

REF. 411

CERAMIC RESONATOR – CERALOCK®

APPLICATION MANUAL

FOR V.C.O.



*Innovator
in Electronics*

Murata
Manufacturing Co., Ltd.

TD.No.P05E

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Equivalent Circuit Constants of CERALOCK[®]

■ NOTICE

- Matching condition should be evaluated thoroughly to perform stable electrical characteristics which are specified.
- We can not warrant against defects caused by any use of the filter which deviates from the intended use as described in this databook. Please contact us for any other characteristics, using conditions or application to the device which need to be extremely reliable.

1.Introduction

Ceramic resonator or CERALOCK[®] which is the trade mark of Murata's ceramic resonator, has been used as a timing clock for microprocessors. The demand of CERALOCK[®] has been increasing remarkably along with the rapid advance of electronic technology.

V.C.O.(Voltage Controlled Oscillator) has now become popular because no adjustment is needed, and it offers good stability of the circuit. V.C.O. needs to have a wide variable frequency range and good stability. CERALOCK[®] is suitable for the wide variable frequency range due to the lower mechanical Q(Q_m) than that of quartz crystal. Also, it provide stable characteristics because the frequency tolerance and long term stability of CERALOCK[®] is superior to that of CR, LC as shown in Table 2-1. This manual will describe CERALOCK[®] for V.C.O. application and its technical view.

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.

Fig. 2-1 Vibration Mode and Frequency Range

2.CERALOCK[®]

2 General Characteristics of CERALOCK[®]

Ceramic resonator utilizes the mechanical resonance of the most suitable vibration mode of piezo-electric ceramics. (generally, lead zirconium titanate :PZT.) as shown in Fig.2-1.

Quartz crystal resonators are also well-known as resonator devices using piezo-electric material, while CR and LC oscillation circuits utilize electrical resonance.

Ceramic resonator - CERALOCK[®] has the following characteristics.

(1)High stability of oscillation frequency

The oscillation frequency stability of CERALOCK[®] lie in the middle of quartz crystal resonator and CR, LC oscillation circuits.

The temperature coefficient of oscillation frequency (-20°C to +80°C) is 10⁻⁵/°C for CERALOCK[®], while 10⁻⁶/°C for quartz crystal resonator, and 10⁻³/°C to 10⁻⁴/°C for CR or LC oscillation.

(2)Small size, light weight

CERALOCK[®] is half the size of standard quartz resonators.

(3)Low price, Adjustment free

As CERALOCK[®] utilizes mechanical resonance. it is stable against the external circuits and the fluctuation of the supply voltage.

CERALOCK[®] is less expensive than quartz crystal utilizing the materials and technologies MURATA has developed for ceramic filters.

Name	Symbol	Price	Size	Adjustment	Oscillation Frequency Initial Tolerance	Long-term Stability
LC		Inexpensive	Big	Required	±2.0%	Fair
RC		Inexpensive	Small	Required	±2.0%	Fair
Quartz Crystal		Expensive	Big	Not required	±0.001%	Excellent
Ceramic Resonator		Inexpensive	Small	Not required	±0.5%	Excellent

Table 2-1 Characteristics of Various Oscillator Elements

3.CERALOCK® for V.C.O.

3-1 Current application for V.C.O.

V.C.O. is used for demodulation or detection of signals in TV sets and communication equipments.

In recent years, ceramic resonators are applied in V.C.O. because no adjustment is required and it improve the stability.

The characteristics required for V.C.O. are as follows:

- (1) Stable oscillation frequency against drift in temperature.
- (2) Stable oscillation frequency against drift in supply voltage.
- (3) Long term stability.
- (4) Simple or no adjustment.
- (5) Low cost.

CERALOCK® fulfills the above requirements.

Table 3-1 shows the current application for V.C.O.

The ceramic materials for V.C.O. application is quite different from that of timing clock because it should exhibit wide variable frequency range and high stability. For this purpose, CERALOCK® for V.C.O. uses the materials having relatively lower Qm, and larger $\Delta f/f_{osc}$.

3-2 Part Numbering

CERALOCK® for V.C.O. is identified by the letter "F", which indicates it use the low-Qm ceramic material.

(EX):CSB503F5 (CSB series,unwashable type)

:CSB456JF216 (CSB series,washable type)

:CSA7.34MGF201

(CSA series, thickness shear mode type)

:CSAC3.60MGF103

(CSA series, thickness shear mode type,
SMD type)

Each part number is assigned in conjunction with the IC which CERALOCK® is used with.

On pages 5 and 6, the most of CERALOCK® for V.C.O. applications and its applied ICs are listed.

As for dimensions or other information, please refer to "CERAMIC RESONATOR APPLICATION MANUAL" (Cat. No. P17E-6)

Application	Detect Signal	Oscillation Frequency	CERALOCK®
TV Horizontal Oscillation for NTSC	fH=15.734kHz	503.5kHz	CSB503FXX
TV Horizontal Oscillation for PAL	fH=15.625kHz	500.0kHz	CSB500FXX
FM-Multiplex	Pilot signal=19kHz	456.0kHz	CSB456FXX
RDS-System	Pilot signal=57kHz	456.0kHz	CSB456FXX
TV Multi-sound Decoder (NTCS JAPAN CH.)	Pilot signal =922.5/982.5Hz	472.5kHz	CSB472FXX
TV Multi-sound Decoder (PAL G/B)	Pilot signal =54.6875kHz	437.5kHz	CSB437FXX
AM Stereo Decoder	Pilot signal=25Hz	3.600MHz	CSA3.60MGFXX

Fig.3-1 Application for V.C.O.

4. Application for V.C.O.

4-1 Mechanism of V.C.O.

V.C.O. circuit with CERALOCK[®] has the advantage of no-adjustment and good frequency stability comparing with V.C.O. with LC or CR circuit. V.C.O.s using CERALOCK[®] can be divided into two categories by the method of shifting the oscillation frequency.

1. Varying oscillation frequency by moving the resonant frequency of CERALOCK[®].
2. Varying oscillation frequency by utilizing the phase slope of CERALOCK[®].

4-1-1 V.C.O. varying oscillation frequency

There are two kinds in this type of V.C.O. One is to vary resonant frequency (F_r) and the other is to shift the anti-resonant frequency (F_a).

