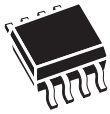
# M24128-BW M24128-BR M24128-BF M24128-DF

## 128-Kbit serial I²C bus EEPROM

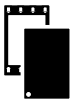
**Datasheet - production data**



TSSOP8 (DW)
169 mil width



SO8 (MN)
150 mil width



UFDFPN8
(MC)



WLCSP (CS)

## Features

- Compatible with all I²C bus modes:
  - 1 MHz
  - 400 kHz
  - 100 kHz
- Memory array:
  - 128 Kbit (16 Kbytes) of EEPROM
  - Page size: 64 bytes
  - Additional Write lockable page (M24128-D order codes)
- Single supply voltage and high speed:
  - 1 MHz clock from 1.7 V to 5.5 V
- Write:
  - Byte Write within 5 ms
  - Page Write within 5 ms
- Operating temperature range: from -40 °C up to +85 °C
- Random and sequential Read modes
- Write protect of the whole memory array
- Enhanced ESD/Latch-Up protection
- More than 4 million Write cycles
- More than 200-year data retention

### Packages

- PDIP8 ECOPACK1®
- SO8 ECOPACK2®
- TSSOP8 ECOPACK2®
- UFDFPN8 ECOPACK2®
- WLCSP ECOPACK2®



This is information on a product in full production. www.st.com

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# Contents


1 Description . . . . . 6

2 Signal description . . . . . 8

2.1 Serial Clock (SCL) . . . . . 8

2.2 Serial Data (SDA) . . . . . 8

2.3 Chip Enable (E2, E1, E0) . . . . . 8

2.4 Write Control ($\overline{WC}$) . . . . . 8

2.5 $V_{SS}$ (ground) . . . . . 8

2.6 Supply voltage ($V_{CC}$) . . . . . 9

2.6.1 Operating supply voltage ($V_{CC}$) . . . . . 9

2.6.2 Power-up conditions . . . . . 9

2.6.3 Device reset . . . . . 9

2.6.4 Power-down conditions . . . . . 9

3 Memory organization . . . . . 10

4 Device operation . . . . . 11

4.1 Start condition . . . . . 12

4.2 Stop condition . . . . . 12

4.3 Data input . . . . . 12

4.4 Acknowledge bit (ACK) . . . . . 12

4.5 Device addressing . . . . . 13

5 Instructions . . . . . 14

5.1 Write operations . . . . . 14

5.1.1 Byte Write . . . . . 15

5.1.2 Page Write . . . . . 16

5.1.3 Write Identification Page (M24128-D only) . . . . . 17

5.1.4 Lock Identification Page (M24128-D only) . . . . . 17

5.1.5 ECC (Error Correction Code) and Write cycling . . . . . 17

5.1.6 Minimizing Write delays by polling on ACK . . . . . 18

5.2 Read operations . . . . . 19

5.2.1 Random Address Read . . . . . 20




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Tel:150-1290-5940
Email:sales@manduic.com

5.2.2 Current Address Read . . . . . 20
5.2.3 Sequential Read . . . . . 20
5.3 Read Identification Page (M24128-D only) . . . . . 20
5.4 Read the lock status (M24128-D only) . . . . . 21

**6 Initial delivery state . . . . . 21**

**7 Maximum rating . . . . . 22**

**8 DC and AC parameters . . . . . 23**

**9 Package mechanical data . . . . . 32**

**10 Part numbering . . . . . 37**

**11 Revision history . . . . . 38**



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Tel:150-1290-5940
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# List of tables

Table 1. Signal names . . . 6
Table 2. Device select code . . . 13
Table 3. Most significant address byte . . . 14
Table 4. Least significant address byte . . . 14
Table 5. Absolute maximum ratings . . . 22
Table 6. Operating conditions (voltage range W) . . . 23
Table 7. Operating conditions (voltage range R) . . . 23
Table 8. Operating conditions (voltage range F) . . . 23
Table 9. AC measurement conditions . . . 23
Table 10. Input parameters . . . 24
Table 11. Cycling performance . . . 24
Table 12. Memory cell data retention . . . 24
Table 13. DC characteristics (M24128-BW, device grade 6) . . . 25
Table 14. DC characteristics (M24128-BR, device grade 6) . . . 26
Table 15. DC characteristics (M24128-BF, M24128-DF, device grade 6) . . . 27
Table 16. 400 kHz AC characteristics . . . 28
Table 17. 1 MHz AC characteristics . . . 29
Table 18. TSSOP8 – 8-lead thin shrink small outline, package mechanical data . . . 32
Table 19. SO8N – 8-lead plastic small outline, 150 mils body width, package data . . . 33
Table 20. UFDFPN8 (MLP8) – package dimensions (UFDFPN: Ultra thin Fine pitch Dual Flat Package, No lead) . . . 34
Table 21. M24128-DFCS6TP/K, WLCSP 8-bump wafer-level chip scale package mechanical data . . . 36
Table 22. Ordering information scheme . . . 37
Table 23. Document revision history . . . 38



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Email:sales@manduic.com

# List of figures

Figure 1. Logic diagram . . . 6
Figure 2. 8-pin package connections, top view . . . 6
Figure 3. WLCSP connections for the M24128-DFCS6TP/K (top view, marking side, with balls on the underside) . . . 7
Figure 4. Chip enable inputs connection . . . 8
Figure 5. Block diagram . . . 10
Figure 6. $I^2C$ bus protocol . . . 11
Figure 7. Write mode sequences with $\overline{WC}$ = 0 (data write enabled) . . . 15
Figure 8. Write mode sequences with $\overline{WC}$ = 1 (data write inhibited) . . . 16
Figure 9. Write cycle polling flowchart using ACK . . . 18
Figure 10. Read mode sequences . . . 19
Figure 11. AC measurement I/O waveform . . . 23
Figure 12. Maximum $R_{bus}$ value versus bus parasitic capacitance ($C_{bus}$) for an $I^2C$ bus at maximum frequency $f_C$ = 400 kHz . . . 30
Figure 13. Maximum $R_{bus}$ value versus bus parasitic capacitance $C_{bus}$) for an $I^2C$ bus at maximum frequency $f_C$ = 1MHz . . . 30
Figure 14. AC waveforms . . . 31
Figure 15. TSSOP8 – 8-lead thin shrink small outline, package outline . . . 32
Figure 16. SO8N – 8-lead plastic small outline, 150 mils body width, package outline . . . 33
Figure 17. UFDFPN8 (MLP8) – package outline (UFDFPN: Ultra thin Fine pitch Dual Flat Package, No lead) . . . 34
Figure 18. M24128-DFCS6TP/K, WLCSP 8-bump wafer-level chip scale package outline . . . 35



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# 1 Description

The M24128 is a 128-Kbit $I^2C$-compatible EEPROM (Electrically Erasable PROgrammable Memory) organized as 16 K × 8 bits.

The M24128-BW can operate with a supply voltage from 2.5 V to 5.5 V, the M24128-BR can operate with a supply voltage from 1.8 V to 5.5 V, and the M24128-BF and M24128-DF can operate with a supply voltage from 1.7 V to 5.5 V. All these devices operate with a clock frequency of 1 MHz (or less), over an ambient temperature range of –40 °C / +85 °C.The M24128-Dx offers an additional page, named the Identification Page (64 bytes). The Identification Page can be used to store sensitive application parameters which can be (later) permanently locked in Read-only mode.

**Figure 1. Logic diagram**

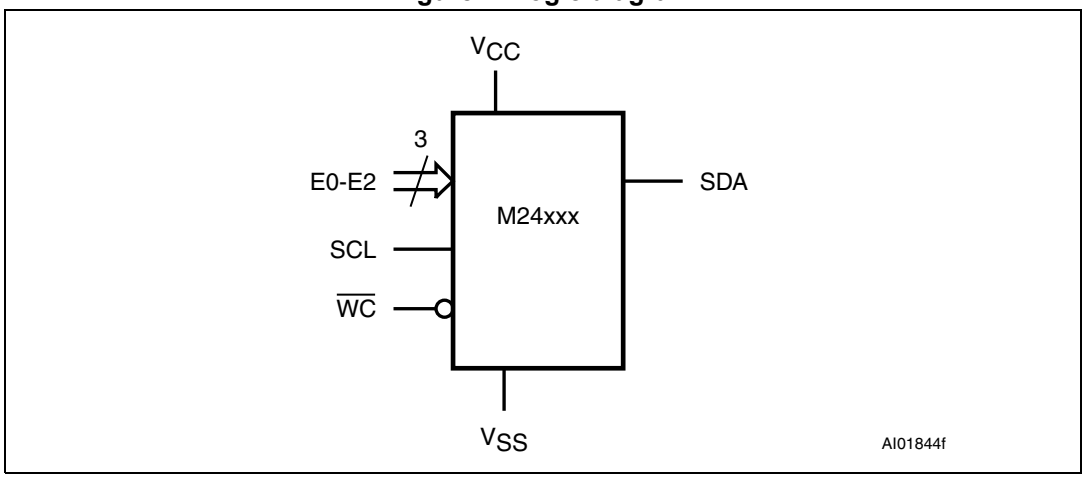
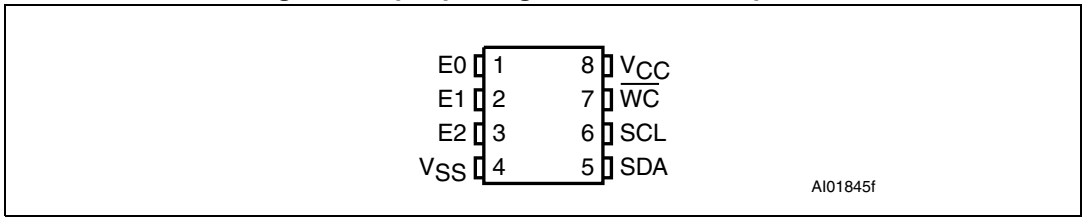



**Table 1. Signal names**

| Signal name | Function | Direction |
|---|---|---|
| E2, E1, E0 | Chip Enable | Input |
| SDA | Serial Data | I/O |
| SCL | Serial Clock | Input |
| $\overline{WC}$ | Write Control | Input |
| $V_{CC}$ | Supply voltage | - |
| $V_{SS}$ | Ground | - |

**Figure 2. 8-pin package connections, top view**

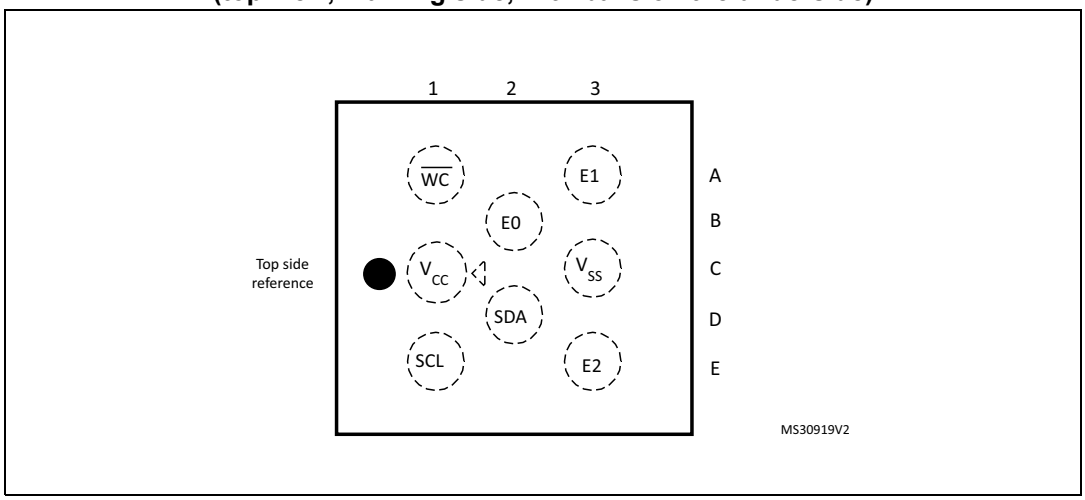



1. See *Section 9: Package mechanical data* for package dimensions, and how to identify pin 1.



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**Figure 3. WLCSP connections for the M24128-DFCS6TP/K (top view, marking side, with balls on the underside)**




**Caution:** As EEPROM cells lose their charge (and so their binary value) when exposed to ultra violet (UV) light, EEPROM dice delivered in wafer form or in WLCSP package by STMicroelectronics must never be exposed to UV light.



