

---

**I<sup>2</sup>C-Compatible (2-Wire) Serial EEPROM**  
**16-Kbit (2,048 x 8)**

---

**DATASHEET**

---

**Features**

---

- Low Voltage Operation
  - $V_{CC} = 1.7V$  to  $3.6V$
- Internally Organized as 2,048 x 8 (16K)
- I<sup>2</sup>C-Compatible (2-Wire) Serial Interface
  - 100kHz Standard Mode, 1.7V to 3.6V
  - 400kHz Fast Mode, 1.7V to 3.6V
  - 1MHz Fast Mode Plus (FM+), 2.5V to 3.6V
- Schmitt Triggers, Filtered Inputs for Noise Suppression
- Bidirectional Data Transfer Protocol
- Write Protect Pin for Full Array Hardware Data Protection (Except WLCSP)
- Ultra Low Active Current (1mA max) and Standby Current (0.8μA max)
- 16-byte Page Write Mode
  - Partial Page Writes Allowed
- Random and Sequential Read Modes
- Self-timed Write Cycle Within 5ms Maximum
- High Reliability
  - Endurance: 1,000,000 Write Cycles
  - Data Retention: 100 Years
- Green Package Options (Lead-free/Halide-free/RoHS Compliant)
  - 8-lead SOIC, 8-lead TSSOP, 8-pad UDFN, 8-lead PDIP,<sup>(1)</sup> 5-lead SOT23, 8-ball VFBGA, and 4-ball WLCSP
- Die Sale Options: Wafer Form and Tape and Reel Available

---

**Description**

---

The Atmel® AT24C16D provides 16,384 bits of Serial Electrically Erasable and Programmable Read-Only Memory (EEPROM) organized as 2,048 words of 8 bits each. This device is optimized for use in many industrial and commercial applications where low power and low voltage operation are essential. The device is available in space-saving 8-lead SOIC, 8-lead TSSOP, 8-pad UDFN, 8-lead PDIP<sup>(1)</sup>, 5-lead SOT23, 8-ball VFBGA, and 4-ball WLCSP packages. The entire family of packages operates from 1.7V to 3.6V.

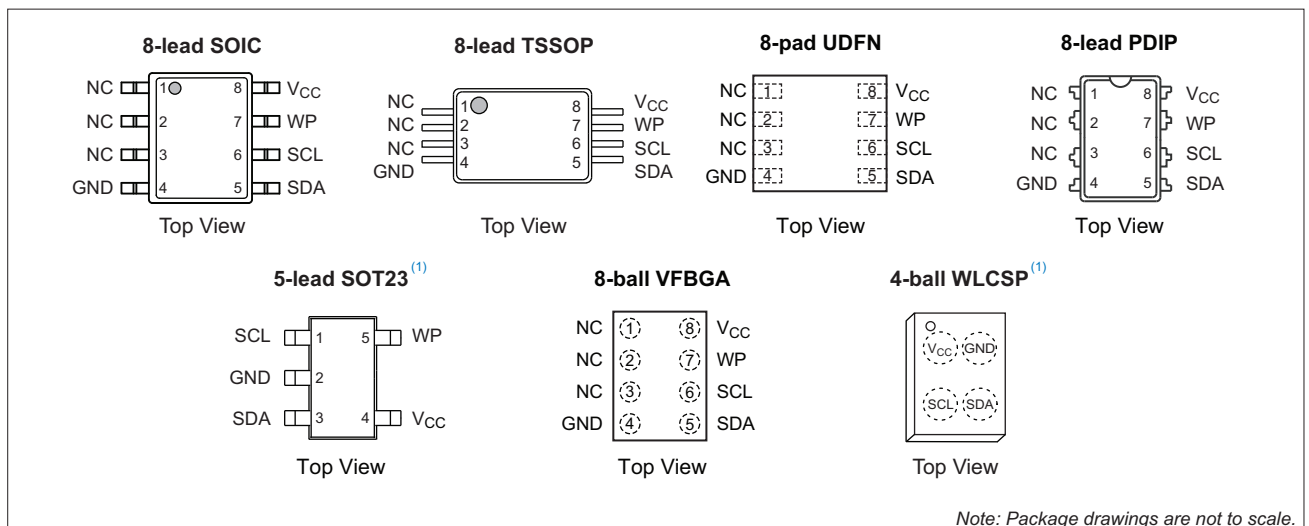
Note: 1. Contact Atmel Sales for the availability of this package.

# 1. Pin Descriptions and Pinouts

**Table 1-1. Pin Descriptions**

| Pin Number | Pin Symbol      | Pin Name and Functional Description                                                                                                                                                                                                                                                                                                                                                                                                      | Asserted State | Pin Type     |
|------------|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|--------------|
| 1, 2, 3    | NC              | <b>No Connect:</b> The NC pins are not bonded to a die pad. These pins can be connected to GND or left floating.                                                                                                                                                                                                                                                                                                                         | —              | —            |
| 4          | GND             | <b>Ground:</b> The ground reference for the power supply. GND should be connected to the system ground.                                                                                                                                                                                                                                                                                                                                  | —              | Power        |
| 5          | SDA             | <b>Serial Data:</b> The SDA pin is an open-drain bidirectional input/output pin used to serially transfer data to and from the device.<br><br>The SDA pin must be pulled-high using an external pull-up resistor (not to exceed 10K $\Omega$ 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.                                                               | —              | Input/Output |
| 6          | SCL             | <b>Serial Clock:</b> 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.<br><br>The SCL pin must either be forced high when the serial bus is idle or pulled-high using an external pull-up resistor. | —              | Input        |
| 7          | WP              | <b>Write Protect:</b> Connecting the WP pin to GND will ensure normal Write operations. When the WP pin is connected to V <sub>CC</sub> , all write operations to the memory are inhibited.<br><br>Refer to <a href="#">Note 1</a> for the behavior of the pin when not connected.                                                                                                                                                       | High           | Input        |
| 8          | V <sub>CC</sub> | <b>Device Power Supply:</b> The V <sub>CC</sub> pin is used to supply the source voltage to the device. Operations at invalid V <sub>CC</sub> voltages may produce spurious results and should not be attempted.                                                                                                                                                                                                                         | —              | Power        |

Note: 1. If the WP pin is not driven, it is 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 ( $\sim 0.5 \times V_{CC}$ ), the pull-down mechanism disengages. Atmel recommends connecting these pins to a known state whenever possible. Since the WLCSP has no WP pin, the write protection feature is not offered on the WLCSP.



Note: 1. Refer to “[Device Addressing](#)” for details about addressing the SOT23 and WLCSP version of the device. Since the WLCSP has no WP pin, the write protection feature is not offered on the WLCSP.

## 2. Device Block Diagram and System Configuration

Figure 2-1. Block Diagram

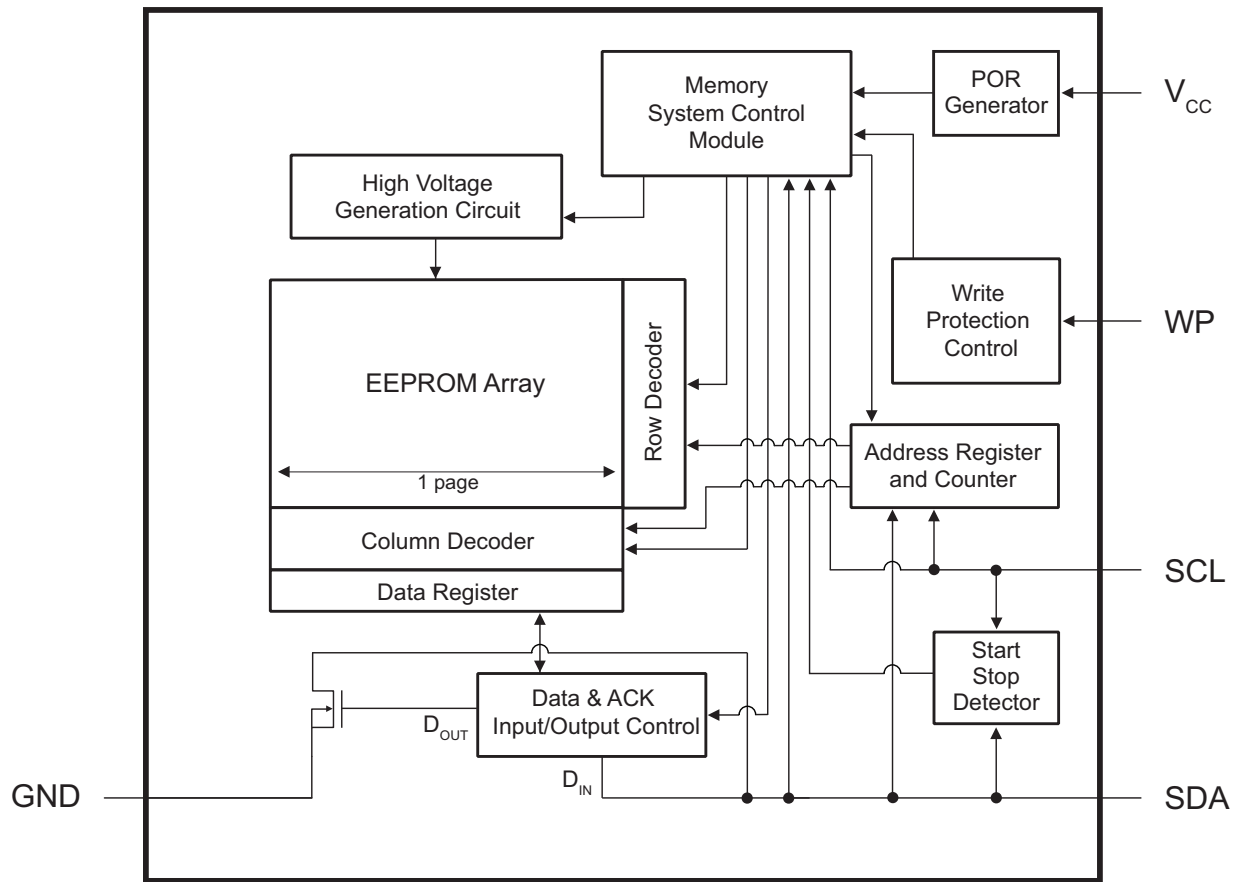
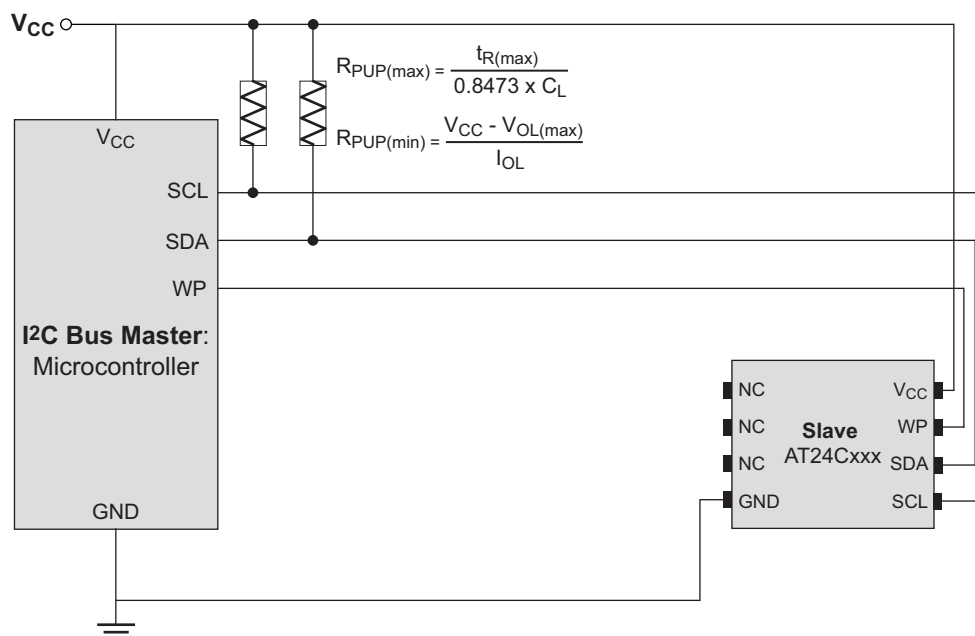