Fig.4-1 shows an example of moving F_r type using Colpitts circuit with a transistor. This circuit has a varactor diode in series to CERALOCK[®]. By changing the capacitance of the diode, the resonant frequency and the oscillation frequency, as a result, is varied. Impedance characteristics of this case is shown in fig.4-2.

As an example of moving anti-resonant frequency (F_a), positive feedback oscillator with differential amplifier is shown in Fig.4-3. The oscillation circuit can be voltage controlled by adding a positive or negative reactance equivalently in parallel to the CERALOCK[®].

Impedance characteristics of this case is shown in Fig.4-4.

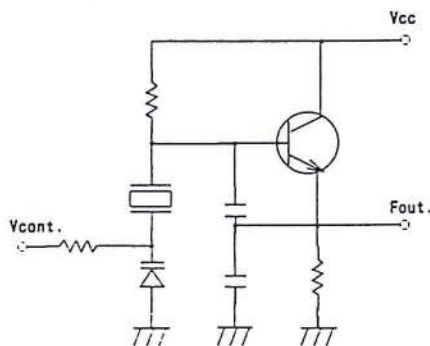


Fig.4-1 Application Circuit for Tr.

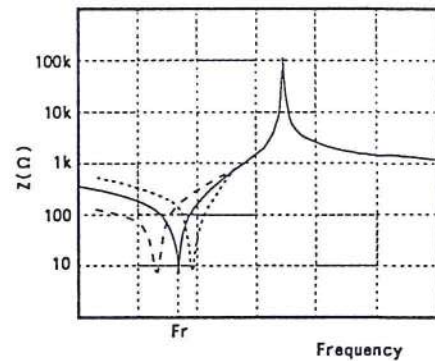


Fig.4-2 Impedance Characteristics

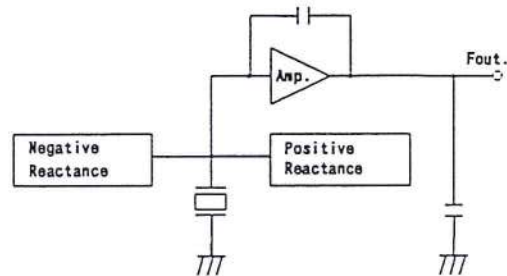


Fig.4-3 Concept of symmetrical Reactance Circuit

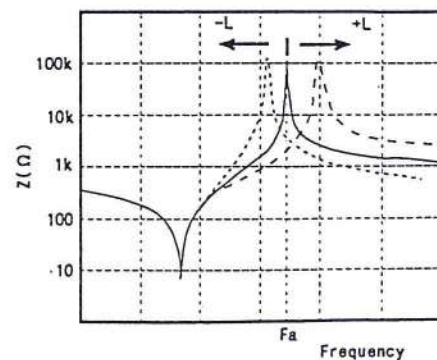


Fig.4-4 Impedance Characteristics

4-1-2 V.C.O. utilizing the phase slope of CERALOCK®

Oscillation condition, in general, is fulfilled when,
 $\text{Loop-Gain} \geq 1, \text{Phase-shift } \theta = 360^\circ \times n$
 $(n=1,2,\dots)$

With the oscillation circuit of Fig.4-5, by changing the amount of phase shift externally, oscillation frequency can be controlled.

Because oscillation condition is satisfied at the zero degree phase point, when circuit phase shift by $\Delta \phi$ by the control voltage, oscillation takes place at $-\Delta \phi$ phase point of ceramic resonator. Phase characteristics of ceramic resonator is normally dumped by series resistance as shown in Fig.4-6 to have wide variable range.

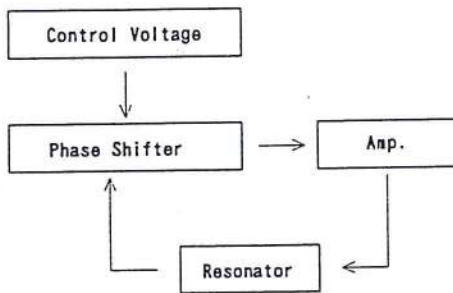


Fig.4-5 Simplified Block Diagram

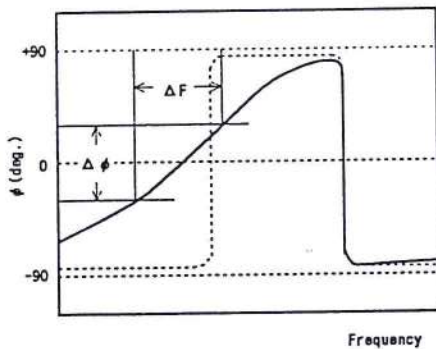


Fig.4-6 Phase Characteristics

4-2 Application examples of V.C.O.

4-2-1 Application for FM-MPX demodulator

To demodulate stereo signal, PLL(Phase lock loop) is commonly used. It can be said that the demodulation signal quality in FM stereo demodulator depends on the purity of sub-carrier reproduced by the PLL. Major cause of degrading the purity of sub-carrier is the free-run frequency drift of V.C.O. By controlling this free-run frequency with CERALOCK®, very stable oscillator without need of adjustment can be accomplished. For the application of FM-MPX, oscillation circuit moving anti-resonant frequency(F_a) is mostly used.

Its oscillation circuit is the same as Fig.4-3 with CERALOCK® connected in parallel to reactance element equivalently. Fig.4-7 is one of the V.C.O. characteristics of this type.

4-2-2 Application for TV Horizontal oscillator

V.C.O. circuit using CERALOCK® can be applied in the TV Horizontal Oscillation circuit which control frequency and phase.

Oscillation principle is as per Fig.4-5 using phase characteristics of ceramic resonator at the resonance. In the actual application, series resistance(R_s) is connected with CERALOCK® to slant the phase slope. Example of characteristics is shown in Fig.4-8.

