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Book C9 1986

Piezoelectric quartz devices

PIEZOELECTRIC QUARTZ DEVICES

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T12 **Vidicon and Newvicon camera tubes**

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S13 **Semiconductor sensors**

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The purple series of data handbooks comprises:

EXISTING SERIES		Superseded by:
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IC2	**Bipolar ICs for video equipment**	IC02Na and IC02Nb
IC3	**ICs for digital systems in radio, audio and video equipment**	IC01N, IC02Na and IC02Nb
IC4	**Digital integrated circuits** CMOS HE4000B family	
IC5	**Digital integrated circuits — ECL** ECL10 000 (GX family), ECL100 000 (HX family), dedicated designs	IC08N
IC6	**Professional analogue integrated circuits**	IC03N and Supplement to IC11N
IC7	**Signetics bipolar memories**	
IC8	**Signetics analogue circuits**	IC11N
IC9	**Signetics TTL logic**	IC09N and IC15N
IC10	**Signetics Integrated Fuse Logic (IFL)**	IC13N
IC11	**Microprocessors, microcomputers and peripheral circuitry**	IC14N

NEW SERIES

IC01N	**Radio, audio and associated systems** Bipolar, MOS	(published 1985)
IC02Na	**Video and associated systems** Bipolar, MOS Types MAB8031AH to TDA1524A	(published 1985)
IC02Nb	**Video and associated systems** Bipolar, MOS Types TDA2501 to TEA1002	(published 1985)
IC03N	**Integrated circuits for telephony**	(published 1985)
IC04N	**HE4000B logic family** CMOS	
IC05N	**HE4000B logic family – incased ICs** CMOS	(published 1984)
IC06N*	**High-speed CMOS; PC74HC/HCT/HCU** Logic family	(published 1986)
IC07N	**High-speed CMOS; PC54/74HC/HCT/HCU – uncased ICs** Logic family	
IC08N	**ECL 10K and 100K logic families**	(published 1984)
IC09N	**TTL logic series**	(published 1984)
IC10N	**Memories** MOS, TTL, ECL	
IC11N	**Linear LSI**	(published 1985)
Supplement to IC11N	**Linear LSI**	(published 1986)
IC12N	**Semi-custom gate arrays & cell libraries** ISL, ECL, CMOS	
IC13N	**Semi-custom** Integrated Fuse Logic	(published 1985)
IC14N	**Microprocessors, microcontrollers & peripherals** Bipolar, MOS	(published 1985)
IC15N	**FAST TTL logic series**	(published 1984)

Note

Books available in the new series are shown with their date of publication.

* Supersedes the IC06N 1985 edition and the Supplement to IC06N issued Autumn 1985.

COMPONENTS AND MATERIALS (GREEN SERIES)

The green series of data handbooks comprises:

C1	**Programmable controller modules** PLC modules, PC20 modules
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C3	**Loudspeakers**
C4	**Ferroxcube potcores, square cores and cross cores**
C5	**Ferroxcube for power, audio/video and accelerators**
C6	**Synchronous motors and gearboxes**
C7	**Variable capacitors**
C8	**Variable mains transformers**
C9	**Piezoelectric quartz devices**
C10	**Connectors**
C11	**Varistors, thermistors and sensors**
C12	**Potentiometers, encoders and switches**
C13	**Fixed resistors**
C14	**Electrolytic and solid capacitors**
C15	**Ceramic capacitors**
C16	**Permanent magnet materials**
C17	**Stepping motors and associated electronics**
C18	**Direct current motors**
C19	**Piezoelectric ceramics**
C20	**Wire-wound components for TVs and monitors**
C21*	**Assemblies for industrial use** HNIL FZ/30 series, NORbits 60-, 61-, 90-series, input devices
C22	**Film capacitors**

* To be issued shortly.

QUARTZ CRYSTAL UNITS, GENERAL

SURVEY OF TYPES

See p.32 for additional details

Table 1
Specifications of quartz crystal units in RW-43 holder; economy range.

catalogue number 4322 143	frequency range kHz	typical application
04033	4782,720	general purpose
04043	4433,619	video
04051	8867,238	video
04083	4194,304	clock
04093	4000,000	digital tuners
04101	6000,000	teletext, VCR
04111	4500,000	video
04121	4531,468	video
04132	4905,021	video
04141	4915,200	record player
04151	5000,000	cameras
04161	5120,000	car radio
04171	7151,223	CTV (subcarrier)
04181	7159,090	CTV (subcarrier)
04191	7164,112	CTV (subcarrier)
04201	4915,200	video
04222	8867,238	video
04252	4433,619	VCR
04261	4000,000	video
04271	4000,000	video
04282	4433,619	video
04291	4782,720	two-tone dialling
04301	8000,000	general purpose
04311	6400,000	general purpose
04321	6144,000	microprocessor
04331	5068,800	general purpose
04341	4608,000	general purpose
04351	4406,250	general purpose
04361	4250,000	video
04371	3686,400	general purpose
04381	3582,056	video
04391	3579,545	video
04401	3579,545	two-tone dialling
04411	3000,000	automotive
04421	3276,800	general purpose
04431	3750,000	VLP
04441	3840,000	general purpose
04451	5068,800	general purpose
04461	4233,600	compact disc

catalogue number 4322 143	frequency range kHz	typical application
04471	4194,304	automotive, Hi Rel
04481	3997,696	general purpose
04491	3547,000	video games
04521	5911,000	video games
04532	6000,000	video
04541	5068,800	general purpose
04551	3686,400	general purpose
04561	4233,600	compact disc
04571	3440,000	general purpose
04582	6000,000	temperature sensing
04591	6041,957	teletext, USA
04601	4905,021	general purpose
04611	9830,400	microprocessor
04621	10000,000	automotive, Hi Rel
04631	12000,000	automotive, Hi Rel
04670	3932,160*	automotive, Hi Rel
04680	3000,000*	automotive, Hi Rel
04690	3640,890*	automotive, Hi Rel
04700	4096,000*	automotive, Hi Rel
04710	6000,000	automotive, Hi Rel
04721	8000,000	automotive, Hi Rel
04731	8867,238	automotive
04741	11000,000	automotive, Hi Rel
04751	5120,000	car radio
04761	3440,000	general purpose
04771	4096,000	general purpose
04781	4865,000	general purpose
04791	7000,000	general purpose
04810	5760,000*	automotive
04821	8388,608	automotive, Hi Rel
04830	6000,000*	automotive
04840	4000,000*	automotive
04850	3276,800*	automotive
04860	3000,000*	automotive
04872	4435,571	general purpose
04881	4000,000	general purpose
04891	13875,000	computer coded teletext
04911	3439,593	automotive
04921	11059,000	CD-ROM
04931	11059,200	teletext
04941	11000,000	automotive
04951	7372,800	automotive, Hi Rel
04961	13875,000	teletext
04971	10000,000	automotive, Hi Rel
04981	6000,000*	compact disc
05031	11289,600	compact disc

* Development types.

AT-cut quartz crystals for general frequency stabilization.

mode of vibration	frequency range MHz	holder			catalogue number	page
		type	housing	connections		
funda-metal	3 to 10	RW-10	resistance welded	leads	4322 148	48
funda-mental	3 to 20	RW-43	resistance welded	pins	4322 144	44
funda-mental	1 to 1,8	HC-6/U	solder sealed	pins	4322 152	54
	1,8 to 25	HC-27/U	all-glass	pins	4322 154	56
		HC-27 ext.	all-glass	pins	4322 154	56
		HC-33/U	solder sealed	pins	4322 149	50
		RW-36	resistance welded	pins	4322 149	50
	4,5 to 25	HC-26/U	all-glass	leads	4322 155	60
		HC-29/U	all-glass	pins	4322 155	60
		RW-42	resistance welded	pins	4322 156	63
		RW-43	resistance welded	leads	4322 156	63
third overtone	10 to 75	HC-27/U	all-glass	pins	4322 159	64
		HC-33/U	solder sealed	pins	4322 162	68
		RW-36	resistance welded	pins	4322 162	68
	17 to 75	RW-42	resistance welded	pins	4322 161	67
		RW-43	resistance welded	leads	4322 161	67
	20 to 75	HC-26/U	all-glass	leads	4322 160	66
		HC-29/U	all-glass	pins	4322 160	66
fifth overtone	50 to 125	HC-26/U	all-glass	leads	4322 166	70
		HC-27/U	all-glass	pins	4322 165	69
		HC-29/U	all-glass	pins	4322 166	70
		HC-33/U	solder sealed	pins	4322 168	72
		RW-36	resistance welded	pins	4322 168	72
		RW-42	resistance welded	pins	4322 167	71
		RW-43	resistance welded	leads	4322 167	71

Special types

funda-mental	1	HC-6/U	solder sealed	pins	4322 152 01241	55
	6,144	TO-39	resistance welded	leads	4322 150 00011	53
	21,480	RW-80	resistance welded	leads	4322 145 00011	46
third overtone	10 MHz high precision	HC-27/U	all-glass	pins	4322 159 00001	65

7th, 9th and 11th overtone crystals up to 250 MHz are available upon request.

INTRODUCTION

A quartz crystal unit consists of a quartz crystal element with electrodes, mounted in an hermetically sealed enclosure with connecting pins or leads.

The quartz crystal element is a vibrating resonant plate which relies upon the piezoelectric effect to couple it to electrical circuits. The intrinsic properties of quartz make it a unique device for accurate and stable frequency control and selection. Although the properties of quartz (T.C., ageing, high Q-factor) are very stable, the ultimate performance of the element is largeley dependent on the environment and the associated electrical circuits. We strongly advise that a particular application be discussed with the crystal manufacturer at the earliest stage in any design.

Crystal elements are normally cut in the form of plates or bars. 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 herewith is from 1 to 250 MHz. A practical range is from 1,8 to 125 MHz. The crystal element may vibrate in the frequency of a fundamental mode of vibration or in the third, fifth or higher overtone.
Several cuts specially for digital temperature measurements are applied as temperature sensors.

Note

All dimensional drawings are in mm unless otherwise indicated.

TERMS AND DEFINITIONS

in accordance with IEC 122-1

Resonance frequency f_r

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

Anti-resonance frequency f_a

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

Load resonance frequency f_L

One of the two frequencies of a crystal unit in association with a series or with a 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. 2). 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 crystal unit.

Working frequency f_w

The operational frequency of the crystal unit 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 refe- rance temperature.

Tolerance due to level of drive variation

The permissible deviation due to the variation of level of drive.

Operating temperature range

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

Operable temperature range

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

Reference temperature

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

Resonance resistance R_r

The resistance of the crystal unit alone at the resonance frequency f_r.

Load resonance resistance R_L

The resistance of the crystal unit 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 crystal unit expressed in terms of power dissipated.

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

Unwanted response

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 crystal unit which determines the load resonance frequency f_L.

Ageing (long-term parameter variation)

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

Note: Such parameter variation is due to long-term changes in the crystal unit 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 in the motional (series) arm of the equivalent circuit.

ELECTRICAL PROPERTIES AND BEHAVIOUR

CRYSTAL UNIT EQUIVALENT CIRCUIT

The equivalent circuit, which has the same impedance as the unit 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. 1).

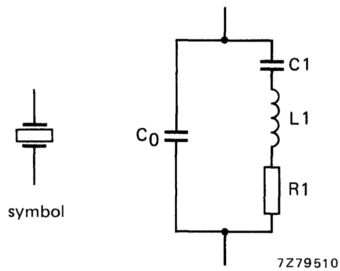


Fig. 1 Crystal unit equivalent circuit.

The parameters of the series branch are termed the "motional parameters" of the crystal unit. 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 $R_1 \ll \frac{1}{\omega C_0}$ the following relations hold:

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

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

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

LOAD CAPACITANCE AND FREQUENCY PULLING

During manufacture, definable limits are set to the accuracy of frequency. In an oscillator, a load capacitance C_L is required to trim the working frequency f_w to the nominal frequency f_n. Figure 2 shows the crystal unit equivalent circuit with a load capacitance in series and in 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 capacitance is connected in series and the higher, when it is connected in parallel are termed "load resonance frequencies f_L". At the frequency f_L the resistance of the combination with the load capacitance in series is termed "load resonance resistance R_L".
For $R_1 \ll 1/\omega C_0$:

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

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

For a given value of C_L the load resonance frequencies of the series and the parallel combinations are identical.
In practice, however, the parallel combination shown in Fig. 2c rarely occurs in an oscillator.
From equation (4) two second parameters of vital concern can be derived: the difference between load resonance frequency f_L and resonance frequency f_r, "Δf", and the relative change in frequency as a function of the change in load capacitance, termed "pulling sensitivity S".

"Δf"

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

with f_L from equation (4)

$$\Delta f = ½ f_r \frac{C_1}{C_0 + C_L} - \frac{\Delta f^2}{2 f_s} \qquad (7)$$

and to a close approximation

$$\boxed{\Delta f = ½ f_r \frac{C_1}{C_0 + C_L}} \qquad (8)$$

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

$$R_{L\,par} = \frac{1}{R_1 . \omega_r^2 (C_0 + C_L)^2}$$

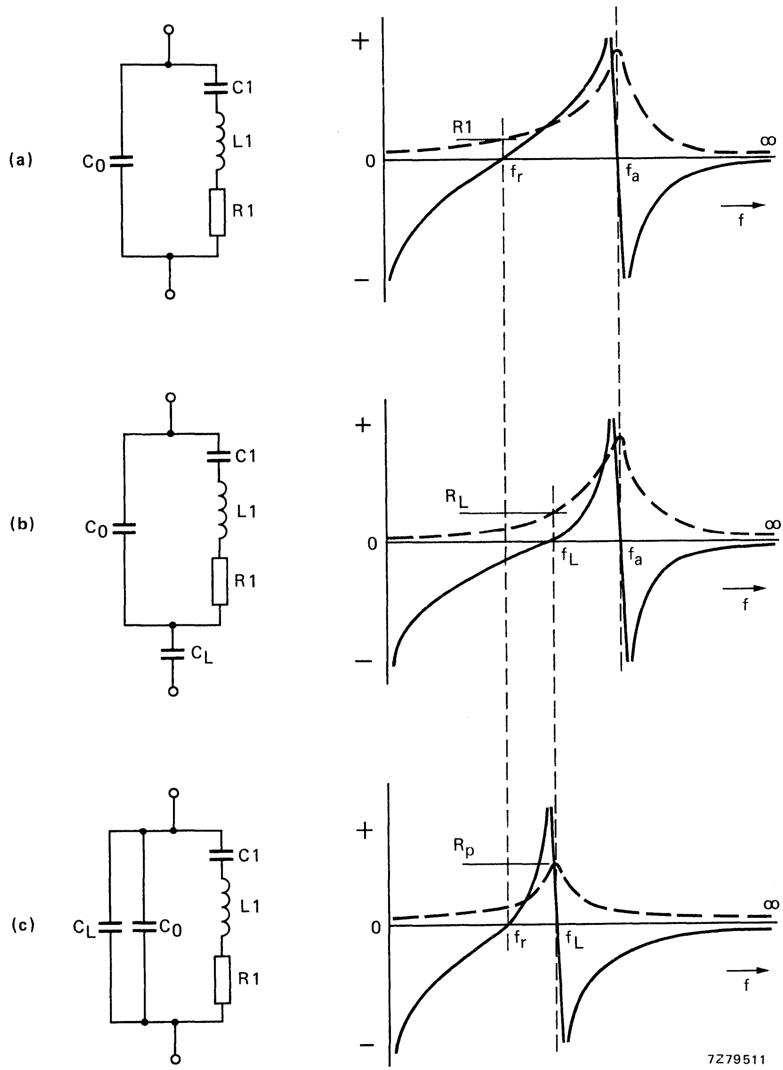


Fig. 2 Resonance, anti-resonance and load resonance frequency.
——— reactance
– – – resistance

Pulling sensitivity S

$$S = \frac{1}{f_L} \left(\frac{\delta f}{\delta C_L}\right)_{f = f_L} = + \frac{1}{f_L} \cdot \frac{\delta \Delta f}{\delta C_L}$$

with Δf from equation (8)

$$S = -\frac{1}{2} f_r \frac{C1}{(C_0 + C_L)^2} \cdot \frac{1}{f_L} \qquad (9)$$

and to a close approximation

$$\boxed{S = -\frac{C1}{2(C_0 + C_L)^2}} \qquad (10)$$

Standard values of load capacitance

The standard values of load capacitance for crystal units operating at the fundamental frequency of the mode are:

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

Note that in some countries 32 pF is still in use, but this value should not be considered as 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 crystal units.

Overtone 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.

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 3 illustrates Δf and the pulling sensitivity S as a function of the load capacitance, for two quartz crystals having different C_1 values. It should be noted that a tolerance of ½ pF on a 20 pF load capacitance may lead to an error of $\pm 11.10^{-6}$.

Crystal (a)	Crystal (b)
f_r = 10 000,000 kHz	f_r = 10 000,000 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 = 10 005,600 kHz	f_L = 10 001,273 kHz
S = $-22{,}4.10^{-6}$/pF	S = $-5{,}79.10^{-6}$/pF

Specified, or in special cases, measured Δf and S, as given for crystal (a) in Table 1, offer a simple direct guidance.

Table 1

nominal frequency $f_n = f_L$	10 000,000 kHz	
nominal load capacitance C_L	20 pF	
	specified	measured
Δf	5,600 kHz	5,700 kHz
pulling sensitivity S	$-22 \pm 2 \times 10^{-6}$/pF	$-22{,}4 \times 10^{-6}$/pF

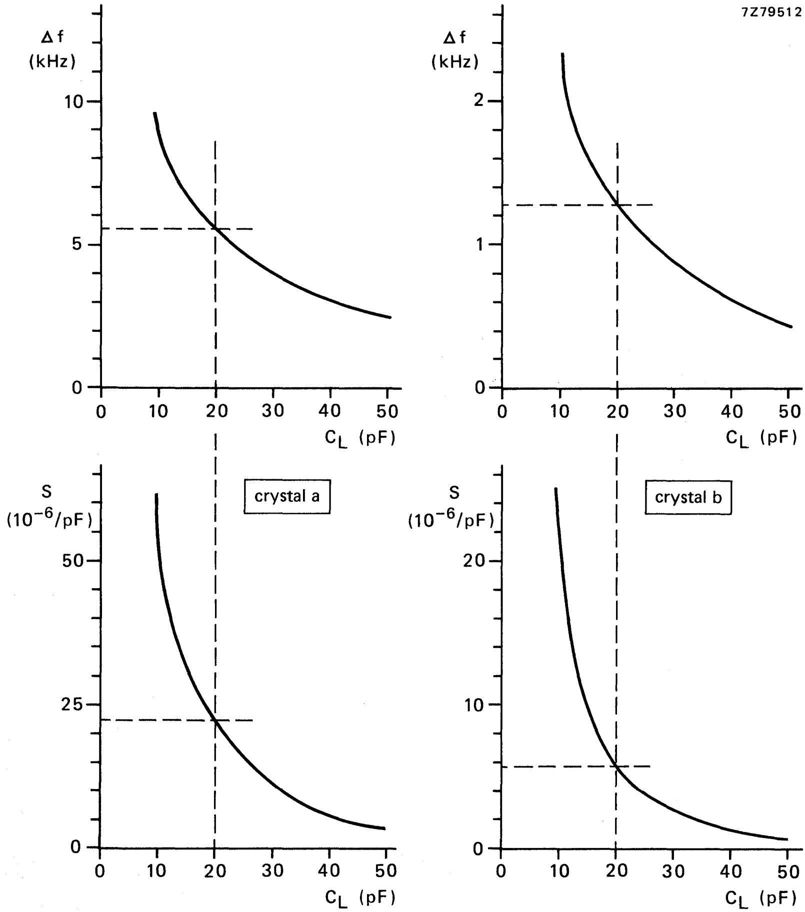


Fig. 3. Δf and pulling sensitivity as a function of the load capacitance. Tolerances on the parameters f_r, C_0 and C_1 are required for calculating the "Δf" and the "pullability at f_n".

