

DATA SHEET

OM4085

Universal LCD driver for low
multiplex rates

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Universal LCD driver for low multiplex rates

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FEATURES

- Single-chip LCD controller/driver
- Selectable backplane drive configuration: static or 2, 3 or 4 backplane multiplexing
- Selectable display bias configuration: static, $\frac{1}{2}$ or $\frac{1}{3}$
- Internal LCD bias generation with voltage-follower buffers
- 24 segment drives: up to twelve 8-segment numeric characters; up to six 15-segment alphanumeric characters; or any graphics of up to 96 elements
- 24×4 -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
- LCD and logic supplies may be separated
- 2.0 to 6 V power supply range
- Low power consumption
- Power saving mode for extremely low power consumption in battery-operated and telephone applications
- I²C-bus interface
- TTL/CMOS compatible
- Compatible with any 4-bit, 8-bit or 16-bit microprocessors/microcontrollers
- May be cascaded for large LCD applications (up to 1536 segments possible)
- Cascadable with the 40 segment LCD driver PCF8576C
- Optimized pinning for single plane wiring in both single and multiple OM4085 applications
- Space-saving 40 lead plastic very small outline package (VSO40; SOT158-1)
- No external components required (even in multiple device applications)
- Manufactured in silicon gate CMOS process.



GENERAL DESCRIPTION

The OM4085 is a peripheral device which interfaces to almost any Liquid Crystal Display (LCD) having low multiplex rates. It generates the drive signals for any static or multiplexed LCD containing up to four backplanes and up to 24 segments and can easily be cascaded for larger LCD applications. The OM4085 is compatible with most microprocessors/microcontrollers and communicates via a two-line bidirectional I²C-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).

ORDERING INFORMATION

| TYPE NUMBER | PACKAGE | | |
|-------------|---------|--|----------|
| | NAME | DESCRIPTION | VERSION |
| OM4085T | VSO40 | plastic very small outline package; 40 leads | SOT158-1 |

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BLOCK DIAGRAM

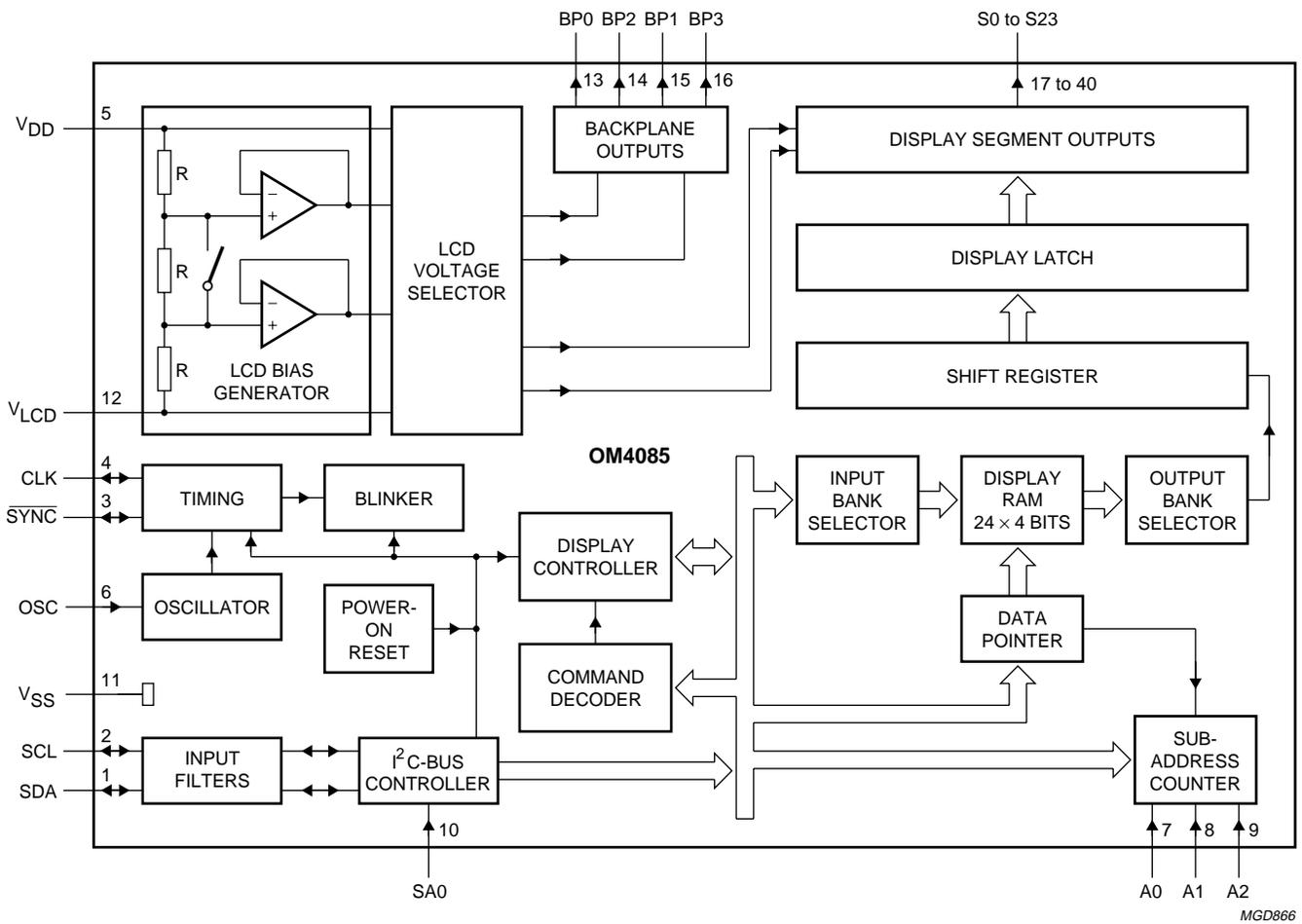


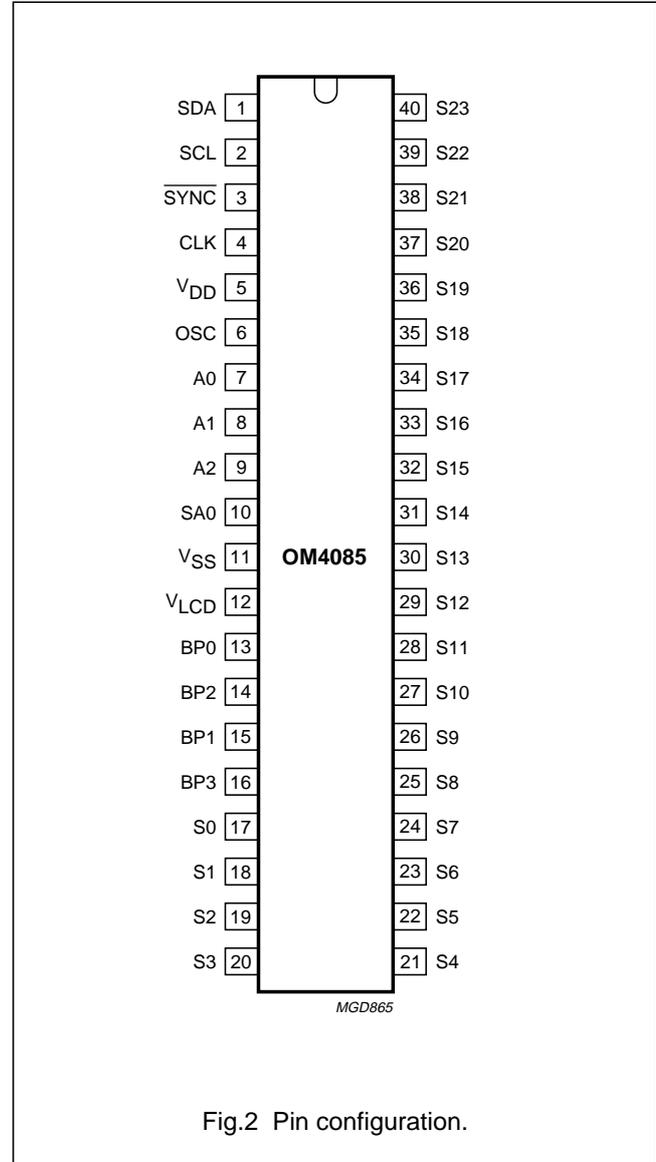
Fig.1 Block diagram.

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PINNING

| SYMBOL | PIN | DESCRIPTION |
|--------------------------|----------|--|
| SDA | 1 | I ² C-bus data input/output |
| SCL | 2 | I ² C-bus clock input/output |
| $\overline{\text{SYNC}}$ | 3 | cascade synchronization input/output |
| CLK | 4 | external clock input/output |
| V _{DD} | 5 | positive supply voltage |
| OSC | 6 | oscillator input |
| A0 | 7 | I ² C-bus subaddress inputs |
| A1 | 8 | |
| A2 | 9 | |
| SA0 | 10 | I ² C-bus slave address bit 0 input |
| V _{SS} | 11 | logic ground |
| V _{LCD} | 12 | LCD supply voltage |
| BP0 | 13 | LCD backplane outputs |
| BP2 | 14 | |
| BP1 | 15 | |
| BP3 | 16 | |
| S0 to S23 | 17 to 40 | LCD segment outputs |



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FUNCTIONAL DESCRIPTION

The OM4085 is a versatile peripheral device designed to interface any microprocessor to a wide variety of LCDs. It can directly drive any static or multiplexed LCD containing up to 4 backplanes and up to 24 segments. The display configurations possible with the OM4085 depend on the number of active backplane outputs required; a selection of display configurations is given in Table 1.

All of the display configurations given in Table 1 can be implemented in the typical system shown in Fig.3. The host microprocessor/microcontroller maintains the two-line I²C-bus communication channel with the OM4085. The internal oscillator is selected by tying OSC (pin 6) to 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 to the LCD panel chosen for the application.

Table 1 Selection of display configurations

| ACTIVE BACKPLANE OUTPUTS | NUMBER OF SEGMENTS | 7-SEGMENT NUMERIC | 14-SEGMENT ALPHANUMERIC | DOT MATRIX |
|--------------------------|--------------------|----------------------------------|-------------------------------------|------------------|
| 4 | 96 | 12 digits + 12 indicator symbols | 6 characters + 12 indicator symbols | 96 dots (4 × 24) |
| 3 | 72 | 9 digits + 9 indicator symbols | 4 characters + 16 indicator symbols | 72 dots (3 × 24) |
| 2 | 48 | 6 digits + 6 indicator symbols | 3 characters + 6 indicator symbols | 48 dots (2 × 24) |
| 1 | 24 | 3 digits + 3 indicator symbols | 1 character + 10 indicator symbols | 24 dots |

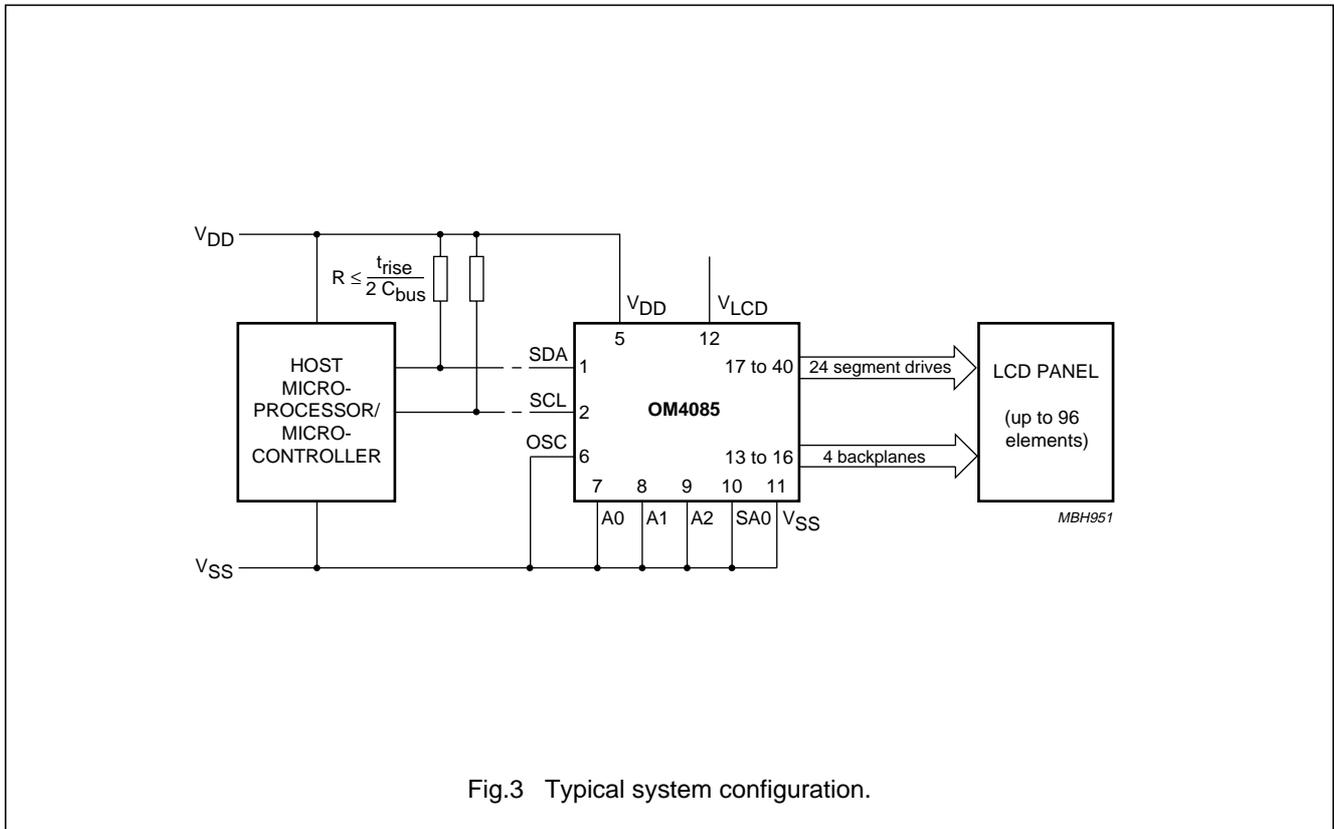


Fig.3 Typical system configuration.

