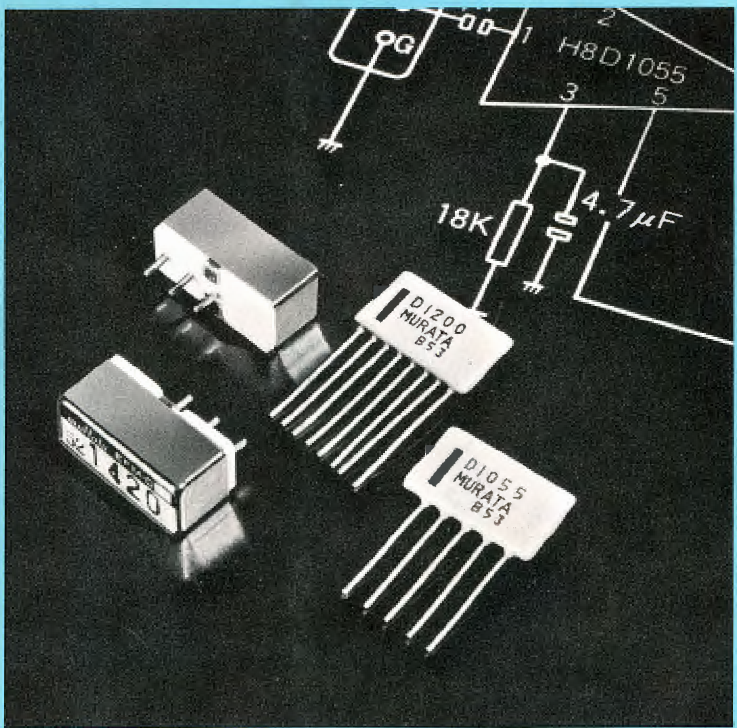
MICROFORK

APPLICATION MANUAL



muRata

MURATA MFG.CO.,LTD.

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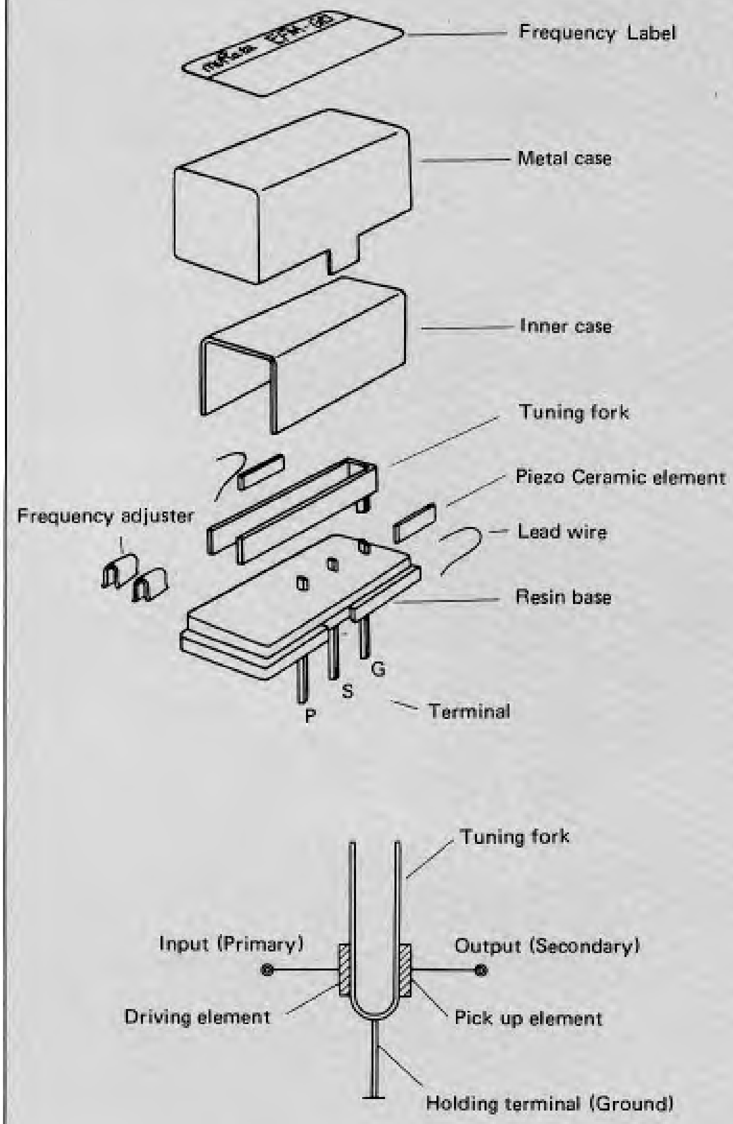
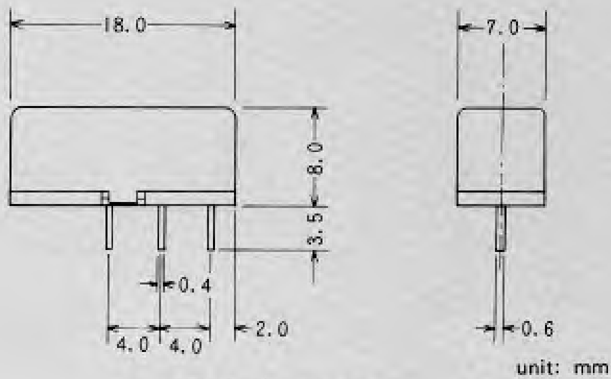


Fig. 1 Fundamental structure of microforks



EFM-G Dimensions

1. Outline

Microfork is a small size piezoelectric tuning fork newly designed by Murata.
The tuning fork is a contactless piezoelectric resonant element in which full advantage is taken of the stability and precision of the resonant frequency in the special metal used in its manufacture. The Microfork (EFM-G type) has excellent features such as small size, low cost, high performance and high reliability.

Application field:

1. Portable and vehicle-mounted transceiver
2. Centralized and remote control systems
3. Transmission and reception of call or control signals on reference frequencies

Application examples

1. Pocket bell (or Bell boy, Pager)
2. Answer-phone, Tele-control
3. Transceiver, Mobile transceiver, Radio buoy
4. Wide-area traffic control system, Automatic ticket or seat reservation system
5. Facsimile, Telemetering facilities
6. Cash dispenser
7. Burglar alarm system, Banking system, Disaster safeguard system
8. Garage door opener
9. Remote controlled synchronous motor timing for clock, disc player and tape or cassette recorder

The Microfork is a new electronic device utilizing mechanical vibration of the tuning fork and has various different features in the circuit or system design and operation, compared with conventional types.
The operating principle, structure, characteristics and operating notes are explained hereunder.

2. Principle

2-1 Basic structure

The basic structure of the Microfork is shown in Fig. 1. A piezoelectric element is mounted close to the base of a tuning fork that is precision-made from a special metal and activates the tuning fork by a piezoelectric effect whereby an input signal (electrical vibration) is converted to mechanical oscillation.

When the input signal (electrical vibration) corresponds with the inherent resonant frequency of the tuning fork, the latter itself will vibrate and mechanical oscillation which is transmitted by means of a coupling is again converted to an electrical signal by a pick-up piezoelectric element and extracted as the output signal.

2-2 Resonalt frequency of Microfork

Resonant frequency is considered to be closely similar to the bending vibration of a cantilever and is calculated by the following formula.

$$f = \frac{mi^2}{4\pi\sqrt{3}} X \frac{d}{\ell^2}\sqrt{\frac{E}{\rho}}$$

Note: f : Resonant frequency

mi : Constant corresponding to each vibration mode (1.88 for the fundamental vibration, 4.69 for the secondary, ...)

ℓ : Length of cantilever

d : Thickness of cantilever

E : Elastic constant

ρ : Density

The frequency is determined by the length, thickness and loaded mass of the tuning fork.

2-3 Equivalent circuit

The equivalent circuit of the Microfork is shown in Fig. 2. When using the same piezoelectric element, $Co_1 = Co_2 = Co$, $A_1 = A_2 = A$, and when converted to the electrical circuit, the equivalent circuit shown in Fig. 3 will be obtained.

However, the equivalent circuit like Fig. 2 or Fig. 3 is relatively unfamiliar in its actual circuit design. An equivalent circuit that is frequently adopted in electronic circuit design is the "Transistor h Parameter" circuit.

Fig. 4 shows a simple equivalent circuit of that type. The circuit shown in Fig. 4 could be easily and practically utilized whenever an electronic circuit is designed. (However, this equivalent circuit can be used only at the resonant frequency.) When wide bandwidth and high selectivity characteristics are required, a double tuned Microfork is suitable for this purpose.

A double tuned microfork is a parallel connection of Microforks in which resonant frequencies are virtually identical and in which phase characteristics have opposite polarities.

Examples of structure, equivalent circuit and bandwidth characteristics are shown in Fig. 5.