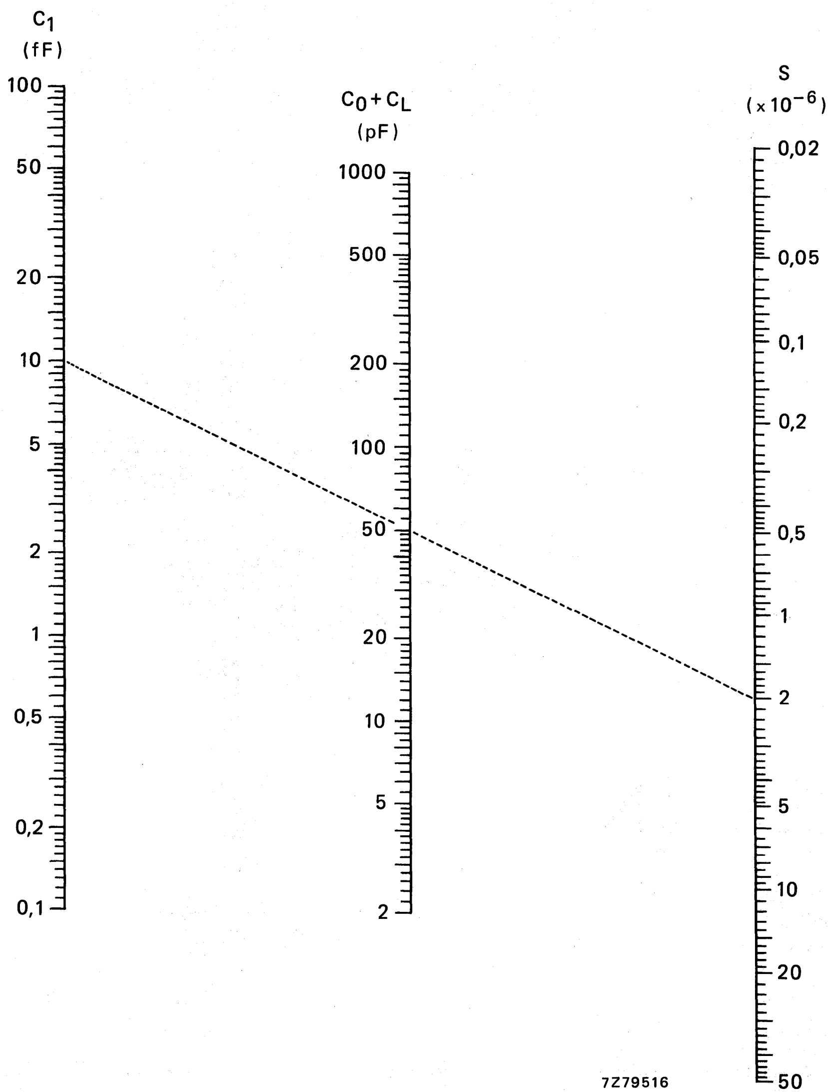


Fig. 4 Nomogram enabling the determination of the pulling sensitivity S.

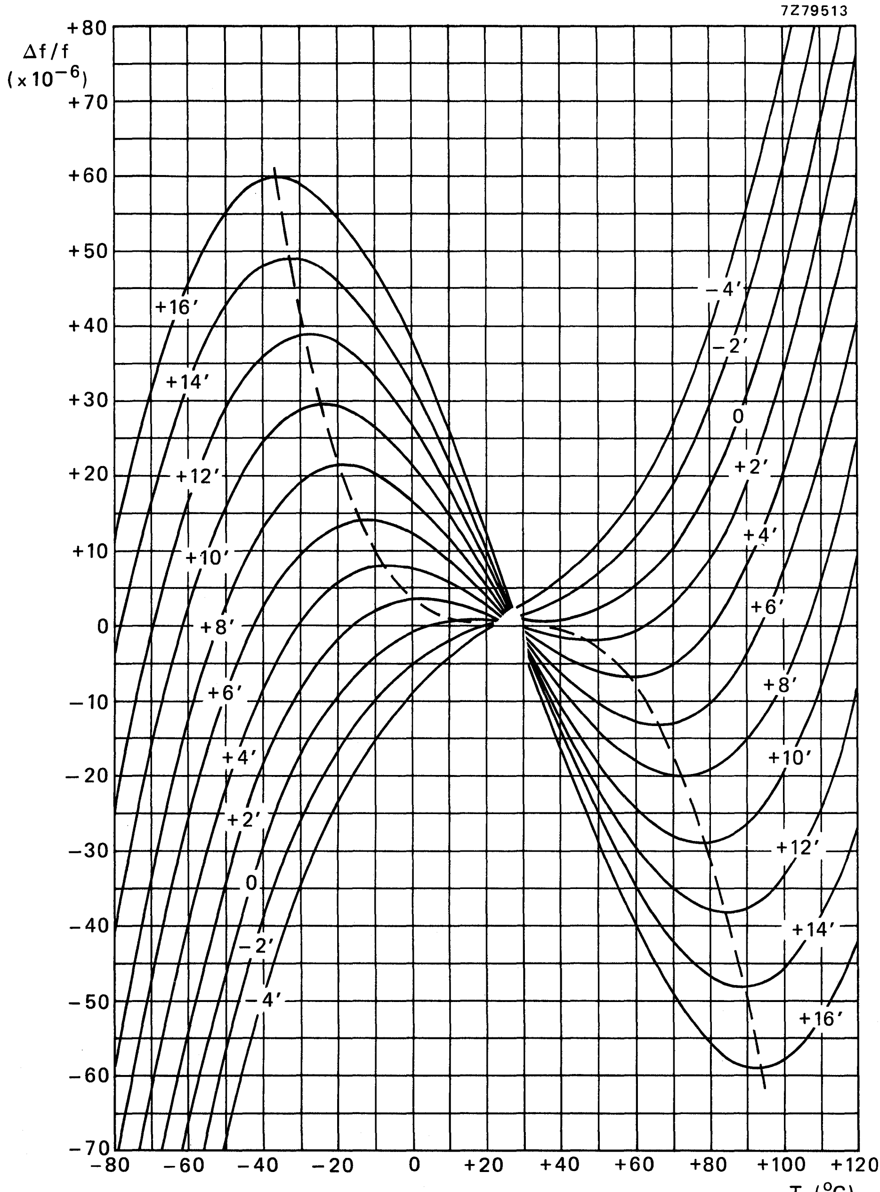


Fig. 5 Frequency/temperature characteristics of a special crystal design.

LEVEL OF DRIVE

The power dissipated in a crystal unit 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 unit characteristics is almost negligible. For drive level greater than approximately 0,5 mW, the crystal unit characteristics tend to change. For this reason the crystal unit characteristics are specified at a level of drive of 0,5 mW.

Low drive levels

When a 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 crystal unit, 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 crystal oscillator should, therefore, → have sufficient loop gain to avoid start-up problems. As a rule of thumb, a negative resistance of twice 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 greater that 0,5 mW should be avoided, and excessively high drive levels (greater than say 5 mW) may seriously affect the crystal's behaviour.

FREQUENCY/TEMPERATURE CHARACTERISTICS

The frequency drift as a function of temperature can be represented by a graph, the T.C. 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 the other cuts is parabolic.

Figure 5 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 27 °C, and it is not possible to shift this point. 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 quite steep temperature coefficient at room temperature.

It will be evident that, for AT-cut crystals, the angle of cut and its accuracy are decisive for the frequency drift over a given temperature range.

ADVANTAGES OF ALL-GLASS HOLDERS

Crystal units with all-glass holders show the following advantages over those with metal holders:

(a) a lower series resistance, which also means a higher Q-factor, thanks to the fact that glass holders are evacuated giving less mechanical damping;

(b) better performance under adverse climatic conditions;

(c) a higher frequency stability.

AGEING

A non-reversible, mostly gradual change with time in resonance frequency 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) crystal units having an all-glass holder are preferred to those having a metal holder;

(b) low frequency crystals are favourable preferred to high frequency crystals having the same crystal cut;

(c) overtone crystals are preferred to fundamental crystals for the same frequency (or fifth overtone compared with third overtone crystals).

CRYSTAL BEHAVIOUR IN AN OSCILLATOR

In the vicinity of resonance the impedance of a quartz crystal unit can be represented by a circle (see Fig. 6). 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 unit 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

$$f_a - f_r \approx \frac{C_1}{2C_0} \cdot f_r \cdot \frac{C_L}{C_0 + C_L}$$

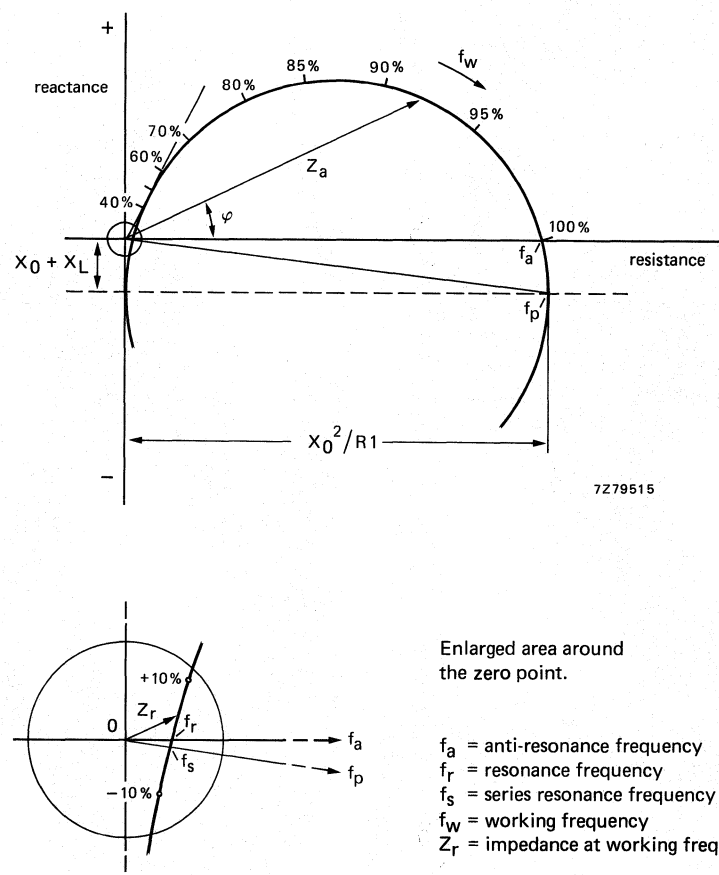
is assumed to be 100%.

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

Quartz crystal units 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.



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. 6 Working frequency and impedance of a quartz crystal unit in the impedance diagram.

Indications for use

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

Ensure that amplification is sufficiently high, in particular when applying phase variation.

Keep crystal unit drive level low (generally ⩽ 0,5 mW), see Fig. 7.

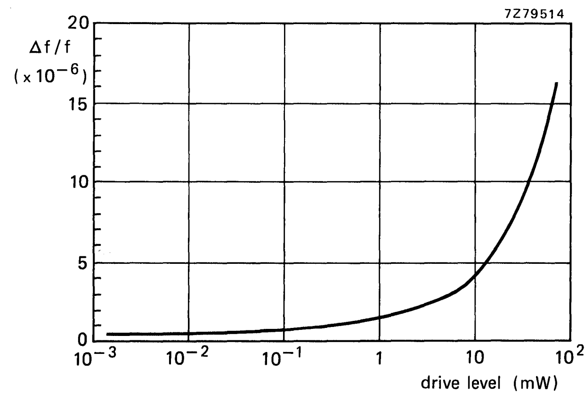


Fig. 7.

MEASURING PROCEDURES

Several methods of measuring quartz crystal units are in use.* Because different methods may give different results, our measuring procedure is given below. This is the *passive method with π-network* according to IEC publication 444. Further, the method is mentioned with *crystal test oscillator type 150A,* (make Saunders), which is recommended if a frequency correlation of 2 to 5 x 10^{-6} is tolerable. The accuracy of reproduction of the π-network method ranges between 10^{-6} and 10^{-8} depending on the type of crystal unit to be measured. The π-network method can be extended for measuring crystal unit parameters very accurately. This is achieved by a slight modification of the π-network, the use of precision reference resistors and two precision high-frequency load capacitors.

PASSIVE METHOD WITH π-NETWORK (IEC)

The principle of this method is very simple. With the equipment shown in the block diagram of Fig. 1, 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 (A.F.C. loop shown by dashed line).

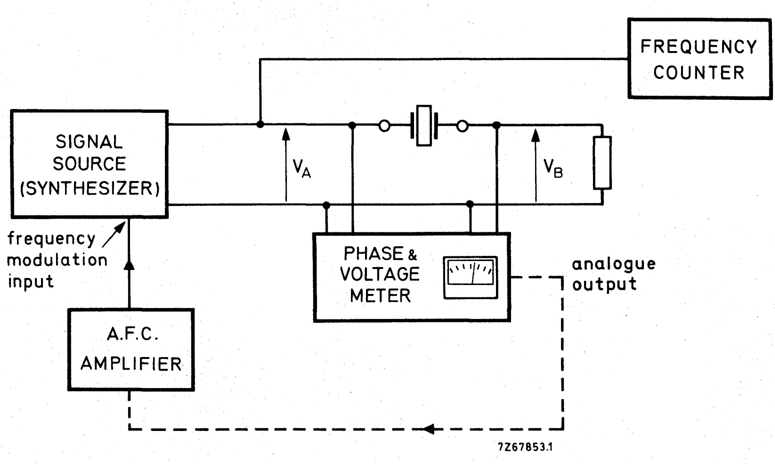


Fig. 1.

* The following measuring methods can be applied on request for the time the obsolete equipment is available:
Method using *Crystal Test Set, type TS193A* (British Military Standard).
Method using *Crystal Impedance Meter TS330/TSM* (U.S. Army Standard).
Method using *Crystal Impedance Meter TS683/TSM* (U.S. Army Standard).

π-network

The first departure which must be made from the simple system of Fig. 1 is the test jig for holding the crystal. The 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 (see Fig. 2).

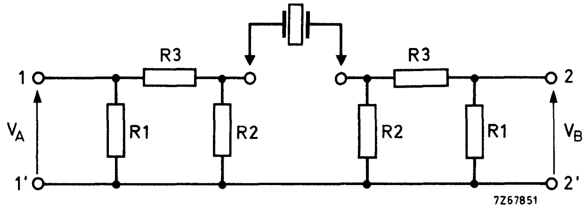


Fig. 2.

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.

Quartz crystal parameter measurements

A 5 pF trimming capacitor should be connected in parallel with each of the resistors R2 for accurate compensation of the transmission circuit. A shield is mounted between the contacting plates to reduce the capacitance between them. Two measuring procedures for crystal parameter measurement with the modified π-network are in use:

The C_L method

In general, this method is used for fundamental mode crystal units with frequencies up to 25 MHz.

Precision load capacitors are inserted in the π-network. Load resonance frequency and load resonance resistance can then be measured directly. C1 can be calculated.

The impedance method

Generally this method is used for higher frequencies up to approximately 125 MHz.

Phase and impedance are measured, all other parameters can be calculated by means of a computer.

Crystal shielding

Depending on the application, crystal shielding may give rise to frequency deviations, in particular for fundamental mode crystal units with a considerable pulling sensitivity.
In our procedure the metal enclosure of the crystal unit normally is not earthed. If, in special cases, earthing is required this should be mentioned in the specification for ordering.

TESTS AND REQUIREMENTS

Table 1 RW-43 - economy range

IEC 68-2 test method	TEST	PROCEDURE	REQUIREMENTS
B	Ageing	storage for 1000h at +100 °C	$\Delta f/f < \pm 5 \times 10^{-6}$
Db	Accelerated damp-heat	+25 to +55 °C 6 cycles at > 95% R.H.	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$ $R_{ins} > 10^8\ \Omega$ at 50 V (d.c.)
Na	Temperature cycling	–40 / +85 °C 10 cycles 1h/cycle	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$
Ea	Shock	100g half sine 6 directions 1 blow/direction	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$
Fc	Vibration	10-500-10 Hz acceleration 10g 3 directions 30 min/direction	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$
Eb	Bump	4000 bumps of 40g	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$
–	Free fall	3 times h = * on hard wood	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$
UB	Bending of terminations	1 x 90 ° load 5 N	No visual damage No leaks
Qc, Qk	Sealing	16 hours 700 kPa Helium	$< 10^{-8}$ ncc/s He
Tb	Resistance to soldering heat	350 ± 10 °C 3,5 ± 0,5 s	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$
Ta	Solderability	235 ± 5 °C 2 ± 0,5 s	Good tinning No visual damage No leaks

* h = 750 mm for the frequency range from 3 to 8 MHz
h = 250 mm for the frequency range from 8 to 14 MHz

Table 2 RW-10 and RW 43

IEC 68-2 test method	TEST	PROCEDURE	REQUIREMENTS
	Ageing	storage for 1000 h at + 85 °C	$\Delta f/f < \pm 5 \times 10^{-6}$
Db	Accelerated damp-heat	+25 to +55 °C 6 cycles at > 95% R.H.	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$ $R_{ins} > 10^8\ \Omega$ at 50 V (d.c.)
Na	Temperature cycling	−40 / +85 °C 10 cycles 1h/cycle	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$
Ea	Shock	100g half sine 6 directions 1 blow/direction	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$
Fc	Vibration	10-500-10 Hz acceleration 10g 3 directions 30 min/directions	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$
Eb	Bump	3000 bumps of 30g	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$
Ed	Free fall	3 times h = 250 mm on hard wood	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$
UB	Bending of terminations	1 x 90 ° load 5 N	No visual damage No leaks
Qc, Qx	Sealing	16 hours 700 kPa Helium	$< 10^{-8}$ ncc/s
Tb	Resistance to heat	350 ± 5 °C 3 ± 1 s	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$
T	Solderability	260 ± 5 °C 10 ± 1 s	Good tinning No visual damage No leaks

Table 3, RW-36; RW-42/43; RW 80; TO-39

IEC 68-2 test method	TEST	PROCEDURE	REQUIREMENTS
	Ageing	storage for 1000h at + 85 °C	$\Delta f/f < \pm 10 \times 10^{-6}$
Db	Accelerated damp heat	+25 to +55 °C 6 cycles at > 95% R.H.	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$ $R_{ins} > 10^8\ \Omega$ at 50 V (d.c.)
Na	Temperature cycling	–40 / +85 °C 10 cycles 1h/cycle	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$
Ea	Shock	100g half sine 6 directions 1 blow/direction	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$
Fc	Vibration	10-500-10 Hz acceleration 10g 3 directions 30 min/direction	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$
Eb	Bump	3000 bumps of 30g	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$
UB*	Bending of terminations	1 x 90 ° load 5 N	No visual damage No leaks
Qc, Qx	Sealing	16 hours 700 kPa Helium	$< 10^{-8}$ ncc/s
Tb*	Resistance to soldering heat	350 ± 5 °C 3 ± 1 s	$\Delta f/f < \pm 5 \times 10^{-6}$ $\Delta R_r < \pm 20\%$
T*	Solderability	260 ± 5 °C 10 ± 1 s	Good tinning No visual damage No leaks

* Only for encapsulation-types with leads.

