PCF8576D

40 × 4 universal LCD driver for low multiplex rates

Rev. 15 — 12 February 2015 Product data sheet

1. General description

The PCF8576D is a peripheral device which interfaces to almost any Liquid Crystal Display (LCD)[1] with low multiplex rates. It generates the drive signals for any static or multiplexed LCD containing up to four backplanes and up to 40 segments. It can be easily cascaded for larger LCD applications. The PCF8576D is compatible with most microcontrollers and communicates via the two-line bidirectional I^2C-bus. Communication overheads are minimized by a display RAM with auto-incremented addressing, by hardware subaddressing and by display memory switching (static and duplex drive modes).

- PCF8576DT/2 should not be used for new design-ins. Replacement part is PCF85176T/1 for industrial applications
- PCF8576DT/S400/2 should not be used for new design-ins. Replacement part is PCA85176T/Q900/1 for automotive applications

For a selection of NXP LCD segment drivers, see Table 30 on page 50.

2. Features and benefits

- AEC-Q100 compliant (PCF8576DT/S400/2) for automotive applications
- Single chip LCD controller and driver
- Selectable backplane drive configuration: static or 2, 3, 4 backplane multiplexing
- Selectable display bias configuration: static, ½, or ⅓
- Internal LCD bias generation with voltage-follower buffers
- 40 segment drives:
  - Up to 20 7-segment numeric characters
  - Up to 10 14-segment alphanumeric characters
  - Any graphics of up to 160 segments/elements
- 40 × 4-bit RAM for display data storage
- Auto-incremented display data loading across device subaddress boundaries
- Display memory bank switching in static and duplex drive modes
- Versatile blinking modes
- Independent supplies possible for LCD and logic voltages
- Wide power supply range: from 1.8 V to 5.5 V
- Wide logic LCD supply range:
  - From 2.5 V for low-threshold LCDs
  - Up to 6.5 V for high-threshold twisted nematic LCDs

1. The definition of the abbreviations and acronyms used in this data sheet can be found in Section 22.

- Low power consumption
- 400 kHz I^2C-bus interface
- May be cascaded for large LCD applications (up to 2560 segments/elements possible)
- No external components required
- Compatible with chip-on-glass and chip-on-board technology
- Manufactured in silicon gate CMOS process

3. Ordering information

Table 1. Ordering information

Product type number	Package		
	Name	Description	Version
PCF8576DT/2[1]	TSSOP56	plastic thin shrink small outline package, 56 leads; body width 6.1 mm	SOT364-1
PCF8576DT/S400/2[2]	TSSOP56	plastic thin shrink small outline package, 56 leads; body width 6.1 mm	SOT364-1
PCF8576DU/DA/2	wire bond die	59 bonding pads	PCF8576DU/DA
PCF8576DU/2DA/2	bare die	59 bumps	PCF8576DU/2DA

[1] Not to be used for new designs. Replacement part is PCF85176T/1 for industrial applications.

[2] Not to be used for new designs. Replacement part is PCA85176T/Q900/1 for automotive applications.

3.1 Ordering options

Table 2. Ordering options

Product type number	Orderable part number	Sales item (12NC)	Delivery form	IC revision
PCF8576DT/2	PCF8576DT/2,118	935276166118	tape and reel, 13 inch	2
PCF8576DT/S400/2	PCF8576DT/S400/2,1	935287131118	tape and reel, 13 inch	2
PCF8576DU/DA/2	PCF8576DU/DA/2,026	935276239026	chips in tray	2
PCF8576DU/2DA/2	PCF8576DU/2DA/2,02	935276249026	chips in tray	2

4. Marking

Table 3. Marking codes

Product type number	Marking code
PCF8576DT/2	PCF8576DT
PCF8576DT/S400/2	PCF8576DT/S400
PCF8576DU/DA/2	PC8576D-2
PCF8576DU/2DA/2	PC8576D-2

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5. Block diagram

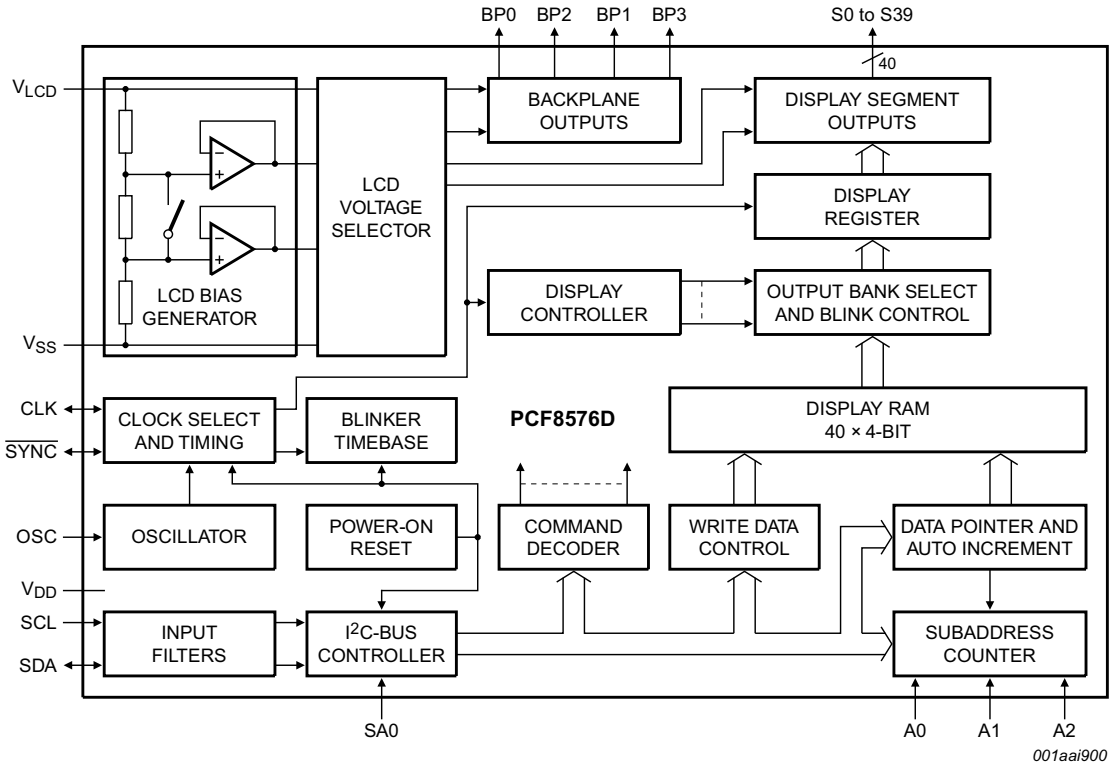


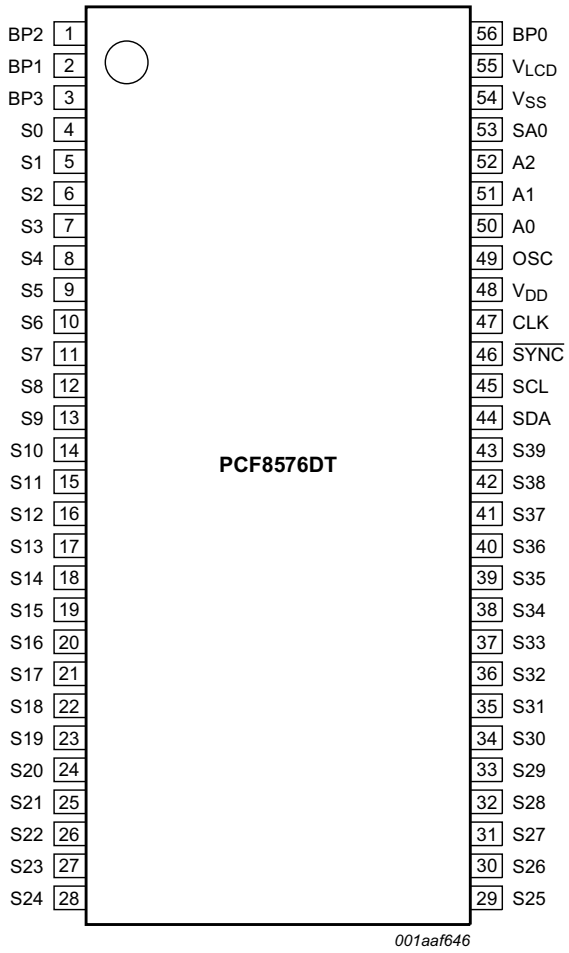
Fig 1. Block diagram of PCF8576D

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6. Pinning information

6.1 Pinning

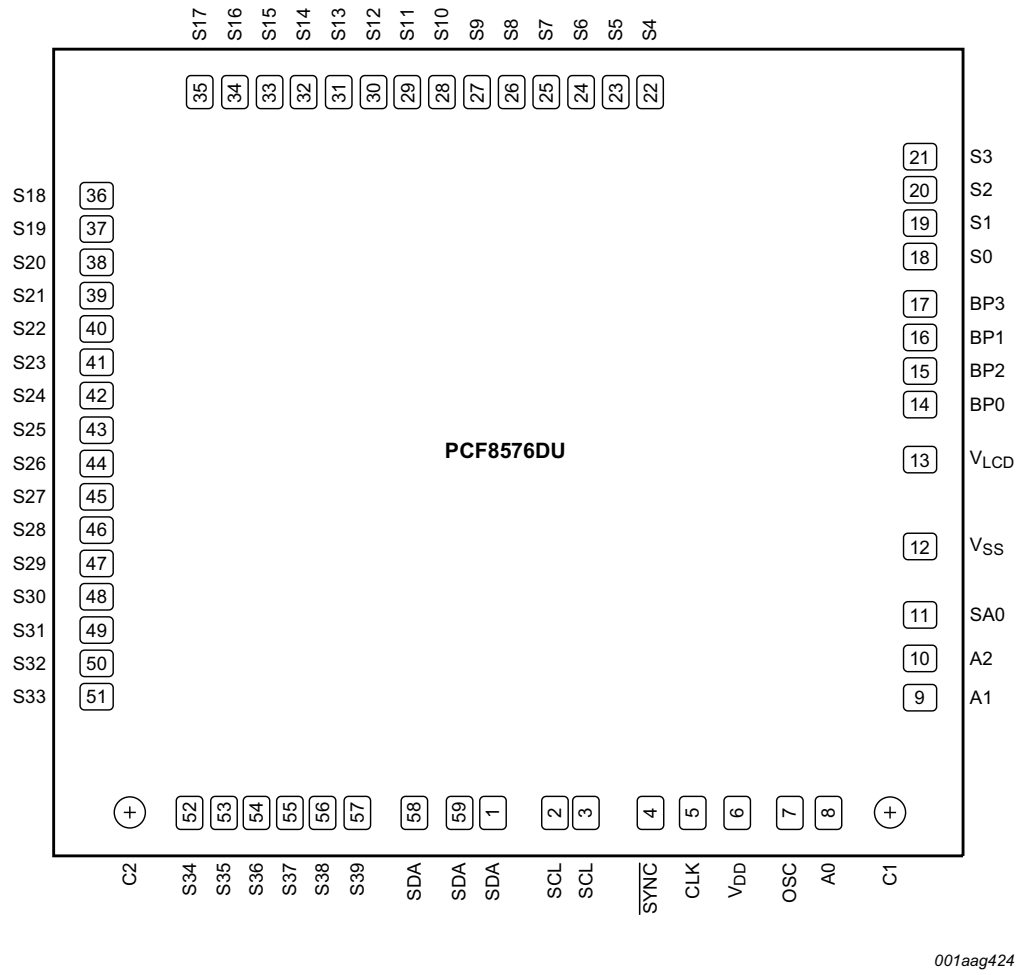


Top view. For mechanical details, see Figure 25.

Fig 2. Pinning diagram for PCF8576DT (TSSOP56)

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Viewed from active side. C1 and C2 are alignment marks. For mechanical details, see Figure 26 and Figure 27.

Fig 3. Pinning diagram for PCF8576DU (bare die)

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6.2 Pin description

Table 4. Pin description

Input or input/output pins must always be at a defined level (V_{SS} or V_{DD}) unless otherwise specified.

Symbol	Pin		Description
	PCF8576DT	PCF8576DU	
SDA	44	1, 58, 59	I^2C-bus serial data input and output
SCL	45	2, 3	I^2C-bus serial clock input
CLK	47	5	external clock input or output
V_{DD}	48	6	supply voltage
$\overline{SYNC}$	46	4	cascade synchronization input or output; if not used it must be left open
OSC	49	7	internal oscillator enable input
A0 to A2	50 to 52	8 to 10	subaddress inputs
SA0	53	11	I^2C-bus address input; bit 0
V_{SS}	54	12[1]	ground supply voltage
V_{LCD}	55	13	LCD supply voltage
BP0, BP2, BP1, BP3	56, 1, 2, 3	14 to 17	LCD backplane outputs
S0 to S39	4 to 43	18 to 57	LCD segment outputs
n.c.	-	-	not connected

[1] The substrate (rear side of the die) is connected to V_{SS} and should be electrically isolated.

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7. Functional description

The PCF8576D is a versatile peripheral device designed to interface between any microcontroller to a wide variety of LCD segment or dot matrix displays (see Figure 4). It can directly drive any static or multiplexed LCD containing up to four backplanes and up to 40 segments.

The possible display configurations of the PCF8576D depend on the number of active backplane outputs required. A selection of display configurations is shown in Table 5. All of these configurations can be implemented in the typical system shown in Figure 5.

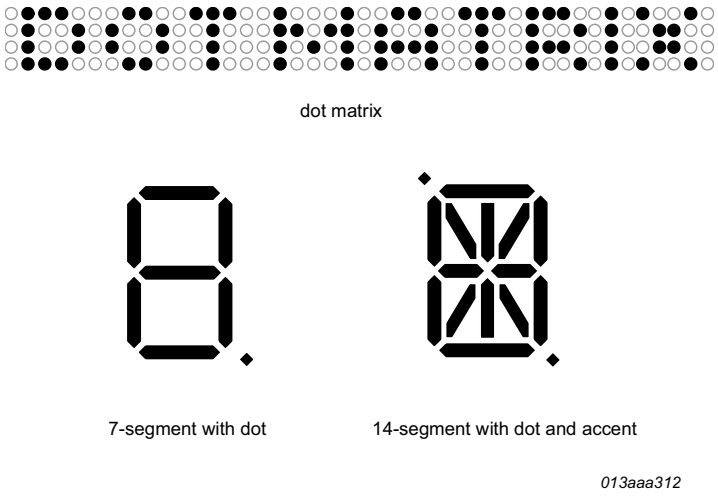


Fig 4. Example of displays suitable for PCF8576D

Table 5. Selection of possible display configurations

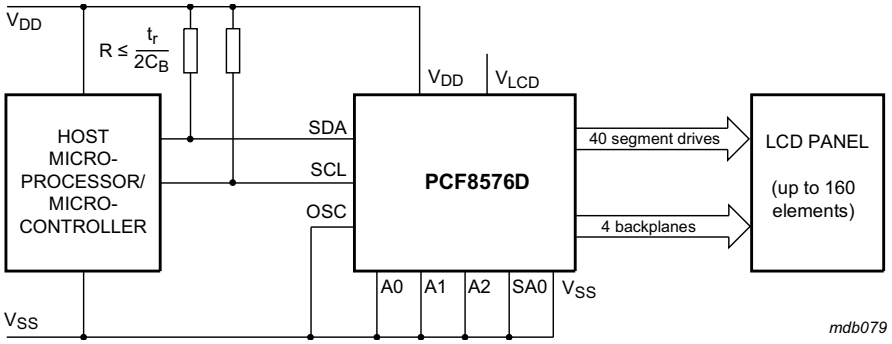
Number of				
Backplanes	**Icons**	**Digits/Characters**		**Dot matrix: segments/ elements**
		7-segment[1]	**14-segment[2]**	
4	160	20	10	160 (4 × 40)
3	120	15	7	120 (3 × 40)
2	80	10	5	80 (2 × 40)
1	40	5	2	40 (1 × 40)

[1] 7 segment display has 8 segments/elements including the decimal point.