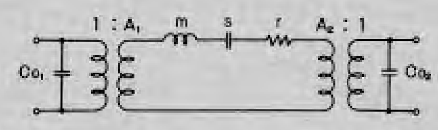


Fig. 2 Equivalent circuit microfork

Co_1, Co_2 : Damping capacitance of piezo element
A_1, A_2 : Force factor of piezo element
m : Equivalent mass
s : Equivalent stiffness
r : Equivalent resistance

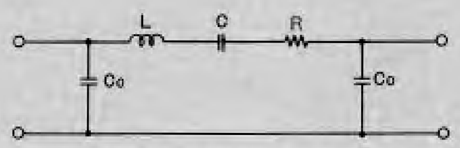
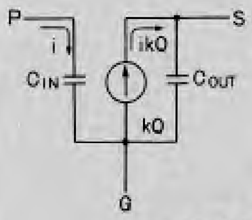


Fig. 3 Equivalent circuit microfork

L: m/A^2 C: A^2s R: r/A^2



P	:	Input terminal	Equivalent to base
S	:	Output terminal	Equivalent to collector
G	:	Ground terminal	Equivalent to emitter
C_{IN}	:	Input capacitance	Equivalent to hie
C_{OUT}	:	Output capacitance	Equivalent to hoe
KQ	:	Coefficient x Q	Equivalent to hfe

Fig. 4 (a) Equivalent circuit simplified

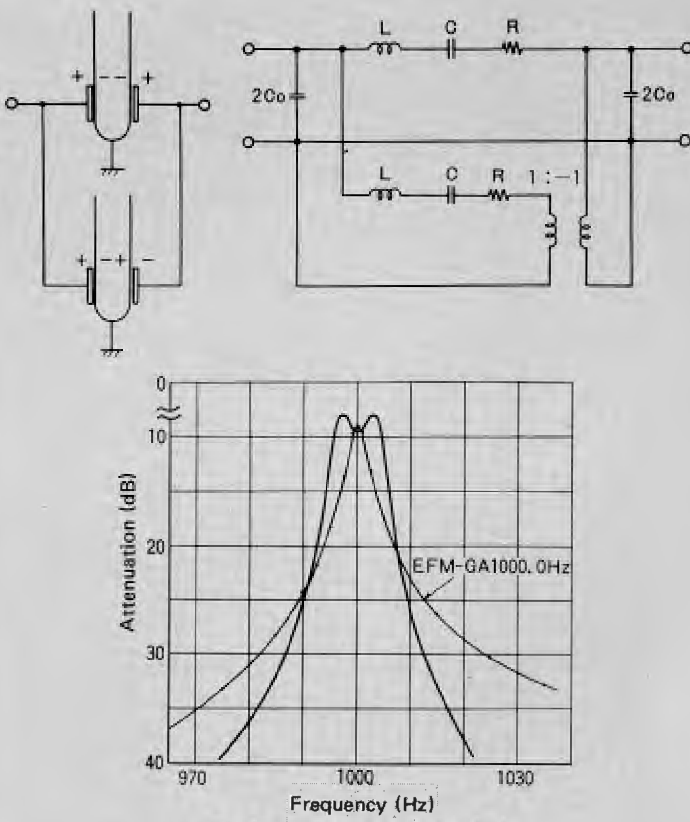


Fig. 5 Double tuned microfork

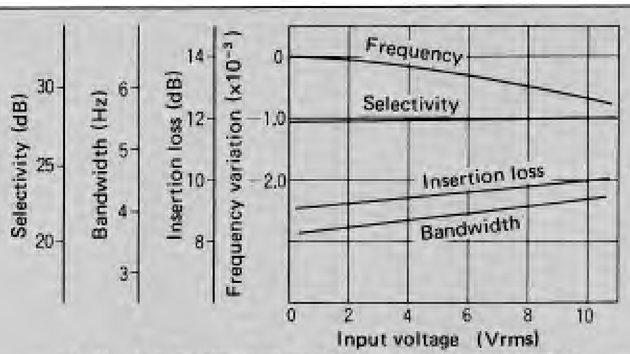


Fig. 6 Input voltage characteristics EFM-GA 1000.0Hz

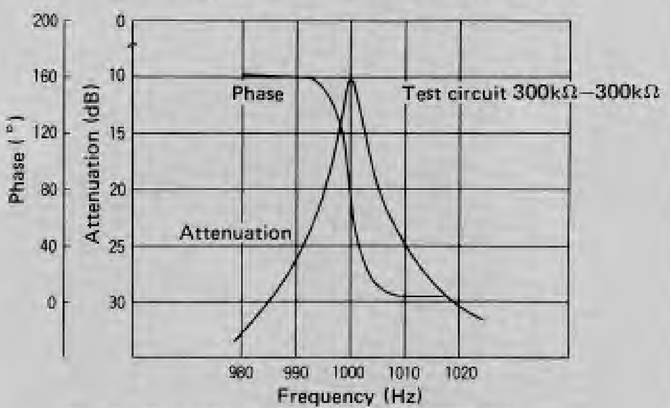


Fig. 7 Phase characteristics EFM-GA 1000.0Hz

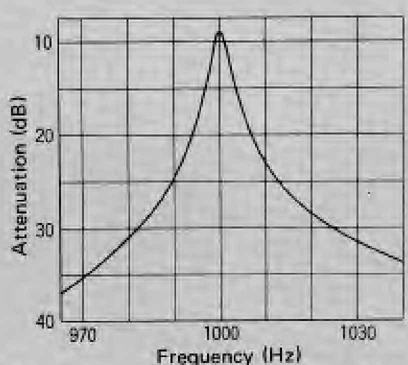


Fig. 8 (a) Frequency characteristic EFM-GA 1000.0Hz

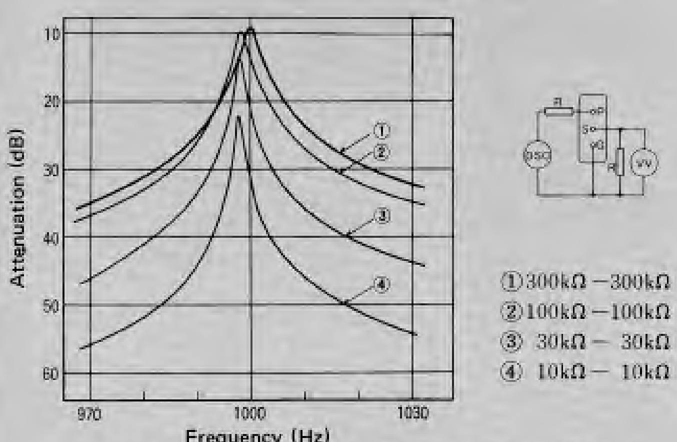


Fig. 8 (b) Frequency characteristics EFM-GA 1000.0Hz

3. Characteristics

3-1 Input voltage characteristic

The input voltage characteristics of center frequency, insertion loss, 3 dB bandwidth and selectivity are shown in Fig. 6;

There is no problem, in practical use, over a voltage range of up to 3 Vrms but our standard input voltage is 1 Vrms or 0 dB (0.775 Vrms).

When a high D.C. voltage is applied, the characteristics are liable to variation due to the polarity conditions of piezoelectric element and therefore voltages of more than 20V D.C. should not be applied.

3-2 Phase characteristic

The resonant phase is approx. +90° in our standard measuring circuit in which both the input and output terminal resistances are 300K ohms. But, when both the input and output terminal resistances are dissimilar, it should be noted that the phase characteristic will change in proportion to that difference.

A typical curve of the phase characteristic near the center frequency is shown in Fig. 7.

When the Microfork is used for the oscillator, please refer to section 4 "Notes on circuit design", because the oscillator frequency changes by the phase characteristic and input or output impedance of the oscillator.

3-3 Filter characteristic

As the Microfork's Q is as high as 300~500 due to mechanical resonance of the tuning fork, the insertion loss, bandwidth and selectivity should be carefully checked before designing the circuit. Fig. 8 (a) shows typical frequency characteristic of the Microfork.

When the input and output terminal resistance values are changed, it should be noted that the center frequency, insertion loss, bandwidth and selectivity will also change as shown in Fig. 8 (b). The matching of both resistance is optimum to stabilize various characteristics, so that both resistance values in our standard circuit are 300K ohms.

3-4 Spurious response

In general, spurious response (high frequency oscillation) is observed near 5 to 7 times (secondary harmonic vibration) and 15 to 17 times (third harmonic vibration) of the fundamental resonant frequency.
To avoid interference by spurious response when the frequency is used over a wider range, the relation between fH (maximum higher frequency) and fL (minimum lower frequency) should be as follows.

$fH/fL \leqq 5$
(Ex.) fL: 288.5Hz, fH: 1433.4Hz

A typical curve of spurious response is shown in Fig. 9.
A special type EFM-R40 is available in which the secondary or third vibration is virtually eliminated using a specially designed tuning fork.

3-5 Temperature characteristics

Typical temperature characteristics of the center frequency, insertion loss, 3 dB bandwidth and selectivity are shown in Fig. 10. The frequency temperature coefficient is within $\pm 3.0 \times 10^{-5}/°C$. The standard operating temperature range is -20°C~+60°C.
If frequency variation, insertion loss or attenuation is allowable, the temperature range may be: -40°C~+80°C.

3-6 Humidity resistance

The special electrode material used in the piezo-elements will avoid such insulation resistance failures (short circuit of electrodes) as are caused by migration of silver ion in moist conditions. Typical humidity resistance is shown in Fig. 11. A coupling capacitor is not necessary for D.C. cut. As the Microfork is not hermetically sealed, the entire equipment should be moisture-proofed if the Microfork is to be used in humid conditions.

3-7 Vibration stability

Test results based on MIL-STD-202B-201A are shown in Table 1.
There are no problems in the center frequency and insertion loss. However, it should be noted that external vibration may cause noise or false operation in the Microfork.
Moreover, when used as a receiver, it is necessary to set a switching level in higher than such noise level caused by outside vibration.

