1GB to 16GB
USB Flash Module

www.stec-inc.com

SLUFMxGU2U(I)-y

USB Solid-State Flash Disk

Capacity: 1GB - 16GB

USB 2.0 Compliant

Form Factors:

- Horizontal Mount
- Standard Connector or 9-Pin D-Connector
- 1-High TSOP Flash Placement or Stacked TSOP Flash Placement

High Reliability:

- Guaranteed 2M Program/Erase Cycles
- Advanced Wear-Leveling
- BCH ECC Engine corrects up to 12 bits/512 Bytes errors
- Automatic Bad Block Management
- Single Level Cell (SLC) NAND Flash Memory
- 10 Year Data Retention

Unique Serial Number

Commercial and Extended Operating Temperature

RoHS-6 Compliant

General Description

USB Flash Module (UFM) provides non-volatile, solid-state storage in a compact design, making it perfectly suited for embedded applications. The standard USB 2.0 interface provides designers with a true plug-n-play storage device, allowing for short design cycles and fast time to market.

STEC's U2, state-of-the-art, USB 2.0 flash memory controller is incorporated in the UFM, providing high data reliability and endurance. The flash management software that is embedded in the controller emulates a hard disk, enabling read/write operations that are identical to a standard, sector-based hard disk. Sophisticated wear leveling algorithms ensures greater flash endurance, while automatic bad block management and a built-in ECC Engine guarantee the highest data reliability. Based on a BCH error correct algorithm, the ECC engine can correct up to 12-bit errors and per 512 bytes.

USB Flash Module is available with a standard 2.54mm connector or a 9-pin Hirose connector.

High performance, high reliability and low cost per MByte make the USB Flash Module the product of choice in embedded applications, such as Gaming, POS Workstations, Networking Equipment and Industrial PCs.

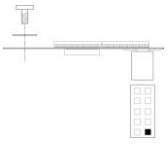
STEC offers value-added services to OEM customers, such as customized form factors and test solutions, custom firmware, controlled Bill Of Materials, customer-specific labeling and serialization.

Ordering Information: USB Flash Module

Part Number	Flash Placement	Capacity
SLUFM1GU2U(I)-y	1-High TSOP Flash	1 GBytes
SLUFM2GU2U(I)-y	1-High TSOP Flash	2 GBytes
SLUFM4GU2U(I)-y	1-High TSOP Flash	4 GBytes
SLUFM8GU2U(I)-y	1-High TSOP Flash	8 GBytes
SLUFM16GU2U-A	Stacked TSOP Flash	16 GBytes

Legend:

- **SLUFM =** STEC standard USB Flash Module part number prefix.
- **G =** proceeding capacity (x) is in Gigabytes (G).
- **U2 =** STEC U2 controller
- **U =** RoHS-6 compliant
- **Part numbers without (I) =** Commercial Temperature Range (0ºC to 70ºC).
- **(I) =** Extended Temperature Range (-15ºC to +85 ºC).
- **(y) =** A for standard 7.4mm height connector **(y) =** C for 9-Pin Hirose connector



Note: 16GB is available with Commercial Temperature Range and standard height connector only.

Table of Contents

1.0 Introduction

This datasheet includes the following sections:

- *Product Specifications* covers the most referenced specifications, such as mechanical dimensions, ball assignment, signal description, and performance.
- *Theory of Operation* explains the USB Flash Module block diagram, and flash management features.
- *Environmental Specifications* characterizes the recommended operating conditions, reliability parameters and shock, vibration and humidity parameters.
- *Electrical Specifications* describes the absolute maximum ratings and AC/DC characteristics.
- *Evaluating USB Flash Module* describes how designers can evaluate the USB Flash Module if there is no 2x5-pin or Hirose connector yet available on the hardware design.
- *Product Marking* describes the marking on the USB Flash Module.

Figure 1: USB Flash Module

2.0 Product Specifications

2.1 Mechanical Dimensions

2.1.1 2x5 Standard "A" Connector Form Factor

Table 1 and Figure 2 show the mechanical dimensions of the USB Flash Module with 2x5 standard connector.

