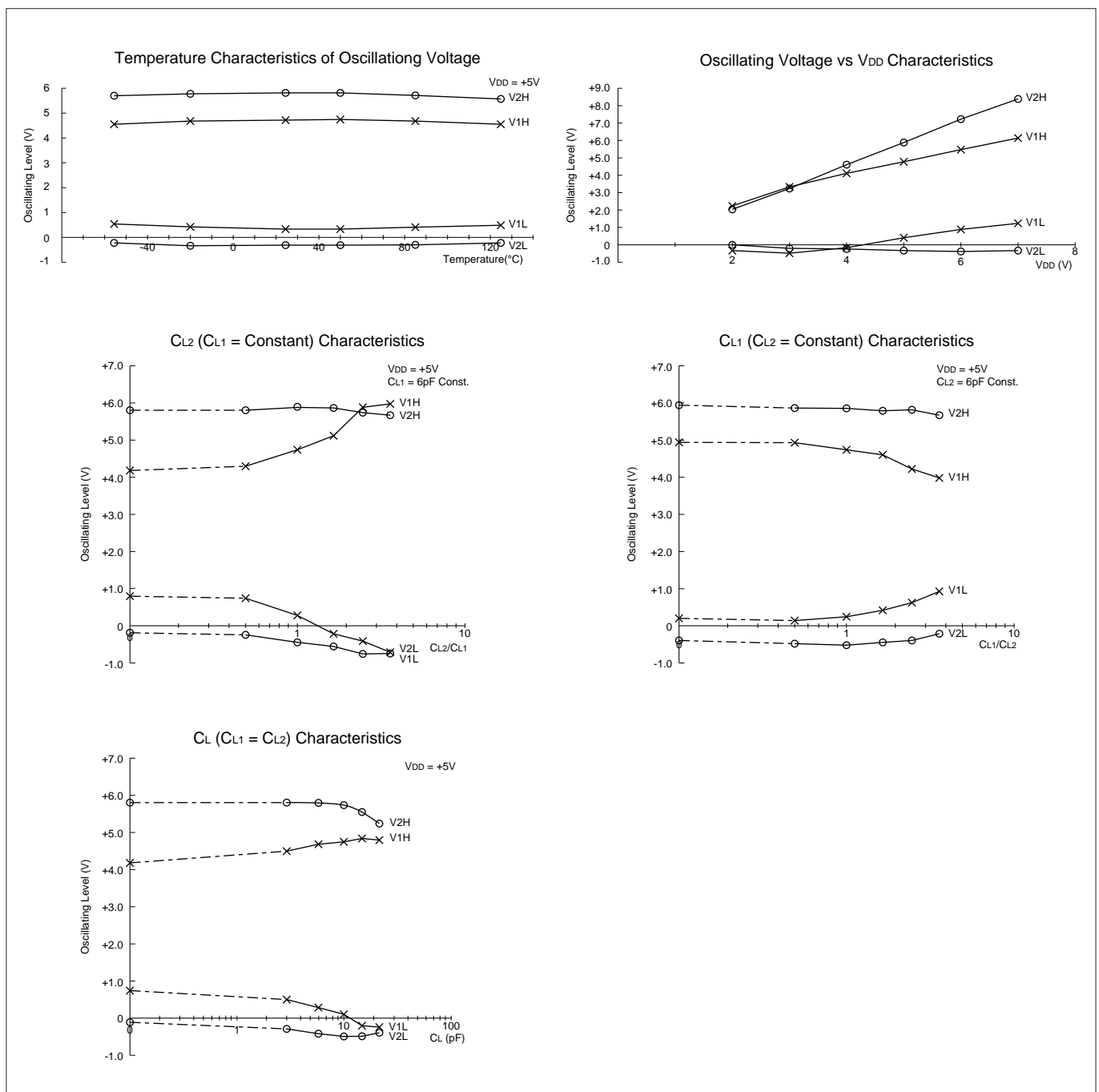
Fig.5-2 Examples of Actual Measurement of Oscillating Amplitude (IC:TC74HCU04, CERALOCK®:CSACW3386MX01)

5 Characteristics of CERALOCK® Oscillation Circuit

3. Characteristics of Oscillation Rise Time

Oscillation rise time means the time when oscillation develops from a transient area to a steady state condition, at the time the power of the IC is activated. With a CERALOCK®, this is defined as the time to reach 90% of the oscillation level under steady state conditions as shown in Fig.5-3.

Rise time is primarily a function of the oscillation circuit design. Generally, smaller loading capacitance, higher frequency of ceramic resonator, and lower mechanical Q of ceramic resonator cause a faster rise time. The effect of load capacitance becomes more apparent as the capacitance of the resonator decreases.

Fig.5-4 shows how the rise time increases as the load capacitance of the resonator increases. Also, Fig.5-4 shows how the rise time varies with supply voltage. It is noteworthy that the rise time of the ceramic resistor is one or two decades faster than a quartz crystal.

