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Product Data Sheet

Secure Industrial USB Flash Drive

PU-50n DP Series

USB 3.1 SuperSpeed, MLC

Commercial and Industrial Temperature Grade

Date: December 17, 2020
Revision: 1.10

Made in Germany

Contents

PU-50n DP Series – Industrial USB Flash Drive
8 GBytes up to 64 GBytes

1. Product Summary

- **Capacities:** 8 GBytes, 16 GBytes, 32 GBytes, 64 GBytes
- **Form Factor:** USB3.1 solid state flash drive with USB Type-A connector (24.0 mm x 12.1 mm x 4.5 mm)
- **Compliance:** USB 3.1 Gen 1 SuperSpeed specification compatible (backward compliance with USB 2.0/1.1)
- **Performance:**
  - Read Performance: Sequential Read up to 126 MBytes/s, Random Read IOPS up to 2,450
  - Write Performance: Sequential Write up to 45 MBytes/s, Random Write IOPS up to 540
- **Operating Temperature Range**[1]**:**
  - Commercial: 0 °C to 70 °C
  - Industrial: -40 °C to 85 °C
- **Storage Temperature Range:** -40 °C to 85 °C
- **Operating Voltage:** 5.0 V ± 10%
- **Data Retention:** 10 Years @ Life Begin; 1 Year @ Life End
- **Endurance in TeraBytes Written (TBW) @ Max Capacity:** 181 (seq. write 128KB); 6.2 (random write 4KB)
- **High-Performance 32-Bit Processor with Integrated, Parallel Flash Interface Engines:**
  - Multi-Level Cell (MLC) NAND Flash
  - Hardware BCH Code ECC (up to 40bit correction per 1 KByte page)
- **High Reliability:**
  - Mean Time Between Failure (MTBF): > 3,000,000 hours
  - Data Reliability: < 1 non-recoverable error per 10^{16} bits read

[1] Adequate airflow is required to ensure the drive temperature, as reported in the S.M.A.R.T. data, does not exceed the specified maximum operating temperature.

2. Product Features

2.1 Security Features

Table 1: Security Feature List PU-50n DP

	Access protection of data partition with configurable retry counter
	AES 256 bit flash memory encryption
	CD-ROM Emulation
	Private Partition
	Hidden Storage / OTP memory
	Fast crypto wipe option
	Implicit and replay safe secure authenticity and integrity check
	User PIN and administrator login
	Unique ID

2.2 Security Use Cases

Table 2: Use Cases List PU-50n DP

	Secure boot
	Counterfeit protection by authenticity and integrity check
	License control
	WORM functionality

2.3 Memory related features

Table 3: Memory related Features List PU-50n DP

	Description
	Wide Temperature Support
	ESD & EMI Safe
	Shock & Vibration
	Life Time Monitor
	Conformal Coating
	Power Loss Protected
	Wear Leveling
	Data Care Managed
	Read-Only Improved
	WAF Reduction

3. Ordering Information

Table 4: Standard Product List

Capacity	Temperature	
	Commercial	Industrial
	Part Number	Part Number
8 GBytes	SFU3008GCxPE2T0-C-GE-xyz-SW4	SFU3008GCxPE2T0-I-GE-xyz-SW4
16 GBytes	SFU3016GCxPE1T0-C-GE- xyz-SW4	SFU3016GCxPE1T0-I-GE- xyz-SW4
32 GBytes	SFU3032GCxPE2T0-C-GE- xyz-SW4	SFU3032GCxPE2T0-I-GE- xyz-SW4
64 GBytes	SFU3064GCxPE2T0-C-LF- xyz-SW4	SFU3064GCxPE2T0-I-LF- xyz-SW4

Table 5: Available Part Numbers

Capacity	Temperature	
	Commercial	Industrial
	Part Number	Part Number
8 GBytes	SFU3008GC1PE2T0-C-GE-020-SW4	SFU3008GC1PE2T0-I-GE-020-SW4
16 GBytes	SFU3016GC2PE1T0-C-GE-020-SW4	SFU3016GC2PE1T0-I-GE-020-SW4
32 GBytes	SFU3032GC2PE2T0-C-GE-020-SW4	SFU3032GC2PE2T0-I-GE-020-SW4
64 GBytes	SFU3064GC2PE2T0-C-LF-020-SW4	SFU3064GC2PE2T0-I-LF-020-SW4

4. Product Description

The Swissbit PU-50n DP USB 3.1 USB flash drive provides a robust, high performance, and reliable storage product with industry compatible interface and small form factor. The PU-50n DP MLC technology both enables high NAND flash operation and excellent endurance. The use of page based Flash management and a global wear leveling extends the endurance to unprecedented values for USB products.

