



Product Specification

- **CWH series** -

(UFS 3.1)

MA2H064CWHAQ

Document Number: E24010 (Version 2.3)

History of Specification Change

Revision	History	Date	Author
1.0	Preliminary version	2023/04/01	Hank
1.2	Updated MDV for Device Descriptor Offset 18h (4.1.1)	2023/06/12	Hank
2.0	Added 2.5V VCC support (2.2.2) (5.1)	2023/08/11	Hank
2.1	- Added HPB commands to SCSI Command Support List (3.1) - Added performance features to Features Support List (3.2) - Updated the MDV or size for Device Descriptor Offsets: 22h and 55h (4.1.1) - Updated the MDV or size for Configuration Descriptor Header Offsets: 0Bh and 03h (4.1.2) - Updated the name or value for Geometry Descriptor Offsets: 18h, 4Ah, 4Bh, 4Fh and 55h (4.1.3) - Updated the User Conf. column for Unit Descriptor Offsets: 23h, 25h and 07h (4.1.4) - Updated the access property, size, MDV or comment for Attribute IDNs: 01h, 03h, 0Ah, 0Fh, 18h, 19h, 1Ah and 23h:2Bh, and modified table notes (4.3) - Updated the size for Control Mode Page Offset: 06h (4.4.1) - Updated the size or MDV for VPD Page Offsets: 01h, 02h, 0Ch and 08h (4.5) Updated the description for M-RX Capability Attribute IDs: 0x90 and 0x91 (4.7)	2023/10/28	Hank
2.2	- Updated the MDV and comment for Device Descriptor Offsets: 1Fh and 4Fh (4.1.1) - Updated the MDV for Power Parameters Descriptor Offsets: 02h, 04h, 20h, 42h, 44h and 60h, and added Power Parameters Descriptor Offsets: 22h, 24h and 40h (4.1.5) - Updated the Default value for Flags IDN: 00h (4.2) Updated the MDV for Attribute IDN: 0Fh (4.3)	2023/12/13	Hank
2.3	Capacity summation	2024/11/6	Wang

Requirement and Notice

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Product Overview

- UFS 3.1 Standard Interface Compliant
 - Supports HS-Gear4 x 2-lane
 - Supports M-PHY version 4.1
 - LS-mode supports rate of up to PWM-G4 (from 3 Mbps to 72 Mbps)
 - HS-mode supports up to HS-Gear4 with both rate A and rate B
 - Supports UniPro standard version 1.8
 - Supports reference clock: 19.2 MHz, 26 MHz, 38.4 MHz and 52 MHz
- Robust Data Protection and Endurance
 - Performance-optimized LDPC engine supports bit-flip and minimum-sum hard decoding and provides maximum error correction capability
 - StaticDataRefresh and EarlyRetirement technologies ensure the data reliability
 - PowerShield and DataPhoenix technologies support power-down data protection
 - Global wear leveling maximizes product lifespan with minimal wear leveling and write amplification overhead
- Dynamic power management technology enables multiple power saving modes
- Supply Voltage
 - UFS Interface Power (VCCQ): 1.14-1.26V
 - NAND Memory Power (VCC): 2.4-2.7V, 2.7-3.6V
- Multiple Densities and Packages
 - 153-ball standard BGA package
 - Green Package and RoHS Compliant
- Operating Temperature (Ta)
 - Automotive Grade 2: -40°C ~ +105°C

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1. Introduction

Metorage UFS is a highly integrated solution which combines a feature-wise flash controller compliant with the latest Metorage UFS 3.1 standard and standard NAND flash memory. Its high-performance storage accessing, better power efficiency, and ease of system design make The Metorage UFS a fabulous solution for automotive, industry, embedded and portable applications.

The Metorage UFS leverages industry leading technology and experience in NAND management, and supports The Metorage UFS 3.1 advanced features such as HS-Gear4 x 2-lane mode and command queue. With extended temperature and various capacity support, offering easy and rapid design integration, The Metorage UFS also ideally fits the requirements of point-of-sale terminals, networking and telecommunications equipment, and a variety of leading-edge industrial applications. With superior performance, multitasking support, and high stability, The Metorage UFS can seamlessly serve the needs of a wide variety of mobile devices and new booming embedded/portable applications.

Available in various densities, the Metorage UFS products offers the features, performance, and flexibility exactly for mobile handset, navigation, automotive infotainment, multi-function printer, and next-generation consumer applications. With extended temperature support and high data reliability, offering easy and rapid design integration, the Metorage UFS products also ideally fits the requirements of point-of-sale terminals, networking and telecommunications equipment, and a variety of leading-edge industrial applications.

Table 1-1 Product Part Number

Product Part Number	NAND Density	Package	Operating voltage
MA2H064CWHAQ	64GB	153-ball standard BGA	$V_{CC}=2.4-2.7V$, $2.7-3.6V$ $V_{CCQ}=1.14-1.26V$
MA2H128CWHAQ	128GB	153-ball standard BGA	$V_{CC}=2.4-2.7V$, $2.7-3.6V$ $V_{CCQ}=1.14-1.26V$
MA2H256CWHAQ	256GB	153-ball standard BGA	$V_{CC}=2.4-2.7V$, $2.7-3.6V$ $V_{CCQ}=1.14-1.26V$
MA2H512CWHAQ	512GB	153-ball standard BGA	$V_{CC}=2.4-2.7V$, $2.7-3.6V$ $V_{CCQ}=1.14-1.26V$

Table 1-2 Read/Write Performance

Capacity	Sequential [MB/sec]		Random(IOPS)	
	Read	Write	Read	Write
64GB (512Gbit/1Die)	550	255	43K	56K
128GB (512Gbit/1Die)	1090	480	82K	104K
256GB (512Gbit/1Die)	1780	860	141K	142K
512GB (512Gbit/1Die)	1780	1080	180K	171K

Note: Performance numbers might be subject to changes without notice.

2. UFS Device and System

2.1 UFS Block Diagram

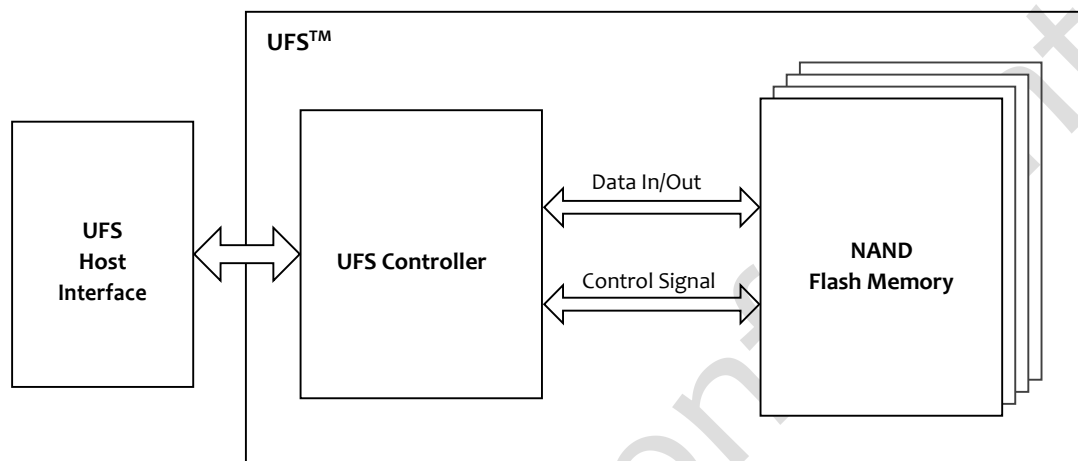


Figure 2-1 UFS System Overview

2.2 Ball Assignments and Signal Descriptions

JESD21-C defines two types of ball assignments. The standard edition is for commercial or industrial applications, and the automotive edition is for automotive applications.

2.2.1 Ball Assignments

Figure 2-2 153-Ball Package Ball Assignments (Standard Edition)

A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14
NC	NC	VDDIQ	VCCQ	VCCQ	NC	NC	VDDIQ2	DNU	NC	NC	NC	NC	NC
B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14
NC	VSS	RFU	VCCQ	VCCQ	NC	NC	VCC	VCC	NC	VSS	VSS	RFU	NC
C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
VSS	VSS	VSS	VCCQ	VCCQ	NC	NC	VCC	VCC	RFU	VSS	VSS	RFU	RFU
D1	D2	D3	D4								D12	D13	D14
DIN1_t	DIN1_c	VSS	NC								VSS	VSS	VSS
E1	E2	E3		E5	E6	E7	E8	E9	E10		E12	E13	E14
VSS	VSS	VSS		VCCQ	JTMS	DNU	VCC	JTDI	UTX		VSS	RFU	RFU
F1	F2	F3		F5					F10		F12	F13	F14
DIN0_t	DIN0_c	VSS		VCCQ					DNU		VSS	VSS	VSS
G1	G2	G3		G5					G10		G12	G13	G14
VSS	VSS	VSS		JTCK					VSS		VSS	RFU	RFU
H1	H2	H3		H5					H10		H12	H13	H14
REF_CLK	RST_n	VSS		VSS					VSS		VSS	VSS	VSS
J1	J2	J3		J5					J10		J12	J13	J14
VSS	VSS	VSS		VSS					DNU		VSS	RFU	RFU
K1	K2	K3		K5	K6	K7	K8	K9	K10		K12	K13	K14
DOUT0_c	DOUT0_t	VSS		VSS	NC	NC	VCC	NC	URX		VSS	VSS	VSS
L1	L2	L3									L12	L13	L14
VSS	VSS	VSS									VSS	RFU	RFU
M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
DOUT1_c	DOUT1_t	VSS	VSS	VSS	RFU	RFU	NC	NC	RFU	NC	VSS	VSS	VSS
N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14
NC	VSS	VSS	VSS	VSS	RFU	RFU	VCC	VCC	RFU	VSS	VSS	RFU	NC
P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14
NC	NC	RFU	VSS	VSS	RFU	RFU	VCC	VCC	JTDO	VSS	VSS	NC	NC