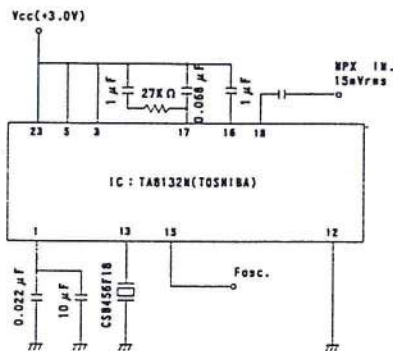
APPLICATION : FM Multiplexer

Type : CSB456F18
 IC : TA8132N(TOSHIBA)

Specifications

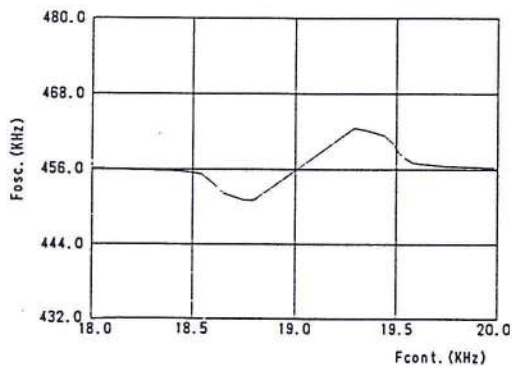
- ① Oscillating Frequency : 19.000 kHz \pm 38 Hz
- ② Temperature Stability : \pm 0.2 %
 (Temperature Range : -20~80°C)
- ③ Resonant Impedance : 30 Ω max.
- ④ Static Capacitance : 420 pF \pm 10 %
- ⑤ ΔF (Fa-Fr) : 19 kHz min.

1. Application Circuit



2. Application Data

V.C.O. Characteristics



Temperature Characteristics of Pull in Range

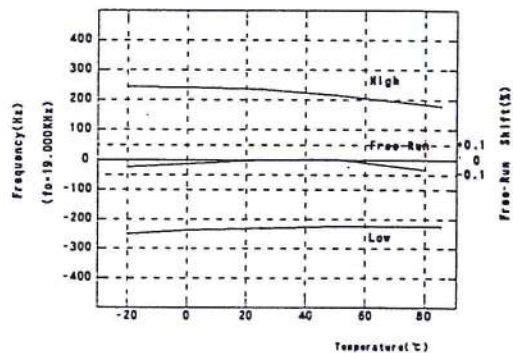


Fig.4-7 Application and measured data for FM Multiplexer

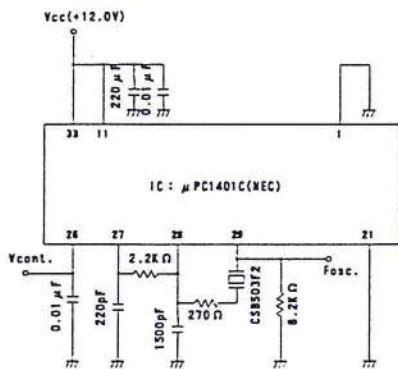
APPLICATION : TV Horizontal Oscillator for NTSC System

Type : CSB503F2
 IC : μ PC1401C(NEC)

Specifications

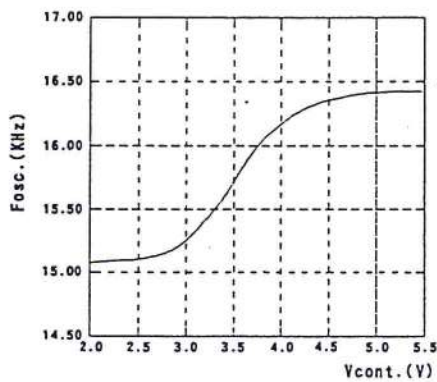
- ① Oscillating Frequency : 503.5 kHz \pm 2.0 kHz
- ② Temperature Stability : \pm 0.5 %
 (Temperature Range : -20~80°C)
- ③ Resonant Impedance : 30 Ω max.
- ④ Static Capacitance : 500 pF \pm 20 %

1. Application Circuit



2. Application Data

V.C.O. Characteristics



Temperature Characteristics of Pull in Range

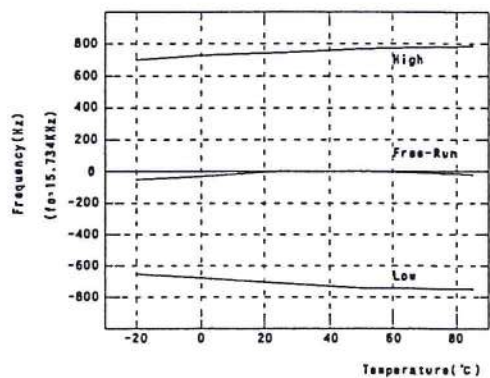


Fig.4-8 Application and measured data for TV Horizontal Oscillator for NTSC system

5. Application of V.C.O. with various ICs

Not only for FM-MPX and TV Horizontal oscillation, CERALOCK[®] is applied to some other types of V.C.O. In this section, many application example with various IC's are shown.

For detailed V.C.O. characteristics and data sheet, please contact us.

5-1 Applications for stereo demodulation (FM-MPX)

Fig.5-1 through Fig.5-5 shows its application.

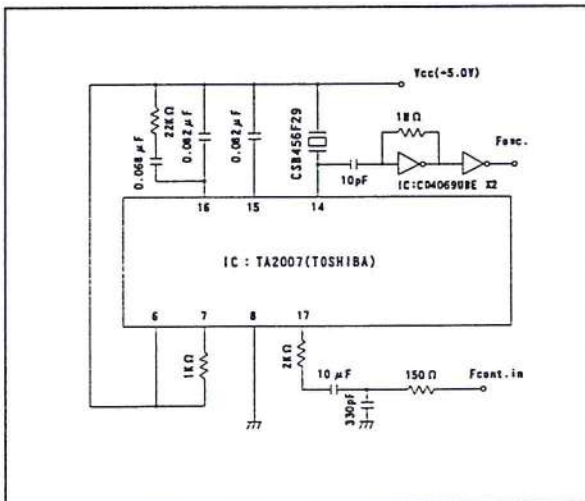


Fig.5-1 Application for TA2007(TOSHIBA)

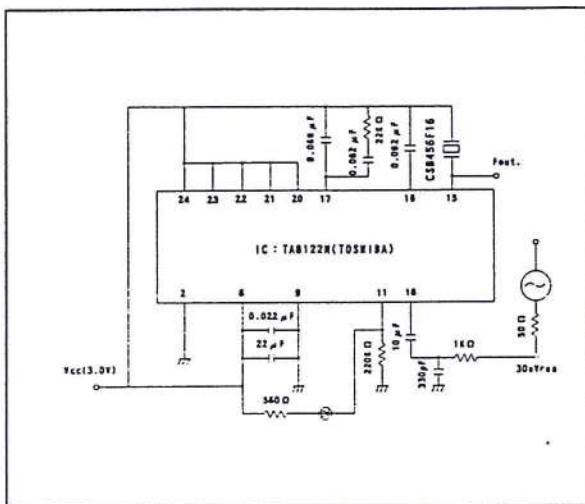


Fig.5-2 Application for TA8122N(TOSHIBA)

