AT24CM02

I²C-Compatible (Two-Wire) Serial EEPROM 2-Mbit (262,144 x 8)

Features

- Low-Voltage and Standard-Voltage Operation:
  - V_{CC} = 1.7V to 5.5V
  - V_{CC} = 2.5V to 5.5V
- Internally Organized as 262,144 x 8 (2-Mbit)
- Industrial Temperature Range: -40°C to +85°C
- I²C-Compatible (Two-Wire) Serial Interface:
  - 100 kHz Standard mode, 1.7V to 5.5V
  - 400 kHz Fast mode, 1.7V to 5.5V
  - 1 MHz Fast Mode Plus (FM+), 2.5V to 5.5V
- Schmitt Triggers, Filtered Inputs for Noise Suppression
- Bidirectional Data Transfer Protocol
- Write-Protect Pin for Full Array Hardware Data Protection
- Ultra Low Active Current (3 mA maximum) and Standby Current (3 µA maximum)
- 256-byte Page Write Mode:
  - Byte write and partial page writes allowed
- Random and Sequential Read Modes
- Self-Timed Write Cycle:
  - All write operations complete within 10 ms maximum
- Built-in Error Detection and Correction
- High Reliability:
  - Endurance: 1,000,000 write cycles
  - Data retention: 100 years
- Green Package Options (Lead-free/Halide-free/RoHS compliant)
- Die Sale Options: Wafer Form and Bumped Wafers

Packages

- 8-Lead SOIC and Thin or Standard Thickness 8-Ball WLCSP.

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Table of Contents

Features..... 1

Packages.....1

1. Package Types (not to scale)..... 4

2. Pin Descriptions.....5

2.1. Device Address Input (A2)..... 5
2.2. Ground..... 5
2.3. Serial Data (SDA).....5
2.4. Serial Clock (SCL).....5
2.5. Write-Protect (WP)..... 6
2.6. Device Power Supply..... 6

3. Description.....7

3.1. System Configuration Using Two-Wire Serial EEPROMs 7
3.2. Block Diagram.....8

4. Electrical Characteristics..... 9

4.1. Absolute Maximum Ratings.....9
4.2. DC and AC Operating Range.....9
4.3. DC Characteristics..... 9
4.4. AC Characteristics.....10
4.5. Electrical Specifications.....12

5. Device Operation and Communication.....14

5.1. Clock and Data Transition Requirements.....14
5.2. Start and Stop Conditions..... 14
5.3. Acknowledge and No-Acknowledge.....15
5.4. Standby Mode..... 15
5.5. Software Reset.....16

6. Memory Organization..... 17

6.1. Device Addressing..... 17

7. Write Operations.....19

7.1. Byte Write.....19
7.2. Page Write.....19
7.3. Internal Writing Methodology.....20
7.4. Acknowledge Polling..... 20
7.5. Write Cycle Timing..... 21
7.6. Write Protection.....21

8. Read Operations..... 23

8.1. Current Address Read.....23
8.2. Random Read..... 23

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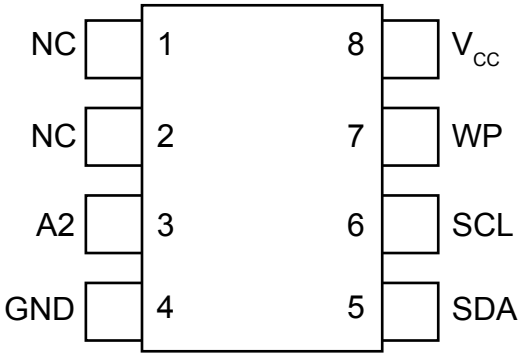
8.3. Sequential Read....24
9. Device Default Condition from Microchip....25
10. Packaging Information....26
10.1. Package Marking Information....26
11. APPENDIX A: Revision History....32
The Microchip Website....33
Product Change Notification Service....33
Customer Support....33
Product Identification System....34
Microchip Devices Code Protection Feature....35
Legal Notice....35
Trademarks....35
Quality Management System....36
Worldwide Sales and Service....37

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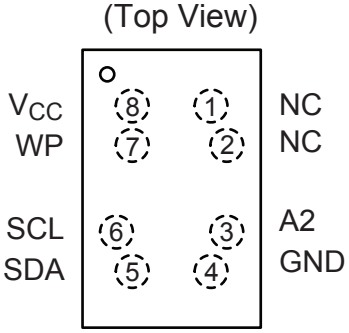
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1. Package Types (not to scale)

8-Lead SOIC
(Top View)



8-Ball WLCSP
Thin or Standard Thickness
(Top View)



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2. Pin Descriptions

The descriptions of the pins are listed in Table 2-1.

Table 2-1. Pin Function Table

Name	8-Lead SOIC	8-Ball WLCSP	Function
NC	1	A3	No Connect
NC	2	B4	No Connect
A2(1)	3	C4	Device Address Input
GND	4	D3	Ground
SDA	5	D2	Serial Data
SCL	6	C1	Serial Clock
WP(1)	7	B2	Write-Protect
V_{CC}	8	A2	Device Power Supply

Note:

1. If the A2 or WP pins are not driven, they are internally pulled down to GND. In order to operate in a wide variety of application environments, the pull-down mechanism is intentionally designed to be somewhat strong. Once these pins are biased above the CMOS input buffer's trip point (~0.5 x V_{CC}), the pull-down mechanism disengages. Microchip recommends connecting these pins to a known state whenever possible.

2.1 Device Address Input (A2)

The A2 pin is a device address input that is hard-wired (directly to GND or to V_{CC}) for compatibility with other two-wire Serial EEPROM devices. When the pin is hard-wired, as many as two devices may be addressed on a single bus system. A device is selected when a corresponding hardware and software match is true. If the pin is left floating, the A2 pin will be internally pulled down to GND. However, due to capacitive coupling that may appear in customer applications, Microchip recommends always connecting the address pin to a known state. When using a pull-up resistor, Microchip recommends using 10 kΩ or less.

2.2 Ground

The ground reference for the power supply. GND should be connected to the system ground.

2.3 Serial Data (SDA)

The SDA pin is an open-drain bidirectional input/output pin used to serially transfer data to and from the device. The SDA pin must be pulled high using an external pull-up resistor (not to exceed 10 kΩ in value) and may be wire-ORed with any number of other open-drain or open-collector pins from other devices on the same bus.

2.4 Serial Clock (SCL)

The SCL pin is used to provide a clock to the device and to control the flow of data to and from the device. Command and input data present on the SDA pin is always latched in on the rising edge of SCL, while output data on the SDA pin is clocked out on the falling edge of SCL. The SCL pin must either be forced high when the serial bus is idle or pulled high using an external pull-up resistor.

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2.5 Write-Protect (WP)

The write-protect input, when connected to GND, allows normal write operations. When the WP pin is connected directly to V_{CC}, all write operations to the protected memory are inhibited.

If the pin is left floating, the WP pin will be internally pulled down to GND. However, due to capacitive coupling that may appear in customer applications, Microchip recommends always connecting the WP pin to a known state. When using a pull-up resistor, Microchip recommends using 10 kΩ or less.

Table 2-2. Write-Protect

WP Pin Status	Part of the Array Protected
At V_{CC}	Full Array
At GND	Normal Write Operations

2.6 Device Power Supply

The V_{CC} pin is used to supply the source voltage to the device. Operations at invalid V_{CC} voltages may produce spurious results and should not be attempted.

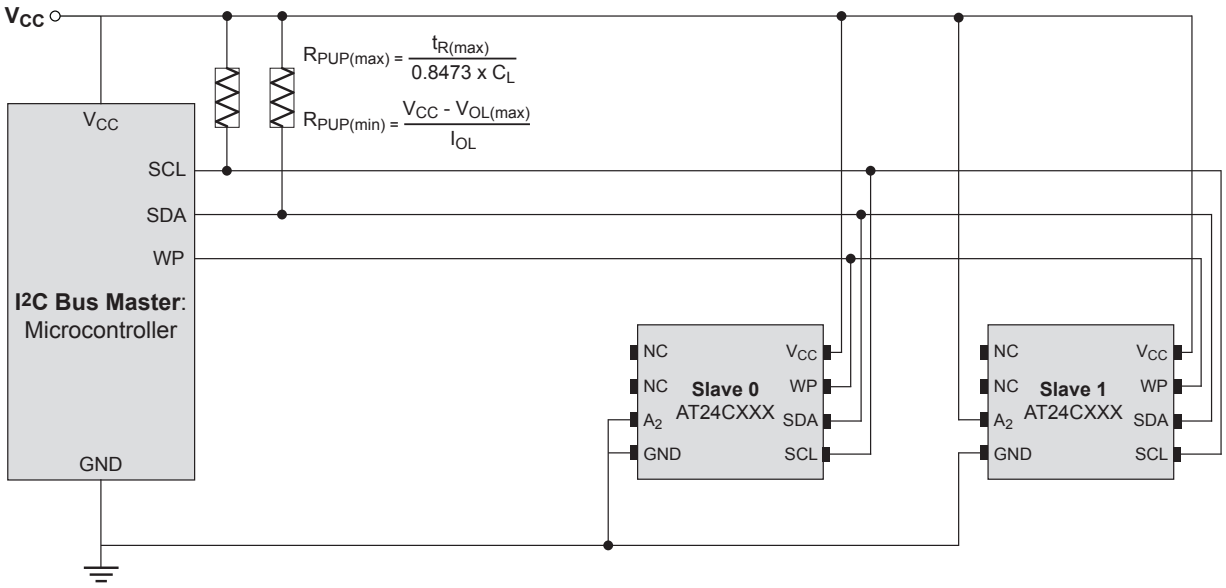
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3. Description

