DATA SHEET

PCA159x series
32 kHz watch circuits with frequency adjustment

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32 kHz watch circuits with frequency adjustment

PCA159x series

FEATURES

- 32 kHz oscillator frequency
- Low current consumption; typically 1.5 μA, maximum 5 μA
- Low minimum supply voltage: 1.1 V
- Alarm input
- Motor test
- Test mode speed-up for fast testing
- Quartz frequency electrically programmable and reprogrammable (via EEPROM)
- Protected against electrostatic charges.

GENERAL DESCRIPTION

The PCA159x series devices are silicon-gate CMOS integrated circuits specially suited for battery-operated, quartz-crystal-controlled clocks, with a bipolar stepping motor.

ORDERING INFORMATION

TYPE NUMBER	PACKAGE			
	NAME	DESCRIPTION[1]		VERSION
PCA1593U/10	–	chip on film frame carrier (FFC)		–
PCA1594U/10	–	chip on film frame carrier (FFC)		–
PCA1595U/10	–	chip on film frame carrier (FFC)		–
PCA1596U/10	–	chip on film frame carrier (FFC)		–
PCA1597U/10	–	chip on film frame carrier (FFC)		–

Note

1. Figure 1 and Chapter "Package outlines" show details of standard packages, available for large orders only. Chapter "Chip dimensions and bonding pad locations" shows exact pad locations for other delivery formats.

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PINNING

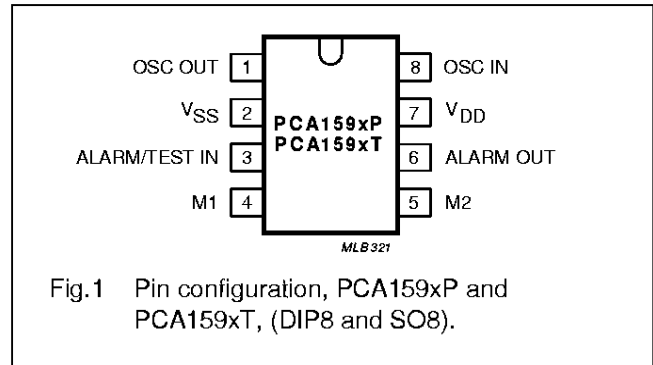| SYMBOL	PIN	DESCRIPTION
OSC OUT	1	oscillator output
V_{SS}	2	ground (0 V)
ALARM/TEST IN	3	alarm and test input
M1	4	motor 1 output
M2	5	motor 2 output
ALARM OUT	6	alarm output
V_{DD}	7	supply voltage
OSC IN	8	oscillator input

Fig.1   Pin configuration, PCA159xP and PCA159xT, (DIP8 and SO8).

FUNCTIONAL DESCRIPTION AND TESTING

Operating mode

The alarm input (pin 3) is left open-circuit. Motor pulses as shown in Fig.2 are provided at M1 and M2. An output frequency of 256 Hz is provided at pin 3 for test purposes.

Alarm mode

The alarm input is connected to V_{SS}. The alarm signal in accordance with Fig.3 is provided at pin 6.

Test mode (see Fig.4)

The circuit must be in normal operating mode for at least 10 ms before entering test mode.

The test mode consists of two parts: motor test and IC test.

MOTOR TEST

The alarm input is connected to V_{DD}. In this test mode the motor output period is 125 ms (all types) and the motor pulse width is identical to that of the normal mode. The alarm output periods are also increased by a factor of 128. The alarm modulation is also suppressed.

IC TEST (IC SUPPLIER ONLY)

The customer uses this mode during frequency programming. On the negative edge of the first positive pulse (see Fig.7) the IC test is enabled. The motor output is increased by a factor of 1024. The duty factor in this mode is 1 : 1. The alarm mode is disabled.

On the positive edge of the second pulse (corresponding to the first program pulse) the motor test mode is re-selected.