The PU-50n DP product allows easy operation with USB3 or USB2 Type-A sockets.

For outdoor use or in poorly ventilated systems the PU-50n DP is available in industrial temperature grade from -40°C to +85°C. Each individual industrial temperature grade drive is tested at these corners to verify the temperature resistance.

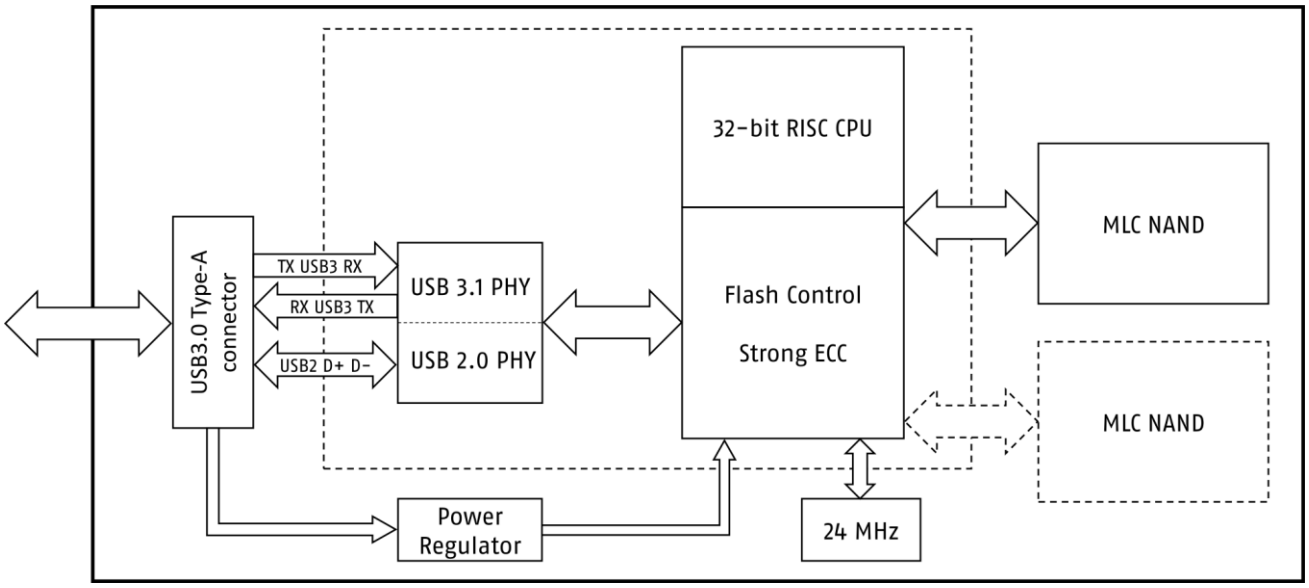
The PU-50n DP firmware includes data care management features which refresh storage areas that are not or only infrequently read. At high temperature storage, these areas are prone to retention loss. The firmware monitors the state of the NAND blocks and refreshes those that show a high level of degradation, thus preventing uncorrectable errors. This is an important feature for USB flash drives that are used as read only boot media.

The PU-50n DP uses a high performance 32bit RISC USB controller to address different numbers of NAND dies. The PU-50n DP 8, 32 and 64GB drives use two flash channels for best performance.

The PU-50n DP operates at 5V nominal with ±10% tolerance.

It supports USB 3.1 Gen 1 SuperSpeed and is fully backwards compatible to USB 2.0/1.1 High/Full Speed.

Figure 1: PU-50n DP Functional Block Diagram



4.1 Performance Specifications

The PU-50n DP read/write sequential and random I/O performance benchmarks are detailed in the following Table 6.

