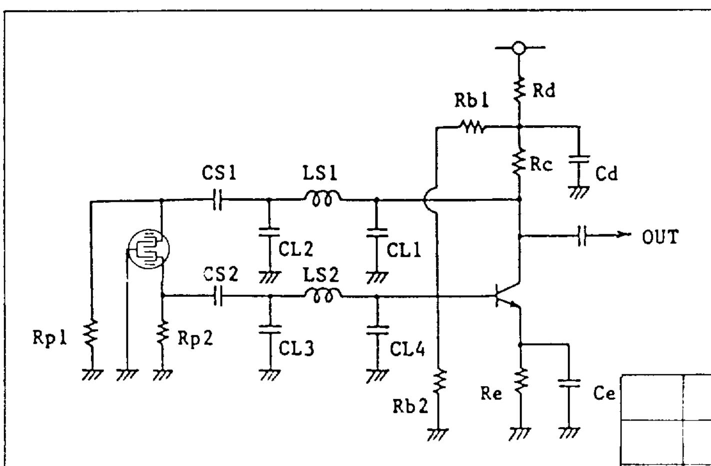
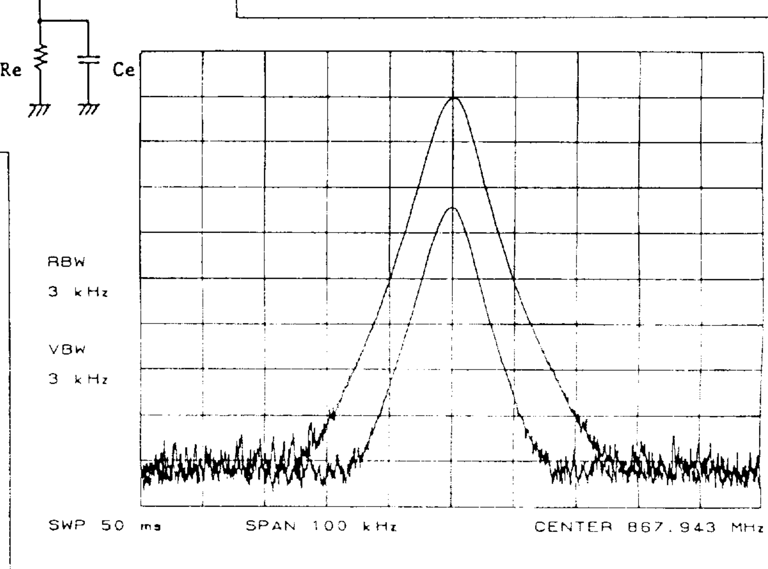
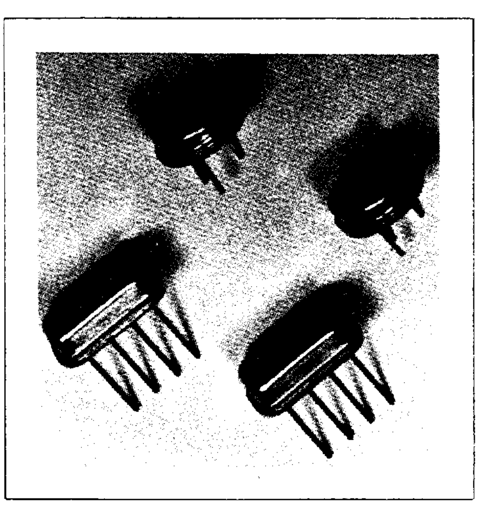
SURFACE ACOUSTIC WAVE RESONATOR

APPLICATION MANUAL







muRata *Innovator in Electronics*

Murata Manufacturing Co., Ltd.

TD. No. P01E-1

CONTENTS

1. INTRODUCTION

SAW RESONATOR utilizes Surface Acoustic Wave, and is able to be applied to high frequency circuits where conventional crystal, ceramic resonators are not available, as SAW RESONATOR oscillates stably with its fundamental mode over frequency range from 50 MHz to around 1 GHz. (See Fig.1-1)

MURATA SAW RESONATOR - SAR series - has high stability, good temperature characteristics provided by quartz crystal substrate and is developed with SAW technology accumlated for SAW FILTERs through MURATA's long experience.

SAW RESONATOR can be applied to many types of high frequency devices including RF remote controls, CATV FSK demodulators and CATV 2nd. local oscillators.

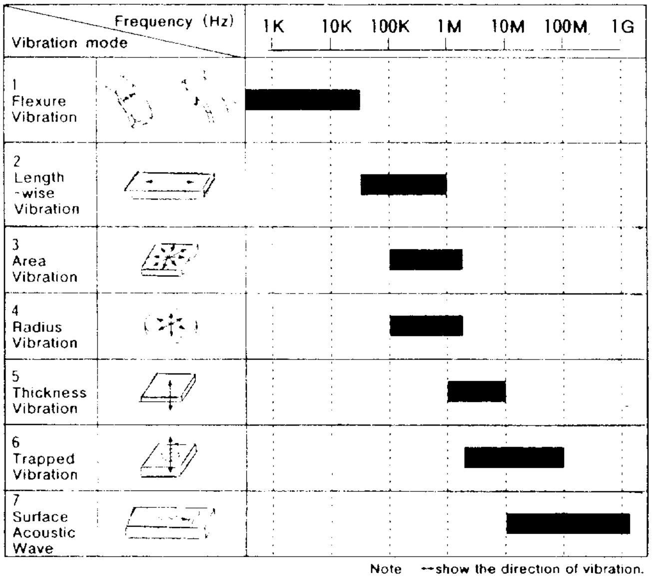


Fig.1-1 Vibration Mode and Suitable Frequency Range

2. GENERAL CHARACTERISTICS

SAW RESONATOR generally has the following features.

① HIGH OSCILLATION FREQUENCY STABILITY

Both initial tolerance and temperature coefficient of oscillating frequency of SAW RESONATOR are between quartz bulk resonator's and LC's / RC's.
Temperature coefficient of oscillating frequency for quartz crystal: $10^{-6}/^{\circ}C$, LC: 10^{-3}-$10^{-4}/^{\circ}C$, while SAW RESONATOR: $5\times10^{-6}/^{\circ}C$. (See Fig.2-1)

② ADJUSTMENT FREE

As SAW RESONATOR utilizes mechanical vibration of piezoelectric material, while LC/RC utilizes electrical resonance, oscillator using SAW RESONATOR is stable against peripheral circuit or supply voltage fluctuation, and is basically free from adjustment.

③ SIMPLE/LOW COST CIRCUIT BY FUNDAMENTAL OSCILLATION

Multiplying circuit necessary for quartz bulk wave resonator is not required as SAW RESONATOR oscillates with its fundamental mode over the frequency range of 50 MHz to 1 GHz. Therefore, oscillation circuit is simple and low cost.

SAR series also has the following features.

① QUARTZ CRYSTAL SUBSTRATE

SAR series realizes better temperature characteristics, higher stability against peripheral circuit, by utilizing quartz crystal substrate, compared to SAW RESONATORS with other materials.

② EPITAXIALLY GROWN ALUMINUM THIN FILM ELECTRODES

High power handling and long life have been achieved by specially developed epitaxially grown aluminum thin film electrodes. (See Sec.4.)

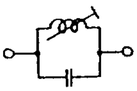
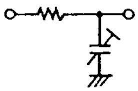
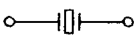
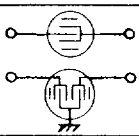
NAME	SYMBOL	INITIAL TOLERANCE	ADJUSTMENT	NOTE
LC		±2.0%	NEEDED	need delicate adjustment of resonant frequency.
CR		±2.0%	NEEDED	unsuitable for high frequency circuits.
QUARTZ CRYSTAL		±0.001%	FREE	need another devices to oscillate at overtone mode in high frequency.
SAW RESONATOR		±0.1%	FREE	high frequency oscillation with fundamental mode.

Table 2-1 Characteristics of Various Resonator

3. TYPE / TYPE NAME

Part numbering system for MURATA SAW RESONATOR - SAR series - is as follows;

SAR [b] M [d] [e] [f] X [h]

a b c d e f g h

a/ SAW RESONATOR
b/ oscillating frequency [MHz]
c/ MHz
d/ Resonator Type
  'B' ---- 1-port type
  'DA' --- 2-port type (in/out phase shift: 180°)
e/ Package
  '3' ---- TO-39 (round metal case hermetically sealed) ※
  '4' ---- SF-712 (square metal case hermetically sealed) ※
f/ Specification
  '0' ---- Standard
  '1-9' -- Custom Specification
g/ Quartz Crystal Substrate
h/ Initial Frequency Tolerance [± KHz]

※ See Fig.3-1

Standard frequency list is shown in Appendix attached.