Table 1: Mechanical dimensions, 2x5 standard connector

Parameter		Value
Length		38.00 ± 0.15 mm (1.496 ±. 0.006 in)
Width		23.00 ± 0.15 mm (0.906 ± 0.006 in)
Height	1-High TSOP Flash Placement	10.27 mm (0.404 in) max
	Stacked TSOP Flash Placement	11.16 mm (0.439 in) max

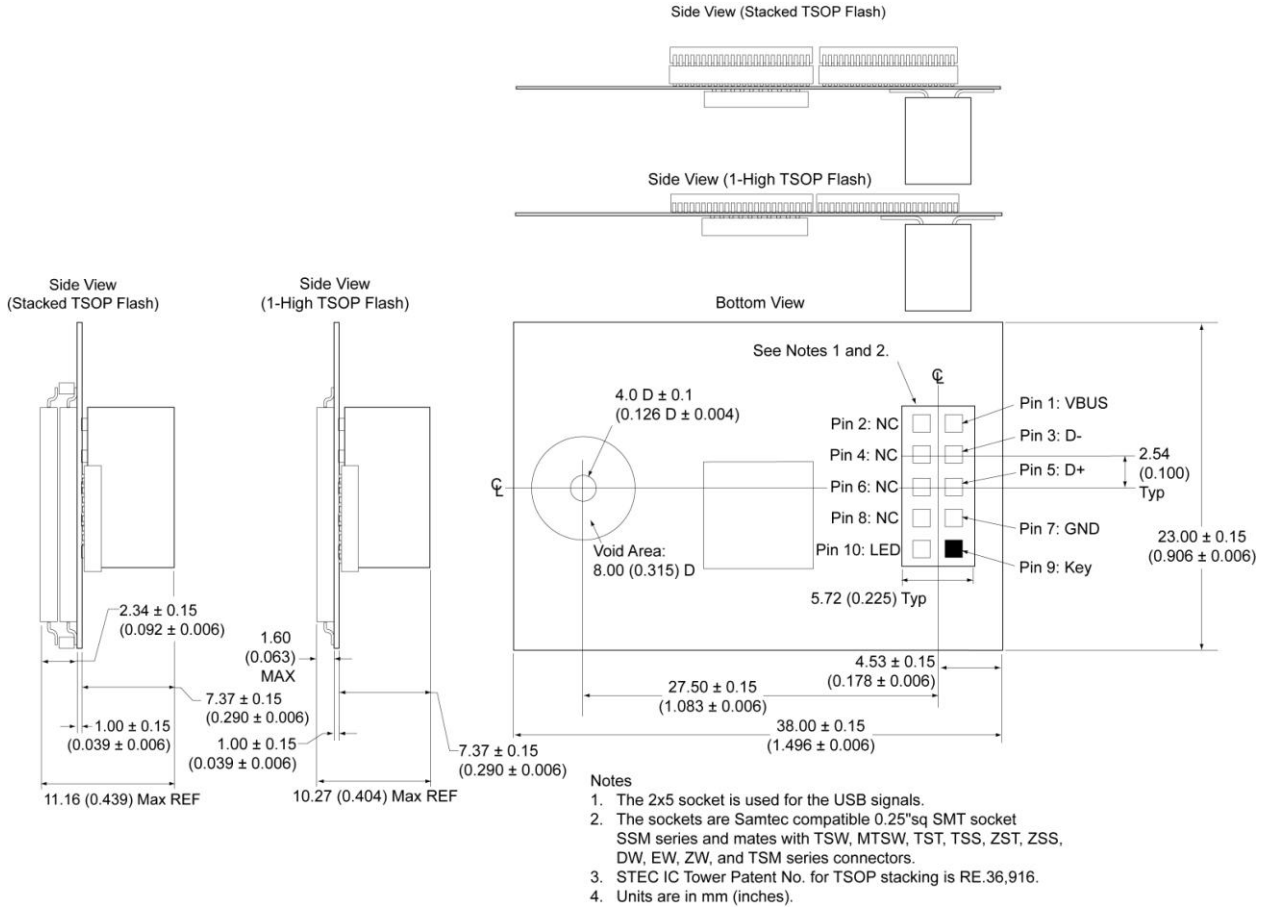


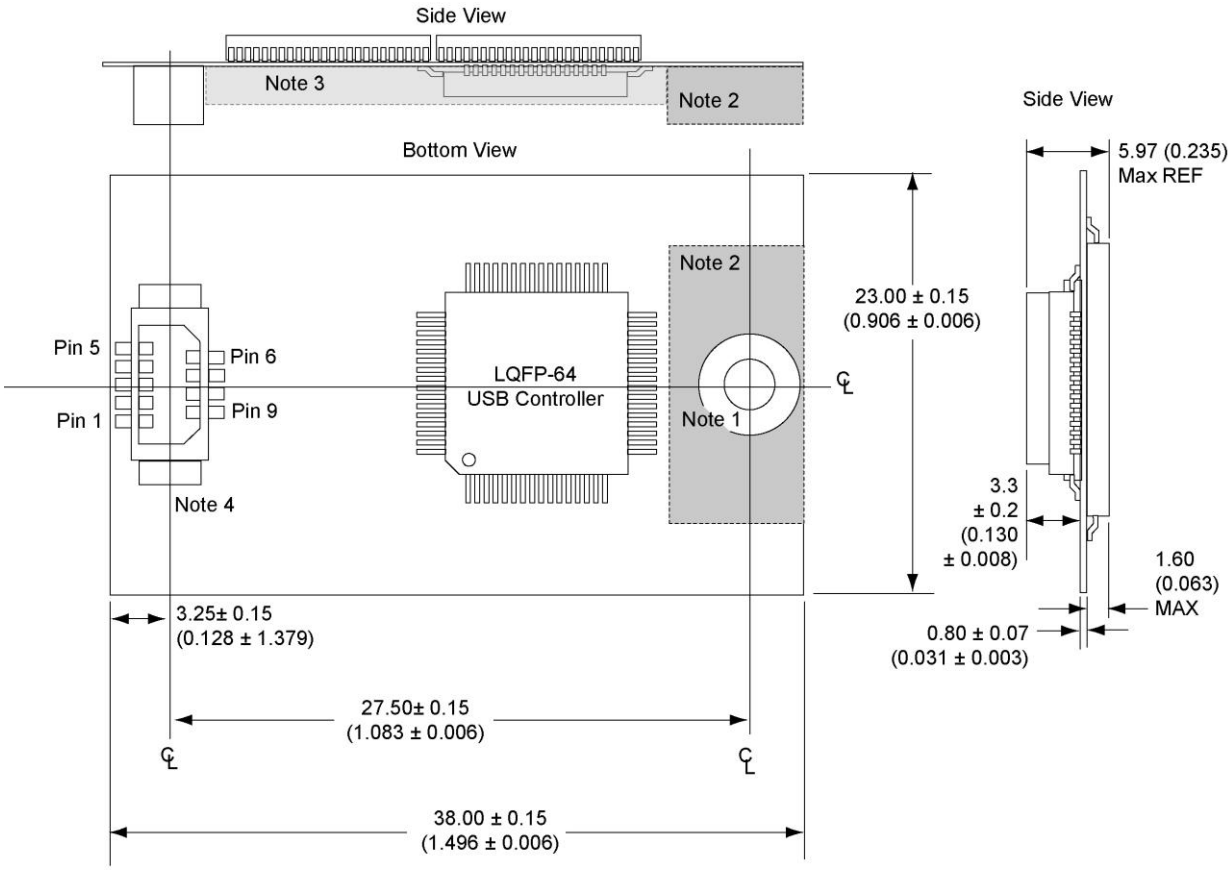
Figure 2: Mechanical dimensions, 2x5 standard connector

2.1.2 9-Pin Hirose "C" Connector Form Factor

Table 2 and Figure 3 show the mechanical dimensions of the USB Flash Module with 9-pin Hirose connector.

Table 2: Mechanical dimensions, 9-pin Hirose connector

Parameter	Value
Length	38.00 ± 0.15 mm (1.496 ±. 0.006 in)
Width	23.00 ± 0.15 mm (0.906 ± 0.006 in)
Height	5.97 mm (0.235 in) max



Notes
1. a. Hole for M2.5 x 4 mm panhead machine screw.
   b. 2.9 mm drill diameter.
   c. 5.56 mm plated annular ring top and bottom of PCB.
   d. Main board will use threaded standoff.
   e. Connect annular ring to ground.
   f. Topside Keepout of 6.3 mm (0.248 in) circular area.
2. Standoff Keep Out: of 15.24 x 7.37 mm (0.60 x 0.29 in).
3. Component area on bottom side region extends 3.66 mm (0.145 in) below PCB.
4. Hirose DF9-9S-1V(61) Recepticle.