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Power-on reset

At power-on the OM4085 resets to a defined starting condition as follows:

1. All backplane outputs are set to V_{DD}
2. All segment outputs are set to V_{DD}
3. The drive mode '1 : 4 multiplex with $\frac{1}{3}$ bias' is selected
4. Blinking is switched off
5. Input and output bank selectors are reset (as defined in Table 5)
6. The I²C-bus interface is initialized
7. The data pointer and the subaddress counter are cleared.

Data transfers on the I²C-bus should be avoided for 1 ms following power-on to allow completion of the reset action.

LCD bias generator

The full-scale LCD voltage (V_{op}) is obtained from $V_{DD} - V_{LCD}$. The LCD voltage may be temperature compensated externally through the V_{LCD} supply to pin 12. Fractional LCD biasing voltages are obtained from an internal voltage divider of three series resistors connected between V_{DD} and V_{LCD} . The centre resistor can be switched out of circuit to provide a $\frac{1}{2}$ bias voltage level for the 1 : 2 multiplex configuration.

LCD voltage selector

The LCD voltage selector coordinates the multiplexing of the LCD according to the selected LCD drive configuration. The operation of the voltage selector is controlled by MODE SET commands from the command decoder. The biasing configurations that apply to the preferred modes of operation, together with the biasing characteristics as functions of $V_{op} = V_{DD} - V_{LCD}$ and the resulting discrimination ratios (D), are given in Table 2.

A practical value of V_{op} is determined by equating $V_{off(rms)}$ with a defined LCD threshold voltage (V_{th}), typically when the LCD exhibits approximately 10% contrast. In the static drive mode a suitable choice is $V_{op} \geq 3 V_{th}$. Multiplex drive ratios of 1 : 3 and 1 : 4 with $\frac{1}{2}$ bias are possible but the discrimination and hence the contrast ratios are smaller ($\sqrt{3} = 1.732$ for 1 : 3 multiplex or $\sqrt{21}/3 = 1.528$ for 1 : 4 multiplex). The advantage of these modes is a reduction of the LCD full scale voltage V_{op} as follows:

1 : 3 multiplex ($\frac{1}{2}$ bias):

$$V_{op} = \sqrt{6} V_{op(mrs)} = 2.449 V_{off(rms)}$$

1 : 4 multiplex ($\frac{1}{2}$ bias):

$$V_{op} = \sqrt[4]{3}/3 V_{off(rms)} = 2.309 V_{off(rms)}$$

These compare with $V_{op} = 3 V_{off(rms)}$ when $\frac{1}{3}$ bias is used.

Table 2 Preferred LCD drive modes: summary of characteristics

| LCD DRIVE MODE | LCD BIAS CONFIGURATION | $\frac{V_{off(rms)}}{V_{op}}$ | $\frac{V_{on(rms)}}{V_{op}}$ | $D = \frac{V_{on(rms)}}{V_{off(rms)}}$ |
|------------------|--------------------------|-------------------------------|------------------------------|--|
| Static (1 BP) | static (2 levels) | 0 | 1 | ∞ |
| 1 : 2 MUX (2 BP) | $\frac{1}{2}$ (3 levels) | $\sqrt{2}/4 = 0.354$ | $\sqrt{10}/4 = 0.791$ | $\sqrt{5} = 2.236$ |
| 1 : 2 MUX (2 BP) | $\frac{1}{3}$ (4 levels) | $\frac{1}{3} = 0.333$ | $\sqrt{5}/3 = 0.745$ | $\sqrt{5} = 2.236$ |
| 1 : 3 MUX (3 BP) | $\frac{1}{3}$ (4 levels) | $\frac{1}{3} = 0.333$ | $\sqrt{33}/9 = 0.638$ | $\sqrt{33}/3 = 1.915$ |
| 1 : 4 MUX (4 BP) | $\frac{1}{3}$ (4 levels) | $\frac{1}{3} = 0.333$ | $\sqrt{3}/3 = 0.577$ | $\sqrt{3} = 1.732$ |

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LCD drive mode waveforms

The static LCD drive mode is used when a single backplane is provided in the LCD. Backplane and segment drive waveforms for this mode are shown in Fig.4.

When two backplanes are provided in the LCD the 1 : 2 multiplex drive mode applies. The OM4085 allows use of 1/2 or 1/3 bias in this mode as shown in Figs 5 and 6.

The backplane and segment drive waveforms for the 1 : 3 multiplex drive mode (three LCD backplanes) and for the 1 : 4 multiplex drive mode (four LCD backplanes) are shown in Figs 7 and 8 respectively.

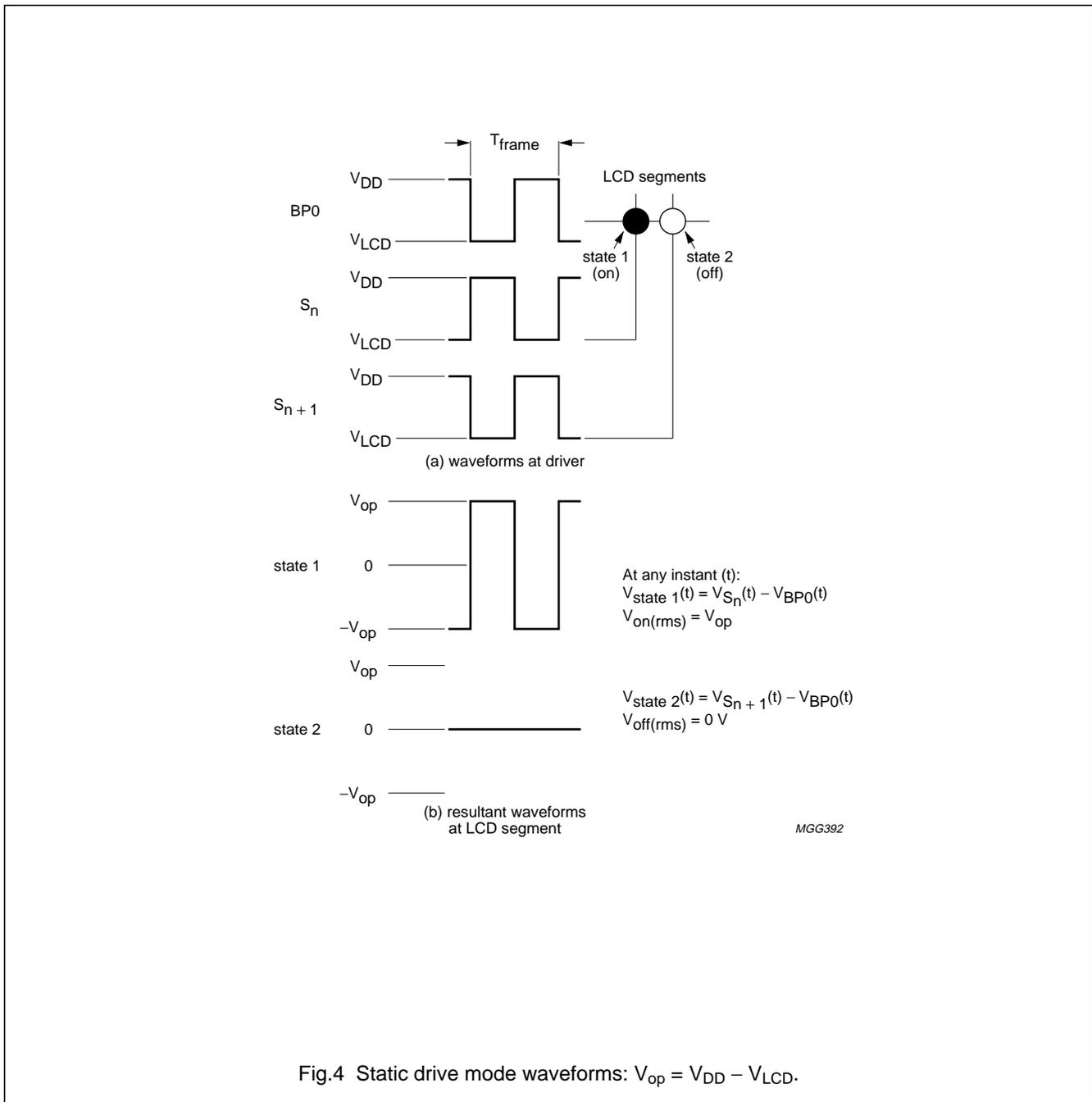


Fig.4 Static drive mode waveforms: $V_{op} = V_{DD} - V_{LCD}$.

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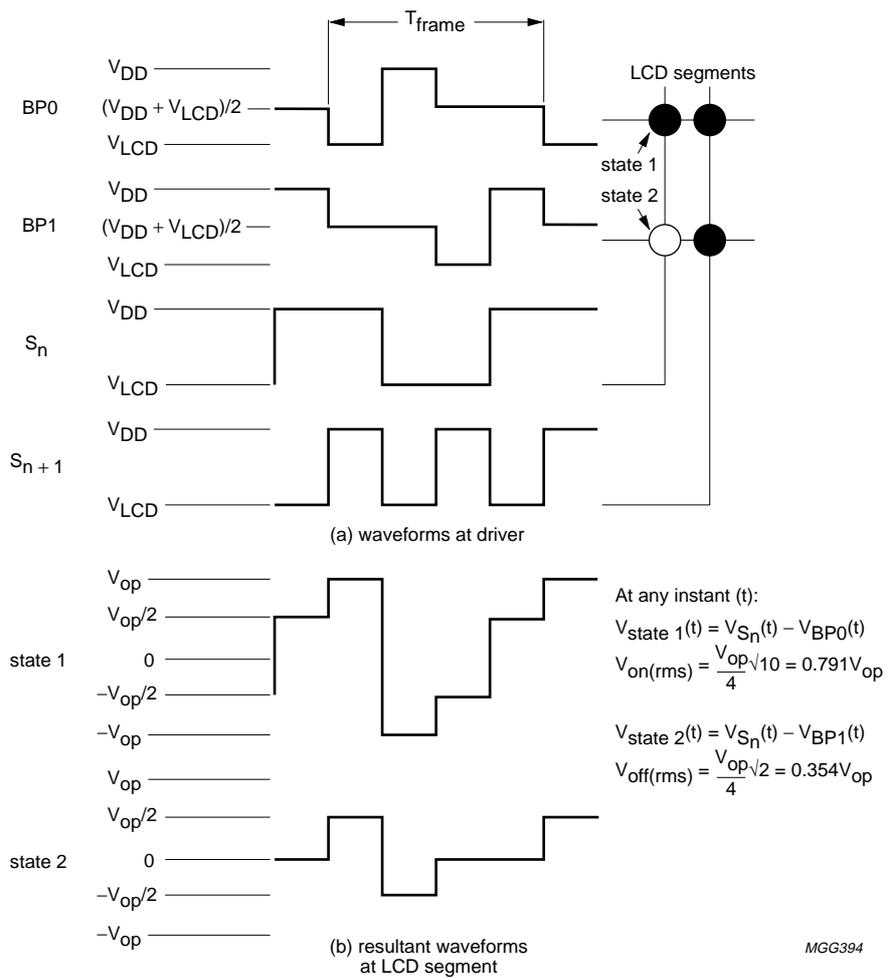


Fig.5 Waveforms for 1 : 2 multiplex drive mode with 1/2 bias: $V_{op} = V_{DD} - V_{LCD}$.