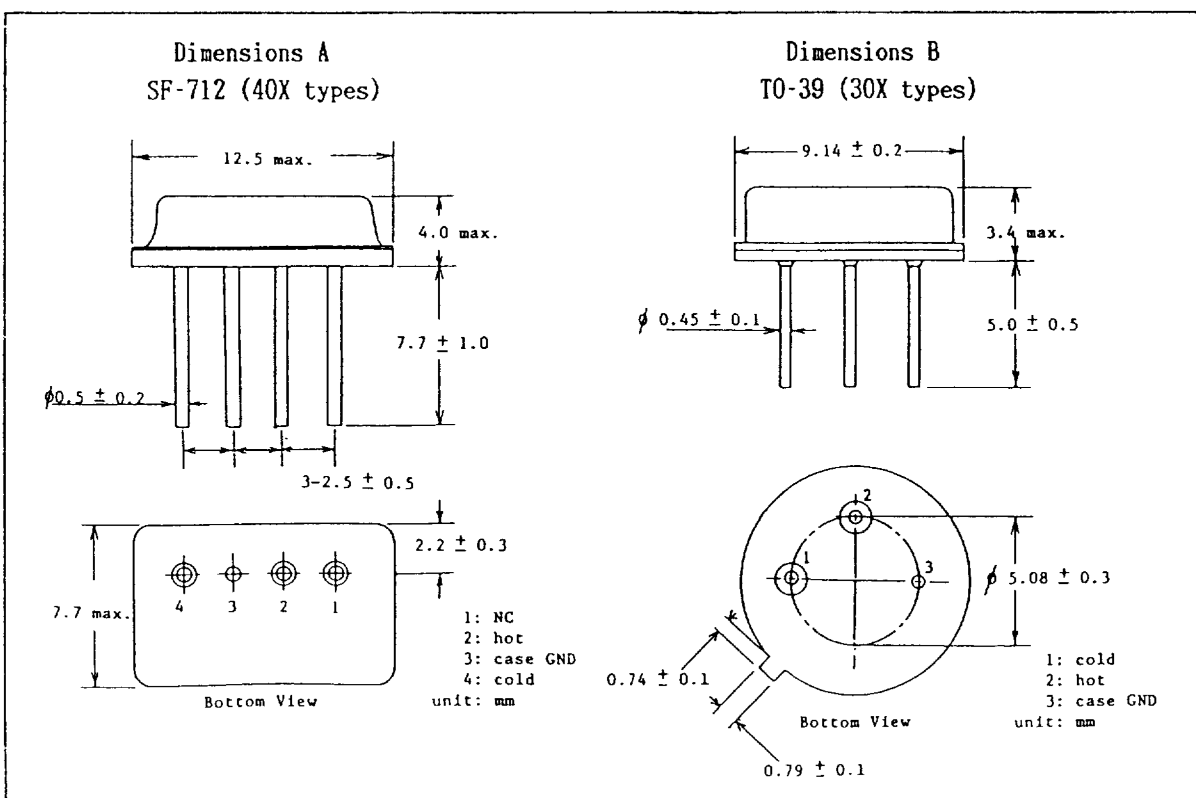


Fig.3-1 Dimensions

4. ELECTRICAL CHARACTERISTICS

Frequency stability of SAW RESONATOR is between that of quartz bulk wave resonator and LC/RC. Temperature coefficient of SAR series is ±5 ppm/°C max., and initial tolerance of standard products is ±150 - ±250 KHz depending on nominal oscillting frequency. Tighter initial tolerance down to ±50 KHz may be available. Please contact MURATA.

1-port SAW RESONATOR is basically a 2 terminal device and its application is similar to that of quartz bulk wave resonator or ceramic resonator. Most of the application circuit is Colpitts or similar type that can be made with low cost. 1-port SAW RESONATOR is also applicable to V.C.O. application.

2-port SAW RESONATOR is a kind of very narrow, low loss band-pass filter. Oscillation circuit is mostly like a RF amplifier with feedback loop. Oscillation circuit design is easier with 2-port SAW RESONATOR in high frequency because oscillation can be analyzed by evaluating transmission characteristics, which can be measured with a network analyzer.

4-1. 1-PORT SAW RESONATOR

1-port SAW RESONATOR has one IDT(Interdigital Transducer), which generates and receives SAW(Surface Acoustic Wave), and two grating reflectors, which reflect SAW and generate a standing wave between the two reflectors. IDT and reflectors are fabricated on quartz crystal substrate by photolithographic process. Cut angle of the substrate shall be selected carefully. SAW RESONATOR chip is encapsuled in a metal case hermetically sealed.

Fig. 4-1: Basic structure of 1-port SAW RESONATOR
Table 4-2: Examples of electrical specification for 1-port SAW RESONATOR
Fig. 4-3: Test circuit
Fig. 4-4: Transmission, temperature characteristics of 1-port SAW RESONATOR
Fig. 4-5: Electrical equvalent circuit of 1-port SAW RESONATOR
Table 4-6: Typical constant values in equivalent circuit

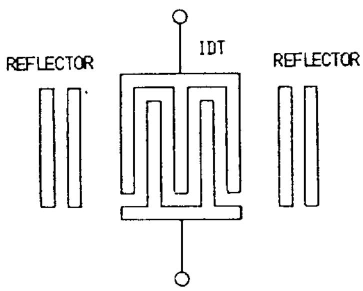


Fig.4-1 Basic Structure of 1-port SAW RESONATOR

Part Number	Resonant Loss [dB] max.	Resonant Frequency [MHz]	Parallel Capacitance [pF]	Temp. Coef. of Resonant Freq. [ppm/°C] max.	Test Circuit	Dimensions
SAR173.2MB40X150	1.8	173.18 +/- 0.15	4.2 +/- 1	+/- 5	1	A
SAR224.5MB40X200	2.0	224.46 +/- 0.20	3.9 +/- 1	+/- 5	1	A
SAR300.0MB40X250	2.0	299.95 +/- 0.25	3.1 +/- 1	+/- 5	1	A
SAR418.0MB30X250	2.5	417.95 +/- 0.25	2.5 +/- 1	+/- 5	2	B
SAR433.9MB30X250	2.5	433.87 +/- 0.25	2.5 +/- 1	+/- 5	2	B

Table 4-2 Specification of 1-port SAW RESONATOR

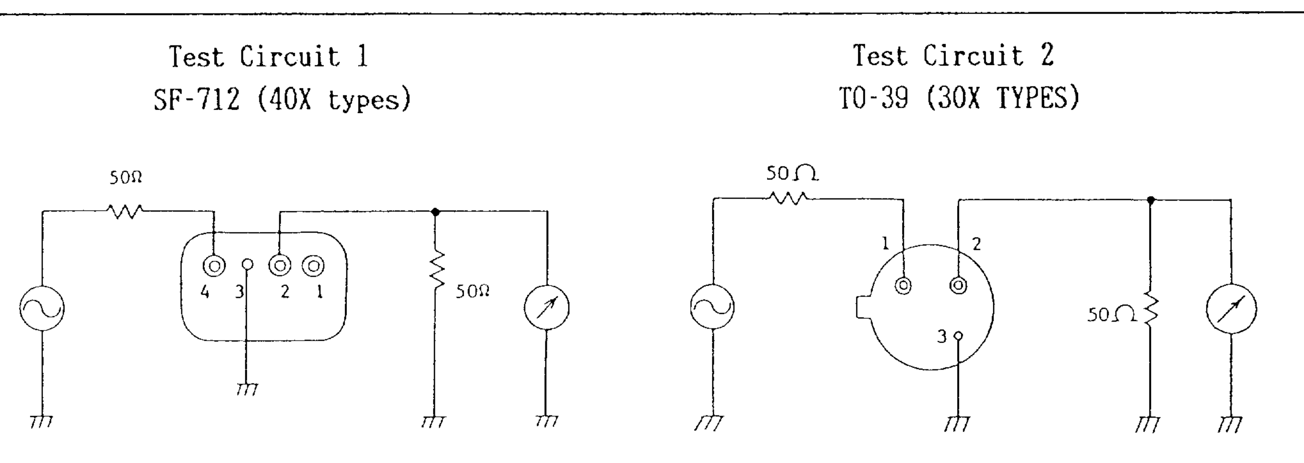


Fig.4-3 Test circuit

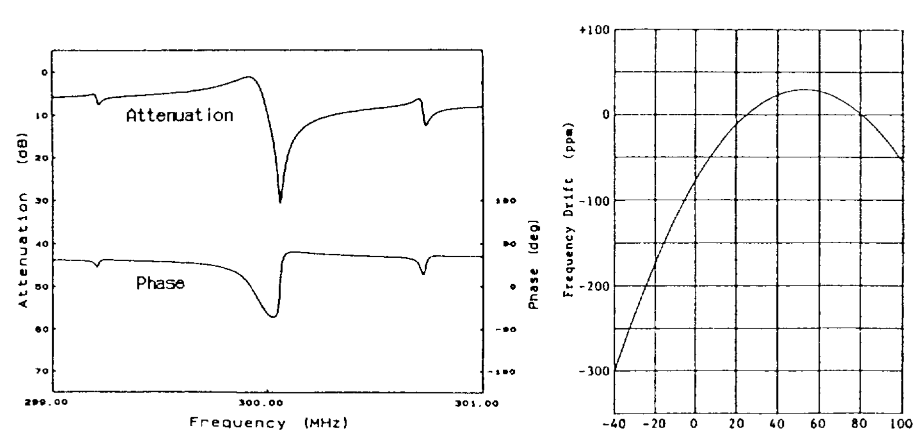


Fig.4-4 Transmission, Temperature Characteristics of 1-port SAW RESONATOR

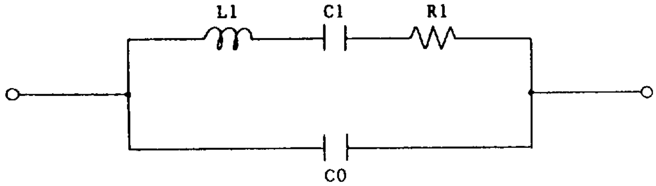


Fig.4-5 Equivalent Circuit of 1-port SAW RESONATOR

	L1 [mH]	C1 [pF]	R1 [Ohm]	C0 [pF]
SAR173.2MB40X150	0.30	0.0028	17.1	4.19
SAR224.5MB40X200	0.20	0.0025	19.1	3.76
SAR300.0MB40X250	0.13	0.0022	19.3	3.22
SAR418.0MB30X250	0.08	0.0018	20.6	2.83
SAR433.9MB30X250	0.08	0.0016	21.9	2.67

Table 4-6 Typical Constant Values of Equivalent Circuit

4-2. 2-PORT SAW RESONATOR

2-port SAW RESONATOR has two IDTs, one for input, another for output of signal and two grating reflectors. It is basically an ultra-low loss B.P.F. in the feedback loop of oscillation circuit. For popular oscillation circuit using transistor or linear IC, suitable phase shift across the resonator is 180 degrees. It is easier in measurement and circuit design to take 2-port SAW RESONATOR instead of 1-port especially for relatively high frequency application.