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# 2 Signal description

## 2.1 Serial Clock (SCL)

The signal applied on the SCL input is used to strobe the data available on SDA(in) and to output the data on SDA(out).

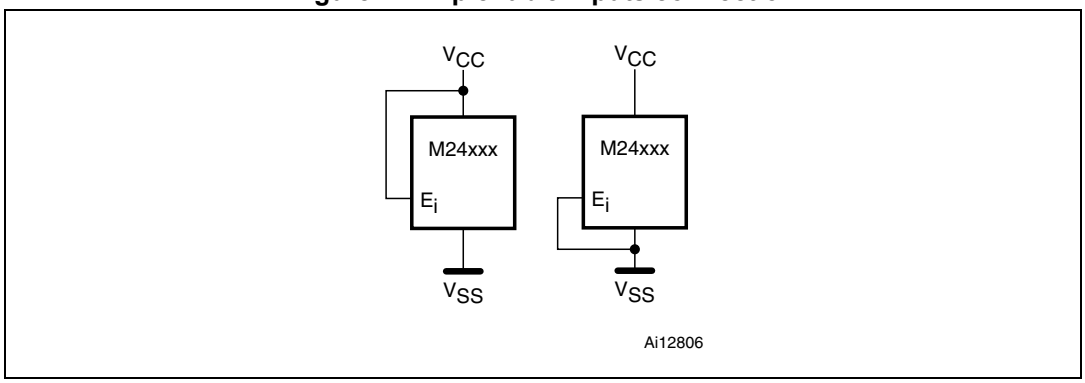
## 2.2 Serial Data (SDA)

SDA is an input/output used to transfer data in or data out of the device. SDA(out) is an open drain output that may be wire-OR'ed with other open drain or open collector signals on the bus. A pull-up resistor must be connected from Serial Data (SDA) to $V_{CC}$ (*Figure 12* indicates how to calculate the value of the pull-up resistor).

## 2.3 Chip Enable (E2, E1, E0)

(E2,E1,E0) input signals are used to set the value that is to be looked for on the three least significant bits (b3, b2, b1) of the 7-bit device select code (see *Table 2*). These inputs must be tied to $V_{CC}$ or $V_{SS}$, as shown in *Figure 4*. When not connected (left floating), these inputs are read as low (0).

**Figure 4. Chip enable inputs connection**




## 2.4 Write Control ($\overline{WC}$)

This input signal is useful for protecting the entire contents of the memory from inadvertent write operations. Write operations are disabled to the entire memory array when Write Control ($\overline{WC}$) is driven high. Write operations are enabled when Write Control ($\overline{WC}$) is either driven low or left floating.

When Write Control ($\overline{WC}$) is driven high, device select and address bytes are acknowledged, Data bytes are not acknowledged.

## 2.5 $V_{SS}$ (ground)

$V_{SS}$ is the reference for the $V_{CC}$ supply voltage.



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## 2.6 Supply voltage ($V_{CC}$)

### 2.6.1 Operating supply voltage ($V_{CC}$)

Prior to selecting the memory and issuing instructions to it, a valid and stable $V_{CC}$ voltage within the specified [$V_{CC}$(min), $V_{CC}$(max)] range must be applied (see Operating conditions in *Section 8: DC and AC parameters)*. In order to secure a stable DC supply voltage, it is recommended to decouple the $V_{CC}$ line with a suitable capacitor (usually of the order of 10 nF to 100 nF) close to the $V_{CC}$/$V_{SS}$ package pins.

This voltage must remain stable and valid until the end of the transmission of the instruction and, for a write instruction, until the completion of the internal write cycle ($t_W$).

### 2.6.2 Power-up conditions

The $V_{CC}$ voltage has to rise continuously from 0 V up to the minimum $V_{CC}$ operating voltage (see Operating conditions in *Section 8: DC and AC parameters)* and the rise time must not vary faster than 1 V/µs.

### 2.6.3 Device reset

In order to prevent inadvertent write operations during power-up, a power-on-reset (POR) circuit is included.

At power-up, the device does not respond to any instruction until $V_{CC}$ has reached the internal reset threshold voltage. This threshold is lower than the minimum $V_{CC}$ operating voltage (see Operating conditions in *Section 8: DC and AC parameters*). When $V_{CC}$ passes over the POR threshold, the device is reset and enters the Standby Power mode; however, the device must not be accessed until $V_{CC}$ reaches a valid and stable DC voltage within the specified [$V_{CC}$(min), $V_{CC}$(max)] range (see Operating conditions in *Section 8: DC and AC parameters*).

In a similar way, during power-down (continuous decrease in $V_{CC}$), the device must not be accessed when $V_{CC}$ drops below $V_{CC}$(min). When $V_{CC}$ drops below the power-on-reset threshold voltage, the device stops responding to any instruction sent to it.

### 2.6.4 Power-down conditions

During power-down (continuous decrease in $V_{CC}$), the device must be in the Standby Power mode (mode reached after decoding a Stop condition, assuming that there is no internal write cycle in progress).

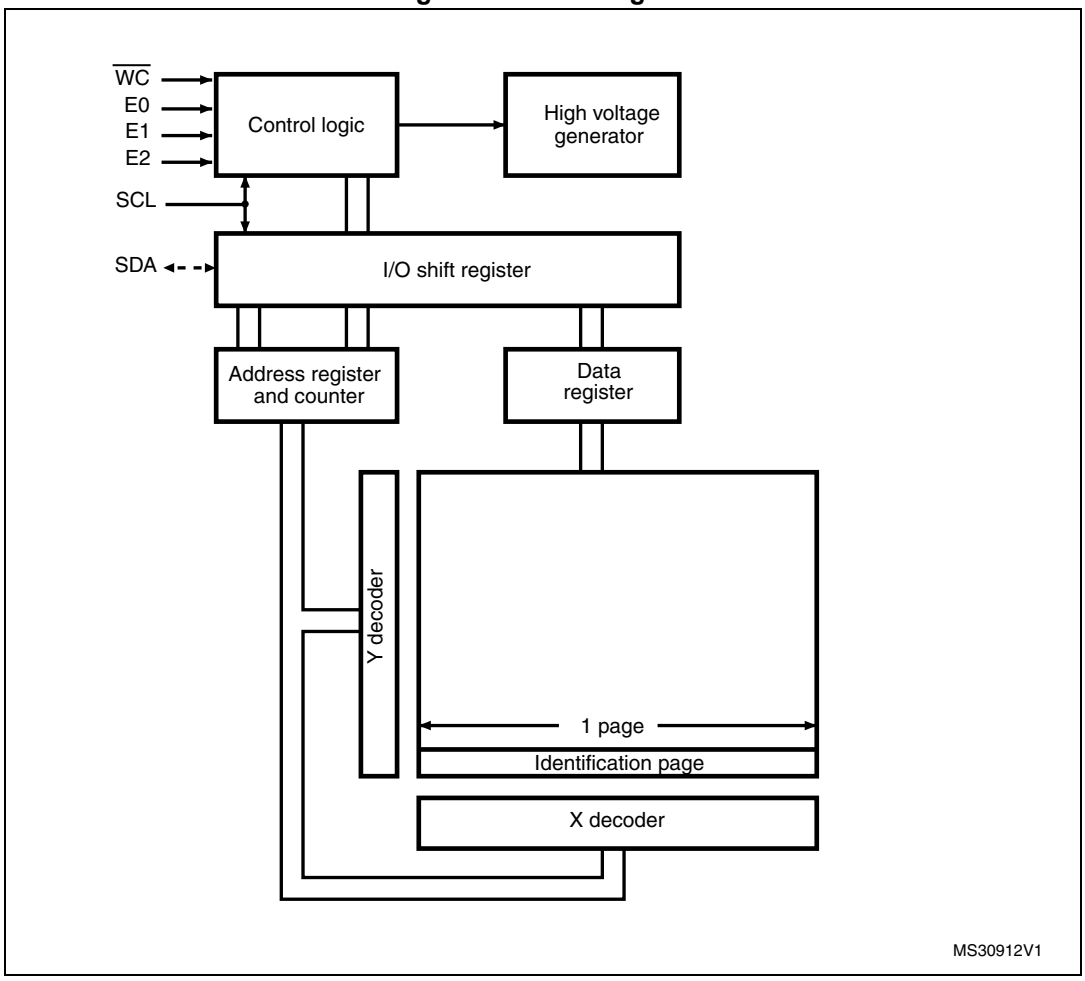


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# 3 Memory organization

The memory is organized as shown below.

**Figure 5. Block diagram**



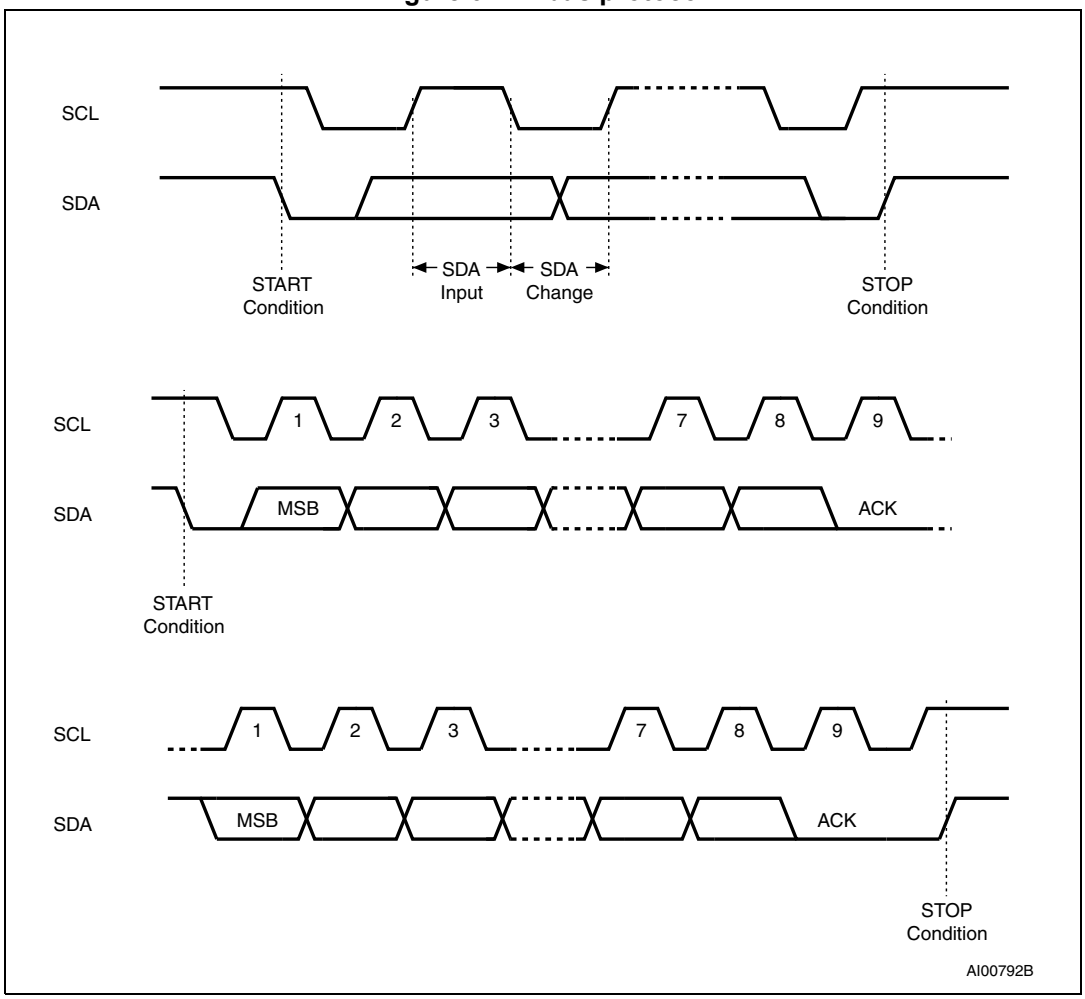



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# 4 Device operation

The device supports the $I^2C$ protocol. This is summarized in *Figure 6*. Any device that sends data on to the bus is defined to be a transmitter, and any device that reads the data to be a receiver. The device that controls the data transfer is known as the bus master, and the other as the slave device. A data transfer can only be initiated by the bus master, which will also provide the serial clock for synchronization. The device is always a slave in all communications.

