DATA HANDBOOK

Quartz Crystals for Automotive and Standard Applications

BOOK PA10 1992

Philips Components

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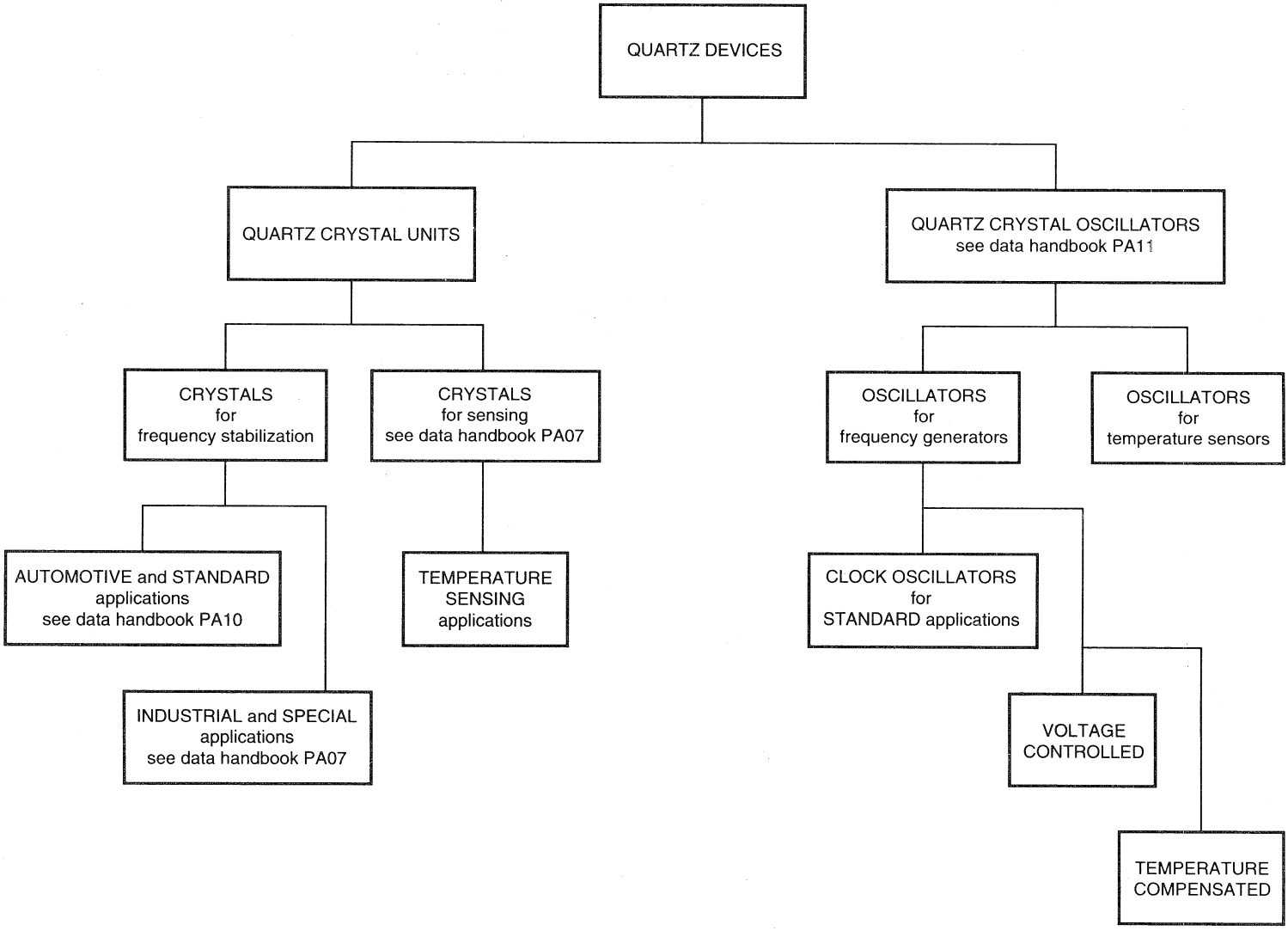

QUARTZ DEVICES
QUARTZ CRYSTAL UNITS
QUARTZ CRYSTAL OSCILLATORS
see data handbook PA11
CRYSTALS
for
frequency stabilization
CRYSTALS
for sensing
see data handbook PA07
OSCILLATORS
for
frequency generators
OSCILLATORS
for
temperature sensors
AUTOMOTIVE and STANDARD
applications
see data handbook PA10
TEMPERATURE
SENSING
applications
CLOCK OSCILLATORS
for
STANDARD applications
INDUSTRIAL and SPECIAL
applications
see data handbook PA07
VOLTAGE
CONTROLLED
TEMPERATURE
COMPENSATED

MLA357 - 1

Quartz crystals for Automotive and Standard applications

Contents

Quartz crystals for Automotive and Standard applications

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.
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

Quartz crystals for Automotive and Standard applications

General Introduction

INTRODUCTION

For practical reasons, technical information on piezoelectric quartz devices is separated into three parts:

PA07 - Quartz crystals for industrial and special 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.

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 optimised 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.

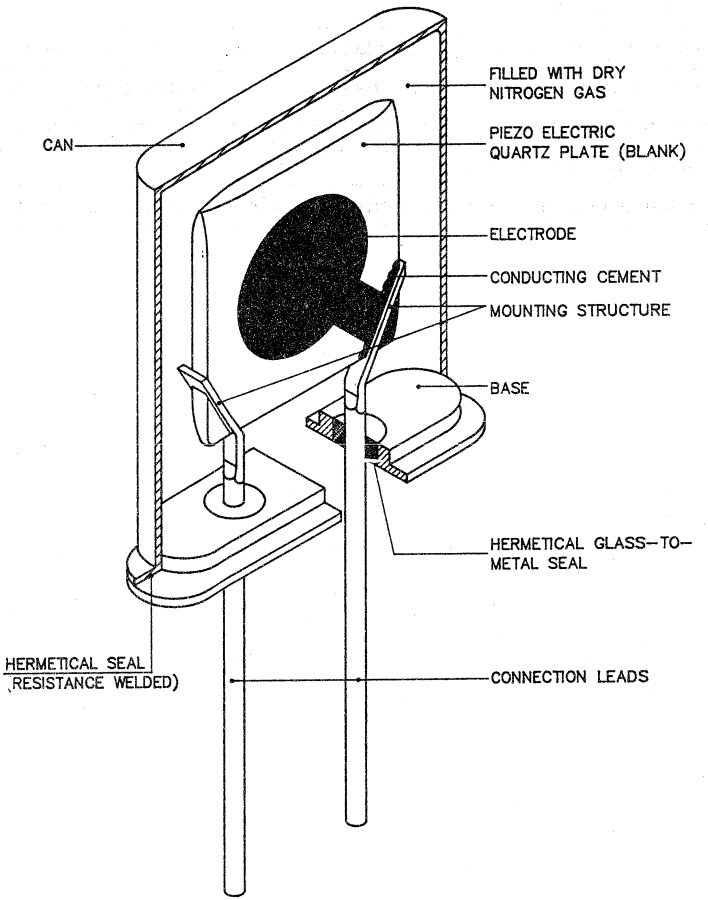


Fig.1 Section of a quartz crystal unit.

SELECTION GUIDE

HOLDER TYPE	FREQUENCY RANGE (MHz)	MODE OF VIBRATION	PAGE
HC-49/U-SMD	2.4 to 27.0	fundamental	19
HC-49/U-SMD	20.0 to 75.0	third overtone	19
Automotive and high reliability			
HC-49/U13	2.4 to 27.0	fundamental	27
HC-49/U13	20.0 to 75.0	third overtone	27
HC-45/U	8.0 to 24.0	fundamental	39
HC-45/U	24.0 to 70.0	third overtone	39
HC-45/U-SMD	8.0 to 24.0	fundamental	49
HC-45/U-SMD	24.0 to 70.0	third overtone	49
Standard			
HC-49/U13	2.4 to 27.0	fundamental	59
HC-49/U13	20.0 to 75.0	third overtone	59
HC-49/U9	9.0 to 27.0	fundamental	75
HC-49/U9	24.0 to 75.0	third overtone	75
HC-45/U	8.0 to 24.0	fundamental	85
HC-45/U	24.0 to 70.0	third overtone	85

INDEX OF CATALOGUE NUMBERS

CATALOGUE NUMBER	HOLDER TYPE	PAGE
9922 524	HC-49/U-SMD	19
Automotive and high reliability		
9922 520 4....	HC-49/U13	27
9922 521 2....	HC-45/U	39
9922 522 2....	HC-45/U-SMD	49
9922 522 6....	HC-45/U-SMD	49
Standard		
9922 520 0....	HC-49/U13	59
9922 520 3....	HC-49/U13	59
9922 520 1....	HC-49/U9	75
9922 521 0....	HC-45/U	85

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

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

Operable temperature range

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 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).

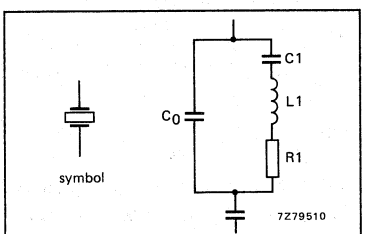


Fig.2 Quartz crystal equivalent circuit.

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 3 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) two second 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). (see below)

$$\Delta f = f_L - f_r$$

with f_L from equation (4) and f_r from equation (1) (6)

$$\Delta f = \tfrac{1}{2} f_r \frac{C_1}{C_0 + C_L} - \frac{\Delta f^2}{2 f_R}$$

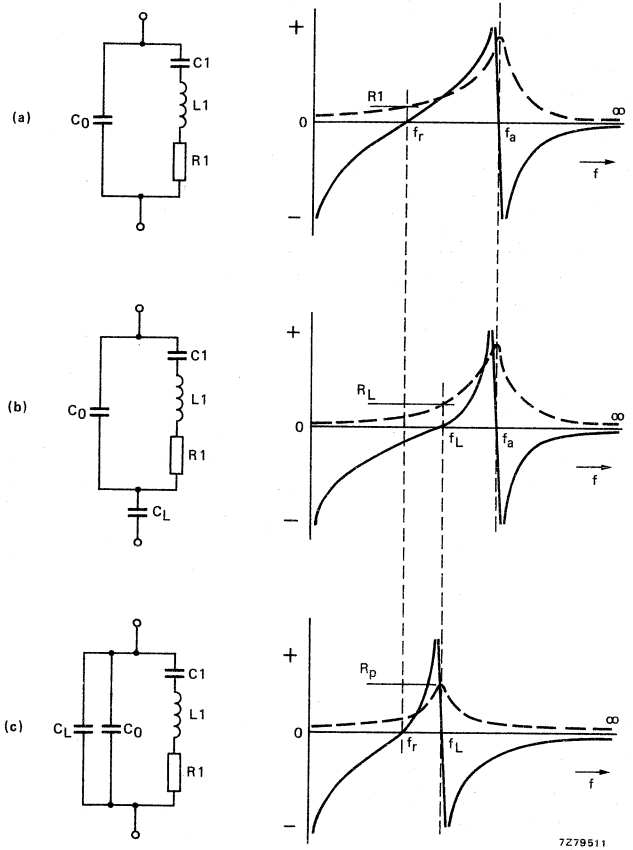
and to a close approximation (7)

$$\Delta f = \tfrac{1}{2} f_r \frac{C_1}{C_0 + C_L} \quad (8)$$

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:

$$R_{Lpar} = \frac{1}{R_1 . \omega_p{}^2 (C_0 + C_L)^2}$$



_____reactance
--------resistance

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)

$$S = \frac{1}{f_L}\frac{\delta f}{\delta C_L} = +\frac{1}{f_L}\cdot\frac{\delta \Delta f}{\delta C_L}$$

with Δf from equation (8)

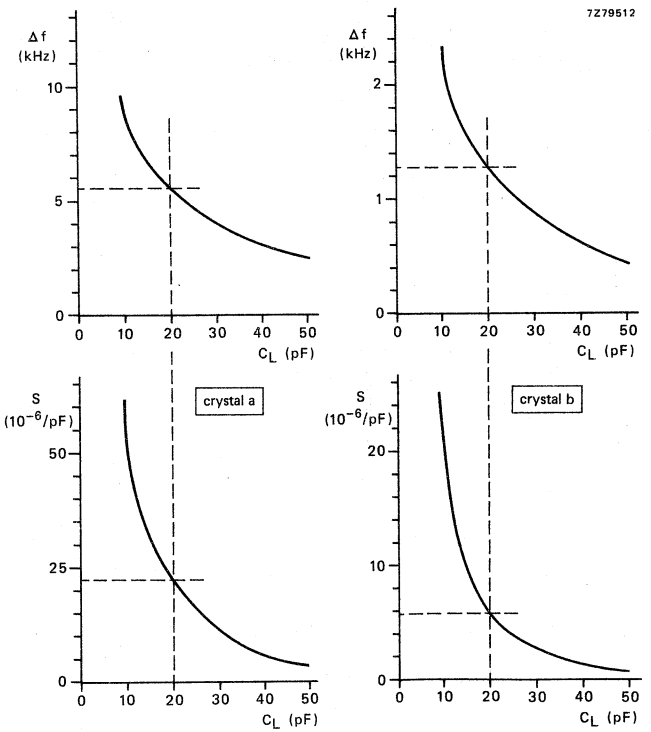
$$S = -\frac{1}{2} f_r \frac{C1}{(C_0 + C_L)^2}\cdot\frac{1}{f_L}$$

and to a close approximation

$$S = -\frac{C1}{2(C_0 + C_1)^2}$$

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 x 10^{-6}.

QUARTZ CRYSTAL (a)	QUARTZ CRYSTAL (b)
f_r = 9994.400 kHz	f_r = 9998.727 kHz
C_0 = 5 pF	C_0 = 2 pF
C_1 = 28 fF	C_1 = 5.6 fF
C_L = 20 pF	C_L = 20 pF
f_L = 10 000.000 kHz	f_L = 10 000.000 kHz
S = -22.4×10^{-6} pF	S = -5.79×10^{-6} pF



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.

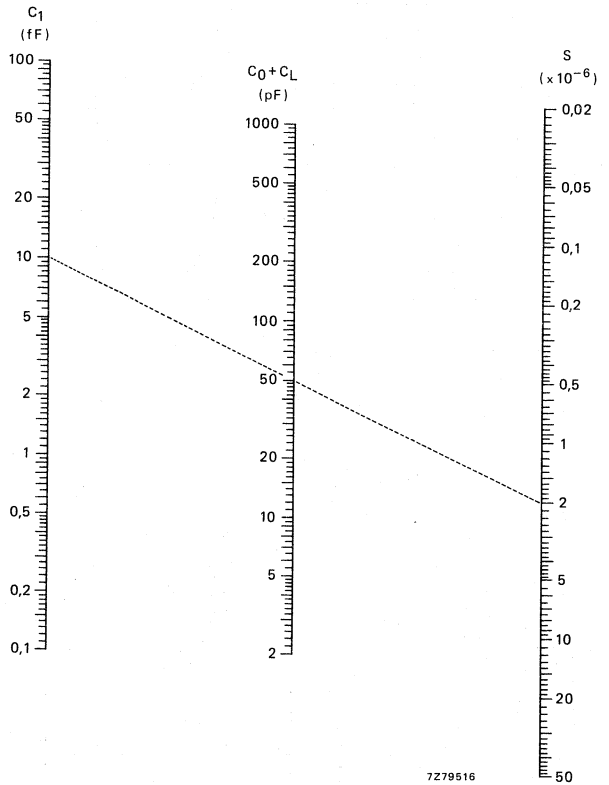


Fig.5 Nomogram enabling the determination of pulling sensitivity (S).

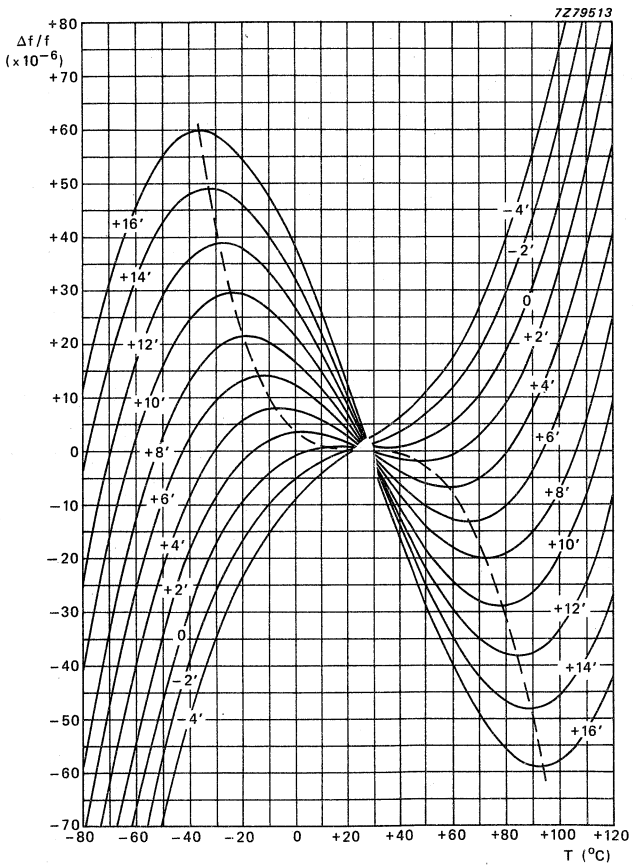


Fig.6 Examples of frequency/temperature characteristics of AT-cuts as a function of the cutting angle.

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 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 0.5 mW should be used. Drive levels exceeding 0.5 mW 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 - 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:

(a) a lower ageing rate
(b) a lower series resistance, which also means a higher Q-factor, due to the fact that glass holders are evacuated giving less mechanical damping
(c) better performance under adverse climatic conditions
(d) 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):

(a) Quartz crystals with an all-glass holder have a lower ageing rate.
(b) Low frequency crystals are preferred to high frequency crystals.
(c) 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:

$$X_0 = \frac{1}{2\pi f_r C_0}$$

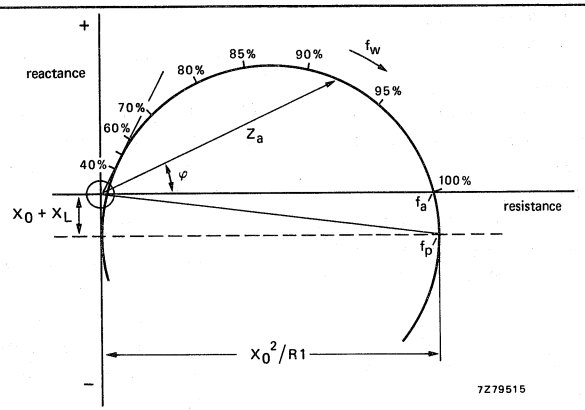
When a load capacitance is connected in series with the quartz crystal the shift is $X_0 + X_L$, where

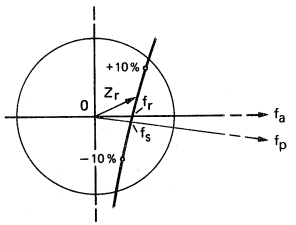
$$X_L = \frac{1}{2\pi f_L C_L}$$

The difference between anti-resonance frequency and resonance frequency

$f_a - f_r \approx \frac{C_1}{2C_0} \cdot f_r \cdot \frac{C_L}{C_0 + C_L}$ is assumed to be 100%.

