DELKIN DEVICES®

A370 Series

SATA III Industrial mSATA

Solid State Drive

Engineering Specification

Document Number: 401-0415-00

Revision: C

Product Overview

- **Capacity**
  - 8GB to 128GB
- **SATA Interface**
  - SATA Revision 3.0
  - SATA 1.5Gbps, 3Gbps, and 6Gbps interface
- **Flash Interface**
  - Flash type: SLC
- **Performance**
  - Read: up to 170 MB/s
  - Write: up to 150 MB/s
- **Power Consumption[Note1]**
  - Active mode: < 1485 mW
  - Idle mode: <825 mW
- **TBW (Terabytes Written) [Note2]**
  - 9360 TBW for 128GB

- **MTBF**
  - More than 2,000,000 hours
- **Features**
  - Global Wear Leveling
  - Bad Block Management
  - TRIM
  - SMART
  - NCQ
  - Over-Provisioning [Note3]
  - Firmware Update Capability
  - Hardware Write Protection Option
  - Hardware Quick Erase Pin
- **Temperature Range**
  - Operation: -40°C ~ 85°C
  - Storage: -50°C ~ 100°C
- **RoHS compliant**

Notes:

1. Please see "4.2 Power Consumption" for details.

2. Please see "TBW (Terabytes Written)" in Chapter 2" for details.

3. Contact Delkin for overprovisioned configurations

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1. INTRODUCTION

1.1. General Description

Delkin Devices' A370 Series SATA III Industrial SLC mSATA Solid State Drive (SSD) delivers all the advantages of flash disk technology with Serial ATA III interface and is fully compliant with the JEDEC MO-300C form factor standard.   The mSATA draws significantly lower power compared to traditional hard drives and is also much smaller and lighter. The SLC drive is available in capacities up to 128GB and can reach speeds up to 170MB/s read as well as 150MB/s write (measured by CrystalDiskMark v3.0).

1.2. Product Block Diagram
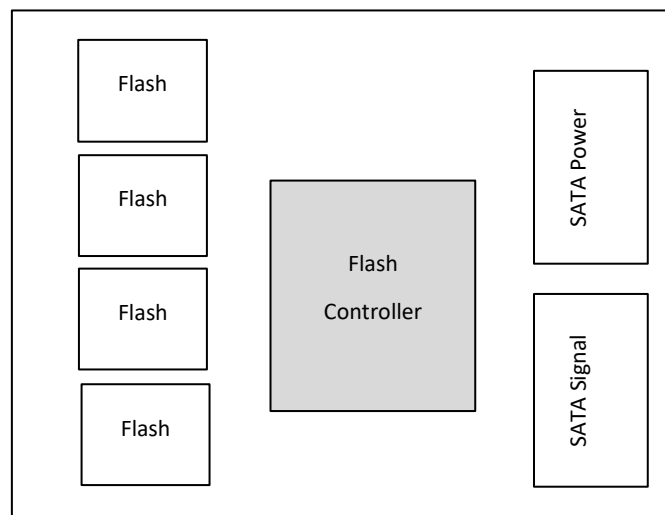
Figure 1-1   mSATA SSD Product Block Diagram

1.3. Flash Management

1.3.1. Error Correction Code (ECC)

Flash memory cells will deteriorate with use, which might generate random bit errors in the stored data. Thus, Delkin's SATA III Industrial SLC mSATA SSD applies a BCH ECC algorithm, which can detect and correct errors occur during read process, ensure data been read correctly, as well as protect data from corruption.

1.3.2.   Wear Leveling

NAND flash devices can only undergo a limited number of program/erase cycles, and in most cases, the flash media are not used evenly. If some areas are updated more frequently than others, the lifetime of the device would be reduced significantly. Thus, Wear Leveling is applied to extend the lifespan of NAND flash by evenly distributing write and erase cycles across the media.

Delkin utilizes advanced Wear Leveling algorithms, which can efficiently distribute flash usage through the whole flash media area. Moreover, by implementing a Global Wear Leveling algorithm, the life expectancy of the NAND flash is greatly improved.