**Figure 6. $I^2C$ bus protocol**






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## 4.1 Start condition

Start is identified by a falling edge of Serial Data (SDA) while Serial Clock (SCL) is stable in the high state. A Start condition must precede any data transfer instruction. The device continuously monitors (except during a Write cycle) Serial Data (SDA) and Serial Clock (SCL) for a Start condition.

## 4.2 Stop condition

Stop is identified by a rising edge of Serial Data (SDA) while Serial Clock (SCL) is stable and driven high. A Stop condition terminates communication between the device and the bus master. A Read instruction that is followed by NoAck can be followed by a Stop condition to force the device into the Standby mode.

A Stop condition at the end of a Write instruction triggers the internal Write cycle.

## 4.3 Data input

During data input, the device samples Serial Data (SDA) on the rising edge of Serial Clock (SCL). For correct device operation, Serial Data (SDA) must be stable during the rising edge of Serial Clock (SCL), and the Serial Data (SDA) signal must change *only* when Serial Clock (SCL) is driven low.

## 4.4 Acknowledge bit (ACK)

The acknowledge bit is used to indicate a successful byte transfer. The bus transmitter, whether it be bus master or slave device, releases Serial Data (SDA) after sending eight bits of data. During the $9^{th}$ clock pulse period, the receiver pulls Serial Data (SDA) low to acknowledge the receipt of the eight data bits.



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## 4.5 Device addressing

To start communication between the bus master and the slave device, the bus master must initiate a Start condition. Following this, the bus master sends the device select code, shown in *Table 2* (on Serial Data (SDA), most significant bit first).

**Table 2. Device select code**

| | Device type identifier(1) | | | | Chip Enable address(2) | | | RW |
|---|---|---|---|---|---|---|---|---|
| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
| Device select code when addressing the memory array | 1 | 0 | 1 | 0 | E2 | E1 | E0 | RW |
| Device select code when accessing the Identification page | 1 | 0 | 1 | 1 | E2 | E1 | E0 | RW |

1. The most significant bit, b7, is sent first.
2. E0, E1 and E2 are compared with the value read on input pins E0, E1,and E2.

When the device select code is received, the device only responds if the Chip Enable Address is the same as the value on the Chip Enable (E2, E1, E0) inputs.

The 8th bit is the Read/Write bit (RW). This bit is set to 1 for Read and 0 for Write operations.

If a match occurs on the device select code, the corresponding device gives an acknowledgment on Serial Data (SDA) during the 9th bit time. If the device does not match the device select code, it deselects itself from the bus, and goes into Standby mode.



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# 5 Instructions

## 5.1 Write operations

Following a Start condition the bus master sends a device select code with the R/$\overline{W}$ bit (R$\overline{W}$) reset to 0. The device acknowledges this, as shown in *Figure 7*, and waits for two address bytes. The device responds to each address byte with an acknowledge bit, and then waits for the data byte.

**Table 3. Most significant address byte**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A15 | A14 | A13 | A12 | A11 | A10 | A9 | A8 |

**Table 4. Least significant address byte**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0 |

When the bus master generates a Stop condition immediately after a data byte Ack bit (in the “$10^{th}$ bit” time slot), either at the end of a Byte Write or a Page Write, the internal Write cycle $t_W$ is triggered. A Stop condition at any other time slot does not trigger the internal Write cycle.

After the Stop condition and the successful completion of an internal Write cycle ($t_W$), the device internal address counter is automatically incremented to point to the next byte after the last modified byte.

During the internal Write cycle, Serial Data (SDA) is disabled internally, and the device does not respond to any requests.

If the Write Control input (WC) is driven High, the Write instruction is not executed and the accompanying data bytes are *not* acknowledged, as shown in *Figure 8*.

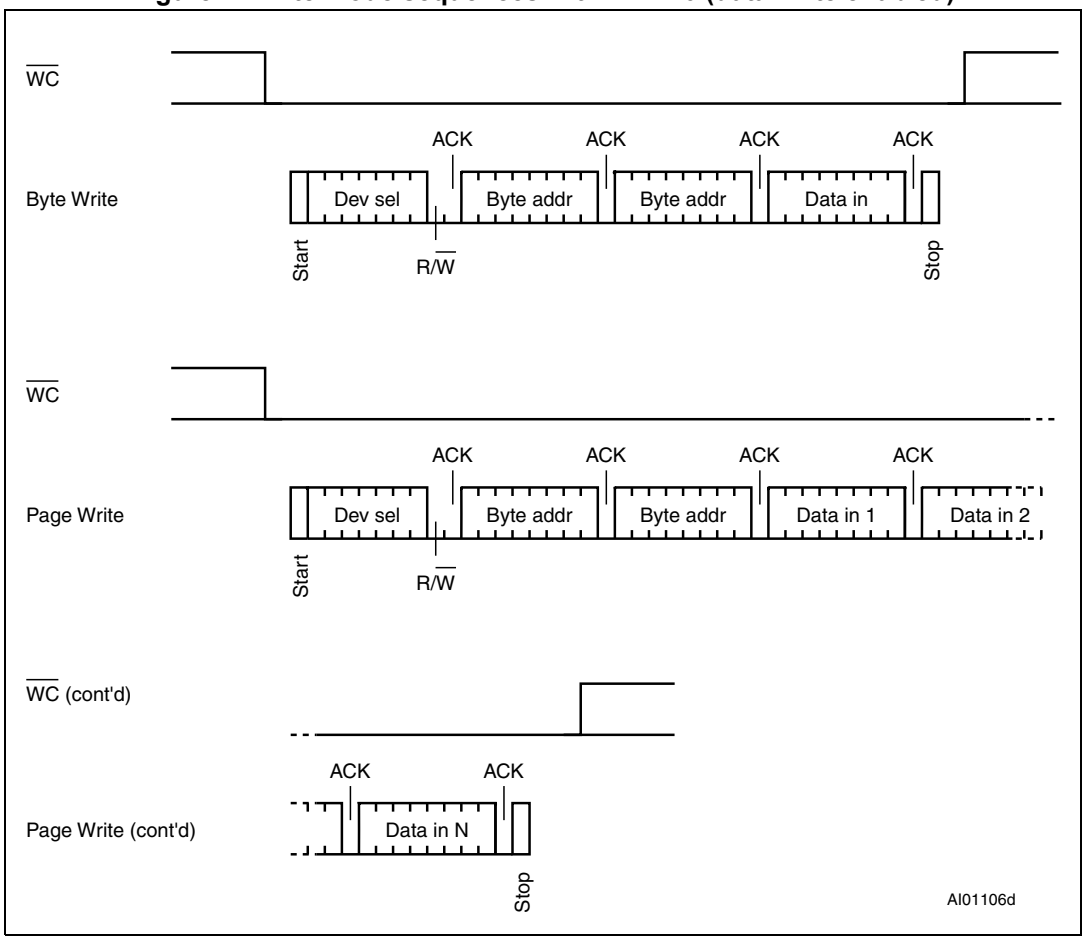


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### 5.1.1 Byte Write

After the device select code and the address bytes, the bus master sends one data byte. If the addressed location is Write-protected, by Write Control ($\overline{WC}$) being driven high, the device replies with NoAck, and the location is not modified. If, instead, the addressed location is not Write-protected, the device replies with Ack. The bus master terminates the transfer by generating a Stop condition, as shown in *Figure 7*.

**Figure 7. Write mode sequences with $\overline{WC}$ = 0 (data write enabled)**






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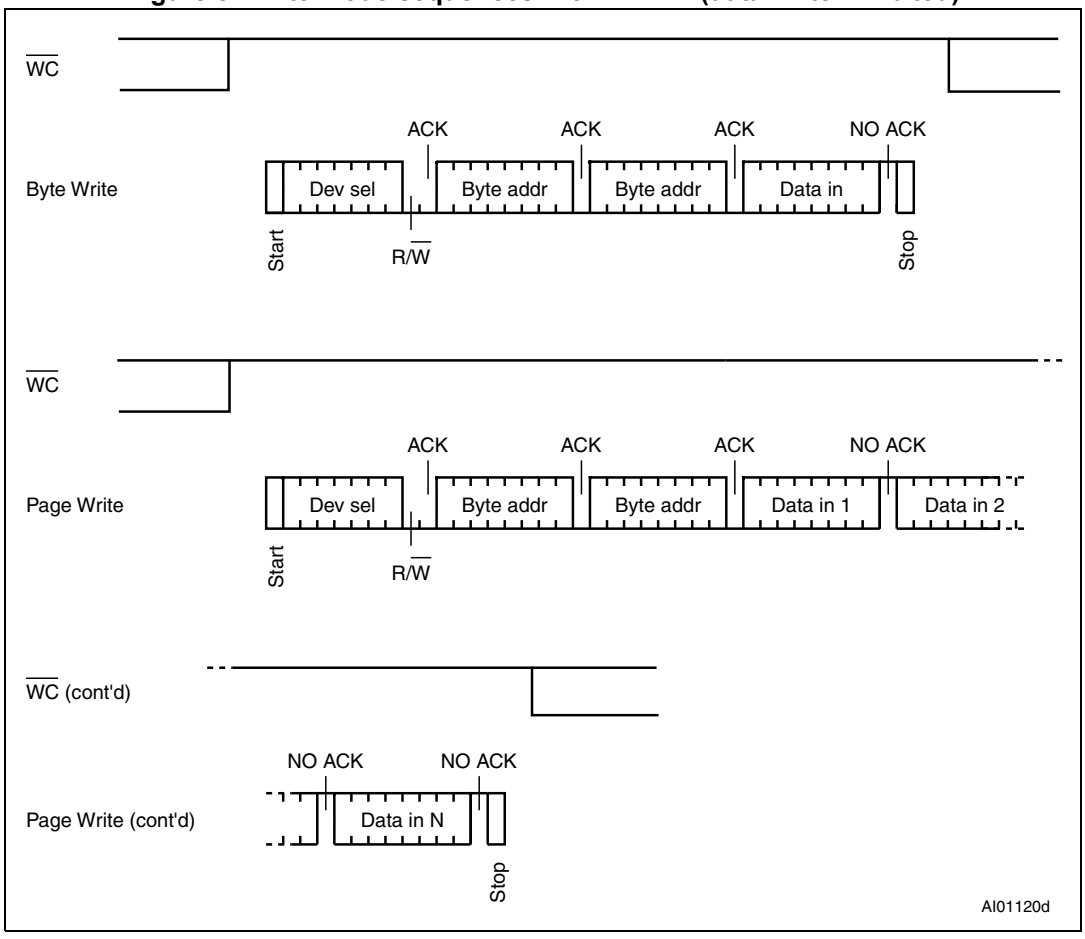
### 5.1.2 Page Write

The Page Write mode allows up to 64 bytes to be written in a single Write cycle, provided that they are all located in the same page in the memory: that is, the most significant memory address bits, A15/A6, are the same. If more bytes are sent than will fit up to the end of the page, a “roll-over” occurs, i.e. the bytes exceeding the page end are written on the same page, from location 0.

The bus master sends from 1 to 64 bytes of data, each of which is acknowledged by the device if Write Control ($\overline{WC}$) is low. If Write Control ($\overline{WC}$) is high, the contents of the addressed memory location are not modified, and each data byte is followed by a NoAck, as shown in *Figure 8*. After each transferred byte, the internal page address counter is incremented.

The transfer is terminated by the bus master generating a Stop condition.