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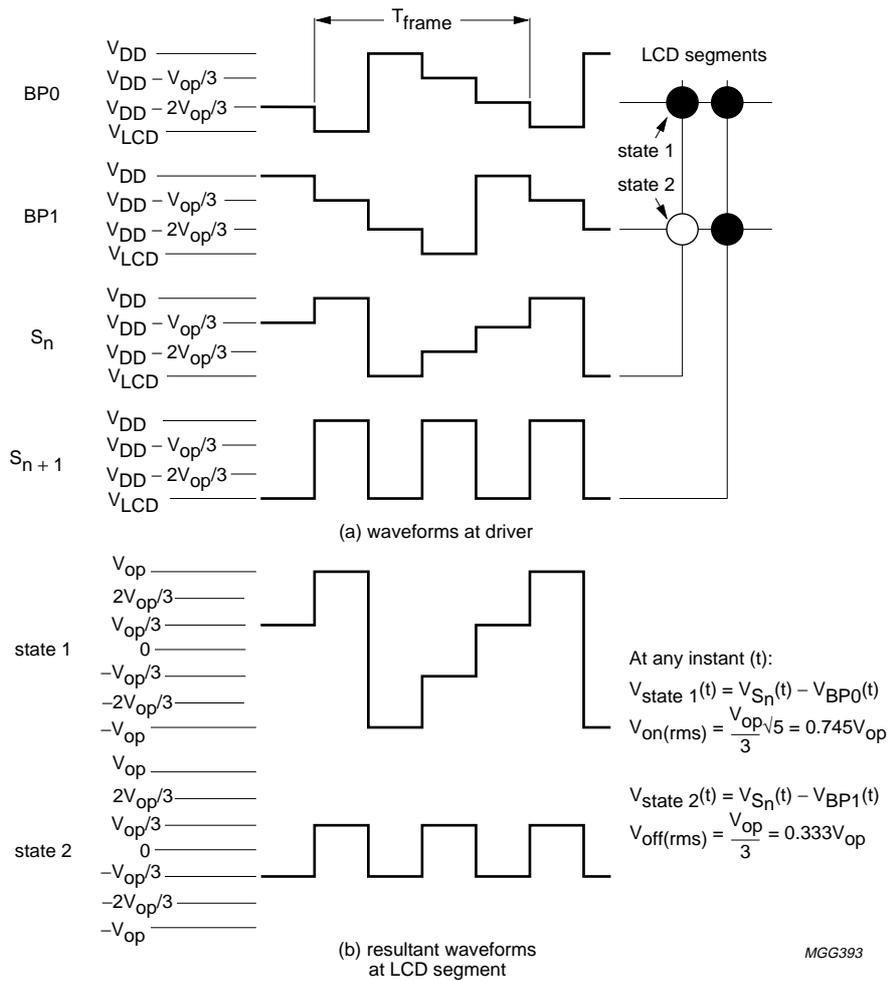


Fig.6 Waveforms for 1 : 2 multiplex drive mode with $\frac{1}{3}$ bias: $V_{op} = V_{DD} - V_{LCD}$.

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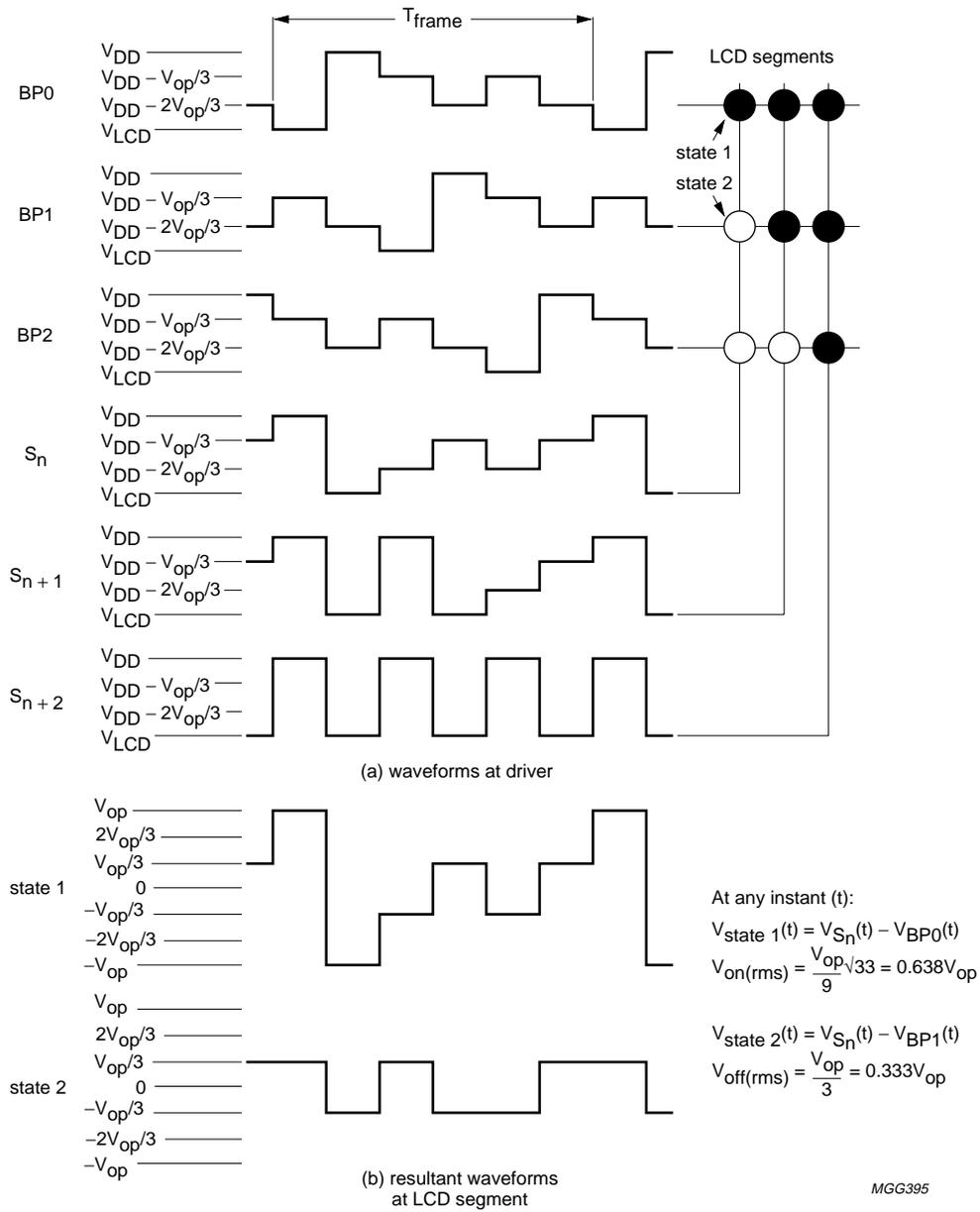
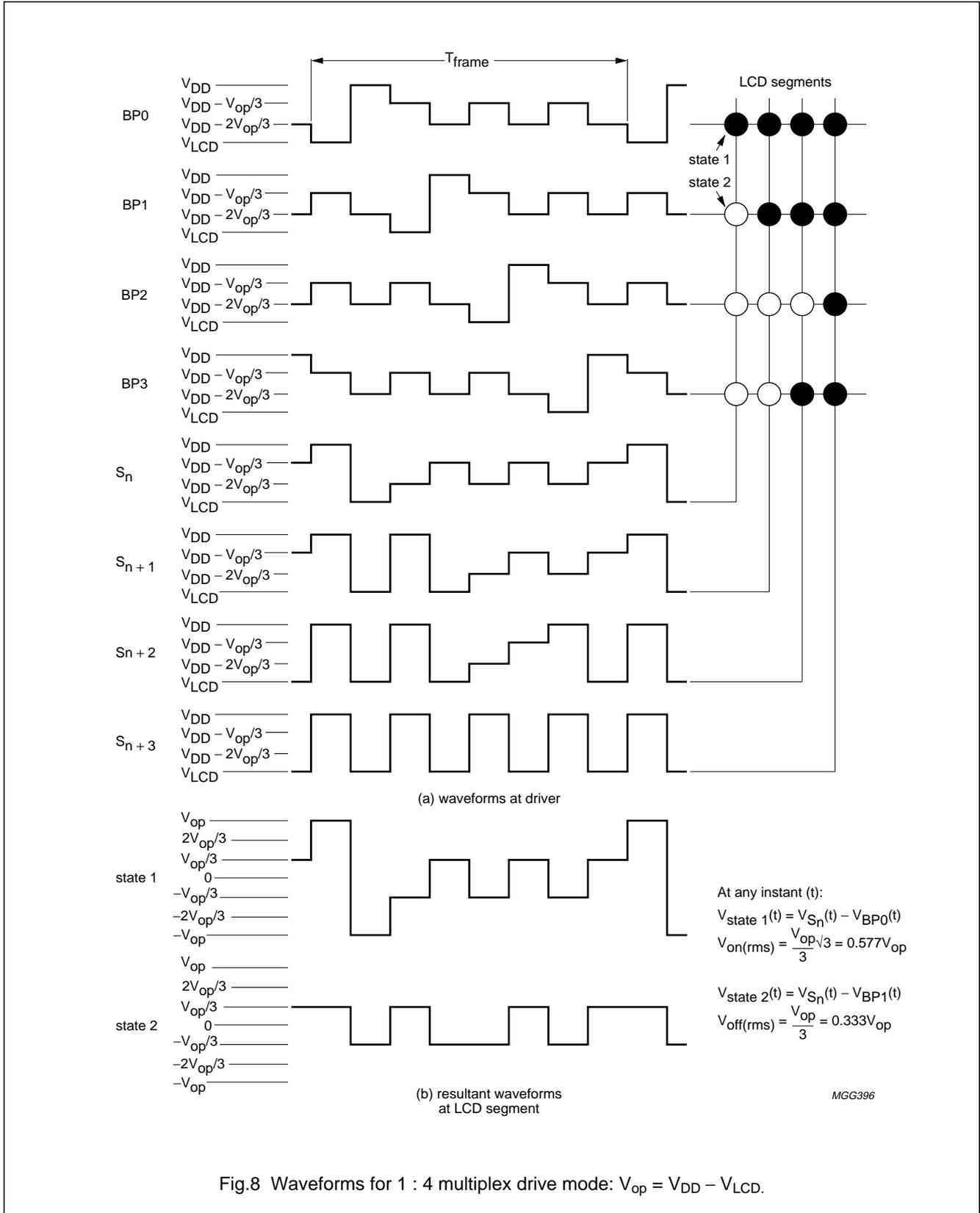


Fig.7 Waveforms for 1 : 3 multiplex drive mode: $V_{op} = V_{DD} - V_{LCD}$.

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Oscillator

The internal logic and the LCD drive signals of the OM4085 or PCF8576 are timed either by the built-in oscillator or from an external clock.

The clock frequency (f_{CLK}) determines the LCD frame frequency and the maximum rate for data reception from the I²C-bus. To allow I²C-bus transmissions at their maximum data rate of 100 kHz, f_{CLK} should be chosen to be above 125 kHz.

A clock signal must always be supplied to the device; removing the clock may freeze the LCD in a DC state.

Internal clock

When the internal oscillator is used, OSC (pin 6) should be tied to V_{SS} . In this case, the output from CLK (pin 4) provides the clock signal for cascaded OM4085s and PCF8576s in the system.

External clock

The condition for external clock is made by tying OSC (pin 6) to V_{DD} ; CLK (pin 4) then becomes the external clock input.

Timing

The timing of the OM4085 organizes 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 synchronization signal SYNC maintains the correct timing relationship between the OM4085s in the system. The timing also generates the LCD frame frequency which it derives as an integer multiple of the clock frequency (Table 3). The frame frequency is set by MODE SET commands when internal clock is used, or by the frequency applied to pin 4 when external clock is used.

Table 3 LCD frame frequencies

| OM4085 MODE | f_{frame} | NOMINAL f_{frame} (Hz) |
|-------------------|-----------------------|---------------------------------|
| Normal mode | $f_{\text{CLK}}/2880$ | 64 |
| Power saving mode | $f_{\text{CLK}}/480$ | 64 |

The ratio between the clock frequency and the LCD frame frequency depends on the mode in which the device is operating. In the power saving mode the reduction ratio is six times smaller; this allows the clock frequency to be reduced by a factor of six. The reduced clock frequency results in a significant reduction in power dissipation.