1.3.3.   Bad Block Management

Bad blocks are blocks that include one or more invalid bits, and their reliability is not guaranteed. Blocks that are identified and marked as bad by the manufacturer are referred to as "Initial Bad Blocks". Bad blocks that are developed during usage of the flash are named "Later Bad Blocks". Delkin implements an efficient bad block management algorithm to detect the factory-produced bad blocks and manages any bad blocks that appear with use. This practice further prevents data being stored into bad blocks and improves data reliability.

1.3.4.   TRIM

TRIM is a feature which helps improve the read/write performance and speed of solid-state drives (SSD). Unlike hard disk drives (HDD), SSDs are not able to overwrite existing data, so the available space gradually becomes smaller with each use. With the TRIM command, the operating system can inform the SSD which blocks of data are no longer in use and can be removed permanently. Thus, the SSD will perform an erase action, which prevents unused data from occupying blocks.

1.3.5.   SMART

SMART, an acronym for Self-Monitoring, Analysis and Reporting Technology, is an open standard that allows a drive to automatically detect its health and report potential failures. When a failure is recorded by SMART, users can choose to replace the drive to prevent unexpected outage or data loss. Moreover, SMART can inform users of impending failures while there is still time to perform proactive actions, such as copy data to another device.

1.3.6.   Over-Provisioning

Over Provisioning refers to the inclusion of extra NAND capacity in a SSD, which is not visible or usable by users. With Over Provisioning, the performance and IOPS (Input/Output Operations per Second) are improved by providing the controller additional space to manage P/E cycles, which enhances the reliability and endurance as well. Moreover, the write amplification of the SSD becomes lower when the controller writes data to the flash.   Contact Delkin for this option.

1.3.7.   Firmware Upgrades

Firmware can be considered as a set of instructions on how the device communicates with the host. Firmware can be upgraded when new features are added or enhancements are developed, as controlled by the user.

1.4. Advanced Device Security Features

1.4.1.   Secure Erase

Secure Erase is a standard ATA command and will write "0xFF" to all cells, to fully wipe all the data on hard drives and SSDs. When this command is issued, the SSD controller will erase its storage blocks and return to its factory default settings.

1.4.2.   Write Protect

Pin 45 of the mSATA connector is designated as the hardware write protect pin on drives configured with this capability (see part number table on page 10), enabling the drive to be write protected on the fly.   The pin is active LOW, so that when it is pulled low, write protect is enabled. The pin has an internal pull up resistor and should be driven with an open drain driver.

1.4.3. Quick Erase

Pin 47 of the mSATA connector is designated as the hardware quick erase control pin for all configurations, enabling ATA security erase to be triggered.   The pin is active LOW, so that when it is pulled low, the erase process is started.

1.5. SSD Lifetime Management

1.5.1. Terabytes Written (TBW)

TBW (Terabytes Written) is a measurement of SSDs' expected lifespan, which represents the amount of data written to the device. To calculate the TBW of a SSD, the following equation is applied:

$$TBW = [(NAND\ Endurance) \times (SSD\ Capacity) \times (WLE)] / WAF$$

NAND Endurance: NAND endurance refers to the P/E (Program/Erase) cycle rating of NAND flash, per the manufacturer's specification.

SSD Capacity: The SSD capacity is the specific capacity in total of a SSD.

WLE: Wear Leveling Efficiency (WLE) represents the ratio of the average amount of erases on all the blocks to the erases on any block at maximum.

WAF: Write Amplification Factor (WAF) is a numerical value representing the ratio between the amount of data that a SSD controller writes to the flash and the amount of data that the host's flash controller writes. A better WAF, which is near 1, guarantees better endurance and lower frequency of data written to flash memory.

2. PRODUCT SPECIFICATIONS

- ## Capacity
  - 8 to 128GB SLC

- ## Electrical/Physical Interface
  - SATA Interface
    - ◆ Compliant with SATA Revision 3.0
    - ◆ Compatible with SATA 1.5Gbps, 3Gbps and 6Gbps interface
    - ◆ NCQ support up to queue depth = 32
    - ◆ Supports SATA Device Sleep (DevSleep), with automatic sleep and wake-up mechanism for power conservation
    - ◆ Supports expanded register for SATA protocol 48 bit addressing mode

- ## ECC Scheme
  - Capable of correcting up to 66 bits per 1K Byte

- ## Supports SMART and TRIM commands

- ## Performance and Power Consumption

Capacity	Performance		Power Consumption		
	CrystalDiskMark		Read (mW)	Write (mW)	IDLE (mW)
	Read (MB/s)	Write (MB/s)			
8GB	75	40	825	860	630
16GB	155	80	825	860	630
32GB	170	150	1025	1420	630
64GB	180	160	1155	1485	825
128GB	560	420	2310	3680	644

NOTE:

For more details on Power Consumption, please refer to Chapter 4.2.

