# RM25C256C-L
# 256 Kbit 1.65V Minimum Non-volatile Serial EEPROM SPI Bus

**Preliminary Datasheet**

## Features

- Memory array: 256 Kbit non-volatile serial EEPROM memory
- Single supply voltage: 1.65V - 3.6V
- Serial peripheral interface (SPI) compatible
  -Supports SPI modes 0 and 3
- 1.6 MHz maximum clock rate for normal read
- 10 MHz maximum clock rate for fast read
- Flexible Programming
  - Byte/Page Program (1 to 64 Bytes)
  - Page size: 64 Bytes
- Low Energy Byte Write
  -Byte Write consuming 50 nJ
- Low power consumption
  -0.25 mA active Read current (Typical)
  -1 mA active Write current (Typical)
  -2.2 µA power down current (Typical)
- Fast Page Write
  -Page Write in 3 ms (64 byte page)
  -Byte Write within 60 µs
- Industry's lowest read cycle latency
- Unlimited read cycles
- Page or chip erase capability
- 8-lead SOIC, TSSOP and WLCSP packages
- RoHS-compliant and halogen-free packaging
- Data Retention: >40 years at 125°C
- Endurance: 100,000 Write Cycles (for both byte and page write cycles)
  - No degradation across temperature range
- No data loss under UV exposure on bare die or WLCSP
- Based on Adesto's proprietary CBRAM® technology

## Description

The Adesto® RM25C256C-L is a 256 Kbit, serial EEPROM device that utilizes Adesto's CBRAM® resistive memory technology. The memory devices use a single low-voltage supply ranging from 1.65V to 3.6V.

The RM25C-Series family is accessed through a 4-wire SPI interface consisting of a Serial Data Input (SDI), Serial Data Output (SDO), Serial Clock (SCK), and Chip Select ($\overline{CS}$). The maximum clock (SCK) frequency in normal read mode is 1.6 MHz. In fast read mode the maximum clock frequency is 10 MHz.

Writing into the device can be done from 1 to 64 bytes at a time. All writing is internally self-timed. The device also features an Erase which can be performed on 64 byte pages or on the whole chip.

Adesto's EEPROM endurance can be as much as 40X higher than industry standard EEPROM devices operating in byte write mode at 85°C. Unlike EEPROMs based on floating gate technology (which require read-modify-write on a whole page for every write operation) CBRAM write endurance is based on the capability to write each byte individually, irrespective of whether the user writes single bytes or an entire page. Additionally, unlike floating gate technology, CBRAM does not experience any degradation of endurance across the full temperature range. By contrast, in order to modify a single byte, most EEPROMs modify and write full pages of 32, 64 or 128 bytes. This provides significantly less endurance for floating gate devices used in byte write mode when compared to page write mode.

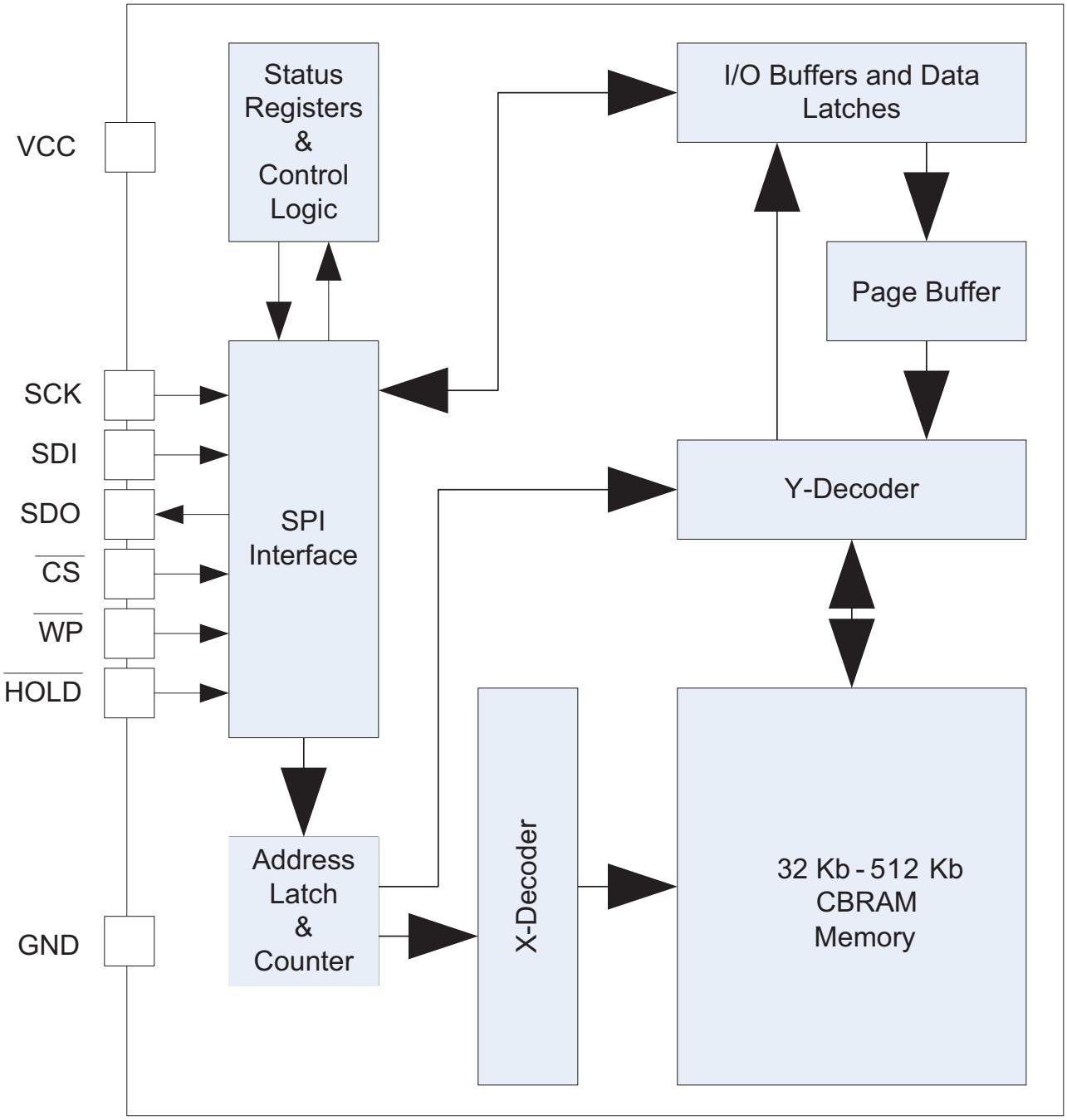
The device has both Byte Write and Page Write capability. Page Write is 64 bytes. The Byte Write operation of CBRAM consumes only 10% of the energy consumed by a Byte Write operation of EEPROM devices of similar size.

The Page Write operation of CBRAM is 4-6 times faster than the Page Write operation of similar EEPROM devices.

Both random and sequential reads are available. Sequential reads are capable of reading the entire memory in one operation.

# 1. Block Diagram

**Figure 1-1. Block Diagram**



# 2. Absolute Maximum Ratings

**Table 2-1. Absolute Maximum Ratings**[1]

| Parameter | Specification |
|---|---|
| Operating ambient temp range | -40°C to +85°C |
| Storage temperature range | -65°C to +150°C |
| Input supply voltage, VCC to GND | - 0.3V to 3.6V |
| Voltage on any pin with respect to GND | -0.5V to ($V_{CC}$ + 0.5V) |
| ESD protection on all pins (Human Body Model) | >2kV |
| Junction temperature | 125°C |
| DC output current | 5mA |

1. CAUTION: Stresses greater than Absolute Maximum Ratings may cause permanent damage to the devices. These are stress ratings only, and operation of the device at these, or any other conditions outside those indicated in other sections of this specification, is not implied. Exposure to absolute maximum rating conditions for extended periods may reduce device reliability

# 3. Electrical Characteristics

## 3.1 DC Operating Characteristics

Applicable over recommended operating range: $T_A$ = -40°C to +85° C, VCC = 1.65V to 3.6V

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| | | $T_A$ = -40°C to +85° C, $V_{CC}$ = 1.65V to 3.6V | | | | |
| $V_{CC}$ | Supply Range | | 1.65 | | 3.6 | V |
| $V_{Vccl}$ | $V_{CC}$ Inhibit | | | | 1.55 | V |
| $I_{CC1}$ | Supply current, Fast Read | $V_{CC}$= 3.3V SCK at 10 MHz<br>SDO = Open, Read | | 1.0 | 3 | mA |
| $I_{CC2}$ | Supply Current, Read Operation | $V_{CC}$= 3.3V SCK at 1.0 MHz<br>SDO = Open, Read | | 0.25 | 0.5 | mA |
| $I_{CC3}$ | Supply Current, Program or Erase | $V_{CC}$= 3.3V, $\overline{CS}$ = $V_{CC}$ | | 1 | 3 | mA |
| $I_{CC4}$ | Supply Current, Standby, LPSE=0 | $V_{CC}$= 3.3V, $\overline{CS}$ = $V_{CC}$ | @25°C | 80 | 90 | µA |
| | | | @85°C | 100 | 120 | |
| | Supply Current, Standby, LPSE=1 | | @25°C | 45 | 55 | |
| | | | @85°C | 65 | 75 | |
| | Supply Current, Standby, Auto Power Down enabled | | @25°C | 2.2 | 3 | |
| | | | @85°C | 11 | 17 | |
| $I_{CC5}$ | Supply Current, Power Down | $V_{CC}$= 3.3V Power Down | @25°C | 2.2 | 3 | µA |
| | | | @85°C | 11 | 17 | |
| $I_{CC6}$ | Supply Current, Ultra Deep Power Down | $V_{cc}$ = 3.3V,<br>Ultra Deep Power Down | @25°C | 1.6 | 2.5 | µA |
| | | | @85°C | 11 | 17 | |
| $I_{IL}$ | Input Leakage | SCK, SDI, $\overline{CS}$, $\overline{HOLD}$, $\overline{WP}$<br>$V_{IN}$=0V to $V_{CC}$ | | | 1 | µA |
| $I_{OL}$ | Output Leakage | SDO , $\overline{CS}$ = $V_{CC}$<br>$V_{IN}$=0V to $V_{CC}$ | | | 1 | µA |
| $V_{IL}$ | Input Low Voltage | SCK, SDI, $\overline{CS}$, $\overline{HOLD}$, $\overline{WP}$ | -0.3 | | $V_{CC}$ x 0.3 | V |
| $V_{IH}$ | Input High Voltage | SCK, SDI, $\overline{CS}$, $\overline{HOLD}$, $\overline{WP}$ | $V_{CC}$ x 0.7 | | $V_{CC}$ + 0.3 | V |
| $V_{OL}$ | Output Low Voltage | $I_{OL}$ = 3.0mA | | | 0.4 | V |
| $V_{OH}$ | Output High Voltage | $I_{OH}$ = -100µA | $V_{CC}$ - 0.2 | | | V |

## 3.2 AC Operating Characteristics

Applicable over recommended operating range: $T_A$ = -40°C to +85° C, VCC = 1.65V to 3.6V

$C_L$ = 1 TTL Gate plus 10pF (unless otherwise noted)

| Symbol | Parameter | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| $f_{SCKF}$ | SCK Clock Frequency for Fast Read Mode | 0 | | 10 | MHz |
| $f_{SCK}$ | SCK Clock Frequency for Normal Read Mode | 0 | | 1.6 | MHz |
| $f_{APD}$ | SCK Clock Frequency for Auto Power Down Mode | 0 | | 1.0 | MHz |
| $t_{RI}$ | SCK Input Rise Time | | | 1 | µs |
| $t_{FL}$ | SCK Input Fall Time | | | 1 | µs |
| $t_{SCKH}$ | SCK High Time | 7.5 | | | ns |
| $t_{SCKL}$ | SCK Low Time | 7.5 | | | ns |
| $t_{CS}$ | $\overline{CS}$ High Time | 100 | | | ns |
| $t_{CSS}$ | $\overline{CS}$ Setup Time | 10 | | | ns |
| $t_{CSH}$ | $\overline{CS}$ Hold Time | 10 | | | ns |
| $t_{DS}$ | Data In Setup Time | 4 | | | ns |
| $t_{DH}$ | Data In Hold Time | 4 | | | ns |
| $t_{HS}$ | $\overline{HOLD}$ Setup Time | 30 | | | ns |
| $t_{HD}$ | $\overline{HOLD}$ Hold Time | 30 | | | ns |
| $t_{OV}$ | Output Valid | | | 6.5 | ns |
| $t_{OH}$ | Output Hold Time Normal Mode | 0 | | | ns |
| $t_{LZ}$ | $\overline{HOLD}$ to output Low Z | 0 | | 200 | ns |
| $t_{HZ}$ | $\overline{HOLD}$ to output High Z | | | 200 | ns |
| $t_{DIS}$ | Output Disable Time | | | 100 | ns |
| $t_{PW}$ | Page Write Cycle Time, 64 byte page (up to 30K write cycles) | | 3 | 5 | ms |
| | Page Write Cycle Time, 64 byte page (up to 100K write cycles) | | 18 | | |
| $t_{BP}$ | Byte Write Cycle Time | | 60 | 100 | µs |
| $t_{PUD}$ | $V_{cc}$ Power-up Delay(1) | | | 75 | µs |
| $t_{RPD}$ | Exit Power Down Time | 50 | | | µs |
| $t_{CSLU}$ | Minimum Chip Select Low to Exit Ultra-Deep Power-Down | 20 | | | ns |
| $t_{XUDPD}$ | Exit Ultra-Deep Power Down Time | 70 | | | µs |
| $t_{RDPD}$ | Chip Select High to Standby Mode | | | 8 | µs |
| $C_{IN}$ | SCK, SDI, $\overline{CS}$, $\overline{HOLD}$, $\overline{WP}$ $V_{IN}$=0V | | | 6 | pf |
| $C_{OUT}$ | SDO $V_{IN}$=0V | | | 8 | pf |

| Symbol | Parameter | | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| Endurance | | | | 100,000(2) | | Write Cycles |
| | | | | Unlimited | | Read Cycles |
| Retention | | | | 40 | | Years |

Notes: 1. VCC must be within operating range.