It can be seen that the difference between the two frequencies, determined by the phase angle ∂, disappears at f_w = 50%. The phase angle in the oscillator should be kept sufficiently small to avoid quartz





Enlarged area around the zero point.

f_a = anti-resonance frequency

f_r = resonance frequency

f_s = series resonance frequency

f_W = working frequency

Z_r = impedance at working frequency

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

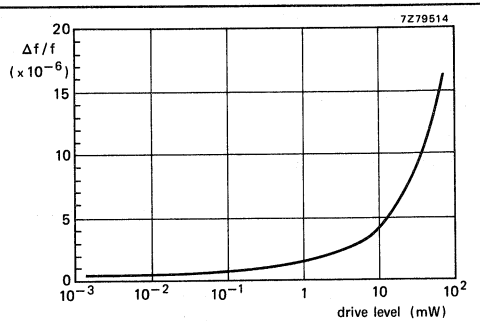


Fig.8 Quartz crystal drive level.

crystal operation in the uncertain 50% area (frequency switching).

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

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

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 ≤ 0.5 mW), see Fig.8.

MEASURING PROCEDURES

Several methods of measuring quartz crystals are in use. Because different methods may give differing results, refer to 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)

The principle of this method is very simple. With the equipment shown in the block diagram (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.

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.

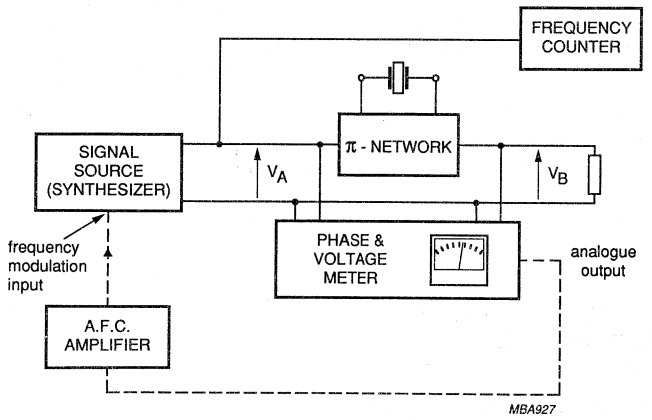


Fig.9 Test equipment block diagram.

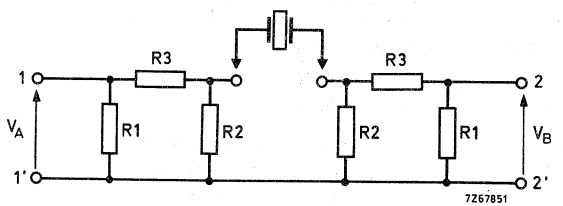


Fig.10 Test jig.

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

(a) to match the crystal impedance to the associated equipment,

(b) to attenuate reflections from the associated equipment.

For further particulars 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 RW 42) 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 shockwaves in the leads.
- If bending of the leads is necessary e.g. in the case 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 tests and requirements). 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 $+80 \cdot 10^{-6}$ /K, depending on the cutting angle. There are several ways of processing this signal, as shown in Figs 11 to 14.
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.

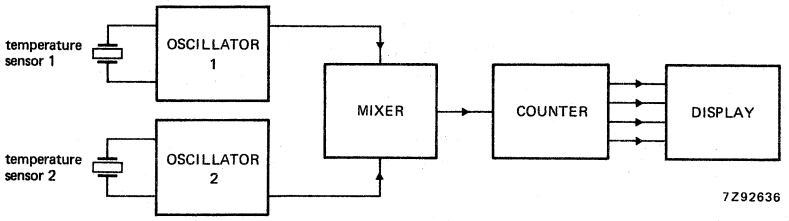


Fig.11 Typical temperature sensor.

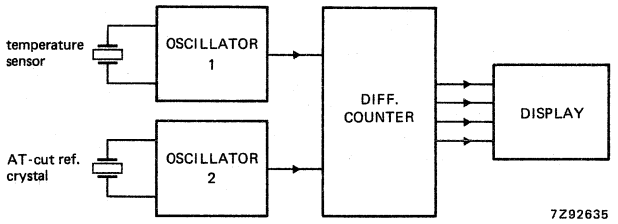


Fig.12 Typical temperature sensor.

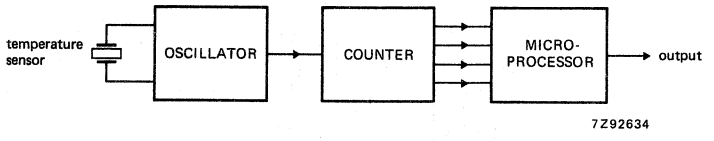


Fig.13 Typical temperature sensor.

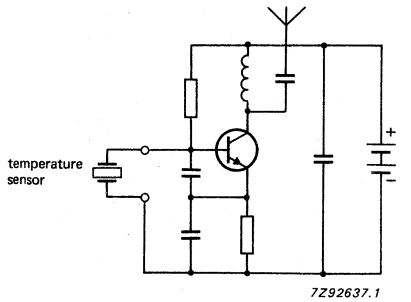


Fig.14 Miniature wireless temperature sensor.

How to specify a quartz crystal unit

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) : _____ °C to _____ °C

Frequency tolerances :

adjustment	± : _____	$\times 10^{-6}$ (at 25 °C)
temperature stability	± : _____	$\times 10^{-6}$
additional offset	± : _____	$\times 10^{-6}$ (if required)
total tolerance	± : _____	$\times 10^{-6}$ from _____ to _____ °C
ageing	± : _____	$\times 10^{-6}$

Max. resonance resistance (R_r) : _____ Ω (over temp. range)

Level of drive : _____ mW

(method of measurement acc. to IEC-444 related to 25 Ω)

Equivalent parameters C_0 : _____ pF

C_1 : _____ fF

L_1 : _____ mH

Additional data :

9922 524 series — Quartz crystals in HC-49/U-SMD

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 two 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. These units are mass produced on an automated production line which guarantees a very high level of uniformity and reliability.

Note: Special types are available on request.

STANDARD MARKING

- PHILIPS (PH)
- Frequency
- Last five digits of catalogue number; manufacturing date code (last three digits of week code).

QUICK REFERENCE DATA

Mass, typical value	1.2 g
Frequency range fundamental mode third overtone	 2400 to 27 000 kHz 20 000 to 75 000 kHz

FAMILY DATA

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
T_{op}	operable temperature range	–40	155	°C
R_{ins}	insulation resistance DC test voltage = 100 V	500	–	MΩ

PACKING

HC-49/U-SMD holder.

STYLE	PACKAGING	QUANTITY
style 1 unit	boxes	700 pieces per box
	blister taped on reel	700 pieces per reel
style 2 unit	boxes	700 pieces per box
	blister taped on reel	700 pieces per reel

CHARACTERISTICS PER CRYSTAL: FUNDAMENTAL MODE

Measured at +25 ±2 °C at a drive level of 0.5 mW into 25 Ω unless otherwise specified. Measuring system: π-network in accordance with IEC 444. For some crystals, the old numbering series (4322 143) may still apply, see characteristics table.

CATALOGUE NUMBER	f_n (kHz)	C_L (pF)	T_o (°C)	$\Delta f/f_n$ ($\times 10^{-6}$)	$\Delta f/f_{25}$ ($\times 10^{-6}$)	R_{rT} (Ω)	R_{r25} (Ω)	R_{dld} (Ω)	C_1 (fF)	C_0 (pF)	WL (mm)
Development types											
9922 524 00001	3 840.000	20	–25/+85	±20	±30L	100	100L	80	6.0	1.5	TB
9922 524 00002	4 032.000	20	–25/+85	±20	±25L	100	100L	80	6.0	1.5	TB
9922 524 00003	4 194.300	12	–20/+85	±25	±30	70	35	70	12.0	2.6	TB
9922 524 00004	4 433.619	20	–25/+85	±20	±100L	100	100L	70	6.0	1.8	TB
9922 524 00005	15 710.300	20	–30/+90	±10	±11L	25	25L	50	25.0	5.5	TB
9922 524 00006	8 000.000	20	–20/+70	±40	±25	60	35	50	21.0	5.0	TB
9922 524 60003	1 300.000	12	–30/+85	±15	±20	25	25	40	20.0	<5.5	TB

Key to symbols

f_n Nominal frequency

T_o Operating temperature range

$\Delta f/f_n$ Adjustment tolerance at 25 °C

$\Delta f/f_{25}$ Frequency stability over temperature range, with respect to the frequency at 25 °C

C_L Load capacitance

R_{rT} Resonance resistance over the operating temperature range, maximum value, measured in series resonance

R_{r25} Resonance resistance at 25 °C, maximum value, measured in series resonance

R_{dld} Drive level dependency (resonance resistance in the drive level range 10^{-12} to 10^{-3} W), maximum value, measured in series resonance

C_1 Motional capacitance, typical value, tolerance ±20%

C_0 Parallel capacitance, typical value, tolerance ±20%

L Measured in load resonance

x Series resonance

WL Wire length ±0.4 mm as indicated by dimension 'L' in Fig.1

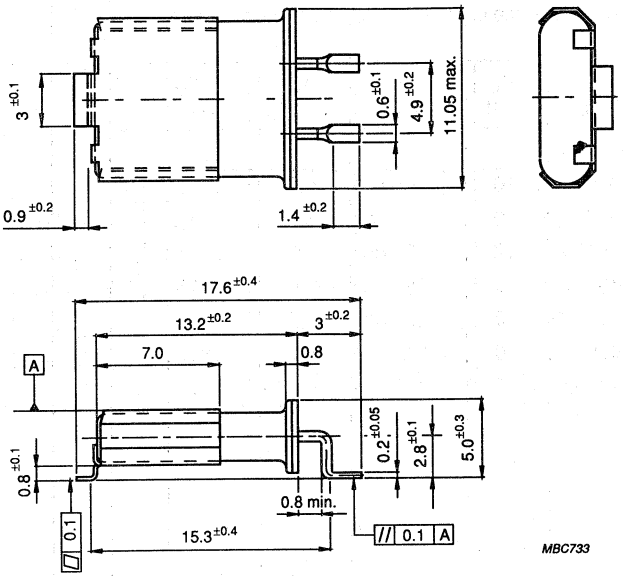
TB Taped in blister.

Derivatives

R_n Resonance resistance of unwanted response: $2 \times R_{rT}$ Ω (–6 dB), for fundamental mode

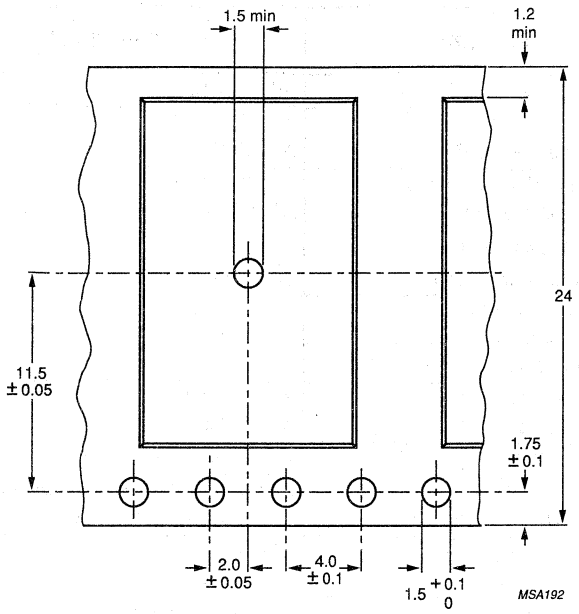
S Pulling sensitivity: $\frac{-C_1}{2(C_o + C_L)^2}$

MECHANICAL DATA



Dimensions in mm.

Fig.1 Style 1 unit; HC-49/U17-SMD.



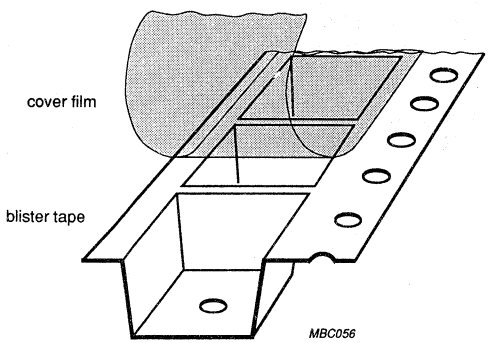
Pocket dimensions

length	18.3 ±0.1
width	11.4 ±0.1
depth	5.6 +0.05/–0

Dimensions in mm.

Crystal connections are adjacent to sprocket holes.

Cumulative pitch error: ≤0.2 mm over 10 pitches.



Total height of tape with top film: 5.8 mm max.

Note: The blister is made of conductive polystyrene. Taping is performed in accordance with IEC 286-3, including minimum 40 sealed empty pockets at leader and trailer ends.

Fig.2 Blister tape.

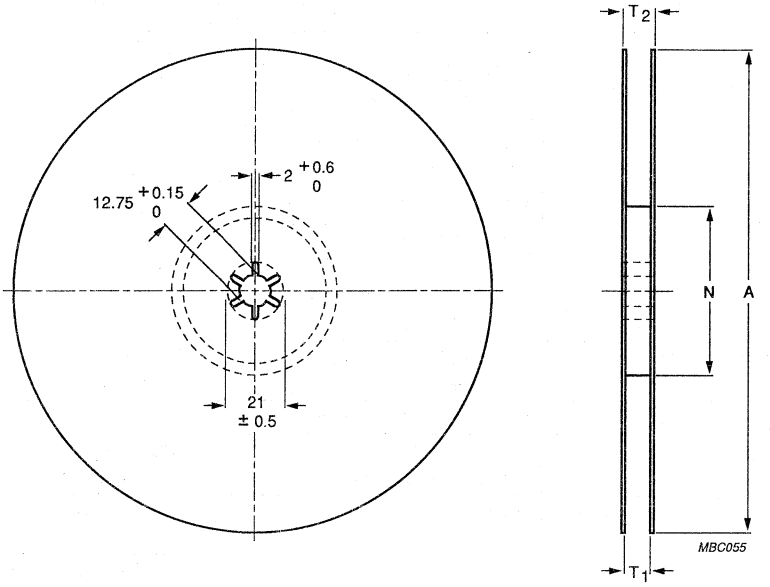
TESTS AND REQUIREMENTS

IEC 68-2 METHOD	TEST	PROCEDURE	REQUIREMENTS
Ba	ageing	1000 hours at +70 °C	$\Delta f/f \leq 5 \times 10^{-6}$
Db	accelerated damp heat	+25 °C to +55 °C; 6 cycles at RH >95%	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Ea	shock	100 g half sine; 6 directions; 1 blow per direction	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Eb	bump	4000 bumps of 40 g	
Ed	free fall	3 falls onto hard wood	see notes 1 and 2
Fc	vibration	frequency 10-500-10 Hz; acceleration 10 g; 3 directions; 30 minutes per direction	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Na	temperature cycling test	–40 to +85 °C; 10 cycles; 6 minutes per cycle	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
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	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Ub	bending of terminations	1 x 90°; load 5 N	no visible damage

Notes

1. Fall height (fundamental mode):
750 mm for the frequency range from 2.40 to 7.5 MHz
500 mm for the frequency range from 7.51 to 10.0 MHz
250 mm for the frequency range from 10.10 to 27.0 MHz.

2. Fall height (third overtone)
500 mm for the frequency range from 24.00 to 30.0 MHz
250 mm for the frequency range from 30.10 to 75.0 MHz.



Dimensions in mm.

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

Fig.3 Reel dimensions.

SOLVENT RESISTANCE TESTS

Procedure: in accordance with IEC 68-2-45 (XA) and IEC 653; immersion time 5 minutes.

Severity 1	At ambient temperature, at boiling temperature, in vapour of boiling solvent, and ultrasonic (40 kHz)
Severity 2	At ambient temperature and ultrasonic (40 kHz)
Solvents for severity 1	Mixtures of 1.1.2-trichloro - 1.2.2-trifluoroethane (fluorocarbon 113 or Freon TF) and the following solvents in the respective mass percentage ratios of these solvents to fluorocarbon 113: 2-propanol (isopropanol), 30% : 70% up to 55% : 45% (Freon TP55) methanol and nitromethane, 5.7% : 0.3% : 94% (Freon TMS)
Solvents for severity 2	Bio-Act EC7 Neutropon P3 and Saxin P3 Meta Clean 820 Lonco 446 Isopropanol cleaning solvent

9922 520 4 series

Quartz crystals in HC-49/U13 holder, automotive and high reliability applications

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 a high mechanical stability. The quartz design yields low resistance and high pullability values. These units are mass produced on an automated production line which guarantees a very high level of uniformity. Additional procedures are followed to ensure operation under severe environmental conditions.

Note: Special types are available on request.

STANDARD MARKING

- PHILIPS (PH)
- Frequency in kHz (fundamental mode) or in MHz (overtone)
- Last five digits of catalogue number; manufacturing date code (last three digits of week code).

QUICK REFERENCE DATA

Mass, typical value	1.2 g
Frequency range fundamental mode third overtone	 2400 to 27 000 kHz 20 000 to 75 000 kHz

FAMILY DATA

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
T_{op}	operable temperature range	−40	155	°C
R_{ins}	insulation resistance DC test voltage = 100 V	500	–	MΩ

PACKING

HC-49/U13 holder; automotive and high reliability applications

STYLE	PACKAGING	QUANTITY
style 1 unit	boxes	1000 pieces per box
style 2 unit	taped on reel taped on reel in ammopack	1000 pieces per reel 1000 pieces per ammopack
style 3 unit	taped on reel taped on reel in ammopack	1000 pieces per reel 1000 pieces per ammopack
style 4 unit	tray in box	100 pieces per tray
style 5 unit	tray in box	100 pieces per tray
style 6 unit	tray in box	100 pieces per tray
style 7 unit	tray in box	100 pieces per tray

CHARACTERISTICS PER CRYSTAL: FUNDAMENTAL MODE

Measured at +25 ±2 °C at a drive level of 0.5 mW into 25 Ω unless otherwise specified. Measuring system: π-network in accordance with IEC 444. For some crystals, the old numbering series (4322 143) may still apply, see characteristics table.

