PASSIVE COMPONENTS

DATA HANDBOOK

BOOK PA07 1994

Quartz Crystals for Special and Industrial Applications

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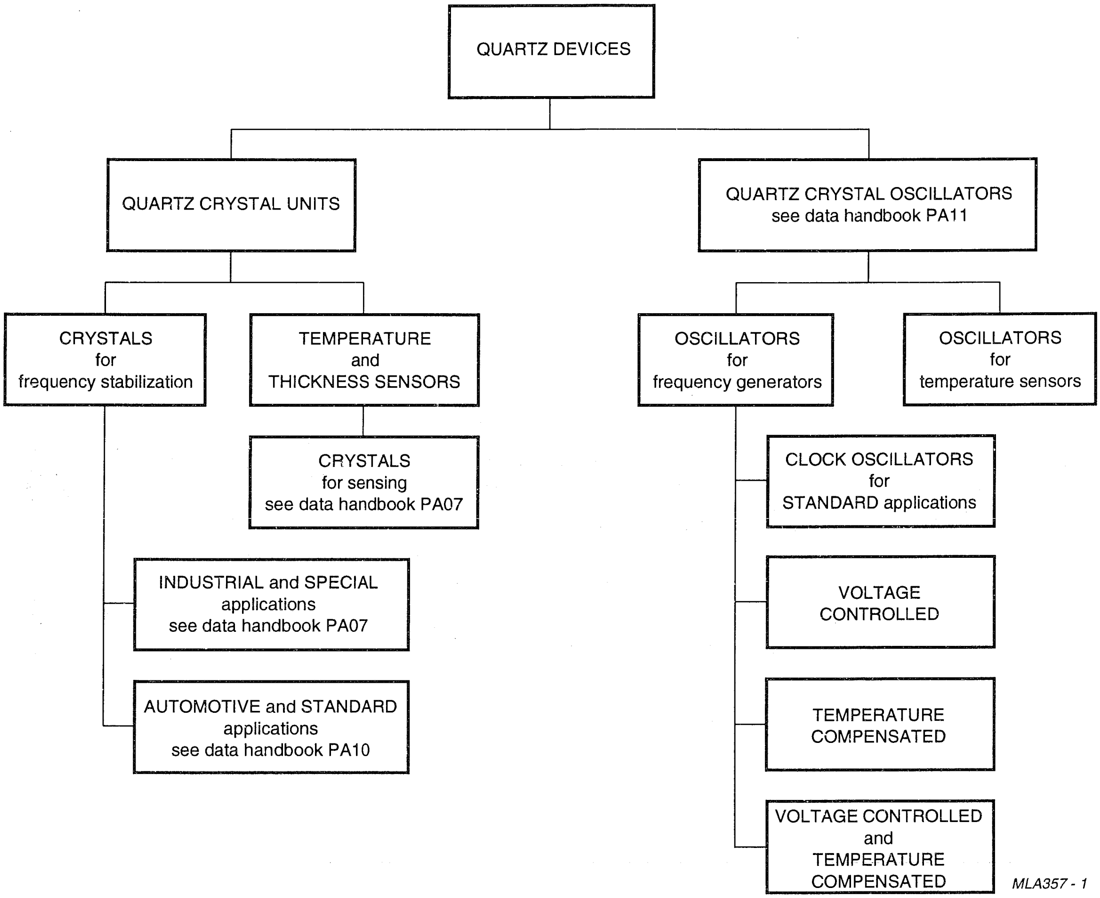
QUARTZ DEVICES
QUARTZ CRYSTAL UNITS
QUARTZ CRYSTAL OSCILLATORS
see data handbook PA11
CRYSTALS
for
frequency stabilization
TEMPERATURE
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OSCILLATORS
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Quartz Crystals for Special and Industrial Applications

CONTENTS

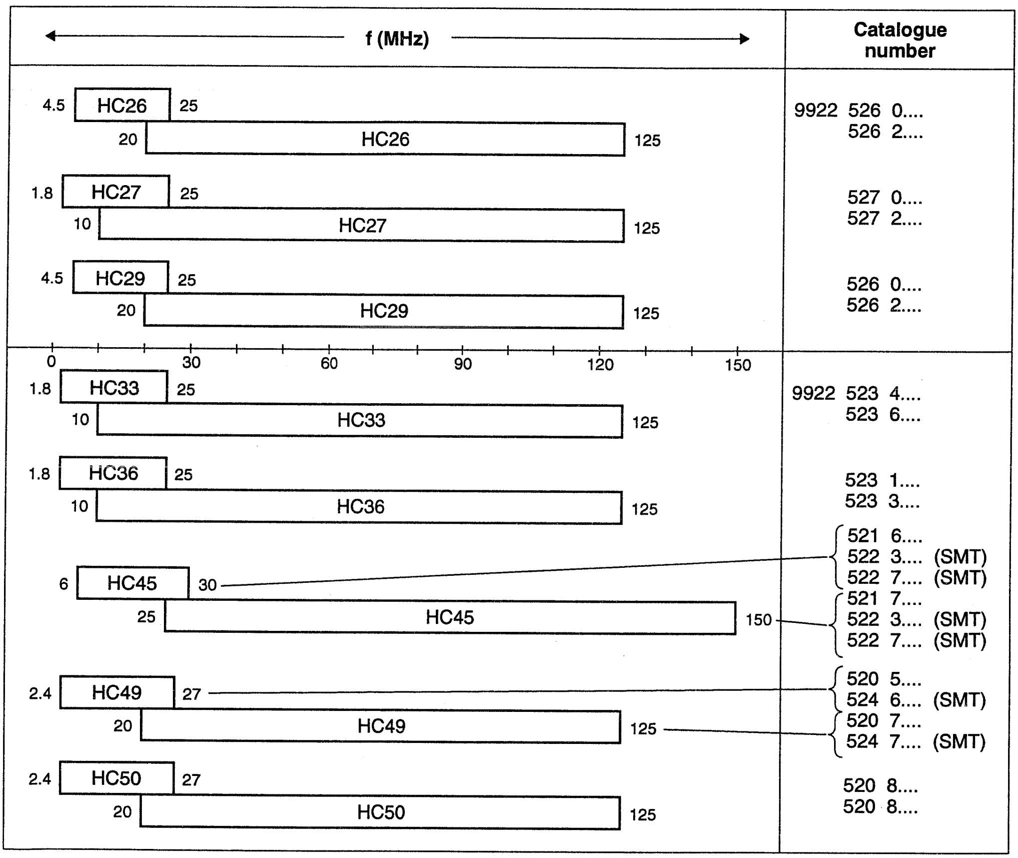
DEFINITIONS

Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Limiting values	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

LIFE SUPPORT APPLICATIONS

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Philips customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Philips for any damages resulting from such improper use or sale.

OVERVIEW OF HOLDER TYPES AND FREQUENCIES


f (MHz)
Catalogue number
4.5 HC26 25
20 HC26 125
9922 526 0....
526 2....
1.8 HC27 25
10 HC27 125
527 0....
527 2....
4.5 HC29 25
20 HC29 125
526 0....
526 2....
0 30 60 90 120 150
1.8 HC33 25
10 HC33 125
9922 523 4....
523 6....
1.8 HC36 25
10 HC36 125
523 1....
523 3....
6 HC45 30
25 HC45 150
521 6....
522 3.... (SMT)
522 7.... (SMT)
521 7....
522 3.... (SMT)
522 7.... (SMT)
2.4 HC49 27
20 HC49 125
520 5....
524 6.... (SMT)
520 7....
524 7.... (SMT)
2.4 HC50 27
20 HC50 125
520 8....
520 8....

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GENERAL INTRODUCTION

INTRODUCTION

For practical reasons, technical information on piezoelectric quartz devices is divided into three handbooks which have the following titles:

PA07 - Quartz crystals for special and industrial applications

PA10 - Quartz crystals for automotive and standard applications

PA11 - Quartz oscillators.

A quartz crystal consists of a quartz crystal element with electrodes, mounted in a hermetically sealed holder with connecting pins or leads. Quartz crystals are normally used in oscillator and filter circuits.

The quartz crystal element is a vibrating resonant plate which relies upon the piezoelectric effect to couple it to electrical circuits. Crystal elements are normally cut in the form of plates. The dimensions of these elements and their orientation with respect to the axes of the crystal give the characteristic of the element. The dimensions are such that the mechanical resonance frequency equals the desired electrical frequency. There are a large number of crystal cuts but the most advantageous orientation is the so-called AT-cut. The frequency range that can be covered is from 1 to 250 MHz. The crystal element may vibrate in the fundamental vibration mode or in the third, fifth or higher overtone. Special cuts for temperature sensors used in digital temperature measurement equipment, are also available.

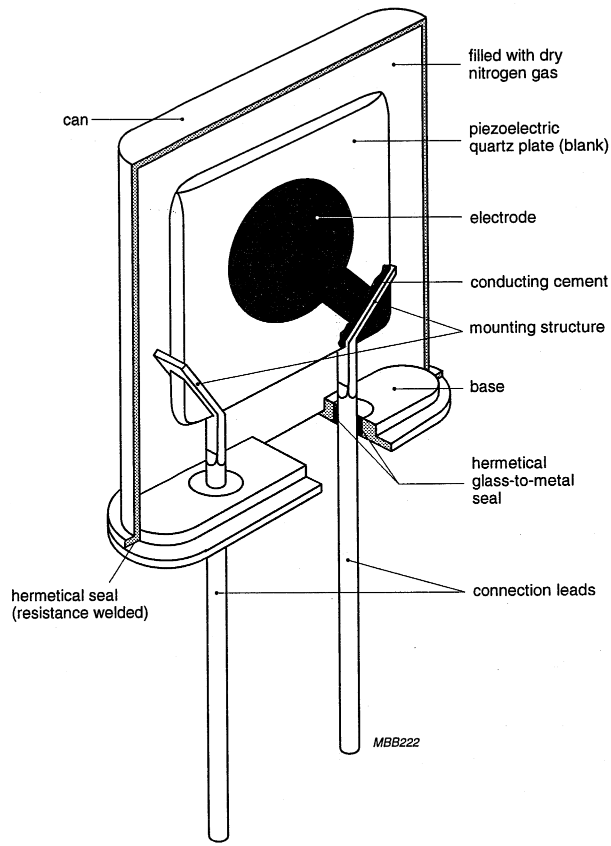


Fig.1 Section of a quartz crystal unit.

The intrinsic properties of quartz make it a unique device for accurate and stable frequency control and selection. As the properties of quartz (temperature coefficient, ageing, high Q factor) are very stable, the ultimate performance of the element is largely dependent on the environment and the associated electrical circuits. The design of an oscillator requires high technical skill to give the maximum possible efficiency out of the connection between the crystal and the circuit. A range of oscillator circuits have been designed for all kinds of applications with an optimum pack of specifications. It is advised that any particular application should be discussed with the crystal manufacturer at the earliest possible stage of the design.

QUARTZ CRYSTAL UNITS FOR FREQUENCY STABILIZATION

HOLDER TYPE	CATALOGUE NUMBER(1)	FREQUENCY RANGE(2) (MHz)	MODE OF VIBRATION	PAGE
Metal holders				
HC-45/U	9922 521 6....	6.0 to 30.0	fundamental	39
HC-45/U-SMD	9922 522			53
HC-45/U	9922 521 7....	24.0 to 150.0	3rd and 5th overtone	39
HC-49/U	9922 520 5....	2.4 to 27.0	fundamental	23
HC-49/U	9922 520 7....	16.8 to 125.0	3rd and 5th overtone	23
HC-49/U-SMD	9922 524 6....	2.4 to 27.0	fundamental	73
HC-49/U-SMD	9922 524 7....	20.0 to 75.0	3rd overtone	73
HC-50/U	9922 520 8....	2.4 to 27.0	fundamental	23
HC-50/U	9922 520 8....	16.8 to 125.0	3rd and 5th overtone	23
HC-33/U	9922 523 4....	1.8 to 25.0	fundamental	67
HC-33/U	9922 523 6....	10.0 to 125.0	3rd and 5th overtone	67
HC-36/U	9922 523 1....	1.8 to 25.0	fundamental	67
HC-36/U	9922 523 3....	10.0 to 125.0	3rd and 5th overtone	67
All-glass holders				
HC-27/U	9922 527 0....	1.8 to 25.0	fundamental	93
HC-27/U	9922 527 2....	10.0 to 125.0	3rd and 5th overtone	93
HC-26/U	9922 526 0....	4.5 to 25.0	fundamental	85
HC-26/U	9922 526 3....	20.0 to 125.0	3rd and 5th overtone	85
HC-29/U	9922 526 0....	4.5 to 25.0	fundamental	85
HC-29/U	9922 526 3....	20.0 to 125.0	3rd and 5th overtone	85

Notes

1. In previous years a different code number system (4322 ... .) has been used. Existing products may still be delivered under that code number system.
2. Frequencies up to 250 MHz including higher modes of vibration, are available on special request only.

QUARTZ THICKNESS UNITS FOR TEMPERATURE SENSING APPLICATIONS

HOLDER TYPE	CATALOGUE NUMBER	FREQUENCY RANGE (MHz)	MODE OF VIBRATION	PAGE
Metal holders				
HC-45/U	9922 521 5....	8.0 to 25.0	fundamental	115
HC-49/U	9922 520 6....	4.0 to 25.0	fundamental	105
All-glass holders				
HC-26/U	9922 526 2....	5.0 to 25.0	fundamental	123
HC-29/U	9922 526 2....	5.0 to 25.0	fundamental	123

QUARTZ THICKNESS SENSOR ELEMENTS

HOLDER TYPE	CATALOGUE NUMBER	FREQUENCY RANGE (MHz)	MODE OF VIBRATION	PAGE
Naked blank	9922 529 8....	4.0 to 9.5	fundamental	129

CROSS REFERENCE OF HOLDER TYPES

Corresponding IEC, DIN and MIL Type Numbers.

HOLDER TYPE	IEC 122-3	DIN 45110	MIL 3098	OTHERS(1)
HC-6/U	AA	K1A	HC-6/U	–
HC-26/U	CY	R2A	HC-26/U	–
HC-27/U	DA	Q1A	HC-27/U	–
HC-27/U, extended	DB	Q1B	HC-28/U	–
HC-29/U	CZ	R1A	HC-29/U	–
HC-33/U	DZ	K6B	HC-51/U	–
HC-45/U	EB; EK	N4B	HC-52/U	UM-1
HC-49/U9	–	–	–	–
HC-49/U11	EH	M4B	HC-49/U	HC-43/U
HC-49/U13	DP	M4C	HC-49/U	HC-18U
HC-50/U13	DQ	M3C	HC-42/U	–
RW-36	DN	K3A	HC-48/U	HC-36/U
RW-10	DS	K4A	–	–

Note

1. Corresponding numbers may have different sealing techniques.

TERMS AND DEFINITIONS IN ACCORDANCE WITH IEC 122-1

Resonance frequency (f_r)

The lower of the two frequencies of the quartz crystal alone, under specified conditions, at which the electrical impedance of the quartz crystal is resistive.

Anti-resonance frequency (f_a)

The higher of the two frequencies of the quartz crystal alone, under specified conditions, at which the electrical impedance of the quartz crystal is resistive.

Load resonance frequency (f_L)

One of the two frequencies of a quartz crystal in association with a series or parallel load capacitance, under specified conditions, at which the electrical impedance of the combination is resistive. This frequency is the lower of the two frequencies when the load capacitance is in series and the higher when it is in parallel (see Fig.3). For a given value of load capacitance (C_L), these frequencies are identical for all practical purposes and given by:

$$\frac{1}{f} = 2\pi\sqrt{\frac{L_1 C_1 (C_0 + C_L)}{C_1 + C_0 + C_L}}$$

Nominal frequency (f_n)

The frequency assigned by the specification of the quartz crystal.

Working frequency (f_w)

The operational frequency of the quartz crystal together with its associated circuits.

Overall tolerance

The maximum permissible deviation of the working frequency from nominal frequency due to a specific cause or a combination of causes.

Adjustment tolerance

The permissible deviation from the nominal frequency at the reference temperature under specified conditions.

Ageing tolerance

The permissible deviation due to time under specified conditions.

Tolerance over the temperature range

The permissible deviation over the temperature range with respect to the frequency at the specified reference temperature.

Tolerance due to level of drive variation

The permissible deviation due to the variation of level of drive. Also called Drive Level Dependency (DLD).

Operating temperature range (T_{oper})

The range of temperatures as measured on the holder over which the quartz crystal must function within the specified tolerances.

Operable temperature range (T_{op})

The range of temperatures as measured on the holder over which the quartz crystal must function within though not necessarily within the specified tolerances.

Reference temperature (T_{ref})

The temperature at which certain crystal measurements are made. For controlled temperature crystals, the reference temperature is the mid-point of the controlled temperature range, for example +70 °C. For non-controlled temperature crystals, the reference temperature is normally 25 ±2 °C.

Resonance resistance (R_r)

The resistance of the quartz crystal alone at the resonance frequency (f_r).

Load resonance resistance (R_L)

The resistance of the quartz crystal in series with a stated external capacitance at the load resonance frequency (f_L).

Note: The value of R_L is related to the value of R_r by the following expression:

$$R_L = R_r\left(1 + \frac{C_0}{C_L}\right)^2$$

Level of drive

A measure of the conditions imposed upon the quartz crystal expressed in terms of dissipated power.

Note: In special cases, the level of drive may be specified in terms of crystal current or voltage.

Unwanted response (R_n)

A state of resonance of a crystal vibrator other than that associated with the working frequency.

Load capacitance (C_L)

The effective external capacitance associated with the quartz crystal which determines the load resonance frequency (f_L).

Ageing (long term parameter variation)

The relationship which exists between any parameter (e.g. resonance frequency) and time.

Note: Such parameter variation is due to long-term changes in the quartz crystal and is usually expressed in fractional parts per period of time.

Motional capacitance (C_1)

The capacitance of the motional (series) arm of the equivalent circuit.

Motional inductance (L_1)

The inductance of the motional (series) arm of the equivalent circuit.

ELECTRICAL PROPERTIES AND BEHAVIOUR

Quartz crystal equivalent circuit

The equivalent circuit, which has the same impedance as the quartz crystal in the immediate neighbourhood of resonance, is usually represented by an inductance, capacitance and resistance in series, this series branch being shunted by the capacitance between the terminals of the unit. The parameters of the series branch are usually given by L_1, C_1 and R_1. The parallel capacitance is given by C_0 (see Fig.2).

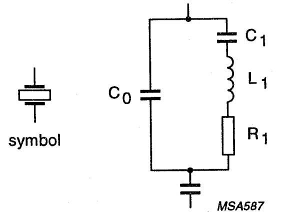


Fig.2 Quartz crystal equivalent circuit.

The parameters of the series branch are termed the 'motional parameters' of the quartz crystal.
The parameter C_0 is termed the 'parallel capacitance'.

The equivalent circuit has two resonance frequencies at which the electrical impedance is resistive: the 'resonance frequency' (f_r) and the 'anti-resonance frequency' (f_a).
The resistance of the equivalent circuit at the resonance frequency (f_r) is termed the 'resonance resistance' (R_r).

For $R_1 < \frac{1}{\omega C_0}$

the following relationships hold:

$$f_r = \frac{1}{2\pi\sqrt{L_1 C_1}} \quad (1)$$

$$f_a = \frac{1}{2\pi\sqrt{L_1 \frac{C_1 C_0}{C_1 + C_0}}} \quad (2)$$

$$R_r = R_1 \quad (3)$$

Load capacitance and frequency pulling

During manufacture, definable limits are set to the accuracy of frequency. In an oscillator, a load capacitance (C_L) is required to trim the working frequency (f_w) to the nominal frequency (f_n). Figure 2 shows the quartz crystal equivalent circuit with a load capacitance in series and parallel. Each combination has two resonance frequencies at which the electrical impedance of the circuit is resistive. The lower of the two frequencies, when the load resistance is connected in series and the higher with the load connected in parallel, are termed 'load resonance frequencies' (f_L). At this frequency the resistance of the combination with the load capacitance in series is termed 'load resonance resistance' (R_L).

For $R_1 < \frac{1}{\omega C_0}$

$$f_L = \frac{1}{2\pi\sqrt{L_1 \frac{C_1 (C_0 + C_L)}{C_1 + C_0 + C_L}}} \quad (4)$$

$$R_L = R_r \left(1 + \frac{C_0}{C_L}\right)^2 \quad (5)$$

For a given value of C_L the load resonance frequencies of the series and parallel combination are identical. In practice, however, the parallel combination shown in Fig.3 (c) rarely occurs in an oscillator. From equation (4) another two parameters of vital concern can be derived: the difference (Δf) between load resonance frequency (f_L) and resonance frequency (f_r), and the relative change in frequency as a function of the change in load capacitance, termed 'pulling sensitivity' (S).

$$\Delta f = f_L - f_r \quad (6)$$

with f_L from equation (4) and f_r from equation (1)

$$\Delta f = \frac{f_r}{2} \times \frac{C_1}{C_0 + C_L} - \frac{\Delta f^2}{2 f_L} \quad (7)$$

and to a close approximation

$$\Delta f = \frac{f_r}{2} \times \frac{C_1}{C_0 + C_L} \quad (8)$$

Equation (8) greatly simplifies calculations and methods of measurement, whilst the error is negligible in nearly all cases.

The resistance of the combination with the load capacitance in parallel is given by:

$$R_{Lpar} = \frac{1}{\omega_r^2 R_1 (C_0 + C_L)^2} \quad (9)$$

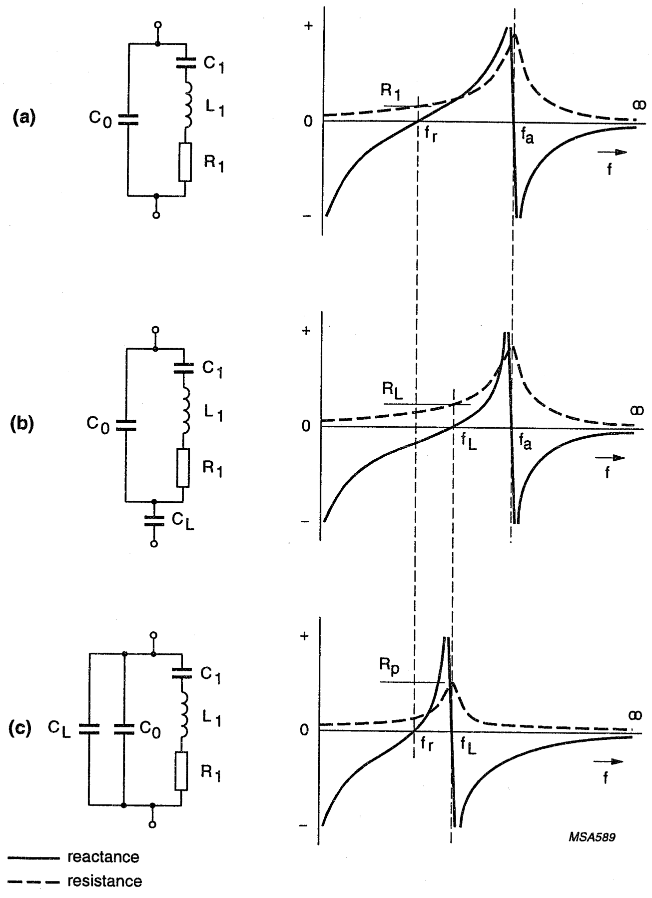


Fig.3 Resonance, anti-resonance and load resonance frequency.

Standard values of load capacitance

The standard values of load capacitance for quartz crystals operating at the fundamental frequency of the mode are:

20 pF, 30 pF, 50 pF, 100 pF.

Note: In some countries 32 pF is still in use, but this value should not be considered a standard value and its use is not recommended.

In special cases, load capacitances of the values 8, 12 and 15 pF may be used for fundamental mode quartz crystals.

Overtone quartz crystals are often operated at series resonance. Where a load capacitance is used, it should be chosen from the following standard values:

8 pF, 12 pF, 15 pF, 20 pF, 30 pF.

Pulling Sensitivity (S)

$$S = \frac{1}{f_L} \times \frac{\delta f}{\delta C_L} = \frac{1}{f_L} \times \frac{\delta \Delta f}{\delta C_L} \qquad (10)$$

with Δf from equation (8)

$$S = -\left[\frac{f_r}{2} \times \frac{C_1}{(C_0 + C_L)^2} \times \frac{1}{f_L}\right] \qquad (11)$$

and to a close approximation

$$S = -\frac{C_1}{2(C_0 + C_L)^2} \qquad (12)$$

The pulling sensitivity expressed in 10^{-6}/pF is a good measure for the frequency sensitivity as a function of load capacitance variations at the working frequency. Figure 4 illustrates Δf and the pulling sensitivity (S) as a function of the load capacitance, for two quartz crystals having different C_1 and C_0 values. It should be noted that a tolerance of 0.5 pF on a 20 pF load capacitance may lead to an error of $\pm 11 \times 10^{-6}$.

Table 1 Quartz crystal parameters (see Fig.4).

QUARTZ CRYSTAL (a)	QUARTZ CRYSTAL (b)
f_r = 9994.400 kHz (1)	f_r = 9998.727 kHz (1)
C_0 = 5 pF (1)	C_0 = 2 pF (1)
C_1 = 28 pF (1)	C_1 = 5.6 fF (1)
C_L = 20 pF	C_L = 20 pF
f_L = 10000000 kHz	f_L = 10000000 kHz
S = -22.4×10^{-6} pF	S = -5.79×10^{-6} pF

Note

1. Tolerances on the parameters f_r, C_0 and C_1 are required for calculating the 'Δf' and the 'pullability at f_n'.

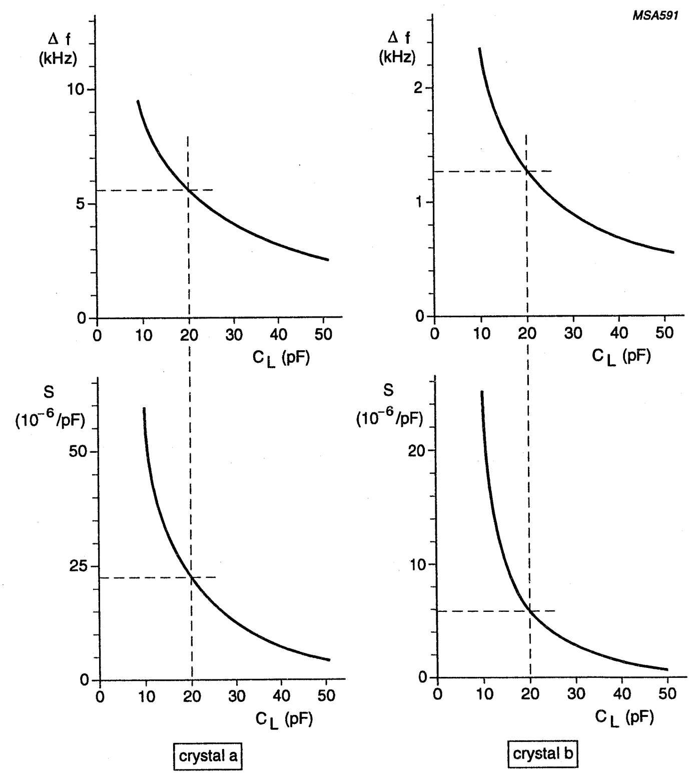


Fig.4 Change in frequency (Δf) and pulling sensitivity (S) as a function of the load capacitance.

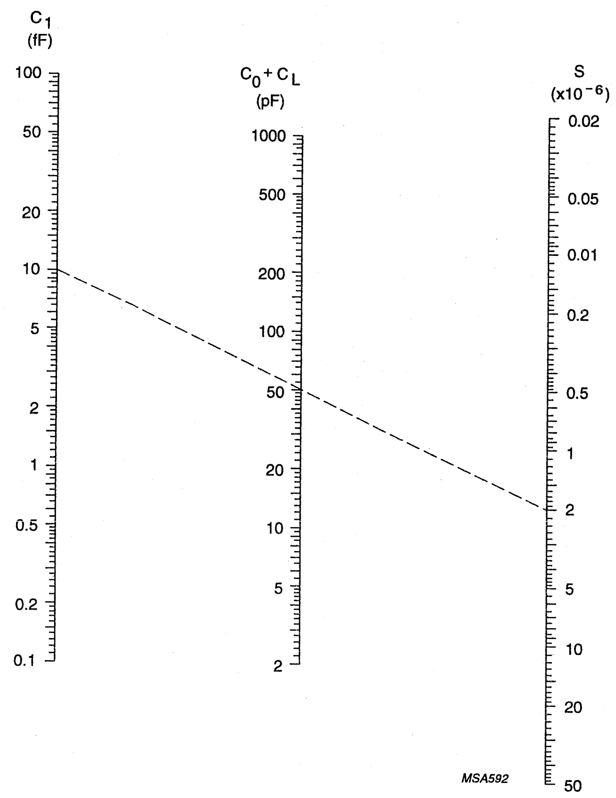


Fig.5 Nomogram enabling the determination of pulling sensitivity (S).

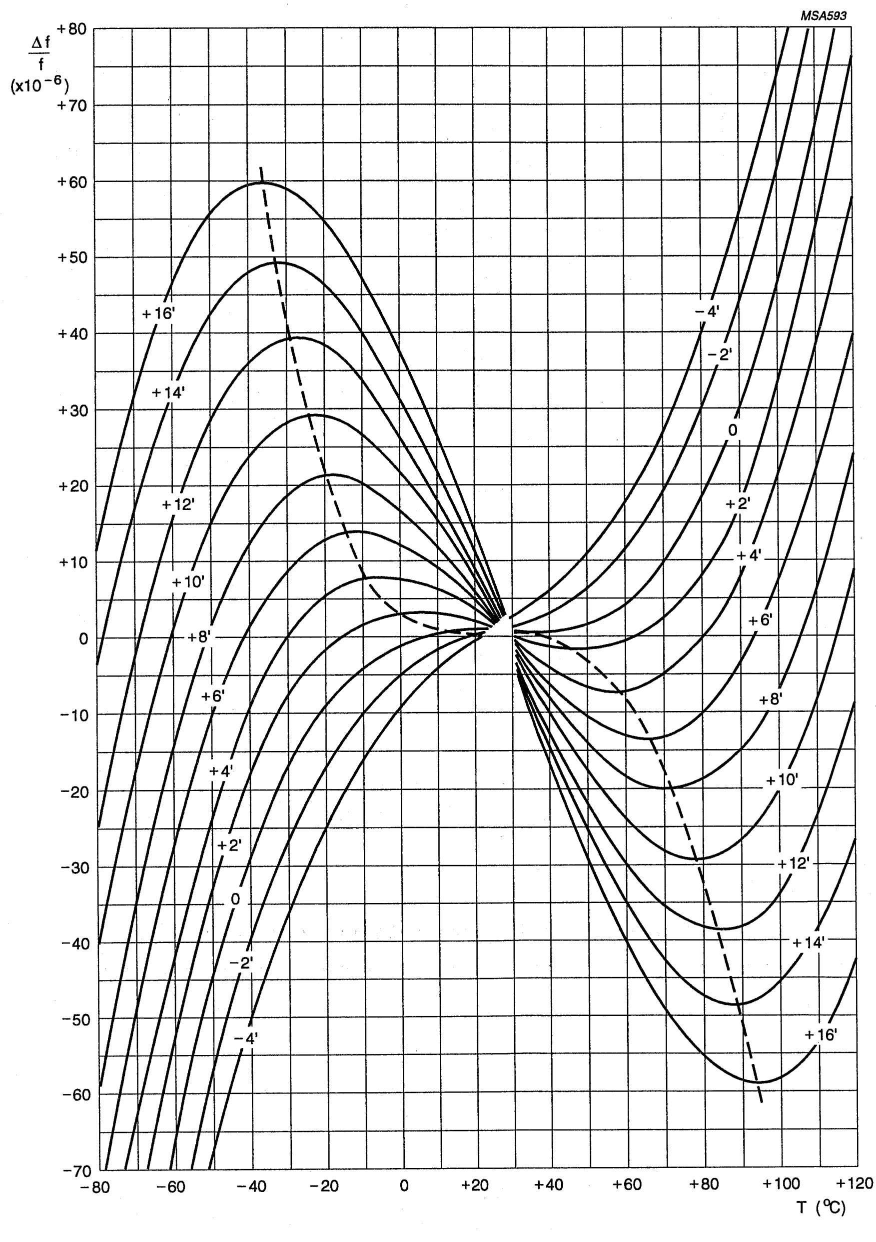


Fig.6 Examples of frequency/temperature characteristics of AT-cuts as a function of the cutting angle.

Level of drive

The power dissipated in a quartz crystal is termed ‘level of drive’ and is usually expressed in mW. In the level of drive range 10^{-12} to 10^{-3} W the drive level dependency of the crystal characteristics is almost negligible. For drive levels greater than approximately 0.5 mW, the crystal characteristics tend to change. For this reason the crystal characteristics are specified at drive levels of 0.05 mW to 0.5 mW depending on the crystal type.