Fig.5-5 shows comparison of rise time between the two.
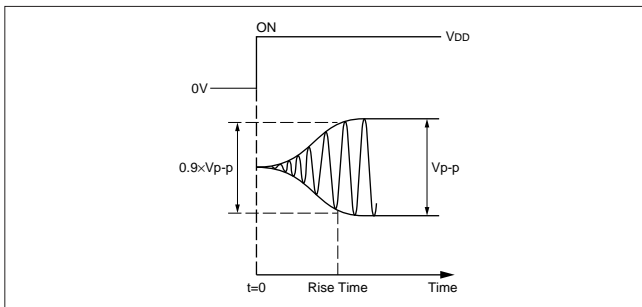
Fig.5-3 Definition of Rise Time
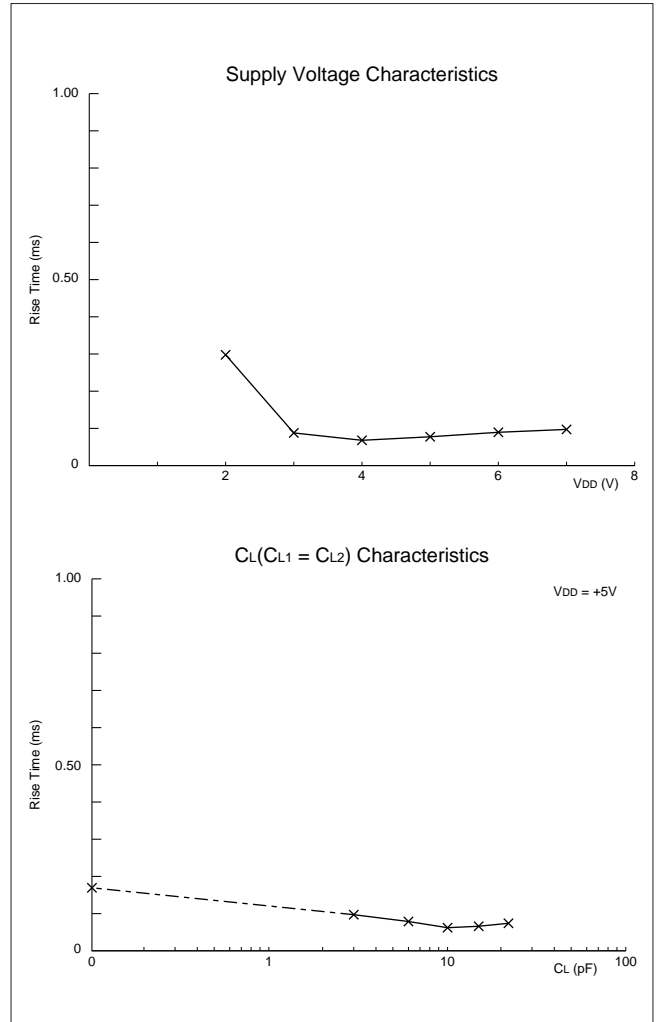
Fig.5-4 Examples of Characteristics of Oscillation Rise Time
(IC:TC74HCU04, CERALOCK®:CSACW3386MX01)

IC : TC74HCU04AP
V_{DD}=+5V, C_{L1}=C_{L2}=6pF
↑ 2.0V/div.
→0.1msec./div.
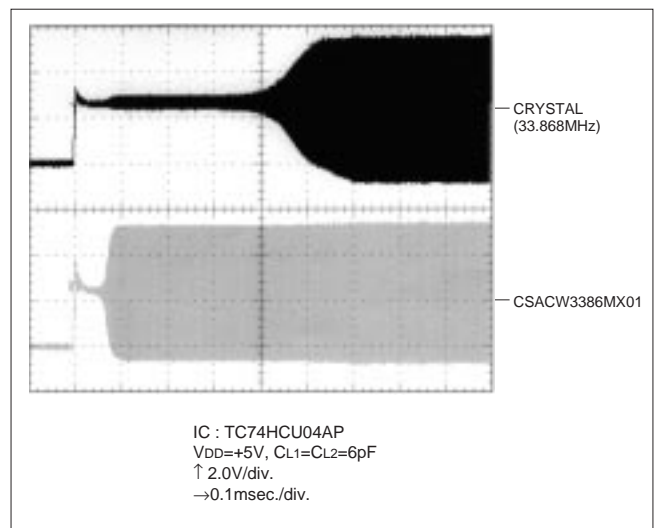
Fig.5-5 Comparison of the Rise Time of
a Ceramic Resonator vs. a Quartz Crystal

Characteristics of CERALOCK® Oscillation Circuit **5**

4. Starting Voltage

Starting voltage means the minimum supply voltage at which an oscillation circuit can operate. Starting voltage is affected by all the circuit elements, but it is determined mostly by the characteristics of the IC. Fig.5-6 shows an example of an actual measurement for the starting voltage characteristics against the loading capacitance.
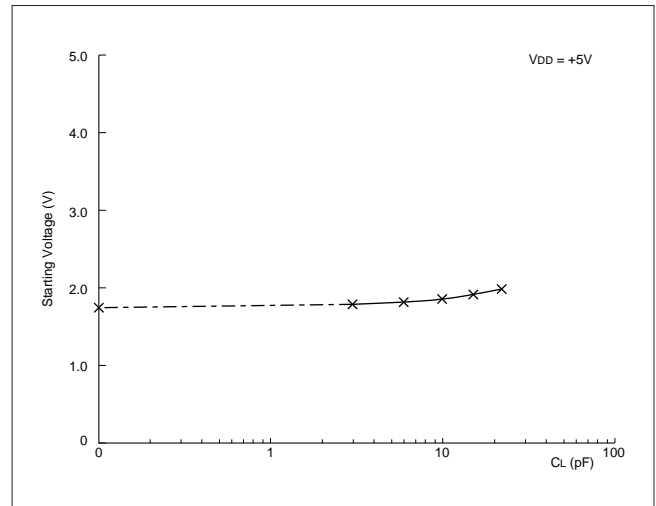
Fig.5-6 Starting Voltage Characteristics against C_L ($C_{L1}=C_{L2}$)
(IC:TC74HCU04, CERALOCK®:CSACW3386MX01)

5

6 Application Circuits to Various ICs/LSIs

CERALOCK®, by making good use of the above mentioned features, is used in a
wide range of applications to various kinds of ICs.
The followings are a few examples of actual applications.