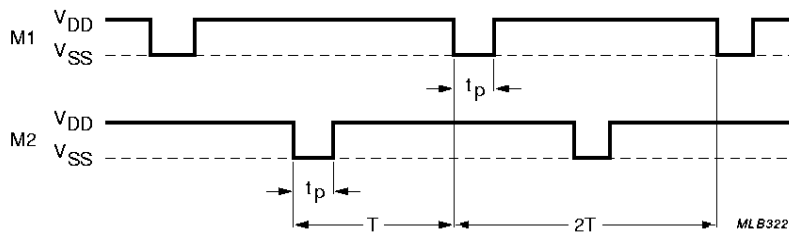To disable the test mode, pin 3 must be left open-circuit or connected to V_{SS}.
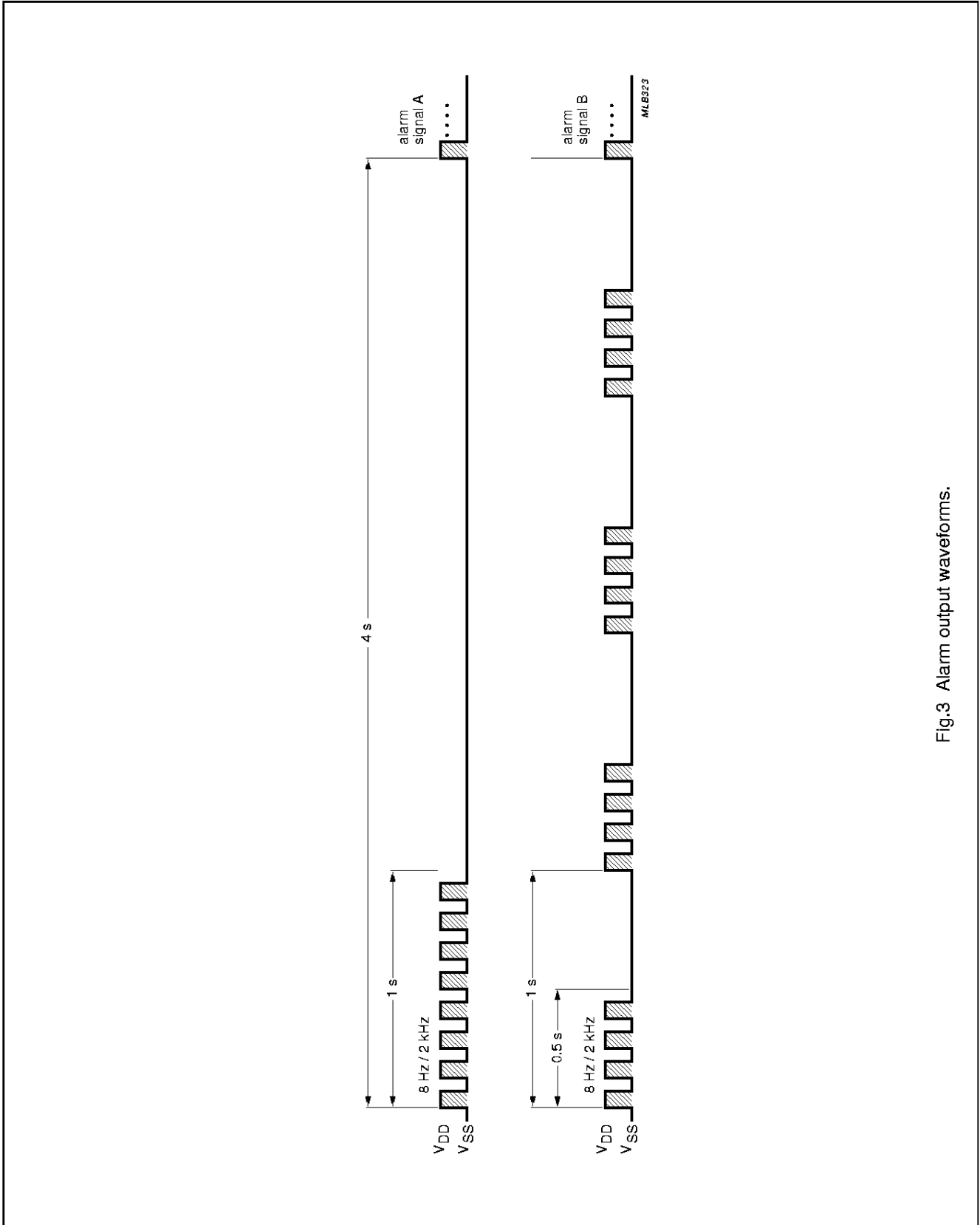

Fig.2 Motor output waveforms.

Fig.3 Alarm output waveforms.