Low drive levels

When a quartz crystal oscillator is switched on, there will initially be some noise in the circuit. The noise power, which depends on the circuit design and on the components used, will be in the region of 10^{-16} W. From this level, the oscillatory power builds up in the quartz crystal, passing through a power range of approximately 12 decades to its maximum value. At the extremely low power levels that occur during build up of oscillation, the resonance resistance (R_r) may increase slightly. The quartz crystal oscillator should, therefore, have sufficient loop gain to avoid start-up problems. Typically, a negative resistance of three times the specified $R_{r(max)}$ value is sufficient.

High drive levels

For applications requiring high stability, a drive level between 5 µW and 100 µW should be used. Drive levels <<0.5 µW should be avoided, and excessively high drive levels (exceeding 5 mW) may seriously affect the quartz crystal's behaviour.

Frequency/temperature characteristics

The frequency drift as a function of temperature can be represented by a graph showing the temperature coefficient (TC) curve or drift characteristic. In the case of AT cuts, the relation of drift and temperature is approximated by a cubic curve; the drift characteristic of most other cuts is parabolic.

Figure 6 shows a number of frequency-temperature curves obtained from AT-cut crystals with various angles of cut (α from –4' to +16' increasing angle of cut). The curves are symmetrical with respect to approximately +27 °C.

A temperature range which is fairly symmetrical with respect to 27 °C (e.g. 0 to 60 °C) will, therefore, result in the smallest frequency drift in that range. A small frequency drift over a wide temperature range, e.g. –40 to +80 °C, will result in a fairly steep temperature coefficient at room temperature.

Advantages of all-glass holders

Quartz crystals with all-glass holders show the following advantages over those with metal holders:

1. A lower ageing rate.
2. A lower series resistance, which also means a higher Q-factor, due to the fact that glass holders are evacuated giving less mechanical damping.
3. Better performance under adverse climatic conditions.
4. Smaller adjusting tolerances.

Ageing

A gradual change in resonance frequency with time is called (an effect of) ageing. Only where very good long-term stability is required should ageing be of consequence. It should be borne in mind that (with a view to ageing only):

1. Quartz crystals with an all-glass holder have a lower ageing rate.
2. Low frequency crystals are preferred to high frequency crystals.
3. Overtone crystals are preferred to fundamental crystals for the same frequency.

Crystal behaviour in an oscillator

In the vicinity of resonance, the impedance of a quartz crystal can be represented by a circle (see Fig.7). The circle is shifted downwards with respect to the resistance axis over:

$$X_0 = \frac{1}{2\pi f_r C_0} \qquad (13)$$

When a load capacitance is connected in series with the quartz crystal the shift is $X_0 + X_L$, where

$$X_L = \frac{1}{2\pi f_L C_L} \qquad (14)$$

The difference between anti-resonance frequency and resonance frequency

$$f_a - f_r \approx \frac{C_1}{2C_0} \times f_r \times \frac{C_L}{C_0 + C_L} \qquad (15)$$

is assumed to be 100%.

It can be seen that the difference between the two frequencies, determined by the phase angle φ, disappears at f_w = 50%. The phase angle in the oscillator should be kept sufficiently small to avoid quartz crystal operation in the uncertain 50% area (frequency switching).

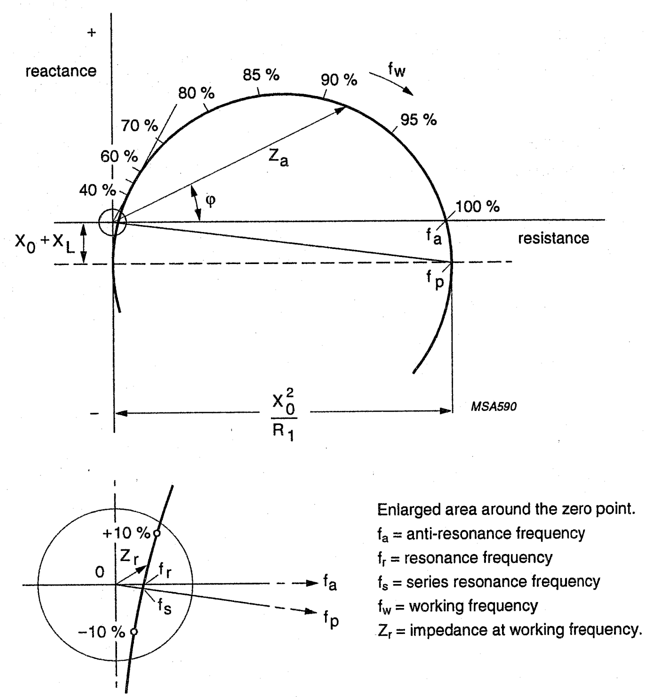


Fig.7 Working frequency and impedance of a quartz crystal in the impedance diagram.

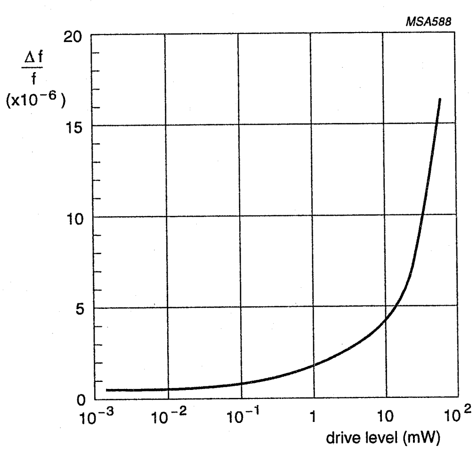


Fig.8 Quartz crystal drive level.

Quartz crystals for frequencies higher than 100 to 125 MHz (depending on type) have an impedance circle with a greater downwards shift, even to below the real axis. When the figure of merit given by

$$M = \frac{X_0}{R_1} = \frac{1}{(2\pi f_r)\,R_1 C_0} \qquad (16)$$

is less than approximately 5, the resonance frequency (f_r) is arbitrary.

Indications for use

Keep phase deviations in the circuit sufficiently low to avoid quartz crystal operation in the 50% working frequency area, in particular when phase variation is used for frequency pulling (PLL system).

Ensure that the amplification is sufficiently high, particularly when applying phase variation.

Keep quartz crystal drive level low (generally ≤100 μW), (see Fig.8).

MEASURING PROCEDURES

Several methods of measuring quartz crystals are in use. Because different methods may give various results (see Fig.9).

This is the passive method with π-network in accordance with IEC publication 444. The accuracy of reproduction of the π-network method ranges between 10^{-6} and 10^{-8} for frequency measurements, depending on the type of quartz crystal to be measured.

Passive method with π-network (IEC 444)

The principle of this method is very simple. With the equipment shown in Fig.9, a stable signal source (frequency synthesizer) is adjusted to the frequency at which the signal has zero phase change when passing through the crystal, as measured by the phase meter; this frequency (measured with the frequency counter) is then the resonance frequency of the crystal.

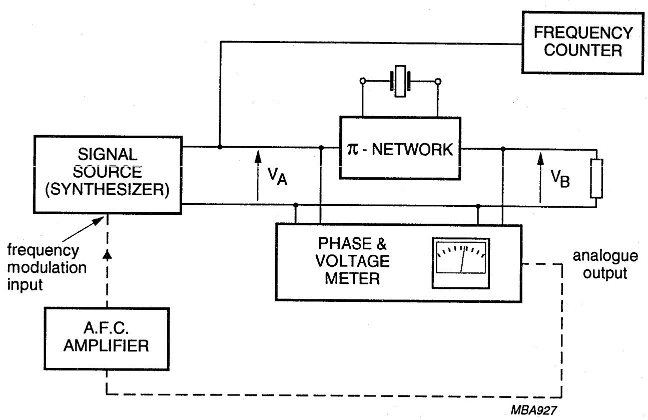


Fig.9 Test equipment block diagram.

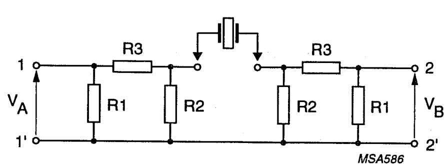


Fig.10 Test jig.

For ease of operation, it is possible to phase-lock the system by feeding back the analogue output of the phase error (from zero) to control the precise frequency of the signal source (AFC loop shown by dashed line).

Measuring methods can also be applied by using the following equipment if it is available:

SAUNDERS Test Set, type 150 (A, B, C).

Crystal Test Set, type TS193A (British Military Standard).

Crystal Impedance Meter TS330/TSM (U.S. Army Standard).

Crystal Impedance Meter TS683/TSM (U.S. Army Standard).

A π-network test jig is used to connect the quartz crystal to the measuring equipment (see Fig.10). This test jig consists of two π-connected resistive pads, carefully manufactured to represent a pure, constant resistance, which is frequency insensitive at the terminals of the quartz crystal.

The function of the input and output 'pads' is twofold:

1. To match the crystal impedance to the associated equipment.
2. To attenuate reflections from the associated equipment.

For further information consult IEC recommendations, Publication 444.

Crystal shielding

Depending on the application, crystal shielding may give rise to frequency deviations, in particular for fundamental mode quartz crystals with a considerable pulling sensitivity.

In our procedure the metal enclosure of the quartz crystal is normally not earthed. If, in special cases, earthing is required this should be mentioned in the specification for ordering.

MOUNTING

Quartz crystals provided with pins (such as HC-6/U, HC-27/U, HC-29U and HC-50/U) are for mounting in sockets.

Quartz crystals with leads are for mounting on printed-circuit boards. There are basically two methods: horizontal and vertical mounting. Horizontal (flat) mounting gives better mechanical stability whilst vertical mounting uses less printed-circuit board space. To prevent permanent damage of quartz crystals during mounting operations, some precautions have to be taken:

- Glass feed-throughs are rather vulnerable so avoid excessive forces on the leads which can cause breakage. If cutting of the leads is necessary, use suitable tools to prevent shock waves in the leads.
- If bending of the leads is necessary e.g. in the event of flat mounting, make the bend at least 2 mm away from the body with a bending radius >0.5 mm.
- Note that, especially when the component is vertically mounted, the first mm of tinned leads away from the body, are not guaranteed for use. When mounting on thin printed-circuit boards (e.g. 0.7 mm), the use of spacers is recommended.

All crystal types are designed such that they withstand all commonly used soldering techniques, see Chapter *"Tests and requirements"* in the individual data sheets. Exposing the crystal units to high temperatures for a prolonged time, however, should be avoided.

For utmost mechanical stability and electrical reproducibility, metal types can be supplied with a third (top) lead which serves both as a ground wire and a three-point attachment to the printed circuit board.

QUARTZ CRYSTAL UNITS AS DIGITAL TEMPERATURE SENSORS

The most well known applications of quartz crystal units are those where the crystal is used in oscillator and filter circuits, as a frequency-selective element with an extremely high Q-factor. By correct choice of the cutting angle of the vibrating plate, it is possible to obtain a very low TC over a limited temperature range. Examples of such crystal cuts are: AT, BT, CT and GT cuts.

In addition, it is also possible to cut crystal plates so that the resonance frequency is an almost linear function of the temperature. It should be noted, that the first quartz crystal cut to be discovered was in fact a 'Y- cut'. However, there are some disadvantages which make this cut unsuitable for temperature sensing, therefore special cuts have been introduced, depending on the application.

How to use a quartz crystal unit as a temperature sensor

In order to measure temperatures with a quartz crystal sensor, the device should be connected to an oscillator circuit which usually consists of one or two transistors or an integrated circuit. The oscillator will produce an output signal whose frequency will change by -40 to $+80 \times 10^{-6}$/K. There are several ways of processing this signal. Due to excellent stability, low ageing and its 'digital' nature, resolutions of 0.001 K are easily achieved without noise problems. This renders the device especially suitable for measurements of very small temperature differences as in distillation columns and flow meters.

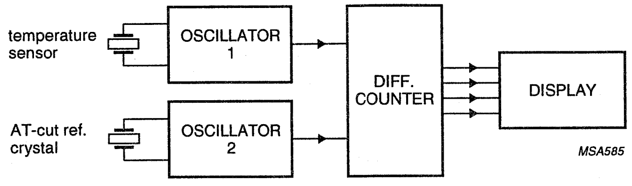


Fig.11 Typical temperature sensor.

HOW TO SPECIFY A QUARTZ CRYSTAL UNIT

DESCRIPTION	REQUIREMENTS
Customer	
Application	
Holder	
Wire length	mm (if not standard)
Frequency	kHz
Mode of vibration:	
fundamental	( )
overtone	( )
Resonance mode	( ) load resonance with C_L = pF ( ) series resonance
Operating temperature range (T_{oper})	°C to °C
Frequency tolerances; note 1	
adjustment	± ppm (at 25 °C)
temperature stability	± ppm
additional offset	± ppm (if required)
total tolerance	± ppm from °C to °C
ageing	± ppm
Maximum resonance resistance (R_r)	Ω (over temperature range)
Level of drive (method of measurement in accordance with IEC 144 related to 25 Ω)	μW
Equivalent parameters:	
C_0	pF tolerance: ± pF
C_1	fF tolerance: ± fF
L_1	mH tolerance: ± mH
Additional data	

Note

1. All references to ppm = 10^{-6}.

QUARTZ CRYSTALS

Quartz crystals - special and industrial applications HC-49/U and HC-50/U

9922 520 5/7.... series; 9922 520 8.... series

DESCRIPTION

The unit consists of a silver-plated AT-cut quartz plate, encapsulated in a nitrogen-filled metal holder. The holder is hermetically sealed by resistance-welding and provided with connecting leads (HC-49/U) or pins (HC-50/U). The unit has an outstanding electrical performance combined with a high mechanical stability, and a very high level of reliability. The quartz design yields low resistance and high pullability values.

APPLICATIONS

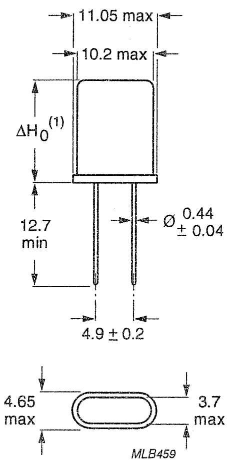
- Microprocessors
- Traffic control
- Weather balloons
- Medical systems
- Military applications
- Communication systems
- Agrarian applications
- Machine control
- Environmental applications.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
f_{nom}	nominal frequency:				
	fundamental mode	2400	–	27000	kHz
	third overtone	16800	–	75000	kHz
	fifth overtone	50000	–	125000	kHz
m	mass	–	1.2	–	g

MECHANICAL DATA

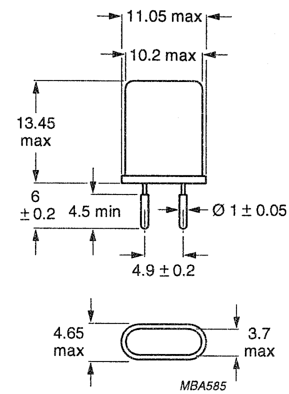
Package outlines



Dimensions in mm.

(1) For ΔH_0 see Table 1.

Fig.1 Style 1: HC-49/U in box.



Dimensions in mm.

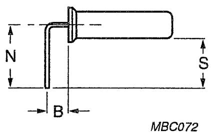
Fig.2 Style 10: HC-50/U in box.

Table 1 Component height; note 1.

MAXIMUM PRODUCT HEIGHT ΔH_0 (mm)	MINIMUM FREQUENCY (MHz)		
	FUNDAMENTAL MODE	THIRD OVERTONE	FIFTH OVERTONE
9.6	4.5	20.0	50.0
11.0	4.5	16.8	50.0
13.4	2.4	16.8	50.0

Note

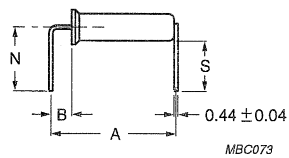
1. A plastic sleeve can be fitted around the case on request.
   Available lead length: up to 13 mm.
   Lead length tolerance for Style 1:
   a) Lead length > 3 mm: ±0.5 mm
   b) Lead length ≤ 3 mm: ±0.2 mm.



Dimensions in mm.

STYLE 4	N	B	S
a	7.0 ±0.6	2.5 ±0.6	5.2 ±0.6
b	8.0 ±0.6	2.0 ±0.6	6.2 ±0.6
c	9.7 ±0.6	3.0 ±0.6	7.9 ±0.6

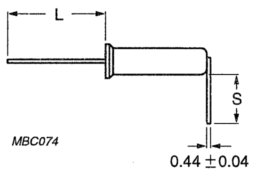
Fig.3 Style 4: HC-49/U in box.



Dimensions in mm.

STYLE 5	N	B	A	S
a	5.7 ±1.0	1.5	15.2 ±0.2	3.9 ±1.0
b	5.9 ±1.0	4.1	17.8 ±0.2	4.1 ±1.0
c	10.2 ±1.0	3.2	16.5 ±0.2	8.4 ±1.0

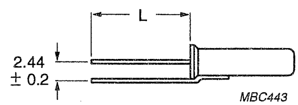
Fig.4 Style 5: HC-49/U in box.



Dimensions in mm.

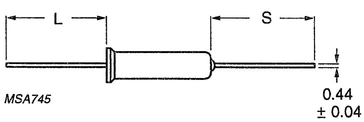
STYLE 6	L	S
a	13.2 ±0.5	4.5 ±1.0
b	13.2 ±0.5	10.0 ±1.0
c	5.0 ±0.5	19.5 ±1.0

Fig.5 Style 6: HC-49/U in box.



L: min. 12.7 mm; max. 13.0 mm.
Dimensions in mm.

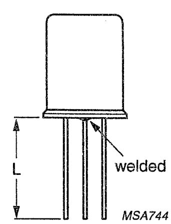
Fig.6 Style 7: HC-49/U in box.



Dimensions in mm.

STYLE 8	L	S
a	13.2 ±0.5	16.0 ±1.0
b	5.0 ±0.5	16.0 ±1.0

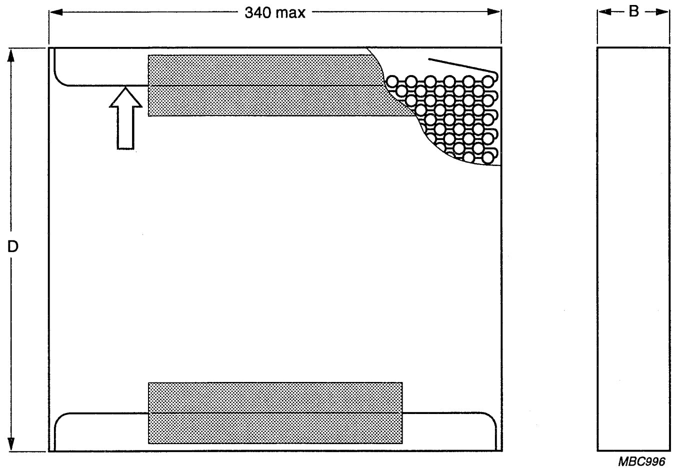
Fig.7 Style 8: HC-49/U in box.



L: min. 12.7 mm; max. 13.0 mm.

Fig.8 Style 9: HC-49/U in box.

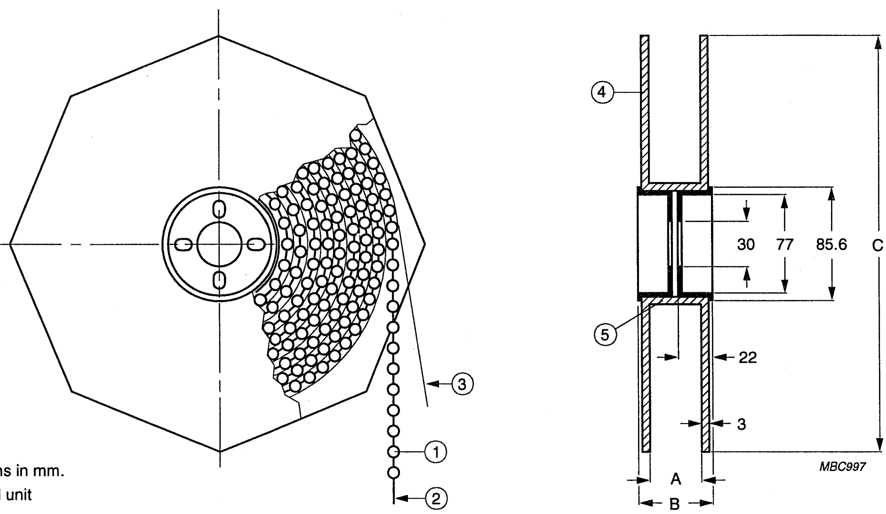
Tape and reel data



Dimensions in mm.
B = 46 mm max.
D = 185 mm max.

Style 3a is with insulation plate; see Fig.12.

Fig.9 Style 2a and 3a units on tape in ammopack.



Dimensions in mm.
1 = crystal unit
2 = tape
3 = paper
4 = flange
5 = cylinder

A = 45 mm
B = 55 mm max.
C = 355 mm max.

Style 3b is with insulation plate; see Fig.12.

Fig.10 Style 2b and 3b units on tape on reel.

Quartz crystals - special and industrial applications HC-49/U and HC-50/U

9922 520 5/7.... series; 9922 520 8.... series

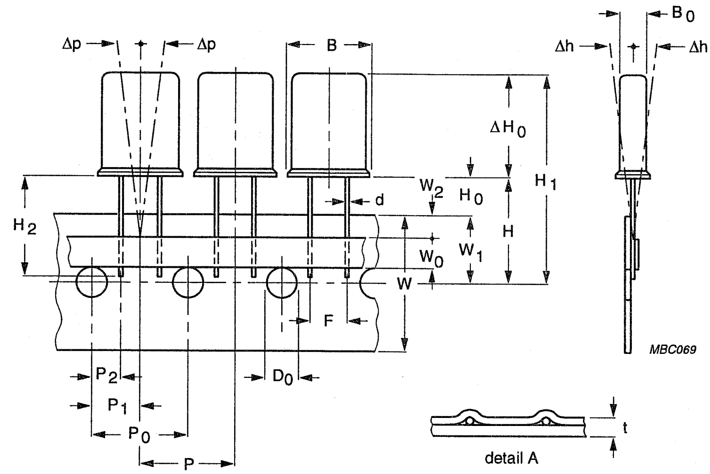


Fig.11 HC-49/U on tape.

Table 2 Taping dimensions (without the insulation plate) in accordance with IEC 286-2; see Fig.11.

SYMBOL	PARAMETER	VALUE	TOLERANCE	UNIT
B_0	body thickness	4.43	±0.05	mm
B	body width	10.75	±0.1	mm
Δh	component alignment vertical to tape plane	–	±2	mm
Δp	component alignment in tape plane	–	±1.3	mm
d	lead wire diameter	0.44	±0.04	mm
F	lead-to-lead	4.9	–	mm
P	pitch of components	12.7	±1	mm
P_0	feed-hole pitch	12.7	±0.3	mm
P_2	feed-hole centre to lead	3.9	±0.7	mm
P_1	feed-hole centre to component centre	6.35	±0.3	mm
D_0	feed-hole diameter	4.0	±0.2	mm
H	distance of component from tape centre	16.0	+2/0	mm
H_0	minimum component base to tape top	7.0	–	mm
H_2	lead length	13.2	±0.5	mm
W	carrier tape width	18.0	+1/–0.5	mm
W_0	maximum hold-down tape width	7.0	–	mm
W_1	feed-hole position	9.0	+0.75/–0.5	mm
W_2	maximum hold-down tape position	3.0	–	mm
t	maximum total tape thickness	0.9	–	mm

Insulation plate

Style 3 units are equipped with an insulation plate (see Fig.12) at the unit base. The insulation plate is made of PEEK (polyetherketone) in 0.25 mm thickness and resistant to soldering heat tests.

STANDARD MARKING(1)

- Line 1: PHILIPS
- Line 2: frequency in kHz (fundamental mode) or in MHz (overtone)
- LIne 3: last five digits of catalogue number followed by the manufacturing date code (last four digits of week code in accordance with UN-D1120).

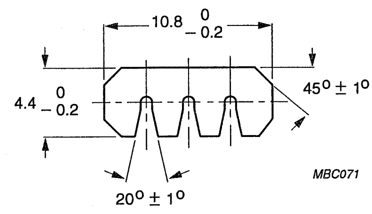
(1) Special marking on product and/or package is available on request.

MASS AND LEADS

Typical mass: 1.2 g.

The leads are finished with either Sn99Cu1, Sn60Pb40 or a gold finish on a nickel underplate.

The first 1 mm from the body is not guaranteed for soldering.



Dimensions in mm.

Fig.12 Insulation plate outline.

PACKAGING AND QUANTITIES

Table 3

STYLE	PACKAGING	QUANTITY
1	blister	24 units per blister
	box	maximum 1000 units per box
	tray	100 units per tray; 1 or 10 trays per box
2a and 3a	on tape in ammopack	1000 units per pack
2b and 3b	on tape on reel	1000 units per reel
4, 5, 6, 7, 9 and 10	blister	24 units per blister
	box	maximum 1000 units per box
	tray	100 units per tray; 1 or 10 trays per box
8	blister	12 units per blister

ELECTRICAL DATA

Measured at T_{amb} = 25 ±2 °C and a nominal drive level of 100 µW into 25 Ω unless otherwise specified. Measuring system: π-network in accordance with IEC 444 recommendations.

Table 4

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT(5)
f_{nom}	nominal frequency	fundamental	2.4	–	27.0	MHz
		third overtone	16.8	–	75.0	MHz
		fifth overtone	50.0	–	125.0	MHz
$\Delta f/f_{nom}$	adjustment tolerance	note 1	±10	–	–	ppm
R_r	resonance resistance	note 2	see Figs 13, 16 and 19			
C_L	load capacitance	fundamental mode; note 3	5	20	∞	pF
		overtones; note 3	5	∞	–	pF
T_{oper}	operating temperature		–40	–	+130	°C
T_{op}	operable temperature		–50	–	+130	°C
$\Delta f/f_{25}$	frequency stability over temperature range, with respect to T_{amb} = 25 °C		see Table 5			
R_r (T)	resonance resistance over temperature range	note 2	available from R_r upward			
C_1	motional capacitance		see Figs 14, 17 and 20			
	tolerance	note 4	–	–	10	%
C_0	parallel capacitance		see Figs 15, 18 and 21			
	tolerance	note 4	–	–	10	%
S	pulling sensitivity		$S = -C_1 / 2(C_0 + C_L)^2$			
R_n	resonance resistance of unwanted response (spurious)	fundamental mode; f_{nom} ±20%	2 R_r (T)	–	–	Ω
			–6	–	–	dB
		overtones; f_{nom} ±200 kHz	2 R_r (T)	–	–	Ω
			–6	–	–	dB
R_{dld}	drive level dependency, being the resonance resistance in the drive level range	drive level range 10^{-12} W to 10^{-4} W; note 2	note 3			
R_{ins}	insulation resistance	DC test voltage = 100 V	500	–	–	MΩ
	frequency hysteresis or curve fit		1	–	–	ppm
$\Delta f/f$	ageing		see Figs 22 and 23			

Notes

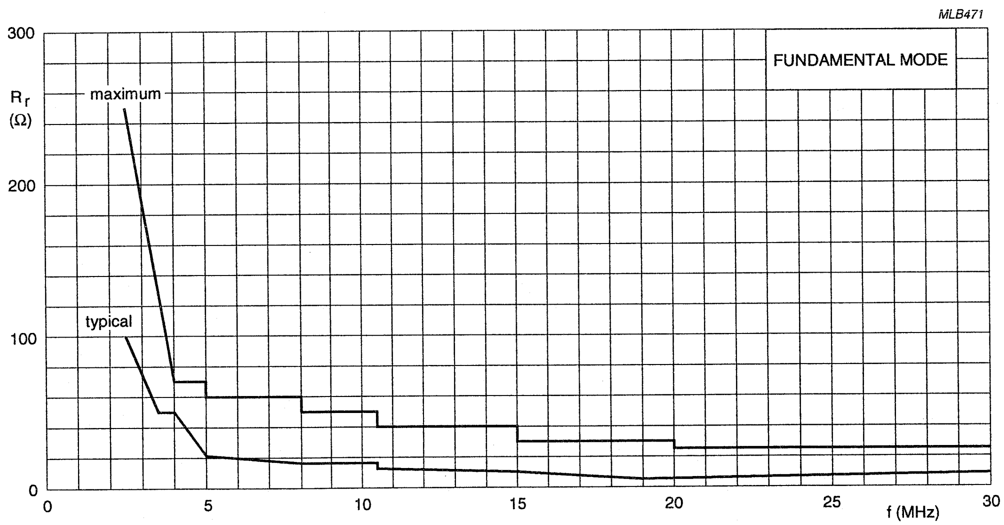
1. $\Delta f/f_{nom} \geq \pm 5$ ppm available on request.
2. All resistance values are measured in series resonance, other values available on request.
3. Values available on request.
4. Capacitance tolerance ≤5% available on request.
5. All references to ppm = 10^{-6}.

Table 5 Frequency stability with temperature variation (available maximum values).

TEMPERATURE RANGE(1) (°C)	FREQUENCY STABILITY (ppm)(2)		
	CLASS 0	CLASS 1	CLASS 2
+20/+30	±1.0	±1.5	±2.0
0/+50	±5.0	±7.5	±10.0
−10/+60	±7.5	±10.0	±15.0
−20/+70	±10.0	±15.0	±20.0
−30/+80	±12.5	±20.0	±25.0
−40/+90	±17.5	±25.0	±30.0
−55/+105	±25.0	±30.0	±40.0
−40/+130	−	±50.0	±80.0

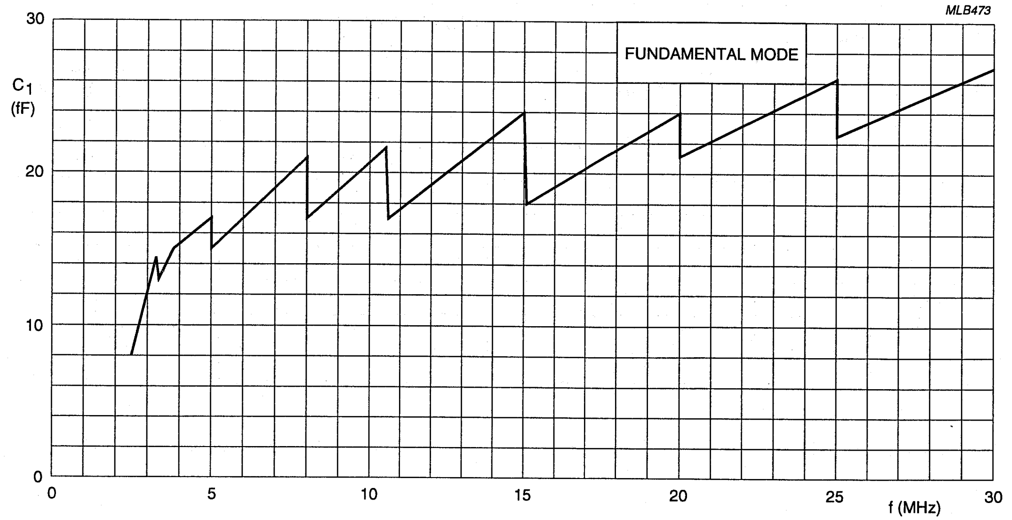
Notes

1. For frequencies below 8.0 MHz, the upper temperature limit is 10 °C lower to obtain the same stability.
2. All references to ppm = 10^{-6}.



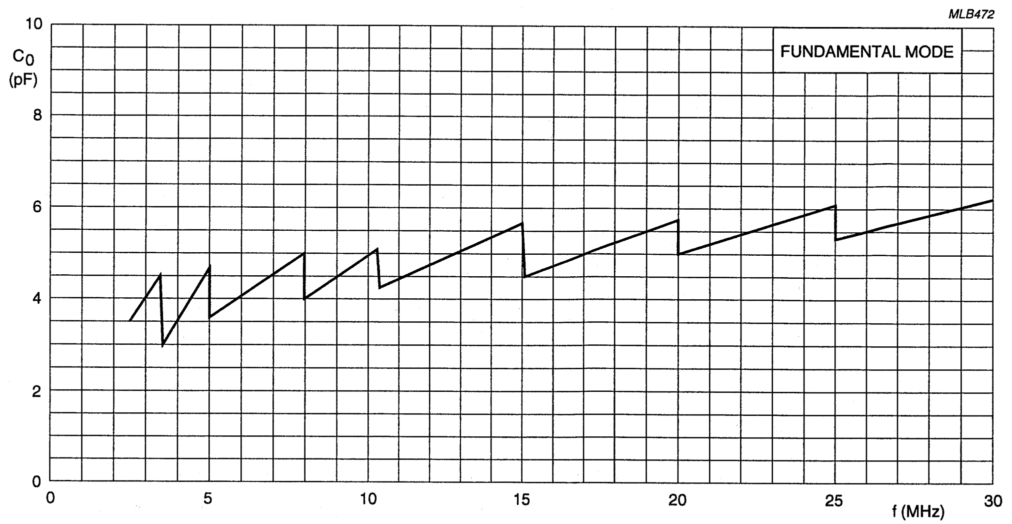
HC-49/U in the fundamental mode.
Values at 25 °C.
Other values available by extrapolation with C_0 and C_1 values.