1. Application to Microcomputers

CERALOCK® is optimum for a stable oscillation element
for various kinds of microcomputers : 4-bit, 8-bit and 16-
bit.
With the general frequency tolerance required for the
reference clock of microcomputers at ±2 to ±3%,
standard CERALOCK® meets this requirement. Please
consult with MURATA or LSI manufacturers about the
circuit constants, because these constants vary with
frequency and the LSI circuit being used.
Fig.6-1 to 6-6 show applications to various kinds of
4-bit microcomputers, and Figs.6-7 to 6-15 show
applications to 8-bit microcomputers.
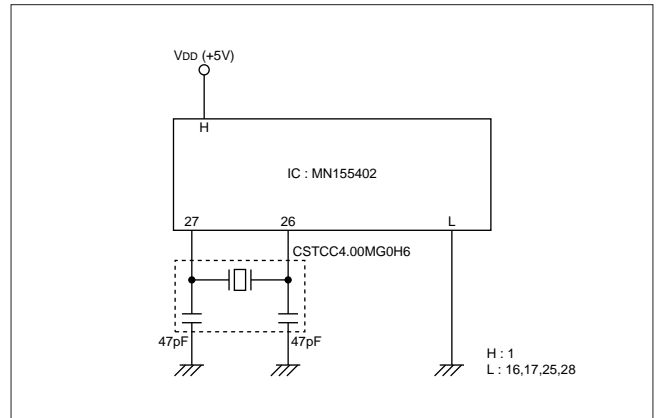
Fig.6-1 Application to MN155402 (MATSUSHITA)
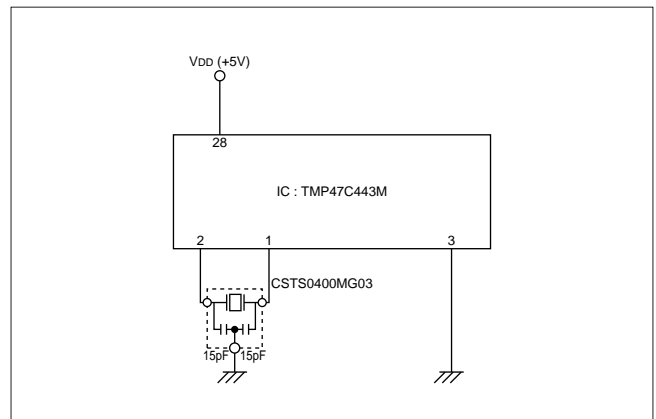
Fig.6-2 Application to TMP47C443M (TOSHIBA)
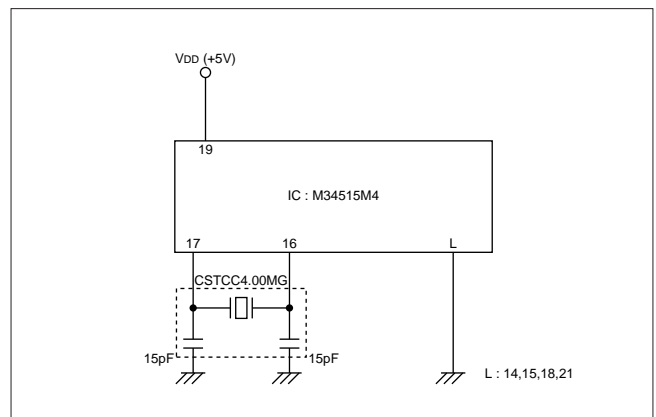
Fig.6-3 Application to M34515M4 (MITSUBISHI)

Application Circuits to Various ICs/LSIs **6**
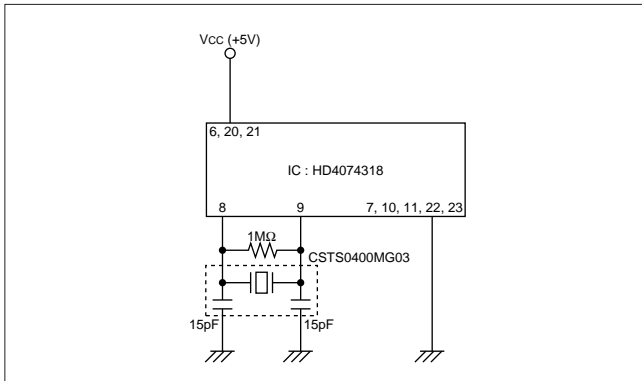
Fig.6-4 Application to HD4074318 (HITACHI)
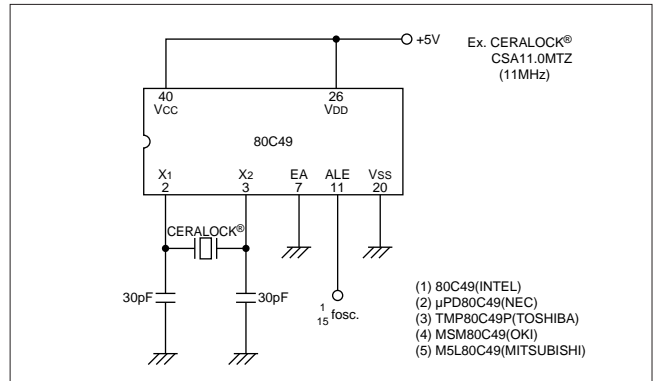
Fig.6-7 Application to 80C49s by Various Manufacturers

