

DELKIN DEVICES®

CFast™ Embedded Flash Module Gen II

Engineering Specification

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1 General Specifications

Delkin's Gen II Industrial CFast embedded drive combines solid state reliability in a compact form factor, with SATA connectivity for significant performance advantages over traditional hard disk drives. Manufactured to CFast 1.1 specifications established by the CompactFlash Association, the CFast embedded module is suited to embedded industrial applications where space is restricted. The utilization of a rugged, industrial controller delivers reliability and robustness in applications where unstable power and unique usage models will tax commercial grade cards. The shock, vibration, and temperature ratings allow usage in extreme environments. The drives can achieve sustained read & write rates of up to 120 MB/s and feature storage capacities from 2GB to 128GB. Delkin's CFast cards also support the ability to be placed in a write protected state.

Table 1. Specification Summary

Specification	Value
Model number	See Table 2
Capacity	SLC: 2GB – 64GB
Interface	SATA revision 2.6, compatible with SATA 1.5Gb/s and 3.0Gb/s interface rates.
Form Factor	CFAST Type I Conforms to CFast 1.1 Standard
Hot swappable	Yes
Environmental certifications	RoHS, ESD, and CE/FCC
Performance	
Interface burst speed	1.5 or 3.0 Gb/s
Sustained read & write speed (configuration dependent)	Up to 120 MB/s
Reliability/Data Integrity	
MTBF	>2,000,000 power on hours at 0 - 25°C >300,000 power on hours @ 60°C
Endurance	See table in Section 2
Power	
Supply voltage (allowable)	3.3V ±10%
Typical current (configuration dependent – values are for 32GB):	
Idle	80 mA
Read	200 mA
Write	250 mA

Environmental	
Storage temperature (°C)	-50 ~ 100°C
Operating temperature (°C)	-40 ~ 85°C
Relative humidity (non-condensing)	95% under 55°C
Vibration (operating/non-operating)	7.7G _{RMS} 20Hz – 1000Hz @ 0.04 G ² /Hz, 1000Hz – 2000Hz @ 0.01 G ² /Hz
Shock (operating/non-operating)	1,500G/0.5 ms
Acoustic noise	0 dB
Altitude	80,000 feet max.
Physical Dimensions	
Height	3.6 mm
Width	42.8 mm
Length	36.4 mm

1.1 Interfaces

Electrical / Physical Interfaces

- SATA Interface—supports SATA 1.5Gbps and 3Gbps interface
- Flash IO—Asynchronous Flash (3.3V)

Controller Features

- **SATA II**
 - SATA Revision 2.6 compliant
 - Compatible with SATA 1.5Gbps and 3Gbps interface

1.2 Part Number Availability & Performance

Delkin CFast embedded Solid State Drives are available in the capacities shown in the table below. Drives are also available with optional conformal coating for greater protection in extreme environments.

Table 2. Delkin CFast Embedded Module Part Numbers & Performance

Capacity	Product Type	Standard Part Number	Seq. Read Speed Seq. Write Speed
2GB	SLC Industrial (-40 to 85 °C)	BE02TLQZZ-XN000-D	30 MB/s 21 MB/s
4GB	SLC Industrial (-40 to 85 °C)	BE04TGPZZ-XN000-D	40 MB/s 30 MB/s
8GB	SLC Industrial (-40 to 85 °C)	BE08TGPZZ-XN000-D	61 MB/s 46 MB/s
16GB	SLC Industrial (-40 to 85 °C)	BE16TGPZZ-XN000-D	95 MB/s 88 MB/s
32GB	SLC Industrial (-40 to 85 °C)	BE32MGGZZ-XN000-D	105 MB/s 114 MB/s
64GB	SLC Industrial (-40 to 85 °C)	BE64MGMZZ-XN000-D	120 MB/s 120 MB/s

*Note: Usable capacities are within 10% of the gross capacity figures shown above, which is typical with all NAND flash devices, as a small portion of the total is needed for controller firmware and spare block reserves.

2 Endurance

Endurance

The table below provides estimates of drive endurance (expressed as Terabytes Written or TBW) based on specific workload scenarios, using a theoretical model that takes into account the specific flash specifications in each drive configuration. Contact Delkin for endurance estimates for other specific workload scenarios.

Table 3. Endurance Estimates by Part Number

Part Number(s)	Description	Sequential Write, 24/7 Operation
		8KBytes/Sec
BE02TLQZZ-XN000-D	2GB SLC, Industrial Grade	117 TBW
BE04TGPZZ-XN000-D	4GB SLC, Industrial Grade	234 TBW
BE08TGPZZ-XN000-D	8GB SLC, Industrial Grade	468 TBW
BE16TGPZZ-XN000-D	16GB SLC, Industrial Grade	937 TBW
BE32MGGZZ-XN000-D	32GB SLC, Industrial Grade	1875 TBW
BE64MGMZZ-XN000-D	64GB SLC, Industrial Grade	3750 TBW

The figures provided are estimates and not guarantees of endurance. Actual results may vary depending on usage, operating temperature and other conditions.

3 Electrical Specifications

3.1 Pin and Signal Assignments

Table 4. Power and Signal Pin-out

Pin #	CFAST	Description
S1	SGND	Signal Ground
S2	A+	SATA PAIR A
S3	A-	
S4	SGND	Digital GND
S5	B-	SATA PAIR B
S6	B+	
S7	SGND	Signal Ground
Key		
Key		
PC1	CDI	Card Detect In
PC2	GND	Ground
PC3	NC	No Connect
PC4	NC	No Connect
PC5	NC	No Connect
PC6	NC	No Connect
PC7	GND	Ground
PC8	LED1	LED Output
PC9	LED2	LED Output
PC10	IO1	Reserved (Write Protect, if enabled)
PC11	IO2	Reserved
PC12	IO3	Reserved
PC13	3.3V	Power
PC14	3.3V	Power
PC15	GND	Ground
PC16	GND	Ground
PC17	CDO	Card Detect Out