[2] 14 segment display has 16 segments/elements including decimal point and accent dot.

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The resistance of the power lines must be kept to a minimum.

For chip-on-glass applications, due to the Indium Tin Oxide (ITO) track resistance, each supply line must be routed separately between the chip and the connector.

Fig 5. Typical system configuration

The host microcontroller maintains the 2-line I²C-bus communication channel with the PCF8576D. The internal oscillator is enabled by connecting pin OSC to pin V_{SS}. The appropriate biasing voltages for the multiplexed LCD waveforms are generated internally. The only other connections required to complete the system are to the power supplies (V_{DD}, V_{SS}, and V_{LCD}) and the LCD panel chosen for the application.

7.1 Power-On Reset (POR)

At power-on the PCF8576D resets to the following starting conditions:

- All backplane and segment outputs are set to V_{LCD}
- The selected drive mode is: 1:4 multiplex with $\frac{1}{3}$ bias
- Blinking is switched off
- Input and output bank selectors are reset
- The I²C-bus interface is initialized
- The data pointer and the subaddress counter are cleared (set to logic 0)
- The display is disabled (bit E = 0, see Table 12)

Remark: Do not transfer data on the I²C-bus for at least 1 ms after a power-on to allow the reset action to complete.

7.2 LCD bias generator

Fractional LCD biasing voltages are obtained from an internal voltage divider of three impedances connected between pins V_{LCD} and V_{SS}. The center impedance is bypassed by switch if the $\frac{1}{2}$ bias voltage level for the 1:2 multiplex drive mode configuration is selected. The LCD voltage can be temperature compensated externally using the supply to pin V_{LCD}.

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7.3 LCD voltage selector

The LCD voltage selector coordinates the multiplexing of the LCD in accordance with the selected LCD drive configuration. The operation of the voltage selector is controlled by the mode-set command from the command decoder. The biasing configurations that apply to the preferred modes of operation, together with the biasing characteristics as functions of V_{LCD} and the resulting discrimination ratios (D) are given in Table 6.

Discrimination is a term which is defined as the ratio of the on and off RMS voltage across a segment. It can be thought of as a measurement of contrast.

Table 6. Biasing characteristics

LCD drive mode	Number of:		LCD bias configuration	$\frac{V_{off(RMS)}}{V_{LCD}}$	$\frac{V_{on(RMS)}}{V_{LCD}}$	$D = \frac{V_{on(RMS)}}{V_{off(RMS)}}$
	Backplanes	Levels				
static	1	2	static	0	1	∞
1:2 multiplex	2	3	½	0.354	0.791	2.236
1:2 multiplex	2	4	⅓	0.333	0.745	2.236
1:3 multiplex	3	4	⅓	0.333	0.638	1.915
1:4 multiplex	4	4	⅓	0.333	0.577	1.732

A practical value for V_{LCD} is determined by equating $V_{off(RMS)}$ with a defined LCD threshold voltage ($V_{th(off)}$), typically when the LCD exhibits approximately 10 % contrast. In the static drive mode a suitable choice is $V_{LCD} > 3V_{th(off)}$.

Multiplex drive modes of 1:3 and 1:4 with ½ bias are possible but the discrimination and hence the contrast ratios are smaller.

Bias is calculated by $\frac{1}{1+a}$, where the values for a are

a = 1 for ½ bias

a = 2 for ⅓ bias

The RMS on-state voltage ($V_{on(RMS)}$) for the LCD is calculated with Equation 1:

$$V_{on(RMS)} = V_{LCD}\sqrt{\frac{a^2 + 2a + n}{n \times (1+a)^2}} \quad (1)$$

where the values for n are

n = 1 for static drive mode

n = 2 for 1:2 multiplex drive mode

n = 3 for 1:3 multiplex drive mode

n = 4 for 1:4 multiplex drive mode

The RMS off-state voltage ($V_{off(RMS)}$) for the LCD is calculated with Equation 2:

$$V_{off(RMS)} = V_{LCD}\sqrt{\frac{a^2 - 2a + n}{n \times (1+a)^2}} \quad (2)$$

Discrimination is the ratio of $V_{on(RMS)}$ to $V_{off(RMS)}$ and is determined from Equation 3:

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$$D = \frac{V_{on(RMS)}}{V_{off(RMS)}} = \sqrt{\frac{a^2 + 2a + n}{a^2 - 2a + n}} \quad (3)$$

Using Equation 3, the discrimination for an LCD drive mode of 1:3 multiplex with ½ bias is $\sqrt{3} = 1.732$ and the discrimination for an LCD drive mode of 1:4 multiplex with ½ bias is $\frac{\sqrt{21}}{3} = 1.528$.

The advantage of these LCD drive modes is a reduction of the LCD full scale voltage V_{LCD} as follows:

- 1:3 multiplex (½ bias): $V_{LCD} = \sqrt{6} \times V_{off(RMS)} = 2.449 V_{off(RMS)}$
- 1:4 multiplex (½ bias): $V_{LCD} = \left[\frac{(4 \times \sqrt{3})}{3}\right] = 2.309 V_{off(RMS)}$

These compare with $V_{LCD} = 3V_{off(RMS)}$ when ⅓ bias is used.

It should be noted that V_{LCD} is sometimes referred as the LCD operating voltage.

7.3.1 Electro-optical performance

Suitable values for $V_{on(RMS)}$ and $V_{off(RMS)}$ are dependent on the LCD liquid used. The RMS voltage, at which a pixel will be switched on or off, determine the transmissibility of the pixel.

For any given liquid, there are two threshold values defined. One point is at 10 % relative transmission (at $V_{th(off)}$) and the other at 90 % relative transmission (at $V_{th(on)}$), see Figure 6. For a good contrast performance, the following rules should be followed:

$$V_{on(RMS)} \geq V_{th(on)} \quad (4)$$

$$V_{off(RMS)} \leq V_{th(off)} \quad (5)$$

$V_{on(RMS)}$ and $V_{off(RMS)}$ are properties of the display driver and are affected by the selection of a, n (see Equation 1 to Equation 3) and the V_{LCD} voltage.

$V_{th(off)}$ and $V_{th(on)}$ are properties of the LCD liquid and can be provided by the module manufacturer. $V_{th(off)}$ is sometimes just named V_{th}. $V_{th(on)}$ is sometimes named saturation voltage V_{sat}.

It is important to match the module properties to those of the driver in order to achieve optimum performance.

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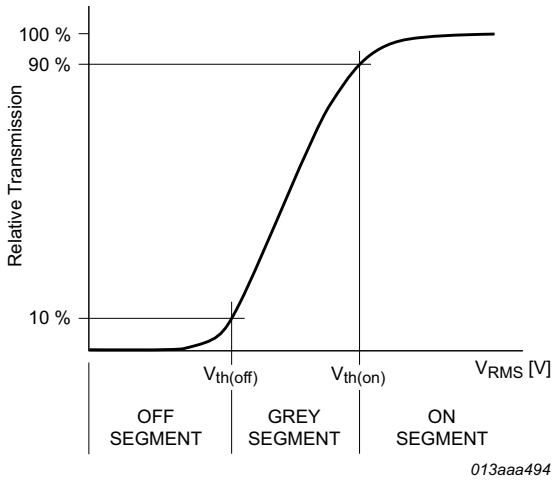


Fig 6. Electro-optical characteristic: relative transmission curve of the liquid

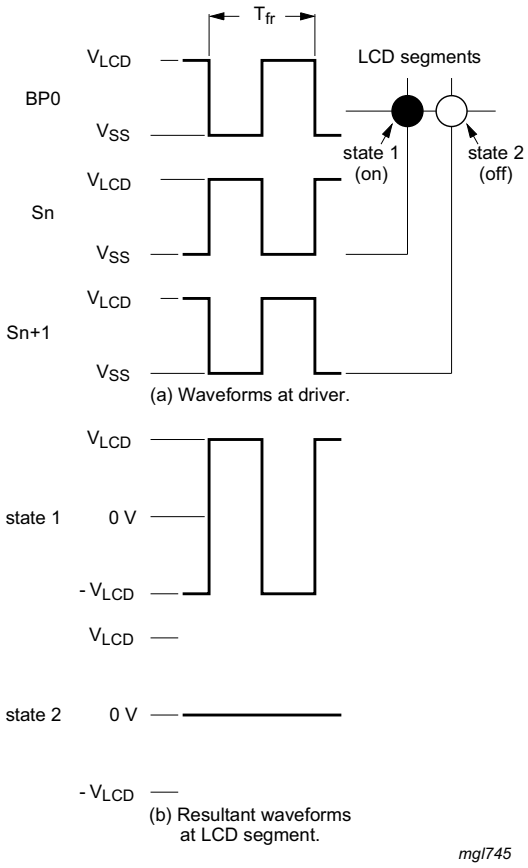
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7.4 LCD drive mode waveforms

7.4.1 Static drive mode

The static LCD drive mode is used when a single backplane is provided in the LCD. The backplane (BPn) and segment drive (S_n) waveforms for this mode are shown in Figure 7.



(1) $V_{state1}(t) = V_{Sn}(t) - V_{BP0}(t)$.

(2) $V_{on(RMS)} = V_{LCD}$.

(3) $V_{state2}(t) = V_{Sn+1}(t) - V_{BP0}(t)$.

(4) $V_{off(RMS)} = 0$ V.

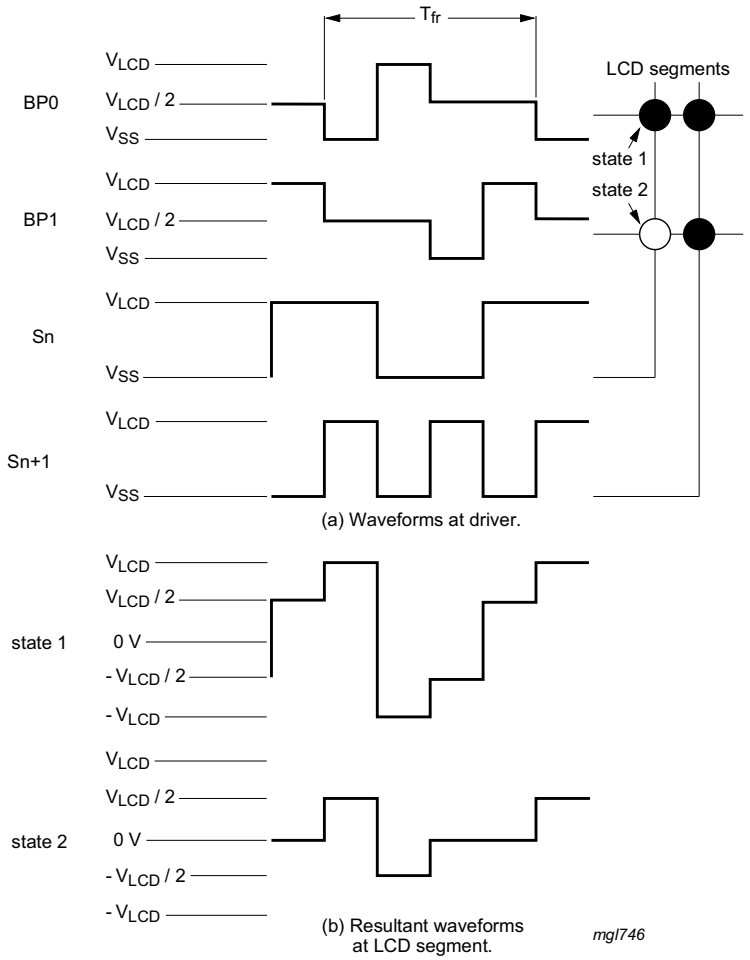
Fig 7. Static drive mode waveforms

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7.4.2 1:2 Multiplex drive mode

The 1:2 multiplex drive mode is used when two backplanes are provided in the LCD. This mode allows fractional LCD bias voltages of ½ bias or ⅓ bias as shown in Figure 8 and Figure 9.



(1) $V_{state1}(t) = V_{Sn}(t) - V_{BP0}(t)$.

(2) $V_{on(RMS)} = 0.791V_{LCD}$.

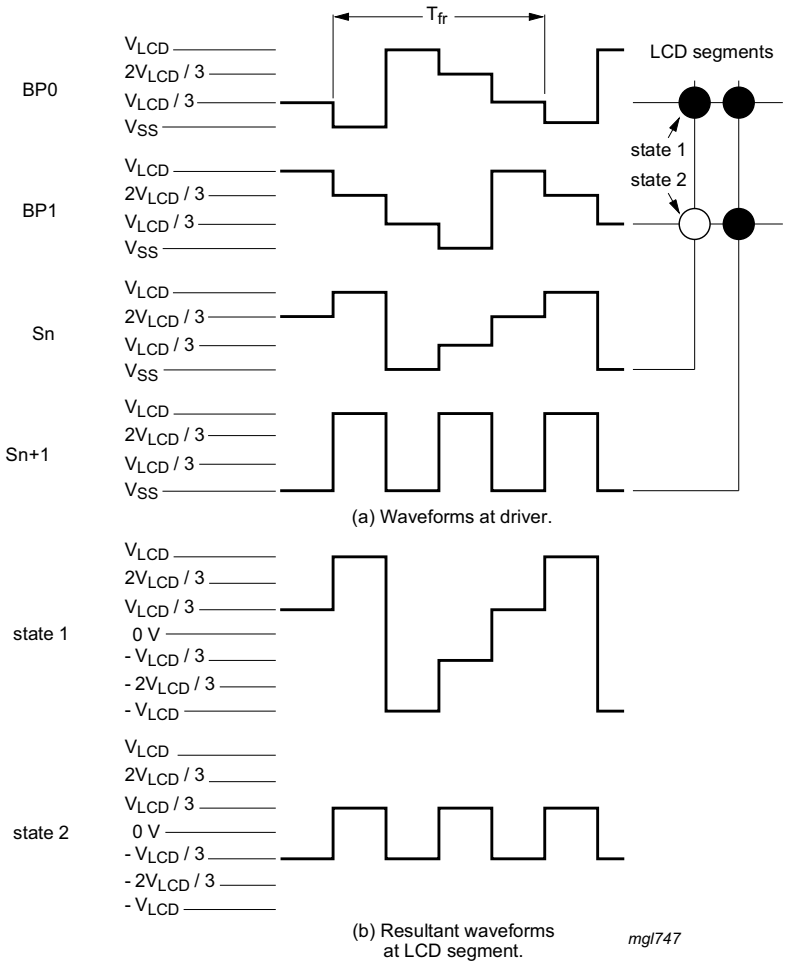
(3) $V_{state2}(t) = V_{Sn+1}(t) - V_{BP1}(t)$.

(4) $V_{off(RMS)} = 0.354V_{LCD}$.

Fig 8. Waveforms for the 1:2 multiplex drive mode with ½ bias

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(1) $V_{state1}(t) = V_{Sn}(t) - V_{BP0}(t)$.

(2) $V_{on(RMS)} = 0.745V_{LCD}$.

(3) $V_{state2}(t) = V_{Sn+1}(t) - V_{BP1}(t)$.

(4) $V_{off(RMS)} = 0.333V_{LCD}$.