(1) 80C49(INTEL)
(2) µPD80C49(NEC)
(3) TMP80C49P(TOSHIBA)
(4) MSM80C49(OKI)
(5) M5L80C49(MITSUBISHI)
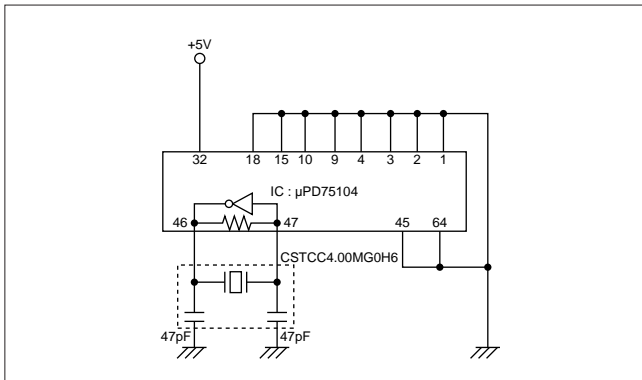
Fig.6-5 Application to µPD75104 (NEC)
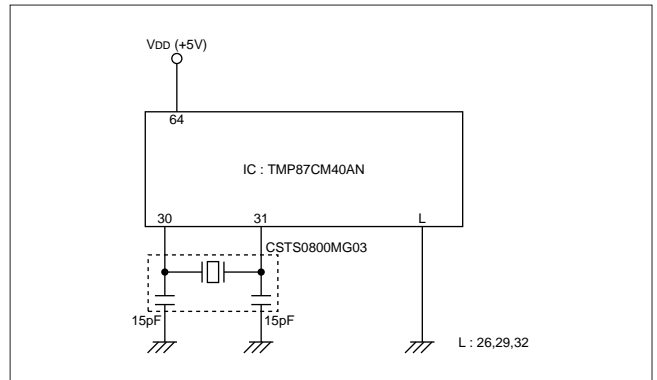
Fig.6-8 Application to TMP87CM40AN (TOSHIBA)
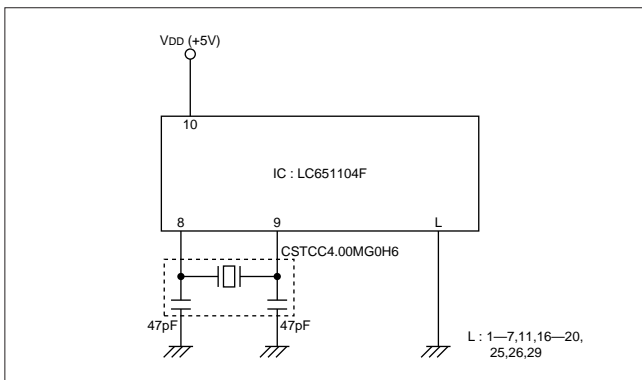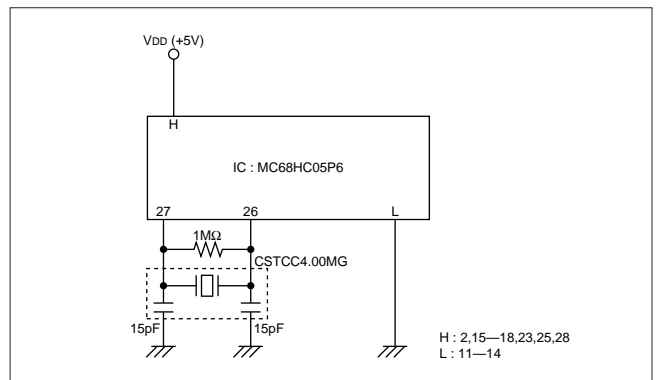
Fig.6-6 Application to LC651104F (SANYO)

Fig.6-9 Application to MC68HC05P6 (MOTOROLA)
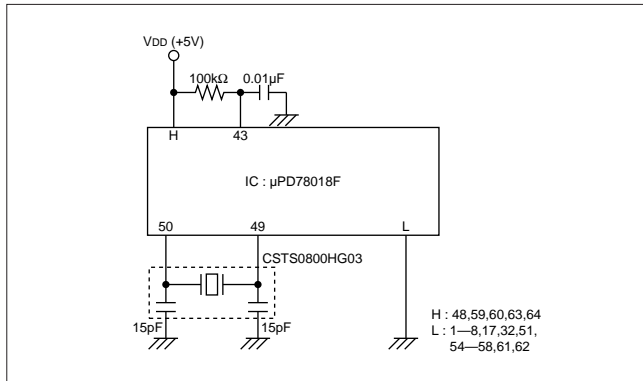
6

6　Application Circuits to Various ICs/LSIs

Fig.6-10 Application to μPD78018F (NEC)
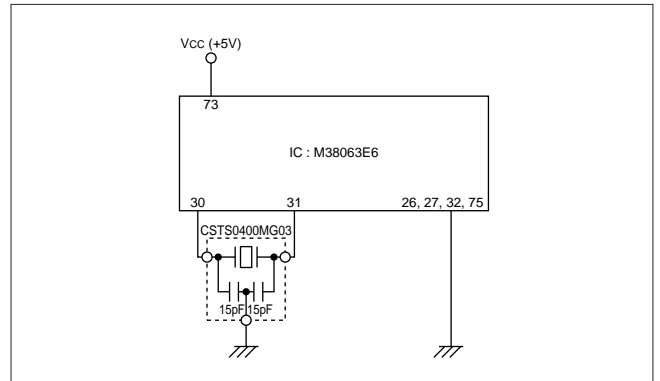
Fig.6-13 Application to M38063E6 (MITSUBISHI)
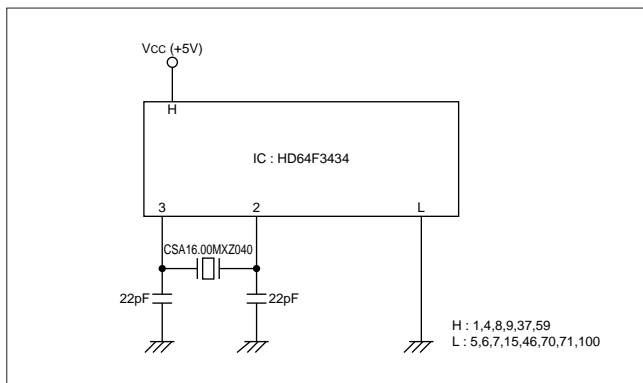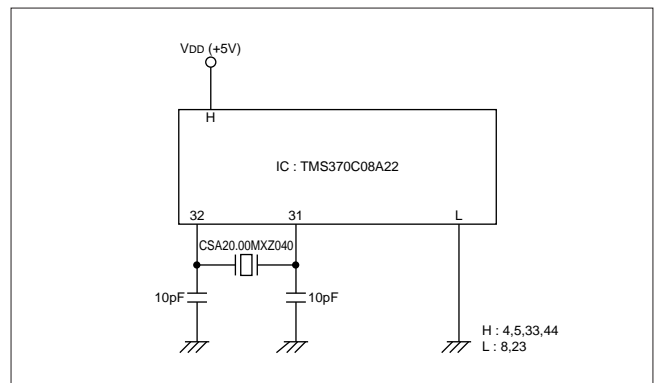

Fig.6-11 Application to HD64F3434 (HITACHI)

Fig.6-14 Application to TMS370C08A22 (T.I.)