The lower clock frequency has the disadvantage of increasing the response time when large amounts of display data are transmitted on the I²C-bus. When a device is unable to 'digest' a display data byte before the next one arrives, it holds the SCL line LOW until the first display data byte is stored. This slows down the transmission rate of the I²C-bus but no data loss occurs.

Display latch

The display latch holds the display data while the corresponding multiplex signals are generated. There is a one-to-one relationship between the data in the display latch, the LCD segment outputs and one column of the display RAM.

Shift register

The shift register serves to transfer display information from the display RAM to the display latch while previous data are displayed.

Segment outputs

The LCD drive section includes 24 segment outputs S0 to S23 (pins 17 to 40) which should be connected directly to the LCD. The segment output signals are generated in accordance with the multiplexed backplane signals and with the data resident in the display latch. When less than 24 segment outputs are required the unused segment outputs should be left open-circuit.

Backplane outputs

The LCD drive section includes four backplane outputs BP0 to BP3 which should 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. In the 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 the 1 : 2 multiplex drive mode BP0 and BP2, BP1 and BP3 respectively carry the same signals and may also be paired to increase the drive capabilities. In the 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.

Display RAM

The display RAM is a static 24×4 -bit RAM which stores LCD data. A logic 1 in the RAM bit-map indicates the 'on' state of the corresponding LCD segment; similarly, a logic 0 indicates the 'off' state.

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There is a one-to-one correspondence between the RAM addresses and the segment outputs, and between the individual bits of a RAM word and the backplane outputs. The first RAM column corresponds to the 24 segments operated with respect to backplane BP0 (see Fig.9). In multiplexed LCD applications the segment data of the second, third and fourth column of the display RAM are time-multiplexed with BP1, BP2 and BP3 respectively.

When display data are transmitted to the OM4085 the display bytes received are stored in the display RAM according to the selected LCD drive mode. To illustrate the filling order, an example of a 7-segment numeric display showing all drive modes is given in Fig.10; the RAM filling organization depicted applies equally to other LCD types.

With reference to Fig.10, in the static drive mode the eight transmitted data bits are placed in bit 0 of eight successive display RAM addresses. In the 1 : 2 multiplex drive mode the eight transmitted data bits are placed in bits 0 and 1 of four successive display RAM addresses. In the 1 : 3 multiplex drive mode these bits are placed in bits 0, 1 and 2 of three successive addresses, with bit 2 of the third address left unchanged. This last bit may, if necessary, be controlled by an additional transfer to this address but care should be taken to avoid overriding adjacent data because full bytes are always transmitted. In the 1 : 4 multiplex drive mode the eight transmitted data bits are placed in bits 0, 1, 2 and 3 of two successive display RAM addresses.

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. Following this, an arriving data byte is stored starting at the display RAM address indicated by the data pointer thereby observing the filling order shown in Fig.10. The data pointer is automatically incremented according to the LCD configuration chosen. That is, after each byte is stored, the contents of the data pointer are incremented by eight (static drive mode), by four (1 : 2 multiplex drive mode), by three (1 : 3 multiplex drive mode) or by two (1 : 4 multiplex drive mode).

Subaddress counter

The storage of display data is conditioned by the contents of the subaddress counter. Storage is allowed to take place only when the contents of the subaddress counter agree with the hardware subaddress applied to A0, A1 and A2 (pins 7, 8, and 9). A0, A1 and A2 should be tied to V_{SS} or V_{DD}. The subaddress counter value is defined by the DEVICE SELECT command. If the contents of the subaddress counter and the hardware subaddress do not agree 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 being sent to the display RAM, automatic wrap-over to the next OM4085 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.

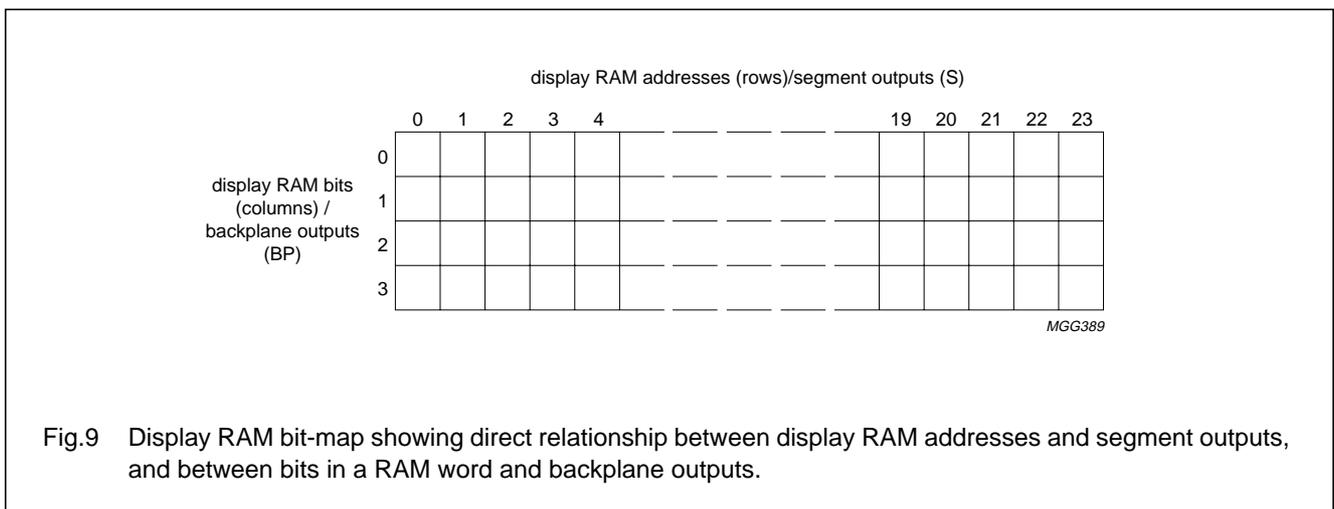


Fig.9 Display RAM bit-map showing direct relationship between display RAM addresses and segment outputs, and between bits in a RAM word and backplane outputs.

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Output bank selector

This selects one of the four bits per display RAM address for transfer to the display latch. The actual bit chosen depends on the particular LCD drive mode in operation and on the instant in the multiplex sequence. In 1 : 4 multiplex, all RAM addresses of bit 0 are the first to be selected, these are followed by the contents of bit 1, bit 2 and then bit 3. Similarly in 1 : 3 multiplex, bits 0, 1 and 2 are selected sequentially. In 1 : 2 multiplex, bits 0 then 1 are selected and, in the static mode, bit 0 is selected.

The OM4085 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 bit 2 to be selected for display instead of bit 0 contents. In the 1 : 2 drive mode, the contents of bits 2 and 3 may be selected instead of bits 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.

Input bank selector

The input bank selector loads display data into the display RAM according to the selected LCD drive configuration. Display data can be loaded in bit 2 in static drive mode or in bits 2 and 3 in 1 : 2 drive mode by using the BANK SELECT command. The input bank selector functions independently of the output bank selector.

Blinker

The display blinking capabilities of the OM4085 are very versatile. The whole display can be blinked at frequencies selected by the BLINK command. The blinking frequencies are integer multiples of the clock frequency; the ratios between the clock and blinking frequencies depend on the mode in which the device is operating, as shown in Table 4.

An additional feature is for an arbitrary selection of LCD segments to be blinked. This applies to the static and 1 : 2 LCD 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 blinking frequency. This mode can also be specified by the BLINK command.

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

If the entire display is to be blinked at a frequency other than the nominal blinking frequency, this can be effectively performed by resetting and setting the display enable bit E at the required rate using the MODE SET command.

Table 4 Blinking frequencies

| BLINKING MODE | NORMAL OPERATING MODE RATIO | POWER-SAVING MODE RATIO | NOMINAL BLINKING FREQUENCY f_{blink} (Hz) |
|---------------|-----------------------------|-------------------------|---|
| Off | – | – | blinking off |
| 2 Hz | $f_{\text{CLK}}/92160$ | $f_{\text{CLK}}/15360$ | 2 |
| 1 Hz | $f_{\text{CLK}}/184320$ | $f_{\text{CLK}}/30720$ | 1 |
| 0.5 Hz | $f_{\text{CLK}}/368640$ | $f_{\text{CLK}}/61440$ | 0.5 |

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I²C-BUS DESCRIPTION

The I²C-bus is for 2-way, 2-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.

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 control signals.

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).

System configuration

A device generating a message is a 'transmitter', a device receiving a message is a 'receiver'. The device that controls the message is the 'master' and the devices which are controlled by the master are the 'slaves'.

Acknowledge

The number of data bytes transferred between the START and STOP conditions from transmitter to receiver is not limited. Each byte is followed by one acknowledge bit. The acknowledge bit is a HIGH level put on the bus by the transmitter whereas the master generates an extra acknowledge related clock pulse. A slave receiver which is addressed must generate an acknowledge after the reception of each byte. Also a master must generate an acknowledge after the reception of each byte that has been clocked out of the slave transmitter. The device that acknowledges has to 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 account. 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.

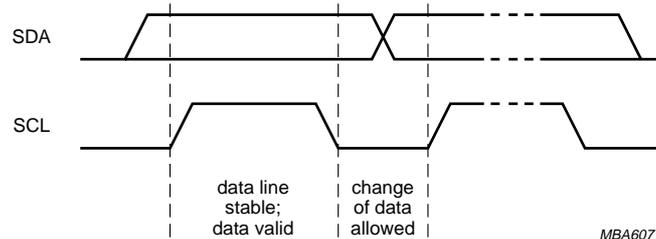


Fig.11 Bit transfer.

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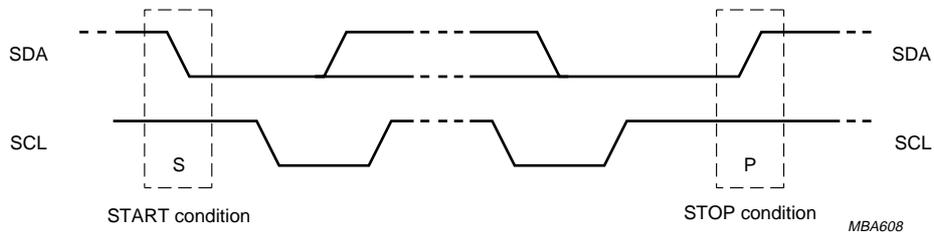


Fig.12 Definition of START and STOP conditions.

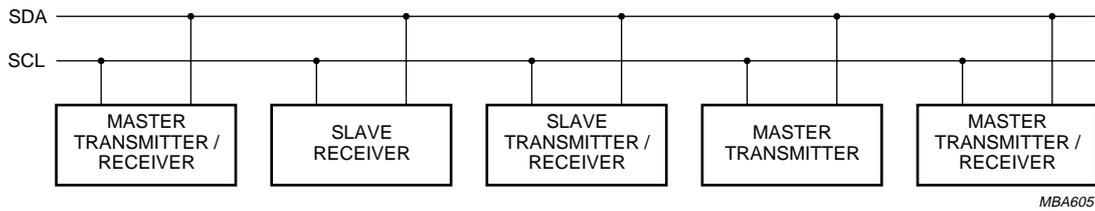


Fig.13 System configuration.

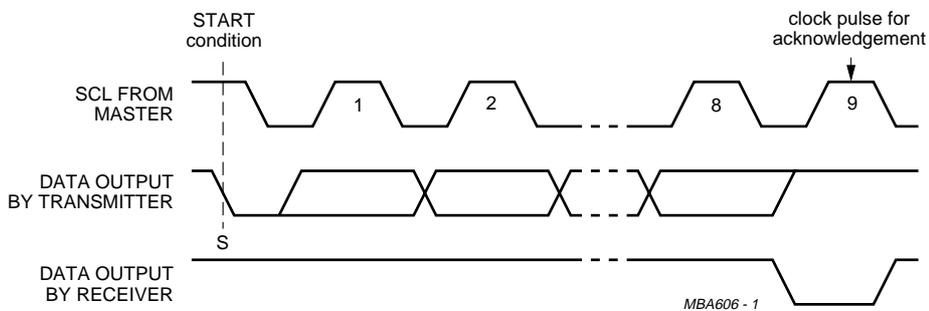


Fig.14 Acknowledgement on the I²C-bus.

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OM4085 I²C-bus controller

The OM4085 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 OM4085 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 left open-circuit or tied to V_{SS} which defines the hardware subaddress 0.

In multiple device applications A0, A1 and A2 are left open-circuit or tied to V_{SS} or V_{DD} according to a binary coding scheme such that no two devices with a common I²C-bus slave address have the same hardware subaddress.

In the power-saving mode it is possible that the OM4085 is not able to keep up with the highest transmission rates when large amounts of display data are transmitted. If this situation occurs, the OM4085 forces the SCL line LOW until its internal operations are completed. This is known as the 'clock synchronization feature' of the I²C-bus and serves to slow down fast transmitters. Data loss does not occur.