Fig. 4-7: Basic structure of 2-port SAW RESONATOR
Table 4-8: Examples of electrical specification for 2-port SAW RESONATOR
Fig. 4-9: Transmission, temperature characteristics of 2-port SAW RESONATOR
Fig. 4-10: Electrical equivalent circuit of 2-port SAW RESONATOR
Table 4-11: Typical constant values in equivalent circuit

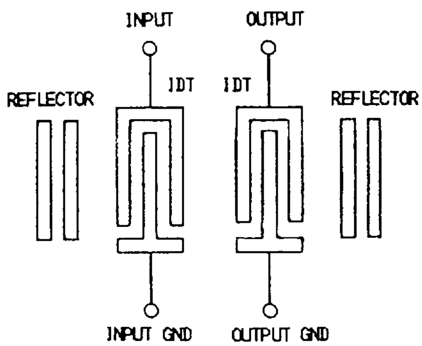


Fig.4-7 Basic Structure of 2-port SAW RESONATOR

Part Number	Insertion Loss [dB] max.	Center Frequency [MHz]	In / Out Capacitance [pF]	Spurious Response [dB] min.	Temp. Coef. of Resonant Freq. [ppm/°C] max.	Test Circuit	Dimensions
SAR224.5MDA30X200	12.5	224.5 +/- 0.20	1.65 +/- 1	12.0	+/- 5	2	B
SAR300.0MDA30X250	12.5	300.0 +/- 0.25	1.65 +/- 1	10.0	+/- 5	2	B
SAR418.0MDA30X250	12.0	418.0 +/- 0.25	1.65 +/- 1	7.0	+/- 5	2	B
SAR433.9MDA30X250	12.0	433.92 +/- 0.25	1.65 +/- 1	8.0	+/- 5	2	B

Table 4-8 Specification of 2-port SAW RESONATOR

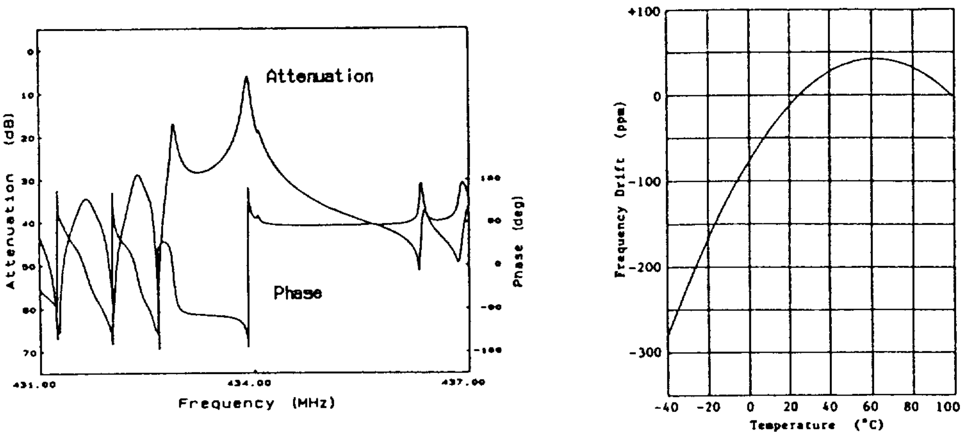


Fig.4-9 Transmission, Temperature Characteristics of 2-port SAW RESONATOR

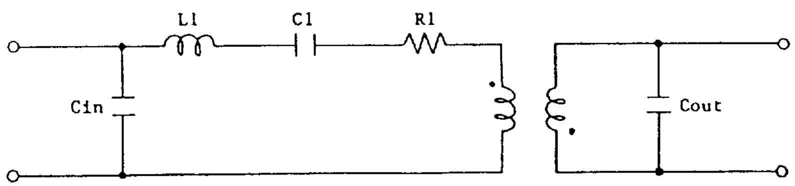


Fig.4-10 Equivalent Circuit of 2-port SAW RESONATOR

	L1 [mH]	C1 [pF]	R1 [Ohm]	Cin [pF]	Cout[pF]
SAR224.5MDA30X200	1.70	2.9	138	1.6	1.7
SAR300.0MDA30X250	0.98	2.9	104	1.7	1.7
SAR418.0MDA30X250	0.46	3.2	86	1.6	1.6
SAR433.9MDA30X250	0.44	3.1	87	1.6	1.7

$\times 10^{-}$[illegible]

Table 4-11 Typical Constant Values of Equivalent Circuit

4-3. POWER HANDLING AND LIFE

As frequency available by SAW RESONATOR goes high, it is getting a problem that stress migration of aluminum electrode is caused by a high power applied.

MURATA has successfully developed a new technology: epitaxially grown aluminum electrodes and realized much greater power handling, long life

Epitaxial aluminum film can be grown by controlling deposition condition. Fig.4-12 shows the RHEED(Reflection High Energy Electron Diffraction) analysis result of epitaxial aluminum film. Fig.4-13 shows RHEED result of polycrystal aluminum film for comparison.

Set-up and result of operational life test are shown in Fig.4-14, 4-15 respectively. Here, SAW RESONATOR under test is a 674MHz 2-port type designed for CATV 2nd. local oscillator, and applied power is 1 Watt. The computer controls the frequency of the signal generator to trace the resonant frequency of the device under test.

When defining the life of resonator in terms of resonant frequency shift: 100ppm, life with epitaxial aluminum is more than 10,000 minutes, which is about 100-1,000 times longer than that of the conventional SAW RESONATOR using polycrystal aluminum electrodes.

Long term stability/reliability is required especially for the application, such as CATV 2nd. local oscillator, which keeps SAW RESONATOR under operation.

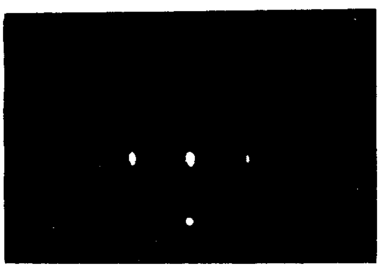


Fig.4-12 RHEED Result of Epitaxial Aluminum Film

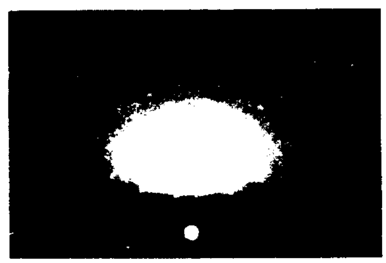


Fig.4-13 RHEED Result of Polycrystal Aluminum Film

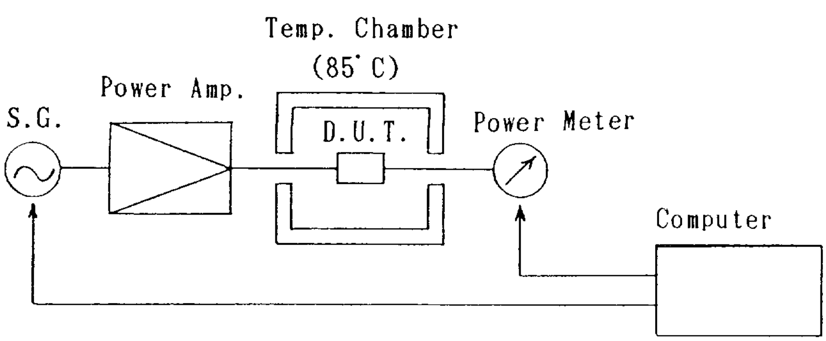


Fig.4-14 Operating Life Test Set-up

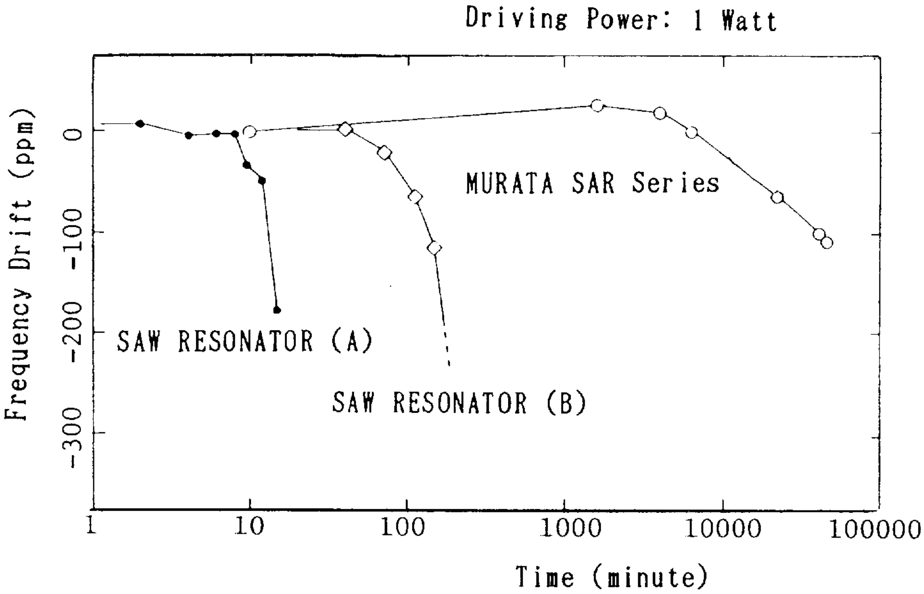


Fig.4-15 Life Test Results

5. PRINCIPLE OF OSCILLATION

Oscillation circuits using LC or quartz crystal are called 'Feedback Oscillators'. Feedback oscillator consists of an amplifier and a feedback circuit.

The circuit oscillates, with no input singal applied from outside of the oscillator, when feedbacked signal from the output of the amplifier has the same amplitude and phase to the input signal. The conditions required to the feedback to enable oscillation are as follows;

Amplitude: $G = \alpha + \beta \geqq 0$ [dB]

Phase: $\theta = \theta 1 + \theta 2 = 360 \times n$ [degree] (n: Natural number)

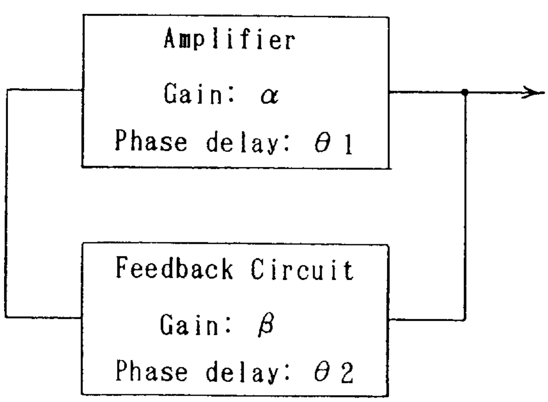


Fig.5-1 Principle of Oscillation

6. OSCILLATION CIRCUITS

6-1. OSC. USING 1-PORT SAW RESONATOR

1-port SAW RESONATOR is a kind of two terminal resonant device utilizing piezoelectricity, like quartz crystal bulk wave resonator or ceramic resonator. The equivalent circuit of 1-port SAW RESONATOR is same to that of quartz or ceramic resonator, and therefore, impedance characteristics of SAW RESONATOR is as shown in Fig.6-1.