Fig.13 Resonance resistance R_r as a function of resonance frequency.



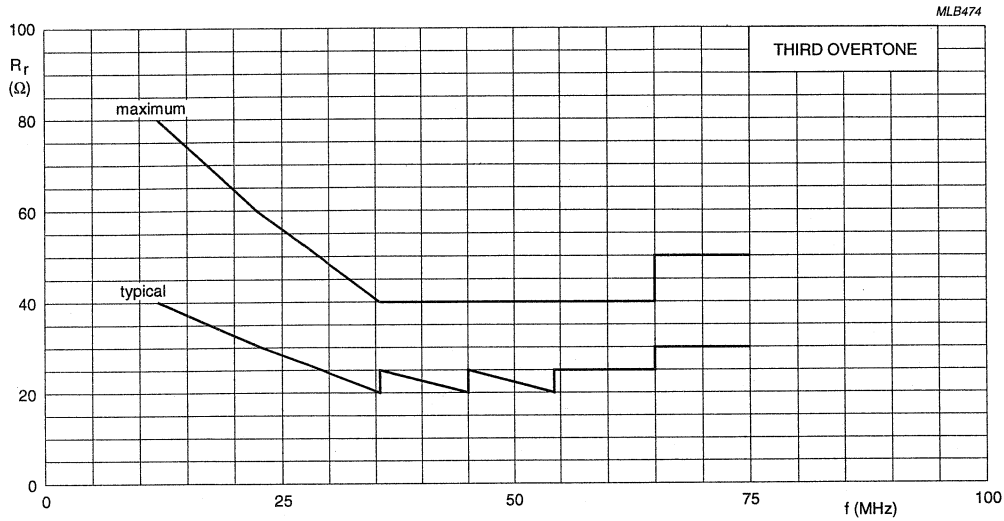
HC-49/U in the fundamental mode.
Typical values at 25 °C.
Other values available by extrapolation of the curve segments.

Fig.14 Motional capacitance C_1 as a function of resonance frequency.



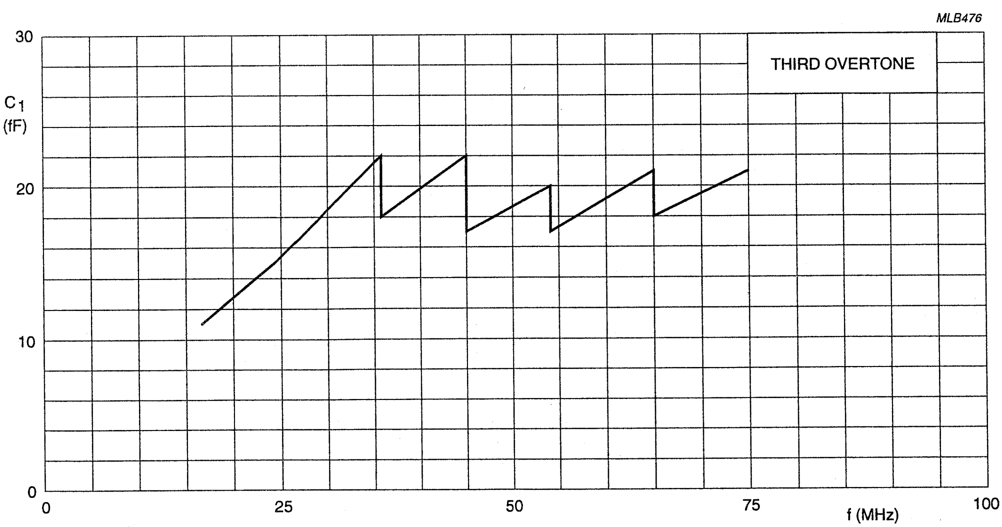
HC-49/U in the fundamental mode.
Typical values at 25 °C.
Other values available by extrapolation of the curve segments.

Fig.15 Parallel capacitance C_0 as a function of resonance frequency.



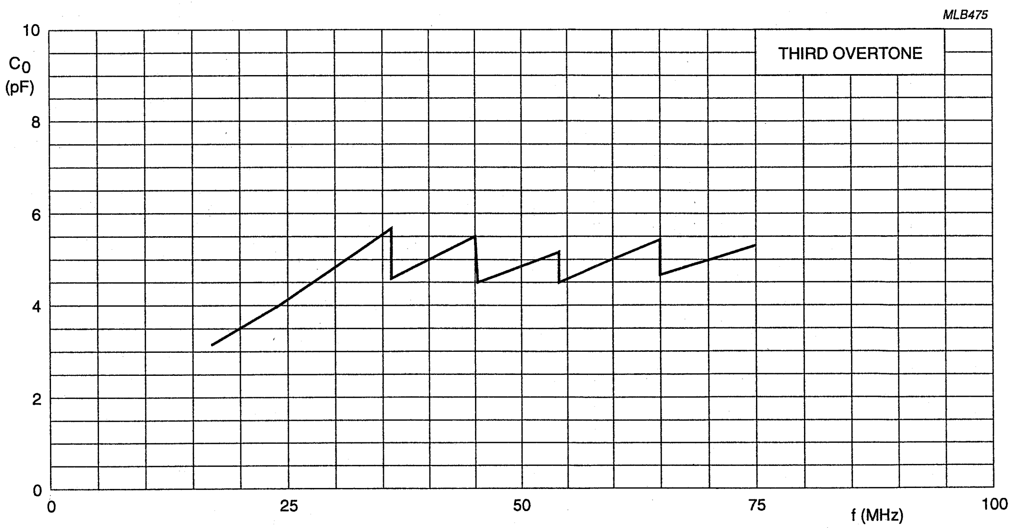
HC-49/U in the third overtone.
Values at 25 °C.
Other values available by extrapolation with C_0 and C_1 values.

Fig.16 Resonance resistance R_r as a function of resonance frequency.



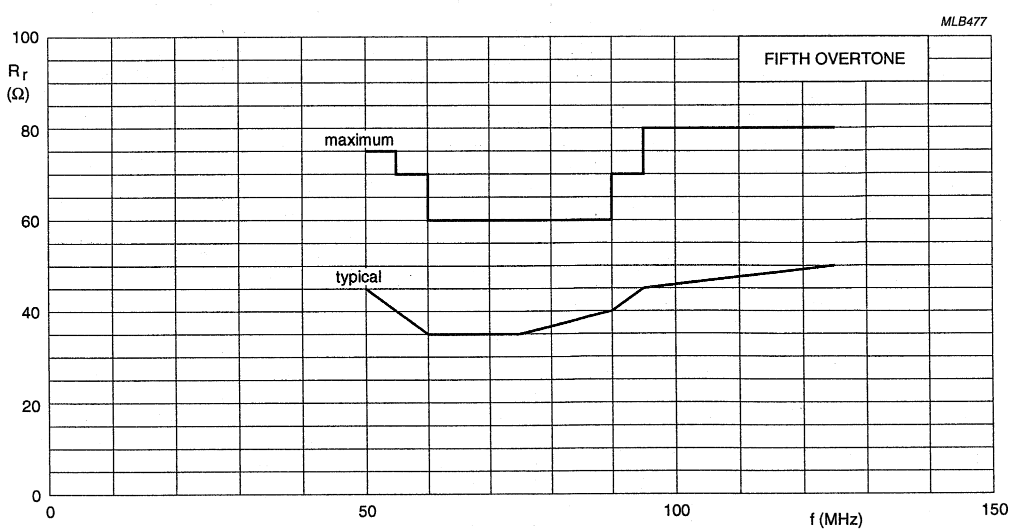
HC-49/U in the third overtone.
Typical values at 25 °C.
Other values available by extrapolation with C_0 values.

Fig.17 Motional capacitance C_1 as a function of resonance frequency.



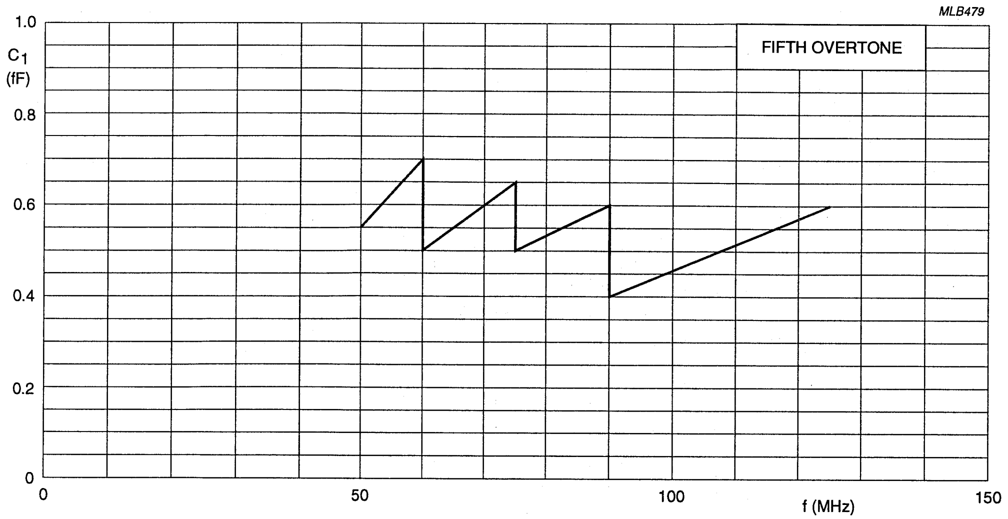
HC-49/U in the third overtone.
Typical values at 25 °C.
Other values available by extrapolation with C_1 values.

Fig.18 Parallel capacitance C_0 as a function of resonance frequency.



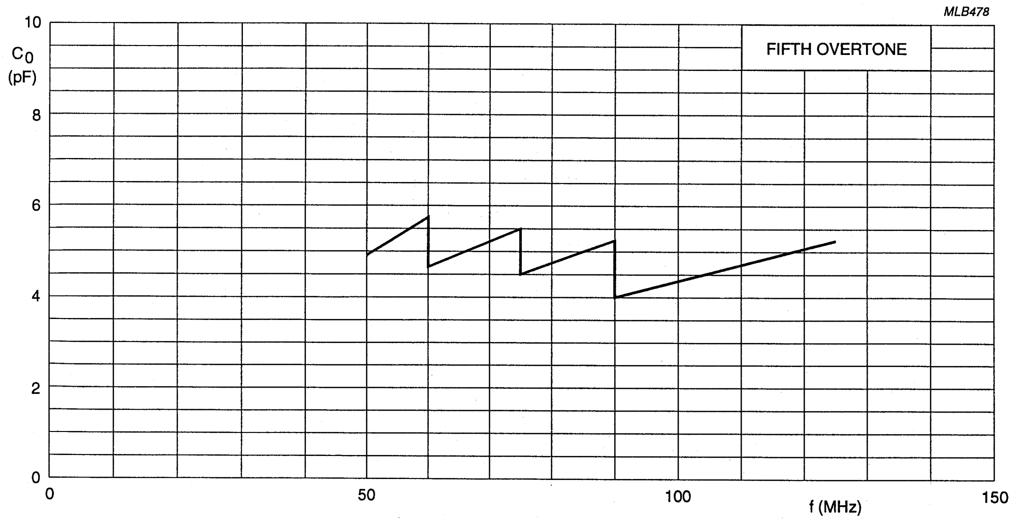
HC-49/U in the fifth overtone.
Values at 25 °C.
Other values available by extrapolation with C_0 and C_1 values.

Fig.19 Resonance resistance R_r as a function of resonance frequency.



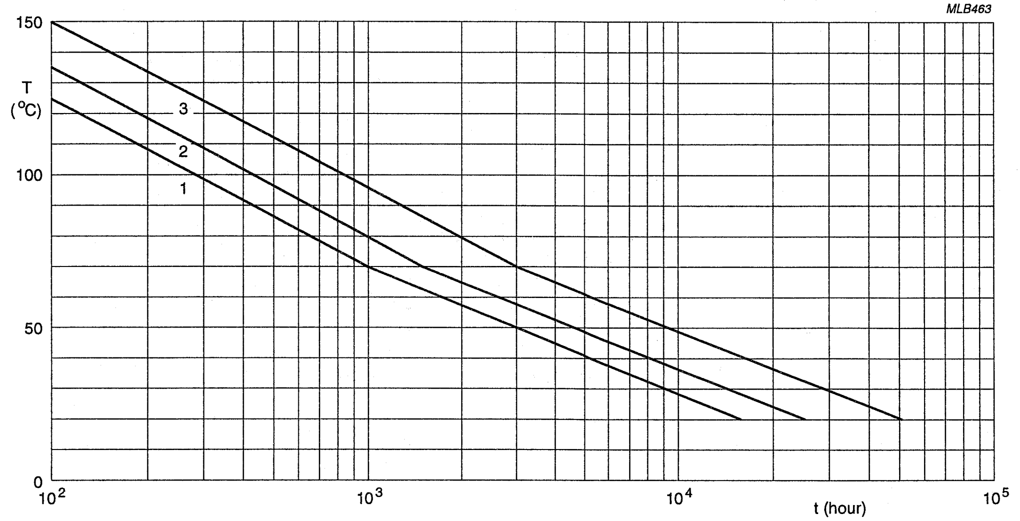
HC-49/U in the fifth overtone.
Typical values at 25 °C.
Other values available by extrapolation with C_0 values.

Fig.20 Motional capacitance C_1 as a function of resonance frequency.



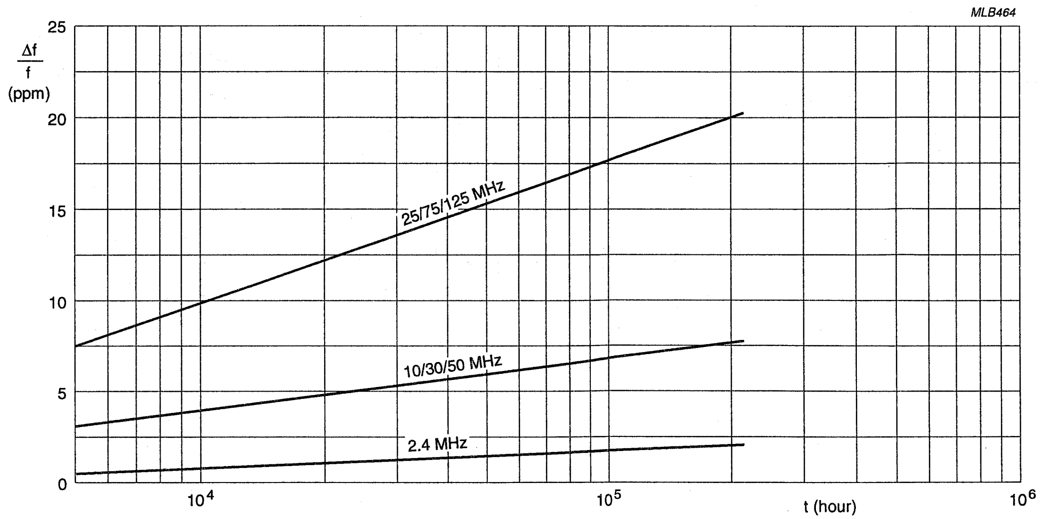
HC-49/U in the fifth overtone.
Typical values at 25 °C.
Other values available by extrapolation with C_1 values.

Fig.21 Parallel capacitance C_0 as a function of resonance frequency.



Curve 1 = 1000 hours at 70 °C.
Curve 2 = 720 hours at 85 °C.
Curve 3 = 240 hours at 130 °C.

Fig.22 Time - temperature relation at which ageing is approximately equivalent.



Fundamental, third and fifth overtones.
Necessary pre-ageing can be calculated using Fig.22.

Fig.23 Typical frequency ageing as a function of time at 25 °C, **without pre-ageing of crystals.**

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with IEC publication 68-2, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"*. Ageing test is in accordance with IEC publication 679-1.

Table 6

IEC 68-2	TEST	PROCEDURE	REQUIREMENTS(1)
Ba	ageing	1000 hours at 70 °C	$\Delta f/f \leq 5$ ppm
Db	accelerated damp heat	+25 to +55 °C; 6 cycles at RH >95%	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Ea	shock	100 g; half sinewave; 6 directions; 1 blow/direction	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Eb	bump	4000 bumps of 40 g	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Ed	free fall	3 times on hard wood; for height of fall (h) see Table 7	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Fc	vibration	frequency 10 to 500 to 10 Hz; acceleration 10 g; 3 directions; 30 minutes/direction	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Na	temperature cycling test	−40/+85 °C; 10 cycles; 0.1 hour/cycle	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Q	sealing (method 1)	16 hours; 700 kPa He	$<10^{-8}$ ncc/s He
Ta	solderability	235 ±5 °C; 2 ±0.5 s; flux 600 (activated)	>90%, except for 1 mm from body; no visible damage, no leaks
Tb	resistance to soldering heat	350 ±5 °C; 3.5 ±0.5 s;	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Ub	bending of terminations	1 × 90°; 5 N	no visible damage

Note

1. All references to ppm = 10^{-6}.

Table 7 Height of fall.

h (mm)	FREQUENCY RANGE[1] (MHz)		
	FUNDAMENTAL MODE	THIRD OVERTONE	FIFTH OVERTONE
750	2.4 to 16	16.8 to 48	50 to 80
500	16.1 to 27	48.1 to 75	80.1 to 125

Note

1. Typical values. Actual designs can be made to obtain higher or lower values.

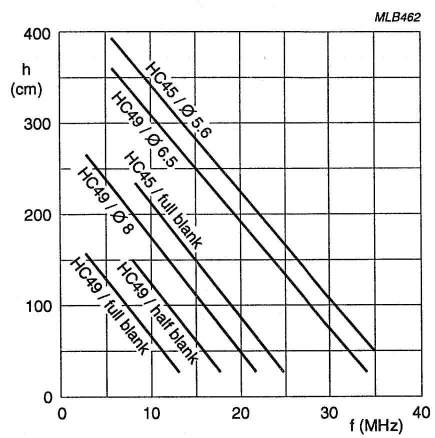


Fig.24 Typical height of fall values (3× on hard wood) for various quartz blank and holder combinations. 'Full' and 'half' blanks refer to rectangular quartz designs; 'Ø' designates circular quartz designs and the appropriate diameter.

SOLVENT RESISTANCE TESTS

Procedure	In accordance with IEC 68-2-45 (XA) and IEC 653 (immersion time 5 minutes) as well as MIL 202 E215. At ambient temperature, and ultrasonic (40 kHz).
Solvents	Bio-Act EC7 Neutropon P3 and Saxin P3 Meta Clean 820 Lonco 446 Isopropanol cleaning solvent Dowanol DPM (glass crystals only)
Requirements	no degradation of marking

Quartz crystals - special and industrial applications HC-45/U

9922 521 6/7.... series

DESCRIPTION

The unit consists of a silver-plated AT-cut quartz plate, encapsulated in a nitrogen-filled metal holder. The holder is hermetically sealed by resistance-welding and provided with connecting leads. The unit has an outstanding electrical performance combined with a high mechanical stability, small dimensions and a very high level of reliability.

APPLICATIONS

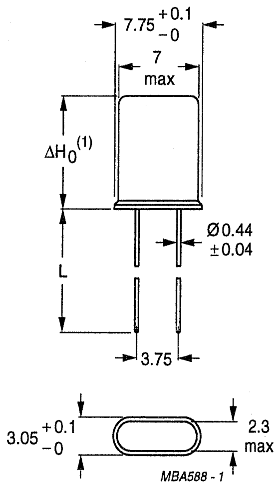
- Microprocessors
- Traffic control
- Weather balloons
- Medical systems
- Military applications
- Communication systems
- Agrarian applications
- Machine control
- Environmental applications.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
f_{nom}	nominal frequency				
	fundamental mode	6000	–	30000	kHz
	third overtone	24000	–	90000	kHz
	fifth overtone	60000	–	150000	kHz
m	mass	–	0.4	–	g

MECHANICAL DATA

Package outlines



Dimensions in mm.

(1) For ΔH_0 see Table 1.

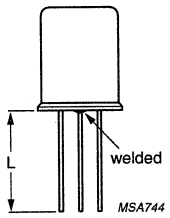
Fig.1 Style 1: HC-45/U in box.

Table 1 Component height and lead length; note 1.

MAXIMUM HEIGHT ΔH_0 (mm)	MAXIMUM LEAD LENGTH L (mm)	MINIMUM FREQUENCY (MHz)		
		FUNDAMENTAL MODE	THIRD OVERTONE	FIFTH OVERTONE
8.0	13.2	6.0	20	50
8.8	13.2	6.0	20	50

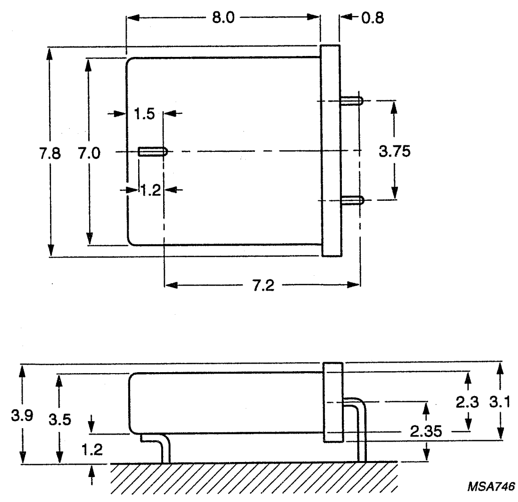
Note

1. Lead length tolerance for Style 1:
   a) Lead length > 3 mm: ±0.5 mm
   b) Lead length ≤ 3 mm: ±0.2 mm.



L: min. 12.7 mm; max. 13.0 mm.

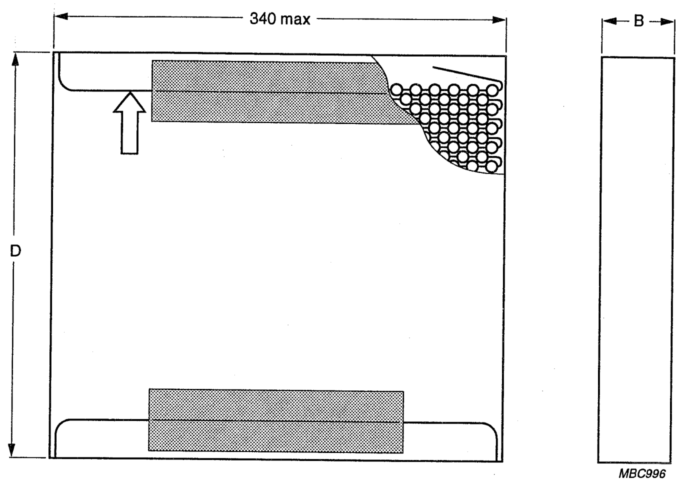
Fig.2 Style 4: HC-45/U in box.



Dimensions in mm.

Fig.3 Style 5: HC-45/U in box.

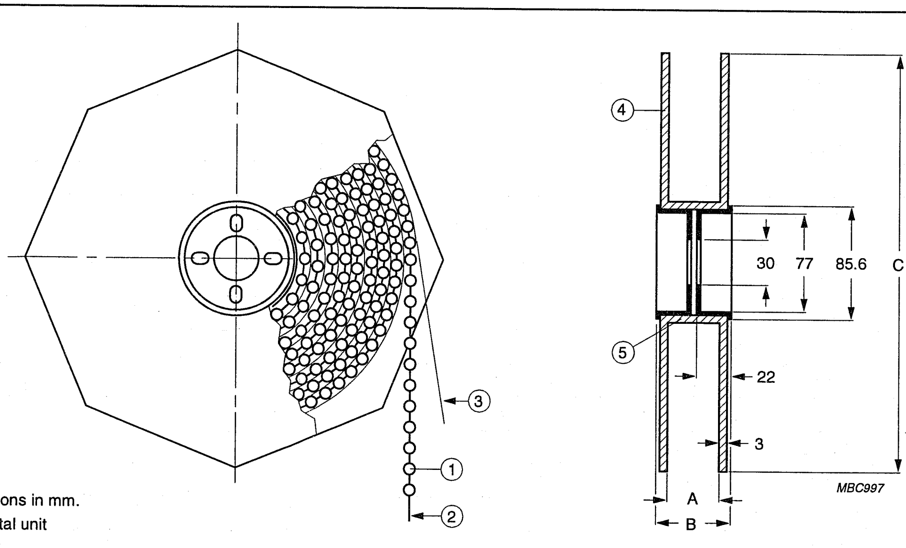
Tape and reel data



Dimensions in mm.
B = 46 mm max.
D = 185 mm max.

Style 3a is with insulation plate; see Fig.7.

Fig.4 Style 2a and 3a units on tape in ammopack.



Dimensions in mm.
1 = crystal unit
2 = tape
3 = paper
4 = flange
5 = cylinder

A = 45 mm
B = 55 mm max.
C = 355 mm max.

Style 3b is with insulation plate; see Fig.7.

Fig.5 Style 2b and 3b units on tape on reel.

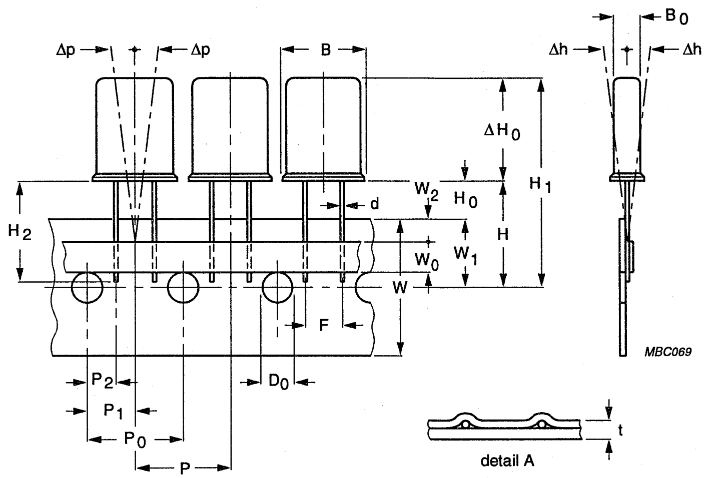


Fig.6 Style 2: HC-45/U on tape.

Table 2 Taping dimensions (without the insulation plate) in accordance with IEC 286-2; see Fig.6.

SYMBOL	PARAMETER	VALUE	TOLERANCE	UNIT
B_0	body thickness	3.05	+0.1/0	mm
B	body width	7.75	+0.1/0	mm
Δh	component alignment vertical to tape plane	0	±2	mm
Δp	component alignment in tape plane	0	±1.3	mm
d	lead wire diameter	0.44	±0.04	mm
F	lead-to-lead distance	3.75	–	mm
P	pitch of components	12.7	±1	mm
P_0	feed-hole pitch	12.7	±0.3	mm
P_2	feed-hole centre to lead	4.47	±0.7	mm
P_1	feed-hole centre to component centre	6.35	±0.3	mm
D_0	feed-hole diameter	4.0	±0.2	mm
H	distance of component from tape centre	16.0	+2/0	mm
H_1	maximum component height from tape centre	24.8	–	mm
$ΔH_0$	maximum component height	see Table 1		mm
H_0	minimum component base to tape top	7.0	–	mm
H_2	lead length	13.2	±0.5	mm
W	carrier tape width	18.0	+1/–0.5	mm
W_0	maximum hold-down tape width	7.0	–	mm
W_1	feed-hole position	9.0	+0.75/–0.5	mm
W_2	maximum hold-down tape position	3.0	–	mm
t	maximum total tape thickness	0.9	–	mm

Insulation plate

Style 3 units are equipped with an insulation plate (see Fig.7) at the unit base. The insulation plate is made of PEEK (polyetherketone) in 0.25 mm thickness and resistant to soldering heat tests.

STANDARD MARKING(1)

- Line 1: PHILIPS
- Line 2: frequency in kHz (fundamental mode) or in MHz (overtone)
- LIne 3: last five digits of catalogue number followed by the manufacturing date code (last four digits of week code in accordance with UN-D1120).

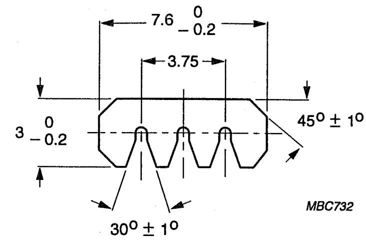
(1) Special marking on product and/or package is available on request.

MASS AND LEADS

Typical mass: 0.4 g.

The leads are finished with either Sn99Cu1, Sn60Pb40 or a gold finish on a nickel underplate.

The first 1 mm from the body is not guaranteed for soldering.



Dimensions in mm.

Fig.7 Insulation plate outline.

PACKAGING AND QUANTITIES

Table 3

STYLE	PACKAGING	QUANTITY
1	blister	24 units per blister
	box	maximum 1000 units per box
2a and 3a	on tape in ammopack	1000 units per pack
2b and 3b	on tape on reel	1000 units per reel
4	blister	24 units per blister
	box	maximum 1000 units per box
	tray	100 units per tray; 1 or 10 trays per box

ELECTRICAL DATA

Measured at T_{amb} = 25 ±2 °C and a nominal drive level of 100 µW into 25 Ω unless otherwise specified. Measuring system: π-network in accordance with IEC 444 recommendations.

Table 4

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT(5)
f_{nom}	nominal frequency	fundamental	6.0	–	30.0	MHz
		third overtone	24.0	–	90.0	MHz
		fifth overtone	60.0	–	150.0	MHz
$\Delta f/f_{nom}$	adjustment tolerance	standard length: note 1	±10	–	–	ppm
		6.2 mm height	±20	–	–	ppm
R_r	resonance resistance	note 2	see Figs 8, 10 and 12			
C_L	load capacitance	fundamental mode; note 3	5	20	∞	pF
		overtones; note 3	5	∞	–	pF
T_{oper}	operating temperature		–40	–	+130	°C
T_{op}	operable temperature		–55	–	+155	°C
$\Delta f/f_{25}$	frequency stability over temperature range	T_{amb} = 25 °C	see Table 5			
R_r (T)	resonance resistance over temperature range	note 2	available from R_r upward			
C_1	motional capacitance		see Figs 9, 11 and 13			
	tolerance	note 4	–	–	10	%
C_0	parallel capacitance		see Figs 9, 11 and 13			
	tolerance	note 4	–	–	10	%
S	pulling sensitivity		$S = -C_1 / 2(C_0 + C_L)^2$			
R_n	resonance resistance of unwanted response (spurious)	fundamental mode; f_{nom} ±20%	2 R_r (T)	–	–	Ω
			–6	–	–	dB
		overtones; f_{nom} ±200 kHz	2 R_r (T)	–	–	Ω
			–6	–	–	dB
R_{did}	drive level dependency, being the resonance resistance in the drive level range	drive level range 10^{-12} W to 10^{-4} W; note 2	note 3			
R_{ins}	insulation resistance	DC test voltage = 100 V	500	–	–	MΩ
	frequency hysteresis or curve fit		1	–	–	ppm
$\Delta f/f$	ageing	10 years at T_{amb} = 25 °C	3	–	5	ppm

Notes

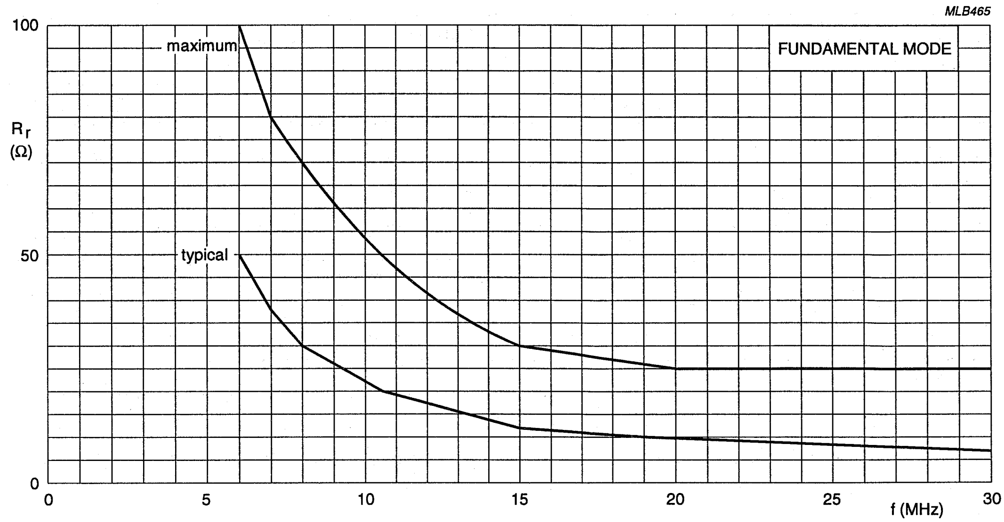
1. $\Delta f/f_{nom} \geq \pm5$ ppm available on request.
2. All resistance values are measured in series resonance, other values available on request.
3. Values available on request.
4. Capacitance tolerance ≤5% available on request.
5. All references to ppm = 10^{-6}.

Table 5 Frequency stability with temperature variation (available maximum values).