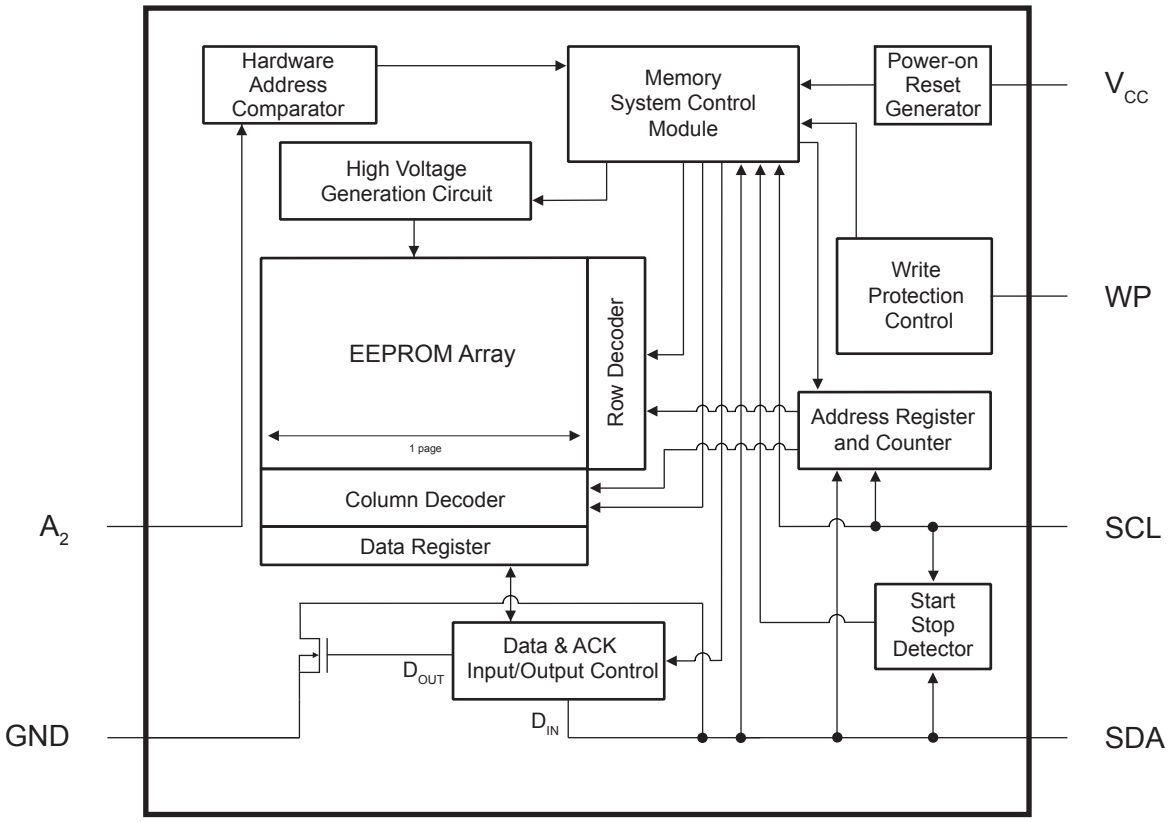
The AT24CM02 provides 2,097,152 bits of Serial Electrically Erasable and Programmable Read-Only Memory (EEPROM) organized as 262,144 words of 8 bits each. The device's cascading feature allows up to four devices to share a common two-wire bus. This device is optimized for use in many industrial and commercial applications where low-power and low-voltage operations are essential. The device is available in space-saving 8-lead SOIC and 8-ball WLCSP packages. All packages operate from 1.7V to 5.5V.

3.1 System Configuration Using Two-Wire Serial EEPROMs



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3.2 Block Diagram



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4. Electrical Characteristics

4.1 Absolute Maximum Ratings

Temperature under bias	-55°C to +125°C
Storage temperature	-65°C to +150°C
V_{CC}	6.25V
Voltage on any pin with respect to ground	-1.0V to +7.0V
DC output current	5.0 mA
ESD protection	>3 kV

Note: Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

4.2 DC and AC Operating Range

Table 4-1. DC and AC Operating Range

AT24CM02		
Operating Temperature (Case)	Industrial Temperature Range	-40°C to +85°C
V_{CC} Power Supply	Low-Voltage Grade	1.7V to 5.5V
	Standard-Voltage Grade	2.5V to 5.5V

4.3 DC Characteristics

Table 4-2. DC Characteristics

Parameter	Symbol	Minimum	Typical(1)	Maximum	Units	Test Conditions
Supply Voltage, 1.7V Option	V_{CC1}	1.7	—	5.5	V	
Supply Voltage, 2.5V Option	V_{CC2}	2.5	—	5.5	V	
Supply Current, Read	I_{CC}	—	0.1	0.5	mA	V_{CC} = 1.8V (2), Read at 400 kHz
		—	0.3	1.0	mA	V_{CC} = 5.0V, Read at 1 MHz

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Parameter	**Symbol**	**Minimum**	**Typical(1)**	**Maximum**	**Units**	**Test Conditions**
Supply Current, Write(3)	I_{CC}	—	0.4	1.0	mA	V_{CC} = 1.8V (2), averaged during t_{WR}
		—	1.7	3.0	mA	V_{CC} = 5.0V, averaged during t_{WR}
Standby Current	I_{SB}	—	0.08	1.0	µA	V_{CC} = 1.8V (2), V_{IN} = V_{CC} or V_{SS}
		—	0.08	2.0	µA	V_{CC} = 2.5V, V_{IN} = V_{CC} or V_{SS}
		—	0.15	3.0	µA	V_{CC} = 5.5V, V_{IN} = V_{CC} or V_{SS}
Input Leakage Current	I_{LI}	—	0.10	3.0	µA	V_{IN} = V_{CC} or V_{SS}
Output Leakage Current	I_{LO}	—	0.05	3.0	µA	V_{OUT} = V_{CC} or V_{SS}
Input Low Level	V_{IL}	-0.6	—	V_{CC} x 0.3	V	Note 2
Input High Level	V_{IH}	V_{CC} x 0.7	—	V_{CC} + 0.5	V	Note 2
Output Low Level	V_{OL1}	—	—	0.2	V	V_{CC} = 1.7V, I_{OL} = 0.15 mA
Output Low Level	V_{OL2}	—	—	0.4	V	V_{CC} = 3.0V, I_{OL} = 2.1 mA

Note:

1. Typical values characterized at T_A = +25°C unless otherwise noted.
2. This parameter is characterized but is not 100% tested in production.
3. Averaged during t_{WR}.

4.4 AC Characteristics

Table 4-3. AC Characteristics(1)

Parameter	**Symbol**	**Standard Mode**		**Fast Mode**		**Fast Mode Plus**		**Units**
		V_{CC} = 1.7V to 5.5V		**V_{CC} = 1.7V to 5.5V**		**V_{CC} = 2.5V to 5.5V**		
		Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	
Clock Frequency, SCL	f_{SCL}	—	100	—	400	—	1000	kHz
Clock Pulse Width Low	t_{LOW}	4,700	—	1,300	—	500	—	ns
Clock Pulse Width High	t_{HIGH}	4,000	—	600	—	400	—	ns

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Parameter	Symbol	Standard Mode		Fast Mode		Fast Mode Plus		Units
		V_{CC} = 1.7V to 5.5V		V_{CC} = 1.7V to 5.5V		V_{CC} = 2.5V to 5.5V		
		Min.	Max.	Min.	Max.	Min.	Max.	
Input Filter Spike Suppression (SCL,SDA)(2)	t_I	—	100	—	100	—	50	ns
Clock Low to Data Out Valid	t_{AA}	—	4,500	—	900	—	450	ns
Bus Free Time between Stop and Start(2)	t_{BUF}	4,700	—	1,300	—	500	—	ns
Start Hold Time	$t_{HD.STA}$	4,000	—	600	—	250	—	ns
Start Set-up Time	$t_{SU.STA}$	4,700	—	600	—	250	—	ns
Data In Hold Time	$t_{HD.DAT}$	0	—	0	—	0	—	ns
Data In Set-up Time	$t_{SU.DAT}$	200	—	100	—	100	—	ns
Inputs Rise Time(1)	t_R	—	1,000	—	300	—	100	ns
Inputs Fall Time(1)	t_F	—	300	—	300	—	100	ns
Stop Condition Set-up Time	$t_{SU.STO}$	4,700	—	600	—	250	—	ns
Write-Protect Setup Time	$t_{SU.WP}$	4,000	—	600	—	250	—	ns
Write-Protect Hold Time	$t_{HD.WP}$	4,000	—	600	—	250	—	ns
Data Out Hold Time	t_{DH}	100	—	50	—	50	—	ns
Write Cycle Time	t_{WR}	—	10	—	10	—	10	ms

