

# DATA SHEET

## **PCF1178C** 4-digit duplex LCD car clock

Product specification

1997 Apr 16

Supersedes data of September 1993

File under Integrated Circuits, IC16

**4-digit duplex LCD car clock****PCF1178C****FEATURES**

- Internal voltage regulator is electrically programmable for various LCD voltages
- Time calibration is electrically programmable (no trimming capacitor required)
- LCD voltage adjusts with temperature for good contrast
- 4.19 MHz oscillator
- 12-hour or 24-hour mode
- Operating ambient temperature: -40 to +85 °C
- 28-lead plastic SMD (SO28)
- 1 Hz set mode.

**GENERAL DESCRIPTION**

The PCF1178C is a single chip, 4.19 MHz CMOS car clock circuit providing hours, minutes and seconds functions. It is designed to drive a 4-digit duplex liquid crystal display (LCD).

Two external single-pole, single-throw switches will accomplish all time setting functions. Time calibration and voltage regulator are electrically programmable via an on-chip EEPROM. The circuit is battery-operated via an internal voltage regulator and an external resistor.

**ORDERING INFORMATION**

| TYPE NUMBER  | PACKAGE |   |          |
|--------------|---------|---|----------|
|              | NAME    | DESCRIPTION   | VERSION  |
| PCF1178CT    | SO28    | plastic small outline package; 28 leads; body width 7.5 mm <sup>(1)</sup> | SOT136-1 |
| PCF1178CU    | –       | uncased chip in tray <sup>(2)</sup>                                       | –        |
| PCF1178CU/10 | –       | chip-on-film frame carrier (FFC) <sup>(2)</sup>                           | –        |
| PCF1178CU/5  | –       | unsawn wafer <sup>(2)</sup>   | –        |

**Notes**

1. See Fig.1 and Chapter "Package outline" for pin layout and package details.
2. See Chapter "Chip dimensions and bonding pad locations" for pad layout and package details.

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## PINNING

| SYMBOL          | PIN | DESCRIPTION                  |
|-----------------|-----|------------------------------|
| BP1             | 1   | backplane 1                  |
| BP2             | 2   | backplane 2                  |
| AM/PM           | 3   | segment driver               |
| A2/ADEG1        | 4   | segment driver               |
| B1/C1           | 5   | segment driver               |
| F2/E2           | 6   | segment driver               |
| G2/D2           | 7   | segment driver               |
| B2/C2           | 8   | segment driver               |
| A4/COL          | 9   | segment driver               |
| F3/E3           | 10  | segment driver               |
| G3/AD3          | 11  | segment driver               |
| B3/C3           | 12  | segment driver               |
| F4/E4           | 13  | segment driver               |
| G4/D4           | 14  | segment driver               |
| B4/C4           | 15  | segment driver               |
| S2              | 16  | minute adjustment input      |
| SEL             | 17  | EEPROM select input          |
| FLASH           | 18  | colon option input           |
| V <sub>DD</sub> | 19  | positive supply voltage      |
| ENABLE          | 20  | enable input (for S1 and S2) |
| TS              | 21  | test speed-up mode input     |
| V <sub>PP</sub> | 22  | programming voltage input    |
| MODE            | 23  | 12/24-hour mode select input |
| V <sub>SS</sub> | 24  | negative supply voltage      |
| OSC OUT         | 25  | oscillator output            |
| OSC IN          | 26  | oscillator input             |
| DATA            | 27  | EEPROM data input            |
| S1              | 28  | hour adjustment input        |