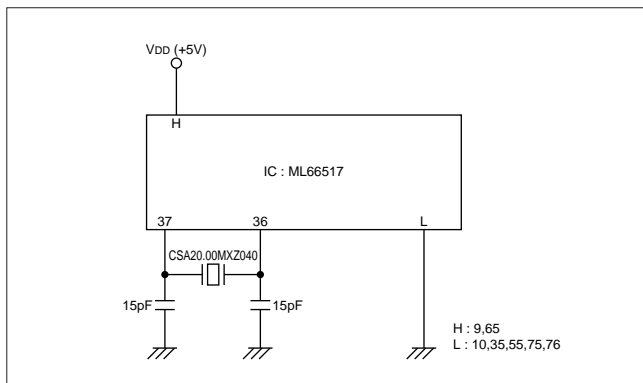Fig.6-12 Application to ML66517 (OKI)

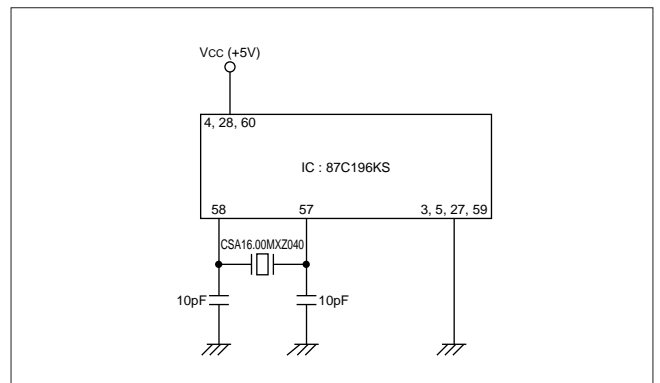Fig.6-15 Application to 87C196KS (INTEL)

2. Application to Remote Control ICs

Remote controllers have become an increasingly more popular feature in TVs, stereos, VCRs, and air conditioners.

Fig.6-16 to 6-18 show examples of CERALOCK® in remote control transmission ICs. Oscillation frequency is normally 400 to 500kHz, with 455kHz being the most popular. This 455kHz is divided by a carrier signal generator, so that a carrier of approximately 38kHz is generated.
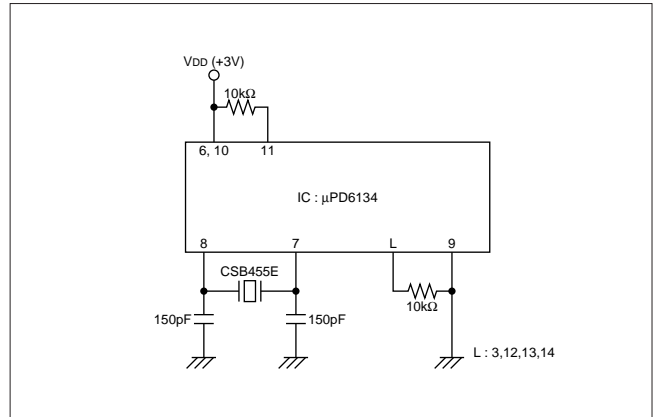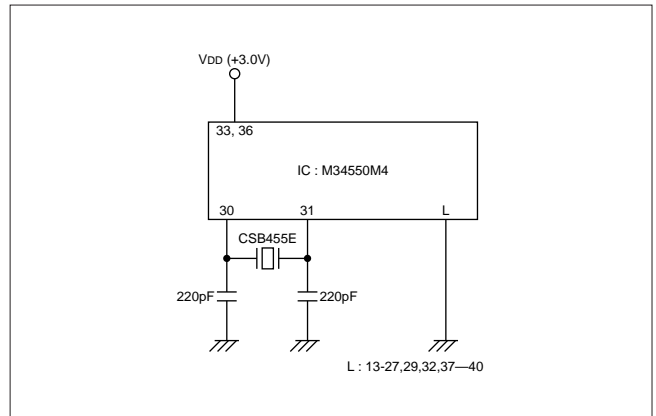

Fig.6-16 Application to μPD6134 (NEC)
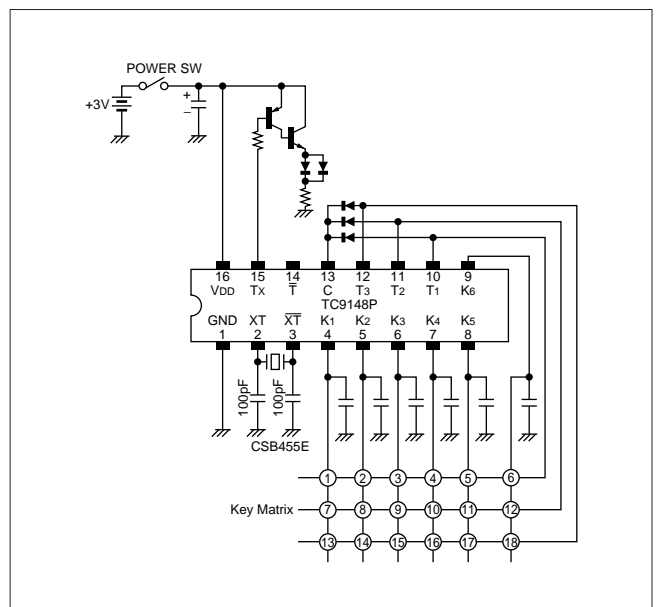

Fig.6-17 Application to M34550M4 (MITSUBISHI)

Fig.6-18 Application to TC9148P (TOSHIBA)

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6 Application Circuits to Various ICs/LSIs

3. Application to Various Kinds of VCOs (Voltage Controlled Oscillators)

VCO circuits are used in TVs and audio equipment, because the signals need to be processed in synchronization with pilot signals transmitted from broadcasting stations. Oscillation circuits, such as LC and RC, were previously often used, but CERALOCK® is now widely used as well, because they require no adjustment and have superior stability over the older type circuit.
Resonators, for VCO applications, are required to have a wide variable frequency range. We supply CERALOCK® devices with specially designed ceramic materials for VCO applications.

Application to TV Horizontal Oscillation Circuits

Figs.6-19 to 6-21 show application examples of horizontal oscillation circuits.
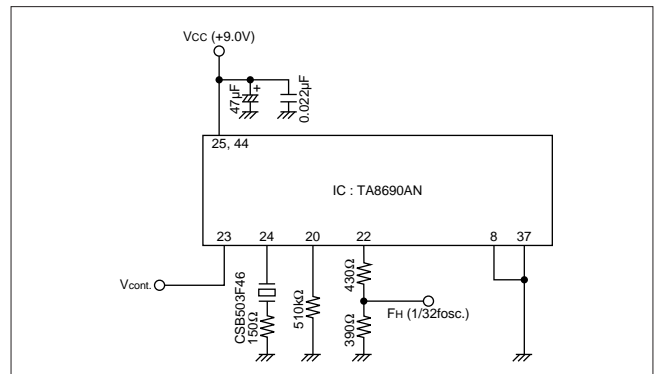Fig.6-19 and 6-20 are examples of NTSC system (FH=15.734kHz) and Fig.6-21 is for PAL system (FH=15.625kHz).