2. Adesto memory products based on CBRAM technology are “Direct-Write” memories. Endurance cycle calculations follow JEDEC specification JESD22-A117B. Endurance data characterized at 2.5V, +85° C. Endurance specification is identical for both byte and page write (unlike current EEPROM technologies where byte write operations result in lower endurance).

## 3.3 AC Test Conditions

| AC Waveform | Timing Measurement Reference Level | |
|---|---|---|
| $V_{LO}$ = 0.2V | Input | 0.5 $V_{cc}$ |
| $V_{HI}$ = 3.4V | Output | 0.5 $V_{cc}$ |
| $C_L$ = 30pF (for 1.6 MHz SCK) | | |
| $C_L$ = 10pF (for 10 MHz SCK) | | |

# 4. Timing Diagrams

**Figure 4-1. Synchronous Data Timing with HOLD high**

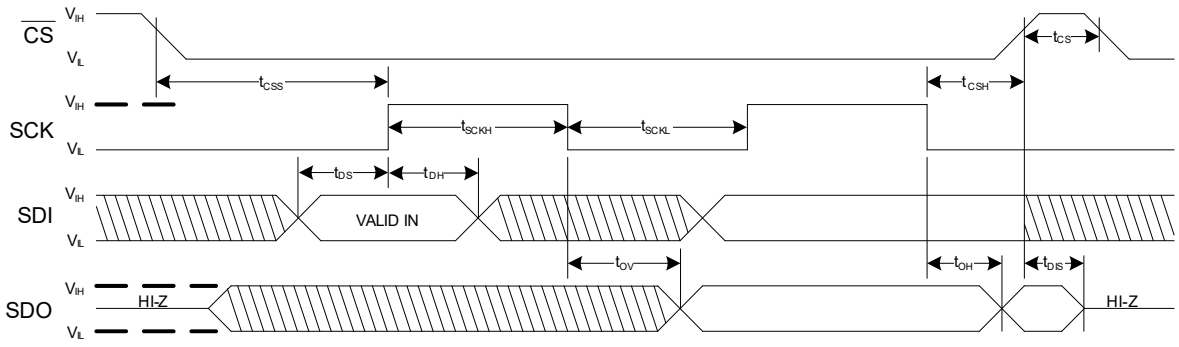


**Figure 4-2. Hold Timing**

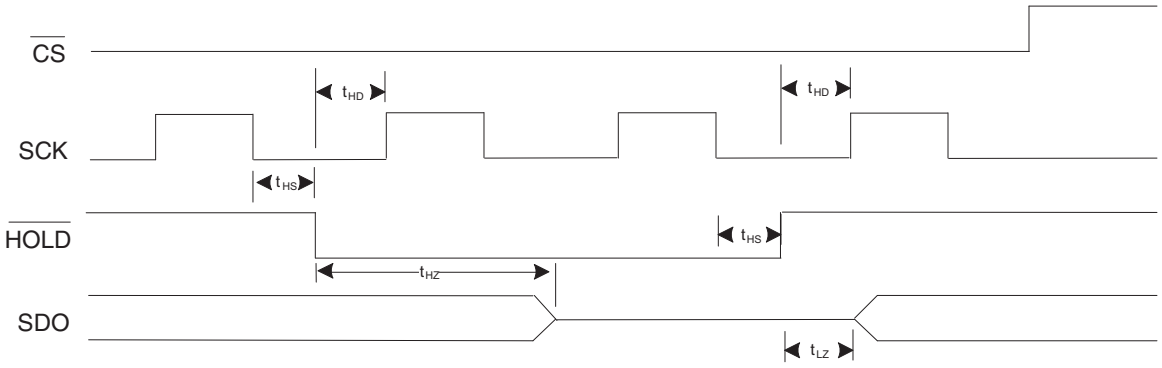
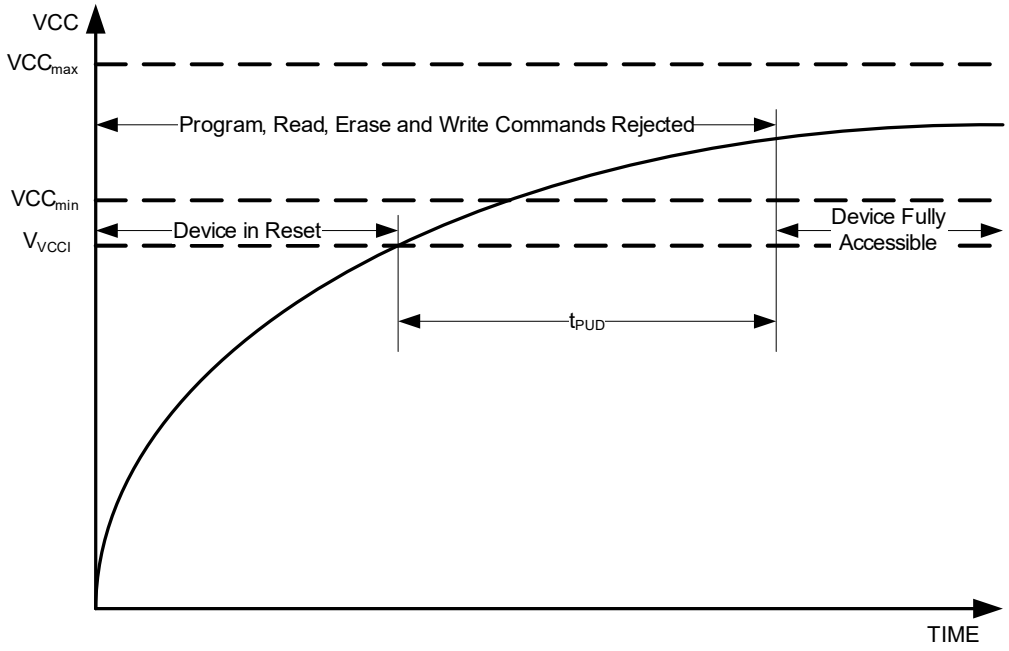



**Figure 4-3. Power-up Timing**



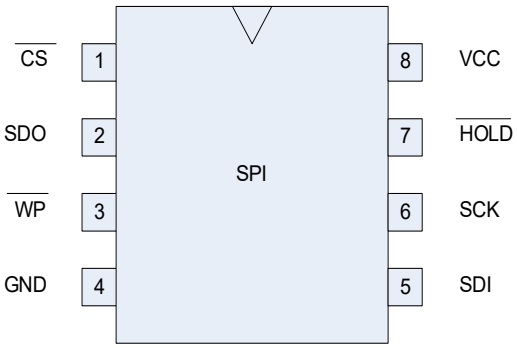
# 5. Pin Descriptions and Pin-out

**Table 5-1. Pin Descriptions**

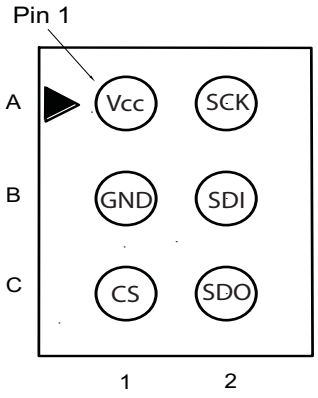
| Mnemonic | Pin Number | Pin Name | Description |
|---|---|---|---|
| $\overline{CS}$ | 1 | Chip Select | Making $\overline{CS}$ low activates the internal circuitry for device operation. Making $\overline{CS}$ high deselects the device and switches into standby mode to reduce power. When the device is not selected ($\overline{CS}$ high), data is not accepted via the Serial Data Input pin (SDI) and the Serial Data Output pin (SDO) remains in a high-impedance state. |
| SDO | 2 | Serial Data Out | Sends read data or status on the falling edge of SCK. |
| $\overline{WP}$ | 3 | Write Protect | N/A |
| GND | 4 | Ground | |
| SDI | 5 | Serial Data In | Device data input; accepts commands, addresses, and data on the rising edge of SCK. |
| SCK | 6 | Serial Clock | Provides timing for the SPI interface. SPI commands, addresses, and data are latched on the rising edge on the Serial Clock signal, and output data is shifted out on the falling edge of the Serial Clock signal. |
| $\overline{HOLD}$ | 7 | Hold | When pulled low, serial communication with the master device is paused, without resetting the serial sequence. |
| $V_{cc}$ | 8 | Power | Power supply pin. |