Colpitts is one of the popular oscillation circuits. Basic structure of Colpitts oscillator is as shown in Fig.6-2. The oscillating frequency is approximately same to the resonant frequency of L, CL1 and CL2.

$$fosc = 1 / 2\pi (L \cdot CL1 \cdot CL2 / (CL1+CL2))^{1/2}$$

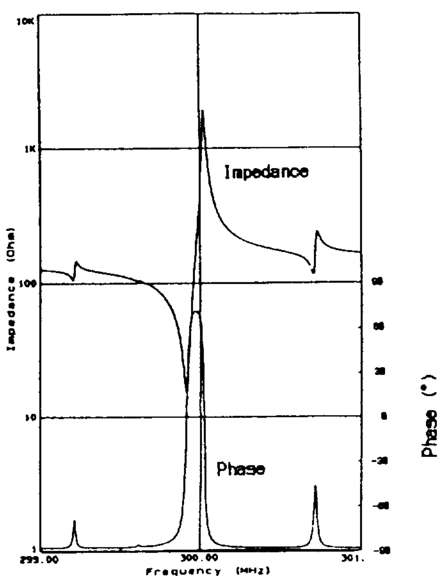


Fig.6-1 Impedance Characteristics of 1-port SAW RESONATOR

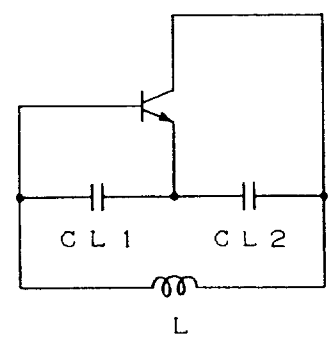


Fig.6-2 Basic Structure of Corpitts Osciilator

In the case of an oscillation circuit using piezo resonator, the inductor in Fig.6-2 can be replaced by the resonator because its impedance is inductive between fr (impedance minimum) and fa (impedance maximum) as shown in Fig.6-1.

Fig.6-3 shows an example of oscillation circuit using 1-port SAW RESONATOR. Rb1, Rb2 are for DC bias. Re is a load impedance. Rd, Cd are for power line de-coupling. CL1, CL2 are load capacitances to satisfy oscillation conditions.

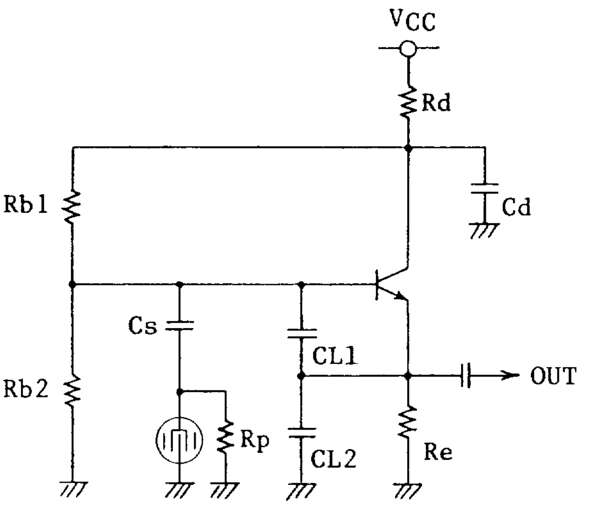


Fig.6-3 Example of 1-port SAW Oscillator

Values of CL1, CL2 must be evaluated to get desired oscillating frequency.

Transistor shall be a high frequency type - fT a few GHz or more.

SMT type transistor, resistor, capacitor are recommended for application more than 100 MHz due to the inductance of the lead terminals.

Cs and Rp are recommended for DC de-coupling and discharge respectively to protect SAW RESONATOR from electro-migration.

6-2. OSC. USING 2-PORT SAW RESONATOR

2-port SAW RESONATOR is a four-terminal device. The simplified oscillation circuit diagram is as shown in Fig.6-4.

SAW RESONATOR is connected to tuning networks, and the networks are connected to input / output of amplifier. Network here is generally a π-type consists of one inductor and two capacitors. The networks control phase shift in the feedback loop to satisfy oscillating conditions, and work as tuning circuit for impedance matching of SAW RESONATOR and amplifier to get small insertion loss.

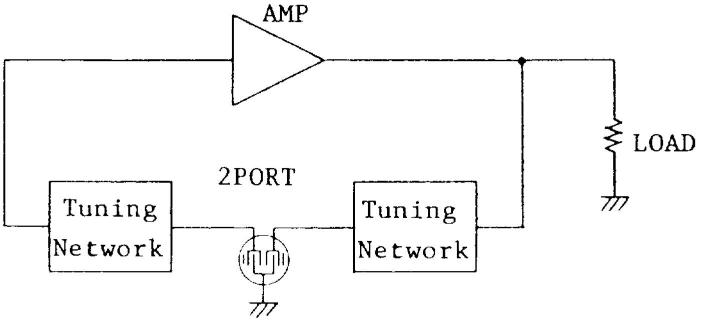


Fig.6-4 Basic Structure of 2-port SAW Oscillator

Fig.6-5 shows an example of oscillation circuit using 2-port SAW RESONATOR. Amplifier here is a grounded-emitter transistor. The smaller Re, the larger gain, however, proper Re value shall be selected considering current consumption and DC bias condition. To get large RF gain, it is recommended to put Ce, however, Ce value shall not be too large because of its low self-resonance. Ce shall be between 100 and 1000 pF generally.

One π-type tuning network consists of LS1, CL1 and CL2, and another LS2, CL3 and CL4. Input / ouput capacitance of SAW RESONATOR may be substitutive to CL2, CL3. Input / output capacitance of transistor may be substitutive to CL1, CL4.

Phase shift in the feedback loop is controlled mainly by the resonance of LS1 / CL2 and LS2 / CL3. The values of those elements shall be especially precise, so LS1, LS2 shall be fine tuned. Air core coils are recommended due to high self-resonant frequency and high Q.

DC de-coupling capacitor: CS1, CS2, discharge resistor: RP1, RP2 are recommended.

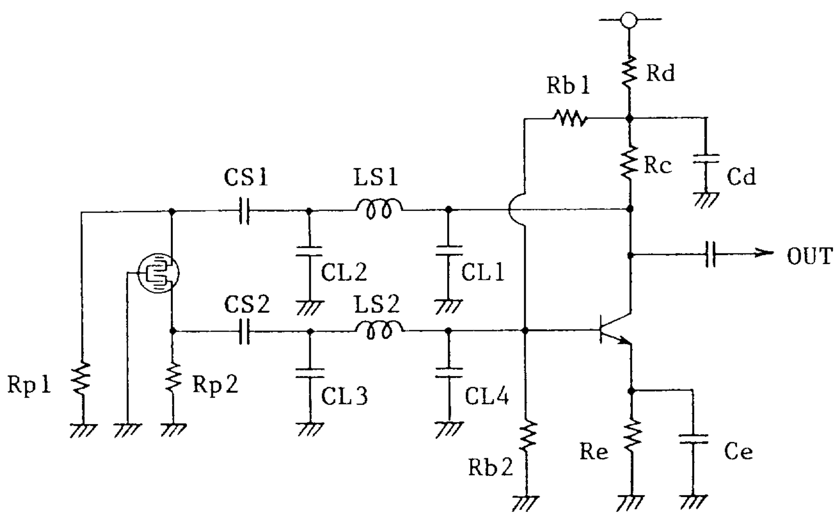


Fig.6-5 Example of 2-port SAW Oscillator

7. ACTUAL MEASUREMENTS OF SAW OSCILLATOR

7-1. 1-PORT SAW OSCILLATOR

Fig.7-1 shows an example of oscillator with 1-port SAW RESONATOR. Here, transistor is NEC 2SC3356, SAW RESONATOR is SAR300.0MB40X250 (300.0 MHz resonator).

Supply voltage (Vcc) characteristics and temperature characteristics are shown in Fig. 7-2, 7-3 respectively. Vcc characteristics depends partly on amplifier (Tr or FET) used, but is generally within ± 200 ppm. Temperature characteristics of the circuit mainly depends on that of SAW RESONATOR itself as you can see comparing to Fig.4-4. Capacitors taken here are CH grade types. Some popular transistors may have relatively strong dependence upon temperature. It is important to test the whole circuit in a temperature chamber.