3.2 Host Write Protection Schematic

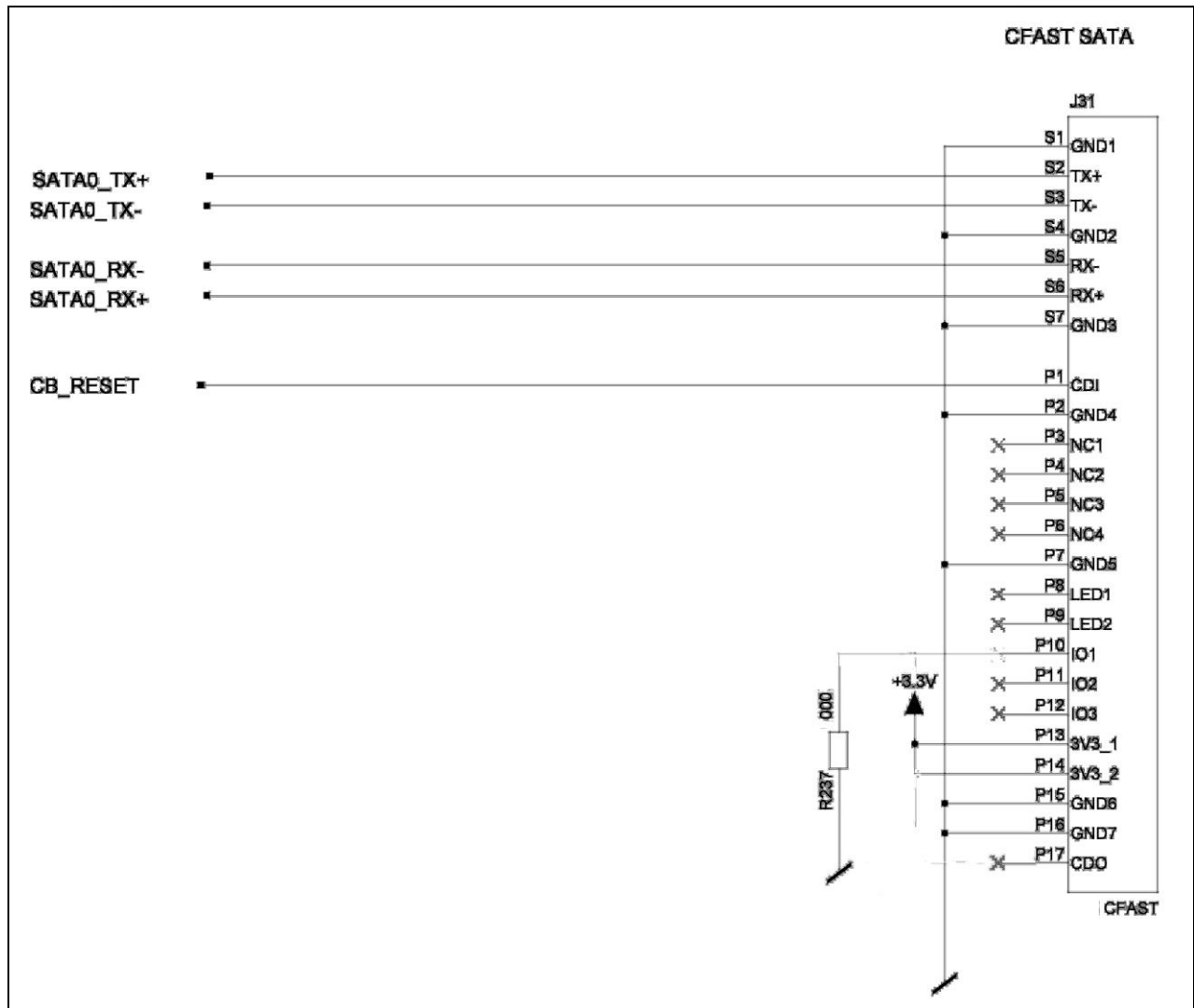


Figure 1. Schematic for Implementation of Write Protection on Enabled Devices

3.3 Supply Voltage

Table 5. Supply Voltage

Parameter	Rating
Operating Voltage	3.3V

3.4 Power Consumption

Table 6. Power Consumption Max Figures

Part Number	Capacity	Idle (mA)	Read (mA)	Write (mA)
BE02TLQZZ-XN000-D	2GB	80	110	120
BE04TGPZZ-XN000-D	4GB	80	130	150
BE08TGPZZ-XN000-D	8GB	80	140	170
BE16TGPZZ-XN000-D	16GB	80	170	240
BE32MGGZZ-XN000-D	32GB	80	150	200
BE64MGMZZ-XN000-D	64GB	80	200	250

4 Command Descriptions

4.1 Supported ATA Commands

The commands listed in the following table are supported by the CFast embedded MODULE.