QUARTZ CRYSTAL UNITS AS DIGITAL TEMPERATURE SENSOR

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.

On the other hand, it is also possible to cut crystal plates in such a way that the resonance frequency is an almost linear function of the temperature. In fact, the very first discovered quartz crystal cut, the "Y-cut", was such a cut.
There are, however, some disadvantages which make this cut less suitable for temperature sensing, for which reason special cuts have been introduced depending on the application.

How to use a quartz crystal unit as a temperature sensor

To be able 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 possible ways of processing this signal as shown in Figs 1 to 4.

Thanks to the excellent stability, the low ageing and its 'digital' nature, resolutions of 0,001 K are easy to achieve without noise problems. This renders the device particular suitable for measurements of very small temperature differences as in distillation columns and flow meters.

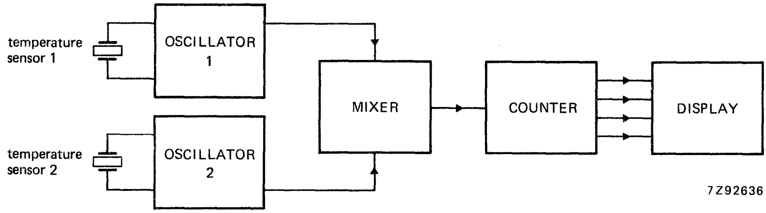


Fig. 1.

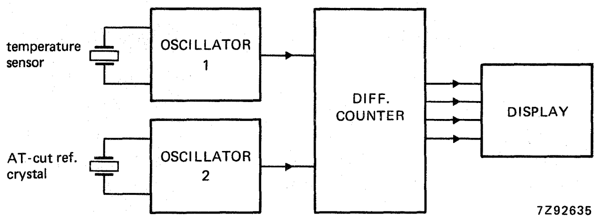


Fig. 2.

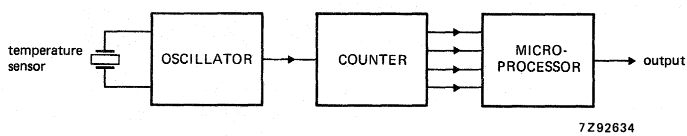


Fig. 3.

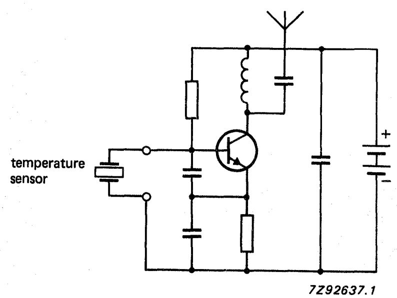


Fig. 4 Miniature wireless temperature sensor.

HOW TO SPECIFY A QUARTZ CRYSTAL UNIT

When ordering quartz crystal units for which a catalogue number (12 digits) has been fixed, please quote catalogue numbers as stated in this Data Handbook.

For quotation or ordering a quartz crystal unit which still has no complete catalogue number the supplier needs to know certain basic information. Please use the following check list.

Type of crystal unit	
Type of holder	
Nominal frequency	kHz
Mode of vibration	fundamental or $\frac{\text{third}}{\text{fifth}}$ overtone
Permissible deviation from nominal frequency (adjustment tolerance) at + 25 °C	x 10^{-6}
Temperature range	from to °C
Frequency drift over specified temperature range	x 10^{-6}
Circuit conditions:	
resonant frequency f_r or	kHz
load resonant frequency f_L and	kHz
load capacitance C_L	pF
maximum resonance resistance R_r or	Ω
maximum load resonance resistance R_L	Ω
Crystal unit equivalent parameters	
C_1	fF
C_0	pF
R_1	Ω
L_1	mH
Level of drive	mW
Ageing Δf/f per month or year	x 10^{-6}
Mechanical requirements/tests	

MARKING

The marking on the unit includes the nominal frequency by means of 7 or 8 figures, in kHz in the case of fundamental crystals and in MHz in the case of overtone crystals. Other figures include the five last digits of the catalogue number. The last digit printed on the unit may, however, be different. Also a manufacturing date is stated, referring to the year and month of manufacture, e.g. 424 means the 24th week of 1984.

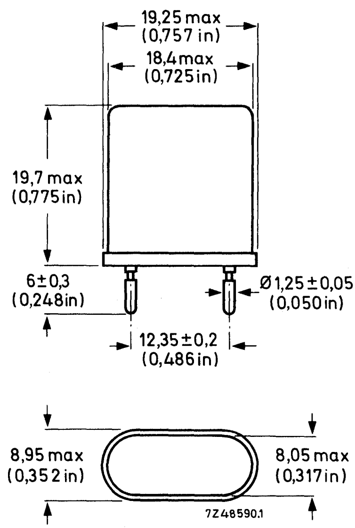
HOLDERS

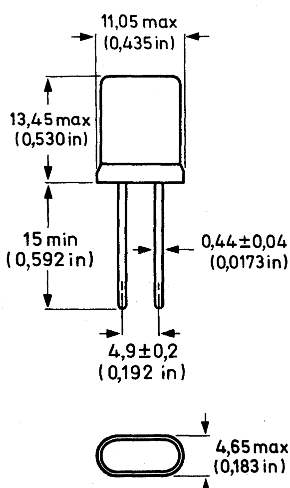
ALL-GLASS HOLDERS

Dimensions in mm
(in inches between brackets)

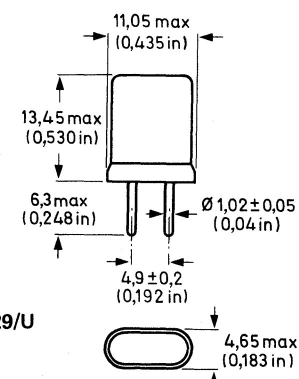
HC-27/U

(IEC type DB is identical except for the height which is 26 mm max. instead of 19,7 max.).





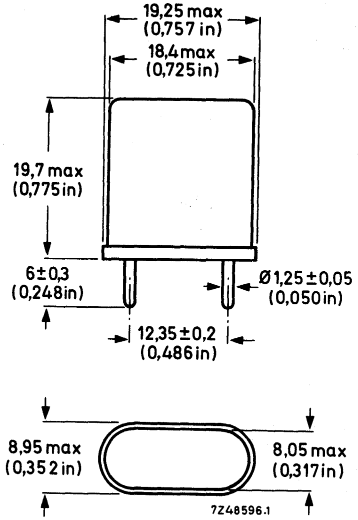
HC-26/U



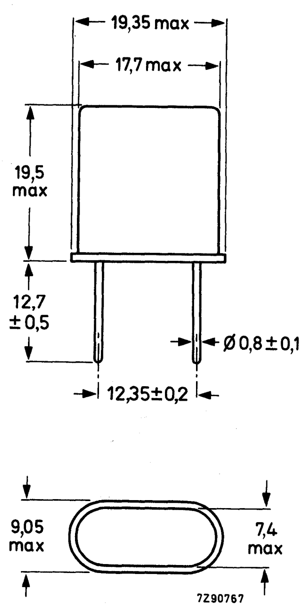
HC-29/U

METAL HOLDERS

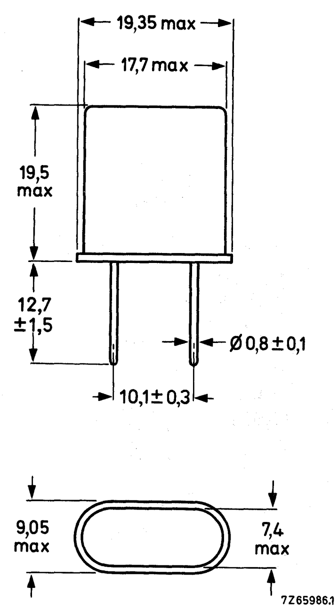
Dimensions in mm
(in inches between brackets)



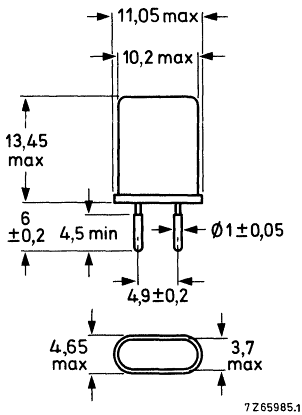
HC-6/U, solder sealed
RW-36, resistance welded



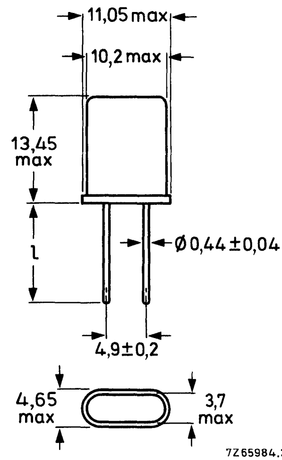
HC-33/U
solder sealed



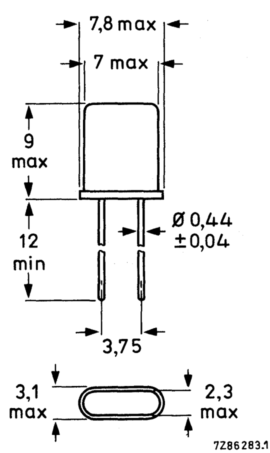
RW-10
resistance welded



RW-42
resistance welded



RW-43
resistance welded
ℓ is specified per type

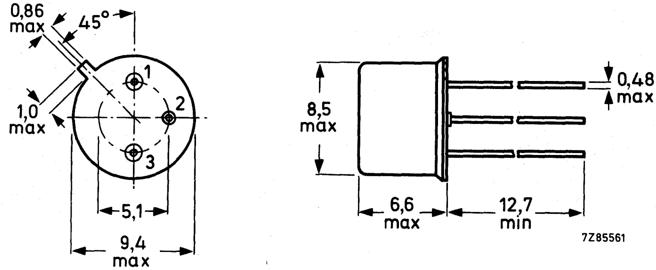


RW-80
resistance welded

TO-39

Resistance welded

Pin 2 is connected to the case.



CORRESPONDING IEC AND DIN TYPE NUMBERS

	IEC 122-3	DIN 45110
HC-6/U	AA	K1A
HC-26/U	CY	R2A
HC-27/U	DA	Q1A
HC-27/U, extended	DB	Q1B
HC-29/U	CZ	R1A
HC-33/U	–	–
RW-10	DS	K4A
RW-36	–	K3A
RW-42	DQ	M3A
RW-43	DP	M4A
RW-80	35/EB	N4B
TO-39	17/CK	T1A

MOUNTING

Crystal units provided with pins (such as HC-6/U, HC-27/U etc.) are for mounting in sockets. These sockets are not supplied by us.

Crystal units with leeds are for mounting on p.c. boards. There are basicly two methods: horizontal and vertical mounting.
Horizontal (flat) mounting gives better mechanical stability while vertical mounting uses less p.c. board space.
To prevent a permanent damage of crystal units 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 leakage. If cutting of the leads is nessesary, use suitable tools to prevent shockwaves in the leads.
- If bending of the leads is nessesary e.g. in case of flat mounting, make the bend at least 2 mm away from the body with a bending radius > 0,5 mm.
- Keep in mind, especially in case of vertical mounting, that for the first mm of the leads away from the body tinning is not guaranteed. For thin p.c. 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 technics (see tests and requirements). Exposing the crystal units to high temperatures for a prolonged time, however, should be avoided.

Several crystal types can be ordered with two lead-lengths: standard 12 mm for flat mounting and 5 mm for vertical mounting.
For utmost mechanical stability and electrical reproducebility, metal types can be supplied with a third (top)lead which serves both as a ground wire and a three-point attachment to the p.c. board.

QUARTZ CRYSTAL UNITS, ECONOMY TYPES

QUARTZ CRYSTAL UNITS

economy types in RW-43 encapsulation

QUICK REFERENCE DATA

Nominal frequency	3 000,000 to 14 000,000 kHz
Mode of vibration	fundamental
Type of encapsulation	RW-43

APPLICATION

Industrial and consumer equipment. See table on next pages.

DESCRIPTION

The unit consists of a metal-plated AT-cut quartz plate, mounted in a hermetically sealed resistance welded RW-43 encapsulation and is provided with two connecting leads.
These units are massproduced on an automated production line which guarantees a very high level of uniformity and reliability.
See also "General" section.

MECHANICAL DATA

Outlines: see General section, RW-43

Mass: 2 g approximately

ELECTRICAL DATA

Unless otherwise specified the values apply at a temperature of 25 ± 2 °C and a level of drive of 0,5 mW related to 25 Ω. Measuring system π-network according to IEC-444 recommendation.

Frequency tolerance		$< \pm 25 \times 10^{-6}$ *
Load capacitance C_L		20 pF **
Motional capacitance C_1		see Fig. 1
Parallel capacitance C_0		see Fig. 1
Resonance resistance R_r		see Fig. 2
Frequency tolerance w.r.t. +25 °C		see Fig. 2
in the temperature range:	0 to +50 °C	$< \pm 15 \times 10^{-6}$ *
	−20 to +70 °C	$< \pm 25 \times 10^{-6}$ *
	−40 to +85 °C	$< \pm 40 \times 10^{-6}$ *
Resonance of unwanted responses		$> 2\ R_r$
Insulation resistance		$> 10^{10}$ Ω at 100 V (d.c.)
Permissible d.c. voltage between the leads		max. 100 V

See table on the next pages for other parameters and for standard frequencies.

TESTS AND REQUIREMENTS

See General section, Table 1

* Other combinations of tolerance and temperature range available on request.

** 20 pF is the standard load capacitance for 4322 143 series. Crystals can be calibrated at other C_L - values on request.

Table 1
Specifications of quartz crystal units in RW-43 holder; economy range.

frequency range kHz	catalogue number 4322 143	temp. range °C	C_L pF	freq. tol. $< \pm x\ 10^{-6}$
3000,000	04411	–20 to + 70	20	30
3000,000	04680	–40 to + 90	30	60
3000,000*	04860			
3276,800	04421	–20 to + 70	20	30
3276,800*	04850			
3439,593	04911	–40 to + 80	–	30
3440,000	04571	–40 to + 80	20	30
3440,000	04761	–40 to + 80	30	30
3547,000	04491	–10 to + 60	30	20
3579,545	04391	–20 to + 70	20	30
3579,545	04401	–20 to + 70	–	100
3582,056	04381	–10 to + 60	20	25
3640,890	04690	–40 to + 90	20	50
3686,400	04371	–10 to + 60	30	25
3686,400	04551	–20 to + 70	–	40
3750,000	04431	–10 to + 65	13	7
3840,000	04441	–20 to + 70	30	50
3932,160	04670	–40 to + 90	17	50
3997,696	04481	0 to + 60	20	15
4000,000	04093	–10 to + 60	30	25
4000,000	04261	–10 to + 60	20	25
4000,000	04271	0 to + 60	30	15
4000,000*	04840			
4000,000	04881	–10 to + 60	20	40
4096,000	04700	–40 to + 90	20	50
4096,000*	04771	–10 to + 60	30	25
4194,304	04083	–10 to + 60	11,4	25
4194,304	04471	–40 to + 80	20	50
4233,600	04461	–20 to + 70	–	30
4233,600	04561	–20 to + 70	30	30
4250,000	04361	–10 to + 60	20	25
4406,250	04351	–10 to + 60	20	25
4433,619	04043	–10 to + 60	20	25
4433,619	04252	+ 10 to + 55	20	15
4433,619	04282	–10 to + 60	20	25
4435,571	04872	–10 to + 60	20	25
4500,000	04111	–10 to + 65	13	7
4531,468	04121	–10 to + 65	13	7
4608,000	04341	0 to + 70	–	40
4782,720	04033	–20 to + 70	–	30
4782,720	04291	–20 to + 70	–	100
4865,000	04781	–20 to + 70	–	50
4905,021	04601	–20 to + 70	20	30
4905,021	04132	–20 to + 70	20	30

* Development types.

R Ω	C_0 pF	C_1 fF	pullability 10^{-6}/pF	wire length mm	application
< 150	4,0	10,0	> 8	12	automotive
< 200	–	–	–	12	automotive
< 100	4,3	13,5	> 7	12	automotive general purpose automotive
< 100	4,3	13,5	–	12	automotive
< 100	4,3	13,5	> 9	12	general purpose
< 100	4,3	13,5	> 4	12	general purpose
< 100	4,5	14,5	> 5	12	video games
< 100	4,5	14,7	> 10	12	video
< 100	4,5	14,7	–	12	two-tone dialling
< 100	4,5	14,7	> 10	12	video
< 100	–	–	–	12	automotive
< 100	4,5	15,0	> 5	12	general purpose
< 100	4,5	15,0	–	12	general purpose
< 75	4,5	15,0	> 22	12	VLP
< 75	4,6	15,4	> 5	12	general purpose
< 75	4,7	15,8	> 14	12	automotive
< 75	2,8	11,0	> 7	12	general purpose
< 75	2,8	11,0	> 3	12	digital tuners
< 75	2,8	11,0	> 9	12	video
< 75	2,8	11,0	> 3	12	video
< 75	2,8	11,0	> 9	13,2	automotive general purpose
< 60	5,0	18,5	> 12	12	automotive,
< 75	5,0	18,5	> 6	12	general purpose
< 60	2,9	11,6	> 24	12	clock
< 90	2,9	11,6	> 9	12	automotive
< 60	5,2	16,7	–	12	compact disc
< 60	5,2	16,7	> 6	12	compact disc
< 60	5,2	16,7	> 12	12	video
< 60	5,4	20,5	> 15	12	general purpose
< 60	5,5	20,6	> 12	12	general purpose
< 60	5,5	20,6	> 12	5	VCR
< 60	5,5	20,6	> 12	5	video
< 60	5,5	20,6	> 12	5	video
< 60	5,6	18,4	> 22	12	video
< 60	5,6	18,4	> 22	12	video
< 60	5,8	22,0	–	12	general purpose
< 60	5,7	21,4	–	12	general purpose
< 60	5,7	21,4	–	12	two-tone dialling
< 60	5,7	22,5	–	12	general purpose
< 60	5,9	22,9	> 13	12	general purpose
< 60	5,9	22,9	> 13	5	video

Table 1 (continued)

frequency range kHz	catalogue number 4322 143	temp. range °C	C_L pF	freq. tol. < ± x 10^{-6}
4915,200	04141	+ 5 to + 45	30	50
4915,200	04201	+ 5 to + 45	30	20
5000,000	04151	−20 to + 70	20	20
5068,800	04331	−20 to + 70	20	30
5068,800	04451	−20 to + 70	–	30
5068,800	04541	−15 to + 70	–	30
5120,000	04161	−20 to + 70	20	30
5120,000	04751	−20 to + 70	20	30
5760,000*	04810	−40 to + 105	20	100
5911,000	04521	−20 to + 60	20	20
6000,000	04101	−20 to + 70	20	30
6000,000	04532	−20 to + 70	20	30
6000,000	04582	−10 to + 40	20	−27,5/K
6000,000	04710	−40 to + 115	22	80
6000,000*	04830	−40 to + 105	20	80
6000,000*	04981	−20 to + 70		
6041,957	04591	−20 to + 70	20	30
6144,000	04321	0 to + 70	20	50
6400,000	04311	−20 to + 70	20	25
7000,000	04791	−10 to + 60	20	30
7151,223	04171	−10 to + 60	20	25
7159,090	04181	−10 to + 60	20	25
7164,112	04191	−20 to + 70	20	25
7372,800	04951	−40 to + 115	20	80
8000,000	04301	−20 to + 70	20	25
8000,000	04721	−40 to + 115	20	80
8388,608	04821	−40 to + 115	20	80
8867,238	04051	−10 to + 60	20	25
8867,238	04222	−10 to + 60	20	25
8867,238	04731	−40 to + 115	20	80
9830,400	04611	0 to + 70	–	50
10000,000	04621	−40 to + 115	20	80
10000,000	04971	−40 to + 115	22	80
11000,000	04741	−40 to + 115	20	80
11059,000	04921	−10 to + 60	30	30
11059,200	04931	−10 to + 60	30	30
11289,600	05031	−20 to + 70	30	19
12000,000	04631	−40 to + 115	20	80
13875,000	04891	−20 to + 70	20	30
13875,000	04961	−20 to + 70	20	30

* Development types.