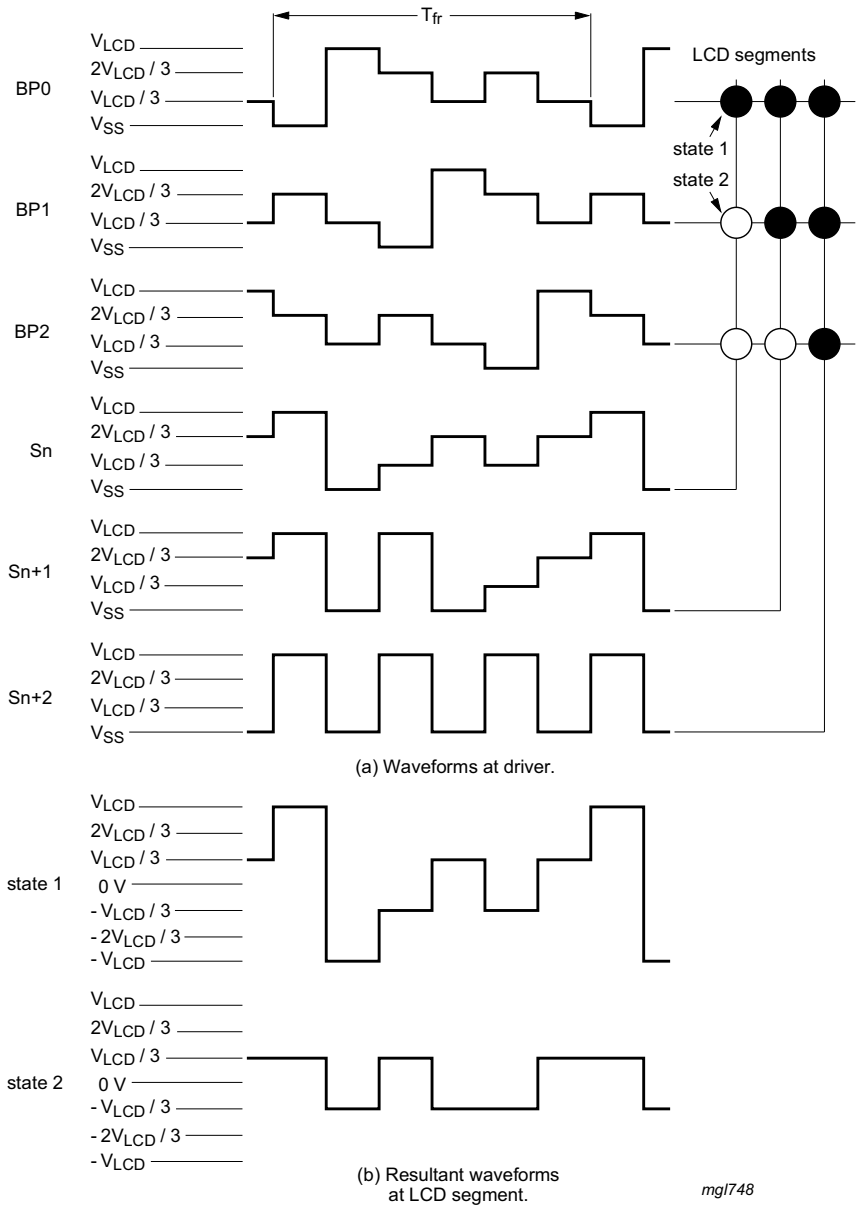
Fig 9. Waveforms for the 1:2 multiplex drive mode with ⅓ bias

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7.4.3 1:3 Multiplex drive mode

When three backplanes are provided in the LCD, the 1:3 multiplex drive mode applies (see Figure 10).



(1) $V_{state1}(t) = V_{Sn}(t) - V_{BP0}(t)$.

(2) $V_{on(RMS)} = 0.638V_{LCD}$.

(3) $V_{state2}(t) = V_{Sn+1}(t) - V_{BP1}(t)$.

(4) $V_{off(RMS)} = 0.333V_{LCD}$.

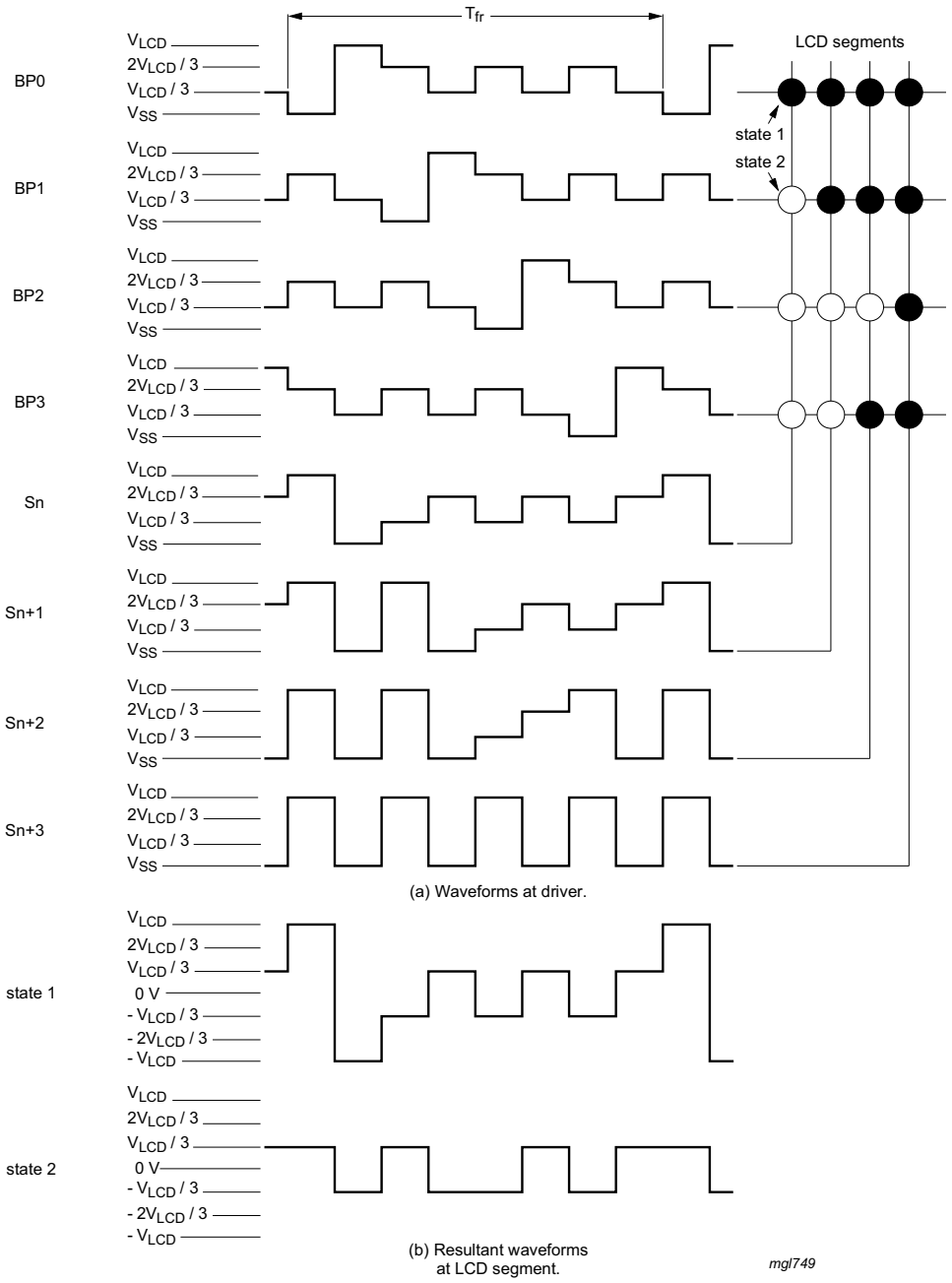
Fig 10. Waveforms for the 1:3 multiplex drive mode with ⅓ bias

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7.4.4 1:4 Multiplex drive mode

When four backplanes are provided in the LCD, the 1:4 multiplex drive mode applies (see Figure 11).



(1) $V_{state1}(t) = V_{Sn}(t) - V_{BP0}(t)$.

(2) $V_{on(RMS)} = 0.577V_{LCD}$.

(3) $V_{state2}(t) = V_{Sn+1}(t) - V_{BP1}(t)$.

(4) $V_{off(RMS)} = 0.333V_{LCD}$.

Fig 11. Waveforms for the 1:4 multiplex drive mode with ⅓ bias

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7.5 Oscillator

7.5.1 Internal clock

The internal logic of the PCF8576D and its LCD drive signals are timed either by its internal oscillator or by an external clock. The internal oscillator is enabled by connecting pin OSC to pin V_{SS}. If the internal oscillator is used, the output from pin CLK can be used as the clock signal for several PCF8576Ds in the system that are connected in cascade.

7.5.2 External clock

Pin CLK is enabled as an external clock input by connecting pin OSC to V_{DD}. The LCD frame signal frequency is determined by the clock frequency (f_{clk}).

Remark: A clock signal must always be supplied to the device; removing the clock may freeze the LCD in a DC state, which is not suitable for the liquid crystal.

7.6 Timing

The PCF8576D timing controls the internal data flow of the device. This includes the transfer of display data from the display RAM to the display segment outputs. In cascaded applications, the correct timing relationship between each PCF8576D in the system is maintained by the synchronization signal at pin $\overline{SYNC}$. The timing also generates the LCD frame signal whose frequency is derived from the clock frequency. The frame signal frequency is a fixed division of the clock frequency from either the internal or an external clock: $f_{fr} = \frac{f_{clk}}{24}$.

7.7 Display register

The display latch holds the display data while the corresponding multiplex signals are generated.

7.8 Segment outputs

The LCD drive section includes 40 segment outputs S0 to S39 which should be connected directly to the LCD. The segment output signals are generated in accordance with the multiplexed backplane signals and with data residing in the display latch. When less than 40 segment outputs are required, the unused segment outputs should be left open-circuit.

7.9 Backplane outputs

The LCD drive section includes four backplane outputs BP0 to BP3 which must be connected directly to the LCD. The backplane output signals are generated in accordance with the selected LCD drive mode. If less than four backplane outputs are required, the unused outputs can be left open-circuit.

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- In 1:3 multiplex drive mode, BP3 carries the same signal as BP1, therefore these two adjacent outputs can be tied together to give enhanced drive capabilities.
- In 1:2 multiplex drive mode, BP0 and BP2, respectively, BP1 and BP3 all carry the same signals and may also be paired to increase the drive capabilities.
- In static drive mode the same signal is carried by all four backplane outputs and they can be connected in parallel for very high drive requirements.

7.10 Display RAM

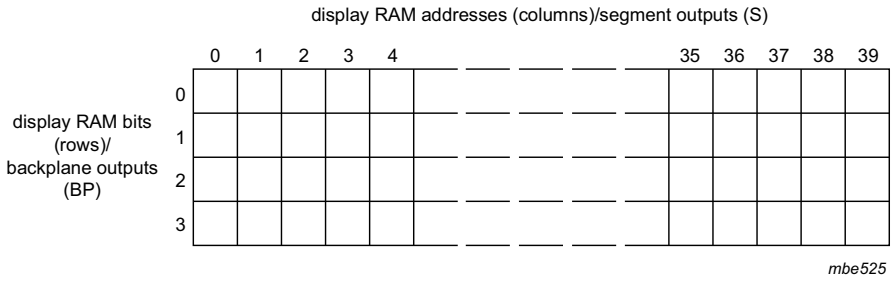
The display RAM is a static 40 × 4-bit RAM which stores LCD data.

There is a one-to-one correspondence between

- the bits in the RAM bitmap and the LCD segments/elements
- the RAM columns and the segment outputs
- the RAM rows and the backplane outputs.

A logic 1 in the RAM bitmap indicates the on-state of the corresponding LCD element; similarly, a logic 0 indicates the off-state.

The display RAM bit map, Figure 12, shows the rows 0 to 3 which correspond with the backplane outputs BP0 to BP3, and the columns 0 to 39 which correspond with the segment outputs S0 to S39. In multiplexed LCD applications the segment data of the first, second, third and fourth row of the display RAM are time-multiplexed with BP0, BP1, BP2, and BP3 respectively.



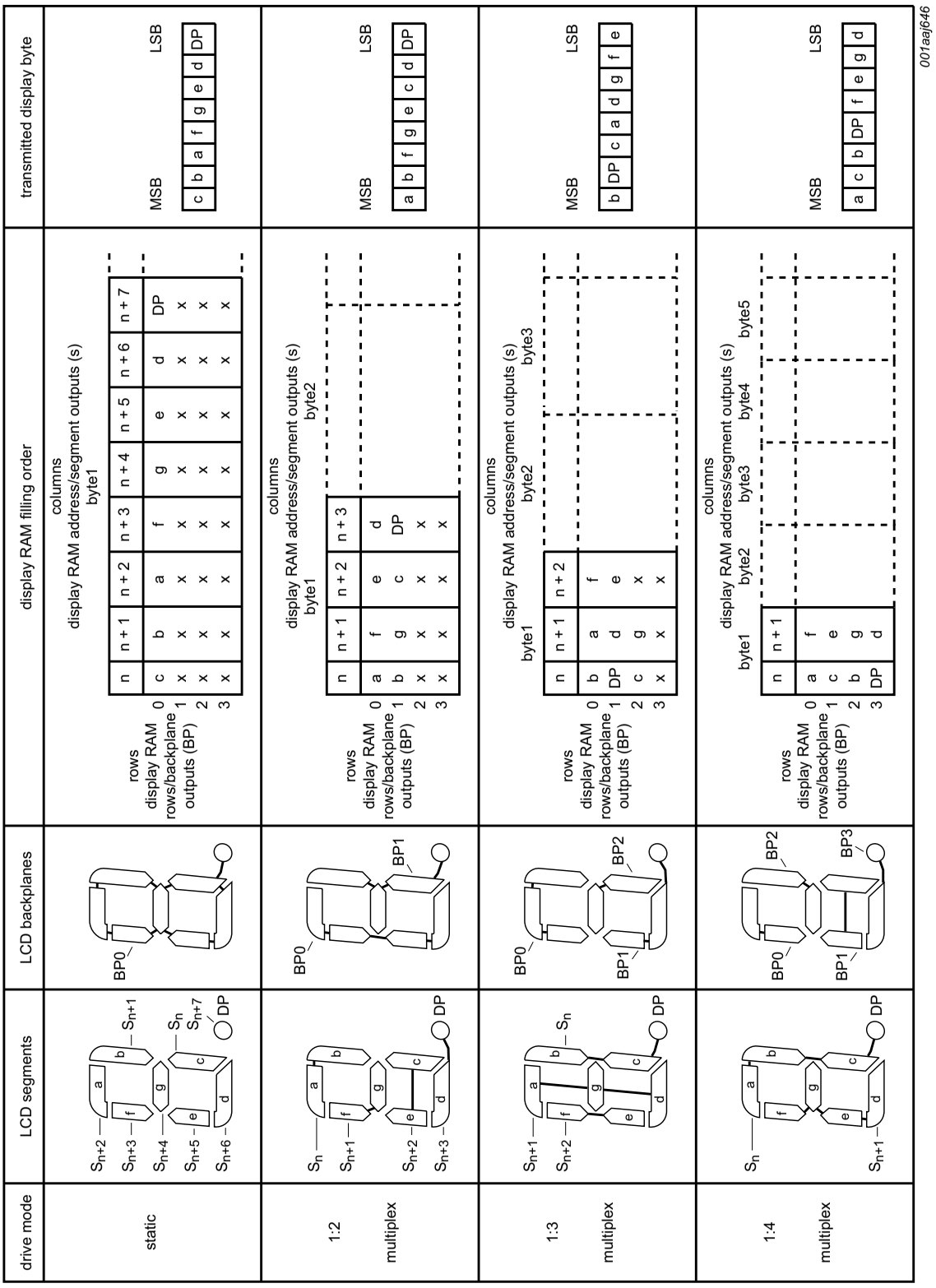
The display RAM bitmap shows the direct relationship between the display RAM column and the segment outputs; and between the bits in a RAM row and the backplane outputs.

Fig 12. Display RAM bit map

When display data is transmitted to the PCF8576D, the received display bytes are stored in the display RAM in accordance with the selected LCD drive mode. The data is stored as it arrives and depending on the current multiplex drive mode the bits are stored singularly, in pairs, triples, or quadruples. To illustrate the filling order, an example of a 7-segment display showing all drive modes is given in Figure 13; the RAM filling organization depicted applies equally to other LCD types.

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x = data bit unchanged.

Fig 13. Relationship between LCD layout, drive mode, display RAM filling order and display data transmitted over the I²C-bus

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The following applies to Figure 13:

- In static drive mode the eight transmitted data bits are placed into row 0 as one byte.
- In 1:2 multiplex drive mode the eight transmitted data bits are placed in pairs into row 0 and 1 as four successive 2-bit RAM words.
- In 1:3 multiplex drive mode the eight bits are placed in triples into row 0, 1, and 2 as three successive 3-bit RAM words, with bit 3 of the third address left unchanged. It is not recommended to use this bit in a display because of the difficult addressing. This last bit may, if necessary, be controlled by an additional transfer to this address, but care should be taken to avoid overwriting adjacent data because always full bytes are transmitted (see Section 7.10.3).
- In 1:4 multiplex drive mode, the eight transmitted data bits are placed in quadruples into row 0, 1, 2, and 3 as two successive 4-bit RAM words.