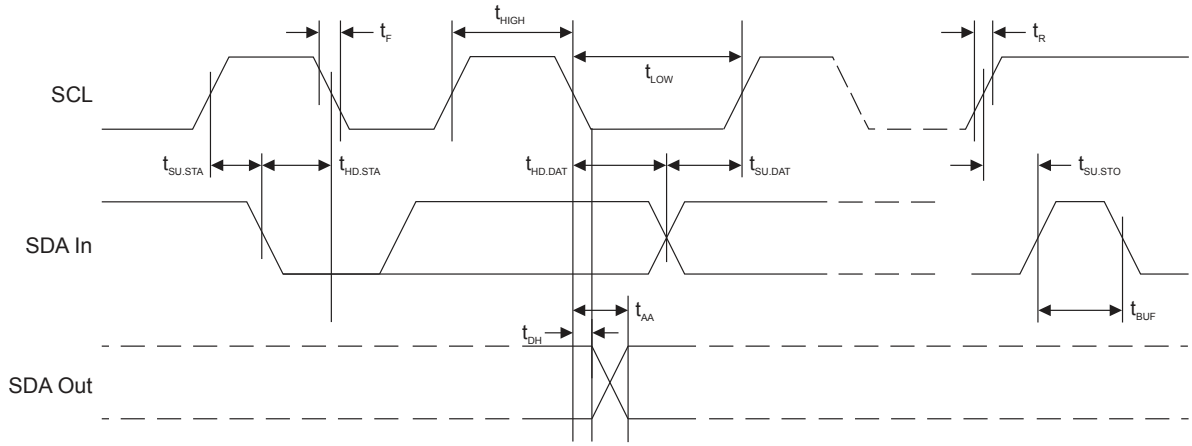
Note:

1. AC measurement conditions:
   - C_L: 100 pF
   - R_{PUP} (SDA bus line pull-up resistor to V_{CC}): 1.3 kΩ (1000 kHz), 4 kΩ (400 kHz), 10 kΩ (100 kHz)
   - Input pulse voltages: 0.3 x V_{CC} to 0.7 x V_{CC}
   - Input rise and fall times: ≤50 ns
   - Input and output timing reference voltages: 0.5 x V_{CC}
2. These parameters are determined through product characterization and are not 100% tested in production.

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Figure 4-1. Bus Timing



4.5 Electrical Specifications

4.5.1 Power-Up Requirements and Reset Behavior

During a power-up sequence, the V_{CC} supplied to the AT24CM02 should monotonically rise from GND to the minimum V_{CC} level, as specified in Table 4-1, with a slew rate no faster than 0.1 V/µs.

4.5.1.1 Device Reset

To prevent inadvertent write operations or any other spurious events from occurring during a power-up sequence, the AT24CM02 includes a Power-on Reset (POR) circuit. Upon power-up, the device will not respond to any commands until the V_{CC} level crosses the internal voltage threshold (V_{POR}) that brings the device out of Reset and into Standby mode.

The system designer must ensure the instructions are not sent to the device until the V_{CC} supply has reached a stable value greater than or equal to the minimum V_{CC} level. Additionally, once the V_{CC} is greater than or equal to the minimum V_{CC} level, the bus master must wait at least t_{PUP} before sending the first command to the device. See Table 4-4 for the values associated with these power-up parameters.

Table 4-4. Power-Up Conditions(1)

Symbol	Parameter	Min.	Max.	Units
t_{PUP}	Time required after V_{CC} is stable before the device can accept commands	100	—	µs
V_{POR}	Power-on Reset Threshold Voltage	—	1.5	V
t_{POFF}	Minimum time at V_{CC} = 0V between power cycles	1	—	ms

Note:

1. These parameters are characterized but they are not 100% tested in production.

If an event occurs in the system where the V_{CC} level supplied to the AT24CM02 drops below the maximum V_{POR} level specified, it is recommended that a full-power cycle sequence be performed by first driving the V_{CC} pin to GND, waiting at least the minimum t_{POFF} time and then performing a new power-up sequence in compliance with the requirements defined in this section.

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4.5.2 Pin Capacitance

Table 4-5. Pin Capacitance(1)

Symbol	Test Condition	Max.	Units	Conditions
$C_{I/O}$	Input/Output Capacitance (SDA)	8	pF	$V_{I/O}$ = 0V
C_{IN}	Input Capacitance (A2 and SCL)	6	pF	V_{IN} = 0V

Note:

1. This parameter is characterized but is not 100% tested in production.

4.5.3 EEPROM Cell Performance Characteristics

Table 4-6. EEPROM Cell Performance Characteristics

Operation	Test Condition	Min.	Max.	Units
Write Endurance(1)	T_A = 25°C, V_{CC}(min.) < V_{CC} < V_{CC}(max.), Byte(2) or Page Write mode	1,000,000	—	Write Cycles
Data Retention(1)	T_A = 55°C	100	—	Years

Note:

1. Performance is determined through characterization and the qualification process.
2. Due to the memory array architecture, the Write Cycle Endurance is specified for writes in groups of 4 data bytes. The beginning of any 4-byte boundaries can be determined by multiplying any integer (N) by four (i.e., 4*N). The end address can be found by adding three to the beginning value (i.e., 4*N+3). See Internal Writing Methodology for more details on this implementation.

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5. Device Operation and Communication

The AT24CM02 operates as a slave device and utilizes a simple I^2C-compatible two-wire digital serial interface to communicate with a host controller, commonly referred to as the bus master. The master initiates and controls all read and write operations to the slave devices on the serial bus, and both the master and the slave devices can transmit and receive data on the bus.

The serial interface is comprised of just two signal lines: Serial Clock (SCL) and Serial Data (SDA). The SCL pin is used to receive the clock signal from the master, while the bidirectional SDA pin is used to receive command and data information from the master as well as to send data back to the master. Data is always latched into the AT24CM02 on the rising edge of SCL and always output from the device on the falling edge of SCL. Both the SCL and SDA pins incorporate integrated spike suppression filters and Schmitt Triggers to minimize the effects of input spikes and bus noise.

All command and data information is transferred with the Most Significant bit (MSb) first. During bus communication, one data bit is transmitted every clock cycle, and after eight bits (one byte) of data have been transferred, the receiving device must respond with either an Acknowledge (ACK) or a No-Acknowledge (NACK) response bit during a ninth clock cycle (ACK/NACK clock cycle) generated by the master. Therefore, nine clock cycles are required for every one byte of data transferred. There are no unused clock cycles during any read or write operation, so there must not be any interruptions or breaks in the data stream during each data byte transfer and ACK or NACK clock cycle.

During data transfers, data on the SDA pin must only change while SCL is low, and the data must remain stable while SCL is high. If data on the SDA pin changes while SCL is high, then either a Start or a Stop condition will occur. Start and Stop conditions are used to initiate and end all serial bus communication between the master and the slave devices. The number of data bytes transferred between a Start and a Stop condition is not limited and is determined by the master. In order for the serial bus to be idle, both the SCL and SDA pins must be in the logic high state at the same time.

5.1 Clock and Data Transition Requirements

The SDA pin is an open-drain terminal and therefore must be pulled high with an external pull-up resistor. SCL is an input pin that can either be driven high or pulled high using an external pull-up resistor. Data on the SDA pin may change only during SCL low time periods. Data changes during SCL high periods will indicate a Start or Stop condition as defined below. The relationship of the AC timing parameters with respect to SCL and SDA for the AT24CM02 are shown in the timing waveform in Figure 4-1. The AC timing characteristics and specifications are outlined in AC Characteristics.

5.2 Start and Stop Conditions

5.2.1 Start Condition

A Start condition occurs when there is a high-to-low transition on the SDA pin while the SCL pin is at a stable logic '1' state and will bring the device out of Standby mode. The master uses a Start condition to initiate any data transfer sequence; therefore, every command must begin with a Start condition. The device will continuously monitor the SDA and SCL pins for a Start condition but will not respond unless one is detected. Refer to Figure 5-1 for more details.

5.2.2 Stop Condition

A Stop condition occurs when there is a low-to-high transition on the SDA pin while the SCL pin is stable in the logic '1' state.

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The master can use the Stop condition to end a data transfer sequence with the AT24CM02, which will subsequently return to Standby mode. The master can also utilize a repeated Start condition instead of a Stop condition to end the current data transfer if the master will perform another operation. Refer to Figure 5-1 for more details.

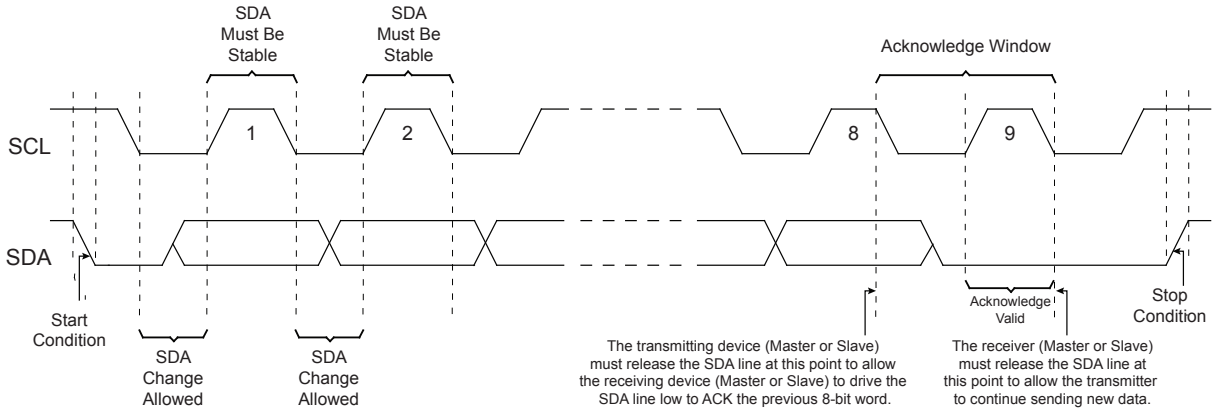
5.3 Acknowledge and No-Acknowledge

After every byte of data is received, the receiving device must confirm to the transmitting device that it has successfully received the data byte by responding with what is known as an Acknowledge (ACK). An ACK is accomplished by the transmitting device first releasing the SDA line at the falling edge of the eighth clock cycle followed by the receiving device responding with a logic '0' during the entire high period of the ninth clock cycle.