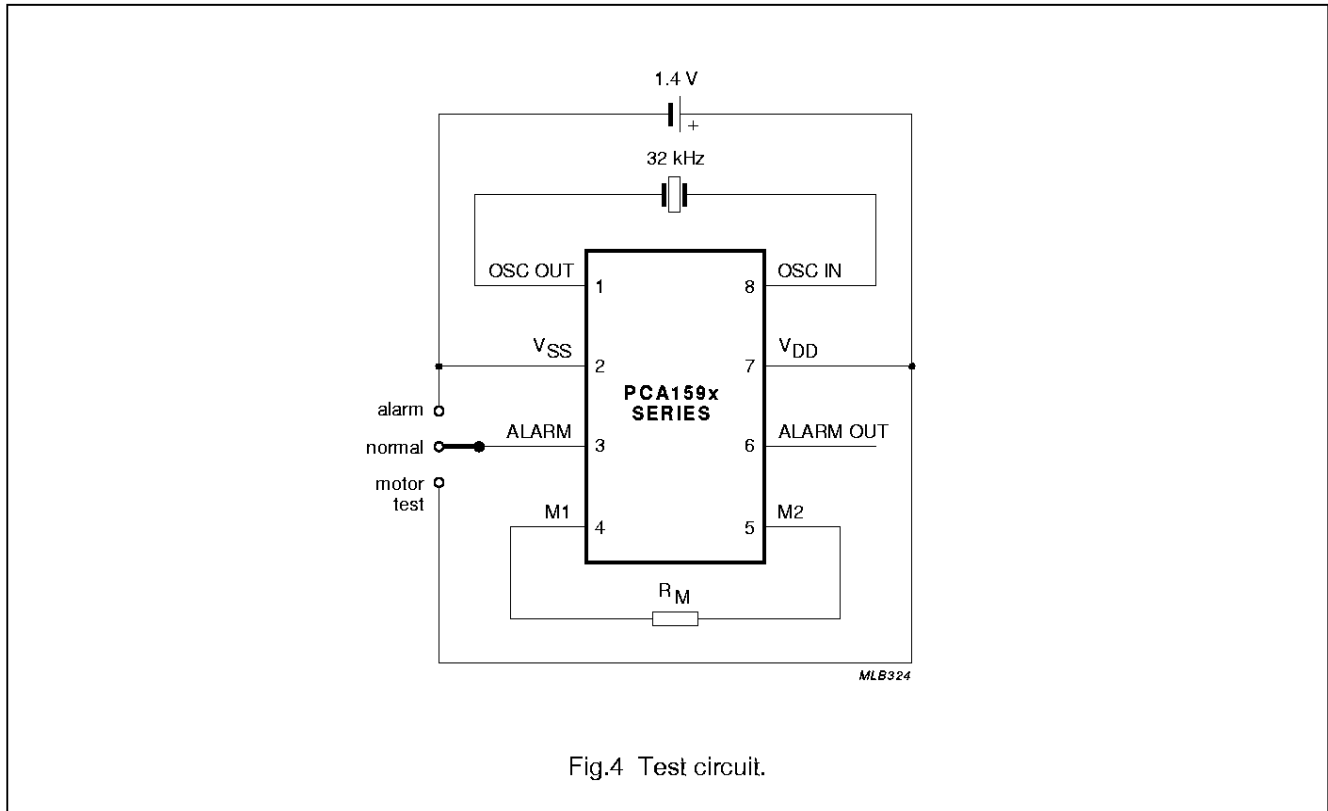# 32 kHz watch circuits with frequency adjustment

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Fig.4 Test circuit.

Frequency trimming

Frequency trimming is carried out by electrically programming the oscillator input capacitance to one of 64 values contained within the non-volatile memory. This is accomplished by carrying out the following five steps; Figs 5, 6 and 7 illustrate this procedure.

1. **Erasing**

   With $V_{SS} = -1.4$ V, the generator (pin 3) is taken from −1.4 V to 0 V. The device is now in test mode. Erasure is carried out by increasing V_{SS} to −5.5 V and setting the generator (pin 3) to +1.4 V.

2. **Checking erasing/zero**

   With $V_{SS} = -1.4$ V, the generator (pin 3) is taken from −1.4 V to 0 V. The device is in test mode and minimum capacitance is obtained.

3. **Measure/data input**

   On the first 1.4 V pulse (pin 3) the test mode is changed from motor test to IC test. This pulse releases the program register thus allowing the frequency to be programmed. The positive edge of the second pulse switches the IC test mode back to the motor test mode.

The negative edge of the second pulse increases the capacitance by one unit, this occurs on all the subsequent pulses. The frequency can be measured between these increases. This procedure is repeated until the required frequency is obtained. If the adjustment to the frequency is greater than required, the procedure can be restarted with step 2.

4. **Writing**

   The capacitance is fixed by increasing V_{SS} to −5.5 V.

5. **Checking writing**

   With $V_{SS} = -1.4$ V, the generator (pin 3) is taken from −1.4 V to 0 V. The device is in test mode and trimmed capacitance is obtained. The frequency can be checked.

Remark

The information concerning the capacitive value is obtained from the EEPROM cells and the program register. Therefore the program register must be reset before the frequency can be measured (see steps 1 to 5). Programming can be performed 100 times.
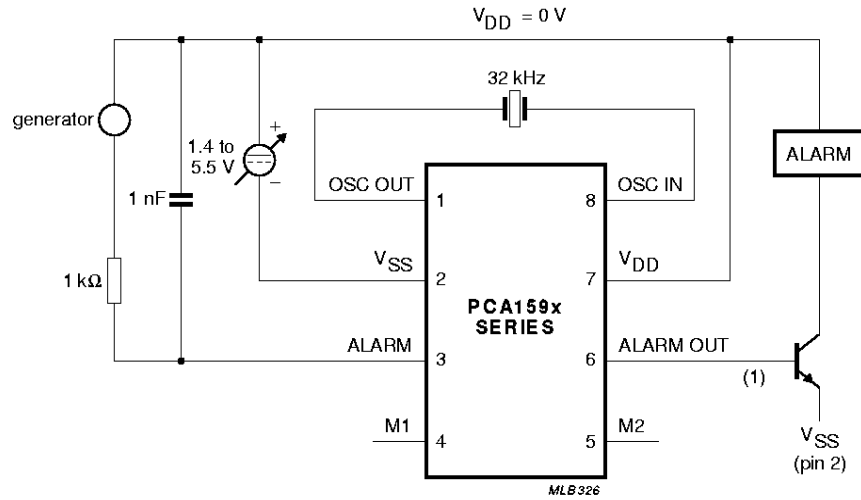
(1) During programming ALARM OUT is active LOW, so that programming is possible when the alarm transistor is connected to pin 6.