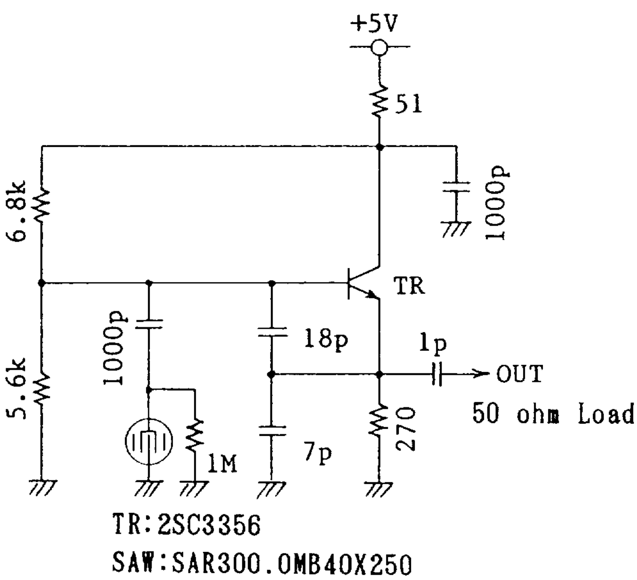


Fig.7-1 1-port SAW Oscillator

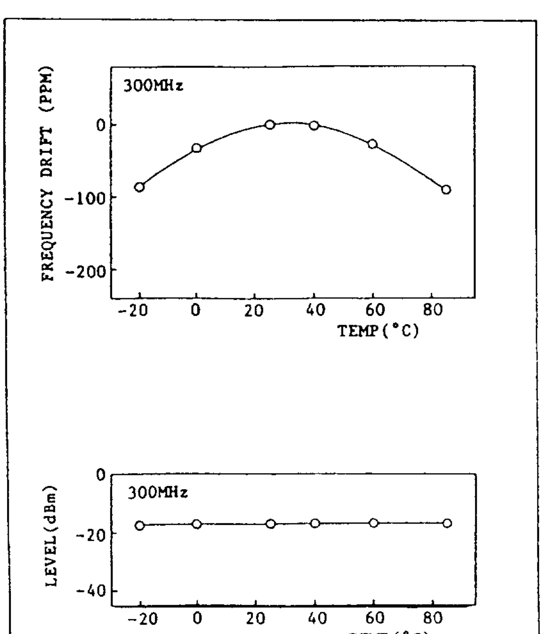


Fig.7-2 Vcc Characteristics

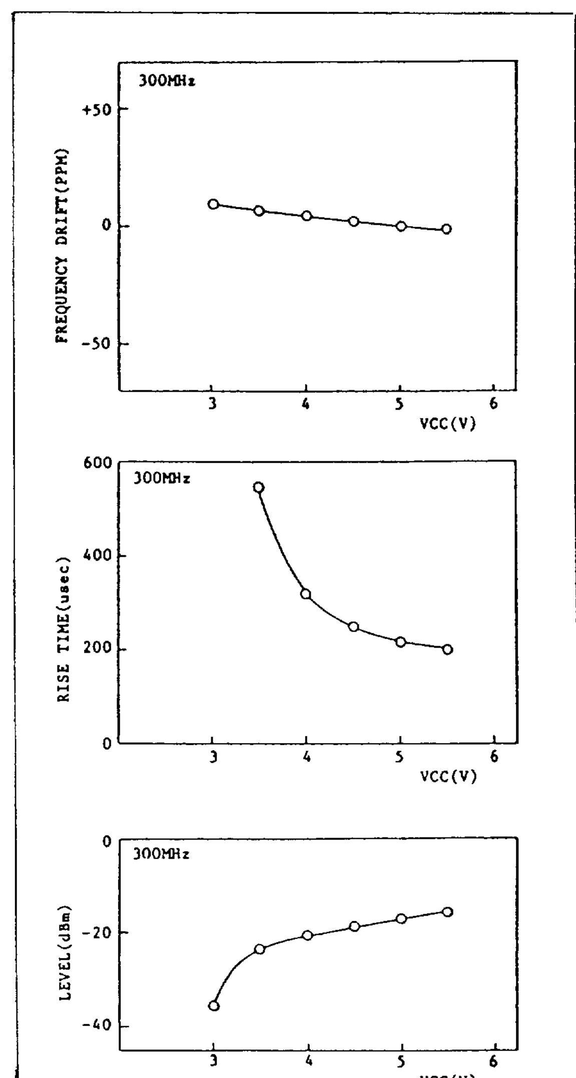


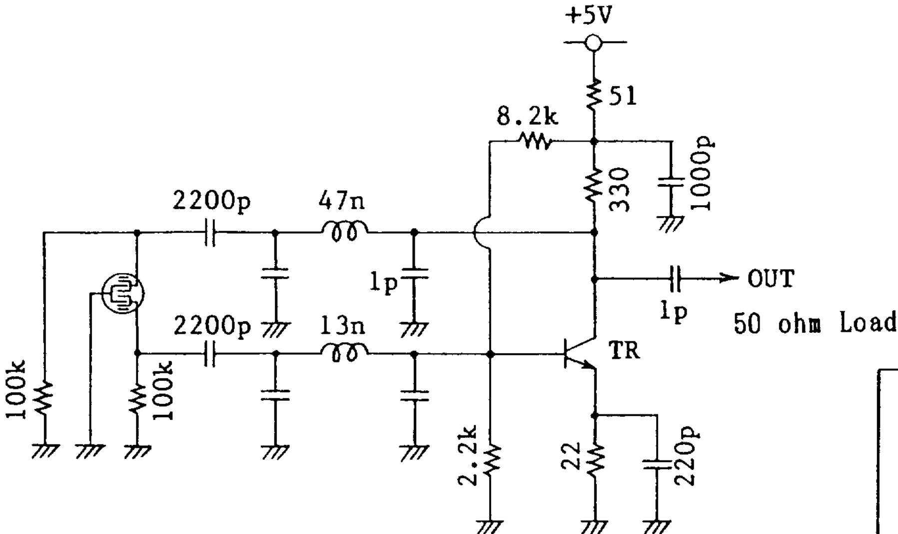
Fig.7-3 Temperature Characteristics

7-2. 2-PORT SAW OSCILLATOR

An oscillator using SAR674.0MDA30X250 (674 MHz 2-port SAW RESONATOR) shown in Fig.7-4 was measured.

Measurement results are shown in Fig.7-5, 7-6.

Results are similar to that of 1-port type.



TR:2SC3356
SAW:SAR674.0MDA30X250

Fig.7-4 2-port SAW Oscillator

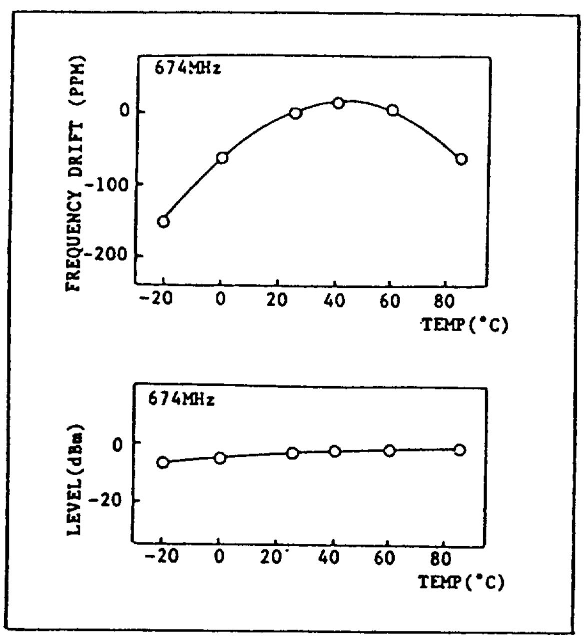


Fig.7-5 Vcc Characteristics

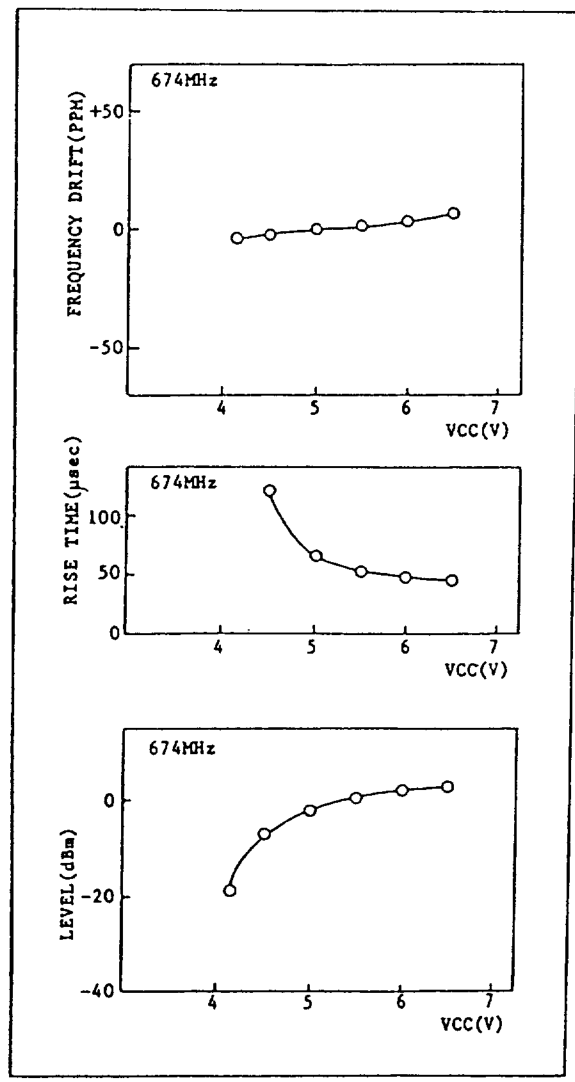


Fig.7-6 Temperature Characteristics

8. DESIGNING SAW OSCILLATOR

8-1. DESIGNING 1-PORT SAW OSCILLATOR

1-port SAW RESONATOR shows an impedance curve just like a quartz crystal or ceramic resonator. The oscillation circuit is also similar to that with quartz crystal or ceramic resonator.

For example, Fig.8-1 shows the "Sabaroff Oscillator" using emitter follower amplifier.

When admittance of resonator is Y=G-jB, mutual conductance of amplifier is gm, then from Fig.8-2, the oscillation conditions are;

$$gm \geqq G*(1+CL2/CL1)+1/RE-B/w*CL1*RE$$
$$B*(1+CL2/CL1)-w*CL2+G/w*CL1*RE = 0$$

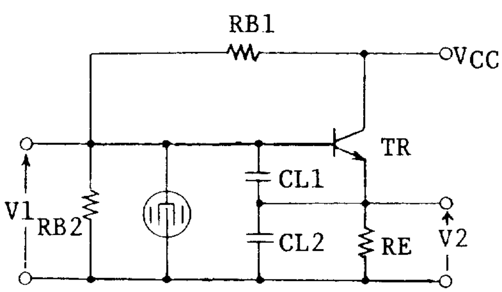


Fig.8-1 Sabaroff Oscillator

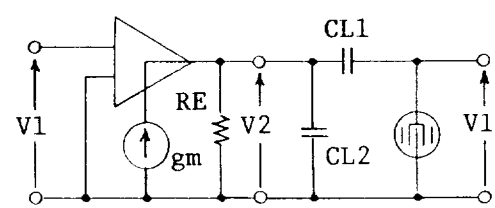


Fig.8-2 Equivalent Circuit of Sabaroff Oscillator

Oscillation condition will be affected by CL1, CL2 other than gm and admittance of the resonator. Therefore, the values of CL1, CL2 shall be different for different types of resonator, transistor. In the case of the oscillation circuit shown in Fig.8-1 with SAW RESONATOR 300 MHz or so, the aim for loarding capacitors are: CL1 = 10-20 pF, CL2 = 5-10 pF.

In high frequency or with small gm, suitable CL1 and CL2 may be a few pF. Stray capacitance of P.C.B. pattern will not be negligible and require careful consideration.

8-2. DESIGNING 2-PORT SAW OSCILLATOR

2-port SAW oscillator consists of an amplifier, SAW RESONATOR and tuning network circuit. The tuning network circuit has two roles: impedance matching between amplifier and SAW RESONATOR, Controlling phase shift. Generally it is a π-type circuitof one inductor and two capacitors.

Values of the inductor and capacitors can be obtained by the following procedure.

