
Product Specification

# SMART Modular
# Small Form Factor USB Key

**SLC NAND**
**SH9MKxxGQxx**

**August 2015 Rev E**

RoHS COMPLIANT 2002/95/EC

***www.smartm.com***

# REVISION HISTORY

| Date | Revision | Section(s) | Description |
|---|---|---|---|
| June 2014 | A | All | Initial release |
| October 2014 | B | 1.4.1, 1.4.2, 2.2, 4.2, 4.4, & 7.0 | Remove Endurance section and update maximum active current value for consistency. Remove geometry from Table 17.<br>Add support for MLC-based NAND products. |
| November 2014 | C | Table 5 | Update to dimensions to comply with mechanical specification |
| May 2015 | D | 7.0 and Table 11 | Specify SLC-based parts only and update product ID field. |
| August 2015 | E | 7.0 | Update Part Numbers and add new extended capacity. |

**ESD Caution – Handling**

Static electricity may be discharged through this disk subsystem. In extreme cases, this may temporarily interrupt the operation or damage components. To prevent this, make sure you are working in an ESD-safe environment. For example, before handling the disk subsystem, touch a grounded device, such as a computer case, prior to handling.

This document is subject to change without notice.

**SMART Modular Technologies**
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# TABLE OF CONTENTS



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# 1.0 GENERAL DESCRIPTION

## 1.1 Overview

The SMART Modular Small Form Factor USB Memory Keys provide low power, high capacity mass storage for embedded applications. The USB memory keys use an injection molding process to fit the smallest form factor requirements. The USB Memory key acts like a hard drive, but has the transportability of a solid state device.

The USB SLC Memory key is available in capacities of 1 GBytes to 32 GBytes and is designed for applications requiring the high reliability and performance.

SMART Modular Small Form Factor USB Memory keys address the need for enhanced reliability by incorporating on-board error detection and correction, with global wear leveling algorithms that provide reliable operation over the product life cycle. These USB Memory keys offer sustained read performance up to 34 MBytes/sec and sustained write performance of up to 29 MBytes/sec.

SMART has built its foundation by providing proven technology and quality products to the most demanding Fortune 100 OEMs. SMART engineers its products to perform at the highest degree of reliability and compatibility while backing these products with outstanding services and technology expertise.

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## 1.2 Features

- **Type:** Internal flash-based USB memory key module
- **Interface:** Compliant with USB 2.0 high-speed bus protocol
- **Supported USB Mode:** Bulk Only Transfer (BOT)
- **USB Interface Transfer Rate:** 480 Mbits/s (max)
- **Capacity:**
  - 1 GBytes to 32 GBytes
- **Data Rates:**
  - **Read, Sustained:** up to 34 MBytes/second
  - **Write, Sustained:** up to 29 MBytes/second
- **Operating Temperatures:**
  - **Commercial:** 0 °C to 70 °C
- **Power Requirements:**
  - **Active (Typical):** 110 mA
  - **Idle (Typical):** 50 mA

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## 1.3 Unique Features

- Whole-drive global wear leveling
- Advanced Error Detection/Correction circuitry for superior data reliability
- Shock and vibration resistant
- Low power dissipation
- USB-class definition for boot-ability support
- Field-upgradeable firmware via USB bus
- Small Form Factor

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## 1.4 Operational Characteristics

All listed values are typical unless otherwise stated.

### 1.4.1 Performance

**Table 1:** Performance Characteristics

| Item | Estimated Performance |
|---|---|
| Sustained Sequential Read (Maximum) | 34 MBytes/second |
| Sustained Sequential Write (Maximum) | 29 MBytes/second |
| Host Interface Transfer Rate (Maximum) | 480 Mbits/second |

### 1.4.2 Reliability

**Table 2:** Reliability Characteristics

| Item | Value |
|---|---|
| Data Retention @ 25 °C | 10 years > 90% life remaining<br>1 years < 10% life remaining |
| Endurance* | 3 TBW (1GB); 6 TBW (2GB); 12 TBW (4GB); 24 TBW (8GB);<br>80 TBW (16GB); 160 TBW (32GB) |
| Error Correction/Error Detection | Multi-bit correction supported for programmed NAND data. |

* Endurance is directly related to the User specific workload.