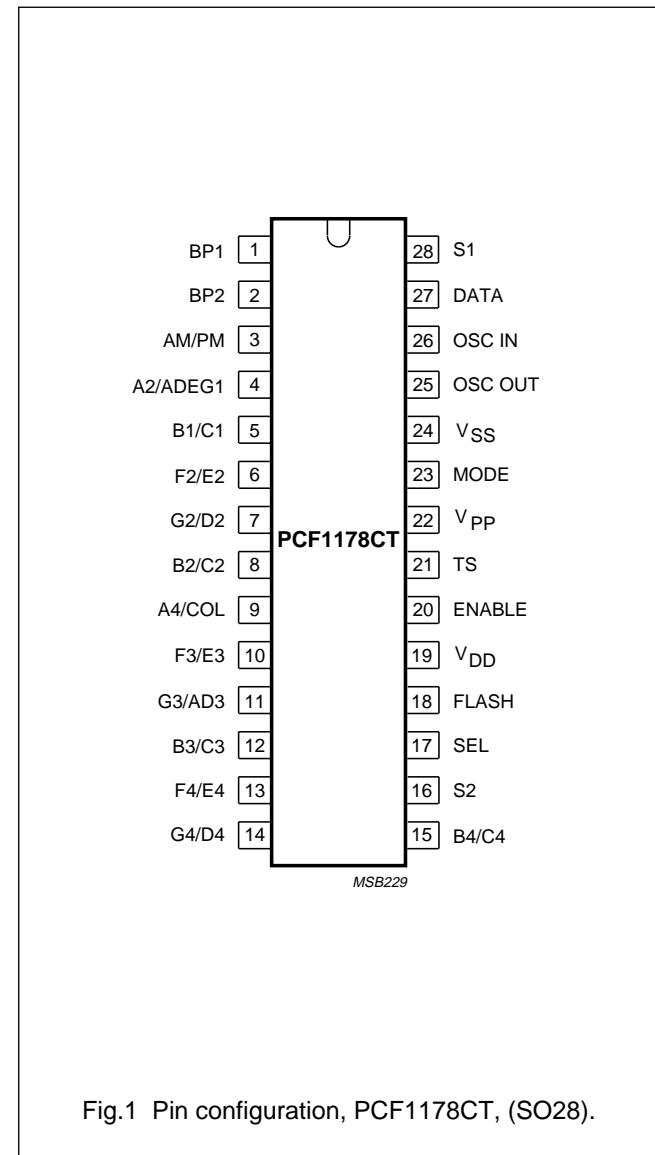


Fig.1 Pin configuration, PCF1178CT, (SO28).

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## FUNCTIONAL DESCRIPTION AND TESTING

## Outputs

The circuit outputs 1 : 2 multiplexed data (duplex) to the LCD. Generation of BP1 and BP2 (three-level backplane signals) and the output signals are shown in Fig.4.

The average voltages across the segments are:

1.  $V_{ON(RMS)} = 0.79 V_{DD}$
2.  $V_{OFF(RMS)} = 0.35 V_{DD}$ .

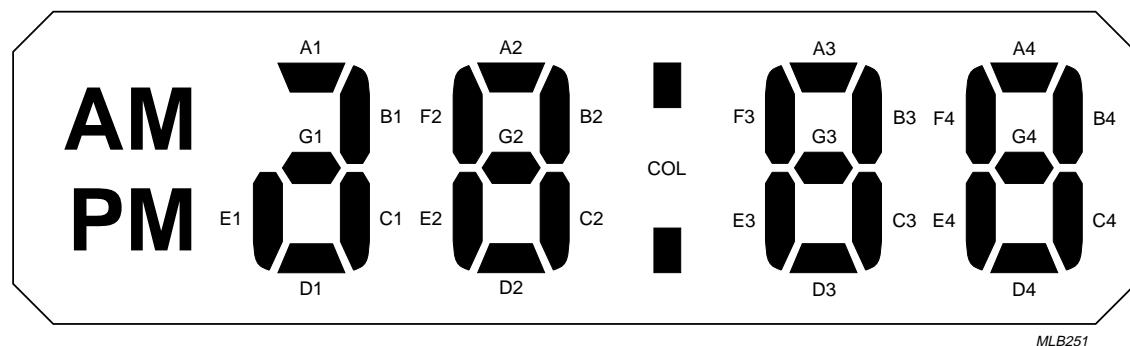
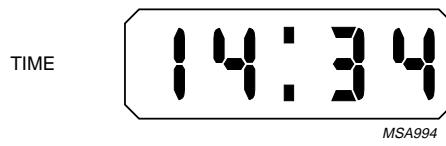


Fig.2 Segment designation of LCD.



a. 12-hour mode.



b. 24-hour mode.

Fig.3 Typical displays.

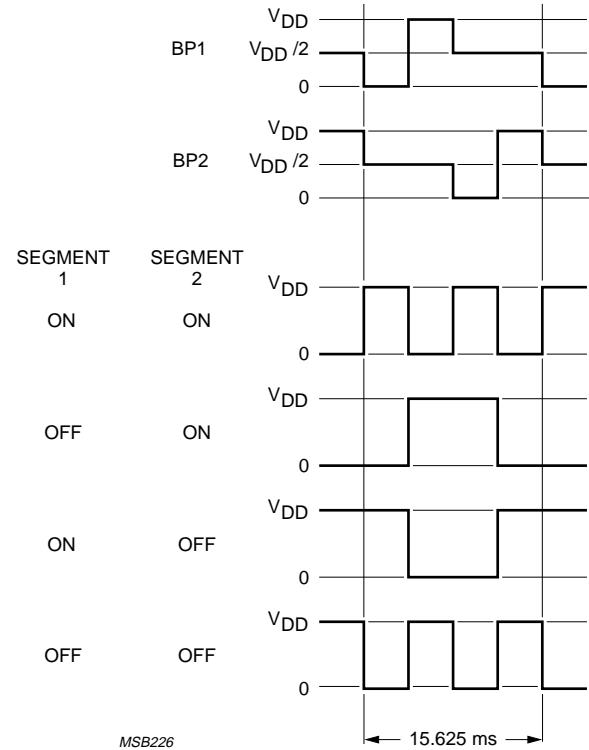


Fig.4 Backplane and output signals.