Note: Top View - Balls Down

Figure 2-3 153-Ball Package Ball Assignments (Automotive Edition)

A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14
NC	NC	VDDIQ	VCCQ	VCCQ	NC	NC	VDDIQ2	DNU	NC	NC	NC	NC	NC
B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14
NC	VSS	RFU	VCCQ	VCCQ	NC	NC	VCC	VCC	NC	VSS	VSS	RFU	NC
C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
NC	VSS	VSS	VCCQ	VCCQ	NC	NC	VCC	VCC	RFU	VSS	VSS	RFU	RFU
D1	D2	D3	D4								D12	D13	D14
DIN1_t	DIN1_c	VSS	NC								VSS	VSS	VSS
E1	E2	E3		E5	E6	E7	E8	E9	E10		E12	E13	E14
NC	VSS	VSS		VCCQ	JTMS	DNU	VCC	JTDI	UTX		VSS	RFU	RFU
F1	F2	F3		F5					F10		F12	F13	F14
DIN0_t	DIN0_c	VSS		VCCQ					DNU		VSS	VSS	VSS
G1	G2	G3		G5					G10		G12	G13	G14
NC	VSS	VSS		JTCK					VSS		VSS	RFU	RFU
H1	H2	H3		H5					H10		H12	H13	H14
REF_CLK	RST_n	VSS		VSS					VSS		VSS	VSS	VSS
J1	J2	J3		J5					J10		J12	J13	J14
NC	VSS	VSS		VSS					DNU		VSS	RFU	RFU
K1	K2	K3		K5	K6	K7	K8	K9	K10		K12	K13	K14
DOUT0_c	DOUT0_t	VSS		VSS	NC	NC	VCC	NC	URX		VSS	VSS	VSS
L1	L2	L3									L12	L13	L14
NC	VSS	VSS									VSS	RFU	RFU
M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
DOUT1_c	DOUT1_t	VSS	VSS	VSS	RFU	RFU	NC	NC	RFU	NC	VSS	VSS	VSS
N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14
NC	VSS	VSS	VSS	VSS	RFU	RFU	VCC	VCC	RFU	VSS	VSS	RFU	NC
P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14
NC	NC	RFU	VSS	VSS	RFU	RFU	VCC	VCC	JTDO	VSS	VSS	NC	NC

Note: Top View - Balls Down

2.2.2 Signal Descriptions

Table 2-1 Signal Descriptions (Standard Edition)

Name	Type	Pad No.	Description
REF_CLK	Input	H1	UFS reference clock input.
RST_n	Input	H2	UFS hardware reset input.
DOU0_t	Output	K2	UFS interface upstream lane 0 output. Differential TX signal pair from device.
DOU0_c	Output	K1	
DINO_t	Input	F1	UFS interface downstream lane 0 input. Differential RX signal pair from the host.
DINO_c	Input	F2	
DOU1_t	Output	M2	UFS interface upstream lane 1 output. Differential TX signal pair from device.
DOU1_c	Output	M1	
DIN1_t	Input	D1	UFS interface downstream lane 1 input. Differential RX signal pair from the host.
DIN1_c	Input	D2	
JTDI	I/O	E9	JTAG interface signals. These signals can also be used as GPIO.
JTDO	I/O	P10	
JTMS	I/O	E6	
JTCK	I/O	G5	
UTX	I/O	E10	UART interface signals. These signals can also be used as GPIO.
URX	I/O	K10	
VCCQ	Supply	A4, A5, B4, B5, C4, C5, E5, F5	UFS controller core, PHY interface and NAND Flash I/O power supply (1.2V).
VCC	Supply	B8, B9, C8, C9, E8, K8, N8, N9, P8, P9	NAND Flash core power supply (2.5V/3.3V).
VDDIQ2	-	A8	Internal voltage node. A 1.0uF capacitor is required for VDDIQ2 for core and PHY power stabilization. Do not tie to supply voltage or ground.
VDDIQ	-	A3	Internal voltage node. A 1.0uF capacitor is required for VDDIQ for core power stabilization. Do not tie to supply voltage or ground.
VSS	Supply		

Name	Type	Pad No.	Description
DNU	-	A9, E7, F10, J10	Do not use.
RFU	-	B3, B13, C10, C13, C14, E13, E14, G13, G14, J13, J14, L13, L14, M6, M7, M10, N6, N7, N10, N13, P3, P6, P7	Reserved for future use. Leave it floating.
NC	-	A1, A2, A6, A7, A10 - A14, B1, B6, B7, B10, B14, C6, C7, D4, K6, K7, K9, M8, M9, M11, N1, N14, P1, P2, P13, P14	No connect.

Table 2-2 Signal Descriptions (Automotive Edition)

Name	Type	Pad No.	Description
REF_CLK	Input	H1	UFS reference clock input.
RST_n	Input	H2	UFS hardware reset input.
DOUT0_t	Output	K2	UFS interface upstream lane 0 output. Differential TX signal pair from device.
DOUT0_c	Output	K1	
DIN0_t	Input	F1	UFS interface downstream lane 0 input. Differential RX signal pair from the host.
DIN0_c	Input	F2	
DOUT1_t	Output	M2	UFS interface upstream lane 1 output. Differential TX signal pair from device.
DOUT1_c	Output	M1	
DIN1_t	Input	D1	UFS interface downstream lane 1 input. Differential RX signal pair from the host.
DIN1_c	Input	D2	
JTDI	I/O	E9	JTAG interface signals. These signals can also be used as GPIO.
JTDO	I/O	P10	
JTMS	I/O	E6	
JTCK	I/O	G5	
UTX	I/O	E10	UART interface signals. These signals can also be used as GPIO.
URX	I/O	K10	
VCCQ	Supply	A4, A5, B4, B5, C4, C5, E5, F5	UFS controller core, PHY interface and NAND Flash I/O power supply (1.2V).
VCC	Supply	B8, B9, C8, C9, E8, K8, N8, N9, P8, P9	NAND Flash core power supply (2.5V/3.3V).
VDDIQ2	-	A8	Internal voltage node. A 1.0uF capacitor is required for VDDIQ2 for core and PHY power stabilization. Do not tie to supply voltage or ground.
VDDIQ	-	A3	Internal voltage node. A 1.0uF capacitor is required for VDDIQ for core power stabilization. Do not tie to supply voltage or ground.
VSS	Supply	B2, B11, B12, C2, C3, C11, C12, D3, D12 - D14, E2, E3, E12, F3, F12 - F14, G2, G3, G10, G12, H3, H5, H10, H12 - H14, J2, J3, J5, J12, K3, K5, K12 - K14, L2, L3, L12, M3 - M5, M12 - M14, N2 - N5, N11, N12, P4, P5, P11, P12	Core ground connection.
DNU	-	A9, E7, F10, J10	Do not use.

Name	Type	Pad No.	Description
RFU	-	B3, B13, C10, C13, C14, E13, E14, G13, G14, J13, J14, L13, L14, M6, M7, M10, N6, N7, N10, N13, P3, P6, P7	Reserved for future use. Leave it floating.
NC	-	A1, A2, A6, A7, A10 - A14, B1, B6, B7, B10, B14, C1, C6, C7, D4, E1, G1, J1, K6, K7, K9, L1, M8, M9, M11, N1, N14, P1, P2, P13, P14	No connect.

3. Supported Features

3.1 SCSI Command

Table 3-1 UFS 3.1 SCSI Command Support List

Command Name	Opcode	Mandatory / Optional ¹	Supported
FORMAT UNIT	04h	M	Yes
INQUIRY	12h	M	Yes
MODE SELECT (10)	55h	M	Yes
MODE SENSE (10)	5Ah	M	Yes
PRE-FETCH (10)	34h	M	Yes
PRE-FETCH (16)	90h	O	Yes
READ (6)	08h	M	Yes
READ (10)	28h	M	Yes
READ (16)	88h	O	Yes
READ BUFFER ³	3Ch	O	Yes
READ CAPACITY (10)	25h	M	Yes
READ CAPACITY (16)	9Eh	M	Yes
REPORT LUNS	A0h	M	Yes
REQUEST SENSE	03h	M	Yes
SECURITY PROTOCOL IN ²	A2h	M	Yes
SECURITY PROTOCOL OUT ²	B5h	M	Yes
SEND DIAGNOSTIC	1Dh	M	Yes
START STOP UNIT	1Bh	M	Yes
SYNCHRONIZE CACHE (10)	35h	M	Yes
SYNCHRONIZE CACHE (16)	91h	O	Yes
TEST UNIT READY	00h	M	Yes
UNMAP	42H	M	Yes
VERIFY (10)	2Fh	M	Yes
WRITE (6)	0Ah	M	Yes
WRITE (10)	2Ah	M	Yes
WRITE (16)	8Ah	O	Yes
WRITE BUFFER	3Bh	M	Yes
HPB READ	F8h	O	Yes
HPB READ BUFFER	F9h	O	Yes
HPB WRITE BUFFER	FAh	O	Yes

Notes:

- The following describes the Mandatory/Optional definitions:
M = Mandatory. O = Optional. R = RPMB (Replay Protected Memory Block).
- SECURITY PROTOCOL IN command and SECURITY PROTOCOL OUT command are supported by the RPMB well known logical unit.
- READ BUFFER command supports Vendor Specific Mode.