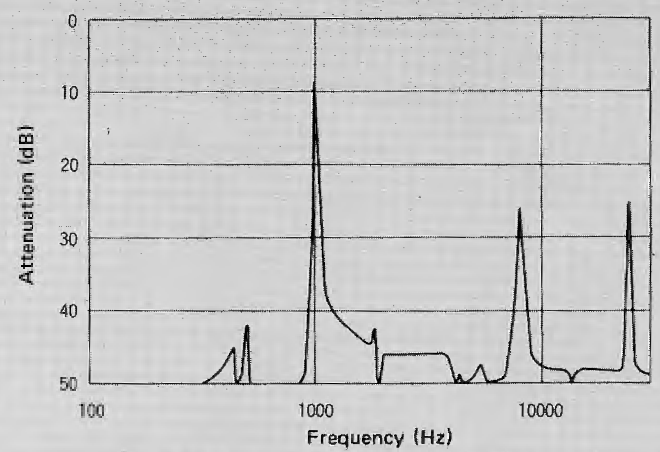


Fig. 9 Spurious response EFM-GA 1000.0Hz

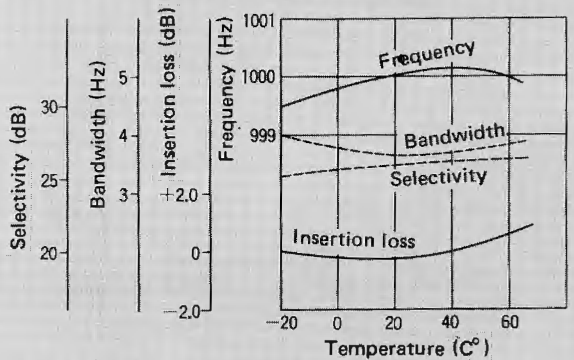


Fig. 10 Temperature characteristics EFM-GA 1000.0Hz

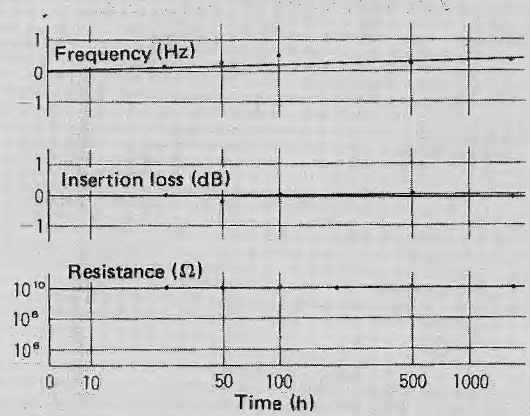


Fig. 11 Humidity characteristics EFM-GA 1000.0Hz
(Temperature: 45° Humidity: 95%)

Table 1 Vibration test EFM-GA 1000.0Hz

Center Frequency (Hz)			Insertion loss (dB)		
Before test (A)	After test (B)	Variation (B-A)	Before test (A)	After test (B)	Variation (B-A)
1000.6	1000.4	-0.2	9.1	9.0	-0.1
1000.0	1000.0	0	10.0	10.0	0
1000.5	1000.4	-0.1	9.0	9.0	0
1000.5	1000.3	-0.2	10.0	10.1	+0.1
999.7	999.9	+0.2	9.0	9.0	0

*Amplitude : 1.5mm P-P Vibration Freq : 10~55~10Hz 1 minute
Direction : 3 perpendicular directions
Time : 2 hour per one direction (Total 6 hr.)

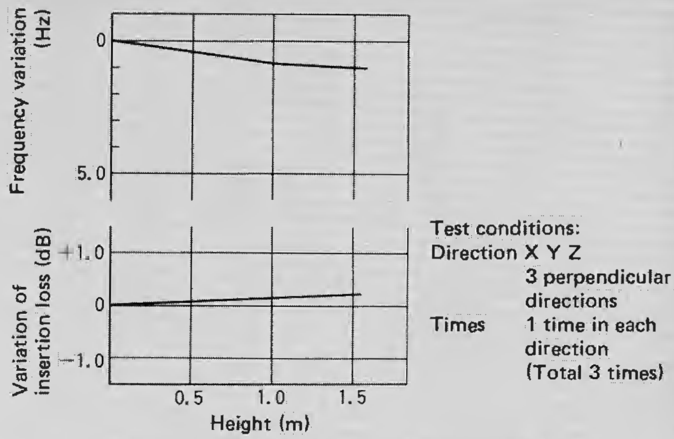


Fig. 12 Shock stability characteristics EFM-GA 1000.0Hz

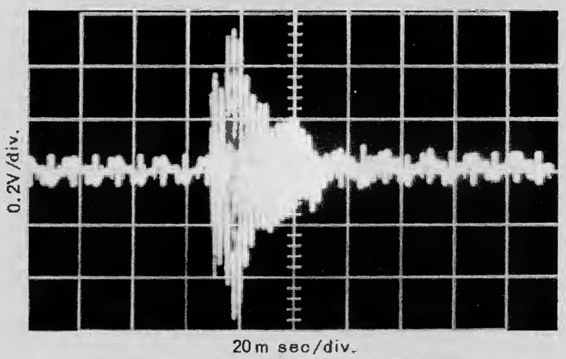


Fig. 13 Shock noise EFM-GA 1000.0Hz

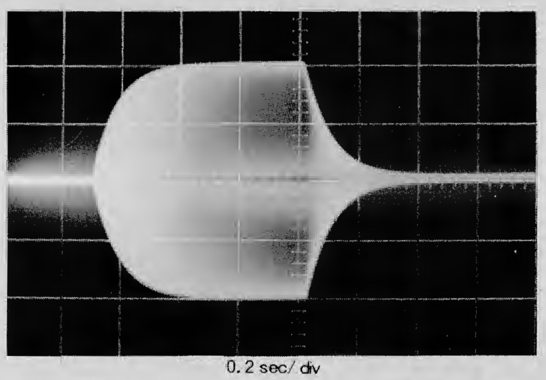


Fig. 14 Rise and decay time characteristics EFM-GA 1000.0Hz

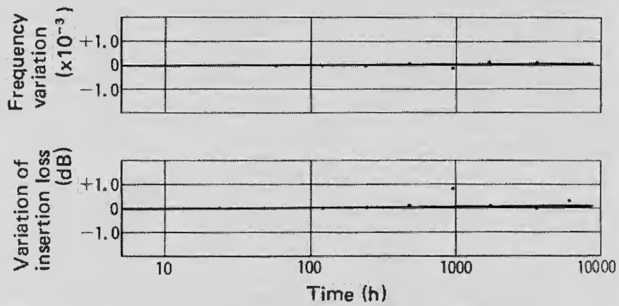


Fig. 15 Aging characteristics EFM-GA 1000.0Hz

3-8 Shock stability

Microfork is designed not to vary its performance even in shock conditions of approx. 100G. (When Microfork is free-dropped onto a concrete floor from 50cm height, the acceleration by shock is equivalent to 100G and more.) A typical example of the shock stability relative to a concrete floor is shown in Fig. 12.

As noise is caused by shock as well as by vibration, it will be necessary to take into consideration both the switching level and the time constant when designing the circuit. For portable remote-control use, it is desirable to use a shock absorber such as rubber, which will also provide protection to the Microfork and prevent noise.

A typical example of the shock noise is shown in Fig. 13.

3-9 Rise and decay time characteristic

The rise and decay time is extended because Q of the tuning fork is high (300~500) and will be about 0.3 sec. at around 1000Hz.

A typical example of rise and decay time is shown in Fig. 14.

A certain time is needed in order to send a sufficient tone signal to receivers.

3-10 Ageing characteristic

There is no contact point or contact closure subject to wear in the Microfork and therefore a semipermanent life is guaranteeable.

However, some characteristics will change as a result of applied conditions or the ageing of materials. Artificial ageing is, therefore, applied to the Microfork in the manufacturing stages in order to stabilize its quality.

An example of ageing characteristics is shown in Fig. 15.

4. Notes on circuit design

4-1 The Microfork in an oscillator circuit

When used in an oscillator circuit, the performance is affected by the phase characteristic of that oscillator circuit, the input and output impedances and gain etc., and the following phenomena may occur:

1. Oscillator frequency deviation
2. Spurious oscillation
3. Cumulative spurious signal in the fundamental signal required
4. Rise time decay in desired signal
5. Unstable oscillation

Therefore, it is necessary to design the circuit with phase characteristics fully taken into account.

a) Design of oscillator circuit

The main points in the design of oscillator circuits are stated hereunder in relation to an example of the design.

The conditions of oscillation depend on both phase and amplitude. Usually, the problems mentioned in 4-1 may arise in an oscillator circuit using the Microfork if the phase is not correctly assessed.

Such problems are illustrated in Fig. 16 (a).

If the phase is not properly corrected in the oscillator circuit, point A', which is reciprocal to point A, will be the resonating point, since the phase between the input and the output is 180°. The points A and A' both differ widely in frequency and level from the resonating point, and the equivalent Q is also low. Consequently, oscillating conditions will be very unstable.

For satisfactory operation of the Microfork in an oscillator circuit, it is most important that the Microfork be adjusted so that it can oscillate exactly at the resonating point. The phase in the resonant Microfork is calculated by the following formula. In our standard circuit a matching condition is considered with the input impedance and the output impedance both at 300K ohms.

When these values are applied to the equivalent circuit shown in Fig. 4 (a), the circuit will take the form shown in Fig. 4 (b). From this new circuit it will be noticed that the phase is shifted at R_1, Cin and R_2, Cout.