Fig.5 Frequency trimming circuit.
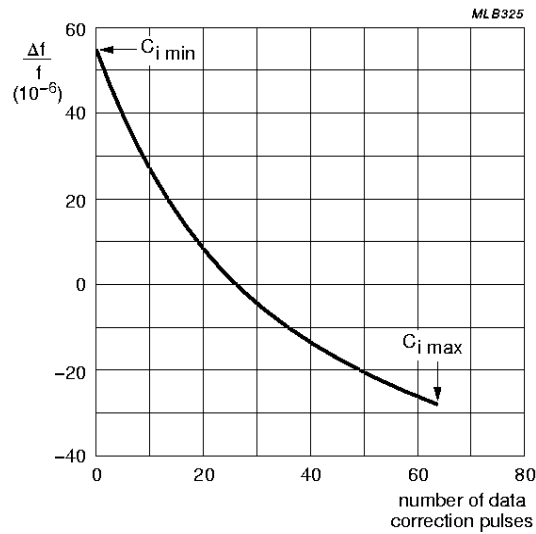
Fig.6 Typical frequency characteristic; C_1 = 2.8 fF, C_0 = 3 pF, C_L = 10 pF, f = 32.768 kHz.

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Fig.7 Frequency trimming signals (V_{DD} = 0 V).
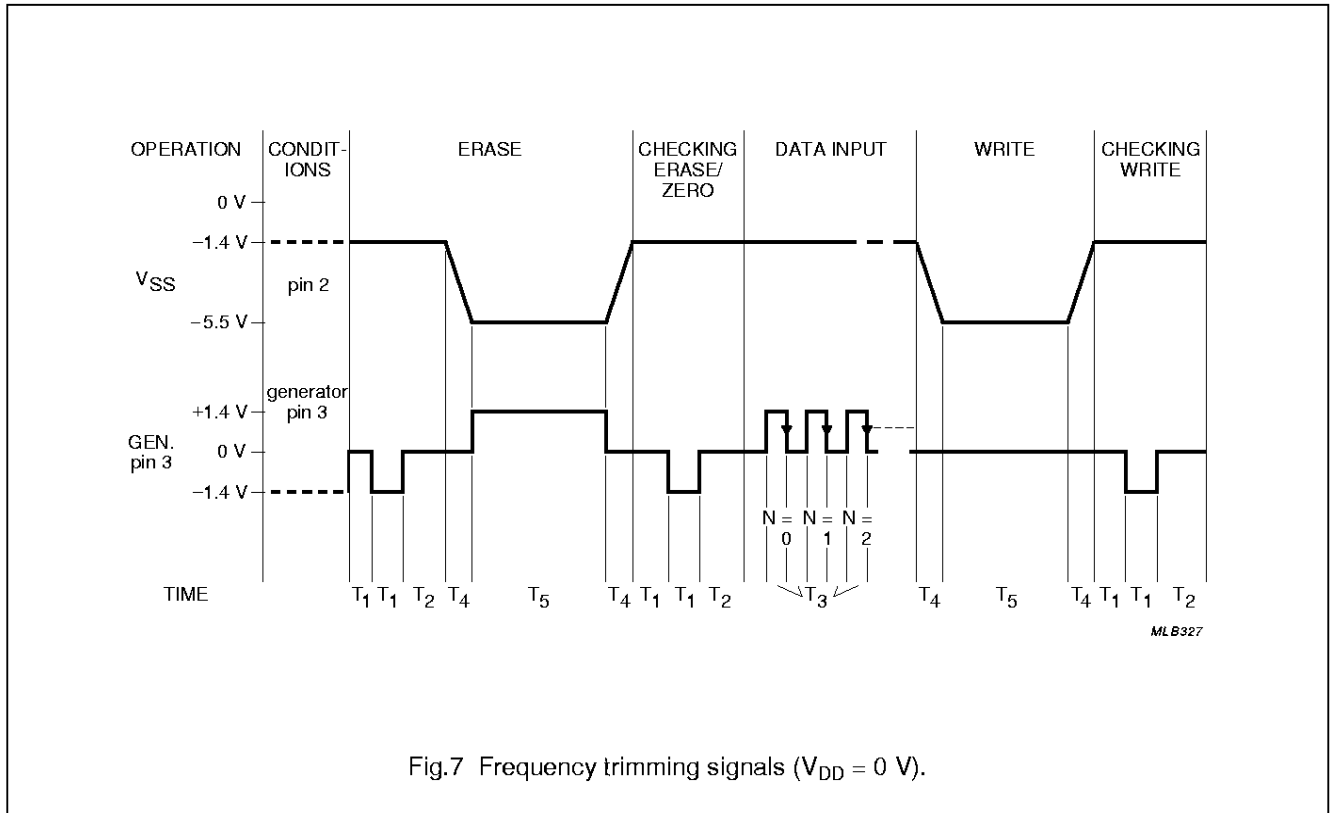
Table 1 Frequency trimming timing requirements