When the AT24CM02 is transmitting data to the master, the master can indicate that it is done receiving data and wants to end the operation by sending a logic '1' response to the AT24CM02 instead of an ACK response during the ninth clock cycle. This is known as a No-Acknowledge (NACK) and is accomplished by the master sending a logic '1' during the ninth clock cycle, at which point the AT24CM02 will release the SDA line so the master can then generate a Stop condition.

The transmitting device, which can be the bus master or the Serial EEPROM, must release the SDA line at the falling edge of the eighth clock cycle to allow the receiving device to drive the SDA line to a logic '0' to ACK the previous 8-bit word. The receiving device must release the SDA line at the end of the ninth clock cycle to allow the transmitter to continue sending new data. A timing diagram has been provided in Figure 5-1 to better illustrate these requirements.

Figure 5-1. Start Condition, Data Transitions, Stop Condition and Acknowledge



5.4 Standby Mode

The AT24CM02 features a low-power Standby mode that is enabled when any one of the following occurs:

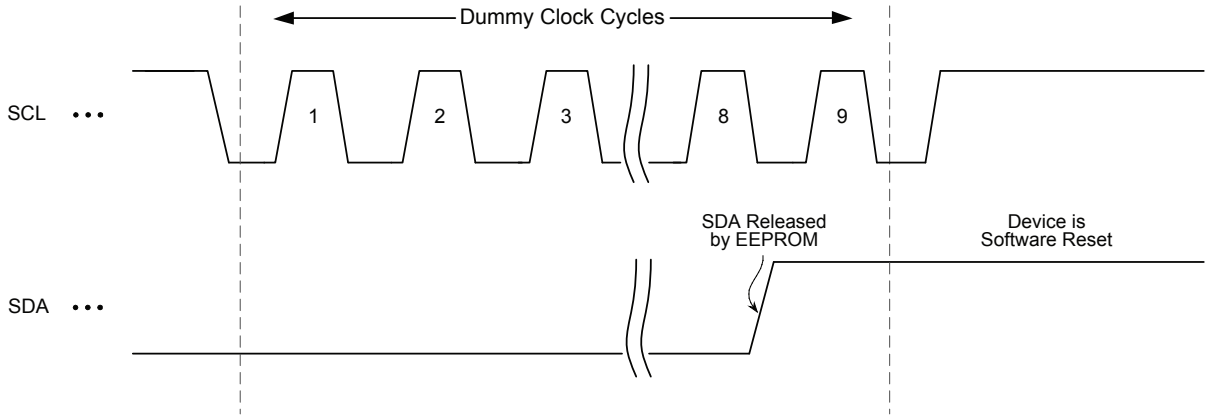
- A valid power-up sequence is performed (see Power-Up Requirements and Reset Behavior).
- A Stop condition is received by the device unless it initiates an internal write cycle (see Write Operations).
- At the completion of an internal write cycle (see Write Operations).

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5.5 Software Reset

After an interruption in protocol, power loss or system Reset, any two-wire device can be protocol reset by clocking SCL until SDA is released by the EEPROM and goes high. The number of clock cycles until SDA is released by the EEPROM will vary. The software Reset sequence should not take more than nine dummy clock cycles. Once the software Reset sequence is complete, new protocol can be sent to the device by sending a Start condition followed by the protocol. Refer to Figure 5-2 for an illustration.

Figure 5-2. Software Reset



In the event that the device is still non-responsive or remains active on the SDA bus, a power cycle must be used to reset the device (see Power-Up Requirements and Reset Behavior).

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6. Memory Organization

The AT24CM02 is internally organized as 1,024 pages of 256 bytes each.

6.1 Device Addressing

Accessing the device requires an 8-bit device address byte following a Start condition to enable the device for a read or write operation. Since multiple slave devices can reside on the serial bus, each slave device must have its own unique address so the master can access each device independently.

The Most Significant four bits of the device address byte is referred to as the device type identifier. The device type identifier '1010' (Ah) is required in bits 7 through 4 of the device address byte (see Table 6-1).

Following the 4-bit device type identifier is the hardware slave address bit, A2. This bit can be used to expand the address space by allowing up to two Serial EEPROM devices on the same bus. The hardware slave address bit must correlate with the voltage level on the corresponding hardwired device address input pin A2. The A2 pin uses an internal proprietary circuit that automatically biases the pin to a logic '0' state if the pin is allowed to float. In order to operate in a wide variety of application environments, the pull-down mechanism is intentionally designed to be somewhat strong. Once the pin is biased above the CMOS input buffer's trip point (~0.5 x VCC), the pull-down mechanism disengages. Microchip recommends connecting the A2 pin to a known state whenever possible.

Following the A2 hardware slave address bit are A17 and A16 (bit 2 and bit 1 of the device address byte), which are the Most Significant bits of the memory array word address. Refer to Table 6-1 to review the bit position.

The eighth bit (bit 0) of the device address byte is the Read/Write Select bit. A read operation is initiated if this bit is high and a write operation is initiated if this bit is low.

Upon the successful comparison of the device address byte, the AT24CM02 will return an ACK. If a valid comparison is not made, the device will NACK.

Table 6-1. Device Addressing

Package	Device Type Identifier				Hardware Slave Address Bit	Most Significant Bits of the Word Address		R/$\overline{W}$ Select
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
SOIC,WLCSP	1	0	1	0	A_2	A17	A16	R/$\overline{W}$

For all operations except the current address read, two 8-bit word address bytes must be transmitted to the device immediately following the device address byte. The word address bytes contain the lower 16 significant memory array address bits, and are used to specify which byte location in the EEPROM to start reading or writing. See Table 6-2 and Table 6-3 to review their bit positions.

Table 6-2. First Word Address Byte

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
A15	A14	A13	A12	A11	A10	A9	A8

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Table 6-3. Second Word Address Byte

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
A7	A6	A5	A4	A3	A2	A1	A0

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7. Write Operations

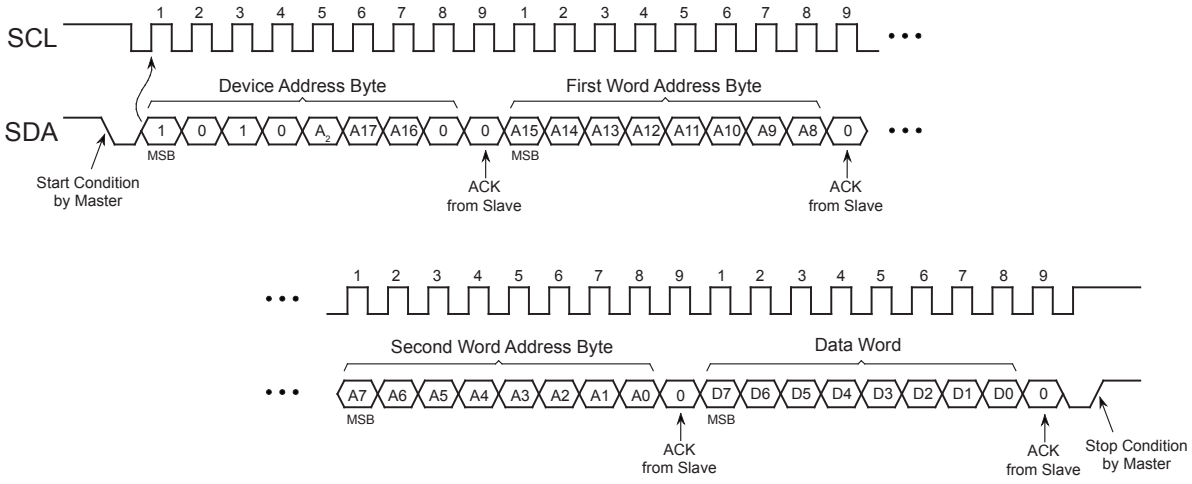
All write operations for the AT24CM02 begin with the master sending a Start condition, followed by a device address byte with the R/$\overline{W}$ bit set to logic '0', and then by the word address bytes. The data value(s) to be written to the device immediately follow the word address bytes.

7.1 Byte Write

The AT24CM02 supports the writing of a single 8-bit byte. Selecting a data word in the AT24CM02 requires 18-bit word address.

Upon receipt of the proper device address and the word address bytes, the EEPROM will send an Acknowledge. The device will then be ready to receive the 8-bit data word. Following receipt of the 8-bit data word, the EEPROM will respond with an ACK. The addressing device, such as a bus master, must then terminate the write operation with a Stop condition. At that time, the EEPROM will enter an internally self-timed write cycle, which will be completed within t_{WR}, while the data word is being programmed into the nonvolatile EEPROM. All inputs are disabled during this write cycle, and the EEPROM will not respond until the write is complete.

Figure 7-1. Byte Write



7.2 Page Write

A page write operation allows up to 256 bytes to be written in the same write cycle, provided all bytes are in the same row of the memory array (where address bits A17 through A8 are the same). Partial page writes of less than 256 bytes are also allowed.