### 1.4.3 Power Requirements

**Table 3:** Power Requirements (5V)

| Parameter | Value (Typ) | Value (Max) | Unit |
|---|---|---|---|
| $V_{IN}$ | 5.0 | 5.5 | V |
| Read | 100 | 120 | mA |
| Write | 100 | 120 | mA |
| Idle | 50 | 60 | mA |

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### 1.4.4 Environmental Conditions

**Table 4:** Environmental Conditions and Testing

| Parameter | Value |
|---|---|
| Shock/Acceleration – Operating Half-Sine | 70 in/sec, 3 shocks along each axis, X, Y, Z, in each direction |
| Vibration – Operating | 0.9 *g* rms 10-500 Hz, 30 minutes per side (total of 6 sides) |
| Vibration – Non-Operating, Random | 13.6 *g* rms 10-500 Hz, 30 minutes per side (total of 6 sides) |
| Operating Temperature – Commercial | 0 °C to 70 °C |
| Storage Temperature | -40 °C to 85 °C |

### 1.4.5 Physical Characteristics

**Table 5:** Physical Characteristics

| Parameter | Value |
|---|---|
| Length | 45.97 mm [1.81 in] |
| Width | 15.49 mm [0.61 in] |
| Height (Mounted) | 6.0 mm [0.24 in] |

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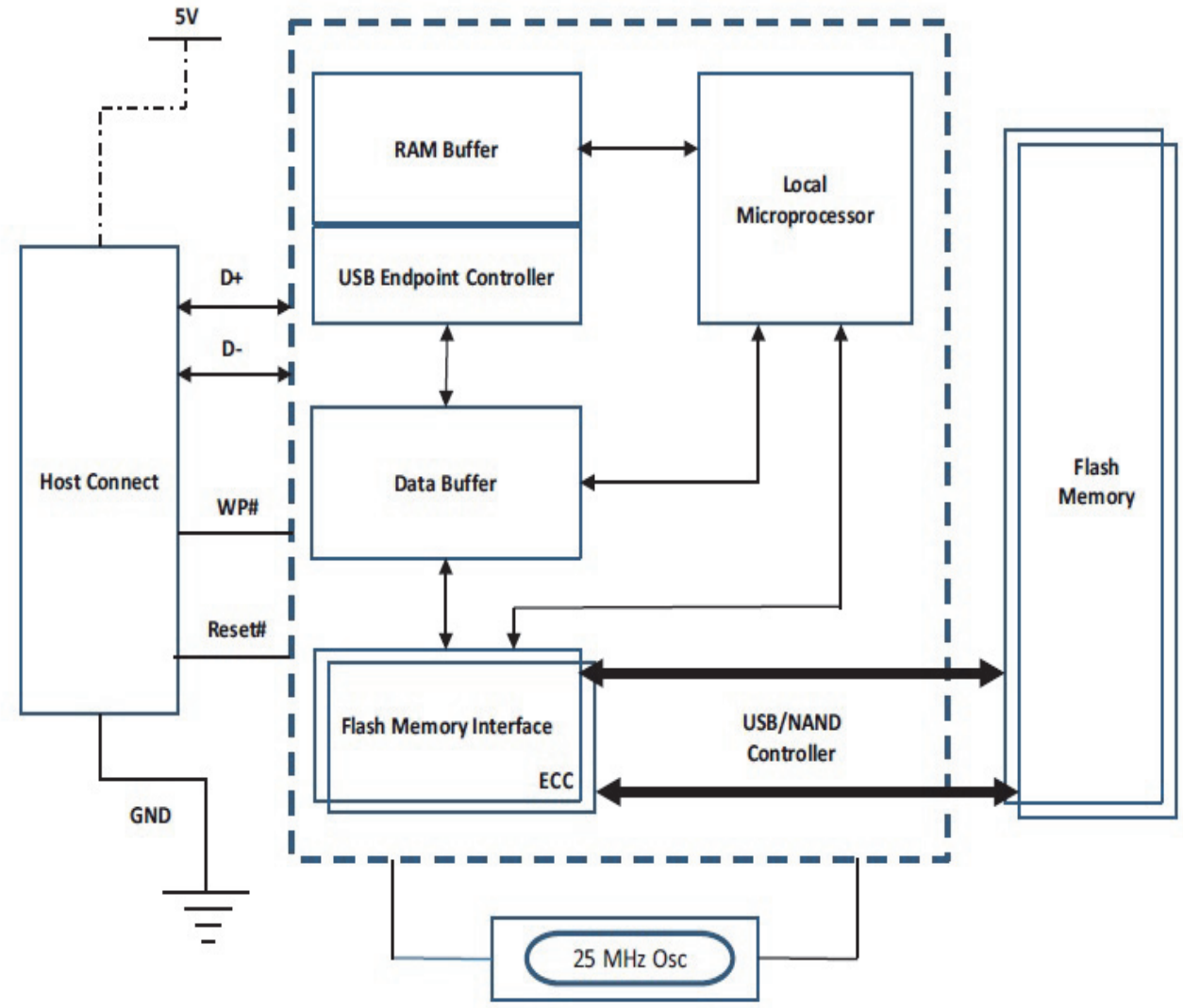
# 2.0 PRODUCT DESCRIPTION