Figure 3: Mechanical dimensions, 9-pin Hirose connector

2.2 Pin Assignment

2.2.1 "A" Connector, 2x5 Standard

Table 3: 2x5 Standard Pin Assignment

Pin Number	Signal Name	Pin Type	Pin Number	Signal Name	Pin Type
1	VBUS	Power	6	NC	I/O
2	NC	—	7	GND	Ground
3	D-	I/O	8	NC	—
4	NC	—	9	Key	Blocked Pin
5	D+	I/O	10	LED	I/O

2.2.2 "C" Connector, 9-Pin Hirose

Table 4: Hirose Pin Assignment

Pin Number	Signal Name	Pin Type	Pin Number	Signal Name	Pin Type
1	NC	—	6	GND	Ground
2	NC	—	7	D+	I/O
3	LED	I/O	8	D-	I/O
4	NC	—	9	GND	Ground
5	VBUS	Power	—		

2.3 Signal Description

Table 5: Signal Description

Signal Name	Type	Pin Number (A Connectors)	Pin Number (C Connector)	Description
VBUS	Power	1	5	Bus voltage supply from source
D-	I/O	3	8	Data line –
D+	I/O	5	7	Data line +
GND	Ground	7	6, 9	Ground
NC	Open	2, 4, 6, 8, 10	1, 2, 4	No Connect
Key	Open	9	—	Alignment pin
LED	I/O	—	3	Activity indicator Can be connected to LED on host board

2.4 Performance

Table 6: Read/Write Performance

Parameter	Value
Sustained Read	up to 30 MB/sec
Sustained Write	up to 20 MB/sec

2.5 Power Consumption

The power consumption currents listed in Table 7 are for reference only. Power consumption may change according to flash memory used.

Table 7: Power Consumption

Power State	Symbol	Typ Power Consumption (2 Flash Components)	Typ Power Consumption (4 Flash Components)	Unit
Normal	I_{NORMAL}	67.03	77.03	mA
Suspend	$I_{SUSPEND}$	0.39	2.39	mA
Sleep	I_{SLEEP}	0.38	1.38	mA
Read	I_{READ}	104.12	134.12	mA
Write	I_{WRITE}	118.74	148.74	mA

Table 8: Number of Flash Components

Capacity	Number of Flash Components
1GB	2
2GB	2
4GB	2
8GB	2
16GB	4

3.0 Theory of Operation

3.1 Block Diagram

The USB Flash Module uses STEC's U2, state-of-the art, USB 2.0 controller, and is combined with SLC NAND Flash for optimal device reliability. The controller's firmware supports the latest NAND flash technology from multiple vendors, and is optimized for the highest performance and reliability.

The USB Flash Module controller consists of the functional blocks shown in Figure 4 and described below.