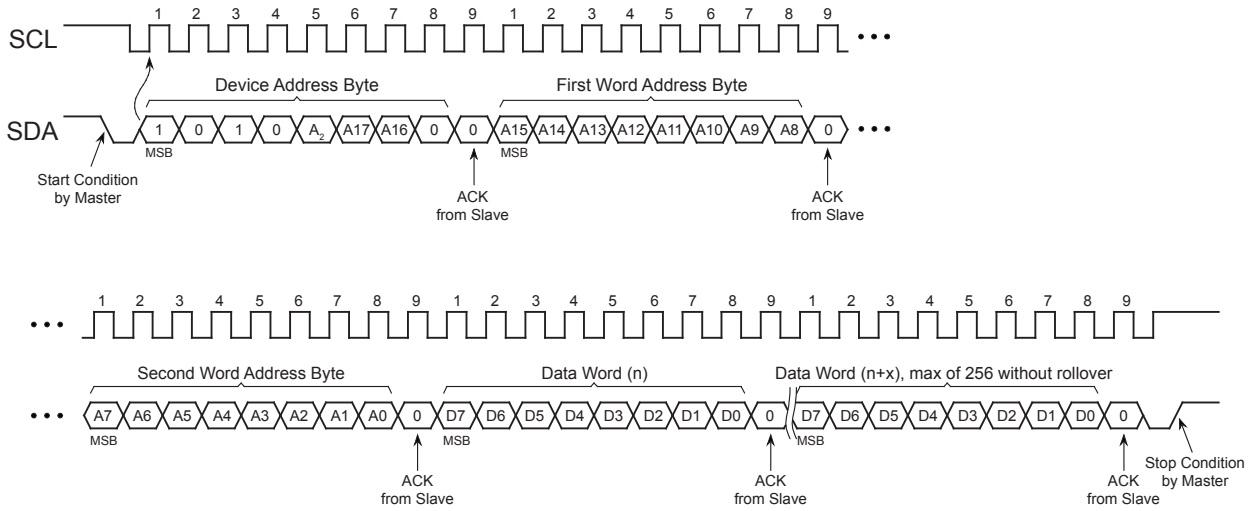
A page write is initiated the same way as a byte write, but the bus master does not send a Stop condition after the first data word is clocked in. Instead, after the EEPROM acknowledges receipt of the first data word, the bus master can transmit up to 255 additional data words. The EEPROM will respond with an ACK after each data word is received. Once all data to be written has been sent to the device, the bus master must issue a Stop condition (see Figure 7-2) at which time the internally self-timed write cycle will begin.

The lower eight bits of the word address are internally incremented following the receipt of each data word. The higher order address bits are not incremented and retain the memory page row location. Page

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write operations are limited to writing bytes within a single physical page, regardless of the number of bytes actually being written. When the incremented word address reaches the page boundary, the address counter will rollover to the beginning of the same page. Nevertheless, creating a rollover event should be avoided as previously loaded data in the page could become unintentionally altered.

Figure 7-2. Page Write



7.3 Internal Writing Methodology

The AT24CM02 incorporates a built-in error detection and correction (EDC) logic scheme. The EEPROM array is internally organized as a group of four connected 8-bit bytes plus an additional six ECC (Error Correction Code) bits of EEPROM. These 38 bits are referred to as the internal physical data word. During a read sequence, the EDC logic compares each 4-byte physical data word with its corresponding six ECC bits. If a single bit out of the 4-byte region reads incorrectly, the EDC logic will detect the bad bit and replace it with a correct value before the data is serially clocked out. This architecture significantly improves the reliability of the AT24CM02 compared to an implementation that does not utilize EDC.

It is important to note that data is always physically written to the part at the internal physical data word level, regardless of the number of bytes written. Writing single bytes is still possible with the Byte Write operation, but internally, the other three bytes within that 4-byte location where the single byte was written, along with the six ECC bits will be updated. Due to this architecture, the AT24CM02 EEPROM write endurance is rated at the internal physical data word level (4-byte word). The system designer needs to optimize the application writing algorithms to observe these internal word boundaries in order to reach the endurance rating.

7.4 Acknowledge Polling

An Acknowledge Polling routine can be implemented to optimize time-sensitive applications that would prefer not to wait the fixed maximum write cycle time (t_{WR}). This method allows the application to know immediately when the Serial EEPROM write cycle has completed, so a subsequent operation can be started.

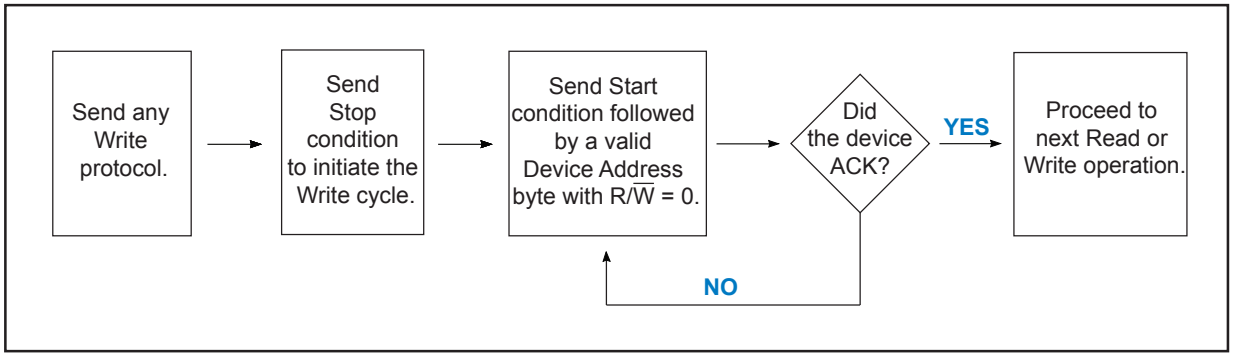
Once the internally self-timed write cycle has started, an Acknowledge Polling routine can be initiated. This involves repeatedly sending a Start condition followed by a valid device address byte with the R/$\overline{W}$ bit set at logic '0'. The device will not respond with an ACK while the write cycle is ongoing. Once the internal write cycle has completed, the EEPROM will respond with an ACK, allowing a new read or write

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operation to be immediately initiated. A flowchart has been included below in Figure 7-3 to better illustrate this technique.

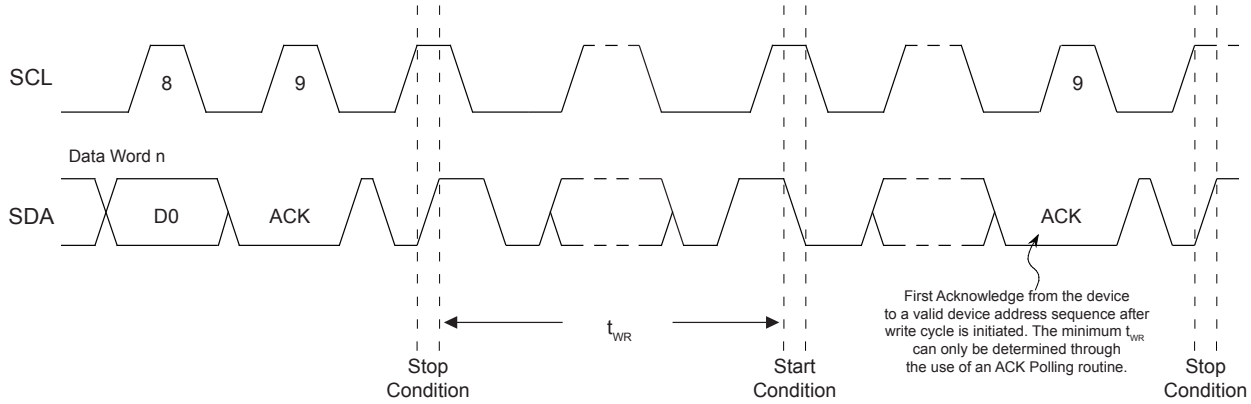
Figure 7-3. Acknowledge Polling Flowchart



7.5 Write Cycle Timing

The length of the self-timed write cycle (t_{WR}) is defined as the amount of time from the Stop condition that begins the internal write cycle to the Start condition of the first device address byte sent to the AT24CM02 that it subsequently responds to with an ACK. Figure 7-4 has been included to show this measurement. During the internally self-timed write cycle, any attempts to read from or write to the memory array will not be processed.

Figure 7-4. Write Cycle Timing



7.6 Write Protection

The AT24CM02 utilizes a hardware data protection scheme that allows the user to write-protect the entire memory contents when the WP pin is at V_{CC} (or a valid V_{IH}). No write protection will be set if the WP pin is at GND or left floating.