7.10.1 Data pointer

The addressing mechanism for the display RAM is realized using the data pointer. This allows the loading of an individual display data byte, or a series of display data bytes, into any location of the display RAM. The sequence commences with the initialization of the data pointer by the load-data-pointer command (see Table 13). Following this command, an arriving data byte is stored at the display RAM address indicated by the data pointer. The filling order is shown in Figure 13. After each byte is stored, the content of the data pointer is automatically incremented by a value dependent on the selected LCD drive mode:

- In static drive mode by eight.
- In 1:2 multiplex drive mode by four.
- In 1:3 multiplex drive mode by three.
- In 1:4 multiplex drive mode by two.

If an I^2C-bus data access terminates early then the state of the data pointer is unknown. Consequently, the data pointer must be rewritten prior to further RAM accesses.

7.10.2 Subaddress counter

The storage of display data is determined by the contents of the subaddress counter. Storage is allowed only when the content of the subaddress counter match with the hardware subaddress applied to A0, A1, and A2. The subaddress counter value is defined by the device-select command (see Table 14). If the content of the subaddress counter and the hardware subaddress do not match then data storage is inhibited but the data pointer is incremented as if data storage had taken place. The subaddress counter is also incremented when the data pointer overflows.

The storage arrangements described lead to extremely efficient data loading in cascaded applications. When a series of display bytes are sent to the display RAM, automatic wrap-over to the next PCF8576D occurs when the last RAM address is exceeded. Subaddressing across device boundaries is successful even if the change to the next device in the cascade occurs within a transmitted character.

The hardware subaddress must not be changed while the device is being accessed on the I^2C-bus interface.

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7.10.3 RAM writing in 1:3 multiplex drive mode

In 1:3 multiplex drive mode, the RAM is written as shown in Table 7 (see Figure 13 as well).

Table 7. Standard RAM filling in 1:3 multiplex drive mode

*Assumption: BP2/S2, BP2/S5, BP2/S8 etc. **are not connected** to any segments/elements on the display.*

Display RAM bits (rows)/ backplane outputs (BPn)	Display RAM addresses (columns)/segment outputs (Sn)										
	0	1	2	3	4	5	6	7	8	9	:
0	a7	a4	a1	b7	b4	b1	c7	c4	c1	d7	:
1	a6	a3	a0	b6	b3	b0	c6	c3	c0	d6	:
2	a5	a2	-	b5	b2	-	c5	c2	-	d5	:
3	-	-	-	-	-	-	-	-	-	-	:

If the bit at position BP2/S2 would be written by a second byte transmitted, then the mapping of the segment bits would change as illustrated in Table 8.

Table 8. Entire RAM filling by rewriting in 1:3 multiplex drive mode

*Assumption: BP2/S2, BP2/S5, BP2/S8 etc. **are connected** to segments/elements on the display.*

Display RAM bits (rows)/ backplane outputs (BPn)	Display RAM addresses (columns)/segment outputs (Sn)										
	0	1	2	3	4	5	6	7	8	9	:
0	a7	a4	a1/b7	b4	b1/c7	c4	c1/d7	d4	d1/e7	e4	:
1	a6	a3	a0/b6	b3	b0/c6	c3	c0/d6	d3	d0/e6	e3	:
2	a5	a2	b5	b2	c5	c2	d5	d2	e5	e2	:
3	-	-	-	-	-	-	-	-	-	-	:

In the case described in Table 8 the RAM has to be written entirely and BP2/S2, BP2/S5, BP2/S8 etc. have to be connected to segments/elements on the display. This can be achieved by a combination of writing and rewriting the RAM like follows:

- In the first write to the RAM, bits a7 to a0 are written.
- In the second write, bits b7 to b0 are written, overwriting bits a1 and a0 with bits b7 and b6.
- In the third write, bits c7 to c0 are written, overwriting bits b1 and b0 with bits c7 and c6.

Depending on the method of writing to the RAM (standard or entire filling by rewriting), some segments/elements remain unused or can be used, but it has to be considered in the module layout process as well as in the driver software design.

7.10.4 Writing over the RAM address boundary

In all multiplex drive modes, depending on the setting of the data pointer, it is possible to fill the RAM over the RAM address boundary. If the PCF8576D is part of a cascade the additional bits fall into the next device that also generates the acknowledge signal. If the PCF8576D is a single device or the last device in a cascade the additional bits will be discarded and no acknowledge signal will be generated.

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7.10.5 Output bank selector

The output bank selector (see Table 15) selects one of the four rows per display RAM address for transfer to the display register. The actual row selected depends on the selected LCD drive mode in operation and on the instant in the multiplex sequence.

- In 1:4 multiplex mode, all RAM addresses of row 0 are selected, these are followed by the contents of row 1, 2, and then 3
- In 1:3 multiplex mode, rows 0, 1, and 2 are selected sequentially
- In 1:2 multiplex mode, rows 0 and 1 are selected
- In static mode, row 0 is selected

The PCF8576D includes a RAM bank switching feature in the static and 1:2 multiplex drive modes. In the static drive mode, the bank-select command may request the contents of row 2 to be selected for display instead of the contents of row 0. In the 1:2 multiplex mode, the contents of rows 2 and 3 may be selected instead of rows 0 and 1. This gives the provision for preparing display information in an alternative bank and to be able to switch to it once it is assembled.

7.10.6 Input bank selector

The input bank selector loads display data into the display RAM in accordance with the selected LCD drive configuration. Display data can be loaded in row 2 in static drive mode or in rows 2 and 3 in 1:2 multiplex drive mode by using the bank-select command (see Table 15). The input bank selector functions independently to the output bank selector.

7.11 Blinking

The display blinking capabilities of the PCF8576D are very versatile. The whole display can blink at frequencies selected by the blink-select command (see Table 16). The blink frequencies are derived from the clock frequency. The ratio between the clock and blink frequencies depends on the blink mode selected (see Table 16).

An additional feature is for an arbitrary selection of LCD segments/elements to blink. This applies to the static and 1:2 multiplex drive modes and can be implemented without any communication overheads. By means of the output bank selector, the displayed RAM banks are exchanged with alternate RAM banks at the blink frequency. This mode can also be specified by the blink-select command.

In the 1:3 and 1:4 multiplex modes, where no alternative RAM bank is available, groups of LCD segments/elements can blink by selectively changing the display RAM data at fixed time intervals.

The entire display can blink at a frequency other than the nominal blink frequency. This can be effectively performed by resetting and setting the display enable bit E at the required rate using the mode-set command (see Table 12).

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Table 9. Blinking frequencies

Blink mode	Normal operating mode ratio	Nominal blink frequency[1]
off	-	blinking off
1	$\frac{f_{clk}}{768}$	2 Hz
2	$\frac{f_{clk}}{1536}$	1 Hz
3	$\frac{f_{clk}}{3072}$	0.5 Hz

[1] Blink modes 1, 2 and 3 and the nominal blink frequencies 0.5 Hz, 1 Hz and 2 Hz correspond to an oscillator frequency (f_{clk}) of 1536 Hz (see Section 13).

7.12 Command decoder

The command decoder identifies command bytes that arrive on the I²C-bus. The commands available to the PCF8576D are defined in Table 10.

Table 10. Definition of PCF8576D commands

Command	Operation code								Reference
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	
mode-set	C	1	0	-[1]	E	B	M[1:0]		Table 12
load-data-pointer	C	0	P[5:0]						Table 13
device-select	C	1	1	0	0	A[2:0]			Table 14
bank-select	C	1	1	1	1	0	I	O	Table 15
blink-select	C	1	1	1	0	AB	BF[1:0]		Table 16

[1] Not used.

All available commands carry a continuation bit C in their most significant bit position as shown in Figure 19. When this bit is set logic 1, it indicates that the next byte of the transfer to arrive will also represent a command. If this bit is set logic 0, it indicates that the command byte is the last in the transfer. Further bytes will be regarded as display data (see Table 11).

Table 11. C bit description

Bit	Symbol	Value	Description
7	C		**continue bit**
		0	last control byte in the transfer; next byte will be regarded as display data
		1	control bytes continue; next byte will be a command too

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Table 12. Mode-set command bit description

Bit	Symbol	Value	Description
7	C	0, 1	see Table 11
6, 5	-	10	fixed value
4	-	-	unused
3	E		**display status**[1]
		0[2]	disabled (blank)[3]
		1	enabled
2	B		**LCD bias configuration**[4]
		0[2]	$\frac{1}{3}$ bias
		1	$\frac{1}{2}$ bias
1 to 0	M[1:0]		**LCD drive mode selection**
		01	static; BP0
		10	1:2 multiplex; BP0, BP1
		11	1:3 multiplex; BP0, BP1, BP2
		00[2]	1:4 multiplex; BP0, BP1, BP2, BP3

[1] The possibility to disable the display allows implementation of blinking under external control.

[2] Default value.

[3] The display is disabled by setting all backplane and segment outputs to V_{LCD}.

[4] Not applicable for static drive mode.

Table 13. Load-data-pointer command bit description

See Section 7.10.1.

Bit	Symbol	Value	Description
7	C	0, 1	see Table 11
6	-	0	fixed value
5 to 0	P[5:0]	000000[1] to 100111	6 bit binary value, 0 to 39; transferred to the data pointer to define one of forty display RAM addresses

[1] Default value.

Table 14. Device-select command bit description

See Section 7.10.2.

Bit	Symbol	Value	Description
7	C	0, 1	see Table 11
6 to 3	-	1100	fixed value
2 to 0	A[2:0]	000[1] to 111	3 bit binary value, 0 to 7; transferred to the subaddress counter to define one of eight hardware subaddresses

[1] Default value.

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Table 15. Bank-select command bit description

See Section 7.10.5 and Section 7.10.6.

Bit	Symbol	Value	Description	
			Static	**1:2 multiplex[1]**
7	C	0, 1	see Table 11	
6 to 2	-	11110	fixed value	
1	I		**input bank selection**; storage of arriving display data	
		0[2]	RAM row 0	RAM rows 0 and 1
		1	RAM row 2	RAM rows 2 and 3
0	O		**output bank selection**; retrieval of LCD display data	
		0[2]	RAM row 0	RAM rows 0 and 1
		1	RAM row 2	RAM rows 2 and 3

[1] The bank-select command has no effect in 1:3 and 1:4 multiplex drive modes.

[2] Default value.

Table 16. Blink-select command bit description

See Section 7.11.

Bit	Symbol	Value	Description
7	C	0, 1	see Table 11
6 to 3	-	1110	fixed value
2	AB		**blink mode selection**
		0[2]	normal blinking[1]
		1	alternate RAM bank blinking[3]
1 to 0	BF[1:0]		**blink frequency selection**
		00[2]	off
		01	1
		10	2
		11	3

[1] Normal blinking is assumed when the LCD multiplex drive modes 1:3 or 1:4 are selected.

[2] Default value.

[3] Alternate RAM bank blinking does not apply in 1:3 and 1:4 multiplex drive modes.

7.13 Display controller

The display controller executes the commands identified by the command decoder. It contains the device's status registers and coordinates their effects. The display controller is also responsible for loading display data into the display RAM in the correct filling order.

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8. Characteristics of the I²C-bus

The I²C-bus is for bidirectional, two-line communication between different ICs or modules. The two lines are a Serial DAta line (SDA) and a Serial CLock line (SCL). Both lines must be connected to a positive supply via a pull-up resistor when connected to the output stages of a device. Data transfer may be initiated only when the bus is not busy.

8.1 Bit transfer

One data bit is transferred during each clock pulse. The data on the SDA line must remain stable during the HIGH period of the clock pulse as changes in the data line at this time will be interpreted as a control signal (see Figure 14).

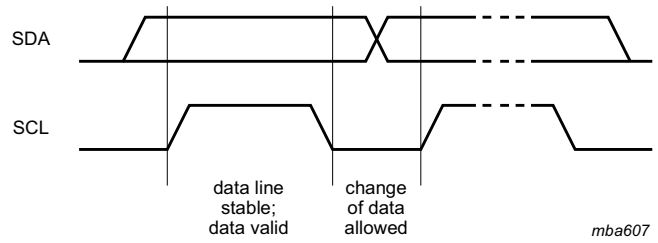


Fig 14. Bit transfer

8.2 START and STOP conditions

Both data and clock lines remain HIGH when the bus is not busy.

A HIGH-to-LOW transition of the data line while the clock is HIGH is defined as the START condition - S.

A LOW-to-HIGH transition of the data line while the clock is HIGH is defined as the STOP condition - P.

The START and STOP conditions are illustrated in Figure 15.

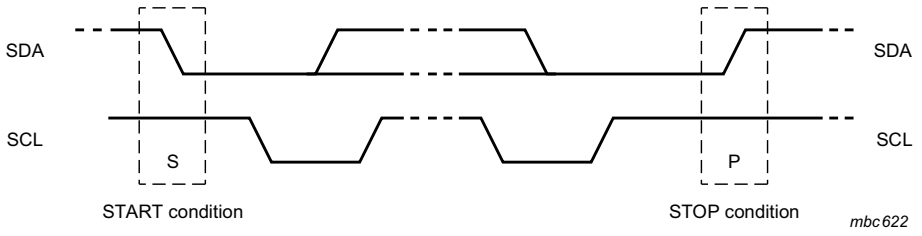


Fig 15. Definition of START and STOP conditions

8.3 System configuration

A device generating a message is a transmitter, a device receiving a message is the receiver. The device that controls the message is the master and the devices which are controlled by the master are the slaves. The system configuration is shown in Figure 16.

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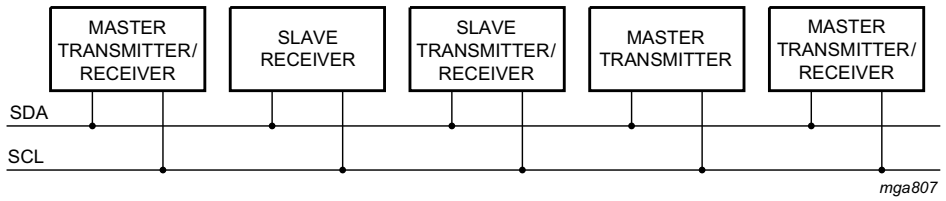


Fig 16. System configuration

8.4 Acknowledge

The number of data bytes transferred between the START and STOP conditions from transmitter to receiver is unlimited. Each byte of eight bits is followed by an acknowledge cycle.

- A slave receiver, which is addressed, must generate an acknowledge after the reception of each byte.
- A master receiver must generate an acknowledge after the reception of each byte that has been clocked out of the slave transmitter.
- The device that acknowledges must pull-down the SDA line during the acknowledge clock pulse, so that the SDA line is stable LOW during the HIGH period of the acknowledge related clock pulse (set-up and hold times must be taken into consideration).
- A master receiver must signal an end of data to the transmitter by not generating an acknowledge on the last byte that has been clocked out of the slave. In this event, the transmitter must leave the data line HIGH to enable the master to generate a STOP condition.

Acknowledgement on the I^2C-bus is illustrated in Figure 17.