The SMART USB Memory Keys contains an integrated USB 2.0 high-speed interface and a NAND flash controller with corresponding flash memory devices. This system architecture logically and efficiently translates standard USB reduced block commands (RBCs) into flash memory accesses. Parallel access to the flash memory allows overlapped, multi-block access to complete data transfer requests rapidly.

## 2.1 Functional Block Diagram

**Figure 1:** USB Memory Key Module Block Diagram



## 2.2 Mean Time Between Failures (MTBF)

The MTBF statistic for the USB Memory Key was calculated based on the RDF2000 UTE C80-810 Telecom Standard at 25 °C (drive temperature).

**Table 6:** MTBF Values

| Drive Capacity | # of Chips | MTBF (Hours) |
|---|---|---|
| All | 1 | 4,645,509 |

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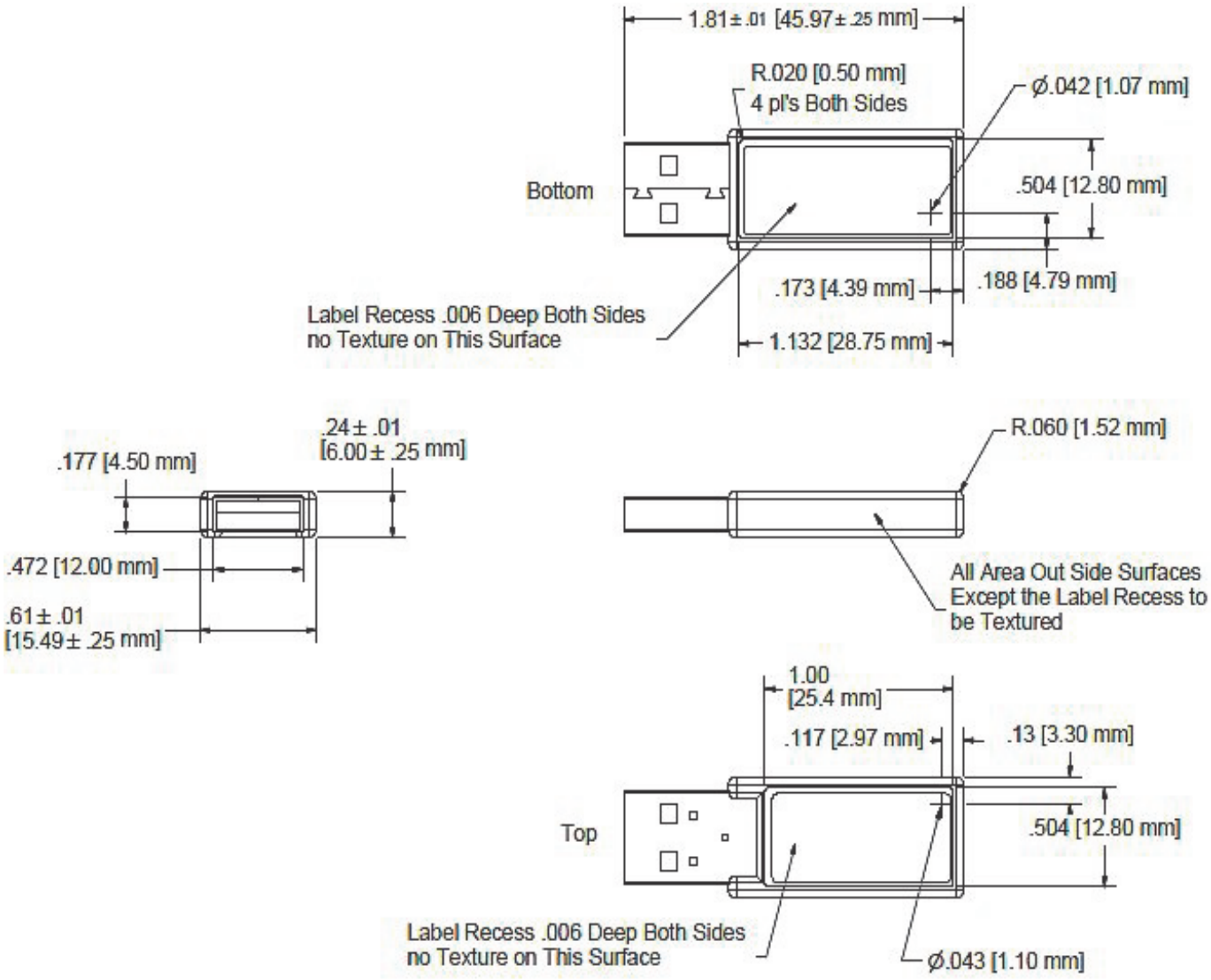
## 3.0 MECHANICAL SPECIFICATION