Table 6: Read/Write Performance[2]

Capacity	Sequential Read (MBPS)	Sequential Write (MBPS)	Random Read 4k (IOPS)	Random Write 4k (IOPS)
8 GBytes	115	27	3100	670
16 GBytes	79	20	2501	535
32 GBytes	115	35	2498	549
64 GBytes	126	45	2458	546

4.2 Current Consumption

The drive-level current consumption as a function of operating mode is shown in the following Table 7.

Table 7: Typical Current Consumption for max transfer speed at 5V[3]

Drive Capacity	Sequential Read	Sequential Write	Random Read 4k	Random Write 4k	Idle	Unit
8 GBytes	142	131	105	109	86	mA
16 GBytes	109	104	79	84	75	
32 GBytes	118	113	79	87	67	
64 GBytes	117	127	80	88	67	

[2] The values are measured using CrystalDiskMark 6.0.0 x64 (CDM) in SuperSpeed mode (Seq Q1T1 and 4KiB Q8T8). Performance depends on flash type and number, file/cluster size, and burst speed.

[3] All values are the typical recorded at 25 °C, with 5V supply voltage at fastest CrystalDiskMark 6.0.0 x64 (CDM) in SuperSpeed mode.

4.3 Environmental Specifications

4.3.1 Recommended Operating Conditions

The recommended operating conditions for the PU-50n DP USB flash drives are provided in the following Table 8.

Table 8: Recommended Operating Conditions[4]

Parameter	Value
Commercial Operating Temperature	0 °C to 70 °C
Industrial Operating Temperature	-40 °C to 85 °C
Power Supply V_{CC} Voltage	5.0 V ± 10%

4.3.2 Recommended Storage Conditions

The recommended storage conditions are listed in the following Table 9.

Table 9: Recommended Storage Conditions

Parameter	Value
Commercial Storage Temperature	-40 °C to 85 °C[5]
Industrial Storage Temperature	-40 °C to 85 °C[5]

4.3.3 Humidity

The maximum humidity conditions are listed in the following Table 10.

Table 10: Humidity

Parameter	Value
Shock	1,500 g, 0.5 ms pulse duration, half-sine wave (IEC 60068-2-27, JESD22-B110)
Vibration	50 g, 10Hz – 2000Hz, 3 axes (IEC 60068-2-6, MIL-STD-883 H M2007.3)
Humidity (Non-Condensing)	85% RH 85 °C, 1000 hrs (JESD22-A101)

[4] Adequate airflow is required to ensure the drive temperature, as reported in the S.M.A.R.T. data, does not exceed the specified maximum operating temperature.

[5] The retention at high temperature is reduced. The acceleration factor at 85°C compared with 40°C is 170, i.e. the initial endurance at 10 years@40°C is reduced to 22 days@85°C.

4.4 Regulatory Compliance

The PU-50n DP devices comply with the standards listed in the following Table 11.

Table 11: Regulatory Compliance

Abbreviation	Regulation/ Standard
EMC	(EU) 2014/30 (FCC) 47 CFR Part 15
RoHS	(EU) 2011/65/EU with 2015/863 and 2017/2102
REACh	(EU) 1907/2006 and 207/2011
WEEE	(EU) 2012/19

4.5 Mechanical Specifications

The PU-50n DP uses a USB Type-A connector fully integrated into the metal housing. Physical dimensions and tolerances are detailed in the following Table 12. Figure 3 on page 14 illustrates the PU-50n DP dimensions.

Table 12: Measured Physical Dimensions

Physical Dimensions		Unit
Length	24.00±0.2	mm
Width	12.10±0.10	
Thickness (Max)	4.50±0.10	
Weight (Max Capacity)	3,5	g

4.6 Reliability and Endurance

The Mean Time Between Failure (MTBF) is specified to exceed the value listed in the following Table 13. Data reliability with effective error tolerance and data retention at the beginning and end of life is also provided.

Table 13: Reliability

Parameter	Value
MTBF (at 25 °C)	> 3,000,000 hours
Data Reliability	< 1 Non-Recoverable Error per 10^{16} Bits Read
Data Retention	10 Years at Start (JESD47), 1 Year at EOL

Endurance represented as TeraBytes Written (TBW) is provided in the following Table 14.