3.2 UFS Functional Features

Table 3-2 UFS 3.1 Features Support List

Function		Supported	Comment
H/W	H/W Reset Pin	Yes	-
Logical Unit / Partitions	LUs	Yes (up to 32)	-
	Boot LUs	Yes (up to 2)	-
	RPMB LUs	Yes (up to 1)	-
	LU Priority	Yes	-
	Logical Block Size	4KB	-
UFS Security Features	ERASE	Yes	-
	DISCARD	Yes	-
	Purge	Yes	-
	Wipe Device	Yes	-
	Secure Write Protect	Yes	-
Host Device Interaction	Inter-LU Priority	Yes	-
	Queue Priority [HPI]	Yes	-
	Out of Order Data Transfer	No	-
	Background Operation Mode	Yes	-
	Power Off Notification	Yes	-
	Data Reliability	Yes	-
	Dynamic Device Capacity	Yes	Protocol support only
	Real-Time Clock Information	Yes	
	Context Management	Yes	
	System Data Tag Mechanism	Yes	
	Exception Events Mechanism	Yes	-
UFS Cache	Cache	Yes	-
Vendor Specific	UFS Field Firmware Update (FFU)	Yes	-
Reflow	Production State Awareness (PSA)	Yes	-
Performance Features	Write Booster	Yes	-
	Host Performance Booster (HPB)	Yes	-

3.3 Field Firmware Update (FFU)

UFS Field Firmware Update (FFU) is based on microcode download. UFS FFU uses the following mechanism:

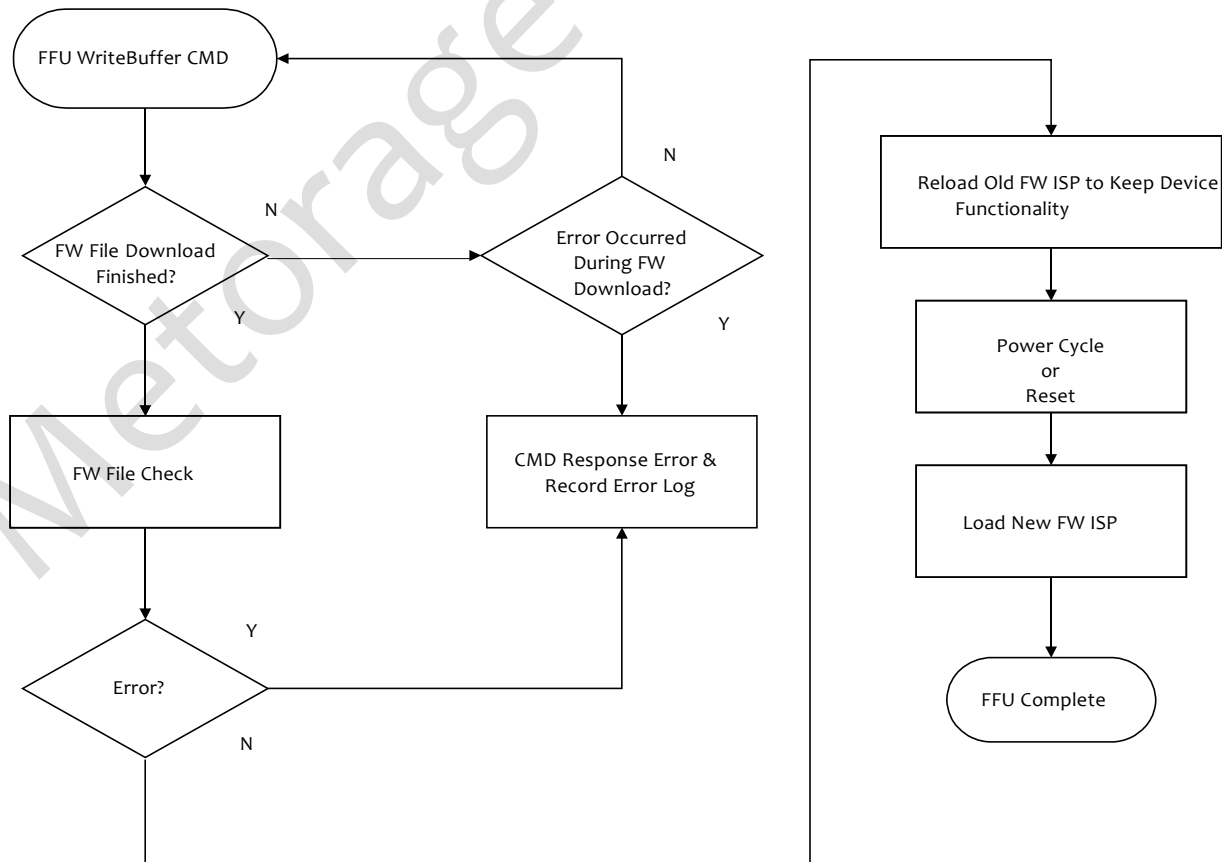
1. Host delivers the microcode using one or more WRITE BUFFER commands through any logical unit which supports the WRITE BUFFER command. The host specifies: MODE = 0Eh, BUFFER OFFSET, which should be aligned to 4 Kbyte, BUFFER ID = 00h, and the PARAMETER LIST LENGTH field indicating the number of bytes to be transferred.

All WRITE BUFFER commands should be sent to the same logical unit with task attribute set to simple or ordered. In the sequence of WRITE BUFFER commands used to deliver the microcode, the BUFFER OFFSET values should be in increasing order and it should start from zero.

2. bFFUTimeout indicates the maximum time in which the device may handle the WRITE BUFFER command. Within this time access to the device is limited or not possible.
3. Following a successful delivery of the microcode, the host activates the new firmware using a hardware reset or a power cycle. The UFS device shall use new firmware upon hard reset or power up. Host should be aware that the first initialization flow after a successful delivery of the microcode may be longer than usual.
4. After device initialization, the host should read bDeviceFFUStatus attribute and verify that the new firmware was updated successfully.

Note: Other modes of WRITE BUFFER command are not supported by the UFS device for FFU process.

Figure 3-1 Field Firmware Update Sequence

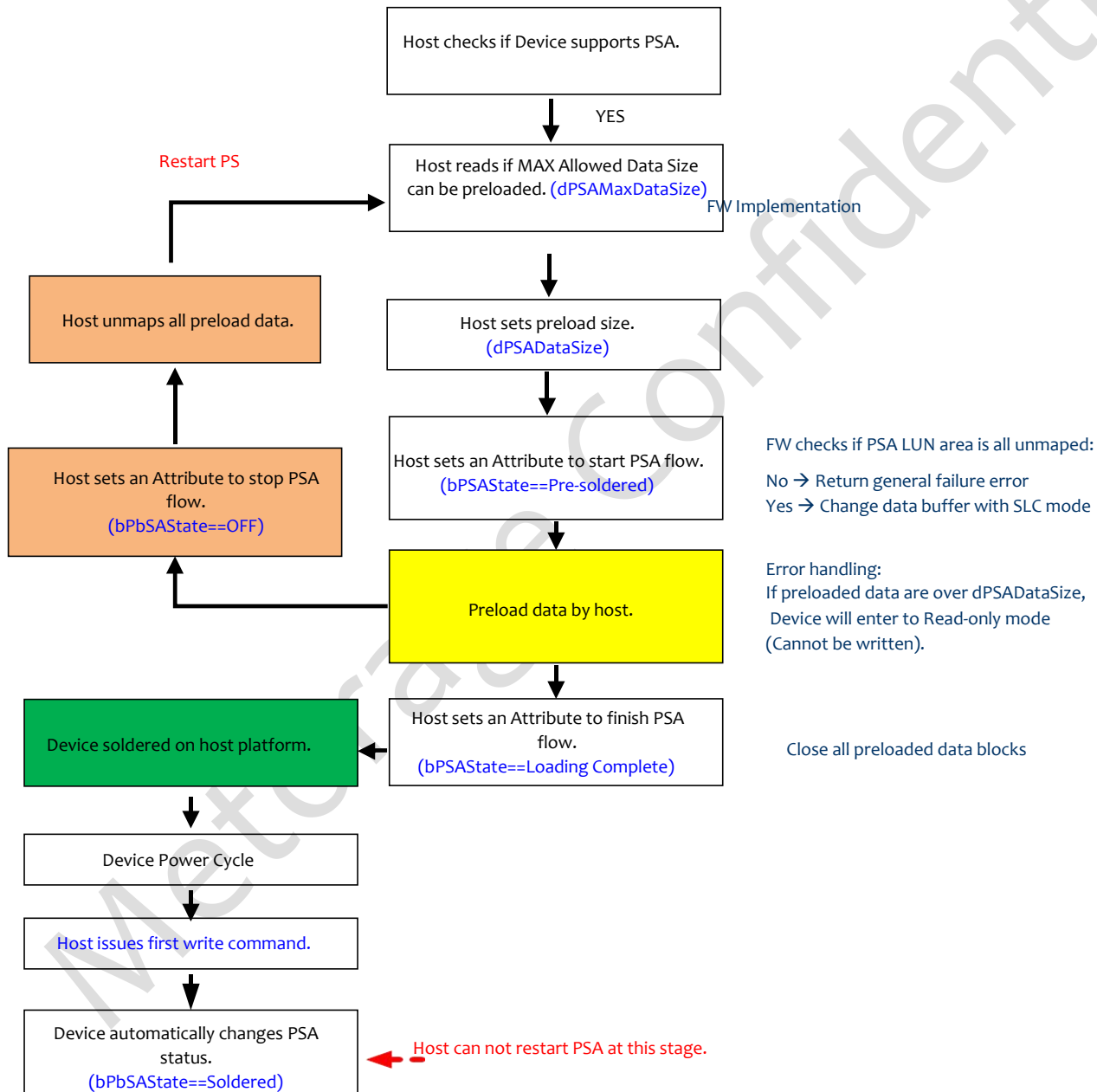


3.4 Production State Awareness (PSA)

The Metorage UFS device can utilize knowledge about its production status and adjust internal operations accordingly.