CATALOGUE NUMBER	f_n (kHz)	C_L (pF)	T_o (°C)	$\Delta f/f_n$ ($\times 10^{-6}$)	$\Delta f/f_{25}$ ($\times 10^{-6}$)	R_{rT} (Ω)	R_{r25} (Ω)	R_{dld} (Ω)	C_1 (fF)	C_0 (pF)	WL (mm)
4322 143 04861	3 000.000	30	–40/+115	±50	±100	190	150	180	7.5	2.2	13.2
4322 143 05111	3 000.000	30	–40/+115	±3000	±100	190	150	160	7.5	2.2	13.2B HR
4322 143 04851	3 276.800	30	–40/+115	±50	±100	150	150	180	14.0	4.1	13.2
4322 143 05121	3 276.800	30	–40/+115	±3500	±100	150	150	160	14.0	4.1	13.2B HR
4322 143 04691	3 640.890	20	–40/+90	±50	±50	100	80	100	15.0	4.5	13.2
4322 143 04671	3 932.160	17	–40/+115	±30		75	50	60	16.5	4.7	13.2
			–40/+90		±50						
			–40/+115		±100						
4322 143 04841	4 000.000	30	–40/+115	±40	±80	60	40	60	11.0	2.8	13.2
4322 143 05131	4 000.000	30	–40/+130	±40	±80	85	60	60	11.0	2.8	13.2B HR
9922 520 40005	4 000.000	30	–40/+130	±40	±80	85	60	60	11.0	2.8	TRI18
9922 520 40002	4 194.304	20	–40/+130	±40	±75	50	30	60	15	4.9	13.2 HR
4322 143 04471	4 194.304	20	–40/+130	±40	±75	90	40	70	11.5	2.9	13.2B HR
4322 143 05161	6 000.000	20	–40/+115	±40	±80	60	60	50	28.0	6.7	13.2B HR
4322 143 04241	6 144.000	20	–40/+115	±40	±80	60	60	80	17.0	3.8	13.2B HR
4322 143 04951	7 372.800	20	–40/+115	±40	±80	60	50	60	20.0	4.4	13.2B HR
4322 143 04721	8 000.000	20	–40/+115	±40	±80	60	40	60	17.5	4.4	13.2B HR
			+115/+130		±130	70					
4322 143 04821	8 388.608	20	–40/+115	±40	±80	60	40	60	19.0	4.4	13.2B HR
4322 143 05151	8 867.238	20	–40/+115	±40	±80	40	40	60	20.0	4.6	13.2B HR
4322 143 04621	10 000.000	20	–40/+115	±40	±80	40	40	60	17.5	4.1	13.2B HR
			+115/+130		±130	50					
4322 143 04971	10 000.000	22	–40/+115	±100	±80	60	40	60	17.5	4.1	5.0 HR
9922 520 00045	10 050.000	20	–40/+115	±40	±80	40	40	60	16.0	4.1	13.2B HR

CHARACTERISTICS PER CRYSTAL: FUNDAMENTAL MODE

4322 143 04651	10 240.000	20	–40/+130	±40	±150	60	40	60	17.5	4.1	13.2B HR
4322 143 05671	10 240.000	22	–40/+115	±100	±80	40	40	60	17.5	4.2	13.2
4322 143 04741	11 000.000	20	–40/+115	±40	±80	30	25	50	20.0	4.7	13.2B HR
9922 520 04621	11 880.000	20	–40/+115	±40	±80	40	40	60	19.5	5.0	13.2B HR
			+115/+130		±130	50					
4322 143 04631	12 000.000	20	–40/+115	±40	±80	40	40	50	19.5	5.0	13.2B HR
			+115/+130		±130	50					
4322 143 05271	12 000.000	25	–40/+105	±4900	±100	250	150	180	19.5	5.0	13.2
9922 520 40004	12 000.000	20	–40/+115	±40	±80	40	40	50	20.0	4.5	13.2B HR
			+115/+130		±130	50					

Key to symbols

f_n Nominal frequency

T_o Operating temperature range

$\Delta f/f_n$ Adjustment tolerance at 25 °C

$\Delta f/f_{25}$ Frequency stability over temperature range, with respect to the frequency at 25 °C

C_L Load capacitance

R_{rT} Resonance resistance over the operating temperature range, maximum value, measured in series resonance

R_{r25} Resonance resistance at 25 °C, maximum value, measured in series resonance

R_{dld} Drive level dependency (resonance resistance in the drive level range 10^{-12} to 10^{-3} W), maximum value, measured in series resonance

C_1 Motional capacitance, nominal value, tolerance ±20%

C_0 Parallel capacitance, nominal value, tolerance ±20%

WL Wire length ±0.5 mm as indicated by dimension 'L' in Fig.1

x Series resonance

TR Taped on reel

TRI Taped on reel plus insulation plate

TA Taped on reel in ammunition pack

18 Height of component from tape = 18 mm, indicated by 'H' in Fig.2

B Customer barcode information, see Table 3

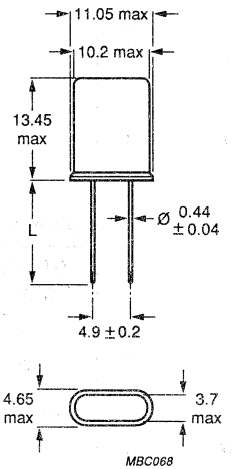
HR High reliability procedures, see also Table 2. In addition, a label showing the ordering data, is displayed on the packaging.

Derivatives

R_n Resonance resistance of unwanted response: 2 x R_{rT} Ω (–6dB), for fundamental mode

S Pulling sensitivity: $\frac{-C_1}{2(C_o + C_L)^2}$

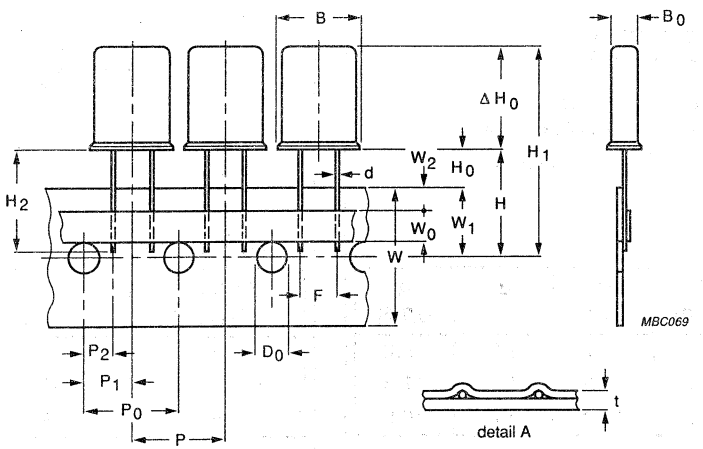
MECHANICAL DATA



Dimensions in mm.

A plastic sleeve can be fitted around the case on request.
Lead length L: for values see 'L' in characteristics table.

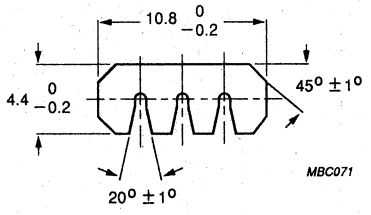
Fig.1 Style 1 unit; standard holder for all types.



Dimensions in mm.

See Table 1 for dimensions.
Note: styles 2 and 3 units can be supplied on tape on reel and in ammopack, see Figs 8 and 9.

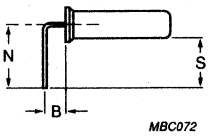
Fig.2 Style 2 and 3 units.



Dimensions in mm.

Style 3 units are supplied on tape, with an insulation plate (washer) at the unit base. The washer is made of PEEK (polyetherketone), 0.25 mm thick and resistant to soldering heat test.

Fig.3 Washer outline.

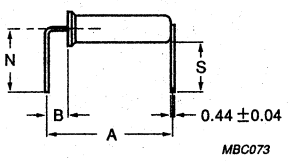


Dimensions in mm.

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

Other dimensions are as style 1.

Fig.4 Style 4 unit.

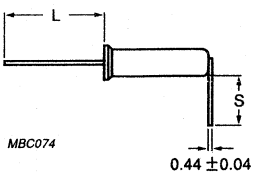


Dimensions in mm.

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

Other dimensions are as style 1.

Fig.5 Style 5 unit.

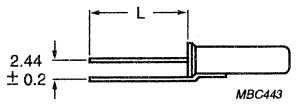


Dimensions in mm.

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

Other dimensions are as style 1.

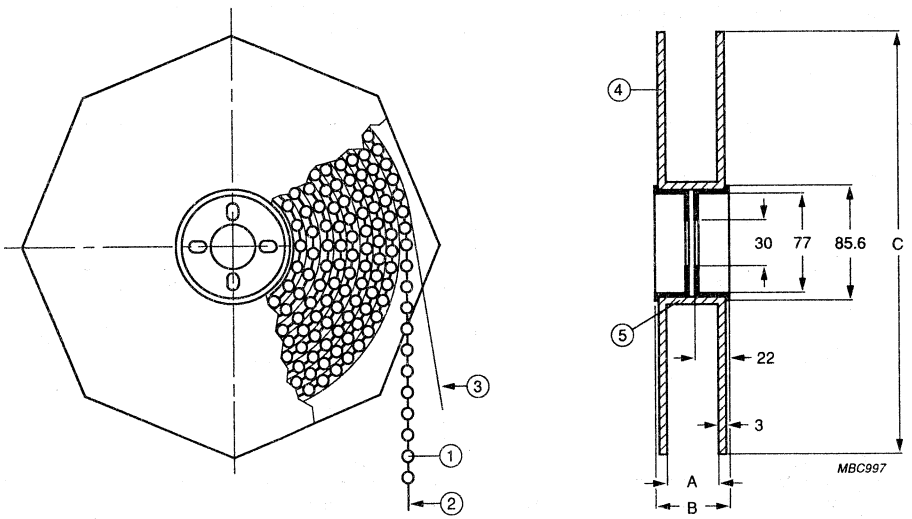
Fig.6 Style 6 unit.



Dimensions in mm.

Other dimensions as style 1.

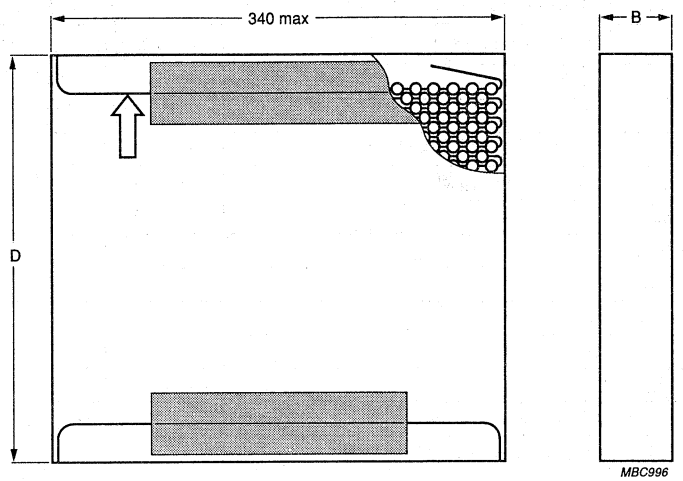
Fig.7 Style 7 unit.



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.

Fig.8 Style 2 and 3 units supplied on tape on reel.



Dimensions in mm.

B = 50 mm max.

D = 190 mm max.

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

Table 1 Taping dimensions
HC-49/U13 holder; style 2 unit (without the washer); in accordance with IEC 286-2 recommendations.

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	0	±2.0	mm
Δp	component alignment in tape plane	0	±1.3	mm
d	lead wire diameter	0.44	±0.04	mm
Δs	lead straightness	t.b.f.	t.b.f.	–
L	length of snipped leads	t.b.f.	t.b.f.	–
F	lead-to-lead distance	4.9	–	mm
P	pitch of components	12.7	±1.0	mm
P_0	feed-hole pitch	12.7	±0.3	mm
P_2	feed-hole centre to lead distance	3.9	±0.7	mm
P_1	feed-hole centre to component centre distance	6.35	±0.3	mm
D_0	feed-hole diameter	4.0	±0.2	mm
H	distance of component from tape centre unless otherwise specified in characteristics table	16.0	+2/0	mm
H_1	maximum component height from tape centre	29.3	–	mm
ΔH_0	maximum component height	13.4	–	mm
H_0	minimum component base to tape top height	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	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

TESTS AND REQUIREMENTS

IEC 68-2 METHOD	TEST	PROCEDURE	REQUIREMENTS
Ba	ageing	250 hours at +130 °C 1000 hours at +70 °C	$\Delta f/f \leq 20 \times 10^{-6}$ $\Delta R_r \leq 20\%$ $\Delta f/f \leq 5 \times 10^{-6}$
Db	accelerated damp heat	+25 °C to +55 °C; 6 cycles at RH >95%	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Ea	shock	100 g half sine; 6 directions; 1 blow per direction	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Eb	bump	4000 bumps of 40 g	
Ed	free fall	3 falls onto hard wood	see notes 1 and 2
Fc	vibration	frequency 10-500-10 Hz; acceleration 40 g; 3 directions; 80 hours **HR types:** acceleration 10 g; 3 directions; 30 minutes per direction	$\Delta f/f \leq 20 \times 10^{-6}$ $\Delta R_r \leq 20\%$ $\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Na	temperature cycling test	−40 to +150 °C; 500 cycles; 30 minutes per cycle **HR types:** −40/+85 °C; 10 cycles; 6 minutes per cycle	$\Delta f/f \leq 20 \times 10^{-6}$ $\Delta R_r \leq 20\%$ $\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
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 °C; 3 s	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Ub	bending of terminations	1 x 90°; load 5 N	no visible damage

Notes

1. Fall height (fundamental mode):
1000 mm for the frequency range from 2.4 to 12 MHz
250 mm for the frequency range from 12.1 to 27.0 MHz.

2. Fall height (third overtone):
500 mm for the frequency range 24.0 to 30.0 MHz
250 mm for the frequency range 30.1 to 75.0 MHz.

SOLVENT RESISTANCE TESTS

Procedure: in accordance with IEC 68-2-45 (XA) and IEC 653; immersion time 5 minutes.

Severity 1	At ambient temperature, at boiling temperature, in vapour of boiling solvent and ultrasonic (40 kHz)
Severity 2	At ambient temperature and ultrasonic (40 kHz)
Solvents for severity 1	Mixtures of 1.1.2-trichloro - 1.2.2-trifluoroethane (fluorocarbon 113 or Freon TF) and the following solvents in the respective mass percentage ratios of these solvents to fluorocarbon 113: 2-propanol (isopropanol), 30% : 70% up to 55% : 45% (Freon TP55) methanol and nitromethane, 5.7% : 0.3% : 94% (Freon TMS)
Solvents for severity 2	Bio-Act EC7 Neutropon P3 and Saxin P3 Meta Clean 820 Lonco 446 Isopropanol cleaning solvent

Table 2 Level of Quality, general for **high reliability** specifications

SYMBOL	PARAMETER	AQL (Level II)
$\Delta f/f_n$	frequency tolerance at 25 °C	0.1
R_{r25}	resonance resistance at 25 °C	0.1
R_{dld}	drive level dependency	0.1
C_1	motional capacitance at 25 °C	0.15
C_0	parallel capacitance at 25 °C	0.15
$\Delta f/f_{25}$	frequency stability over temperature range	0.15
R_{rT}	resonance resistance over temperature range	0.15
	visual appearance	0.25
	sealing	0.1

Table 3 Customer barcode information

CATALOGUE NUMBER	NOMINAL FREQUENCY (kHz)	CUSTOMER BARCODE INFORMATION		
4322 143 05111	3 000.000	CAQ520		
4322 143 05121	3 276.800	CAQ511	8906189504	
4322 143 05131	4 000.000	CAQ513	8906189505	1267369202
4322 143 04471	4 194.304	CAQ512	8906189502	1267369200
4322 143 05161	6 000.000	CAQ513	8906189506	1267369203
4322 143 04241	6 144.000	CAQ524	8906189537	
4322 143 04951	7 372.800	CAQ523	8906189510	
4322 143 04721	8 000.000	CAQ515	8906189511	
4322 143 04821	8 388.608	CAQ517	8906189512	
4322 143 05151	8 867.238	CAQ519		
4322 143 04621	10 000.000	CAQ521	8906189514	1267369204
9922 520 00045	10 050.000	CAQ556	8906189539	2229992296
4322 143 04651	10 240.000	CAQ528	8906189538	2289993561
4322 143 04741	11 000.000	CAQ510	8906189509	
9922 520 00092	11 880.000	CAQ557	8906189540	1267369209
4322 143 04631	12 000.000	CAQ522	8906189536	1267369205
9922 520 40004	12 000.000	CAQ522	8906189536	1267369205

9922 521 2 series

Quartz crystals in HC-45/U holder, automotive and high reliability applications

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 two connecting leads. The unit has a high mechanical stability and small dimensions. These units are mass produced on an automated production line which guarantees a very high level of uniformity and reliability. Additional procedures are followed to ensure operation under severe environmental conditions.

Note: Special types are available on request.

STANDARD MARKING

- PHILIPS (PH)
- Frequency
- Last five digits of catalogue number; manufacturing date code (last three digits of week code).

QUICK REFERENCE DATA

Mass, typical value	0.4 g
Frequency range fundamental mode third overtone	 8000 to 24 000 kHz 24 000 to 70 000 kHz

FAMILY DATA

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
T_{op}	operable temperature range	–40	155	°C
R_{ins}	insulation resistance DC test voltage = 100 V	500	–	MΩ

PACKING

HC-45/U holder; automotive and high reliability applications

STYLE	PACKAGING	QUANTITY
style 1 unit	boxes	1000 pieces per box
style 2 unit	taped on reel taped on reel in ammopack	1000 pieces per reel 1000 pieces per ammopack
style 3 unit	taped on reel taped on reel in ammopack	1000 pieces per reel 1000 pieces per ammopack

CHARACTERISTICS PER CRYSTAL: FUNDAMENTAL MODE

Measured at +25 ±2 °C at a drive level of 0.5 mW into 25 Ω unless otherwise specified. Measuring system: π-network in accordance with IEC 444.

CATALOGUE NUMBER	f_n (kHz)	C_L (pF)	T_o (°C)	$\Delta f/f_n$ ($\times 10^{-6}$)	$\Delta f/f_{25}$ ($\times 10^{-6}$)	R_{rT} (Ω)	R_{r25} (Ω)	R_{dld} (Ω)	C_1 (fF)	C_0 (pF)	WL (mm)
9922 521 20046	8 000.000	20	−40/+130	±40	±80	150	90	90	4.0	1.4	TR[1]
9922 521 20024	8 000.000	20	−40/+130	±40	±80	150	90	90	4.0	1.4	20.0[1]
9922 521 20044	10 000.000	20	−40/+130	±40	±80	150	90	90	5.5	1.6	TR[1]
9922 521 20025	10 000.000	20	−40/+130	±40	±80	150	90	90	5.5	1.6	20.0[1]
9922 521 20005	10 050.000	20	−40/+130	±40	±80	150	90	90	5.5	1.6	20.0
9922 521 20026	10 050.000	20	−40/+130	±40	±80	150	90	90	5.5	1.6	20.0[1]
9922 521 20042	10 240.000	20	−40/+130	±40	±80	150	90	90	5.5	1.7	20.0
9922 521 20027	10 240.000	20	−40/+130	±40	±80	150	90	90	5.5	1.7	20.0[1]
9922 521 20003	11 059.200	20	−40/+130	±40	±80	100	75	90	6.0	1.8	20.0
9922 521 20028	11 059.200	20	−40/+130	±40	±80	100	75	90	6.0	1.8	20.0[1]
9922 521 20031	11 880.000	20	−40/+130	±40	±80	100	65	90	6.5	1.9	20.0[1]
9922 521 20045	11 880.000	20	−40/+130	±40	±80	100	65	90	6.5	1.9	TR[1]
9922 521 20029	12 000.000	20	−40/+130	±40	±80	100	65	90	6.5	1.9	20.0[1]
9922 521 20033	12 000.000	20	−40/+130	±40	±80	100	65	90	6.5	1.9	TR[1]

Note

[1] New holder.

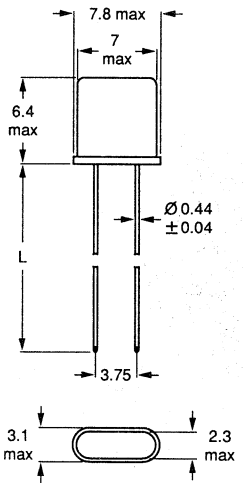
Key to symbols

f_n	Nominal frequency
T_o	Operating temperature range
$\Delta f/f_n$	Adjustment tolerance at 25 °C
$\Delta f/f_{25}$	Frequency stability over temperature range, with respect to the frequency at 25 °C
C_L	Load capacitance
R_{rT}	Resonance resistance over the operating temperature range, maximum value, measured in series resonance
R_{r25}	Resonance resistance at 25 °C, maximum value, measured in series resonance
R_{dld}	Drive level dependency (resonance resistance in the drive level range 10^{-12} to 10^{-3} W), maximum value, measured in series resonance
C_1	Motional capacitance, typical value, tolerance ±40%
C_0	Parallel capacitance, typical value, tolerance ±40%
WL	Wire length ±0.5 mm as indicated by dimension 'L' in Fig.1
x	Series resonance
TR	Taped on reel
TRI	Taped on reel plus insulation plate
TA	Taped on reel in ammopack.