R Ω	C_0 pF	C_1 fF	pullability 10^{-6}/pF	wire length mm	application
< 60	3,2	13,6	> 5	12	record player
< 60	3,2	13,6	> 5	12	video
< 60	3,2	13,8	> 12	12	cameras
< 60	3,2	14,0	> 12	12	general purpose
< 60	3,2	14,0	–	12	general purpose
< 60	3,2	14,0	–	12	general purpose
< 60	3,5	14,6	> 11	12	car radio
< 60	3,5	14,6	> 11	5	car radio
< 100	3,5	16,5	–	12	automotive
< 60	3,7	16,5	> 6	12	video games
< 60	6,9	27,6	> 17	12	teletext, VCR
< 60	6,9	27,6	> 17	5	video
< 60	3,7	10,7	> 7	12	temperature sensing
< 40	5,0	21,0	–	12	automotive
< 60	3,8	17,0	–	12	automotive
					compact disc
< 60	6,9	27,6	> 17	12	teletext, USA
< 60	3,8	17,0	> 12	12	microprocessor
< 60	4,0	18,0	> 12	12	general purpose
< 60	4,2	19,2	> 12	12	general purpose
< 60	4,4	19,5	> 14	12	CTV (subcarrier)
< 60	4,4	19,5	> 14	12	CTV (subcarrier)
< 60	4,4	19,5	> 14	12	CTV (subcarrier)
< 60	4,4	20,0	> 14	12	automotive
< 60	5,0	21,0	> 15	12	general purpose
< 60	4,2	18,0	> 10	13,2	automotive
< 60	4,4	19,0	> 10	13,2	automotive
< 60	5,5	22,0	> 16	13,2	video
< 60	5,5	22,0	> 16	5	video
< 60	4,6	20,0	> 10	13,2	automotive
< 50	5,7	25,3	–	12	general purpose
< 60	4,1	19,0	> 12	12	automotive
< 60	4,1	19,0	> 10	12	automotive
< 50	4,7	20,0	> 10	13,2	automotive
< 60	6,1	28,5	> 8	12	CD-ROM
< 60	6,1	28,5	> 8	12	teletext
< 11	4,7	20	> 8	12	compact disc
< 40	5,0	21,0	> 12	12	automotive
< 40	5,8	24,5	> 14	12	computer coded teletext
< 40	5,8	24,5	> 14	5	teletext

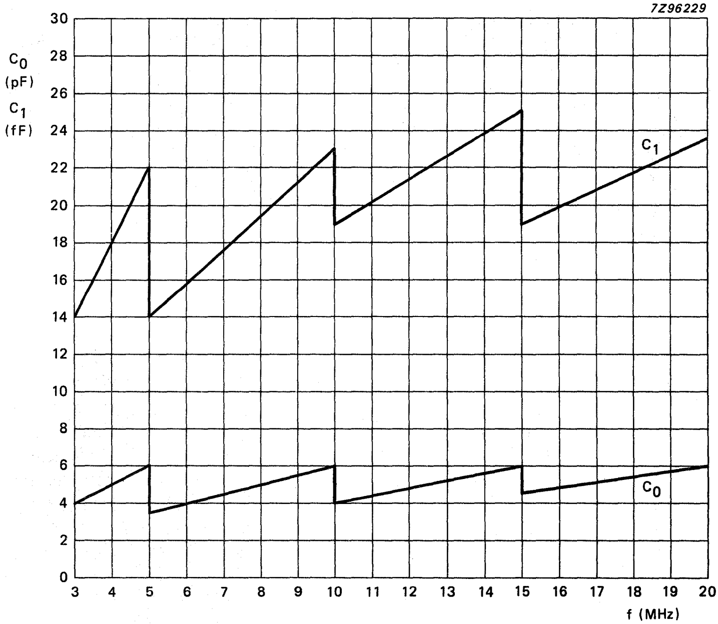


Fig. 1 Motional (C_1) and parallel (C_0) capacitances as a function of frequency.

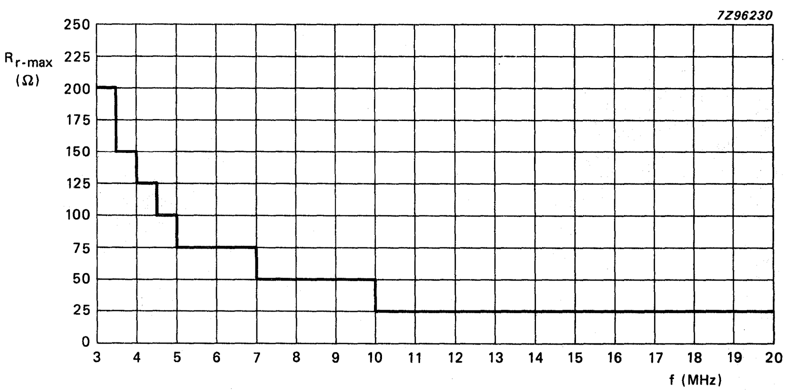


Fig. 2 Resonance resistance, R_r as a function of frequency.

QUARTZ CRYSTAL UNITS FOR GENERAL FREQUENCY STABILIZATION

QUARTZ CRYSTAL UNIT

QUICK REFERENCE DATA

Nominal frequency	21480,000 kHz
Mode of vibration	fundamental
Type of holder	RW-80

APPLICATION

I.F. oscillator in small portable professional radio equipment, e.g. pagers.

DESCRIPTION

The unit consists of a metal-plated AT-cut quartz plate, mounted in a hermetically sealed resistance welded metal holder, provided with two connecting leads.

MECHANICAL DATA

Outlines : see general section "Holders"

Mass : 0,5 g approximately

ELECTRICAL DATA

Unless otherwise specified the values apply at a temperature of 25 ± 2 °C and a level of drive of 0,5 mW related to 25 Ω.

Load resonance frequency f_L load capacitance 32 pF	21480,000 kHz
Adjustment tolerance	± max. 15×10^{-6}
Tolerance over the temperature range of −5 to +45 °C, with respect to + 25 °C	± max. 15×10^{-6}
Motional capacitance (C_1)	typ. 17,5 fF
Parallel capacitance (C_0)	typ. 4,6 pF
Resonance resistance	max. 40 Ω
Pullability $\left(-\frac{df}{dC}\right)$ at f_L with load capacitance variation	min. + $5 \times 10^{-6} \times f_L$/pF
Maximum permissible d.c. voltage between terminations	100 V
Operating temperature range	−5 to + 45 °C

TESTS AND REQUIREMENTS

See general section, table 3

LOW COST HIGH PRECISION DIGITAL QUARTZ TEMPERATURE SENSORS

DESCRIPTION

The sensor consists of a metal-plated special T.C.-cut piezoelectric quartz plate, mounted in a hermetically-sealed, resistance-welded metal holder, with two leads. The holder is filled with a dry inert gas. The quartz plate oscillates in a fundamental thickness-shear mode. The resonance frequency is an almost linear function of the temperature. See also section "General".

Features

- no A/D conversion
- excellent linearity
- high stability, very low ageing
- wide temperature range
- high noise immunity
- easy calibration
- quantity production at low cost

APPLICATIONS

These sensors can be used in industrial temperature measurement and control, car electronics, flow meters, weather balloons, medical systems and in energy saving projects such as heat monitors and solar panels.

QUICK REFERENCE DATA

	economy design	special design	
Frequency range	4 to 20	1 to 25	MHz
Temperature range	−100 to + 150	−100 to + 300	°C
Temperature coefficient	−40 to + 80	−50 to + 85	x 10^{-6}/K
Linearity	< ± 2,5	< ± 1,5	%
Adjustment tolerance	< ± 150	< ± 50	x 10^{-6}
Thermal time constant	typ. 10	3 to 30	s
Type of holder	RW-43	RW-43; RW-80; HC-26/U HC-27/U; TO-39	

For additional details the supplier should be contacted.

QUARTZ CRYSTAL UNITS

economy types in RW-10 encapsulation

QUICK REFERENCE DATA

Nominal frequency	3 000,000 to 10 000,000 kHz
Mode of vibration	fundamental
Type of encapsulation	RW-10

APPLICATION

Industrial and consumer equipment in medium quantity series.

DESCRIPTION

The unit consists of a metal-plated AT-cut quartz plate, mounted in a hermetically sealed resistance welded RW-10 encapsulation and is provided with two connecting leads. See also "General" section.

MECHANICAL DATA

Outlines : see general section "Holders"

Mass : 4 g approximately

ELECTRICAL DATA

Unless otherwise specified the values apply at a temperature of 25 ± 2 °C and a level of drive of 0,5 mW related to 25 Ω. Measuring system π - network according to IEC-444 recommendation.

Frequency tolerance		$< \pm 25 \times 10^{-6}$ *
Load capacitance C_L		30 pF **
Motional capacitance C_1		see Fig. 1
Parallel capacitance C_0		see Fig. 1
Motional inductance L_1		see Fig. 1
Resonance resistance R_r		see Fig. 2
Frequency tolerance w.r.t. +25 °C		
in the temperature range:	0 to +50 °C	$< \pm 15 \times 10^{-6}$ *
	−20 to +70 °C	$< \pm 25 \times 10^{-6}$ *
	−40 to +85 °C	$< \pm 40 \times 10^{-6}$ *
Resonance of unwanted responses		$> 2\ R_r$
Insulation resistance		$> 10^8\ \Omega$ at 50 V (d.c.)
Permissible d.c. voltage between the leads		max. 100 V

TESTS AND REQUIREMENTS

See general section, table 2

* Other combinations of tolerance and temperature range available on request.

** 30 pF is the standard load capacitance for 4322 148 series. Crystals can be calibrated at other C_L - values on request.

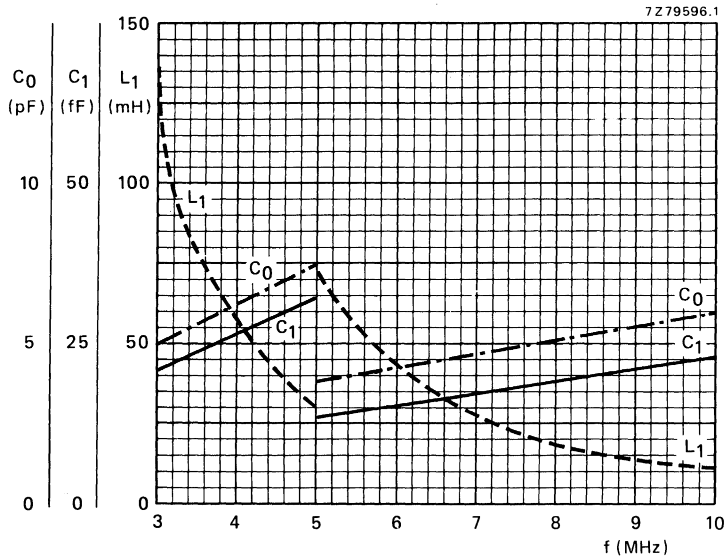


Fig. 1 Typical values for C_0, C_1 and L_1 as a function of frequency.

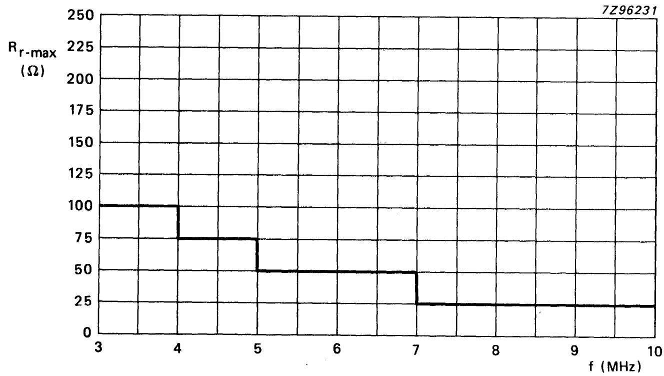


Fig. 2 Resonance resistance R_r as a function of frequency.

QUARTZ CRYSTAL UNITS

QUICK REFERENCE DATA

Frequency range	1,8 to 25 MHz
Mode of vibration	fundamental
Type of holder	RW-33 or RW-36

MECHANICAL DATA

Outlines : See general section "Holders"

Mass : 4 g

ELECTRICAL DATA

Adjustment tolerance at + 25 °C	$\pm 10 \times 10^{-6}$
Load capacitance C_L *	30 pF
Level of drive	0,5 mW
Motional capacitance C_1	5 to 30 fF
Parallel capacitance C_0	max. 7 pF
Resonance resistance R_r	see Table 1
Frequency tolerance in different temperature ranges with respect to + 25 °C	see Table 2
Maximum permissible d.c. voltage between terminations	100 V

TESTS

Mechanical and climatic tests	according to MIL and IEC procedures

* Data at other C_L values and for series resonance available on request.

Table 1 Resonance resistance R_r

frequency MHz	max. R_r Ω
1,800000 – 1,999999	300
2,000000 – 2,249999	250
2,250000 – 3,749999	150
3,750000 – 4,999999	100
5,000000 – 6,999999	50
7,000000 – 9,999999	30
10,000000 – 25,000000	25

Table 2 Frequency tolerance in different temperature ranges with respect to + 25 °C

frequency range MHz	temperature range °C	frequency tolerance		
		class 0	class I	class II
1,8 - 25	−5/+ 45	± 5 x 10^{-6}	± 7,5 x 10^{-6}	± 10 x 10^{-6}
	−10/+ 50	± 7,5 x 10^{-6}	± 10 x 10^{-6}	± 15 x 10^{-6}
	−15/+ 70	± 10 x 10^{-6}	± 15 x 10^{-6}	± 20 x 10^{-6}
1,8 - 2,3	−55/+ 105	± 30 x 10^{-6}	± 35 x 10^{-6}	± 40 x 10^{-6}
2,3 - 4	−55/+ 105	± 32,5 x 10^{-6}	± 35 x 10^{-6}	± 40 x 10^{-6}
4 - 25	−55/+ 105	± 25 x 10^{-6}	± 30 x 10^{-6}	± 40 x 10^{-6}
1,8 - 25	T_{nom} ± 5 •	± 5 x 10^{-6}		

QUARTZ CRYSTAL UNIT

QUICK REFERENCE DATA

Nominal frequency	6144,000 kHz
Mode of vibration	fundamental
Type of holder	TO-39

APPLICATION

General, e.g. microprocessors.

DESCRIPTION

The unit consists of a metal-plated AT-cut quartz plate, mounted in a hermetically sealed resistance welded metal holder, provided with three connecting leads.

MECHANICAL DATA

Outlines : See general section "Holders"

Mass : 0,8 g approximately

ELECTRICAL DATA

Unless otherwise specified the values apply at a temperature of 25 ± 2 °C and a level of drive of 0,5 mW related to 25 Ω.

Load resonance frequency f_L, load capacitance 20 pF	6144,000 kHz
Adjustment tolerance	± max. 25 x 10^{-6}
Tolerance over the temperature range of −10 to + 60 °C, with respect to + 25 °C	± max. 25 x 10^{-6}
Motional capacitance (C_1)	typ. 7,2 fF
Parallel capacitance (C_0)	typ. 2,2 pF
Resonance resistance	max. 75 Ω
Pullability $\left(-\frac{df}{dC}\right)$ at f_L with load capacitance variation	min. + 6 x 10^{-6} x f_L/pF
Maximum permissible d.c. voltage between terminations	100 V
Operating temperature range	−10 to + 60 °C

TESTS AND REQUIREMENTS

See general section, table 3

QUARTZ CRYSTAL UNITS

QUICK REFERENCE DATA

Frequency range	1 to 1,8 MHz
Mode of vibration	fundamental
Type of holder	HC-6/U

MECHANICAL DATA

Outlines See general section "Holders".

Mass 4 g

ELECTRICAL DATA

Adjustment tolerance at + 25 °C	$\pm 20 \times 10^{-6}$
Load capacitance C_L*	30 pF
Level of drive	0,5 mW
Motional capacitance C_1	5 to 30 fF
Parallel capacitance C_0	max. 7 pF
Resonance resistance R_r	
1,000000 – 1,599999 MHz	max. 600 Ω
1,600000 – 1,799999 MHz	max. 300 Ω
Frequency tolerance in different temp. ranges with respect to + 25 °C	see Table
Maximum permissible d.c. voltage between terminations	100 V

TESTS

Mechanical and climatic tests — according to MIL and IEC procedures

Table Frequency tolerance in different temperature ranges with respect to + 25 °C.

frequency range MHz	temperature range °C	frequency tolerance class 0	frequency tolerance class I	frequency tolerance class II
1 to 1,8	−5/+45	$\pm 5 \times 10^{-6}$	$\pm 7,5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$
	−10/+50	$\pm 7,5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$	$\pm 15 \times 10^{-6}$
	−15/+70	$\pm 10 \times 10^{-6}$	$\pm 15 \times 10^{-6}$	$\pm 20 \times 10^{-6}$
1 to 1,8	−55/+105	$\pm 30 \times 10^{-6}$	$\pm 35 \times 10^{-6}$	$\pm 40 \times 10^{-6}$
1 to 1,8	$T_{nom} \pm 5$		$\pm 5 \times 10^{-6}$	

* Data at other C_L values and for series resonance available on request.

QUARTZ CRYSTAL UNIT

QUICK REFERENCE DATA

Nominal frequency	1000,000 kHz
Mode of vibration	fundamental
Type of holder	HC-6/U

MECHANICAL DATA

Outlines: see general section "Holders"

Mass: 4 g approximately

ELECTRICAL DATA

Unless otherwise specified the values apply at a temperature of 25 ± 2 °C and a level of drive of 0,5 mW related to 25 Ω.

Load resonance frequency f_L, load capacitance 30 pF	1000,000 kHz
Adjustment tolerance	± max. 20 x 10^{-6}
Tolerance over the temperature range of −20 to +70 °C, with respect to +25 °C	± max. 30 x 10^{-6}
Motional capacitance C_1	typ. 9 fF
Parallel capacitance C_0	typ. 3,5 pF
Resonance resistance R_r	max. 600 Ω
Pullability $\left(-\frac{df}{dC}\right)$ at f_L with load capacitance variation	min. +4 x 10^{-6} x f_L/pF
Maximum permissible d.c. voltage between terminations	100 V
Operating temperature range	−20 to +70 °C

Marking

The frequency in kHz, the last 5 digits of the catalogue number, and a code for the date of manufacture are stamped on the holder.

QUARTZ CRYSTAL UNITS

QUICK REFERENCE DATA

Frequency range	1,8 to 25 MHz
Mode of vibration	fundamental
Type of holder	
1,8 to 2,3 MHz	HC-27/U, extended (26 mm)
2,4 to 25 MHz	HC-27/U

MECHANICAL DATA

Outlines See general section "Holders".