For example, content which was loaded into the storage device prior to device soldering might be corrupted, at a higher probability than in regular mode. The UFS device could use “special” internal operations for loading content prior to device soldering which would reduce production failures and use “regular” operations post-soldering.

Figure 3-2 PSA Device Handle Flow



3.5 UFS Data Security Operations

The way in which data is removed securely from the device is dependent on the type of memory technology that is used to implement the Metorage UFS device.

Table 3-3 Security Features

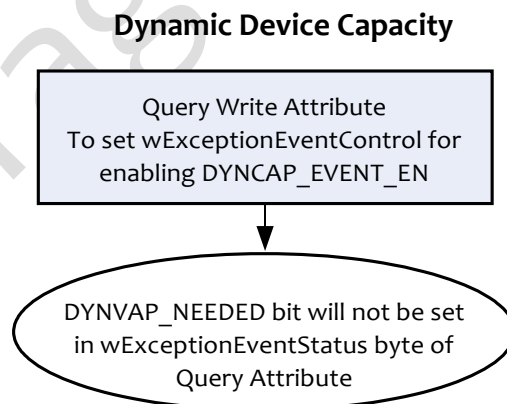
Features	Target Area	Description	
		Value of Deallocated LBA	Erase of Physical Memory
ERASE	Unmapped LBA	Zero	No
DISCARD	Unmapped LBA	Any value	No
PURGE	Unmapped LBA	Zero	Yes
WIPE Device	All Devices	Zero	Yes

3.6 Dynamic Device Capacity

This feature is implemented by protocol-only support .

Host can enable DYNCAP_EVENT_EN by Query UPIU, and device will not report error. However, the device will not set DYNVAP_NEEDED .

Figure 3-3 Dynamic Device Capacity Device Behavior

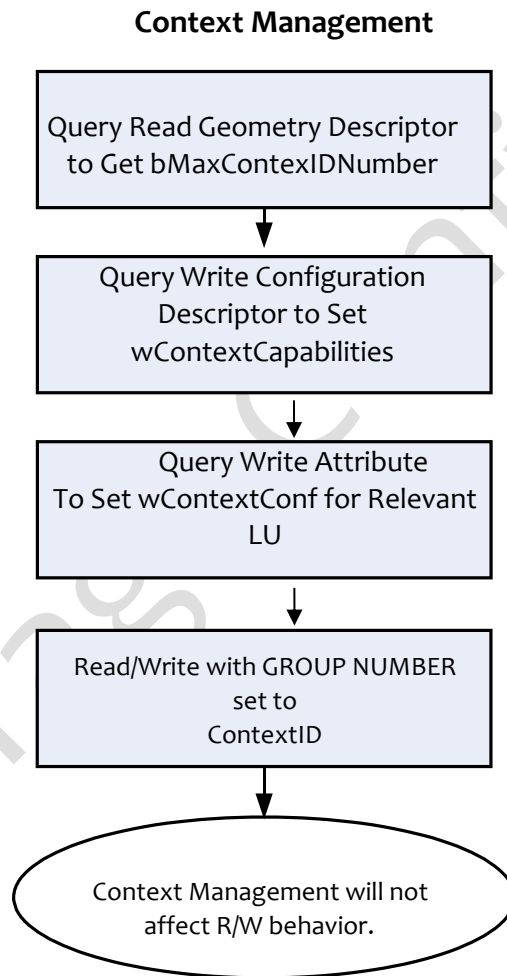


3.7 Context Management

This feature is implemented by protocol-only support :

1. Host uses Query Write Attribute to configure Context ID.
2. Host issues Write/Read CMD with Group Number to select Context ID
3. There is no difference on performance no matter Read/Write Command using or not using Context ID.

Figure 3-4 Context Management Device Behavior

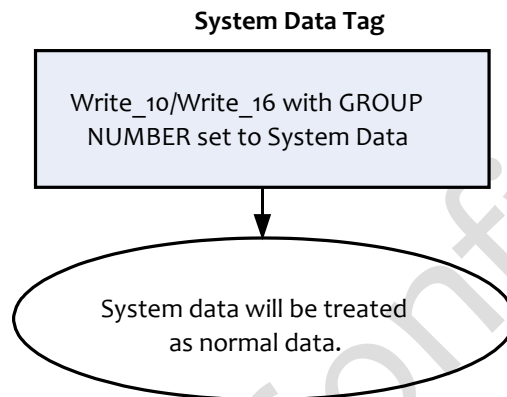


3.8 System Data Tag

This feature is implemented by protocol-only support :

1. Host issues write CMD with Group Number set as System data.
2. System data will be treated as normal data.

Figure 3-5 System Data Tag Device Behavior



4. Registers

4.1 Descriptor

A descriptor is a data structure with a defined format. It is a block or page of parameters that describe something about a Metorage UFS device.

4.1.1 Device Descriptor

Table 4-1 Device Descriptor (IDN = 0)

Offset	Size	Name	MDV ¹	User Conf. ²	Comment
00h	1	bLength	59h	No	-
01h	1	bDescriptorIDN	00h	No	-
02h	1	bDevice	00h	No	-
03h	1	bDeviceClass	00h	No	-
04h	1	bDeviceSubClass	00h	No	-
05h	1	bProtocol	00h	No	-
06h	1	bNumberLU	00h	Yes ³	-
07h	1	bNumberWLU	04h	No	-
08h	1	bBootEnable	00h	Yes	-
09h	1	bDescrAccessEn	00h	Yes	-
0Ah	1	bInitPowerMode	01h	Yes	-
0Bh	1	bHighPriorityLUN	7Fh	Yes	-
0Ch	1	bSecureRemovalType	00h	Yes	-
0Dh	1	bSecurityLU	01h	No	-
0Eh	1	bBackgroundOpsTermLat	05h	No	-
0Fh	1	bInitActiveICCLLevel	00h	Yes	-
10h	2	wSpecVersion	0310h	No	UFS3.1
12h	2	wManufactureDate	TBD	No	-
14h	1	iManufacturerName	00h	No	-
15h	1	iProductName	01h	No	-
16h	1	iSerialNumber	02h	No	-
17h	1	iOemID	03h	No	-
18h	2	wManufacturerID	0EC4h	No	-
1Ah	1	bUD0BaseOffset	16h	No	-
1Bh	1	bUDConfigPLength	1Ah	No	-
1Ch	1	bDeviceRTTCap	04h	No	-
1Dh	2	wPeriodicRTCUpdate	0000h	Yes	-

Offset	Size	Name	MDV ¹	User Conf. ²	Comment
1Fh	1	bUFSFeaturesSupport	See Comment	No	Automotive Grade 2: FFh
20h	1	bFFUTimeout	0Ah	No	-
21h	1	bQueueDepth	20h	No	-
22h	2	wDeviceVersion	10h	No	-
24h	1	bNumSecureWPArea	20h	No	-
25h	4	dPSAMaxDataSize	1/3 * density	No	64GB = 4F7000h 128GB = 9EF000h 256GB = 13DF000h 512GB = 27BE000h
29h	1	bPSAStateTimeout	12h	No	-
2Ah	1	iProductRevisionLevel	TBD	No	-
2Bh	5	Reserved	00h	N/A	-
30h	16	Reserved	00h	N/A	-
40h	2	wHPBVersion	0200h	No	-
42h	1	bHPBControl	1h	Yes	-
43h	12	Reserved	00h	N/A	Reserved
4Fh	4	dExtendedUFSFeaturesSupport	See Comment	No	Automotive Grade 2: 1FFh
53h	1	bWriteBoosterBuffer rPreserveUserSpaceEn	00h	Yes	-
54h	1	bWriteBoosterBufferType	00h	Yes	-
55h	4	dNumSharedWriteBoosterBufferA llocUnit	00h	Yes	-

Notes:

1. The column “MDV” (Manufacturer Default Value) specifies parameter values after device manufacturing. Some parameters may be configured by the user writing the Configuration Descriptor.
2. “User Conf.” column specifies which fields can be configured by the user writing the Configuration Descriptor: “Yes” means that the field can be configured, “No” means that the field is a capability of the device and cannot be changed by the user. The desired value shall be set in the equivalent parameter of the Configuration Descriptor.
3. bNumberLU field value is calculated by the device based on bLUEnable field value in the Unit Descriptors.