**Figure 2:** USB Memory Key Dimensions (in mm [inches])

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# 4.0 ELECTRICAL SPECIFICATION

## 4.1 Electrical Interface

The USB Memory Key is compliant with the USB 2.0 standard.

### 4.1.1 Mating Connector

The USB Memory Key uses a 4-pin, type A USB standard connector. It can use any female connector, such as AMCO P/N 211-100400-051.

### 4.1.2 Pinout Descriptions

**Table 7:** Pinout Descriptions (4-Pin)

| Pin | Signal Name | Signal Description |
|---|---|---|
| 1 | 5V | 5 Volts |
| 2 | DM | Data - |
| 3 | DP | Data + |
| 4 | GND | Ground |

## 4.2 Absolute Maximum Ratings

**Table 8:** Voltage and Storage Temperature*

| Symbol | Parameter | Ratings (Min) | Ratings (Max) | Unit |
|---|---|---|---|---|
| $V_{IN5}$ | 5 V Supply Voltage | 4.5 | 5.5 | V |
| $I_{ACTIVE5}$ | Active Current (5 V) | 80 | 120 | mA |
| $T_A$ | Operating Temperature | 0 | 70 | °C |
| $T_{STG}$ | Storage Temperature | -40 | 85 | °C |

* Stress beyond the Absolute Maximum Rating conditions may result in permanent damage to the device. These are stress ratings only and functional operation should be restricted to those indicated in the operational sections of this specification. Exposure to conditions beyond recommended, up to and including the Absolute Maximum Rating conditions, for extended periods may affect device reliability.

## 4.3 Recommended Operating Conditions

**Table 9:** Recommended Operating Conditions

| Symbol | Parameter | Ratings | Unit |
|---|---|---|---|
| $V_{IN5}$ | 5 V Supply Voltage | 5 ± 10% | V |
| $T_A$ | Operating Temperature – Commercial | 0 °C to 70 °C | °C |

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## 4.4 DC Characteristics

**Table 10:** DC Characteristics

| Symbol | Parameter | Typical | Max | Unit | Condition |
|---|---|---|---|---|---|
| $I_{RD5}$ | Active Read Current | 100 | 120 | mA | $V_{IN}$ = 5 V |
| $I_{WR5}$ | Active Write Current | 100 | 120 | mA | $V_{IN}$ = 5 V |
| $I_{IDLE5}$ | Idle Current | 50 | 60 | mA | $V_{IN}$ = 5 V |

# 5.0 USB COMMANDS

The standard class interface specification is currently implemented in the USB Memory Key. The SMART USB device does not support Interrupt or Isynchronous transport protocols. For the purpose of data integrity, only Bulk and Control Transport modes are implemented.