Mass 2,5 g

ELECTRICAL DATA

Adjustment tolerance at + 25 °C	$\pm$ 10 x 10^{-6}
Load capacitance C_L*	30 pF
Level of drive	0,5 mW
Motional capacitance C_1	see Figs 1 to 4
Parallel capacitance C_0	max. 7 pF, see also Fig. 1
Motional inductance L_1	see Figs 1 to 4
Resonance resistance R_r	see Table 1
Frequency tolerance in different temperature ranges with respect to + 25 °C	see Table 2
Maximum permissible d.c. voltage between terminations	100 V
Ageing after 90 days non-operative at + 85 $\pm$ 2 °C	(−0,5 to + 1) x 10^{-6}

TESTS

Mechanical and climatic tests according to MIL and IEC procedures.

* Data at other C_L values and for series resonance available on request.

Table 1 Resonance resistance R_r

frequency MHz	max. R_r Ω
1,800000 – 1,869999	220
1,870000 – 1,999999	185
2,000000 – 2,119999	165
2,120000 – 2,249999	150
2,250000 – 2,599999	125
2,600000 – 2,999999	90
3,000000 – 3,399999	70
3,400000 – 3,749999	52
3,750000 – 3,999999	45
4,000000 – 4,999999	37
5,000000 – 6,999999	25
7,000000 – 9,999999	20
10,000000 – 14,999999	18
15,000000 – 25,000000	15

Table 2, Frequency tolerance in different temperature ranges with respect to + 25 °C

frequency range MHz	temperature range °C	frequency tolerance		
		class 0	class I	class II
1,8 to 25	−5/+ 45	$\pm 5 \times 10^{-6}$	$\pm 7,5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$
	−10/+ 50	$\pm 7,5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$	$\pm 15 \times 10^{-6}$
	−15/+ 70	$\pm 10 \times 10^{-6}$	$\pm 15 \times 10^{-6}$	$\pm 20 \times 10^{-6}$
1,8 to 2,3	−55/+ 105	$\pm 30 \times 10^{-6}$	$\pm 35 \times 10^{-6}$	$\pm 40 \times 10^{-6}$
2,3 to 7	−55/+ 105	$\pm 32,5 \times 10^{-6}$	$\pm 35 \times 10^{-6}$	$\pm 40 \times 10^{-6}$
7 to 25	−55/+ 105	$\pm 25 \times 10^{-6}$	$\pm 30 \times 10^{-6}$	$\pm 40 \times 10^{-6}$
1,8 to 25	$T_{nom} \pm 5$		$\pm 2,5 \times 10^{-6}$	$\pm 5 \times 10^{-6}$

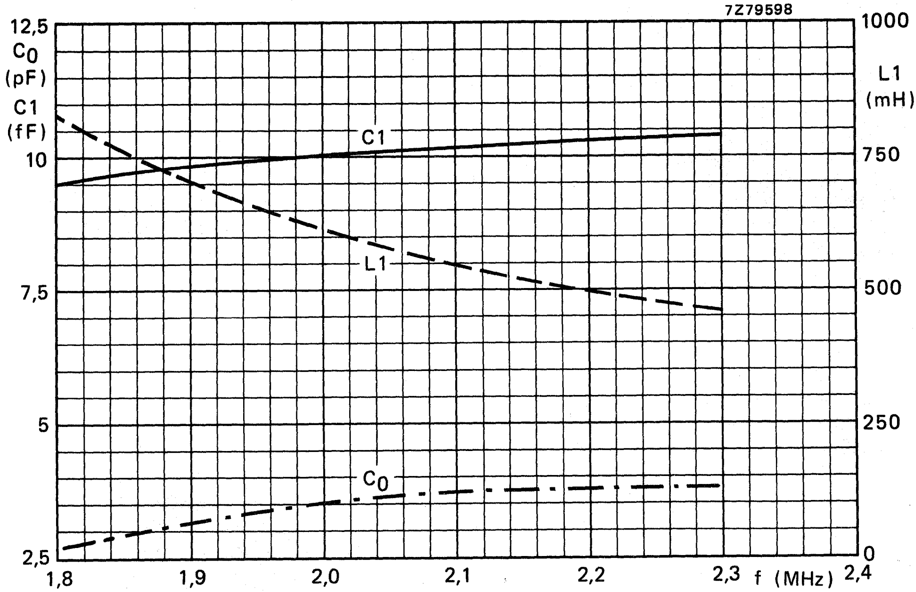


Fig. 1 Typical values for C_0, C_1 and L_1 for frequencies from 1,8 to 2,3 MHz.

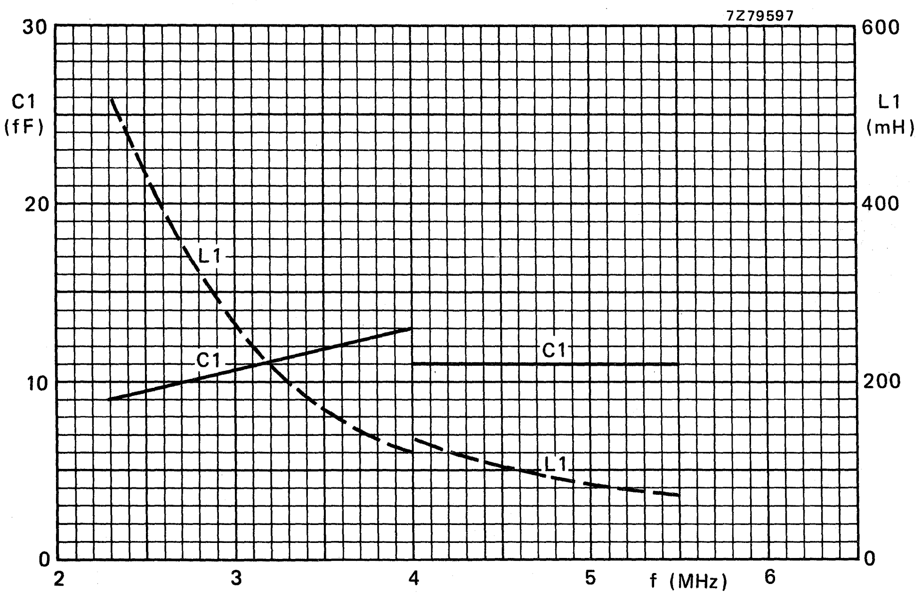


Fig. 2 Typical values for C_1 and L_1 for frequencies from 2,3 to 5,5 MHz.

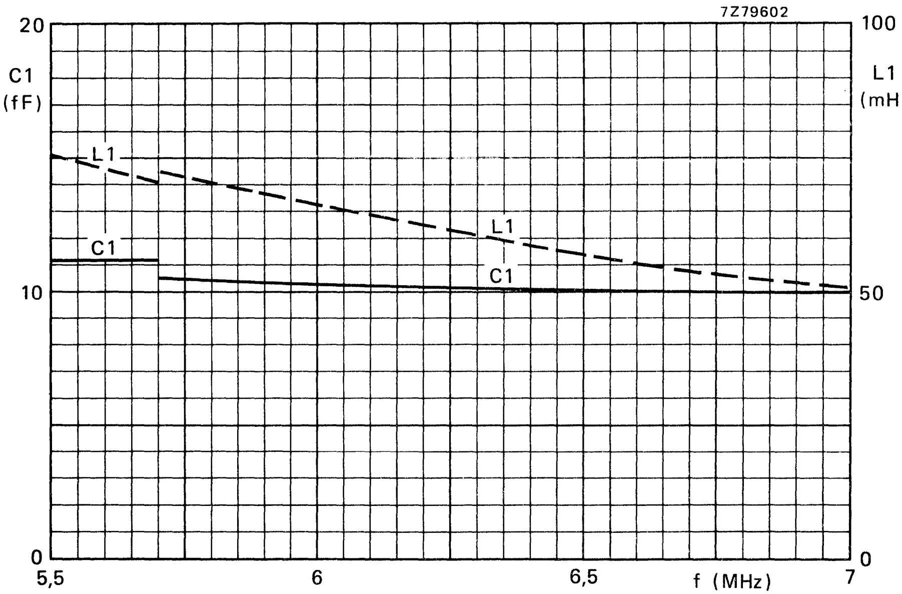


Fig. 3 Typical values for C_1 and L_1 for frequencies from 5,5 to 7 MHz.

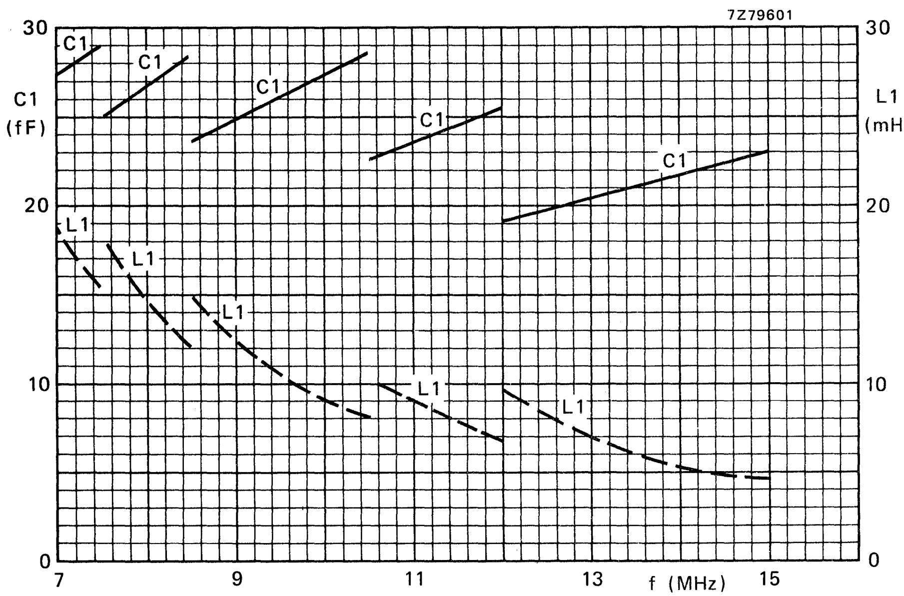


Fig. 4 Typical values for C_1 and L_1 for frequencies from 7 to 15 MHz.

QUARTZ CRYSTAL UNITS

QUICK REFERENCE DATA

Frequency range	4,5 to 25 MHz
Mode of vibration	fundamental
Type of holder	HC-26/U or HC-29/U

MECHANICAL DATA

Outlines See general section "Holders".

Mass 0,8 g

ELECTRICAL DATA

Adjustment tolerance at + 25 °C	± 10 x 10^{-6}
Load capacitance C_L*	30 pF
Level of drive	0,5 mW
Motional capacitance C_1	see Figs 1 and 2
Parallel capacitance C_0	see Figs 1 and 2
Motional inductance L_1	see Figs 1 and 2
Resonance resistance R_r	see Table 1
Frequency tolerance in different temperature ranges with respect to + 25 °C	see Table 2
Maximum permissible d.c. voltage between terminations	100 V
Ageing after 90 days non-operative at + 85 ± 2 °C	(–0,5 to + 1) x 10^{-6}

TESTS

Mechanical and climatic tests according to MIL and IEC procedures.

* Data at other C_L values and for series resonance available on request.

Table 1 Resonance resistance R_r

frequency MHz	max. R_r Ω
4,500000 – 4,749999	110
4,750000 – 5,999999	70
6,000000 – 6,999999	45
7,000000 – 9,999999	30
10,000000 – 14,999999	25
15,000000 – 25,000000	20

Table 2 Frequency tolerance in different temperature ranges with respect to + 25 °C

frequency range MHz	temperature range °C	frequency tolerance		
		class 0	class I	class II
4,5 to 25	–5/+ 45 –10/+ 50 –15/+ 70	$\pm 5 \times 10^{-6}$ $\pm 7,5 \times 10^{-6}$ $\pm 10 \times 10^{-6}$	$\pm 7,5 \times 10^{-6}$ $\pm 10 \times 10^{-6}$ $\pm 15 \times 10^{-6}$	$\pm 10 \times 10^{-6}$ $\pm 15 \times 10^{-6}$ $\pm 20 \times 10^{-6}$
4,5 to 6 6 to 12 12 to 25	–55/+ 105 –55/+ 105 –55/+ 105	$\pm 30 \times 10^{-6}$ $\pm 32,5 \times 10^{-6}$ $\pm 25 \times 10^{-6}$	$\pm 40 \times 10^{-6}$ $\pm 35 \times 10^{-6}$ $\pm 30 \times 10^{-6}$	$\pm 50 \times 10^{-6}$ $\pm 40 \times 10^{-6}$ $\pm 40 \times 10^{-6}$
4,5 to 25	$T_{nom} \pm 5$		$\pm 2,5 \times 10^{-6}$	$\pm 5 \times 10^{-6}$

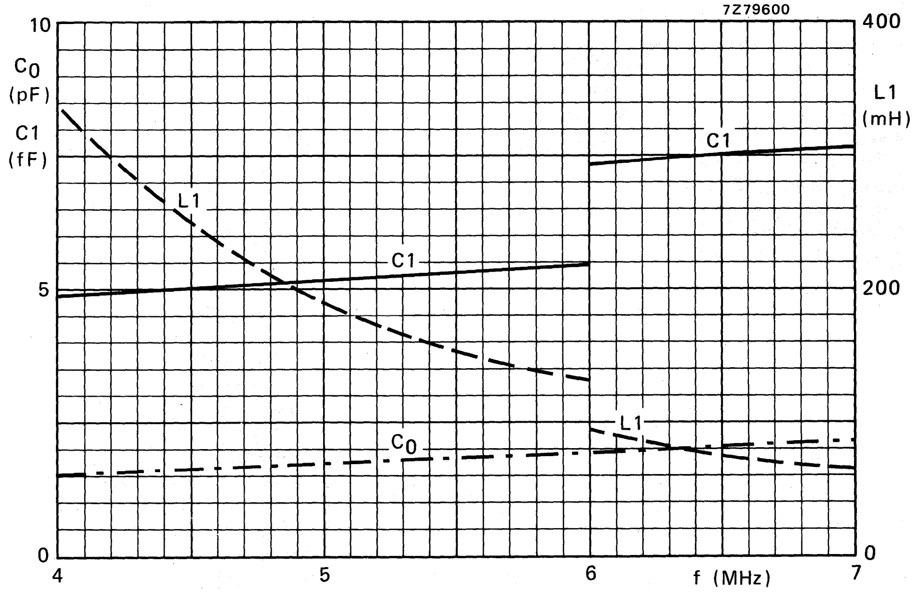


Fig. 1 Typical values of L_1, C_0 and C_1 for frequencies from 4 to 7 MHz.

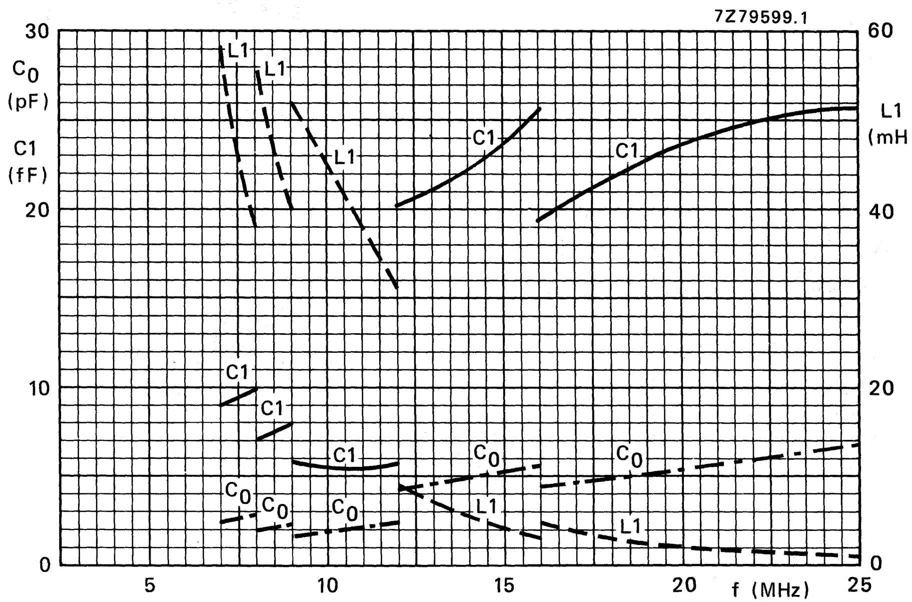


Fig. 2 Typical values of L_1, C_0 and C_1 for frequencies from 7 to 25 MHz.

QUARTZ CRYSTAL UNITS

economy types

QUICK REFERENCE DATA

Frequency range	4,5 to 25 MHz
Mode of vibration	fundamental
Type of holder	RW-42 or RW-43

MECHANICAL DATA

Outlines : See general section "Holders"

Mass : 1 g

ELECTRICAL DATA

Adjustment tolerance at + 25 °C	± 10 x 10^{-6}
Load capacitance C_L *	30 pF
Level of drive	0,5 mW
Motional capacitance C_1	5 to 30 fF
Parallel capacitance C_0	max. 7 pF
Resonance resistance R_r	
4,5 to 7 MHz	max. 80 Ω
7 to 25 MHz	max. 40 Ω
Frequency tolerance in different temperature ranges with respect to + 25 °C	see Table
Maximum permissible d.c. voltage between terminations	100 V

TESTS

Mechanical and climatic tests according to MIL and IEC procedures.

Table Frequency tolerance in different temperature ranges with respect to + 25 °C.

temperature range °C	frequency tolerance		
	class 0	class I	class II
−5/+45	± 5 x 10^{-6}	± 7,5 x 10^{-6}	± 10 x 10^{-6}
−10/+50	± 7,5 x 10^{-6}	± 10 x 10^{-6}	± 15 x 10^{-6}
−15/+70	± 10 x 10^{-6}	± 15 x 10^{-6}	± 20 x 10^{-6}
−55/+105	± 25 x 10^{-6}	± 30 x 10^{-6}	± 40 x 10^{-6}
$T_{nom.}$ ± 5	± 5 x 10^{-6}		

* Data at other C_L values and for series resonance available on request.

QUARTZ CRYSTAL UNITS

QUICK REFERENCE DATA

Frequency range	10 to 75 MHz
Mode of vibration	third overtone
Type of holder	HC-27/U

MECHANICAL DATA

Outlines See general section "Holders".

Mass 2,5 g

ELECTRICAL DATA

Adjustment tolerance at + 25 °C	$\pm 10 \times 10^{-6}$
Level of drive	0,5 mW
Motional capacitance C_1	typ. 1,5 fF
Parallel capacitance C_0	max. 7 pF
Resonance resistance R_r	max. 40 Ω
Frequency tolerance in different temperature ranges with respect to + 25 °C	see Table
Maximum permissible d.c. voltage between terminations	100 V
Ageing after 90 days non-operative at + 85 ± 2 °C	$(-0,5 \text{ to } +1) \times 10^{-6}$

TESTS

Mechanical and climatic tests according to MIL and IEC procedures.