TIME	SYMBOL	MIN.	MAX.	UNIT
Reset time 1	T_1	1	–	ms
Reset time 2	T_2	5	–	ms
Data pulse width/gap	T_3	100	–	μs
Supply rise/fall time	T_4	1	–	ms
WRITE/ERASE time	T_5	10	–	ms

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AVAILABLE TYPES

| SHORT TYPE NUMBER | DELIVERY FORMAT[1] | MOTOR OUTPUT | | | | ALARM SIGNAL (see Fig.3) |
		PERIOD t_T (s)	PULSE t_P (ms)	MINIMUM CURRENT I_M (mA)	EEPROM	
1593	U/10	1	31.25	4.3	yes	B
1594	U/10	1	46.8	4.3	yes	A
1595	U/10	1	46.8	4.3	yes	B
1596	U/10	1	15.6	4.3	yes	A
1597	U/10	4	15.6	4.3	yes	B

Note

1. U/10 = Chip on film frame carrier (FFC).

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{SS}	supply voltage	$V_{DD} = 0$ V; note 1	+1.8	−6	V
V_I	all input voltages except pin 3		V_{SS}	V_{DD}	V
V_{3-2}	input voltage at pin 3		V_{SS}	$V_{DD} + 1$	V
	output short-circuit duration at pins 4, 5 and 6			indefinite	
T_{amb}	operating ambient temperature		−10	+60	°C
T_{stg}	storage temperature		−30	+125	°C

Note

1. Connecting the battery at 1.8 V maximum with reversed polarity does not destroy the circuit, but in this condition a large current flows, which will rapidly discharge the battery.

HANDLING

Inputs and outputs are protected against electrostatic discharges in normal handling. However, to be totally safe, it is advisable to take handling precautions appropriate to handling MOS devices. Advice can be found in *"Data Handbook IC16, General, Handling MOS Devices"*.

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CHARACTERISTICS

$V_{DD} = 0$ V; $V_{SS} = -1.4$ V; $f_{osc} = 32.768$ kHz; $T_{amb} = 25$ °C; crystal: $R_S = 20$ kΩ; $C_1 = 2$ to 3 fF; $C_L = 10$ pF; $C_0 = 3$ pF; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Supply						
V_{SS1}	supply voltage	operating	−1.1	−	−1.8	V
V_{SS2}	supply voltage	starting	−1.2	−	−	V
V_{SS3}	supply voltage	programming	−5.4	−5.5	−5.6	V
I_{DD}	supply current	$R_L = \infty$	−	1.5	5.0	μA
Motor output (pins 4 and 5)						
t_T	period	note 1	1.0	−	60.0	s
t_P	pulse width	note 1	3.9	−	62.5	ms
I_M	current into load	$R_M = 200$ Ω; $V_{SS} = -1.2$ V	4.3	−	−	mA
R_o	output impedance	$R_M = 200$ Ω	−	50	−	Ω
Alarm output (pin 6)						
	output waveforms			see Fig.3		
I_{sink}	sink current	R = 10 Ω; $V_{SS} = -5.5$ V	−	200	−	μA
I_{source}	source current	R = 1 Ω; $V_{SS} = -1.2$ V	0.3	1.0	−	mA
Alarm test input (pin 3)						
t_d	input delay time		−	−	70	ms
I_I	input current	note 2	−	2	−	μA
		$V_{SS} = -5.5$ V	−	50	−	μA
Oscillator (pins 1 and 8)						
R_p	polarization resistance		3	10	30	MΩ
C_o	output capacitance (pin 1)		−	24	−	pF
C_i	input capacitance data pulses (pin 8)	n = 0; note 3	−	9	−	pF
ΔC_i	input capacitance steps		−	0.25	−	pF
$\Delta f/f$	frequency stability	$\Delta V_{SS} = 100$ mV; n = 20	−	0.6×10^{-6}	−	
t_{ret}	data retention time	$T_{amb} = -10$ to +60 °C	−	10	−	years