## 5.1 Standard Descriptor

The SMART Modular USB device supports the following standard USB descriptors:

- **Device Descriptor:** Contains one descriptor.
- **Configuration:** Contains one default configuration descriptor, which supports the Bulk-Only Data Interface.
- **Interface:** Supports the Bulk-Only Data Interface.
- **Endpoint:** Supports the following endpoints:
  - Control
  - Bulk-In
  - Bulk-Out

  **NOTE:** The host uses the first reported Bulk-In and Bulk-Out endpoints for the selected interface.
- **String:** Provides a string field with the following information:
  - SMART Vendor ID = 0E39
  - USB Key Product ID = 2F00
  - Product Inquiry = USB
  - Device ID = See the decoder in Table 16
  - Unique Serial Number

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## 5.2 Device Descriptor

The USB device has one device descriptor which is described below.

**Table 11:** Device Descriptor

| Offset | Field | Size | Value | Description |
|---|---|---|---|---|
| 0 | bLength | Byte | 12h | Size of this descriptor, in bytes. |
| 1 | bDescriptorType | Byte | 01h | Device descriptor type. |
| 2 | bcdUSB | Word | 0200h | USB specification release number in binary-code decimal. |
| 4 | bDeviceClass | Byte | 00h | Class is specified in the interface descriptor. |
| 5 | bDeviceSubClass | Byte | 00h | Subclass is specified in the interface descriptor. |
| 6 | bDeviceProtocol | Byte | 00h | The 00h protocol is specified in the interface descriptor. |
| 7 | bMaxPacketSize0 | Byte | 40h | Maximum packet size for endpoint zero. Valid values are 8, 16, 32, or 64 (08h, 10h, 20h, or 40h). |
| 8 | idVendor | Word | 0E39h | Vendor ID assigned by the USB-IF. |
| 10 | idProduct | Word | 2F00h | SMART Modular product ID. |
| 12 | bcdDevice | Word | Varies | Firmware encoding |
| 14 | iManufactures | Byte | 01h | Index of string descriptor describing the manufacturer. |
| 15 | iProduct | Byte | 02h | Index of string descriptor describing the product. |
| 16 | iSerialNumber | Byte | 03h | Index of string descriptor describing the serial number of the device. |
| 17 | bNumConfiguration | Byte | 01h | Number of possible configurations. |

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## 5.3 Configuration Descriptor

The USB device has one default configuration descriptor which supports the Bulk-Only Data Interface. The configuration descriptor describes information about a specific device configuration. It contains a **bConfiguration Value** field with a value that, when used as a parameter to the setConfiguration() request, causes the device to select the configuration.

**Table 12:** Configuration Descriptor

| Offset | Field | Size | Value | Description |
|---|---|---|---|---|
| 0 | bLength | Byte | 09h | Size of the descriptor, in bytes. |
| 1 | bDescriptorType | Byte | 02h | Configuration descriptor type. |
| 2 | wTotalLength | Word | 0020h | Total length of data returned for this configuration.This includes combined length of all descriptors (configuration, interface, endpoint, and class- or vendor-specific). |
| 4 | bNumInterfaces | Byte | 01h | Number of interfaces supported by this configuration. The device only supports the Bulk-Only Data interface. |
| 5 | bConfigurationValue | Byte | 01h | Value to use as an argument in the setConfiguration() request to select this configuration. |
| 6 | iConfiguration | Byte | 00h | Index of the string descriptor describing this configuration. |
| 7 | bmAttributes | Byte | 80h | Configuration characteristics. Possible values are:<br>**Bit** **Description**<br>7 Reserved (set to 1)<br>6 Self-Powered<br>5 Remote<br>4..0 Reserved (reset to zero) bit<br>7 is reserved and must be set to one. For a full description of the bmAttributes bitmap, refer to the USB 2.0 Standard. |
| 8 | maxPower | Byte | 32h | Maximum power consumption of the USB device from the bus when the device is fully operational, in 2mA units (for example, 50=100mA). |

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## 5.4 Bulk-Only Data Interface Descriptor

The Bulk-Only Data Interface descriptor describes a specific interface within a configuration. A configuration provides one or more interfaces, each with zero or more endpoint descriptors that describe a unique set of endpoints within the configuration.