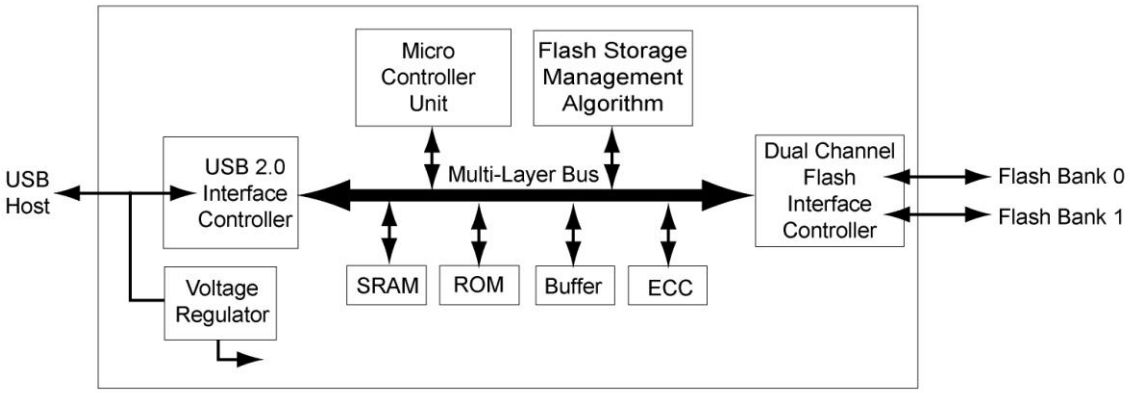


Figure 4: Controller block diagram

3.1.1 Controller Internal Components

- *Microcontroller* which serves as the hardware backbone for the flash controller algorithm.
- *USB 2.0 Interface Controller* with high speed (480 Mbps) device function. This block interfaces with the host system via the USB interface.
- *Flash Interface Controller* that serves as the interface to the NAND flash components. It supports all the major NAND flash memory manufacturers.
- *Flash Storage Management Algorithm Block* is responsible for the flash management, including wear leveling, bad block management, and Error Detection and Correction.
- *ECC block* is responsible for on-the-fly error correction.
- *Sector Buffer* for optimized performance.
- *SRAM* for running controller firmware fast and efficient.
- *ROM* for storing controllers boot code.

3.1.2 Controller external components

In addition to the functional blocks shown in Figure 4, the USB Flash Module has the following external components:

- *SLC NAND Flash* for the most reliable data storage.
- *Crystal Oscillator 12Mhz*, as the main clock source.

3.2 Flash Management

Since the USB Flash Module provides a standard USB interface to the host, no software integration is required, providing the shortest time-to-market for design engineers.

The firmware of the embedded USB 2.0 controller contains STEC's advanced flash memory management algorithms to ensure the most optimum device performance, reliability and endurance. It was designed to maximize the benefits of flash memory, while at the same time overcoming inherent NAND flash limitations. Implemented in firmware are the below features:

- Flash file system management
- Bad-block management
- Wear-leveling
- Performance optimization

3.2.1 Bad Block Management

Inherent to NAND flash technology are areas (blocks) on the media that cannot be used for storage because of their high error rate. These so-called "bad blocks" are already identified by the flash vendor during manufacturing, but can also be accumulated over time during device operation.

The USB 2.0 controller contains a table that lists all the bad blocks on the device (Bad Block Table), and automatically maps out these blocks upon system initialization. During device operation it ensures that newly accumulated bad blocks are also mapped out and added to the Bad Block Table.

Bad block management is 100% transparent to the host application, which will not be aware of the location or existence of bad blocks on the media.

3.2.2 Wear Leveling

The SLC NAND flash devices that are being used in the USB Flash Module are guaranteed for 100,000 Write/Erase cycles per block. This means that after approximately 100,000 erase cycles, the erase block has a higher probability for errors than the error rate that is typical to the flash. While 100,000 write/erase cycles may be good for consumer data storage, such as digital cameras, MP3 players, etc., it is not sufficient for industrial and embedded applications where data is constantly written to the device and long product life is required.

For example, operating systems that use a file system, will update the File Allocation Table (FAT) every time a write is done to the device. Without any wear leveling in place, the area on the flash where the FAT table is located would wear out faster than other areas, reducing the lifetime of the entire flash device.

To overcome this limitation, the flash management algorithm needs to make sure that each block in the device ages, i.e. is “worn out”, at the same rate. The built-in wear leveling scheme makes sure that with every write to the flash, the youngest block is used. This ensures that the full flash media is used uniformly, so that one area of the flash will not reach the endurance limits prematurely before other areas.

3.2.3 Error Correction

The USB 2.0 controller implements an advanced Error Correction scheme, based on the BCH error correct algorithm. The ECC engine can correct up to 12 bits per 512 bytes (symbol based). To ensure the fastest performance, correction is done on-the-fly, in hardware only.

Each time the host application writes a sector of 512 bytes to the USB Flash Module, a unique ECC signature is created by the ECC engine and written together with the data to the flash. When the data is read back by the host, the ECC engine creates again the unique ECC signature. It will then compare the original written signature with the newly created signature, and sets an error flag if the two signatures are not the same. Correction of the data is done on-the-fly when the error flag is set, and the data presented to the host will be the same as the original written data. This powerful Error Correction scheme results in an overall error rate of less than 1 in 10^{14} bits, read.