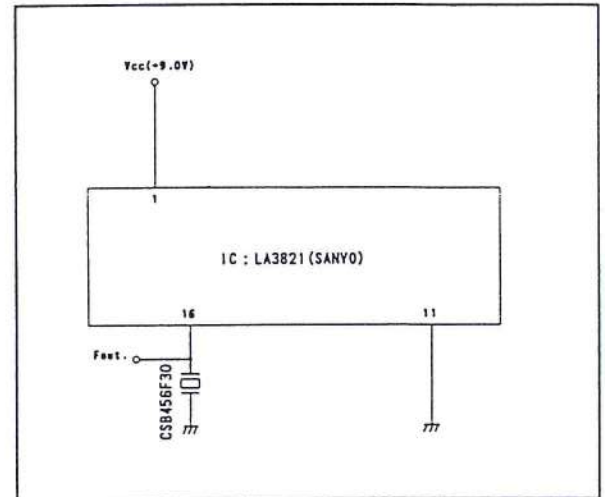


Fig.5-3 Application for LA3821(SANYO)

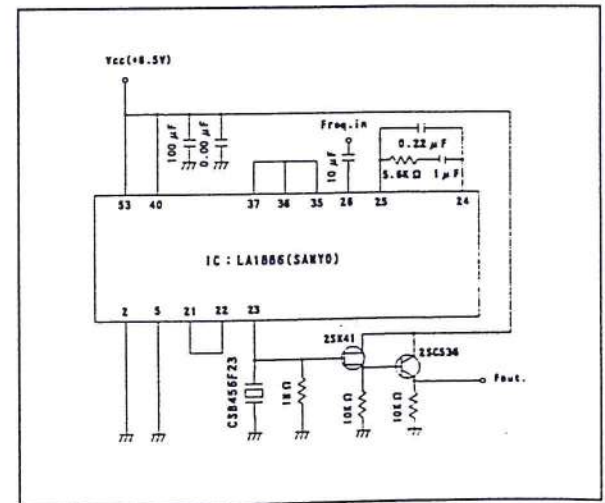


Fig.5-4 Application for LA1886(SANYO)

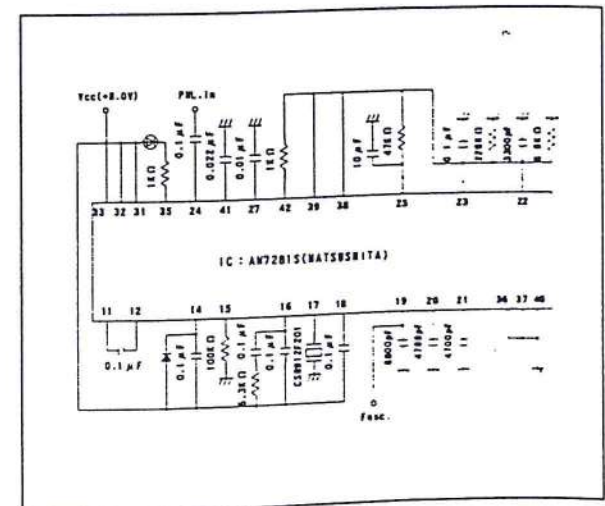


Fig.5-5 Application for AN7281(MATSUSHITA)

5-2 Applications for TV Horizontal oscillation

The following data are applications for TV Horizontal oscillation. Fig.5-6 through Fig.5-14 are for NTSC($f_H=15.734\text{kHz}$) and Fig.5-15 through Fig.5-20 are for PAL($f_H=15.625\text{kHz}$).

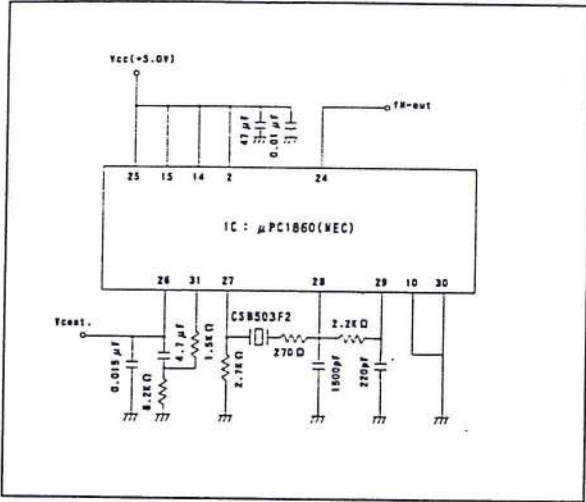


Fig.5-6 Application for $\mu\text{PC1860(NEC)}$

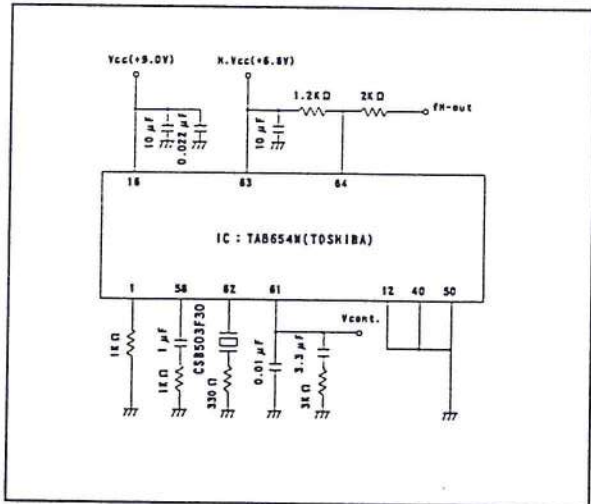


Fig.5-7 Application for TA8654(TOSHIBA)