TEMPERATURE RANGE[1] (°C)	FREQUENCY STABILITY (ppm)[2]		
	CLASS 0	CLASS 1	CLASS 2
+20/+30	±1.0	±1.5	±2.0
0/+50	±5.0	±7.5	±10.0
−10/+60	±7.5	±10.0	±15.0
−20/+70	±10.0	±15.0	±20.0
−30/+80	±12.5	±20.0	±25.0
−40/+90	±17.5	±25.0	±30.0
−55/+105	±25.0	±30.0	±40.0
−40/+130	−	±50.0	±80.0

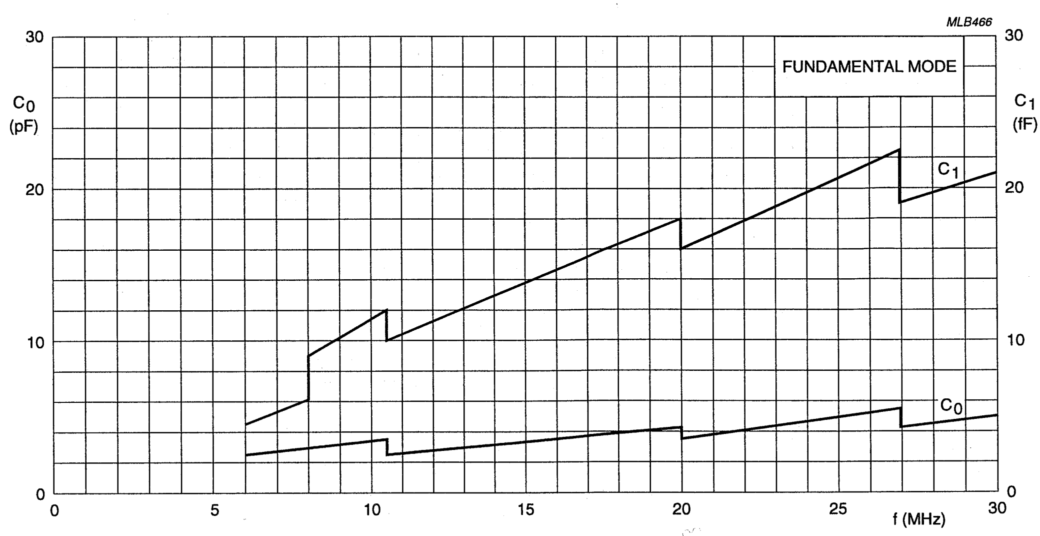
Notes

1. For frequencies below 8.0 MHz, the upper temperature limit is 10 °C lower to obtain the same stability. For glass-encapsulated crystals, better stability values can be obtained.
2. All references to ppm = 10^{-6}.



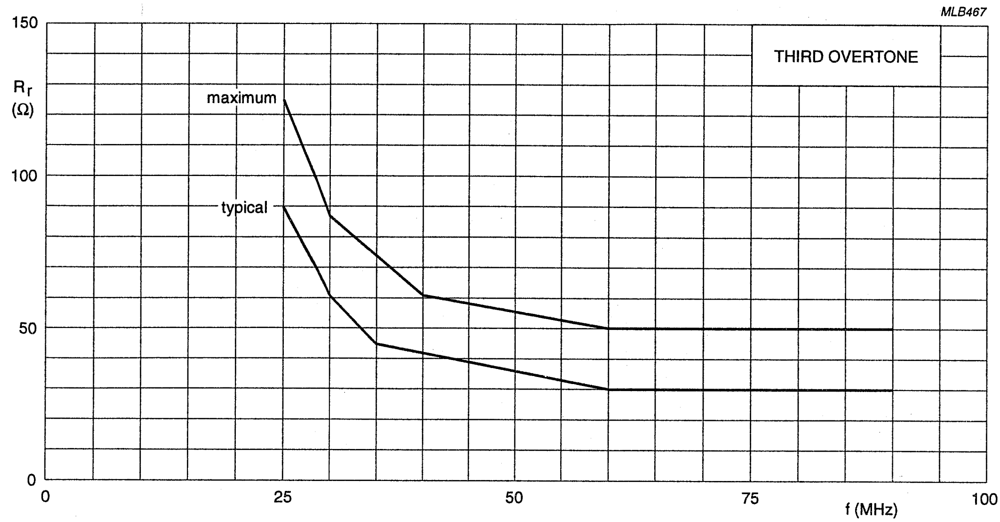
HC-45/U in the fundamental mode.
Values at 25 °C.
Other values available by extrapolation with C_0 and C_1 values.

Fig.8 Resonance resistance R_r as a function of resonance frequency.



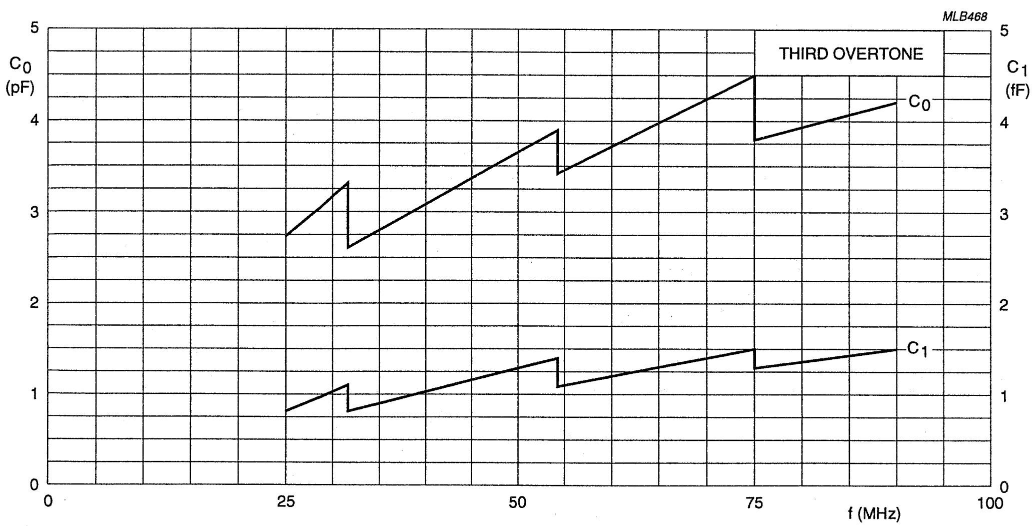
HC-45/U in the fundamental mode.
Typical values at 25 °C.
Other values available by extrapolation of the curve segments.

Fig.9 Motional capacitance C_1 and parallel capacitance C_0 as a function of resonance frequency.



HC-45/U in the third overtone.
Values at 25 °C.
Other values available by extrapolation with C_0 and C_1 values.

Fig.10 Resonance resistance R_r as a function of resonance frequency.

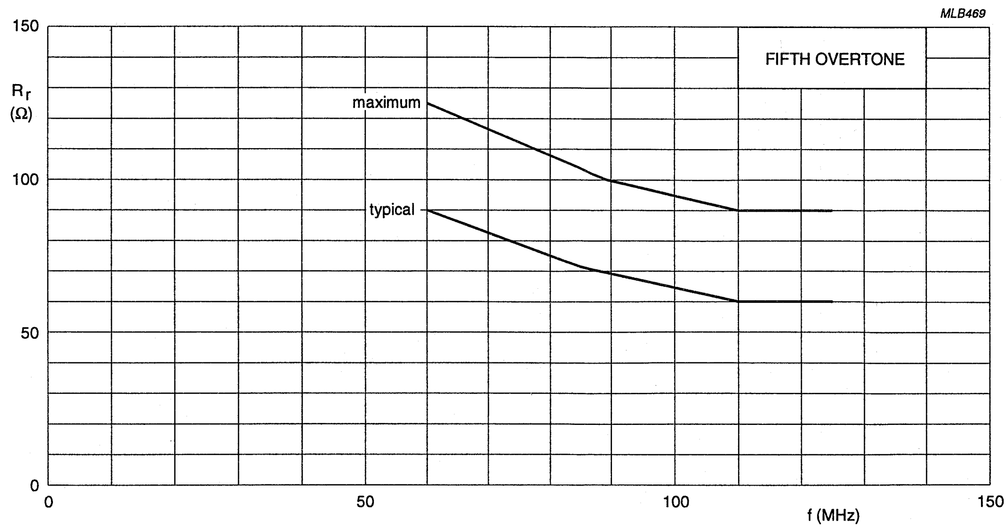


HC-45/U in the third overtone.
Typical values at 25 °C.
Other values available by extrapolation of the curve segments.

Fig.11 Motional capacitance C_1 and parallel capacitance C_0 as a function of resonance frequency.

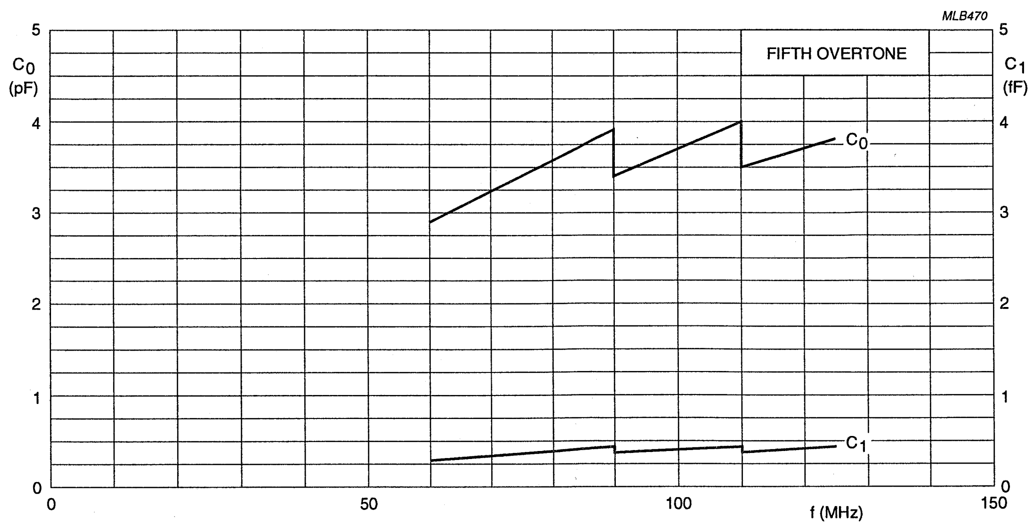
Quartz crystals - special and industrial applications HC-45/U

9922 521 6/7.... series



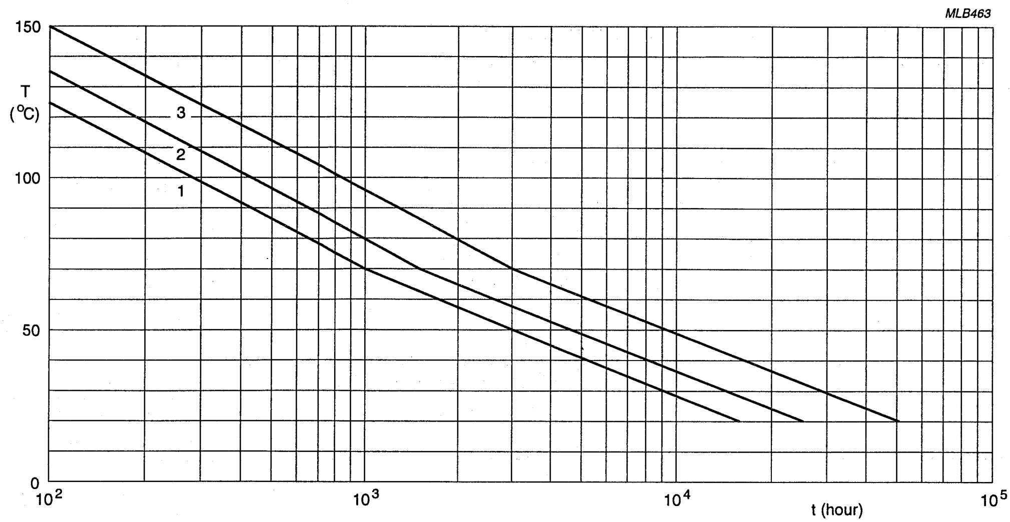
HC-45/U in the fifth overtone.
Values at 25 °C.

Fig.12 Resonance resistance R_r as a function of resonance frequency.



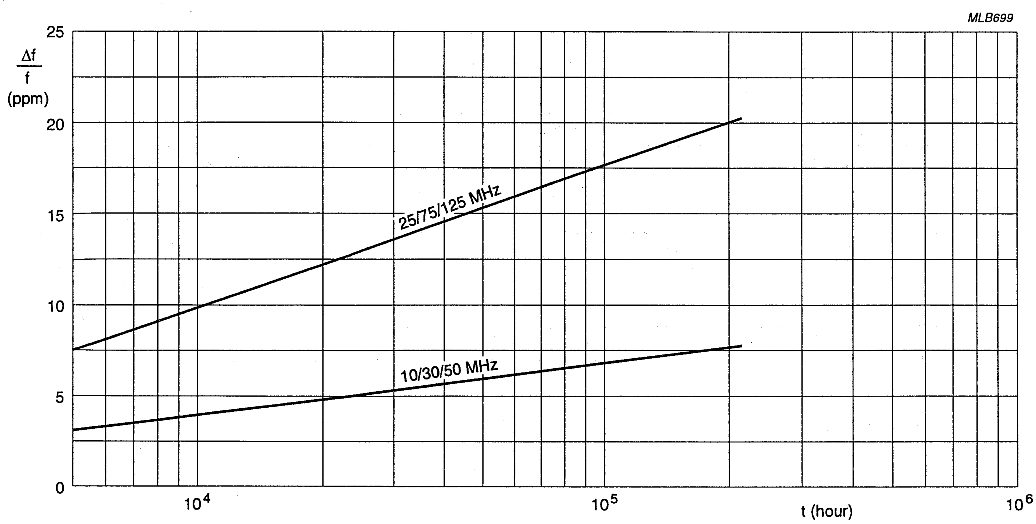
HC-45/U in the fifth overtone.
Typical values at 25 °C.

Fig.13 Motional capacitance C_1 and parallel capacitance C_0 as a function of resonance frequency.



Curve 1 = 1 000 hours at 70 °C.
Curve 2 = 720 hours at 85 °C.
Curve 3 = 240 hours at 130 °C.

Fig.14 Time - temperature relation at which ageing is approximately equivalent.



Fundamental, third and fifth overtones.
Necessary pre-ageing can be calculated using Fig.14.

Fig.15 Typical frequency ageing as a function of time at 25 °C, **without pre-ageing of crystals.**

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with IEC publication 68-2, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"*. Ageing test is in accordance with IEC publication 679-1.

Table 6

IEC 68-2	TEST	PROCEDURE	REQUIREMENTS(1)
Ba	ageing	1000 hours at 70 °C	$\Delta f/f \leq 5$ ppm
Db	accelerated damp heat	+25 to +55 °C; 6 cycles at RH >95%	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
			Rins ≥ 10^8 Ω at 50 VDC
Ea	shock	100 g; half sinewave; 6 directions; 1 blow/direction	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Eb	bump	4000 bumps of 40 g	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Ed	free fall	3 times on hard wood; for height of fall (h) see Table 7	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Fc	vibration	frequency 10 to 500 to 10 Hz; acceleration 10 g; 3 directions; 30 minutes/direction	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Na	temperature cycling test	−40/+85 °C; 10 cycles; 0.1 hour/cycle	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Q	sealing (method 1)	16 hours; 700 kPa He	<10^{-8} ncc/s He
Ta	solderability	235 ±5 °C; 2 ±0.5 s; flux 600 (activated)	>90%, except for 1 mm from body; no visible damage, no leaks
Tb	resistance to soldering heat	350 ±5 °C; 3.5 ±0.5 s;	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Ub	bending of terminations	1 × 90°; 5 N	no visible damage

Note

1. All references to ppm = 10^{-6}.

Table 7 Height of fall.

h (mm)	FREQUENCY RANGE[1] (MHz)		
	FUNDAMENTAL MODE	THIRD OVERTONE	FIFTH OVERTONE
750	6 to 16	24 to 48	60 to 80
500	16.1 to 30	48.1 to 90	80 to 150

Note

1. Typical values. Actual designs can be made to obtain higher or lower values.

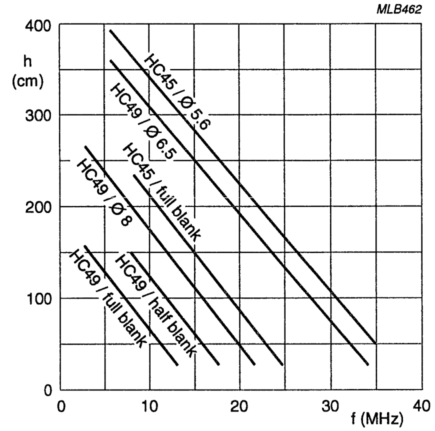


Fig.16 Typical height of fall values (3× on hard wood) for various quartz blank and holder combinations. 'Full' and 'half' blanks refer to rectangular quartz designs; 'Ø' designates circular quartz designs and the appropriate diameter.

SOLVENT RESISTANCE TESTS

Procedure	In accordance with IEC 68-2-45 (XA) and IEC 653 (immersion time 5 minutes) as well as MIL 202 E215. At ambient temperature, and ultrasonic (40 kHz).
Solvents	Bio-Act EC7 Neutropon P3 and Saxin P3 Meta Clean 820 Lonco 446 Isopropanol cleaning solvent Dowanol DPM (glass crystals only)
Requirements	no degradation of marking

Quartz crystals - special and industrial applications HC-45/U-SMD

9922 522 3/7.... series

DESCRIPTION

The unit consists of a silver-plated AT-cut quartz plate, encapsulated in a nitrogen-filled metal holder. The holder is hermetically sealed by resistance welding and provided with three or four connections for surface mounting. The unit has a high mechanical stability and small dimensions.

QUICK REFERENCE

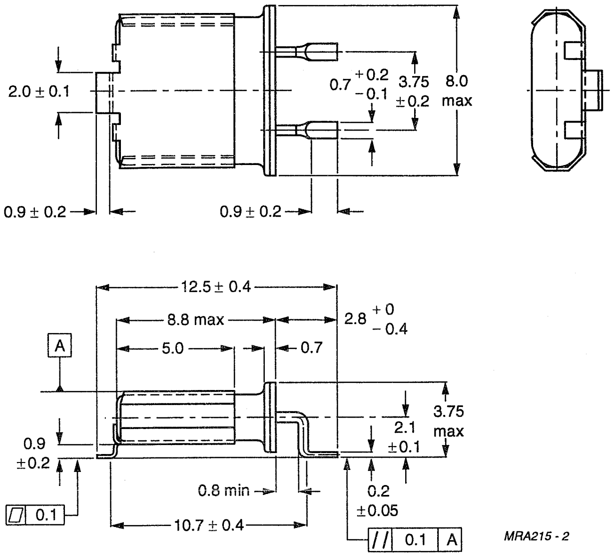
SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
f_{nom}	nominal frequency:				
	fundamental mode	6000	–	30000	kHz
	third overtone	24000	–	90000	kHz
	fifth overtone	60000	–	150000	kHz
m	mass	–	0.5	–	g

APPLICATIONS

- Microprocessors
- Traffic control
- Weather balloons
- Medical systems
- Military applications
- Communication systems
- Agrarian applications
- Machine control
- Environmental applications.

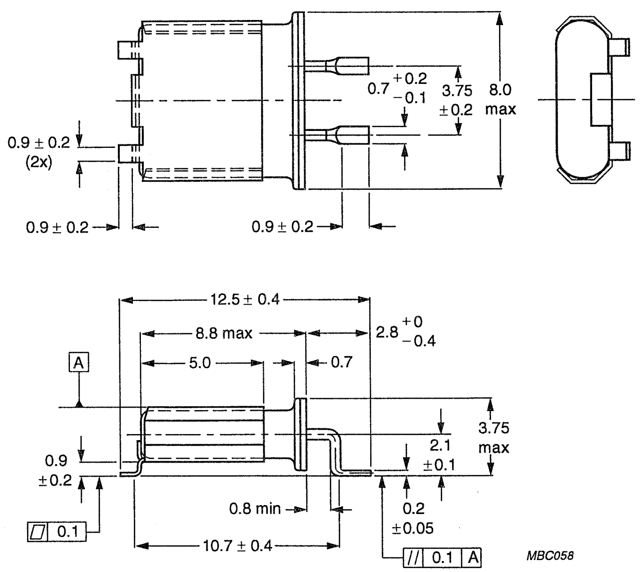
MECHANICAL DATA

Package outlines



Dimensions in mm.

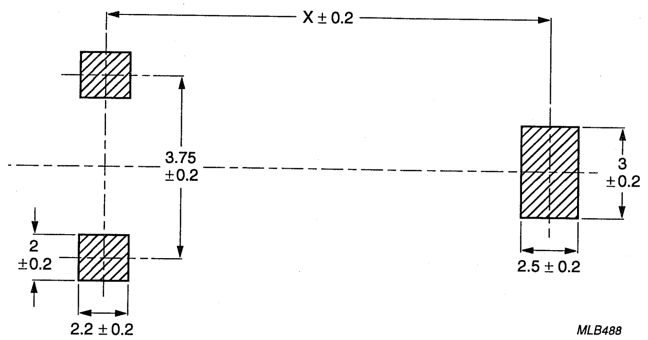
Fig.1 Style 3: HC-45/U12-SMD/Clip I, Catalogue number 9922 522 7.....



Dimensions in mm.

Fig.2 Style 4: HC-45/U12-SMD/Clip II, Catalogue number 9922 522 7....

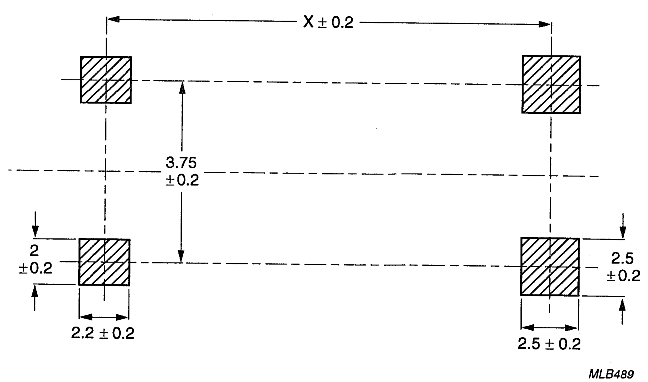
Recommended pad layout



Dimensions in mm.

HC45/U12: X = 11.6 mm

Fig.3 HC-45/U SMD/Clip I.

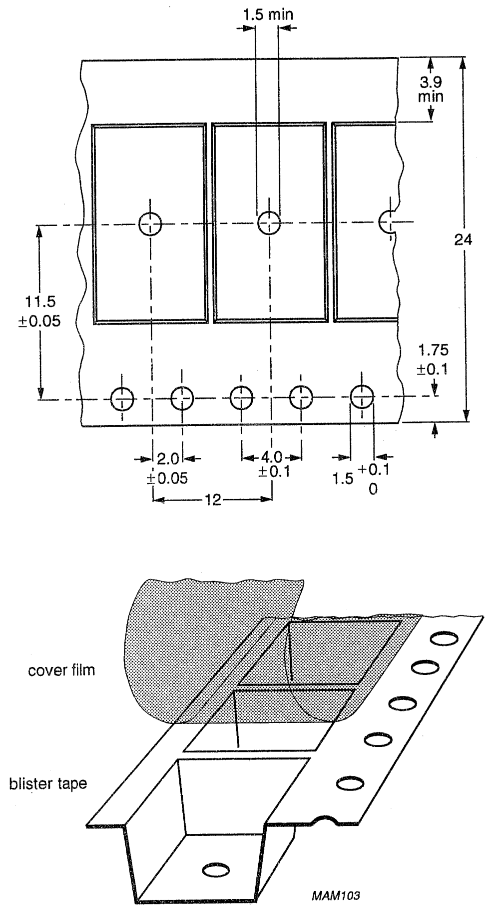


Dimensions in mm.

HC45/U12: X = 11.6 mm

Fig.4 HC-45/U SMD/Clip II.

Tape and reel data

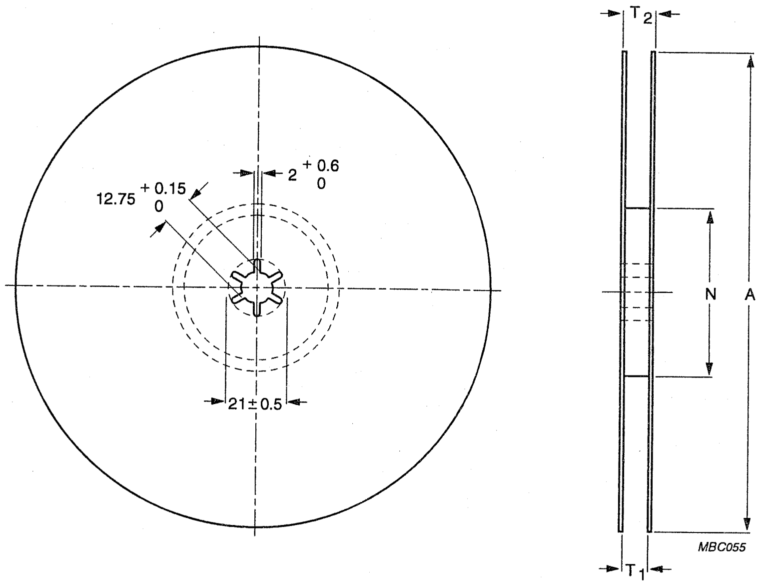


Dimensions in mm.
Crystal connections are adjacent to sprocket holes.
Cumulative pitch error: ≤0.2 mm over 10 pitches.

Total tape height of tape with top film: 4.5 mm maximum.
Tape thickness: 0.3 mm.
The blister is made of conductive polystyrene. Taping is performed in accordance with IEC 286-3.
Leader: minimum 400 mm including 100 mm sealed with empty compartments.
Trailer: minimum 160 mm sealed with empty compartments.

Pocket dimensions:
Length = 13.1 ±0.1 mm
Width = 8.3 ±0.1 mm
Depth = 4.3 +0.05/–0 mm

Fig.5 Blister tape.



Dimensions in mm.

Fig.6 Reel dimensions.

Table 1 Reel dimensions for Fig.6.

TAPE WIDTH (mm)	A (mm)	N (mm)	T_1 (mm)	T_2 (mm)
24	330	62 ±1.5	24.4 +0.2/−0	28.4 ±0.2

STANDARD MARKING(1)

- Line 1: PHILIPS
- Line 2: frequency in kHz (fundamental mode) or in MHz (overtone)
- LIne 3: last five digits of catalogue number followed by the manufacturing date code (last three digits of week code).

MASS AND LEADS

Typical mass: 0.5 g.

The leads are finished with Sn99Cu1 on a nickel underplate.

The first 1 mm from the body is not guaranteed for soldering.

PACKAGING AND QUANTITIES

Crystal units are supplied in boxes; in blister tape on reel or in trays: 1000 units per box or reel; 24 units per tray.

(1) Special marking on product and/or package is available on request.

ELECTRICAL DATA

Measured at T_{amb} = 25 ± 2 °C and a nominal drive level of 100 μW into 25 Ω unless otherwise specified. Measuring system: π-network in accordance with IEC 444 recommendations.

Table 2

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT(4)
f_{nom}	nominal frequency	fundamental	6.0	–	30.0	MHz
		third overtone	24.0	–	90.0	MHz
		fifth overtone	60.0	–	150.0	MHz
$\Delta f/f_{nom}$	adjustment tolerance	standard length	±10	–	–	ppm
		10 mm length	±20	–	–	ppm
R_r	resonance resistance	note 1	see Figs 7, 9 and 11			
C_L	load capacitance	fundamental mode; note 2	5	20	∞	pF
		overtones; note 2	5	∞	–	pF
T_{oper}	operating temperature		–40	–	+130	°C
T_{op}	operable temperature		–55	–	+155	°C
$\Delta f/f_{25}$	frequency stability over temperature range, with respect to T_{amb} = 25 °C		see Table 3			
R_r (T)	resonance resistance over temperature range	note 1	available from R_r upward			
C_1	motional capacitance		see Figs 8, 10 and 12			
	tolerance	note 3	–	–	10	%
C_0	parallel capacitance		see Figs 8, 10 and 12			
	tolerance	note 3	–	–	10	%
S	pulling sensitivity		$S = -C_1 / 2(C_0 + C_L)^2$			
R_n	resonance resistance of unwanted response (spurious)	fundamental mode; f_{nom} ±20%	2 R_r (T)	–	–	Ω
			–6	–	–	dB
		overtones; f_{nom} ±200 kHz	2 R_r (T)	–	–	Ω
			–6	–	–	dB
R_{dld}	drive level dependency, being the resonance resistance in the drive level range	drive level range 10^{-16} W to 10^{-4} W; note 1	note 2			
R_{ins}	insulation resistance	DC test voltage = 100 V	500	–	–	MΩ
$\Delta f/f_{nom}$	total frequency stability with respect to f_{nom}	including temperature range and ageing	see Table 3			
	frequency hysteresis or curve fit		1	–	–	ppm
$\Delta f/f$	ageing		see Figs 13 and 14			

Notes

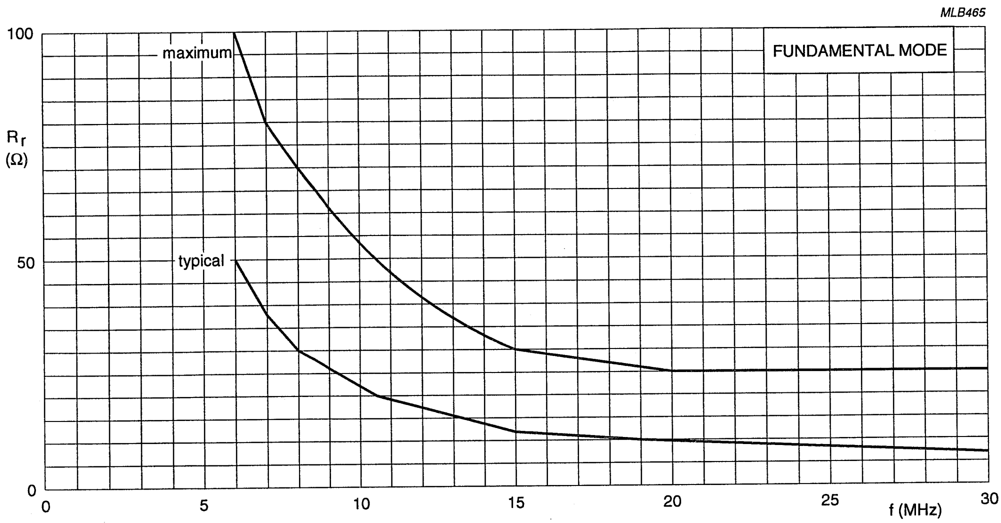
1. All resistance values are measured in series resonance, other values available on request.
2. Values available on request.
3. Capacitance tolerance ≤5% available on request.
4. All references to ppm = 10^{-6}.

Table 3 Frequency stability with temperature variation (available maximum values).

TEMPERATURE RANGE[(1)] (°C)	FREQUENCY STABILITY (ppm)[(2)]		
	CLASS 0	CLASS 1	CLASS 2
+20/+30	±1.0	±1.5	±2.0
0/+50	±5.0	±7.5	±10.0
−10/+60	±7.5	±10.0	±15.0
−20/+70	±10.0	±15.0	±20.0
−30/+80	±12.5	±20.0	±25.0
−40/+90	±17.5	±25.0	±30.0
−55/+105	±25.0	±30.0	±40.0
−40/+130	−	±50.0	±80.0

Notes

1. For frequencies below 8.0 MHz, the upper temperature limit is 10 °C lower to obtain the same stability. For glass-encapsulated crystals, better stability values can be obtained.
2. All references to ppm = 10^{-6}.

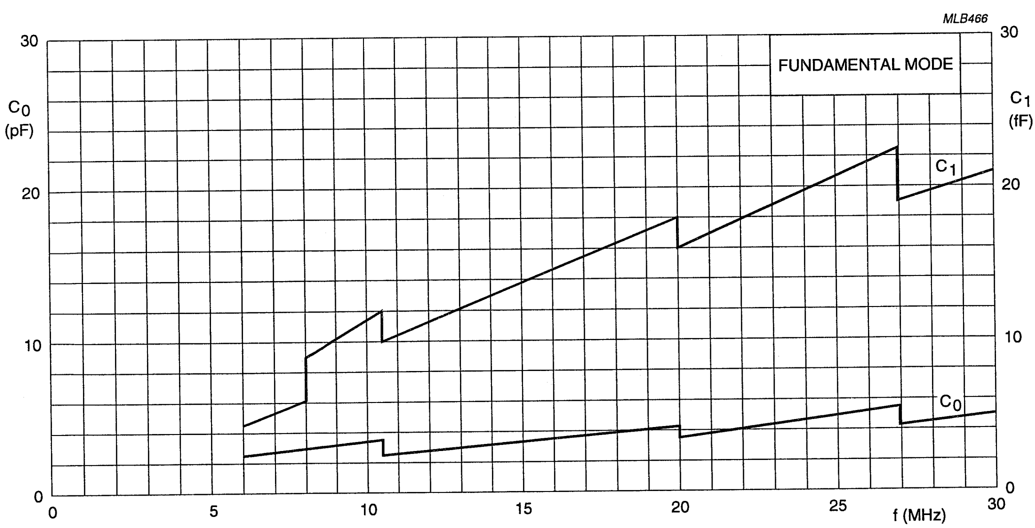


HC-45/U-SMD in the fundamental mode.