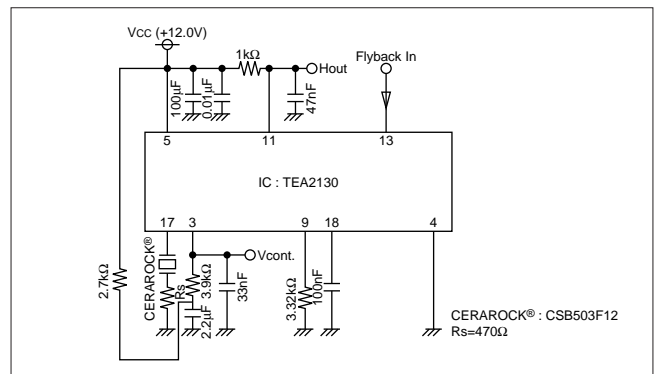Fig.6-19 Application to TA8690AN (TOSHIBA)
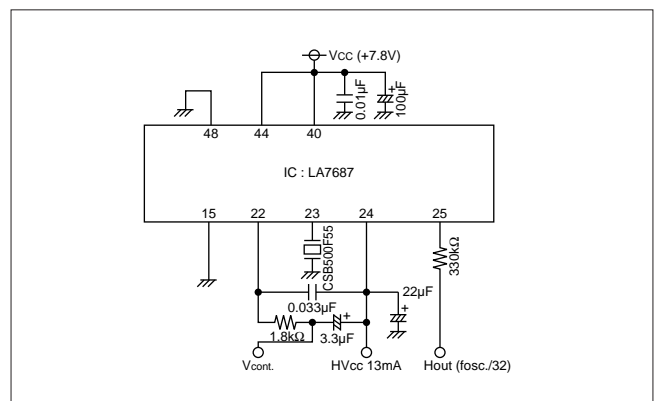

Fig.6-20 Application to TEA2130 (THOMSON)

Fig.6-21 Application to LA7687 (SANYO)

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Application Circuits to Various ICs/LSIs **6**

Application to Stereo Demodulation Circuits

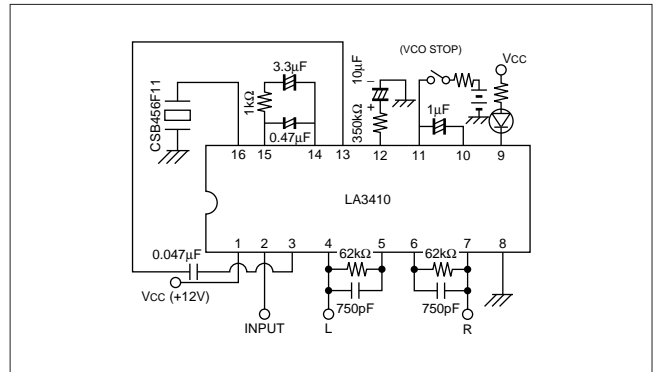Fig.6-22 is an application to the FM-MPX.

Fig.6-22 Application to LA3410 (SANYO) (FM-MPX)

4. Application to Telephone Dialers

The latest developments in telephone technology make it a highly advanced communication terminal. With the change from the pulse dialer to the tone dialer, the telephone key pad can be used for an effective data transmission. The frequency tone of each key is determined by the combination of the allocated frequency tone of the column and row keys. It is mandatory to observe an overall frequency tolerance of 1.5% under any servicing conditions. Since ICs normally have a division error of 0.1 to 0.75%, a maximum of ±0.6% frequency tolerance is allowed for the oscillator of the tone dialer.
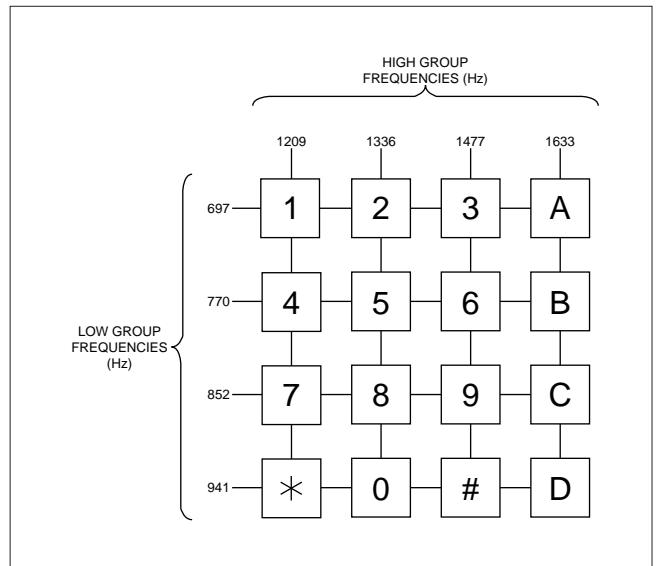

Fig.6-23 Key Matrix

6 Application Circuits to Various ICs/LSIs

In order to satisfy this frequency accuracy, we developed the 3.58MHz CERALOCK® "CSTS0358MG3 series" which is tuned for each IC.

Due to the outstanding features of CERALOCK® such as lower cost, lighter weight, and faster rise-up time, it is widely replacing the quartz crystal.