**Figure 5-1. PInouts**

**SOIC, UDFN and TSSOP**



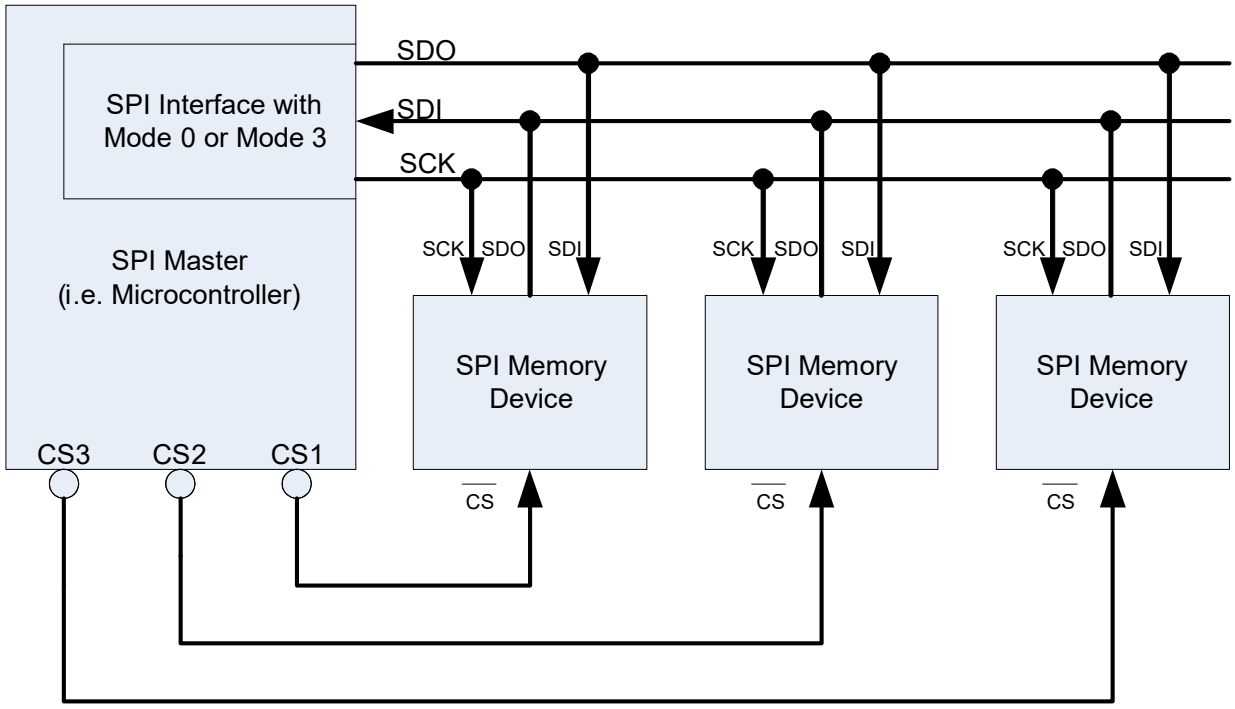

**WLCSP (Bottom View)**




# 6. SPI Modes Description

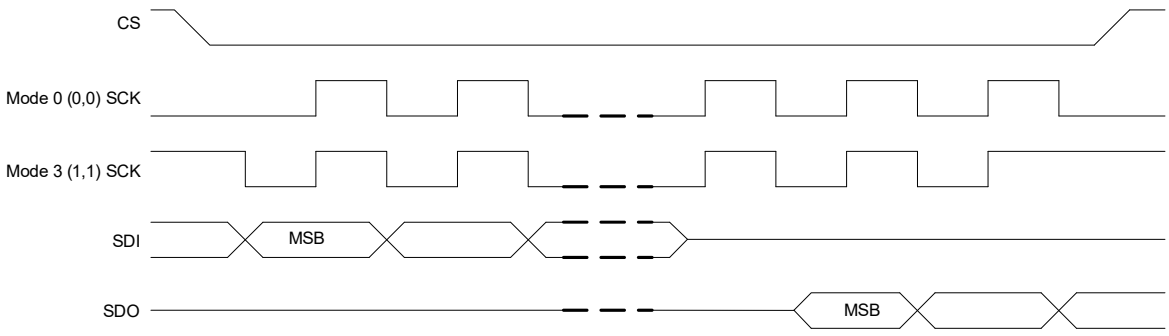
Multiple Adesto SPI devices can be connected onto a Serial Peripheral Interface (SPI) serial bus controlled by an SPI master, such as a microcontroller, as shown in Figure 6-1,

**Figure 6-1. Connection Diagram, SPI Master and SPI Slaves**




The Adesto RM25C family supports two SPI modes: Mode 0 (0, 0) and Mode 3 (1, 1). The difference between these two modes is the clock polarity when the SPI master is in standby mode ($\overline{CS}$ high). In Mode 0, the Serial Clock (SCK) stays at 0 during standby. In Mode 3, the SCK stays at 1 during standby. An example sequence for the two SPI modes is shown in Figure 6-2. For both modes, input data (on SDI) is latched in on the rising edge of Serial Clock (SCK), and output data (SDO) is available beginning with the falling edge of Serial Clock (SCK).

**Figure 6-2. SPI Modes**



# 7. Registers

## 7.1 Instruction Register

The Adesto RM25C family uses a single 8-bit instruction register. The instructions and their operation codes are listed in Table 7-1. All instructions, addresses, and data are transferred with the MSB first, and begin transferring with the first low-to-high SCK transition after the $\overline{CS}$ pin goes low.

**Table 7-1. Device Operating Instructions**

| Instruction | Description | Operation Code | Address Cycles | Dummy Cycles | Data Cycles |
|---|---|---|---|---|---|
| WRSR | Write Status Register | 01H | 0 | 0 | 1 |
| WR | Write 1 to 64 bytes | 02H | 2 | 0 | 1-64 |
| READ | Read data from memory array | 03H | 2 | 0 | 1 to ∞ |
| FREAD | Fast Read data from data memory | 0BH | 2 | 1 | 1 to ∞ |
| WRDI | Write Disable | 04H | 0 | 0 | 0 |
| RDSR | Read Status Register | 05H | 0 | 0 | 1 to ∞ |
| WREN | Write Enable | 06H | 0 | 0 | 0 |
| PERS | Page Erase 64 bytes | 42H | 2 | 0 | 0 |
| CERS | Chip Erase | 60H | 0 | 0 | 0 |
| | | C7H | 0 | 0 | 0 |
| PD | Power Down | B9H | 0 | 0 | 0 |
| UDPD | Ultra Deep Power Down | 79H | 0 | 0 | 0 |
| RES | Resume from Power Down | ABH | 0 | 0 | 0 |

## 7.2 Status Register

The Adesto RM25C family uses a single 8-bit Status Register. The Write In Progress (WIP) and Write Enable (WEL) status of the device can be determined by reading this register.

The Status Register format is shown in Table 7-2 The Status Register bit definitions are shown in Table 7-3.

**Table 7-2. Status Register Format**

| Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|---|---|---|---|---|---|---|---|
| SRWD | APDE | LPSE | 0 | BP1 | BP0 | WEL | WIP |

**Table 7-3. Status Register Bit Definitions**

| Bit | Name | Description | R/W | Non-Volatile Bit |
|---|---|---|---|---|
| 0 | WIP | **Write In Progress**<br>“0” indicates the device is ready<br>“1” indicates that the program/erase cycle is in progress and the device is busy | R | No |
| 1 | WEL | **Write Enable Latch**<br>“0” Indicates that the device is disabled<br>“1” indicates that the device is enabled | R/W | No |
| 2 | BP0 | Block Protection Bits. "0" indicates the specific blocks are not protected.<br>"1" indicates that the specific blocks are protected. | R/W | Yes |
| 3 | BP1 | | | |
| 4 | N/A | Reserved. Read as “0” | N/A | No |
| 5 | LPSE | Low Power Standby Enable.<br>"0" indicates that the device will not use Low Power Standby Mode.<br>"1" indicates that the device will use Low Power Standby Mode. | R/W | Yes |
| 6 | APDE | Auto Power Down Enable.<br>"0" indicates that the device will use Standby Mode.<br>"1" indicates that the device will use Power Down Mode instead of Standby Mode. | R/W | Yes |
| 7 | SRWD | $\overline{WP}$ pin enable. See Table 8-1. | R/W | Yes |

# 8. Write Protection

The Adesto RM25C family has two protection modes: hardware write protection, via the $\overline{WP}$ pin associated with the SRWD bit in the Status Register, and software write protection in the form of the SRWD, WEL, BP0, and BP1 bits in the Status Register.

## 8.1 Hardware Write Protection

There are three hardware write protection features:

- All write instructions must have the appropriate number of clock cycles before $\overline{CS}$ goes high or the write instruction will be ignored.
- If the VCC is below the VCC Inhibit Voltage ($V_{Vccl}$, see DC Characteristics), all Read, Write, and Erase sequence instructions will be ignored.
- The $\overline{WP}$ pin provides write protection for the Status Register. When $\overline{WP}$ is low, the Status Register is write protected if the SRWD bit in the Status Register is High. When WP is high, the Status Register is writable independent of the SRWD bit. See Table 8-1.

**Table 8-1. Hardware Write Protection on Status Register**

| SRWD | $\overline{WP}$ | Status Register |
|---|---|---|
| 0 | Low | Writable |
| 1 | Low | Protected |
| 0 | High | Writable |
| 1 | High | Writable |

## 8.2 Software Write Protection

There are two software write protection features:

- Before any program, erase, or write status register instruction, the Write Enable Latch (WEL) bit in the Status Register must be set to a one by execution of the Write Enable (WREN) instruction. If the WEL bit is not enabled, all program, erase, or write register instructions will be ignored.
- The Block Protection bits (BP0 and BP1) allow a part or the whole memory area to be write protected. See Table 8-2.

**Table 8-2. Block Write Protect Bits**

| BP1 | BP0 | Protected Region | RM25C256C-L | |
|---|---|---|---|---|
| | | | Protected Address | Protected Area Size |
| 0 | 0 | None | None | 0 |
| 0 | 1 | Top ¼ | 3000-3FFF | 4K bytes |
| 1 | 0 | Top ½ | 2000-3FFF | 8K bytes |
| 1 | 1 | All | 0-3FFF | All |

## 8.3 Reducing Energy Consumption

In normal operation, when the device is idle, ($\overline{CS}$ is high, no Write or Erase operation in progress), the device is in Standby Mode, waiting for the next command. To reduce device energy consumption, the Power Down or Ultra-Deep Power Down modes may be used.

### 8.3.1 Power Down mode

Power Down mode allows the user to reduce the power of the device to its lowest power consumption state. The PD command is used to instruct the device to enter Power Down mode.

All instructions given during the Power Down mode are ignored except the Resume From Power Down (RES) instruction. Therefore this mode can be used as an additional software write protection feature.

### 8.3.2 Ultra-Deep Power Down mode

The Ultra-Deep Power Down mode allows the device to further reduce its energy consumption compared to the existing Standby and Power Down modes by shutting down additional internal circuitry. The UDPD command is used to instruct the device to enter Ultra-Deep Power Down mode.

When the device is in the Ultra-Deep Power Down mode, all commands including the Read Status Register and Resume From Power Down commands will be ignored. Since all commands will be ignored, the mode can be used as an extra protection mechanism against inadvertent or unintentional program and erase operations.

Only the Exit Ultra-Deep Power Down signal sequences described in section 8-13 will bring the device out of the Ultra-Deep Power Down mode.

### 8.3.3 Auto Power Down Enable.

For frequencies lower than $f_{APD}$ (see AC Operating Characteristics), the APDE bit in the Status Register may be enabled. The device will then automatically enter Power Down mode instead of Standby mode when idle. ($\overline{CS}$ is high, no Write or Erase operation in progress).

In this mode, the device will behave normally to all commands, and will leave Power Down mode once $\overline{CS}$ is pulled down.

If Auto Power Down is enabled, and the SCK Clock Frequency is increased to a speed higher than $f_{APD}$, the device may not react as expected to the command. Before changing SCK frequency, the APDE bit in the Status Register must be disabled.

Note that the PD or UDPD commands may still be used as additional software write protection features when Auto Power Down is enabled. Note that if the PD command is issued while Auto Power Down is enabled, the device will enter Power Down mode, and all instructions given will be ignored except the Resume From Power Down (RES) instruction. The device will not wake up immediately after $\overline{CS}$ is pulled down.

### 8.3.4 Low Power Standby Enable.

For frequencies lower than $f_{APD}$ (see AC Operating Characteristics), the LPSE bit in the Status Register may be enabled. The device will then automatically enter Low Power Standby mode when idle. ($\overline{CS}$ is high, no Write or Erase operation in progress).

In this mode, the device will behave normally to all commands, and will leave Low Power Standby mode once $\overline{CS}$ is pulled down.

If Low Power Standby Mode is enabled, and the SCK Clock Frequency is increased to a speed higher than $f_{APD}$, the device may not react as expected to the command. Before changing SCK frequency, the LPSE bit in the Status Register must be disabled.

Note that the PD or UDPD commands may still be used as additional software write protection features when Low Power Standby Mode is enabled. Note that if the PD command is issued while Low Power Standby Mode is enabled, the device will enter Power Down mode, and all instructions given will be ignored except the Resume From Power Down (RES) instruction. The device will not wake up immediately after $\overline{CS}$ is pulled down.

# 9. Command Descriptions

## 9.1 WREN (Write Enable):

The device powers up with the Write Enable Latch set to zero. This means that no write or erase instructions can be executed until the Write Enable Latch is set using the Write Enable (WREN) instruction. The Write Enable Latch is also set to zero automatically after any non-read instruction. Therefore, all page programming instructions and erase instructions must be preceded by a Write Enable (WREN) instruction. The sequence for the Write Enable instruction is shown in Figure 9-1.

**Figure 9-1. WREN Sequence (06h)**

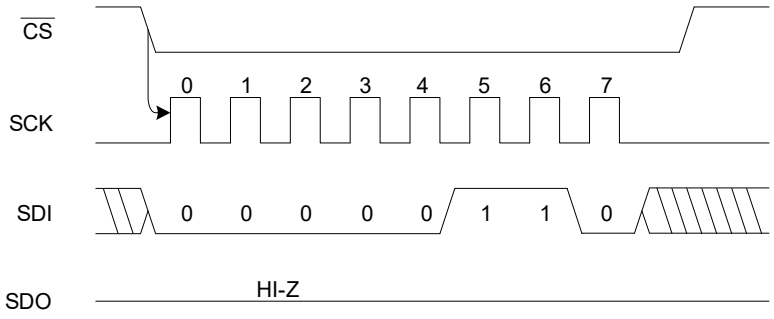



Table 9-1 is a list of actions that will automatically set the Write Enable Latch to zero when successfully executed. If an instruction is not successfully executed, for example if the $\overline{CS}$ pin is brought high before an integer multiple of 8 bits is clocked, the Write Enable Latch will not be reset.