Figure 2-2. System Configuration Using 2-Wire Serial EEPROMs



## 3. Device Operation and Communication

The AT24C16D operates as a slave device and utilizes a simple I<sup>2</sup>C-compatible 2-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 AT24C16D on the rising edge of SCL and always output from the device on the falling edge of SCL. Both the SCL and SDA pin 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.

### 3.1 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. 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.

### 3.2 Start and Stop Conditions

#### 3.2.1 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. Please refer to [Figure 3-1](#) for more details.

#### 3.2.2 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. The Master can use the Stop condition to end a data transfer sequence with the AT24C16D 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. Please refer to [Figure 3-1](#) for more details.

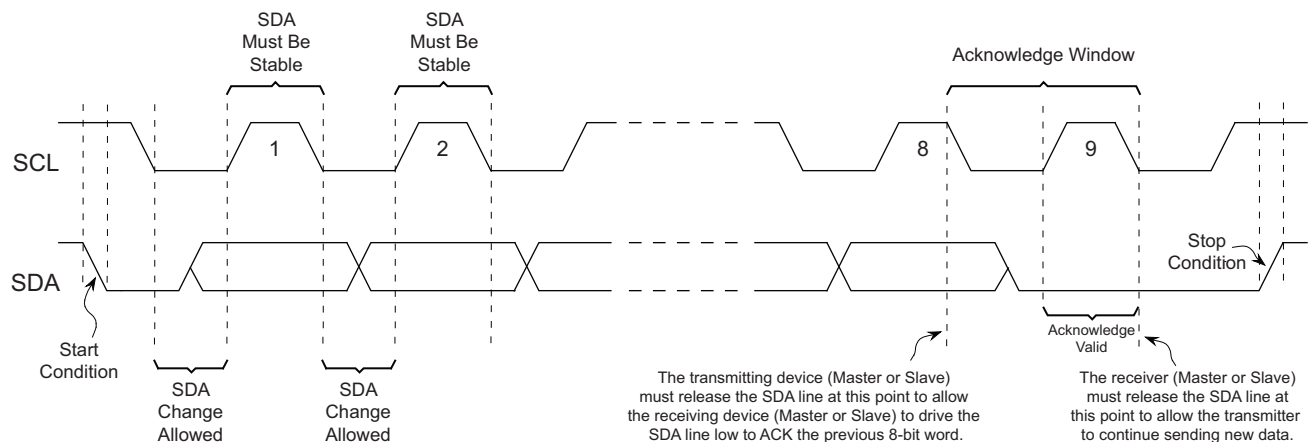
### 3.3 Acknowledge and No-Acknowledge

After every byte of data is received, the receiving device must confirm to the Master 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 AT24C16D 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 AT24C16D 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 AT24C16D 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 3-1 to better illustrate these requirements.

**Figure 3-1. Start Condition, Data Transitions, Stop Condition, and Acknowledge**



### 3.4 Standby Mode

The AT24C16D features a low power standby mode which is enabled when any one of the following occurs:

- A valid power-up sequence is performed (see [Section 8.5](#)).
- A Stop condition is received by the device unless it initiates an internal write cycle (see [Section 5](#)).
- At the completion of an internal write cycle (see [Section 5](#)).
- An unsuccessful match of the device type identifier or hardware address in the Device Address byte occurs (see [Section 4.1](#)).
- The bus Master does not ACK the receipt of data read out from the device; instead it sends a NACK response. (see [Section 6](#)).

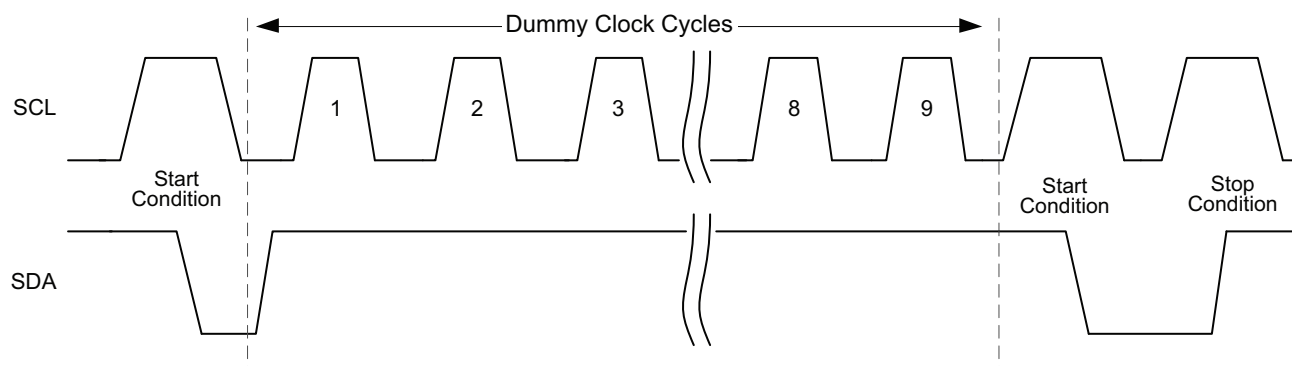
### 3.5 Software Reset

After an interruption in protocol, power loss, or system reset, any 2-Wire part can be protocol reset by following these steps:

1. Create a Start condition (if possible).
2. Clock nine cycles.
3. Create another Start condition followed by a Stop condition as seen in [Figure 3-2](#).

The device should be ready for the next communication after above steps have been completed. 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 [Section 8.5.1, “Device Reset”](#)).

**Figure 3-2. Software Reset**



## 4. Memory Organization

The AT24C16D is internally organized as 128 pages of 16 bytes each.

### 4.1 Device Addressing

Accessing the device requires an 8-bit Device Address word 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 word 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 4-1](#)).

Following the four bit device type identifier in the bit 3, bit 2, and bit 1 position of the Device Address byte are bits A10, A9, and A8 which are the three most significant bits of the memory array word address. The eighth bit (bit 0) of the Device Address byte is the Read/Write operation select bit. A Read operation is initiated if this bit is high, and a Write operation is initiated if this bit is low. Please refer to [Table 4-1](#) to review these bit positions.

Upon the successful comparison of the Device Address byte, the EEPROM will return an ACK. If a valid comparison is not made, the device will NACK and return to a standby state.

**Table 4-1. Device Address Byte**

| Package           | Device Type Identifier |       |       |       | Most Significant Bits of the Word Address |       |       | Read/Write        |
|-------------------|------------------------|-------|-------|-------|-------------------------------------------|-------|-------|-------------------|
|                   | Bit 7                  | Bit 6 | Bit 5 | Bit 4 | Bit 3                                     | Bit 2 | Bit 1 | Bit 0             |
| All Package Types | 1                      | 0     | 1     | 0     | A10                                       | A9    | A8    | R/ $\overline{W}$ |

For all operations except the Current Address Read, a Word Address byte must be transmitted to the device immediately following the Device Address byte. The Word Address byte consists of the remaining eight bits of the 11-bit memory array word address, and is used to specify which byte location in the EEPROM to start reading or writing. Please refer to [Table 4-2](#) to review these bit positions.

**Table 4-2. 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    |

The relationship of the AC timing parameters with respect to SCL and SDA for the AT24C16D are shown in the timing waveform [Figure 8-1](#) on page 14. The AC timing characteristics and specifications are outlined in [Section 8.4 "AC Characteristics" on page 14](#).

## 5. Write Operations

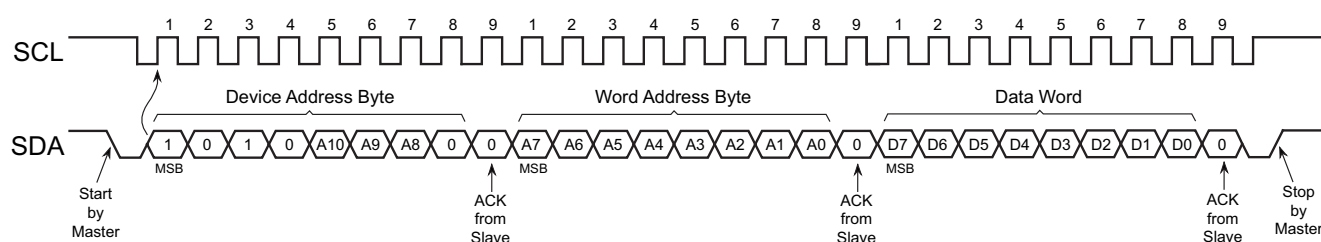
All Write operations for the AT24C16D begin with the Master sending a Start condition, followed by a Device Address byte with the R/W bit set to '0', and then by the Word Address byte. The data value(s) to be written to the device immediately follow the Word Address byte.

### 5.1 Byte Write

The AT24C16D supports the writing of single 8-bit bytes. Selecting a data word in the AT24C16D requires an 11-bit word address.