3.3 OS and Boot Support

USB Flash Module can be used as the OS boot and main storage device for most Microsoft Operating Systems, as well as most embedded Operating Systems, as listed in Table 9 In both modes the USB Flash Module is recognized as fixed hard drive in the system.

Table 9: Supported Operating Systems

Operating System	Secondary Storage	Boot	Version
Windows XP Pro/Vista	√	√	
Windows XP Embedded	√	√	Service Pack 2007
Windows CE	√	√	4.2 and 5.0
Windows for POS (WEPOS)	√	-	
VxWorks	√	√	6.1 and up
Linux	√	√	Kernel 2.4 and up

Note: When using the USB Flash Module as the OS boot device, it should be verified that the system BIOS supports booting from a USB device. Please contact your BIOS vendor to verify this.

3.3.1 Using USB Flash Module with XP Embedded

When using USB Flash Module with Windows XP Embedded, it is recommended that the Enhanced Write Filter (EWF) feature is implemented. The EWF intercepts calls at the sector level, and thereby eliminates many file system updates/writes to the flash. Windows XP Embedded Service Pack 2 Feature Pack 2007 introduced an additional write protect feature, called File Based Write Filter (FBWF). The new FBWF function write-protects embedded devices at the file level, in contrast to the EWF, which has been protecting devices at the sector level.

FBWF and EWF, combined with the built-in wear leveling algorithm, ensure that the maximum life span of the flash device is achieved.

3.4 Unique Serial Number

During manufacturing stage, a unique serial number is written to the USB Flash Module that includes a date code related to the time of manufacturing.

The serial number uses the following format: AA[B][C][DD][EE][FFFF]. Table 10 below describes the parameters of the serial number.

Table 10: Unique Serial Number format

Symbol	Parameter
AA	STEC Reserved
B	Year (hex)
C	Month (hex)
DD	Day (hex)
EE	Computer Number (hex)
FFFF	Serial Number, Incremental (hex)

The Serial Number can be obtained through Windows Device Manager or Linux lsusb utility.

4.0 Environmental Specifications

4.1 Recommended Operating Conditions

Table 11: Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Commercial Operating Temperature	T_{A1}	0	25	70	°C
Extended Operating Temperature	T_{A2}	-15	-	85	°C
Bus Voltage (5V)	$V_{BUS(5V)}$	4.75	5.0	5.25	V

4.2 Reliability

Table 12: Reliability

Parameter	Value
Endurance	Guaranteed 2M program/erase cycles
Data reliability	1 in 10^{14} bits, read
Data retention	10 years

4.3 Shock, Vibration, and Humidity

Table 13: Shock, Vibration & Humidity

Parameter	Value
Shock	1500G Peak, 0.5m pulse duration, 5 pulses, 6 axes (per JESD22-B110)
Vibration	20G Peak, 20-2000 Hz, 4 cycles per direction (X, Y and Z) (per JESD22-B103)
Humidity	85°C, 85% RH, Vmax for 500 hrs (per JESD22-A101)

4.4 Electrostatic Discharge (ESD)

USB Flash Module has been tested and approved for immunity from ESD under the conditions described in Table 14 below.

Table 14: ESD Rating for USB Flash Module

ESD Type	Value (KV)
Air	2, 4, 8
Contact	2, 4

4.5 Mean Time Between Failure (MTBF)

STEC estimates Mean Time Between Failure (MTBF), using a prediction methodology based on reliability data for the individual components in the USB Flash Module. Table 15 below summarizes the prediction results for the USB Flash Module, based on the following two methodologies:

- Telcordia Special Report SR-332, Reliability Prediction Procedure for Electronic Equipment.
- MIL-HNBK-217

The analysis was performed using Relex Software.

Table 15: USB Flash Module MTBF

Product	Condition	MTBF (hours)
SLUFM4GU2U-A	Telcordia SR-332, GB, 25°C, MIL-HNBK-217	>8,000,000
SLUFM8GU2U-A	Telcordia SR-332, GB, 25°C, MIL-HNBK-217	>7,000,000

4.6 Standards Compliance

USB Flash Module complies with the following standards:

- CE - EN 55022/55024
- FCC - Class B for Information Technology
- UL 60950
- RoHS-6
- USB 2.0 – Mass Storage Class

5.0 Electrical Specifications

5.1 Absolute Maximum Ratings

Operation not guaranteed at extreme corner cases.