Table 7-1. AT24CM02 Write-Protect Behavior

WP Pin Voltage	Part of the Array Protected
V_{CC}	Full Array
GND	None – Write Protection Not Enabled

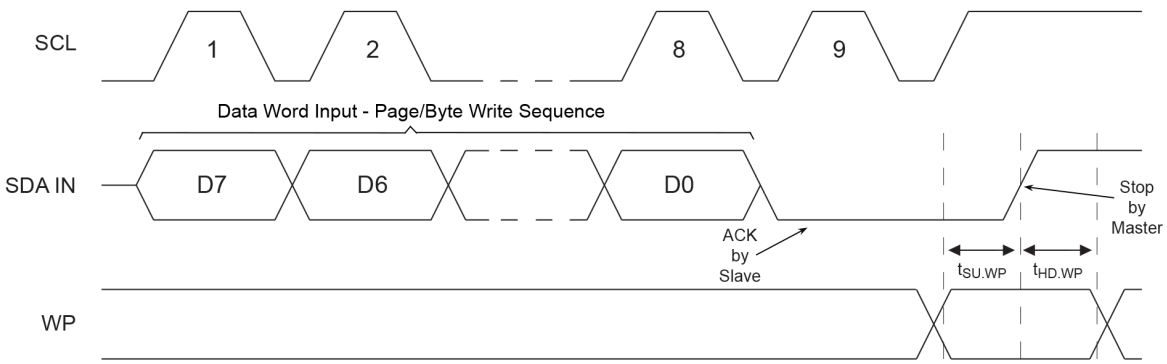
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The status of the WP pin is sampled at the Stop condition for every byte write or page write operation prior to the start of an internally self-timed write cycle. Changing the WP pin state after the Stop condition has been sent will not alter or interrupt the execution of the write cycle. The WP pin state must be valid with respect to the associated setup (tSU.WP) and hold (tHD.WP) timing as shown in Figure 7-5 below. The WP setup time is the amount of time that the WP state must be stable before the Stop condition is issued. The WP hold time is the amount of time after the Stop condition that the WP must remain stable (see Table 4-3, AC Characteristics," for timing specs for tHD.WP and tSU.WP).

If an attempt is made to write to the device while the WP pin has been asserted, the device will acknowledge the device address, word address and data bytes, but no write cycle will occur when the Stop condition is issued. The device will immediately be ready to accept a new read or write command.

Figure 7-5. Write-Protect Setup and Hold Timing



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8. Read Operations

Read operations are initiated the same way as write operations with the exception that the Read/Write Select bit in the device address byte must be a logic '1'. There are three read operations:

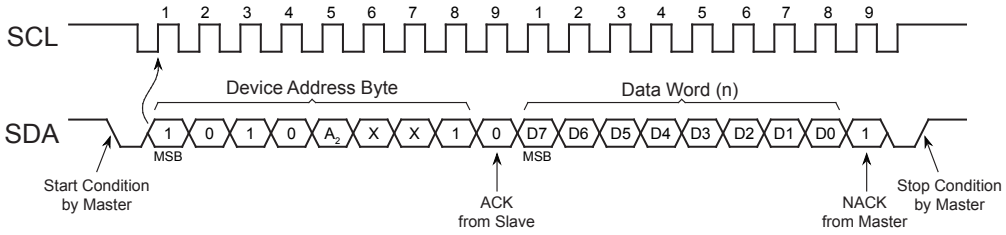
- Current Address Read
- Random Address Read
- Sequential Read

8.1 Current Address Read

The internal data word address counter maintains the last address accessed during the last read or write operation, incremented by one. This address stays valid between operations as long as the V_{CC} is maintained to the part. The address roll-over during a read is from the last byte of the last page to the first byte of the first page of the memory.

A current address read operation will output data according to the location of the internal data word address counter. This is initiated with a Start condition, followed by a valid device address byte with the R/$\overline{W}$ bit set to logic '1'. The device will ACK this sequence and the current address data word is serially clocked out on the SDA line. All types of read operations will be terminated if the bus master does not respond with an ACK (it NACKs) during the ninth clock cycle. After the NACK response, the master may send a Stop condition to complete the protocol, or it can send a Start condition to begin the next sequence.

Figure 8-1. Current Address Read

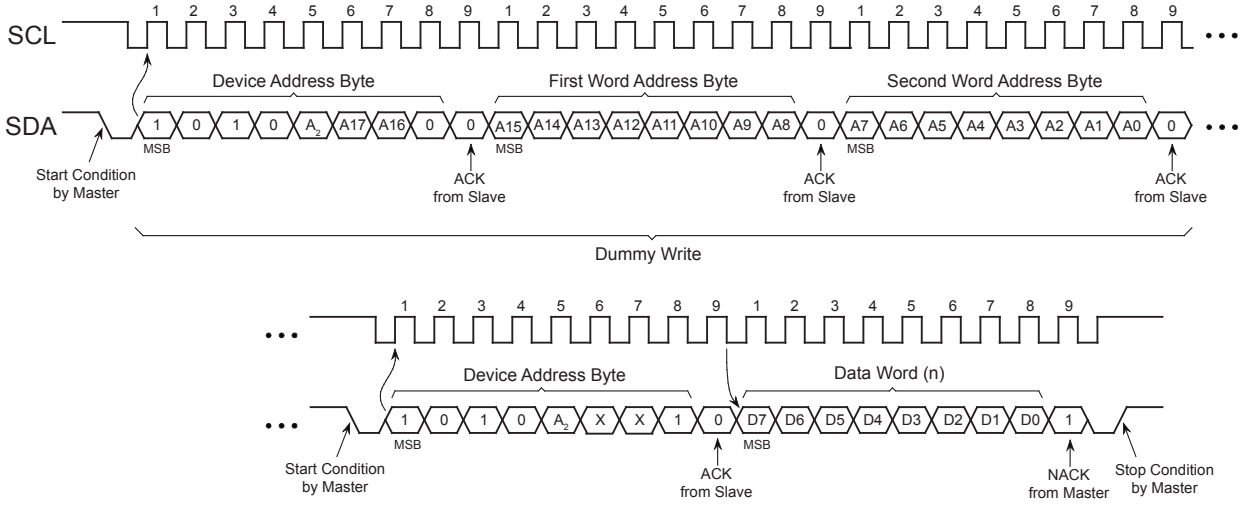


8.2 Random Read

A random read begins in the same way as a byte write operation does to load in a new data word address. This is known as a "dummy write" sequence; however, the data byte and the Stop condition of the byte write must be omitted to prevent the part from entering an internal write cycle. Once the device address and word address are clocked in and acknowledged by the EEPROM, the bus master must generate another Start condition. The bus master now initiates a current address read by sending a Start condition, followed by a valid device address byte with the R/$\overline{W}$ bit set to logic '1'. The EEPROM will ACK the device address and serially clock out the data word on the SDA line. All types of read operations will be terminated if the bus master does not respond with an ACK (it NACKs) during the ninth clock cycle. After the NACK response, the master may send a Stop condition to complete the protocol, or it can send a Start condition to begin the next sequence.

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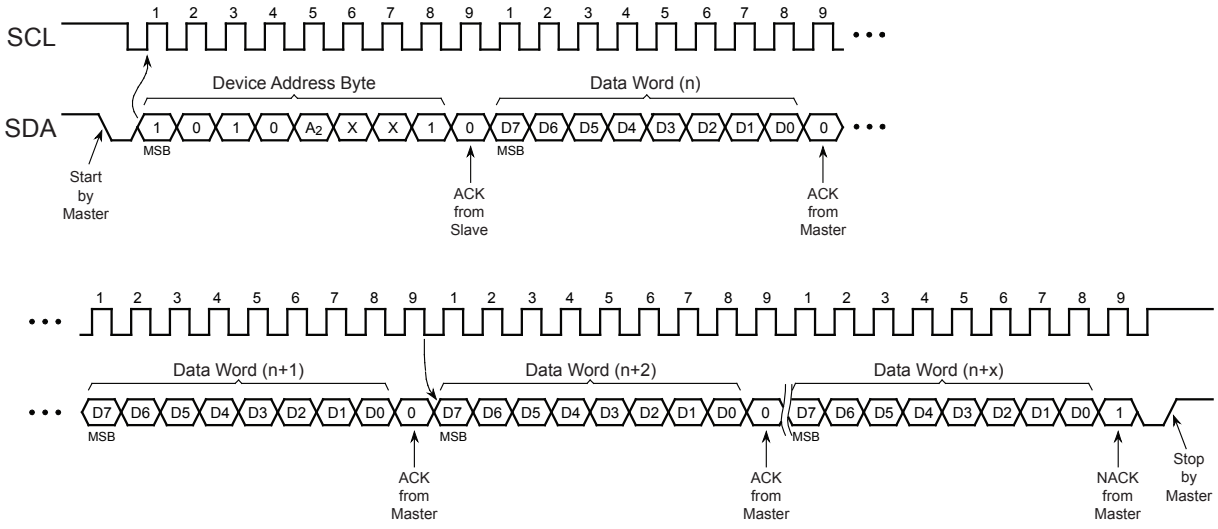
Figure 8-2. Random Read



8.3 Sequential Read

Sequential reads are initiated by either a current address read or a random read. After the bus master receives a data word, it responds with an Acknowledge. As long as the EEPROM receives an ACK, it will continue to increment the word address and serially clock out sequential data words. When the maximum memory address is reached, the data word address will roll-over and the sequential read will continue from the beginning of the memory array. All types of read operations will be terminated if the bus master does not respond with an ACK (it NACKs) during the ninth clock cycle. After the NACK response, the master may send a Stop condition to complete the protocol, or it can send a Start condition to begin the next sequence.

Figure 8-3. Sequential Read



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9. Device Default Condition from Microchip

The AT24CM02 is delivered with the EEPROM array set to logic '1', resulting in FFh data in all locations.