## 4-digit duplex LCD car clock

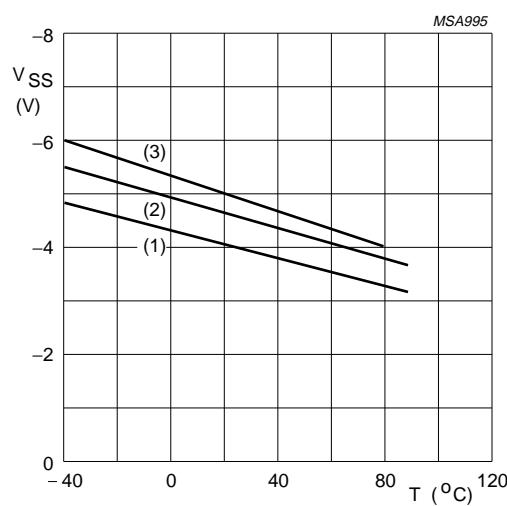
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**LCD voltage** (see Fig.5)

The adjustable voltage regulator controls the supply voltage (see Section "LCD voltage programming") in relation to temperature for good contrast, for example when  $V_{DD} = 4.5$  V at  $+25$  °C, then:

$V_{DD} = 3$  to  $4$  V at  $+85$  °C.

$V_{DD} = 5$  to  $6$  V at  $-40$  °C.



- (1) Programmed to 4.0 V at 25 °C (value within the specified operating range).
- (2) Programmed to 4.5 V at 25 °C (value within the specified operating range).
- (3) Programmed to 5.0 V at 25 °C (value within the specified operating range).

Fig.5 Regulated voltage as a function of temperature (typical).

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### 12/24-hour mode

Operation in 12-hour or 24-hour mode is selected by connecting MODE to  $V_{DD}$  or  $V_{SS}$  respectively. If MODE is left open-circuit and a reset occurs, the mode will change from 12-hour to 24-hour mode or vice versa.

### Power-on

After connecting the supply, the start-up mode is:

MODE connected to  $V_{DD}$ : 12-hour mode, 1:00 AM.

MODE connected to  $V_{SS}$ : 24-hour mode, 0:00.

MODE left open-circuit: 24-hour mode, 0:00 or 1:00.

### Colon

If FLASH is connected to  $V_{DD}$  the colon pulses at 0.5 Hz. If FLASH is connected to  $V_{SS}$  the colon is static.

### Time setting

Switch inputs S1 and S2 have a pull-up resistor to facilitate the use of single-pole, single-throw contacts. A debounce circuit is incorporated to protect against contact bounce and parasitic voltages.

#### Set enable

Inputs S1 and S2 are enabled by connecting ENABLE to  $V_{DD}$  or disabled by connecting to  $V_{SS}$ .

#### Set hours

When S1 is connected to  $V_{SS}$  the hours displayed advances by one and after one second continues with one advance per second until S1 is released (auto-increment).

#### Set minutes

When S2 is connected to  $V_{SS}$  the time displayed in minutes advances by one and after one second continues with two advances per second until S2 is released (auto-increment). In addition to minute correction, the seconds counter is reset to zero.

### Segment test/reset

When S1 and S2 are connected to  $V_{SS}$ , all LCD segments are switched ON. Releasing switches S1 and S2 resets the display. No reset occurs when DATA is connected to  $V_{SS}$  (overlapping S1 and S2).

### Test mode

When TS is connected to  $V_{DD}$ , the device is in normal operating mode. When connecting TS to  $V_{SS}$  all counters (seconds, minutes and hours) are stopped, allowing quick testing of the display via S1 and S2 (debounce and auto-increment times are 64 times faster). TS has a pull-up resistor but for reasons of safety it should be connected to  $V_{DD}$ .

### EEPROM

$V_{PP}$  has a pull-up resistor but for reasons of safety it should be connected to  $V_{DD}$ .