4.1.2 Configuration Descriptor

Table 4-2 Configuration Descriptor (IDN = 0x01) with INDEX = 00h

Offset	Size	Name	MDV	User Conf.	Comment
Configuration Descriptor Header and Device Descriptor Configurable Parameters					
00h	1	bLength	E6h	No	-
01h	1	bDescriptorIDN	01h	No	-
02h	1	bConfDescContinue	00h	No	-
03h	1	bBootEnable	00h	Yes	-
04h	1	bDescrAccessEn	00h	Yes	-
05h	1	bInitPowerMode	01h	Yes	-
06h	1	bHighPriorityLUN	7Fh	Yes	-
07h	1	bSecureRemovalType	00h	Yes	-
08h	1	bInitActiveICCLLevel	00h	Yes	-
09h	2	wPeriodicRTCUpdate	00h	Yes	-
0Bh	1	bHPBControl	01h	Yes	-
0Ch	1	bRPMBRegionEnable	00h	Yes	-
0Dh	1	bRPMBRegion1Size	00h	Yes	-
0Eh	1	bRPMBRegion2Size	00h	Yes	-
0Fh	1	bRPMBRegion3Size	00h	Yes	-
10h	1	bWriteBoosterBufferPreserveUserSpaceEn	00h	Yes	-
11h	1	bWriteBoosterBufferType	00h	Yes	-
12h	4	dNumSharedWriteBoosterBufferAllocUnits	00h	Yes	-
Unit Descriptor Configurable Parameters					
00h	1	bLUEnable	00h	Yes	-
01h	1	bBootLunID	00h	Yes	-
02h	1	bLUWriteProtect	00h	Yes	-
03h	1	bMemoryType	00h	Yes	-
04h	4	dNumAllocUnits	00h	Yes	-
08h	1	bDataReliability	00h	Yes	-
09h	1	bLogicalBlockSize	0Ch	Yes	-
0Ah	1	bProvisioningType	00h	Yes	-
0Bh	2	wContextCapabilities	00h	Yes	-
0Dh	3	Reserved	00h	Yes	-
10h	2	wLUMaxActiveHPBRegions	00h	Yes	-
12h	2	wHPBPinnedRegionStartIdx	00h	Yes	-
14h	2	wNumHPBPinnedRegions	00h	Yes	-
16h	4	dLUNumWriteBoosterBufferAllocUnits	00h	Yes	-

Table 4-3 Configuration Descriptor (IDN = 0x01) with INDEX = 01h/02h/03h

Offset	Size	Name	MDV	User Conf.	Comment
Configuration Descriptor Header					
00h	1	bLength	E6h	No	-
01h	1	bDescriptorIDN	01h	No	-
02h	1	bConfDescContinue	00h	No	-
03h	19	Reserved	00h	No	-
Unit Descriptor Configurable Parameters					
00h	1	bLUEnable	00h	Yes	-
01h	1	bBootLunID	00h	Yes	-
02h	1	bLUWriteProtect	00h	Yes	-
03h	1	bMemoryType	00h	Yes	-
04h	4	dNumAllocUnits	00h	Yes	-
08h	1	bDataReliability	00h	Yes	-
09h	1	bLogicalBlockSize	0Ch	Yes	-
0Ah	1	bProvisioningType	00h	Yes	-
0Bh	2	wContextCapabilities	00h	Yes	-
0Dh	3	Reserved	00h	No	-
10h	2	wLUMaxActiveHPBRegion	00h	Yes	-
12h	2	wHPBPinnedRegionStartIdx	00h	Yes	-
14h	2	wNumHPBPinnedRegions	00h	Yes	-
16h	4	dLUNumWriteBoosterBufferAlloc Units	00h	Yes	-

Note: UFS 3.1 supports up to 32 LUs.

4.1.3 Geometry Descriptor

Table 4-4 Geometry Descriptor (IDN = 0x07)

Offset	Size	Name	Value	Comment
00h	1	bLength	57h	-
01h	1	bDescriptorIDN	07h	-
02h	1	bMediaTechnology	00h	-
03h	1	Reserved	00h	-
04h	8	qTotalRawDeviceCapacity	See Comment	64,013,467,648 = 773C000h 64GB 128,026,935,296 = EE78000h 128GB 256,053,870,592 = 1DCF0000h 256GB 512,107,741,184 = 3B9E0000h 512GB
0Ch	1	bMaxNumberLU	01h	-
0Dh	4	dSegmentSize	2000h	2000hx512 = 4MB.
11h	1	bAllocationUnitSize	01h	1hx4MB = 4MB.
12h	1	bMinAddrBlockSize	08h	4KB
13h	1	bOptimalReadBlockSize	00h	-
14h	1	bOptimalWriteBlockSize	80h	64KB
15h	1	bMaxInBufferSize	40h	32KB
16h	1	bMaxOutBufferSize	40h	32KB
17h	1	bRPMB_ReadWriteSize	20h	256Bx32 = 8KB.
18h	1	bDynamicCapacityResourcePolicy	00h	-
19h	1	bDataOrdering	00h	-
1Ah	1	bMaxContextIDNumber	05h	Minimum number of supported contexts shall be 5.
1Bh	1	bSysDataTagUnitSize	00h	-
1Ch	1	bSysDataTagResSize	00h	-
1Dh	1	bSupportedSecRTypes	01h	-
1Eh	2	wSupportedMemoryTypes	8009h	-
20h	4	dSystemCodeMaxNAllocU	00h	-
24h	2	wSystemCodeCapAdjFac	00h	-
26h	4	dNonPersistMaxNAllocU	00h	-
2Ah	2	wNonPersistCapAdjFac	00h	-
2Ch	4	dEnhanced1MaxNAllocU	See Comment	3B9Eh = 64GB 773Ch = 128GB EE78h = 256GB 1DCF0h = 512GB
30h	2	wEnhanced1CapAdjFac	0300h	-
32h	4	dEnhanced2MaxNAllocU	00h	Not Supported.
36h	2	wEnhanced2CapAdjFac	00h	Not Supported.
38h	4	dEnhanced3MaxNAllocU	00h	Not Supported.

Offset	Size	Name	Value	Comment
3Ch	2	wEnhanced3CapAdjFac	00h	Not Supported.
3Eh	4	dEnhanced4MaxNAllocU	00h	Not Supported.
42h	2	wEnhanced4CapAdjFac	00h	Not Supported.
44h	4	dOptimalLogicalBlockSize	00h	Not Supported.
48h	1	bHPBRegionSize	0Fh	-
49h	1	bHPBNumberLU	20h	-
4Ah	1	bHPBSubRegionSize	0Fh	-
4Bh	2	wDeviceMaxActiveHPBRegions	See Comment	64GB = EE7h 128GB = 1DCFh 256GB = 3B9Eh 512GB = 773Ch
4Dh	2	Reserved	0h	-
4Fh	4	dWriteBoosterBufferMaxNAllocUnits	See Comment	64GB = 600h 128GB = C00h 256GB = 1800h 512GB = 3000h
53h	1	bDeviceMaxWriteBoostrLUs	1h	-
54h	1	bWriteBoosterBufferCapAdjFac	3h	-
55h	1	bSupportWriteBoosterBufferUser SpaceReductionTypes	1h	-
56h	1	bSupportedWriteBoosterBufferTypes	1h	-

4.1.4 Unit Descriptor Configurable Parameter

Table 4-5 Unit Descriptor (IDN = 02h, INDEX = unit index)

Offset	Size	Name	MDV	User Conf.	Comment
00h	1	bLength	2Dh	No	-
01h	1	bDescriptorIDN	02h	No	-
02h	1	bUnitIndex	Xh	No	X = 0 ~ bMaxNumberLU
03h	1	bLUEnable	00h	Yes	-
04h	1	bBootLunID	00h	Yes	-
05h	1	bLUWriteProtect	00h	Yes	-
06h	1	bLUQueueDepth	00h	No	-
07h	1	bPSASensitive	01h	No	-
08h	1	bMemoryType	00h	Yes	-
09h	1	bDataReliability	00h	Yes	-
0Ah	1	bLogicalBlockSize	0Ch	Yes	-
0Bh	8	qLogicalBlockCount	00h	Yes	-
13h	4	dEraseBlockSize	00h	No	-
17h	1	bProvisioningType	00h	Yes	-
18h:1Fh	8	qPhyMemResourceCount	00h	No	-
20h	2	wContextCapabilities	00h	Yes	-
22h	1	bLargeUnitGranularity_M1	00h	No	-
23h	2	wLUMaxActiveHPBRegions	00h	Yes	-
25h	2	wHPBPinnedRegionStartIdx	00h	Yes	-
27h	2	wNumHPBPinnedRegions	00h	Yes	-
29h	4	dLUNumWriteBoosterBuffer AllocUnits	00h	Yes	-

Table 4-6 RPMB Unit Descriptor (IDN = 02h, INDEX = 0xC4)