Values at 25 °C.

Other values available by extrapolating in combination with C_0 and C_1 values.

Fig.7 Resonance resistance R_r as a function of resonance frequency.

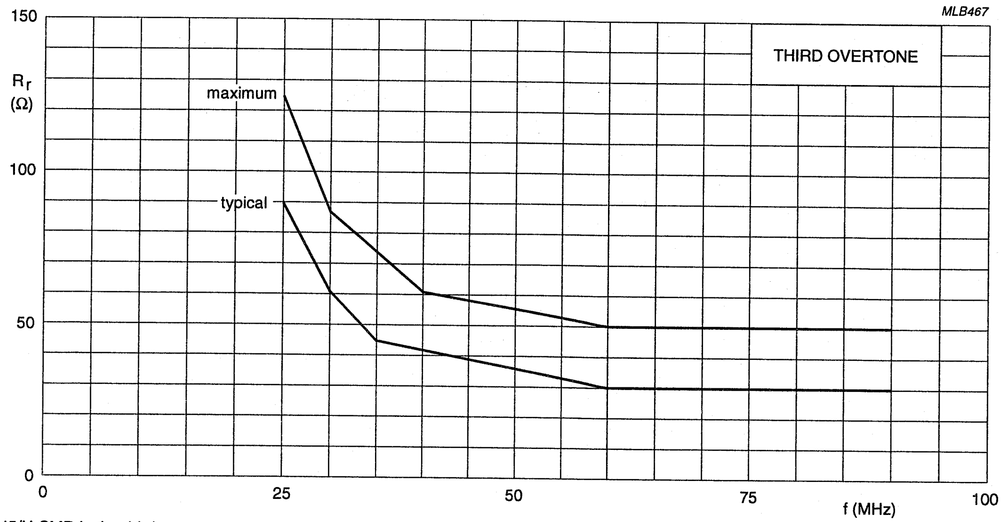


HC-45/U-SMD in the fundamental mode.

Typical values at 25 °C.

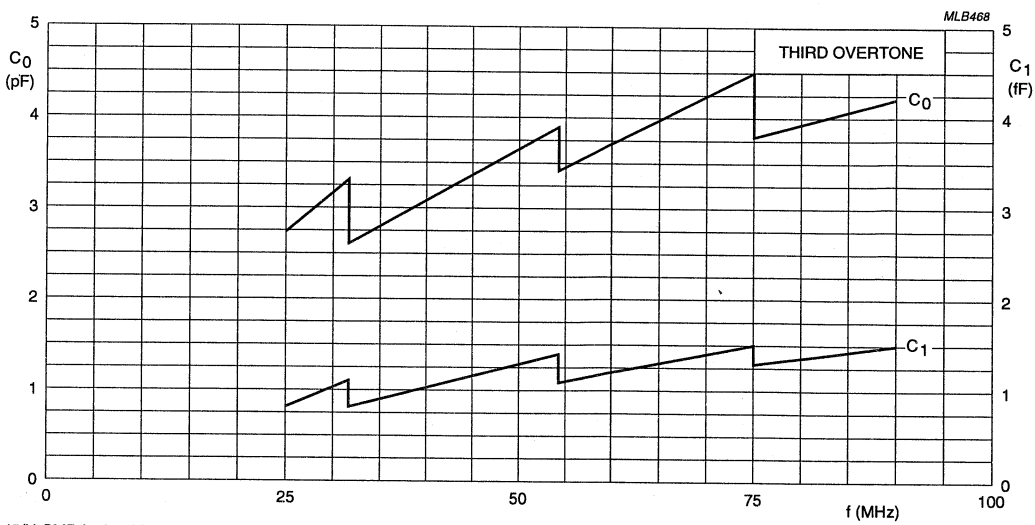
Other values available by extrapolation of the curve segments.

Fig.8 Motional capacitance C_1 and parallel capacitance C_0 as a function of resonance frequency.



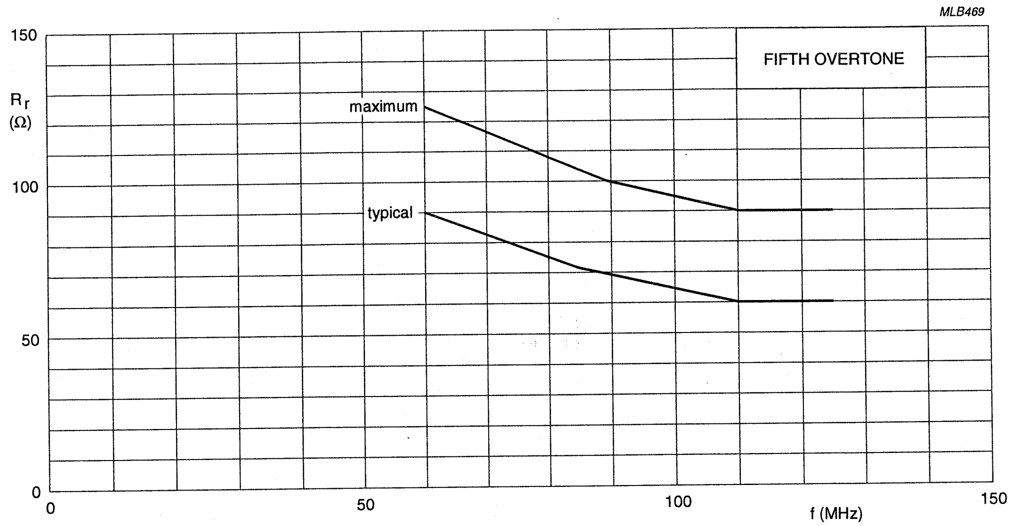
HC-45/U-SMD in the third overtone.
Values at 25 °C.
Other values available by extrapolating in combination with C_0 and C_1 values.

Fig.9 Resonance resistance R_r as a function of resonance frequency.



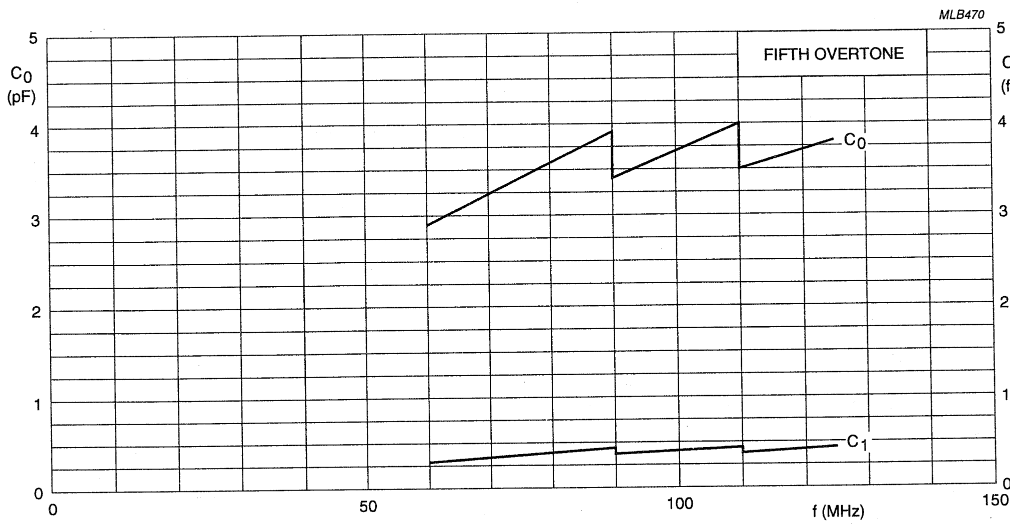
HC-45/U-SMD in the third overtone.
Typical values at 25 °C.
Other values available by extrapolation of the curve segments.

Fig.10 Motional capacitance C_1 and parallel capacitance C_0 as a function of resonance frequency.



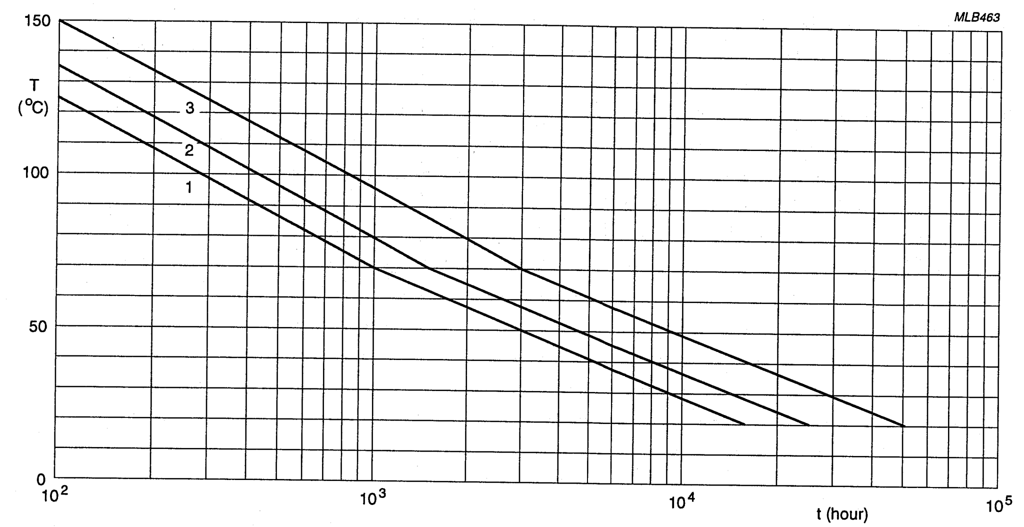
HC-45/U-SMD in the fifth overtone.
Values at 25 °C.

Fig.11 Resonance resistance R_r as a function of resonance frequency.



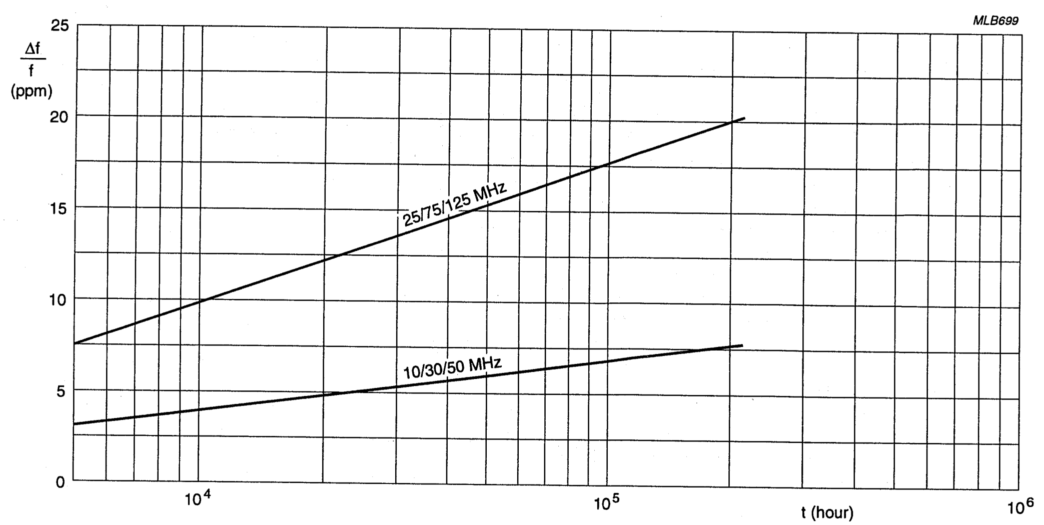
HC-45/U-SMD in the fifth overtone.
Typical values at 25 °C.

Fig.12 Motional capacitance C_1 and parallel capacitance C_0 as a function of resonance frequency.



Curve 1 = 1000 hours at 70 °C
Curve 2 = 720 hours at 85 °C
Curve 3 = 240 hours at 130 °C.

Fig.13 Time - temperature relation at which ageing is approximately equivalent.



Fundamental, third and fifth overtones.
Necessary pre-ageing can be calculated using Fig.13.

Fig.14 Typical frequency ageing as a function of time at 25 °C , **without pre-ageing of crystals.**

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with IEC publication 68-2, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"*. Ageing test is in accordance with IEC publication 679-1.

Table 4

IEC 68-2	TEST	PROCEDURE	REQUIREMENTS(1)
Ba	ageing	1000 hours at 70 °C	$\Delta f/f \leq 5$ ppm
Db	accelerated damp heat	+25 to +55 °C; 6 cycles at RH >95%	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Ea	shock	100 g; half sinewave; 6 directions; 1 blow/direction	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Eb	bump	4000 bumps of 40 g	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Ed	free fall	3 times on hard wood; for height of fall (h) see Table 4	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Fc	vibration	frequency 10 to 500 to 10 Hz; acceleration 10 g; 3 directions; 30 minutes/direction	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Na	temperature cycling test	−40/+85 °C; 10 cycles; 0.1 hour/cycle	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Q	sealing (method 1)	16 hours; 700 kPa He	$<10^{-8}$ ncc/s He
Ta	solderability	235 ±5 °C; 2 ±0.5 s; flux 600 (activated)	>90%, except for 1 mm from body; no visible damage, no leaks
Tb	resistance to soldering heat	350 ±5 °C; 3.5 ±0.5 s;	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Ub	bending of terminations	1 × 90°; 5 N	no visible damage

Note

1. All references to ppm = 10^{-6}.

Table 5 Height of fall.

h (mm)	FREQUENCY RANGE(1) (MHz)		
	FUNDAMENTAL MODE	THIRD OVERTONE	FIFTH OVERTONE
750	6 to 16	24 to 48	60 to 80
500	16.1 to 30	48.1 to 90	80 to 125

Note

1. Typical values. Actual designs can be made to obtain higher or lower values.

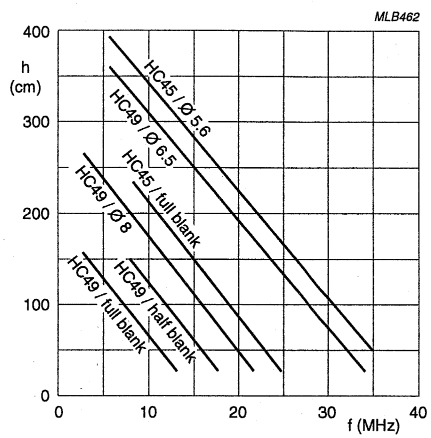


Fig.15 Typical height of fall values (3× on hard wood) for various quartz blank and holder combinations. 'Full' and 'half' blanks refer to rectangular quartz designs; 'Ø' designates circular quartz designs and the appropriate diameter.

SOLVENT RESISTANCE TESTS

Procedure	In accordance with IEC 68-2-45 (XA) and IEC 653 (immersion time 5 minutes) as well as MIL 202 E215. At ambient temperature, and ultrasonic (40 kHz).
Solvents	Bio-Act EC7 Neutropon P3 and Saxin P3 Meta Clean 820 Lonco 446 Isopropanol cleaning solvent Dowanol DPM (glass crystals only)
Requirements	no degradation of marking

Quartz crystals - special and industrial applications HC-33/U and HC-36/U

9922 523 1/3/4/6.... series

DESCRIPTION

The unit consists of a metal-plated AT-cut quartz plate, encapsulated in a hermetically sealed resistance-welded metal holder and provided with two connecting leads. Products are also available with connecting pins (HC-36/U) and have the same parameters.

APPLICATIONS

- Low frequency applications
- Transmitters.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
f_{nom}	nominal frequency				
	fundamental mode	1800	–	25000	kHz
	third overtone	10000	–	75000	kHz
	fifth overtone; note 1	50000	–	125000	kHz
m	mass:				
	fundamental	–	4	–	g
	overtone	–	1	–	g

Note

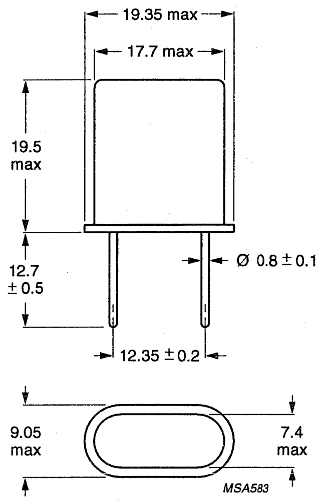
1. Crystals with 7th and 9th overtone are available on request.

Quartz crystals - special and industrial applications HC-33/U and HC-36/U

9922 523 1/3/4/6.... series

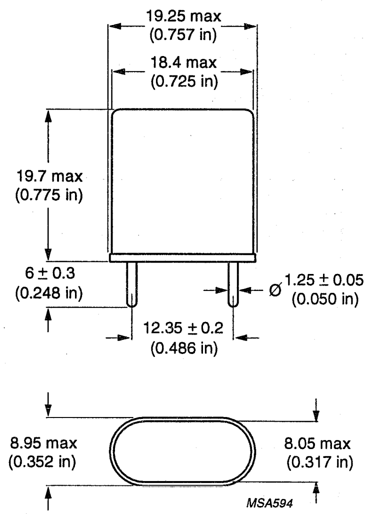
MECHANICAL DATA

Package outlines



Dimensions in mm.

Fig.1 HC-33/U, resistance welded.



Dimensions in mm.

Fig.2 HC-36/U, resistance welded.

STANDARD MARKING[(1)]

- Line 1: PHILIPS
- Line 2: frequency in kHz (fundamental mode) or in MHz (overtone)
- Line 3: last five digits of catalogue number followed by the manufacturing date code (last four digits of week code in accordance with UN-D1120).

(1) Special marking on product and/or package is available on request.

MASS AND LEADS

Typical mass:

fundamental: 4 g.

overtone: 1 g.

PACKAGING AND QUANTITIES

Crystal units are supplied in blister, 4 units per blister.

Crystal units can be supplied in bulk for larger quantities.

ELECTRICAL DATA

Measured at T_{amb} = 25 ± 2 °C and a nominal drive level of 100 μW into 25 Ω unless otherwise specified. Measuring system: π-network in accordance with IEC 444 recommendations.

Table 1

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT(3)
f_{nom}	nominal frequency	fundamental	1.8	–	25	MHz
		third overtone	10	–	75	MHz
		fifth overtone	50	–	125	MHz
$\Delta f/f_{nom}$	adjustment tolerance		±10	–	–	ppm
R_r	resonance resistance; note 1	fundamental mode	see Table 3			
		third overtone				
		10 to 15 MHz	–	–	60	Ω
		15 to 75 MHz	–	–	40	Ω
		fifth overtone				
		50 to 90 MHz	–	–	60	Ω
		90 to 125 MHz	–	–	80	Ω
C_L	load capacitance	fundamental mode; note 2	5	20	∞	pF
T_{oper}	operating temperature		–55	–	+105	°C
$\Delta f/f_{25}$	frequency stability over temperature range, with respect to T_{amb} = 25 °C		see Table 2			
R_r (T)	resonance resistance	available from R_r upward	see Table 3			
C_1	motional capacitance	fundamental mode	5	–	30	fF
		third overtone	–	1.5	–	fF
		fifth overtone	–	0.5	–	fF
C_o	parallel capacitance		–	–	7	pF
R_n	resonance resistance of unwanted response (spurious)	fundamental mode; f_{nom} ±20%	2 R_r (T)	–	–	Ω
			–6	–	–	dB
		overtones; f_{nom} ±200 kHz	2 R_r (T)	–	–	Ω
			–6	–	–	dB
R_{ins}	insulation resistance	DC test voltage = 100 V	500	–	–	MΩ
	frequency hysteresis or curve fit		1	–	–	ppm
$\Delta f/f$	ageing	10 years at T_{amb} = 25 °C	3	–	5	ppm

Notes

1. All resistance values are measured in series resonance, other values available on request.
2. Other values available on request.
3. All references to ppm = 10^{-6}.

Table 2 Frequency stability in different temperature ranges with respect to +25 °C. Other temperature ranges and tolerances on request.

FREQUENCY RANGE (MHz)	TEMPERATURE RANGE (°C)	FREQUENCY STABILITY (ppm)[1]		
		CLASS 0	CLASS 1	CLASS 2
Fundamental mode				
1.8 to 25.0	−5/+45	±5	±7.5	±10
	−10/+50	±7.5	±10	±15
	−15/+70	±10	±15	±20
1.8 to 2.3	−55/+105	±30	±13	±20
2.3 to 7.0	−55/+105	±32.5	±35	+40
7.0 to 25.0	−55/+105	+25	+30	+40
1.8 to 25.0	T_{nom} ±5	–	±2.5	−5
Third and fifth overtones				
	−5/+50	±5	±7.5	±10
	−10/+60	±7.5	±10	±15
	−20/+70	±10	±13	±20
	−55/+105	±25	±30	±40
	T_{nom} ±5	–	±2.5	±5

Note

1. All references to ppm = 10^{-6}.

Table 3 Resonance resistance (R_r).

FREQUENCY (kHz)	MAXIMUM R_r (Ω)
Fundamental mode	
1800 to 1999	300
2000 to 2249	250
2250 to 3749	150
3750 to 4999	100
5000 to 6999	50
7000 to 9999	30
10000 to 25000	25
Third overtone	
10000 to 15000	60
15000 to 75000	40
Fifth overtone	
50000 to 90000	60
90000 to 125000	80

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with IEC publication 68-2, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"*. Ageing test is in accordance with IEC publication 679-1.

Table 4

IEC 68-2	TEST	PROCEDURE	REQUIREMENTS(3)
Ba; note 1	ageing	1 000 hours at 70 °C	$\Delta f/f \leq 5$ ppm
Db	accelerated damp heat	+25 to +55 °C; 6 cycles at RH >95%	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Ea	shock	100 g; half sinewave; 6 directions; 1 blow/direction	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Eb	bump	3000 bumps of 40 g	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Fc	vibration	frequency 10 to 500 to 10 Hz; acceleration 10 g; 3 directions; 30 minutes/direction	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Na	temperature cycling test	−40/+85 °C; 10 cycles; 0.1 hour/cycle	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Q	sealing (method 1)	16 hours; 700 kPa He	$<10^{-8}$ ncc/s He
Ta; note 2	solderability	260 ±5 °C; 10 ±1 s; flux 600 (activated)	>90%, good tinning; no visible damage, no leaks
Tb; note 2	resistance to soldering heat	350 ±5 °C; 3 ±1 s;	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Ub; note 2	bending of terminations	1 × 90°; 5 N	no visible damage, no leaks

Notes

1. Overtone: $\Delta f/f \leq 10$ ppm.
2. Not valid for HC-36/U.
3. All references to ppm = 10^{-6}.

SOLVENT RESISTANCE TESTS

Procedure	In accordance with IEC 68-2-45 (XA) and IEC 653 (immersion time 5 minutes) as well as MIL 202 E215. At ambient temperature, and ultrasonic (40 kHz).
Solvents	Bio-Act EC7 Neutropon P3 and Saxin P3 Meta Clean 820 Lonco 446 Isopropanol cleaning solvent Dowanol DPM (glass crystals only)
Requirements	no degradation of marking

Quartz crystals - special and industrial applications HC-49/U-SMD

9922 524 6/7.... series

DESCRIPTION

The unit consists of a silver-plated AT-cut quartz plate, encapsulated in a nitrogen-filled metal holder. The holder is hermetically sealed by resistance-welding, provided with connecting leads and a metal clip for surface mounting. The unit has a high mechanical stability. The quartz design yields low resistance and high pullability values.

APPLICATIONS

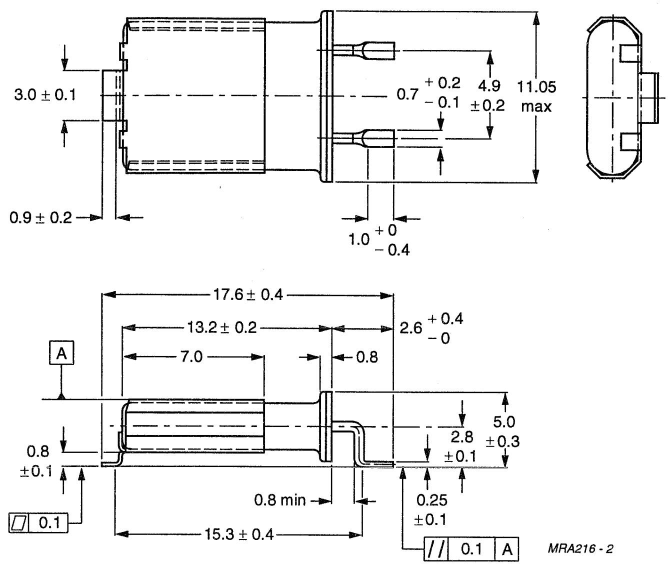
- Microprocessors
- Traffic control
- Weather balloons
- Medical systems
- Military applications
- Communication systems
- Agrarian applications
- Machine control
- Environmental applications.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
f_{nom}	nominal frequency				
	fundamental mode	2400	–	27000	kHz
	third overtone	20000	–	75000	kHz
m	mass	–	1.2	–	g

MECHANICAL DATA

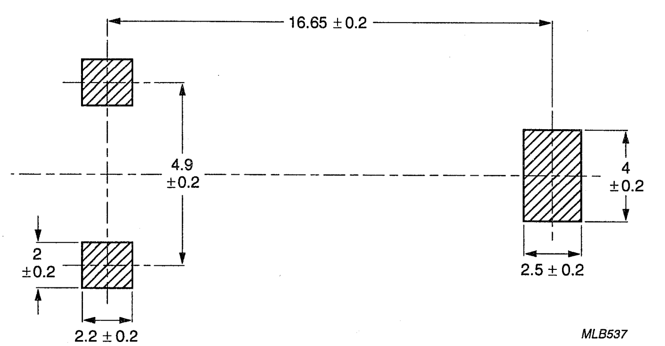
Package outlines



Dimensions in mm.

Fig.1 Style 1: HC-49/U17-SMD.

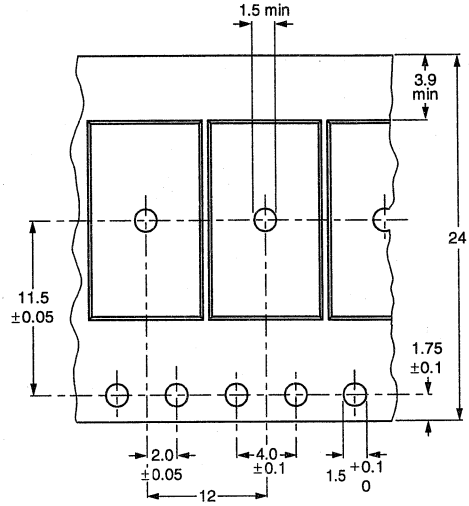
Recommended pad layout

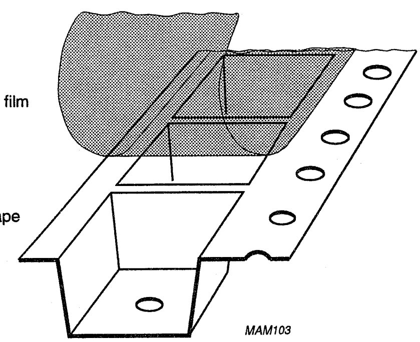


Dimensions in mm.

Fig.2 HC-49/U17-SMD.

Tape and reel data



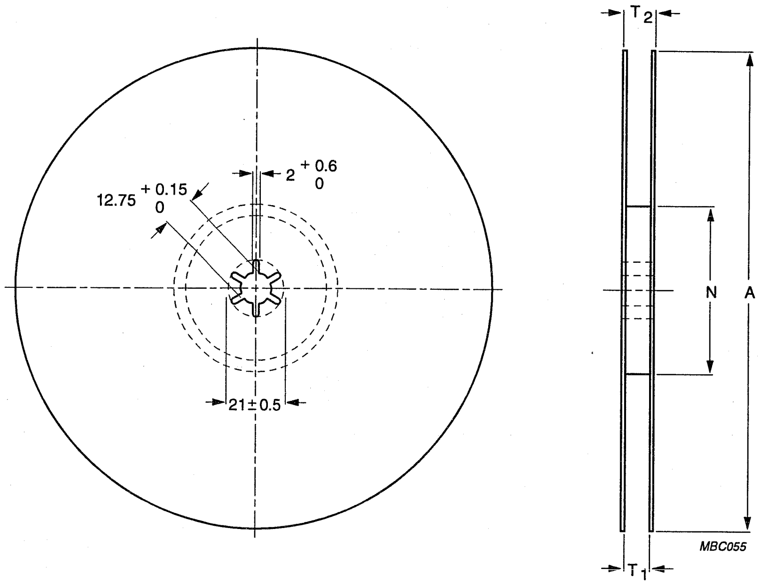


Dimensions in mm.
Crystal connections are adjacent to sprocket holes.
Cumulative pitch error: ≤0.2 mm over 10 pitches.

Total tape height of tape with top film: 5.8 mm maximum.
Tape thickness: 0.3 mm.
The blister is made of conductive polystyrene. Taping is performed in accordance with IEC 286-3.
Leader: minimum 400 mm including 100 mm sealed with empty compartments.
Trailer: minimum 160 mm sealed with empty compartments.

Pocket dimensions:
Length = 13.1 ±0.1 mm
Width = 8.3 ±0.1 mm
Depth = 4.3 +0.05/−0 mm

Fig.3 Blister tape.



Dimensions in mm.

Fig.4 Reel dimensions.

Table 1 Reel dimensions for Fig.4.

TAPE WIDTH (mm)	A (mm)	N (mm)	T_1 (mm)	T_2 (mm)
24	330	62 ±1.5	24.4 +0.2/−0	28.4 ±0.2

STANDARD MARKING(1)

- Line 1: PHILIPS
- Line 2: frequency in kHz (fundamental mode) or in MHz (overtone)
- Line 3: last five digits of catalogue number followed by the manufacturing date code (last three digits of week code in accordance with UN-D1120).

(1) Special marking on product and/or package is available on request.

MASS AND LEADS

Typical mass: 1.2 g.

The leads are finished with Sn99Cu1 on a nickel underplate.

The first 1 mm from the body is not guaranteed for soldering.

PACKAGING AND QUANTITIES

Crystal units are supplied in boxes, in blister tape on reel or in trays:
700 units per box or reel; 24 units per tray.

Quartz crystals - special and industrial applications HC-49/U-SMD

9922 524 6/7.... series

ELECTRICAL DATA

Measured at T_{amb} = 25 ±2 °C and a nominal drive level of 100 µW into 25 Ω unless otherwise specified. Measuring system: π-network in accordance with IEC 444 recommendations.

Table 2

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT(5)
f_{nom}	nominal frequency	fundamental	2.4	–	27.0	MHz
		third overtone	16.8	–	75.0	MHz
		fifth overtone	50.0	–	125.0	MHz
$\Delta f/f_{nom}$	adjustment tolerance	note 1	±10	–	–	ppm
R_r	resonance resistance	note 2	see Figs 5 and 8			
C_L	load capacitance	fundamental mode; note 3	5	20	∞	pF
		overtones; note 3	5	∞	–	pF
T_{oper}	operating temperature		–40	–	+130	°C
T_{op}	operable temperature		–50	–	+130	°C
$\Delta f/f_{25}$	frequency stability over temperature range, with respect to T_{amb} = 25 °C		see Table 3			
R_r (T)	resonance resistance over temperature range	note 2	available from R_r upward			
C_1	motional capacitance		see Figs 6 and 9			
	tolerance	note 4	–	–	10	%
C_o	parallel capacitance		see Figs 7 and 10			
	tolerance	note 4	–	–	10	%
S	pulling sensitivity		$S = -C_1 / 2(C_0 + C_L)^2$			
R_n	resonance resistance of unwanted response (spurious)	fundamental mode; f_{nom} ±20%	2 R_r (T)	–	–	Ω
			–6	–	–	dB
		overtones; f_{nom} ±200 kHz	2 R_r (T)	–	–	Ω
			–6	–	–	dB
R_{dld}	drive level dependency, being the resonance resistance in the drive level range	drive level range 10^{-12} W to 10^{-4} W; note 2	note 3			
R_{ins}	insulation resistance	DC test voltage = 100 V	500	–	–	MΩ
	frequency hysteresis or curve fit		1	–	–	ppm
$\Delta f/f$	ageing		see Figs 11 and 12			

Notes

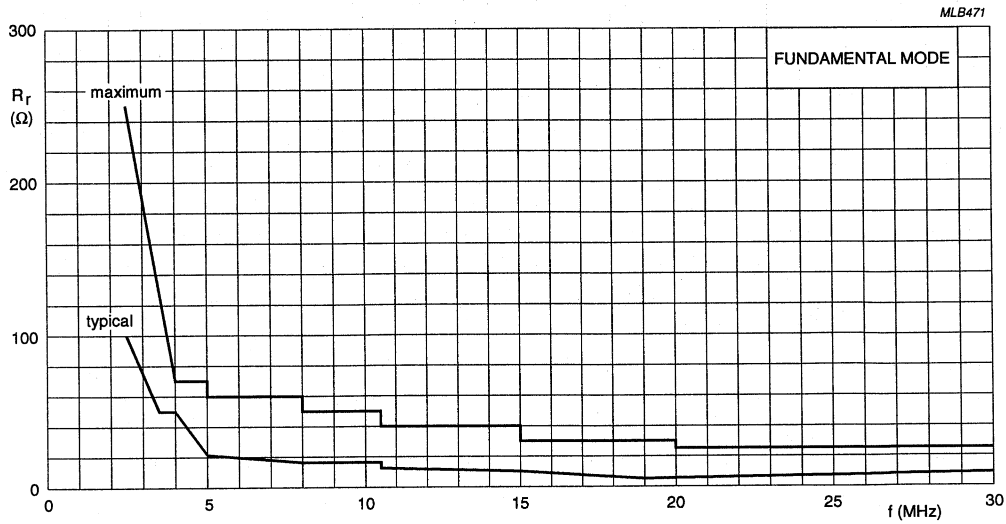
1. $\Delta f/f_{nom} \geq \pm 5$ ppm available on request.
2. All resistance values are measured in series resonance, other values available on request.
3. Values available on request.
4. Capacitance tolerance ≤5% available on request.
5. All references to ppm = 10^{-6}.