### LCD voltage programming

To enable LCD voltage programming, SEL is set to open-circuit and a level of  $V_{DD} - 5$  V is applied to  $V_{PP}$  (see Fig.6). The first pulse ( $t_E$ ) applied to the DATA input clears the EEPROM to give the lowest voltage output. Further pulses ( $t_L$ ) will increment the output voltage by steps of typically 150 mV ( $T_{amb} = 25$  °C). For programming, measure  $V_{DD} - V_{SS}$  and apply a store pulse ( $t_W$ ) when the required value is reached. If the maximum number of steps ( $n = 31$ ) is reached and an additional pulse is applied the voltage will return to the lowest value.

### Time calibration

To compensate for the tolerance in the quartz crystal frequency which has been positively offset (nominal deviation  $+60 \times 10^{-6}$ ) by capacitors at the oscillator input and output, a number ( $n$ ) of 262144 Hz pulses are inhibited every second of operation.

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The number (n) is stored in a non-volatile memory which is achieved by the following steps (see Fig.6):

1. Set SEL to  $V_{SS}$  and a level of  $V_{DD} - 5$  V to  $V_{PP}$
2. The quartz-frequency deviation  $\Delta f/f$  is measured and (n) is calculated (see Table 1)
3. A first pulse  $t_E$  is applied to the DATA input clears the EEPROM to give the highest backplane frequency
4. The calculated pulses (n) are entered in  $(t_H, t_L)$ . If the maximum backplane period is reached and an additional pulse is applied the period will return to the lowest value.
5. The backplane period is controlled and when correct fixed by applying the store pulse  $t_W$
6. Release SEL and VPP.

**Table 1** Time calibration ( $\Delta t = 7.63 \mu s$ ; SEL at  $V_{SS}$ )

| OSCILLATOR-FREQUENCY DEVIATION<br>$\Delta f/f$<br>( $\times 10^{-6}$ ) | NUMBER OF PULSES<br>(n) | BACKPLANE PERIOD<br>(ms) |
|--|-------------------------|--------------------------|
| 0  | 0                       | 15.625                   |
| +3.8   | 1                       | 15.633                   |
| +7.6   | 2                       | 15.641                   |
| +11.4  | 3                       | 15.648                   |
| .  | .                       | .                        |
| .  | .                       | .                        |
| .  | .                       | .                        |
| +117.8   | 31                      | 15.861                   |

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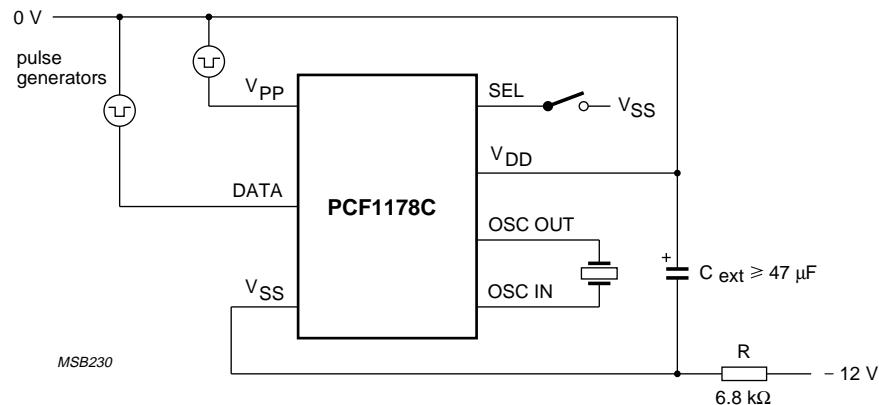
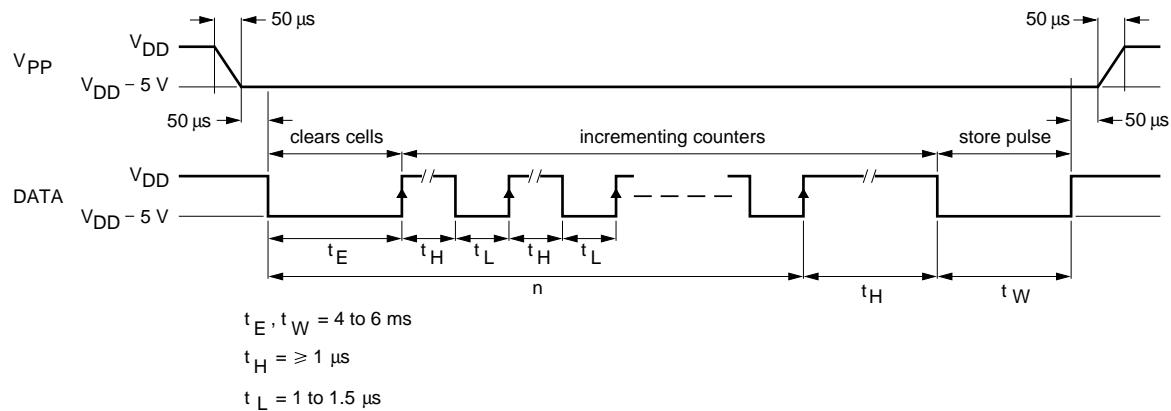


Fig.6 Programming diagram.