Upon receipt of the proper Device Address and Word Address bytes, the EEPROM will send an Acknowledge. The device will then be ready to receive the first 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 5-1. Byte Write



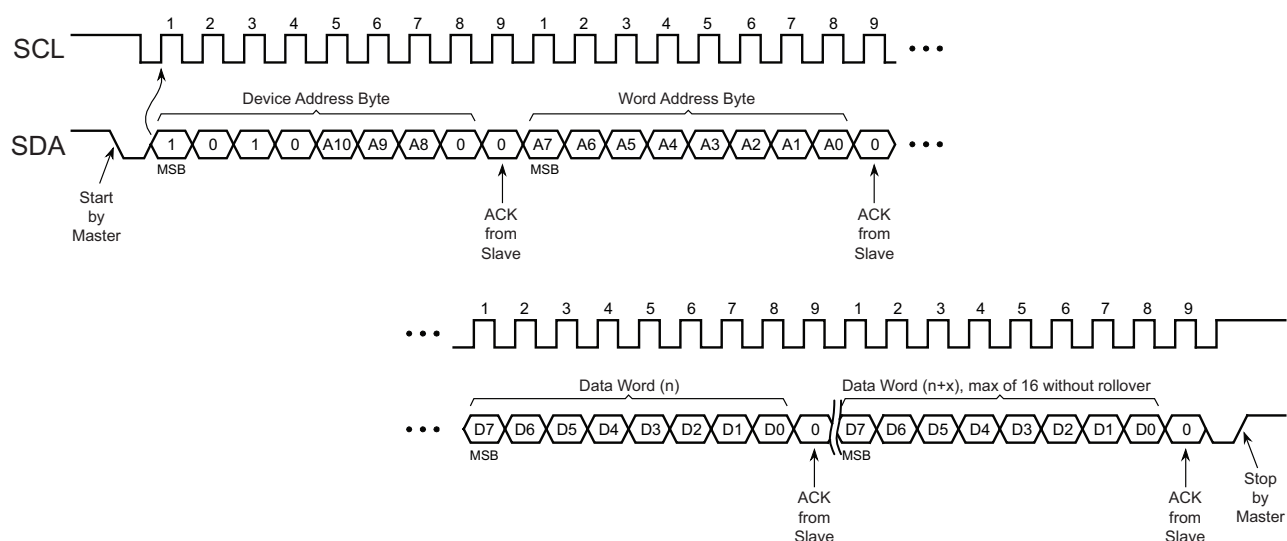
### 5.2 Page Write

A Page Write operation allows up to 16 bytes to be written in the same write cycle, provided all bytes are in the same row of the memory array (where address bits A10 through A4 are the same). Partial Page Writes of less than 16 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 fifteen 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 5-2) at which time the internally self-timed write cycle will begin.

The lower four 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 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 roll-over to the beginning of the same page. Nevertheless, creating a roll-over event should be avoided as previously loaded data in the page could become unintentionally altered.

**Figure 5-2. Page Write**

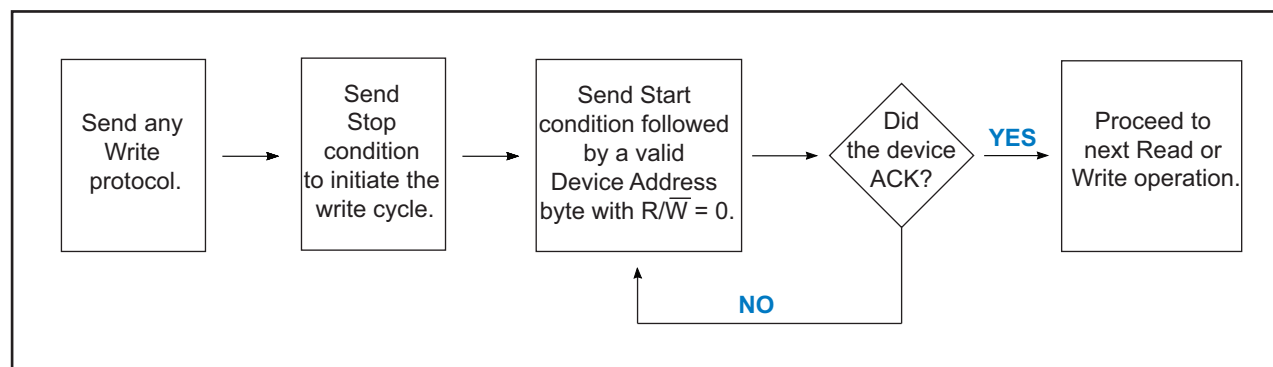


### 5.3 Acknowledge Polling

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 operation to be immediately initiated. A flow chart has been included below in [Figure 5-3](#) to better illustrate this technique.

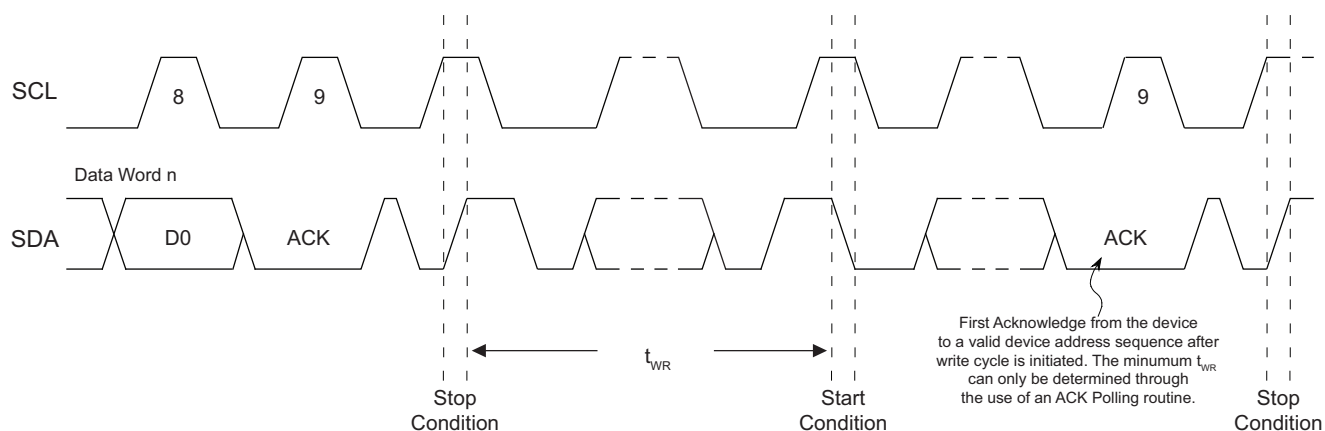
**Figure 5-3. Acknowledge Polling Flow Chart**



### 5.4 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 operation to the Start condition of the first Device Address byte sent to the AT24C16D that it subsequently responds to with an ACK. [Figure 5-4](#) 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 5-4. Write Cycle Timing**



## 5.5 Write Protection

The AT24C16D 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. Since the WLCSP has no WP pin, the write protection feature is not offered on the WLCSP.

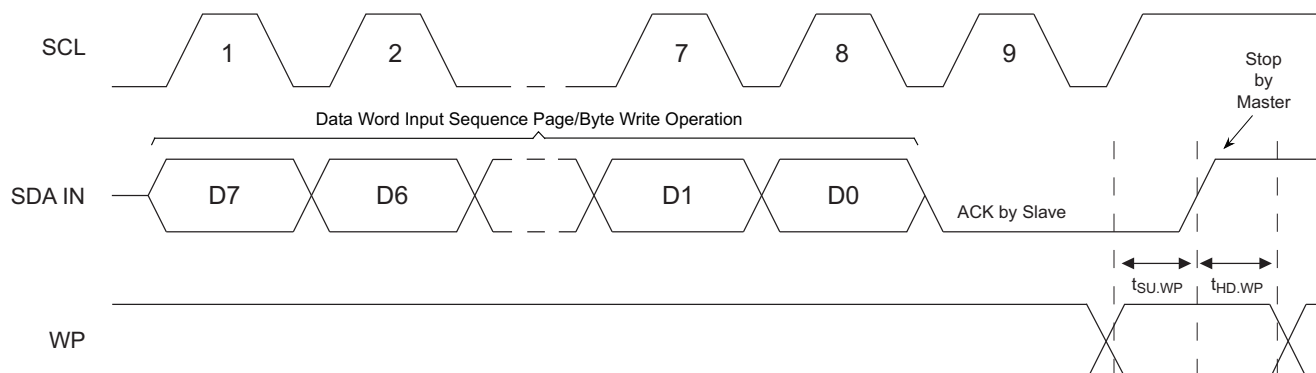
**Table 5-1. AT24C16D Write Protect Behavior**

| WP Pin Voltage | Part of the Array Protected         |
|----------------|-------------------------------------|
| $V_{CC}$       | Full Array                          |
| GND            | None — Write Protection Not Enabled |

The status of the WP pin is sampled at the Stop condition for every Byte Write or Page Write command prior to the start of an internally self-timed Write operation. 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 ( $t_{SU,WP}$ ) and hold ( $t_{HD,WP}$ ) timing as shown in the Figure 5-5 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.

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, and the device will immediately be ready to accept a new Read or Write command.

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



## 6. 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 word must be a Logic 1. There are three Read operations:

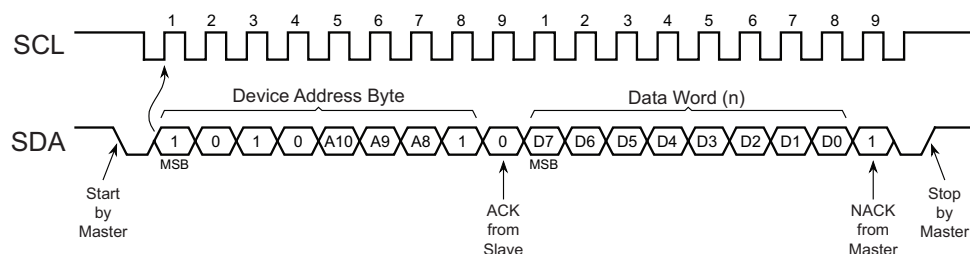
- Current Address Read
- Random Address Read
- Sequential Read

### 6.1 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 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/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, which will force the device into standby mode. 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.