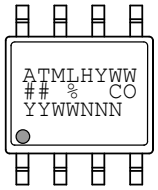
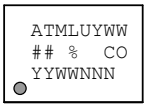
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10. Packaging Information

10.1 Package Marking Information

AT24CM02: Package Marking Information

8-lead SOIC	8-ball WLCSP Thin and Standard Thickness Options
	

Note 1: ● designates pin 1
Note 2: Package drawings are not to scale

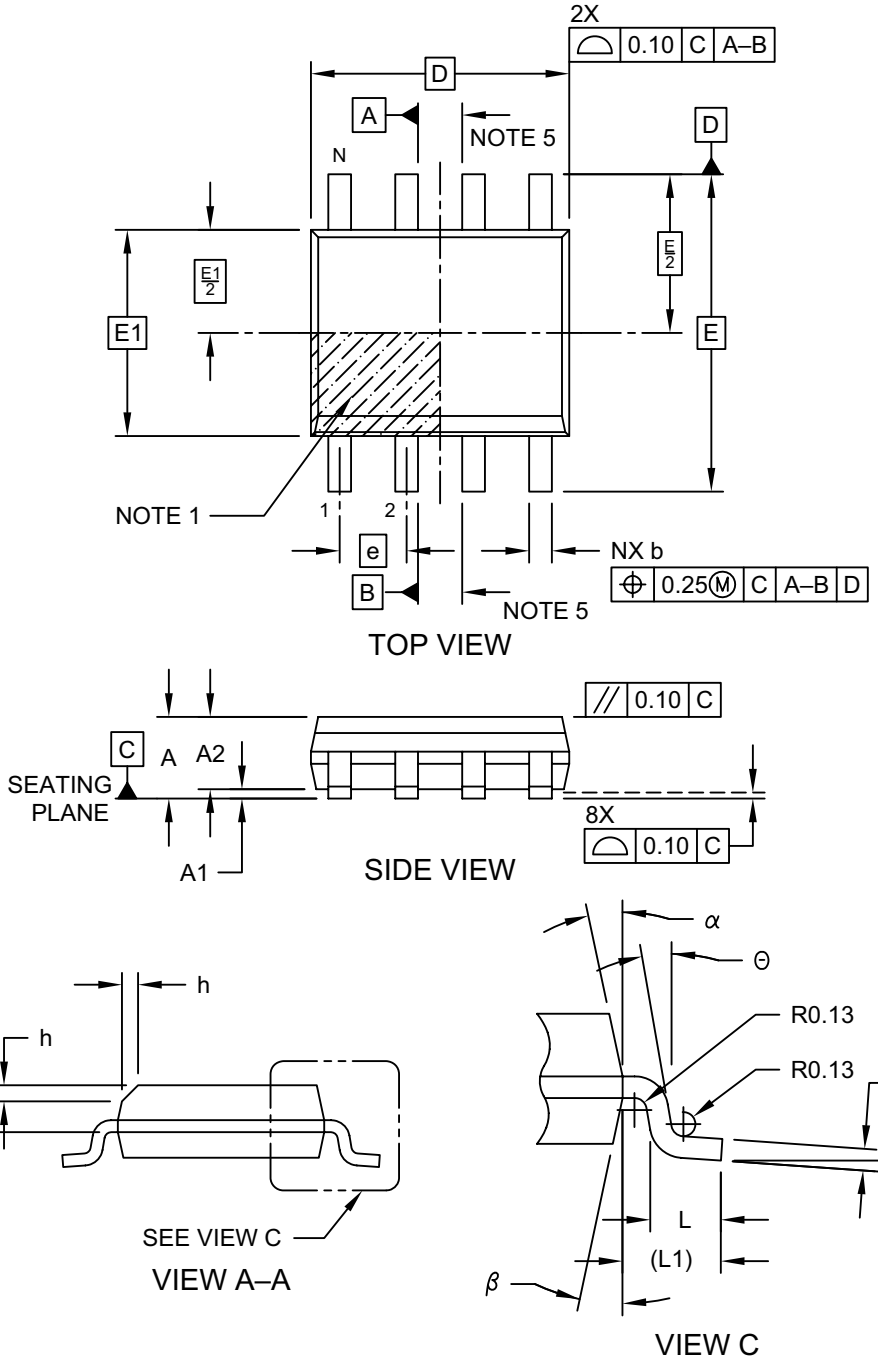
Catalog Number Truncation		
AT24CM02	Truncation Code ##: 2H	
Date Codes		**Voltages**
YY = Year 15: 2015 19: 2019 16: 2016 20: 2020 17: 2017 21: 2021 18: 2018 22: 2022	WW = Work Week of Assembly 02: Week 2 04: Week 4 ... 52: Week 52	% = Minimum Voltage M: 1.7V min D: 2.5V min
Country of Origin	**Device Grade**	**Atmel Truncation**
CO = Country of Origin	H or U: Industrial Grade	ATML: Atmel
Lot Number or Trace Code		
NNN = Alphanumeric Trace Code (2 Characters for small packages)		

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8-Lead Plastic Small Outline (SN) - Narrow, 3.90 mm (.150 In.) Body [SOIC]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging

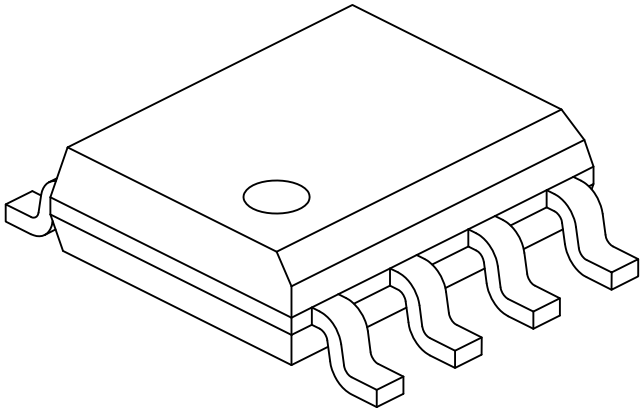


Microchip Technology Drawing No. C04-057-SN Rev D Sheet 1 of 2

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Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		8	
Pitch	e		1.27 BSC	
Overall Height	A	-	-	1.75
Molded Package Thickness	A2	1.25	-	-
Standoff §	A1	0.10	-	0.25
Overall Width	E		6.00 BSC	
Molded Package Width	E1		3.90 BSC	
Overall Length	D		4.90 BSC	
Chamfer (Optional)	h	0.25	-	0.50
Foot Length	L	0.40	-	1.27
Footprint	L1		1.04 REF	
Foot Angle	φ	0°	-	8°
Lead Thickness	c	0.17	-	0.25
Lead Width	b	0.31	-	0.51
Mold Draft Angle Top	α	5°	-	15°
Mold Draft Angle Bottom	β	5°	-	15°

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm per side.
4. Dimensioning and tolerancing per ASME Y14.5M

   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

   REF: Reference Dimension, usually without tolerance, for information purposes only.
5. Datums A & B to be determined at Datum H.

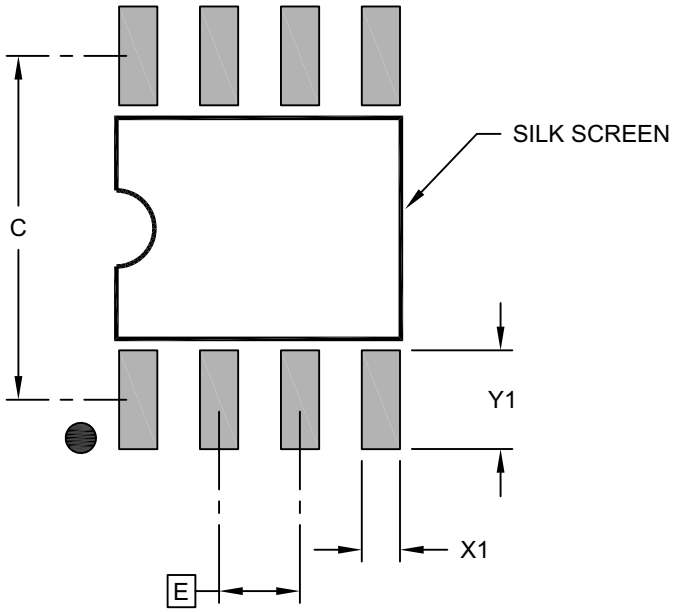
Microchip Technology Drawing No. C04-057-SN Rev D Sheet 2 of 2

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Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E		1.27 BSC	
Contact Pad Spacing	C		5.40	
Contact Pad Width (X8)	X1			0.60
Contact Pad Length (X8)	Y1			1.55

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

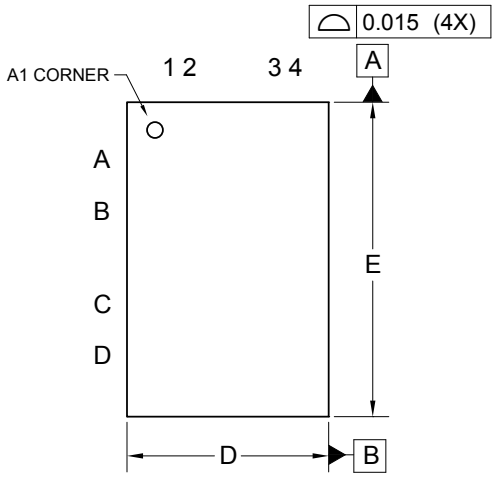
BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-2057-SN Rev B