Offset	Size	Name	MDV	User Conf.	Comment
00h	1	bLength	23h	No	-
01h	1	bDescriptorIDN	02h	No	-
02h	1	bUnitIndex	C4h	No	-
03h	1	bLUEnable	01h	No	-
04h	1	bBootLunID	00h	No	-
05h	1	bLUWriteProtect	00h	No	-
06h	1	bLUQueueDepth	00h	No	-
07h	1	bPSASensitive	00h	No	-
08h	1	bMemoryType	0Fh	No	0Fh: RPMB Memory Type
09h	1	bRPMBRegionEnable	00h	Yes	-
0Ah	1	bLogicalBlockSize	08h	No	08h: 256-byte Logical Block Size
0Bh	8	qLogicalBlockCount	10000h	No	16MB
13h	1	bRPMBRegion0Size	80h	Yes	-
14h	1	bRPMBRegion1Size	00h	Yes	-
15h	1	bRPMBRegion2Size	00h	Yes	-
16h	1	bRPMBRegion3Size	00h	Yes	-
17h	1	bProvisioningType	00h	No	-
18h:1Fh	8	qPhyMemResourceCount	10000h	No	16MB
20h:22h	3	Reserved	00h	N/A	-

4.1.5 Other Descriptors

Table 4-7 Other Descriptors

Offset	Size	Name	MDV	Comment
Interconnect Descriptor (IDN = 04h)				
00h	1	bLength	06h	-
01h	1	bDescriptorIDN	04h	-
02h	2	bcdUniproVersion	0180h	MIPI UniPro version number in BCD format. (i.e., version 3.21 = 0321h)
04h	2	bcdMphyVersion	0410h	MIPI M-PHY version number in BCD format. (i.e., version 3.21 = 0321h)
Power Parameters Descriptor (IDN = 08h)				
00h	1	bLength	62h	-
01h	1	bDescriptorIDN	08h	-
02h	2	wActiveICCLevelsVCC[0]	8320h	Maximum VCC current value for bActiveICCLevel = 0.
04h	2	wActiveICCLevelsVCC[1]	8320h	Maximum VCC current value for bActiveICCLevel = 1.
...	...	...	...	...
20h	2	wActiveICCLevelsVCC[15]	8320h	Maximum VCC current value for bActiveICCLevel = 15.
22h	2	wActiveICCLevelsVCCQ[0]	8320h	Maximum VCCQ current value for bActiveICCLevel = 0.
24h	2	wActiveICCLevelsVCCQ[1]	8320h	Maximum VCCQ current value for bActiveICCLevel = 1.
...	...	...	...	...
40h	2	wActiveICCLevelsVCCQ[15]	8320h	Maximum VCCQ current value for bActiveICCLevel = 15.
42h	2	wActiveICCLevelsVCCQ2[0]	0000h	Maximum VCCQ2 current value for bActiveICCLevel = 0.
44h	2	wActiveICCLevelsVCCQ2[1]	0000h	Maximum VCCQ2 current value for bActiveICCLevel = 1.
...	...	...	...	...
60h	2	wActiveICCLevelsVCCQ2[15]	0000h	Maximum VCCQ2 current value for bActiveICCLevel = 15.

4.1.6 String Descriptors (IDN = 05h)

Table 4-8 String Descriptors

Offset	Size	Name	MDV	Comment
Manufacturer Name String with Index=iManufacturerName				
00h	1	bLength	12h	Size of this descriptor
01h	1	bDescriptorIDN	05h	String Descriptor Type Identifier
02h	2	UC[0]	004Dh	Unicode string character "M"
04h	2	UC[1]	0045h	Unicode string character "E"
06h	2	UC[2]	0054h	Unicode string character "T"
08h	2	UC[3]	004Fh	Unicode string character "O"
0Ah	2	UC[4]	0052h	Unicode string character "R"
0Ch	2	UC[5]	0041h	Unicode string character "A"
0Eh	2	UC[6]	0047h	Unicode string character "G"
10h	2	UC[7]	0045h	Unicode string character "E"
Product Name String with Index=iProductName				
00h	1	bLength	22h	Size of this descriptor
01h	1	bDescriptorIDN	05h	String Descriptor Type Identifier
02h	2	UC[0]	004Dh	Unicode string character "M"
04h	2	UC[1]	0045h	Unicode string character "E"
06h	2	UC[2]	0054h	Unicode string character "T"
08h	2	UC[3]	004Fh	Unicode string character "O"
0Ah	2	UC[4]	0052h	Unicode string character "R"
0Ch	2	UC[5]	0041h	Unicode string character "A"
0Eh	2	UC[6]	0047h	Unicode string character "G"
10h	2	UC[7]	0045h	Unicode string character "E"
12h	2	UC[8]	002Dh	Unicode string character "-."
14h	2	UC[9]	0055h	Unicode string character "U"
16h	2	UC[10]	0046h	Unicode string character "F"
18h	10	UC[11]-UC[15]	0053h	Unicode string character "S"
OEM ID String with Index=iOemID				
00h	1	bLength	40h	Size of this descriptor
01h	1	bDescriptorIDN	05h	String Descriptor Type Identifier
02h	2	UC[0]	0000h	Unicode string character
04h	2	UC[1]	0000h	Unicode string character
06h	2	UC[2]	0000h	Unicode string character
08h	2	UC[3]	0000h	Unicode string character
0Ah	2	UC[4]	0000h	Unicode string character
0Ch	2	UC[5]	0000h	Unicode string character

Offset	Size	Name	MDV	Comment
0Eh	2	UC[6]	0000h	Unicode string character
10h	48	UC[7]-UC[30]	0000h	Unicode string character
Serial Number String with Index=iSerialNumber				
00h	1	bLength	40h	Size of this descriptor
01h	1	bDescriptorIDN	05h	String Descriptor Type Identifier
02h	2	UC[0]	TBD	Unicode string character
04h	-	-	TBD	-
06h	58	UC[2]-UC[30]	TBD	Unicode string character
Product Revision Level String with Index=iProductRevisionLevel				
00h	1	bLength	0Ah	Size of this descriptor
01h	1	bDescriptorIDN	05h	String Descriptor Type Identifier
02h	2	UC[0]	0031h	Unicode string character "1"
04h	2	UC[1]	002eh	Unicode string character "."
06h	2	UC[2]	0030h	Unicode string character "0"
08h	2	UC[3]	0030h	Unicode string character "0"

4.1.7 Device Health Descriptor

Table 4-9 Device Health Descriptor

Offset	Size	Name	MDV	User Conf.	Comment
00h	1	bLength	2Dh	No	-
01h	1	bDescriptorIDN	09h	No	-
02h	1	bPreEOLInfo	01h	No	-
03h	1	bDeviceLifeTimeEstA	01h	No	-
04h	1	bDeviceLifeTimeEstB	00h	No	-
05h	32	VendorPropInfo	00h	No	-
25h	4	dRefreshTotalCount	00h	No	-
29h	4	dRefreshProgress	00h	No	-

4.2 Flags

A flag is a single Boolean value that represents a TRUE or FALSE, '0' or '1', ON or OFF type of value. It can be cleared or reset, set, toggled or read.

Table 4-10 Flags

IDN	Name	Access Property	Type ¹ / #Ind. ² / #Sel. ³	Default
00h	Reserved	-	-	-
01h	fDeviceInit	Read / Set only	D	0
02h	fPermanentWPEn	Read / Write once	D	0
03h	fPowerOnWPEn	Read / Power-on reset	D	0
04h	fBackgroundOpsEn	Read / Volatile	D	1
05h	fDeviceLifeSpanModeEn	Read / Volatile	D	0
06h	fPurgeEnable	Write only / Volatile	D	-
07h	fRefreshEnable	Write only / Volatile	D	-
08h	fPhyResourceRemoval	Read / Persistent	D	0
09h	fBusyRTC	Read only	D	0
0Ah	Reserved	-	-	-
0Bh	fPermanentlyDisableFwUpdate	Read / Write once	D	0
0Ch	Reserved	-	-	-
0Dh	Reserved	-	-	-
0Eh	fWriteBoosterEn	Read / Volatile	A/LU/0 or D ⁴	0
0Fh	fWriteBoosterBufferFlushEn	Read / Volatile	A/LU/0 or D ⁴	0
10h	fWriteBoosterBufferFlushDuring Hibernate	Read / Volatile	A/LU/0 or D ⁴	0
11h	fHPBReset	Read / Set only	D	0
12h	fHPBEn	Read / Persistent	D	0

Notes: The definitions of Type / #Ind. / #Sel. are shown as follows:

1. The type "D" identifies a device level flag, while the type "A" identifies an array of flags. If Type = "D", the flag is addressed setting INDEX = 00h and SELECTOR = 00h.
2. For array of flags, "# Ind." specifies the amount of valid values for the INDEX field in QUERY REQUEST/RESPONSE UPIU. If # Ind = 0, the flag is addressed setting INDEX = 00h.
3. For array of flags, "# Sel." specifies the amount of valid values for the SELECTOR field in QUERY REQUEST/RESPONSE UPIU. If # Sel = 0, the flag is addressed setting SELECTOR = 00h.
4. If the bWriteBoosterBufferType is configured as 01h (shared type), the WriteBooster Buffer is configured as a single shared buffer for the whole device. In this case, the value of LU does not matter.

4.3 Attributes

An attribute is a parameter that represents a specific range of numeric values that can be written or read.