(1) Measurement of Input/Output Impedance of Amplifier

Measure input/output impedace, gain and phase shift of amplifier used.

Actual measurement result using a circuit shown in Fig.8-3 is about 9 dB at the desired oscillation frequency.

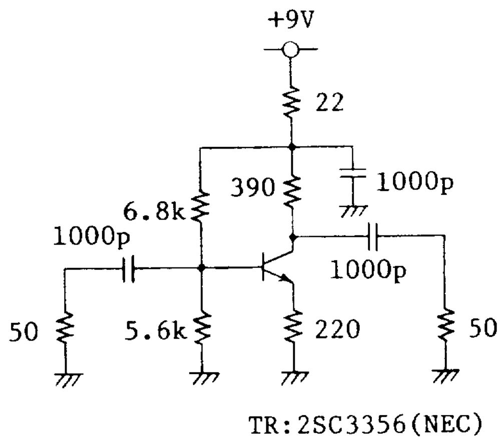


Fig.8-3 Amplifier

(2) Determination Source/Load Impedance for SAW RESONATOR

The higher source/load impedance, the lower insertion loss.

Insertion loss should be much smaller than the gain measured in (1) for stable oscillation. Although you want to design source/load impedance large, however, there is a limitation for capacitance value controllable by discrete capacitor. Impedance in this case is determined to be 300 ohms because larger impedance will require capacitor of smaller than 1 pF.

Fig.8-4 shows transmission characteristics of 674MHz 2-port SAW RESONATOR with 300 ohms source/load impedance.

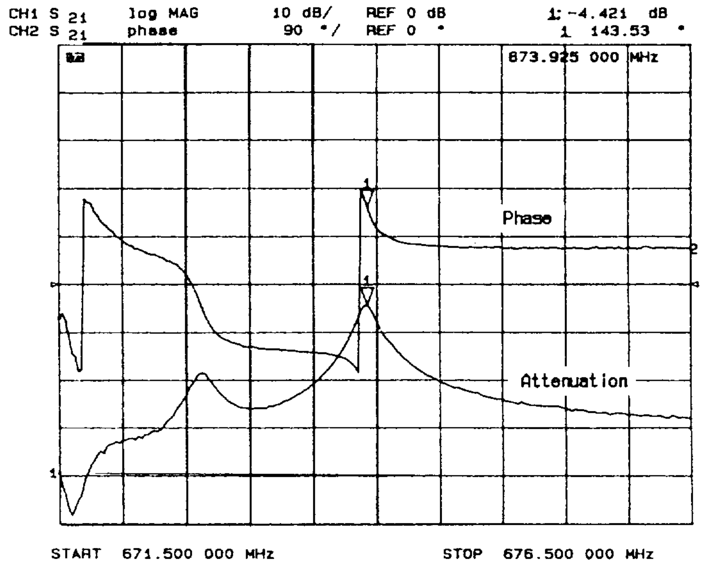


Fig.8-4 Transmission Characteristics of SAR674.0MDA in 300 ohm system

(3) Calculation of Network Circuit

Fig.8-5 shows amplifier and two tuning networks. Here, R1, R4 are the impedance determined in (2), and R2, R3 are input/output impedance of amplifier respectively. Surpose the phase shift through Network-1, Amp, Network-2 are $\theta 1$, $\theta 2$, $\theta 3$, respectively. Then,

$$Xi1 = R1*R2*\sin\theta_1/(R2*\cos\theta_1-(R1*R2)^{1/2})$$
$$Xi2 = R1*R2*\sin\theta_1/(R1*\cos\theta_1-(R1*R2)^{1/2})$$
$$Xi3 = (R1*R2)^{1/2}*\sin\theta_1$$
$$Xo1 = R3*R4*\sin\theta_3/(R4*\cos\theta_3-(R3*R4)^{1/2})$$
$$Xo2 = R3*R4*\sin\theta_3/(R3*\cos\theta_3-(R3*R4)^{1/2})$$
$$Xo3 = (R3*R4)^{1/2}*\sin\theta_3$$
$$\theta_1+\theta_3 = 180^\circ+\theta_2$$ (when phase shift through SAW RESONATOR is 180°)

By solving above equations, values of network components are obtained. Note that Xi1, Xo2 include shunt capacitance of SAW RESONATOR and it should be subtracted.

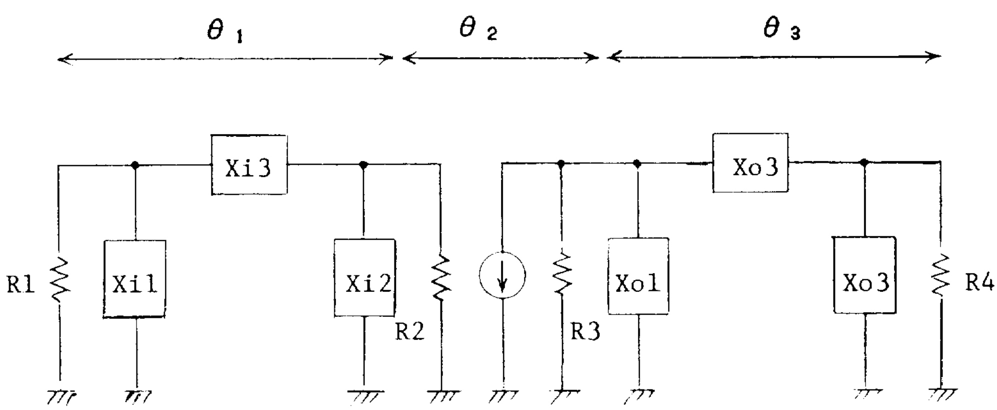


Fig.8-5 Amplifier and two networks

The values obtained here shall be considered to be a starting point for circuit design. It is recommended that values, especially inductance Xi2, Xo2, shall be optimized by actual circuit evaluation.
Put inductance Xi2, Xo2 apart so that the coupling of those will not afect oscillation characteristics.

9. APPLICATION CIRCUITS

9-1. RF REMOTE CONTROL TRANSMITTER

RF remote control transmitter for automotive security device is getting popular especially in Europe. MURATA SAR series are suitable for this application due to the advantage of adjustment-free (or easy adjustment) and high stability.

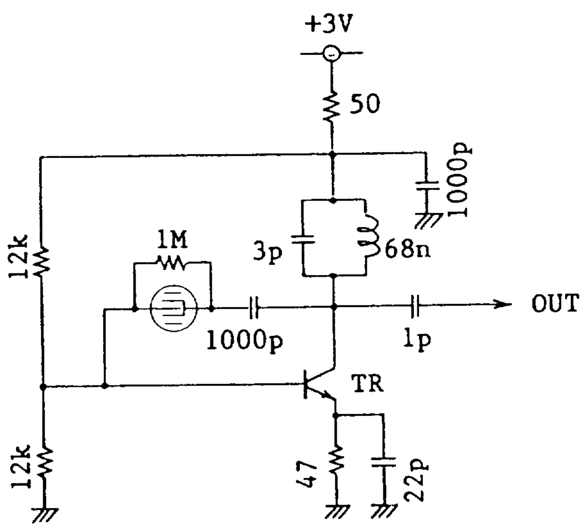
Examples of application circuit are shown in Fig.9-1, 2 and 3.

Fig.9-1: 1-port SAW RESONATOR as a feedback device from Collector to Base.
L and C connected to Collector.

Resonance of L / C at Collector provides good selectivity for fundamental mode and good suppression for harmonics.
For an application which requires high precision, tune the L value.

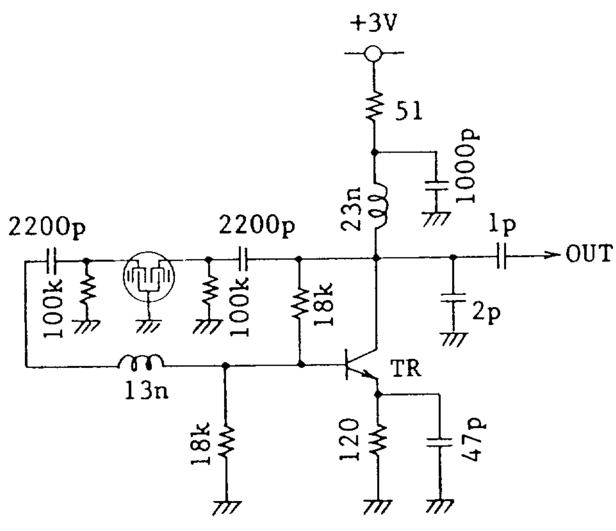
Fig.9-2: 2-port SAW RESONATOR between Collector and Base.
Tuning coils between Collector and Vcc, Base and SAW RESONATOR.

The circuit utilizes the resonance of L(23nH) at Collector-Vcc and C(2pF) at Collector-Ground.
It is recommended to fine tune the L.



TR:2SC3356
SAW:SAR433.9MB40X250

Fig.9-1 Application to RF Remote Controller (1)



TR:2SC3356
SAW:SAR300.0MDA30X250

Fig.9-2 Application to RF Remote Controller (2)

Fig.9-3: 1-port SAW RESONATOR connected between Base and Ground.
L connected to Collector, C between Collector-Emitter, Emitteter-Ground.

The circuit has relatively small current consumption.
Need fine tuning of L, or trimmer capacitor.
R connected in parallel to L is for Q dump. But too large R will cause LC oscillation.

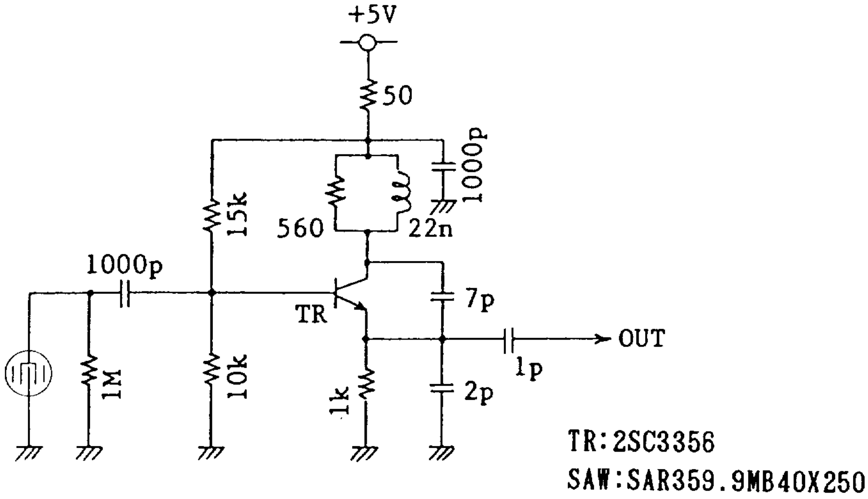


Fig.9-3 Application to RF Remote Controller (3)

9-2. CATV FSK DEMODULATOR

One of the CATV service program employs data communication by FSK (Frequency Shift Keying). SAW RESONATOR is widely used for the local oscillation for FSK signal demodulation.