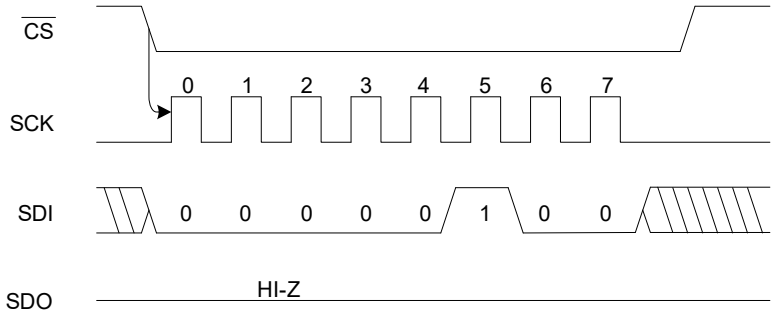
**Table 9-1. Write Enable Latch to Zero**

| Instruction/Operation |
|---|
| **Power-Up** |
| **WRDI (Write Disable)** |
| **WR (Write)** |
| **PERS (Page Erase)** |
| **CERS (Chip Erase)** |
| **PD (Power Down)** |

## 9.2 WRDI (Write Disable):

To protect the device against inadvertent writes, the Write Disable instruction disables all write modes. Since the Write Enable Latch is automatically reset after each successful write instruction, it is not necessary to issue a WRDI instruction following a write instruction. The WRDI instruction is independent of the status of the WP pin. The WRDI sequence is shown in Figure 9-2.

**Figure 9-2. WRDI Sequence (04h)**

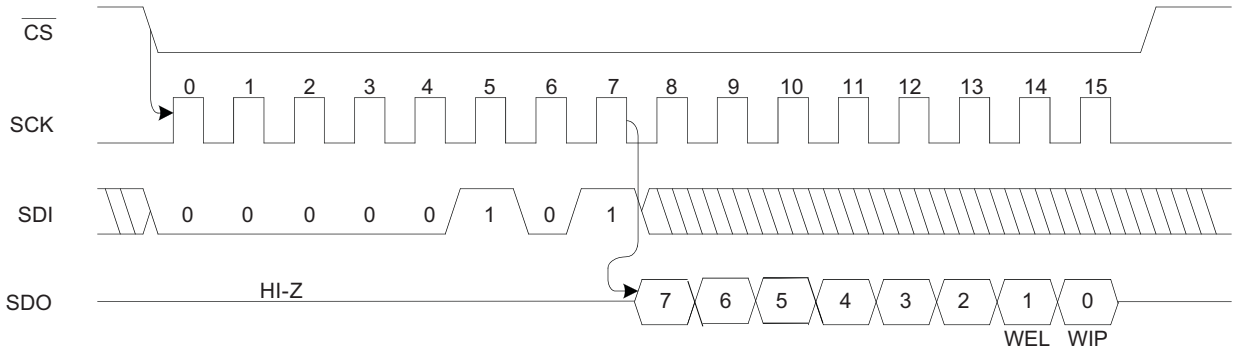



## 9.3 RDSR (Read Status Register):

The Read Status Register instruction provides access to the Status Register and indication of write protection status of the memory.

**Caution:** The Write In Progress (WIP) and Write Enable Latch (WEL) indicate the status of the device. The RDSR sequence is shown in Figure 9-3.

**Figure 9-3. RDSR Sequence (05h)**

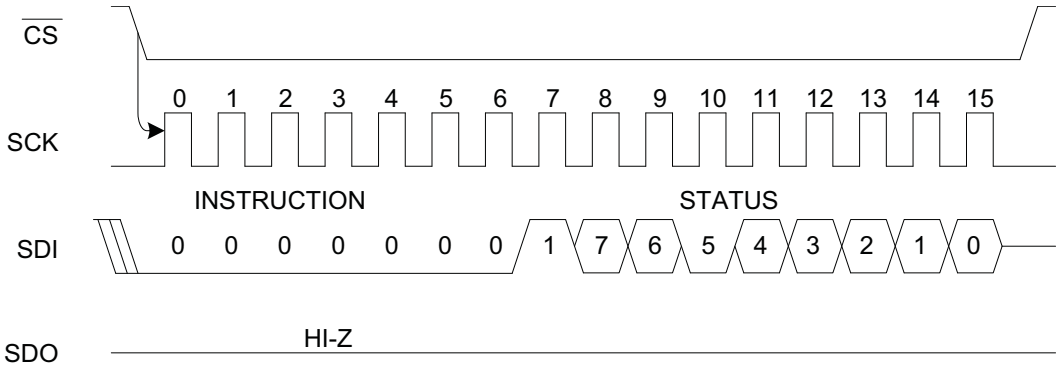



## 9.4 WRSR (Write Status Register):

The Write Status Register (WRSR) instruction allows the user to select one of three levels of protection. The memory array can be block protected (see Table 8-2) or have no protection at all. The SRWD bit (in conjunction with the $\overline{WP}$ pin) sets the write status of the Status Register (see Table 8-1).

Only the BP0, BP1, APDE, LPSE and SRWD bits are writable and are nonvolatile cells. When the $\overline{WP}$ pin is low, and the SRWD bit in the Status Register is a one, a zero cannot be written to SRWD to allow the part to be writable. To set the SRWD bit to zero, the $\overline{WP}$ pin must be high. The WRSR sequence is shown in Figure 9-4.

**Figure 9-4. WRSR Sequence (01h)**



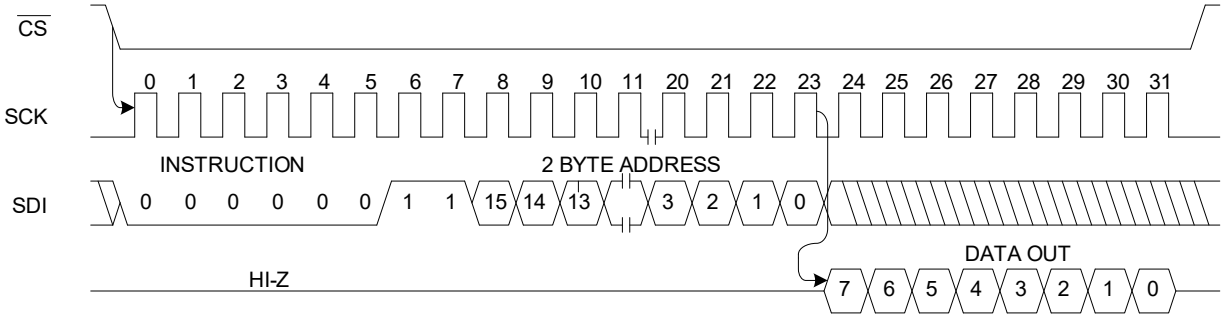

## 9.5 READ (Read Data):

Reading the Adesto RM25C family via the Serial Data Output (SDO) pin requires the following sequence: First the $\overline{CS}$ line is pulled low to select the device; then the READ op-code is transmitted via the SDI line, followed by the address to be read (A15-A0). Although not all 16 address bits are used, a full 2 bytes of address must be transmitted to the device. For the 256 Kb device, only address A0 to A14 are used; the rest are don't cares and must be set to “0”.

Once the read instruction and address have been sent, any further data on the SDI line will be ignored. The data (D7-D0) at the specified address is then shifted out onto the SDO line. If only one byte is to be read, the $\overline{CS}$ line should be driven high after the byte of data comes out. This completes the reading of one byte of data.

The READ sequence can be automatically continued by keeping the $\overline{CS}$ low. At the end of the first data byte the byte address is internally incremented and the next higher address data byte will be shifted out. When the highest address is reached, the address counter will roll over to the lowest address (00000), thus allowing the entire memory to be read in one continuous read cycle. The READ sequence is shown in Figure 9-5.

**Figure 9-5. Single Byte READ Sequence (03h)**



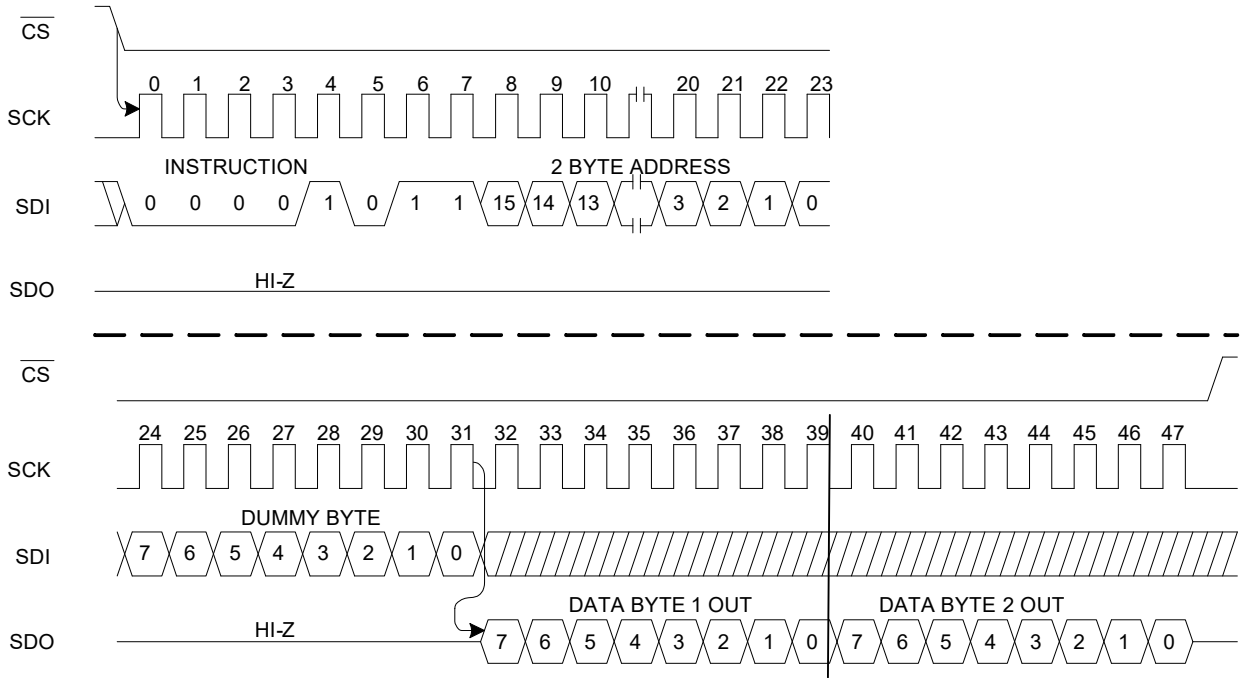

## 9.6 FREAD (Fast Read Data):

The Adesto RM25C family also includes the Fast Read Data command, which facilitates reading memory data at higher clock rates, up to 10 MHz. After the $\overline{CS}$ line is pulled low to select the device, the FREAD op-code is transmitted via the SDI line. This is followed by the 2-byte address to be read (A15-A0) and then a 1-byte dummy. For the 256-Kbit device, only address A0 to A14 are used; the rest are don't cares and must be set to "0".

The next 8 bits transmitted on the SDI are dummy bits. The data (D7-D0) at the specified address is then shifted out onto the SDO line. If only one byte is to be read, the $\overline{CS}$ line should be driven high after the data comes out. This completes the reading of one byte of data.

The FREAD sequence can be automatically continued by keeping the $\overline{CS}$ low. At the end of the first data byte, the byte address is internally incremented and the next higher address data byte is then shifted out. When the highest address is reached, the address counter rolls over to the lowest address (00000), allowing the entire memory to be read in one continuous read cycle. The FREAD sequence is shown in Figure 9-6.