**Figure 8. Write mode sequences with $\overline{WC}$ = 1 (data write inhibited)**






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### 5.1.3 Write Identification Page (M24128-D only)

The Identification Page (64 bytes) is an additional page which can be written and (later) permanently locked in Read-only mode. It is written by issuing the Write Identification Page instruction. This instruction uses the same protocol and format as Page Write (into memory array), except for the following differences:

- Device type identifier = 1011b
- MSB address bits A15/A6 are don't care except for address bit A10 which must be ‘0’. LSB address bits A5/A0 define the byte address inside the Identification page.

If the Identification page is locked, the data bytes transferred during the Write Identification Page instruction are not acknowledged (NoAck).

### 5.1.4 Lock Identification Page (M24128-D only)

The Lock Identification Page instruction (Lock ID) permanently locks the Identification page in Read-only mode. The Lock ID instruction is similar to Byte Write (into memory array) with the following specific conditions:

- Device type identifier = 1011b
- Address bit A10 must be ‘1’; all other address bits are don't care
- The data byte must be equal to the binary value xxxx xx1x, where x is don't care

### 5.1.5 ECC (Error Correction Code) and Write cycling

The Error Correction Code (ECC) is an internal logic function which is transparent for the $I^2C$ communication protocol.

The ECC logic is implemented on each group of four EEPROM bytes[a]. Inside a group, if a single bit out of the four bytes happens to be erroneous during a Read operation, the ECC detects this bit and replaces it with the correct value. The read reliability is therefore much improved.

Even if the ECC function is performed on groups of four bytes, a single byte can be written/cycled independently. In this case, the ECC function also writes/cycles the three other bytes located in the same group[a]. As a consequence, the maximum cycling budget is defined at group level and the cycling can be distributed over the 4 bytes of the group: the sum of the cycles seen by byte0, byte1, byte2 and byte3 of the same group must remain below the maximum value defined *Table 11: Cycling performance*.

a. A group of four bytes is located at addresses [4*N, 4*N+1, 4*N+2, 4*N+3], where N is an integer.



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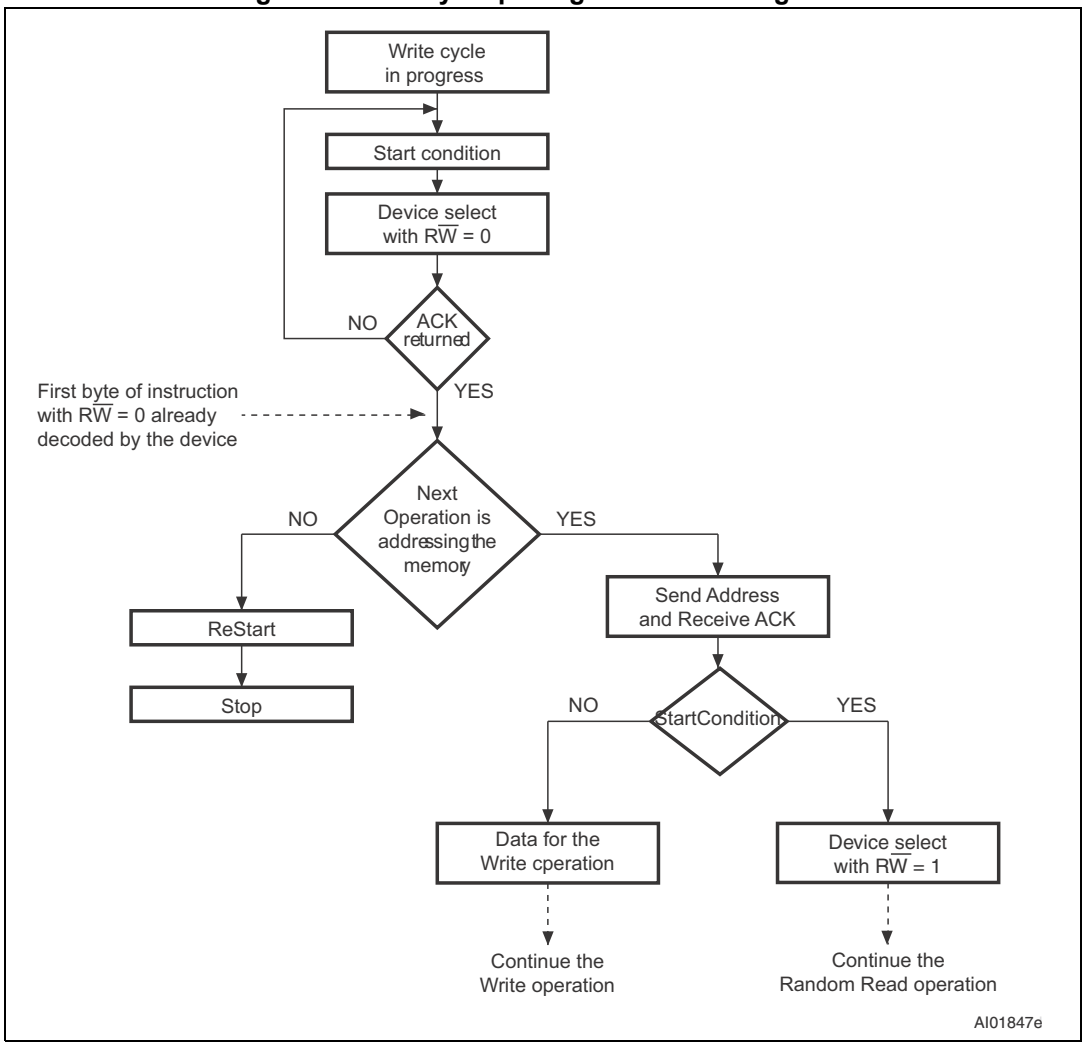
### 5.1.6 Minimizing Write delays by polling on ACK

The maximum Write time ($t_w$) is shown in AC characteristics tables in *Section 8: DC and AC parameters*, but the typical time is shorter. To make use of this, a polling sequence can be used by the bus master.

The sequence, as shown in *Figure 9*, is:

- Initial condition: a Write cycle is in progress.
- Step 1: the bus master issues a Start condition followed by a device select code (the first byte of the new instruction).
- Step 2: if the device is busy with the internal Write cycle, no Ack will be returned and the bus master goes back to Step 1. If the device has terminated the internal Write cycle, it responds with an Ack, indicating that the device is ready to receive the second part of the instruction (the first byte of this instruction having been sent during Step 1).

**Figure 9. Write cycle polling flowchart using ACK**




1. The seven most significant bits of the Device Select code of a Random Read (bottom right box in the figure) must be identical to the seven most significant bits of the Device Select code of the Write (polling instruction in the figure).



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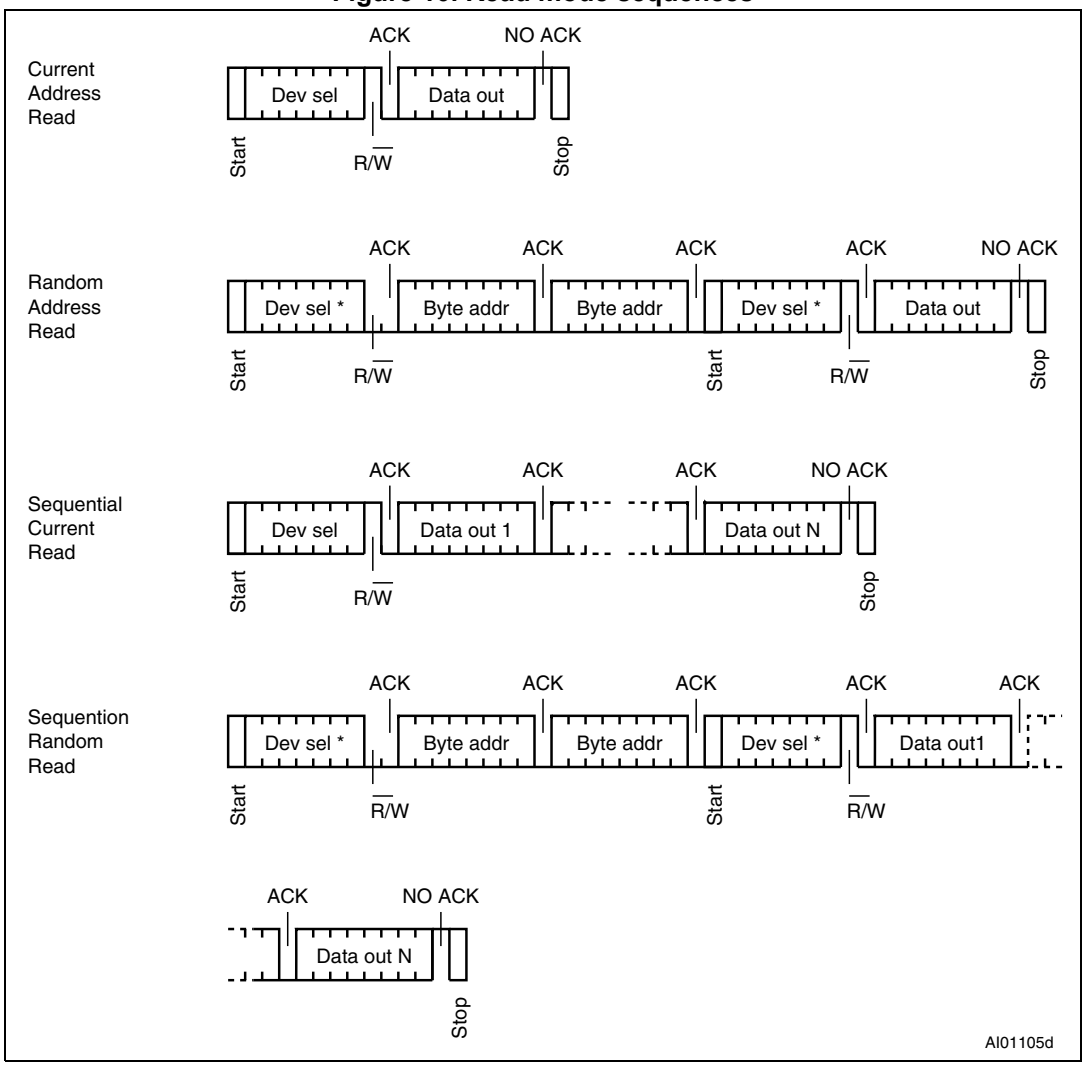
## 5.2 Read operations

Read operations are performed independently of the state of the Write Control ($\overline{WC}$) signal.

After the successful completion of a Read operation, the device internal address counter is incremented by one, to point to the next byte address.

For the Read instructions, after each byte read (data out), the device waits for an acknowledgment (data in) during the 9th bit time. If the bus master does not acknowledge during this 9th time, the device terminates the data transfer and switches to its Standby mode.

**Figure 10. Read mode sequences**






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### 5.2.1 Random Address Read

A dummy Write is first performed to load the address into this address counter (as shown in *Figure 10*) but *without* sending a Stop condition. Then, the bus master sends another Start condition, and repeats the device select code, with the RW bit set to 1. The device acknowledges this, and outputs the contents of the addressed byte. The bus master must *not* acknowledge the byte, and terminates the transfer with a Stop condition.

### 5.2.2 Current Address Read

For the Current Address Read operation, following a Start condition, the bus master only sends a device select code with the R/W bit set to 1. The device acknowledges this, and outputs the byte addressed by the internal address counter. The counter is then incremented. The bus master terminates the transfer with a Stop condition, as shown in *Figure 10*, *without* acknowledging the byte.

Note that the address counter value is defined by instructions accessing either the memory or the Identification page. When accessing the Identification page, the address counter value is loaded with the byte location in the Identification page, therefore the next Current Address Read in the memory uses this new address counter value. When accessing the memory, it is safer to always use the Random Address Read instruction (this instruction loads the address counter with the byte location to read in the memory, see *Section 5.2.1*) instead of the Current Address Read instruction.

### 5.2.3 Sequential Read

This operation can be used after a Current Address Read or a Random Address Read. The bus master *does* acknowledge the data byte output, and sends additional clock pulses so that the device continues to output the next byte in sequence. To terminate the stream of bytes, the bus master must *not* acknowledge the last byte, and *must* generate a Stop condition, as shown in *Figure 10*.