Table 7. Supported ATA Commands

Command Name	Command Code Hex)	FR	SC	SN	CY	DR	FR	LBA
Check Power Mode	E5h or 98h	-	-	-	-	Y	-	-
Data Set Management	06h	-	Y	-	-	Y	-	-
Download Microcode	92h	Y	Y	Y	-	Y	-	-
Execute Drive Diagnostic	90h	-	-	-	-	-	-	-
Flush Cache	E7h	-	-	-	-	Y	-	-
Flush Cache Ext	Eah	-	-	-	-	Y	-	-
format track	50h	-	Y	-	Y	Y	Y	Y
Identify Device	ECh	-	-	-	-	Y	-	-
Idle	E3h or 97h	-	-	Y	-	Y	-	-
Idle Immediate	E1h or 95h	-	-	-	-	Y	-	-
Initialize Drive Parameters	91h	-	Y	-	-	Y	Y	-
Media Lock	DEh	-	-	-	-	Y	-	-
Media Unlock	DFh	-	-	-	-	Y	-	-
NOP	00h	-	-	-	-	Y	-	-
Read Buffer	E4h	-	-	-	-	Y	-	-
Read DMA	C8h or C9h	-	Y	Y	Y	Y	Y	Y
Read DMA Ext	25h	-	Y	Y	Y	Y	-	Y
Read FPDMA Queued	60h	Y	Y	Y	Y	Y	-	Y
Read Log Ext	2Fh	-	Y	Y	Y	Y	-	Y
Read Multiple	C4h	-	Y	Y	Y	Y	Y	Y
Read Multiple Ext	29h	-	Y	Y	Y	Y	-	Y
Read Native Max Address	F8h	-	-	-	-	Y	-	-
Read Native Max Address Ext	27h	-	-	-	-	Y	-	-
Read Sector(s)	20h or 21h	-	Y	Y	Y	Y	Y	Y
Read Sector(s) Ext	24h	-	Y	Y	Y	Y	-	Y
Read Verify Sector(s)	40h	-	Y	Y	Y	Y	Y	Y
Read Verify Sector(s) Ext	42h	-	Y	Y	Y	Y	-	Y
Recalibrate	1Xh	-	-	-	-	Y	-	-
Sanitize Device	B4h	-	-	-	-	Y	-	-
Security Disable Password	F6h	-	-	-	-	Y	-	-
Security Erase Prepare	F3h	-	-	-	-	Y	-	-
Security Erase Unit	F4h	-	-	-	-	Y	-	-
Security Freeze Lock	F5h	-	-	-	-	Y	-	-
Security Set Password	F1h	-	-	-	-	Y	-	-
Security Unlock	F2h	-	-	-	-	Y	Y	-
Seek	7Xh	-	-	Y	Y	Y	Y	Y
Set Feature	EFh	Y	-	-	-	Y	-	-
Set Max Address	F9h	-	Y	Y	Y	Y	Y	Y
Set Max Address Ext	37h	-	Y	Y	Y	Y	-	Y
Set Multiple Mode	C6h	-	Y	-	-	Y	-	-
Set Sleep Mode	E6h or 99h	-	-	-	-	Y	-	-

SMART Disable Operations	B0h	Y	Y	-	Y	Y	-	-
SMART Enable Operations	B0h	Y	Y	-	Y	Y	-	-
SMART Enable/Disable Autosave	B0h	Y	Y	-	Y	Y	-	-
SMART Execute Off-Line Immediate	B0h	Y	Y	-	Y	Y	-	-
SMART Read Data	B0h	Y	Y	-	Y	Y	-	-
SMART Return Status	B0h	Y	Y	-	Y	Y	-	-
Standby	E2h or 96h	-	Y	-	-	Y	-	-
Standby Immediate	E0h or 94h	-	-	-	-	Y	-	-
Write Buffer	E8h	-	-	-	-	Y	-	-
Write DMA	CAh or CBh	-	Y	Y	Y	Y	Y	Y
Write DMA Ext	35h	-	Y	Y	Y	Y	-	Y
Write FPDMA Queued	61h	Y	Y	Y	Y	Y	-	Y
Write Log Ext	3Fh	-	Y	Y	Y	Y	-	Y
Write Multiple	C5h	-	Y	Y	Y	Y	Y	Y
Write Multiple Ext	39h	-	Y	Y	Y	Y	-	Y
Write Sector(s)	30h or 31h	-	Y	Y	Y	Y	Y	Y
Write Sector(s) Ext	34h	-	Y	Y	Y	Y	-	Y
Write Verify	3Ch	-	Y	Y	Y	Y	Y	Y

Notes:

- FR: Feature Register
- SC: Sector Count Register
- SN: Sector Number Register
- CY: Cylinder Low/High Register
- DR: Drive bit of Drive/Head Register
- HD: Head No. (0 to 15) of Drive/Head Register
- LBA: LBA bit of Drive/Head Register
- Y: Used for the command
- : Not used for the command

4.2 Identify Device Data

The following table details the information returned by the IDENTIFY DEVICE ATA command.

Table 8. Device Sector Data

Word	Default Value	Bytes	Description
0	045Ah	2	General configuration bit-significant information (-id)
1	XXXXh	2	Default number of cylinders
2	0000h	2	Reserved
3	00XXh	2	Default number of heads
4	0000h	2	Number of unformatted bytes per track
5	0200h	2	Number of unformatted bytes per sector
6	XXXXh	2	Default number of sectors per track
7-8	XXXXh	4	Number of sectors per card
9	0000h	2	Reserved
10-19	XXXXh	20	Serial number (20 ASCII characters)
20	0002h	2	Buffer type (dual-ported multi-sector)
21	0001h	2	Buffer size in 512 byte increments
22	0004h	2	# ECC bytes passed on Read/Write Long Commands
23-26	XXXXh	8	Firmware revision (8 ASCII characters)
27-46	XXXXh	40	Model number (40 ASCII characters)
47	8001h	2	Maximum 1 sector on Read/Write Multiple command
48	0000h	2	Double Word Not Supported
49	0F00h	2	Capabilities: DMA, LBA, IORDY supported
50	4001h	2	Capabilities: device specific standby timer minimum
51	0200h	2	PIO data transfer cycle timing mode 2
52	0000h	2	DMA data transfer cycle timing mode not supported
53	0007h	2	Data fields 54 to 58, 64 to 70 and 88 are valid
54	XXXXh	2	Number of current logical cylinders
55	XXXXh	2	Number of current logical heads
56	XXXXh	2	Number of current logical sectors per track
57-58	XXXXh	4	Current capacity in sectors
59	D10Xh	2	Multiple sector setting is valid, Sanitize Device feature set, Block Erase Ext, Overwrite Ext supported
60-61	XXXXh	4	Total number of addressable sectors in LBA mode
62	0000h	2	Single word DMA transfer not implemented
63	0X07h	2	Multi-word DMA transfer mode, modes 0, 1, 2 supported
64	0003h	2	Advanced PIO modes, modes 3 and 4 supported
65	0078h	2	Minimum Multiword DMA cycle time, 0 if no MDMA
66	0078h	2	Recommended Multiword DMA cycle time, 0 if no MDMA
67	0078h	2	Minimum PIO cycle time without flow control