Table 14: Endurance[6]

Drive Capacity	TeraBytes Written (TBW) @ Seq. Write 128kB Operation[7]	TeraBytes Written (TBW) @ Random Write 128kB Operation[7]	TeraBytes Written (TBW) @ Random Write 4kB Operation[7]
8 GBytes	25.8	6.4	1.0
16 GBytes	46.6	11.3	1.5
32 GBytes	92.9	23.2	3.2
64 GBytes	180.6	38.2	6.2

4.7 Drive Geometry Specification

Table 15: Drive Geometry

Raw Capacity	Total LBA	User Addressable Bytes
	Decimal	(Unformatted)
8 GBytes	15,663,104	8,019,509,248
16 GBytes	31,326,208	16,039,018,496
32 GBytes	62,533,296	32,017,047,552
64 GBytes	125,045,424	64,023,257,088

[6] The Endurance values depend strongly on the use case, the preconditioning, the operation sequence, use of trim commands and usage level of the flash drive. The given values are for orientation only.

[7] Sequential write 128kB simulates a continuous stream recording on a drive which has been preconditioned with a sequential write of the complete drive, Random Write 128KB or 4KB represent data logging applications with large or small block sizes.

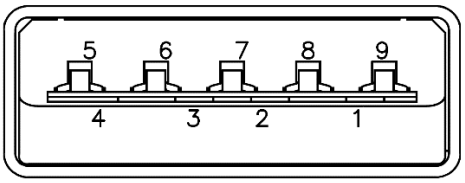
5. Electrical Interface

- USB3 Type-A connector, 9pin
- USB 3.1 Gen1 SuperSpeed interface, USB2.0 high-speed and 1.1 full-speed compatible

Table 16: Electrical pinout from device and host view.

Pin	Signal device view	Signal host view	Description host view
1	V_Bus	V_Bus	Operating voltage
2	D-	D-	Data signal pair
3	D+	D+	Data signal pair
4	GND	GND	Power Ground
5	SSTX-	SSRX-	Host receive -
6	SSTX+	SSRX+	Host receive +
7	GND	GND	Signal Ground
8	SSRX-	SSTX-	Host transmit -
9	SSRX+	SSTX+	Host transmit +
Shield			Connector shield

Figure 2: USB3 Type-A connector pinout



6. Electrical Specification

Table 17: Absolute Maximum Ratings

Parameter	Symbol	Min	Max	Unit
Power Supply Voltage	V_Bus	-0.5	6.0	V
Voltage at D+ and D-	V_Data	-0.5	5.0	
Voltage at USB3 pins	V_Data	-0.5	1.8	
Commercial Operating Temperature	T_A	0	70	°C
Industrial Operating Temperature		-40	85	

Table 18: DC characteristics for SuperSpeed operation (T=25°C, V_Bus=5V)

Parameter	Symbol	Density	Min	Typ	Max	Unit
Supply Voltage	V_Bus	all	4.5	5.0	5.5	V
Write current	I_WR	8GB		131	144	mA
		16GB		104	120	
		32GB		113	130	
		64GB		127	150	
Read current	I_RD	8GB		142	156	
		16GB		109	130	
		32GB		118	140	
		64GB		117	140	
Idle current	I_IDL	all		86[8]	95	
Suspend current	I_CCS	all		2.1	2.5	

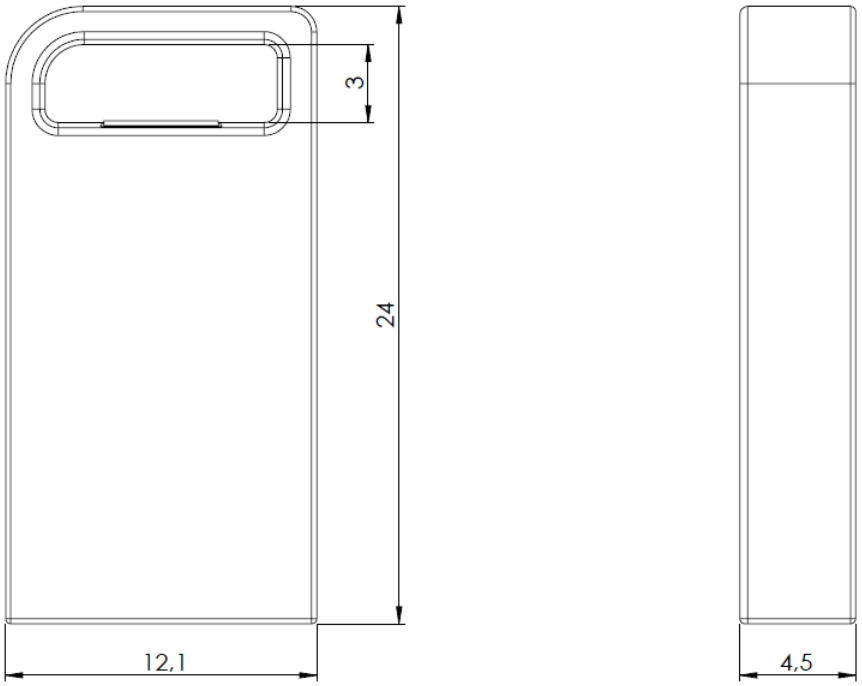
Table 19: DC characteristics for High-Speed operation (T=25°C, V_Bus=5V)