- ## Endurance - TBW (Terabytes Written)

Capacity	TBW
8GB	585
16GB	1170
32GB	2340
64GB	4685
128GB	9360

NOTES:

Many factors affect drive endurance / TBW, including flash configuration, SDR configuration, host platform, usage model, write amplification factor, etc.   The figures above are estimates based on the JEDEC JESD219A Client Workload model and are not guaranteed.

- ## Part Numbers

Industrial SLC mSATA (-40 to 85°C Operating Temperature)

Capacity	Standard Part Number	Part Number w/ Write Protect Capability
8GB	ME08TQJAK-3N000-D	ME08TQJAK-3P000-D
16GB	ME16TQJAK-3N000-D	ME16TQJAK-3P000-D
32GB	ME32TNKAK-3N000-D	ME32TNKAK-3P000-D
64GB	ME64TNJAK-3N000-D	ME64TNJAK-3P000-D
128GB	ME1HTRDAK-3N000-D	ME1HTRDAK-3P000-D

NOTES:

1. Contact Delkin for customization options, which will involve a modified part number.

2. Conformal coating (Acrylic) available – replace 000 in part number with 050.

3. ENVIRONMENTAL SPECIFICATIONS

3.1. Environmental Conditions

3.1.1. Temperature and Humidity
- Temperature:
  - ◆ Operational: -40°C to 85°C
  - ◆ Storage: -50°C to 100°C

- Humidity:
  - ◆ RH 95% under 55°C (operational)

3.1.2. Shock & Vibration
- Shock Specification
  - ◆ 20g, ½ Sine, 10ms, 3 pulses in each direction (+/-), all 3 Axes
- Vibration Specification
  - ◆ 2Hz to 5000Hz, Random 3 Axis, 19G_{RMS}

3.1.3. EMI Compliance

- FCC: CISPR22
- CE: EN55022
- BSMI 13438

3.2. MTBF

MTBF, an acronym for Mean Time Between Failures, is a measure of a device's reliability. Its value represents the average time between a repair and the next failure. The measure is typically in units of hours. The higher the MTBF value, the higher the reliability of the device. The predicted result of the Delkin A370 Series mSATA SSD is more than 2,000,000 hours at 0°C.

3.3. Certification & Compliance

- RoHS
- SATA III (SATA Rev. 3.2)
- Up to ATA/ATAPI-8 (Including S.M.A.R.T)
- WARNING: This product may contain chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm. For more information go to www.p65warnings.ca.gov.

4. ELECTRICAL SPECIFICATIONS

4.1. Supply Voltage

Table 4-1 Supply Voltage

Parameter	Rating
Operating Voltage	3.3V

4.2. Power Consumption

Table 4-2 Current Draw

Capacity	Read	Write	Idle
8GB	250	260	190
16GB	250	260	190
32GB	310	430	190
64GB	350	450	250
128GB	700	1115	195

Unit: mA

NOTES:

1. The average value of power consumption is achieved based on 100% conversion efficiency.

2. The measured input power voltage is 3.3V.

3. Sequential R/W is measured while testing 4000MB sequential R/W 5 times with CrystalDiskMark.

4. Power Consumption may vary with benchmark tool, host platform and test method.

5. INTERFACE

5.1. Pin Assignment and Descriptions

Table 5-1 Pin Assignment and Description for mSATA

Pin Number	mSATA Pin	Description
1	NC	No Connect
2	+3.3V	3.3V Source
3	NC	No Connect
4	DGND	Digital GND
5	NC	No Connect
6	NC	No Connect
7	NC	No Connect
8	NC	No Connect
9	DGND	Digital GND
10	NC	No Connect
11	NC	No Connect
12	NC	No Connect
13	NC	No Connect
14	NC	No Connect
15	DGND	Digital GND
16	NC	No Connect
17	NC	No Connect
18	DGND	Digital GND
19	NC	No Connect
20	NC	No Connect
21	SATA GND	SATA Ground Return Pin
22	NC	No Connect
23	TXP (out)	Host Receiver Differential Signal Pair
24	+3.3V	3.3V Source
25	TXN (out)	Host Receiver Differential Signal Pair
26	SATA GND	SATA Ground Return Pin
27	SATA GND	SATA Ground Return Pin
28	NC	No Connect
29	SATA GND	SATA Ground Return Pin
30	NC	No Connect
31	RXN (in)	Host Transmitter Differential Signal Pair
32	NC	No Connect