Table 16: Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Power Supply Voltage Relative to Ground	V_{BUS}-V_{SS}	-0.3 to 5.5	V
Voltage on D+ and D- Relative to Ground	V_{DATA}	-0.3 to 3.6	V
Ambient Operating Temperature (Commercial)	T_{A1}	0 to +70	°C
Ambient Operating Temperature (Extended)	T_{A2}	-15 to +85	°C
Storage Temperature	Tstg	-40 to +85	°C

5.2 DC Characteristics

Measurements at Recommended Operating Conditions, unless otherwise specified.

Table 17: DC Characteristics for Full-Speed Operation (T_A=25ºC, Vdd=5V, Vss=0V)

Parameter	Symbol	Test conditions	Min	Typ	Max	Unit
Supply Voltage	V_{BUS}		3.0	5	5.5	V
Input LOW Voltage	V_{IL}		-	-	0.8	V
Input HIGH Voltage	V_{IH}		2.0	-	-	V
Output LOW Voltage	V_{OL}	R_L of 1.5kΩ to 3.6V	-	-	0.3	V
Output HIGH Voltage	V_{OH}	R_L of 15kΩ to GND	2.8	-	3.6	V
Output Signal Crossover Voltage	V_{CRS}		1.3	-	2.0	V

Table 18: DC Characteristics for High-Speed Operation (T_A=25ºC, Vdd=5V, Vss=0V)

Parameter	Symbol	Test conditions	Min	Typ	Max	Unit
Supply Voltage	V_{BUS}		3.0	5	5. 5	V
High Speed Idle Level	VHSOI		-10	-	10	mV
High Speed Data Signaling High	VHSOH		360	-	440	mV
High Speed Data Signaling Low	VHSOL		-10	-	10	mV
Chirp J Level (differential Voltage)	VCHIRPJ		0.7	-	1.1	V
Chirp K Level (differential Voltage)	VCHIRPK		-0.9	-	-0.5	mV

5.3 AC Characteristics

Measurements at Recommended Operating Conditions, unless otherwise specified.

Table 19: AC Characteristics Full Speed

Parameter	Symbol	Min	Typ	Max	Unit
Rise Time	T_{FR}	4	-	20	ns
Fall Time	T_{FF}	4	-	20	ns
Differential Rise and Fall Time Matching	T_{FRFM}	90		111.11	%
Driver Output Resistance	Z_{DRV}	28	-	44	Ω

Table 20: AC Characteristics High Speed

Parameter	Symbol	Min	Typ	Max	Unit
Rise Time (10%~90%)	T_{HSR}	500	-	-	ps
Fall Time (10%~90%)	T_{HSF}	500	-	-	ps
Driver Output Resistance	Z_{HSDRV}	40.5	-	49.5	Ω

6.0 SCSI Command List

Table 21: SCSI Command List

Command List	OpCode	RBC	SPC-2	SPC-3
INQUIRY	12h	√	√	√
MODESENSE(6)	1Ah	√	√	√
MODESENSE(10)	5Ah	-	√	√
PREVENT/ALLOW MEDIUM REMOVAL	1Eh	√	√	√
READ(10)	28h	√	-	-
READ CAPACITY	25h	√	-	-
REQUEST SENSE	03h	-	√	√
START STOP UNIT	1Bh	√	-	-
TEST UNIT READY	00h	√	√	√
WRITE(10)	2Ah	√	-	-
VERIFY(10)	2Fh	√	-	-
SYNC CACHE	35h	√	-	-

7.0 Evaluating USB Flash Module

Adapters are available for customers that do not have the hardware layout ready for the USB Flash Module. The adapter shown in Figure 5 uses a standard “series A” (2.54mm) connector and enable inserting the USB Flash Module into a standard USB port on a desktop or laptop PC. Inquire for adapters that use the “series C” (9-pin Hirose) connector.