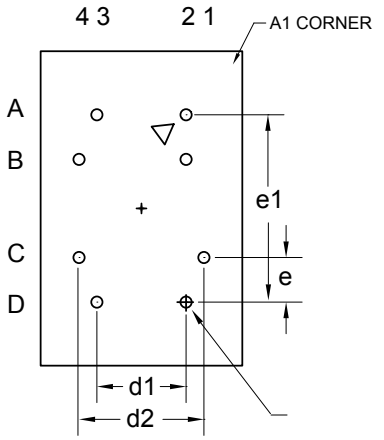
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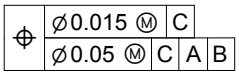
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TOP VIEW

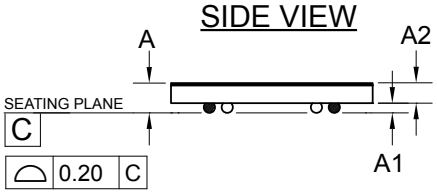


BOTTOM SIDE





SIDE VIEW



PIN ASSIGNMENT MATRIX

	1	2	3	4
A	n/a	V_{CC}	NC	n/a
B	n/a	WP	n/a	NC
C	SCL	n/a	n/a	A_2
D	n/a	SDA	GND	n/a

NC = Not Connected

COMMON DIMENSIONS
(Unit of Measure = mm)

SYMBOL	MIN	TYP	MAX	NOTE
A	0.313	0.334	0.355	
A1	—	0.094	—	
A2	—	0.240	—	3
D	Contact Microchip for details			
d1	1.00 BSC			
d2	1.40 BSC			
E	Contact Microchip for details			
e	0.50 BSC			
e1	2.10 BSC			
b	0.170	0.185	0.200	

Note: 1. Dimensions are NOT to scale.
2. Solder ball composition is 95.5Sn-4.0Ag-0.5Cu.
3. Product offered with Back Side Coating.

8/7/15

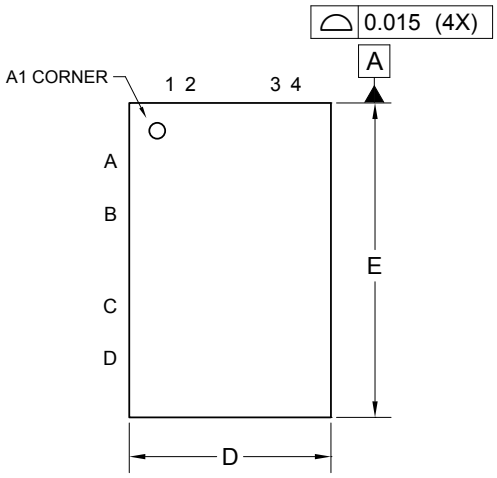
	TITLE	GPC	DRAWING NO.	REV.
	8U-11, 8-ball 4x4 Array, Custom Pitch Wafer Level Chip Scale Package (WLCSP) with BSC	GEN	8U-11	E

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging.

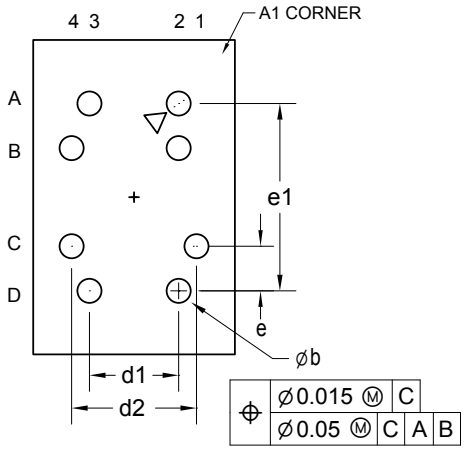
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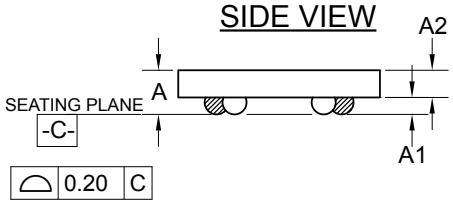
TOP VIEW



BOTTOM SIDE



SIDE VIEW



PIN ASSIGNMENT MATRIX

	1	2	3	4
A	n/a	V_{CC}	NC	n/a
B	n/a	WP	n/a	NC
C	SCL	n/a	n/a	A_2
D	n/a	SDA	GND	n/a

NC = Not Connected

COMMON DIMENSIONS
(Unit of Measure = mm)

SYMBOL	MIN	TYP	MAX	NOTE
A	0.456	0.495	0.534	
A1	—	0.190	—	
A2	—	0.305	—	
D	Contact Microchip for details.			
d1	1.00 BSC			
d2	1.40 BSC			
E	Contact Microchip for details.			
e	0.50 BSC			
e1	2.10 BSC			
b	—	0.270	—	

Note: 1. Dimensions are NOT to scale.
2. Solder ball composition is 95.5Sn-4.0Ag-0.5Cu.

4/5/16

	TITLE	GPC	DRAWING NO.	REV.
	8U-18, 8-ball 4x4 Array, Custom Pitch Wafer Level Chip Scale Package (WLCSP)	GQA	8U-18	01

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging.

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11. APPENDIX A: Revision History

Doc Rev.	Date	Comments
A	05/2019	Updated to Microchip template. Microchip DS20006197 replaces Atmel document 8812. Corrected t_{LOW} typo from 400 ns to 500 ns. Corrected t_{AA} typo from 550 ns to 450 ns. Updated Part Marking Information. Updated the “Software Reset” section. Added ESD rating. Removed lead finish designation. Update trace code format in package markings. Updated section content throughout for clarification. Updated SOIC package drawing to Microchip format.
E	01/2017	Atmel Document 8828 - Updated Power-on Requirements and Reset Behavior section.
D	05/2016	Atmel Document 8828 - Added the 8U-18 standard thickness WLCSP package option. Updated the “Clock and Data Transition Requirements” section and the “DC Characteristics” table.
C	11/2015	Atmel Document 8828 - Corrected 8-ball WLCSP pinout.
B	08/2015	Atmel Document 8828 - Updated the 8U-11 package drawing, data retention discrepancy, and 8-ball pinout.
A	05/2015	Atmel Document 8828 - Initial document release.

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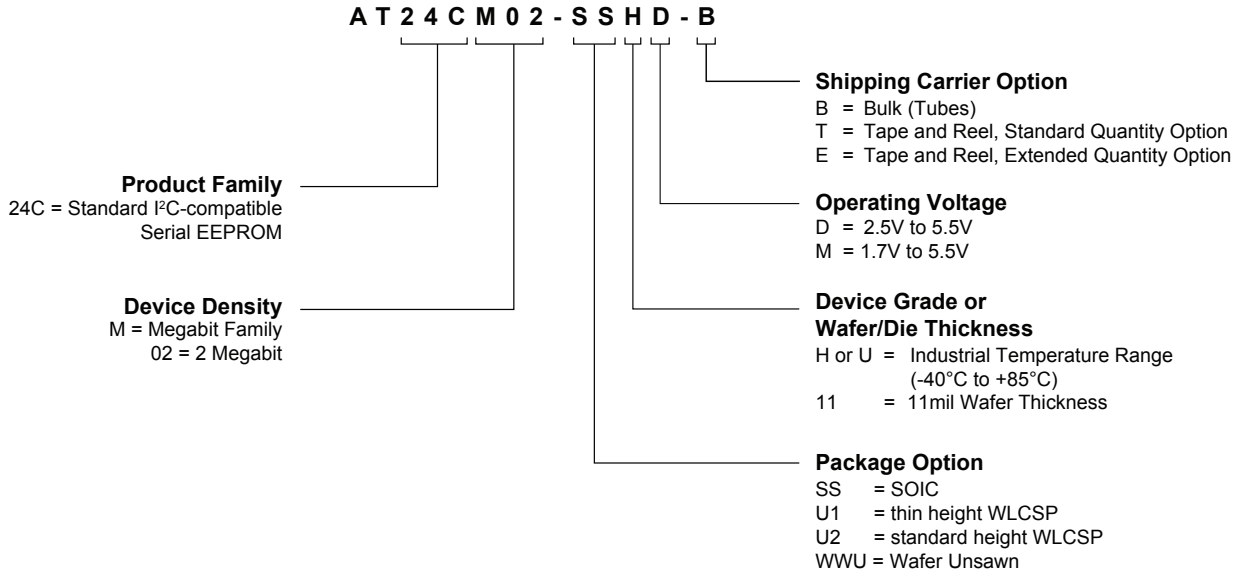
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Examples

Device	Package	Package Drawing Code	Package Option	Voltage	Shipping Carrier Option	Device Grade
AT24CM02-SSHM-B	SOIC	SN	SS	1.7V to 5.5V	Bulk (Tubes)	Industrial Temperature (-40°C to 85°C)
AT24CM02-SSHM-T	SOIC	SN	SS	1.7V to 5.5V	Tape and Reel	
AT24CM02-SSHD-B	SOIC	SN	SS	2.5V to 5.5V	Bulk (Tubes)	
AT24CM02-SSHD-T	SOIC	SN	SS	2.5V to 5.5V	Tape and Reel	
AT24CM02-U1UM0B-T (1)(2)	WLCSP	8U-11	U1	1.7V to 5.5V	Tape and Reel	
AT24CM02-U2UM-T(2)	WLCSP	8U-18	U2	1.7V to 5.5V	Tape and Reel	

Note:

1. This device includes a backside coating to increase product robustness.
2. **CAUTION*:*** Exposure to ultraviolet (UV) light can degrade the data stored in EEPROM cells. Therefore, customers who use a WLCSP package or the product at a die level must ensure that exposure to ultraviolet light does ***not*** occur.

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