Table Frequency tolerance in different temperature ranges with respect to + 25 °C

temperature range °C	frequency tolerance		
	class 0	class I	class II
−5/+50	$\pm 5 \times 10^{-6}$	$\pm 7,5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$
−10/+60	$\pm 7,5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$	$\pm 15 \times 10^{-6}$
−20/+70	$\pm 10 \times 10^{-6}$	$\pm 13 \times 10^{-6}$	$\pm 20 \times 10^{-6}$
−55/+105	$\pm 25 \times 10^{-6}$	$\pm 30 \times 10^{-6}$	$\pm 40 \times 10^{-6}$
$T_{nom} \pm 5$		$\pm 2,5 \times 10^{-6}$	$\pm 5 \times 10^{-6}$

QUARTZ CRYSTAL UNIT

QUICK REFERENCE DATA

Nominal frequency	10,00000 MHz
Mode of vibration	third overtone
Type of holder	HC-27/U

MECHANICAL DATA

Outlines See general section "Holders"

Mass 2,5 g approximately

ELECTRICAL DATA

Unless otherwise specified the values apply at a temperature of +25 ± 2 °C and a level of drive of 1 mA.*

Load resonance frequency f_L, load capacitance 75 pF**	10,000 00 MHz
Adjustment tolerance	± max. 5 x 10^{-6}
Tolerance over the temperature range of +69 to +71 °C, with respect to +70 °C	± max. 3 x 10^{-7}
Motional capacitance (C_1)	typ. 2,1 fF
Parallel capacitance (C_0)	typ. 5 pF
Motional inductance (L_1)	typ. 120 mH
Resonance resistance over the temperature range of −40 to +75 °C	max. 40 Ω
Maximum permissible d.c. voltage between terminations	100 V
Ageing	±5 x 10^{-8}/month
Operating temperature range	−40 to +75 °C

Stability of oscillator frequency. This depends on the crystal oven used. Stability figures of 1 x 10^{-6} or better can be achieved.

TESTS AND REQUIREMENTS

According to MIL-C-3098.	$\Delta f/f$	± max. 3 x 10^{-6}
	$\Delta R/R$	± max. 15%

Marking

The frequency in kHz, the last 5 digits of the catalogue number, and a code for the date of manufacture are stamped on the holder.

Mounting

The unit is provided with pins for socket mounting.

* Influence of drive level on frequency is max. 2 x 10^{-8}/dB.

** Data at other C_L and for series resonance available on request.

QUARTZ CRYSTAL UNITS

QUICK REFERENCE DATA

Frequency range	20 to 75 MHz
Mode of vibration	third overtone
Type of holder	HC-26/U or HC-29/U

MECHANICAL DATA

Outlines See general section "Holders".

Mass 0,8 g

ELECTRICAL DATA

Adjustment tolerance at + 25 °C	$\pm 10 \times 10^{-6}$
Level of drive	0,5 mW
Motional capacitance C_1	typ. 1,5 fF
Parallel capacitance C_0	max. 7 pF
Resonance resistance R_r	max. 30 Ω
Frequency tolerance in different temperature ranges with respect to + 25 °C	see Table
Maximum permissible d.c. voltage between terminations	100 V
Ageing after 90 days non-operative at + 85 ± 2 °C	$(-0,5 \text{ to } +1) \times 10^{-6}$

TESTS

Mechanical and climatic tests according to MIL and IEC procedures.

Table Frequency tolerance in different temperature ranges with respect to + 25 °C

temperature range °C	frequency tolerance		
	class 0	class I	class II
–5/+ 50	$\pm 5 \times 10^{-6}$	$\pm 7,5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$
–10/+ 60	$\pm 7,5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$	$\pm 15 \times 10^{-6}$
–20/+ 70	$\pm 10 \times 10^{-6}$	$\pm 13 \times 10^{-6}$	$\pm 20 \times 10^{-6}$
–55/+ 105	$\pm 25 \times 10^{-6}$	$\pm 30 \times 10^{-6}$	$\pm 40 \times 10^{-6}$
$T_{nom} \pm 5$		$\pm 2,5 \times 10^{-6}$	$\pm 5 \times 10^{-6}$

QUARTZ CRYSTAL UNITS

QUICK REFERENCE DATA

Frequency range	17 to 75 MHz
Mode of vibration	third overtone
Type of holder	RW-42 or RW-43

MECHANICAL DATA

Outlines : See general section "Holders".

Mass : 1 g

ELECTRICAL DATA

Adjustment tolerance at + 25 °C	$\pm 10 \times 10^{-6}$
Level of drive	0,5 mW
Motional capacitance C_1	typ. 1,5 fF
Parallel capacitance C_0	max. 7 pF
Resonance resistance R_r	max. 40 Ω
Frequency tolerance in different temperature ranges with respect to + 25 °C	see Table
Maximum permissible d.c. voltage between terminations	100 V

TESTS

Mechanical and climatic tests according to MIL and IEC procedures.

Table Frequency tolerance in different temperature ranges with respect to + 25 °C

temperature range °C	frequency tolerance		
	class 0	class I	class II
−5/+ 50	$\pm 5 \times 10^{-6}$	$\pm 7,5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$
−10/+ 60	$\pm 7,5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$	$\pm 15 \times 10^{-6}$
−20/+ 70	$\pm 10 \times 10^{-6}$	$\pm 13 \times 10^{-6}$	$\pm 20 \times 10^{-6}$
−55/+ 105	$\pm 25 \times 10^{-6}$	$\pm 30 \times 10^{-6}$	$\pm 40 \times 10^{-6}$
$T_{nom} \pm 5$	$\pm 5 \times 10^{-6}$		

QUARTZ CRYSTAL UNITS

QUICK REFERENCE DATA

Frequency range	10 to 75 MHz
Mode of vibration	third overtone
→ Type of holder	HC-33/U or RW-36

MECHANICAL DATA

Outlines : See general section "Holders"

Mass : 4 g

ELECTRICAL DATA

Adjustment tolerance at + 25 °C	$\pm 10 \times 10^{-6}$
Level of drive	0,5 mW
Motional capacitance C_1	typ. 1,5 fF
Parallel capacitance C_0	max. 7 pF
Resonance resistance R_r	max. 60 Ω
Frequency tolerance in different temperature ranges with respect to + 25 °C	see Table
Maximum permissible d.c. voltage between terminations	100 V

TESTS

Mechanical and climatic tests according to MIL and IEC procedures.

Table Frequency tolerance in different temperature ranges with respect to + 25 °C

temperature range °C	frequency tolerance		
	class 0	class I	class II
–5/+ 50	$\pm 5 \times 10^{-6}$	$\pm 7{,}5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$
–10/+ 60	$\pm 7{,}5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$	$\pm 15 \times 10^{-6}$
–20/+ 70	$\pm 10 \times 10^{-6}$	$\pm 13 \times 10^{-6}$	$\pm 20 \times 10^{-6}$
–55/+ 105	$\pm 25 \times 10^{-6}$	$\pm 30 \times 10^{-6}$	$\pm 40 \times 10^{-6}$
$T_{nom} \pm 5$	$\pm 5 \times 10^{-6}$		

QUARTZ CRYSTAL UNITS

QUICK REFERENCE DATA

Frequency range	50 to 125 MHz
Mode of vibration	fifth overtone
Type of holder	HC-27/U

MECHANICAL DATA

Outlines See general section "Holders".

Mass 2,5 g

ELECTRICAL DATA

Adjustment tolerance at + 25 °C	$\pm 10 \times 10^{-6}$
Level of drive	0,5 mW
Motional capacitance C_1	typ. 0,5 fF
Parallel capacitance C_0	max. 7 pF
Resonance resistance R_r	max. 50 Ω
Frequency tolerance in different temperature ranges with respect to + 25 °C	see Table
Maximum permissible d.c. voltage between terminations	100 V
Ageing after 90 days non-operative at + 85 ± 2 °C	$(-0,5 \text{ to } +1) \times 10^{-6}$

TESTS

Mechanical and climatic tests according to MIL and IEC procedures.

Table Frequency tolerance in different temperature ranges with respect to + 25 °C

temperature range °C	frequency tolerance		
	class 0	class I	class II
−5/+ 50	$\pm 5 \times 10^{-6}$	$\pm 7,5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$
−10/+ 60	$\pm 7,5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$	$\pm 15 \times 10^{-6}$
−20/+ 70	$\pm 10 \times 10^{-6}$	$\pm 13 \times 10^{-6}$	$\pm 20 \times 10^{-6}$
−55/+ 105	$\pm 25 \times 10^{-6}$	$\pm 30 \times 10^{-6}$	$\pm 40 \times 10^{-6}$
$T_{nom} \pm 5$		$\pm 2,5 \times 10^{-6}$	$\pm 5 \times 10^{-6}$

QUARTZ CRYSTAL UNITS

QUICK REFERENCE DATA

Frequency range	50 to 125 MHz
Mode of vibration	fifth overtone
Type of holder	HC-26/U or HC-29/U

MECHANICAL DATA

Outlines See general section "Holders".

Mass 0,8 g

ELECTRICAL DATA

Adjustment tolerance at + 25 °C	± 10 x 10^{-6}
Level of drive	0,5 mW
Motional capacitance C_1	typ. 0,5 fF
Parallel capacitance C_0	max. 7 pF
Resonance resistance R_r	
50 to 90 MHz	max. 50 Ω
90 to 125 MHz	max. 70 Ω
Frequency tolerance in different temperature ranges with respect to + 25 °C	see Table
Maximum permissible d.c. voltage between terminations	100 V
Ageing after 90 days non-operative at + 85 ± 2 °C	(–0,5 to + 1) x 10^{-6}

TESTS

Mechanical and climatic tests according to MIL and IEC procedures.

Table Frequency tolerance in different temperature ranges with respect to + 25 °C

temperature range °C	frequency tolerance		
	class 0	class I	class II
–5/+ 50	± 5 x 10^{-6}	± 7,5 x 10^{-6}	± 10 x 10^{-6}
–10/+ 60	± 7,5 x 10^{-6}	± 10 x 10^{-6}	± 15 x 10^{-6}
–20/+ 70	± 10 x 10^{-6}	± 13 x 10^{-6}	± 20 x 10^{-6}
–55/+ 105	± 25 x 10^{-6}	± 30 x 10^{-6}	± 40 x 10^{-6}
T_{nom} ± 5		± 2,5 x 10^{-6}	± 5 x 10^{-6}

QUARTZ CRYSTAL UNITS

QUICK REFERENCE DATA

Frequency range	50 to 125 MHz
Mode of vibration	fifth overtone
Type of holder	RW-42 or RW-43

MECHANICAL DATA

Outlines : See general section "Holders".

Mass : 1 g

ELECTRICAL DATA

Adjustment tolerance at + 25 °C	$\pm 10 \times 10^{-6}$
Level of drive	0,5 mW
Motional capacitance C_1	typ. 0,5 fF
Parallel capacitance C_0	max. 7 pF
Resonance resistance R_r	
50 to 90 MHz	max. 60 Ω
90 to 125 MHz	max. 80 Ω
Frequency tolerance in different temperature ranges with respect to + 25 °C	see Table
Maximum permissible d.c. voltage between terminations	100 V

TESTS

Mechanical and climatic tests according to MIL and IEC procedures.

Table Frequency tolerance in different temperature ranges with respect to + 25 °C

temperature range °C	frequency tolerance		
	class 0	class I	class II
−5/+ 50	$\pm 5 \times 10^{-6}$	$\pm 7,5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$
−10/+ 60	$\pm 7,5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$	$\pm 15 \times 10^{-6}$
−20/+ 70	$\pm 10 \times 10^{-6}$	$\pm 13 \times 10^{-6}$	$\pm 20 \times 10^{-6}$
−55/+ 105	$\pm 25 \times 10^{-6}$	$\pm 30 \times 10^{-6}$	$\pm 40 \times 10^{-6}$
$T_{nom} \pm 5$	$\pm 5 \times 10^{-6}$		

QUARTZ CRYSTAL UNITS

QUICK REFERENCE DATA

Frequency range	50 to 125 MHz
Mode of vibration	fifth overtone
→ Type of holder	HC-33/U or RW-36

MECHANICAL DATA

Outlines : See general section "Holders"

Mass : 4 g

ELECTRICAL DATA

Adjustment tolerance at + 25 °C	$\pm 10 \times 10^{-6}$
Level of drive	0,5 mW
Motional capacitance C_1	typ. 0,5 fF
Parallel capacitance C_0	max. 7 pF
Resonance resistance R_r	20 to 100 Ω
Frequency tolerance in different temperature ranges with respect to + 25 °C	see Table
Maximum permissible d.c. voltage between terminations	100 V

TESTS

Mechanical and climatic tests according to MIL and IEC procedures.

Table Frequency tolerance in different temperature ranges with respect to + 25 °C

temperature range °C	frequency tolerance		
	class 0	class I	class II
–5/+ 50	$\pm 5 \times 10^{-6}$	$\pm 7{,}5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$
–10/+ 60	$\pm 7{,}5 \times 10^{-6}$	$\pm 10 \times 10^{-6}$	$\pm 15 \times 10^{-6}$
–20/+ 70	$\pm 10 \times 10^{-6}$	$\pm 13 \times 10^{-6}$	$\pm 20 \times 10^{-6}$
–55/+ 105	$\pm 25 \times 10^{-6}$	$\pm 30 \times 10^{-6}$	$\pm 40 \times 10^{-6}$
$T_{nom} \pm 5$	$\pm 5 \times 10^{-6}$		

QUARTZ CRYSTAL CONTROLLED OSCILLATORS

SURVEY OF TYPES

frequency range MHz	temperature range °C	supply voltage . . V ± . .		frequency tolerance ± . . x 10^{-6}	adjustment facility	catalogue number 4322	page
4,5 to 15 (TCXO)	0 to + 50 −10 to + 60 −20 to + 70	12 12 12	10% 10% 10%	1,0 1,5 2,0	none	4322 190 2 . . . . 190 1 . . . . 190 0	81
4,5 to 15 (TCXO)	0 to + 50 −10 to + 60 −20 to + 70	12 12 12	10% 10% 10%	1,0 1,5 2,0	external variable capacitor	4322 191 2 . . . . 191 1 . . . . 191 0	85
4,5 to 12 (TCXO)	0 to + 50 −10 to + 60 −20 to + 70	12 12 12	10% 10% 10%	1,0 1,5 2,0	external variable resistor	4322 192 2 . . . . 192 1 . . . . 192 0	89
20 to 50 (TCXO)	0 to + 50 −20 to + 70 0 to + 50 −20 to + 70	12 12 12 12	2% 2% 10% 10%	1,0 2,0 2,0 3,0	external variable capacitor	4322 195 0 . . . . 195 1 . . . . 195 2 . . . . 195 3	93
4,5 to 15 (DTCXO)	−40 to + 85	5	5%	0,5	external variable resistor	4322 198	97
1,0 to 20 (CIO)	0 to + 70	5	10%	100	none	4322 199	99
8 to 15 (VCXO)	−5 to + 60	5	5%	20	control voltage	t.b.f.	101

INTRODUCTION

Our quartz crystal controlled oscillators consists in general of a quartz crystal unit and an oscillator circuit, packaged together in a hermetically sealed encapsulation. When connected to a fit supply voltage, the oscillator produces an output signal with a certain waveform and frequency.
For applications where a high frequency stability is a demand, a temperature compensating network is added to the oscillator circuit which reduces the original temperature drift of the quartz crystal unit with a factor 20 to 60. Our range of quartz crystal controlled oscillators comprise the following main groups:

I COMPACT INTEGRATED OSCILLATORS (CIO)

These are small oscillators in a DIL-14/4 encapsulation without temperature compensation. The frequency stability is moderate, the output characteristic is designed for TTL-level applications with symmetric waveform. Microprocessor and logic circuitry are typical applications for CIOs.

II TEMPERATURE COMPENSATED X-TAL OSCILLATORS (TCXO)

In this type of oscillator, an analog circuit is incorporated which compensates the temperature influence on the frequency stability of the oscillator.
TCXOs are available with stability figures of $\pm$ 1 to 3 x 10^{-6}. Oscillators of this type are used i.a. in measuring and communication equipment.

III DIGITAL TEMPERATURE COMPENSATED X-TAL OSCILLATORS (DTCXO)

This is the latest development in temperature compensated crystal oscillator design. Temperature compensation is carried out by means of a digital circuit and is based upon the following principle:
A memory chip contains a table with temperature correction data for both crystal and oscillator over a certain temperature range of say −40 to + 85 oC.
The memory is addressed by a digital (quartz-) thermometer. So at each temperature within this range, a certain memory cell contains the specific correction factor to keep the output frequency within very close tolerances.
Oscillators of this type show a frequency stability of $< \pm$ 0,5 x 10^{-6} in the temperature range of −40 to + 85 ^{o}C.
DTCXOs are used in high-professional equipment especially where high frequency stability combined with low power consumption, small dimensions and no warming-up time is a demand.

IV VOLTAGE CONTROLLED CRYSTAL OSCILLATORS (VCXO)

These units comprise a quartz crystal and a low power Schottky integrated circuit device. The frequency can be shifted by means of a control voltage.
VCXOs are specially suitable for digital telephone switching networks.

TERMS AND DEFINITIONS

Nominal frequency:
The frequency assigned to the oscillator when operated under specified conditions.

Frequency offset:
The frequency difference, positive or negative, which should be added to the specified nominal frequency of the oscillator, when adjusting the oscillator frequency at + 25 ^{o}C, in order to minimize its deviation from nominal frequency over the specified range of operating conditions.

Frequency tuning range:
Frequency tuning range is the range over which the oscillator frequency may be varied by means of an external resistor (4322 192 and 198 series) or by an external capacitance (4322 191, 193 and 195 series), for the purpose of:

— Setting the frequency to a particular value f.e. to give a frequency offset.

— Correcting the oscillator frequency after deviation due to ageing or other changed conditions.

Operating temperature range:
The temperature range over which the oscillator shall function, maintaining frequency and other output signal atributes within specified tolerances.

Operable temperature range:
The temperature range over which the oscillator shall continue to provide an output signal, though not within the specified tolerances of frequency, level, waveform, etc.

Storage temperature range:
The temperature range within which the (non operating) oscillator may be stored for a prolonged time without any damage.
After storage, the oscillator shall maintain frequency and other output attributes within specified tolerances.

Frequency ageing:
The relationship between oscillator frequency and time. This long-term frequency drift is caused by secular changes in the crystal unit and/or other elements of the oscillator circuit, and is expressed as fractional change in mean frequency per specified time interval (f.e. $\pm 1 \times 10^{-6}$ per year).