Figure 5: USB Flash Module Adapter

The adapters can be ordered with the following ordering information:

- SLUFDM-2x5-ADPT-A
- SLUFDM-ADPT-C (Preliminary, inquire for availability)

With:

A = Adapter for USB Flash Module with standard 2.54mm connector

C = Adapter for USB Flash Module with 9-pin Hirose connector

8.0 Product Marking

USB Flash Module will be shipped with 2 labels. The first label shows the manufacturing date code, which can be used for lot traceability. Table 22 below shows the information that can be found on this label.

Table 22: Manufacturing label

Kanban ID yymmdd-XXX-xxx	Description	BOM Assembly Number 94000-ppppp-nnnTP	Description
yymmdd	Date code of manufacturing	94000*	STEC designation for OEM Flash products
XXX	SMT Line at which the part was manufactured	ppppp	PCB number
xxx	lot code	nnn	Capacity designator

*** Note:** If custom P/N was set up, then 94000 will be replaced with custom BOM Assembly Number designator.

The second label (Figure 6) shows the standards for which the USB Flash Module is certified.

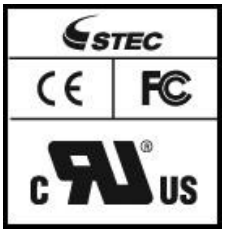


Figure 6: Standards Label

9.0 Programmed Vendor and Product Names

The USB Flash Module can be manufactured with standard or customer-specific Vendor and Product Names. Table 23 lists the STEC standard names for USB Flash Module.

The names can be displayed by the OS, for example, Windows XP displays the names in the notifications area in the right corner of the screen the first time the module is installed. Windows Device Manager and the properties of the USB Flash Module also can display the names

Table 23: STEC Standard USB Vendor and Product Names

Parameter	Value
Vendor Name	“STEC”
Product Name	“STEC USB 2.0”

10.0 Contact Information

10.1 STEC Worldwide Headquarters

STEC INC		
3001 Daimler Street	General Support:	1-949-476-1180
Santa Ana, California 92705	Fax Number:	1-949-476-1209
United States of America (USA)	E-mail:	oemsupport@stec-inc.com

10.2 STEC Worldwide Locations

STEC ITALY S. R. L.	**STEC TAIWAN**	**STEC JAPAN G.K.**
Via del Caravaggio, 3 20111 Milano Italy	RM1101, 11F, No. 495 Guang-Fu S. Road Taipei Taiwan	Shinyurigaoka-City Building 4-402 1-1-1, Manpukuji, Aso-ku, Kawaski-shi Kanagawa-ken 215-0004 Japan
Phone: +39 02 497 56 213	Phone: +886 2 8780 8000 Ext. 1101 Fax: +886 2 8725 7711	Phone: +81 44-959-2883 Fax: +81 44-959-2887
STEC MALAYSIA	**STEC CHINA**	
STEC Technology Sdn Plot 107 Bayan Lepas Industrial Park Phase 4 11900 Penang, Malaysia	RM1805, 18F Bund Centre 222 Yan An Road East HuangPu District Shanghai 200002 P.R. China	
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11.0 Revision History

Revision	*Date*	*Description*
-101	10/24/2008	Preliminary initial release.
-102	11/17/2008.	Dimension line from center of connector to center of mounting hole corrected.
-103	11/27/2008	Form Factor with low profile connector (y=B) is not offered.
-104	12/03/2008	ECC engine corrects 12 bits/512 bytes.
-105	12/12/2008	Endurance added to Features and Reliability table.
-106	12/22/2008	Serial Number definition updated. Bus Voltage corrected. Absolute Maximum Ratings at extreme corners or not guaranteed. Product Name programmed into device updated. Preliminary notice removed.
-107	01/09/2009	$V_{BUS(3V3)}$ removed from Recommended Operating Conditions.
-108	02/06/2009	$V_{BUS(5V)}$ tolerance updated to ±5%
-109	92/18/2009	Mounting hole dimension of standard height uFM corrected from 3.2mm to 4.0mm.
-110	92/23/2909	Linux utility to obtain Serial Number is corrected to lsusb.
-111	10/27/2009	16GB capacity added.
-112	12/01/2009	Stacked Flash Package Dimensions added for 16GB.
-113	12/07/2009	Industrial Temperature option updated to Extended Temperature option.