The output data comes from consecutive addresses, with the internal address counter automatically incremented after each byte output. After the last memory address, the address counter “rolls-over”, and the device continues to output data from memory address 00h.

## 5.3 Read Identification Page (M24128-D only)

The Identification Page (64 bytes) is an additional page which can be written and (later) permanently locked in Read-only mode.

The Identification Page can be read by issuing an Read Identification Page instruction. This instruction uses the same protocol and format as the Random Address Read (from memory array) with device type identifier defined as 1011b. The MSB address bits A15/A6 are don't care, the LSB address bits A5/A0 define the byte address inside the Identification Page. The number of bytes to read in the ID page must not exceed the page boundary (e.g.: when reading the Identification Page from location 10d, the number of bytes should be less than or equal to 54, as the ID page boundary is 64 bytes).



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## 5.4 Read the lock status (M24128-D only)

The locked/unlocked status of the Identification page can be checked by transmitting a specific truncated command [Identification Page Write instruction + one data byte] to the device. The device returns an acknowledge bit if the Identification page is unlocked, otherwise a NoAck bit if the Identification page is locked.

Right after this, it is recommended to transmit to the device a Start condition followed by a Stop condition, so that:

- Start: the truncated command is not executed because the Start condition resets the device internal logic,
- Stop: the device is then set back into Standby mode by the Stop condition.

# 6 Initial delivery state

The device is delivered with all the memory array bits and Identification page bits set to 1 (each byte contains FFh).



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# 7 Maximum rating

Stressing the device outside the ratings listed in *Table 5* may cause permanent damage to the device. These are stress ratings only, and operation of the device at these, or any other conditions outside those indicated in the operating sections of this specification, is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**Table 5. Absolute maximum ratings**

| Symbol | Parameter | Min. | Max. | Unit |
|---|---|---|---|---|
| | Ambient operating temperature | –40 | 130 | °C |
| $T_{STG}$ | Storage temperature | –65 | 150 | °C |
| $T_{LEAD}$ | Lead temperature during soldering | see note (1) | | °C |
| $I_{OL}$ | DC output current (SDA = 0) | - | 5 | mA |
| $V_{IO}$ | Input or output range | –0.50 | 6.5 | V |
| $V_{CC}$ | Supply voltage | –0.50 | 6.5 | V |
| $V_{ESD}$ | Electrostatic pulse (Human Body model)(2) | - | 4000 | V |

1. Compliant with JEDEC Std J-STD-020D (for small body, Sn-Pb or Pb-free assembly), the ST ECOPACK® 7191395 specification, and the European directive on Restrictions of Hazardous Substances (RoHS directive 2011/65/EU of July 2011).
2. Positive and negative pulses applied on different combinations of pin connections, according to AEC-Q100-002 (compliant with JEDEC Std JESD22-A114, C1=100 pF, R1=1500 Ω).



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# 8 DC and AC parameters

This section summarizes the operating and measurement conditions, and the DC and AC characteristics of the device.

**Table 6. Operating conditions (voltage range W)**

| Symbol | Parameter | Min. | Max. | Unit |
|---|---|---|---|---|
| $V_{CC}$ | Supply voltage | 2.5 | 5.5 | V |
| $T_A$ | Ambient operating temperature | –40 | 85 | °C |
| $f_C$ | Operating clock frequency | - | 1 | MHz |

**Table 7. Operating conditions (voltage range R)**

| Symbol | Parameter | Min. | Max. | Unit |
|---|---|---|---|---|
| $V_{CC}$ | Supply voltage | 1.8 | 5.5 | V |
| $T_A$ | Ambient operating temperature | –40 | 85 | °C |
| $f_C$ | Operating clock frequency | - | 1 | MHz |

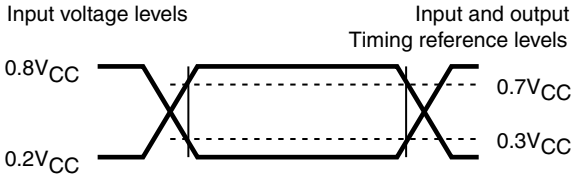
**Table 8. Operating conditions (voltage range F)**

| Symbol | Parameter | Min. | Max. | Unit |
|---|---|---|---|---|
| $V_{CC}$ | Supply voltage | 1.7 | 5.5 | V |
| $T_A$ | Ambient operating temperature | –40 | 85 | °C |
| $f_C$ | Operating clock frequency | - | 1 | MHz |

**Table 9. AC measurement conditions**

| Symbol | Parameter | Min. | Max. | Unit |
|---|---|---|---|---|
| $C_{bus}$ | Load capacitance | 100 | | pF |
| | SCL input rise/fall time, SDA input fall time | - | 50 | ns |
| | Input levels | 0.2 $V_{CC}$ to 0.8 $V_{CC}$ | | V |
| | Input and output timing reference levels | 0.3 $V_{CC}$ to 0.7 $V_{CC}$ | | V |

**Figure 11. AC measurement I/O waveform**






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**Table 10. Input parameters**

| Symbol | Parameter[1] | Test condition | Min. | Max. | Unit |
|---|---|---|---|---|---|
| $C_{IN}$ | Input capacitance (SDA) | - | - | 8 | pF |
| $C_{IN}$ | Input capacitance (other pins) | - | - | 6 | pF |
| $Z_L$ | Input impedance (E2, E1, E0, $\overline{WC}$)[2] | $V_{IN} < 0.3\ V_{CC}$ | 50 | - | kΩ |
| $Z_H$ | | $V_{IN} > 0.7\ V_{CC}$ | 500 | - | kΩ |

1. Characterized only, not tested in production.
2. E2, E1, E0 input impedance when the memory is selected (after a Start condition).

**Table 11. Cycling performance**

| Symbol | Parameter | Test condition[1] | Max. | Unit |
|---|---|---|---|---|
| Ncycle | Write cycle endurance[2] | $T_A \leq 25$ °C, $V_{CC}(min) < V_{CC} < V_{CC}(max)$ | 4,000,000 | Write cycle[3] |
| | | $T_A = 85$ °C, $V_{CC}(min) < V_{CC} < V_{CC}(max)$ | 1,200,000 | |

1. Cycling performance for products identified by process letter K.
2. The write cycle endurance is defined for group of four bytes located at addresses [4*N, 4*N+1, 4*N+2, 4*N+3] where N is an integer. The Write cycle endurance is defined by characterization and qualification.
3. A Write cycle is executed when either a Page Write, a Byte write, a Write Identification Page or a Lock Identification Page instruction is decoded. When using the Byte Write, the Page Write or the WRite Identification Page, refer also to *Section 5.1.5: ECC (Error Correction Code) and Write cycling*

**Table 12. Memory cell data retention**

| Parameter | Test condition | Min. | Unit |
|---|---|---|---|
| Data retention[1] | $T_A = 55$ °C | 200 | Year |

1. For products identified by process letter K . The data retention behavior is checked in production, while the 200-year limit is defined from characterization and qualification results.



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**Table 13. DC characteristics (M24128-BW, device grade 6)**

| Symbol | Parameter | Test conditions (in addition to those in *Table 6*) | Min. | Max. | Unit |
|---|---|---|---|---|---|
| $I_{LI}$ | Input leakage current (SCL, SDA, E2, E1, E0) | $V_{IN} = V_{SS}$ or $V_{CC}$, device in Standby mode | - | ± 2 | µA |
| $I_{LO}$ | Output leakage current | SDA in Hi-Z, external voltage applied on SDA: $V_{SS}$ or $V_{CC}$ | - | ± 2 | µA |
| $I_{CC}$ | Supply current (Read) | $V_{CC}$ = 2.5 V, $f_c$ = 400 kHz (rise/fall time < 50 ns) | - | 1(1) | mA |
| | | $V_{CC}$ = 5.5 V, $f_c$ = 400 kHz (rise/fall time < 50 ns) | - | 2 | mA |
| | | 2.5 V < $V_{CC}$ < 5.5 V, $f_c$ = 1 MHz(2) (rise/fall time < 50 ns) | - | 2.5 | mA |
| $I_{CC0}$ | Supply current (Write) | During $t_W$, 2.5 V ≤ $V_{CC}$ ≤ 5.5 V | - | 2(3)(4) | mA |
| $I_{CC1}$ | Standby supply current | Device not selected(5), $V_{IN} = V_{SS}$ or $V_{CC}$, $V_{CC}$ = 2.5 V | - | 2 | µA |
| | | Device not selected(5), $V_{IN} = V_{SS}$ or $V_{CC}$, $V_{CC}$ = 5.5 V | - | 3 | µA |
| $V_{IL}$ | Input low voltage (SCL, SDA, $\overline{WC}$, E2, E1, E0)(6) | - | –0.45 | 0.3 $V_{CC}$ | V |
| $V_{IH}$ | Input high voltage (SCL, SDA) | - | 0.7 $V_{CC}$ | 6.5 | V |
| | Input high voltage ($\overline{WC}$, E2, E1, E0)(7) | - | 0.7 $V_{CC}$ | $V_{CC}$+0.6 | V |
| $V_{OL}$ | Output low voltage | $I_{OL}$ = 2.1 mA, $V_{CC}$ = 2.5 V or $I_{OL}$ = 3 mA, $V_{CC}$ = 5.5 V | - | 0.4 | V |

1. 2 mA for previous devices identified by process letter A.
2. Only for devices identified by process letter K (devices operating at $f_C$ max = 1 MHz, see *Table 17*).
3. Characterized value, not tested in production.
4. 5 mA for previous devices identified by process letter A.
5. The device is not selected after power-up, after a Read instruction (after the Stop condition), or after the completion of the internal write cycle $t_W$ ($t_W$ is triggered by the correct decoding of a Write instruction).
6. $E_i$ inputs should be tied to $V_{ss}$ (see *Section 2.3*).
7. $E_i$ inputs should be tied to $V_{cc}$ (see *Section 2.3*).



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**Table 14. DC characteristics (M24128-BR, device grade 6)**

| Symbol | Parameter | Test conditions(1) (in addition to those in *Table 7*) | Min. | Max. | Unit |
|---|---|---|---|---|---|
| $I_{LI}$ | Input leakage current (E0, E1, E2, SCL, SDA) | $V_{IN}$ = $V_{SS}$ or $V_{CC}$, device in Standby mode | - | ± 2 | µA |
| $I_{LO}$ | Output leakage current | SDA in Hi-Z, external voltage applied on SDA: $V_{SS}$ or $V_{CC}$ | - | ± 2 | µA |
| $I_{CC}$ | Supply current (Read) | $V_{CC}$ = 1.8 V, $f_c$= 400 kHz | - | 0.8 | mA |
| | | $f_c$= 1 MHz(2) | - | 2.5 | mA |
| $I_{CC0}$ | Supply current (Write) | During $t_W$, 1.8 V ≤$V_{CC}$ ≤2.5 V | - | 2(3)(4) | mA |
| $I_{CC1}$ | Standby supply current | Device not selected(5), $V_{IN}$ = $V_{SS}$ or $V_{CC}$, $V_{CC}$ = 1.8 V | - | 1 | µA |
| $V_{IL}$ | Input low voltage (SCL, SDA, $\overline{WC}$, E2, E1, E0)(6) | 1.8 V ≤ $V_{CC}$ < 2.5 V | –0.45 | 0.25 $V_{CC}$ | V |
| $V_{IH}$ | Input high voltage (SCL, SDA) | 1.8 V ≤ $V_{CC}$ < 2.5 V | 0.75 $V_{CC}$ | 6.5 | V |
| | Input high voltage ($\overline{WC}$, E2, E1, E0)(7) | 1.8 V ≤ $V_{CC}$ < 2.5 V | 0.75 $V_{CC}$ | $V_{CC}$+ 0.6 | V |
| $V_{OL}$ | Output low voltage | $I_{OL}$ = 1 mA, $V_{CC}$ = 1.8 V(8) | - | 0.2 | V |

1. If the application uses the voltage range R device with 2.5 V < $V_{cc}$ < 5.5 V and -40 °C < $T_A$ < +85 °C, please refer to *Table 13* instead of this table.
2. Only for devices identified with process letter K.
3. Characterized value, not tested in production.
4. 3 mA for previous devices identified by process letter A.
5. The device is not selected after power-up, after a Read instruction (after the Stop condition), or after the completion of the internal write cycle $t_W$ ($t_W$ is triggered by the correct decoding of a Write instruction).
6. $E_i$ inputs should be tied to $V_{ss}$ (see *Section 2.3*).
7. $E_i$ inputs should be tied to $V_{cc}$ (see *Section 2.3*).
8. $I_{OL}$ = 0.7 mA for devices identified by process letters G or S.