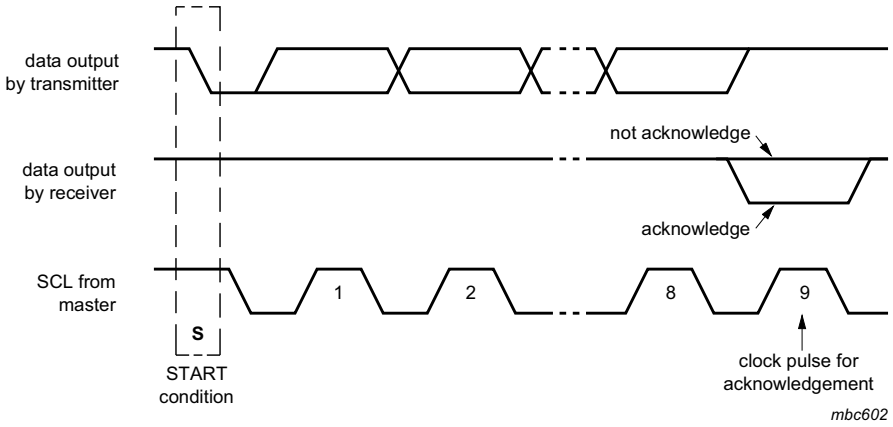


Fig 17. Acknowledgement of the I^2C-bus

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8.5 I²C-bus controller

The PCF8576D acts as an I²C-bus slave receiver. It does not initiate I²C-bus transfers or transmit data to an I²C-bus master receiver. The only data output from the PCF8576D are the acknowledge signals of the selected devices. Device selection depends on the I²C-bus slave address, on the transferred command data and on the hardware subaddress.

In single device applications, the hardware subaddress inputs A0, A1, and A2 are normally tied to V_{SS} which defines the hardware subaddress 0. In multiple device applications A0, A1, and A2 are tied to V_{SS} or V_{DD} using a binary coding scheme, so that no two devices with a common I²C-bus slave address have the same hardware subaddress.

8.6 Input filters

To enhance noise immunity in electrically adverse environments, RC low-pass filters are provided on the SDA and SCL lines.

8.7 I²C-bus protocol

Two I²C-bus slave addresses (0111 000 and 0111 001) are used to address the PCF8576D. The entire I²C-bus slave address byte is shown in Table 17.

Table 17. I²C slave address byte

	Slave address							
Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
	MSB							**LSB**
	0	1	1	1	0	0	SA0	R/$\overline{W}$

The PCF8576D is a write-only device and will not respond to a read access, therefore bit 0 should always be logic 0. Bit 1 of the slave address byte that a PCF8576D will respond to, is defined by the level tied to its SA0 input (V_{SS} for logic 0 and V_{DD} for logic 1).

Having two reserved slave addresses allows the following on the same I²C-bus:

- Up to 16 PCF8576D for very large LCD applications
- The use of two types of LCD multiplex drive

The I²C-bus protocol is shown in Figure 18. The sequence is initiated with a START condition (S) from the I²C-bus master which is followed by one of two possible PCF8576D slave addresses available. All PCF8576Ds whose SA0 inputs correspond to bit 0 of the slave address respond by asserting an acknowledge in parallel. This I²C-bus transfer is ignored by all PCF8576Ds whose SA0 inputs are set to the alternative level.

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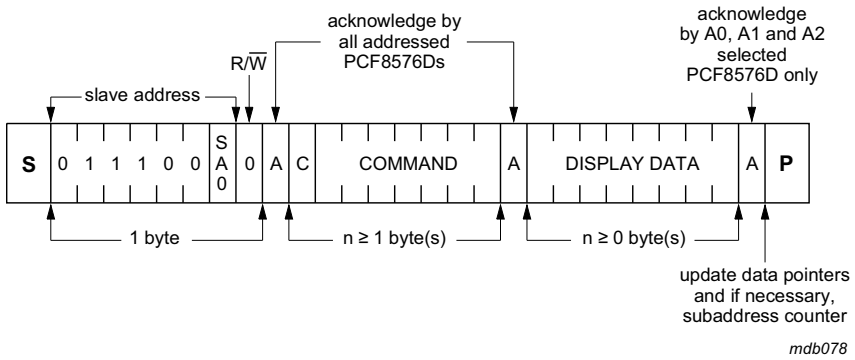


Fig 18. I²C-bus protocol

After an acknowledgement, one or more command bytes follow, that define the status of each addressed PCF8576D.

The last command byte sent is identified by resetting its most significant bit, continuation bit C, (see Figure 19). The command bytes are also acknowledged by all addressed PCF8576D on the bus.

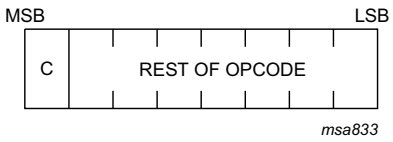


Fig 19. Format of command byte

After the last command byte, one or more display data bytes may follow. Display data bytes are stored in the display RAM at the address specified by the data pointer and the subaddress counter. Both data pointer and subaddress counter are automatically updated and the data directed to the intended PCF8576D device.

An acknowledgement after each byte is asserted only by the PCF8576Ds that are addressed via address lines A0, A1, and A2. After the last display byte, the I²C-bus master asserts a STOP condition (P). Alternately a START may be asserted to restart an I²C-bus access.

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9. Internal circuitry

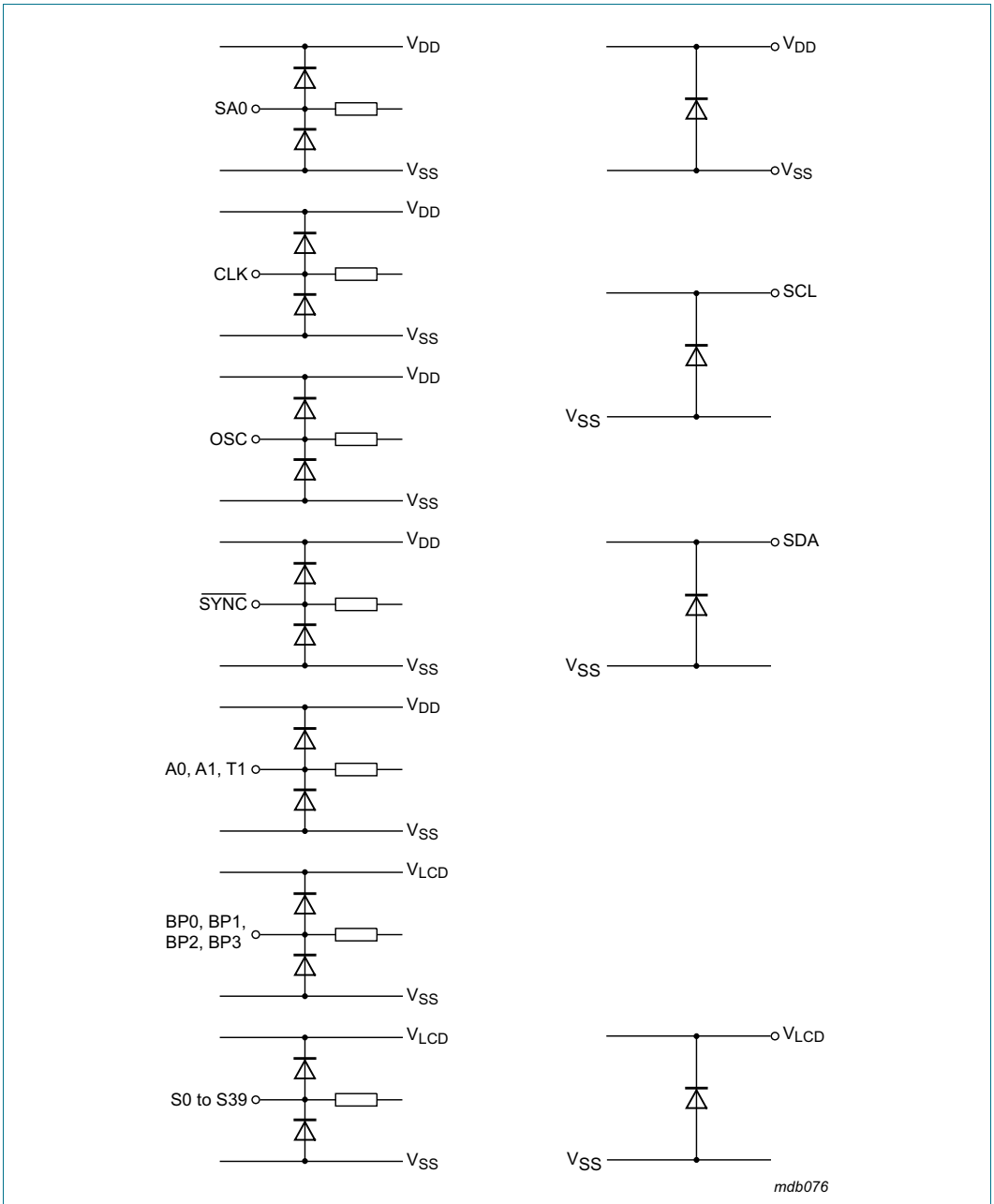


Fig 20. Device protection circuits

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10. Safety notes

CAUTION



This device is sensitive to ElectroStatic Discharge (ESD). Observe precautions for handling electrostatic sensitive devices.

Such precautions are described in the *ANSI/ESD S20.20*, *IEC/ST 61340-5*, *JESD625-A* or equivalent standards.

CAUTION



Static voltages across the liquid crystal display can build up when the LCD supply voltage (V_{LCD}) is on while the IC supply voltage (V_{DD}) is off, or vice versa. This may cause unwanted display artifacts. To avoid such artifacts, V_{LCD} and V_{DD} must be applied or removed together.

CAUTION



Semiconductors are light sensitive. Exposure to light sources can cause the IC to malfunction. The IC must be protected against light. The protection must be applied to all sides of the IC.

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11. Limiting values

Table 18. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit
V_{DD}	supply voltage		–0.5	+6.5	V
V_{LCD}	LCD supply voltage		–0.5	+7.5	V
V_I	input voltage	on each of the pins CLK, SDA, SCL, $\overline{SYNC}$, SA0, OSC, A0 to A2	–0.5	+6.5	V
V_O	output voltage	on each of the pins S0 to S39, BP0 to BP3	–0.5	+7.5	V
I_I	input current		–10	+10	mA
I_O	output current		–10	+10	mA
I_{DD}	supply current		–50	+50	mA
$I_{DD(LCD)}$	LCD supply current		–50	+50	mA
I_{SS}	ground supply current		–50	+50	mA
P_{tot}	total power dissipation		-	400	mW
P_o	output power		-	100	mW
V_{ESD}	electrostatic discharge voltage	HBM [1]	-	±5000	V
		MM [2]	-	±200	V
		CDM [3]	-	±1500	V
I_{lu}	latch-up current	[4]	-	200	mA
T_{stg}	storage temperature	[5]	–65	+150	°C
T_{amb}	ambient temperature	operating device	–40	+85	°C

[1] Pass level; Human Body Model (HBM) according to Ref. 8 “JESD22-A114”.

[2] Pass level; Machine Model (MM), according to Ref. 9 “JESD22-A115”.

[3] Pass level; Charged-Device Model (CDM), according to Ref. 10 “JESD22-C101”.

[4] Pass level; latch-up testing according to Ref. 11 “JESD78” at maximum ambient temperature ($T_{amb(max)}$).

[5] According to the store and transport requirements (see Ref. 15 “UM10569”) the devices have to be stored at a temperature of +8 °C to +45 °C and a humidity of 25 % to 75 %.

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12. Static characteristics

Table 19. Static characteristics

V_{DD} = 1.8 V to 5.5 V; V_{SS} = 0 V; V_{LCD} = 2.5 V to 6.5 V; T_{amb} = −40 °C to +85 °C; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Supplies						
V_{DD}	supply voltage		1.8	-	5.5	V
V_{LCD}	LCD supply voltage	[1]	2.5	-	6.5	V
I_{DD}	supply current	$f_{clk(ext)}$ = 1536 Hz [2]	-	3.5	7	µA
		V_{DD} = 3.0 V; T_{amb} = 25 °C	-	2.7	-	µA
$I_{DD(LCD)}$	LCD supply current	$f_{clk(ext)}$ = 1536 Hz [2]	-	23	32	µA
		$V_{DD(LCD)}$ = 3.0 V; T_{amb} = 25 °C	-	13	-	µA
Logic[3]						
$V_{P(POR)}$	power-on reset supply voltage		1.0	1.3	1.6	V
V_{IL}	LOW-level input voltage	on pins CLK, $\overline{SYNC}$, OSC, A0 to A2, SA0, SCL, SDA	V_{SS}	-	$0.3V_{DD}$	V
V_{IH}	HIGH-level input voltage	on pins CLK, $\overline{SYNC}$, OSC, A0 to A2, SA0, SCL, SDA [4][5]	$0.7V_{DD}$	-	V_{DD}	V
I_{OL}	LOW-level output current	output sink current; V_{OL} = 0.4 V; V_{DD} = 5 V				
		on pins CLK and $\overline{SYNC}$	1	-	-	mA
		on pin SDA	3	-	-	mA
$I_{OH(CLK)}$	HIGH-level output current on pin CLK	output source current; V_{OH} = 4.6 V; V_{DD} = 5 V	1	-	-	mA
I_L	leakage current	$V_I = V_{DD}$ or V_{SS}; on pins CLK, SCL, SDA, A0 to A2 and SA0	−1	-	+1	µA
$I_{L(OSC)}$	leakage current on pin OSC	$V_I = V_{DD}$	−1	-	+1	µA
C_I	input capacitance	[6]	-	-	7	pF
LCD outputs						
ΔV_O	output voltage variation	on pins BP0 to BP3 and S0 to S39	−100	-	+100	mV
R_O	output resistance	V_{LCD} = 5 V [7]				
		on pins BP0 to BP3	-	1.5	-	kΩ
		on pins S0 to S39	-	6.0	-	kΩ

[1] V_{LCD} > 3 V for ⅓ bias.

[2] LCD outputs are open-circuit; inputs at V_{SS} or V_{DD}; external clock with 50 % duty factor; I^2C-bus inactive.

[3] The I^2C-bus interface of PCF8576D is 5 V tolerant.

[4] When tested, I^2C pins SCL and SDA have no diode to V_{DD} and may be driven to the V_I limiting values given in Table 18.

[5] Propagation delay of driver between clock (CLK) and LCD driving signals.

[6] Periodically sampled, not 100 % tested.

[7] Outputs measured one at a time.

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13. Dynamic characteristics

Table 20. Dynamic characteristics

V_{DD} = 1.8 V to 5.5 V; V_{SS} = 0 V; V_{LCD} = 2.5 V to 6.5 V; T_{amb} = −40 °C to +85 °C; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Clock						
$f_{clk(int)}$	internal clock frequency	[1]	1440	1850	2640	Hz
$f_{clk(ext)}$	external clock frequency		960	-	2640	Hz
$t_{clk(H)}$	HIGH-level clock time		60	-	-	µs
$t_{clk(L)}$	LOW-level clock time		60	-	-	µs
Synchronization						
$t_{PD(SYNC_N)}$	$\overline{SYNC}$ propagation delay		-	30	-	ns
t_{SYNC_NL}	$\overline{SYNC}$ LOW time		1	-	-	µs
$t_{PD(drv)}$	driver propagation delay	V_{LCD} = 5 V [2]	-	-	30	µs
I²C-bus[3]						
Pin SCL						
f_{SCL}	SCL clock frequency		-	-	400	kHz
t_{LOW}	LOW period of the SCL clock		1.3	-	-	µs
t_{HIGH}	HIGH period of the SCL clock		0.6	-	-	µs
Pin SDA						
$t_{SU;DAT}$	data set-up time		100	-	-	ns
$t_{HD;DAT}$	data hold time		0	-	-	ns
Pins SCL and SDA						
t_{BUF}	bus free time between a STOP and START condition		1.3	-	-	µs
$t_{SU;STO}$	set-up time for STOP condition		0.6	-	-	µs
$t_{HD;STA}$	hold time (repeated) START condition		0.6	-	-	µs
$t_{SU;STA}$	set-up time for a repeated START condition		0.6	-	-	µs
t_r	rise time of both SDA and SCL signals	f_{SCL} = 400 kHz	-	-	0.3	µs
		f_{SCL} < 125 kHz	-	-	1.0	µs
t_f	fall time of both SDA and SCL signals		-	-	0.3	µs
C_b	capacitive load for each bus line		-	-	400	pF
$t_{w(spike)}$	spike pulse width	on the I²C-bus	-	-	50	ns

[1] Typical output duty factor: 50 % measured at the CLK output pin.

[2] Not tested in production.