Input filters

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

I²C-bus protocol

Two I²C-bus slave addresses (0111110 and 0111111) are reserved for OM4085. The least-significant bit of the slave address that a OM4085 will respond to is defined by the level tied at its input SA0 (pin 10). Therefore, two types of OM4085 can be distinguished on the same I²C-bus which allows:

1. Up to 16 OM4085s on the same I²C-bus for very large LCD applications
2. The use of two types of LCD multiplex on the same I²C-bus.

The I²C-bus protocol is shown in Fig.15. The sequence is initiated with a START condition (S) from the I²C-bus master which is followed by one of the two OM4085 slave addresses available. All OM4085s with the corresponding SA0 level acknowledge in parallel the slave address but all OM4085s with the alternative SA0 level ignore the whole I²C-bus transfer. After acknowledgement, one or more command bytes (m) follow which define the status of the addressed OM4085s. The last command byte is tagged with a cleared most-significant bit, the continuation bit C. The command bytes are also acknowledged by all addressed OM4085s on the bus.

After the last command byte, a series of display data bytes (n) may follow. These 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 are directed to the intended OM4085 device.

The acknowledgement after each byte is made only by the (A0, A1, A2) addressed OM4085. After the last display byte, the I²C-bus master issues a STOP condition (P).

Command decoder

The command decoder identifies command bytes that arrive on the I²C-bus. All available commands carry a continuation bit C in their most-significant bit position (see Fig.16). When this bit is set, it indicates that the next byte of the transfer to arrive will also represent a command.

If the bit is reset, it indicates the last command byte of the transfer. Further bytes will be regarded as display data.

The five commands available to the OM4085 are defined in Table 5.

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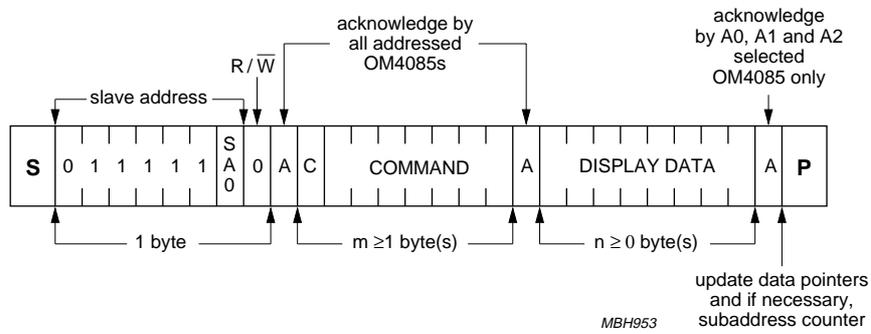


Fig.15 I²C-bus protocol.

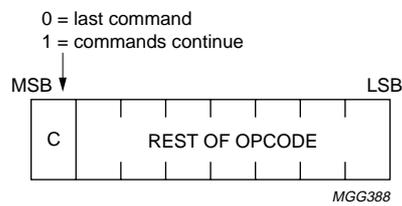


Fig.16 General format of command byte.

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Table 5 Definition of OM4085 commands

| COMMAND/OPCODE | | | | | | | | OPTIONS | DESCRIPTION |
|--------------------------|---|---|----|----|----|-----|-----|--------------|---|
| Mode set | | | | | | | | | |
| C | 1 | 0 | LP | E | B | M1 | M0 | see Table 6 | defines LCD drive mode |
| | | | | | | | | see Table 7 | defines LCD bias configuration |
| | | | | | | | | see Table 8 | defines display status; the possibility to disable the display allows implementation of blinking under external control |
| | | | | | | | | see Table 9 | defines power dissipation mode |
| Load data pointer | | | | | | | | | |
| C | 0 | 0 | P4 | P3 | P2 | P1 | P0 | see Table 10 | five bits of immediate data, bits P4 to P0, are transferred to the data pointer to define one of twenty-four display RAM addresses |
| Device select | | | | | | | | | |
| C | 1 | 1 | 0 | 0 | A2 | A1 | A0 | see Table 11 | three bits of immediate data, bits A0 to A2, are transferred to the subaddress counter to define one of eight hardware subaddresses |
| Bank select | | | | | | | | | |
| C | 1 | 1 | 1 | 1 | 0 | I | O | see Table 12 | defines input bank selection (storage of arriving display data) |
| | | | | | | | | see Table 13 | defines output bank selection (retrieval of LCD display data) |
| | | | | | | | | | the BANK SELECT command has no effect in 1 : 3 and 1 : 4 multiplex drive modes |
| Blink | | | | | | | | | |
| C | 1 | 1 | 1 | 0 | A | BF1 | BF0 | see Table 14 | defines the blinking frequency |
| | | | | | | | | see Table 15 | selects the blinking mode; normal operation with frequency set by bits BF1 and BF0, or blinking by alternation of display RAM banks. Alternation blinking does not apply in 1 : 3 and 1 : 4 multiplex drive modes |

Table 6 LCD drive mode

| LCD DRIVE MODE | BIT M1 | BIT M0 |
|------------------|--------|--------|
| Static (1 BP) | 0 | 1 |
| 1 : 2 MUX (2 BP) | 1 | 0 |
| 1 : 3 MUX (3 BP) | 1 | 1 |
| 1 : 4 MUX (4 BP) | 0 | 0 |

Universal LCD driver for low multiplex rates

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Table 7 LCD bias configuration

| LCD BIAS | BIT B |
|--------------------|-------|
| $\frac{1}{3}$ bias | 0 |
| $\frac{1}{2}$ bias | 1 |

Table 8 Display status

| DISPLAY STATUS | BIT E |
|------------------|-------|
| Disabled (blank) | 0 |
| Enabled | 1 |

Table 9 Power dissipation mode

| MODE | BIT LP |
|-------------------|--------|
| Normal mode | 0 |
| Power-saving mode | 1 |

Table 10 Load data pointer

| BITS | P4 | P3 | P2 | P1 | P0 |
|-------------------------------|----|----|----|----|----|
| 5-bit binary value of 0 to 23 | | | | | |

Table 11 Device select

| BITS | A0 | A1 | A2 |
|------------------------------|----|----|----|
| 3-bit binary value of 0 to 7 | | | |

Table 12 Input bank selection

| STATIC | 1 : 2 MUX | BIT 1 |
|-----------|---------------|-------|
| RAM bit 0 | RAM bits 0, 1 | 0 |
| RAM bit 2 | RAM bits 2, 3 | 1 |

Table 13 Output bank selection

| STATIC | 1 : 2 MUX | BIT 0 |
|-----------|---------------|-------|
| RAM bit 0 | RAM bits 0, 1 | 0 |
| RAM bit 2 | RAM bits 2, 3 | 1 |

Table 14 Blinking frequency

| BLINK FREQUENCY | BIT BF1 | BIT BF0 |
|-----------------|---------|---------|
| Off | 0 | 0 |
| 2 Hz | 0 | 1 |
| 1 Hz | 1 | 0 |
| 0.5 Hz | 1 | 1 |

Table 15 Blink mode selection

| BLINK MODE | BIT A |
|----------------------|-------|
| Normal blinking | 0 |
| Alternation blinking | 1 |

Display controller

The display controller executes the commands identified by the command decoder. It contains the status registers of the OM4085 and coordinates their effects.

The controller is also responsible for loading display data into the display RAM as required by the filling order.

Cascaded operation

In large display configurations, up to 16 OM4085s can be distinguished on the same I²C-bus by using the 3-bit hardware subaddress (A0, A1 and A2) and the programmable I²C-bus slave address (SA0). It is also possible to cascade up to 16 OM4085s. When cascaded, several OM4085s are synchronized so that they can share the backplane signals from one of the devices in the cascade. Such an arrangement is cost-effective in large LCD applications since the outputs of only one device need to be through-plated to the backplane electrodes of the display. The other OM4085s of the cascade contribute additional segment outputs but their backplane outputs are left open-circuit (Fig.17).

The $\overline{\text{SYNC}}$ line is provided to maintain the correct synchronization between all cascaded OM4085s. 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 accidentally lost (e.g. by noise in adverse electrical environments; or by the definition of a multiplex mode when OM4085s with differing SA0 levels are cascaded). $\overline{\text{SYNC}}$ is organized as an input/output pin; the output section being realized as an open-drain driver with an internal pull-up resistor. A OM4085 asserts the $\overline{\text{SYNC}}$ line at the onset of its last active backplane signal and monitors the $\overline{\text{SYNC}}$ line at all other times.

Should synchronization in the cascade be lost, it will be restored by the first OM4085 to assert $\overline{\text{SYNC}}$. The timing relationships between the backplane waveforms and the $\overline{\text{SYNC}}$ signal for the various drive modes of the PCF8576 are shown in Fig.18. The waveforms are identical with the parent device PCF8576. Cascade ability between OM4085s and PCF8576s is possible, giving cost effective LCD applications.

Universal LCD driver for low multiplex rates

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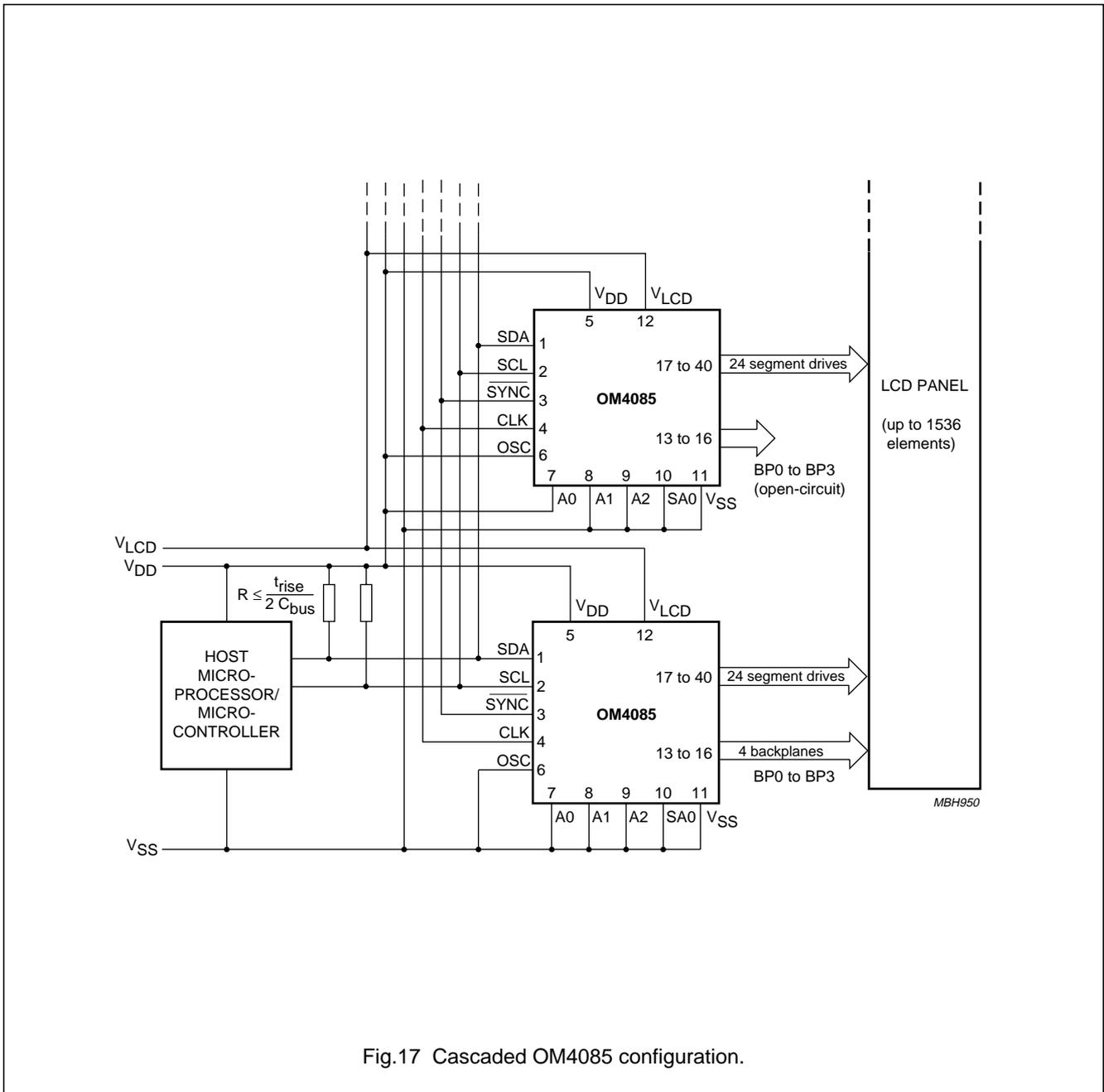


Fig.17 Cascaded OM4085 configuration.