**Table 13:** Bulk-Only Data Interface Descriptor

| Offset | Field | Size | Value | Description |
|---|---|---|---|---|
| 0 | bLength | Byte | 09h | Size of the descriptor, in bytes. |
| 1 | bDescriptorType | Byte | 04h | Interface descriptor type. |
| 2 | bInterfaceNumber | Byte | 00h | Interface number. This is a zero-based value identifying the index in the array of concurrent interfaces supported by this configuration. |
| 3 | bAlternateSetting | Byte | 00h | Value used to select alternate setting for the interface identified in the **bInterfaceNumber** field. |
| 4 | bNumEndpoints | Byte | 02h | Number of endpoints used by this interface, excluding endpoint zero. |
| 5 | bInterfaceClass | Byte | 08h | Mass storage class. |
| 6 | bInterfaceSubClass | Byte | 06h | Subclass code assigned by the USB-IF which indicates the industry-standard command block definition to use. The 06h value indicates the USB is using the SCSI transparent command set based on the USB Mass Storage Overview Standard. |
| 7 | bInterfacedProtocol | Byte | 50h | Bulk-Only Transport. |
| 8 | iInterface | Byte | 00h | Index to the string descriptor describing this interface. |

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## 5.5 Endpoint Descriptors

The SMART Modular USB device supports three endpoints: Control, Bulk-In and Bulk-Out. The Control endpoint defaults to 0 and does not require a descriptor.

### 5.5.1 Bulk-In Endpoint Descriptor

**Table 14:** Bulk-In Endpoint Descriptor

| Offset | Field | Size | Value | Description |
|---|---|---|---|---|
| 0 | bLength | Byte | 07h | Size of the descriptor, in bytes. |
| 1 | bDescriptorType | Byte | 05h | Endpoints descriptor type. |
| 2 | bEndpointAddress | Byte | 81h | Address of this endpoint on the USB device. The address is encoded as follows:<br>**Bit Description**<br>7 1 = In<br>6..4 Reserved (set to 0)<br>3..0 The endpoint number |
| 3 | bAttributes | Byte | 02h | This is a bulk endpoint. |
| 4 | wMaxPacketSize | Word | 0200h | Maximum packet size. |
| 6 | bInterval | Byte | 00h | Does not apply to bulk endpoints. |

### 5.5.2 Bulk-Out Endpoint Descriptor

**Table 15:** Bulk-Out Endpoint Descriptor

| Offset | Field | Size | Value | Description |
|---|---|---|---|---|
| 0 | bLength | Byte | 07h | Size of the descriptor, in bytes. |
| 1 | bDescriptorType | Byte | 05h | Endpoints descriptor type. |
| 2 | bEndpointAddress | Byte | 02h | Address of this endpoint on the USB device. The address is encoded as follows:<br>**Bit Description**<br>7 0 = Out<br>6..4 Reserved (set to 0)<br>3..0 The endpoint number |
| 3 | bAttributes | Byte | 02h | This is a bulk endpoint. |
| 4 | wMaxPacketSize | Word | 0200h | Maximum packet size. |
| 6 | bInterval | Byte | 00h | Does not apply to bulk endpoints. |

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# 6.0 REDUCED BLOCK COMMANDS (RBC) DESCRIPTORS

The Reduced Block Commands (RBC) - simplified versions of SCSI Block Commands - 2(SBC-2), along with the required SCSI Primary Commands - 2(SPC-2), fully specify the complete command set for RBC logical block devices.

**Table 16:** Reduced Block Command Descriptor Descriptions

| Command | OpCode | Command Support | SMART Supported | Revised Spec |
|---|---|---|---|---|
| FORMAT UNIT | 04h | O | No | RBC |
| INQUIRY | 12h | M | Yes | SPC-2 |
| MODE SELECT (6) | 15h | M | Yes | SPC-2 |
| MODE SENSE (6) | 1Ah | M | Yes | SPC-2 |
| PERSISTENT RESERVE IN | 5Eh | O | No | SPC-2 |
| PERSISTENT RESERVE OUT | 5Fh | O | No | SPC-2 |
| PREVENT.ALLOW MEDIUM REMOVAL | 1Eh | M | Yes | SPC-2 |
| READ (10) | 28h | M | Yes | RBC |
| READ CAPACITY | 25h | M | Yes | RBC |
| RELEASE (6) | 17h | O | No | SPC-2 |
| REQUEST SENSE | 03h | O | Yes | SPC-2 |
| RESERVE (6) | 16h | O | No | SPC-2 |
| START STOP UNIT | 1Bh | M | Yes | RBC |
| SYNCHRONIZE CACHE | 35h | O | No | RBC |
| TEST UNIT READY | 00h | M | Yes | SPC-2 |
| VERIFY (10) | 2Fh | M | Yes | RBC |
| WRITE (10) | 2Ah | M | Yes | RBC |
| WRITE BUFFER | 3Bh | O | Yes | SPC-2 |
| MODE SENSE (10) | 5Ah | B | Yes | USB-Boot |