[3] All timing values are valid within the operating supply voltage and ambient temperature range and are referenced to V_{IL} and V_{IH} with an input voltage swing of V_{SS} to V_{DD}.

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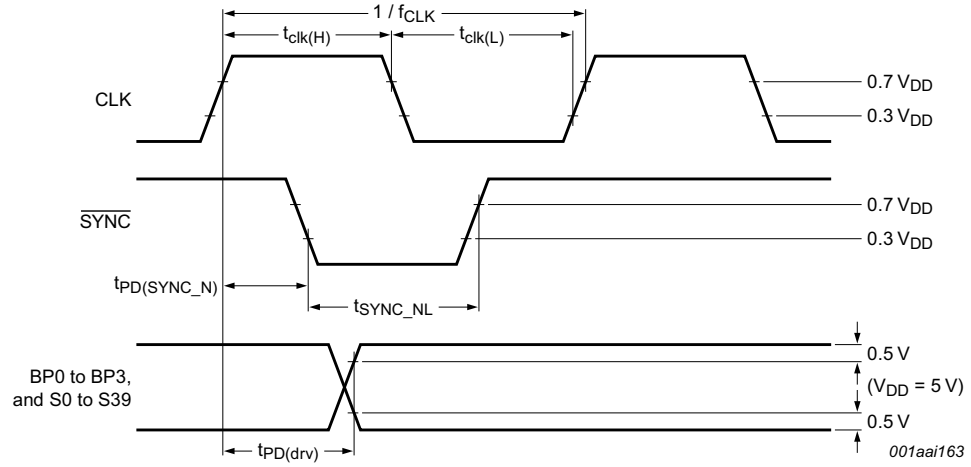


Fig 21. Driver timing waveforms

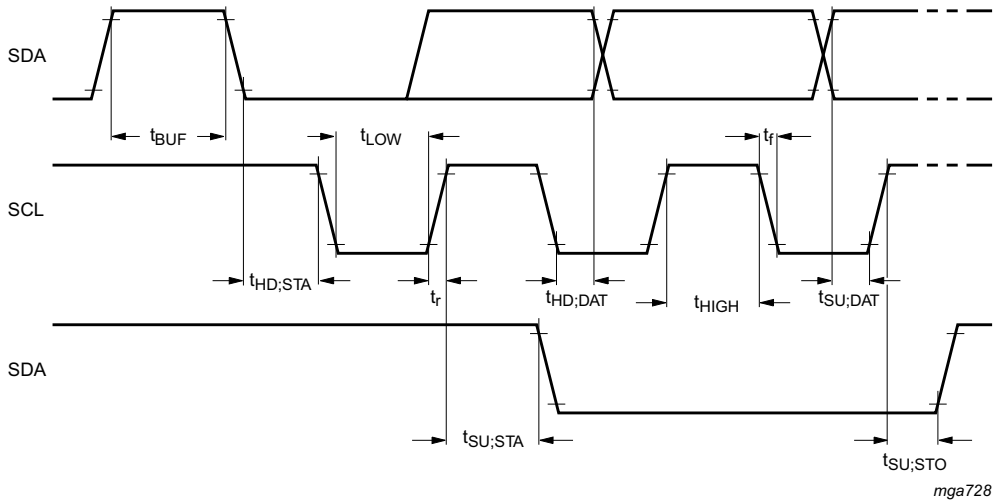


Fig 22. I²C-bus timing waveforms

14. Application information

14.1 Cascaded operation

In large display configurations, up to 16 PCF8576Ds can be differentiated on the same I²C-bus by using the 3-bit hardware subaddresses (A0, A1 and A2) and the programmable I²C-bus slave address (SA0).

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Table 21. Addressing cascaded PCF8576D

Cluster	Bit SA0	Pin A2	Pin A1	Pin A0	Device
1	0	0	0	0	0
		0	0	1	1
		0	1	0	2
		0	1	1	3
		1	0	0	4
		1	0	1	5
		1	1	0	6
		1	1	1	7
2	1	0	0	0	8
		0	0	1	9
		0	1	0	10
		0	1	1	11
		1	0	0	12
		1	0	1	13
		1	1	0	14
		1	1	1	15

PCF8576Ds connected in cascade are synchronized to allow the backplane signals from only one device in the cascade to be shared. This arrangement is cost-effective in large LCD applications since the backplane outputs of only one device need to be through-plated to the backplane electrodes of the display. The other PCF8576D of the cascade contribute additional segment outputs. The backplanes can either be connected together to enhance the drive capability or some can be left open-circuit (such as the ones from the slave in Figure 23) or just some of the master and some of the slave will be taken to facilitate the layout of the display.

All PCF8576Ds connected in cascade are correctly synchronized by the $\overline{\text{SYNC}}$ signal. This synchronization is guaranteed after the power-on reset. The only time that $\overline{\text{SYNC}}$ is likely to be needed is if synchronization is lost accidentally, for example, by noise in adverse electrical environments, or if the LCD multiplex drive mode is changed in an application using several cascaded PCF8576Ds, as the drive mode cannot be changed on all of the cascaded devices simultaneously. $\overline{\text{SYNC}}$ can be either an input or an output signal; a $\overline{\text{SYNC}}$ output is implemented as an open-drain driver with an internal pull-up resistor. The PCF8576D asserts $\overline{\text{SYNC}}$ at the start of its last active backplane signal and monitors the $\overline{\text{SYNC}}$ line at all other times. If cascade synchronization is lost, it is restored by the first PCF8576D to assert $\overline{\text{SYNC}}$. The timing relationship between the backplane waveforms and the $\overline{\text{SYNC}}$ signal for each LCD drive mode is shown in Figure 24.

The contact resistance between the $\overline{\text{SYNC}}$ on each cascaded device must be controlled. If the resistance is too high, the device is not able to synchronize properly; this is particularly applicable to chip-on-glass applications. The maximum $\overline{\text{SYNC}}$ contact resistance allowed for the number of devices in cascade is given in Table 22.

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Table 22. $\overline{\text{SYNC}}$ contact resistance

Number of devices	Maximum contact resistance
2	6 kΩ
3 to 5	2.2 kΩ
6 to 10	1.2 kΩ
10 to 16	700 Ω

The PCF8576D can be cascaded with the PCF8562. This allows optimal drive selection for a given number of pixels to display. Figure 21 and Figure 22 show the timing of the synchronization signals.

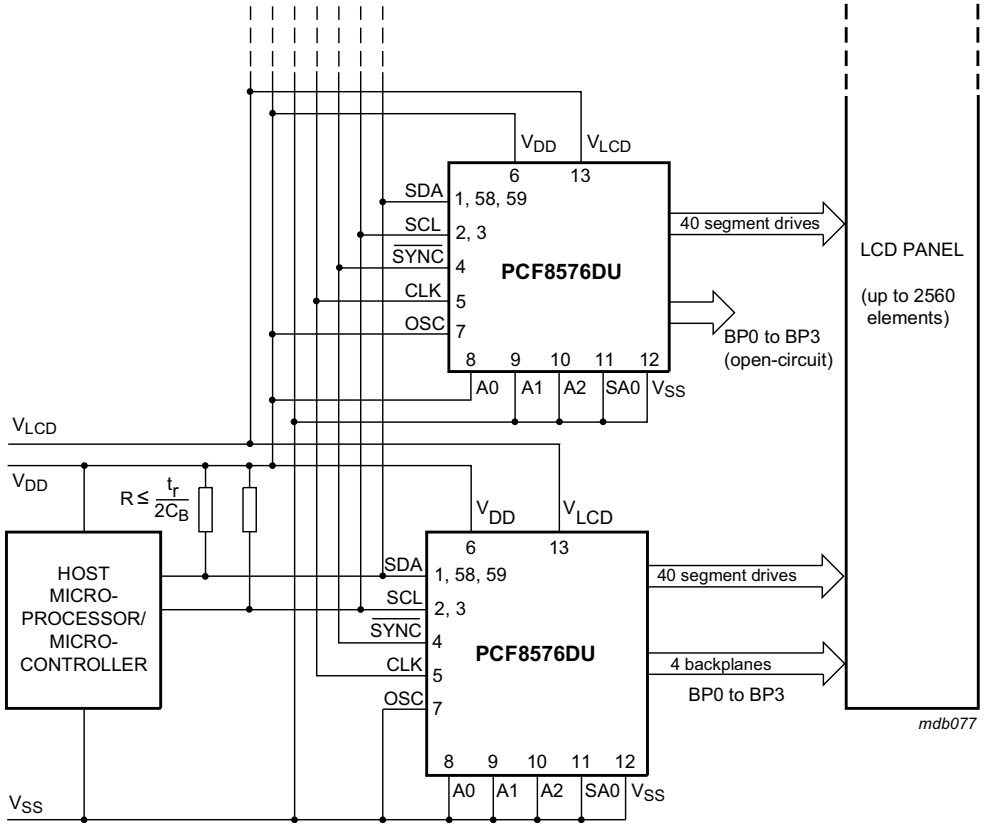


Fig 23. Cascaded PCF8576D configuration

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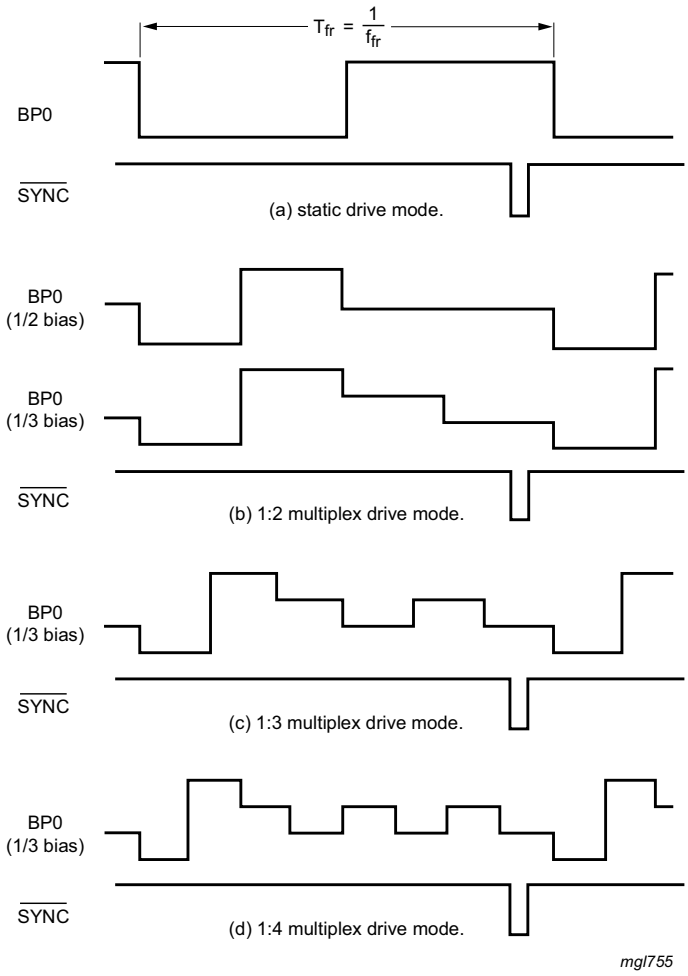


Fig 24. Synchronization of the cascade for the various PCF8576D drive modes

15. Test information

The following quality information corresponds with the product type: PCF8576DT/S400/2

15.1 Quality information

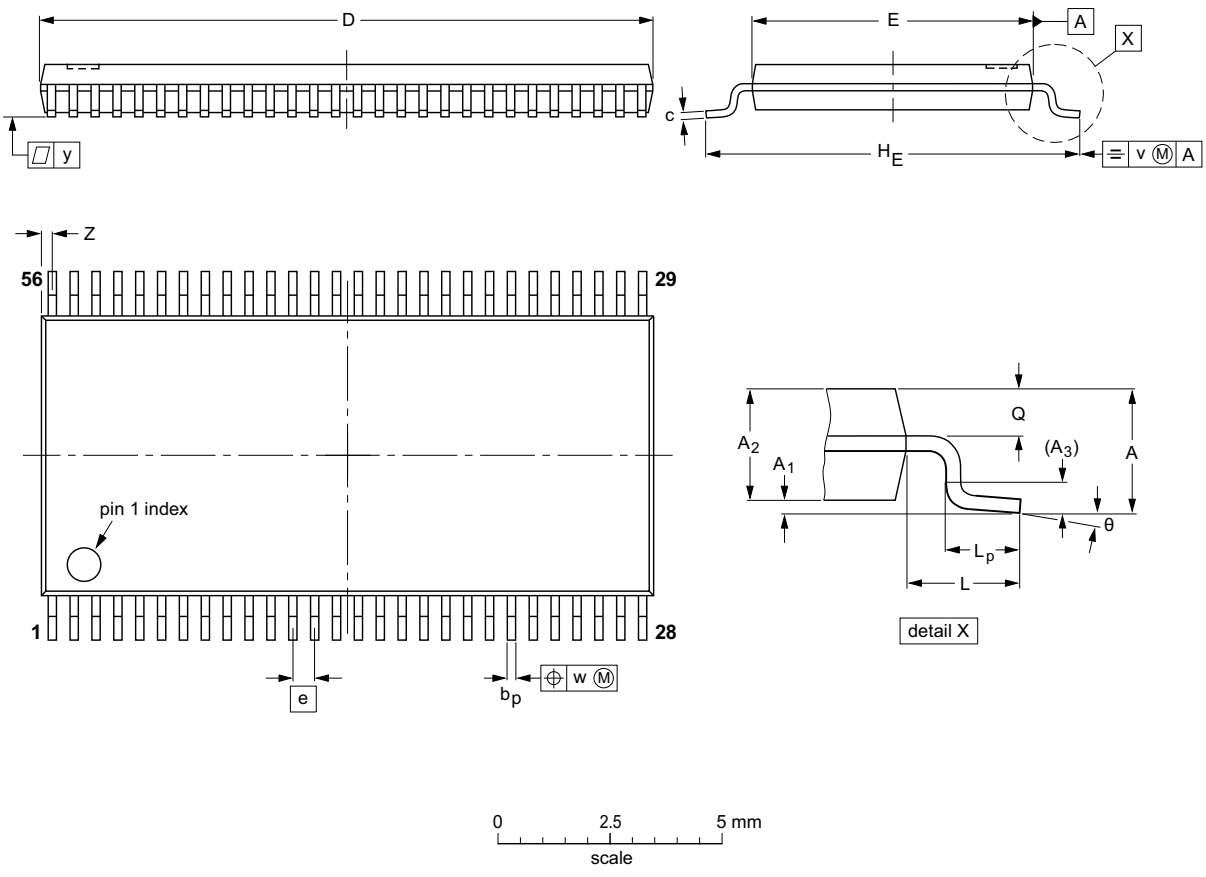
This product has been qualified in accordance with the Automotive Electronics Council (AEC) standard *Q100 - Failure mechanism based stress test qualification for integrated circuits*, and is suitable for use in automotive applications.

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16. Package outline

TSSOP56: plastic thin shrink small outline package; 56 leads; body width 6.1 mm **SOT364-1**



DIMENSIONS (mm are the original dimensions).