33	RXN (in)	Host Transmitter Differential Signal Pair
34	DGND	Digital GND
35	SATA GND	SATA Ground Return Pin
36	NC	No Connect
37	SATA GND	SATA Ground Return Pin
38	NC	No Connect
39	+3.3V	3.3V Source
40	DGND	Digital GND
41	+3.3V	3.3V Source
42	NC	No Connect
43	NC	No Connect
44	DEVSLP	Enter/Exit DevSleep
45	NC/WP	Write Protect (on enabled drives)
46	NC	No Connect
47	VS	Quick Erase
48	NC	No Connect
49	DAS	Device Activity Signal
50	DGND	Digital GND
51	GND	Default Connect to GND
52	+3.3V	3.3V Source

6. SUPPORTED COMMANDS

6.1. ATA Command List

Table 6-1 ATA Command List

Op Code	Description	Op Code	Description
00h	NOP	97h	IDLE
06h	Data Set Management	98h	CHECK POWER MODE
10h-1Fh	Recalibrate	99h	SLEEP
20h	Read Sectors	B0h	SMART
21h	Read Sectors without Retry	B1h	DEVICE CONFIGURATION
24h	Read Sectors EXT	C4h	Read Multiple
25h	Read DMA EXT	C5h	Write Multiple
27h	Read Native Max Address EXT	C6h	Set Multiple Mode
29h	Read Multiple EXT	C8h	Read DMA
2Fh	Read Log EXT	C9h	Read DMA without Retry
30h	Write Sectors	CAh	Write DMA
31h	Write Sectors without Retry	CBh	Write DMA without Retry
34h	Write Sectors EXT	CEh	Write Multiple FUA EXT
35h	Write DMA EXT	E0h	Standby Immediate
37h	Set Native Max Address EXT	E1h	Idle Immediate
38h	CFA WRITE SECTORS WITHOUT ERASE	E2h	Standby
39h	Write Multiple EXT	E3h	Idle
3Dh	Write DMA FUA EXT	E4h	Read Buffer
3Fh	Write Long EXT	E5h	Check Power Mode
40h	Read Verify Sectors	E6h	Sleep
41h	Read Verify Sectors without Retry	E7h	Flush Cache
42h	Read Verify Sectors EXT	E8h	Write Buffer
45h	WRITE UNCORRECTABLE EXT	EAh	Flush Cache EXT
60h	Read FPDMA Queued	ECh	Identify Device
61h	Write FPDMA Queued	EFh	Set Features
70h-7Fh	Seek	F1h	Security Set Password
90h	Execute Device Diagnostic	F2h	Security Unlock
91h	Initialize Device Parameters	F3h	Security Erase Prepare
92h	Download Microcode	F4h	Security Erase Unit
93h	DOWNLOAD MICROCODE DMA	F5h	Security Freeze Lock
94h	STANDBY IMMEDIATE	F6h	Security Disable Password
95h	IDLE IMMEDIATE	F8h	Read Native Max Address
96h	STANDBY	F9h	Set Max Address

6.2. Identify Device Data

The following table details the sector data returned by the IDENTIFY DEVICE command.