TESTS AND REQUIREMENTS

I Compact integrated oscillators, CIO

IEC-68-2 test method	test	procedure	requirements
Db	Accelerated damp heat	+ 25 to + 55 °C 6 cycles at > 95% R.H.	$\Delta f/f < \pm 5 \times 10^{-6}$
Na	Temperature cycling	–40/+ 85 °C 10 cycles 1 h + 1h/cycle	$\Delta f/f < \pm 5 \times 10^{-6}$ no damage
Ea	Shock	100g half sine 6 directions 1 blow/direction	$\Delta f/f < \pm 5 \times 10^{-6}$
Fc	Vibration	10-500-10 Hz acceleration 10g 3 directions 30 min/direction	$\Delta f/f < \pm 5 \times 10^{-6}$ no damage
Eb	Bump	3000 bumps of 30g	$\Delta f/f < \pm 5 \times 10^{-6}$
Ed	Free fall	3 times h = 250 mm on hard wood	$\Delta f/f < \pm 5 \times 10^{-6}$
UB	Bending of terminations	1 x 90° load 5 N	no visible damage no leaks
Qc, Qx	Sealing	16 hours 700 kPa Helium	$< 10^{-8}$ ncc/s
Tb	Resistance to soldering heat	350 ± 5 °C 3 ± 1 s	$\Delta f/f < \pm 5 \times 10^{-6}$
T	Solderability	260 ± 5 °C 10 ± 1 s	Good tinning No visual damage No leaks
MIL-0-55310/16	Ageing	30 days continuous operation at + 70 °C	$\Delta f/f < \pm 1,5 \times 10^{-6}$
MIL-Std-883	Visual inspection	method 2017.1	by agreement with customer

II Temperature compensated quartz crystal oscillator, TCXO

IEC-68-2 test method	test	procedure	requirements
Db	Accelerated damp heat	+ 25 to + 55 °C 6 cycles at > 95% R.H.	$\Delta f/f < \pm 0{,}5 \times 10^{-6}$
Ea	Shock	50 g 6 directions 1 blow/direction	$\Delta f/f < \pm 0{,}5 \times 10^{-6}$
Fc	Vibration	10-500-10 Hz acceleration 10g 3 directions 30 min/direction	$\Delta f/f < \pm 0{,}5 \times 10^{-6}$
Tb	Resistance to soldering heat	260 +/– 5 °C 10 +/– 1 s	$\Delta f/f < \pm 0{,}5 \times 10^{-6}$

III Digital temperature compensated quartz crystal oscillators, DTCXO

IEC-68-2 test method	test	procedure	requirements
Db	Accelerated damp heat	+ 25 to + 55 °C 6 cycles at > 95% R.H.	$\Delta f/f < \pm 0{,}2 \times 10^{-6}$
Ea	Shock	50 g 6 directions 1 blow/direction	$\Delta f/f < \pm 0{,}2 \times 10^{-6}$
Fc	Vibration	10-500-10 Hz acceleration 10g 3 directions 30 min/direction	$\Delta f/f < \pm 0{,}2 \times 10^{-6}$
Tb	Resistance to soldering heat	260 +/– 5 °C 10 +/– 1 s	$\Delta f/f < \pm 0{,}2 \times 10^{-6}$

IV Voltage controlled crystal oscillators, VCXO

IEC 68 test method	test	procedure	requirements
Aa, Ba	storage	16 h, 125 °C/2 h, –55 °C	no failures
Db	accelerated damp heat	+ 25 °C to + 55 °C 6 cycles	$\Delta f \leqslant 5 \times 10^{-6}$
Ea	shock	100 g 6 shocks, 3 directions	$\Delta f \leqslant 5 \times 10^{-6}$
Ed	free fall	250 mm on wood	
Fc	vibration	frequency 10 - 500 Hz acceleration 20 g, three directions, 30 min.	no damage $\Delta f \leqslant 5 \times 10^{-6}$
Na	temperature cycling	1 h, –40 °C/1 h, + 85 °C 10 cycles	no damage $\Delta f \leqslant 5 \times 10^{-6}$
Q_c, Q_x	sealing	16 h, 700 kPa He	$< 1 \times 10^{-8}$ ncc/s
T	soldering	solderability: max. 10 s, 260 °C thermal shock: 3 s, 350 °C	good tinning no damage $\Delta f \leqslant 5 \cdot 10^{-6}$
Ub	bending of terminations	load 5 N, method 1	no visible damage no leaks

Table 2

MIL test method	test	method	requirements
MIL-0-55310/16	ageing	30 days, 60 °C continuous	$\Delta f \leqslant 1{,}5 \times 10^{-6}$
MIL-Std-883	visual inspection	2017.1	by agreement with customer

TEMPERATURE COMPENSATED CRYSTAL OSCILLATOR (TCXO)

QUICK REFERENCE DATA

Catalogue numbers	4322 190 0	4322 190 1	4322 190 2	
Frequency range	4,5 to 15*	4,5 to 15	4,5 to 15	MHz ←
Frequency tolerance	$\pm 2 \times 10^{-6}$	$\pm 1{,}5 \times 10^{-6}$	$\pm 1 \times 10^{-6}$	
Temperature range	−20 to + 70	−10 to + 60	0 to + 50	°C
Supply voltage	+ 12	+ 12	+ 12	V

APPLICATION

Temperature compensated crystal oscillators (TCXOs) are used in mobilophones, electronic timing devices, measuring equipment, synthesizers, etc.

DESCRIPTION

A TCXO module comprises a quartz crystal oscillator, and a thermally controlled circuit that compensates for frequency changes over the whole temperature range. The metal housing is filled with dry nitrogen and hermetically sealed. The unit is provided with 5 connecting pins which are arranged to fit printed-wiring boards with a grid pitch of 2,54 mm (see Fig. 1).

MECHANICAL DATA

Outlines

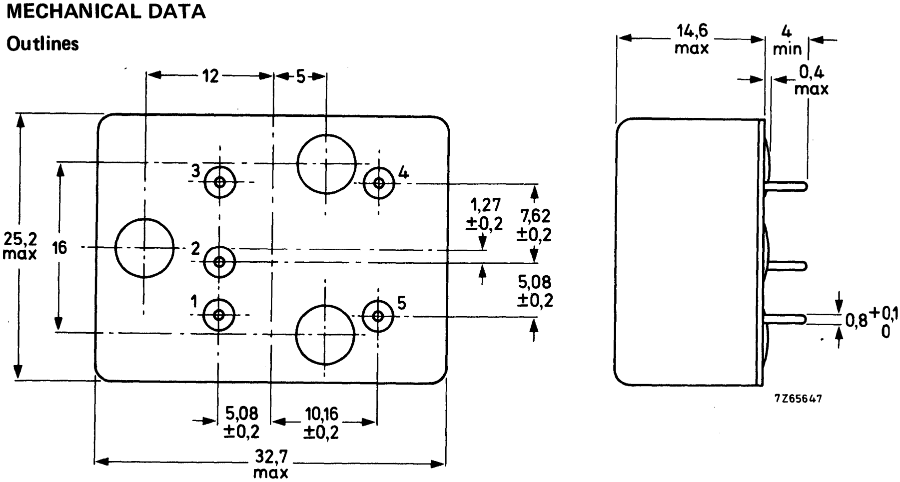


Fig. 1.

* Complete 12-digit catalogue numbers have been fixed for TCXOs for the following frequencies:

5 MHz : 4322 190 00011
10 MHz : 4322 190 00001
Catalogue numbers for TCXOs with other frequencies will be fixed upon request.

Mass

25 g approximately

Marking

The units are provided with a label showing the following information:

TCXO	Type 4322 190
Frequency	MHz
Δf 25 °C	Hz
Range	°C
No.	

ELECTRICAL DATA

→ Supply voltage, V_S		+ 12 V ± 10% via R_1 = 470 Ω (see Fig. 2)
→ Power consumption		max. 150 mW
Frequency range		4,5 - 15 MHz
Frequency tolerance/temperature range at specified V_S, Z_L, and at a temp. rate of max. 1 K/min.		
cat. numbers 4322 190 0	−20 to + 70 °C	$\pm 2 \times 10^{-6}$
cat. numbers 4322 190 1	−10 to + 60 °C	$\pm 1{,}5 \times 10^{-6}$
cat. numbers 4322 190 2	0 to 50 °C	$\pm 1 \times 10^{-6}$
Ageing		$\pm 1 \times 10^{-6}$ per year
Correction on aging influence by connecting pin 3 to pin 2		$-2^{+1}_{-0,5} \times 10^{-6}$
Internal resistance, R_i		2800 Ω ± 5%
Internal capacitance, C_i		5,5 pF ± 5%
Internal voltage source, V_i		600 mV ± 40%
Load impedance, Z_L		min. 500 Ω
Output voltage, V_o		see Figs 3 and 4
Storage temperature range		−25 to + 85 °C

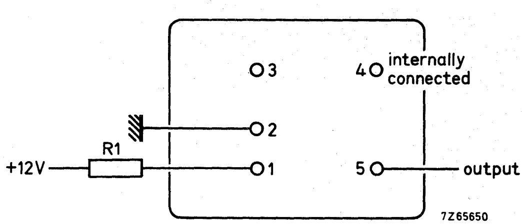


Fig. 2 Connection diagram.

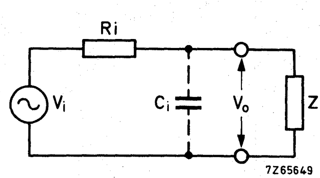


Fig. 3 Equivalent circuit.

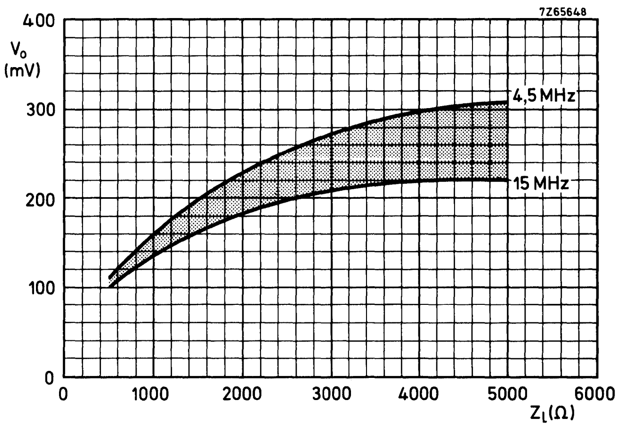


Fig. 4 Output voltage as a function of load impedance (typical values).

ENVIRONMENTAL TESTS AND REQUIREMENTS

See general section, table II

TEMPERATURE COMPENSATED CRYSTAL OSCILLATOR (TCXO)

QUICK REFERENCE DATA

Catalogue numbers	4322 191 0	4322 191 1	4322 191 2	
Frequency range	4,5 to 15*	4,5 to 15	4,5 to 15	MHz ←
Frequency tolerance	$\pm 2 \times 10^{-6}$	$\pm 1{,}5 \times 10^{-6}$	$\pm 1 \times 10^{-6}$	
Temperature range	−20 to + 70	−10 to + 60	0 to + 50	°C
Supply voltage	+ 12	+ 12	+ 12	V
Frequency is adjustable by external variable capacitor				

APPLICATION

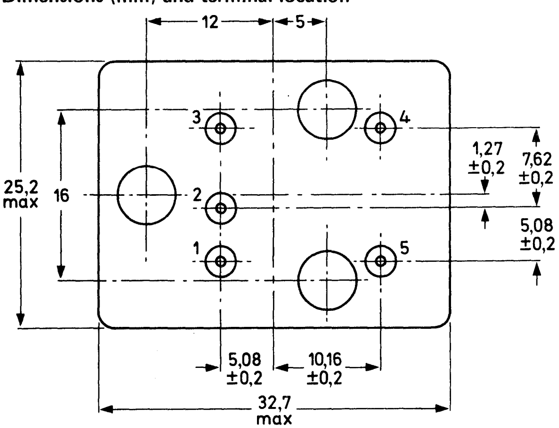
Temperature compensated crystal oscillators (TCXOs) are used in mobilophones, electronic timing devices, measuring equipment, synthesizers, etc.

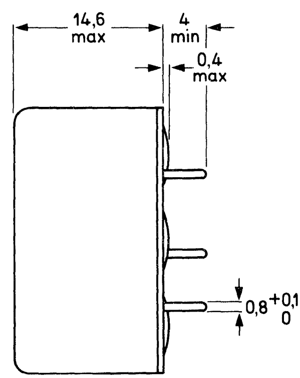
DESCRIPTION

A TCXO module comprises a quartz crystal oscillator, and a thermally controlled circuit that compensates for frequency changes over the whole temperature range. The metal housing is filled with dry nitrogen and hermetically sealed. The unit is provided with 5 connecting pins which are arranged to fit printed-wiring boards with a grid pitch of 2,54 mm (see Fig. 1).

MECHANICAL DATA

Dimensions (mm) and terminal location





* Complete 12-digit catalogue numbers have been fixed for TCXOs for the following frequencies:

5 MHz : 4322 191 00011 — 4,194304 MHz : 4322 191 00031
10 MHz : 4322 191 00001 — 4,433619 MHz : 4322 191 00041

Catalogue numbers for TCXOs with other frequencies will be fixed upon request.

Mass

25 g approximately

Marking

The units are provided with a label showing the following information:

TCXO	Type 4322 191
Frequency	MHz
Δf 25 °C	Hz
Range	°C
No.	

ELECTRICAL DATA

→ Supply voltage, V_s		+ 12 V ± 10% via R_1 = 470 Ω (see Fig. 2)
→ Power consumption		max. 150 mW
Frequency range		4,5 – 15 MHz
Frequency tolerance/temperature range after adjustment (see note), at specified V_s, Z_L and at a temperature rate of max. 1 K/min.		
cat. numbers 4322 191 0	−20 to + 70 °C	$\pm 2 \times 10^{-6}$
cat. numbers 4322 191 1	−10 to + 60 °C	$\pm 1{,}5 \times 10^{-6}$
cat. numbers 4322 191 2	0 to 50 °C	$\pm 1 \times 10^{-6}$
Ageing		$\pm 1 \times 10^{-6}$ per year
Correction on aging influence		$\pm 2 \times 10^{-6}$ (see note below)
Internal resistance, R_i		2800 Ω ± 5%
Internal capacitance, C_i		5,5 pF ± 5%
Internal voltage source, V_i		600 mV ± 40%
Load impedance, Z_L		min. 500 Ω
Output voltage, V_o		see Figs 3 and 4
Storage temperature range		−25 to + 85 °C

Note

It is not guaranteed that the nominal frequency occurs at room temperature. The nominal frequency can be shifted by connecting a variable capacitor of max. 60 pF externally between pin 2 and 3. For optimum stability over the whole temperature range the oscillator should be adjusted at room temperature to a frequency which deviates from the nominal one by an amount mentioned as "Δf 25 °C ... Hz" on the label on the module. After this adjustment a trimming range of ± min. 2×10^{-6} is still available to correct ageing influences.

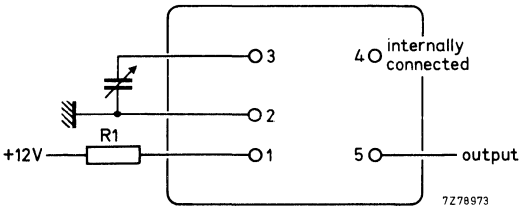


Fig. 2 Connection diagram.

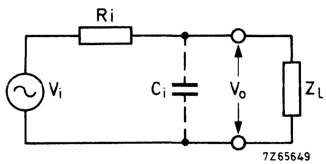


Fig. 3 Equivalent circuit.

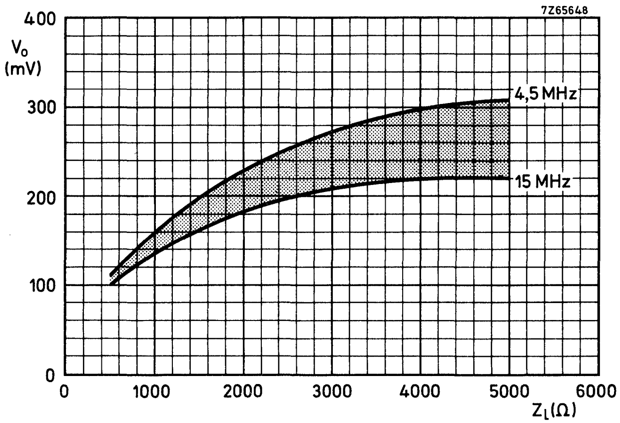


Fig. 4 Output voltage as a function of load impedance (typical values).

ENVIRONMENTAL TESTS AND REQUIREMENTS

See general section, table II

TEMPERATURE COMPENSATED CRYSTAL OSCILLATOR (TCXO)

QUICK REFERENCE DATA

Catalogue numbers	4322 192 0	4322 192 1	4322 192 2	
Frequency range	4,5 to 12*	4,5 to 12	4,5 to 12	MHz
Frequency tolerance	$\pm 2 \times 10^{-6}$	$\pm 1,5 \times 10^{-6}$	$\pm 1 \times 10^{-6}$	
Temperature range	−20 to +70	−10 to +60	0 to +50	°C
Supply voltage	+12	+12	+12	V

Frequency is adjustable by external variable resistor

APPLICATION

Temperature compensated crystal oscillators (TCXOs) are used in mobilophones, electronic timing devices, measuring equipment, synthesizers, etc.

DESCRIPTION

A TCXO module comprises a quartz crystal oscillator, and a thermally controlled circuit that compensates for frequency changes over the whole temperature range. The metal housing is filled with dry nitrogen and hermetically sealed. The unit is provided with 5 connecting pins which are arranged to fit printed-wiring boards with a grid pitch of 2,54 mm (see Fig. 1).

MECHANICAL DATA

Outlines

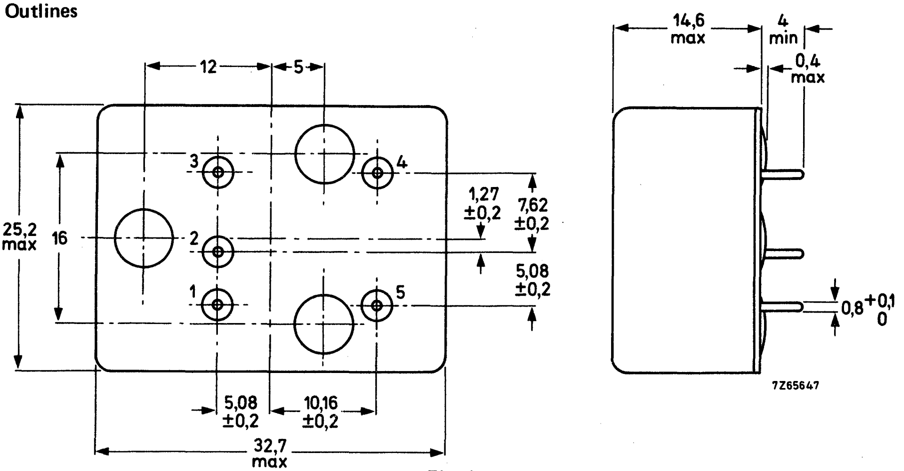


Fig. 1.

* Complete 12-digit catalogue number has been fixed for TCXOs for the following frequency:

10 MHz: 4322 192 00001
Catalogue numbers for TCXOs with other frequencies will be fixed upon request.

Mass

25 g approximately

Marking

The units are provided with a label showing the following information:

TCXO	Type 4322 192
Frequency Δf 25 °C Range No.	MHz Hz °C

ELECTRICAL DATA

Supply voltage, V_S	+ 12 V ± 10% via R_1 = 470 Ω (see Fig. 2)
→ Supply current, I_S	max. 12 mA via R_1 = 470 Ω (see Fig. 2)
Power consumption	max. 200 mW
→ Frequency range	4,5 – 12 MHz
Frequency tolerance/temperature range after adjustment (see note), at specified V_S, Z_L, and at a temperature rate of max. 1 K/min.	
cat. numbers 4322 192 0 . . . . –20 to +70°	$\pm 2 \times 10^{-6}$
cat. numbers 4322 192 1 . . . . –10 to +60°	$\pm 1,5 \times 10^{-6}$
cat. numbers 4322 192 2 . . . . 0 to 50°	$\pm 1 \times 10^{-6}$
Ageing	$\pm 1 \times 10^{-6}$ per year
Correction on ageing influence	$\pm 2 \times 10^{-6}$ (see note below)
Internal resistance, R_i	2800 Ω ± 5%
Internal capacitance, C_i	5,5 pF ± 5%
Internal voltage source, V_i	600 mV ± 40%
Load impedance, Z_L	min. 500 Ω
Output voltage, V_o	see Figs 3 and 4
Storage temperature range	–25 to +85 °C

Note

It is not guaranteed that the nominal frequency occurs at room temperature. The nominal frequency can be shifted by connecting a variable resistor of 2 kΩ externally between pin 2 and 3. For optimum stability over the whole temperature range the oscillator should be adjusted at room temperature to a frequency which deviates from the nominal one by an amount mentioned as "Δf 25 °C ... Hz" on the label on the module. After this adjustment a trimming range of ± min. 2×10^{-6} is still available to correct ageing influences.