Notes

1. See Chapter "Available types" for the typical values.

2. These are average values for the 256 Hz output with 1 : 1 duty factor.

3. Number of data correction pulses (n).

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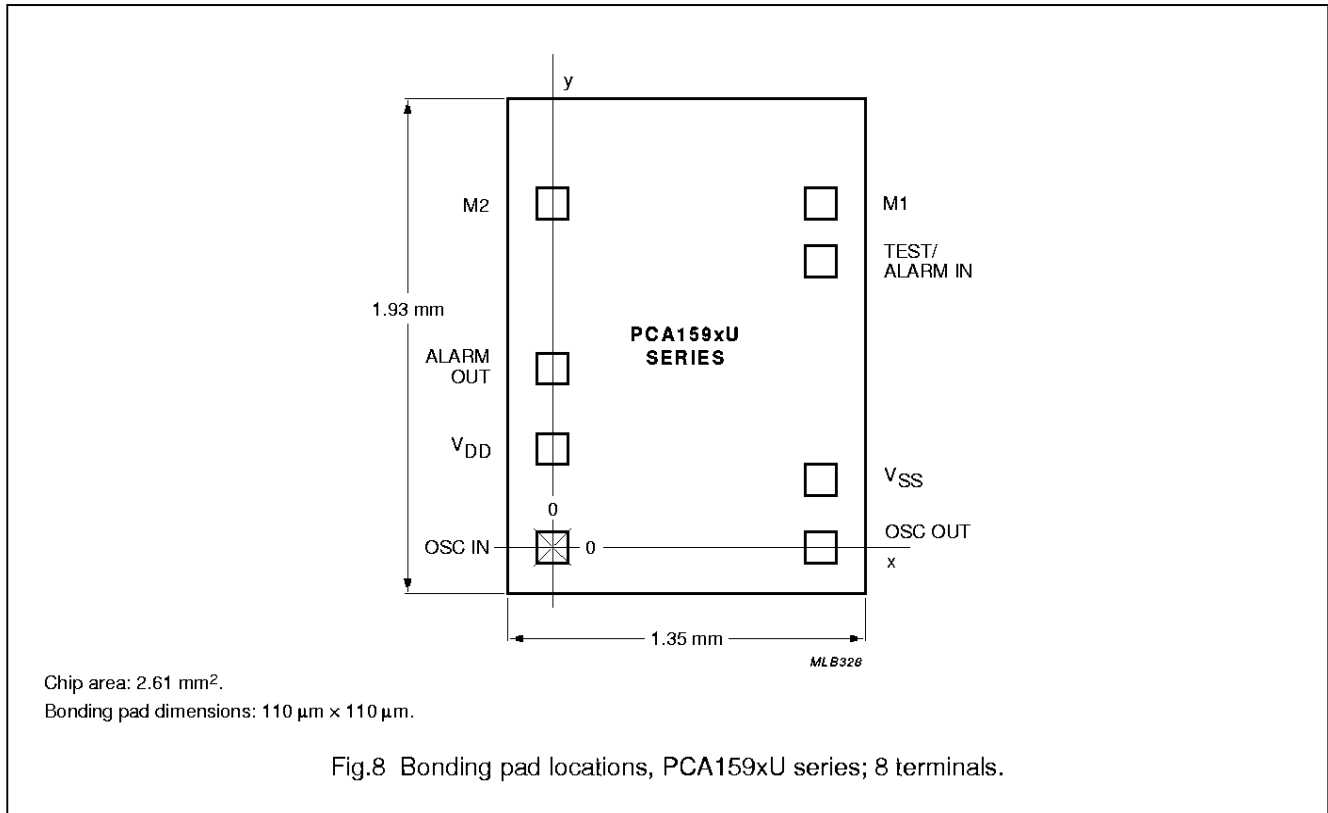## PCA159x series

CHIP DIMENSIONS AND BONDING PAD LOCATIONS

Chip area: 2.61 mm².
Bonding pad dimensions: 110 μm × 110 μm.

Fig.8 Bonding pad locations, PCA159xU series; 8 terminals.

Table 2 Bonding pad locations (dimensions in μm)

All x/y coordinates are referenced to bottom left pad (OSC IN), see Fig.8.

PAD	x	y
OSC OUT	1006	0
V_{SS}	1006	220
TEST/ALARM IN	1006	1111
M1	1006	1296
M2	0	1296
ALARM OUT	0	651
V_{DD}	0	376
OSC IN	0	0
chip corner (max. value)	−202	−225