Word	Default Value	Bytes	Description
68	0078h	2	Minimum PIO cycle time with flow control
69	8000h	2	CFast specification not supported
70-74	0000h	10	Reserved
75	001Fh	2	Queue depth 32 for NCQ
76	0306h	2	SATA capabilities: SATA Gen 1 & Gen II, NCQ, host initiated power management requests supported
77-79	0000h	6	Reserved
80	01E0h	2	Major Version Number, ATA-5 to ATA-8 support
81	FFFFh	2	Minor Version Number, not reported
82	742Bh	2	Command set: NOP, READ BUFFER, WRITE BUFFER, HPA, volatile write cache, power management feature set, Security Mode feature set, SMART feature set
83	7501h	2	Command set: FLUSH CACHE, FLUSH CACHE EXT, LBA48, HPA Security Extensions, DOWNLOAD MICROCODE
84	4120H	2	Command set/feature supported extension: World Wide Name, General Purpose Logging
85	74XXh	2	Command set enabled: NOP, READ BUFFER, WRITE BUFFER, HPA, volatile write cache enabled/disabled, power management feature set, Security Mode feature set enabled/disabled, SMART feature set enabled/disabled
86	BX01h	2	Command set enabled: FLUSH CACHE, FLUSH CACHE EXT, LBA48, DOWNLOAD MICROCODE, words 119...120 valid
87	4120h	2	Command set/feature default
88	XX7Fh	2	Ultra DMA Mode, modes 0 - 6 supported
89	0000h	2	Time required for security erase unit not specified
90	0000h	2	Time required for Enhanced security erase unit not specified
91	0000h	2	Reserved
92	XXXXh	2	Master Password Revision Code
93-99	0000h	14	Reserved
100-103	XXXXh	8	Total number of sectors addressable in LBA48 mode
104	0000h	2	Reserved
105	0001h	2	Number of sectors per Data Set Management command
106-107	0000h	4	Reserved
108-111	XXXXh	8	World Wide Name
112-118	0000h	14	Reserved
119	4000h	2	Command set/Feature set Supported extension
120	4000h	2	Command set/Feature Enabled extension
121-127	0000h	14	Reserved
128	0XXXh	2	Security status

Word	Default Value	Bytes	Description
129	XX00h	2	Write Protect status Bit 15 = permanent write protect, out of spare blocks Bit 14 = permanent write protect, due to table corruption Bit 13 = read protection due to table corruption Bit 9 = permanent write protect from vendor command Bit 8 = temporary write protect from vendor command
130-133	XXXXh	8	Firmware date string
134-135	XXXXh	4	Firmware minor revision number
136-141	XXXXh	12	Firmware file name
142-147	XXXXh	12	Preformat file name
148-153	XXXXh	12	Anchor program file name
154-158	0000h	10	Reserved
159	A2XXh	2	Controller major and minor revision number
160	0000h	2	CF feature set and CFA power modes not supported
161	8001h	2	CFast specific support: PHYSLP mode supported
162	0000h	2	Key Management schemes: CPRM not supported
163	0000h	2	CFA advanced modes: not relevant for CFast
164	0000h	2	CFA advanced modes: not relevant for CFast
165-168	0000h	8	Reserved
169	0001h	2	Trim bit in Data Set Management supported
170-216	0000h	94	Reserved
217	0001h	2	Solid State Device (non-rotating media)
218-221	0000h	8	Reserved
222	101Fh	2	Transport major version: Serial transport, SATA rev 2.6
223	FFFFh	2	Transport minor version: not reported
224-254	0000h	62	Reserved
255	XXA5h	2	Integrity word (Checksum and Signature)

5 SMART Functionality

Delkin Devices Industrial CFast cards support the following SMART commands, determined by the Feature Register value.

Table 9: SMART Feature Register Values

Value	Command
D0h	SMART Read Data
D1h	SMART Read Attribute Thresholds
D2h	SMART Enable / Disable Attribute Autosave
D5h	SMART Read Log
D6h	SMART Write Log
D8h	SMART Enable Operations
D9h	SMART Disable Operations
DAh	Return Status
E0h	SMART Read Remap Data
E1h	SMART Read Wear Level Data

SMART commands with Feature Register values not mentioned in the above table are not supported and will be aborted.

5.1 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.)

Table 10. Smart Data Structure

Byte	Value	Description
0 – 1	0010h	SMART structure version
2 – 361		Attribute entries 1 to 30 (12 bytes each)
362	00h	Off-line data collection status (no off-line data collection)
363	00h	Self-test execution status byte (self-test completed)
364 – 365	0000h	Total time in seconds to complete off-line data collection activity
366	00h	Vendor specific
367	00h	Off-line data collection capability (no off-line data collection)
368 – 369	0003h	SMART capability
370	00h	Error logging capability (no error logging)
371	00h	Vendor specific
372	00h	Short self-test routine recommended polling time (in minutes)
373	00h	Extended self-test routine recommended polling time (in minutes)
374 – 385	00h	Reserved
386 – 387	0004h	SMART Structure Version
388 – 391		Firmware “Commit” Counter
392 - 395		Firmware Wear Level Threshold
396		Global Wear Leveling Active
397		Global Bad Block Management active (returns 0 if bad block management is still at local chip level, and returns 1 if global bad block management has begun.)
398 – 401		Average Flash Block Erase Count
402 – 405		Number of Flash Blocks involved in the Wear Leveling
406 – 409		Number of total ECC errors during firmware initialization
410 – 413		Number of correctable ECC errors during firmware initialization
414 – 510	00h	Vendor specific
511		Data structure checksum

5.1.1 Spare Block Count Attribute

This attribute gives information about the amount of available spare blocks.