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**Table 15. DC characteristics (M24128-BF, M24128-DF, device grade 6)**

| Symbol | Parameter | Test conditions(1) (in addition to those in *Table 8*) | Min. | Max. | Unit |
|---|---|---|---|---|---|
| $I_{LI}$ | Input leakage current (E0, E1, E2, SCL, SDA) | $V_{IN} = V_{SS}$ or $V_{CC}$ device in Standby mode | - | ± 2 | µA |
| $I_{LO}$ | Output leakage current | SDA in Hi-Z, external voltage applied on SDA: $V_{SS}$ or $V_{CC}$ | - | ± 2 | µA |
| $I_{CC}$ | Supply current (Read) | $V_{CC}$ = 1.7 V, $f_c$= 400 kHz | - | 0.8 | mA |
| | | $f_c$= 1 MHz(2) | - | 2.5 | mA |
| $I_{CC}$ | Supply current (Read) | $V_{CC}$ = 1.6 V, $f_c$= 400 kHz | - | 0.8 | mA |
| $I_{CC0}$ | Supply current (Write) | During $t_W$ 1.7 V < $V_{CC}$ < 2.5 V | - | 2(3)(4) | mA |
| $I_{CC1}$ | Standby supply current | Device not selected(5), $V_{IN} = V_{SS}$ or $V_{CC}$, $V_{CC}$ = 1.7 V | - | 1 | µA |
| $V_{IL}$ | Input low voltage (SCL, SDA, WC, $E_i$)(6) | 1.7 V ≤ $V_{CC}$ < 2.5 V | –0.45 | 0.25 $V_{CC}$ | V |
| $V_{IH}$ | Input high voltage (SCL, SDA) | 1.7 V ≤ $V_{CC}$ < 2.5 V | 0.75 $V_{CC}$ | 6.5 | V |
| | Input high voltage (WC, E2, E1, E0)(7) | 1.7 V ≤ $V_{CC}$ < 2.5 V | 0.75 $V_{CC}$ | $V_{CC}$+0.6 | V |
| $V_{OL}$ | Output low voltage | $I_{OL}$ = 1 mA, $V_{CC}$ = 1.7 V | - | 0.2 | V |

1. If the application uses the voltage range F device with 2.5 V < $V_{CC}$ < 5.5 V and -40 °C < $T_A$ < +85 °C, please refer to *Table 13* instead of this table.
2. Only for devices identified by process letter K (see *Table 17*).
3. Characterized value, not tested in production.
4. 3 mA for previous devices identified by process letter A.
5. The device is not selected after power-up, after a Read instruction (after the Stop condition), or after the completion of the internal write cycle $t_W$ ($t_W$ is triggered by the correct decoding of a Write instruction).
6. $E_i$ inputs should be tied to $V_{SS}$ (see *Section 2.3*).
7. $E_i$ inputs should be tied to $V_{CC}$ (see *Section 2.3*).



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**Table 16. 400 kHz AC characteristics**

| Symbol | Alt. | Parameter | Min. | Max. | Unit |
|---|---|---|---|---|---|
| $f_C$ | $f_{SCL}$ | Clock frequency | - | 400 | kHz |
| $t_{CHCL}$ | $t_{HIGH}$ | Clock pulse width high | 600 | - | ns |
| $t_{CLCH}$ | $t_{LOW}$ | Clock pulse width low | 1300 | - | ns |
| $t_{QL1QL2}$(1) | $t_F$ | SDA (out) fall time | 20(2) | 300 | ns |
| $t_{XH1XH2}$ | $t_R$ | Input signal rise time | (3) | (3) | ns |
| $t_{XL1XL2}$ | $t_F$ | Input signal fall time | (3) | (3) | ns |
| $t_{DXCH}$ | $t_{SU:DAT}$ | Data in set up time | 100 | - | ns |
| $t_{CLDX}$ | $t_{HD:DAT}$ | Data in hold time | 0 | - | ns |
| $t_{CLQX}$(4) | $t_{DH}$ | Data out hold time | 100(5) | - | ns |
| $t_{CLQV}$(6) | $t_{AA}$ | Clock low to next data valid (access time) | - | 900 | ns |
| $t_{CHDL}$ | $t_{SU:STA}$ | Start condition setup time | 600 | - | ns |
| $t_{DLCL}$ | $t_{HD:STA}$ | Start condition hold time | 600 | - | ns |
| $t_{CHDH}$ | $t_{SU:STO}$ | Stop condition set up time | 600 | - | ns |
| $t_{DHDL}$ | $t_{BUF}$ | Time between Stop condition and next Start condition | 1300 | - | ns |
| $t_{WLDL}$(7)(1) | $t_{SU:WC}$ | $\overline{WC}$ set up time (before the Start condition) | 0 | - | µs |
| $t_{DHWH}$(8)(1) | $t_{HD:WC}$ | $\overline{WC}$ hold time (after the Stop condition) | 1 | - | µs |
| $t_W$ | $t_{WR}$ | Internal Write cycle duration | - | 5 | ms |
| $t_{NS}$(1) | | Pulse width ignored (input filter on SCL and SDA) - single glitch | - | 80(9) | ns |

1. Characterized only, not tested in production.
2. With $C_L$ = 10 pF.
3. There is no min. or max. values for the input signal rise and fall times. It is however recommended by the I²C specification that the input signal rise and fall times be more than 20 ns and less than 300 ns when $f_C$ < 400 kHz.
4. To avoid spurious Start and Stop conditions, a minimum delay is placed between SCL=1 and the falling or rising edge of SDA.
5. 200 ns for previous devices identified by process letter A.
6. $t_{CLQV}$ is the time (from the falling edge of SCL) required by the SDA bus line to reach either $0.3V_{CC}$ or $0.7V_{CC}$, assuming that $R_{bus} \times C_{bus}$ time constant is within the values specified in *Figure 12*.
7. $\overline{WC}$=0 set up time condition to enable the execution of a WRITE command.
8. $\overline{WC}$=0 hold time condition to enable the execution of a WRITE command.
9. 100 ns for previous devices identified by process letter A.



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**Table 17. 1 MHz AC characteristics**

| Symbol | Alt. | Parameter[1] | Min. | Max. | Unit |
|---|---|---|---|---|---|
| $f_C$ | $f_{SCL}$ | Clock frequency | 0 | 1 | MHz |
| $t_{CHCL}$ | $t_{HIGH}$ | Clock pulse width high | 260 | - | ns |
| $t_{CLCH}$ | $t_{LOW}$ | Clock pulse width low | 500 | - | ns |
| $t_{XH1XH2}$ | $t_R$ | Input signal rise time | (2) | (2) | ns |
| $t_{XL1XL2}$ | $t_F$ | Input signal fall time | (2) | (2) | ns |
| $t_{QL1QL2}$[3] | $t_F$ | SDA (out) fall time | 20[4] | 120 | ns |
| $t_{DXCX}$ | $t_{SU:DAT}$ | Data in setup time | 50 | - | ns |
| $t_{CLDX}$ | $t_{HD:DAT}$ | Data in hold time | 0 | - | ns |
| $t_{CLQX}$[5] | $t_{DH}$ | Data out hold time | 100 | - | ns |
| $t_{CLQV}$[6] | $t_{AA}$ | Clock low to next data valid (access time) | - | 450 | ns |
| $t_{CHDL}$ | $t_{SU:STA}$ | Start condition setup time | 250 | - | ns |
| $t_{DLCL}$ | $t_{HD:STA}$ | Start condition hold time | 250 | - | ns |
| $t_{CHDH}$ | $t_{SU:STO}$ | Stop condition setup time | 250 | - | ns |
| $t_{DHDL}$ | $t_{BUF}$ | Time between Stop condition and next Start condition | 500 | - | ns |
| $t_{WLDL}$[7][3] | $t_{SU:WC}$ | $\overline{WC}$ set up time (before the Start condition) | 0 | - | µs |
| $t_{DHWH}$[8][3] | $t_{HD:WC}$ | $\overline{WC}$ hold time (after the Stop condition) | 1 | - | µs |
| $t_W$ | $t_{WR}$ | Write time | - | 5 | ms |
| $t_{NS}$[3] | | Pulse width ignored (input filter on SCL and SDA) | - | 80 | ns |

1. Only for M24128 devices identified by the process letter K (devices qualified at 1 MHz).
2. There is no min. or max. values for the input signal rise and fall times. It is however recommended by the I²C specification that the input signal rise and fall times be less than 120 ns when $f_C$ < 1 MHz.
3. Characterized only, not tested in production.
4. With $C_L$ = 10 pF.
5. To avoid spurious Start and Stop conditions, a minimum delay is placed between SCL=1 and the falling or rising edge of SDA.
6. $t_{CLQV}$ is the time (from the falling edge of SCL) required by the SDA bus line to reach either 0.3 $V_{CC}$ or 0.7 $V_{CC}$, assuming that the Rbus × Cbus time constant is within the values specified in *Figure 13*.
7. $\overline{WC}$=0 set up time condition to enable the execution of a WRITE command.
8. $\overline{WC}$=0 hold time condition to enable the execution of a WRITE command.



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**Figure 12. Maximum $R_{bus}$ value versus bus parasitic capacitance ($C_{bus}$) for an $I^2C$ bus at maximum frequency $f_C$ = 400 kHz**

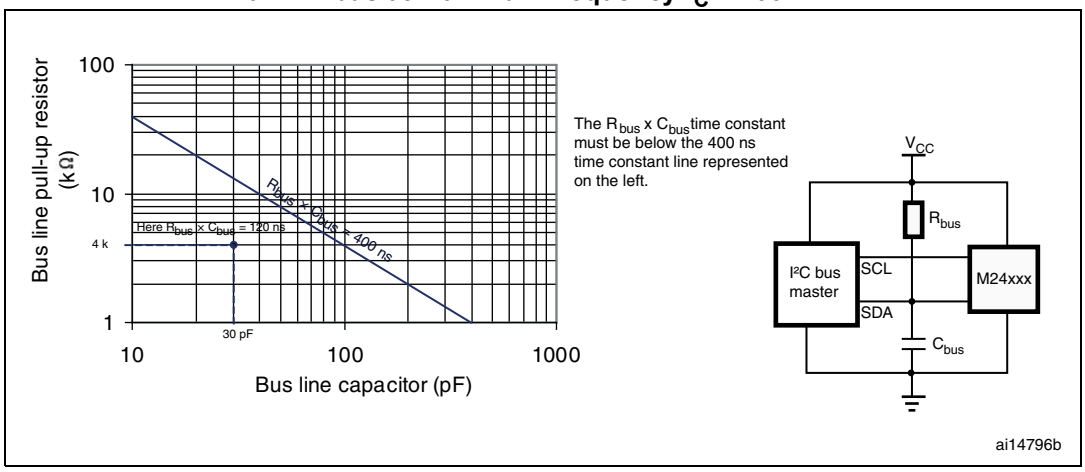
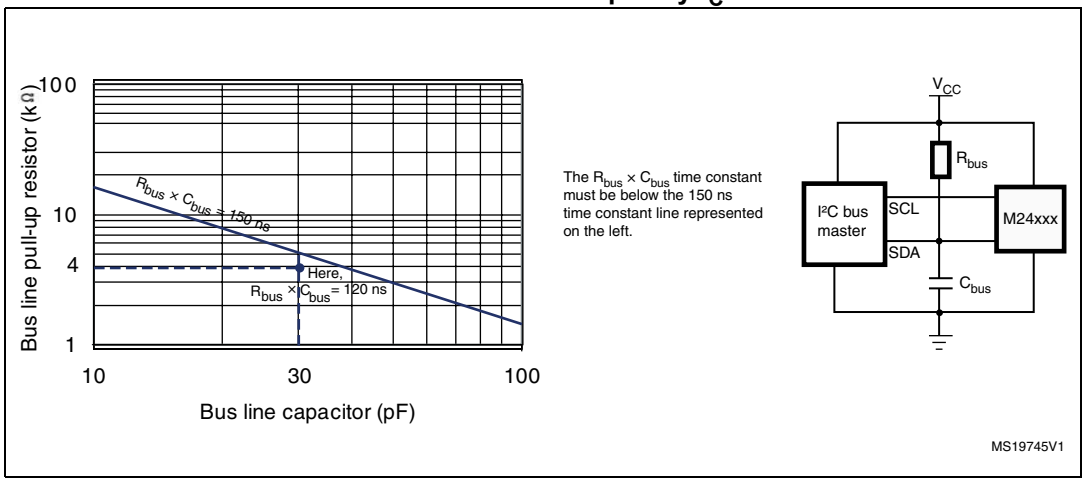