This phase shift φ_1 or φ_2 is calculated as follows:-

$$\varphi_1 = -\tan^{-1}\frac{R_1}{\frac{1}{2\pi f C_{in}}} = -48.5^\circ$$

$R_1 = R_2$, $C_{in} = C_{out}$ therefore, $\varphi_2 = -48.5^\circ$

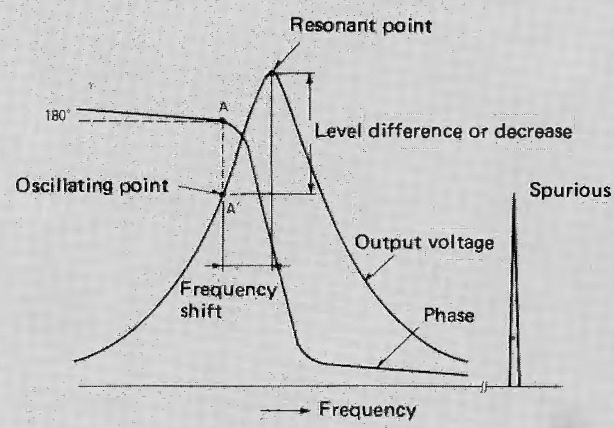


Fig. 16 (a) Phase characteristics

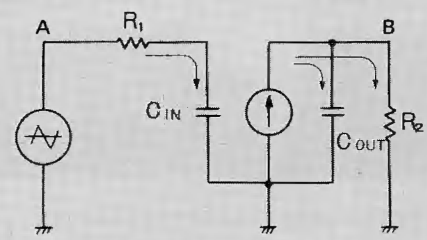


Fig. 4 (b) Equivalent circuit simplified

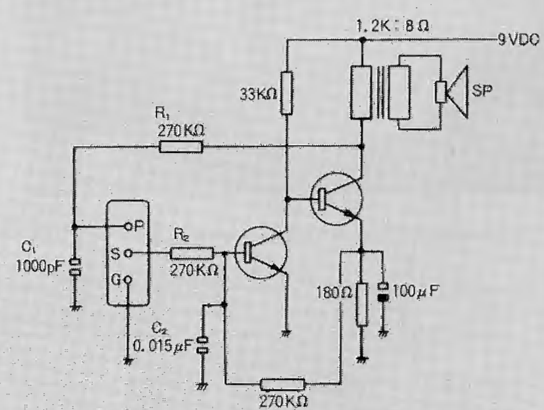


Fig. 16 (b) Simple oscillator circuit

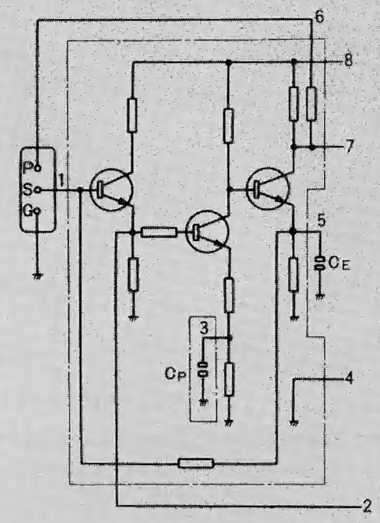


Fig. 17 H8D1200 Equivalent circuit

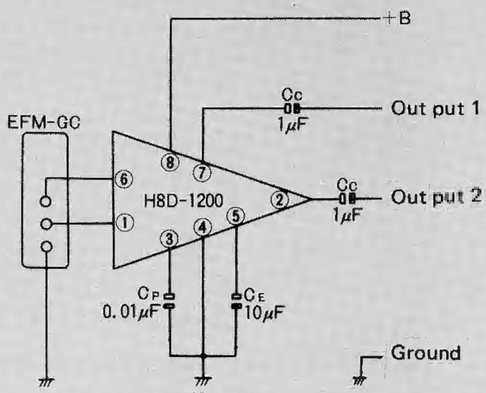


Fig. 18 H8D1200 Connections

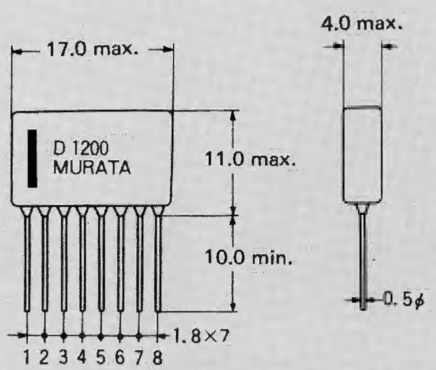


Fig. 19 H8D1200 Dimensions

As the phase difference between the input and the output in conditions of resonance is 180°, the total phase (between A and B) is as follows: (See Fig. 7)

$\varphi = 180° + \varphi_1 + \varphi_2 = 83°$

Consequently, the phase should be corrected by -80° in the oscillator circuit. The gain of the oscillator circuit should be determined in consideration of the following points.

1. Microfork's insertion loss and its distribution (13 dB max.).
2. Loss variation due to ambient conditions at the Microfork.
3. Correction loss in phase correcting circuit.
4. Gain margin (Rise time should be considered).

Generally, the gain should be more than 30 dB. An example of a circuit in which the phase is corrected is shown in Fig. 16 (b).
The constant in the phase correcting circuit is variable, depending on the oscillating frequency, and when oscillating frequencies are applied over a wider range, the oscillator circuit structure should be checked to avoid the following trouble.

1. Change-over necessary in phase correcting circuits.
2. Occurrence of output level errors.
3. Occurrence of load variation.

In consideration of the foregoing, Murata has now produced a special HYBRID IC H8D1200 for oscillator applications, which creates an ideal oscillator circuit by contact with only two or three additional components and which gives the following characteristics to such circuits:

1. Absence of higher harmonic oscillation
2. Rapid rise time
3. Switching of phase correcting circuit is not required, even when used over a wide frequency range.
4. Constant oscillator output level

Therefore, the combined use of EFM-GC and H8D1200 is highly recommended.

Hybrid IC H8D1200

The equivalent circuit, external connections and dimensions are shown in Fig. 17, 18 and 19.

Power Source voltage characteristic

H8D1200 is designed so that it can be used over a wide range of the supply voltage from 6 to 24V. A further model, H8D1200A, is available for low voltages below 6V.
A typical example of the supply voltage characteristic is shown in Fig. 20.

Temperature characteristic

Because it is a direct-coupled oscillator circuit at the Microfork resonant point, there will be very slight variations in both frequency and oscillating level.

A typical example of the temperatuare characteristic is shown in Fig. 21.

Load impedance characteristic

When the load impedance diminishes, the output voltage also decreases and wave distortion is generated. Therefore, the load impedance should be more than 10K ohms.

A typical example of the load impedance characteristic is shown in Fig. 22.

Power source ripple characteristic

When the power source provides an alternating current or when noise is superposed on a DC power source, a ripple or noise effect may result.

A typical example of the power source ripple (120Hz) characteristic is shown in Fig. 23.

Power source impedance characteristic

When used with a power source of high impedance, its characteristics may be affected by internal impedance. It is recommended that the power source impedance should be 30 ohms (max.).

A typical example of the power source impedance characteristic is shown in Fig. 24.

b) Notes on oscillator circuit connection

If many oscillator circuits are to be used by parallel connections and direct output terminals are connected in parallel, the load impedance will be abnormally reduced owing to the fact that the output impedance of the oscillator circuit will represent the load on other oscillator circuits. In that case, insert a buffer resistor (about 10K ohms) or a buffer circuit, in series with the oscillator circuit output terminal, and connect the circuits in parallel. This circuit is shown in Fig. 25. When the impedance in the power source is high or there is a power source ripple, the circuit may be affected by the power source circuit or another oscillator circuit and therefore, when designing the power source circuit, it is advisable to use a ripple filter.

As shown in Fig. 25, the influence of power source noise or other noises can be reduced by mutual decoupling.

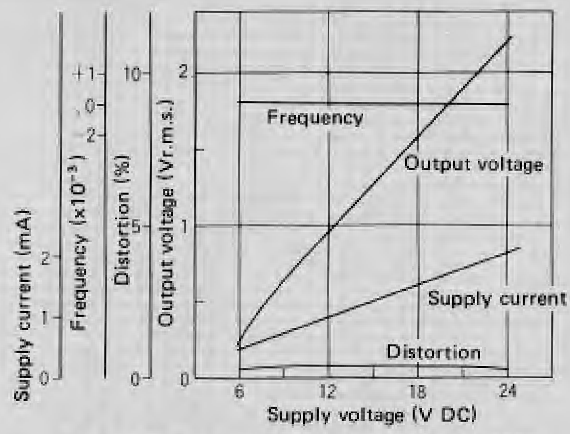


Fig. 20 Supply voltage characteristics H8D1200
(Microfork : EFM-GC1000.0Hz
R_L : 10kΩ)

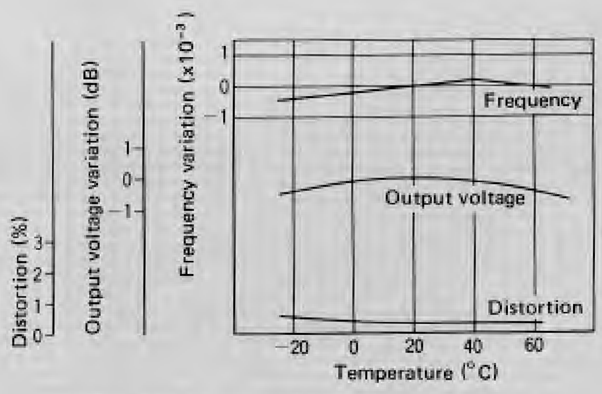


Fig. 21 Temperature characteristics H8D1200
(Microfork : EFM-GC1000.0Hz)