Fig.6-24 to Fig.6-26 are some examples for various dialer ICs. For more information, "Piezoelectric Components Application Manual for the New Telephone" is available upon request.
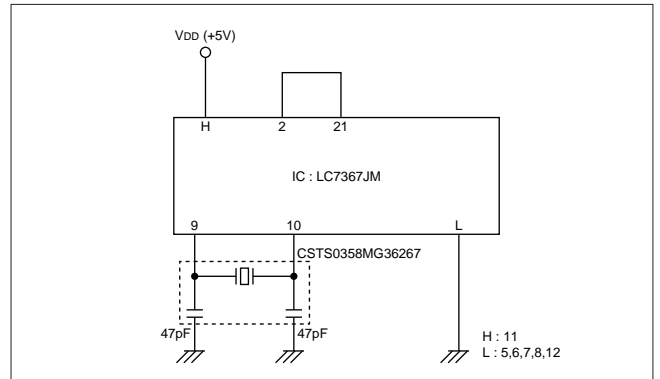
Fig.6-24 Application to LC7367J (SANYO) (Tone-Pulse Dialer)
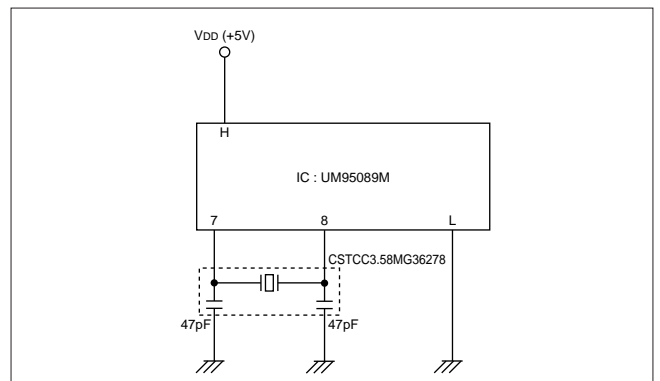
Fig.6-25 Application to UM95089M (UMC) (Tone-Pulse Dialer)
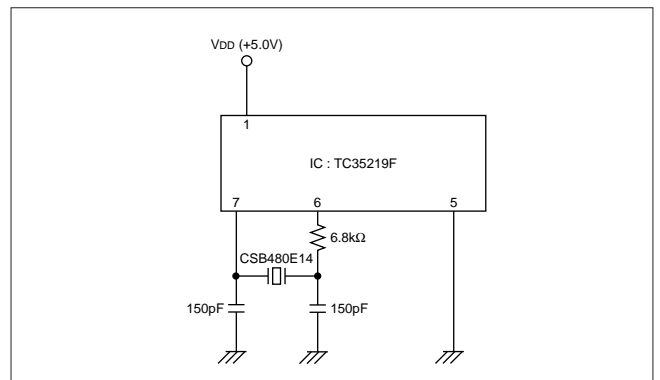
Fig.6-26 Application to TC35219F (TOSHIBA) (Tone-Pulse Dialer)

5. Application to ICs for Office Equipments

With the applications of ICs in office machines, many CERALOCK®s are used for motor drivers/controllers/ digital signal processor (D.S.P.) in floppy disk driver (F.D.D.) and CD/CD-ROM's ICs. Figs.6-27 to 6-29 show application examples. It is believed that this type of application will be increased in the future.
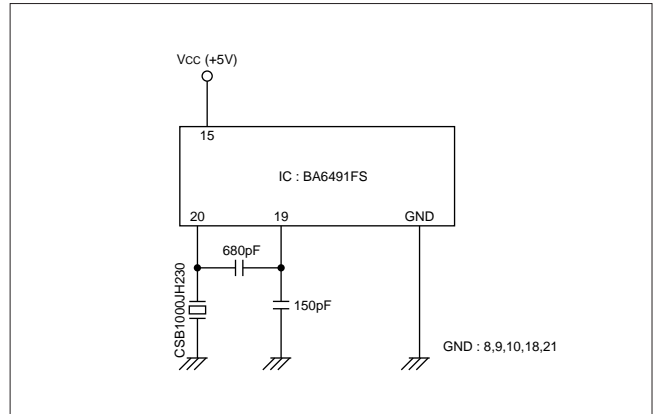
Fig.6-27 Application to BA6491FS (ROHM)
(Motor Driver)
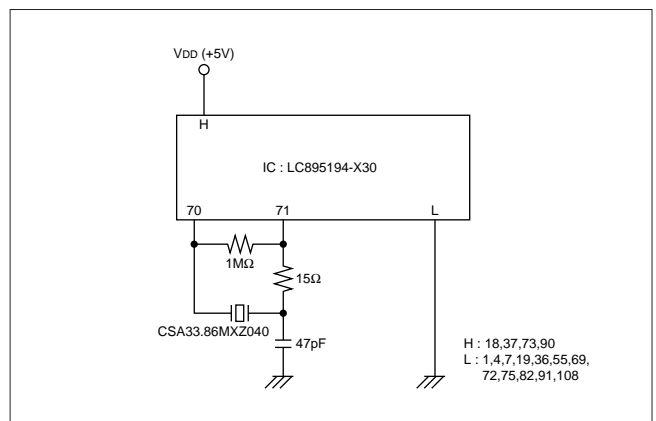
Fig.6-28 Application to LC895194-X30 (SANYO)
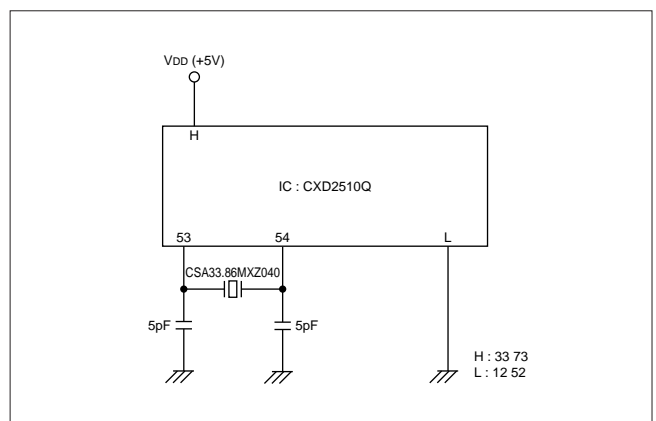
Fig.6-29 Application to CXD2510Q (SONY)