Table4-11 Attributes

IDN	Name	Access Property	Size (Byte)	Type ¹ / #Ind. ² / #Sel. ³	MDV	Comment
00h	bBootLunEn	Read / Persistent	1	D	00h	-
01h	bMAX_DATA_SIZE_F OR_HPB_SIN_GLE_CMD	Read / Read only	1	D	00h	4KB
02h	bCurrentPowerMode	Read only	1	D	11h	00h: Idle mode 10h: Pre-Active mode 11h: Active mode 20h: Pre-Sleep mode 22h: UFS-Sleep mode 30h: Pre- PowerDown mode 33h: UFS- PowerDown mode
03h	bActiveICCLLevel	Read / Volatile	1	D	00h	-
04h	bOutOfOrderDataEn	Read / Write once	1	D	00h	-
05h	bBackgroundOpStatus	Read only	1	D	00h	-
06h	bPurgeStatus	Read only	1	D	00h	-
07h	bMaxDataInSize	Read / Persistent	1	D	40h	32KB
08h	bMaxDataOutSize	Read / Persistent	1	D	40h	32KB
09h	dDynCapNeeded	Read only	4	A ----- Number of LU specified by bMaxNumber LU (LUN) ----- 0	00h	-
0Ah	bRefClkFreq	Read / Persistent	1	D	01h	-
0Bh	bConfigDescrLock	Read / Write once	1	D	00h	-
0Ch	bMaxNumOfRTT	Read / Persistent	1	D	04h	-
0Dh	wExceptionEventControl	Read / Volatile	2	D	00h	-

IDN	Name	Access Property	Size (Byte)	Type ¹ / #Ind. ² / #Sel. ³	MDV	Comment
0Eh	wExceptionEventStatus	Read only	2	D	00h	-
0Fh	dSecondsPassed	Write only / Volatile	4	D	-	-
10h	wContextConf	Read / Volatile	2	A ----- Number of LU specified by bMaxNumber LU (LUN) ----- 15 (ID)	00h	-
11h	Obsolete	-	-	-	-	-
12h	Reserved	-	-	-	-	-
13h	Reserved	-	-	-	-	-
14h	bDeviceFFUStatus	Read only	1	D	00h	-
15h	bPSAState	Read / Persistent	1	D	00h	-
16h	dPSADDataSize	Read / Persistent	4	D	00h	-
17h	bRefClkGatingWaitTime	Read only	1	D	01h	-
18h	bDeviceCaseRoughTemperature	Read only	1	D	See Comment	Related to the current temperature
19h	bDeviceTooHighTempBoundary	Read only	1	D	See Comment	Automotive Grade 2: BEh
1Ah	bDeviceTooLowTempBoundary	Read only	1	D	See Comment	Automotive Grade 2: 28h
1Bh	bThrottlingStatus	Read only	1	D	00h	-
1Ch	bWriteBoosterBufferFlushStatus	Read only	1	A/LU/0 or D	0	-
1Dh	bAvailableWriteBoosterBufferSize	Read only	1	A/LU/0 or D	0	-

IDN	Name	Access Property	Size (Byte)	Type ¹ / #Ind. ² / #Sel. ³	MDV	Comment
1Eh	bWriteBoosterBufferLifeTimeEst	Read only	1	A/LU/0 or D	00h	-
1Fh:22h	dCurrentWriteBoosterBufferSize	Read only	4	A/LU/0 or D	0	-
23h:2Bh	Reserved	-	9	-	-	-
2Ch	bRefreshStatus	Read only	1	D	00h	-
2Dh	bRefreshFreq	Read / Persistent	1	D	00h	-
2Eh	bRefreshUnit	Read / Persistent	1	D	00h	-
2Fh	bRefreshMethod	Read / Persistent	1	D	00h	-

Notes: The definitions of Type / #Ind. / #Sel. are shown as follows:

1. The type “D” identifies a device level flag, while the type “A” identifies an array of flags. If Type = “D”, the flag is addressed setting INDEX = 00h and SELECTOR = 00h.
2. For array of flags, “# Ind.” specifies the amount of valid values for the INDEX field in QUERY REQUEST/RESPONSE UPIU. If # Ind = 0, the flag is addressed setting INDEX = 00h.
3. For array of flags, “# Sel.” specifies the amount of valid values for the SELECTOR field in QUERY REQUEST/RESPONSE UPIU. If # Sel = 0, the flag is addressed setting SELECTOR = 00h.
4. If the bWriteBoosterBufferType is configured as 01h (shared type), the WriteBooster Buffer is configured as a single shared buffer for the whole device. In this case, the value of LU does not matter.

4.4 Mode Pages

The Metorage UFS device supports the following mode pages. This section describes the mode pages used with MODE SELECT command and MODE SENSE command.

4.4.1 Control Mode Page

Table 4-12 Control Mode Page (Control [0]~[7])

Offset	Size	Field	MDV	User Conf.	Comment
00h	6b	PAGE CODE	0Ah	No	-
00h	1b	SPF	0b	No	-
00h	1b	PS	1b	No	-
01h	01h	PAGE LENGTH	0Ah	No	-
02h	1b	RLEC	0b	No	-
02h	1b	GLTSD	0b	No	-
02h	1b	D_SENSE	0b	No	-
02h	1b	DPICZ	0b	No	-
02h	1b	TMF_ONLY	0b	No	-
02h	3b	TST	0b	No	-
03h	1b	Obsolete	0b	No	-
03h	2b	QERR	00b	No	-
03h	1b	NUAR	0b	No	-
03h	4b	QUEUE ALGORITHM MODIFIER	0001b	No	-
04h	3b	Obsolete	000b	No	-
04h	1b	SWP	0b	Yes	-
04h	2b	UA_INTLCK_CTRL	00b	No	-
04h	1b	RAC	0b	No	-
04h	1b	VS	0b	No	-
05h	3b	AUTOLOAD MODE	000b	No	-
05h	1b	Reserved	0b	No	-
05h	1b	RWWP	0b	No	-
05h	1b	ATMPE	0b	No	-
05h	1b	TAS	0b	No	-
05h	1b	ATO	0b	No	-
06h	02h	Obsolete	0000h	No	-
08h	02h	BUSY TIMEOUT PERIOD	01h	No	Command Latency: Typical: 10ms Max.: 100ms
0Ah	02h	EXTENDED SELF-TEST COMPLETION TIME	0000h	No	-

4.4.2 Read-Write Error Recovery Mode Page

Table 4-13 Read-Write Error Recovery Mode Page

Offset	Size	Field	MDV	User Conf.	Comment
00h	6b	PAGE CODE	01h	No	-
00h	1b	SPF	0b	No	-
00h	1b	PS	1b	No	-
01h	01h	PAGE LENGTH	0Ah	No	-
02h	1b	DCR	0b	No	-
02h	1b	DTE	0b	No	-
02h	1b	PER	0b	No	-
02h	1b	EER	0b	No	-
02h	1b	RC	0b	No	-
02h	1b	TB	0b	No	-
02h	1b	ARRE	0b	No	-
02h	1b	AWRE	1b	No	-
03h	01h	READ RETRY COUNT	00h	Yes	-
04h	01h	Obsolete	00h	No	-
05h	01h	Obsolete	00h	No	-
06h	01h	Obsolete	00h	No	-
07h	2b	Restricted for MMC-6	00b	No	-
07h	5b	Reserved	00000b	No	-
07h	1b	TPERE	0b	No	-
08h	01h	WRITE RETRY COUNT	00h	Yes	-
09h	01h	Reserved	0b	No	-
0Ah	02h	RECOVERY TIME LIMIT	4B0h	Yes	-

4.4.3 Caching Mode Page

Table 4-14 Caching Mode Page

Offset	Size	Field	MDV	User Conf.	Comment
00h	6b	PAGE CODE	08h	No	-
00h	1b	SPF	0b	No	-
00h	1b	PS	1b	No	-
01h	01h	PAGE LENGTH	12h	No	-
02h	1b	RCD	0b	Yes	-
02h	1b	MF	0b	No	-
02h	1b	WCE	1b	Yes	Cache On: WCE = 1 Cache Off: WCE = 0
02h	1b	SIZE	0b	No	-
02h	1b	DISC	0b	No	-
02h	1b	CAP	0b	No	-
02h	1b	ABPF	0b	No	-
02h	1b	IC	0b	No	-
03h	4b	WRITE RETENTION PRIORITY	0000b	No	-
03h	4b	DEMAND READ RETENTION PRIORITY	0000b	No	-
04h	02h	DISABLE PRE-FETCH TRANSFER LENGTH	0000h	No	-
06h	02h	MINIMUM PRE-FETCH	0000h	No	-
08h	02h	MAXIMUM PRE-FETCH	0000h	No	-
0Ah	02h	MAXIMUM PRE-FETCH CEILING	0000h	No	-
0Ch	1b	NV_DIS	0000h	No	-
0Ch	2b	Reserved	0b	No	-
0Ch	2b	Vendor Specific	00b	No	-
0Ch	1b	DRA	00b	No	-
0Ch	1b	LBCSS	0b	No	-
0Ch	1b	FSW	0b	No	-
0Dh	01h	NUMBER OF CACHE SEGMENTS	0b	No	-
0Eh	02h	CACHE SEGMENT SIZE	00h	No	-
10h	01h	Reserved	0000h	No	-
11h	03h	Obsolete	00h	No	-