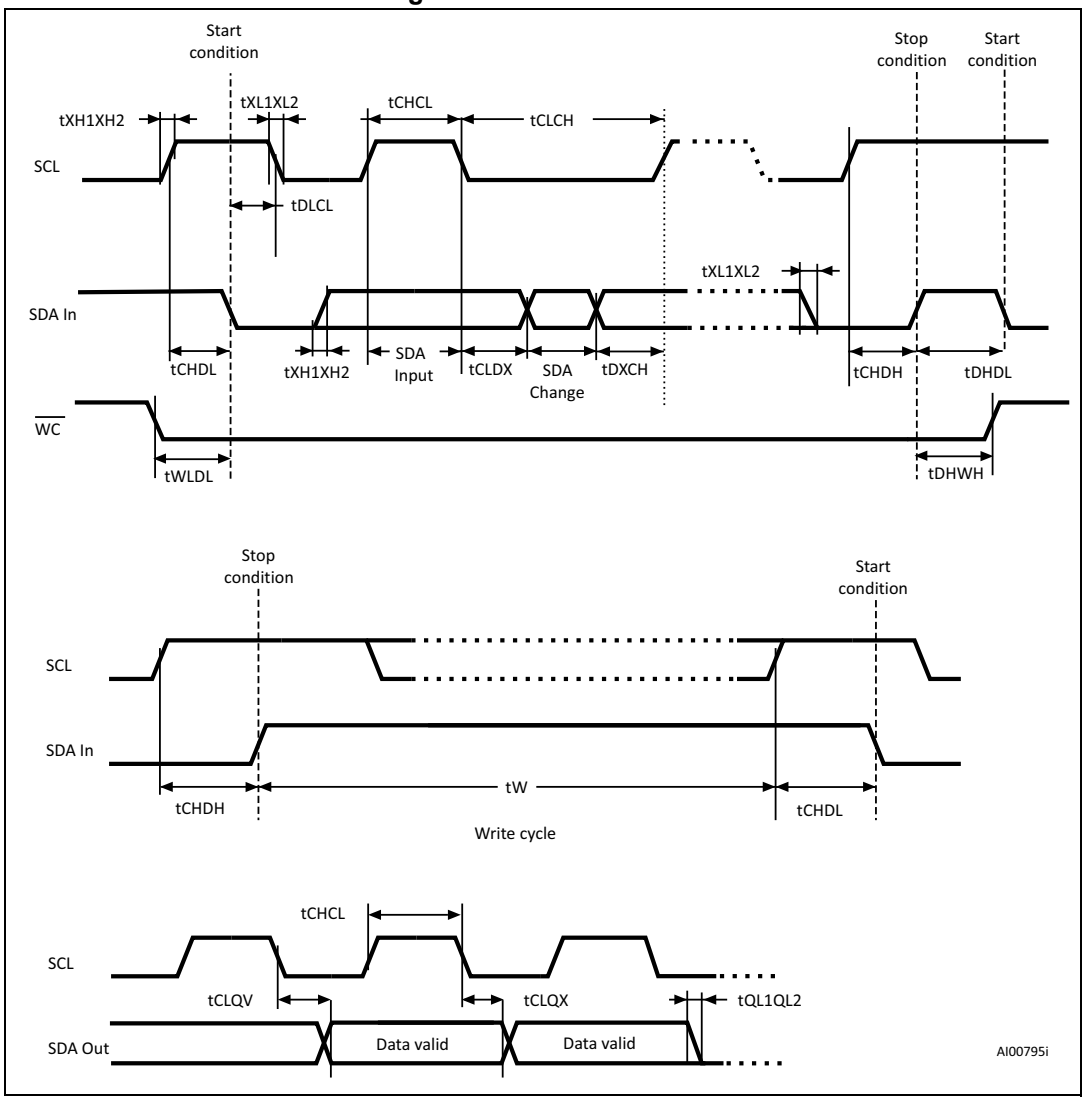

**Figure 13. Maximum $R_{bus}$ value versus bus parasitic capacitance $C_{bus}$) for an $I^2C$ bus at maximum frequency $f_C$ = 1MHz**






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**Figure 14. AC waveforms**



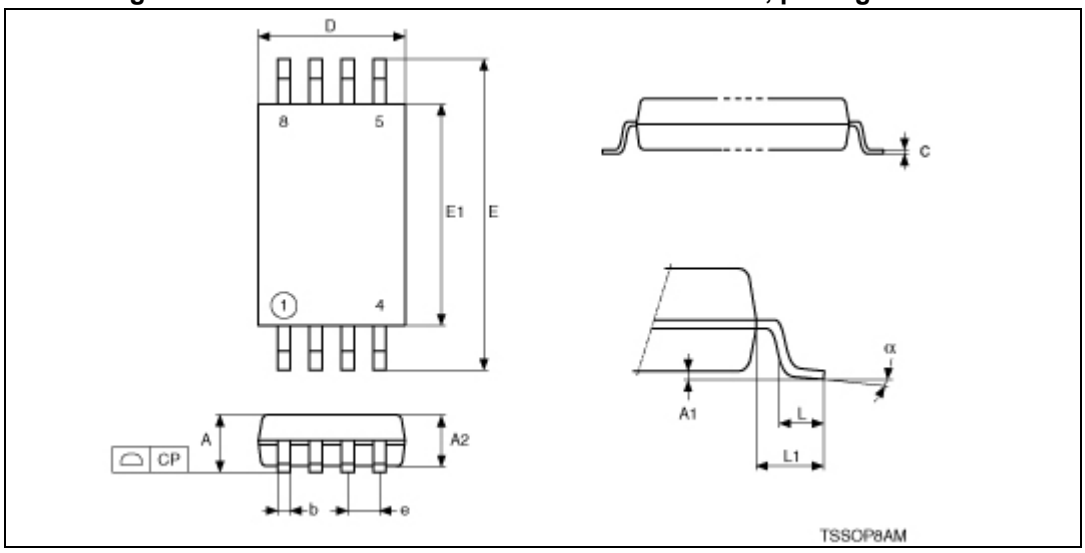



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# 9 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: *www.st.com*. ECOPACK® is an ST trademark.

**Figure 15. TSSOP8 – 8-lead thin shrink small outline, package outline**




1. Drawing is not to scale.

**Table 18. TSSOP8 – 8-lead thin shrink small outline, package mechanical data**

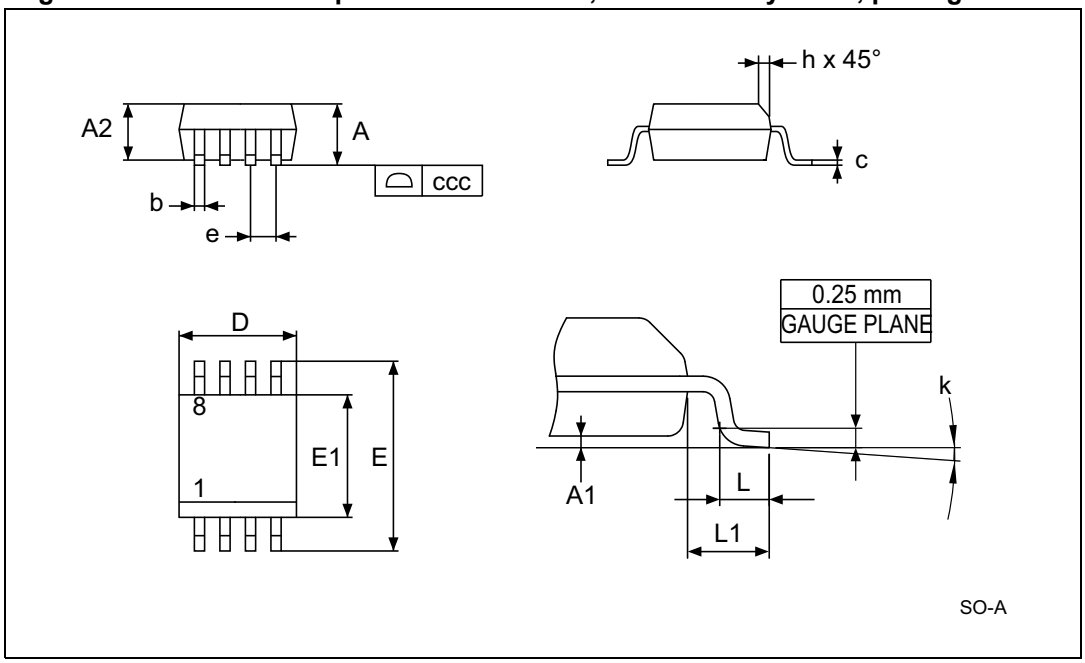
| Symbol | millimeters | | | inches(1) | | |
|---|---|---|---|---|---|---|
| | Typ. | Min. | Max. | Typ. | Min. | Max. |
| A | – | – | 1.200 | – | – | 0.0472 |
| A1 | – | 0.050 | 0.150 | – | 0.0020 | 0.0059 |
| A2 | 1.000 | 0.800 | 1.050 | 0.0394 | 0.0315 | 0.0413 |
| b | – | 0.190 | 0.300 | – | 0.0075 | 0.0118 |
| c | – | 0.090 | 0.200 | – | 0.0035 | 0.0079 |
| CP | – | – | 0.100 | – | – | 0.0039 |
| D | 3.000 | 2.900 | 3.100 | 0.1181 | 0.1142 | 0.1220 |
| e | 0.650 | – | – | 0.0256 | – | – |
| E | 6.400 | 6.200 | 6.600 | 0.2520 | 0.2441 | 0.2598 |
| E1 | 4.400 | 4.300 | 4.500 | 0.1732 | 0.1693 | 0.1772 |
| L | 0.600 | 0.450 | 0.750 | 0.0236 | 0.0177 | 0.0295 |
| L1 | 1.000 | – | – | 0.0394 | – | – |
| α | – | 0° | 8° | – | 0° | 8° |

1. Values in inches are converted from mm and rounded to four decimal digits.



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**Figure 16. SO8N – 8-lead plastic small outline, 150 mils body width, package outline**