Universal LCD driver for low multiplex rates

OM4085

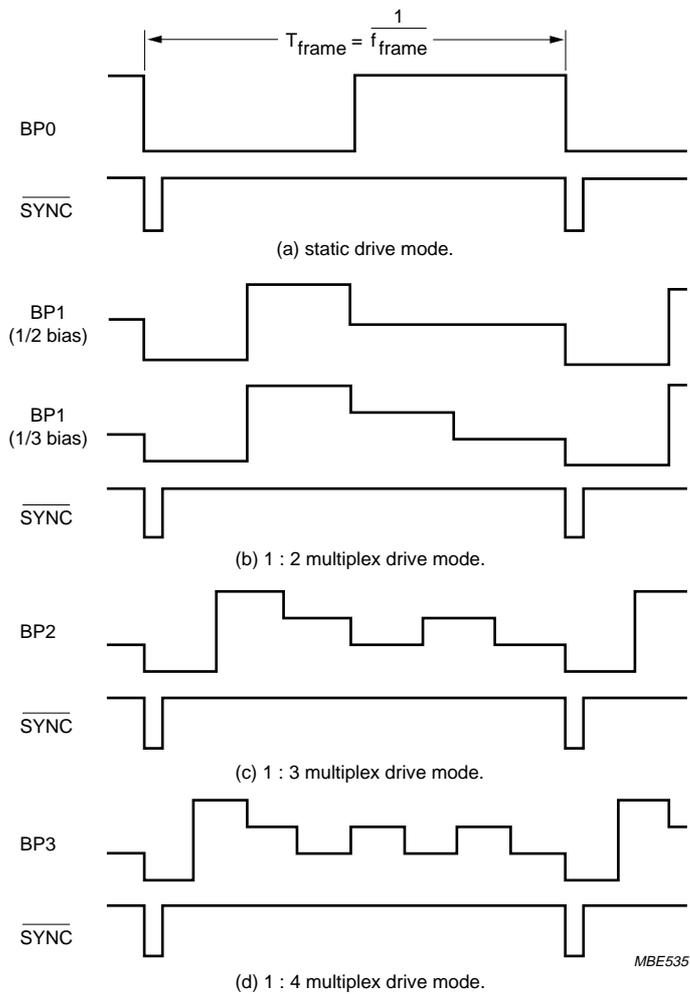


Fig.18 Synchronization of the cascade for the various OM4085 drive modes.

For single plane wiring of OM4085s, see Chapter "Application information".

Universal LCD driver for low multiplex rates

OM4085

LIMITING VALUES

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

| SYMBOL | PARAMETER | MIN. | MAX. | UNIT |
|---------------------------|---|-----------------|----------------|------|
| V_{DD} | supply voltage | -0.5 | +7 | V |
| V_{LCD} | LCD supply voltage | $V_{DD} - 7$ | V_{DD} | V |
| V_I | input voltage (SCL, SDA, A0 to A2, OSC, CLK, \overline{SYNC} and SA0) | $V_{SS} - 0.5$ | $V_{DD} + 0.5$ | V |
| V_O | output voltage (S0 to S23 and BP0 to BP3) | $V_{LCD} - 0.5$ | $V_{DD} + 0.5$ | V |
| I_I | DC input current | - | ± 20 | mA |
| I_O | DC output current | - | ± 25 | mA |
| I_{DD}, I_{SS}, I_{LCD} | V_{DD}, V_{SS} or V_{LCD} current | - | ± 50 | mA |
| P_{tot} | power dissipation per package | - | 400 | mW |
| P_O | power dissipation per output | - | 100 | mW |
| T_{stg} | storage temperature | -65 | +150 | °C |

HANDLING

Inputs and outputs are protected against electrostatic discharges in normal handling. However, to be totally safe, it is advised to take handling precautions appropriate to handling MOS devices (see "Handling MOS devices").

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DC CHARACTERISTICS

$V_{SS} = 0\text{ V}$; $V_{DD} = 2.0\text{ to }6\text{ V}$; $V_{LCD} = V_{DD} - 2.0\text{ to }V_{DD} - 6\text{ V}$; $T_{amb} = -40\text{ to }+85\text{ }^{\circ}\text{C}$; unless otherwise specified.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|--------------------------------|--|---|-----------------|----------|----------------|------------------|
| Supplies | | | | | | |
| V_{DD} | operating supply voltage | | 2.0 | – | 6 | V |
| V_{LCD} | LCD supply voltage | | $V_{DD} - 6$ | – | $V_{DD} - 2.0$ | V |
| I_{DD} | operating supply current (normal mode) | $f_{CLK} = 200\text{ kHz}$; note 1 | – | 30 | 90 | μA |
| I_{LP} | power saving mode supply current | $V_{DD} = 3.5\text{ V}$; $V_{LCD} = 0\text{ V}$; $f_{CLK} = 35\text{ kHz}$; A0, A1 and A2 tied to V_{SS} ; note 1 | – | 15 | 40 | μA |
| Logic | | | | | | |
| V_{IL} | LOW level input voltage | | V_{SS} | – | $0.3V_{DD}$ | V |
| V_{IH} | HIGH level input voltage | | $0.7V_{DD}$ | – | V_{DD} | V |
| V_{OL} | LOW level output voltage | $I_O = 0\text{ mA}$ | – | – | 0.05 | V |
| V_{OH} | HIGH level output voltage | $I_O = 0\text{ mA}$ | $V_{DD} - 0.05$ | – | – | V |
| I_{OL1} | LOW level output current (CLK and $\overline{\text{SYNC}}$) | $V_{OL} = 1\text{ V}$; $V_{DD} = 5\text{ V}$ | 1 | – | – | mA |
| I_{OH} | HIGH level output current (CLK) | $V_{OH} = 4\text{ V}$; $V_{DD} = 5\text{ V}$ | – | – | –1 | mA |
| I_{OL2} | LOW level output current (SDA and SCL) | $V_{OL} = 0.4\text{ V}$; $V_{DD} = 5\text{ V}$ | 3 | – | – | mA |
| I_{LI} | leakage current (SA0, CLK, OSC, A0, A1, A2, SCL and SDA) | $V_I = V_{SS}\text{ or }V_{DD}$ | – | – | ± 1 | μA |
| I_{pd} | pull-down current (A0, A1, A2 and OSC) | $V_I = 1\text{ V}$; $V_{DD} = 5\text{ V}$ | 15 | 50 | 150 | μA |
| $R_{pu\overline{\text{SYNC}}}$ | pull-up resistor ($\overline{\text{SYNC}}$) | | 15 | 25 | 60 | $\text{k}\Omega$ |
| V_{ref} | power-on reset level | note 2 | – | 1.3 | 2 | V |
| t_{sw} | tolerable spike width on bus | | – | – | 100 | ns |
| C_i | input capacitance | note 3 | – | – | 7 | pF |
| LCD outputs | | | | | | |
| V_{BP} | DC voltage component (BP0 to BP3) | $C_{BP} = 35\text{ nF}$ | – | ± 20 | – | mV |
| V_S | DC voltage component (S0 to S23) | $C_S = 5\text{ nF}$ | – | ± 20 | – | mV |
| Z_{BP} | output impedance (BP0 to BP3) | $V_{LCD} = V_{DD} - 5\text{ V}$; note 4 | – | 1 | 5 | $\text{k}\Omega$ |
| Z_S | output impedance (S0 to S23) | $V_{LCD} = V_{DD} - 5\text{ V}$; note 4 | – | 3 | 7 | $\text{k}\Omega$ |

Notes

1. Outputs open; inputs at V_{SS} or V_{DD} ; external clock with 50% duty factor; I²C-bus inactive.
2. Resets all logic when $V_{DD} < V_{ref}$.
3. Periodically sampled, not 100% tested.
4. Outputs measured one at a time.

Universal LCD driver for low multiplex rates

OM4085

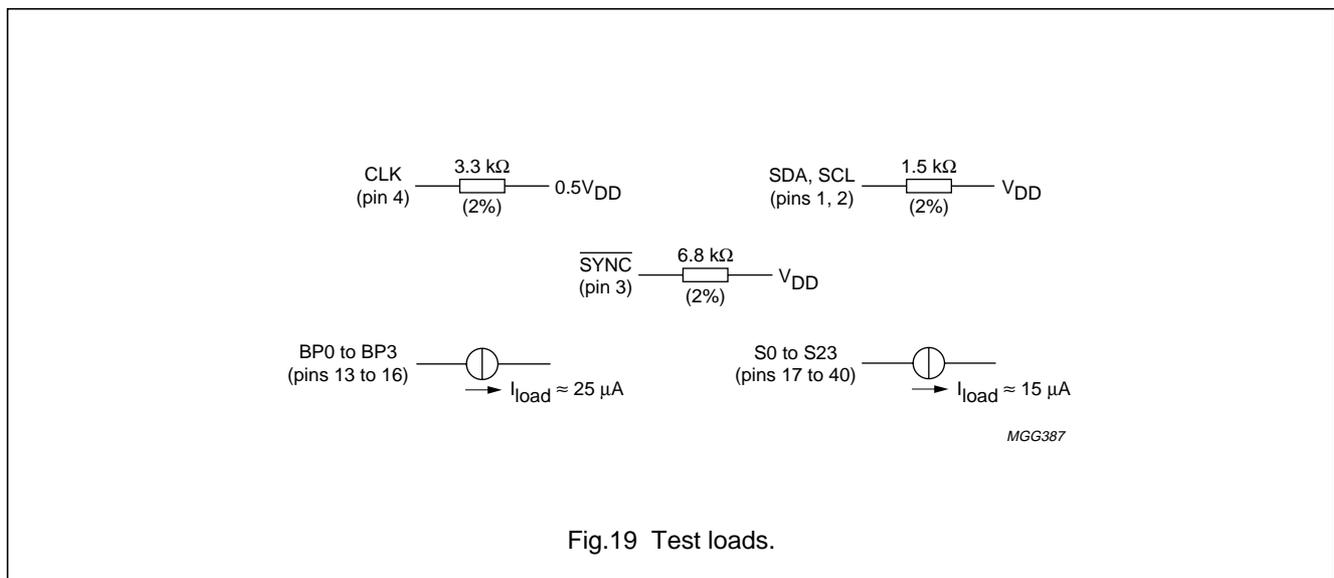
AC CHARACTERISTICS

$V_{SS} = 0\text{ V}$; $V_{DD} = 2.0\text{ to }6\text{ V}$; $V_{LCD} = V_{DD} - 2.0\text{ to }V_{DD} - 6\text{ V}$; $T_{amb} = -40\text{ to }+85\text{ }^{\circ}\text{C}$; unless otherwise specified; note 1.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---------------------------|--|---------------------------------|------|------|------|---------------|
| f_{CLK} | oscillator frequency (normal mode) | $V_{DD} = 5\text{ V}$; note 2 | 125 | 200 | 315 | kHz |
| f_{CLKLP} | oscillator frequency (power saving mode) | $V_{DD} = 3.5\text{ V}$ | 21 | 31 | 48 | kHz |
| t_{CLKH} | CLK HIGH time | | 1 | – | – | μs |
| t_{CLKL} | CLK LOW time | | 1 | – | – | μs |
| t_{PSYNC} | $\overline{\text{SYNC}}$ propagation delay | | – | – | 400 | ns |
| t_{SYNCL} | $\overline{\text{SYNC}}$ LOW time | | 1 | – | – | μs |
| t_{PLCD} | driver delays with test loads | $V_{LCD} = V_{DD} - 5\text{ V}$ | – | – | 30 | μs |
| I²C-bus | | | | | | |
| t_{BUF} | bus free time | | 4.7 | – | – | μs |
| $t_{HD; STA}$ | START condition hold time | | 4 | – | – | μs |
| t_{LOW} | SCL LOW time | | 4.7 | – | – | μs |
| t_{HIGH} | SCL HIGH time | | 4 | – | – | μs |
| $t_{SU; STA}$ | START condition set-up time (repeated start code only) | | 4.7 | – | – | μs |
| $t_{HD; DAT}$ | data hold time | | 0 | – | – | μs |
| $t_{SU; DAT}$ | data set-up time | | 250 | – | – | ns |
| t_r | rise time | | – | – | 1 | μs |
| t_f | fall time | | – | – | 300 | ns |
| $t_{SU; STO}$ | STOP condition set-up time | | 4.7 | – | – | μs |

Notes

- All timing values referred to V_{IH} and V_{IL} levels with an input voltage swing of V_{SS} to V_{DD} .
- At $f_{CLK} < 125\text{ kHz}$, I²C-bus maximum transmission speed is derated.