6   **Application Circuits to Various ICs/LSIs**

6. Other Kinds of Applications to Various ICs

Other than the above mentioned uses, CERALOCK® is widely used with ICs for voice synthesis.
Figs.6-30 and 6-31 show examples of voice synthesis.
We can provide CERALOCK® application data for many ICs which are not mentioned in this manual. Please consult us for details.
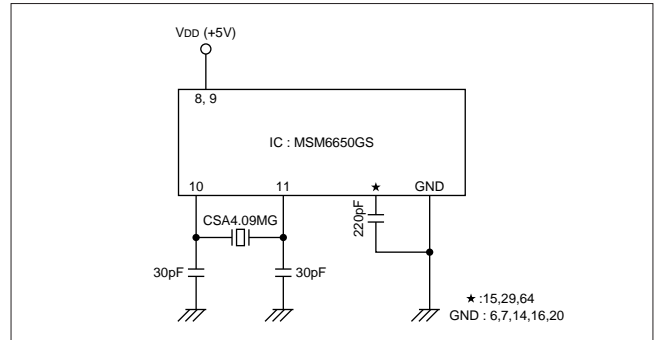
Fig.6-30 Application to ICs for Voice Synthesis MSM6650GS (OKI)
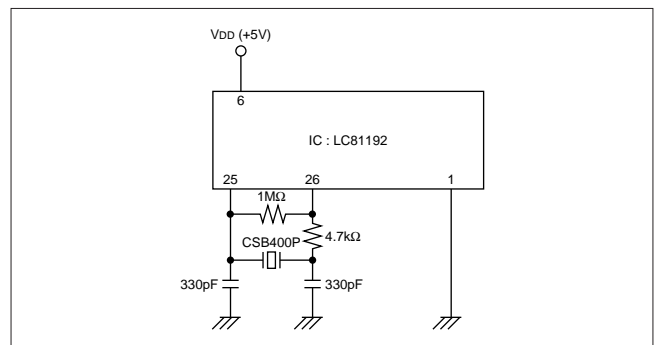
Fig.6-31 Application to ICs for Voice Synthesis LC81192 (SANYO)

7   **Notice**

· The component may be damaged if excess mechanical
  stress is applied.

· Please do not apply excess mechanical stress to the
  component and lead terminals at soldering.

· Conformal coating of the component is acceptable.
  However, the resin material, curing temperature, and
  other process conditions should be evaluated to
  confirm stable electrical characteristics are
  maintained.

· Unstable oscillation or oscillation stoppage might
  happen when CERALOCK® is used in improper way in
  conjunction with ICs. We are happy to evaluate the
  application circuit to avoid this for you.

· Oscillation frequency of our standard CERALOCK® is
  adjusted with our standard measuring circuit. There
  could be slight shift in frequency other types of IC are
  used. When you require exact oscillation frequency in
  your application, we can adjust it with your specified
  circuit.

· Please consult with us regarding ultrasonic cleaning
  conditions to avoid possible damage during ultrasonic
  cleaning.

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8 Appendix Equivalent Circuit Constants of CERALOCK®

(The equivalent circuit constants are not the guaranteed value but the standard value.)

Equivalent Constant / Part Number	Fr(kHz)	Fa(kHz)	ΔF(kHz)	$R_1(\Omega)$	L_1(mH)	C_1(pF)	C_0(pF)	Qm
CSB400P	388.5	402.4	13.9	6.2	6.7041	25.0462	344.3647	2650
CSB455E	443.9	457.3	13.4	10.1	7.6800	16.7421	272.7610	2136
CSB500E	487.2	503.2	16.0	8.5	7.1632	14.9069	222.8248	2619
CSB600P	586.5	604.2	17.7	11.8	6.1860	11.9121	194.2629	2140
CSB700J	683.5	706.5	23.0	11.1	5.3876	10.0678	146.8621	2158
CSB1000J	978.5	1013.3	34.7	13.7	4.4407	5.9576	82.4807	2009
CSB1200J	1179.6	1220.8	41.2	45.4	4.5330	4.0184	56.4891	780
CSB456F11	436.6	457.9	21.2	11.4	4.1631	31.9247	320.3785	1006
CSB456F14	435.9	457.4	21.5	11.0	3.9472	33.7848	333.5176	989
CSB500F2	506.1	549.8	43.7	8.5	1.3209	74.8959	415.5858	496
CSB500F9	489.0	543.9	55.0	27.9	0.9089	116.5686	490.9133	100
CSB503F2	509.5	554.0	44.6	8.5	1.2460	78.3331	429.0170	474
CSTS0200MG06	1926.8	2104.0	177.2	43.9	1.7051	4.0025	20.8018	475
CSTS0300MG06	2896.8	3149.2	252.5	18.9	0.8501	3.5539	19.5362	831
CSTS0400MG03	3784.4	4135.3	350.9	9.0	0.4611	3.8377	19.7730	1220
CSTS0600MG03	5710.9	6199.5	488.6	7.5	0.2381	3.2635	18.2899	1135
CSTS0800MG03	7604.7	8246.3	641.6	8.0	0.1251	3.5030	19.9175	775
CSTS1000MG03	9690.1	10399.1	709.0	7.0	0.0984	2.7448	18.0899	947
CSA11.0MTZ	10586.9	11403.8	816.9	5.3	0.0430	5.2548	32.7819	543
CSA12.0MTZ	11511.2	12348.5	837.3	5.8	0.0341	5.6033	37.1964	428
CSA16.00MXZ040	15961.9	16059.5	97.7	11.7	0.5513	0.1803	14.6945	4715
CSA18.00MXZ040	17960.0	18071.2	111.2	11.1	0.4908	0.1600	12.8846	5009
CSA20.00MXZ040	19968.9	20091.7	122.8	12.1	0.4760	0.1335	10.8212	4968
CSA25.00MXZ040	24976.9	25126.7	149.8	12.1	0.3663	0.1109	9.2153	4740
CSA30.00MXZ040	29901.8	30071.9	170.1	11.9	0.2778	0.1021	8.9482	4387
CSA32.00MXZ040	31918.2	32089.5	171.3	12.0	0.2508	0.0992	9.2139	4188
CSA33.86MXZ040	33781.5	33932.1	150.7	12.7	0.2384	0.0931	10.4171	3992
CSA40.00MXZ040	39955.2	40122.0	166.8	15.7	0.1674	0.0949	11.3374	2733
CSA50.00MXZ040	49987.3	50174.0	186.7	15.4	0.1208	0.0840	11.2187	2483

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