Parameter	Symbol	Density	Min	Typ	Max	Unit
Supply Voltage	V_Bus	all	4.5	5.0	5.5	V
Write current	I_WR	8GB		81	100	mA
		16GB		57	65	
		32GB		62	70	
		64GB		64	70	
Read current	I_RD	8GB		78	100	
		16GB		58	65	
		32GB		60	65	
		64GB		59	65	
Idle current	I_IDL	all		31[8]	55	
Suspend current	I_CCS	all		2.2	2.5	
High Speed Idle Level	V_HSOI	all	-10		10	mV
High Speed Data Signaling LOW	V_HSOL	all	-10		10	
High Speed Data Signaling HIGH	V_HSOH	all	360		440	
Chirp J Level (differential)	V_CHIRPJ	all	360		440	
Chirp K Level (differential)	V_CHIRPK	all	-440		-360	

[8] Typically 5 minutes after power on the device performs a background data care management, that needs up to 180mA

7. Package Mechanical

Figure 3: Mechanical Dimensions in mm for PU-50n DP



All dimensions are in millimeters, tolerances as listed in Table 12 on page 10.

8. ATA Pass-Through commands (Identify Device and S.M.A.R.T.)

8.1 ATA Pass-Through commands

Additional to the standard SCSI commands the device also supports the ATA Pass-Through commands.

Table 20: ATA PASS-TRHOUGH(x) commands

SCSI command	OpCode	Description
ATA PASS-THROUGH(12)	A1h	Write and read ATA registers to send commands and read information
ATA PASS-THROUGH(16)	85h	

http://www.t10.org/ftp/t10/document.04/04-262r8.pdf

Table 21: ATA register addressing

Offset address	Input	Output	Type	Identify device	e.g. SMART commands
0	Data		Word		
1	Feature	Error	Byte	xx	yyh*
2	Sector count		Byte	xx	01h
3	LBA_Low		Byte	xx	xx
4	LBA_Mid		Byte	xx	4Fh
5	LBA_High		Byte	xx	C2h
6	Drive/head		Byte	E0h	E0h
7	Command	Status	Byte	ECh	B0h

* see below

8.2 Identify Device

The Identify Device returns a identify sector compatible to ATA and SATA devices.
Here an example of the interpretation of this sector.

Table 22: Identify Device Information

Word(s)	Default Value		Total Bytes	Data Field Type Information
0	0040h		2	Standard Configuration Fixed (optional 848Ah for removable)
...	...	...	...	...
10-19	aaaa*		20	Serial number in ASCII (right-justified)
...	...	...	...	...
23-26	XXXX*		8	Firmware revision in ASCII (big-endian byte order in Word)
27-46	XXXX*		40	Model number in ASCII (right-justified)
...	...	...	...	...
60-61	XXXXh		4	Total number of sectors addressable in LBA mode
...	...	...	...	...
82	0101h 7701h* 4063h*		2	Command set: SMART feature set, service interrupt
...	...	...	...	...
85	000Xh 0701h* 4063h*		2	Command set enabled: SMART feature set enabled/disabled
...	...	...	...	...
255	XXA5h		2	Integrity Word

* Values depend on device configuration.