Universal LCD driver for low multiplex rates

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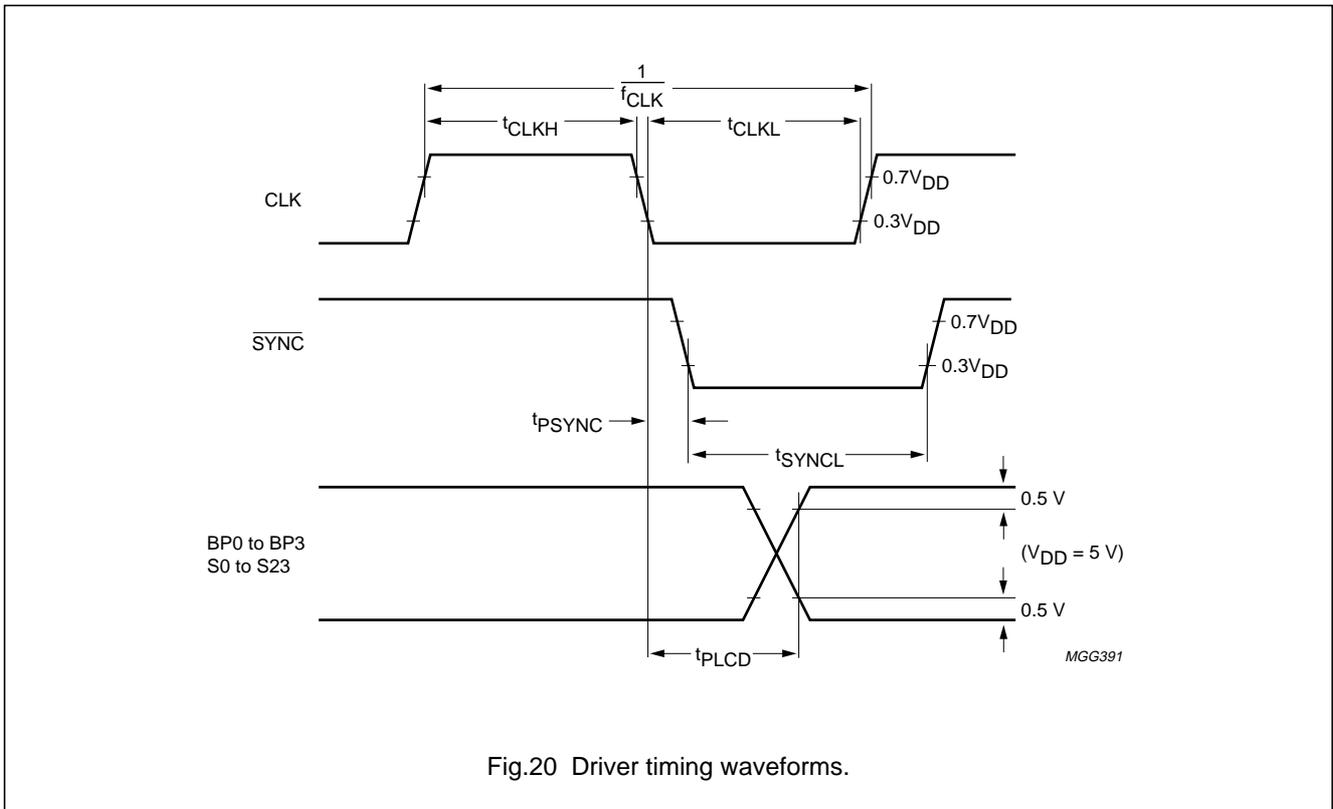


Fig.20 Driver timing waveforms.

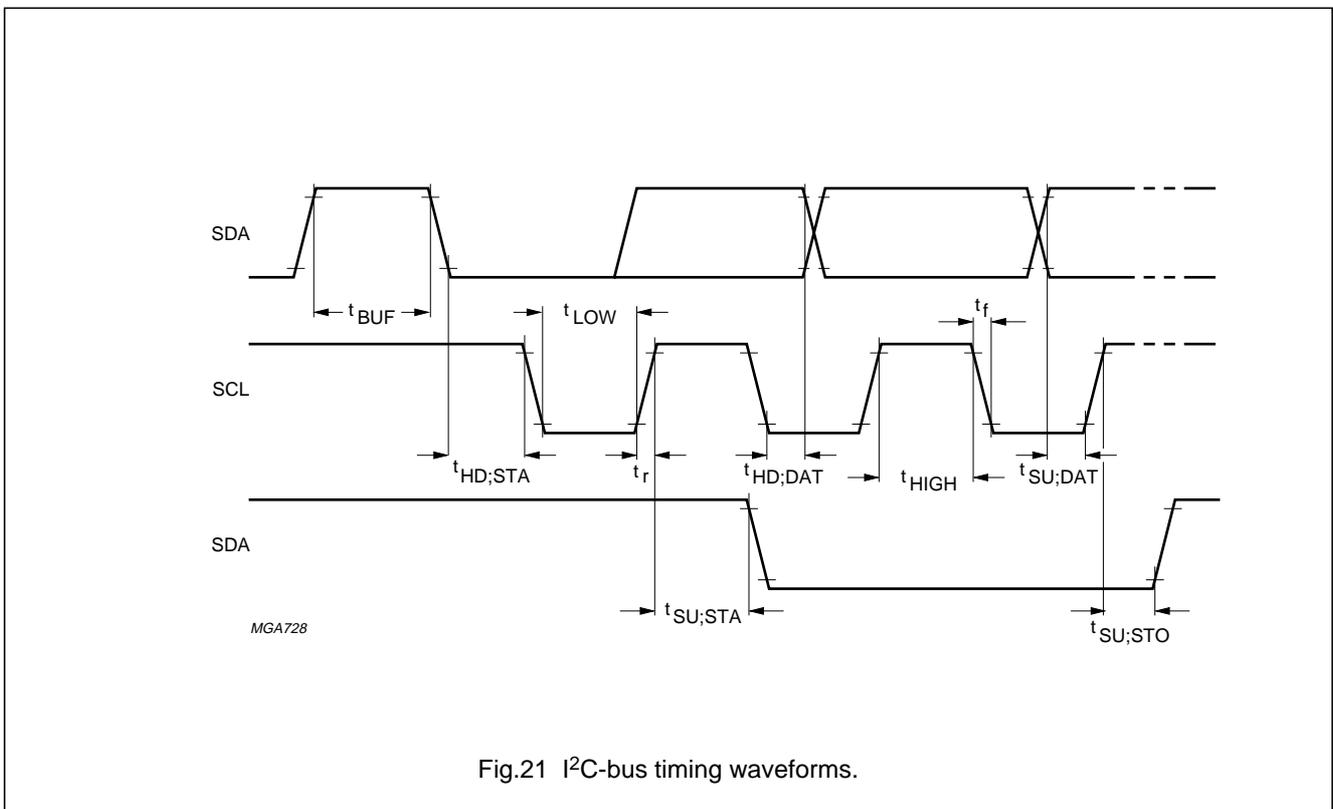
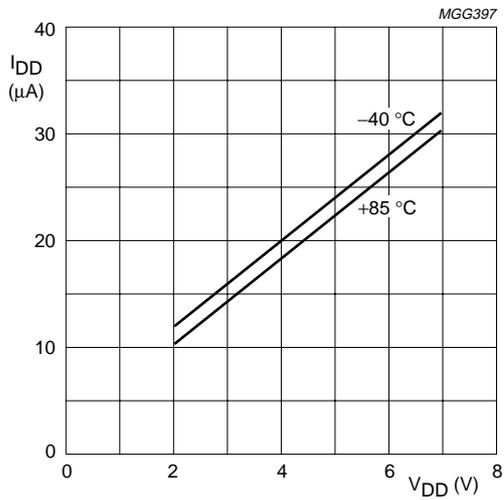


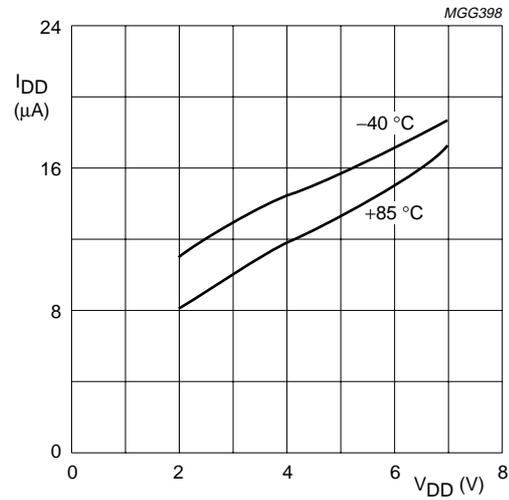
Fig.21 I²C-bus timing waveforms.

Universal LCD driver for low multiplex rates

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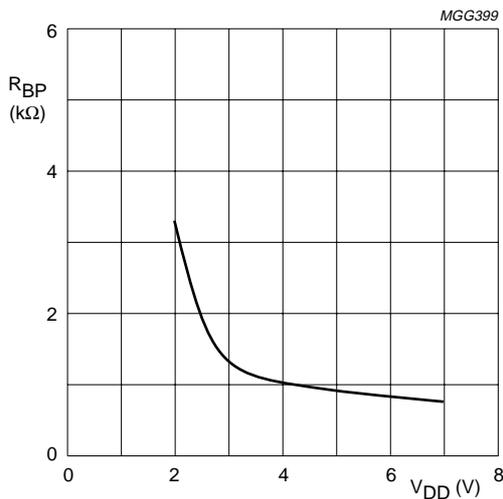


a. Normal mode; $V_{LCD} = 0\text{ V}$;
external clock = 200 kHz.

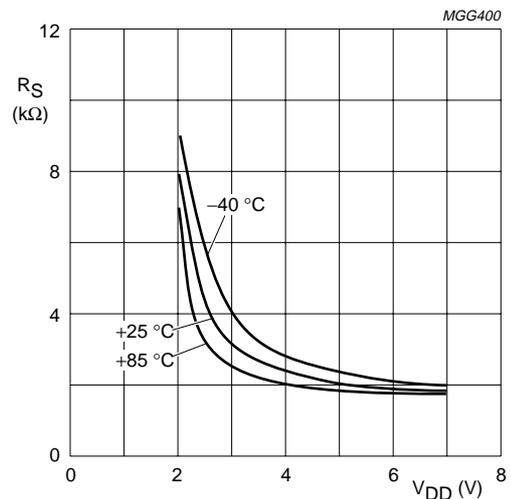


b. Low power mode; $V_{LCD} = 0\text{ V}$;
external clock = 35 kHz.

Fig.22 Typical supply current characteristics.



a. Backplane output impedance BP0 to BP3 (R_{BP}); $V_{DD} = 5\text{ V}$; $T_{amb} = -40\text{ to }+85\text{ °C}$.



b. Segment output impedance S0 to S23 (R_S); $V_{DD} = 5\text{ V}$.

Fig.23 Typical characteristics of LCD outputs.