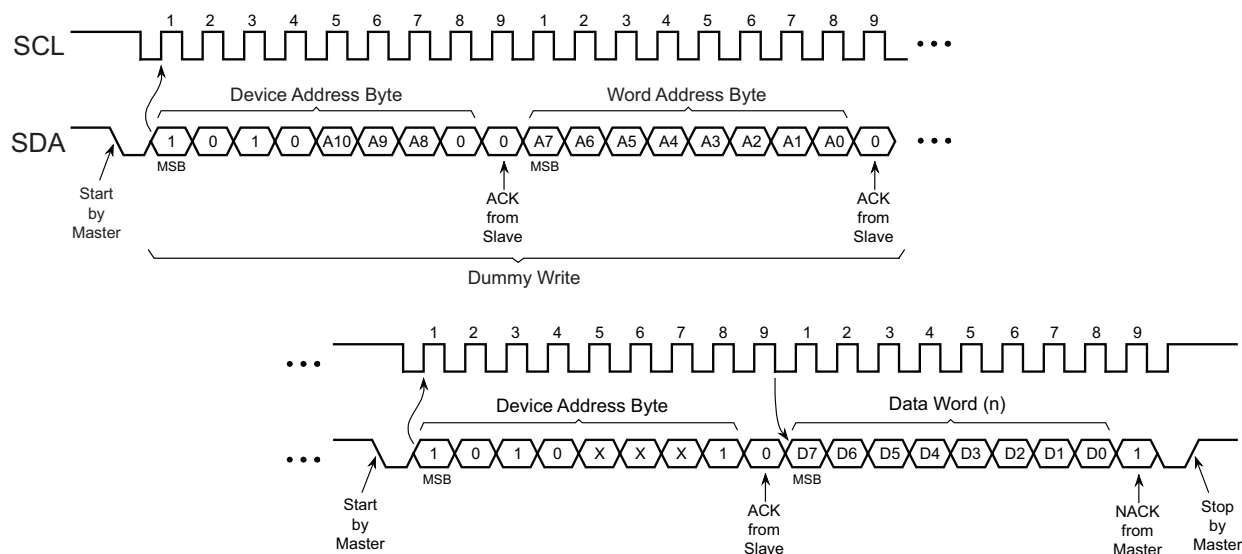
**Figure 6-1. Current Address Read**



### 6.2 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/W bit set to Logic 1. In this second Device Address byte, the bit positions usually reserved for the most significant bits of the Word Address (bit 3, 2, and 1) are don't care bits since the address that will be read from is determined only by what was sent in the dummy write portion of the sequence. 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, which will force the device into standby mode. 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.

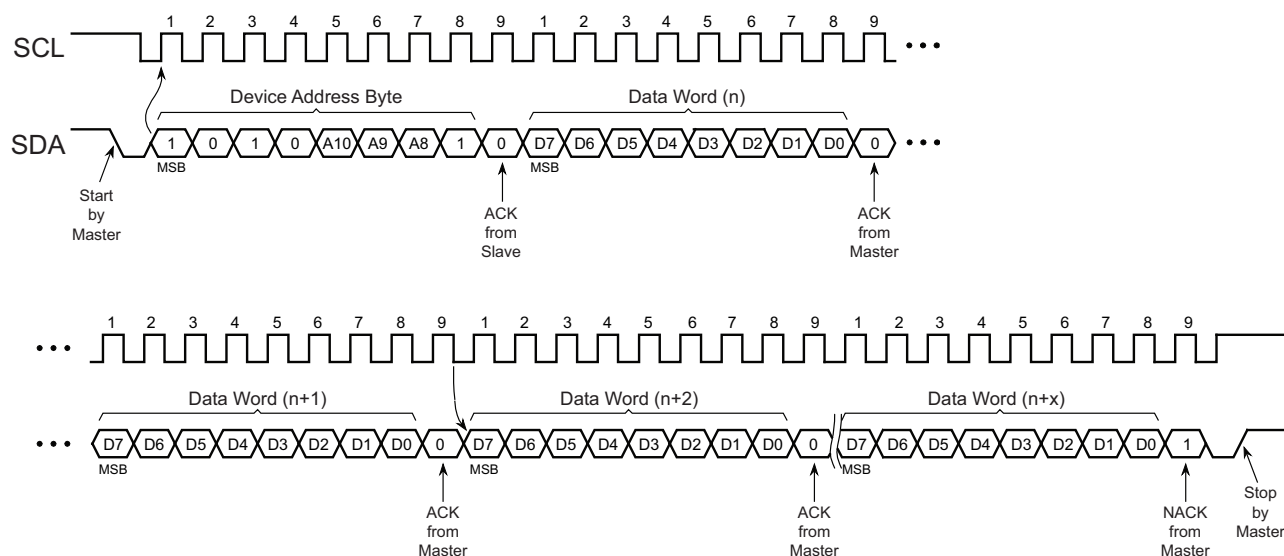
**Figure 6-2. Random Read**



## 6.3 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, which will force the device into standby mode. 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 6-3. Sequential Read**



## 7. Device Default Condition from Atmel

The AT24C16D is delivered with the EEPROM array set to Logic 1, resulting in FFh data in all locations.

## 8. Electrical Specifications

### 8.1 Absolute Maximum Ratings

|                                                        |                          |
|--------------------------------------------------------|--------------------------|
| Temperature under Bias . . . . .                       | -55°C to +125°C          |
| Storage Temperature . . . . .                          | -65°C to +150°C          |
| Supply Voltage<br>with respect to ground . . . . .     | -0.5V to +4.10V          |
| Voltage on any pin<br>with respect to ground . . . . . | -0.6V to $V_{CC} + 0.5V$ |
| DC Output Current . . . . .                            | 5.0mA                    |

Functional operation at the “Absolute Maximum Ratings” or any other conditions beyond those indicated in [Section 8.2 “DC and AC Operating Range”](#) is not implied or guaranteed. Stresses beyond those listed under “Absolute Maximum Ratings” and/or exposure to the “Absolute Maximum Ratings” for extended periods may affect device reliability and cause permanent damage to the device.

The voltage extremes referenced in the “Absolute Maximum Ratings” are intended to accommodate short duration undershoot/overshoot pulses that the device may be subjected to during the course of normal operation and does not imply or guarantee functional device operation at these levels for any extended period of time.

### 8.2 DC and AC Operating Range

Table 8-1. DC and AC Operating Range

|                              |                              | AT24C16D       |
|------------------------------|------------------------------|----------------|
| Operating Temperature (Case) | Industrial Temperature Range | -40°C to +85°C |
| $V_{CC}$ Power Supply        | Low Voltage Grade            | 1.7V to 3.6V   |

### 8.3 DC Characteristics

Table 8-2. DC Characteristics

| Symbol           | Parameter                       | Test Conditions                                       |                                                      | Min                   | Typical <sup>(1)</sup> | Max                   | Units |
|------------------|---------------------------------|-------------------------------------------------------|------------------------------------------------------|-----------------------|------------------------|-----------------------|-------|
| V <sub>CC</sub>  | Supply Voltage                  |                                                       |                                                      | 1.7                   |                        | 3.6                   | V     |
| I <sub>CC1</sub> | Supply Current, Read            | V <sub>CC</sub> = 1.8V <sup>(2)</sup>                 | Read at 400kHz                                       |                       | 0.08                   | 0.3                   | mA    |
|                  |                                 | V <sub>CC</sub> = 3.6V                                | Read at 1MHz                                         |                       | 0.15                   | 0.5                   | mA    |
| I <sub>CC2</sub> | Supply Current, Write           | V <sub>CC</sub> = 3.6V                                | Write at 1MHz                                        |                       | 0.20                   | 1.0                   | mA    |
| I <sub>SB</sub>  | Standby Current                 | V <sub>CC</sub> = 1.8V <sup>(2)</sup>                 | V <sub>IN</sub> = V <sub>CC</sub> or V <sub>SS</sub> |                       | 0.08                   | 0.4                   | μA    |
|                  |                                 | V <sub>CC</sub> = 3.6V                                |                                                      |                       | 0.10                   | 0.8                   | μA    |
| I <sub>LI</sub>  | Input Leakage Current           | V <sub>IN</sub> = V <sub>CC</sub> or V <sub>SS</sub>  |                                                      |                       | 0.10                   | 3.0                   | μA    |
| I <sub>LO</sub>  | Output Leakage Current          | V <sub>OUT</sub> = V <sub>CC</sub> or V <sub>SS</sub> |                                                      |                       | 0.05                   | 3.0                   | μA    |
| V <sub>IL</sub>  | Input Low Level <sup>(2)</sup>  |                                                       |                                                      | -0.6                  |                        | V <sub>CC</sub> x 0.3 | V     |
| V <sub>IH</sub>  | Input High Level <sup>(2)</sup> |                                                       |                                                      | V <sub>CC</sub> x 0.7 |                        | V <sub>CC</sub> + 0.5 | V     |
| V <sub>OL1</sub> | Output Low Level                | V <sub>CC</sub> = 1.8V                                | I <sub>OL</sub> = 0.15mA                             |                       |                        | 0.2                   | V     |
| V <sub>OL2</sub> | Output Low Level                | V <sub>CC</sub> = 3.0V                                | I <sub>OL</sub> = 2.1mA                              |                       |                        | 0.4                   | V     |

- Notes: 1. Typical values characterized at  $T_A = +25^\circ C$  unless otherwise noted.  
2. This parameter is characterized but is not 100% tested in production.