**NOTES**:

- The CONTROL byte (last byte of CDB) is set to zero.
- When a reduced block command is not supported, the USB drive returns STALL and waits for the host to send a Clear Feature command to reset the drive.
- Command Support Key:

  M = Mandatory

  N/A = Not applicable

  O = Optional

  B = Bootability

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# 7.0 PART NUMBERS

## 7.1 Part Numbering Information

**Table 17:** Device Part Numbering Information

| SMART Part Number | Capacity | Chip Density | Page Size | Chip Qty | Read Speed (MB/s) | Write Speed (MB/s) | Random Access Time (msec) | Typ. Write Current (mA) |
|---|---|---|---|---|---|---|---|---|
| SH9MK1GQ9 | 1 GB | 1 Gb | 4K | 1 | 14 | 19 | 0.9 | 85 |
| SH9MK2GQA | 2 GB | 16 Gb | 4K | 1 | 15 | 19 | 0.8 | 90 |
| SH9MK4GQB | 4 GB | 32 Gb | 8K | 1 | 26 | 33 | 0.6 | 100 |
| SH9MK8GQC | 8 GB | 64 Gb | 8K | 1 | 27 | 33 | 0.7 | 110 |
| SH9MK8EQC | 8 GB | 64 Gb | 8K | 1 | 27 | 33 | 0.7 | 110 |
| SH9MK16GQD | 16 GB | 128 Gb | 8K | 1 | 30 | 33 | 0.8 | 122 |
| SH9MK32GQE | 32 GB | 256 Gb | 8K | 1 | 27 | 34 | 0.8 | 140 |

**Table 18:** Part Capacity Information

| SMART Part Number | Capacity | Addressable LBAs | Unformatted Capacity |
|---|---|---|---|
| SH9MK1GQ9 | 1 GB | 1,957,888 | 1,002,438,656 |
| SH9MK2GQA | 2 GB | 3,909,632 | 2,001,731,584 |
| SH9MK4GQB | 4 GB | 7,745,536 | 3,965,714,432 |
| SH9MK8GQC | 8 GB | 15,466,496 | 7,918,845,952 |
| SH9MK8EQC | 8 GB | 15,646,720 | 8,011,120,640 |
| SH9MK16GQD | 16 GB | 30,941,184 | 15,841,886,208 |
| SH9MK32GQE | 32 GB | 61,751,296 | 31,616,663,552 |