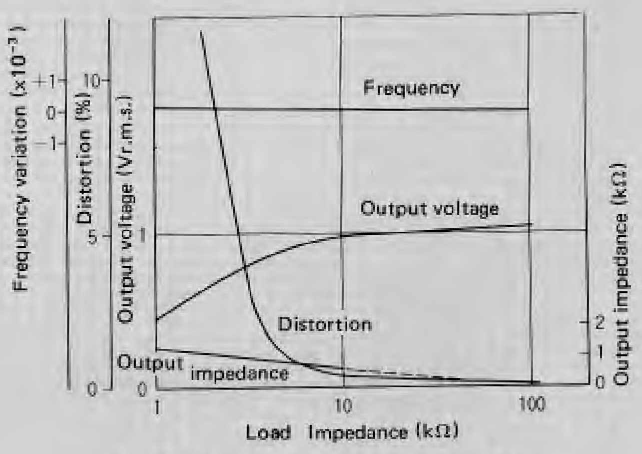


Fig. 22 Impedance characteristics H8D1200
(Microfork : EFM-GC1000.0Hz
V_{CC} : 12V DC)

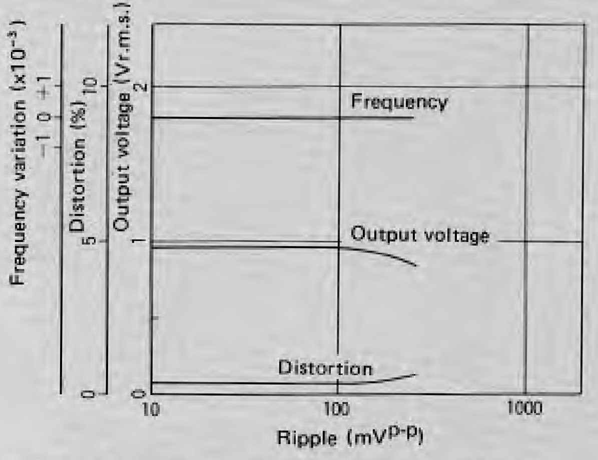


Fig. 23 Supply voltage ripple characteristics H8D1200

(Microfork : EFM-GC1000.0Hz
V_{CC} : 12V DC
R_L : 10kΩ)

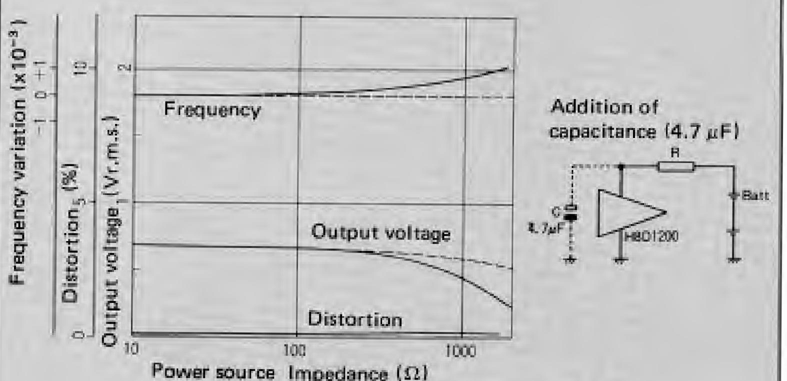


Fig. 24 Battery impedance characteristics H8D1200

(Microfork : EFM-GC1000.0Hz
+B : 9V DC)

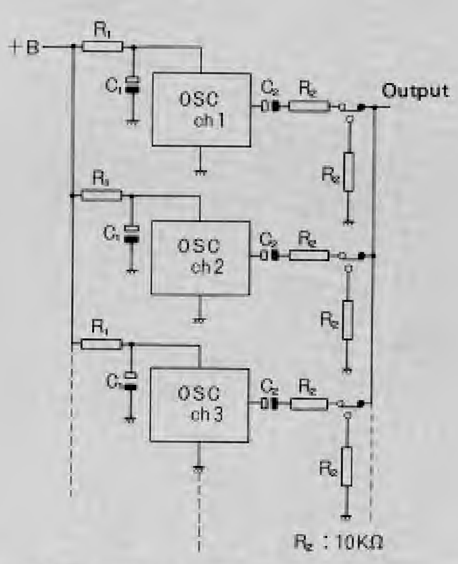


Fig. 25 Parallel connection of multi-oscillation circuit

c) General applications

When an oscillator output signal is required instantaneously, the circuit should be always in an oscillation state and the signal can be taken out by ON/OFF switching at the output terminal.
When some delay time is permissible, a signal can be extracted by ON/OFF switching at the power source for the oscillator circuit.
When transmitting two or more signals simultaneously, the mixer circuit is often used. In such a case, as mentioned in the paragraph above b), insert a buffer resistor, a buffer circuit or isolation between oscillators and the mixer circuit. (Mixers with buffer resistors are most commonly used.)
As a special case, the series tone system is adopted. The duration of each tone should be set against the Microfork's rise time. (Generally, it is approx. 0.5~1.0 sec.)

d) Other notes

If distortion occurs in the oscillator circuit or the mixer circuit as far as the output signal is concerned, a false operation will be generated as a result of harmonics. Care should therefore be taken to avoid the occurrence of wave-form distortion.
If the tone duration in the series tone application is abnormally short, the Microfork in the receiver side will not only be able to rise sufficient level, but there will be variations in the timing of the tone signals and this will be liable to cause such false operation as "beating".
Because it is not possible to use a multiplicity of Microforks simultaneously in a single circuit, one Microfork should be used in each individual oscillator circuit.

4-2 Use of the Microfork in a Receiver Circuit

When the Microfork is used in a receiver circuit as a filter, the input and output impedance should be carefully matched. Variations may arise in the resonant frequency, insertion loss and selectivity due to input and output impedance of receiver circuits (drive/detector amplifiers).
(See filter characteristic 3-3)
It is essential to use Microfork in balanced conditions to obtain stable characteristics.
Murata sets the matching impedance at our standard of 300K ohms ~ 300K ohms in input and output.
A typical example of circuit is shown in Fig. 26.

a. Frequency Selection

For a multi-channel remote control system with a wide range of frequency, set the frequency as follows.

1. Set f_H (maximum frequency) and f_L (minimum frequency) as follows.

   $f_H/f_L \leqq 5$

2. Set the frequency interval so as to keep sufficient selectivity for the next channel.
3. When carrying out simultaneous operation, it is recommended that equally spaced frequencies should be avoided and that equally related bandwidth adopted.

b. Setting of switching level

When the switching level is set in the receiving circuit, it is necessary to consider the following characteristics in the circuit design.

1. Insertion loss at the nominal frequency.
2. Variation of frequency and insertion loss due to ambient conditions (temperature etc.).
3. Variation of input signal.
4. Selectivity and operating margin for the next channel.
5. Spurious level.
6. Noise level caused by vibration or shock.

A low switching sensitivity is ideal, and the driving level should be as high as possible. As a guide it is recommended that the following levels should be adopted.

Driving level : 1~3 Vrms
Switching level : 0.1~0.5 Vrms
Time constant : approx. 0.5 sec.

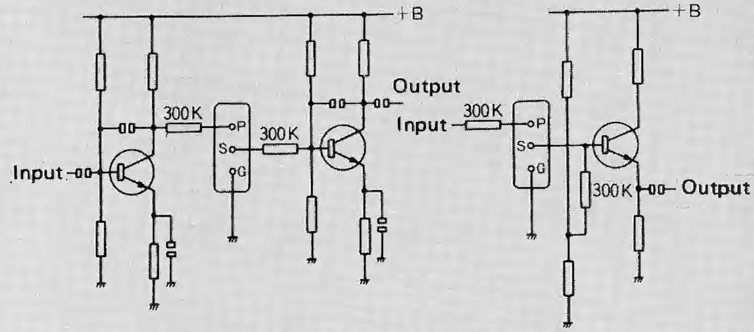


Fig. 26 Receiving circuit (Matching conditions)

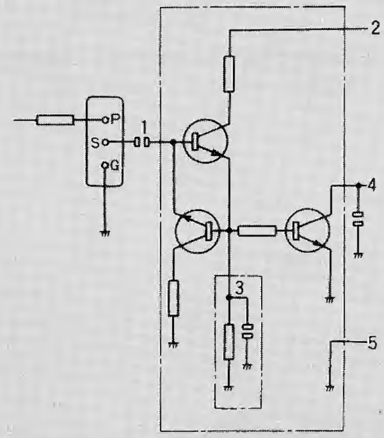


Fig. 27 H8D1055 Equivalent circuit

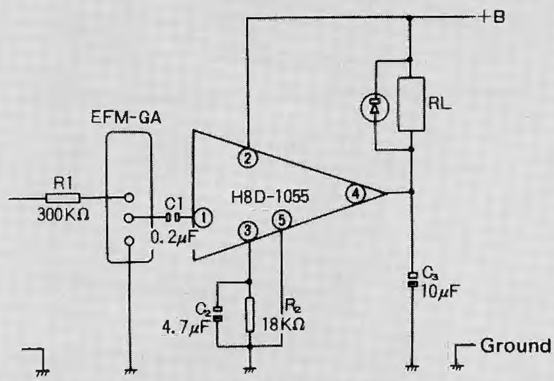


Fig. 28 H8D1055 Connections

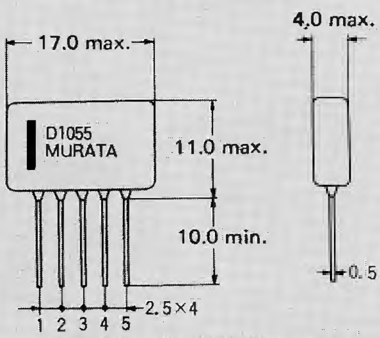


Fig. 29 H8D1055 Dimensions

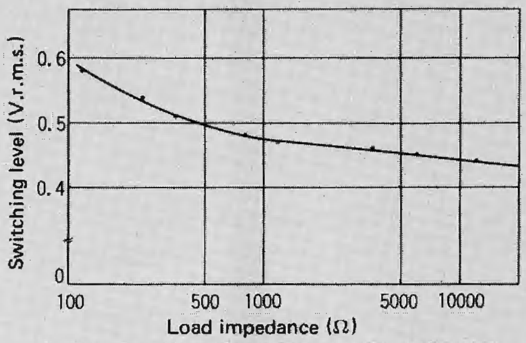


Fig. 30 Load impedance characteristic H8D1055

(+B : 12V DC)