Derivatives

R_n	Resonance resistance of unwanted response: $2 \times R_{rT}$ Ω (–6 dB), for fundamental mode
S	Pulling sensitivity: $\frac{-C_1}{2(C_o + C_L)^2}$ (see Fig.7)

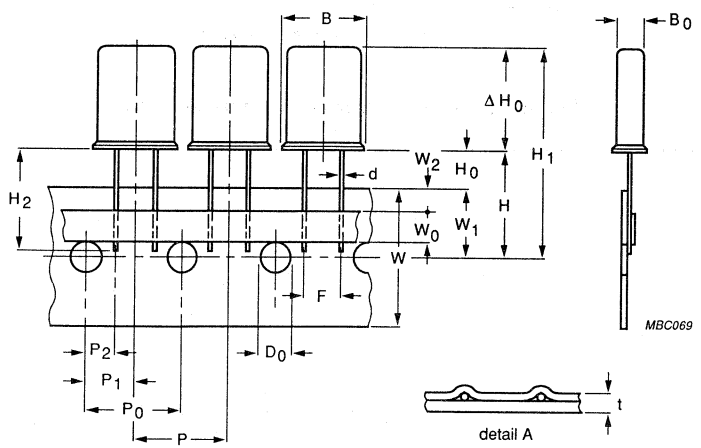
MECHANICAL DATA



Dimensions in mm.

Lead length L: for values see 'L' in characteristics table.

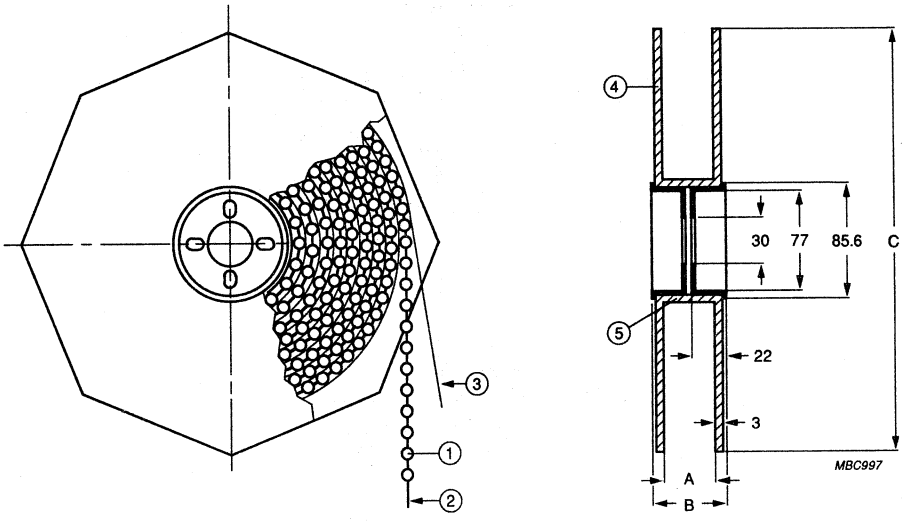
Fig.1 Style 1 unit.



See Table 1 for dimensions.

Note: styles 2 and 3 units can be supplied on tape in reel and in ammunition packing, see Figs 3 and 4.

Fig.2 Style 2 and 3 units.

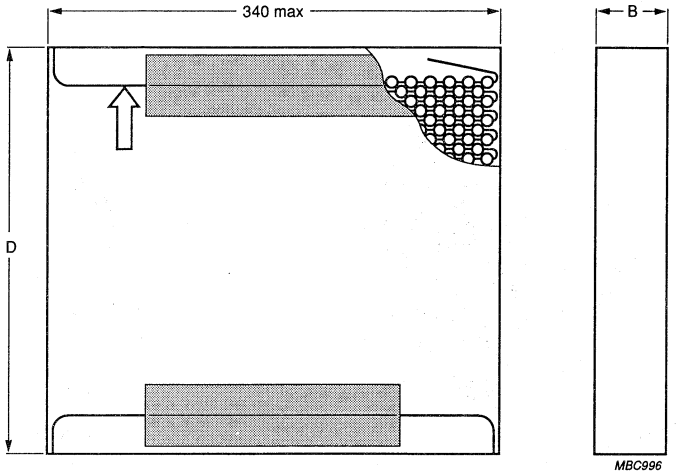


Dimensions in mm.

1 = crystal unit
2 = tape
3 = paper
4 = flange
5 = cylinder

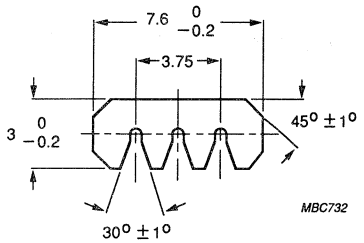
A = 45 mm
B = 55 mm max.
C = 355 mm max.

Fig.3 Style 2 and 3 units supplied on tape in reel.



Dimensions in mm.
B = 55 mm max.
D = 185 mm max.

Fig.4 Style 2 and 3 units supplied on tape in ammunition packing.



Dimensions in mm.

Style 3 units are supplied on tape with an insulation plate (washer) at the unit base. The washer is made of PEEK (polyetherketone), 0.25 mm thick and resistant to soldering heat test.

Fig.5 Washer outline.

Table 1 Taping dimensions
HC-45/U holder; style 2 unit (without the washer); in accordance with IEC 286-2 recommendations.

SYMBOL	PARAMETER	VALUE	TOLERANCE	UNIT
B_o	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	±2.0	mm
Δp	component alignment in tape plane	0	±1.3	mm
d	lead wire diameter	0.44	±0.04	mm
Δs	lead straightness	t.b.f.	–	–
L	length of snipped leads	t.b.f.	–	–
F	lead-to-lead distance	3.75	–	mm
P	pitch of components	12.7	±1.0	mm
P_0	feed-hole pitch	12.7	±0.3	mm
P_2	feed-hole centre to lead distance	4.47	±0.7	mm
P_1	feed-hole centre to component centre distance	6.35	±0.3	mm
D_0	feed-hole diameter	4.0	±0.2	mm
H	distance of component from tape centre unless otherwise specified in characteristics table	18.0	+2/0	mm
H_0	minimum component base to tape top height	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	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

TESTS AND REQUIREMENTS

IEC 68-2 METHOD	TEST	PROCEDURE	REQUIREMENTS
Ba	ageing	250 hours at +130 °C	$\Delta f/f \leq 40 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Db	accelerated damp heat	+25 °C to +55 °C; 6 cycles at RH >95%	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Ea	shock	100 g half sine; 6 directions; 1 blow per direction	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Eb	bump	4000 bumps of 40 g	
Ed	free fall	10 falls onto hard wood	see note 1
Fc	vibration	frequency 10-500-10 Hz; acceleration 40 g; 3 directions; 80 hours	$\Delta f/f \leq 20 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Na	temperature cycling test	−40 to +150 °C; 500 cycles; 30 minutes per cycle	$\Delta f/f \leq 40 \times 10^{-6}$ $\Delta R_r \leq 20\%$
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	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Ub	bending of terminations	1 x 90°; load 5 N	no visible damage

Note

1. Fall height (fundamental mode):
1000 mm for the frequency range from 8 to 12 MHz
500 mm for the frequency range from 12 to 20 MHz.

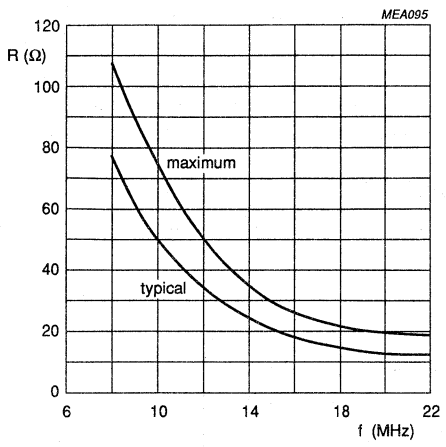
SOLVENT RESISTANCE TESTS

Procedure: in accordance with IEC 68-2-45 (XA) and IEC 653; immersion time 5 minutes.

Severity 1	At ambient temperature, at boiling temperature, in vapour of boiling solvent, and ultrasonic (40 kHz)
Severity 2	At ambient temperature and ultrasonic (40 kHz)
Solvents for severity 1	Mixtures of 1.1.2-trichloro - 1.2.2-trifluoroethane (fluorocarbon 113 or Freon TF) and the following solvents in the respective mass percentage ratios of these solvents to fluorocarbon 113: 2-propanol (isopropanol), 30% : 70% up to 55% : 45% (Freon TP55) methanol and nitromethane, 5.7% : 0.3% : 94% (Freon TMS)
Solvents for severity 2	Bio-Act EC7 Neutropon P3 and Saxin P3 Meta Clean 820 Lonco 446 Isopropanol cleaning solvent

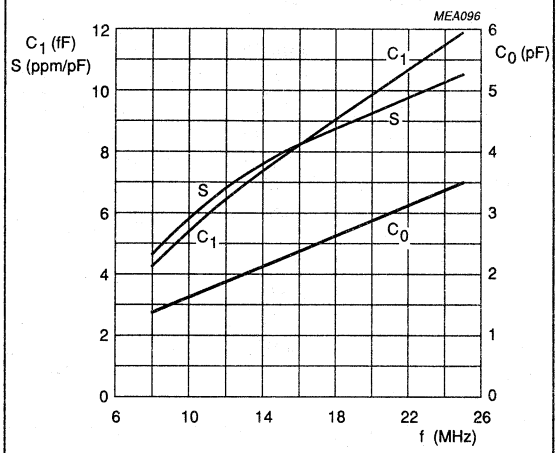
Table 2 Level of Quality, general for **high reliability** specifications

SYMBOL	PARAMETER	AQL (Level II)
$\Delta f/f_n$	frequency tolerance at 25 °C	0.1
R_{r25}	resonance resistance at 25 °C	0.1
R_{dld}	drive level dependency	0.1
C_1	motional capacitance at 25 °C	0.15
C_0	parallel capacitance at 25 °C	0.15
$\Delta f/f_{25}$	frequency stability over temperature range	0.15
R_{rT}	resonance resistance over temperature range	0.15
	visual appearance	0.25
	sealing	0.1



For HC-45/U automotive and high reliability crystals.

Fig.6 Resonance resistance R_r at 25 °C as a function of resonance frequency.



For HC-45/U automotive and high reliability crystals.

Typical values at 25 °C.

Fig.7 Motional capacitance C_1, parallel capacitance C_0 and pulling sensitivity S (assuming C_L = 20 pF) as a function of resonance frequency.

Table 3 Customer barcode information

CATALOGUE NUMBER	NOMINAL FREQUENCY (kHz)	CUSTOMER BARCODE INFORMATION	
9922 521 20005	10 050.000	CAQ560	8906189551
9922 521 20042	10 240.000	CAQ549	
9922 521 20003	11 059.200	CAQ555	
9922 521 20001	11 880.000	CAQ558	8906189548

9922 522 2 and 6 series

Quartz crystals in HC-45/U-SMD, automotive and high reliability applications

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 two connecting leads and a metal clip for surface mounting. The unit has a high mechanical stability and small dimensions. These units are mass produced on an automated production line which guarantees a very high level of uniformity and reliability. Additional procedures are followed to ensure operation under severe environmental conditions.

Note: Special types are available on request.

STANDARD MARKING

- PHILIPS (PH)
- Frequency
- Last five digits of catalogue number; manufacturing date code (last three digits of week code).

QUICK REFERENCE DATA

Mass, typical value	0.5 g
Frequency range fundamental mode third overtone	 8000 to 24 000 kHz 24 000 to 70 000 kHz

FAMILY DATA

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
T_{op}	operable temperature range	−40	155	°C
R_{ins}	insulation resistance DC test voltage = 100 V	500	–	MΩ

PACKING

HC-45/U-SMD holder; automotive and high reliability applications

STYLE	PACKAGING	QUANTITY
style 1 unit	boxes blister taped on reel	1000 pieces per box 1000 pieces per reel
style 2 unit	boxes blister taped on reel	1000 pieces per box 1000 pieces per reel
style 3 unit	boxes blister taped on reel	1000 pieces per box 1000 pieces per reel
style 4 unit	boxes blister taped on reel	1000 pieces per box 1000 pieces per reel

CHARACTERISTICS PER CRYSTAL: FUNDAMENTAL MODE (Development types)

Measured at +25 ±2 °C at a drive level of 0.5 mW into 25 Ω unless otherwise specified. Measuring system: π-network in accordance with IEC 444.

CATALOGUE NUMBER	f_n (kHz)	C_L (pF)	T_o (°C)	$\Delta f/f_n$ ($\times 10^{-6}$)	$\Delta f/f_{25}$ ($\times 10^{-6}$)	R_{rT} (Ω)	R_{r25} (Ω)	R_{dld} (Ω)	C_1 (fF)	C_0 (pF)	CLIP TYPE
9922 522 20001	8 000.000	20	−40/+130	±40	±80	150	100	100	4.0	1.4	I
9922 522 20005	10 000.000	20	−40/+130	±40	±80	150	100	100	5.5	1.6	I
9922 522 20006	10 240.000	20	−40/+130	±40	±80	150	100	100	5.5	1.7	I
9922 522 20008	11 059.200	20	−40/+130	±40	±80	100	20	100	6.0	1.8	I
9922 522 20003	12 000.000	20	−40/+130	±40	±80	100	75	100	6.5	1.9	I
9922 522 20002	16 000.000	20	−40/+130	±40	±80	100	75	100	8.0	2.4	I

Key to symbols

f_n Nominal frequency

T_o Operating temperature range

$\Delta f/f_n$ Adjustment tolerance at 25 °C

$\Delta f/f_{25}$ Frequency stability over temperature range, with respect to the frequency at 25 °C

C_L Load capacitance

R_{rT} Resonance resistance over the operating temperature range, maximum value, measured in series resonance

R_{r25} Resonance resistance at 25 °C, maximum value, measured in series resonance

R_{dld} Drive level dependency (resonance resistance in the drive level range 10^{-12} to 10^{-3} W), maximum value, measured in series resonance

C_1 Motional capacitance, typical value, tolerance ±40%

C_0 Parallel capacitance, typical value, tolerance ±40%

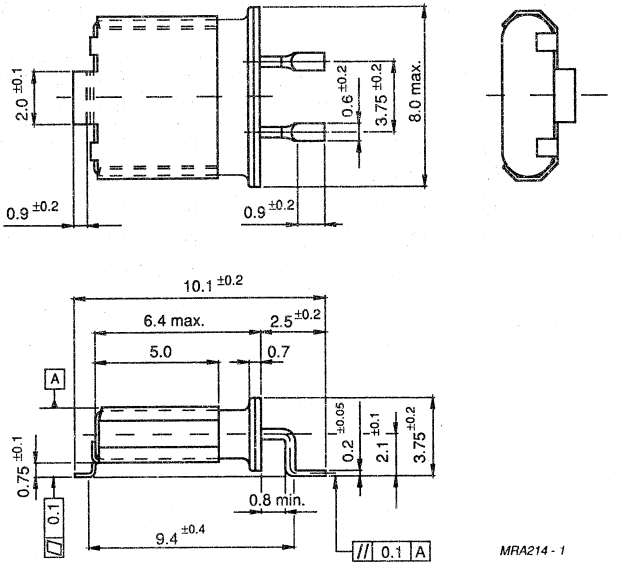
x Series resonance.

Derivatives

R_n Resonance resistance of unwanted response: $2 \times R_{rT}$ Ω (−6 dB), for fundamental mode

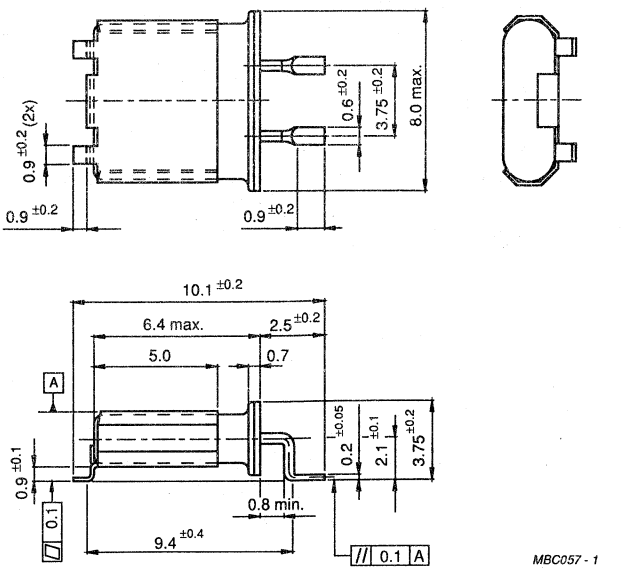
S Pulling sensitivity: $\frac{-C_1}{2(C_o + C_L)^2}$ (see Fig.8).

MECHANICAL DATA



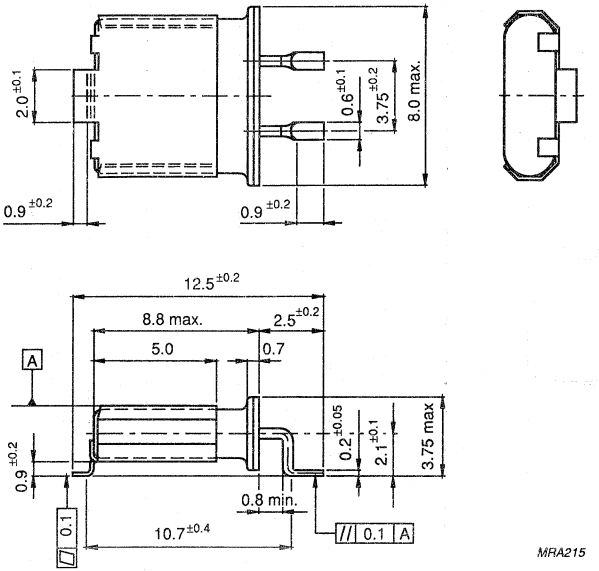
Dimensions in mm.

Fig.1 Style 1 unit; HC-45/U11-SMD/Clip I. Catalogue number 9922 522 2....



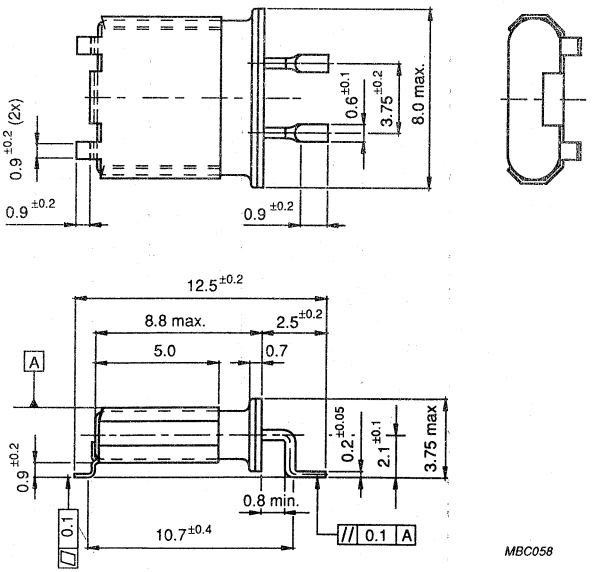
Dimensions in mm.

Fig.2 Style 2 unit; HC-45/U11-SMD/Clip II. Catalogue number 9922 522 2....



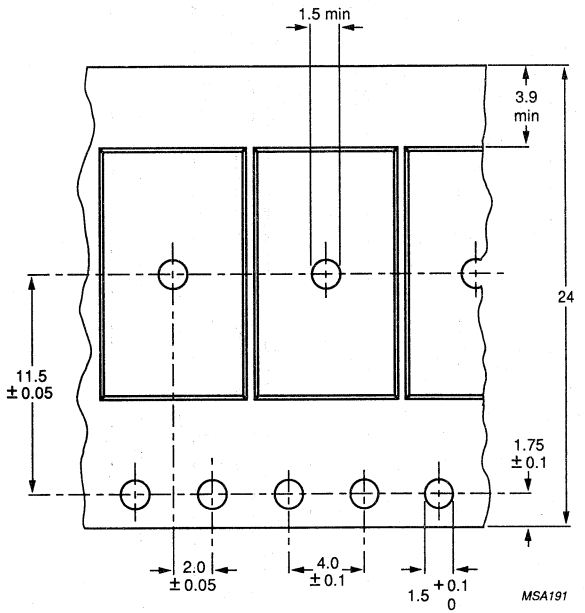
Dimensions in mm.