**Figure 9-6. Two Byte FREAD Sequence (0Bh)**



## 9.7 WRITE (WR):

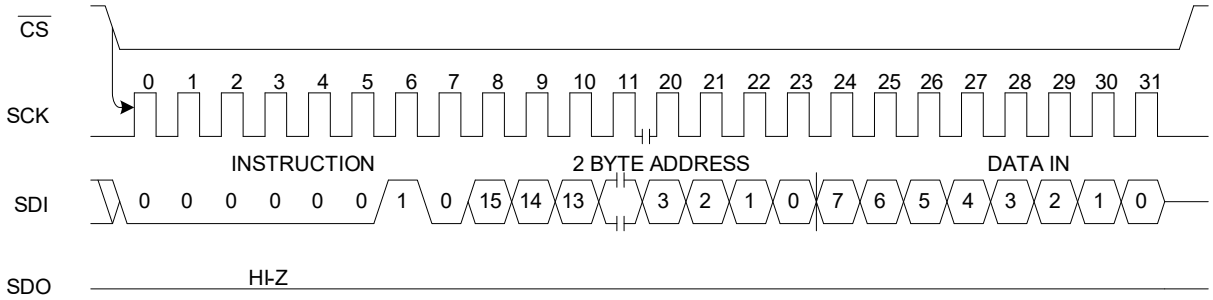
| Product | Density | Page Size (bytes) |
|---|---|---|
| **RM25C256C-L** | **256 Kbit** | **64** |

The Write (WR) instruction allows bytes to be written to the memory. But first, the device must be write-enabled via the WREN instruction. The $\overline{CS}$ pin must be brought high after completion of the WREN instruction; then the $\overline{CS}$ pin can be brought back low to start the WR instruction. The $\overline{CS}$ pin going high at the end of the WR input sequence initiates the internal write cycle. During the internal write cycle, all commands except the RDSR instruction are ignored.

A WR instruction requires the following sequence: After the $\overline{CS}$ line is pulled low to select the device, the WR op-code is transmitted via the SDI line, followed by the byte address (A15-A0) and the data (D7-D0) to be written. For the 256Kb device, only address A0 to A14 are used; the rest are don't cares and must be set to “0”. The internal write cycle sequence will start after the $\overline{CS}$ pin is brought high. The low-to-high transition of the $\overline{CS}$ pin must occur during the SCK low-time immediately after clocking in the D0 (LSB) data bit.

The Write In Progress status of the device can be determined by initiating a Read Status Register (RDSR) instruction and monitoring the WIP bit. If the WIP bit (Bit 0) is a “1”, the write cycle is still in progress. If the WIP bit is “0”, the write cycle has ended. Only the RDSR instruction is enabled during the write cycle. The sequence of a one-byte WR is shown in Figure 9-7.

**Figure 9-7. One Byte Write Sequence (0Bh)**



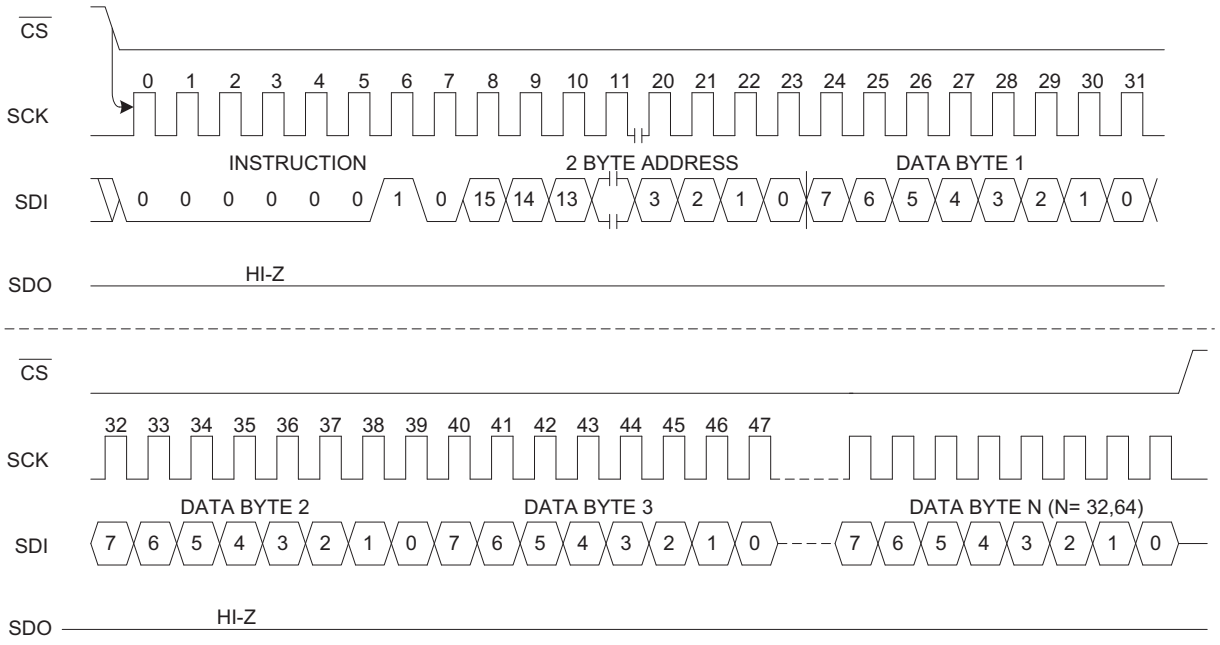

The Adesto RM25C family is capable of a 64-byte write operation.

For the RM25C256C-L: After each byte of data is received, the six low-order address bits (A5-A0) are internally incremented by one; the high-order bits of the address will remain constant. All transmitted data that goes beyond the end of the current page are written from the start address of the same page (from the address whose 6 least significant bits [A5-A0] are all zero). If more than 64 bytes are sent to the device, previously latched data are discarded and the last 64 data bytes are ensured to be written correctly within the same page. If less than 64 data bytes are sent to the device, they are correctly written at the requested addresses without having any effects on the other bytes of the same page.

The Adesto RM25C256C-L is automatically returned to the write disable state at the completion of a program cycle. The sequence for a 64 byte WR is shown in Figure 9-8. Note that the Multi-Byte Write operation is internally executed by sequentially writing the words in the Page Buffer.

NOTE: If the device is not write enabled (WREN) previous to the Write instruction, the device will ignore the write instruction and return to the standby state when $\overline{CS}$ is brought high. A new $\overline{CS}$ falling edge is required to re initiate the serial communication.

**Figure 9-8. WRITE Sequence (02h)**



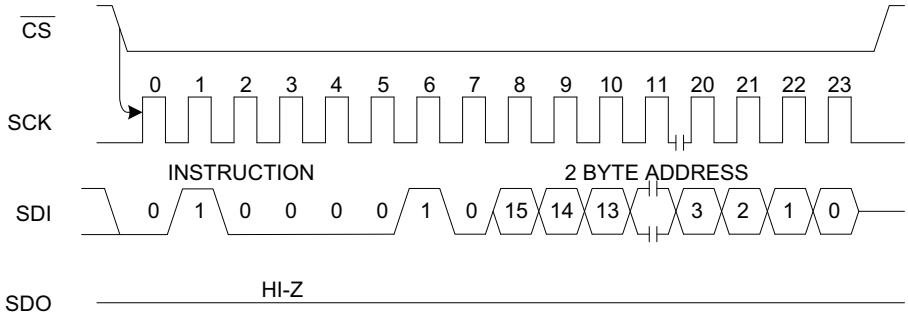

## 9.8 PER (Page Erase 64 bytes):

Page Erase sets all bits inside the addressed 64 byte page to a 1. A Write Enable (WREN) instruction is required prior to a Page Erase. After the WREN instruction is shifted in, the $\overline{CS}$ pin must be brought high to set the Write Enable Latch.

The Page Erase sequence is initiated by bringing the $\overline{CS}$ pin low; this is followed by the instruction code, then 2 address bytes. Any address inside the page to be erased is valid. This means the bottom six bits (A5-A0) of the address are ignored. Once the address is shifted in, the $\overline{CS}$ pin is brought high, which initiates the self-timed Page Erase function. The WIP bit in the Status Register can be read, using the RDSR instruction, to determine when the Page Erase cycle is complete.

The sequence for the PER is shown in Figure 9-9.

**Figure 9-9. PERS Sequence (42h)**




## 9.9 CERS (Chip Erase):

Chip Erase sets all bits inside the device to a 1. A Write Enable (WREN) instruction is required prior to a Chip Erase. After the WREN instruction is shifted in, the $\overline{CS}$ pin must be brought high to set the Write Enable Latch.

The Chip Erase sequence is initiated by bringing the $\overline{CS}$ pin low; this is followed by the instruction code. There are two different instruction codes for CER, 60h and C7h. Either instruction code will initiate the Chip Erase sequence. No

address bytes are needed. Once the instruction code is shifted in, the $\overline{CS}$ pin is brought high, which initiates the self-timed Chip Erase function. The WIP bit in the Status Register can be read, using the RDSR instruction, to determine when the Chip Erase cycle is complete.

The sequence for the 60h CER instruction is shown in Figure 9-10. The sequence for the C7h CER instruction is shown in Figure 9-11.

**Figure 9-10. CERS Sequence (60h)**

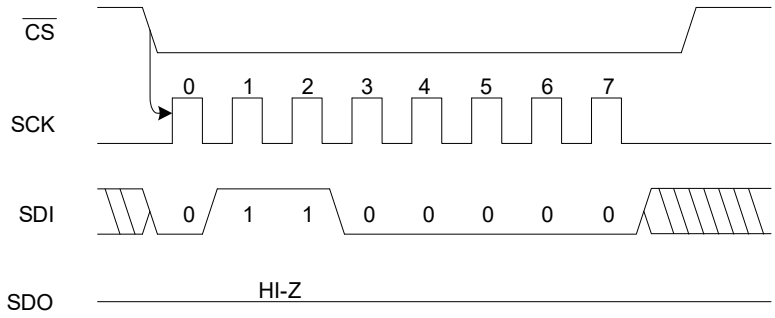
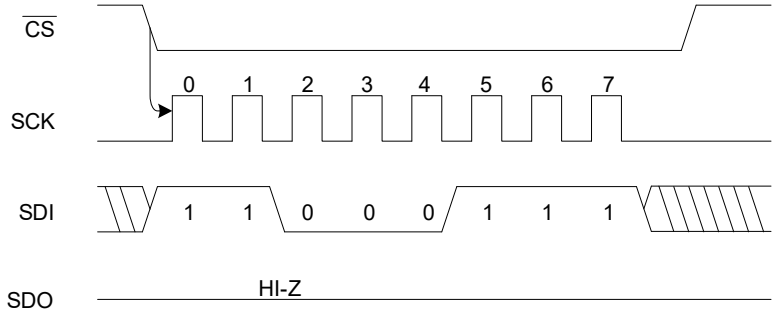



**Figure 9-11. CERS Sequence (C7h)**



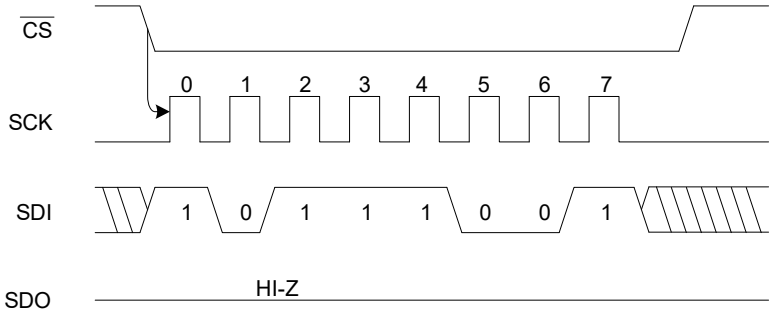

## 9.10 PD (Power Down):

Power Down mode allows the user to reduce the power of the device to its lowest power consumption state.

All instructions given during the Power Down mode are ignored except the Resume from Power down (RES) instruction. Therefore this mode can be used as an additional software write protection feature.

The Power Down sequence is initiated by bringing the $\overline{CS}$ pin low; this is followed by the instruction code. Once the instruction code is shifted in the $\overline{CS}$ pin is brought high, which initiates the PD mode. The sequence for PD is shown in Figure 9-12.

**Figure 9-12. PD Sequence**



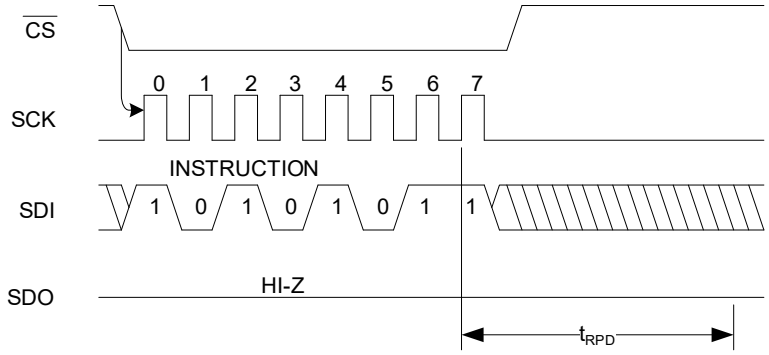
## 9.11 RES (Resume from Power Down):

The Resume from Power Down mode is the only command that will wake the device up from the Power Down mode. All other commands are ignored.