Offset	Value	Description
0	196	Attribute ID – Reallocation Count
1 – 2	0003h	Flags – Pre-fail type, attribute value is updated during normal operation
3		Attribute value. The value returned here is the percentage of remaining spare blocks summed over all flash chips, i.e. (100 x current spare blocks / initial spare blocks)
4		Attribute value (worst value)
5 – 7		Sum of the initial number of spare blocks for all flash chips
8 – 10		Sum of the current number of spare blocks for all flash chips
11	00h	Reserved

This attribute is used for the SMART Return Status command. If the attribute value field is less than the spare block threshold (set with the `-tsbc` preformat option), the SMART Return Status command will indicate a threshold exceeded condition.

5.1.2 Spare Block Count Worst Chip Attribute Threshold

This attribute gives information about the amount of available spare blocks on the flash chip that has the lowest current number of spare blocks.

Offset	Value	Description
0	213	Attribute ID – Spare Block Count Worst Chip (vendor specific)
1 – 2	0002h	Flags – Advisory type, attribute value is updated during normal operation
3	64h	Attribute value. This value is fixed at 100.
4	64h	Attribute value (worst value)
5 – 7		Initial number of spare blocks for the flash chip with the lowest current number of spare blocks.
8 – 10		Current number of spare blocks for the flash chip with the lowest current number of spare blocks.
11	00h	Reserved

5.1.3 Erase Count Attribute

This attribute gives information about the amount of flash block erases that have been performed.

Offset	Value	Description
0	229	Attribute ID – Erase Count Usage (vendor specific)
1 – 2	000Xh	Flags – Pre-fail or Advisory type, attribute value is updated during normal operation
3		Attribute value. The value returned here is an estimation of the remaining card life, in percent, based on the number of flash block erases compared to the target number of erase cycles per block.
4		Attribute value (worst value)
5 - 10		Estimated total number of block erases.
11	00h	Reserved

This attribute is used for the SMART Return Status command. If the attribute value field is less than the erase count threshold (set with the `-tec` preformat option), the SMART Return Status command will indicate a threshold exceeded condition.

The target number of erase cycles per flash block is taken from the `-mbec` preformat option, or if this option is absent, from the `MaxBlockEraseCount` column in the Device Description file.

The attribute type (pre-fail or advisory) can be set with the `-ecwl` preformat option.

5.1.4 Total ECC Errors Attribute

This attribute gives information about the total number of ECC errors that have occurred on flash read commands during firmware runtime. This attribute is not used for the SMART Return Status command.

Offset	Value	Description
0	203	Attribute ID – Number of ECC Errors
1 – 2	0002h	Flags – Advisory type, attribute value is updated during normal operation
3	64h	Attribute value. This value is fixed at 100.
4	64h	Attribute value (worst value)
5 – 8		Total number of ECC errors (correctable and uncorrectable)
9 – 10		---
11	00h	Reserved

5.1.5 Correctable ECC Errors Attribute

This attribute gives information about the total number of correctable ECC errors that have occurred on flash read commands during firmware runtime. This attribute is not used for the SMART Return Status command.

Offset	Value	Description
0	204	Attribute ID – Number of corrected ECC Errors
1 – 2	0002h	Flags – Advisory type, attribute value is updated during normal operation
3	64h	Attribute value. This value is fixed at 100.
4	64h	Attribute value (worst value)
5 – 8		Total number of correctable ECC errors
9 - 10		---
11	00h	Reserved

5.1.6 SATA CRC Errors Attribute

This attribute gives information about the total number of SATA CRC errors that have occurred on flash read commands. This attribute is not used for the SMART Return Status command.

Offset	Value	Description
0	199	Attribute ID – SATA CRC error rate
1 – 2	0002h	Flags – Advisory type, attribute value is updated during normal operation
3	64h	Attribute value. This value is fixed at 100.
4	64h	Attribute value (worst value)
5 – 8		Total number of SATA CRC errors
9 – 10		---
11	00h	Reserved

5.1.7 Total Number of Reads Attribute

This attribute gives information about the total number of flash read commands. This can be useful for interpretation of the number of correctable or total ECC errors. This attribute is not used for the SMART Return Status command.

Offset	Value	Description
0	232	Attribute ID – Number of Reads (vendor specific)
1 – 2	0002h	Flags – Advisory type, attribute value is updated during normal operation
3	64h	Attribute value. This value is fixed at 100.
4	64h	Attribute value (worst value)
5 – 10		Total number of flash read commands
11	00h	Reserved

5.1.8 Power On Count Attribute

Offset	Value	Description
0	12	Attribute ID – Power On Count
1 – 2	0002h	Flags – Advisory type, attribute value is updated during normal operation
3	64h	Attribute value. This value is fixed at 100.
4	64h	Attribute value (worst value)
5 – 8		Number of Power On cycles
9 – 10		---
11	00h	Reserved

5.1.9 Total LBA's Written Attribute

This attribute gives the total amount of data written to the disk, in units of 32MB (65536 sectors.) This number can be converted to Terabytes written (TBW) by dividing the raw attribute value by 2^{31} .

Offset	Value	Description
0	241	Attribute ID – Total LBA's Written (vendor specific)
1 – 2	0002h	Flags – Advisory type, attribute value is updated during normal operation
3	64h	Attribute value. This value is fixed at 100.
4	64h	Attribute value (worst value)
5 – 10		Total number of LBA's written to the disk, divided by 65536
11	00h	Reserved

5.1.10 Total LBA's Read Attribute

This attribute gives the total amount of data read from the disk, in units of 32MB (65536 sectors.) This number can be converted to Terabytes read (TBW) by dividing the raw attribute value by 2^{31} .

Offset	Value	Description
0	242	Attribute ID – Total LBA's Read (vendor specific)
1 – 2	0002h	Flags – Advisory type, attribute value is updated during normal operation
3	64h	Attribute value. This value is fixed at 100.
4	64h	Attribute value (worst value)
5 – 10		Total number of LBA's read from the disk, divided by 65536
11	00h	Reserved

5.1.11 Anchor Block Status Attribute

This attribute reports how many times the Anchor Block of the card has been re-written, either by the Anchor Block repair routine or by a firmware update.