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APPLICATION INFORMATION
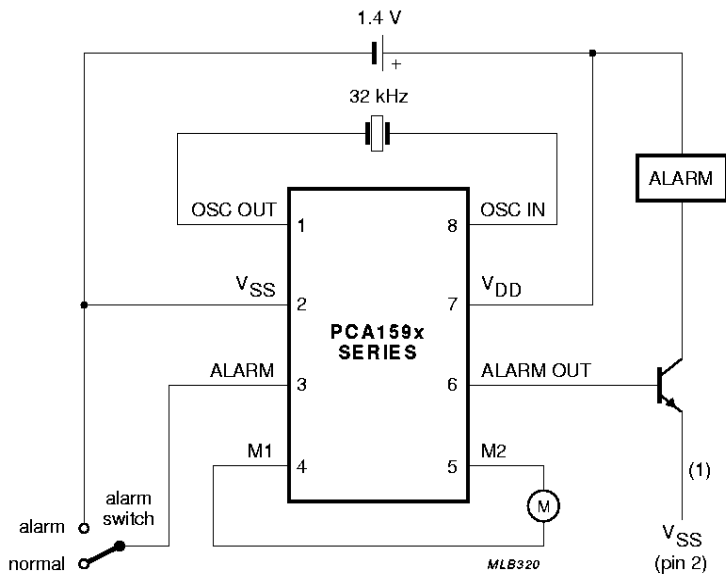
(1) The emitter of the transistor must be connected to V_{SS}, except when used as a replacement for the PCA158X series where it must be connected to pin 3; in this event the base of the alarm transistor must be connected via a 1 kΩ series resistor.
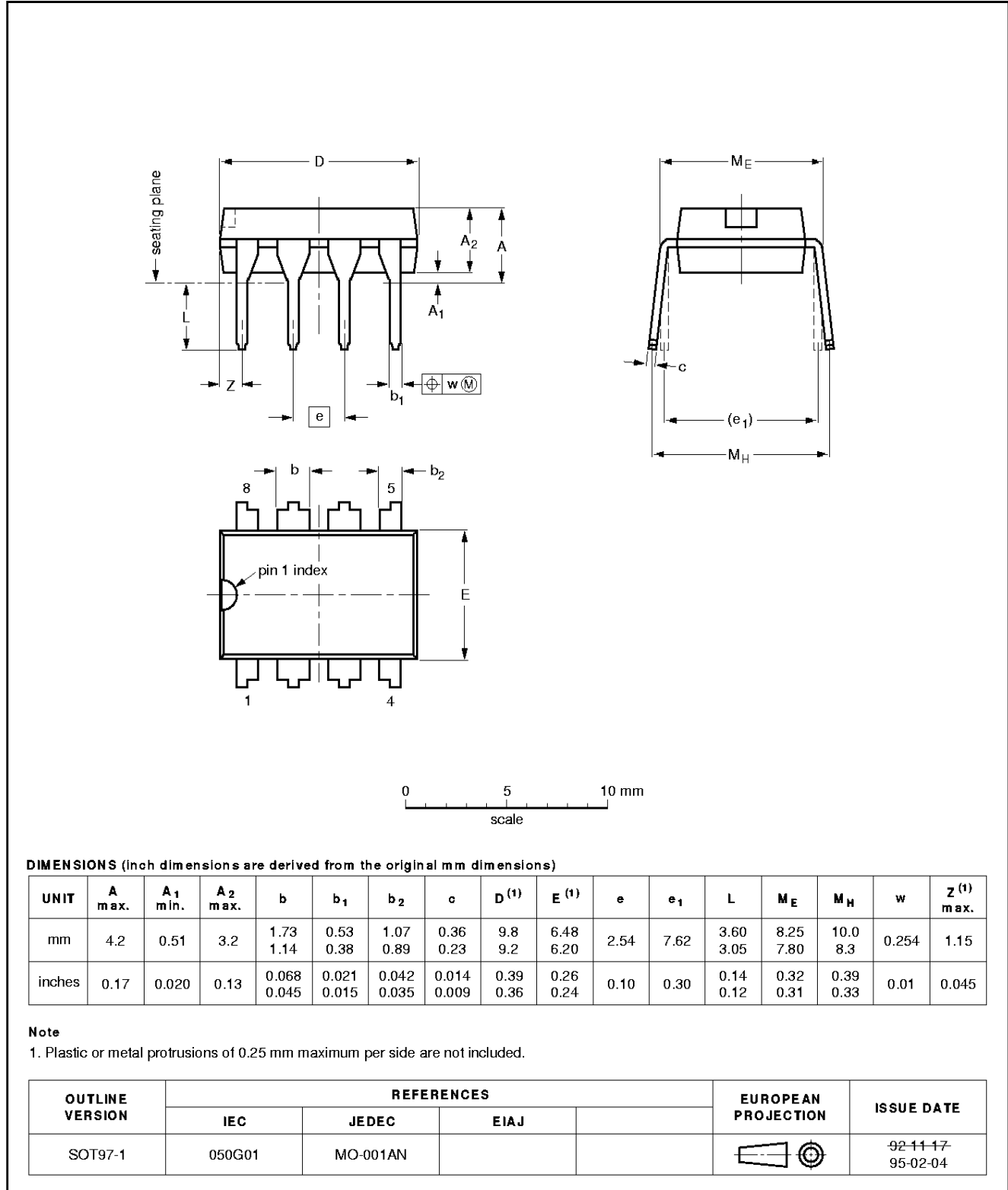
Fig.9 Typical application circuit diagram.

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PACKAGE OUTLINES

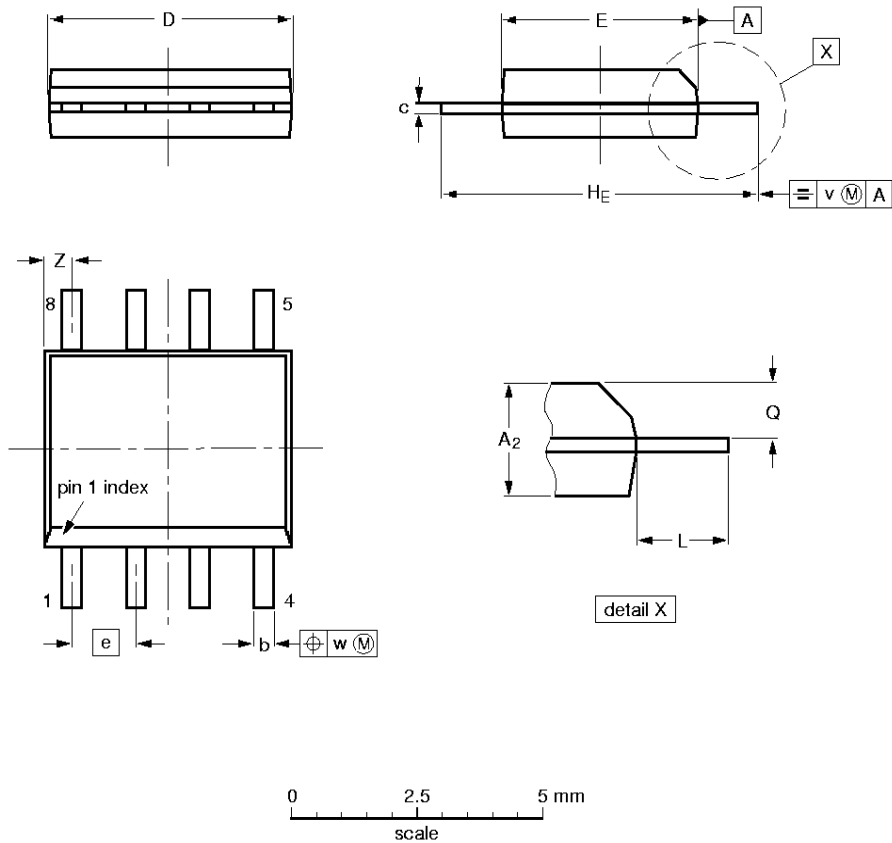**DIP8: plastic dual in-line package; 8 leads (300 mil)**