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**LIMITING VALUES**

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

| SYMBOL    | PARAMETER                     | CONDITIONS                        | MIN. | MAX.           | UNIT |
|-----------|-------------------------------|-----------------------------------|------|----------------|------|
| $V_{DD}$  | supply voltage                | with respect to $V_{SS}$          | –    | 8              | V    |
| $I_{DD}$  | supply current                | $V_{SS} = 0$ V; note 1            | –    | 3              | mA   |
| $V_I$     | input voltage                 | all pins except $V_{PP}$ and DATA | –0.3 | $V_{DD} + 0.3$ | V    |
|           |                               | pins $V_{PP}$ and DATA            | –3   | $V_{DD} + 0.3$ | V    |
| $T_{amb}$ | operating ambient temperature |                                   | –40  | +85            | °C   |
| $T_{stg}$ | storage temperature           |                                   | –55  | +125           | °C   |

**Note**

1. Connecting the supply voltage with reverse polarity, will not harm the circuit, provided the current is limited to 10 mA by an external resistor.

**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

$V_{DD} = 3$  to  $6$  V;  $V_{SS} = 0$  V;  $T_{amb} = -40$  to  $+85$  °C; crystal:  $f = 4.194304$  MHz;  $R_s = 50$  Ω;  $C_L = 12$  pF; maximum frequency tolerance =  $\pm 30 \times 10^{-6}$ ; unless otherwise specified.

| SYMBOL   | PARAMETER                                   | CONDITIONS   | MIN. | TYP.                | MAX.                 | UNIT |
|--|---|--|------|---------------------|----------------------|------|
| <b>Supply</b>                                  |   |  |      |                     |                      |      |
| $V_{DD}$                                       | supply voltage                              | voltage regulator programmed to 4.5 V at $T_{amb} = 25$ °C | 3    | —                   | 6                    | V    |
| $\Delta V_{DD}$                                | supply voltage variation                    | S1 or S2 closed  | —    | —                   | 50                   | mV   |
| TC   | supply voltage variation due to temperature | —  | —    | -0.35               | —                    | %/K  |
|  |   | $V_{DD} = 4.5$ V   | —    | -16                 | —                    | mV/K |
| $I_{DD}$                                       | supply current                              | note 1   | 700  | 950                 | —                    | μA   |
| $C_{EXT}$                                      | capacitance                                 | external capacitor   | 47   | —                   | —                    | μF   |
| <b>Oscillator</b>                              |   |  |      |                     |                      |      |
| $t_{osc}$                                      | start time                                  | —  | —    | 200                 | —                    | ms   |
| $\Delta f/f$                                   | frequency deviation                         | nominal $n = 0$  | 0    | $60 \times 10^{-6}$ | $110 \times 10^{-6}$ |      |
| $\Delta f/f$                                   | frequency stability                         | $\Delta V_{DD} = 100$ mV                                   | —    | —                   | $1 \times 10^{-6}$   |      |
| $R_{fb}$                                       | feedback resistance                         | —  | 300  | 1000                | 3000                 | kΩ   |
| $C_i$  | input capacitance                           | —  | —    | 16                  | —                    | pF   |
| $C_o$  | output capacitance                          | —  | —    | 27                  | —                    | pF   |
| <b>Inputs</b>                                  |   |  |      |                     |                      |      |
| $R_O$  | pull-up resistance                          | S1, S2, TS, SEL and DATA                                   | 45   | 90                  | 180                  | kΩ   |
| $R_O$  | pull-up/pull-down resistance                | MODE   | 100  | 300                 | 1000                 | kΩ   |
| $I_{IL}$                                       | leakage current                             | ENABLE, FLASH  | —    | —                   | 2                    | μA   |
| $t_d$  | debounce time                               | S1 and S2 only   | 30   | 65                  | 100                  | ms   |
| <b><math>V_{PP}</math> programming voltage</b> |   |  |      |                     |                      |      |
| $I_{O2}$                                       | output current                              | $V_{PP} = V_{DD} - 5$ V                                    | 70   | —                   | 700                  | μA   |
|  |   | during programming   | —    | 500                 | —                    | μA   |
| <b>Backplane (high and low levels)</b>         |   |  |      |                     |                      |      |
| $R_{BP}$                                       | output resistance                           | $\pm 100$ μA   | —    | —                   | 3                    | kΩ   |
| <b>Segment</b>                                 |   |  |      |                     |                      |      |
| $R_{SEG}$                                      | output resistance                           | $\pm 100$ μA   | —    | —                   | 5                    | kΩ   |
| <b>LCD</b>                                     |   |  |      |                     |                      |      |
| $V_{offset(DC)}$                               | DC offset voltage                           | 200 kΩ/1 nF  | —    | —                   | 50                   | mV   |