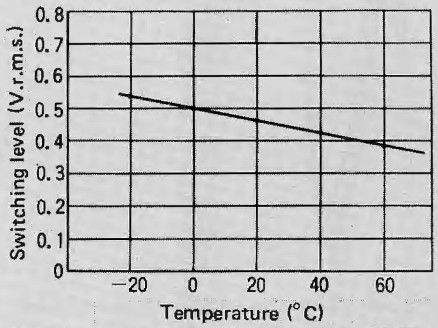


Fig. 31 Temperature characteristic H8D1055

(R_L : 1.2kΩ +B : 12V DC)

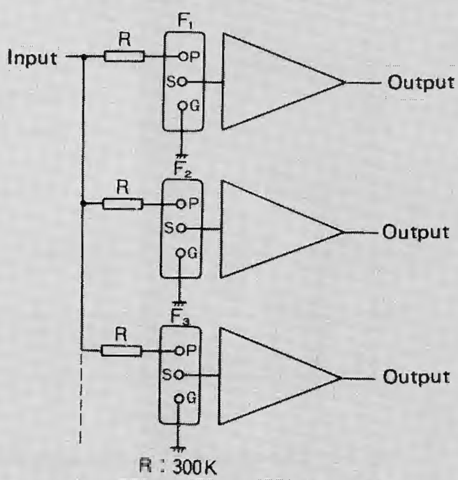


Fig. 32 Parallel connection for signal line

A midget relay can be directly driven by H8D1055 by connecting it with some of the additional components to give a DC output.

For this purpose it is recommended that EFM-GA and H8D1055 be used in conjunction, with a drive amplifier that is compatible with the system design. The equivalent H8D1055 circuit, external connections and dimensions are shown in Fig. 27, 28 and 29.

Load Impedance Characteristic

The standard load impedance is set at 1.2K ohms (12V D.C.)

If the load impedance decreases, the switching level for H8D1055 will vary proportionally.

A typical example of the load impedance characteristic is shown in Fig. 30.

Temperature Characteristic

A typical example of the switching level temperature characteristic for H8D1055 is shown in Fig. 31.

Variable setting of switching level

The switching level of H8D1055 can be changed by an external resistance at No. 3 terminal.

If resistance is set at more than 18K ohms (upto ∞), it shall be highly sensitive.

If resistance is set at less than 18K ohms (upto 1K ohm), it shall be not so sensitive.

c. Notes on Microfork Connection

If a multiplicity of Microforks is used in parallel connection for the purpose of mixing a number of tone signals in a single signal circuit or to apply a timed system of transmission, characteristic variations due to impedance must be taken into consideration and therefore connection should be made in parallel with the signal circuit prior to the buffer resistor (300K ohms) or the buffer circuit. An example of such connection is shown in Fig. 32.

d. Other Notes

Microfork is a high Q filter. Besides its fundamental response, it also has a spurious response. If there is a spurious signal in the input, place a bandpass filter or a lowpass filter in the drive amplifier in the receiver circuit.
If a high selective switching level is required and Microfork is affected by vibrations or shocks, the following countermeasures are needed to avoid false operation.

1. Protection of the Microfork by using a shock-absorber such as rubber.
2. Inclusion of a circuit to prevent false operation (e.g. sensor circuit, cut-out circuit, comparator circuit).

5. Notes on system design

As mentioned above, in a remote control system using the tone signal, distortion may cause a serious problem. This is in tune not only of Microfork, but also in LC filters and other filter types.

a) Malfunction due to signal distortion

Fig. 33 gives a diagrammatic explanation of the cause of false operation when signal distortion occurs.
If the driving amplifier's gain is A and the saturation level (limit or clip) fixed by the supply voltage is B, (See Fig. 33).

(1) shows that the output signal does not distort under normal conditions with one signal.
(2) shows that the input signal increases and the output waveform is distorted. However, the desired frequency is maintained.
(3) shows a mixture of dual tones. As the output waveform is distorted, the component (a) decreases, compared with the input signal.
(4) shows that the input signal increases. The component ingredient (a) is so small that it is almost impossible to detect its level.

In such conditions operation will be unstable or impossible. When many signals are transmitted simultaneously, the total level of the mixed wave becomes higher than for one signal. It is necessary to make the dynamic range of the drive amplifier as wide as possible.

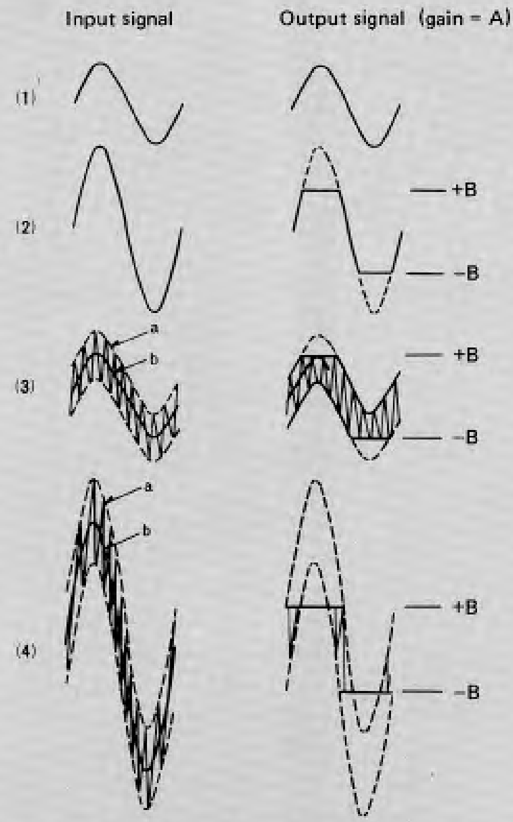


Fig. 33 Operation error by distorted signals

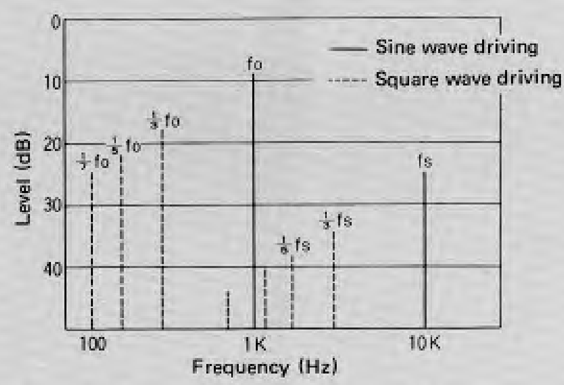


Fig. 34 Characteristics in square wave driving

b) False operation due to Tone Distortion

In the case of a single signal, the existence of the frequency component will ensure that, although there may be distortion of the signal wave form, the degree of false operation will not be such as to render the system inoperable.
But, when the signal adopts a square wave form, harmonics of 3 times, 5 times, ... is involved in the tone.
The harmonics with the drive signal in a sine or square wave form are shown in Fig. 34.
As a countermeasure, it is necessary to consider the operating frequency range or the harmonic level.

c) General Application

For a drive amplifier, a transformer-coupling circuit, using a step-up-transformer, is the most suitable. The transformer coupling circuit is not influenced by the supply voltage and the high impedance of the Microfork is able to work effectively. It is recommended to use AGC circuit in transmitting systems, using radio frequency, electromagnetic induction or ultrasonic sound. When the level variation is small in a system such as wired transmission, it is desirable to set the level using a variable resistor or similar device.

6. Conclusion

The foregoing notes may suggest that the Microfork is a highly complex device but so long as those points have been understood, it will be appreciated that no another electronic component could be simpler or more adaptable. The following appendices give examples of circuitry design for both the oscillator and receiver applications.
It is hoped that these notes will be of assistance in designing circuits using the Microfork.

Application Appendices

1. Switching circuit for encoder

– H8D1200 –

The oscillator circuit is in a permanently oscillating condition and a sharp output signal may be obtained by ON/OFF switching of the signal, using an external transistor switching circuit.
This circuit example is one of an emitter follower but if an emitter earth is employed, a switching circuit with high amplification will be obtained.
If the push switch is replaced by a thermal sensor, the circuit may be incorporated in a fire alarm system. (If the sensor "chatters", it should be combined with a time-delay or a holding circuit.)
Transistors such as 2SC 373, 458, 536, 711, 828 and 945 are suitable for this.