SOT97-1

DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A₁ min.	A₂ max.	b	b₁	b₂	c	D (1)	E (1)	e	e₁	L	M_E	M_H	w	Z (1) max.
mm	4.2	0.51	3.2	1.73 1.14	0.53 0.38	1.07 0.89	0.36 0.23	9.8 9.2	6.48 6.20	2.54	7.62	3.60 3.05	8.25 7.80	10.0 8.3	0.254	1.15
inches	0.17	0.020	0.13	0.068 0.045	0.021 0.015	0.042 0.035	0.014 0.009	0.39 0.36	0.26 0.24	0.10	0.30	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.045

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT97-1	050G01	MO-001AN				~~92-11-17~~ 95-02-04

SO8: plastic small outline package; 8 leads (straight); body width 3.9 mm

SOT96-2

0   2.5   5 mm
scale

DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A₂	b	c	D(1)	E(2)	e	H_E	L	Q	v	w	Z(1)
mm	1.45 1.25	0.49 0.36	0.25 0.19	5.0 4.8	4.0 3.8	1.27	6.4 6.2	1.2	0.7 0.6	0.25	0.25	0.7 0.3
inches	0.057 0.049	0.019 0.014	0.0098 0.0075	0.20 0.19	0.16 0.15	0.050	0.025 0.024	0.047	0.028 0.024	0.01	0.01	0.028 0.012

Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT96-2						~~92-11-17~~ 95-02-04

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SOLDERING

Introduction

There is no soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and surface mounted components are mixed on one printed-circuit board. However, wave soldering is not always suitable for surface mounted ICs, or for printed-circuits with high population densities. In these situations reflow soldering is often used.

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our "IC Package Databook" (order code 9398 652 90011).

DIP

SOLDERING BY DIPPING OR BY WAVE

The maximum permissible temperature of the solder is 260 °C; solder at this temperature must not be in contact with the joint for more than 5 seconds. The total contact time of successive solder waves must not exceed 5 seconds.

The device may be mounted up to the seating plane, but the temperature of the plastic body must not exceed the specified maximum storage temperature ($T_{stg\ max}$). If the printed-circuit board has been pre-heated, forced cooling may be necessary immediately after soldering to keep the temperature within the permissible limit.

REPAIRING SOLDERED JOINTS

Apply a low voltage soldering iron (less than 24 V) to the lead(s) of the package, below the seating plane or not more than 2 mm above it. If the temperature of the soldering iron bit is less than 300 °C it may remain in contact for up to 10 seconds. If the bit temperature is between 300 and 400 °C, contact may be up to 5 seconds.

SO

REFLOW SOLDERING

Reflow soldering techniques are suitable for all SO packages.

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied

to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement.

Several techniques exist for reflowing; for example, thermal conduction by heated belt. Dwell times vary between 50 and 300 seconds depending on heating method. Typical reflow temperatures range from 215 to 250 °C.

Preheating is necessary to dry the paste and evaporate the binding agent. Preheating duration: 45 minutes at 45 °C.

WAVE SOLDERING

Wave soldering techniques can be used for all SO packages if the following conditions are observed:

- A double-wave (a turbulent wave with high upward pressure followed by a smooth laminar wave) soldering technique should be used.
- The longitudinal axis of the package footprint must be parallel to the solder flow.
- The package footprint must incorporate solder thieves at the downstream end.

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Maximum permissible solder temperature is 260 °C, and maximum duration of package immersion in solder is 10 seconds, if cooled to less than 150 °C within 6 seconds. Typical dwell time is 4 seconds at 250 °C.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

REPAIRING SOLDERED JOINTS

Fix the component by first soldering two diagonally-opposite end leads. Use only a low voltage soldering iron (less than 24 V) applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C. When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

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DEFINITIONS

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

LIFE SUPPORT APPLICATIONS

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