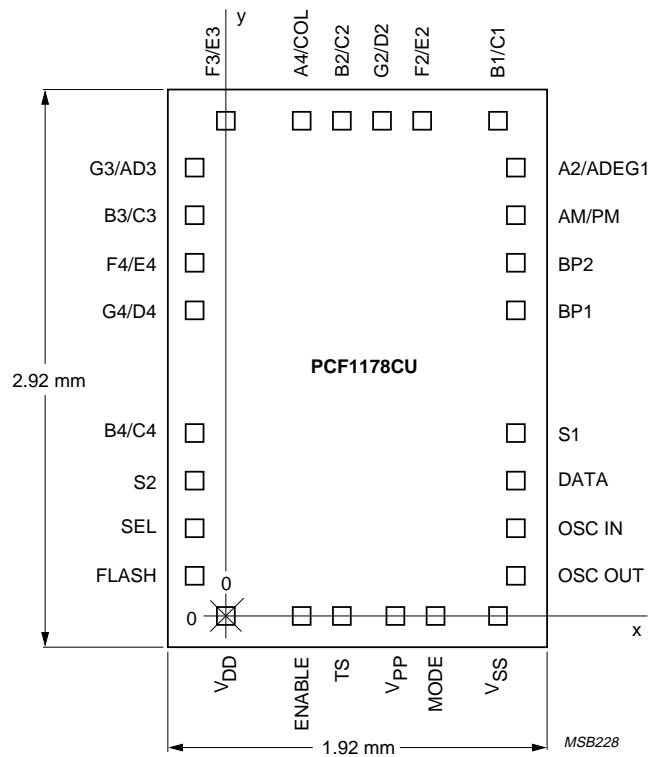
**Note**

1. A suitable resistor (R) must be selected (example):
  - a)  $V_{DD} = 5$  V;  $R$  max.  $(12 V - 5 V)/700 \mu A = 10$  kΩ.
  - b)  $V_{DD} = 5$  V;  $R$  typ.  $(12 V - 5 V)/900 \mu A = 7.8$  kΩ (more reserve).
  - c)  $I_{DD}$  must not exceed 3 mA.

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## CHIP DIMENSIONS AND BONDING PAD LOCATIONS



Chip area: 5.61 mm<sup>2</sup>.

Bonding pad dimensions: 110 µm × 110 µm.

Chip thickness: 381 ±25 µm.

Fig.7 Bonding pad locations, PCF1178CU; 28 terminals.

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**Table 2** Bonding pad locations (dimensions in  $\mu\text{m}$ )All x/y coordinates are referenced to the bottom left pad ( $V_{DD}$ ), see Fig.7.

| <b>PAD</b>               | <b>x</b> | <b>y</b> | <b>PAD</b> | <b>x</b> | <b>y</b> |
|--------------------------|----------|----------|------------|----------|----------|
| S1                       | 1490     | 881      | G4/D4      | -86      | 1588     |
| DATA                     | 1490     | 639      | F4/E4      | -86      | 1808     |
| OSC IN                   | 1490     | 408      | B3/C3      | -86      | 2028     |
| OSC OUT                  | 1490     | 188      | G3/AD3     | -86      | 2248     |
| $V_{SS}$                 | 1352     | 0        | F3/E3      | -48      | 2476     |
| MODE                     | 969      | 0        | A4/COL     | 352      | 2476     |
| $V_{PP}$                 | 770      | 0        | B2/C2      | 552      | 2476     |
| TS                       | 506      | 0        | G2/D2      | 752      | 2476     |
| ENABLE                   | 306      | 0        | F2/E2      | 952      | 2476     |
| $V_{DD}$                 | 0        | 0        | B1/C1      | 1352     | 2476     |
| FLASH                    | -86      | 188      | A2/ADEG1   | 1490     | 2248     |
| SEL                      | -86      | 408      | AM/PM      | 1490     | 2028     |
| S2                       | -86      | 628      | BP2        | 1490     | 1808     |
| B4/C4                    | -86      | 848      | BP1        | 1490     | 1588     |
| chip corner (max. value) | -305     | -175     |            |          |          |