In the simple instruction command, after the $\overline{CS}$ pin is brought low, the RES instruction is shifted in. At the end of the instruction, the $\overline{CS}$ pin is brought back high.

The rising edge of the SCK clock number 7 ($8^{th}$ rising edge) initiates the internal RES instruction. The device becomes available for Read and Write instructions 75µS after the $8^{th}$ rising edge of the SCK ($t_{PUD}$, see AC Characteristics). The sequence for simple RES instruction is shown in Figure 9-13.

**Figure 9-13. Simple RES Sequence (ABh)**

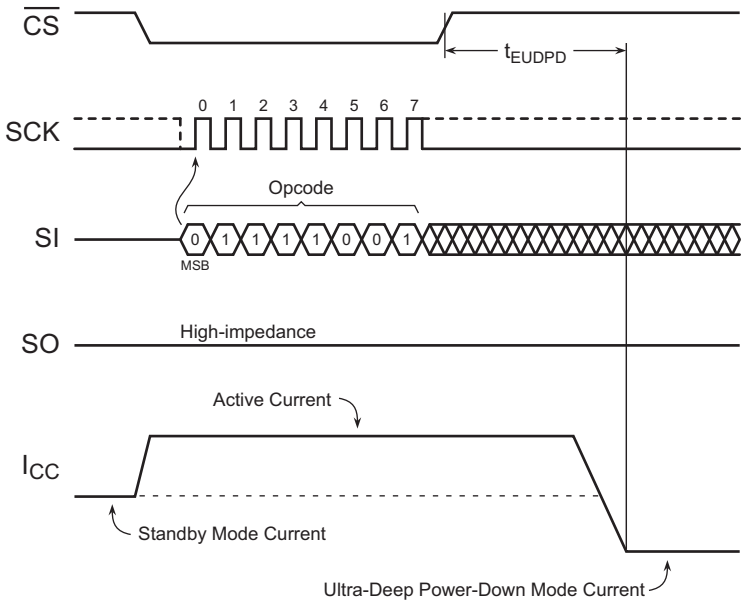



## 9.12 UDPD (Ultra-Deep Power Down):

The Ultra-Deep Power Down mode allows the device to further reduce its energy consumption compared to the existing Standby and Power Down modes by shutting down additional internal circuitry. When the device is in the Ultra-Deep Power Down mode, all commands including the Read Status Register and Resume from Deep Power Down commands will be ignored. Since all commands will be ignored, the mode can be used as an extra protection mechanism against inadvertent or unintentional program and erase operations. Entering the Ultra-Deep Power Down mode is accomplished by simply asserting the $\overline{CS}$ pin, clocking in the opcode 79h, and then deasserting the $\overline{CS}$ pin. Any additional data clocked into the device after the opcode will be ignored. When the $\overline{CS}$ pin is deasserted, the device will enter the Ultra-Deep Power Down mode within the maximum time of $t_{EUDPD}$.

The complete opcode must be clocked in before the $\overline{CS}$ pin is deasserted; otherwise, the device will abort the operation and return to the standby mode once the $\overline{CS}$ pin is deasserted. In addition, the device will default to the standby mode after a power cycle. The Ultra-Deep Power Down command will be ignored if an internally self-timed operation such as a program or erase cycle is in progress. The sequence for UDPD is shown in Figure 9-14.

**Figure 9-14. Ultra-Deep Power Down (79h)**



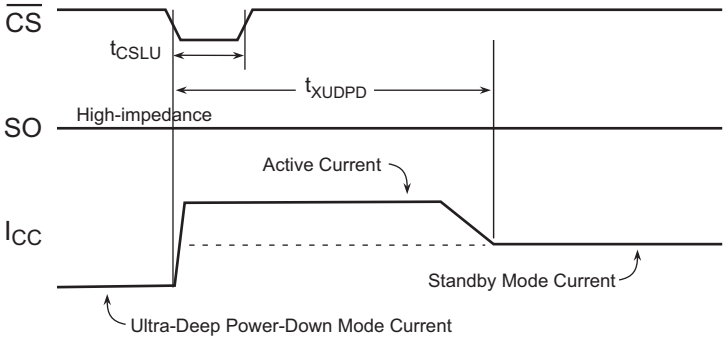

## 9.13 Exit Ultra-Deep Power Down

To exit from the Ultra-Deep Power Down mode, any one of three operations can be performed:

### 9.13.1 Chip Select Toggle

The $\overline{CS}$ pin must simply be pulsed by asserting the $\overline{CS}$ pin, waiting the minimum necessary $t_{CSLU}$ time, and then deasserting the $\overline{CS}$ pin again. To facilitate simple software development, a dummy byte opcode can also be entered while the $\overline{CS}$ pin is being pulsed; the dummy byte opcode is simply ignored by the device in this case. After the $\overline{CS}$ pin has been deasserted, the device will exit from the Ultra-Deep Power Down mode and return to the standby mode within a maximum time of $t_{XUDPD}$ If the $\overline{CS}$ pin is reasserted before the $t_{XUDPD}$ time has elapsed in an attempt to start a new operation, then that operation will be ignored and nothing will be performed.

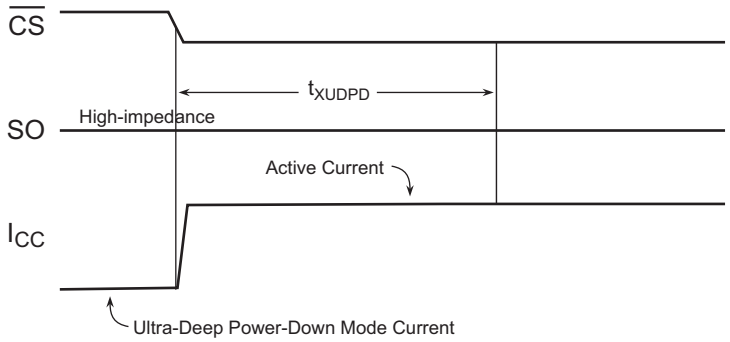
**Figure 9-15. Exit Ultra-Deep Power Down (Chip Select Toggle)**




### 9.13.2 Chip Select Low

By asserting the $\overline{CS}$ pin, waiting the minimum necessary $t_{XUDPD}$ time, and then clocking in the first bit of the next Opcode command cycle. If the first bit of the next command is clocked in before the $t_{XUDPD}$ time has elapsed, the device will exit Ultra Deep Power Down, however the intended operation will be ignored.

**Figure 9-16. Exit Ultra-Deep Power Down (Chip Select Low)**




### 9.13.3 Power Cycling

The device can also exit the Ultra Deep Power Mode by power cycling the device. The system must wait for the device to return to the standby mode before normal command operations can be resumed. Upon recovery from Ultra Deep Power Down all internal registers will be at there Power-On default state.