## 8.4 AC Characteristics

**Table 8-3. AC Characteristics**

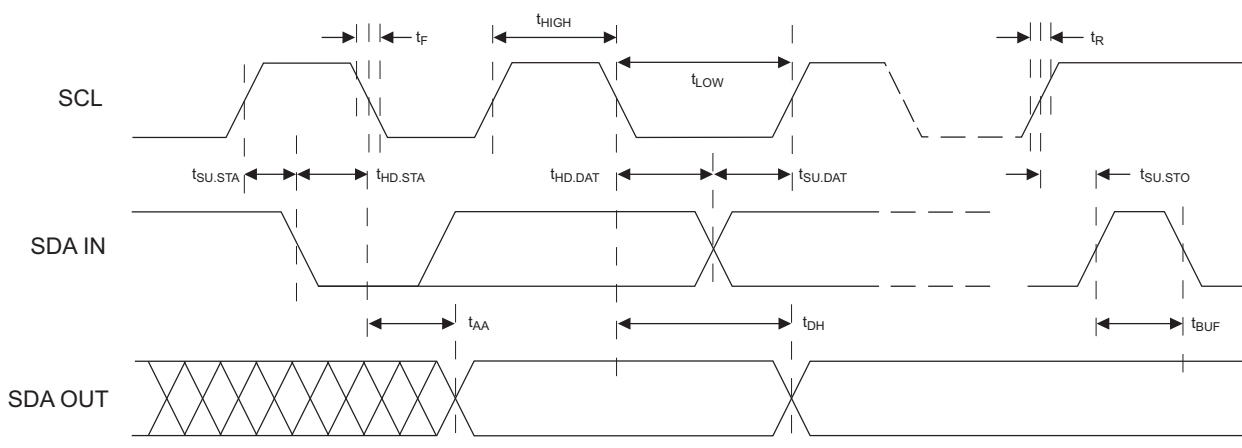
| Symbol              | Parameter                                               | Standard Mode                  |       | Fast Mode                      |     | Fast Mode Plus                 |      | Units |
|---------------------|---------------------------------------------------------|--------------------------------|-------|--------------------------------|-----|--------------------------------|------|-------|
|                     |                                                         | V <sub>CC</sub> = 1.7V to 3.6V |       | V <sub>CC</sub> = 1.7V to 3.6V |     | V <sub>CC</sub> = 2.5V to 3.6V |      |       |
|                     |                                                         | Min                            | Max   | Min                            | Max | Min                            | Max  |       |
| f <sub>SCL</sub>    | Clock Frequency, SCL                                    |                                | 100   |                                | 400 |                                | 1000 | kHz   |
| t <sub>LOW</sub>    | Clock Pulse Width Low                                   | 4,700                          |       | 1,300                          |     | 500                            |      | ns    |
| t <sub>HIGH</sub>   | Clock Pulse Width High                                  | 4,000                          |       | 600                            |     | 400                            |      | ns    |
| t <sub>I</sub>      | Input Filter Spike Suppression (SCL,SDA) <sup>(1)</sup> |                                | 100   |                                | 100 |                                | 100  | ns    |
| t <sub>AA</sub>     | Clock Low to Data Out Valid                             |                                | 4,500 |                                | 900 |                                | 450  | ns    |
| t <sub>BUF</sub>    | Bus Free Time between Stop and Start <sup>(1)</sup>     | 4,700                          |       | 1,300                          |     | 500                            |      | ns    |
| t <sub>HD.STA</sub> | Start Hold Time                                         | 4,000                          |       | 600                            |     | 250                            |      | ns    |
| t <sub>SU.STA</sub> | Start Set-up Time                                       | 4,700                          |       | 600                            |     | 250                            |      | ns    |
| t <sub>HD.DAT</sub> | Data In Hold Time                                       | 0                              |       | 0                              |     | 0                              |      | ns    |
| t <sub>SU.DAT</sub> | Data In Set-up Time                                     | 200                            |       | 100                            |     | 100                            |      | ns    |
| t <sub>R</sub>      | Inputs Rise Time <sup>(1)</sup>                         |                                | 1,000 |                                | 300 |                                | 100  | ns    |
| t <sub>F</sub>      | Inputs Fall Time <sup>(1)</sup>                         |                                | 300   |                                | 300 |                                | 100  | ns    |
| t <sub>SU.STO</sub> | Stop Set-up Time                                        | 4,700                          |       | 600                            |     | 250                            |      | ns    |
| t <sub>SU.WP</sub>  | Write Protect Setup Time                                | 4,000                          |       | 600                            |     | 100                            |      | ns    |
| t <sub>HD.WP</sub>  | Write Protect Hold Time                                 | 4,000                          |       | 600                            |     | 400                            |      | ns    |
| t <sub>DH</sub>     | Data Out Hold Time                                      | 100                            |       | 50                             |     | 50                             |      | ns    |
| t <sub>WR</sub>     | Write Cycle Time                                        |                                | 5     |                                | 5   |                                | 5    | ms    |

Notes: 1. These parameters are determined through product characterization and are not 100% tested in production.

2. AC measurement conditions:

- $C_L$  : 100pF
- $R_{PUP}$  (SDA bus line pull-up resistor to  $V_{CC}$ ): 1.3k $\Omega$  (1000kHz), 4k $\Omega$  (400kHz), 10k $\Omega$  (100kHz)
- Input pulse voltages: 0.3 x  $V_{CC}$  to 0.7 x  $V_{CC}$
- Input rise and fall times:  $\leq 50ns$
- Input and output timing reference voltages: 0.5 x  $V_{CC}$

**Figure 8-1. Bus Timing**



## 8.5 Power-Up Requirements and Reset Behavior

During a power-up sequence, the  $V_{CC}$  supplied to the AT24C16D should monotonically rise from GND to the minimum  $V_{CC}$  level as specified in [Section 8.2](#) with a slew rate no faster than  $0.1V/\mu s$ .

### 8.5.1 Device Reset

To prevent inadvertent write operations or any other spurious events from occurring during a power-up sequence, the AT24C16D 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 8-4](#) for the values associated with these power-up parameters.

**Table 8-4. Power-up Conditions<sup>(1)</sup>**

| Symbol     | Parameter                                                                     | Min | Max | Units   |
|------------|-------------------------------------------------------------------------------|-----|-----|---------|
| $t_{PUP}$  | Time required after $V_{CC}$ is stable before the device can accept commands. | 100 |     | $\mu s$ |
| $V_{POR}$  | 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 AT24C16D 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.

## 8.6 Pin Capacitance

**Table 8-5. Pin Capacitance<sup>(1)</sup>**

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

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

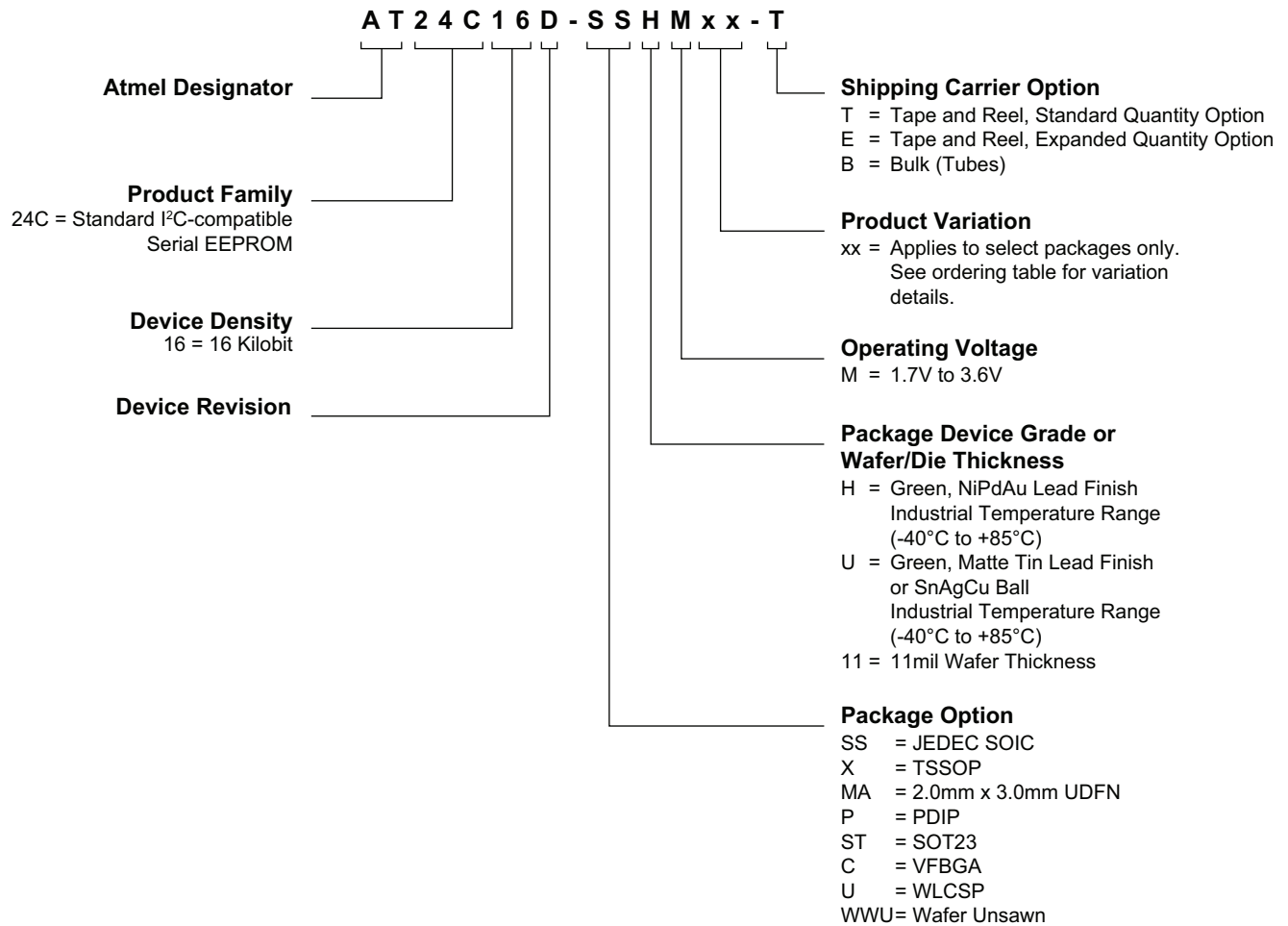
## 8.7 EEPROM Cell Performance Characteristics

**Table 8-6. EEPROM Cell Performance Characteristics**

| Operation                      | Test Condition                                                                          | Min       | Max | Units        |
|--------------------------------|-----------------------------------------------------------------------------------------|-----------|-----|--------------|
| Write Endurance <sup>(1)</sup> | $T_A = 25^{\circ}C$ , $V_{CC}(\min) < V_{CC} < V_{CC}(\max)$<br>Byte or Page Write Mode | 1,000,000 | —   | Write Cycles |
| Data Retention <sup>(2)</sup>  | $T_A = 55^{\circ}C$ , $V_{CC}(\min) < V_{CC} < V_{CC}(\max)$                            | 100       | —   | Years        |

Notes: 1. Write endurance performance is determined through characterization and the qualification process.  
2. The data retention capability is determined through qualification and is checked on each device in production.

## 9. Ordering Code Detail



## 10. Ordering Information

| Atmel Ordering Code             | Lead Finish                             | Package    | Delivery Information |                 | Operation Range                           |
|---------------------------------|-----------------------------------------|------------|----------------------|-----------------|-------------------------------------------|
|                                 |                                         |            | Form                 | Quantity        |                                           |
| AT24C16D-SSHM-T                 | NiPdAu<br>(Lead-free/Halogen-free)      | 8S1        | Tape and Reel        | 4,000 per Reel  | Industrial Temperature<br>(-40°C to 85°C) |
| AT24C16D-SSHM-B                 |                                         |            | Bulk (Tubes)         | 100 per Tube    |                                           |
| AT24C16D-XHM-T                  |                                         | 8X         | Tape and Reel        | 5,000 per Reel  |                                           |
| AT24C16D-XHM-B                  |                                         |            | Bulk (Tubes)         | 100 per Tube    |                                           |
| AT24C16D-MAHM-T                 |                                         | 8MA2       | Tape and Reel        | 5,000 per Reel  |                                           |
| AT24C16D-MAHM-E                 |                                         |            | Tape and Reel        | 15,000 per Reel |                                           |
| AT24C16D-PUM                    | Matte Tin<br>(Lead-free/Halogen-free)   | 8P3        | Bulk (Tubes)         | 50 per Tube     |                                           |
| AT24C16D-STUM-T                 |                                         | 5TS1       | Tape and Reel        | 5,000 per Reel  |                                           |
| AT24C16D-CUM-T                  | SnAgCu Ball<br>(Lead-free/Halogen-free) | 8U3-1      | Tape and Reel        | 5,000 per Reel  |                                           |
| AT24C16D-UUM0B-T <sup>(1)</sup> |                                         | 4U-5       | Tape and Reel        | 5,000 per Reel  |                                           |
| AT24C16D-WWU11M <sup>(2)</sup>  | N/A                                     | Wafer Sale |                      |                 |                                           |

Notes: 1. WLCSP Package:

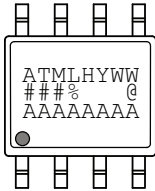
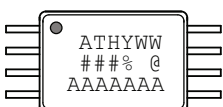
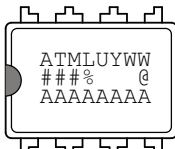
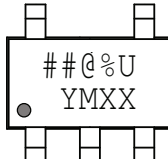
- This device includes a backside coating to increase product robustness.
- **CAUTION:** Exposure to ultraviolet (UV) light can degrade the data stored in the EEPROM cells. Therefore, customers who use a WLCSP product must ensure that exposure to ultraviolet light does **not** occur.