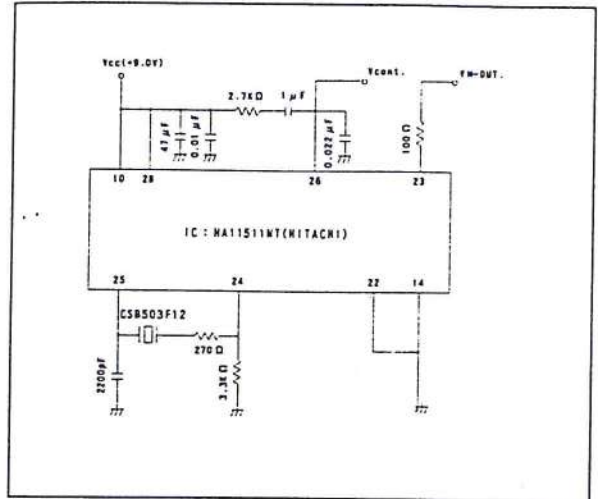


Fig.5-8 Application for HA11511(HITACHI)

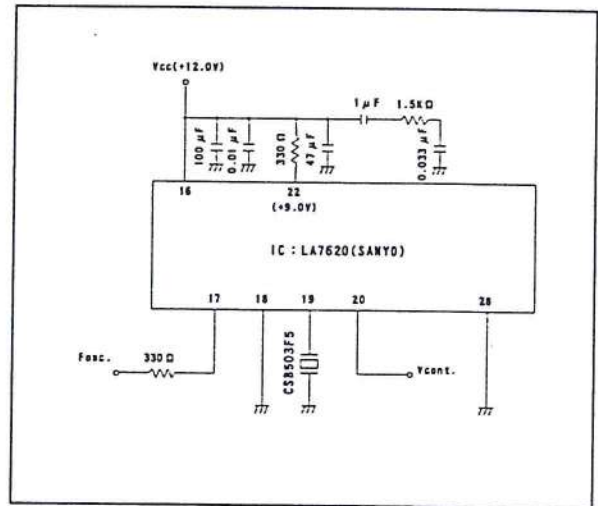


Fig.5-9 Application for LA7620(SANYO)

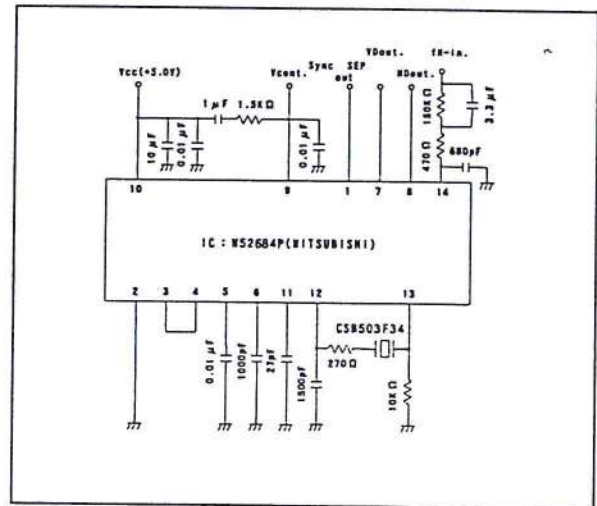


Fig.5-10 Application for M52684(MITSUBISHI)

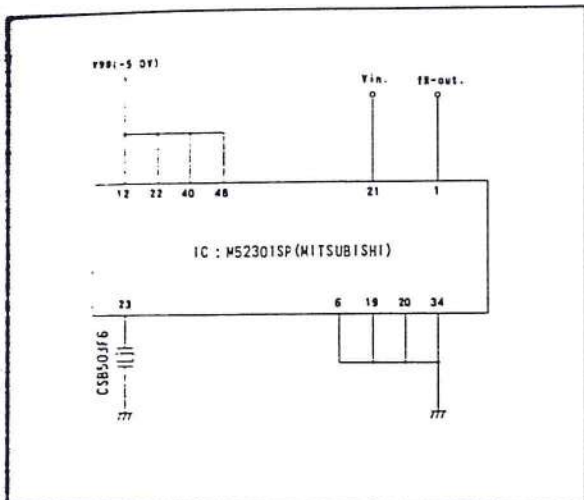


Fig.5-11 Application for
M52301(MITSUBISHI)

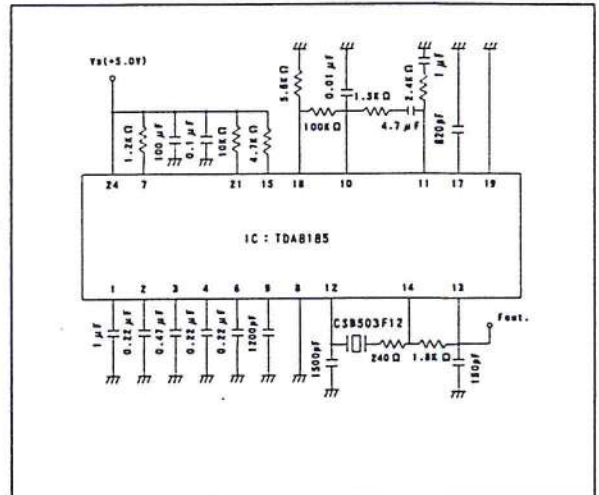


Fig.5-14 Application for
TDA8185(S.G.S.-THOMSON)

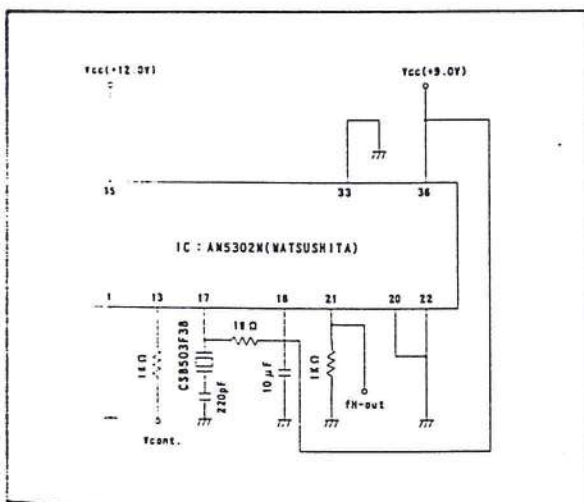


Fig.5-12 Application for
AN5302N(MATSUSHITA)