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## APPLICATION INFORMATION

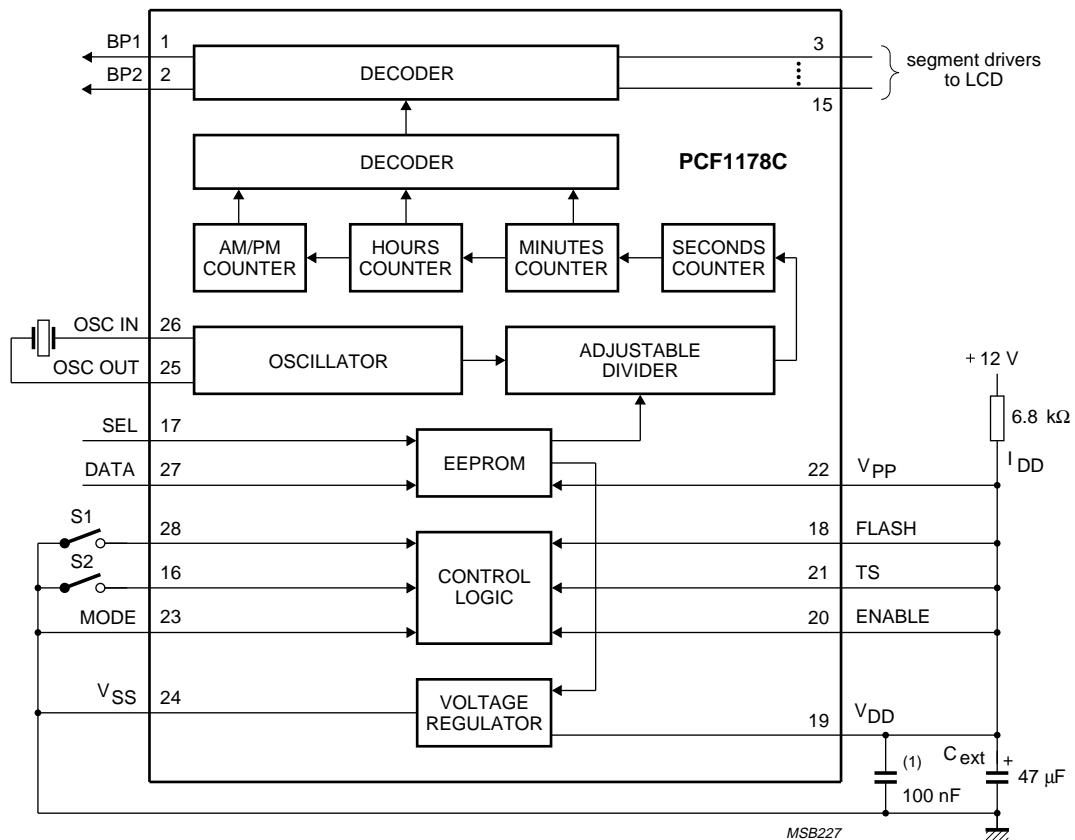


Fig.8 Typical application diagram.