Offset	Value	Description
0	214	Attribute ID – Anchor Block Status (vendor specific)
1 – 2	0002h	Flags – Advisory type, attribute value is updated during normal operation
3	64h	Attribute value. This value is fixed at 100.
4	64h	Attribute value (worst value)
5 – 8		Anchor Block Write Count
9 – 10		---
11	00h	Reserved

5.1.12 Trim Status Attribute

This attribute gives percent ratio for the disk space that is currently in the trimmed state, reported as the attribute value. The range for the attribute value is 1 to 99, and does not reach 100 even for a fully trimmed card since the management blocks are also counted, which do not have trim status.

Offset	Value	Description
0	215	Attribute ID – Trim Status (vendor specific)
1 – 2	0002h	Flags – Advisory type, attribute value is updated during normal operation
3	64h	Attribute value.
4	64h	Attribute value (worst value)
5 – 10		---
11	00h	Reserved

5.2 SMART Read Attribute Thresholds

COMMAND CODE – B0h with a Feature Register value of D1h

PROTOCOL – PIO data in

INPUTS -

Register	7	6	5	4	3	2	1	0
Features	D1h							
Sector Count								
Sector Number								
Cylinder Low	4Fh							
Cylinder High	C2h							
Device / Head	1	1	1	D				
Command	B0h							

NORMAL OUTPUTS – None required

ERROR OUTPUTS – Aborted if either the signature in the Cylinder registers is invalid or if SMART is not enabled.

DESCRIPTION – This command returns one sector of SMART attribute thresholds. The data structure returned is:

Offset	Value	Description
0 - 1	0010h	SMART structure version
2 – 361		Attribute threshold entries 1 to 30 (12 bytes each)
362 – 379	00h	Reserved
380 – 510	00h	----
511		Data structure checksum

5.2.1 Spare Block Count Attribute Threshold

COMMAND CODE – B0h with a Feature Register value of D1h

PROTOCOL – PIO data in

INPUTS -

Register	7	6	5	4	3	2	1	0
Features	D1h							
Sector Count								
Sector Number								
Cylinder Low	4Fh							
Cylinder High	C2h							
Device / Head	1	1	1	D				
Command	B0h							

NORMAL OUTPUTS – None required

ERROR OUTPUTS – Aborted if either the signature in the Cylinder registers is invalid or if SMART is not enabled.

DESCRIPTION – This command returns one sector of SMART attribute thresholds. The data structure returned is:

Offset	Value	Description
0 - 1	0010h	SMART structure version
2 – 361		Attribute threshold entries 1 to 30 (12 bytes each)
362 – 379	00h	Reserved
380 – 510	00h	----
511		Data structure checksum

5.2.2 Spare Block Count Worst Chip Attribute Threshold

Offset	Value	Description
0	213	Attribute ID – Spare Block Count Worst Chip (vendor specific)
1	00h	No threshold for the Spare Block Count Worst Chip Attribute
2 – 11	00h	Reserved

5.2.3 Erase Count Attribute Threshold

Offset	Value	Description
0	229	Attribute ID – Erase Count Usage (vendor specific)
1		Erase Count Threshold as defined in performat
2 – 11	00h	Reserved

5.2.4 Total ECC Errors Attribute Threshold

Offset	Value	Description
0	203	Attribute ID – Number of ECC errors
1	00h	No threshold for the Total ECC Errors Attribute
2 – 11	00h	Reserved

5.2.5 Correctable ECC Errors Attribute

Offset	Value	Description
0	204	Attribute ID – Number of corrected ECC errors
1	00h	No threshold for the Correctable ECC Errors Attribute
2 – 11	00h	Reserved

5.2.6 UDMA CRC Errors Attribute

Offset	Value	Description
0	199	Attribute ID – UDMA CRC error rate
1	00h	No threshold for the UDMA CRC Errors Attribute
2 – 11	00h	Reserved

5.2.7 Total Number of Reads Attribute

Offset	Value	Description
0	232	Attribute ID – Number of Reads (vendor specific)
1	00h	No threshold for the Total Number of Reads Attribute
2 – 11	00h	Reserved

5.2.8 Power On Count Attribute

Offset	Value	Description
0	12	Attribute ID – Power On Count
1	00h	No threshold for the Power On Count Attribute
2 – 11	00h	Reserved

5.2.9 Total LBAs Written Attribute

Offset	Value	Description
0	241	Attribute ID – Total LBAs Written (vendor specific)
1	00h	No threshold for the Total LBAs Written Attribute
2 – 11	00h	Reserved

5.2.10 Total LBAs Read Attribute

Offset	Value	Description
0	242	Attribute ID – Total LBAs Read (vendor specific)
1	00h	No threshold for the Total LBAs Read Attribute
2 – 11	00h	Reserved

5.2.11 Anchor Block Status Attribute

Offset	Value	Description
0	214	Attribute ID – Anchor Block Status (vendor specific)
1	00h	No threshold for the Anchor Block Status Attribute
2 – 11	00h	Reserved

5.2.12 Trim Status Attribute

Offset	Value	Description
0	215	Attribute ID – Trim Status (vendor specific)
1	00h	No threshold for the Trim Status Attribute
2 – 11	00h	Reserved

5.3 SMART Return Status

COMMAND CODE – B0h with a Feature Register value of DAh

PROTOCOL – non-data

INPUTS -

Register	7	6	5	4	3	2	1	0
Features	DAh							
Sector Count								
Sector Number								
Cylinder Low	4Fh							
Cylinder High	C2h							
Device / Head	1	1	1	D				
Command	B0h							

NORMAL OUTPUTS – Returns a status indication as described below.

ERROR OUTPUTS – Aborted if either the signature in the Cylinder registers is invalid or if SMART is not enabled.