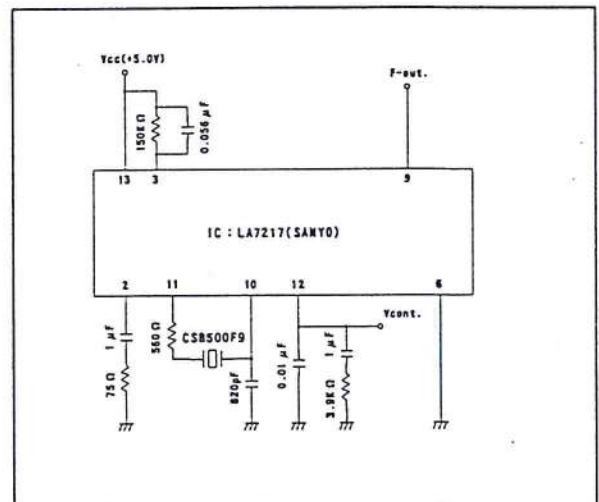


Fig.5-15 Application for LA7217(SANYO)

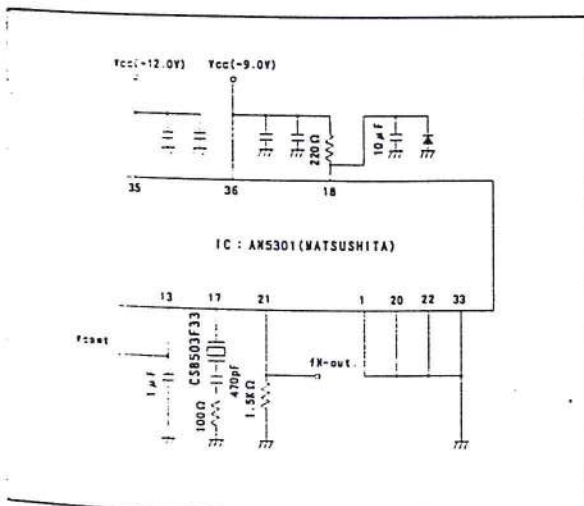


Fig.5-13 Application for
AN5301(MATSUSHITA)

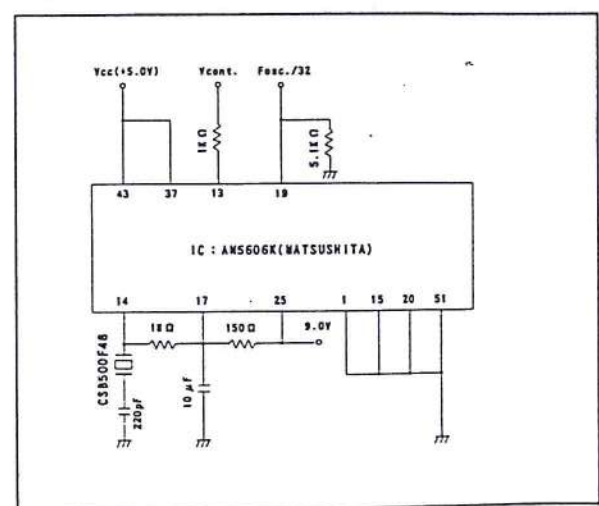


Fig.5-16 Application for
AN5606K(MATSUSHITA)

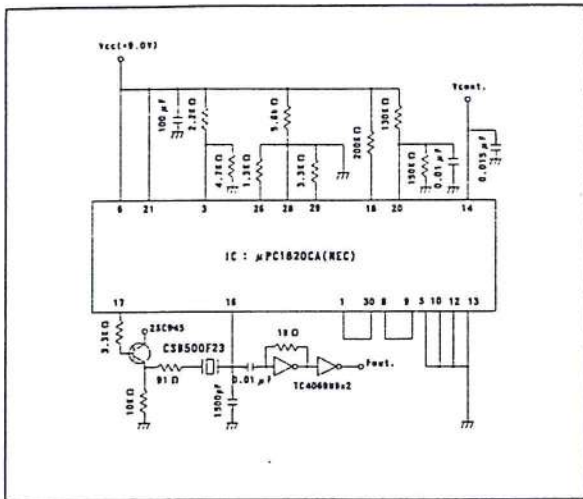


Fig.5-17 Application for μ PC1820(NEC)

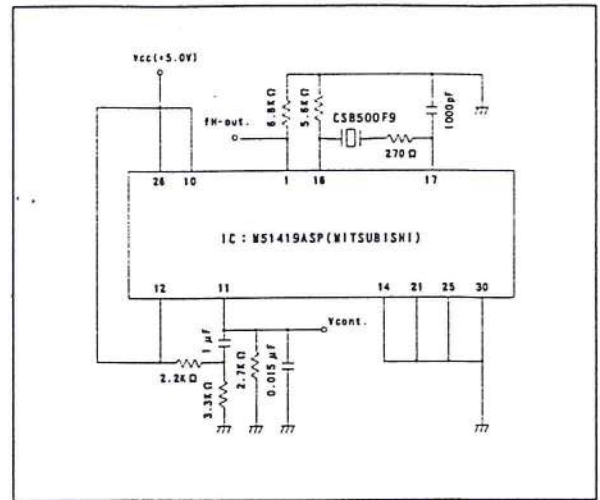


Fig.5-20 Application for
M51419(MITSUBISHI)

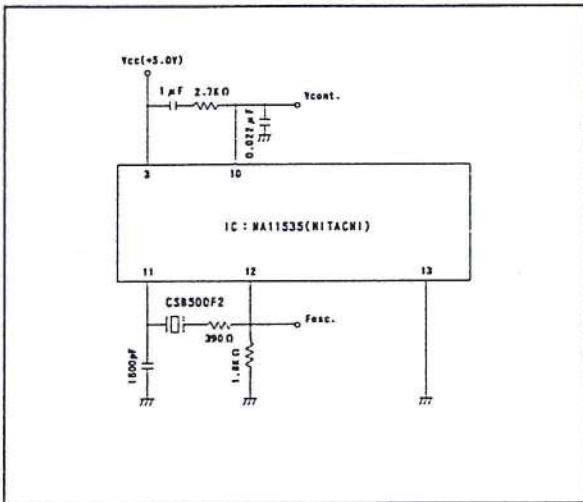


Fig.5-18 Application for HA11535(HITACHI)

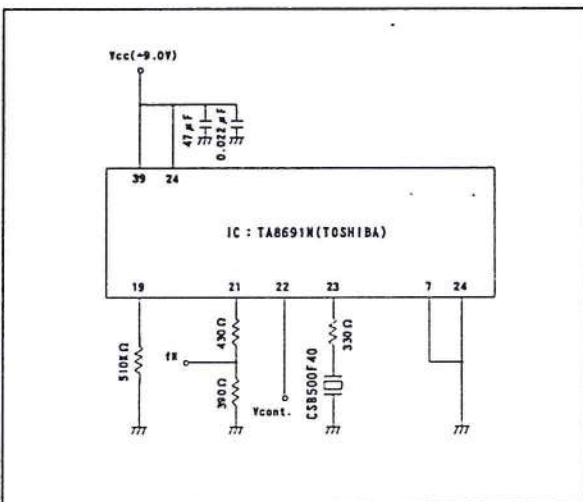


Fig.5-19 Application for TA8691(TOSHIBA)

5-3 Applications for AM stereo decoder

Fig.5-21 and Fig.5-22 shows application for AM stereo decoder.