1. Drawing is not to scale.

**Table 19. SO8N – 8-lead plastic small outline, 150 mils body width, package data**

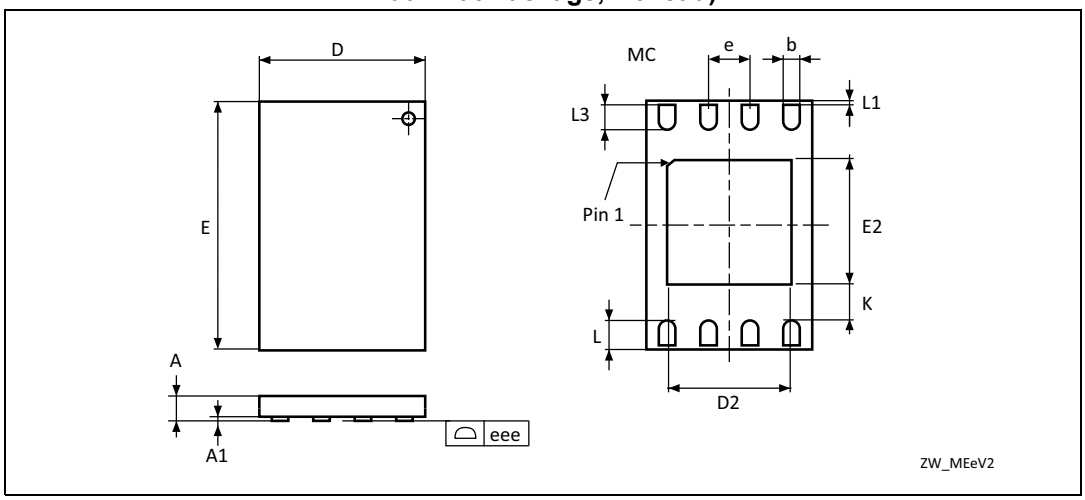
| Symbol | millimeters | | | inches (1) | | |
|---|---|---|---|---|---|---|
| | Typ | Min | Max | Typ | Min | Max |
| A | – | – | 1.750 | – | – | 0.0689 |
| A1 | – | 0.100 | 0.250 | – | 0.0039 | 0.0098 |
| A2 | – | 1.250 | – | – | 0.0492 | – |
| b | – | 0.280 | 0.480 | – | 0.0110 | 0.0189 |
| c | – | 0.170 | 0.230 | – | 0.0067 | 0.0091 |
| ccc | – | – | 0.100 | – | – | 0.0039 |
| D | 4.900 | 4.800 | 5.000 | 0.1929 | 0.1890 | 0.1969 |
| E | 6.000 | 5.800 | 6.200 | 0.2362 | 0.2283 | 0.2441 |
| E1 | 3.900 | 3.800 | 4.000 | 0.1535 | 0.1496 | 0.1575 |
| e | 1.270 | – | – | 0.0500 | – | – |
| h | – | 0.250 | 0.500 | – | 0.0098 | 0.0197 |
| k | – | 0° | 8° | – | 0° | 8° |
| L | – | 0.400 | 1.270 | – | 0.0157 | 0.0500 |
| L1 | 1.040 | – | – | 0.0409 | – | – |

1. Values in inches are converted from mm and rounded to four decimal digits.



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**Figure 17. UFDFPN8 (MLP8) – package outline (UFDFPN: Ultra thin Fine pitch Dual Flat Package, No lead)**




1. Drawing is not to scale.
2. The central pad (area E2 by D2 in the above illustration) is internally pulled to $V_{SS}$. It must not be connected to any other voltage or signal line on the PCB, for example during the soldering process.

**Table 20. UFDFPN8 (MLP8) – package dimensions (UFDFPN: Ultra thin Fine pitch Dual Flat Package, No lead)**

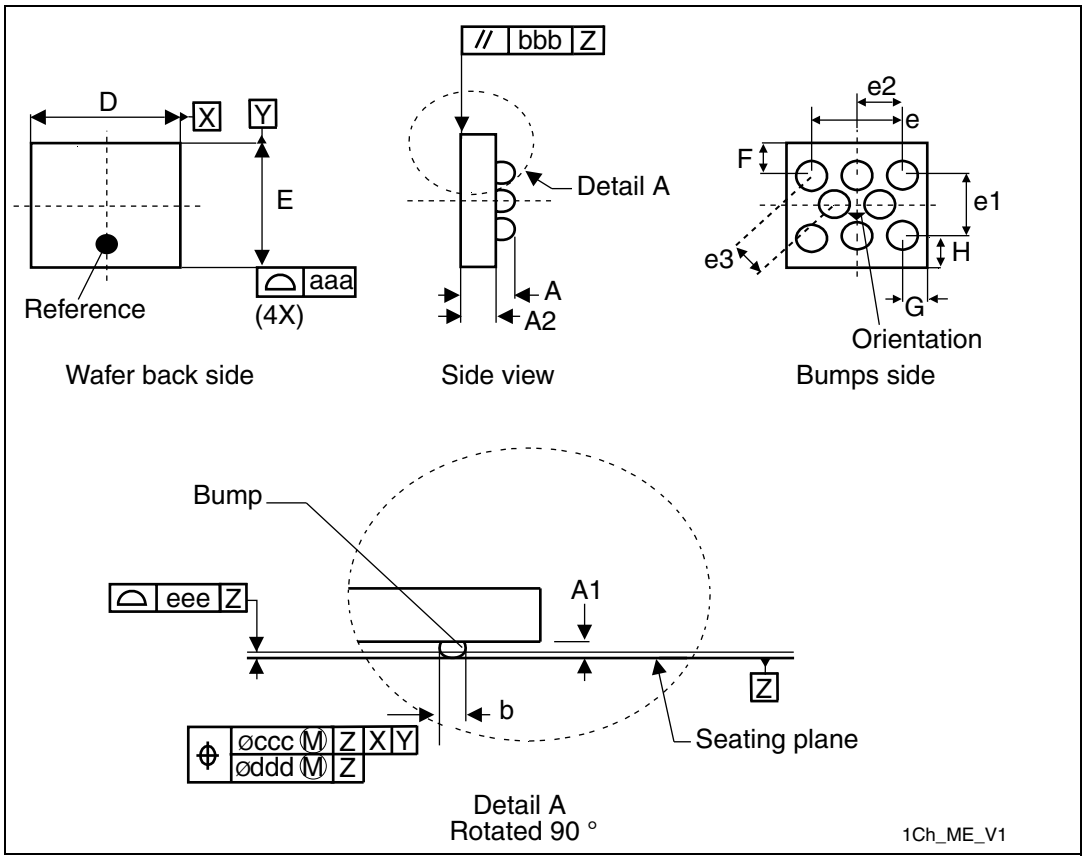
| Symbol | millimeters | | | inches[1] | | |
|---|---|---|---|---|---|---|
| | Typ | Min | Max | Typ | Min | Max |
| A | 0.550 | 0.450 | 0.600 | 0.0217 | 0.0177 | 0.0236 |
| A1 | 0.020 | 0.000 | 0.050 | 0.0008 | 0.0000 | 0.0020 |
| b | 0.250 | 0.200 | 0.300 | 0.0098 | 0.0079 | 0.0118 |
| D | 2.000 | 1.900 | 2.100 | 0.0787 | 0.0748 | 0.0827 |
| D2 (rev MC) | – | 1.200 | 1.600 | – | 0.0472 | 0.0630 |
| E | 3.000 | 2.900 | 3.100 | 0.1181 | 0.1142 | 0.1220 |
| E2 (rev MC) | – | 1.200 | 1.600 | – | 0.0472 | 0.0630 |
| e | 0.500 | – | – | 0.0197 | – | – |
| K (rev MC) | – | 0.300 | – | – | 0.0118 | – |
| L | – | 0.300 | 0.500 | – | 0.0118 | 0.0197 |
| L1 | – | – | 0.150 | – | – | 0.0059 |
| L3 | – | 0.300 | – | – | 0.0118 | – |
| eee[2] | – | 0.080 | – | – | 0.0031 | – |

1. Values in inches are converted from mm and rounded to four decimal digits.
2. Applied for exposed die paddle and terminals. Exclude embedding part of exposed die paddle from measuring.



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**Figure 18. M24128-DFCS6TP/K, WLCSP 8-bump wafer-level chip scale package outline**






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**Table 21. M24128-DFCS6TP/K, WLCSP 8-bump wafer-level chip scale package mechanical data**

| Symbol | millimeters | | | inches[1] | | |
|---|---|---|---|---|---|---|
| | Typ | Min | Max | Typ | Min | Max |
| A | 0.540 | 0.500 | 0.580 | 0.0213 | 0.0197 | 0.0228 |
| A1 | 0.190 | – | – | 0.0075 | – | – |
| A2 | 0.350 | – | – | 0.0138 | – | – |
| b | 0.270 | – | – | 0.0106 | – | – |
| D | 1.271 | – | – | 0.0500 | – | – |
| E | 1.081 | – | – | 0.0425 | – | – |
| e | 0.800 | – | – | 0.0315 | – | – |
| e1 | 0.693 | – | – | 0.0273 | – | – |
| e2 | 0.400 | – | – | 0.0157 | – | – |
| e3 | 0.400 | – | – | 0.0157 | – | – |
| F | 0.184 | – | – | 0.0072 | – | – |
| G | 0.236 | – | – | 0.0093 | – | – |
| H | 0.194 | – | – | 0.0076 | – | – |
| N (number of terminals) | 8 | – | – | 8 | – | – |
| aaa | 0.110 | – | – | 0.0043 | – | – |
| bbb | 0.110 | – | – | 0.0043 | – | – |
| ccc | 0.110 | – | – | 0.0043 | – | – |
| ddd | 0.060 | – | – | 0.0024 | – | – |
| eee | 0.060 | – | – | 0.0024 | – | – |

1. Values in inches are converted from mm and rounded to four decimal digits.



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# 10 Part numbering

**Table 22. Ordering information scheme**

Example: M24128 - D W MN 6 T P /K

**Device type**
M24 = $I^2C$ serial access EEPROM

**Device function**
128 = 128 Kbit (16 K x 8)

**Device family**
B = Without Identification page
D = With additional Identification page

**Operating voltage**
W = $V_{CC}$ = 2.5 V to 5.5 V
R = $V_{CC}$ = 1.8 V to 5.5 V
F = $V_{CC}$ = 1.7 V to 5.5 V

**Package**
MN = SO8 (150 mil width)(1)
DW = TSSOP8 (169 mil width)(1)
MC = UFDFPN8 (MLP8)(1)
CS = 8-bump WLCSP(1)

**Device grade**
6 = Industrial: device tested with standard test flow over –40 to 85 °C

**Option**
blank = standard packing
T = Tape and reel packing

**Plating technology**
P or G = ECOPACK® (RoHS compliant)

**Process**(2)
/K = Manufacturing technology code

1. RoHS-compliant and halogen-free (ECOPACK2®)
2. The process letters apply to WLCSP devices only. The process letters appear on the device package (marking) and on the shipment box. Please contact your nearest ST Sales Office for further information.



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# 11 Revision history

**Table 23. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 12-Jan-2010 | 18 | *Section 4.9: ECC (error correction code) and write cycling* modified. |
| 23-Mar-2010 | 19 | Removed PDIP package. |
| 21-Nov-2011 | 20 | Updated UFDFPN8 silhouette on cover page, *Figure 16: UFDFPN8 (MLP8) – 8-lead ultra thin fine pitch dual flat package no lead 2 × 3mm, package outline* and *Table 19: UFDFPN8 (MLP8) 8-lead ultra thin fine pitch dual flat package no lead 2 x 3 mm, mechanical data* to add MC version.<br>Renamed *Figure 2*.<br>Removed “Available M24128 products“ table.<br>Updated disclaimer on last page. |
| 20-Jul-2012 | 21 | Datasheet revision 20 split into:<br>– M24128-125 datasheet for automotive products (range 3),<br>– M24128-BW M24128-BR M24128-BF M24128-DF (this datasheet) for standard products (range 6).<br>Updated<br>– Cycling: 4 million cycles<br>– Data retention: 200 years<br>– *Table 17*: $t_{CLQX}$, $t_{NS}$<br>Added<br>– Identification page (for M24128-D devices)<br>– *Table 17*: $t_{WLDL}$ and $t_{DHWH}$<br>– *Table 18* (1 MHz) |
| 20-Nov-2012 | 22 | Corrected “Device family” data in *Table 23: Ordering information scheme*. |
| 04-Apr-2013 | 23 | Document reformatted.<br>Removed footnote “3” in *Table 2: Device select code*.<br>Renamed *Figure 17: UFDFPN8 (MLP8) – package outline (UFDFPN: Ultra thin Fine pitch Dual Flat Package, No lead)* and *Table 20: UFDFPN8 (MLP8) – package dimensions (UFDFPN: Ultra thin Fine pitch Dual Flat Package, No lead)*.<br>Updated package information in *Table 22: Ordering information scheme*. |
| 20-Jan-2014 | 24 | Changed MSB address in *Section 5.1.2*<br>Changed MSB and LSB address in *Section 5.1.3*<br>Updated *Figure 14: AC waveforms* |



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