DESCRIPTION – This command checks the device reliability status. If a threshold exceeded condition exists for either the Spare Block Count attribute or the Erase Count attribute, the device will set the Cylinder Low register to F4h and the Cylinder High register to 2Ch. If no threshold exceeded condition exists, the device will set the Cylinder Low register to F4h and the Cylinder High register to C2h.

5.4 SMART Read Log

COMMAND CODE – B0h with a Feature Register value of D5h

PROTOCOL – PIO data in.

INPUTS -

Register	7	6	5	4	3	2	1	0
Features	D5h							
Sector Count	Number of sectors to be read							
Sector Number	Log address							
Cylinder Low	4Fh							
Cylinder High	C2h							
Device / Head	1	1	1	D				
Command	B0h							

NORMAL OUTPUTS – None required.

ERROR OUTPUTS – Aborted if either the signature in the Cylinder registers, the Log address or the number of sectors is invalid, or if SMART is not enabled.

DESCRIPTION – This command will return data of the SMART log. The following Log addresses are defined:

Address	Description
0x00	Log Directory
0x80 – 0x9F	Host Vendor Specific Logs
0xA0	SMART Wear Level Data
0xA1	SMART Remap Data
0xA2	Reserved

The Log Directory (at Log address 0) returns one sector that shows the number of sectors for Log addresses 1 to 255:

Offset	Value	Description
0 - 1	1	SMART Logging Version
256 – 319	16	Number of sectors in the logs at addresses 0x80 – 0x9F
320 – 321	4	Number of sectors in the logs at address 0xA0
322 – 323	1	Number of sectors in the logs at address 0xA1
324 – 325	1	Number of sectors in the logs at address 0xA2

All other bytes in the Log Directory are zero.

The Host Vendor Specific Logs can be used by the host to store and retrieve arbitrary data.

The SMART Wear Level Data and SMART Remap Data Logs return the same data that is also returned by the SMART Read Wear Level Data and SMART Read Remap Data commands.

5.5 SMART Write Log

COMMAND CODE – B0h with a Feature Register value of D6h

PROTOCOL – PIO data out.

INPUTS -

Register	7	6	5	4	3	2	1	0
Features	D6h							
Sector Count	Number of sectors to be written							
Sector Number	Log address							
Cylinder Low	4Fh							
Cylinder High	C2h							
Device / Head	1	1	1	D				
Command	B0h							

NORMAL OUTPUTS – None required.

ERROR OUTPUTS – Aborted if either the signature in the Cylinder registers, the Log address or the number of sectors is invalid, or if SMART is not enabled.

DESCRIPTION – This command can be used to write data into the SMART log (see section 6.4 for the definition of the log addresses.) Writes are allowed only to the Host Vendor Specific logs, all other log addresses can only be read.

5.6 SMART Read Remap Data

COMMAND CODE – B0h with a Feature Register value of E0h

PROTOCOL – PIO data in.

INPUTS -

Register	7	6	5	4	3	2	1	0
Features	E0h							
Sector Count	01h							
Sector Number								
Cylinder Low	4Fh							
Cylinder High	C2h							
Device / Head	1	1	1	D				
Command	B0h							

NORMAL OUTPUTS – None required.

ERROR OUTPUTS – Aborted if either the signature in the Cylinder registers is invalid, if the Sector Count is not 1, or if SMART is not enabled.

DESCRIPTION – This command returns one sector of spare block information. The information is the initial number of blocks (directly after the preformat) per flash chip available for bad block remap, and the current number of blocks per flash chip available for bad block remap. The layout of the returned sector is:

Offset	Description
0 - 31	Initial number of replacement blocks for chips 0 – 15, 2 bytes per entry
32 – 63	Current number of replacement blocks for chips 0 – 15, 2 bytes per entry
64 - 511	----

5.7 SMART Read Wear Level Data

COMMAND CODE – B0h with a Feature Register value of E1h

PROTOCOL – PIO data in.

INPUTS -

Register	7	6	5	4	3	2	1	0
Features	E1h							
Sector Count	04h							
Sector Number								
Cylinder Low	4Fh							
Cylinder High	C2h							
Device / Head	1	1	1	D				
Command	B0h							

NORMAL OUTPUTS – None required.

ERROR OUTPUTS – Aborted if either the signature in the Cylinder registers is invalid, if the Sector Count is not 4, or if SMART is not enabled.

DESCRIPTION – This command will return four sectors of information regarding the status of the wear leveling. The information returned is the distribution of the blocks into the 1024 possible wear level classes. The layout of the returned sector is:

Offset	Description
0 - 3	Marker Bytes, fixed value 0xFFFFFFFF
4 – 5	Lowest Wear Level Class
6 – 7	Highest Wear Level Class
8 – 15	Wear Level Class entry 1
16 – 23	Wear Level Class entry 2
24 – 31	Wear Level Class entry 3
....
2040 - 2047	Wear Level Class entry 255

Each Wear Level Class entry consists of this data:

Offset	Description
0 - 3	Wear Level Class Index
4 – 7	Number of blocks in this Wear Level Class

Unused Wear Level Class entries are zero.

A block moves from one wear level class into the next when it reaches the number of erases that is specified as the “Wear Level Threshold” in the preformat. A common threshold number is 4095, this means that blocks in wear level class 0 have seen 0 to 4095 erases, blocks in wear level class 1 have

seen 4096 to 8191 erases, and so on. Using this information, statements about the wear of the card and of the estimated remaining life can be made.