Fig.9-4 shows an application of SAR84MB40X to a popular IC: LA7770 (SANYO).

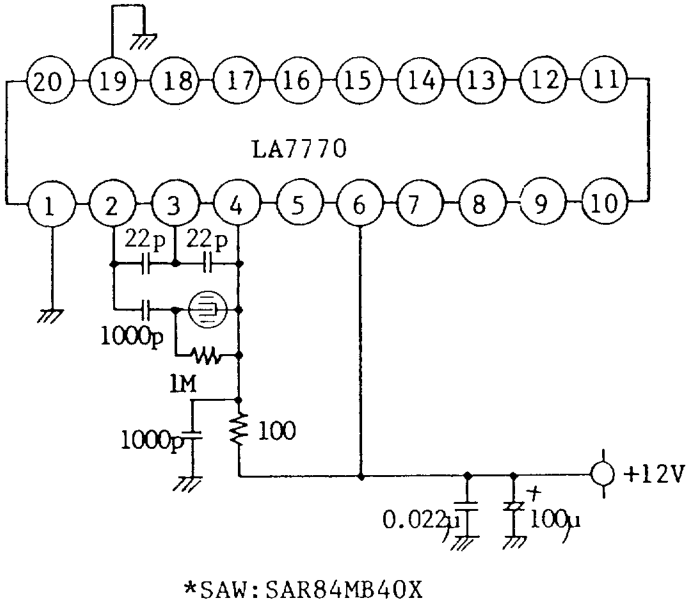
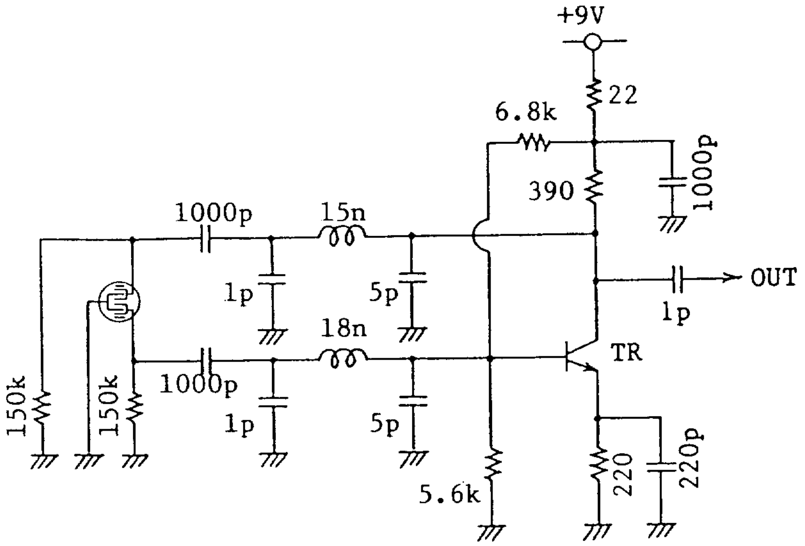


Fig.9-4 Application to FSK Demodulator

9-3. CATV 2ND. LOCAL OSCILLATOR

SAW resonator can be employed for the 2nd. local oscillator in CATV converter.
Fig.9-5 shows an example using 2-port SAW RESONATOR: SAR674.0MDA30X250 in a transistor oscillation circuit.



TR:2SC3356
SAW:SAR674.0MDA30X250

Fig.9-5 Application to CATV 2nd Local Oscillator

9-4. OTHER APPLICATION NOTES

Besides the notes mentioned above - de-coupling capacitor, discharge resistor - some other notes shall be added.

(1) Driving Power
Driving power for SAW RESONATOR is defined as follows;

$P = R * I^2$ where P: driving power
R: real part of the SAW RESONATOR's impedance at oscillating frequency
I: current flowing across the SAW RESONATOR

It is recommended not to apply driving power larger than 2 mW.

(2) Buffer

Some oscillation circuit may create relatively large level of harmonics.
Attempt to reduce the harmonics by changing oscillating circuit design may also suppress fundamental oscillation.
Buffer stage with tuning circuit is recommended for harmonics suppression.
Fig.9-6 is an example of the buffered circuit.

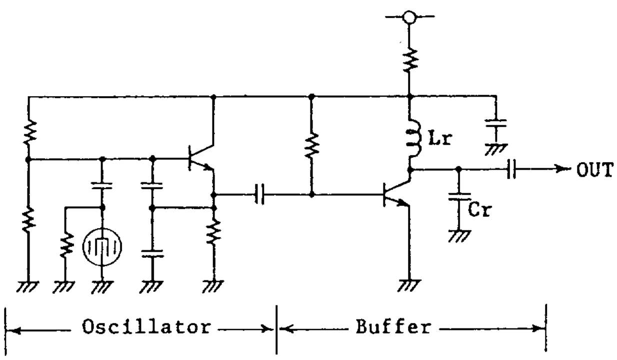


Fig.9-6 Example of Buffer Circuit

(3) Spurious Response

Fig.9-7 shows an example of impedance characteristics of a 2-port SAW RESONATOR: SAR418.0MDA30X250. The spurious response at around 417 MHz is called 'longitudinal mode spurious' and is relatively large, however, the phase at main response and the phase at this spurious are different by 180°, and so circuit will not oscillate at the spurious frequency.
However, the chance of spurious oscillation still exists when values of L, C changes, if the phase condition of oscillation loop are not proper.
It is necessary to design oscillator to set the oscillation loop phase 0° point in the middle of the phase response as per shown in Fig.9-8 to minimize the chance.

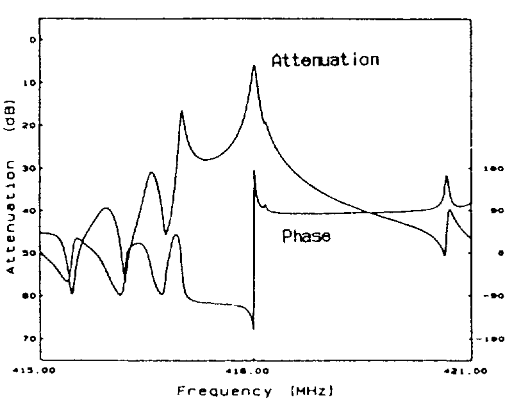


Fig.9-7 Spurious Responce of 2-port SAW RESONATOR

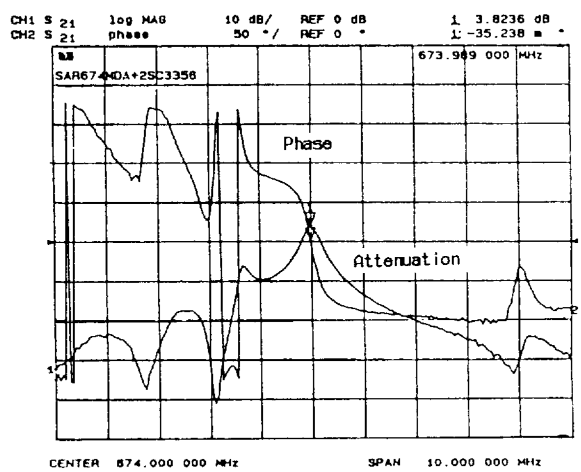


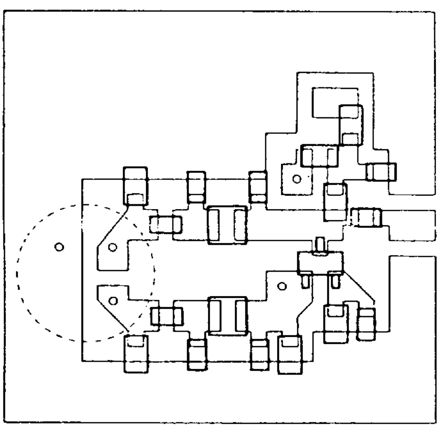
Fig.9-8 Adjustment of Loop Phase (Gain Phase of 2-port SAW Osc.)

(4) P.C.B. Patterning

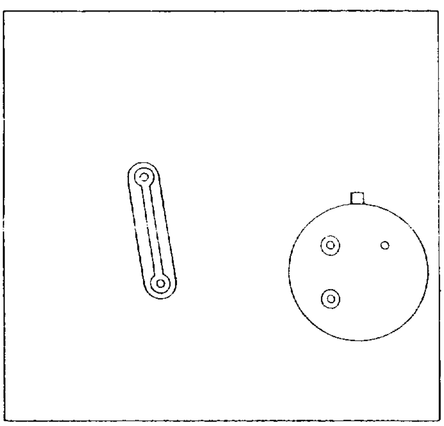
Just like other high frequency application, P.C.B. pattern shall be carefully designed. For example, ground loop, unnecessarily long pattern shall be avoided. And electro-magnetic shield shall be considered if necessary.

An example of P.C.B. pattern for oscillation circuit Fig.9-5 is shown in Fig.9-9.