8.3 S.M.A.R.T. commands

The intent of the SMART command feature set is to protect user data and minimize the likelihood of unscheduled system downtime that may be caused by predictable degradation and/or fault of the device. By monitoring and storing critical performance and calibration parameters, SMART feature set devices attempt to predict the likelihood of a near-term degradation or fault condition. Providing the host system the knowledge of a negative reliability condition allows the host system to warn the user of the impending risk of a data loss and advise the user of the appropriate action.

All S.M.A.R.T. commands have the command code Boh. The different commands are selected by the Feature register.

Table 23: S.M.A.R.T. Features Supported

Operation	Feature	Sect Count	LBA low	LBA mid	LBA high	DRV head	Com-mand
S.M.A.R.T. Read Data	Doh	01h	xx	4Fh	C2h	Eoh	Boh
S.M.A.R.T. Read Attribute Thresholds	D1h	01h	xx	4Fh	C2h	Eoh	Boh
S.M.A.R.T. Enable Operations	D8h	xx	xx	4Fh	C2h	Eoh	Boh
S.M.A.R.T. Disable Operations	D9h	xx	xx	4Fh	C2h	Eoh	Boh
S.M.A.R.T. Return Status	DAh	xx	xx	4Fh	C2h	Eoh	Boh

All commands are aborted, if the LBA signature is invalid.

8.3.1 S.M.A.R.T. Read Data (Doh)

When the drive receives the S.M.A.R.T. Read Data subcommand, it returns one sector (512 bytes) of data. See the following table for the data structure of this sector.

Table 24: S.M.A.R.T. Data Structure

Byte(s)	Value	Description
0-1	0010h	S.M.A.R.T. structure version
2-361	XXh	Attribute entries 1 to 30 (see Table 25)
362	00h	Off-line data collection status (no off-line data collection started)
363	00h	Self-test execution status byte (self-test completed)
364-365	0000h	Total time, in seconds, to complete off-line data collection
366	00h	Vendor specific
367	00h	Off-line data collection capability (no off-line data collection)
368-369	0003h	S.M.A.R.T. capabilities
370	00h	No Error logging capability
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 Version
388-510	XXh	Vendor specific
511	XXh	Data structure checksum

8.3.2 S.M.A.R.T. Attribute Entry Structure

Each attribute entry (Bytes 2-361) consists of 12 bytes. See the following table for the data structure of each entry.

Table 25: Attribute Entry

Offset Byte(s)	Value	Description
0	XXh	Attribute ID (see Table 26)
1-2	XXXXh	Flags (little-endian) Bit0: Advisory (0) or Prefailure (1) Bit1: Not used (0) or updated during normal operation (1)
3	XXh	Current value as a percentage 64h = 100%
4	XXh	Worst value as a percentage 64h = 100%
5-10	XXXXh	Raw value (little-endian)
11	00h	Reserved

8.3.3 S.M.A.R.T. Attributes

The drives support the S.M.A.R.T. attributes listed in the following table.
The Threshold values can be read out with the S.M.A.R.T. Read Attribute Thresholds command (D1h)
The first attributes (196, 213, 229) are "Pre-Fail" type, while all other are Advisory (Old Age).

Table 26: S.M.A.R.T. Attributes

ID dec	ID hex	Value	Worst	Thres-hold	Attribute	Description	RAW values Offset 5-10
196	C4h	X%	X%	25	Spare Block Count	Number of total available NAND spare blocks	Initial (offset 5-7) and current (offset 8-10) number of spare blocks
213	D5h	X%	X%	25	Spare Block Count worst channel	Spare block count for the NAND with the lowest number of remaining spare blocks	Initial (offset 5-7) and current (offset 8-10) number of spare blocks of the channel with the lowest current number of spare blocks
229	E5h	X%	X%	2	Total Erase Count	Estimated number of total NAND block erases	Estimated number of total NAND block erases
203	CBh	100	100	0	Total ECC Errors	All recorded ECC errors	Total number of ECC errors (correctable and uncorrectable) (offset 5-8)
204	CCh	100	100	0	Correctable ECC Errors	Total recorded ECC errors that were corrected during the life of the drive	Total number of correctable ECC errors (offset 5-8)
199	C7h	100	100	0	UDMA CRC Errors	Dummy attribute, included for legacy reasons	This value is fixed at 0.
232	E8h	100	100	0	Total Number of Reads	Total number of NAND READ commands	Total number of NAND READ commands
12	0Ch	100	100	0	Power-On Count	Count of power-on events	Number of power cycles (offset 5-8)
241	F1h	100	100	0	Total LBAs Written	Total amount of data written to the drive	Total number of LBAs written to the disk, divided by 65536
242	F2h	100	100	0	Total LBAs Read	Total amount of data read from the drive	Total number of LBAs read from the disk, divided by 65536
214	D6h	100	100	0	Management Block status	Total number of times the management block has been updated	Management block write count (offset 5-8)
194	C2h	X°C	Max °C	0	Temperature Status	Device temperature in Celsius (°C)	Current (offset 5) /Min (offset 6) / Max temperature (offset 7)