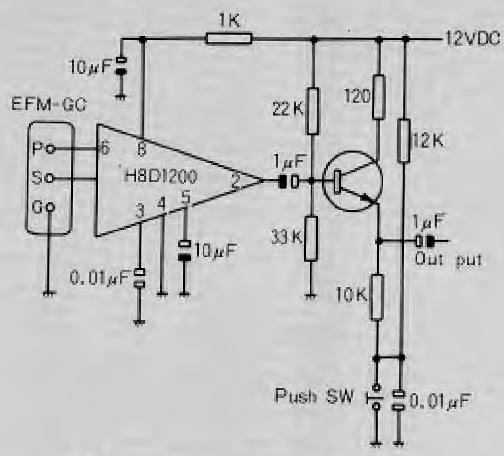


Fig. 35 Switching circuit for encoder
– H8D1200 application –

2. Sensor circuit, using a D.C. feed line

– H8D1200 application –

The oscillator circuit is permanently operating and, after the oscillator output signal (tone signal) is amplified by the transistor switching circuit of the common emitter, it is capable of superposing it on the D.C. feed line.
This example is a circuit with delay time in consideration of the sensor's "chatter" phenomenon.
The switching circuit is composed of double switching circuits, using both diode and transistor.
For multi-channel applications, connect in parallel with the D.C. feed line.
Transistors 2SC 373, 458, 536, 711, 828 and 945 are suitable for this circuit.
It is suitable to use choke coils in which the D.C. resistance is small.
Choke coils with a low D.C. resistance are also suitable.

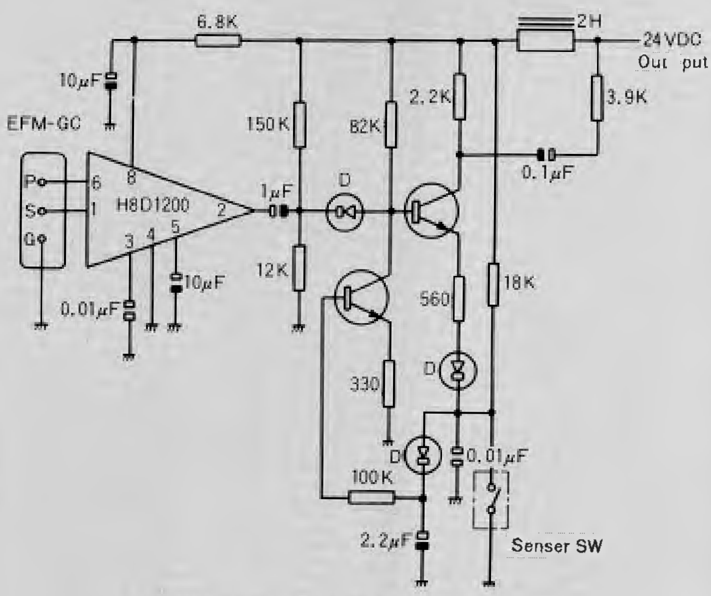


Fig. 36 Sensor circuit, using a DC feed line
– H2D1200 application –

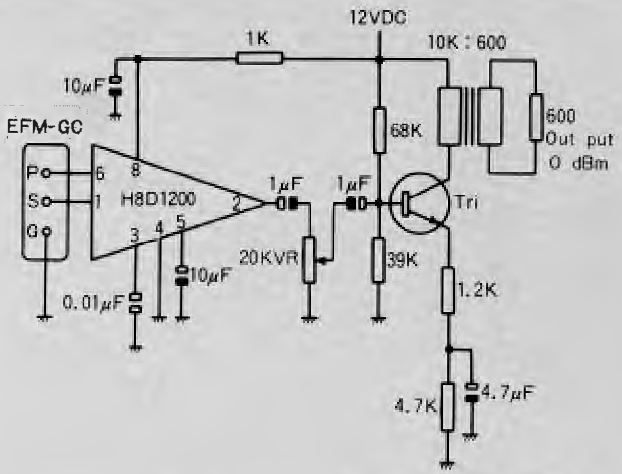


Fig. 37 Balanced oscillator with 600 ohm transformer
— H2D1200 application —

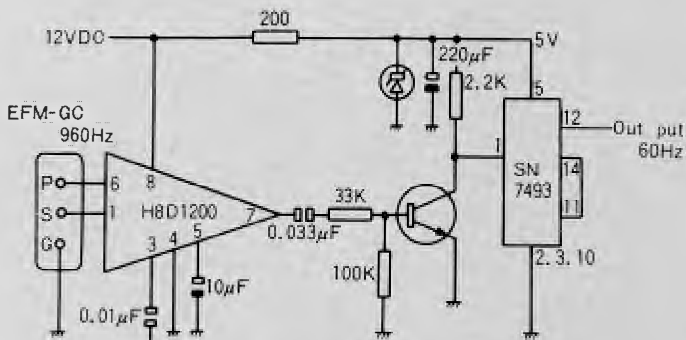


Fig. 38 60Hz Oscillator circuit using TTL IC
— H8D1200 application —

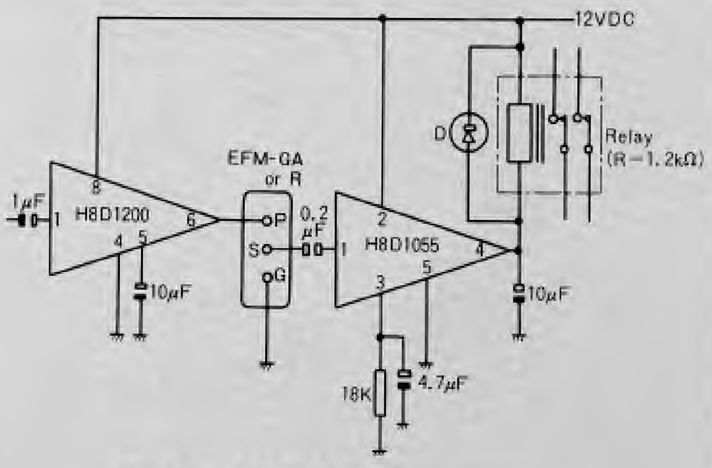


Fig. 39 Single tone decoder
— H8D1200, H8D1055 application —

3. Balanced oscillator with 600 ohm transformer

— H8D1200 application —

The output stage is an 'A' class operation due to the transformer coupling. When the waveform distortion becomes a problem, check the transformer's capacitance, its characteristic and negative feed-back circuit.
For a 600 ohm unbalanced load, a common collector circuit is suitable.
Transistors 2SC 373, 458, 536, 711, 828 and 945 are suitable for this.

4. 60Hz Oscillator Circuit using TTL IC

— H8D1200 application —

This is an example of 60Hz oscillator circuit using a TTL IC (divider circuit). The square wave output of H8D1200 drives a TTL IC, after it is amplified by the buffer transistor and 60Hz is obtained from dividing 960Hz by 4 stage divider circuit.
This is applicable to a basic frequency, clock and also for commercial frequencies. TTL IC is unstable in relation to external noise and supply voltage variation.
A zener diode is inserted in this example to stabilize the supply voltage.
Transistors 2SC 373, 458, 536, 711, 828 and 945 are suitable for this circuit.

5. Single tone decoder

— H8D1200, H8D1055 application —

In this circuit a relay can be driven directly with H8D1200 as a drive amplifier and H8D1055 as a detecting amplifier. This application is appropriate for compact transceivers which require a high level of integration.
Multi-channels cannot be activated simultaneously owing to the presence of an amplitude-limiting circuit in the Microfork drive amplifier.

6. SCHMIDT circuit with H8D1055

– H8D1055 application –

This example is composed of a Schmidt circuit, using a transistor and H8D1055. It is possible to obtain the output voltage with sharp rise and decay. It is suitable for TTL IC drives and protection of power relay driving transistors.
Transistors 2SC 373, 458, 536, 711, 828 and 945 are suitable for this circuit.

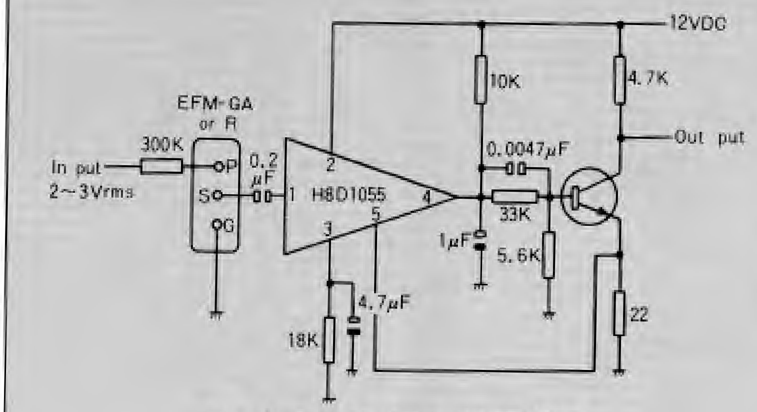


Fig. 40 Schmidt circuit with H8D1055
– H8D1055 application –

7. Power relay driving circuit

– H8D1055 application –

With a 4th terminal composed of H8D1055, this circuit can amplify a D.C. output, using a PNP transistor and can drive a power relay. By changing both R_1 and R_2, it is possible to change the D.C. amplitude. Transistors 2SC 483 and 652 are suitable.