Table 3 Frequency stability with temperature variation (available maximum values).

TEMPERATURE RANGE[1] (°C)	FREQUENCY STABILITY (ppm)[2]	
	CLASS 0	CLASS 1
+20/+30	1.0	1.5
0/+50	5.0	7.5
−10/+60	7.5	10.0
−20/+70	10.0	15.0
−30/+80	12.5	20.0
−40/+90	17.5	25.0
−55/+105	25.0	30.0
−40/+130	−	50.0

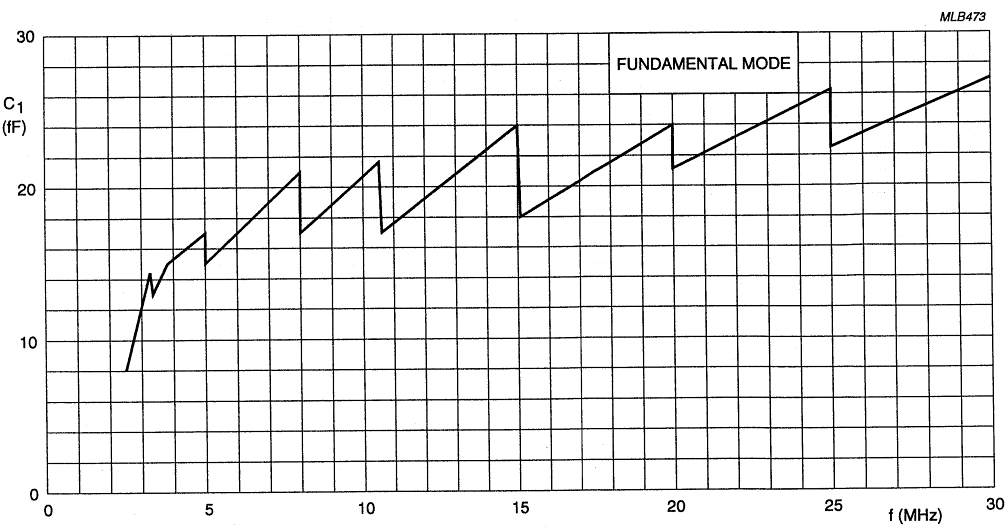
Notes

1. For frequencies below 8 MHz, the upper temperature limit is 10 °C lower to obtain the same stability.
2. All references to ppm = 10^{-6}.



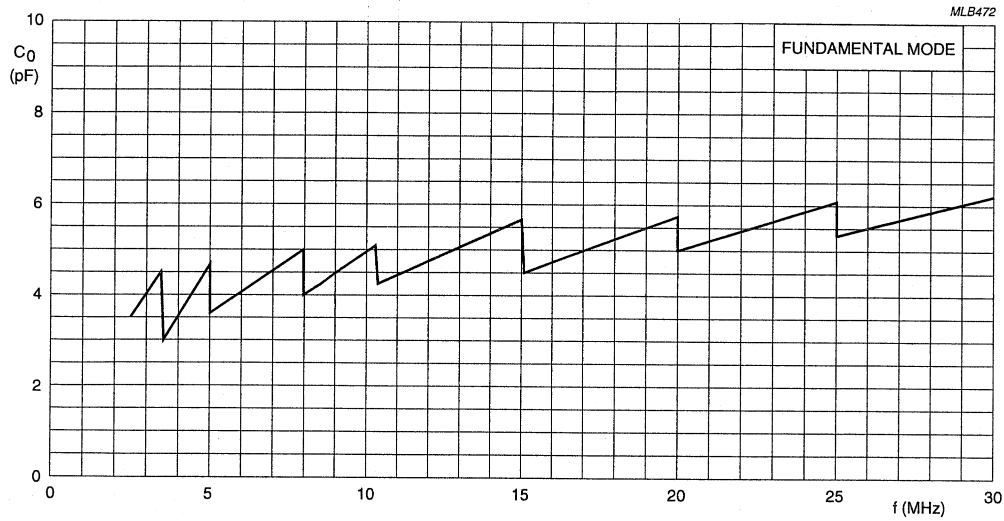
HC-49/U-SMD.
Values at 25 °C.
Other values available by extrapolation with C_0 and C_1 values.

Fig.5 Resonance resistance R_r as a function of resonance frequency.



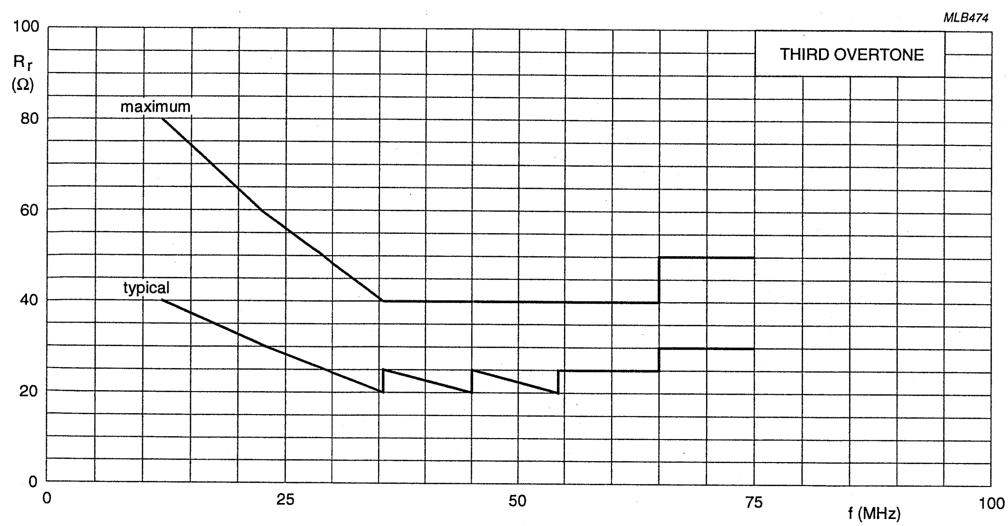
HC-49/U-SMD in the fundamental mode.
Values at 25 °C.
Other values available by extrapolation of the curve segments.

Fig.6 Motional capacitance C_1 as a function of resonance frequency.



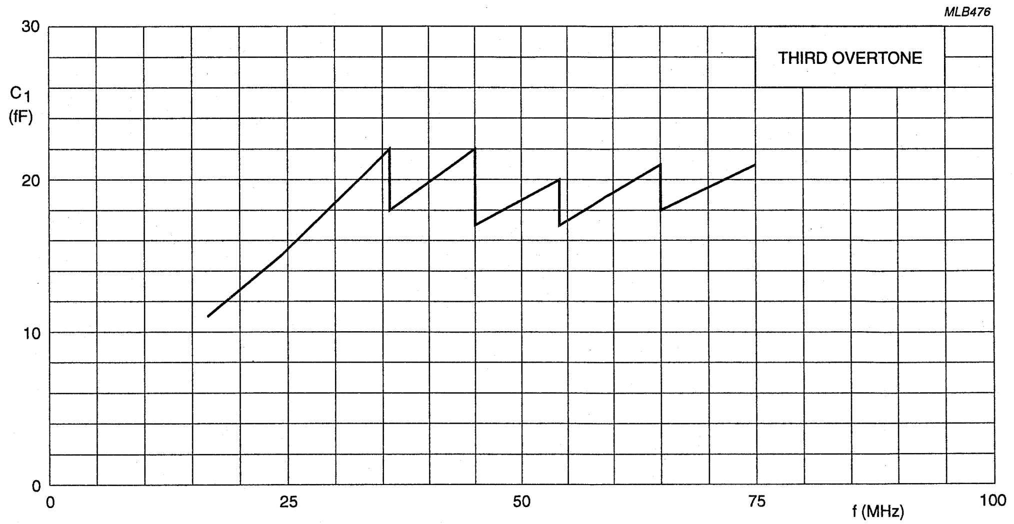
HC-49/U in the fundamental mode.
Typical values at 25 °C.
Other values available by extrapolation of the curve segments.

Fig.7 Parallel capacitance C_0 as a function of resonance frequency



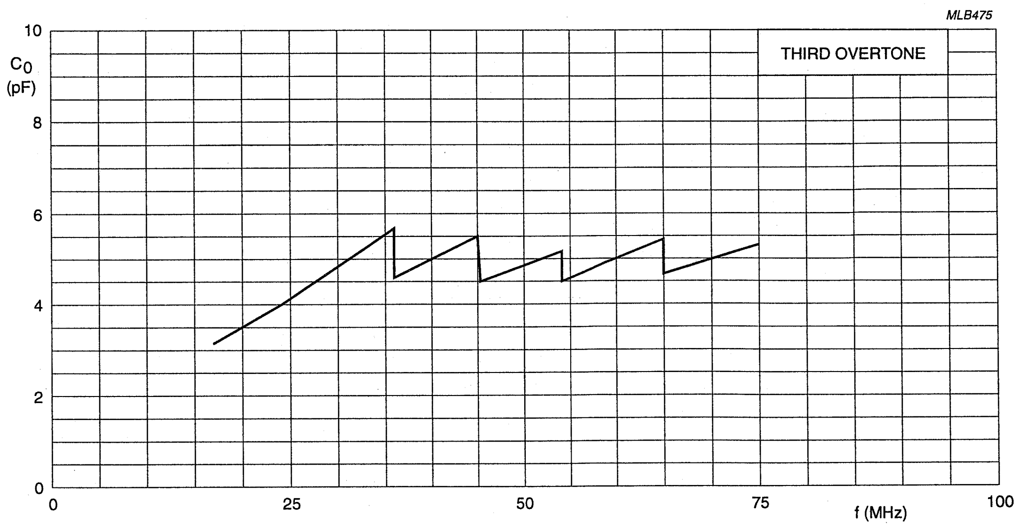
HC-49/U-SMD in the third overtone.
Values at 25 °C.
Other values available by extrapolation with C_0 and C_1 values.

Fig.8 Resonance resistance R_r as a function of resonance frequency.



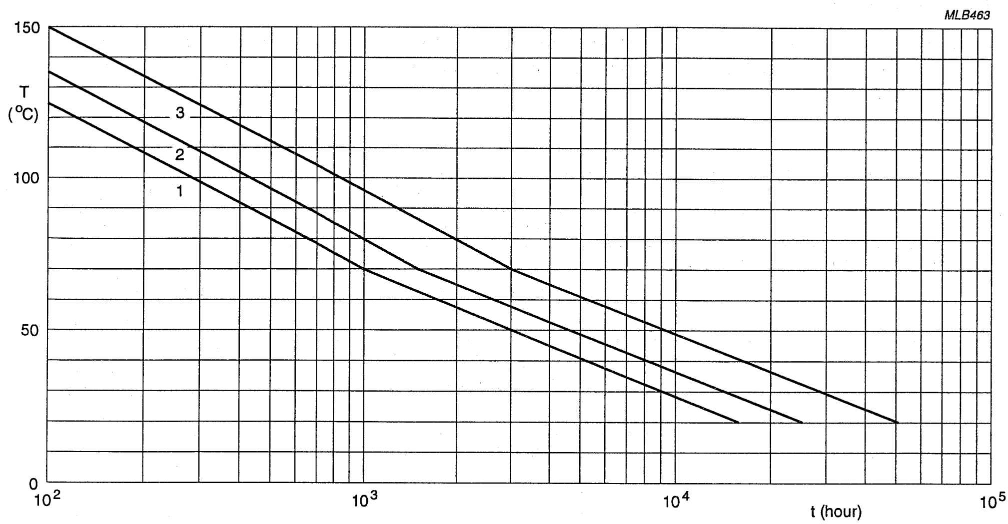
HC-49/U-SMD in the third overtone.
Typical values at 25 °C.
Other values available by extrapolation with C_0 values.

Fig.9 Motional capacitance C_1 as a function of resonance frequency.



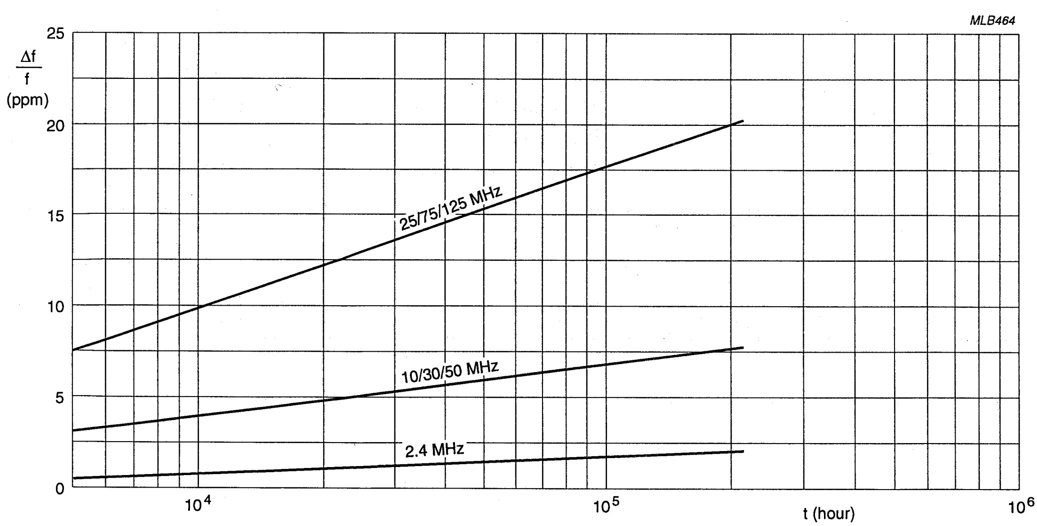
HC-49/U-SMD in the third overtone.
Typical values at 25 °C.
Other values available by extrapolation with C_1 values.

Fig.10 Parallel capacitance C_0 as a function of resonance frequency.



Curve 1 = 1000 hours at 70 °C.
Curve 2 = 720 hours at 85 °C.
Curve 3 = 240 hours at 130 °C.

Fig.11 Time - temperature relation at which ageing is approximately equivalent.



Fundamental, third and fifth overtones.
Necessary pre-ageing can be calculated using Fig.11.

Fig.12 Typical frequency ageing as a function of time at 25 °C, **without pre-ageing of crystals.**

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with IEC publication 68-2, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"*. Ageing test is in accordance with IEC publication 679-1.

Table 4

IEC 68-2	TEST	PROCEDURE	REQUIREMENTS(1)
Ba	ageing	1000 hours at 70 °C	$\Delta f/f \leq 5$ ppm
Db	accelerated damp heat	+25 to +55 °C; 6 cycles at RH >95%	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Ea	shock	100 g; half sinewave; 6 directions; 1 blow/direction	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Eb	bump	4000 bumps of 40 g	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Ed	free fall	3 times on hard wood; for height of fall (h) see Table 5	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Fc	vibration	frequency 10 to 500 to 10 Hz; acceleration 10 g; 3 directions; 30 minutes/direction	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Na	temperature cycling test	−40/+85 °C; 10 cycles; 0.1 hour/cycle	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Q	sealing (method 1)	16 hours; 700 kPa He	$<10^{-8}$ ncc/s He
Ta	solderability	235 ±5 °C; 2 ±0.5 s; flux 600 (activated)	>90%, except for 1 mm from body; no visible damage, no leaks
Tb	resistance to soldering heat	350 ±5 °C; 3.5 ±0.5 s;	$\Delta f/f \leq 5$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Ub	bending of terminations	1 × 90°; 5 N	no visible damage

Note

1. All references to ppm = 10^{-6}.

Table 5 Height of fall.

h (mm)	FREQUENCY RANGE(1) (MHz)		
	FUNDAMENTAL MODE	THIRD OVERTONE	FIFTH OVERTONE
750	2.4 to 16	16.8 to 48	50 to 80
500	16.1 to 27	48.1 to 75	80.1 to 125

Note

1. Typical values. Actual designs can be made to obtain higher or lower values.

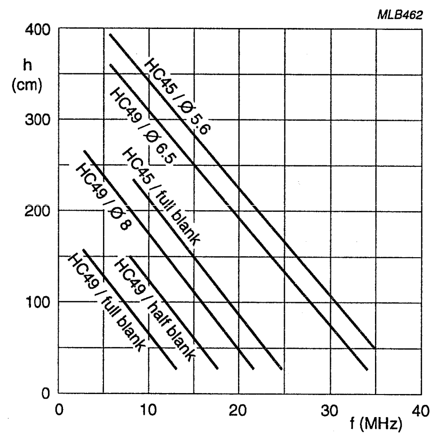


Fig.13 Typical height of fall values (3× on hard wood) for various quartz blank and holder combinations. 'Full' and 'half' blanks refer to rectangular quartz designs; 'Ø' designates circular quartz designs and the appropriate diameter.

SOLVENT RESISTANCE TESTS

Procedure	In accordance with IEC 68-2-45 (XA) and IEC 653 (immersion time 5 minutes) as well as MIL 202 E215. At ambient temperature, and ultrasonic (40 kHz).
Solvents	Bio-Act EC7 Neutropon P3 and Saxin P3 Meta Clean 820 Lonco 446 Isopropanol cleaning solvent Dowanol DPM (glass crystals only)
Requirements	no degradation of marking

Quartz crystals - special and industrial applications HC-26/U and HC-29/U

9922 526 0/3.... series

DESCRIPTION

The unit consists of a silver-plated AT-cut quartz plate, encapsulated in a high-vacuum all-glass holder. The holder is hermetically sealed and provided with connecting leads (HC-26/U) or pins (HC-29/U). The unit has outstanding electrical performance and a very high level of reliability. The quartz design yields low resistance and high pullability values. The low resistance is obtained by a high-vacuum, because there is low acoustic resistance. The product has extremely low ageing characteristics.

APPLICATIONS

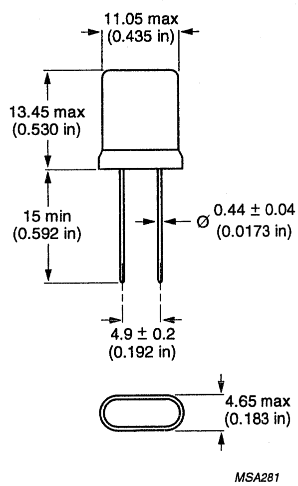
- Transmitters
- Measuring equipment
- Medical applications
- Military applications
- Telephone switchboards
- Oven-controlled oscillators.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
f_{nom}	nominal frequency:				
	fundamental mode	4500	–	25000	kHz
	third overtone	20000	–	75000	kHz
	fifth overtone	50000	–	125000	kHz
m	mass	–	0.8	–	g

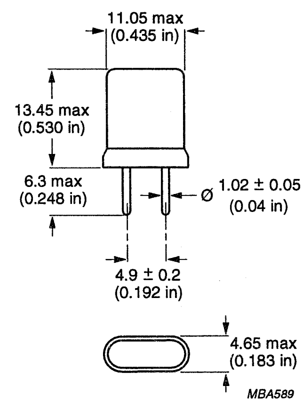
MECHANICAL DATA

Package outlines



Dimensions in mm.

Fig.1 Style 1: HC-26/U.



Dimensions in mm.

Fig.2 Style 2: HC-29/U.

STANDARD MARKING(1)

- Line 1: PHILIPS
- Line 2: frequency in kHz (fundamental mode) or in MHz (overtone)
- Line 3: last five digits of catalogue number followed by the manufacturing date code (last four digits of week code in accordance with UN-D1120).

(1) Special marking on product and/or package is available on request.

MASS

Typical: 0.8 g.

PACKAGING AND QUANTITIES

Crystal units are supplied in trays: 24 units per tray.

ELECTRICAL DATA

Measured at T_{amb} = 25 ±2 °C and a nominal drive level of 100 µW into 25 Ω unless otherwise specified. Measuring system: π-network in accordance with IEC 444 recommendations.

Table 1

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT(5)
f_{nom}	nominal frequency	fundamental	4.5	–	25.0	MHz
		third overtone	20.0	–	75.0	MHz
		fifth overtone	50.0	–	125.0	MHz
$\Delta f/f_{nom}$	adjustment tolerance	note 1	±10	–	–	ppm
R_r	resonance resistance	note 2	see Fig.3			
C_L	load capacitance	fundamental mode; note 3	5	20	∞	pF
		overtones; note 3	5	∞	–	pF
T_{oper}	operating temperature		–55	–	+105	°C
T_{op}	operable temperature		–55	–	+155	°C
$\Delta f/f_{25}$	frequency stability over temperature range, with respect to T_{amb} = 25 °C		see Table 2			
R_r (T)	resonance resistance over temperature range	note 2	available from R_r upward			
C_1	motional capacitance		see Fig.4			
	tolerance	note 4	–	–	10	%
C_0	parallel capacitance		see Fig.4			
	tolerance	note 4	–	–	10	%
S	pulling sensitivity		$S = -C_1 / 2(C_0 + C_L)^2$			
R_n	resonance resistance of unwanted response (spurious)	fundamental mode; f_{nom} ±20%	2 R_r (T)	–	–	Ω
			–6	–	–	dB
		overtones; f_{nom} ±200 kHz	2 R_r (T)	–	–	Ω
			–6	–	–	dB
R_{dld}	drive level dependency, being the resonance resistance in the drive level range	drive level range 10^{-12} W to 10^{-4} W; note 2	note 3			
R_{ins}	insulation resistance	DC test voltage = 100 V	500	–	–	MΩ
	frequency hysteresis or curve fit		1	–	–	ppm
$\Delta f/f$	ageing	10 years at T_{amb} = 25 °C	0.1	–	2	ppm

Notes

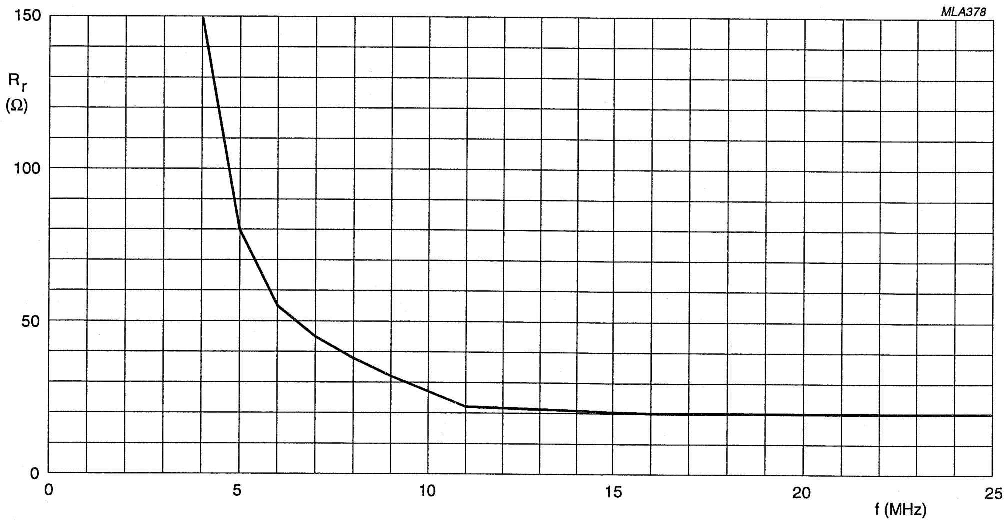
1. $\Delta f/f_{nom} \geq \pm 5$ ppm available on request.
2. All resistance values are measured in series resonance, other values available on request.
3. Values available on request.
4. Capacitance tolerance ≤5% available on request.
5. All references to ppm = 10^{-6}.

Table 2 Frequency stability in different temperature ranges with respect to +25 °C. Other temperature ranges and tolerances on request.

TEMPERATURE RANGE (°C)	FREQUENCY STABILITY (ppm)(1)				
	CLASS 0	CLASS 1	CLASS 2	CLASS 3	CLASS 4
Frequency range 4.5 to 6.0 MHz					
0/+50	–	–	±15	±20	±30
–10/+60	–	–	±15	±20	±30
–20/+70	–	–	±15	±20	±30
–40/+90	–	–	±15	±20	±30
–55/+105	–	–	±15	±20	±30
Frequency range 6.0 to 12 MHz					
0/+50	–	±3.5	±5	±7.5	±10
–10/+60	–	±6	±7.5	±10	±15
–20/+70	–	±8	±12	±15	±20
–40/+90	–	±16	±20	±25	±30
–55/+105	–	±25	±30	±35	±40
Frequency range ≥12 MHz					
+20/+30	±1.0	±1.0	±1.0	±1.5	±2.0
0/+50	±2.5	±4	±5	±7.5	±10
–10/+60	±4	±6	±7.5	±10	±15
–20/+70	±6	±8	±10	±15	±20
–40/+90	±12.5	±15	±20	±25	±30
–55/+105	±20	±25	±30	±35	±40

Note

1. All references to ppm = 10^{-6}.

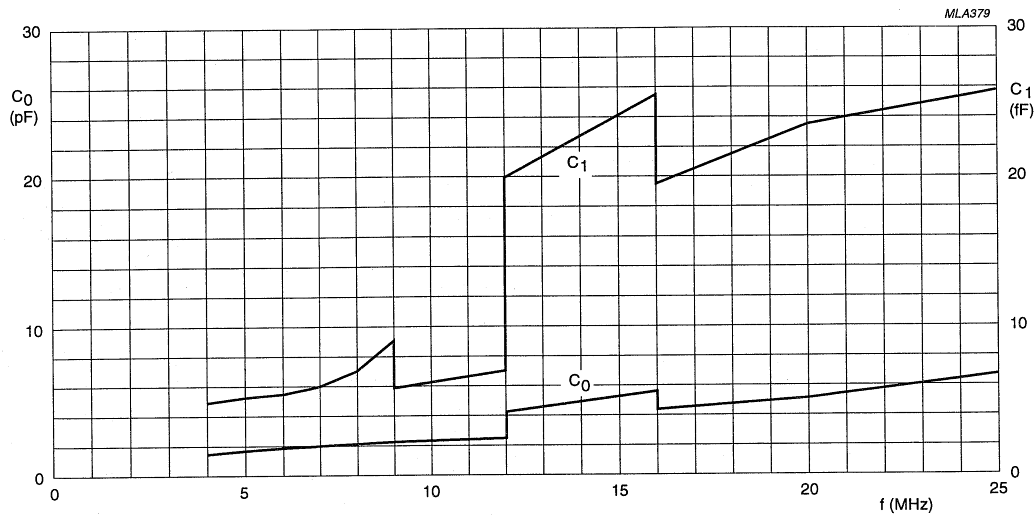


HC-26/U and HC-29/U in the fundamental mode (other modes in Table 3).
Maximum values in the temperature range.
Other values available by extrapolation in combination with C_0 and C_1 values.

Fig.3 Resonance resistance R_r as a function of resonance frequency.

Table 3 Overtones.

MODE	FREQUENCY (MHz)	R_r (Ω)
3	20.0 to 30	50
3	30.1 to 75	30
5	50 to 90	50
5	90.1 to 125	70



HC-26/U and HC-29/U in the fundamental mode (other modes in Table 4).
Typical values at 25 °C.
Other values available by extrapolation of the curve segments.

Fig.4 Parallel capacitance C_0 and motional capacitance C_1 as a function of resonance frequency.

Table 4 Overtones.

MODE	FREQUENCY (MHz)	C_1 (fF)	$C_{0\,max}$ (pF)
3	20.0 to 75	1.5	7
5	75.1 to 125	0.5	7

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with IEC publication 68-2, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"*. Ageing test is in accordance with IEC publication 679-1.

Table 5

IEC 68-2	TEST	PROCEDURE	REQUIREMENTS(2)
Ba	ageing	2000 hours at 85 °C	Δf/f −0.5/+1.0 ppm
			Δf/f typical 0.5 ppm
Db	accelerated damp heat	+25 to +55 °C; 6 cycles at RH >95%	Δf/f ≤ 1 ppm
			ΔR_r ±1 Ω or ±20% whichever is the greater
Ea	shock; note 1	100 g; half sinewave; 6 directions; 1 blow/direction	Δf/f ≤ 1 ppm
			ΔR_r ±1 Ω or ±20% whichever is the greater
Fc	vibration; note 1	frequency 10 to 500 to 10 Hz; acceleration 20 g; 3 directions; 30 minutes/direction	Δf/f ≤ 1 ppm
			ΔR_r ±1 Ω or ±20% whichever is the greater
Na	temperature cycling test	−40/+85 °C; 10 cycles; 2 hours/cycle	Δf/f ≤ 1 ppm
			ΔR_r ±1 Ω or ±20% whichever is the greater
Q	sealing (method 1)	16 hours; 700 kPa He	<10^{-8} ncc/s He
Ta	solderability	235 ±5 °C; 2 ±0.5 s; flux 600 (activated)	>90%, except for 1 mm from body; no visible damage, no leaks
Tb	resistance to soldering heat	350 ±5 °C; 3.5 ±0.5 s;	Δf/f ≤ 1 ppm
			ΔR_r ±1 Ω or ±20% whichever is the greater
Ub	bending of terminations	1 × 90°; 5 N	no visible damage

Notes

1. Mechanical tests to be performed on units clamped to a printed-circuit board (PCB) for the total unit height.
2. All references to ppm = 10^{-6}.

SOLVENT RESISTANCE TESTS

Procedure	In accordance with IEC 68-2-45 (XA) and IEC 653 (immersion time 5 minutes) as well as MIL 202 E215. At ambient temperature, and ultrasonic (40 kHz).
Solvents	Bio-Act EC7 Neutropon P3 and Saxin P3 Meta Clean 820 Lonco 446 Isopropanol cleaning solvent Dowanol DPM (glass crystals only)
Requirements	no degradation of marking

Quartz crystals - special and industrial applications HC-27/U

9922 527 0/2.... series

DESCRIPTION

The unit consists of a metal-plated AT-cut quartz plate, encapsulated in a hermetically sealed all glass holder and provided with two connecting pins. The unit has outstanding electrical performance and a very high level of reliability. The quartz design yields low resistance and high pullability values. The low resistance is obtained by a high-vacuum, because there is low acoustic resistance. The product has extremely low ageing characteristics.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
f_{nom}	nominal frequency:				
	fundamental mode	1800	–	25000	kHz
	third overtone; note 1	10000	–	75000	kHz
	fifth overtone; note 2	50000	–	125000	kHz
m	mass	–	2.5	–	g

Notes

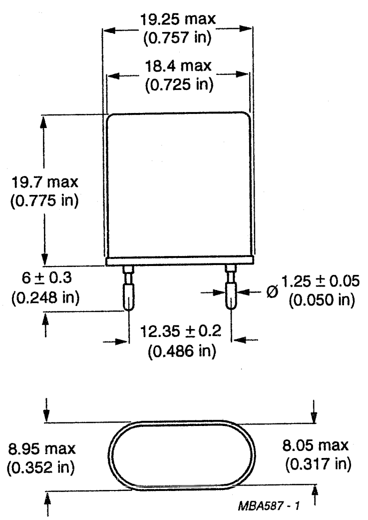
1. Special 3rd overtone 10 MHz crystal is available under code number 9922 527 20011 (previous version 4322 159 0000).
2. Crystals with 7th and 9th overtone are available on request.

APPLICATIONS

- Transmitters
- Measuring equipment
- Medical applications
- Military applications
- Telephone switchboards
- Oven-controlled oscillators
- Low frequency applications
- Frequency counters.

MECHANICAL DATA

Package outlines



Dimensions in mm.
IEC type DB is identical except for the height which is 26 mm max.

Fig.1 HC-27/U.

STANDARD MARKING

- Line 1: PHILIPS
- Line 2: frequency in kHz (fundamental mode) or in MHz (overtone)
- Line 3: last five digits of catalogue number followed by the manufacturing date code (last four digits of week code in accordance with UN-D1120).

MASS AND LEADS

Typical mass: 2.5 g.

PACKAGING AND QUANTITIES

Crystal units are supplied in trays; 4 units per tray.

Quartz crystals - special and industrial applications HC-27/U

9922 527 0/2.... series

ELECTRICAL DATA

Measured at T_{amb} = 25 ±2 °C and a nominal drive level of 100 μW into 25 Ω unless otherwise specified. Measuring system: π-network in accordance with IEC 444 recommendations.