Fig.3 Style 3 unit; HC-45/U12-SMD/Clip I. Catalogue number 9922 522 6....



Dimensions in mm.

Fig.4 Style 4 unit; HC-45/U12-SMD/Clip II. Catalogue number 9922 522 6....



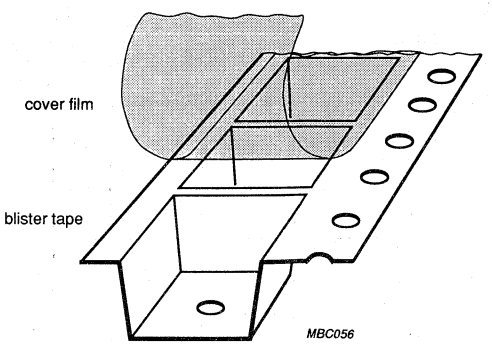
Pocket dimensions

length	13.1 ±0.1
width	8.3 ±0.1
depth	4.3 +0.05/–0

Dimensions in mm.

Crystal connections are adjacent to sprocket holes.

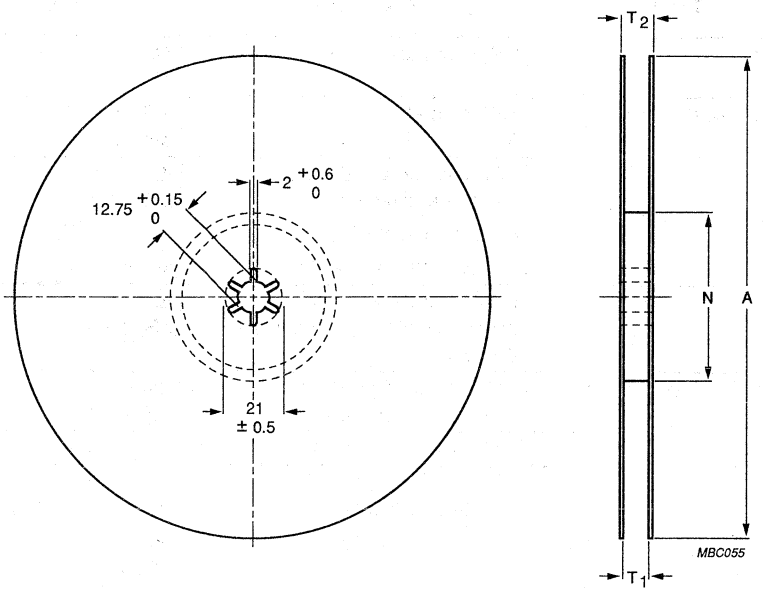
Cumulative pitch error: ≤0.2 mm over 10 pitches.



Total height of tape with topfilm: 4.5 mm max.

Note: The blister is made of conductive polystyrene. Taping is performed according to IEC 286-3, including min. 40 sealed empty pockets at leader and trailer ends.

Fig.5 Blister tape.



Dimensions in mm.

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

Fig.6 Reel dimensions.

TESTS AND REQUIREMENTS

IEC 68-2 METHOD	TEST	PROCEDURE	REQUIREMENTS
Ba	ageing	250 hours at +130 °C	$\Delta f/f \leq 40 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Db	accelerated damp heat	+25 °C to +55 °C; 6 cycles at RH >95%	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Ea	shock	100 g half sine; 6 directions; 1 blow per direction	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Eb	bump	4000 bumps of 40 g	
Ed	free fall	10 falls onto hard wood	see note 1
Fc	vibration	frequency 10-500-10 Hz; acceleration 40 g; 3 directions; 80 hours	$\Delta f/f \leq 20 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Na	temperature cycling test	–40 to +150 °C; 500 cycles; 30 minutes per cycle	$\Delta f/f \leq 40 \times 10^{-6}$ $\Delta R_r \leq 20\%$
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% on the flat lead parts no visible damage no leaks
Tb	resistance to soldering heat	350 ±5 °C; 3.5 ±0.5 s	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Ub	bending of terminations	1 x 90°; load 5 N	no visible damage

Note

1. Fall height (fundamental mode):
1000 mm for the frequency range from 8 to 12 MHz
500 mm for the frequency range from 12 to 20 MHz.

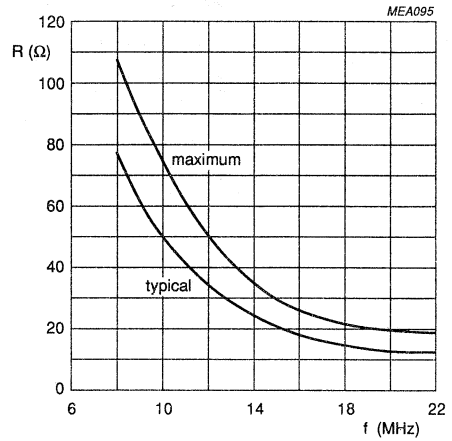
SOLVENT RESISTANCE TESTS

Procedure: in accordance with IEC 68-2-45 (XA) and IEC 653; immersion time 5 minutes.

Severity 1	At ambient temperature, at boiling temperature, in vapour of boiling solvent, and ultrasonic (40 kHz)
Severity 2	At ambient temperature and ultrasonic (40 kHz)
Solvents for severity 1	Mixtures of 1.1.2-trichloro - 1.2.2-trifluoroethane (fluorocarbon 113 or Freon TF) and the following solvents in the respective mass percentage ratios of these solvents to fluorocarbon 113: 2-propanol (isopropanol), 30% : 70% up to 55% : 45% (Freon TP55) methanol and nitromethane, 5.7% : 0.3% : 94% (Freon TMS)
Solvents for severity 2	Bio-Act EC7 Neutropon P3 and Saxin P3 Meta Clean 820 Lonco 446 Isopropanol cleaning solvent

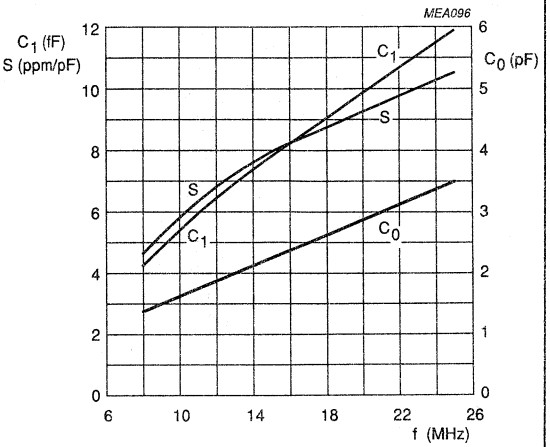
Table 1 Level of Quality, general for **high reliability** specifications

SYMBOL	PARAMETER	AQL (Level II)
$\Delta f/f_n$	frequency tolerance at 25 °C	0.1
R_{r25}	resonance resistance at 25 °C	0.1
R_{dld}	drive level dependency	0.1
C_1	motional capacitance at 25 °C	0.15
C_0	parallel capacitance at 25 °C	0.15
$\Delta f/f_{25}$	frequency stability over temperature range	0.15
R_{rT}	resonance resistance over temperature range	0.15
	visual appearance	0.25
	sealing	0.1



For HC-45/U-SMD crystals.

Fig.7 Resonance resistance R_r at 25 °C as a function of resonance frequency.



For HC-45/U-SMD crystals.
Typical values at 25 °C.

Fig.8 Motional capacitance C_1, parallel capacitance C_0 and pulling sensitivity S (assuming C_L = 20 pF) as a function of resonance frequency.

9922 520 0 and 3 series

Quartz crystals in HC-49/U13 holder, standard applications

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 a high mechanical stability. The quartz design yields low resistance and high pullability values. These units are mass produced on an automated production line which guarantees a very high level of uniformity and reliability.

Note: Special types are available on request.

STANDARD MARKING

- PHILIPS (PH)
- Frequency
- Last five digits of catalogue number; manufacturing date code (last three digits of week code).

QUICK REFERENCE DATA

Mass, typical value	1.2 g
Frequency range fundamental mode third overtone	 2400 to 27 000 kHz 20 000 to 75 000 kHz

FAMILY DATA

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
T_{op}	operable temperature range	−40	155	°C
R_{ins}	insulation resistance DC test voltage = 100 V	500	–	MΩ

PACKING

HC-49/U13 holder; standard applications

STYLE	PACKAGING	QUANTITY
style 1 unit	boxes	1000 pieces per box
style 2 unit	taped on reel taped on reel in ammopack	1000 pieces per reel 1000 pieces per ammopack
style 3 unit	taped on reel taped on reel in ammopack	1000 pieces per reel 1000 pieces per ammopack
style 4 unit	tray in box	100 pieces per tray
style 5 unit	tray in box	100 pieces per tray
style 6 unit	tray in box	100 pieces per tray
style 7 unit	tray in box	100 pieces per tray

CHARACTERISTICS PER CRYSTAL: FUNDAMENTAL MODE

Measured at +25 ±2 °C at a drive level of 0.5 mW into 25 Ω unless otherwise specified. Measuring system: π-network in accordance with IEC 444. For some crystals, the old numbering series (4322 143) may still apply, see characteristics table.

CATALOGUE NUMBER	f_n (kHz)	C_L (pF)	T_o (°C)	$\Delta f/f_n$ ($\times 10^{-6}$)	$\Delta f/f_{25}$ ($\times 10^{-6}$)	R_{rT} (Ω)	R_{r25} (Ω)	R_{dld} (Ω)	C_1 (fF)	C_0 (pF)	WL (mm)
9922 520 00046	3 000.000	20	–10/+60	±30	±25	200	160	180	7.5	2.2	13.2
4322 143 04411	3 000.000	20	–20/+70	±40	±30	190	150	160	7.5	2.2	13.2
4322 143 04421	3 276.800	20	–20/+70	±40	±30	150	100	160	14.0	4.1	13.2
4322 143 04911	3 439.593	x	–20/+70	±40	±30	100	75	90	13.5	4.3	13.2
4322 143 04571	3 440.000	20	–20/+70	±40	±30	100	75	90	13.5	4.3	13.2
4322 143 04761	3 440.000	20	–20/+70	±40	±30	100	75	90	13.5	4.3	13.2
4322 143 04491	3 547.000	30	–10/+60	±30	±30	100	75	90	14.5	4.5	13.2
9922 520 00047	3 579.545	x	–20/+70	±1000	±200	150	75	150	8.0	5.0	TRI
4322 143 04401	3 579.545	x	–20/+70	±5000	±100	100	75	90	14.5	4.5	13.2
9922 520 00174	3 579.545	17	–20/+70	±30	±30	150	150	150	14.5	4.5	13.2
4322 143 05591	3 579.545	17	0/+70	±35	±30	100	100	100	14.5	4.5	5.0
9922 520 00063	3 579.545	17	–20/+70	±40	±30	100	75	90	14.5	4.5	13.2
9922 520 00207	3 579.545	18	–20/+70	±25	±35	100	100		14.5	4.5	13.2
9922 520 00024	3 579.545	18	–20/+70	±30	±50	100	40	150	11.0	2.9	13.2
9922 520 00104	3 579.545	18	–20/+70	±30	±50	120	120	120	14.5	4.5	13.2
9922 520 00144	3 579.545	18	–20/+70	±35	±30	100	100		11.0	2.9	5.0
9922 520 00002	3 579.545	20	–10/+60	±30	±20	100	100	100	14.5	4.5	5.5
			0/+40		±10						
			0/+50		±15						
9922 520 00134	3 579.545	20	0/+60	±30	±20		60	100	14.5	4.5	4.5
4322 143 04391	3 579.545	20	–20/+70	±40	±30	100	75	90	14.5	4.5	13.2
9922 520 00313	3 579.545	20	–20/+70	±40	±30	100	75	90	14.5	4.5	5.0
9922 520 00161	3 579.545	20	–20/+70	±40	±30	100	75	90	14.5	4.5	TR
9922 520 00064	3 579.545	24	–20/+70	±40	±30	100	75	90	14.5	4.5	13.2
4322 143 05201	3 582.056	20	–10/+60	±40	±25	100	75	90	14.5	4.5	5.0
4322 143 04381	3 582.056	20	–10/+60	±40	±25	100	75	90	14.5	4.5	13.2
9922 520 00219	3 600.000	30	0/+70	±100	±100	100	100		14.5	4.5	13.2
4322 143 04551	3 686.400	x	–20/+70	±20	±40	100	75	90	15.0	4.5	13.2
9922 520 00205	3 686.400	16	–20/+70	±30	±30	140	140		15.0	4.5	13.2
9922 520 00247	3 686.400	30	–10/+70	±30	±50	130	130		15.0	4.5	13.2
4322 143 04371	3 686.400	30	–10/+60	±40	±25	100	75	90	15.0	4.5	13.2
9922 520 00244	3 686.400	30	–10/+60	±40	±25	100	75	90	15.0	4.5	TR
4322 143 04431	3 750.000	13	–10/+65	±30	±7	75	50	60	15.0	4.5	13.2
4322 143 04441	3 840.000	30	–20/+70	±20	±50	75	50	60	15.5	4.6	13.2
4322 143 04481	3 997.696	20	0/+60	±40	±15	75	50	60	11.0	2.8	13.2

9922 520 0 and 3 series

Quartz crystals in HC-49/U13 holder, standard applications

CATALOGUE NUMBER	f_n (kHz)	C_L (pF)	T_o (°C)	$\Delta f/f_n$ ($\times 10^{-6}$)	$\Delta f/f_{25}$ ($\times 10^{-6}$)	R_{rT} (Ω)	R_{r25} (Ω)	R_{dld} (Ω)	C_1 (fF)	C_0 (pF)	WL (mm)
4322 143 05661	4 000.000	x	0/+70	±30	±35	60	60	70	11.0	2.8	5.0
4322 143 05611	4 000.000	x	0/+70	±30	±30	100	100	100	11.0	2.8	5.0
9922 520 00057	4 000.000	x	−10/+60	±40	±25	75	50	60	11.0	2.8	13.2
9922 520 00154	4 000.000	20	−10/+60	±15	±25	60	60		11.0	2.8	13.2
9922 520 00004	4 000.000	20	−20/+80	±20	±20	150	150	150	11.0	2.8	13.2
			0/+50		±10						
			0/+60		±15						
4322 143 04231	4 000.000	20	−10/+60	±30	±40	75	50	60	11.0	2.8	5.0
4333 143 04881	4 000.000	20	−10/+60	±30	±40	75	50	60	11.0	2.8	13.2
4322 143 04261	4 000.000	20	−10/+60	±40	±25	75	50	60	11.0	2.8	13.2
9922 520 00016	4 000.000	20	−20/+80	±40	±40	60	60	60	11.0	2.8	3.5
9922 520 00093	4 000.000	20	−40/+130	±40	±80	85	85	100	11.0	2.8	13.2
9922 520 00005	4 000.000	30	−20/+80	±20	±25	60	60	60	11.0	2.8	5.5
				0/+50		±10					
				0/+60		±15					
9922 520 00051	4 000.000	30	−10/+60	±40	±25	60	60	60	11.0	2.8	4.5
9922 520 00114	4 000.000	30	−10/+60	±40	±25	75	50		11.0	2.8	TR
4322 143 04093	4 000.000	30	−10/+60	±40	±25	75	50	60	11.0	2.8	13.2
4322 143 04271	4 000.000	30	0/+60	±40	±15	75	50	60	11.0	2.8	13.2
4322 143 05211	4 000.000	30	−10/+60	±40	±25	75	50	60	11.0	2.8	5.0
9922 520 00088	4 000.000	30	−10/+60	±40	±100	100	75	100	11.0	2.8	13.2
9922 520 03005	4 000.000	32	0/+70	±30	±20	120	120	140			13.2
9922 520 00301	4 096.000	30	−10/+70	±30	±50	75	50	60	18.5	5.0	13.2
4322 143 04771	4 096.000	30	−10/+60	±40	±25	75	50	60	18.5	5.0	13.2
9922 520 00003	4 194.304	11	−10/+60	±40	±20	100	150	150	11.5	2.9	5.5
9922 520 00278	4 194.304	11.4	−10/+60	±40	±25	60	40	60	11.5	2.9	5.0
4322 143 04083	4 194.304	11.4	−10/+60	±40	±25	60	40	60	11.5	2.9	13.2
9922 520 00261	4 194.304	11.4	−10/+60	±40	±25	60	40	60	11.5	2.9	TA
9922 520 00285	4 194.304	12	−20/+60	−30/+10	±20	100	50	100	11.5	2.9	TR
			−40/+80		±50						
4312 065 01864	4 194.304	12	−40/+85	±25	±30	100	60	70	11.5	2.9	3.5
9922 520 00115	4 194.304	12	−10/+60	±30	±50	60	40	60	11.5	2.9	TRI
9922 520 00178	4 194.304	12	−10/+60	±30	±20	60	40	60	11.5	2.9	3.5
4322 143 05411	4 194.304	12	−40/+85	±30	±30	100	60	70	11.5	2.9	13.2
9922 520 00116	4 194.304	12	−10/+60	±40	±25	60	40	50	11.5	2.9	TR
4322 143 04073	4 194.304	12	−10/+60	±40	±25	60	40	60	11.5	2.9	13.2