UNIT	A max.	A_1	A_2	A_3	b_p	c	$D^{(1)}$	$E^{(2)}$	e	H_E	L	L_p	Q	v	w	y	Z	θ
mm	1.2	0.15 0.05	1.05 0.85	0.25	0.28 0.17	**0.2** **0.1**	14.1 13.9	6.2 6.0	0.5	8.3 7.9	1	0.8 0.4	0.50 0.35	0.25	0.08	0.1	0.5 0.1	8^o 0^o

Notes

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

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT364-1		MO-153				~~99-12-27~~ 03-02-19

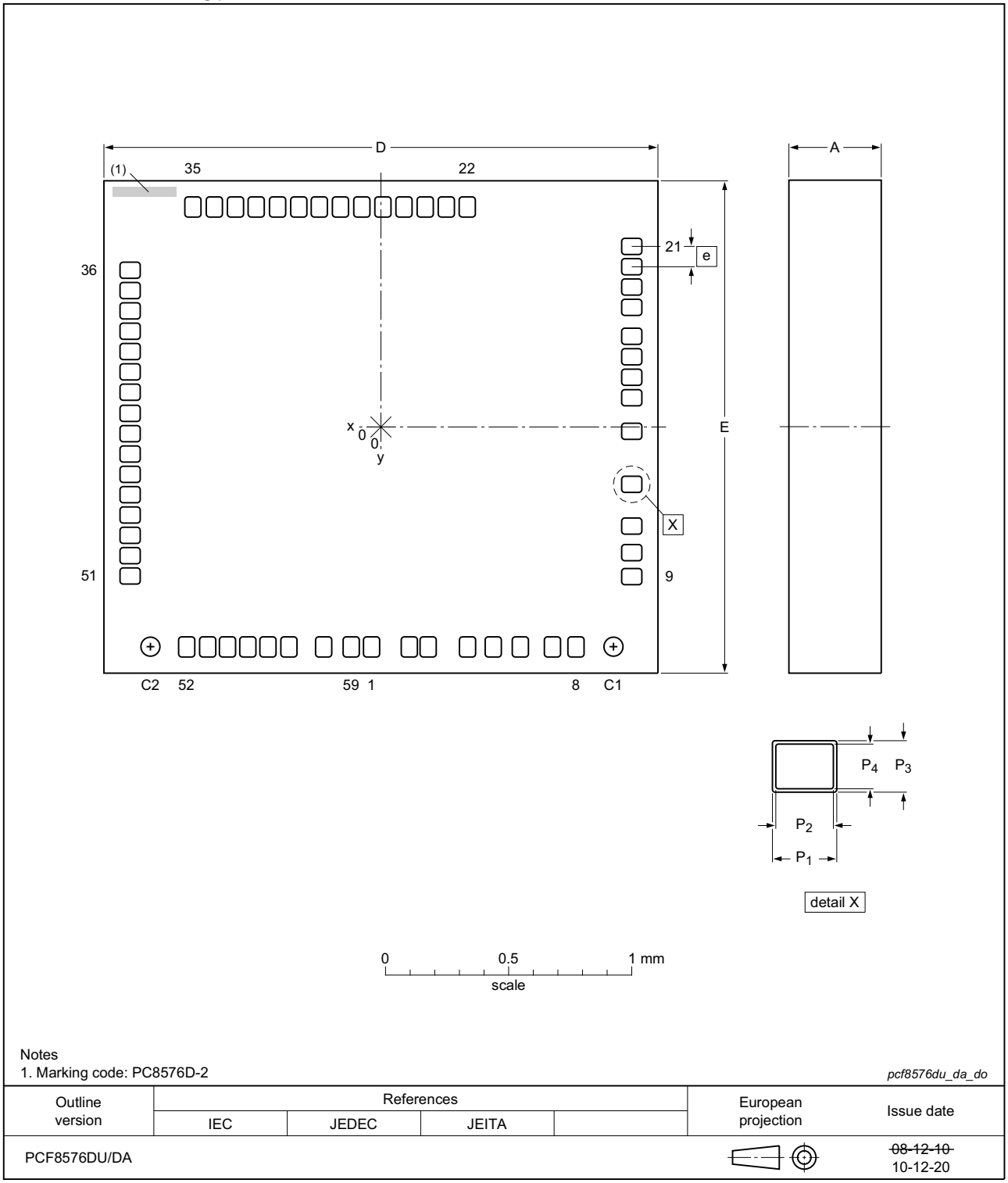
Fig 25. Package outline SOT364-1 (TSSOP56) of PCF8576DT

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17. Bare die outline

Wire bond die; 59 bonding pads **PCF8576DU/DA**



Notes
1. Marking code: PC8576D-2

pcf8576du_da_do

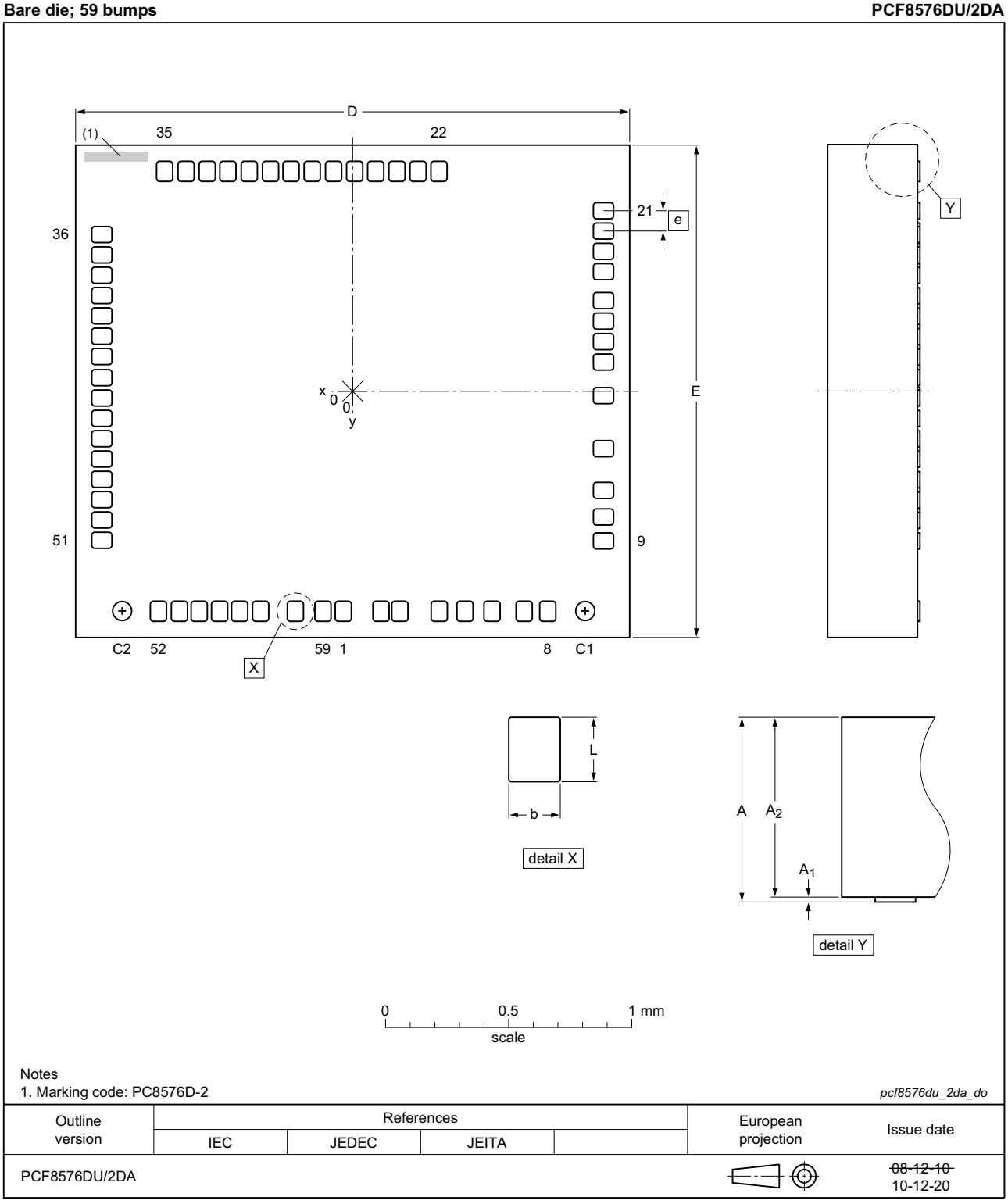
Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
PCF8576DU/DA						~~08-12-10~~ 10-12-20

Fig 26. Bare die outline PCF8576DU/DA (for dimensions see Table 23)

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Bare die; 59 bumps **PCF8576DU/2DA**



Notes
1. Marking code: PC8576D-2

pcf8576du_2da_do

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
PCF8576DU/2DA						~~08-12-10~~ 10-12-20

Fig 27. Bare die outline PCF8576DU/2DA (for dimensions see Table 24)

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Table 23. Dimensions of PCF8576DU/DA

Original dimensions are in mm.

Unit (mm)	A	D	E	e[1]	P_1[2]	P_2[3]	P_3[2]	P_4[3]
max	-	-	-	-	-	-	-	-
nom	0.38	2.2	2.0	-	0.09	0.08	0.066	0.056
min	-	-	-	0.072	-	-	-	-

[1] Dimension not drawn to scale.

[2] Pad size.

[3] Passivation opening.

Table 24. Dimensions of PCF8576DU/2DA

Original dimensions are in mm.

Unit (mm)	A	A_1	A_2	b	D	E	e[1]	L
max	-	0.012	-	-	-	-	-	-
nom	0.40	0.015	0.381	0.052	2.2	2.0	-	0.077
min	-	0.018	-	-	-	-	0.072	-

[1] Dimension not drawn to scale.

Table 25. Bonding pad location for PCF8576DU/x

All x/y coordinates represent the position of the center of each pad with respect to the center (x/y = 0) of the chip (see Figure 3, Figure 26 and Figure 27).

Symbol	Pad	X (μm)	Y (μm)	Description
SDA	1	−34.38	−876.6	I^2C-bus serial data input/output
SCL	2	109.53	−876.6	I^2C-bus serial clock input
SCL	3	181.53	−876.6	
$\overline{SYNC}$	4	365.58	−876.6	cascade synchronization input/output
CLK	5	469.08	−876.6	external clock input/output
V_{DD}	6	577.08	−876.6	supply voltage
OSC	7	740.88	−876.6	internal oscillator enable input
A0	8	835.83	−876.6	subaddress inputs
A1	9	1005.48	−630.9	
A2	10	1005.48	−513.9	
SA0	11	1005.48	−396.9	I^2C-bus address input; bit 0
V_{SS}	12	1005.48	−221.4	ground supply voltage
V_{LCD}	13	1005.48	10.71	LCD supply voltage
BP0	14	1005.48	156.51	LCD backplane outputs
BP2	15	1005.48	232.74	
BP1	16	1005.48	308.97	
BP3	17	1005.48	385.2	
S0	18	1005.48	493.2	LCD segment outputs
S1	19	1005.48	565.2	
S2	20	1005.48	637.2	
S3	21	1005.48	709.2	

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Table 25. Bonding pad location for PCF8576DU/x *...continued*

All x/y coordinates represent the position of the center of each pad with respect to the center (x/y = 0) of the chip (see Figure 3, Figure 26 and Figure 27).

Symbol	Pad	X (μm)	Y (μm)	Description
S4	22	347.22	876.6	LCD segment outputs
S5	23	263.97	876.6	
S6	24	180.72	876.6	
S7	25	97.47	876.6	
S8	26	14.22	876.6	
S9	27	−69.03	876.6	
S10	28	−152.28	876.6	
S11	29	−235.53	876.6	
S12	30	−318.78	876.6	
S13	31	−402.03	876.6	
S14	32	−485.28	876.6	
S15	33	−568.53	876.6	
S16	34	−651.78	876.6	
S17	35	−735.03	876.6	
S18	36	−1005.5	625.59	
S19	37	−1005.5	541.62	
S20	38	−1005.5	458.19	
S21	39	−1005.5	374.76	
S22	40	−1005.5	291.33	
S23	41	−1005.5	207.9	
S24	42	−1005.5	124.47	
S25	43	−1005.5	41.04	
S26	44	−1005.5	−42.39	
S27	45	−1005.5	−125.8	
S28	46	−1005.5	−209.3	
S29	47	−1005.5	−292.7	
S30	48	−1005.5	−376.1	
S31	49	−1005.5	−459.5	
S32	50	−1005.5	−543	
S33	51	−1005.5	−625.6	
S34	52	−735.03	−876.6	
S35	53	−663.03	−876.6	
S36	54	−591.03	−876.6	
S37	55	−519.03	−876.6	
S38	56	−447.03	−876.6	
S39	57	−375.03	−876.6	
SDA	58	−196.38	−876.6	I^2C-bus serial data input/output
SDA	59	−106.38	−876.6	

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Table 26. Alignment marks

All x/y coordinates represent the position of the center of each alignment mark with respect to the center (x/y = 0) of the chip (see Figure 3, Figure 26 and Figure 27).

Symbol	Location		Dimension
	X (μm)	Y (μm)	Diameter (μm)
C1	930.42	−870.3	72
C2	−829.98	−870.3	72

18. Handling information

All input and output pins are protected against ElectroStatic Discharge (ESD) under normal handling. When handling Metal-Oxide Semiconductor (MOS) devices ensure that all normal precautions are taken as described in *JESD625-A*, *IEC 61340-5* or equivalent standards.

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19. Packing information

19.1 Tray information

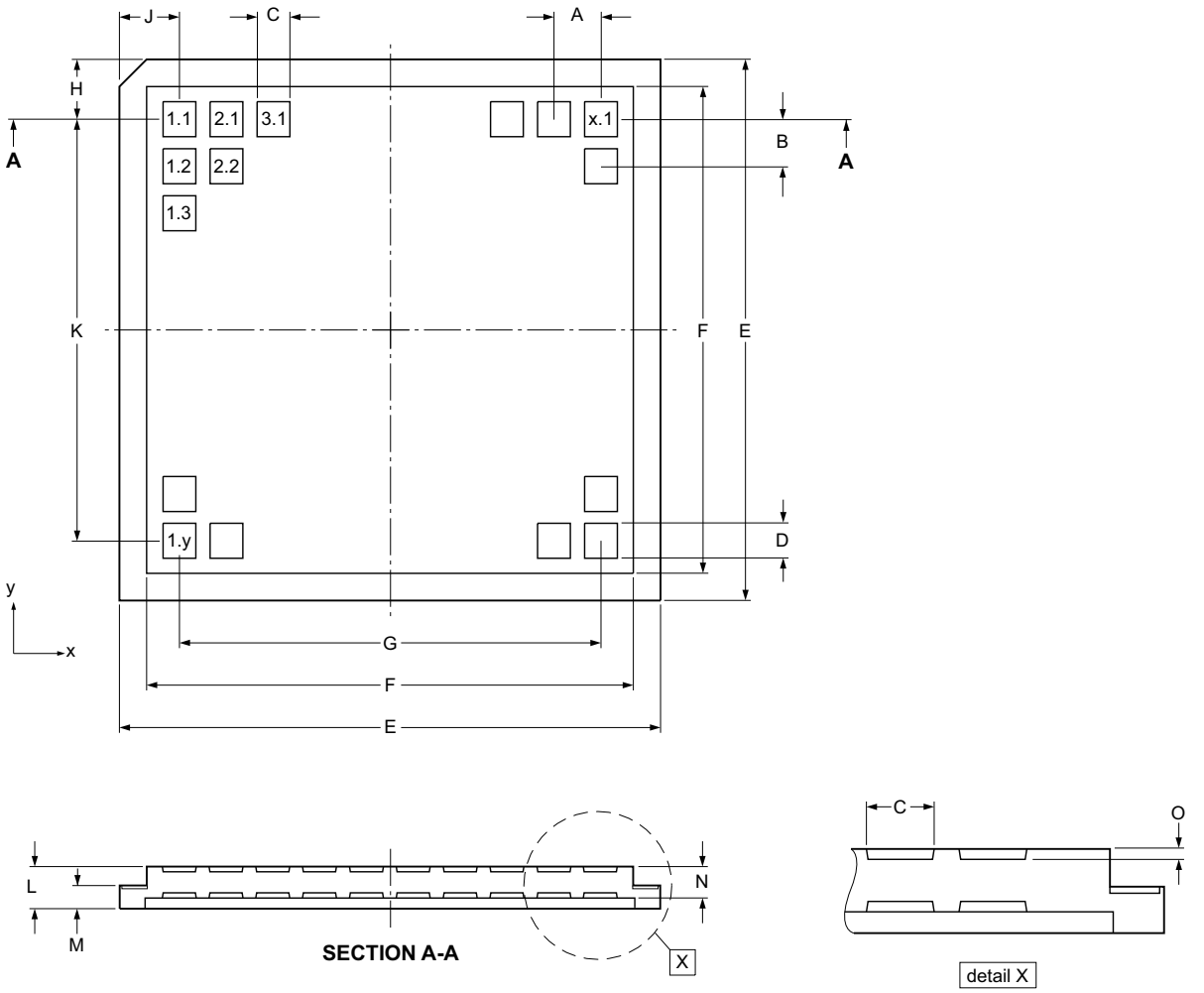


Fig 28. Tray details

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Table 27. Description of tray details

Tray details are shown in Figure 28.