Table 1

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT(3)
f_{nom}	nominal frequency	fundamental	4.5	–	22	MHz
		third overtone	20.0	–	75	MHz
		fifth overtone	50.0	–	125	MHz
		third overtone, high precision	–	10000.000	–	kHz
$\Delta f/f_{nom}$	adjustment tolerance	fundamental, third and fifth; note 1	–	±10	–	ppm
		third overtone, high precision	–	±5	–	ppm
R_r	resonance resistance	fundamental	see Fig.2			
		third overtone	–	≤ 40	–	Ω
		fifth overtone	–	≤ 50	–	Ω
		third overtone, high precision	–	≤ 40	–	Ω
C_L	load capacitance	fundamental; note 2	5	20	∞	pF
		overtones	5	∞	–	pF
		third overtone, high precision	–	75	–	pF
T_{op}	operable temperature		–55	–	+125	°C
T_{ref}	reference temperature	third overtone, high precision	–	+70	–	°C
$\Delta f/f_{25}$	frequency stability over temperature range, with respect to T_{amb} = 25 °C	fundamental, third and fifth	see Table 2			
		third overtone, high precision (69 to 71 °C)	–	±0.3	–	ppm
R_r (T)	resonance resistance		available from R_r upward			
C_1	motional capacitance	fundamental mode	see Fig.3			
		third overtone	–	1.5	–	fF
		fifth overtone	–	0.5	–	fF
		third overtone, high precision	–	2.1	–	fF
	tolerance		–	–	10	%
C_0	parallel capacitance	fundamental mode	see Fig.3			
		third and fifth overtones	–	–	7	pF
		third overtone, high precision	–	5	–	pF
	tolerance		–	–	10	%
	frequency hysteresis or curve fit		1	–	–	ppm
$\Delta f/f$	ageing after 90 days at 85 °C ±2 °C	third overtone, high precision	–	0.05	–	ppm
$\Delta f/f$	ageing	10 years at T_{amb} = 25 °C	0.1	–	2	ppm

Notes

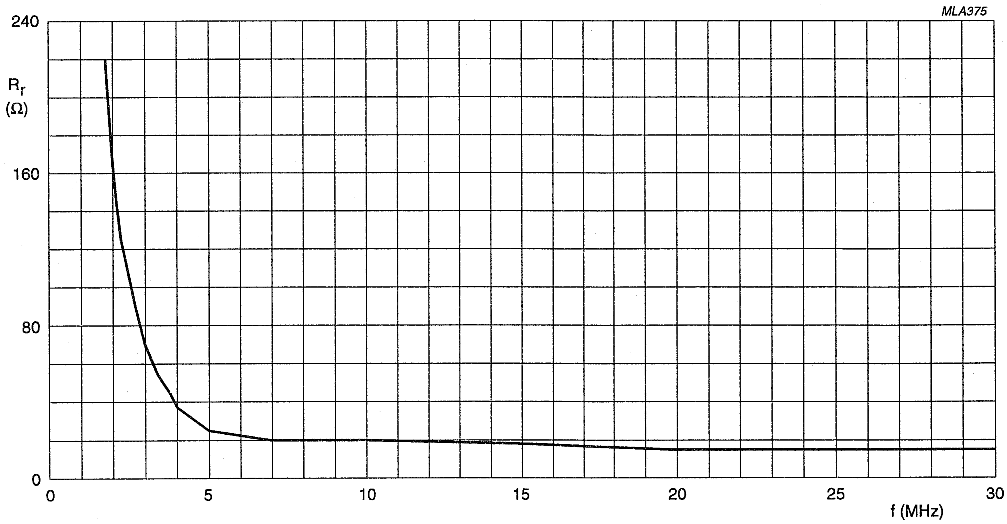
1. $\Delta f/f_{nom}$ ≥ ±5 ppm available on request.
2. Crystals can be calibrated at other values or at series resonance on request.
3. All references to ppm = 10^{-6}.

Table 2 Frequency stability in different temperature ranges with respect to +25 °C. Other temperature ranges and tolerances on request.

FREQUENCY RANGE (MHz)	TEMPERATURE RANGE (°C)	FREQUENCY STABILITY (ppm)[1]		
		CLASS 0	CLASS 1	CLASS 2
Fundamental mode				
4.5 to 25.0	−5/+45	±5	±7.5	±10
	−10/+50	±7.5	±10	±15
	−15/+70	±10	±15	±20
4.5 to 2.3	−55/+105	±30	±13	±20
4.5 to 7.0	−55/+105	±32.5	±35	+40
7.0 to 25.0	−55/+105	+25	+30	+40
4.5 to 25.0	T_{nom} ±5	–	±2.5	−5
Third and fifth overtones				
	−5/+50	±5	±7.5	±10
	−10/+60	±7.5	±10	±15
	−20/+70	±10	±13	±20
	−55/+105	±25	±30	±40
	T_{nom} ±5	–	±2.5	±5

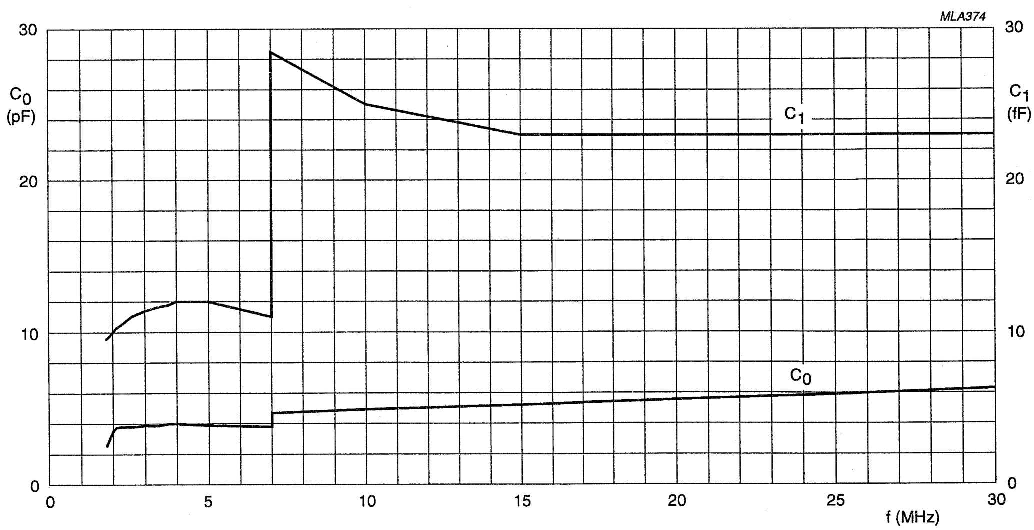
Note

1. All references to ppm = 10^{-6}.



HC-27/U in the fundamental mode.
Typical values at 25 °C.
Other values available by extrapolation of the curve segments.

Fig.2 Resonance resistance R_r as a function of resonance frequency.



HC-27/U in the fundamental mode.
Maximum values in the temperature range.
Other values available by extrapolation in combination with C_0 and C_1 values.

Fig.3 Motional capacitance C_1 and parallel capacitance C_0 as a function of resonance frequency.

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with IEC publication 68-2, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"*. Ageing test is in accordance with IEC publication 679-1.

Table 3

IEC 68-2	TEST	PROCEDURE	REQUIREMENTS[2]
Ba	ageing	2000 hours at 85 °C	$\Delta f/f$ −0.5/+1.0 ppm
			$\Delta f/f$ typical 0.5 ppm
Db	accelerated damp heat	+25 to +55 °C; 6 cycles at RH >95%	$\Delta f/f \leq 1$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Ea	shock; note 1	100 g; half sinewave; 6 directions; 1 blow/direction	$\Delta f/f \leq 1$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Fc	vibration; note 1	frequency 10 to 500 to 10 Hz; acceleration 20 g; 3 directions; 30 minutes/direction	$\Delta f/f \leq 1$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Na	temperature cycling test	−40/+85 °C; 10 cycles; 2 hours/cycle	$\Delta f/f \leq 1$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Q	sealing (method 1)	16 hours; 700 kPa He	$<10^{-8}$ ncc/s He
Ta	solderability	235 ±5 °C; 2 ±0.5 s; flux 600 (activated)	>90%, except for 1 mm from body; no visible damage, no leaks
Tb	resistance to soldering heat	350 ±5 °C; 3.5 ±0.5 s;	$\Delta f/f \leq 1$ ppm
			ΔR_r ±5 Ω or ±20% whichever is the greater
Ub	bending of terminations	1 × 90°; 5 N	no visible damage

Notes

1. Mechanical tests to be performed on units clamped to a printed-circuit board (PCB) for the total unit height.
2. All references to ppm = 10^{-6}.

SOLVENT RESISTANCE TESTS

Procedure	In accordance with IEC 68-2-45 (XA) and IEC 653 (immersion time 5 minutes) as well as MIL 202 E215. At ambient temperature, and ultrasonic (40 kHz).
Solvents	Bio-Act EC7 Neutropon P3 and Saxin P3 Meta Clean 820 Lonco 446 Isopropanol cleaning solvent Dowanol DPM (glass crystals only)
Requirements	no degradation of marking

QUARTZ TEMPERATURE SENSORS

QUARTZ CRYSTAL UNITS AS DIGITAL TEMPERATURE SENSORS

The most well known applications of quartz crystal units are those where the crystal is used in oscillator and filter circuits, as a frequency-selective element with an extremely high Q-factor. By correct choice of the cutting angle of the vibrating plate, it is possible to obtain a very low TC over a limited temperature range. Examples of such crystal cuts are: AT, BT, CT and GT cuts.

In addition, it is also possible to cut crystal plates so that the resonance frequency is an almost linear function of the temperature. It should be noted, that the first quartz crystal cut to be discovered was in fact a 'Y- cut'. However, there are some disadvantages which make this cut unsuitable for temperature sensing, therefore special cuts have been introduced, depending on the application.

How to use a quartz crystal unit as a temperature sensor

In order to measure temperatures with a quartz crystal sensor, the device should be connected to an oscillator circuit which usually consists of one or two transistors or an integrated circuit. The oscillator will produce an output signal whose frequency will change by -40 to $+80 \times 10^{-6}$/K. There are several ways of processing this signal. Due to excellent stability, low ageing and its 'digital' nature, resolutions of 0.001 K are easily achieved without noise problems. This renders the device especially suitable for measurements of very small temperature differences as in distillation columns and flow meters.

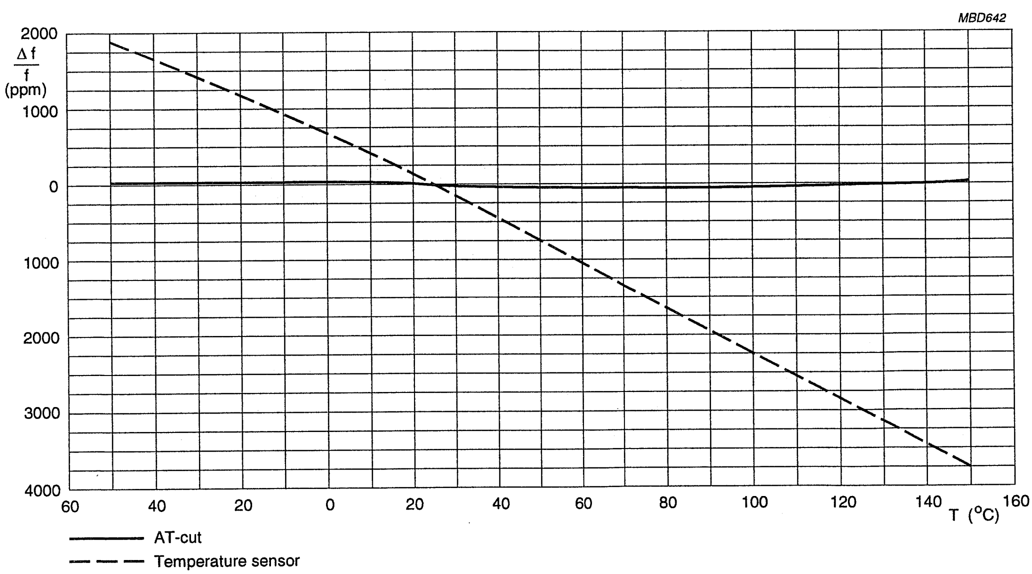


Fig.1 Frequency change as a function of temperature.

APPLICATION EXAMPLES

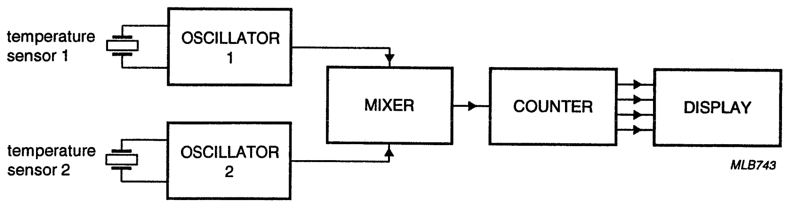


Fig.2 Typical temperature sensing circuit with two sensors.

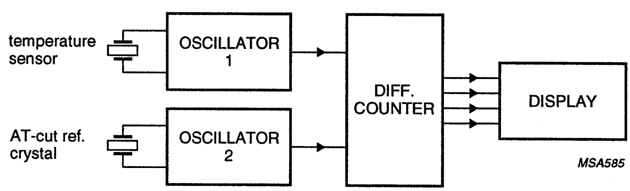


Fig.3 Typical temperature sensing circuit with one sensor and one reference crystal.

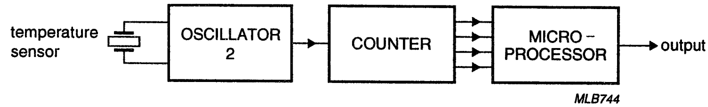


Fig.4 Typical temperature sensing circuit with one sensor and microprocessor.

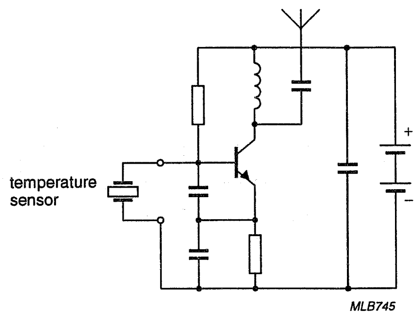


Fig.5 Miniature wireless temperature sensing circuit.

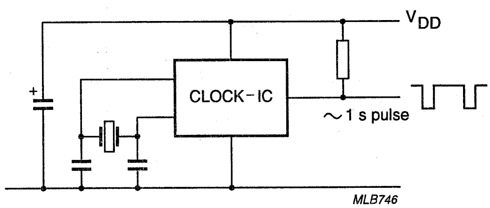


Fig.6 Crystal oscillator using a clock integrated circuit.

Quartz temperature sensor HC-49/U

9922 520 6.... series

FEATURES

- No A/D conversion
- Excellent linearity
- High stability, low ageing
- Wide temperature range
- High noise immunity
- Easy calibration
- Quantity production at low cost.

APPLICATIONS

- In industrial temperature measurement and control
- Car electronics
- Flow meters
- Weather balloons
- Medical systems
- Energy saving projects, for example:
  - heat monitors
  - solar panels.

DESCRIPTION

The sensor consists of a metal-plated special TC-cut piezoelectric quartz plate, mounted in a hermetically sealed resistance-welded metal holder, which has two or three leads and is filled with a dry inert gas. The quartz plate oscillates in a fundamental thickness-shear mode and the resonance frequency is an almost linear function of the temperature.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT(1)
f_{nom}	nominal frequency	4000		25000	kHz
T_{oper}	operating temperature	−55	–	+125	°C
TC	temperature coefficient	−40	–	+80	ppm/K
LIN	linearity	–	±2.5	–	%
$\Delta f/f_{nom}$	adjustment tolerance	–	±150	–	ppm
τ_{th}	thermal time constant	–	10	–	s
m	mass	–	1.2	–	g

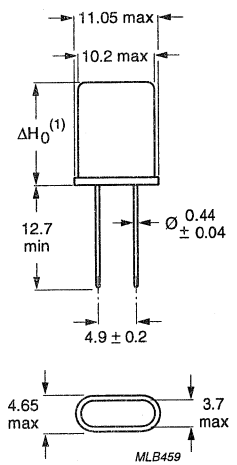
Note

1. All references to ppm = 10^{-6}.

Quartz temperature sensor HC-49/U 9922 520 6.... series

MECHANICAL DATA

Package outlines



Dimensions in mm.

This type is also available as a surface mounting device.

(1) For ΔH_0 see Table 1.

Fig.1 Style 1: HC-49/U in box.

Table 1 Component height; note 1.

MAXIMUM HEIGHT ΔH_0 (mm)	MINIMUM FREQUENCY (MHz)
Fundamental mode	
9.6	8
13.4	2.4

Note

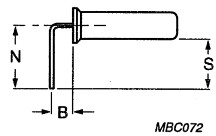
1. A plastic sleeve can be fitted around the case on request.

   Available lead length: up to 13 mm.

   Lead length tolerance:

   a) $H_2 > 3$ mm: ±0.5 mm

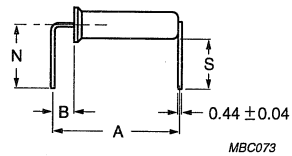
   b) $H_2 \leq 3$ mm: ±0.2 mm.



Dimensions in mm.

STYLE 4	N	B	S
a	7.0 ±0.6	2.5 ±0.6	5.2 ±0.6
b	8.0 ±0.6	2.0 ±0.6	6.2 ±0.6
c	9.7 ±0.6	3.0 ±0.6	7.9 ±0.6

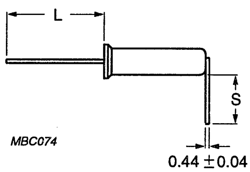
Fig.2 Style 4: HC-49/U in box.



Dimensions in mm.

STYLE 5	N	B	A	S
a	5.7 ±1.0	1.5	15.2 ±0.2	3.9 ±1.0
b	5.9 ±1.0	4.1	17.8 ±0.2	4.1 ±1.0
c	10.2 ±1.0	3.2	16.5 ±0.2	8.4 ±1.0
d	5.7 ±1.0	1.9	15.6 ±0.2	3.9 ±1.0

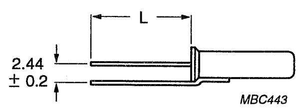
Fig.3 Style 5: HC-49/U in box.



Dimensions in mm.
Third lead is symmetric (±0.5 mm) with respect to other leads.

STYLE 6	L	S
a	13.2 ±0.5	4.5 ±1.0
b	13.2 ±0.5	10.0 ±1.0
c	5.0 ±0.5	19.5 ±1.0

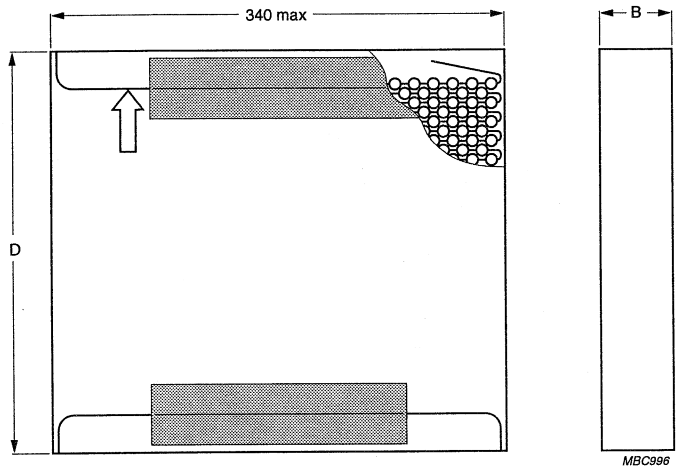
Fig.4 Style 6: HC-49/U in box.



Dimensions in mm.
L: min. 12.7 mm; max. 13.0 mm.

Fig.5 Style 7: HC-49/U in box.

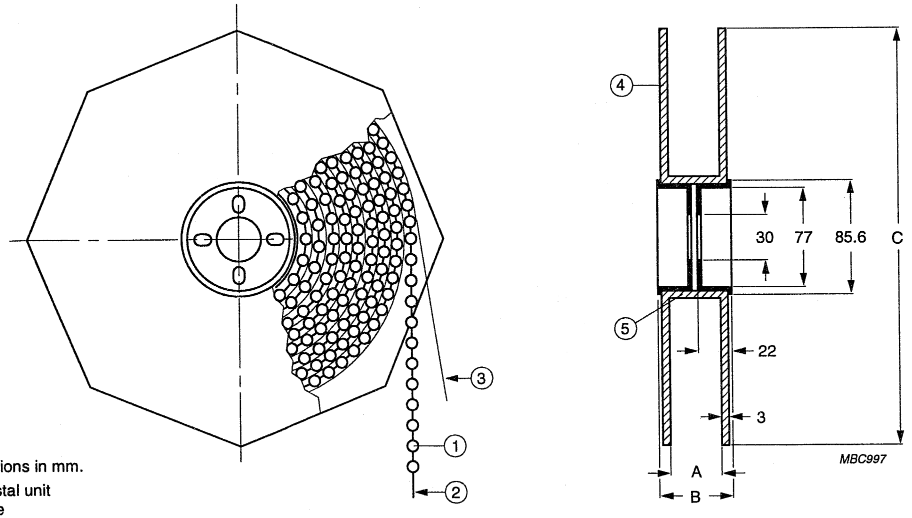
Tape and reel data



Dimensions in mm.
B = 46 mm max.
D = 185 mm max.

Style 3a is with insulation plate; see Fig.9.

Fig.6 Style 2a and 3a units on tape in ammopack.



Dimensions in mm.
1 = crystal unit
2 = tape
3 = paper
4 = flange
5 = cylinder

A = 45 mm
B = 55 mm max.
C = 355 mm max.

Style 3b is with insulation plate; see Fig.9.

Fig.7 Style 2b and 3b units on tape on reel.

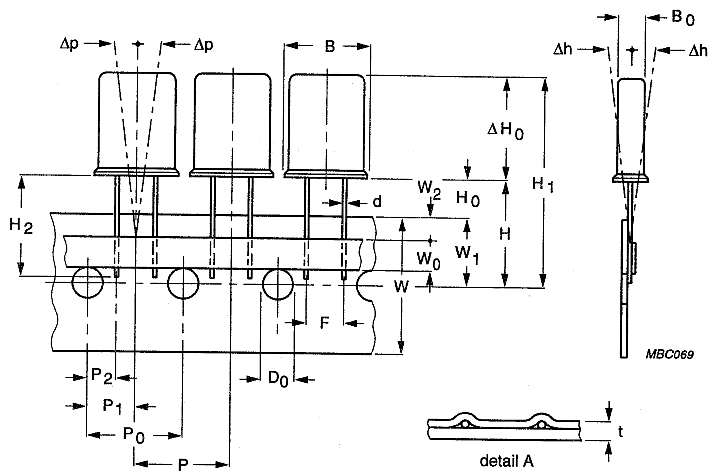


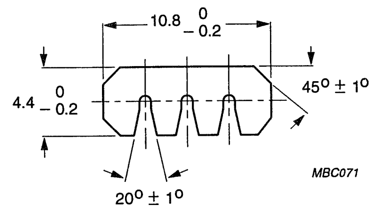
Fig.8 HC-49/U on tape.

Table 2 Taping dimensions (without the insulation plate) in accordance with IEC 286-2; see Fig.8.

SYMBOL	PARAMETER	VALUE	TOLERANCE	UNIT
B_0	body thickness	4.43	±0.05	mm
B	body width	10.75	±0.1	mm
Δh	component alignment vertical to tape plane	–	±2	mm
Δp	component alignment in tape plane	–	±1.3	mm
d	lead wire diameter	0.44	±0.04	mm
F	lead-to-lead	4.9	–	mm
P	pitch of components	12.7	±1	mm
P_0	feed-hole pitch	12.7	±0.3	mm
P_2	feed-hole centre to lead	3.9	±0.7	mm
P_1	feed-hole centre to component centre	6.35	±0.3	mm
D_0	feed-hole diameter	4.0	±0.2	mm
H	distance of component from tape centre	16.0	+2/0	mm
H_0	minimum component base to tape top	7.0	–	mm
H_2	lead length	13.2	±0.5	mm
W	carrier tape width	18.0	+1/–0.5	mm
W_0	maximum hold-down tape width	7.0	–	mm
W_1	feed-hole position	9.0	+0.75/–0.5	mm
W_2	maximum hold-down tape position	3.0	–	mm
t	maximum total tape thickness	0.9	–	mm

Insulation plate

Style 3 units are equipped with an insulation plate (see Fig.9) at the unit base. The insulation plate is made of PEEK (polyetherketone) in 0.25 mm thickness and resistant to soldering heat tests.



Dimensions in mm.

Fig.9 Insulation plate outline.

STANDARD MARKING(1)

- Line 1: PHILIPS
- Line 2: frequency in kHz (fundamental mode)
- Line 3: last five digits of catalogue number followed by the manufacturing date code (last four digits of week code in accordance with UN-D1120).

(1) Special marking on product and/or package is available on request.

MASS AND LEADS

Typical mass: 1.2 g.

The leads are finished with Sn99Cu1 on a nickel underplate.

The first 1 mm from the body is not guaranteed for soldering.

PACKAGING AND QUANTITIES

Table 3

STYLE	PACKAGING	QUANTITY
1	box	1000 units per box
2a and 3a	on tape in ammopack	1000 units per pack
2b and 3b	on tape on reel	1000 units per reel
4, 5, 6 and 7	box	1000 units per box

ELECTRICAL DATA

Measured at T_{amb} = 25 ±2 °C and a nominal drive level of 100 µW into 25 Ω unless otherwise specified. Measuring system: π-network in accordance with IEC 444 recommendations.

Table 4

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT(2)
f_{nom}	nominal frequency	fundamental	4.0	–	25.0	MHz
$\Delta f/f_{nom}$	adjustment tolerance		–	±150	–	ppm
T_{oper}	operating temperature		–55	–	+125	°C
T_{op}	operable temperature		–55	–	+155	°C
TC	temperature coefficient	note 1	–40	–	+80	ppm/K
LIN	linearity		–	±2.5	–	%
τ_{th}	thermal time constant		–	10	–	s

Notes

1. A specific value should be chosen within the given range.
2. All references to ppm = 10^{-6}.

SPECIFIC PRODUCT DATA

CATALOGUE NUMBER	f_{nom} (kHz)	TC (ppm/K)(1)	C_L (pF)	$\Delta f/f_{nom}$ (ppm)(1)	C_1 (fF)	C_0 (pF)	DRIVE LEVEL (µW)	OPERATING TEMP. RANGE (°C)	PACKAGE OUTLINE STYLE
9922 520 60001	16 000	–27.5 ±1%	–	±150	12.8	4.8	100	–10 to +40	1
9922 520 60002	6000	–27.5 ±1%	–	±150	13.6	5.4	100	–10 to +40	1

Note

1. All references to ppm = 10^{-6}.

Quartz temperature sensor HC-49/U

9922 520 6.... series

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with IEC publication 68-2, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"*. Ageing test is in accordance with IEC publication 679-1.

Table 5

IEC 68-2	TEST	PROCEDURE	REQUIREMENTS(1)
Ba	ageing	1 000 hours at 70 °C	$\Delta f/f \leq 10$ ppm
Db	accelerated damp heat	+25 to +55 °C; 6 cycles at RH >95%	$\Delta f/f \leq 10$ ppm
			ΔR_r ±5 Ω or ±50% whichever is the greater
Ea	shock	100 g; half sinewave; 6 directions; 1 blow/direction	$\Delta f/f \leq 10$ ppm
			ΔR_r ±5 Ω or ±50% whichever is the greater
Eb	bump	4 000 bumps of 40 g	$\Delta f/f \leq 10$ ppm
			ΔR_r ±5 Ω or ±50% whichever is the greater
Ed	free fall	3 times on hard wood; for height of fall (h) see Table 6	$\Delta f/f \leq 10$ ppm
			ΔR_r ±5 Ω or ±50% whichever is the greater
Fc	vibration	frequency 10 to 500 to 10 Hz; acceleration 10 g; 3 directions; 30 minutes/direction	$\Delta f/f \leq 10$ ppm
			ΔR_r ±5 Ω or ±50% whichever is the greater
Na	temperature cycling test	−40/+85 °C; 10 cycles; 0.1 hour/cycle	$\Delta f/f \leq 10$ ppm
			ΔR_r ±5 Ω or ±50% whichever is the greater
Q	sealing (method 1)	16 hours; 700 kPa He	$<10^{-8}$ ncc/s He
Ta	solderability	235 ±5 °C; 2 ±0.5 s; flux 600 (activated); optional steam pre-heat 8 hours. This reflects at least 36 months of storage at room conditions.	>90%, except for 1 mm from body; no visible damage, no leaks
Tb	resistance to soldering heat	350 ±5 °C; 3.5 ±0.5 s;	$\Delta f/f \leq 10$ ppm
			ΔR_r ±5 Ω or ±50% whichever is the greater
Ub	bending of terminations	1 × 90°; 5 N	no visible damage

Note

1. All references to ppm = 10^{-6}.

Table 6 Height of fall.

h (mm)	FREQUENCY RANGE (MHz)
Fundamental mode	
750	2.4 to 7.5
500	7.51 to 10.0
250	10.10 to 27.0

SOLVENT RESISTANCE TESTS

Procedure	In accordance with IEC 68-2-45 (XA) and IEC 653 (immersion time 5 minutes) as well as MIL 202 E215. At ambient temperature, and ultrasonic (40 kHz).
Solvents	Bio-Act EC7 Neutropon P3 and Saxin P3 Meta Clean 820 Lonco 446 Isopropanol cleaning solvent Dowanol DPM (glass crystals only)
Requirements	no degradation of marking

Quartz temperature sensor HC-45/U

9922 521 5.... series

FEATURES

- No A/D conversion
- Excellent linearity
- High stability, low ageing
- Wide temperature range
- High noise immunity
- Easy calibration
- Quantity production at low cost.

APPLICATIONS

- In industrial temperature measurement and control
- Car electronics
- Flow meters
- Weather balloons
- Medical systems
- Energy saving projects, for example:
  - heat monitors
  - solar panels.

DESCRIPTION

The sensor consists of a metal-plated special TC-cut piezoelectric quartz plate, mounted in a hermetically sealed resistance-welded metal holder, which has two leads and is filled with a dry inert gas. The quartz plate oscillates in a fundamental thickness-shear mode and the resonance frequency is an almost linear function of the temperature.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT(1)
f_{nom}	nominal frequency	8000		25000	kHz
T_{oper}	operating temperature	−55	–	+125	°C
TC	temperature coefficient	−40	–	+80	ppm/K
LIN	linearity	–	±2.5	–	%
$\Delta f/f_{nom}$	adjustment tolerance	–	±150	–	ppm
τ_{th}	thermal time constant	–	5	–	s
m	mass	–	0.4	–	g

Note

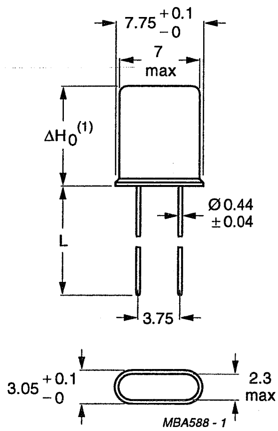
1. All references to ppm = 10^{-6}.

Quartz temperature sensor HC-45/U

9922 521 5.... series

MECHANICAL DATA

Package outlines



Dimensions in mm.

This type is also available as a surface mounting device.

(1) For ΔH_0 see Table 1.

Fig.1 Style 1: HC-45/U in box.

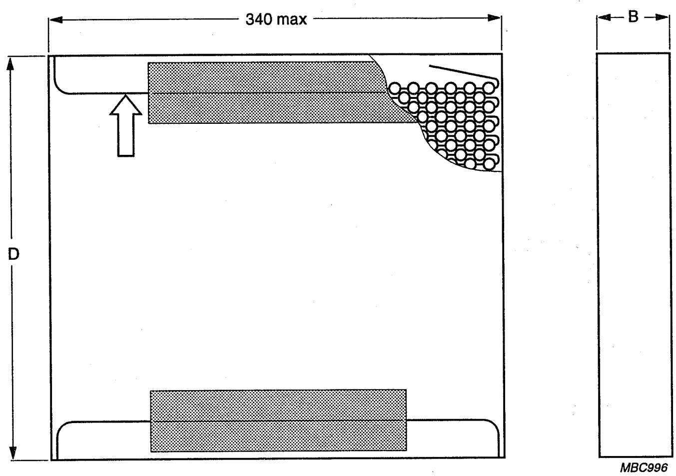
Table 1 Component height; note 1.