## 10. Typical Characteristics

**Figure 10-1. Icc4 , Auto Powerdown**

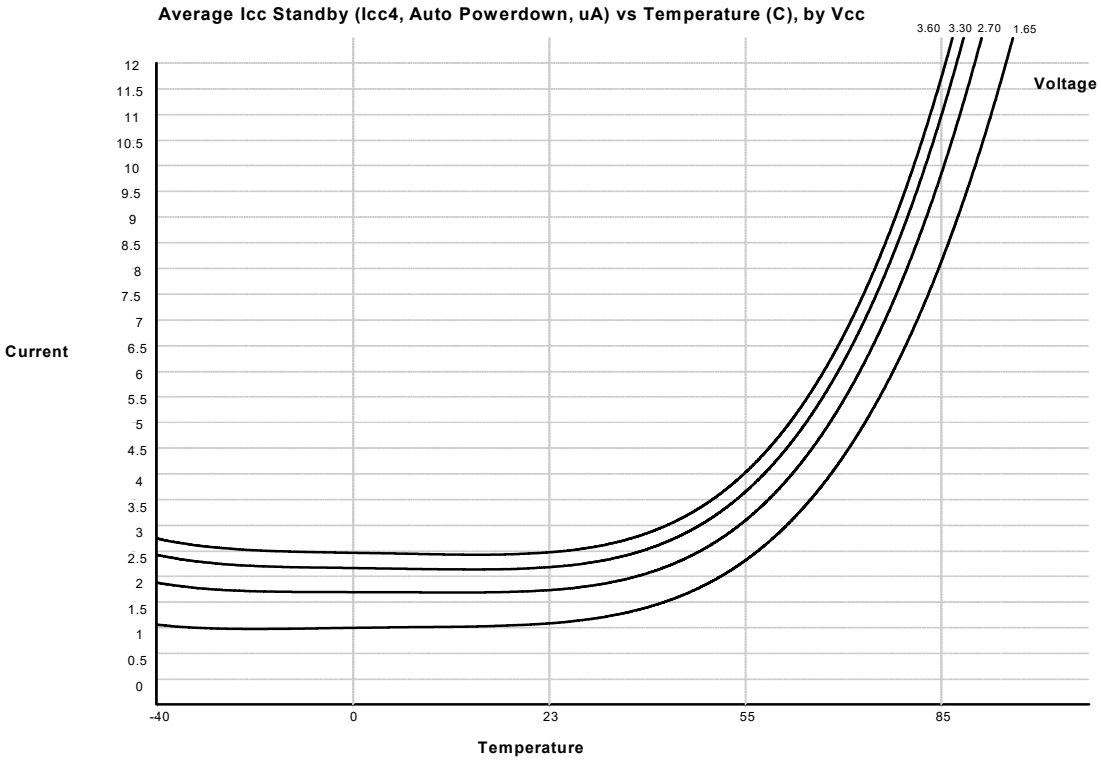


**Figure 10-2. Icc4, Mode 0**

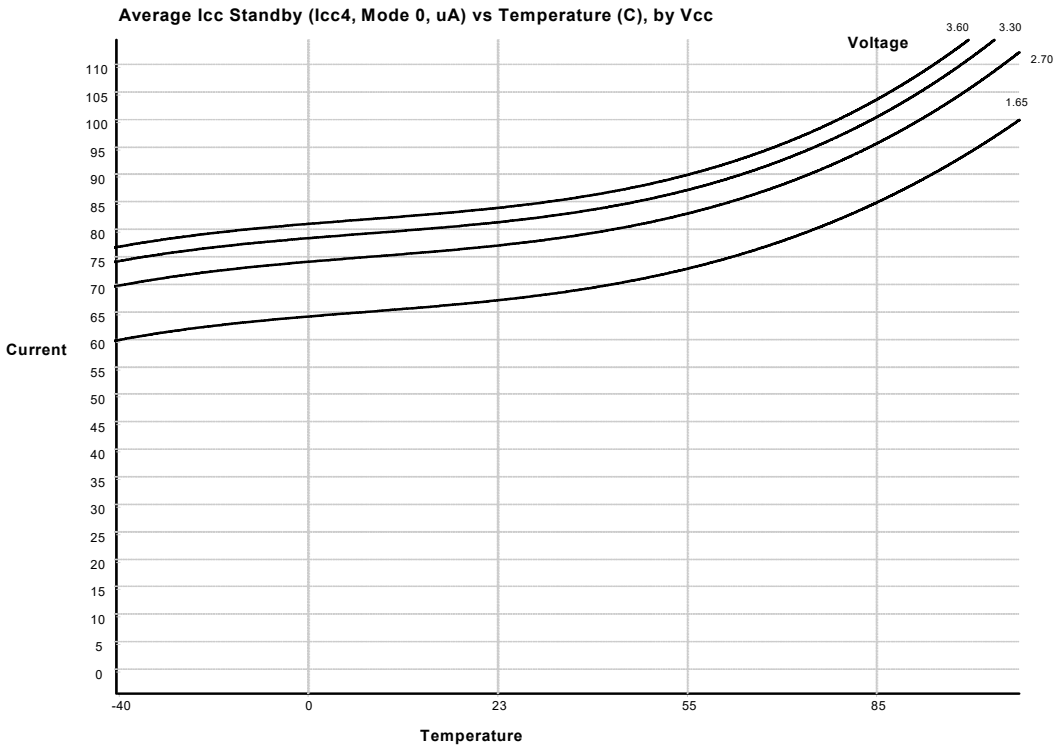



**Figure 10-3. Icc4, Mode 1**

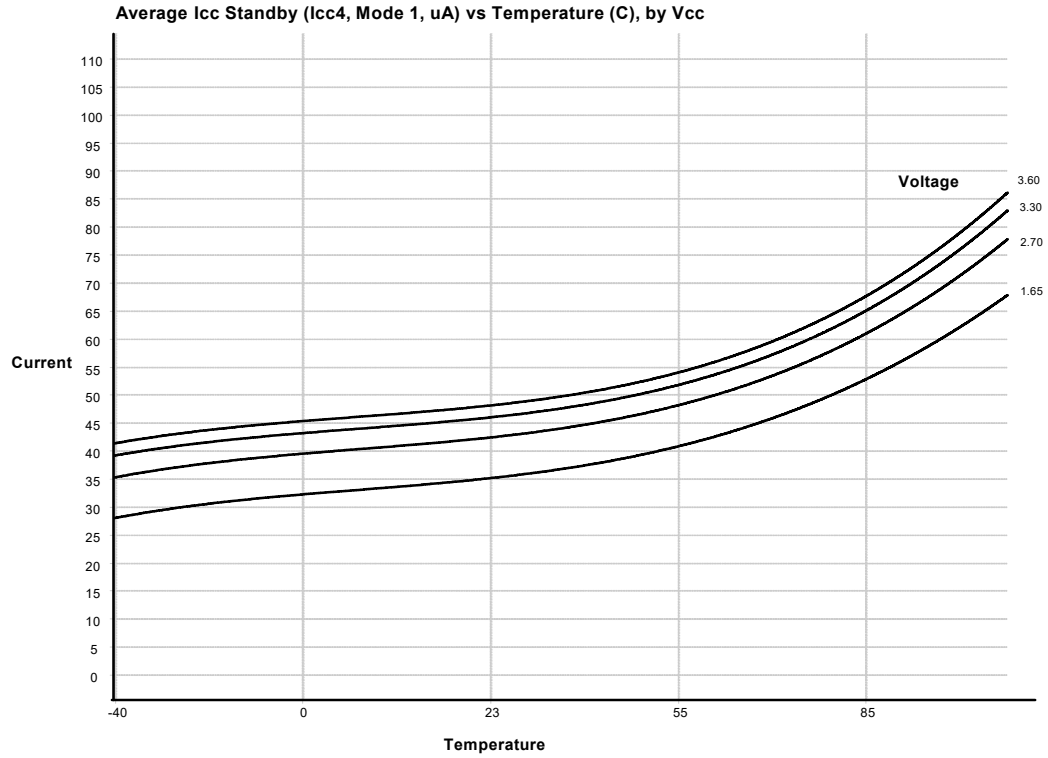


**Figure 10-4. Icc5**

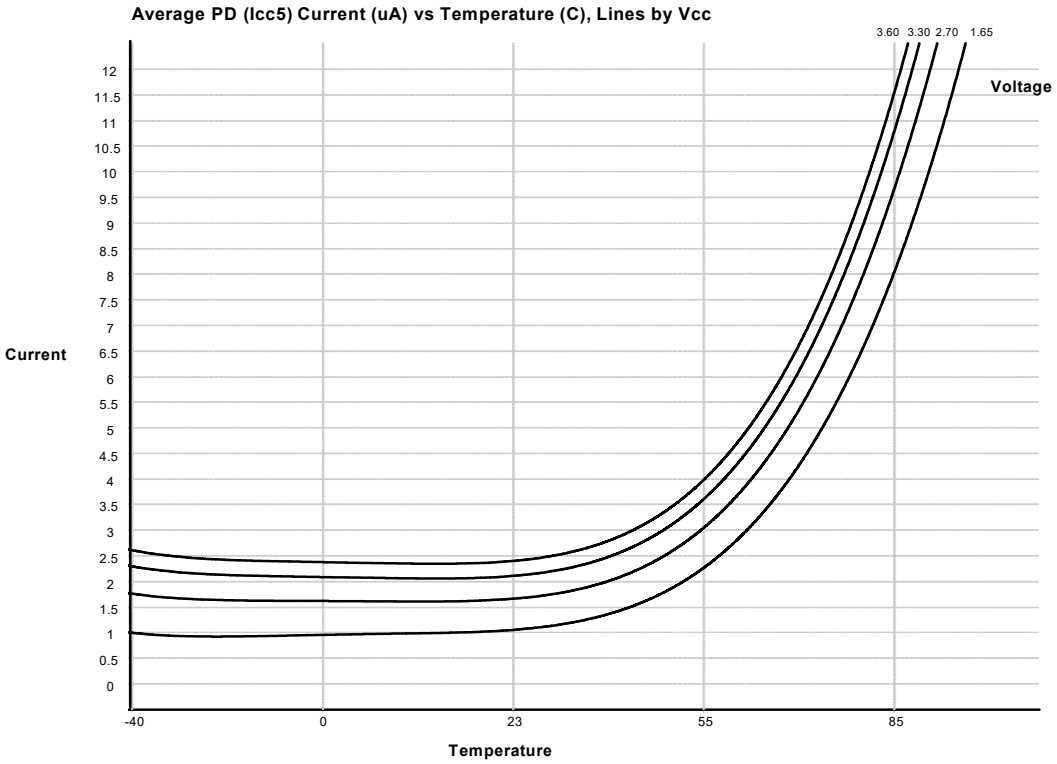
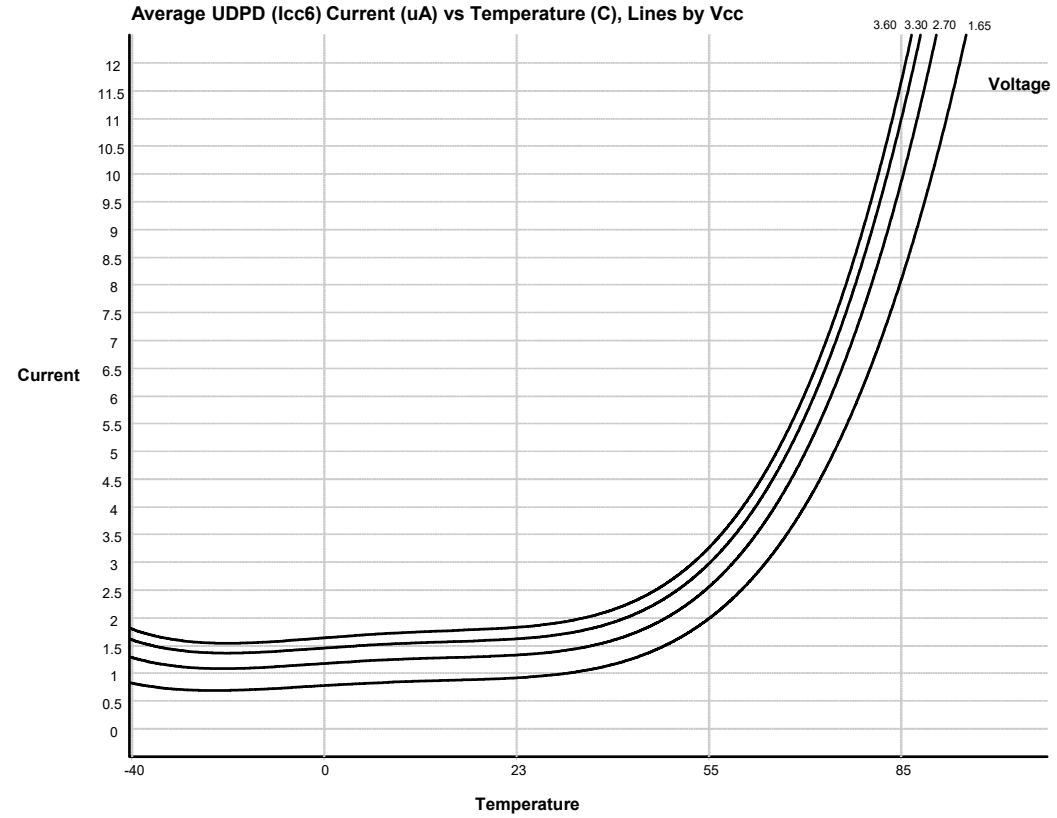
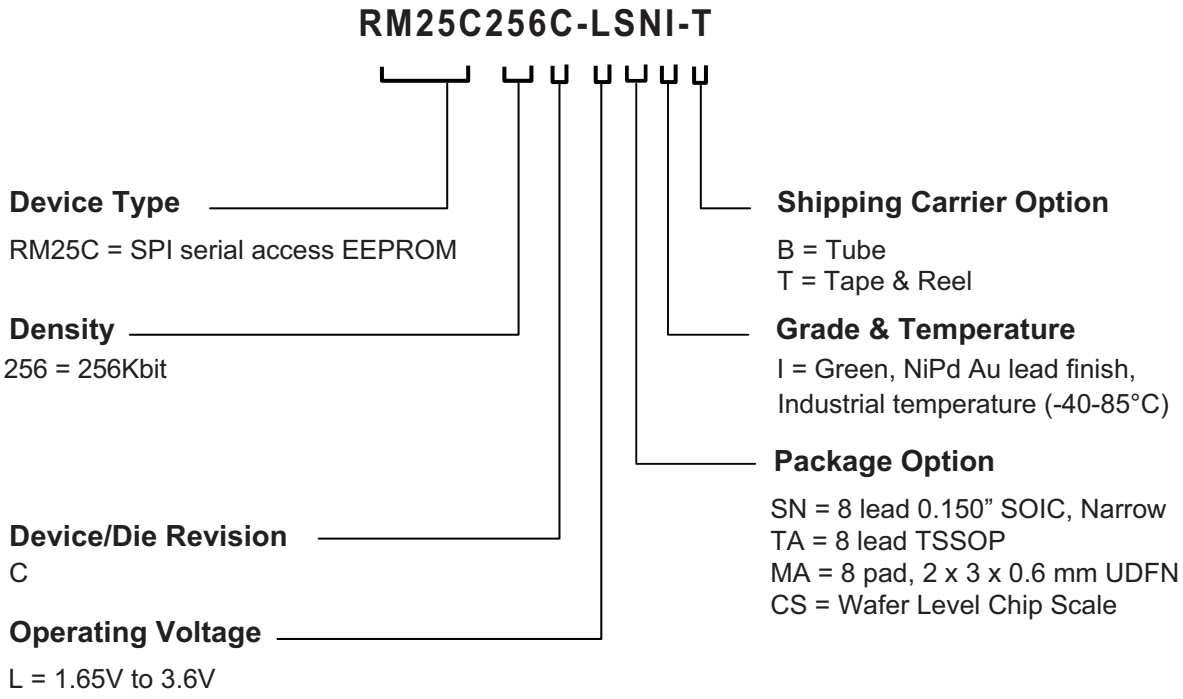



**Figure 10-5. Icc6**



# 11. Ordering Information

## 11.1 Ordering Detail




## 11.2 Ordering Codes

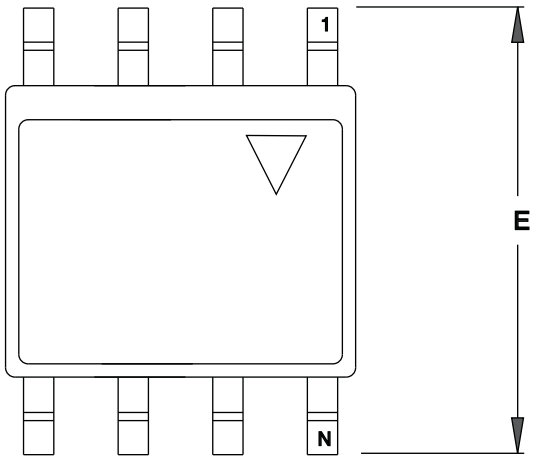
| Ordering Code | Package | Density | Operating Voltage | $f_{SCK}$ | Device Grade | Ship Carrier | Qty. Carrier |
|---|---|---|---|---|---|---|---|
| RM25C256C-LSNI-B | SN | 256 Kbit | 1.65V to 3.6V | 10 MHz | Commercial (-40°C to 85°C) | Tube | 100 |
| RM25C256C-LSNI-T | | | | | | Reel | 4000 |
| RM25C256C-LTAI-B | TA | | | | | Tube | 100 |
| RM25C256C-LTAI-T | | | | | | Reel | 6000 |
| RM25C256C-LMAI-T | MA | | | | | Reel | 5000 |
| RM25C256C-LCSI-T (1) | CS6 | | | | | Contact Factory | |

1. Contact Adesto for availability.

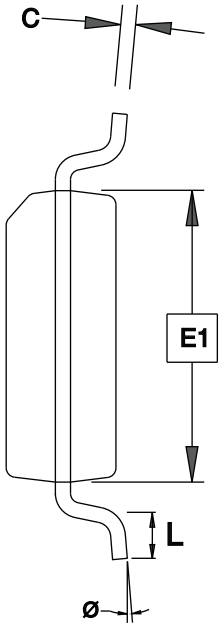
| Package Type | |
|---|---|
| SN | 8-lead 0.150" wide, Plastic Gull Wing Small Outline (JEDEC SOIC) |
| TA | 8-lead 3 x 4.4 mm, Thin Shrink Small Outline Package |
| MA | 8-pad, 2 x 3 x 0.6mm, Thermally Enhanced Plastic Ultra Thin Dual Flat No Lead Package (UDFN) |
| CS6 | 6-Ball Wafer Level Chip Scale Package |

# 12. Package Information

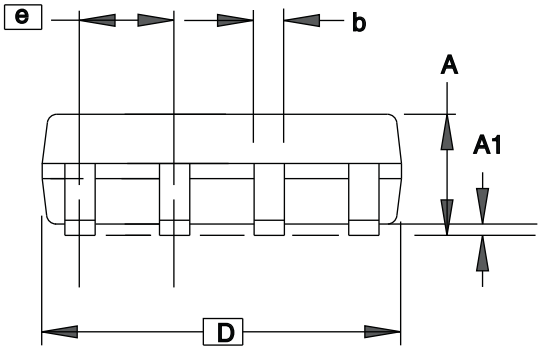
## 12.1 SN (JEDEC SOIC)




TOP VIEW




END VIEW




SIDE VIEW

Notes: This drawing is for general information only.
Refer to JEDEC Drawing MS-012, Variation AA
for proper dimensions, tolerances, datums, etc.