9922 520 0 and 3 series

Quartz crystals in HC-49/U13 holder, standard applications

CATALOGUE NUMBER	f_n (kHz)	C_L (pF)	T_o (°C)	$\Delta f/f_n$ ($\times 10^{-6}$)	$\Delta f/f_{25}$ ($\times 10^{-6}$)	R_{rT} (Ω)	R_{r25} (Ω)	R_{dld} (Ω)	C_1 (fF)	C_0 (pF)	WL (mm)
9922 520 00058	4 194.304	20	−20/+70	±100	±100	100	75	100	11.5	2.9	13.2
4322 143 04461	4 233.600	x	−20/+70	±40	±30	60	40	50	16.5	5.2	13.2
4322 143 04561	4 233.600	30	−20/+70	±40	±30	60	40	50	16.5	5.2	13.2
4322 143 04361	4 250.000	20	−10/+60	±40	±25	60	40	50	16.5	5.2	13.2
9922 520 00189	4 332.000	30	0/+80	±20	±25	60	50	60	12.0	3.0	5.5
			0/+50		±10						
			0/+60		±15						
9922 520 00245	4 332.000	30	0/+80	±20	±25	60	50	60	12.0	3.0	13.2
9922 520 00113	4 406.250	20	−10/+60	±40	±25	60	40	50	20.5	5.4	5.0
4322 143 04351	4 406.250	20	−10/+60	±40	±25	60	40	50	20.5	5.4	13.2
9922 520 00155	4 433.495	30	−10/+60	±15	±20	60	60		20.5	5.5	13.2
9922 520 00286	4 433.619	20	−20/+70	±25	±35	60	40		20.5	5.5	13.2
9922 520 00052	4 433.619	20	0/+60	±30	±20	60	60	60	>13.0	<5.0	4.5
9922 520 00022	4 433.619	20	−10/+60	±30	±30	100	100	100	20.5	5.5	5.5
9922 520 00017	4 433.619	20	−10/+60	±30	±20	100	100	100	20.5	5.5	5.5
9922 520 00137	4 433.619	20	−10/+60	±40	±25	60	40		20.5	5.5	TR
4322 143 04252	4 433.619	20	−10/+55	±40	±15	60	40	50	20.5	5.5	5.0
9922 520 00262	4 433.619	20	−10/+60	±40	±25	60	40	50	20.5	5.5	TA
4322 143 04282	4 433.619	20	−10/+60	±40	±25	60	40	50	20.5	5.5	5.0
4322 143 04043	4 433.619	20	−10/+60	±40	±25	60	40	50	20.5	5.5	13.2
9922 520 00304	4 433.919	x	−10/+60	±20	±25	60	40	50	17.5	4.1	13.2
4322 143 04872	4 435.571	20	−10/+60	±40	±25	60	40	50	20.5	5.5	5.0
4322 143 04111	4 500.000	13	−10/+65	±30	±7	60	40	50	18.5	5.6	13.2
9922 520 00023	4 500.000	20	−20/+80	±20	±40	60	40	50	18.5	5.6	13.2
4322 143 04121	4 531.468	13	−10/+65	±30	±30	60	40	50	18.5	5.6	13.2
4322 143 04341	4 608.000	x	0/+70	±30	±40	60	40	50	21.0	5.8	13.2
9922 520 00055	4 608.000	30	−55/+100	±10	±40	120	120	100	21.0	5.8	13.2
9922 520 00249	4 608.000	30	−10/+70	±30	±50	90	40	60	21.0	5.8	13.2
4322 143 04033	4 782.720	x	−20/+70	±40	±30	60	40	50	21.5	5.7	13.2
4322 143 04291	4 782.720	x	−20/+70	±5000	±100	60	40	50	21.5	5.7	13.2
4322 143 04781	4 865.000	x	−20/+70	±50	±50	60	40	50	22.5	5.7	13.2
4322 143 04601	4 905.021	20	−20/+70	±40	±30	60	40	50	23.0	5.9	13.2
4322 143 04132	4 905.021	20	−20/+70	±40	±30	60	40	50	23.0	5.9	5.0
4322 143 04141	4 915.200	30	+5/+45	±20	±20	60	40	50	13.5	3.2	13.2
9922 520 00305	4 915.200	30	+5/+45	±20	±20	60	40	50	13.5	3.2	TA
9922 520 00099	4 915.200	30	−20/+70	±30	±30	55	55	65	13.5	3.2	13.2
4322 143 04201	4 915.200	30	+5/+45	±2000	±20	60	40	50	13.5	3.2	13.2

9922 520 0 and 3 series

Quartz crystals in HC-49/U13 holder, standard applications

CATALOGUE NUMBER	f_n (kHz)	C_L (pF)	T_o (°C)	$\Delta f/f_n$ ($\times 10^{-6}$)	$\Delta f/f_{25}$ ($\times 10^{-6}$)	R_{rT} (Ω)	R_{r25} (Ω)	R_{dld} (Ω)	C_1 (fF)	C_0 (pF)	WL (mm)
9922 520 00012	5 000.000	20	0/+60	±30	±20	100	100	100	14.0	3.2	5.5
4322 143 04151	5 000.000	20	−20/+70	±40	±30	60	40	50	14.0	3.2	13.2
9922 520 00183	5 000.000	20	−20/+70	±40	±30	60	40	50	14.0	3.2	TR
4322 143 04681	5 000.000	30	−20/+70	±30	±30	60	40	50	14.0	3.2	13.2
9922 520 00086	5 034.964	20	−20/+70	±40	±30	100	100	100	14.0	3.2	13.2
4322 143 04541	5 068.800	x	−15/+70	±20	±30	60	40	50	14.0	3.2	13.2
4322 143 04451	5 068.800	x	−20/+70	±40	±30	60	40	50	14.0	3.2	13.2
4322 143 04331	5 068.800	20	−20/+70	±40	±30	60	40	50	14.0	3.2	13.2
4322 143 04161	5 120.000	20	−20/+70	±40	±30	60	40	50	14.5	3.5	13.2
4322 143 04751	5 120.000	20	−20/+70	±40	±30	60	40	50	14.5	3.5	5.0
4322 143 05361	5 824.000	14	−20/+70	±25	±25	60	60	80	16.5	3.7	5.0
9922 520 00236	5 824.000	14	−20/+70	±25	±25	60	60	80	16.5	3.7	TR
9922 520 00263	5 824.000	14	−20/+70	±25	±25	60	60	80	16.5	3.7	TA
9922 520 00094	5 824.000	16	−10/+60	±25	±30	40	40	60	16.5	3.7	13.2
9922 520 00264	5 850.000	14	−20/+70	±25	±25	60	60	80	16.5	3.7	TA
4322 143 05351	5 850.000	14	−20/+70	±25	±25	60	60	80	16.5	3.7	5.0
9922 520 00237	5 850.000	14	−20/+70	±25	±25	60	60	80	16.5	3.7	TA
4322 143 04521	5 911.000	30	−10/+60	±20	±20	60	40	50	16.5	3.7	13.2
4322 143 05041	6 000.000	x	−20/+70	±40	±30	60	40	50	28.0	6.7	13.2
9922 520 00013	6 000.000	20	−20/+70	±35	±30	60	60	60	28.0	6.7	5.5
4322 143 04101	6 000.000	20	−20/+70	±40	±30	60	40	100	28.0	6.7	13.2
4322 143 04532	6 000.000	20	−20/+70	±40	±30	60	40	100	28.0	6.7	5.0
9922 520 00243	6 000.000	20	−20/+70	±40	±30	60	40	100	28.0	6.7	TR
4322 143 04582 (Y - cut!)	6 000.000	20	−10/+40	±150	−27.5/°C	60	40	50	17.2	6.7	13.2
4322 143 04981	6 000.000	20	−20/+70	±5000	±30	60	40	50	28.0	6.7	13.2
9922 520 00011	6 000.000	32	−10/+60	±100	±100	60	40	50	28.0	6.7	5.0
4322 143 04591	6 041.957	20	−20/+70	±40	±30	60	40	50	28.0	6.7	13.2
4322 143 04321	6 144.000	20	0/+70	±50	±50	60	40	50	17.0	3.8	13.2
9922 520 00119	6 144.000	28	0/+70	±5	±50	50	45	60	17.0	3.8	13.2
9922 520 00279	6 144.000	30	−55/+85	±30	±40	40	40		17.0	3.8	13.2
4322 143 05261	6 400.000	11.4	−20/+70	±40	±25	60	40	50	18.0	4.0	13.2
4322 143 04311	6 400.000	20	−20/+70	±40	±25	60	40	50	18.0	4.0	13.2
4322 143 05431	6 552.000	14	−10/+70	±25	±25	60	60	80	18.0	4.1	5.0
9922 520 00235	6 552.000	14	−10/+70	±25	±25	60	60	80	18.0	4.1	TA
9922 520 00265	6 552.000	14	−10/+60	±25	±25	60	60	80	18.0	4.1	TA
9922 520 00095	6 552.000	16	−10/+60	±25	±30	40	40	60	18.0	4.1	13.2

9922 520 0 and 3 series

Quartz crystals in HC-49/U13 holder, standard applications

CATALOGUE NUMBER	f_n (kHz)	C_L (pF)	T_o (°C)	$\Delta f/f_n$ ($\times 10^{-6}$)	$\Delta f/f_{25}$ ($\times 10^{-6}$)	R_{rT} (Ω)	R_{r25} (Ω)	R_{dld} (Ω)	C_1 (fF)	C_0 (pF)	WL (mm)
4322 143 04791	7 000.000	20	−10/+60	±40	±30	60	35	50	19.0	4.2	13.2
9922 520 00006	7 151.222	20	25/+80	±40	±30	100	100	100	19.5	4.4	5.5
4322 143 04171	7 151.223	20	−10/+60	±40	±25	60	35	50	19.5	4.4	13.2
4322 143 04181	7 159.090	20	−10/+70	±40	±25	60	35	50	19.5	4.4	13.2
9922 520 00151	7 159.090	20	−10/+70	±40	±25	60	35	50	19.5	4.4	TA
4322 143 05471	7 159.090	20	−10/+70	±40	±25	60	60	50	19.5	4.4	5.0
9922 520 00049	7 159.090	20	0/+60	±40	±50	60	60	60	19.5	4.4	4.5
9922 520 00007	7 159.090	20	25/+80	±40	±30	100	100	100	19.5	4.4	5.5
4322 143 04191	7 164.112	20	−20/+70	±40	±25	60	35	50	19.5	4.4	13.2
9922 520 00124	7 164.112	20	−20/+60	±40	±25	60	60	50	19.5	4.4	TR
9922 520 00014	7 164.112	20	−10/+60	±40	±25	60	60	60	19.5	4.4	5.5
4322 143 05501	7 372.800	30	−10/+60	±50	±50	40	40	60	20.0	4.4	13.2
4322 143 05221	7 680.000	11.4	−25/+75	±40	±60	90	40	60	21.0	4.5	13.2
9922 520 00284	7 680.000	20	−25/+70	±20	±30	60	60	70	21.0	4.5	TRI18
9922 520 00065	7 680.000	20	−25/+75	±40	±60	90	40	60	21.0	4.5	13.2
9922 520 00056	8 000.000	x	−20/+70	±40	±25	60	35	50	21.0	5.0	13.2
4322 143 04301	8 000.000	20	−20/+70	±40	±25	60	35	50	21.0	5.0	13.2
9922 520 00038	8 000.000	20	−10/+60	±110	±110	90	60	100	21.0	5.0	13.2
9922 520 00044	8 192.000	10	−20/+70	±40	±50	30	30	40	21.5	5.2	TRI
9922 520 00193	8 192.000	15	−10/+60	±30	±30	60	40	60	21.5	5.2	13.2
9922 520 00059	8 192.000	20	−10/+70	±30	±50	40	40	50	21.5	5.2	13.2
9922 520 00288	8 192.000	30	−10/+70	±30	±50		30	60	21.5	5.2	13.2
4312 065 01833	8 867.238	20	−10/+60	±40	±25	60	40	60	22.0	5.5	13.2
9922 520 00015	8 867.238	20	−10/+60	±40	±25	60	60	60	22.0	5.5	5.5
9922 520 00053	8 867.238	20	−10/+60	±40	±30	60	60	60	22.0	5.5	4.5
9922 520 00128	8 867.238	20	−10/+60	±40	±30	60	60	60	22.0	5.5	5.5
9922 520 00143	8 867.238	20	−10/+60	±40	±30	60	60	60	22.0	5.5	TR
4322 143 04222	8 867.238	20	−10/+60	±40	±25	60	60	100	22.0	5.5	5.0
9922 520 00266	8 867.238	20	−10/+60	±40	±25	60	60	100	22.0	5.5	TA
4322 143 04051	8 867.238	20	−10/+60	±40	±25	60	60	100	22.0	5.5	13.2
9922 520 00123	8 867.238	20	−10/+60	±40	±25	60	60	100	22.0	5.5	TR
4322 143 04611	9 830.400	x	0/+70	±50	±50	50	30	40	25.0	5.7	13.2
4322 143 05581	9 830.400	x	−10/+70	±50	±50	50	30	40	25.0	5.7	5.0
9922 520 00289	9 830.400	x	0/+70	±50	±50	50	30	40	25.0	5.7	TR
4322 065 01658	10 000.000	20	−10/+60	±30	±50	80	50	100	25.0	5.8	13.2
9922 520 00256	10 000.000	20	−10/+60	±30	±50	80	50	100	25.0	5.8	5.5
4322 143 05072	10 000.000	20	−20/+70	±40	±80	60	40	60	17.5	4.1	5.0

9922 520 0 and 3 series

Quartz crystals in HC-49/U13 holder, standard applications

CATALOGUE NUMBER	f_n (kHz)	C_L (pF)	T_o (°C)	$\Delta f/f_n$ ($\times 10^{-6}$)	$\Delta f/f_{25}$ ($\times 10^{-6}$)	R_{rT} (Ω)	R_{r25} (Ω)	R_{dld} (Ω)	C_1 (fF)	C_0 (pF)	WL (mm)
9922 520 00153	10 000.000	22	−10/+60	±100	±50	45	30	45	25.0	5.8	TR
4322 143 05571	10 000.000	22	−10/+60	±100	±50	45	30	45	25.0	5.8	5.5
9922 520 00173	10 000.000	22	−10/+60	±100	±50	45	30	45	25.0	5.8	TA
4322 143 05101	10 000.000	22	0/+70	±100	±50	40	40		25.0	5.8	5.0
9922 520 00025	10 000.000	30	0/+50	±30	±15	50	50	50	25.0	5.8	5.5
9922 520 00084	10 000.000	x	−20/+70	±30	±30	30	30	50	28.5	6.1	13.2
4322 143 05371	11 000.000	x	−10/+60	±40	±30	40	25	50	28.5	6.1	13.2
4322 143 04941	11 000.000	20	−10/+60	±40	±30	40	25	50	28.5	6.1	13.2
9922 520 00108	11 000.000	20	−20/+70	±100	±80	80	80	90	20.0	4.7	13.2
4322 143 04921	11 059.000	30	−10/+60	±40	±30	60	30	50	28.5	6.1	13.2
9922 520 00275	11 059.200	x	−20/+70	±30	±30	30	30		28.5	6.1	13.2
9922 520 00062	11 059.200	x	−10/+60	±40	±30	60	30	50	28.5	6.1	13.2
9922 520 00061	11 059.200	15	−20/+70	±50	±50	50	35	50	28.5	6.1	13.2
9922 520 00287	11 059.200	30	−10/+70	±30	±50	25	20	50	28.5	6.1	13.2
4322 143 04931	11 059.200	30	−10/+60	±40	±30	60	30	50	28.5	6.1	13.2
9922 520 00316	11 059.200	30	−10/+60	±40	±30	60	30	50	28.5	6.1	TR
4322 143 05061	11 059.200	32	−10/+60	±40	±30	60	30	50	28.5	6.1	13.2
9922 520 00125	11 112.000	20	−20/+70	±30	±30	40	30		17.5	4.5	13.2
4322 143 05601	11 289.600	30	0/+70	±15	±25	50	50	50	17.5	4.5	5.0
4322 143 05241	11 289.600	30	−20/+70	±50	±50	50	35	50	17.5	4.5	13.2
9922 520 00171	11 289.600	30	−20/+70	±50	±50	50	35	50	17.5	4.5	TA
9922 520 00259	11 648.000	15	−10/+60	±20	±20	40	30	60	17.5	4.8	13.2
9922 520 00203	11 700.000	15	−10/+60	±20	±20	40	30	60	17.5	4.8	13.2
9922 520 00076	12 000.000	20	−20/+70	±40	±30	40	30	40	18.5	4.9	13.2
4322 143 05341	12 000.000	20	−20/+70	±50	±50	50	35	60	18.5	4.9	5.0
9922 520 00018	12 000.000	20	−10/+60	±50	±30	50	50	50	18.5	4.9	5.5
9922 520 00078	12 000.000	20	−20/+70	±100	±80	80	80	80	19.5	5.0	13.2
4322 143 05561	12 000.000	32	−20/+70	±50	±50	50	35	60	18.5	4.9	4.0
4322 143 05641	12 000.000	32	−20/+70	±50	±50	50	35	60	18.5	4.9	TA
9922 520 00172	12 000.000	32	−20/+70	±50	±50	50	35	60	18.5	4.9	TA
9922 520 00067	12 000.000	40	0/+70	±50	±70	30	25	30	18.5	4.9	13.2
9922 520 00175	12 000.000	40	0/+70	±50	±70	30	25	30	18.5	4.9	TR
9922 520 00202	13 104.000	15	−10/+60	±20	±20	40	30	60	19.5	5.2	13.2
9922 520 00054	13 875.000	x	−10/+60	±30	±30	60	60	60	20.0	5.4	4.5
9922 520 00019	13 875.000	x	0/+60	±30	±30	60	60	60	20.0	5.4	5.5
4322 143 05251	13 875.000	20	−20/+70	±40	±30	50	40	60	20.0	5.4	5.0
9922 520 00152	13 875.000	20	−20/+70	±40	±30	50	40	60	20.0	5.4	TR

CATALOGUE NUMBER	f_n (kHz)	C_L (pF)	T_o (°C)	$\Delta f/f_n$ ($\times 10^{-6}$)	$\Delta f/f_{25}$ ($\times 10^{-6}$)	R_{rT} (Ω)	R_{r25} (Ω)	R_{dld} (Ω)	C_1 (fF)	C_0 (pF)	WL (mm)
4322 143 05331	13 875.000	20	–20/+70	±40	±30	50	40	60	20.0	5.4	13.2
9922 520 00268	13 875.000	20	–20/+70	±40	±30	50	40	60	20.0	5.4	TA
4322 143 05391	14 131.200	22	0/+70	±40	±50	30	30	100	20.0	5.5	13.2
9922 520 00122	14 745.600	30	0/+70	±20	±10	40	35	50	20.0	<4.5	13.2
9922 520 00073	15 000.000	11.4	–10/+60	±40	±25	40	25	40	21.0	6.0	13.2
9922 520 00066	16 384.000	30	0/+50	±10	±7	30	25	30	13.0	4.6	13.2
9922 520 00212	17 472.000	30	–20/+70	±20	±30	40	20	60	22.2	6.8	13.2
9922 520 00074	17 734.475	11.4	–10/+60	±40	±25	40	20	40	22.0	6.6	13.2
9922 520 00135	17 734.475	20	–20/+70	±40	±30	40	25	40	22.0	6.6	TA
9922 520 00191	17 734.475	20	–20/+70	±40	±30	40	25	40	22.0	6.6	13.2
9922 520 00121	19 660.800	x	0/ +70	±50	±70	25	22	30		<7.0	13.2
9922 520 00302	20 480.000	20	–30/+85	±30	±50	20	20	40	22.9	7.8	13.2
9922 520 00282	24 576.000	30	–15/+70	±20	±20	40	20	40	10.4	3.9	13.2
9922 520 00293	25 000.000	30	–10/+70	±30	±50	25	20	40	23.2	6.3	13.2

CHARACTERISTICS PER CRYSTAL: THIRD OVERTONE

Measured at +25 ±2 °C at a drive level of 0.5 mW into 25 Ω unless otherwise specified. Measuring system: π-network in accordance with IEC 444. For some crystals, the old numbering series (4322 143) may still apply, see characteristics table.

CATALOGUE NUMBER	f_n (kHz)	C_L (pF)	T_o (°C)	$\Delta f/f_n$ ($\times 10^{-6}$)	$\Delta f/f_{25}$ ($\times 10^{-6}$)	R_{rT} (Ω)	R_{r25} (Ω)	R_{dld} (Ω)	C_1 (fF)	C_0 (pF)	WL (mm)
4322 143 05291	24 576.000	8	0/+70	±40	±20	60	60	80	1.0	3.3	5.5
9922 520 30009	24 576.000	8	0/+70	±40	±20	60	60	80	1.0	3.3	13.2
4322 143 05401	24 576.000	14	0/+70	±100	±100	60	60	80	1.0	3.3	5.5
9922 520 30004	26 800.000	8	0/+70	±50	±20	50	50	80	1.1	3.5	13.2
9922 520 30003	27 000.000	20	–20/+70	±25	±25	50	40	50	1.2	<7.0	13.2
9922 520 30005	27 000.000	20	–20/+70	±25	±25	50	40	50	1.2	<7.0	TR
9922 520 30006	27 000.000	20	–20/+70	±25	±25	50	40	50	1.2	<7.0	TA
9922 520 30007	27 000.000	20	–20/+70	±25	±25	50	40	50	1.2	<7.0	4.0
9922 520 30012	27 000.000	20	–20/+70	±25	±25	50	40	50	1.2	<7.0	5.0

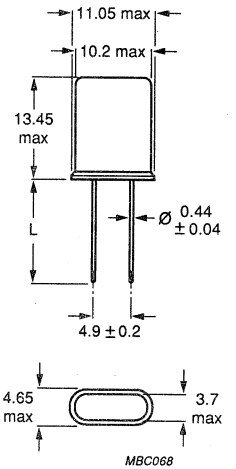
Key to symbols

f_n	Nominal frequency
T_o	Operating temperature range
$\Delta f/f_n$	Adjustment tolerance at 25 °C
$\Delta f/f_{25}$	Frequency stability over temperature range, with respect to the frequency at 25 °C
C_L	Load capacitance
R_{rT}	Resonance resistance over the operating temperature range, maximum value, measured in series resonance
R_{r25}	Resonance resistance at 25 °C, maximum value, measured in series resonance
R_{dld}	Drive level dependency (resonance resistance in the drive level range 10^{-12} to 10^{-3} W), maximum value, measured in series resonance
C_1	Motional capacitance, typical value
C_o	Parallel capacitance, typical value
WL	Wire length ±0.5 mm as indicated by dimension 'L' in Fig.1
x	Series resonance
TR	Taped on reel
TRI	Taped on reel plus insulation plate
TA	Taped on reel in ammunition pack
18	Height of component from tape = 18 mm, indicated by 'H' in Fig.2.