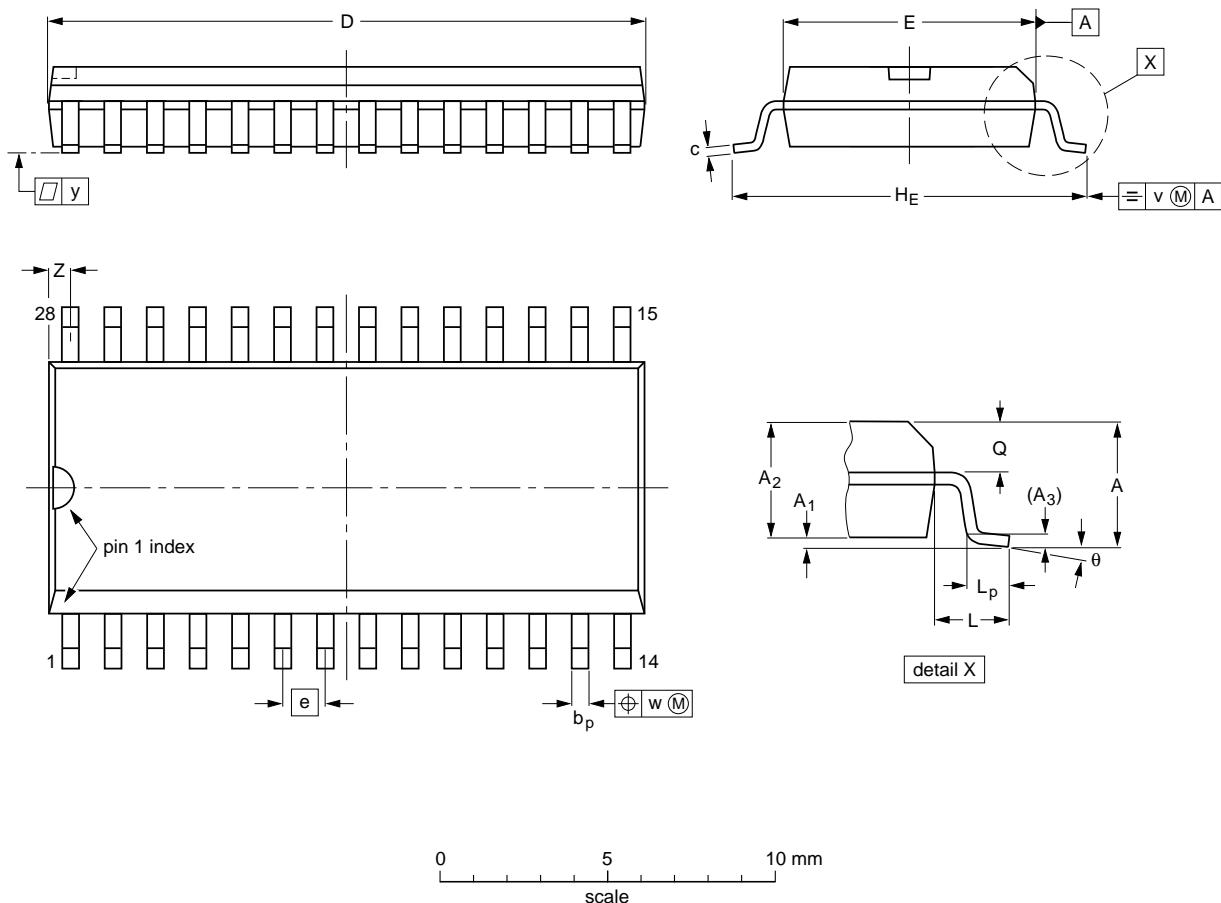
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## PACKAGE OUTLINE

SO28: plastic small outline package; 28 leads; body width 7.5 mm

SOT136-1



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

| UNIT   | A<br>max.     | A <sub>1</sub> | A <sub>2</sub> | A <sub>3</sub> | b <sub>p</sub> | c              | D <sup>(1)</sup> | E <sup>(1)</sup> | e     | H <sub>E</sub> | L     | L <sub>p</sub> | Q              | v    | w    | y     | z <sup>(1)</sup> | θ        |
|--------|---------------|----------------|----------------|----------------|----------------|----------------|------------------|------------------|-------|----------------|-------|----------------|----------------|------|------|-------|------------------|----------|
| mm     | 2.65<br>0.10  | 0.30<br>2.25   | 2.45           | 0.25           | 0.49<br>0.36   | 0.32<br>0.23   | 18.1<br>17.7     | 7.6<br>7.4       | 1.27  | 10.65<br>10.00 | 1.4   | 1.1<br>0.4     | 1.1<br>1.0     | 0.25 | 0.25 | 0.1   | 0.9<br>0.4       | 8°<br>0° |
| inches | 0.10<br>0.004 | 0.012<br>0.089 | 0.096          | 0.01           | 0.019<br>0.014 | 0.013<br>0.009 | 0.71<br>0.69     | 0.30<br>0.29     | 0.050 | 0.42<br>0.39   | 0.055 | 0.043<br>0.016 | 0.043<br>0.039 | 0.01 | 0.01 | 0.004 | 0.035<br>0.016   |          |

## Note

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

| OUTLINE<br>VERSION | REFERENCES |          |      |  | EUROPEAN<br>PROJECTION | ISSUE DATE            |
|--------------------|------------|----------|------|--|------------------------|-----------------------|
|                    | IEC        | JEDEC    | EIAJ |  |                        |                       |
| SOT136-1           | 075E06     | MS-013AE |      |  |                        | -91-08-13<br>95-01-24 |

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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).

#### 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**

| <b>Data sheet status</b>  |   |
|---|---|
| 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.                                |
| <b>Limiting values</b>  |   |
| 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. |   |
| <b>Application information</b>  |   |
| Where application information is given, it is advisory and does not form part of the specification.   |   |

**LIFE SUPPORT APPLICATIONS**

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

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**NOTES**

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**NOTES**

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