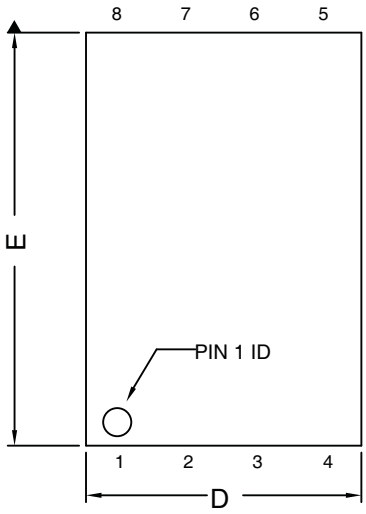
COMMON DIMENSIONS
(Unit of Measure = mm)

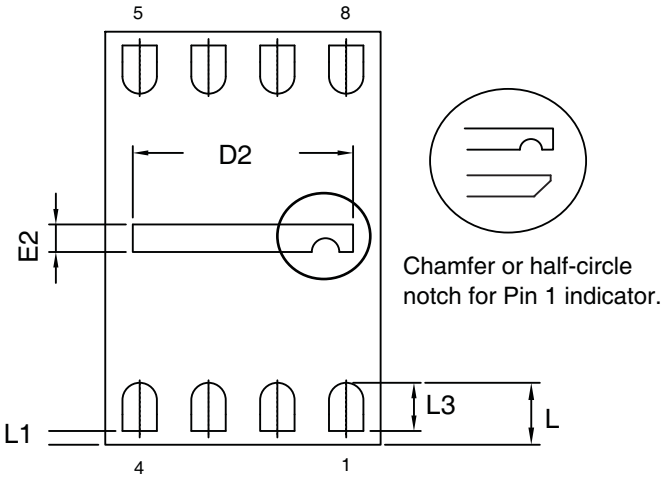
| SYMBOL | MIN | NOM | MAX | NOTE |
|---|---|---|---|---|
| A | 1.35 | – | 1.75 | |
| A1 | 0.10 | – | 0.25 | |
| b | 0.31 | – | 0.51 | |
| C | 0.17 | – | 0.25 | |
| D | 4.80 | – | 5.05 | |
| E1 | 3.81 | – | 3.99 | |
| E | 5.79 | – | 6.20 | |
| e | 1.27 BSC | | | |
| L | 0.40 | – | 1.27 | |
| ø | 0° | – | 8° | |

8/20/14

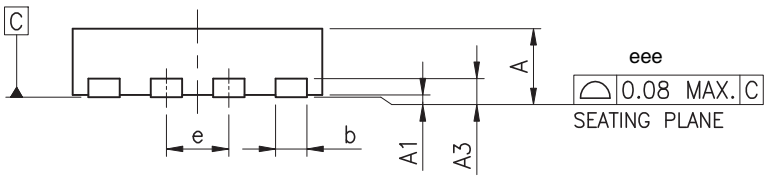
| adesto TECHNOLOGIES<br>Package Drawing Contact:<br>contact@adestotech.com | TITLE<br>8S1, 8-lead (0.150"Wide Body), Plastic Gull Wing Small Outline (JEDEC SOIC) | GPC<br>SWB | DRAWING NO.<br>8S1 | REV.<br>G |
|---|---|---|---|---|

## 12.2 MA – 2x3 UDFN




Chamfer or half-circle notch for Pin 1 indicator.




COMMON DIMENSIONS
(Unit of Measure = mm)

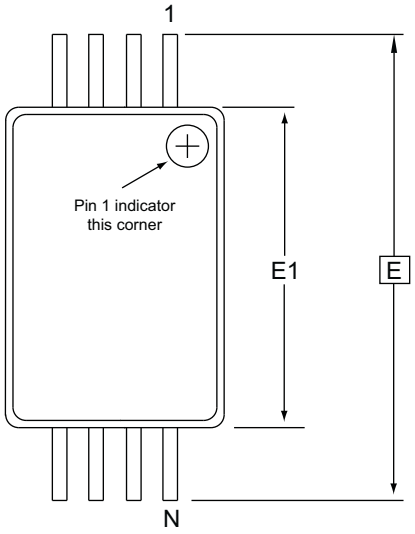
| SYMBOL | MIN | NOM | MAX |
|---|---|---|---|
| A | 0.45 | | 0.60 |
| A1 | 0.00 | | 0.05 |
| A3 | | 0.150 REF | |
| b | 0.20 | | 0.30 |
| D | | 2.00 BSC | |
| D2 | 1.50 | 1.60 | 1.70 |
| E | | 3.00 BSC | |
| E2 | 0.10 | 0.20 | 0.30 |
| e | | 0.50 BSC | |
| L | 0.40 | 0.45 | 0.50 |
| L1 | 0.00 | 0.10 | |
| L3 | 0.30 | | 0.50 |
| eee | – | – | 0.08 |

Notes: 1. All dimensions are in mm. Angles in degrees.
2. Bilateral coplanarity zone applies to the exposed heat sink slug as well as the terminals.

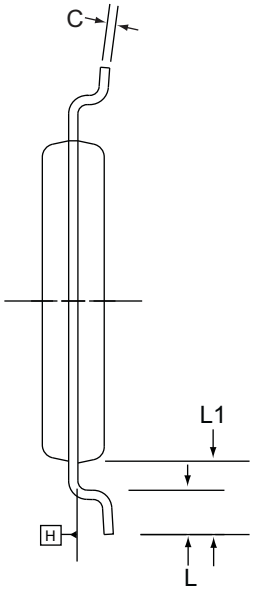
8/26/14

| | TITLE | GPC | DRAWING NO. | REV. |
|---|---|---|---|---|
| adesto TECHNOLOGIES Package Drawing Contact: contact@adestotech.com | 8MA3, 8-pad, 2 x 3 x 0.6 mm Body, 0.5 mm Pitch, 1.6 x 0.2 mm Exposed Pad, Saw Singulated Thermally Enhanced Plastic Ultra Thin Dual Flat No Lead Package (UDFN/USON) | YCQ | 8MA3 | GT |

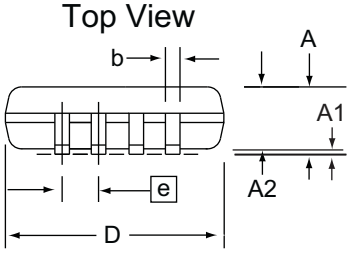
## 12.3 TA-TSSOP




Top View




End View




Side View

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.

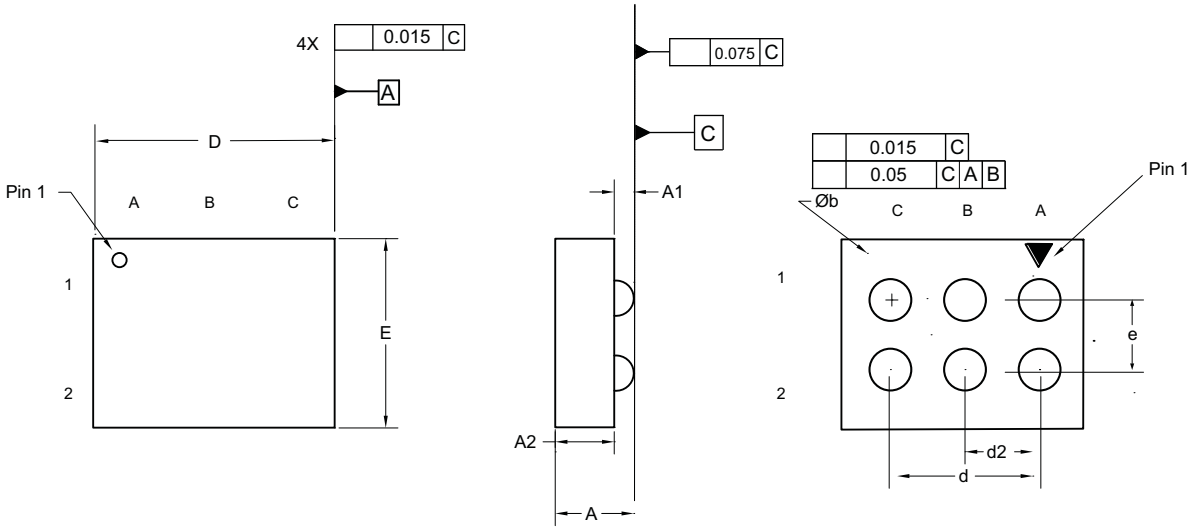
COMMON DIMENSIONS
(Unit of Measure = mm)

| 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 | – | 0.30 | 4 |
| e | | 0.65 BSC | | |
| L | 0.45 | 0.60 | 0.75 | |
| L1 | | 1.00 REF | | |
| C | 0.09 | - | 0.20 | |

12/8/11

| adesto TECHNOLOGIES<br>Package Drawing Contact:<br>contact@adestotech.com | TITLE<br>TA, 8-lead 4.4mm Body, Plastic Thin Shrink Small Outline Package (TSSOP) | GPC<br>TNR | DRAWING NO.<br>8X | REV.<br>E |
|---|---|---|---|---|

## 12.4 CS6- 6-Ball WLCSP




TOP VIEW SIDE VIEW BALL SIDE

* Dimensions are NOT to scale.

Pin Assignment Matrix

| | A | B | C |
|---|---|---|---|
| 1 | $V_{CC}$ | GND | CS |
| 2 | SCK | SDI | SDO |

PCB Land Pad Diameter Recommendation:

| Description | Value |
|---|---|
| Non-soldermask defined (NSMD) | 225um |
| Soldermask defined (SMD) | 250um |

COMMON DIMENSIONS
(Unit of Measure = mm)

| SYMBOL | MIN | TYP | MAX | NOTE |
|---|---|---|---|---|
| A | | 0.35 | | |
| A1 | | 0.08 | | |
| A2 | | 0.27 | | |
| E | | 1.28 | | |
| e | | 0.4 | | |
| d | | 0.8 | | |
| d2 | | 0.4 | | |
| D | | 1.47 | | |

2/29/16

| adesto TECHNOLOGIES<br>Package Drawing Contact:<br>contact@adestotech.com | TITLE<br>CS-6, 6-ball (3x3 Array) Wafer Level Chip Scale Package, WLCSP | GPC<br>GCL | DRAWING NO.<br>CS6-SP | REV.<br>0A |
|---|---|---|---|---|

# 13. Revision History

| Doc. Rev. | Date | Comments |
|---|---|---|
| RM25C256C-L-078A | 3/2016 | Initial document release. Document status changed to Preliminary. |
| RM25C256C-L-078B | 11/2016 | Updated Endurance and Data Retention specifications. Updated $T_{PW}$ and $T_{BW}$ specifications. |
| RM25C256C-L-078C | 11/2017 | Added patent information. |

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