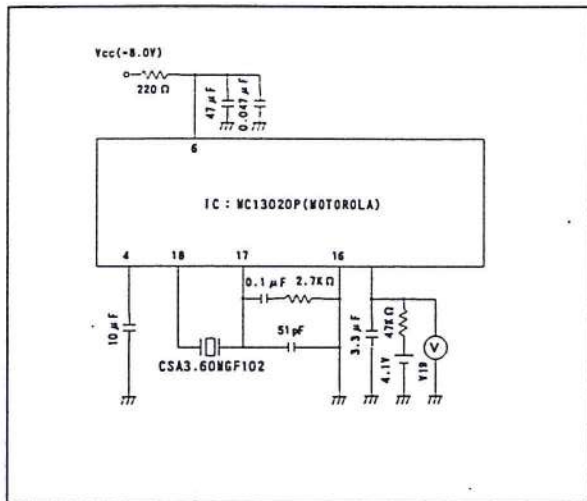


Fig.5-21 Application for MC13020P(MOTOROLA)

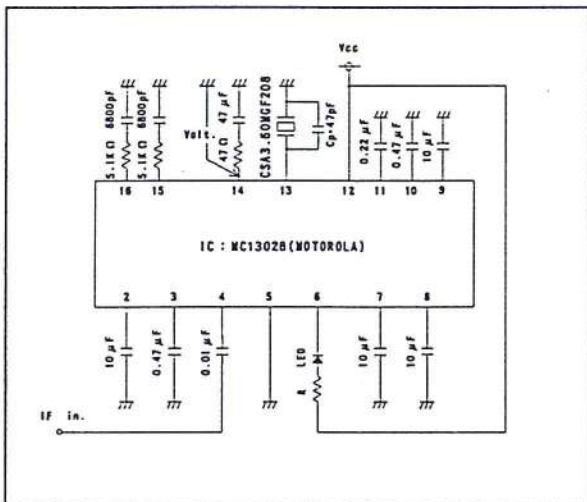


Fig.5-22 Application for MC13028(MOTOROLA)

5-4 Applications for other types of V.C.O.'s.

Fig.5-23 is application TV stereo tone demodulation circuit. Fig.5-24 is for RDS demodulation circuit. Fig.5-25 is for Teletest and lastly Fig.5-26 is application for video IF circuit.

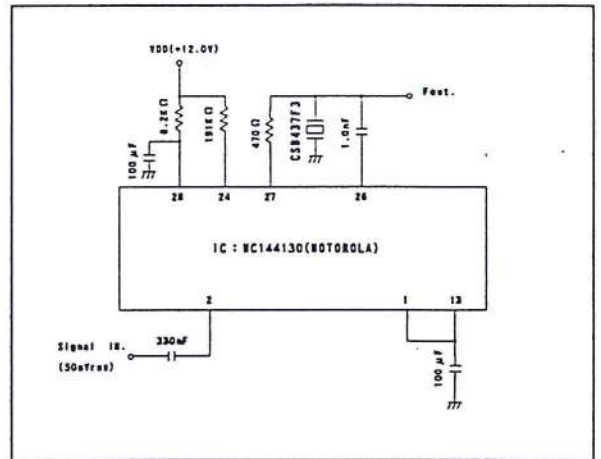


Fig.5-23 Application for MC14430(MOTOROLA)

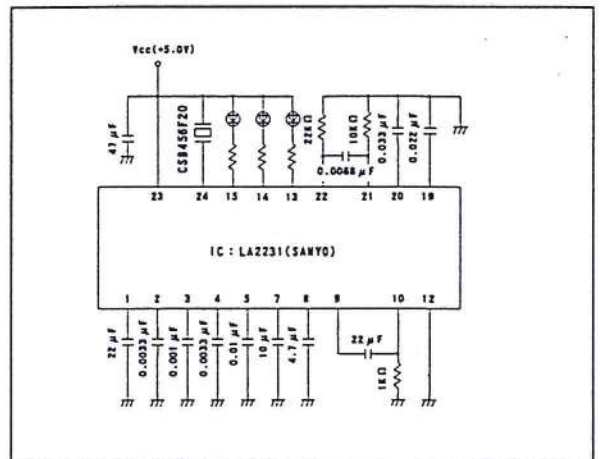


Fig.5-24 Application for LA2231(MITSUBISHI)

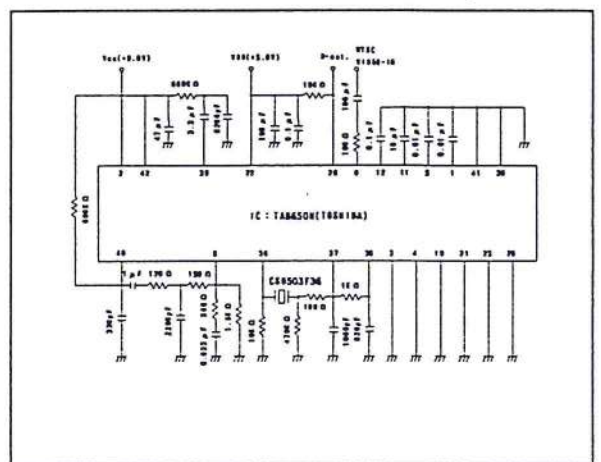


Fig.5-25 Application for TA8650N(TOSHIBA)