MAXIMUM HEIGHT ΔH_0 (mm)	MAXIMUM LEAD LENGTH L (mm)	MINIMUM FREQUENCY (MHz)
Fundamental mode		
8.8	13.2	8

Note

1. A plastic sleeve can be fitted around the case on request.

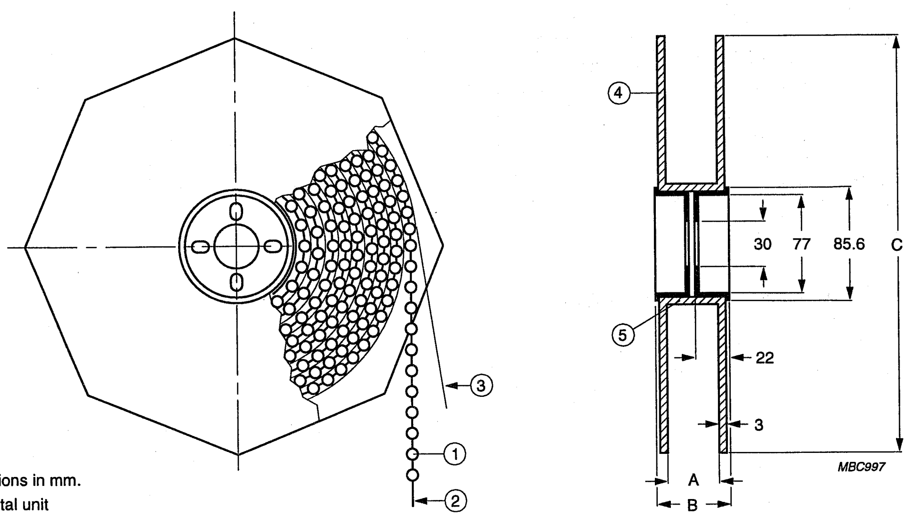
Tape and reel data



Dimensions in mm.
B = 46 mm max.
D = 185 mm max.

Style 3a is with insulation plate; see Fig.5.

Fig.2 Style 2a and 3a units on tape in ammopack.



Dimensions in mm.
1 = crystal unit
2 = tape
3 = paper
4 = flange
5 = cylinder

A = 45 mm
B = 55 mm max.
C = 355 mm max.

Style 3b is with insulation plate; see Fig.5.

Fig.3 Style 2b and 3b units on tape on reel.

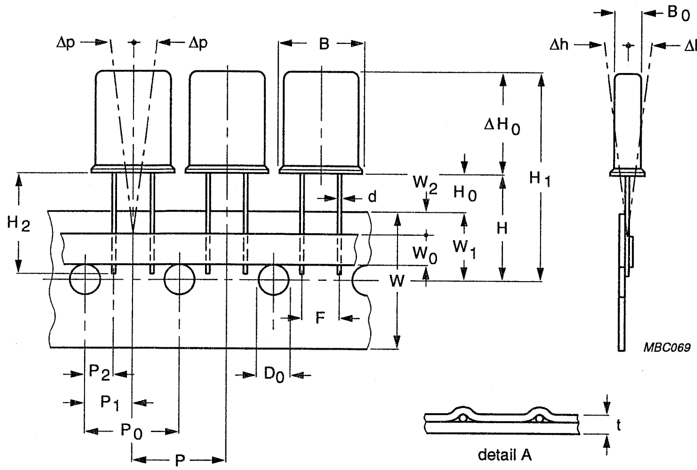


Fig.4 HC-49/U on tape.

Table 2 Taping dimensions (without the insulation plate) in accordance with IEC 286-2; see Fig.4.

SYMBOL	PARAMETER	VALUE	TOLERANCE	UNIT
B_0	body thickness	4.43	±0.05	mm
B	body width	10.75	±0.1	mm
Δh	component alignment vertical to tape plane	–	±2	mm
Δp	component alignment in tape plane	–	±1.3	mm
d	lead wire diameter	0.44	±0.04	mm
F	lead-to-lead	4.9	–	mm
P	pitch of components	12.7	±1	mm
P_0	feed-hole pitch	12.7	±0.3	mm
P_2	feed-hole centre to lead	4.47	±0.7	mm
P_1	feed-hole centre to component centre	6.35	±0.3	mm
D_0	feed-hole diameter	4.0	±0.2	mm
H	distance of component from tape centre	18.0	+2/0	mm
H_0	minimum component base to tape top	9.0	–	mm
H_2	lead length	20.0	±0.5	mm
W	carrier tape width	18.0	+1/–0.5	mm
W_0	maximum hold-down tape width	7.0	–	mm
W_1	feed-hole position	9.0	+0.75/–0.5	mm
W_2	maximum hold-down tape position	3.0	–	mm
t	maximum total tape thickness	0.9	–	mm

Insulation plate

Style 3 units are equipped with an insulation plate (see Fig.5) at the unit base. The insulation plate is made of PEEK (polyetherketone) in 0.25 mm thickness and resistant to soldering heat tests.

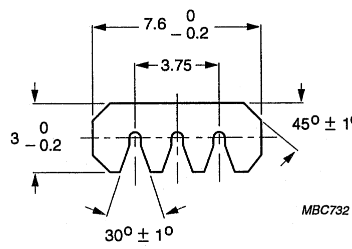


Fig.5 Insulation plate outline.

STANDARD MARKING

- Line 1: PHILIPS
- Line 2: frequency in kHz (fundamental mode)
- Line 3: last five digits of catalogue number followed by the manufacturing date code (last four digits of week code in accordance with UN-D1120).

MASS AND LEADS

Typical mass: 1.2 g.

The leads are finished with Sn99Cu1 on a nickel underplate.

The first 1 mm from the body is not guaranteed for soldering.

PACKAGING AND QUANTITIES

Table 3

STYLE	PACKAGING	QUANTITY
1	box	1000 units per box
2a and 3a	on tape in ammopack	1000 units per pack
2b and 3b	on tape on reel	1000 units per reel

ELECTRICAL DATA

Measured at T_{amb} = 25 ±2 °C and a nominal drive level of 100 μW into 25 Ω unless otherwise specified.
Measuring system: π-network in accordance with IEC 444 recommendations.

Table 4

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT(2)
f_{nom}	nominal frequency	fundamental	8.0	–	25.0	MHz
$\Delta f/f_{nom}$	adjustment tolerance		–	±150	–	ppm
T_{oper}	operating temperature		–55	–	+125	°C
T_{op}	operable temperature		–55	–	+155	°C
TC	temperature coefficient	note 1	–40	–	+80	ppm/K
LIN	linearity		–	±2.5	–	%
τ_{th}	thermal time constant		–	5	–	s

Notes

1. A specific value should be chosen within the given range.
2. All references to ppm = 10^{-6}.

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with IEC publication 68-2, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"*. Ageing test is in accordance with IEC publication 679-1.

Table 5

IEC 68-2	TEST	PROCEDURE	REQUIREMENTS(1)
Ba	ageing	1 000 hours at 70 °C	$\Delta f/f \leq 10$ ppm
Db	accelerated damp heat	+25 to +55 °C; 6 cycles at RH >95%	$\Delta f/f \leq 10$ ppm
			ΔR_r ±5 Ω or ±50% whichever is the greater
Ea	shock	100 g; half sinewave; 6 directions; 1 blow/direction	$\Delta f/f \leq 10$ ppm
			ΔR_r ±5 Ω or ±50% whichever is the greater
Eb	bump	4 000 bumps of 40 g	$\Delta f/f \leq 10$ ppm
			ΔR_r ±5 Ω or ±50% whichever is the greater
Ed	free fall	3 times on hard wood; for height of fall (h) see Table 6	$\Delta f/f \leq 10$ ppm
			ΔR_r ±5 Ω or ±50% whichever is the greater
Fc	vibration	frequency 10 to 500 to 10 Hz; acceleration 10 g; 3 directions; 30 minutes/direction	$\Delta f/f \leq 10$ ppm
			ΔR_r ±5 Ω or ±50% whichever is the greater
Na	temperature cycling test	−40/+85 °C; 10 cycles; 0.1 hour/cycle	$\Delta f/f \leq 10$ ppm
			ΔR_r ±5 Ω or ±50% whichever is the greater
Q	sealing (method 1)	16 hours; 700 kPa He	$<10^{-8}$ ncc/s He
Ta	solderability	235 ±5 °C; 2 ±0.5 s; flux 600 (activated); optional steam pre-heat 8 hours. This reflects at least 36 months of storage at room conditions.	>90%, except for 1 mm from body; no visible damage, no leaks
Tb	resistance to soldering heat	350 ±5 °C; 3.5 ±0.5 s;	$\Delta f/f \leq 10$ ppm
			ΔR_r ±5 Ω or ±50% whichever is the greater
Ub	bending of terminations	1 × 90°; 5 N	no visible damage

Note

1. All references to ppm = 10^{-6}.

Table 6 Height of fall.

h (mm)	FREQUENCY RANGE (MHz)
Fundamental mode	
750	8.0 to 16.0
500	16.1 to 24.0

SOLVENT RESISTANCE TESTS

Procedure	In accordance with IEC 68-2-45 (XA) and IEC 653 (immersion time 5 minutes) as well as MIL 202 E215. At ambient temperature, and ultrasonic (40 kHz).
Solvents	Bio-Act EC7 Neutropon P3 and Saxin P3 Meta Clean 820 Lonco 446 Isopropanol cleaning solvent Dowanol DPM (glass crystals only)
Requirements	no degradation of marking

Quartz temperature sensors HC-26/U and HC-29/U

9922 526 2.... series

FEATURES

- No A/D conversion
- Excellent linearity
- High stability, low ageing
- Wide temperature range
- High noise immunity
- Easy calibration.

APPLICATIONS

- Industrial temperature measurement and control
- Car electronics
- Flow meters
- Weather balloons
- Medical systems
- Energy saving products such as:
  - heat monitors
  - solar panels.

DESCRIPTION

The unit consists of a metal-plated special TC-cut piezoelectric quartz plate mounted in a high-vacuum all-glass holder. The holder is hermetically sealed and provided with connecting leads (HC-26/U) or pins (HC-29/U). The quartz plate oscillates in a fundamental thickness-shear mode and the resonance frequency is an almost linear function of the temperature.

QUICK REFERENCE DATA

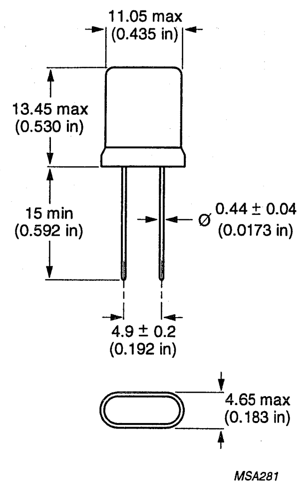
SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT(1)
f_{nom}	nominal frequency	5000	–	25000	kHz
T_{oper}	operating temperature	–100	–	+300	°C
TC	temperature coefficient	–50	–	+85	ppm/K
LIN	linearity	–	±1.5	–	%
$\Delta f/f_{nom}$	adjustment tolerance	–	±100	–	ppm
τ_{th}	thermal time constant	10	–	30	s
m	mass	–	0.8	–	g

Note

1. All references to ppm = 10^{-6}.

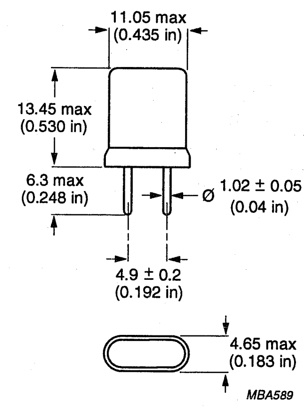
MECHANICAL DATA

Package outlines



Dimensions in mm.

Fig.1 Style 1: HC-26/U.



Dimensions in mm.

Fig.2 Style 2: HC-29/U.

STANDARD MARKING(1)

- Line 1: PHILIPS
- Line 2: Frequency in kHz (fundamental mode)
- Line 3: Last five digits of catalogue number followed by the manufacturing date code (last four digits of week code in accordance with UN-D1120).

(1) Special marking on product and/or package is available on request.

MASS

Typical: 0.8 g.

PACKAGING AND QUANTITIES

Crystal units are supplied in trays: 6 units per tray.

Quartz temperature sensors HC-26/U and HC-29/U

9922 526 2.... series

ELECTRICAL DATA

Measured at T_{amb} = 25 ±2 °C and a nominal drive level of 100 μW into 25 Ω unless otherwise specified. Measuring system: π-network in accordance with IEC 444 recommendations.

Table 1

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT(2)
f_{nom}	nominal frequency	fundamental	5.0	–	25.0	MHz
$\Delta f/f_{nom}$	adjustment tolerance		–	±100	–	ppm
T_{oper}	operating temperature		–100	–	+300	°C
T_{op}	operable temperature		–100	–	+300	°C
TC	temperature coefficient	note 1	–50	–	+85	ppm/K
LIN	linearity		–	±1.5	–	%
τ_{th}	thermal time constant		10	–	30	s

Notes

1. A specific value should be chosen within the given range.
2. All references to ppm = 10^{-6}.

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with IEC publication 68-2, *"Recommended basic climatic and mechanical robustness testing procedure for electronic components"*. Ageing test is in accordance with IEC publication 679-1.

Table 2

IEC 68-2	TEST	PROCEDURE	REQUIREMENTS(2)
Ba	ageing	1000 hours at 70 °C	$\Delta f/f \leq \pm 6$ ppm
			$\Delta f/f$ typical ±2 ppm
Db	accelerated damp heat	+25 to +55 °C; 6 cycles at RH >95%	$\Delta f/f \leq \pm 6$ ppm
			ΔR_r ±5 Ω or ±30% whichever is the greater
Ea	shock; note 1	100 g; half sinewave; 6 directions; 1 blow/direction	$\Delta f/f \leq \pm 6$ ppm
			ΔR_r ±5 Ω or ±30% whichever is the greater
Fc	vibration; note 1	frequency 10 to 500 to 10 Hz; acceleration 20 g; 3 directions; 30 minutes/direction	$\Delta f/f \leq \pm 6$ ppm
			ΔR_r ±5 Ω or ±30% whichever is the greater
Na	temperature cycling test	−40/+85 °C; 10 cycles; 2 hours/cycle	$\Delta f/f \leq \pm 6$ ppm
			ΔR_r ±5 Ω or ±30% whichever is the greater
Q	sealing (method 1)	16 hours; 700 kPa He	<10^{-8} ncc/s He
Ta	solderability	235 ±5 °C; 2 ±0.5 s; flux 600 (activated)	>90%, except for 1 mm from body; no visible damage, no leaks
Tb	resistance to soldering heat	350 ±5 °C; 3.5 ±0.5 s;	$\Delta f/f \leq \pm 6$ ppm
			ΔR_r ±5 Ω or ±30% whichever is the greater
Ub	bending of terminations	1 × 90°; 5 N	no visible damage

Notes

1. Mechanical tests to be performed on units clamped to a printed-circuit board (PCB) for the total unit height.
2. All references to ppm = 10^{-6}.

SOLVENT RESISTANCE TESTS

Procedure	In accordance with IEC 68-2-45 (XA) and IEC 653 (immersion time 5 minutes) as well as MIL 202 E215. At ambient temperature, and ultrasonic (40 kHz).
Solvents	Bio-Act EC7 Neutropon P3 and Saxin P3 Meta Clean 820 Lonco 446 Isopropanol cleaning solvent Dowanol DPM (glass crystals only)
Requirements	no degradation of marking

QUARTZ THICKNESS SENSOR

Quartz thickness sensor elements | 9922 529 8.... series

FEATURES

- Good linearity
- Low resonance resistance
- Low temperature coefficient of frequency
- Packed in an easy-to-use dispenser of 10 elements.

APPLICATIONS

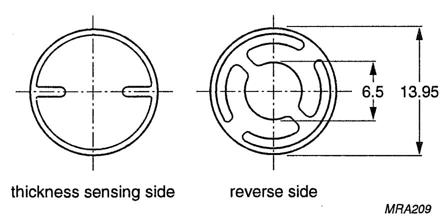
- These sensors can be used in vacuum deposition systems for accurate monitoring of the amount of deposited material.

DESCRIPTION

The sensor consists of a metal-plated special TC-cut piezoelectric quartz blank without encapsulation. Operating in a thickness-shear mode, this sensor acts as a very sensitive microbalance and the design is such that it will fit into many commercially available quartz thickness monitors.

Electrode material is silver (other materials on request).

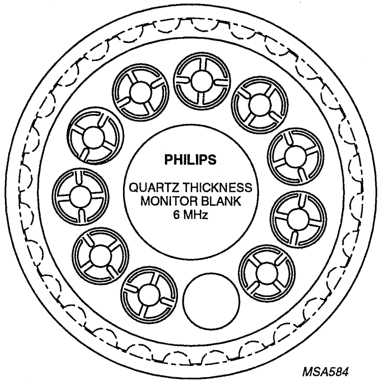
MECHANICAL DATA



Dimensions in mm.

Fig.1 Quartz thickness sensor outline.

PACKAGING



One product has been drawn out of centre to indicate that it can move in the packaging.

Fig.2 Packaging outline.

ORDERING INFORMATION

Specification of quartz thickness sensor elements.

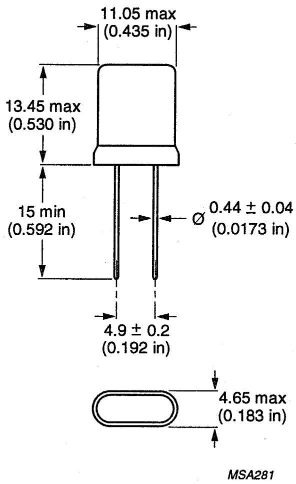
RESONANCE FREQUENCY (kHz)	MAXIMUM RESONANCE RESISTANCE (Ω)	CATALOGUE NUMBER
5000 ±10	50	9922 529 80001
6000 ±10	50	9922 529 80002

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
f_{nom}	nominal frequency				
	fundamental mode	4000	–	9500	kHz
TC	typical temperature coefficient over +25 to +75 °C	–	±0.0025	–	%
m	mass	–	0.1	–	g

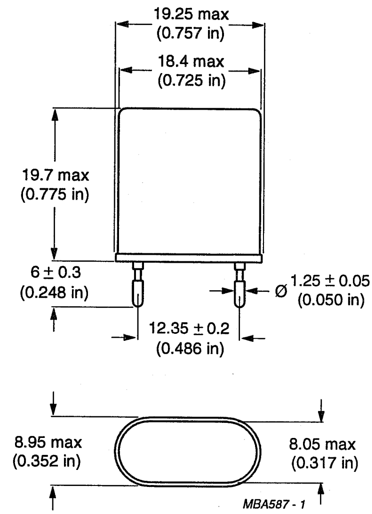
MECHANICAL DATA

MECHANICAL DATA



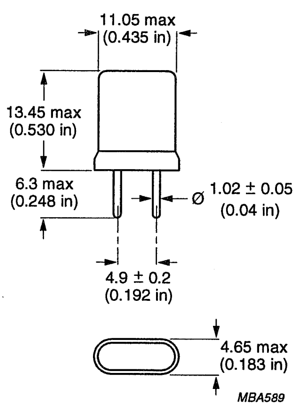
Dimensions in mm.

Fig.1 Style 1: HC-26/U.



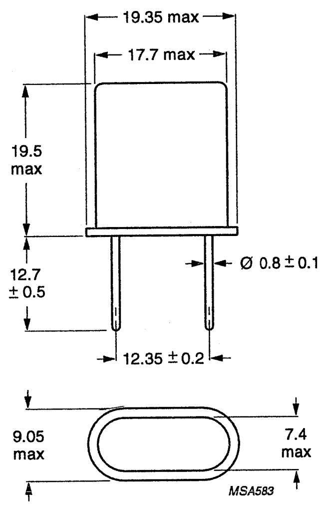
IEC type DB is identical except for the height which is: 26 mm max.
Dimensions in mm.

Fig.2 HC-27/U.



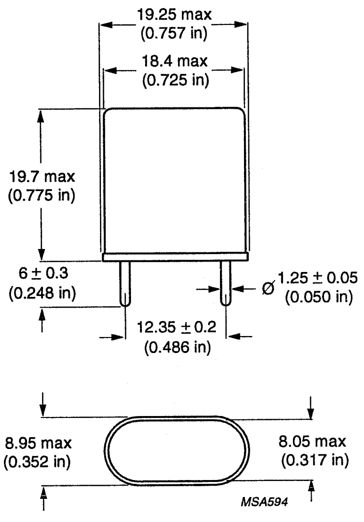
Dimensions in mm.

Fig.3 Style 2: HC-29/U.



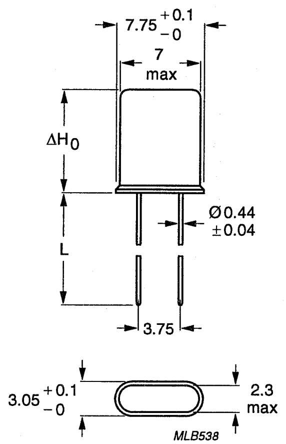
Dimensions in mm.

Fig.4 HC-33/U resistance welded.



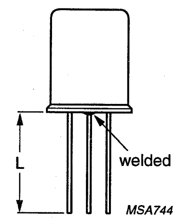
Dimensions in mm.

Fig.5 HC-36/U resistance welded.



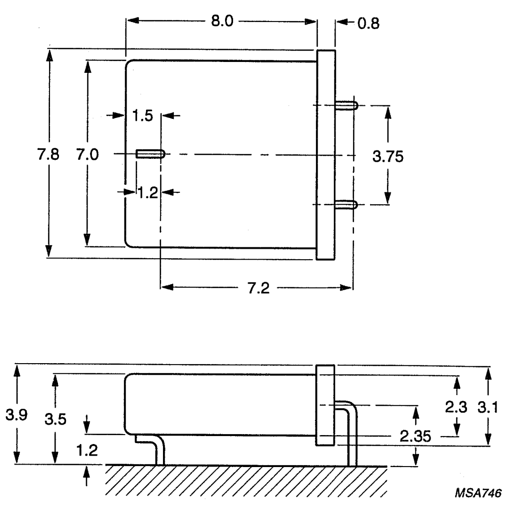
Dimensions in mm.

Fig.6 Style 1: HC-45/U in box.



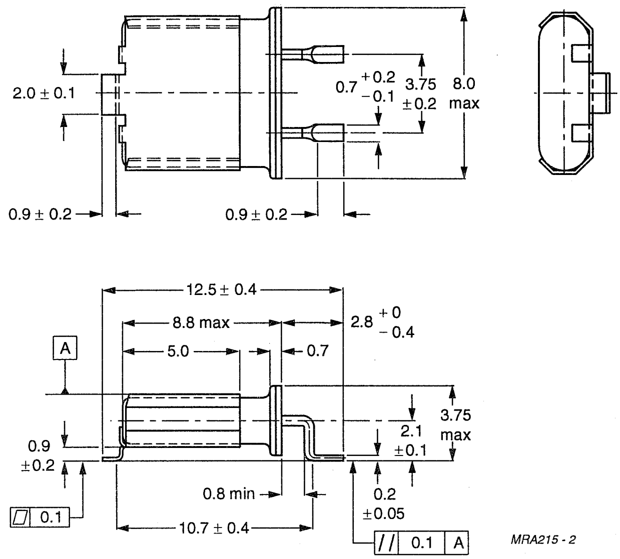
L: min. 12.7 mm; max. 13.0 mm.

Fig.7 Style 4: HC-45/U in box.



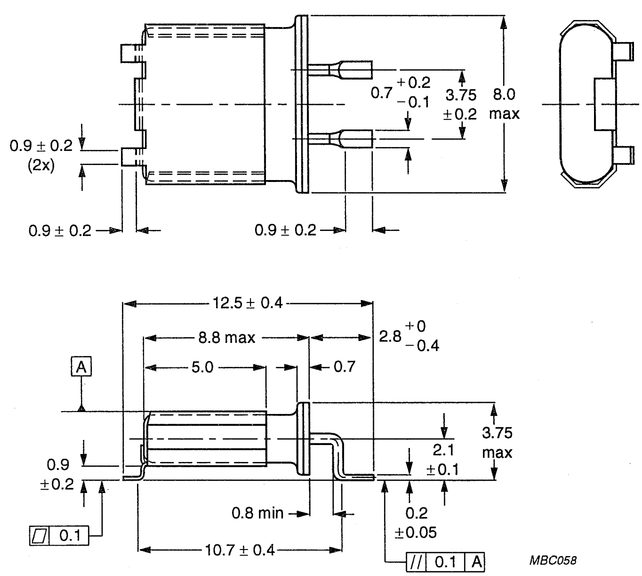
Dimensions in mm.

Fig.8 Style 5: HC-45/U in box.



Dimensions in mm.

Fig.9 Style 3: HC-45/U12-SMD/Clip I, Catalogue number 9922 522 7....



Dimensions in mm.

Fig.10 Style 4: HC-45/U12-SMD/Clip II, Catalogue number 9922 522 7....

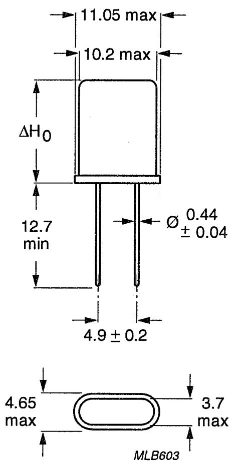
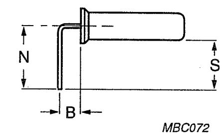


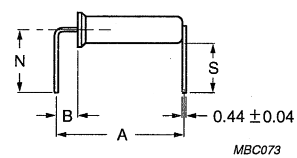
Fig.11 Style 1: HC-49/U in box.



Dimensions in mm.

STYLE 4	N	B	S
a	7.0 ±0.6	2.5 ±0.6	5.2 ±0.6
b	8.0 ±0.6	2.0 ±0.6	6.2 ±0.6
c	9.7 ±0.6	3.0 ±0.6	7.9 ±0.6

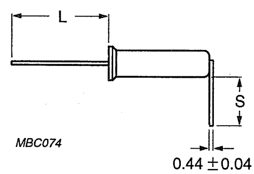
Fig.12 Style 4: HC-49/U in box.



Dimensions in mm.

STYLE 5	N	B	A	S
a	5.7 ±1.0	1.5	15.2 ±0.2	3.9 ±1.0
b	5.9 ±1.0	4.1	17.8 ±0.2	4.1 ±1.0
c	10.2 ±1.0	3.2	16.5 ±0.2	8.4 ±1.0

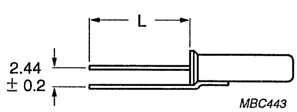
Fig.13 Style 5: HC-49/U in box.



Dimensions in mm.

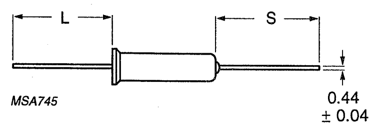
STYLE 6	L	S
a	13.2 ±0.5	4.5 ±1.0
b	13.2 ±0.5	10.0 ±1.0
c	5.0 ±0.5	19.5 ±1.0

Fig.14 Style 6: HC-49/U in box.



L: min. 12.7 mm; max. 13.0 mm.
Dimensions in mm.

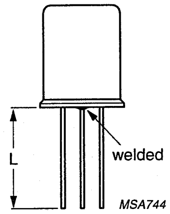
Fig.15 Style 7: HC-49/U in box.



Dimensions in mm.

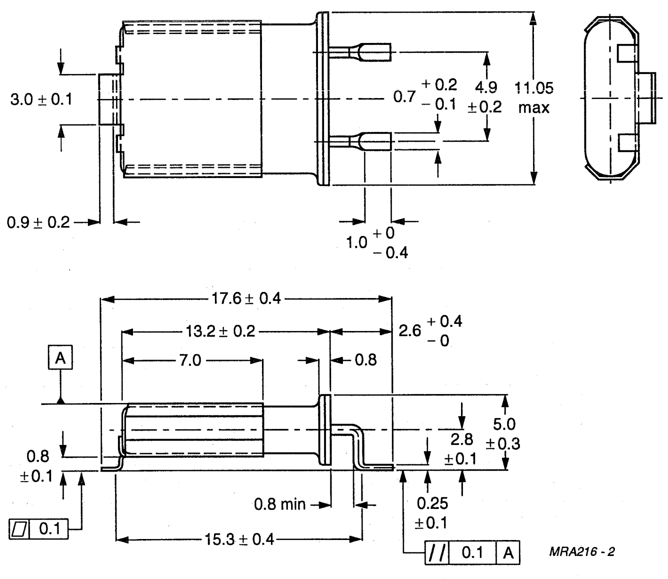
STYLE 8	L	S
a	13.2 ±0.5	16.0 ±1.0
b	5.0 ±0.5	16.0 ±1.0

Fig.16 Style 8: HC-49/U in box.



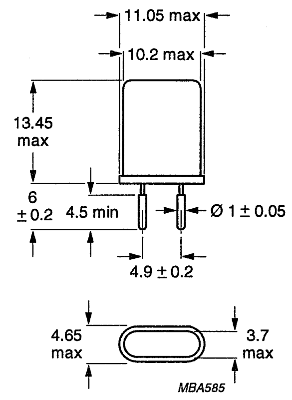
L: min. 12.7 mm; max. 13.0 mm.

Fig.17 Style 9: HC-49/U in box.



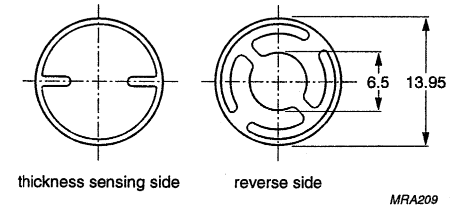
Dimensions in mm.

Fig.18 Style 1: HC-49/U17-SMD.



Dimensions in mm.

Fig.19 Style 10: HC-50/U in box.



Dimensions in mm.

Fig.20 Quartz thickness sensor outline.

CROSS REFERENCE OF HOLDER TYPES

Corresponding IEC, DIN and MIL type numbers.

HOLDER TYPE	IEC 122-3	DIN 45110	MIL 3098	OTHERS(1)
HC-6/U	AA	K1A	HC-6/U	–
HC-26/U	CY	R2A	HC-26/U	–
HC-27/U	DA	Q1A	HC-27/U	–
HC-27/U, extended	DB	Q1B	HC-28/U	–
HC-29/U	CZ	R1A	HC-29/U	–
HC-33/U	DZ	K6B	HC-51/U	–
HC-45/U	EB; EK	N4B	HC-52/U	UM-1
HC-49/U9	–	–	–	–
HC-49/U11	EH	M4B	HC-49/U	HC-43/U
HC-49/U13	DP	M4C	HC-49/U	HC-18U
HC-50/U13	DQ	M3C	HC-42/U	–
RW-36	DN	K3A	HC-48/U	HC-36/U
RW-10	DS	K4A	–	–

Note

1. Corresponding numbers may have different sealing techniques.

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Data handbook system

DATA HANDBOOK SYSTEM

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Book	*Title*
DC01	Colour Display Components Colour TV Picture Tubes and Assemblies Colour Monitor Tube Assemblies
DC02	Monochrome Monitor Tubes and Deflection Units
DC03	Television Tuners, Coaxial Aerial Input Assemblies
DC05	Flyback Transformers, Mains Transformers and General-purpose FXC Assemblies

magnetic products

MA01	Soft Ferrites
MA03	Piezoelectric Ceramics and Specialty Ferrites
MA04	Dry-reed Switches

Passive components

PA01	Electrolytic Capacitors
PA02	Varistors, Thermistors and Sensors
PA03	Potentiometers and Switches
PA04	Variable Capacitors
PA05	Film Capacitors
PA06	Ceramic Capacitors
PA07	Quartz Crystals for Special and Industrial Applications
PA08	Fixed Resistors
PA10	Quartz Crystals for Automotive and Standard Applications
PA11	Quartz Oscillators

professional components

PC04	Photo Multipliers
PC05	Plumbicon Camera Tubes and Accessories
PC07	Vidicon and Newvicon Camera Tubes and Deflection Units
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IC03	Semiconductors for Telecom Systems
IC04	CMOS HE4000B Logic Family
IC05	Advanced Low-power Schottky (ALS) Logic Series
IC06	High-speed CMOS Logic Family
IC08	100K ECL Logic Family
IC10	Memories
IC11	General-purpose/Linear ICs
IC12	Display Drivers and Microcontroller Peripherals (planned)
IC13	Programmable Logic Devices (PLD)
IC14	8048-based 8-bit Microcontrollers
IC15	FAST TTL Logic Series
IC16	ICs for Clocks and Watches
IC17	RF/Wireless Communications
IC18	Semiconductors for In-car Electronics and General Industrial Applications (planned)
IC19	Semiconductors for Datacom: LANs, UARTs, Multi-protocol Controllers and Fibre Optics
IC20	8051-based 8-bit Microcontrollers
IC21	68000-based 16-bit Microcontrollers (planned)
IC22	ICs for Multi-Media Systems (planned)
IC23	QUBIC Advanced BiCMOS Interface Logic ABT, MULTIBYTE™
IC24	Low Voltage Logic

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SC02	Power Diodes
SC03	Thyristors and Triacs
SC04	Small-signal Transistors
SC05	Low-frequency Power Transistors and Hybrid IC Power Modules
SC06	High-voltage and Switching NPN Power Transistors
SC07	Small-signal Field-effect Transistors
SC08a	RF Power Bipolar Transistors
SC08b	RF Power MOS Transistors

Discrete semiconductors (continued)

SC09	RF Power Modules
SC10	Surface Mounted Semiconductors
SC13	PowerMOS Transistors including TOPFETs and IGBTs
SC14	RF Wideband Transistors, Video Transistors and Modules
SC15	Microwave Transistors
SC16	Wideband Hybrid IC Modules
SC17	Semiconductor Sensors

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