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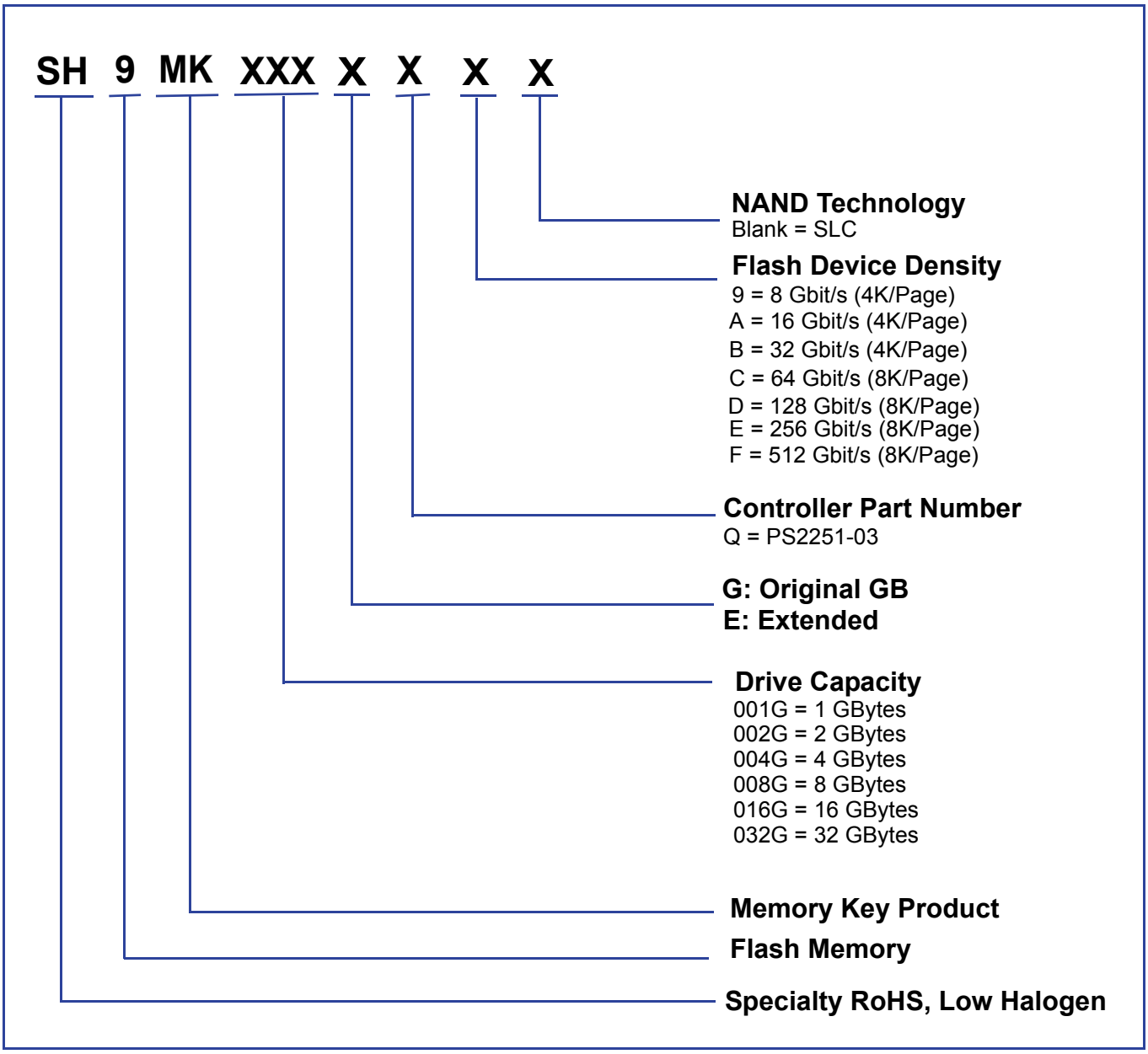
**Asia:** Plot 18, Lrg Jelawat 4, Kawasan Perinudstrian Seberang Jaya 13700, Prai, Penang, Malaysia ♦ Tel:+604-3992909 ♦ Fax:+604-3992903

## 7.2 Part Number Decoder

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# 8.0 PRODUCT LABEL

**Figure 3:** Sample USB Memory Key (SH9MK16GQD) Product Labeling (front and back)

**16 GBytes**

FRONT


BACK


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# Declaration of Conformity

| | |
|---|---|
| Responsible Party Name: | SMART Modular Technologies, Inc. |
| Address: | 39870 Eureka Drive |
| | Newark, CA 94560-4809, USA |
| Phone: | +1-510-623-1231 |

hereby declares that the products:

# PN: SH9MKXXGQXX

to which this declaration relates are in conformity with the following Directives and other normative documents:

## RoHS Directive 2011/65/EU

Restriction of the use of certain hazardous substances in electrical and electronic equipment

- **EN 50581:2012**

  Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

| | |
|---|---|
| Name: | Jeffrey Milano |
| Title: | Director, Worldwide Quality |
| Date: | August 2015 |

**Representative in the European Union (for regulatory topics only):**

Mr. Graham Kyle

SMART Modular Technologies (Europe) Ltd.

312 Nasmyth Building, Nasmyth Avenue

Scottish Enterprise Technology Park

East Kilbride, Scotland, G75 0QR

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