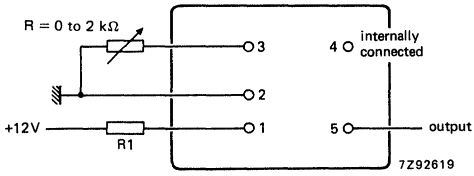


Fig. 2 Connection diagram.

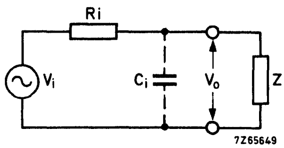


Fig. 3 Equivalent circuit.

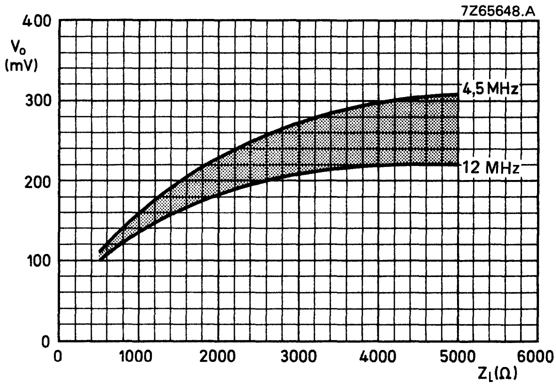


Fig. 4 Output voltage as a function of load impedance (typical values).

ENVIRONMENTAL TESTS AND REQUIREMENTS

See general section, Table II

TEMPERATURE COMPENSATED CRYSTAL OSCILLATOR (TCXO)

QUICK REFERENCE DATA

Catalogue numbers	4322 195 0	4322 195 1	4322 195 2	4322 195 3	
Frequency range	20 to 50	20 to 50	20 to 50	20 to 50	MHz
Frequency tolerance	$\pm 1 \times 10^{-6}$	$\pm 2 \times 10^{-6}$	$\pm 2 \times 10^{-6}$	$\pm 3 \times 10^{-6}$	
Temperature range	0 to + 50	−20 to + 70	0 to + 50	−20 to + 70	°C
Supply voltage	12 V ± 2%	12 V ± 2%	12 V ± 10%	12 V ± 10%	

Frequency is adjustable by external variable capacitor

APPLICATION

Temperature compensated crystal oscillators (TCXOs) are used in mobilophones, electronic timing devices, measuring equipment, synthesizers, etc.

DESCRIPTION

A TCXO module comprises a quartz crystal oscillator, and a thermally controlled circuit that compensates for frequency changes over the whole temperature range. The metal housing is filled with dry nitrogen and hermetically sealed. The unit is provided with 5 connecting pins which are arranged to fit printed-wiring boards with a grid pitch of 2,54 mm (see Fig. 1).

MECHANICAL DATA

Outlines

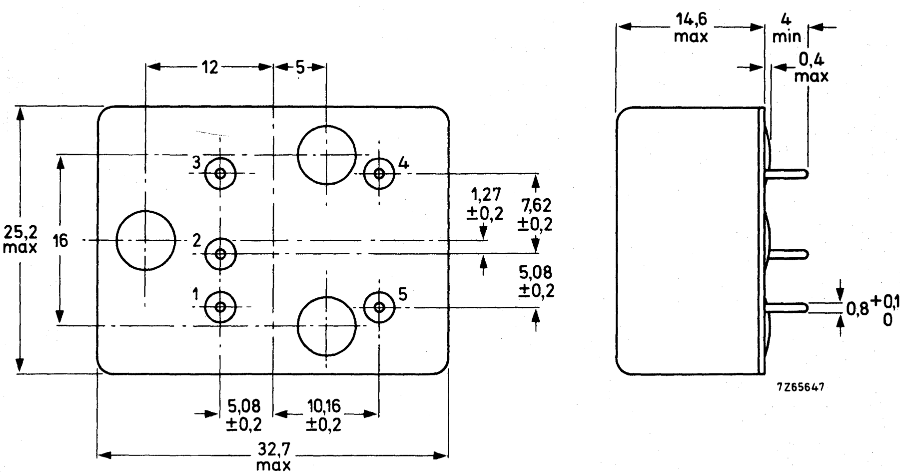


Fig. 1.

Mass

25 g approximately

Marking

The units are provided with a label showing the following information:

TCXO	Type 4322 195
Frequency	MHz
Δf 25 °C	Hz
Range	°C
No.	

ELECTRICAL DATA

Supply voltage, V_S, see Fig. 2		
cat. numbers 4322 195 0 . . . . and 4322 195 1		+ 12 V ± max. 2%
cat. numbers 4322 195 2 . . . . and 4322 195 3		+ 12 V ± max. 10%
Power consumption		typ. 160 mW, max. 180 mW
Frequency range		20 to 50 MHz
Frequency tolerance/temperature range after adjustment (see note), at specified V_S, Z_L, and at a temperature rate of 1 K/min		see also Fig. 4
cat. numbers 4322 195 0	0 to + 50 °C	$\pm 1 \times 10^{-6}$
cat. numbers 4322 195 1	−20 to + 70 °C	$\pm 2 \times 10^{-6}$
cat. numbers 4322 195 2	0 to 50 °C	$\pm 2 \times 10^{-6}$
cat. numbers 4322 195 3	−20 to + 70 °C	$\pm 3 \times 10^{-6}$
Ageing		$\pm 1 \times 10^{-6}$ per year
Correction on ageing influence		$\pm > 2 \times 10^{-6}$, see note
Internal resistance, R_i		2800 Ω ± 5%
Internal capacitance, C_i		5,5 pF ± 5%
Internal voltage source, V_i		600 mV ± 40%
Load impedance, Z_L		min. 500 Ω
Output voltage, V_o		see Fig. 5
Storage temperature range		−25 to + 85 °C

Note

It is not guaranteed that the nominal frequency occurs at room temperature. The nominal frequency can be shifted by connecting a variable capacitor of max. 20 pF externally between pins 2 and 3. For optimum stability over the whole temperature range the oscillator should be adjusted at room temperature to a frequency which deviates from the nominal one by an amount mentioned as "Δf 25 °C . . . Hz" on the label on the module. After this adjustment a trimming range of ± min. 2×10^{-6} is still available to correct aging influences.

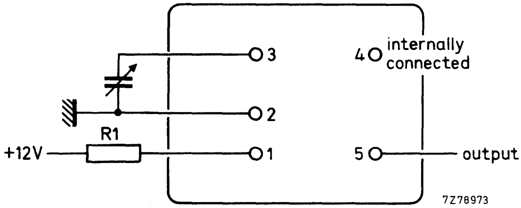


Fig. 2 Connection diagram.
R1 = 390 Ω

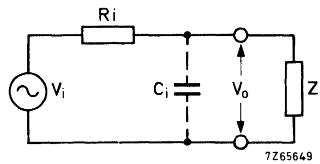


Fig. 3 Equivalent circuit.

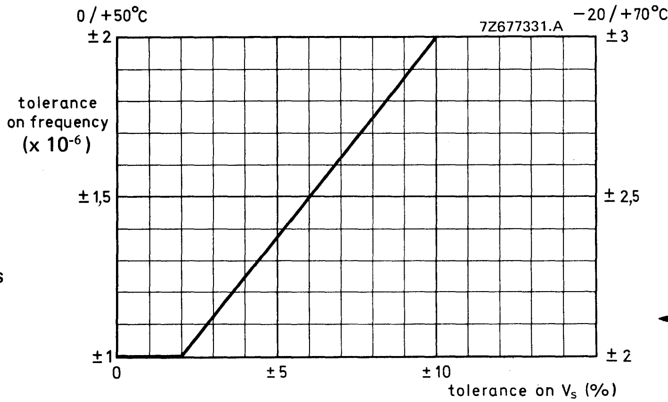


Fig. 4 Frequency tolerance as a function of the tolerance on supply voltage over the entire temperature range.

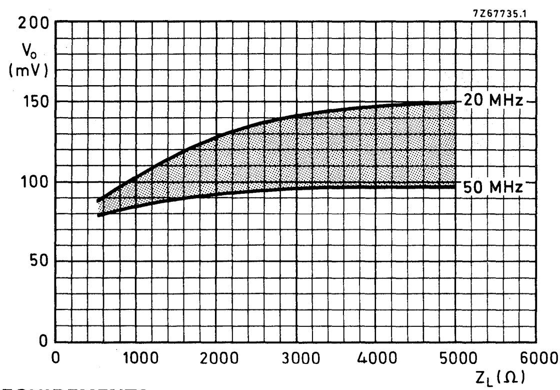


Fig. 5 Output voltage as a function of load impedance (typical values).

ENVIRONMENTAL TESTS AND REQUIREMENTS

See general section, Table II

DIGITAL TEMPERATURE COMPENSATED OSCILLATOR (DTCXO)

QUICK REFERENCE DATA

Frequency range	4,5 to 15 MHz
Stability	$\leqslant \pm 5 \times 10^{-7}$
Supply voltage	5 V ± 5%
Supply current	20 mA (typ.)
Output	10 x LPS TTL (2 x TTL)

APPLICATION

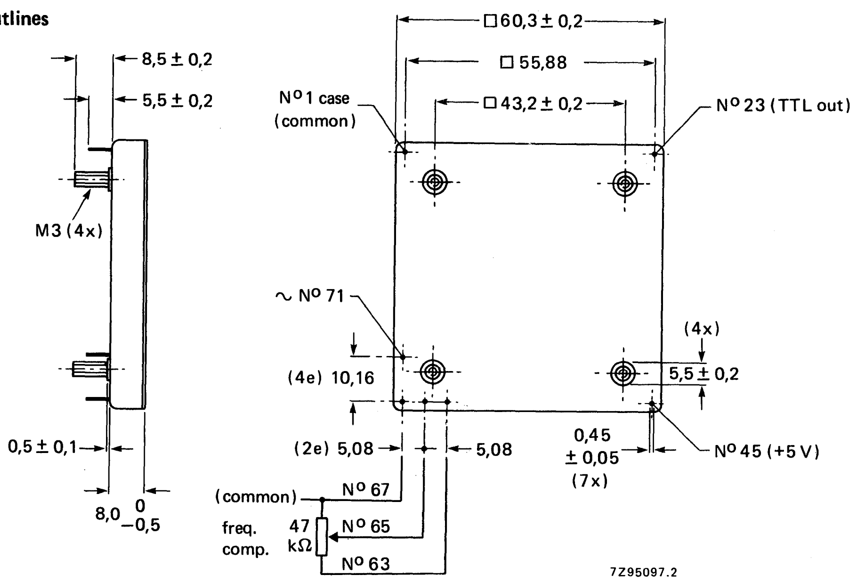
DTCXOs are used in communication and measuring equipment for which a very high stability is required at low power consumption.

DESCRIPTION

A DTCXO comprises a quartz crystal oscillator, a quartz crystal temperature measuring device together with an electronic compensation network which is digitally controlled. The metal housing is filled with dry nitrogen and hermetically sealed.

MECHANICAL DATA

Outlines



Mass: ≈ 70 g

Marking

The frequency in MHz, the stability, the temperature range, the catalogue number, date code (month/year) and the connecting circuit are printed on a label which is stuck to the holder.

Mounting

The unit can be mounted on a printed circuit board and/or secured by 4 bolts M3.

ELECTRICAL DATA

Frequency range	4,5 to 15 MHz
Stability	$\leqslant \pm 5 \times 10^{-7}$
Temperature range	−40 to + 85 °C
Storage temperature range	−55 to + 125 °C
Ageing	$\leqslant 1{,}5 \times 10^{-6}$ during 10 years at 85 °C
Supply voltage	5 V ± 5%
Supply current	max. 25 mA; typ. 20 mA
Output	standard low power Schottky (on request 2 x TTL)
Duty cycle	40 to 60%
Stability versus supply variation	$\leqslant 1 \cdot 10^{-7}$
Time to reach a stability within $\pm 5 \times 10^{-7}$ at switch on	< 1 s

ENVIRONMENTAL TESTS AND REQUIREMENTS

See general section, Table III

Note

For optimum stability over the whole temperature range the oscillator should be adjusted at room temperature to a frequency which deviates from the nominal one by an amount mentioned as "Δf 25 °C . . . Hz" on the label on the module. After this adjustment a trimming range of ± min. 2×10^{-6} is still available to correct ageing influences, by means of an external resistor of 47 kΩ.

COMPACT INTEGRATED OSCILLATORS (CIO)

QUICK REFERENCE DATA

Frequency range	1,0 to 20 MHz
Frequency tolerance, all effects included	± 100 x 10^{-6}
Operating temperature range	0 to + 70 °C
Supply voltage	5 V ± 10%
Load	up to 10 standard TTL

APPLICATION

Due to their small size and hermetical sealing the oscillators can be supplied in microprocessors, measuring equipment, medical equipment, electronic timing devices, etc.

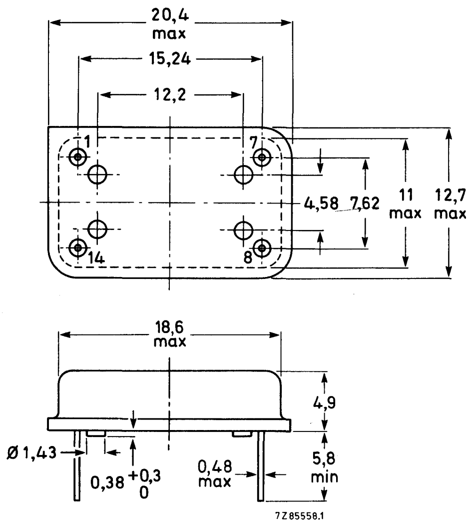
DESCRIPTION

A compact integrated oscillator comprises a quartz crystal and a thin film hybrid oscillator circuit. The metal housing is filled with dry nitrogen and hermetically sealed. The unit is provided with four connecting pins having a spacing compatible with 14-pin DIL packages.

MECHANICAL DATA

Outlines

pin 1 = not connected, can be made available for enable input on special request.
pin 7 = ground, 0 V*
pin 8 = output
pin 14 = supply, + 5 V



* The case can be connected to pin 7 for shielding, on special request.

Marking

The units are marked as follows:

- frequency in kHz
- last five digits of catalogue number
- code for month and year of manufacture

Mounting

Soldering conditions max. 260 °C, max. 10 s

ELECTRICAL DATA

Supply voltage	V_{CC}	+ 5 V ± 10%
Supply current		
at 25 °C	I_{CC}	60 mA
over the whole temp. range	I_{CC}	70 mA
Frequency range		1,0 to 20 MHz
Frequency tolerance		± 500 x 10^{-6}

This tolerance includes:
Initial calibration tolerance at 25 °C; change in operating temperature (0 to + 70 °C); change in supply voltage; change in load; change in environmental conditions and ageing.

Output characteristics		min.	max.
low level voltage	V_{OL}		0,4 V
high level current	I_{OH}	2,4	V
short circuit current (1 s max; V_{CC} = 5,5 V)	I_{OS}	13	100 mA
rise time* (0,5 V to 2,4 V)			10 ns
fall time* (2,4 to 0,5 V)			10 ns
symmetry* (1,4 V; 25 °C)		40	60 %

* At 16 mA sink, 0,4 mA source current, 20 pF load capacitance

Start time	typ. 5 ms; max. 50 ms
Temperature range	
operating	0 to + 70 °C
storage	−55 to + 125 °C

AVAILABLE TYPES

Catalogue number of 12 digits are fixed per contract, but the following preferred types have been fixed.

1,0 MHz : 4322 199 00111
1,5 MHz : 4322 199 00121
2,0 MHz : 4322 199 00131
3,0 MHz : 4322 199 00141
3,6864 MHz : 4322 199 00151
4,0 MHz : 4322 199 00161
4,9152 MHz : 4322 199 00171
6,0 MHz : 4322 199 00181
8,0 MHz : 4322 199 00191
9,216 MHz : 4322 199 00211
10,0 MHz : 4322 199 00201

Special types

Compact integrated oscillatorrs with smaller frequency- or symmetry tolerances or other special requirements are available upon request.
Please consult your supplier for further information.

TESTS AND REQUIREMENTS

See general section, Table I.

VOLTAGE CONTROLLED CRYSTAL OSCILLATORS (VCXO)

QUICK REFERENCE DATA

Frequency range	8 to 15 MHz
Frequency stability	$\pm$ 20 x 10^{-6}
Operating temperature range	−5 to + 60 °C
Supply voltage	5 V ± 5%
Output load	max. 3 standard TTL

APPLICATION

Due to their small size and low power consumption, these hermetically sealed oscillators are especially suitable for digital telephone switching networks.

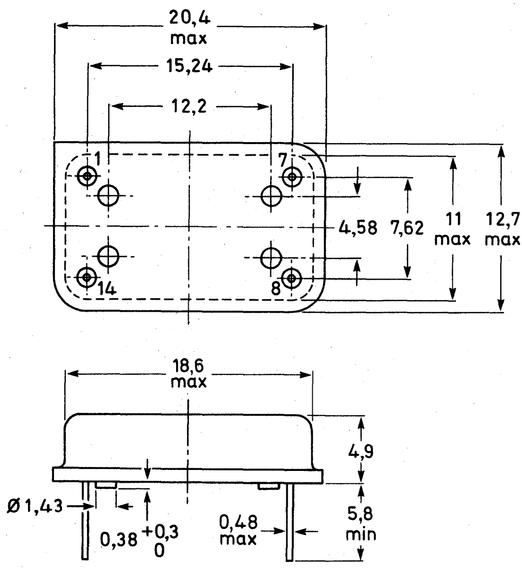
DESCRIPTION

A voltage controlled crystal oscillator comprises a quartz crystal and a low power Schottky integrated circuit as active device. The frequency can be varied by means of a control voltage. The metal housing is filled with dry nitrogen and hermetically sealed. The unit is provided with four connecting pins having a spacing compatible with 14-pin DIL packages.

MECHANICAL DATA

Outlines

pin 1 = control voltage
pin 7 = ground, case terminal
pin 8 = output
pin 14 = supply, + 5 V



Marking

The units are marked as follows:

- frequency in kHz
- last five digits of catalogue number
- code for month and year of manufacture

Mounting

Soldering conditions		max. 260 °C, max. 10 s

ELECTRICAL DATA

Supply voltage	V_{CC}	+ 5 V ± 5%
Supply current	I_{CC}	typ. 6 mA; max. 10 mA
Frequency range		8 to 15 MHz
Frequency stability, temp. range –5 to + 60 °C		± 20 x 10^{-6}
Pullability		typ. ± 160 x 10^{-6}
Control voltage		
low frequency		+ 5 V
medium frequency		0 V
high frequency		–5 V
Adjusting tolerance at zero volt		± 30 x 10^{-6}
Ageing, 10 years, constant condition		typ. ± 10 x 10^{-6}
Output characteristics conform low power Schottky TTL data of Signetics type LS7400		
Dynamic measurements with 15 pF load capacitance		
Start-up time		typ. 10 ms
Temperature range		
operating		–5 to + 60 °C
storage		–40 to +100 °C
Catalogue number		to be fixed

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