* These threshold values are changeable using the Write Attribute Thresholds command.

8.3.4 S.M.A.R.T. Read Attribute Thresholds (D1h)

When the drive receives the S.M.A.R.T. Read Attribute Thresholds subcommand, it returns one sector (512 bytes) of data similar as S.M.A.R.T. Read data sector, but with the threshold value in offset 1 of each attribute (see Table 26).

8.3.5 S.M.A.R.T. Enable Operations (D8h)

This command enables access to the S.M.A.R.T. capabilities of the drive. The state of SMART (enabled or disabled) is preserved across power cycles.

8.3.6 S.M.A.R.T. Disable Operations (D9h)

This command disables access to the S.M.A.R.T. capabilities of the drive. The state of SMART (enabled or disabled) is preserved across power cycles.

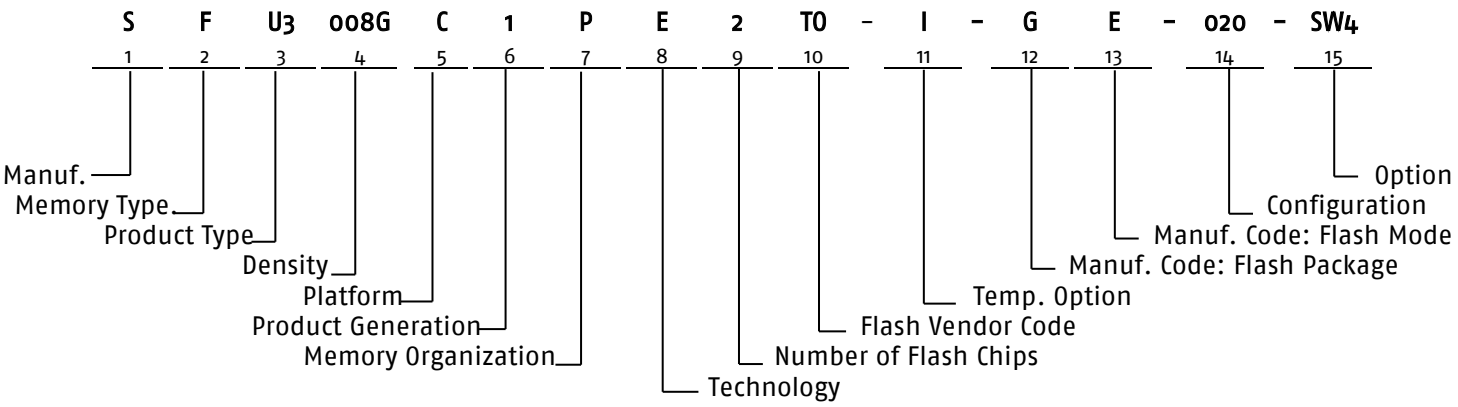
8.3.7 S.M.A.R.T. Return Status (DAh)

Table 27: S.M.A.R.T. Return Status

Operation	Feature	Sect Count	LBA low	LBA mid	LBA high	DRV head	Com-mand
Command S.M.A.R.T. Return Status	DAh	xx	xx	4Fh	C2h	Eoh	Boh
Response							
S.M.A.R.T. Return Status OK	xx	xx	xx	4Fh	C2h	xx	xx
S.M.A.R.T. Return Status Pre-FAIL*	xx	xx	xx	F4h	2Ch	xx	xx

* If a threshold exceeded condition exists for either the Spare Block Count Worst Channel attribute or the Erase Count attribute, the device will set the Cylinder Low register to F4h and the Cylinder High register to 2Ch. In this case the drive should be replaced soon.