6 Mechanical Form Factor

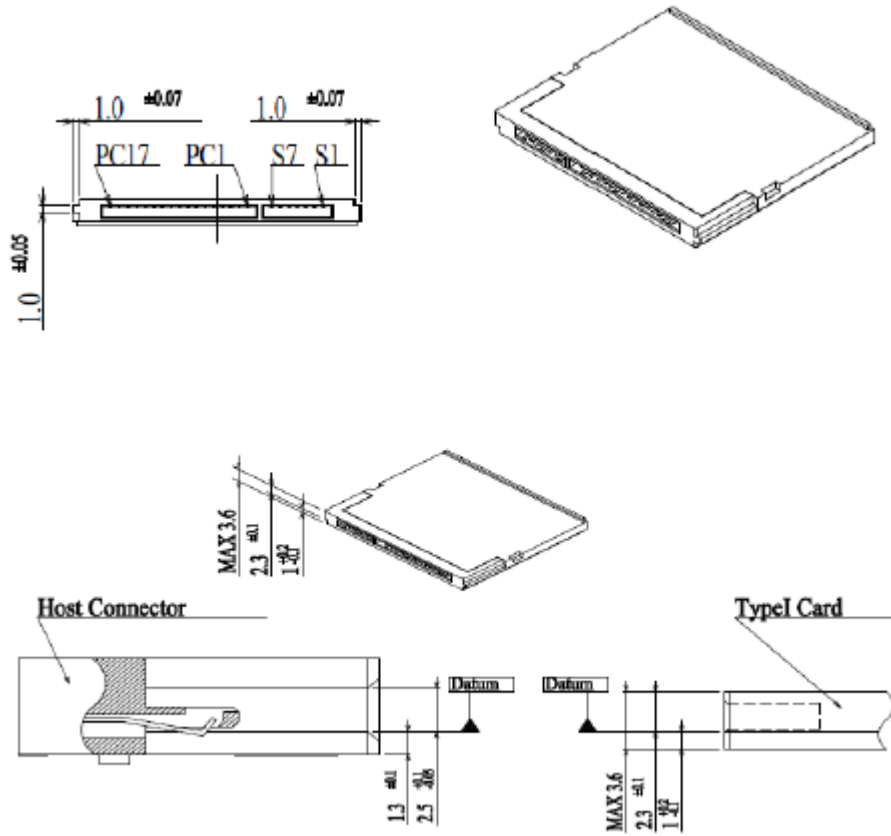


Figure 2. CFast Embedded Module Mechanical Description

6.1 Physical Dimensions

Table 11. CFast Embedded Module Physical Dimensions

Dimension	Measurement
Height	3.6mm
Width	42.8mm
Length	36.4mm

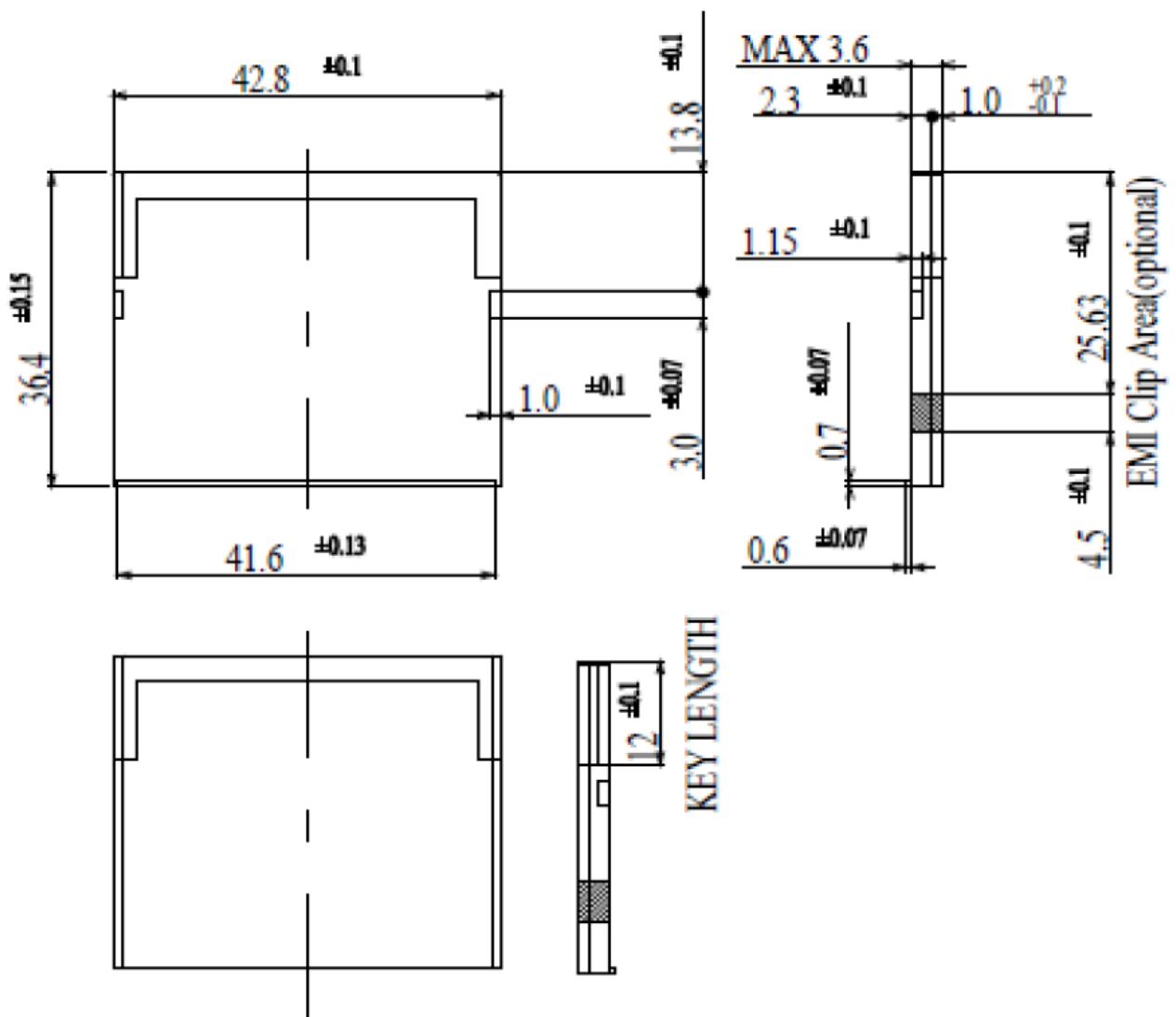


Figure 3. CFast Embedded Module Mechanical Dimensions