Universal LCD driver for low multiplex rates

OM4085

APPLICATION INFORMATION

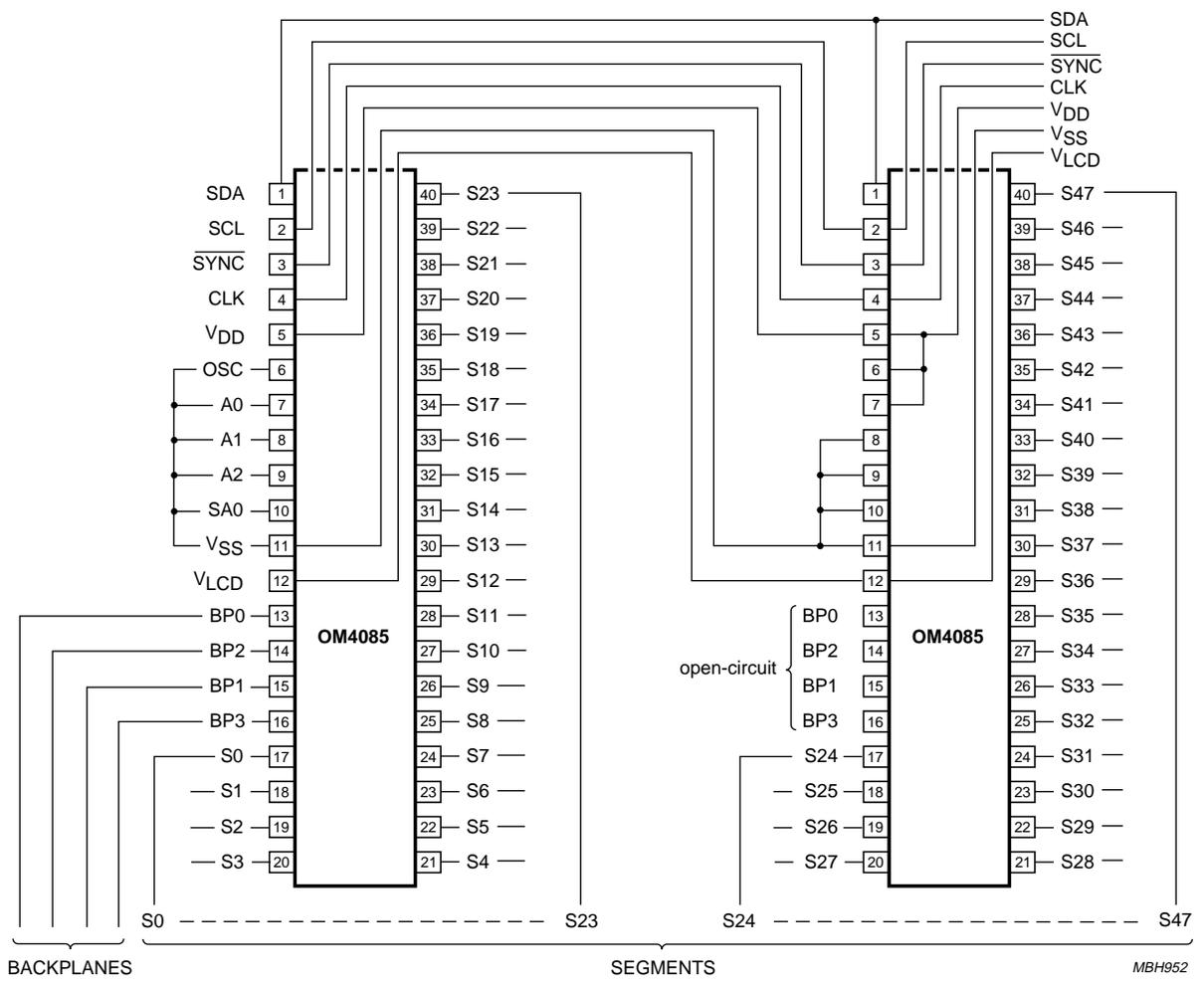
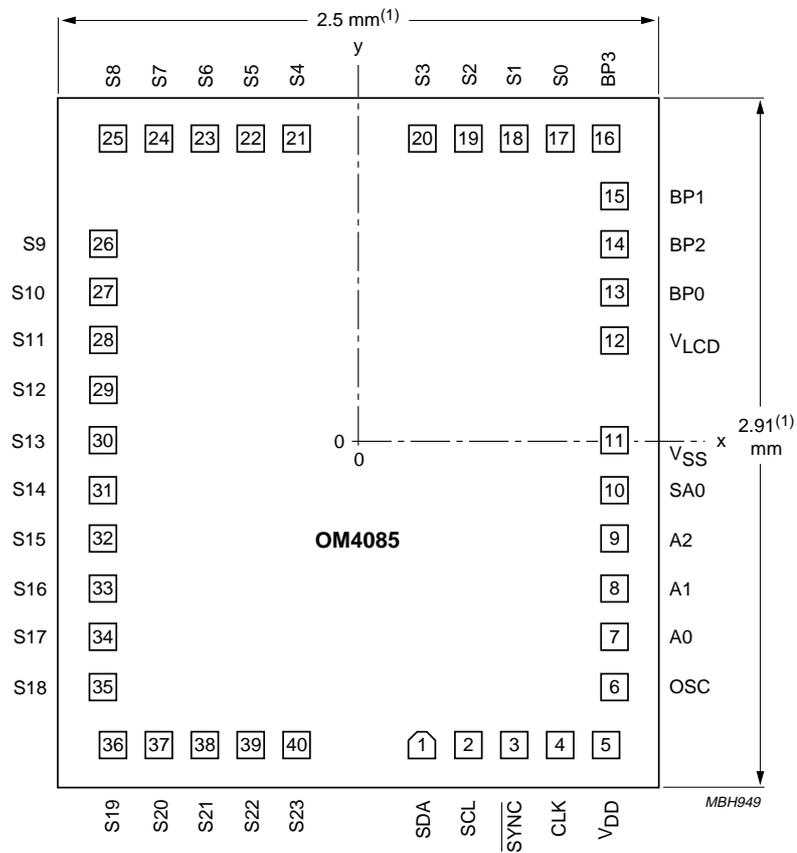


Fig.24 Single plane wiring of package OM4085s.

Universal LCD driver for low multiplex rates

OM4085

CHIP DIMENSIONS AND BONDING PAD LOCATIONS



(1) Typical value.
 Pad size: 120 × 120 μm
 Chip area: 7.27 mm.
 The numbers given in the small squares refer to the pad numbers.

Fig.25 Bonding pad locations.

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Table 16 Bonding pad locations (dimensions in mm)

All x/y coordinates are referenced to centre of chip, (see Fig.25)

| PAD NUMBER | SYMBOL | x | y | PIN |
|------------|------------------|-------|-------|-----|
| 1 | SDA | 200 | -1235 | 1 |
| 2 | SCL | 400 | -1235 | 2 |
| 3 | SYNC | 605 | -1235 | 3 |
| 4 | CLK | 856 | -1235 | 4 |
| 5 | V _{DD} | 1062 | -1235 | 5 |
| 6 | OSC | 1080 | -1025 | 6 |
| 7 | A0 | 1080 | -825 | 7 |
| 8 | A1 | 1080 | -625 | 8 |
| 9 | A2 | 1080 | -425 | 9 |
| 10 | SA0 | 1080 | -225 | 10 |
| 11 | V _{SS} | 1080 | -25 | 11 |
| 12 | V _{LCD} | 1080 | 347 | 12 |
| 13 | BP0 | 1080 | 547 | 13 |
| 14 | BP2 | 1080 | 747 | 14 |
| 15 | BP1 | 1080 | 947 | 15 |
| 16 | BP3 | 1074 | 1235 | 16 |
| 17 | S0 | 674 | 1235 | 17 |
| 18 | S1 | 674 | 1235 | 18 |
| 19 | S2 | 474 | 1235 | 19 |
| 20 | S3 | 274 | 1235 | 20 |
| 21 | S4 | -274 | 1235 | 21 |
| 22 | S5 | -474 | 1235 | 22 |
| 23 | S6 | -674 | 1235 | 23 |
| 24 | S7 | -874 | 1235 | 24 |
| 25 | S8 | -1074 | 1235 | 25 |
| 26 | S9 | -1080 | 765 | 26 |
| 27 | S10 | -1080 | 565 | 27 |
| 28 | S11 | -1080 | 365 | 28 |
| 29 | S12 | -1080 | 165 | 29 |
| 30 | S13 | -1080 | -35 | 30 |
| 31 | S14 | -1080 | -235 | 31 |
| 32 | S15 | -1080 | -435 | 32 |
| 33 | S16 | -1080 | -635 | 33 |
| 34 | S17 | -1080 | -835 | 34 |
| 35 | S18 | -1080 | -1035 | 35 |
| 36 | S19 | -1056 | -1235 | 36 |
| 37 | S20 | -830 | -1235 | 37 |
| 38 | S21 | -630 | -1235 | 38 |
| 39 | S22 | -430 | -1235 | 39 |
| 40 | S23 | -230 | -1235 | 40 |

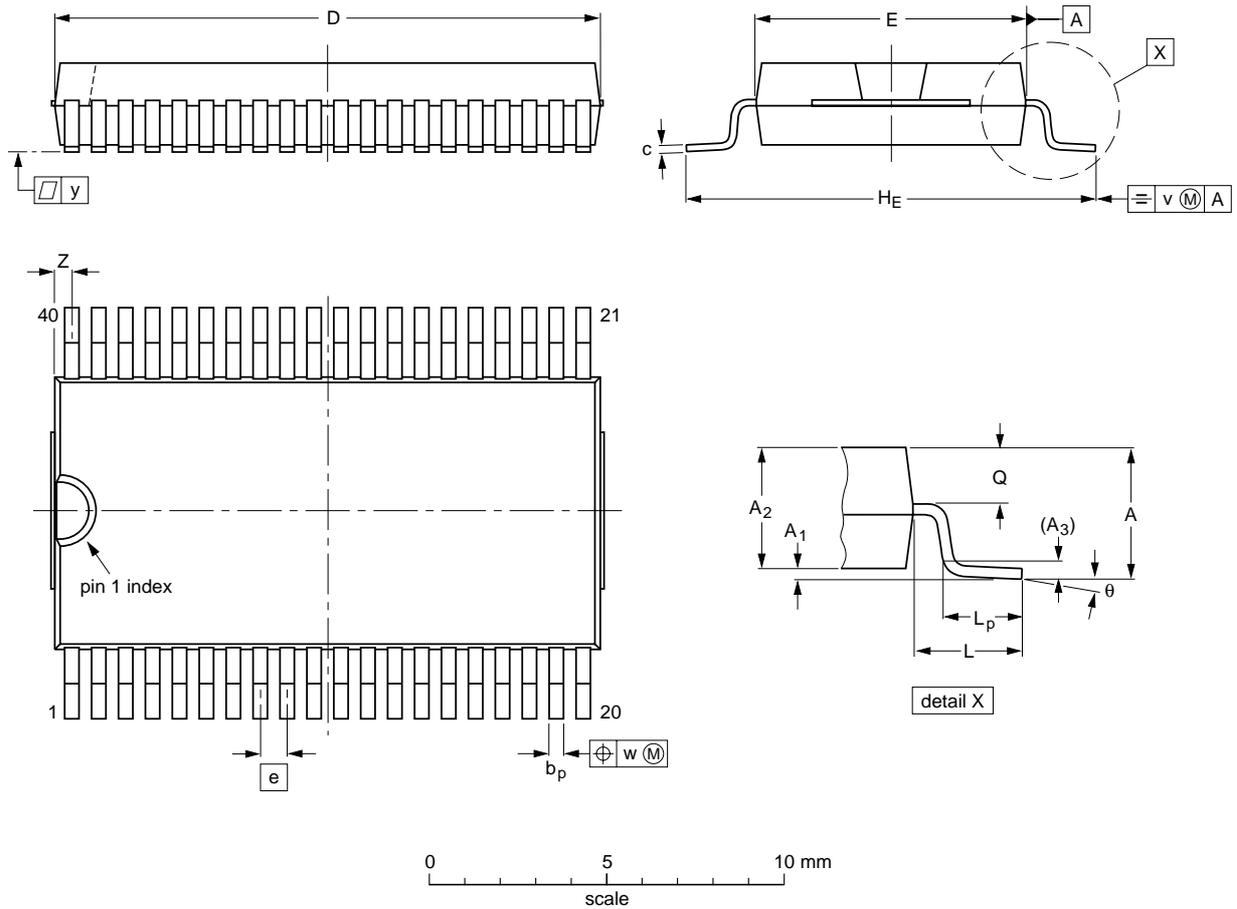
Universal LCD driver for low multiplex rates

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PACKAGE OUTLINE

VSO40: plastic very small outline package; 40 leads

SOT158-1



DIMENSIONS (inch dimensions are derived from the original mm 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 ⁽¹⁾ | θ |
|--------|--------|----------------|----------------|----------------|----------------|------------------|------------------|------------------|-------|----------------|-------|----------------|----------------|-------|-------|-------|------------------|----------|
| mm | 2.70 | 0.3 0.1 | 2.45 2.25 | 0.25 | 0.42 0.30 | 0.22 0.14 | 15.6 15.2 | 7.6 7.5 | 0.762 | 12.3 11.8 | 2.25 | 1.7 1.5 | 1.15 1.05 | 0.2 | 0.1 | 0.1 | 0.6 0.3 | 7° 0° |
| inches | 0.11 | 0.012 0.004 | 0.096 0.089 | 0.010 | 0.017 0.012 | 0.0087 0.0055 | 0.61 0.60 | 0.30 0.29 | 0.03 | 0.48 0.46 | 0.089 | 0.067 0.059 | 0.045 0.041 | 0.008 | 0.004 | 0.004 | 0.024 0.012 | |

Notes

1. Plastic or metal protrusions of 0.4 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 | EIAJ | | | |
| SOT158-1 | | | | | | 92-11-17 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 VSO 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 VSO 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.

Universal LCD driver for low multiplex rates

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DEFINITIONS

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

LIFE SUPPORT APPLICATIONS

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.

PURCHASE OF PHILIPS I²C COMPONENTS



Purchase of Philips I²C components conveys a license under the Philips' I²C patent to use the components in the I²C system provided the system conforms to the I²C specification defined by Philips. This specification can be ordered using the code 9398 393 40011.

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