2. For wafer sales, please contact Atmel Sales.

| Package Type |                                                                                         |
|--------------|-----------------------------------------------------------------------------------------|
| 8S1          | 8-lead, 0.15" wide, Plastic Gull Wing Small Outline (JEDEC SOIC)                        |
| 8X           | 8-lead, 4.40mm body, Plastic Thin Shrink Small Outline Package (TSSOP)                  |
| 8MA2         | 8-pad, 2.00mm x 3.00mm x 0.60mm body, 0.50mm Pitch, Ultra Thin Dual Flat No Lead (UDFN) |
| 8P3          | 8-lead, 0.30" wide, Plastic Dual In-line Package (PDIP)                                 |
| 5TS1         | 5-lead, 1.60mm body, Plastic Thin Shrink Small Outline (SOT23)                          |
| 8U3-1        | 8-ball, 1.50mm x 2.00mm body, 0.50mm pitch, Very thin Fine Ball Grid Array (VFPGA)      |
| 4U-5         | 4-ball, 2 x 2 Grid Array, 0.40mm pitch, Wafer Level Chip Scale Package (WLCSP)          |

## 11. Part Markings

### AT24C16D: Package Marking Information

| 8-lead SOIC                                                                       | 8-lead TSSOP                                                                                           | 8-pad UDFN                                                                                              | 8-lead PDIP                                                                         |
|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|  |                       | 2.0 x 3.0 mm Body<br> |  |
| 5-lead SOT-23                                                                     | 8-ball VFBGA                                                                                           | 4-ball WLCSP                                                                                            |                                                                                     |
|  | 1.5 x 2.0 mm Body<br> |                      |                                                                                     |

Note 1: ● designates pin 1

Note 2: Package drawings are not to scale

Note 3: For SOT23 package with date codes before 7B, the bottom line (YMXX) is marked on the bottom side and there is no Country of Assembly (@) mark on the top line.

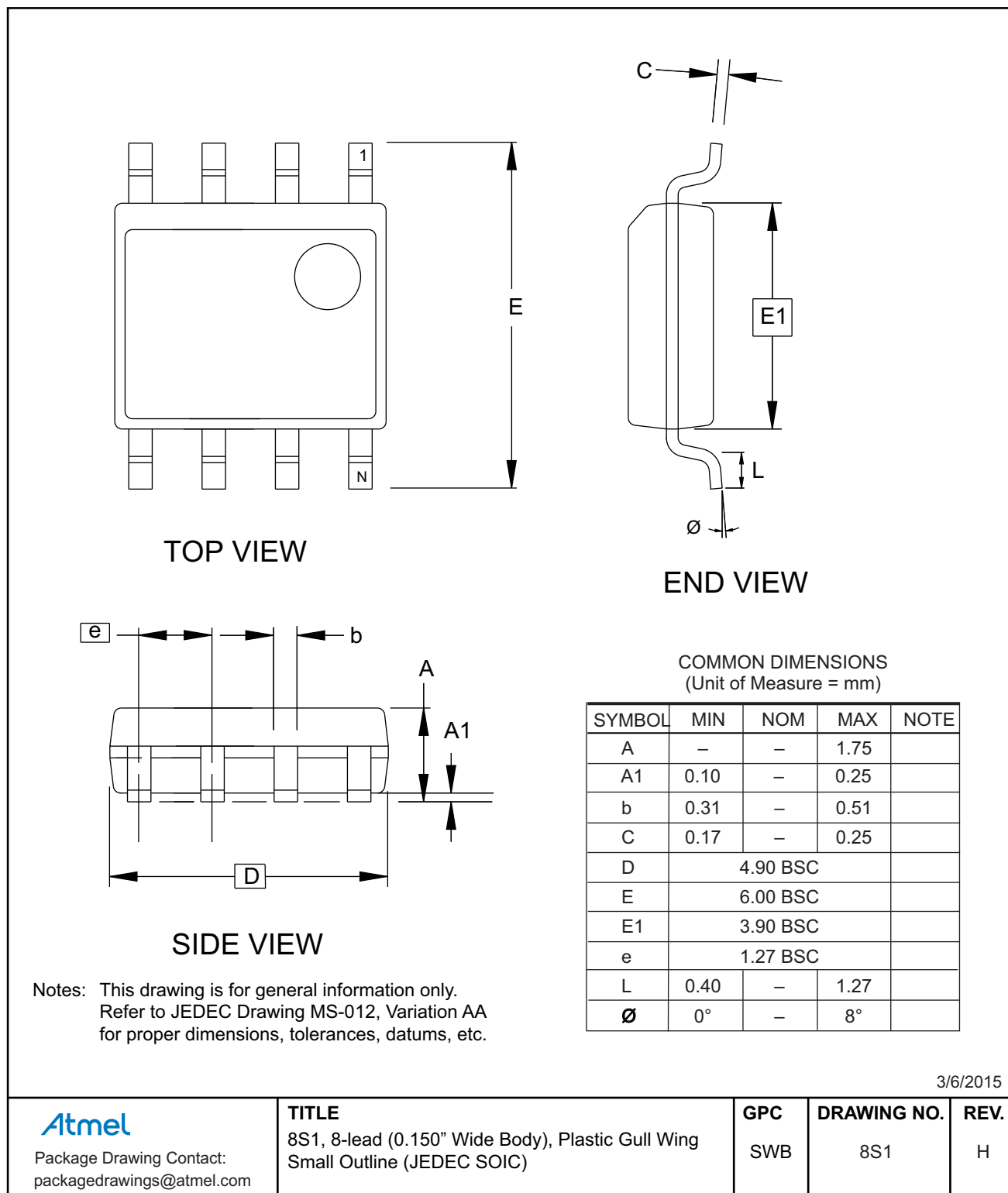
| Catalog Number Truncation                                                            |         |                                   |                                        |                                                        |
|--------------------------------------------------------------------------------------|---------|-----------------------------------|----------------------------------------|--------------------------------------------------------|
| AT24C16D                                                                             |         | Truncation Code ###: 16D / ##: AD |                                        |                                                        |
| Date Codes                                                                           |         |                                   | Voltages                               |                                                        |
| Y = Year                                                                             |         | M = Month                         | WW = Work Week of Assembly             | % = Minimum Voltage                                    |
| 6: 2016                                                                              | 0: 2020 | A: January                        | 02: Week 2                             | M: 1.7V min                                            |
| 7: 2017                                                                              | 1: 2021 | B: February                       | 04: Week 4                             |                                                        |
| 8: 2018                                                                              | 2: 2022 | ...                               | ...                                    |                                                        |
| 9: 2019                                                                              | 3: 2023 | L: December                       | 52: Week 52                            |                                                        |
| Country of Assembly                                                                  |         | Lot Number                        |                                        | Grade/Lead Finish Material                             |
| @ = Country of Assembly                                                              |         | AAA...A = Atmel Wafer Lot Number  |                                        | H: Industrial/NiPdAu<br>U: Industrial/Matte Tin/SnAgCu |
| Trace Code                                                                           |         |                                   | Atmel Truncation                       |                                                        |
| XX = Trace Code (Atmel Lot Numbers Correspond to Code)<br>Example: AA, AB.... YZ, ZZ |         |                                   | AT: Atmel<br>ATM: Atmel<br>ATML: Atmel |                                                        |

12/7/16

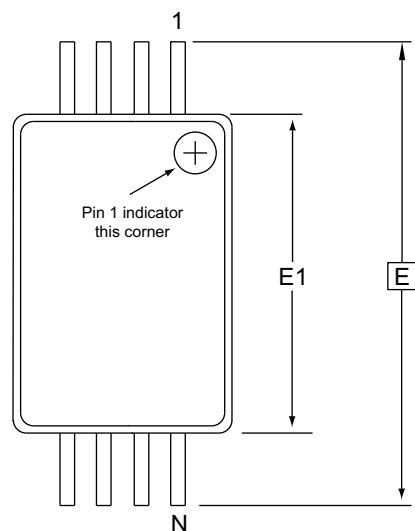
|                                                                                                                                           |                                                |             |      |
|-------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|-------------|------|
| <br>Package Mark Contact:<br>DL-CSO-Assy_eng@atmel.com | TITLE                                          | DRAWING NO. | REV. |
|                                                                                                                                           | 24C16DSM, AT24C16D Package Marking Information | 24C16DSM    | C    |

## 12. Packaging Information

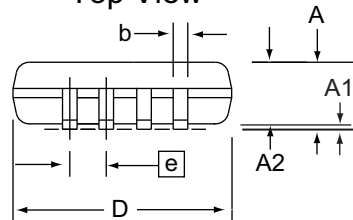
### 12.1 8S1 — 8-lead JEDEC SOIC



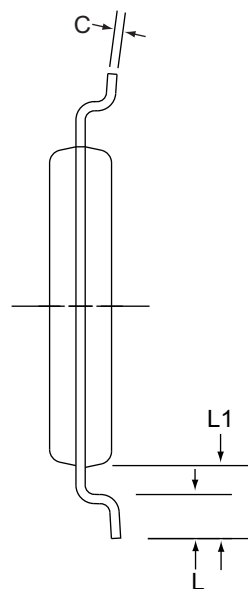
## 12.2 8X — 8-lead TSSOP



Top View



Side View



End View

COMMON DIMENSIONS  
(Unit of Measure = mm)

| SYMBOL | MIN      | NOM  | MAX  | NOTE |
|--------|----------|------|------|------|
| A      | -        | -    | 1.20 |      |
| A1     | 0.05     | -    | 0.15 |      |
| A2     | 0.80     | 1.00 | 1.05 |      |
| D      | 2.90     | 3.00 | 3.10 | 2, 5 |
| E      | 6.40 BSC |      |      |      |
| E1     | 4.30     | 4.40 | 4.50 | 3, 5 |
| b      | 0.19     | 0.25 | 0.30 | 4    |
| e      | 0.65 BSC |      |      |      |
| L      | 0.45     | 0.60 | 0.75 |      |
| L1     | 1.00 REF |      |      |      |
| C      | 0.09     | -    | 0.20 |      |

- Notes:
1. This drawing is for general information only. Refer to JEDEC Drawing MO-153, Variation AA, for proper dimensions, tolerances, datums, etc.
  2. Dimension D does not include mold Flash, protrusions or gate burrs. Mold Flash, protrusions and gate burrs shall not exceed 0.15mm (0.006in) per side.
  3. Dimension E1 does not include inter-lead Flash or protrusions. Inter-lead Flash and protrusions shall not exceed 0.25mm (0.010in) per side.
  4. Dimension b does not include Dambar protrusion. Allowable Dambar protrusion shall be 0.08mm total in excess of the b dimension at maximum material condition. Dambar cannot be located on the lower radius of the foot. Minimum space between protrusion and adjacent lead is 0.07mm.
  5. Dimension D and E1 to be determined at Datum Plane H.