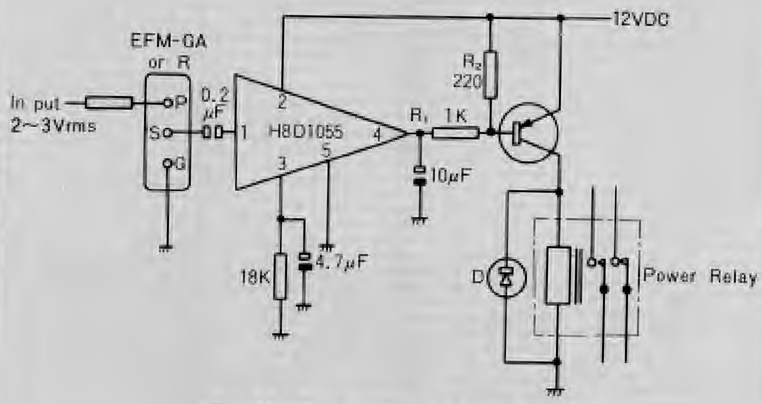


Fig. 41 Power relay driving circuit
– H8D 1055 application –

8. Power relay driving circuit (with FET)

– H8D1055 application –

This circuit uses an amplifier or N channel FET in the pre-amplifier stage, and includes a Darlington circuit with both H8D1055 and a power transistor to provide the power relay drive.
If a delay time is needed, it can be designed with R and C. FET transistors 2SK 30 and 2SK 49 are suitable for N channel FET. Transistors 2SC 496, 614, 959, 1014, 1212 and 1226 are suitable for this circuit.

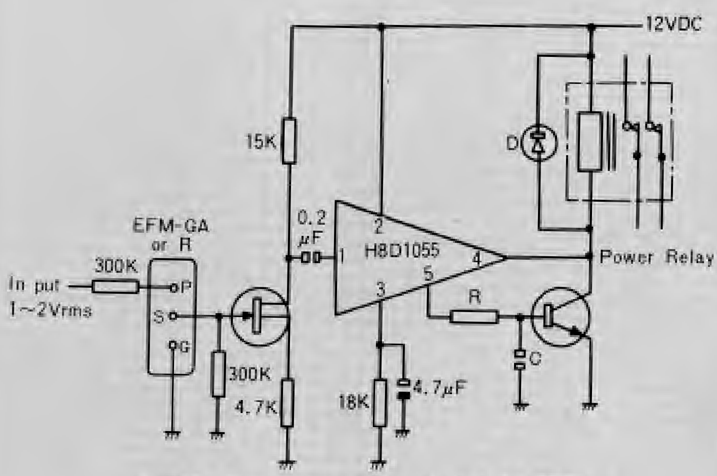


Fig. 42 Power relay driving circuit (with FET)
– H8D1055 application –

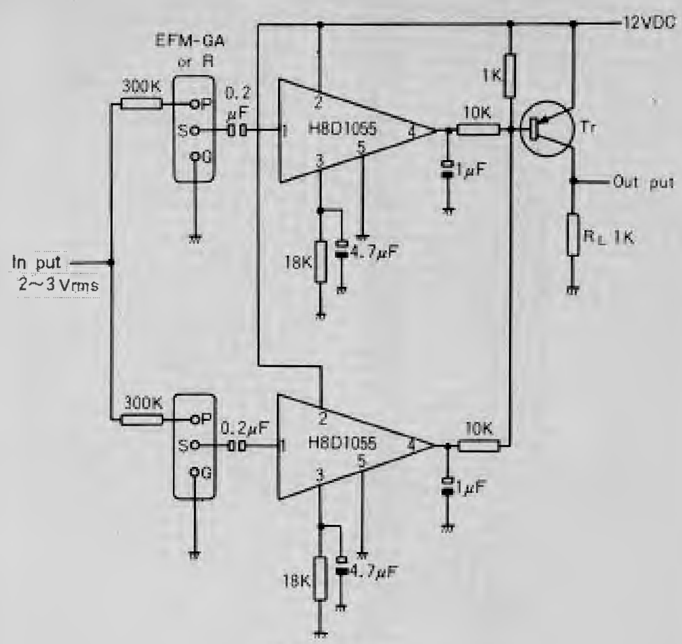


Fig. 43 OR circuit
– H8D1055 application –

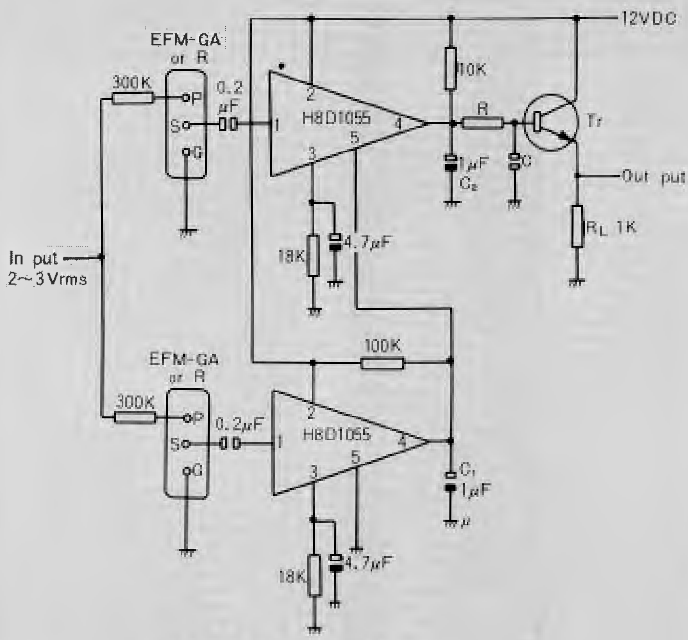


Fig. 44 AND circuit
– H8D1055 application –

9. OR circuit

– H8D1055 application –

This example is composed of an OR circuit, using a PNP transistor and combining the output signal of H8D1055 with a resistor.
If the load R_L is low, it is appropriate to add a power amplifier.
Transistors 2SA 495, 530, 532, 546, 695 and 733 are available.

10. AND circuit

– H8D1055 application –

This example is composed of a AND circuit, using a transistor and connecting D.C. output of H8D 1055 in series.
For a sequential tone system, increase the capacitance of both C_1 and C_2, and set the time-constant as long as possible.
If a D.C. amplitude is needed, use an OR circuit, using a PNP transistor.
If a time-constant is needed in the output stage, it can be set with both R and C.
Transistors 2SC 373, 458, 536, 711, 828 and 945 are suitable.

11. Latching circuit

– H8D1055 application –

This example consists of a Latching circuit, using H8D1055, a transistor and a midget relay.

If there is no signal, the transistor is in an "ON" state. But because the H8D1055 is in an "OFF" state, there will be no output. If a signal enters the "ON" channel, the H8D1055 will come "ON" and the midget relay will operate.

Because of the structure of a self-holding circuit brought about by the contact points, the output will be maintained even if the "ON" signal is no longer present.

If the "OFF" channel signal comes in, the external transistor will act as a cut-off bias and the relay will return.

Transistors 2SC 373, 458, 536, 711, 828 and 945 are suitable (normal small signal transistors).

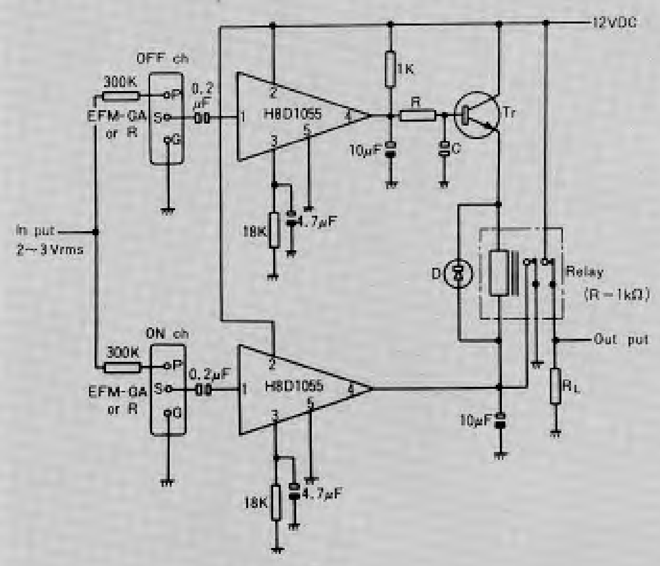


Fig. 45 **Latching circuit**
– H8D1055 application –

Standard frequency list (Hz)

series 1		series 2		
288.5	651.9	367.5	817.5	300.0
296.5	669.9	382.5	832.5	400.0
304.7	688.3	397.5	847.5	500.0
313.0	707.3	412.5	862.5	600.0
321.7	726.8	427.5	877.5	700.0
330.5	746.8	442.5	892.5	800.0
339.6	767.4	457.5	907.5	900.0
349.0	788.5	472.5	922.5	1000
358.6	810.2	487.5	937.5	1100
368.5	832.5	502.5	952.5	1200
378.6	855.5	517.5	967.5	1300
389.0	879.0	532.5	982.5	1400
399.8	903.2	547.5	997.5	1500
410.8	928.1	562.5	1012.5	1600
422.1	953.7	577.5	1027.5	1700
433.7	979.9	592.5	1042.5	1800
445.7	1006.9	607.5	1057.5	1900
457.9	1034.7	622.5	1072.5	2000
470.5	1063.2	637.5	1087.5	2100
483.5	1092.4	652.5	1102.5	2200
496.8	1122.4	662.5	1117.5	2300
510.5	1153.4	682.5	1132.5	2400
524.6	1185.2	697.5	1147.5	2500
539.0	1217.8	712.5		2600
553.9	1251.4	727.5		2700
569.1	1285.8	742.5		2800
584.8	1321.2	757.5		2900
600.9	1357.6	772.5		3000
617.4	1395.0	787.5		
634.5	1433.4	802.5		

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