Tray details													
Dimensions													
A	B	C	D	E	F	G	H	J	K	L	M	N	Unit
3.6	3.6	2.36	2.11	50.8	45.72	39.6	5.6	5.6	39.6	3.96	2.18	2.49	mm
Number of pockets													
x direction							y direction						
12							12						

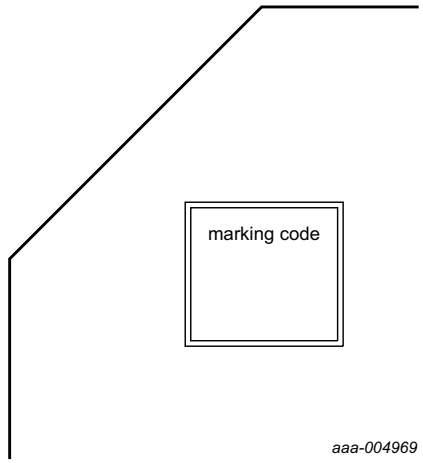


Fig 29. Tray alignment

19.2 Tape and reel information

For tape and reel packing information, please see Ref. 13 “SOT364-1_118” on page 53.

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20. Soldering of SMD packages

This text provides a very brief insight into a complex technology. A more in-depth account of soldering ICs can be found in Application Note *AN10365 "Surface mount reflow soldering description"*.

20.1 Introduction to soldering

Soldering is one of the most common methods through which packages are attached to Printed Circuit Boards (PCBs), to form electrical circuits. The soldered joint provides both the mechanical and the electrical connection. There is no single soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and Surface Mount Devices (SMDs) are mixed on one printed wiring board; however, it is not suitable for fine pitch SMDs. Reflow soldering is ideal for the small pitches and high densities that come with increased miniaturization.

20.2 Wave and reflow soldering

Wave soldering is a joining technology in which the joints are made by solder coming from a standing wave of liquid solder. The wave soldering process is suitable for the following:

- Through-hole components
- Leaded or leadless SMDs, which are glued to the surface of the printed circuit board

Not all SMDs can be wave soldered. Packages with solder balls, and some leadless packages which have solder lands underneath the body, cannot be wave soldered. Also, leaded SMDs with leads having a pitch smaller than ~0.6 mm cannot be wave soldered, due to an increased probability of bridging.

The reflow soldering process involves applying solder paste to a board, followed by component placement and exposure to a temperature profile. Leaded packages, packages with solder balls, and leadless packages are all reflow solderable.

Key characteristics in both wave and reflow soldering are:

- Board specifications, including the board finish, solder masks and vias
- Package footprints, including solder thieves and orientation
- The moisture sensitivity level of the packages
- Package placement
- Inspection and repair
- Lead-free soldering versus SnPb soldering

20.3 Wave soldering

Key characteristics in wave soldering are:

- Process issues, such as application of adhesive and flux, clinching of leads, board transport, the solder wave parameters, and the time during which components are exposed to the wave
- Solder bath specifications, including temperature and impurities

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20.4 Reflow soldering

Key characteristics in reflow soldering are:

- Lead-free versus SnPb soldering; note that a lead-free reflow process usually leads to higher minimum peak temperatures (see Figure 30) than a SnPb process, thus reducing the process window
- Solder paste printing issues including smearing, release, and adjusting the process window for a mix of large and small components on one board
- Reflow temperature profile; this profile includes preheat, reflow (in which the board is heated to the peak temperature) and cooling down. It is imperative that the peak temperature is high enough for the solder to make reliable solder joints (a solder paste characteristic). In addition, the peak temperature must be low enough that the packages and/or boards are not damaged. The peak temperature of the package depends on package thickness and volume and is classified in accordance with Table 28 and 29

Table 28. SnPb eutectic process (from J-STD-020D)

Package thickness (mm)	Package reflow temperature (°C)	
	Volume (mm^3)	
	< 350	≥ 350
< 2.5	235	220
≥ 2.5	220	220

Table 29. Lead-free process (from J-STD-020D)

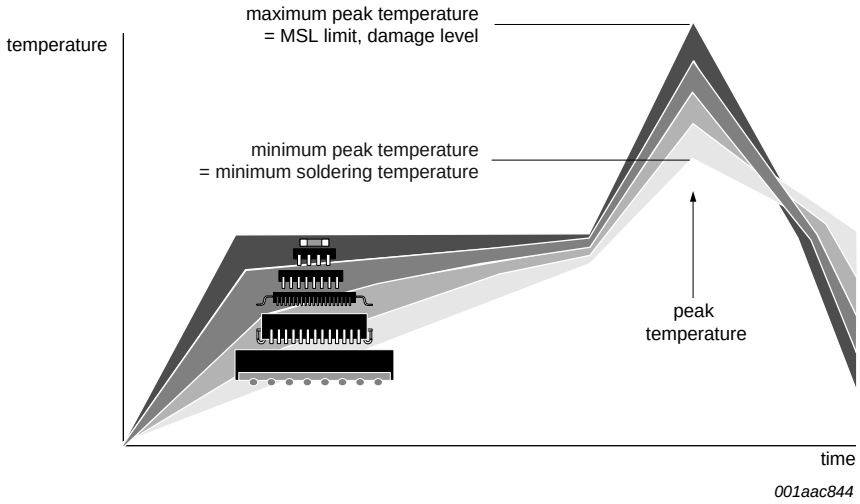
Package thickness (mm)	Package reflow temperature (°C)		
	Volume (mm^3)		
	< 350	350 to 2000	> 2000
< 1.6	260	260	260
1.6 to 2.5	260	250	245
> 2.5	250	245	245

Moisture sensitivity precautions, as indicated on the packing, must be respected at all times.

Studies have shown that small packages reach higher temperatures during reflow soldering, see Figure 30.

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MSL: Moisture Sensitivity Level

Fig 30. Temperature profiles for large and small components

For further information on temperature profiles, refer to Application Note *AN10365 "Surface mount reflow soldering description"*.

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21. Appendix

21.1 LCD segment driver selection

Table 30. Selection of LCD segment drivers

Type name	Number of elements at MUX							V_{DD} (V)	V_{LCD} (V)	f_{fr} (Hz)	V_{LCD} (V) charge pump	V_{LCD} (V) temperature compensat.	T_{amb} (°C)	Interface	Package	AEC-Q100
	1:1	1:2	1:3	1:4	1:6	1:8	1:9									
PCA8553DTT	40	80	120	160	-	-	-	1.8 to 5.5	1.8 to 5.5	32 to 256[1]	N	N	−40 to 105	I^2C / SPI	TSSOP56	Y
PCA8546ATT	-	-	-	176	-	-	-	1.8 to 5.5	2.5 to 9	60 to 300[1]	N	N	−40 to 95	I^2C	TSSOP56	Y
PCA8546BTT	-	-	-	176	-	-	-	1.8 to 5.5	2.5 to 9	60 to 300[1]	N	N	−40 to 95	SPI	TSSOP56	Y
PCA8547AHT	44	88	-	176	-	-	-	1.8 to 5.5	2.5 to 9	60 to 300[1]	Y	Y	−40 to 95	I^2C	TQFP64	Y
PCA8547BHT	44	88	-	176	-	-	-	1.8 to 5.5	2.5 to 9	60 to 300[1]	Y	Y	−40 to 95	SPI	TQFP64	Y
PCF85134HL	60	120	180	240	-	-	-	1.8 to 5.5	2.5 to 6.5	82	N	N	−40 to 85	I^2C	LQFP80	N
PCA85134H	60	120	180	240	-	-	-	1.8 to 5.5	2.5 to 8	82	N	N	−40 to 95	I^2C	LQFP80	Y
PCA8543AHL	60	120	-	240	-	-	-	2.5 to 5.5	2.5 to 9	60 to 300[1]	Y	Y	−40 to 105	I^2C	LQFP80	Y
PCF8545ATT	-	-	-	176	252	320	-	1.8 to 5.5	2.5 to 5.5	60 to 300[1]	N	N	−40 to 85	I^2C	TSSOP56	N
PCF8545BTT	-	-	-	176	252	320	-	1.8 to 5.5	2.5 to 5.5	60 to 300[1]	N	N	−40 to 85	SPI	TSSOP56	N
PCF8536AT	-	-	-	176	252	320	-	1.8 to 5.5	2.5 to 9	60 to 300[1]	N	N	−40 to 85	I^2C	TSSOP56	N
PCF8536BT	-	-	-	176	252	320	-	1.8 to 5.5	2.5 to 9	60 to 300[1]	N	N	−40 to 85	SPI	TSSOP56	N
PCA8536AT	-	-	-	176	252	320	-	1.8 to 5.5	2.5 to 9	60 to 300[1]	N	N	−40 to 95	I^2C	TSSOP56	Y
PCA8536BT	-	-	-	176	252	320	-	1.8 to 5.5	2.5 to 9	60 to 300[1]	N	N	−40 to 95	SPI	TSSOP56	Y
PCF8537AH	44	88	-	176	276	352	-	1.8 to 5.5	2.5 to 9	60 to 300[1]	Y	Y	−40 to 85	I^2C	TQFP64	N
PCF8537BH	44	88	-	176	276	352	-	1.8 to 5.5	2.5 to 9	60 to 300[1]	Y	Y	−40 to 85	SPI	TQFP64	N
PCA8537AH	44	88	-	176	276	352	-	1.8 to 5.5	2.5 to 9	60 to 300[1]	Y	Y	−40 to 95	I^2C	TQFP64	Y
PCA8537BH	44	88	-	176	276	352	-	1.8 to 5.5	2.5 to 9	60 to 300[1]	Y	Y	−40 to 95	SPI	TQFP64	Y
PCA9620H	60	120	-	240	320	480	-	2.5 to 5.5	2.5 to 9	60 to 300[1]	Y	Y	−40 to 105	I^2C	LQFP80	Y
PCA9620U	60	120	-	240	320	480	-	2.5 to 5.5	2.5 to 9	60 to 300[1]	Y	Y	−40 to 105	I^2C	Bare die	Y
PCF8576DU	40	80	120	160	-	-	-	1.8 to 5.5	2.5 to 6.5	77	N	N	−40 to 85	I^2C	Bare die	N
PCF8576EUG	40	80	120	160	-	-	-	1.8 to 5.5	2.5 to 6.5	77	N	N	−40 to 85	I^2C	Bare die	N
PCA8576FUG	40	80	120	160	-	-	-	1.8 to 5.5	2.5 to 8	200	N	N	−40 to 105	I^2C	Bare die	Y
PCF85133U	80	160	240	320	-	-	-	1.8 to 5.5	2.5 to 6.5	82, 110[2]	N	N	−40 to 85	I^2C	Bare die	N
PCA85133U	80	160	240	320	-	-	-	1.8 to 5.5	2.5 to 8	82, 110[2]	N	N	−40 to 95	I^2C	Bare die	Y

PCF8576D

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Table 30. Selection of LCD segment drivers *…continued*

Type name	Number of elements at MUX							V_{DD} (V)	V_{LCD} (V)	f_{fr} (Hz)	V_{LCD} (V) charge pump	V_{LCD} (V) temperature compensat.	T_{amb} (°C)	Interface	Package	AEC-Q100
	1:1	1:2	1:3	1:4	1:6	1:8	1:9									
PCA85233UG	80	160	240	320	-	-	-	1.8 to 5.5	2.5 to 8	150, 220[2]	N	N	–40 to 105	I^2C	Bare die	Y
PCF85132U	160	320	480	640	-	-	-	1.8 to 5.5	1.8 to 8	60 to 90[1]	N	N	–40 to 85	I^2C	Bare die	N
PCA8530DUG	102	204	-	408	-	-	-	2.5 to 5.5	4 to 12	45 to 300[1]	Y	Y	–40 to 105	I^2C / SPI	Bare die	Y
PCA85132U	160	320	480	640	-	-	-	1.8 to 5.5	1.8 to 8	60 to 90[1]	N	N	–40 to 95	I^2C	Bare die	Y
PCA85232U	160	320	480	640	-	-	-	1.8 to 5.5	1.8 to 8	117 to 176[1]	N	N	–40 to 95	I^2C	Bare die	Y
PCF8538UG	102	204	-	408	612	816	918	2.5 to 5.5	4 to 12	45 to 300[1]	Y	Y	–40 to 85	I^2C / SPI	Bare die	N
PCA8538UG	102	204	-	408	612	816	918	2.5 to 5.5	4 to 12	45 to 300[1]	Y	Y	–40 to 105	I^2C / SPI	Bare die	Y

[1] Software programmable.

[2] Hardware selectable.

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22. Abbreviations

Table 31. Abbreviations

Acronym	Description
CDM	Charged-Device Model
CMOS	Complementary Metal-Oxide Semiconductor
HBM	Human Body Model
ITO	Indium Tin Oxide
LCD	Liquid Crystal Display
LSB	Least Significant Bit
MM	Machine Model
MSB	Most Significant Bit
MSL	Moisture Sensitivity Level
PCB	Printed Circuit Board
RAM	Random Access Memory
RMS	Root Mean Square
SCL	Serial CLock line
SDA	Serial DAta line
SMD	Surface Mount Device

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23. References

[1] **AN10170 —** Design guidelines for COG modules with NXP monochrome LCD drivers

[2] **AN10365 —** Surface mount reflow soldering description

[3] **AN10706 —** Handling bare die

[4] **AN10853 —** ESD and EMC sensitivity of IC

[5] **IEC 60134 —** Rating systems for electronic tubes and valves and analogous semiconductor devices

[6] **IEC 61340-5 —** Protection of electronic devices from electrostatic phenomena

[7] **IPC/JEDEC J-STD-020D —** Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices

[8] **JESD22-A114 —** Electrostatic Discharge (ESD) Sensitivity Testing Human Body Model (HBM)

[9] **JESD22-A115 —** Electrostatic Discharge (ESD) Sensitivity Testing Machine Model (MM)

[10] **JESD22-C101 —** Field-Induced Charged-Device Model Test Method for Electrostatic-Discharge-Withstand Thresholds of Microelectronic Components

[11] **JESD78 —** IC Latch-Up Test

[12] **JESD625-A —** Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices

[13] **SOT364-1_118 —** TSSOP56; Reel pack; SMD, 13", packing information

[14] **UM10204 —** I^2C-bus specification and user manual

[15] **UM10569 —** Store and transport requirements

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24. Revision history

Table 32. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
PCF8576D v.15	20150212	Product data sheet	-	PCF8576D v.14
Modifications:	• The format of this data sheet has been redesigned to comply with the new identity guidelines of NXP Semiconductors. • Legal texts have been adapted to the new company name where appropriate. • Changed $I_{DD(LCD)}$ values in Table 19 • Changed Section 14.1 and Section 19.2 • Added Section 21.1 • Fixed typos			
PCF8576D v.14	20130610	Product data sheet	-	PCF8576D v.13
PCF8576D v.13	20120510	Product data sheet	-	PCF8576D v.12
PCF8576D v.12	20120413	Product data sheet	-	PCF8576D v.11
PCF8576D v.11	20110627	Product data sheet		PCF8576D v.10
PCF8576D v.10	20110214	Product data sheet	-	PCF8576D_9
PCF8576D_9	20090825	Product data sheet	-	PCF8576D_8
PCF8576D_8	20090319	Product data sheet	-	PCF8576D_7
PCF8576D_7	20081218	Product data sheet	-	PCF8576D_6
PCF8576D_6	20081202	Product data sheet	-	PCF8576D_5
PCF8576D_5	20041222	Product specification	-	PCF8576D_4
PCF8576D_4	20041008	Product specification	-	PCF8576D_3
PCF8576D_3	20040617	Product specification	-	PCF8576D_2
PCF8576D_2	20030623	Product specification	-	PCF8576D_1
PCF8576D_1	20030401	Objective specification	-	-

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Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
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Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

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