9. Part Number Decoder



9.1 Manufacturer

Swissbit code	S

9.2 Memory Type

Flash	F

9.3 Product Type

USB 3.1 Flash Drive	U3

9.4 Density

8 GBytes	008G
16 GBytes	016G
32 GBytes	032G
64 GBytes	064G

9.5 Platform

USB COB Inlay	C

9.6 Product Generation

First generation	1
Second generation	2

9.7 Memory Organization

Security Product	P

9.8 Technology

U-5xx platform UFD	E

9.9 Number of Flash Channels

1 Channel	1
2 Channel	2

9.10 Flash Code

Kioxia (formerly Toshiba)	T0

9.11 Temperature Option

Industrial Temperature Range: -40 °C to 85 °C	I
Standard Temperature Range: 0 °C to 70 °C	C

9.12 Die Classification

MLC MONO (single die package)	G
MLC DDP (dual die package)	L

9.13 Pin Mode

Single nCE and Single R/nB	E
Dual nCE and Dual R/nB	F

9.14 Configuration XYZ

X = Secure Element

Smart card version	**X**
No secure element	0

Y = Firmware Revision

Data Protection	**Y**
durabit™ Revision 1 with data protection	2

Z = Optional Setting

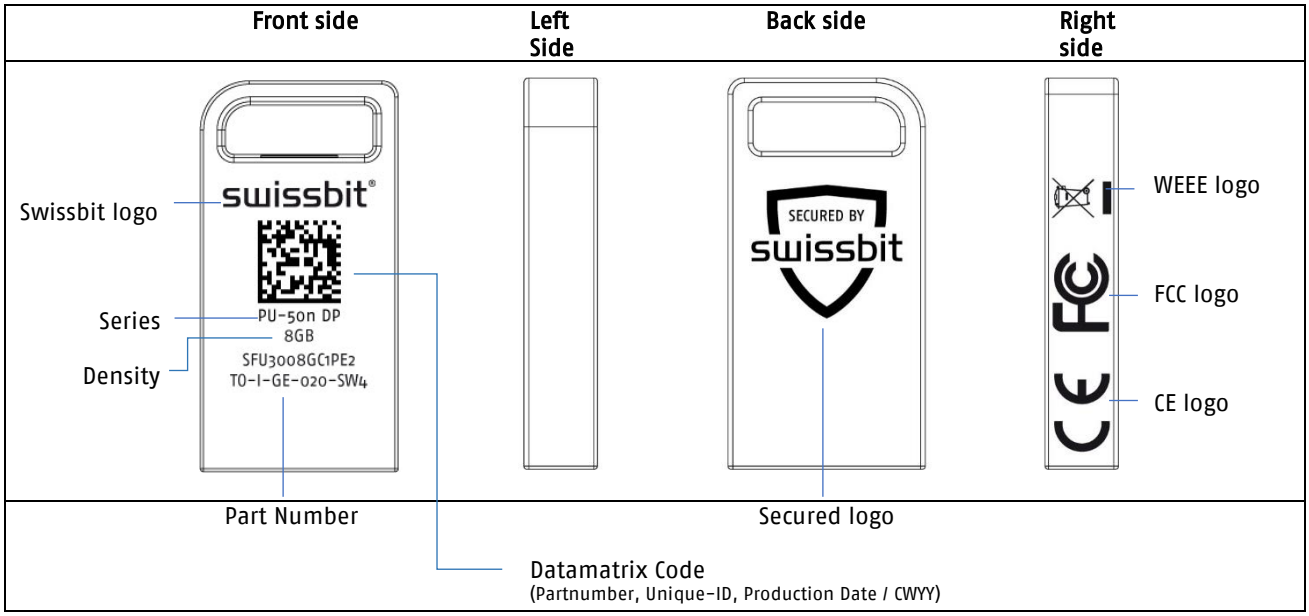
Optional Setting	**Z**
Default (MLC),	0

9.15 Option

Swissbit / Standard	SW4
Customized version	XXX

10. Marking Specification

Figure 4: PU-50n DP product marking



11. Revision History

Table 28: Document Revision History

Date	Revision	Description	Revision Details
12-April-2019	1.00	Initial release. Variant 8GB	Doc-2878
17-Dec-2020	1.10	The variants 16GB, 32GB and 64GB were added.	Doc-4269

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