Table 6-2 List of Device Identification

Word	F: Fixed V: Variable X: Both	Default Value	Description
0	F	0040h	General configuration bit-significant information
1	X	XXXh	Default Number of cylinders
2	V	000h	Reserved
3	X	00XXh	Default Number of heads
4-5	X	0000h	Retired
6	F	XXXh	Default Number of sectors per track
7-8	V	XXXh	Number of sectors per card (Word 7 = MSW, Word 8 = LSW)
9	X	0000h	Retired
10-19	F	Varies	Serial number (20 ASCII characters)
20-21	X	0002h	Retired
22	X	0000h	Obsolete
23-26	F	XXXh	Firmware revision in ASCII Big Endian Byte Order in Word
27-46	F	XXXh	Model number in ASCII (left justified) Big Endian Byte Order in Word
47	F	8001h	Maximum number of sectors on Read/Write Multiple command
48	F	0000h	Reserved
49	F	0F00h	Capabilities
50	F	4000h	Capabilities
51	F	0200h	PIO data transfer cycle timing mode
52	X	0000h	Obsolete
53	F	0007h	Field validity
54	X	XXXXh	Current number of logical cylinders
55	X	XXXXh	Current number of logical heads
56	X	XXXXh	Current number of logical sectors per track
57-58	X	XXXXh	Current capacity in sectors (LBA's) (Word 57 = LSW, Word 58 = MSW)
59	F	0101h	Multiple sector setting
60-61	F	XXXXh	Total number of user addressable logical sectors (28bit LBA mode)
62	X	0000h	Reserved

Word	F: Fixed V: Variable X: Both	Default Value	Description
63	F	0207h	Multi-word DMA transfer Supports MDMA mode 0, 1 and 2
64	F	0003h	PIO modes supported
65	F	0078h	Minimum Multiword DMA transfer cycle time per word
66	F	0078h	Manufacturer's recommended Multiword DMA transfer cycle time
67	F	0078h	Minimum PIO transfer cycle time without flow control
68	F	0078h	Minimum PIO transfer cycle time with IORDY flow control
69	F	4000h	Additional Supported (support download microcode DMA)
70-74	F	0000h	Reserved
75	F	001Fh	Queue depth
76	F	070eh	Serial SATA capabilities • Supports Serial ATA Gen3 • Supports Serial ATA Gen2 • Supports Serial ATA Gen1 • Supports Phy event counters log • Supports receipt of HIPM requests • Supports Native Command Queuing
77	F	0080h	Serial ATA Additional Capabilities • DevSleep_to_ReducedPwerState
78	F	0148h	Serial ATA features supported • Supports Device Sleep • Supports software settings preservation • Device supports initiating power management
79	V	0040h	Reserved
80	F	03F0h	Major Version Number
81	F	0000h	Minor Version Number
82	F	742Bh	Command set supported 0
83	F	7500h	Command set supported 1
84	F	4023h	Command set supported 2
85-87	V	XXXXh	Command set/feature enabled
88	V	007Fh	Ultra DMA Modes supported and selected
89	F	0003h	Time required for a Normal Erase mode Security Erase unit completion
90	F	0001h	Time required for Enhanced Erase mode Security Erase completion
91	V	0000h	Current advanced power management value
92	V	FFFEh	Master Password Revision Code

Word	F: Fixed V: Variable X: Both	Default Value	Description
93-99	F	0000h	Reserved
100-103	V	XXXXh	Maximum user LBA for 48 bit Address feature set
104	V	0000h	Reserved
105	F	0100h	Maximum number of 512-byte blocks per DATA SET MANAGEMENT command
106-127	F	0000h	Reserved
128	V	0001h	Security status
129-159	X	XXXXh	Vendor specific
160	F	0000h	Power requirement description
161	X	0000h	Reserved
162	F	0000h	Key management schemes supported
163	F	0000h	CF Advanced True IDE Timing mode capability and setting
164-168	V	0000h	Reserved
169	F	0001h	DATA SET MANAGEMENT command is supported
170-216	V	XXXXh	Reserved
217	F	0001h	Non-rotating media device
218-221	X	0000h	Reserved
222	F	107Fh	Transport major version number (SATA Rev 3.1)
223-254	X	0000h	Reserved
255	X	XXXXh	Integrity word (Checksum and Signature)

7. SMART FEATURE SET

The Delkin Devices A370 Series mSATA supports the SMART command set and defines vendor-specific data to report information about the status of the drive.

7.1. SMART Feature Register Values

Value	Command	Value	Command
D0h	Read Data	D5h	Read Log
D1h	Read Attribute Threshold	D6h	Write Log
D2h	Enable/Disable Autosave	D8h	Enable SMART Operations
D3h	Save Attribute Values	D9h	Disable SMART Operations
D4h	Execute Off-line Immediate	Dah	Return Status

If the reserved size is below the threshold, the status can be read from the Cylinder Register using the Return Status command (DAh.)