2/27/14

**Atmel**

Package Drawing Contact:  
packagedrawings@atmel.com

### TITLE

8X, 8-lead 4.4mm Body, Plastic Thin  
Shrink Small Outline Package (TSSOP)

### GPC

TNR

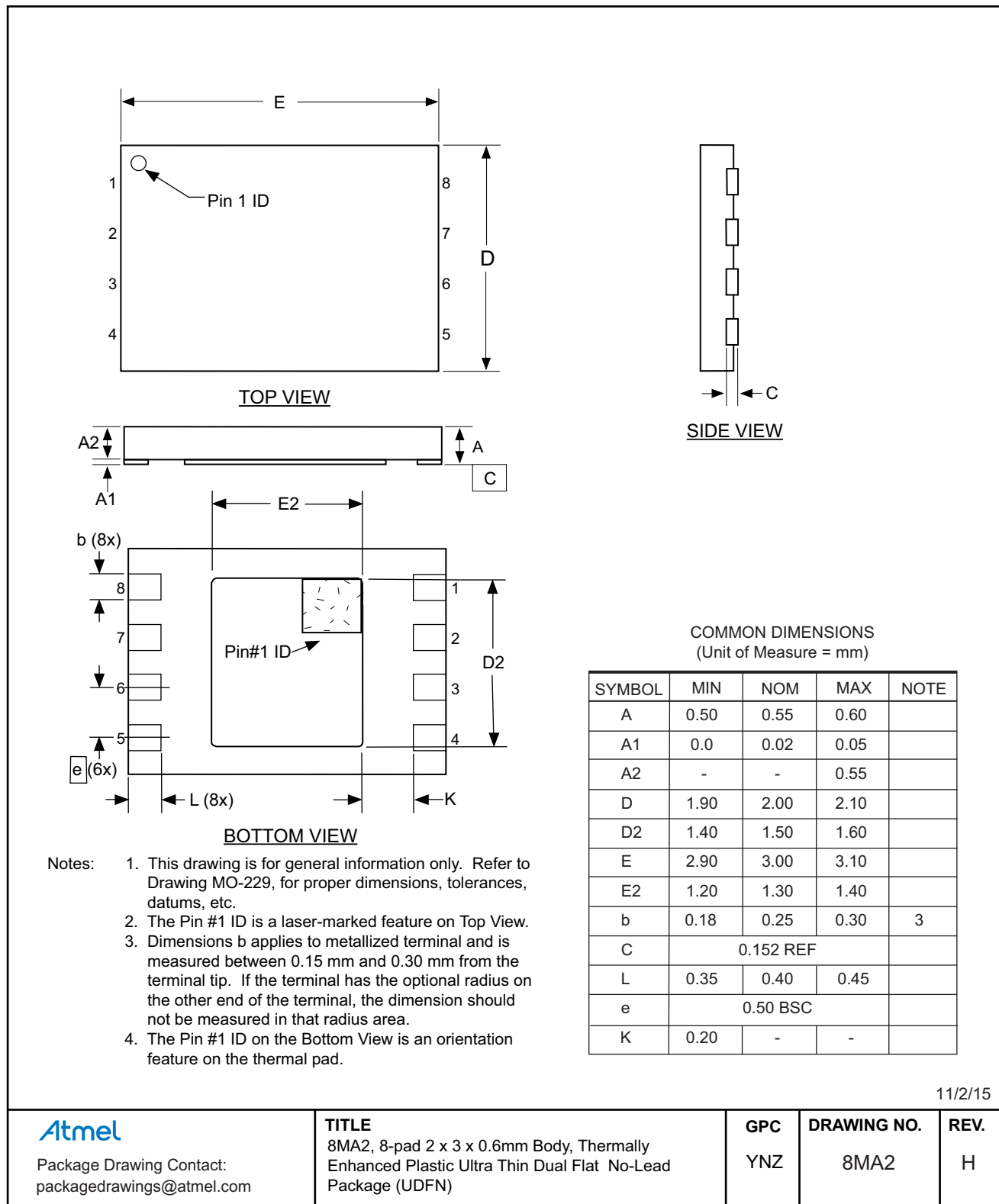
### DRAWING NO.

8X

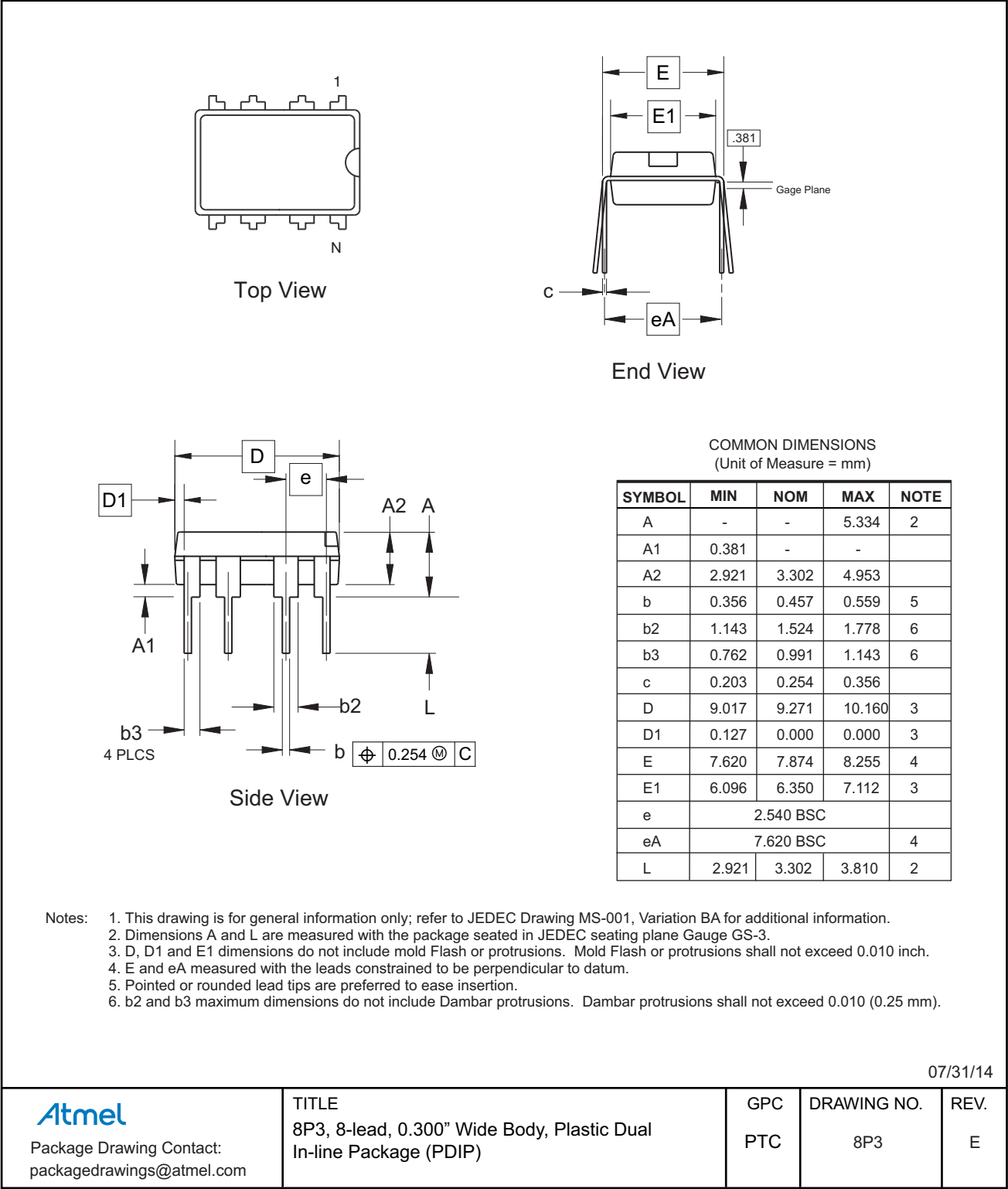
### REV.