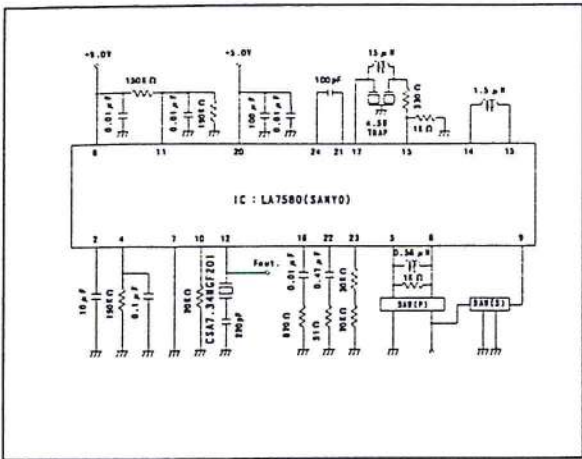


Fig.5-26 Application for LA7580(SANYO)

-Appendix- Cross Reference of ICs V.C.O. and Ceramaic Resonator : CERALOCK®

(Sep.1993)

IC Maker	IC	CERALOCK®	Application
SANYO	LA1830 LA1886 LA3821	CSB456F15 CSB456F23 CSB456F30	FM Multiplexer FM Multiplexer FM Multiplexer
	LA2231	CSB456F20	RDS System
	LA7217 LA7620 LA7685	CSB500F9 CSB503F5 CSB500F55	TV Horizontal Oscillator for PAL TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for PAL
TOSHIBA	TA2007N TA8122AN	CSB456F29 CSB456F16	FM Multiplexer FM Multiplexer
	TA8616AN TA8654AN TA8659AN TA8680BN TA8690AN TA8691N TA8691N TA8725N TA8745CN TA8779N TA8783N TA8801AN	CSB503F2 CSB503F30 CSB503F2 CSB503F30 CSB503F30 CSB503F30 CSB500F40 CSB503F30 CSB503F30 CSB503F30 CSB503F30 CSB503F30 CSB503F30 CSB503F30	TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for PAL TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for NTSC
	TA8650N	CSB500F36	Teletext Decoder in Japan
MITSUBISHI	M51285AFP M51414BSP M51419ASP M51497L M52301SP M52303ASP M52684P	CSB500F9 CSB500F9 CSB500F9 CSB503F34 CSB503F6 CSB503F6 CSB503F34	TV Horizontal Oscillator for PAL TV Horizontal Oscillator for PAL TV Horizontal Oscillator for PAL TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for NTSC
NEC	uPC1820CA uPC1860	CSB500F23 CSB503F2	TV Horizontal Oscillator for PAL TV Horizontal Oscillator for NTSC
HITACHI	HA11511 HA11511 HA11535	CSB500F9 CSB503F12 CSB500F2	TV Horizontal Oscillator for PAL TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for PAL
MATSUSHITA	AN7281	CSB912JF101	FM Multiplexer
	AN5160NK AN5301 AN5302N AN5606K	CSB503F38 CSB503F33 CSB503F38 CSB500F48	TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for NTSC TV Horizontal Oscillator for PAL

-Appendix- Cross Reference of ICs V.C.O. and Ceramaic Resonator : CERALOCK®

(Sep.1993)

IC Maker	IC	CERALOCK®	Application
MOTOROLA	MC13020P	CSA3.60MGF102	AM Stereo Decoder
	MC13022P	CSA3.60MGF103	AM Stereo Decoder
	MC1378	CSA4.00MGF102	TV Horizontal Oscillator for PAL
	MC1378	CSA4.03MGF102	TV Horizontal Oscillator for NTSC
	MC144130	CSB437F3	PAL,B/G Multi-Sound Decoder
PHILIPS	TDA1591	CSB456F11	FM Multiplexer
	SAA5231	CSA6.00MTZ002	Teletext
S.G.S. THOMSON	TDA7338	CSB456F21	FM Multiplexer
	TDA8185	CSB503F12	TV Horizontal Oscillator for NTSC
	TDA3586	CSB503F12	TV Horizontal Oscillator for NTSC
SIEMENS	SDA1000	CSB456F26	RDS System

-Appendix- Cross Reference of ICs V.C.O. and Ceramaic Resonator : CERALOCK*

(Sep.1993)

IC Maker	IC	CERALOCK®	Application
MOTOROLA	MC13020P	CSA3.60MGF102	AM Stereo Decoder
	MC13022P	CSA3.60MGF103	AM Stereo Decoder
	MC1378	CSA4.00MGF102	TV Horizontal Oscillator for PAL
	MC1378	CSA4.03MGF102	TV Horizontal Oscillator for NTSC
	MC144130	CSB437F3	PAL,B/G Multi-Sound Decoder
PHILIPS	TDA1591	CSB456F11	FM Multiplexer
	SAA5231	CSA6.00MTZ002	Teletext
S.G.S. THOMSON	TDA7338	CSB456F21	FM Multiplexer
	TDA8185	CSB503F12	TV Horizontal Oscillator for NTSC
	TDA3586	CSB503F12	TV Horizontal Oscillator for NTSC
SIEMENS	SDA1000	CSB456F26	RDS System

-Appendix- Equivalent Curcuit Constants of CERALOCK[®]

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

CERALOCK [®]	Fr (kHz)	Fa (kHz)	R1 (ohm)	Ra (kohm)	L1 (mH)	C1 (pF)	Co (pF)
CSB456F15	434.67	457.26	7.64	140.04	3.448	38.903	364.777
CSB456F16	434.56	457.27	10.89	127.59	3.896	34.427	321.388
CSB456F21	433.04	456.12	9.20	129.73	3.257	41.488	379.506
CSB456F23	433.57	455.62	8.77	117.26	3.290	40.956	392.834
CSB472F3	450.07	473.04	11.57	141.24	4.132	30.269	289.071
CSB500F9	490.07	548.52	26.84	17.89	0.842	125.261	495.720
CSB503F2	509.10	552.29	7.74	78.03	1.354	72.164	407.935
CSB503F5	509.10	562.51	7.94	76.27	1.356	72.105	405.675
CSB503F6	519.98	583.46	26.46	19.73	0.832	112.613	424.867
CSB503F12	498.39	540.42	8.08	71.42	1.361	74.895	426.145
CSB503F30	513.90	575.54	42.54	29.27	1.324	72.429	284.810
CSB503F33	513.82	574.71	43.84	28.35	1.362	70.460	280.660
CSB503F36	503.51	543.27	9.60	54.10	1.390	71.700	436.780
CSB503F38	489.88	546.79	39.09	27.35	1.369	77.104	313.605
CSA3.60MGF102	3468.29	3779.44	6.00	101.07	0.269	7.810	41.660