7.1.1. SMART Data Structure

The following 512 Bytes make up the device SMART data structure.   Users can obtain the data using the "Read Data" command (D0h.)

Byte	F/V	Description
0 - 1	X	Revision code
2 – 361	X	Vendor specific (see 7.1.2)
362	V	Off-line data collection status
363	X	Self-test execution status byte
364 – 365	V	Total time in seconds to complete off-line data collection activity
366	X	Vendor specific
367	F	Off-line data collection capability
368 – 369	F	SMART capability
370	F	Error logging capability - 7-1 Reserved - 0 1 = Device error logging supported
371	X	Vendor specific
372	F	Short self-test routine recommended polling time (in minutes)
373	F	Extended self-test routine recommended polling time (in minutes)
374	F	Conveyance self-test routine recommended polling time (in minutes)
375 – 385	R	Reserved
386 – 395	F	Firmware version/date code
396 – 399	F	Reserved
400 – 405	F	Reserved
406 – 510	X	Vendor specific
511	V	Data structure checksum

Notes:

1. F = content (byte) is fixed and does not change
2. V = content (byte) is variable and may change depending on the state of the device or the commands executed by the device
3. X = content (byte) is vendor specific and may be fixed or variable.
4. R = content (byte) is reserved and shall be zero.

7.1.2. SMART Attributes

The following table defines the vendor specific data in byte 2 to 361 of the 512-byte SMART data.

Attribute ID (hex)	Raw Attribute Value							Attribute Name
01	MSB	00	00	00	00	00	00	Read Error Rate
05	LSB	MSB	00	00	00	00	00	Reallocated sectors count
09	LSB			MSB	00	00	00	Power-on hours
0C	LSB			MSB	00	00	00	Power cycle count
A0	LSB			MSB	00	00	00	Uncorrectable sector count for read/write
A1	LSB	MSB	00	00	00	00	00	Number of valid spare blocks
A3	LSB	MSB	00	00	00	00	00	Number of initial invalid blocks
A4	LSB			MSB	00	00	00	Total erase count
A5	LSB			MSB	00	00	00	Maximum erase count
A6	LSB			MSB	00	00	00	Minimum erase count
A7	LSB			MSB	00	00	00	Average erase count
A8	LSB			MSB	00	00	00	Max erase count of spec
A9	LSB			MSB	00	00	00	Remaining Life (%)
AF	LSB			MSB	00	00	00	Program fail count in worst die
B0	LSB	MSB	00	00	00	00	00	Erase fail count in worst die
B1	LSB			MSB	00	00	00	Total wear level count
B2	LSB	MSB	00	00	00	00	00	Runtime invalid block count
B5	LSB			MSB	00	00	00	Total program fail count
B6	LSB	MSB	00	00	00	00	00	Total erase fail count
BB	LSB			MSB	00	00	00	Uncorrectable error count
C0	LSB	MSB	00	00	00	00	00	Power off retract count
C2	MSB	00	00	00	00	00	00	Controlled temperature
C3	LSB			MSB	00	00	00	Hardware ECC recovered
C4	LSB			MSB	00	00	00	Reallocation event count
C6	LSB			MSB	00	00	00	Uncorrectable error count off-line
C7	LSB	MSB	00	00	00	00	00	Ultra DMA CRC error count
E1	LSB						MSB	Total LBA's written (each write unit = 32MB)
E8	LSB	MSB	00	00	00	00	00	Available reserved space
F1	LSB						MSB	Total LBA's written (each write unit =32MB)
F2	LSB						MSB	Total LBA's read (each read unit = 32MB)

8. CAPACITY

This section depicts the default storage capacity and settings for cylinders, heads and sectors for standard configurations.

Capacity	Cylinders	Heads	Sectors	Total Sectors
8GB	16,383	15	63	15,481,935
16GB	16,383	15	63	31,277,232
32GB	16,383	15	63	61,865,984
64GB	16,383	15	63	123,731,968
128GB	16,383	15	63	247,463,936

9. PHYSICAL DIMENSIONS

Dimensions: 50.8 ±0.15mm (L) x 29.85 ±0.15mm (W) x 4.85mm (H, max)