Derivatives

R_n	Resonance resistance of unwanted response: $2 \times R_{rT}$ Ω (–6dB), for fundamental mode
S	Pulling sensitivity: $\frac{-C_1}{2(C_o + C_L)^2}$

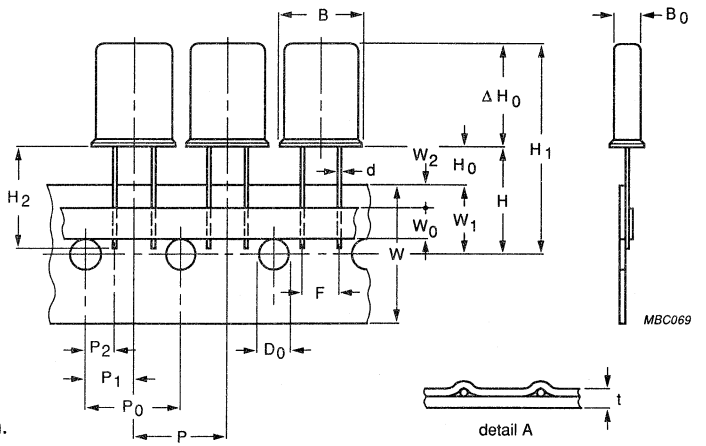
MECHANICAL DATA



Dimensions in mm.

A plastic sleeve can be fitted around the case on request.
Lead length L: for values see 'L' in characteristics table.

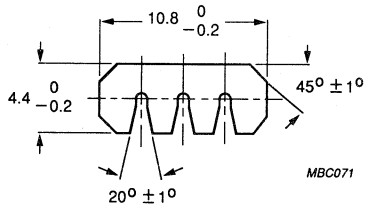
Fig.1 Style 1 unit; standard holder for all types.



Dimensions in mm.

See Table 1 for dimensions.
Note: styles 2 and 3 units can be supplied on tape in reel and in ammunition packing see Figs 8 and 9.

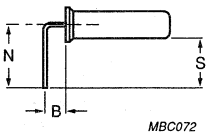
Fig.2 Style 2 and 3 units.



Dimensions in mm.

Style 3 units are equipped with an insulation plate (washer) at the unit base. The washer is made of PEEK (polyetherketone), 0.25 mm thick and resistant to soldering heat test.

Fig.3 Washer outline.

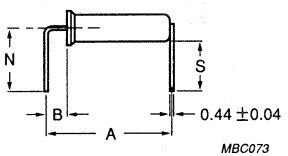


Dimensions in mm.

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

Other dimensions are as style 1.

Fig.4 Style 4 unit.

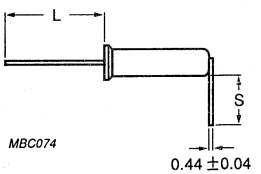


Dimensions in mm.

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

Other dimensions are as style 1.

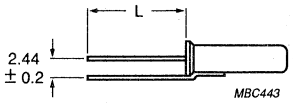
Fig.5 Style 5 unit.



Dimensions in mm.

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

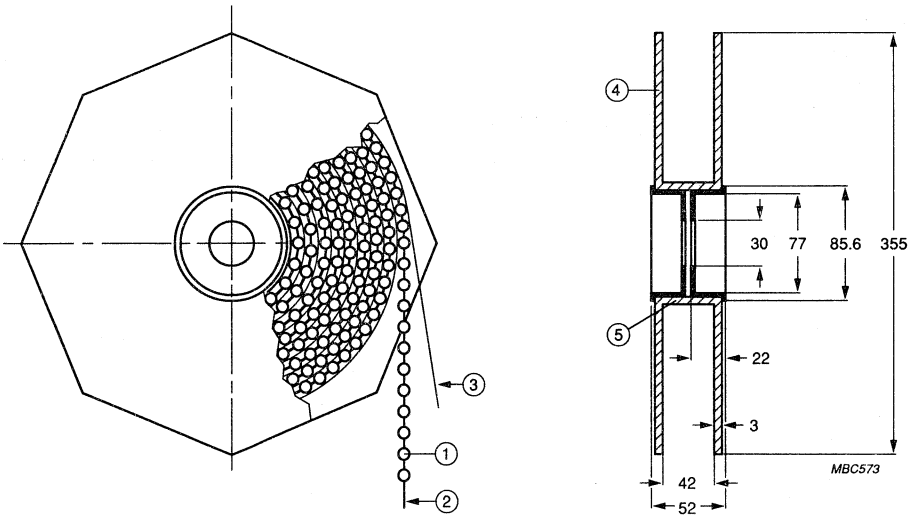
Other dimensions are as style 1.



Dimensions in mm.

Other dimensions as style 1.

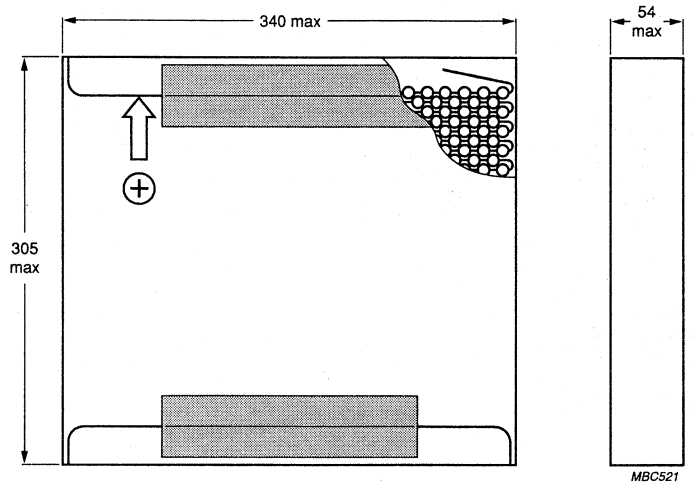
Fig.7 Style 7 unit.



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.

Fig.8 Style 2 and 3 units supplied on tape in reel.



Dimensions in mm.

B = 50 mm max.

D = 190 mm max.

Fig.9 Style 2 and 3 units supplied on tape in ammunition packing.

Table 1 Taping dimensions
HC-49/U13 holder; style 2 unit (without the washer); in accordance with IEC 286-2 recommendations.

SYMBOL	PARAMETER	VALUE	TOLERANCE	UNIT
B_o	body thickness	4.43	±0.05	mm
B	body width	10.75	±0.1	mm
Δh	component alignment vertical to tape plane	0	±2.0	mm
Δp	component alignment in tape plane	0	±1.3	mm
d	lead wire diameter	0.44	±0.04	mm
Δs	lead straightness	t.b.f.	–	–
L	length of snipped leads	t.b.f.	–	–
F	lead-to-lead distance	4.9	–	mm
P	pitch of components	12.7	±1.0	mm
P_0	feed-hole pitch	12.7	±0.3	mm
P_2	feed-hole centre to lead distance	3.9	±0.7	mm
P_1	feed-hole centre to component centre distance	6.35	±0.3	mm
D_0	feed-hole diameter	4.0	±0.2	mm
H	distance of component from tape centre unless otherwise specified in characteristics table	16	+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	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

TESTS AND REQUIREMENTS

IEC 68-2 METHOD	TEST	PROCEDURE	REQUIREMENTS
Ba	ageing	1000 hours at +70 °C	$\Delta f/f \leq 5 \times 10^{-6}$
Db	accelerated damp heat	+25 °C to +55 °C; 6 cycles at RH >95%	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Ea	shock	100 g half sine; 6 directions; 1 blow per direction	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Eb	bump	4000 bumps of 40 g	
Ed	free fall	3 falls onto hard wood	see notes 1 and 2
Fc	vibration	frequency 10-500-10 Hz; acceleration 10 g; 3 directions; 30 minutes per direction	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Na	temperature cycling test	–40 to +85 °C; 10 cycles; 6 minutes per cycle	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
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	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Ub	bending of terminations	1 x 90 °; load 5 N	no visible damage

Notes

1. Fall height (fundamental mode):
750 mm for the frequency range from 2.40 to 7.5 MHz
500 mm for the frequency range from 7.51 to 10.0 MHz
250 mm for the frequency range from 10.10 to 27.0 MHz.

2. Fall height (third overtone):
500 mm for the frequency range from 24.00 to 30.0 MHz
250 mm for the frequency range from 30.10 to 75.0 MHz

SOLVENT RESISTANCE TESTS

Procedure: in accordance with IEC 68-2-45 (XA) and IEC 653; immersion time 5 minutes.

Severity 1	At ambient temperature, at boiling temperature, in vapour of boiling solvent and ultrasonic (40 kHz)
Severity 2	At ambient temperature and ultrasonic (40 kHz)
Solvents for severity 1	Mixtures of 1.1.2-trichloro - 1.2.2-trifluoroethane (fluorocarbon 113 or Freon TF) and the following solvents in the respective mass percentage ratios of these solvents to fluorocarbon 113: 2-propanol (isopropanol), 30% : 70% up to 55% : 45% (Freon TP55) methanol and nitromethane, 5.7% : 0.3% : 94% (Freon TMS)
Solvents for severity 2	Bio-Act EC7 Neutropon P3 and Saxin P3 Lonco 446 Isopropanol cleaning solvent.

9922 520 1 series

Quartz crystals in HC-49/U9 holder, standard applications

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 a high mechanical stability and low height. The quartz design yields low resistance and high pullability values. These units are mass produced on an automated production line which guarantees a very high level of uniformity and reliability.

Note: Special types are available on request.

STANDARD MARKING

- PHILIPS (PH)
- Frequency
- Last five digits of catalogue number; manufacturing date code (last three digits of week code).

QUICK REFERENCE DATA

Mass, typical value	1.1 g
Frequency range fundamental mode third overtone	 9000 to 27 000 kHz 24 000 to 75 000 kHz

FAMILY DATA

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
T_{op}	operable temperature range	–40	155	°C
R_{ins}	insulation resistance DC test voltage = 100 V	500	–	MΩ

PACKING

HC-49/U9 holder; standard applications

STYLE	PACKAGING	QUANTITY
style 1 unit	boxes	1000 pieces per box
style 2 unit	taped on reel taped on reel in ammopack	1000 pieces per reel 1000 pieces per ammopack
style 3 unit	taped on reel taped on reel in ammopack	1000 pieces per reel 1000 pieces per ammopack
style 4 unit	tray in box	100 pieces per tray
style 5 unit	tray in box	100 pieces per tray
style 6 unit	tray in box	100 pieces per tray
style 7 unit	tray in box	100 pieces per tray

CHARACTERISTICS PER CRYSTAL: FUNDAMENTAL MODE

Measured at +25 ±2 °C at a drive level of 0.25 mW into 25 Ω unless otherwise specified. Measuring system: π-network in accordance with IEC 444.

CATALOGUE NUMBER	f_n (kHz)	C_L (pF)	T_o (°C)	$\Delta f/f_n$ ($\times 10^{-6}$)	$\Delta f/f_{25}$ ($\times 10^{-6}$)	R_{rT} (Ω)	R_{r25} (Ω)	R_{dld} (Ω)	C_1 (fF)	C_0 (pF)	WL (mm)
9922 520 10001	18 432.000	20	0/+70	±40	±30	25	–	–	25.0	7.0	13.2

Key to symbols

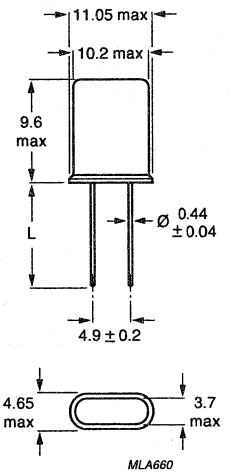
f_n	Nominal frequency
T_o	Operating temperature range
$\Delta f/f_n$	Adjustment tolerance at 25 °C
$\Delta f/f_{25}$	Frequency stability over temperature range, with respect to the frequency at 25 °C
C_L	Load capacitance
R_{rT}	Resonance resistance over the operating temperature range, maximum value, measured in series resonance
R_{r25}	Resonance resistance at 25 °C, maximum value, measured in series resonance
R_{dld}	Drive level dependency (resonance resistance in the drive level range 10^{-12} to 10^{-3} W), maximum value, measured in series resonance
C_1	Motional capacitance, typical value
C_0	Parallel capacitance, typical value
WL	Wire length ±0.5 mm as indicated by dimension 'L' in Fig.1
x	Series resonance
TR	Taped on reel
TRI	Taped on reel plus insulation plate
TA	Taped on reel in ammunition pack
18	Height of component from tape = 18 mm, indicated by 'H' in Fig.2.

Derivatives

R_n Resonance resistance of unwanted response: $2 \times R_{rT}$ Ω (–6 dB), for fundamental mode

S Pulling sensitivity: $\frac{-C_1}{2(C_o + C_L)^2}$

MECHANICAL DATA

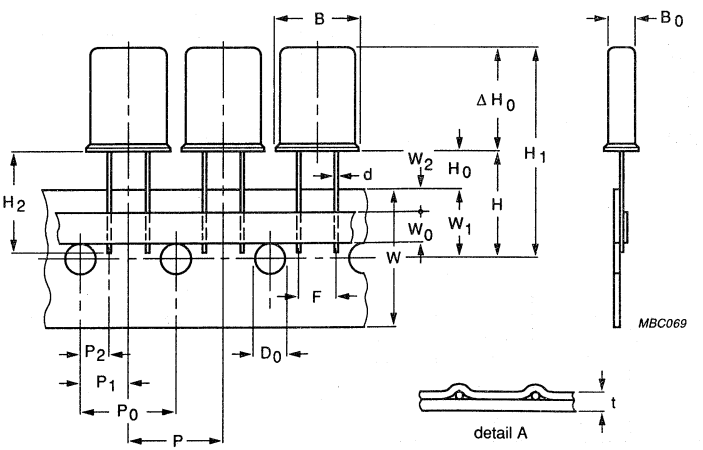


Dimensions in mm.

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

Lead length L: for values see 'L' in characteristics table.

Fig.1 Style 1 unit; standard holder for all types.

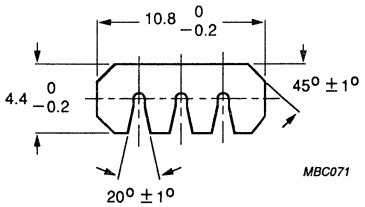


Dimensions in mm.

See Table 1 for dimensions.

Note: styles 2 and 3 units can be supplied on tape in reel and in ammopack, see Figs 8 and 9.

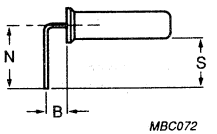
Fig.2 Style 2 and 3 units.



Dimensions in mm.

Style 3 units are supplied on tape with an insulation plate (washer) at the unit base. The washer is made of PEEK (polyetherketone), 0.25 mm thick and resistant to soldering heat test.

Fig.3 Washer outline.

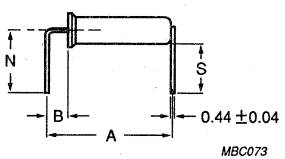


Dimensions in mm.

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

Other dimensions are as style 1.

Fig.4 Style 4 unit.

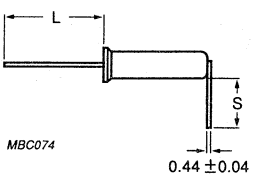


Dimensions in mm.

STYLE 5 VARIANT	S (±1.0)	N (±1.0)	B	A (±0.2)
a	3.9	5.7	1.5	11.4
b	4.1	5.9	4.1	14.0
c	8.4	10.2	3.2	12.6

Other dimensions are as style 1.

Fig.5 Style 5 unit.

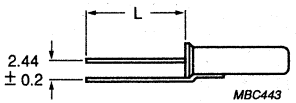


Dimensions in mm.

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

Other dimensions are as style 1.

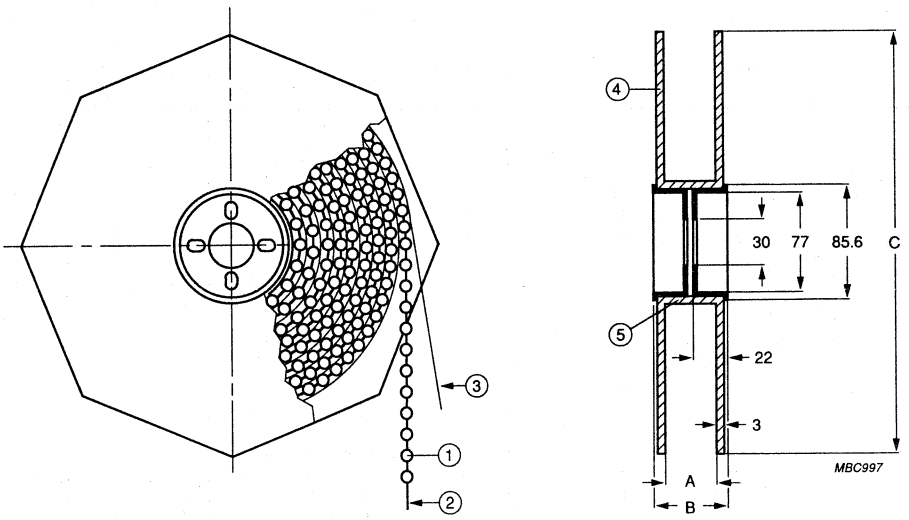
Fig.6 Style 6 unit.



Dimensions in mm.

Other dimensions as style 1.

Fig.7 Style 7 unit.

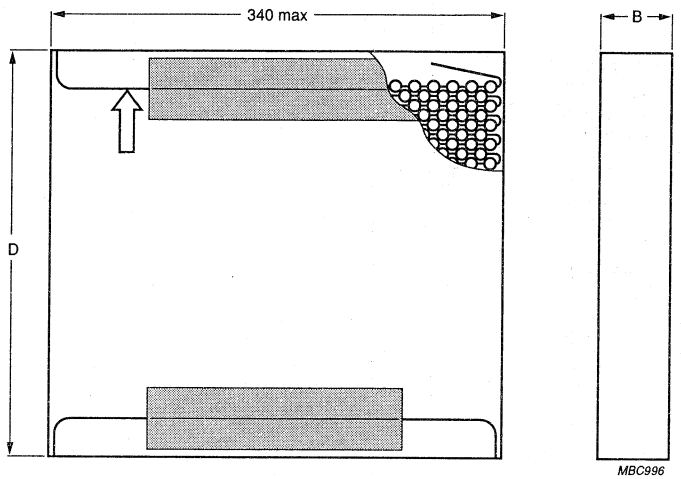


Dimensions in mm.

1 = crystal unit
2 = tape
3 = paper
4 = flange
5 = cylinder

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

Fig.8 Style 2 and 3 units supplied on tape in reel.



Dimensions in mm.

B = 50 mm max.