Substrate: double sided, glass-epoxy, 1.6 mm (Sunhayato)
Transistor: 2SC3356 (NEC)
Chip Capacitor: GR39 series (Murata)
Chip Resistor: MCR10 series (Rohm)
Air Core Inductor: wire 0.6mmϕ coil 5mmϕ 1.5-2.5T
or Chip Inductor: LQN2A series (Murata)
SAW RESONATOR: SAR300.0MDA30X250 (Murata)



Top view



Bottom view

Fig.9-9 Example of P.C.B. Pattern
(Scale: 2X)

10. APPENDIX
SAW RESONATOR PRODUCT LIST FOR RF REMOTE CONTROLS, SECURITY SYSTEMS

(Effective Jan. 1993)

Nominal Oscillating Frequency [MHz]	PART NUMBER	
	1-PORT TYPE	2-PORT TYPE
172.8	SAR172.8MB40X150	-
173.2	SAR173.2MB40X150	SAR173.2MDA30X150
173.7	SAR173.7MB40X150	-
211.25	SAR211.2MB40X200	-
224.3	SAR224.3MB40X200	-
224.5	SAR224.5MB40X200	SAR224.5MDA30X200
224.6	SAR224.6MB40X200	-
224.7	SAR224.7MB40X200	SAR224.7MDA30X200
233.8	SAR233.8MB40X200	-
235.2	SAR235.2MB40X200	-
240.0	-	SAR240.0MDA30X200
240.4	SAR240.4MB40X200	-
270.0	SAR270.0MB40X250	-
289.3	SAR289.3MB40X250	-
300.0	SAR300.0MB40X250	SAR300.0MDA30X250
301.3	SAR301.3MB40X250	-
303.875	SAR303.8MB40X250	SAR303.9MDA30X250
304.0	SAR304.0MB40X250	-
304.3	SAR304.3MB40X250	-
305.0	SAR305.0MB40X250	SAR305.0MDA30X250
306.0	SAR306.0MB40X250	SAR306.0MDA30X250
309.0	SAR309.0MB40X250	-
310.0	SAR310.0MB40X250	SAR310.0MDA30X250
310.7	SAR310.7MB40X250	-
311.0	SAR311.0MB40X250	-
312.0	SAR312.0MB40X250	-
314.2	SAR314.2MB40X250	-
314.4	SAR314.4MB40X250	-
315.0	SAR315.0MB40X250	SAR315.0MDA30X250
317.0	-	SAR317.0MDA30X250
318.0	SAR318.0MB40X250	-
321.4	SAR321.4MB40X250	-
330.0	-	SAR330.0MDA30X250
345.0	SAR345.0MB40X250	-
359.9	SAR359.9MB40X250	-
389.0	SAR389.0MB40X250	-
391.85	SAR391.8MB40X250	-
392.0	SAR392.0MB40X250	-
398.0	SAR398.0MB40X250	-
402.55	SAR402.5MB40X250	-
403.55	SAR403.5MB40X250	SAR403.6MDA30X250
407.7	-	SAR407.7MDA30X250
414.25	SAR414.2MB40X250	-
416.0	SAR416.0MB40X250	-
418.0	SAR418.0MB40X250	SAR418.0MDA30X250
423.2	SAR423.2MB40X250	SAR423.2MDA30X250
428.7	SAR428.7MB40X250	-
433.92	SAR433.9MB40X250	SAR433.9MDA30X250
444.62	SAR444.6MB40X250	-

SAW RESONATOR PRODUCT LIST FOR CATV 2ND LOCAL

(Effective Jan. 1993)

Nominal Oscillating Frequency [MHz]	PART NUMBER	
	1-PORT TYPE	2-PORT TYPE
473.5	-	SAR473.5MDA30X200
536.0	-	SAR536.0MDA30X200
668.0	-	SAR668.0MDA30X200
674.0	-	SAR674.0MDA30X200

Notes) 1. Both SF-712, TO-39 are available for 1-port SAW Resonators.

SF-712 : SAR***.*MB40X***

TO-39 : SAR***.*MB30X***

2. Please contact MURATA for other frequencies not listed above.

11. NOTICE

11-1 Please note that the component may be damaged if an excessive stress is applied.

11-2 Please note that SAW resonator may be deteriorated or damaged, when static electricity is impressed to it.

11-3 Please do not apply DC voltage on your circuit. When DC voltage is applied to SAW resonator, it may be deteriorated or damaged.

11-4 This component is not allowed to be applied in a flow soldering and a washing after flow soldering. Please comfirm if the component keeps appropriate characteristics after going through your soldering and washing processes before starting mass production.
Any kinds of reflow soldering must not be applied on the component.

11-5 This component is not allowed to be applied in ultrasonic cleaning. When ultrasonic vibration is applied to SAW resonator, it may be deteriorated or damaged.

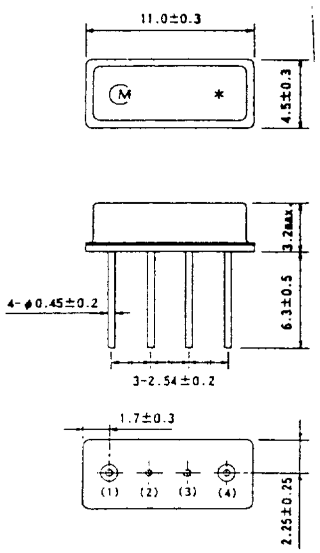
Please note that specification, application (especially for critical case; ex. car electronics), washing condition, and soldering condition which are not mentioned in this application manual may not be allowed to apply. Before ordering, Please consult our sales representative or engineers for details.

Appendix 付録

This application manual(TD.No.P01E)was originally issued on 1993 and Product
アプリケーションマニュアル(TD. No. P01)は 1993 年に発行され、製品リスト
list etc. are different from current version.
は現在のものとは異なります。
We are promoting SAW resonator with F11*(square metal case hermetically
現在 SAW レゾネータとして紹介されているのは F11(角形、ハーメチックシール)
sealed) and SL55*(SMD)package now.
と SL55(表面実装型)パッケージです。
Please see attached our updated Product list.
最新の製品リストを添付しますので参照頂きますようお願い申し上げます。

* See following fig. of dimensions
下記図を参照して下さい。

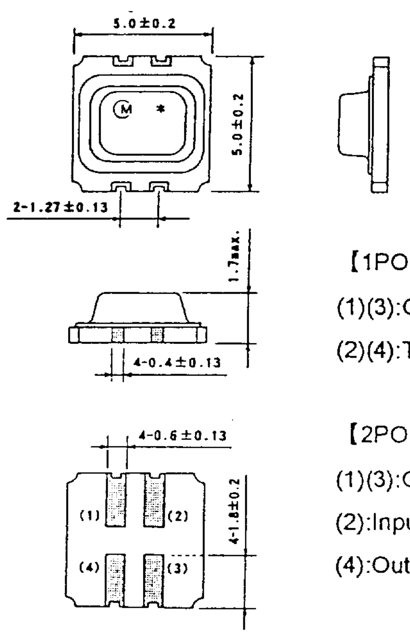
F11 Package



【1PORT】
(1)(4):Terminal
(2)(3):Ground

【2PORT】
(1):Input(Output)
(4):Output(Input)

SL55 Package



【1PORT】
(1)(3):Ground
(2)(4):Terminal

【2PORT】
(1)(3):Ground
(2):Input(Output)
(4):Output(Input)

Fig. dimensions 外形寸法図

issued:1997 March

SAW Resonator // Standard Product List

for Remote controls, Security, CATV Converters and Direct Digital Broadcasting System

updated : November 1, 1996
genereted : September 1, 1995

No.	Nominal Oscillating Frequency [MHz]	SL55 1 port type	SL55 2 port type	F11 1 port type	F11 2 port type
	<< RF Remote Controls, Security Systems >>				
1	211.25	....	....	SAR211.21MB10X***	....
2	224.3	....	....	SAR224.26MB10X***	....
3	224.5	....	....	SAR224.46MB10X***	SAR224.50MDA10X***
4	224.7	....	....	SAR224.66MB10X***	SAR224.70MDA10X***
5	240.4	....	....	SAR240.36MB10X***	....
6	289.3	....	....	SAR289.25MB10X***	....
7	300.0	....	....	SAR299.95MB10X***	SAR300.00MDA10X***
8	303.875	SARL303.83MB10X***	....	SAR303.83MB10X***	SAR303.88MDA10X***
9	304.0	....	....	SAR303.95MB10X***	....
10	304.3	SARL304.25MB10X***	....	SAR304.25MB10X***	....
11	306.0	....	....	SAR305.95MB10X***	SAR306.00MDA10X***
12	308.0	SARL307.95MB10X***	....	SAR307.95MB10X***	....
13	309.0	....	....	SAR308.95MB10X***	....
14	310.0	....	....	SAR309.95MB10X***	SAR310.00MDA10X***
15	310.7	....	....	SAR310.65MB10X***	....
16	311.0	....	....	SAR310.95MB10X***	....
17	312.0	....	....	SAR311.95MB10X***	....
18	314.4	....	....	SAR314.35MB10X***	....
19	315.0	SARL314.95MB10X***	....	SAR314.95MB10X***	SAR315.00MDA10X***
20	318.0	....	....	SAR317.95MB10X***	....
21	321.4	....	....	SAR321.35MB10X***	....
22	325.0	....	....	SAR324.95MB10X***	....
23	330.0	....	....	SAR329.95MB10X***	SAR330.00MDA10X***
24	345.0	....	....	SAR344.95MB10X***	....
25	359.9	....	....	SAR359.85MB10X***	....
26	389.0	....	....	SAR388.95MB10X***	....
27	390.0	SARL390.00MB10X***	....	SAR390.00MB10X***	....
28	392.0	....	....	SAR391.95MB10X***	....
29	398.0	....	....	SAR397.95MB10X***	....
30	402.55	....	....	SAR402.50MB10X***	....
31	403.55	....	....	SAR403.50MB10X***	....
32	414.25	....	....	SAR414.20MB10X***	....
33	417.5	....	SARL417.50MDA10X***	....	....
34	418.0	SARL417.95MB10X***	SARL418.00MDA10X***	SAR417.95MB10X***	SAR418.00MDA10X***
35	423.22	SARL423.17MB10X***	SARL423.22MDA10X***	SAR423.17MB10X***	SAR423.22MDA10X***
36	428.7	....	....	SAR428.65MB10X***	....
37	432.9	SARL432.92MB10X***	....	....	....
38	433.42	SARL433.37MB10X***	....	SAR433.37MB10X***	SAR433.42MDA10X***
39	433.92	SARL433.87MB10X***	SARL433.92MDA10X***	SAR433.87MB10X***	SAR433.92MDA10X***
40	434.42	....	....	SAR434.37MB10X***	SAR434.42MDA10X***
41	437.0	....	....	....	SAR437.00MDA10X***
42	444.62	....	....	SAR444.57MB10X***	....
43	447.7	....	....	....	SAR447.70MDA10X***
	<< Digital Direct Broadcasting System >>				
44	402.78	....	....	....	SAR402.78MDA10X***
45	479.5	....	....	....	SAR479.50MDA10X***