E

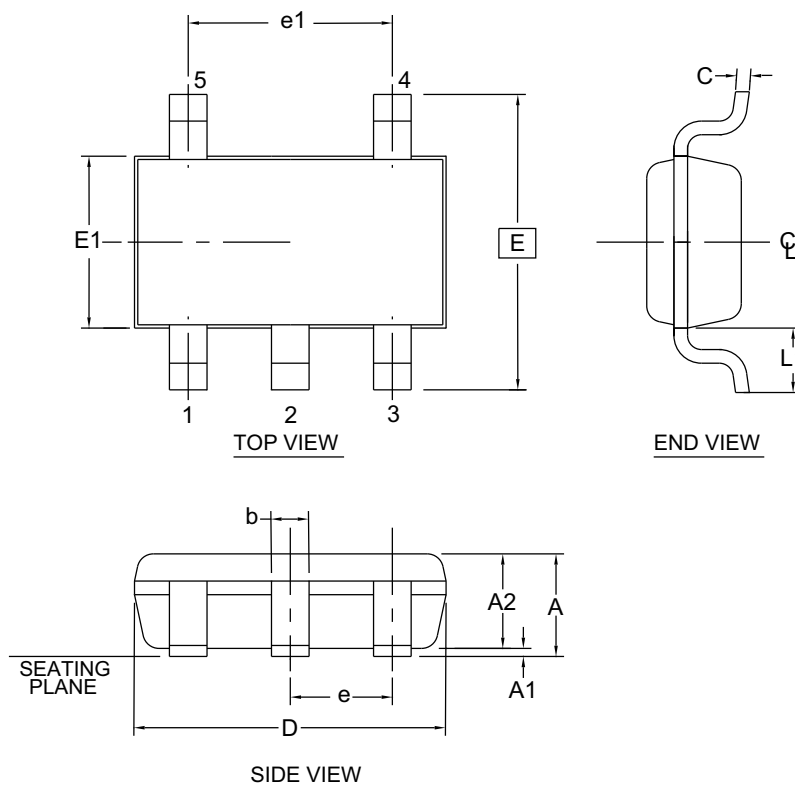
## 12.3 8MA2 — 8-pad UDFN



12.4 8P3 — 8-lead PDIP



## 12.5 5TS1 — 5-lead SOT23



1. Dimension D does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15 mm per end. Dimension E1 does not include interlead flash or protrusion. Interlead flash or protrusion shall not exceed 0.15 mm per side.
2. The package top may be smaller than the package bottom. Dimensions D and E1 are determined at the outermost extremes of the plastic body exclusive of mold flash, tie bar burrs, gate burrs and interlead flash, but including any mismatch between the top and bottom of the plastic body.
3. These dimensions apply to the flat section of the lead between 0.08 mm and 0.15 mm from the lead tip.
4. Dimension "b" does not include dambar protrusion. Allowable dambar protrusion shall be 0.08 mm total in excess of the "b" dimension at maximum material condition. The dambar cannot be located on the lower radius of the foot. Minimum space between protrusion and an adjacent lead shall not be less than 0.07 mm.

This drawing is for general information only. Refer to JEDEC Drawing MO-193, Variation AB for additional information.

COMMON DIMENSIONS  
(Unit of Measure = mm)

| SYMBOL | MIN      | NOM  | MAX  | NOTE |
|--------|----------|------|------|------|
| A      | -        | -    | 1.00 |      |
| A1     | 0.00     | -    | 0.10 |      |
| A2     | 0.70     | 0.90 | 1.00 |      |
| c      | 0.08     | -    | 0.20 | 3    |
| D      | 2.90 BSC |      |      | 1,2  |
| E      | 2.80 BSC |      |      | 1,2  |
| E1     | 1.60 BSC |      |      | 1,2  |
| L1     | 0.60 REF |      |      |      |
| e      | 0.95 BSC |      |      |      |
| e1     | 1.90 BSC |      |      |      |
| b      | 0.30     | -    | 0.50 | 3,4  |

5/31/12

**Atmel**

Package Drawing Contact:  
packagedrawings@atmel.com

TITLE

5TS1, 5-lead 1.60mm Body, Plastic Thin  
Shrink Small Outline Package (Shrink SOT)

GPC

TSZ

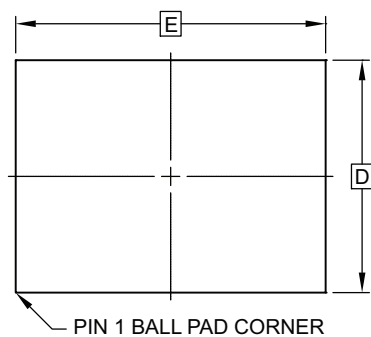
DRAWING NO.

5TS1

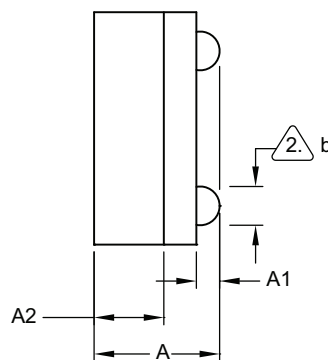
REV.

D

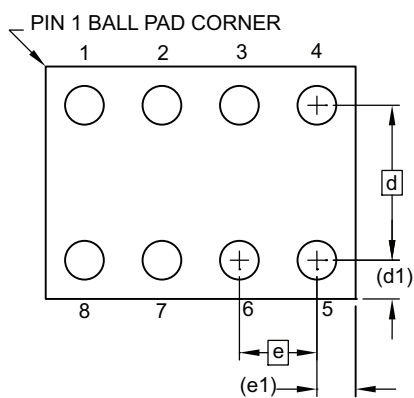
## 12.6 8U3-1 — 8-ball VFBGA



TOP VIEW



SIDE VIEW



BOTTOM VIEW  
8 SOLDER BALLS

**Notes:**

1. This drawing is for general information only.
2. Dimension 'b' is measured at maximum solder ball diameter.
3. Solder ball composition shall be 95.5Sn-4.0Ag-.5Cu.

COMMON DIMENSIONS  
(Unit of Measure - mm)

| SYMBOL | MIN      | NOM  | MAX  | NOTE |
|--------|----------|------|------|------|
| A      | 0.73     | 0.79 | 0.85 |      |
| A1     | 0.09     | 0.14 | 0.19 |      |
| A2     | 0.40     | 0.45 | 0.50 |      |
| b      | 0.20     | 0.25 | 0.30 | 2    |
| D      | 1.50 BSC |      |      |      |
| E      | 2.0 BSC  |      |      |      |
| e      | 0.50 BSC |      |      |      |
| e1     | 0.25 REF |      |      |      |
| d      | 1.00 BSC |      |      |      |
| d1     | 0.25 REF |      |      |      |

6/11/13

**Atmel**

Package Drawing Contact:  
packagedrawings@atmel.com

**TITLE**

8U3-1, 8-ball, 1.50mm x 2.00mm body, 0.50mm pitch,  
Very Thin, Fine-Pitch Ball Grid Array Package (VFBGA)

GPC

GXU

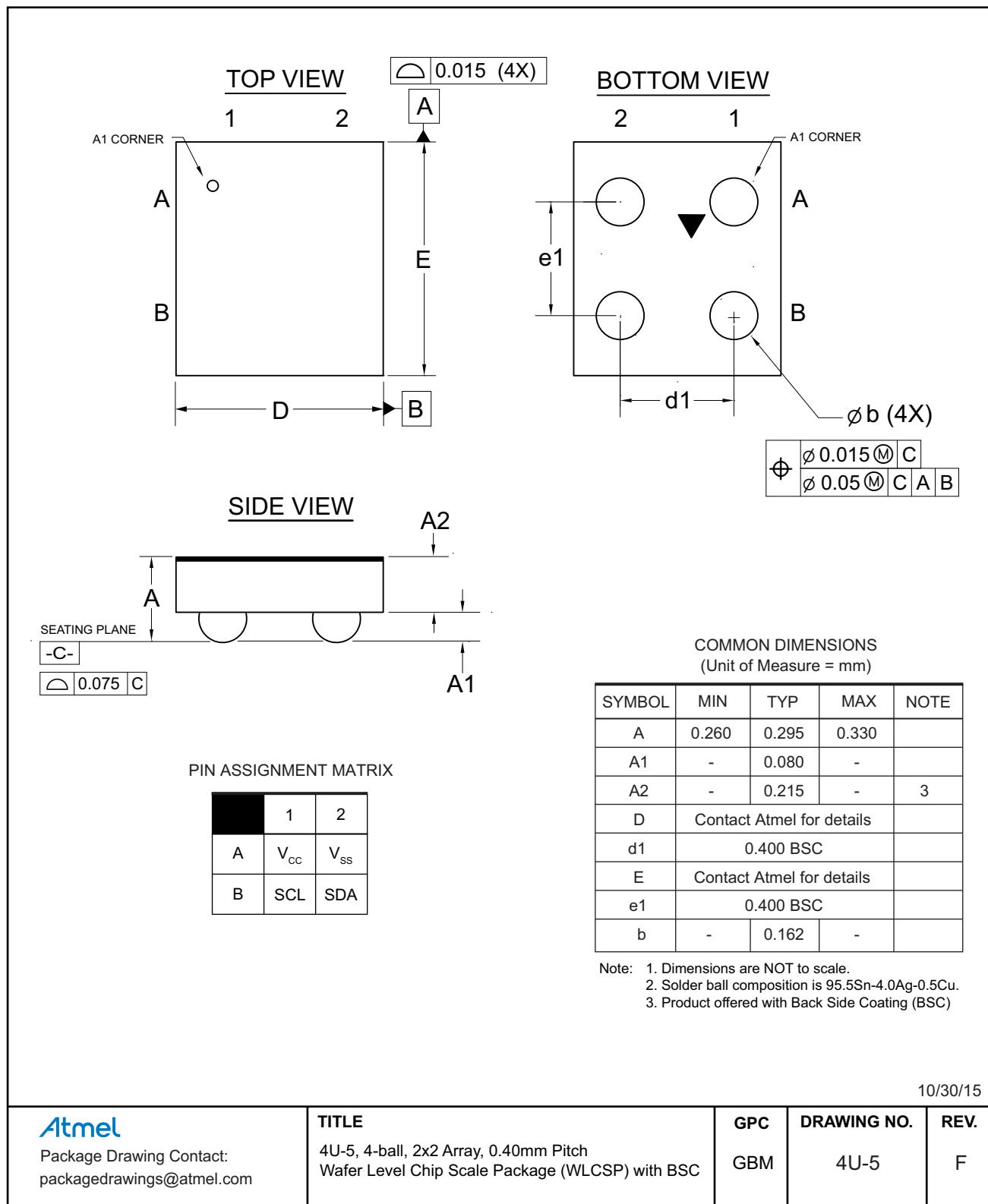
**DRAWING NO.**

8U3-1

**REV.**

F

## 12.7 4U-5 — 4-ball WLCSP



## 13. Revision History

| Doc. No. | Date    | Comments                                                                                                                                                                                                                                                                 |
|----------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8906F    | 01/2017 | Updated Power On Requirements and Reset Behavior section                                                                                                                                                                                                                 |
| 8906E    | 12/2016 | Part marking SOT23:<br>- Moved backside mark (YMXX) to front side line2.<br>- Added @ = Country of Assembly.                                                                                                                                                             |
| 8906D    | 11/2015 | Added, "Since the WLCSP has no WP pin, the write protection feature is not offered on the WLCSP."<br>Updated the 8MA2 - UDFN and 4U-5 - WLCSP package drawings.                                                                                                          |
| 8906C    | 05/2015 | Updated 8S1 - JEDEC SOIC and 4U-5 - WLCSP package drawings.                                                                                                                                                                                                              |
| 8906B    | 01/2015 | Added 100kHz timing set for reference, UDFN extended quantity option, and the figure for "System Configuration Using 2-Wire Serial EEPROMs".<br>Updated the 8X, 8MA2, and 4U-5 package outline drawings and the ordering information section. Remove preliminary status. |
| 8906A    | 04/2014 | Initial document release.                                                                                                                                                                                                                                                |