D = 190 mm max.

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

Table 1 Taping dimensions
HC-49/U9 holder; style 2 unit (without the washer); in accordance with IEC 286-2 recommendations.

SYMBOL	PARAMETER	VALUE	TOLERANCE	UNIT
B_o	body thickness	4.43	±0.05	mm
B	body width	10.75	±0.1	mm
Δh	component alignment vertical to tape plane	0	±2.0	mm
Δp	component alignment in tape plane	0	±1.3	mm
d	lead wire diameter	0.44	±0.04	mm
Δs	lead straightness	0	t.b.f.	–
L	length of snipped leads	t.b.f.	–	mm
F	lead-to-lead distance	4.9	–	mm
P	pitch of components	12.7	±1.0	mm
P_0	feed-hole pitch	12.7	±0.3	mm
P_2	feed-hole centre to lead distance	3.9	±0.7	mm
P_1	feed-hole centre to component centre distance	6.35	±0.3	mm
D_0	feed-hole diameter	4.0	±0.2	mm
H	distance of component from tape centre unless otherwise specified in characteristics table	16.0	+2/0	mm
H_1	maximum component height from tape centre	27.4	–	mm
ΔH_0	maximum component height	9.6	–	mm
H_0	minimum component base to tape top height	7.0	–	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	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

TESTS AND REQUIREMENTS

IEC 68-2 METHOD	TEST	PROCEDURE	REQUIREMENTS
Ba	ageing	1000 hours at +100 °C	$\Delta f/f \leq 15 \times 10^{-6}$
Db	accelerated damp heat	+25 °C to +55 °C; 6 cycles at RH >95%	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Ea	shock	100 g half sine; 6 directions; 1 blow per direction	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Eb	bump	4000 bumps of 40 g	
Ed	free fall	3 falls onto hard wood	see notes 1 and 2
Fc	vibration	frequency 10-500-10 Hz; acceleration 10 g; 3 directions; 30 minutes per direction	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Na	temperature cycling test	–40 to +85 °C; 10 cycles; 6 minutes per cycle	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
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	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Ub	bending of terminations	1 x 90°; load 5 N	no visible damage

Notes

1. Fall height (fundamental mode):
500 mm for the frequency range from 9.00 to 10.0 MHz
250 mm for the frequency range from 10.10 to 27.0 MHz.

2. Fall height (third overtone):
500 mm for the frequency range from 24.00 to 30.0 MHz
250 mm for the frequency range from 30.10 to 75.0 MHz.

SOLVENT RESISTANCE TESTS

Procedure: in accordance with IEC 68-2-45 (XA) and IEC 653; immersion time 5 minutes.

Severity 1	At ambient temperature, at boiling temperature, in vapour of boiling solvent and ultrasonic (40 kHz)
Severity 2	At ambient temperature and ultrasonic (40 kHz)
Solvents for severity 1	Mixtures of 1.1.2-trichloro - 1.2.2-trifluoroethane (fluorocarbon 113 or Freon TF) and the following solvents in the respective mass percentage ratios of these solvents to fluorocarbon 113: 2-propanol (isopropanol), 30% : 70% up to 55% : 45% (Freon TP55) methanol and nitromethane, 5.7% : 0.3% : 94% (Freon TMS)
Solvents for severity 2	Bio-Act EC7 Neutropon P3 and Saxin P3 Meta Clean 820 Lonco 446 Isopropanol cleaning solvent

9922 521 0 series

Quartz crystals in HC-45/U holder, standard applications

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 two connecting leads. The unit has a high mechanical stability and small dimensions. These units are mass produced on an automated production line which guarantees a very high level of uniformity and reliability.

Note: Special types are available on request.

STANDARD MARKING

- PHILIPS (PH)
- Frequency
- Last five digits of catalogue number; manufacturing date code (last three digits of week code).

QUICK REFERENCE DATA

Mass, typical value	0.4 g
Frequency range fundamental mode third overtone	 8000 to 24 000 kHz 24 000 to 70 000 kHz

FAMILY DATA

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
T_{op}	operable temperature range	−40	155	°C
R_{ins}	insulation resistance DC test voltage = 100 V	500	–	MΩ

PACKING

HC-45/U7 holder; standard applications

STYLE	PACKAGING	QUANTITY
style 1 unit	boxes	1000 pieces per box
style 2 unit	taped on reel taped on reel in ammopack	1000 pieces per reel 1000 pieces per ammopack
style 3 unit	taped on reel taped on reel in ammopack	1000 pieces per reel 1000 pieces per ammopack

CHARACTERISTICS PER CRYSTAL: FUNDAMENTAL MODE

Measured at +25 ±2 °C at a drive level of 0.5 mW into 25 Ω unless otherwise specified. Measuring system: π-network in accordance with IEC 444.

CATALOGUE NUMBER	f_n (kHz)	C_L (pF)	T_o (°C)	$\Delta f/f_n$ ($\times 10^{-6}$)	$\Delta f/f_{25}$ ($\times 10^{-6}$)	R_{rT} (Ω)	R_{r25} (Ω)	R_{dld} (Ω)	C_1 (fF)	C_0 (pF)	WL (mm)
9922 521 00006	8 000.000	x	0/+70	±40	±30	220			4.0	1.4	2.6
9922 521 00085	8 000.000	12	0/+70	±40	±30	220			4.0	1.4	2.6
9922 521 00056	9 594.000	x	0/+70	±40	±30	160			5.0	1.6	2.6
9922 521 00035	9 600.000	x	0/+70	±40	±30	160			5.0	1.6	2.6
9922 521 00086	9 600.000	14	0/+70	±40	±30	160			5.0	1.6	2.6
9922 521 00023	9 830.400	x	0/+70	±40	±30	150	100	150	5.5	1.6	2.6
9922 521 00087	9 830.400	14	0/+70	±40	±30	150			5.5	1.6	2.6
9922 521 00007	10 000.000	x	0/+70	±40	±30	150	75	100	5.5	1.6	2.6
9922 521 00088	10 000.000	14	0/+70	±40	±30	150			5.5	1.6	2.6
9922 521 00072	10 000.000	20	0/+70	±40	±30	150			5.5	1.6	20.0
9922 521 00028	10 137.600	x	0/+70	±40	±30	150			5.5	1.6	2.6
9922 521 00089	10 137.600	14	0/+70	±40	±30	150			5.5	1.6	2.6
9922 521 00105	10 240.000	20	0/+70	±40	±30	150	100	100	5.5	1.7	20.0
9922 521 00008	12 000.000	x	0/+70	±40	±30	100			6.5	1.9	2.6
9922 521 00091	12 000.000	14	0/+70	±40	±30	100			6.5	1.9	2.6
9922 521 00074	12 000.000	20	0/+70	±40	±30	100			6.5	1.9	20.0
9922 521 00018	12 000.000	30	0/+70	±50	±30	100			6.5	1.9	20.0
9922 521 00025	12 272.700	x	0/+70	±40	±30	100			6.5	1.9	2.6
9922 521 00092	12 272.700	14	0/+70	±40	±30	100			6.5	1.9	2.6
9922 521 00075	12 272.700	20	0/+70	±40	±30	100			6.5	1.9	20.0
9922 521 00019	12 288.000	x	0/+70	±40	±30	100			6.5	1.9	2.6
9922 521 00093	12 288.000	14	0/+70	±40	±30	100			6.5	1.9	2.6
9922 521 00076	12 288.000	20	0/+70	±40	±30	100			6.5	1.9	20.0
9922 521 00034	14 200.000	x	0/+70	±40	±30	70			7.5	2.1	2.6
9922 521 00094	14 200.000	10	0/+70	±40	±30	70			7.5	2.1	2.6
9922 521 00022	14 745.600	x	0/+70	±40	±30	65	40	60	8.0	2.2	2.6
9922 521 00095	14 745.600	10	0/+70	±40	±30	65			8.0	2.2	2.6
9922 521 00126	14 745.600	12	0/+70	±40	±30	60	40	60	8.0	2.1	2.6
9922 521 00027	15 206.400	x	0/+70	±40	±30	60			8.0	2.3	2.6
9922 521 00026	15 667.200	x	0/+70	±40	±30	55			8.0	2.3	2.6
9922 521 00057	15 667.200	10	0/+70	±40	±30	55			8.0	2.3	2.6
9922 521 00009	16 000.000	x	0/+70	±20	±30	55	75	100	8.0	2.4	2.6
9922 521 00021	16 000.000	10	0/+70	±40	±30	55			8.0	2.4	2.6
9922 521 00011	20 000.000	x	0/+70	±40	±30	45			9.5	2.9	2.6
9922 521 00097	20 000.000	10	0/+70	±40	±30	45			9.5	2.9	2.6

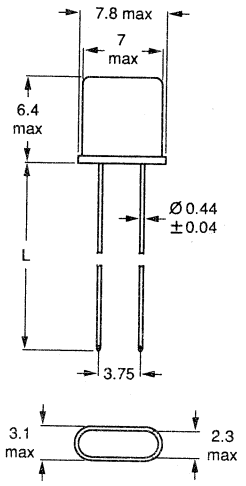
Key to symbols

f_n	Nominal frequency
T_o	Operating temperature range
$\Delta f/f_n$	Adjustment tolerance at 25 °C
$\Delta f/f_{25}$	Frequency stability over temperature range, with respect to the frequency at 25 °C
C_L	Load capacitance
R_{rT}	Resonance resistance over the operating temperature range, maximum value, measured in series resonance
R_{r25}	Resonance resistance at 25 °C, maximum value, measured in series resonance
R_{dld}	Drive level dependency (resonance resistance in the drive level range 10^{-12} to 10^{-3} W), maximum value, measured in series resonance
C_1	Motional capacitance, typical value
C_0	Parallel capacitance, typical value
WL	Wire length ±0.2 mm as indicated by dimension 'L' in Fig.1. Types with L = 2.6 mm are not marked
x	Series resonance
TR	Taped on reel
TRI	Taped on reel plus insulation plate
TA	Taped on reel in ammunition pack.

Derivatives

R_n	Resonance resistance of unwanted response: $2 \times R_{rT}$ Ω (–6 dB), for fundamental mode
S	Pulling sensitivity: $\frac{-C_1}{2(C_o + C_L)^2}$ (see Fig.7)

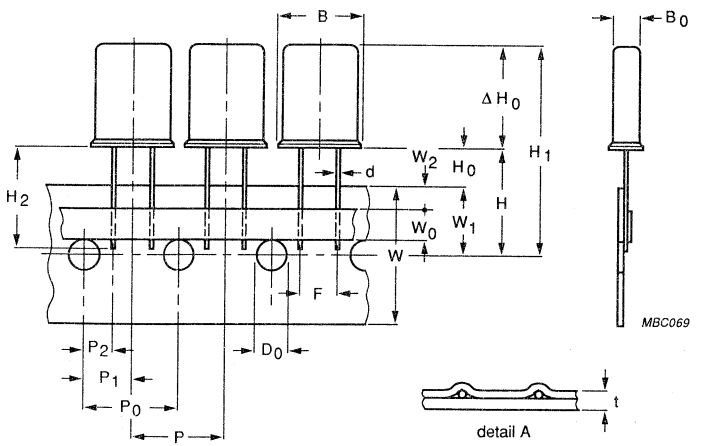
MECHANICAL DATA



Dimensions in mm.

Lead length L: for values see 'L' in characteristics table.

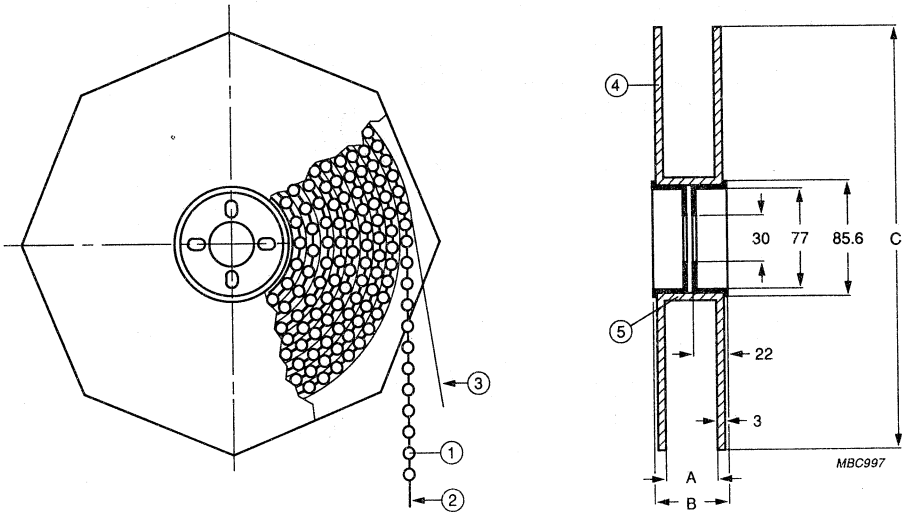
Fig.1 Style 1 unit.



See Table 1 for dimensions.

Note: styles 2 and 3 units can be supplied on tape in reel and in ammopack, see Figs 3 and 4.

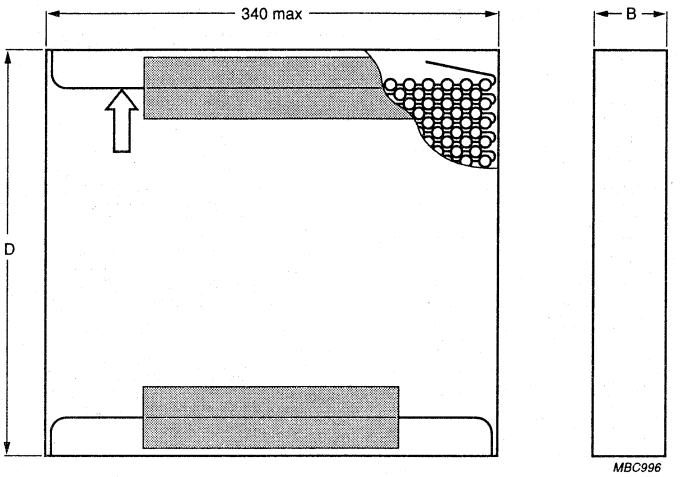
Fig.2 Style 2 and 3 units.



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.

Fig.3 Style 2 and 3 units supplied on tape in reel.

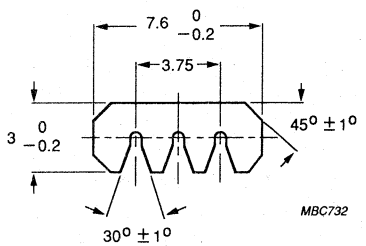


Dimensions in mm.

B = 55 mm max.

D = 185 mm max.

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



Dimensions in mm.

Style 3 units are supplied on tape with an insulation plate (washer) at the unit base. The washer is made of PEEK (polyetherketone), 0.25 mm thick and resistant to soldering heat test.

Fig.5 Washer outline.

Table 1 Taping dimensions
HC-45/U holder; style 2 unit (without the washer); in accordance with IEC 286-2 recommendations.

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	±2.0	mm
Δp	component alignment in tape plane	0	±1.3	mm
d	lead wire diameter	0.44	±0.04	mm
Δs	lead straightness	t.b.f.	–	–
L	length of snipped leads	t.b.f.	–	–
F	lead-to-lead distance	3.75	–	mm
P	pitch of components	12.7	±1.0	mm
P_0	feed-hole pitch	12.7	±0.3	mm
P_2	feed-hole centre to lead distance	4.47	±0.7	mm
P_1	feed-hole centre to component centre distance	6.35	±0.3	mm
D_0	feed-hole diameter	4.0	±0.2	mm
H	distance of component from tape centre unless otherwise specified in characteristics table	18.0	+2/0	mm
H_1	maximum component height from tape centre	25.7	–	mm
ΔH_0	maximum component height	6.4	–	mm
H_0	minimum component base to tape top height	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	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

TESTS AND REQUIREMENTS

IEC 68-2 METHOD	TEST	PROCEDURE	REQUIREMENTS
Ba	ageing	1000 hours at +70 °C	$\Delta f/f \leq 5 \times 10^{-6}$
Db	accelerated damp heat	+25 °C to +55 °C; 6 cycles at RH >95%	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Ea	shock	100 g half sine; 6 directions; 1 blow per direction	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Eb	bump	4000 bumps of 40 g	
Ed	free fall	3 falls onto hard wood	see notes 1 and 2
Fc	vibration	frequency 10-500-10 Hz; acceleration 10 g; 3 directions; 30 minutes per direction	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Na	temperature cycling test	–40 to +85 °C; 10 cycles; 6 minutes per cycle	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
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	$\Delta f/f \leq 5 \times 10^{-6}$ $\Delta R_r \leq 20\%$
Ub	bending of terminations	1 x 90°; load 5 N	no visible damage

Notes

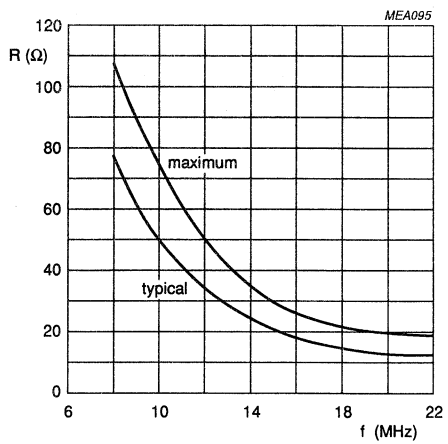
1. Fall height (fundamental mode):
750 mm for the frequency range from 8.0 to 16.0 MHz
500 mm for the frequency range from 16.1 to 24.0 MHz.

2. Fall height (third overtone):
750 mm for the frequency range from 24.0 to 48.0 MHz
500 mm for the frequency range from 48.1 to 70.0 MHz.

SOLVENT RESISTANCE TESTS

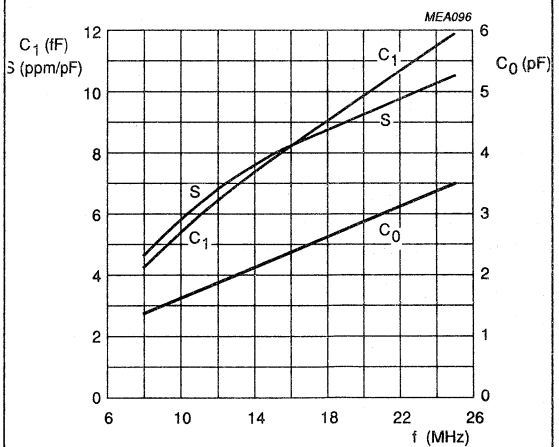
Procedure: in accordance with IEC 68-2-45 (XA) and IEC 653; immersion time 5 minutes.

Severity 1	At ambient temperature, at boiling temperature, in vapour of boiling solvent, and ultrasonic (40 kHz)
Severity 2	At ambient temperature and ultrasonic (40 kHz)
Solvents for severity 1	Mixtures of 1.1.2-trichloro - 1.2.2-trifluoroethane (fluorocarbon 113 or Freon TF) and the following solvents in the respective mass percentage ratios of these solvents to fluorocarbon 113: 2-propanol (isopropanol), 30% : 70% up to 55% : 45% (Freon TP55) methanol and nitromethane, 5.7% : 0.3% : 94% (Freon TMS)
Solvents for severity 2	Bio-Act EC7 Neutropon P3 and Saxin P3 Meta Clean 820 Lonco 446 Isopropanol cleaning solvent



For HC-45/U standard crystals.

Fig.6 Resonance resistance R, at 25 °C as a function of resonance frequency.



For HC-45/U standard crystals.

Typical values at 25 °C.

Fig.7 Motional capacitance C_1, parallel capacitance C_0 and pulling sensitivity S (assuming C_L = 20 pF) as a function of resonance frequency.

NOTES

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Data handbook system

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