4.5 Vital Product Data Register Values

Table 4-15 Vital Product Data Register Values

Offset	Size	Field	MDV	User Conf.	Comment
Standard Inquiry Mode Page					
00h	5b	PERIPHERAL DEVICE TYPE	00000b 1Eh	No	-
00h	3b	PERIPHERAL QUALIFIER	000b	No	-
01h	7b	Reserved	0000000b	No	-
01h	1b	RMB	0b	No	-
02h	01h	VERSION	06h	No	-
03h	4b	RESPONSE DATA FORMAT	0010b	No	-
03h	1b	HISUP	0b	No	-
03h	1b	NORMACA	0b	No	-
03h	1b	Obsolete	0b	No	-
03h	1b	Obsolete	0b	No	-
04h	01h	ADDITIONAL LENGTH	1Fh	No	-
05h	1b	PROTECT	0b	No	-
05h	2b	Reserved	0b	No	-
05h	1b	3PC	0b	No	-
05h	2b	TPGS	0b	No	-
05h	1b	ACC	0b	No	-
05h	1b	SCCS	0b	No	-
06h	1b	ADDR16	0b	No	-
06h	1b	Obsolete	0b	No	-
06h	1b	Obsolete	0b	No	-
06h	1b	Obsolete	0b	No	-
06h	1b	MULTIP	0b	No	-
06h	1b	VS	0b	No	-
06h	1b	ENC SERV	0b	No	-
06h	1b	Obsolete	0b	No	-
07h	1b	VS	0b	No	-
07h	1b	CMDQUE	1b	No	-
07h	1b	Obsolete	0b	No	-
07h	1b	Obsolete	0b	No	-
07h	1b	SYNC	0b	No	-
07h	1b	WBUS16	0b	No	-
07h	1b	Obsolete	0b	No	-
07h	1b	Obsolete	0b	No	-

Offset	Size	Field	MDV	User Conf.	Comment
08h	08h	VENDOR IDENTIFICATION	"METORAGE"	No	TBD
10h	10h	PRODUCT IDENTIFICATION	"METORAGE"	No	TBD
20h	04h	PRODUCT REVISION LEVEL	"1.00"	No	TBD
Supported VPD Pages Mode Page					
00h	5b	PERIPHERAL DEVICE TYPE	00000b 1Eh	No	-
00h	3b	PERIPHERAL QUALIFIER	000b	No	-
01h	01h	PAGE CODE	00h	No	-
02h	02h	PAGE LENGTH	07h	No	-
04h	01h	Supported VPD Page List[0]	00h	No	SUPPORTED_VPD_PAGE
05h	01h	Supported VPD Page List[1]	80h	No	UNIT_SERIAL_NUM
06h	01h	Supported VPD Page List[2]	83h	No	DEVICE_ID
07h	01h	Supported VPD Page List[3]	87h	No	MODE_PAGE_POLICY
08h	01h	Supported VPD Page List[3]	B0h	No	BLOCK_LIMITS
09h	01h	Supported VPD Page List[5]	B1h	No	BLOCK_DEVICE_CHARACTERISTICS
0Ah	01h	Supported VPD Page List[6]	B2h	No	LOGICAL_BLOCK_PROVISIONING
Unit Serial Number Mode Page					
00h	5b	PERIPHERAL DEVICE TYPE	00000b 1Eh	No	-
00h	3b	PERIPHERAL QUALIFIER	000b	No	-
01h	01h	PAGE CODE	80h	No	-
02h	02h	PAGE LENGTH	40h	No	-
04h	40h	PRODUCT SERIAL NUMBER	TBD	No	-
Device Identification Mode Page					
00h	5b	PERIPHERAL DEVICE TYPE	00000b 1Eh	No	-
00h	3b	PERIPHERAL QUALIFIER	000b	No	-
01h	01h	PAGE CODE	83h	No	-
02h	02h	PAGE LENGTH	14h	No	-
N/A	N/A	Designation descriptor[first]	N/A	N/A	-
04h	4b	CODE SET	0010b	No	-
04h	4b	PROTOCOL IDENTIFIER	0000b	No	-
05h	4b	DESIGNATOR TYPE	0010b	No	-
05h	2b	ASSOCIATION	00b	No	-

Offset	Size	Field	MDV	User Conf.	Comment
05h	1b	Reserved	0b	No	-
05h	1b	PIV	0b	No	-
06h	01h	Reserved	00h	No	-
07h	01h	DESIGNATOR LENGTH	08h	No	-
08h	03h	IEEE COMPANY ID	TBD	No	-
08h	05h	VENDOR SPECIFIC EXTENSION IDENTIFIER	TBD	No	-
N/A	N/A	Designation descriptor[second]	N/A	N/A	-
10h	4b	CODE SET	0001b	No	-
10h	4b	PROTOCOL IDENTIFIER	0000b	No	-
11h	4b	DESIGNATOR TYPE	0110b	No	-
11h	2b	ASSOCIATION	10b	No	-
11h	1b	Reserved	0b	No	-
11h	1b	PIV	0b	No	-
12h	01h	Reserved	00h	No	-
13h	01h	DESIGNATOR LENGTH	04h	No	-
14h	02h	Reserved	0000h	No	-
16h	02h	LOGICAL UNIT GROUP	0000h	No	-

Mode Page Policy Mode Page

00h	5b	PERIPHERAL DEVICE TYPE	00000b 1Eh	No	-
00h	3b	PERIPHERAL QUALIFIER	000b	No	-
01h	01h	PAGE CODE	87h	No	-
02h	02h	PAGE LENGTH	14h	No	-
04h	04h	Mode page policy descriptor[0]	0080000Ah	No	-
08h	04h	Mode page policy descriptor[1]	00800001h	No	-
0ch	04h	Mode page policy descriptor[2]	00800008h	No	-
10h	04h	Mode page policy descriptor[3]	0080003Fh	No	-
14h	04h	Mode page policy descriptor[4]	0080FF3Fh	No	-

Block Limits Mode Page

00h	5b	PERIPHERAL DEVICE TYPE	00000b 1Eh	No	-
00h	3b	PERIPHERAL QUALIFIER	000b	No	-
01h	01h	PAGE CODE	80h	No	-
02h	02h	PAGE LENGTH	3Ch	No	-
04h	01h	Reserved	00h	No	-
05h	01h	MAXIMUM COMPARE AND WRITE LENGTH	00h	No	-
06h	02h	OPTIMAL TRANSFER LENGTH GRANULARITY	01h	No	-

Offset	Size	Field	MDV	User Conf.	Comment
08h	04h	MAXIMUM TRANSFER LENGTH	00h	No	-
0Ch	04h	OPTIMAL TRANSFER LENGTH	80h	No	-
10h	04h	MAXIMUM PREFETCH XDREAD XDWRITE TRANSFER LENGTH	00h	No	-
14h	04h	MAXIMUM UNMAP LBA COUNT	FFFFFFFh	No	-
18h	04h	MAXIMUM UNMAP BLOCK DESCRIPTOR COUNT	3Fh	No	-
1Ch	04h	OPTIMAL UNMAP GRANULARITY	1h	No	-
20h	31b	UNMAP GRANULARITY ALIGNMENT	00h	No	-
20h	1b	UGAVALID	00h	No	-
24h	1Ch	Reserved	00h	No	-

Block Device Characteristics Mode Page

00h	5b	PERIPHERAL DEVICE TYPE	00000b 1Eh	No	-
00h	3b	PERIPHERAL QUALIFIER	000b	No	-
01h	01h	PAGE CODE	B1h	No	-
02h	02h	PAGE LENGTH	3Ch	No	-
04h	02h	MEDIUM ROTATION RATE	0001h	No	-
06h	01h	Reserved	00h	No	-
07h	4b	NOMINAL FORM FACTOR	0000b	No	-
07h	4b	Reserved	0000b	No	-
08h	38h	Reserved	00h	No	-

Logical Block Provisioning Mode Page

00h	5b	PERIPHERAL DEVICE TYPE	00000b 1Eh	No	-
00h	3b	PERIPHERAL QUALIFIER	000b	No	-
01h	01h	PAGE CODE	B2h	No	-
02h	02h	PAGE LENGTH	04h	No	-
04h	01h	THRESHOLD EXPONENT	16h	No	-
05h	1b	DP	00h	No	-
05h	1b	ANC_SUP	0000b	No	-
05h	4b	Reserved	0000b	No	-
05h	1b	LBPWS	0b	No	-
05h	1b	LBPU	1b	No	-
06h	3b	PROVISIONING TYPE	000b	No	-
06h	5b	Reserved	00000b	No	-
07h	01h	Reserved	00h	No	-
08h	N/A	PROVISIONING GROUP DESCRIPTOR	N/A	No	-

4.6 MIPI UniPro Related Attributes

In general, the UniPro related attributes, values, and use of them are defined in the MIPI UniPro Specification. Please refer to [MIPI-UniPro], MIPI Alliance Specification for Unified Protocol (UniProSM).

4.7 MIPI M-PHY Related Attributes

Table 21 and Table 4-15 list the expected values for the M-TX and M-RX capability attributes. For detailed description, please refer to [MIPI-M-PHY], MIPI Alliance Specification for M-PHY®, Version 3.00.00.

Table 4-15 M-TX Capability Attribute Values

Attribute Name	Attribute ID	Value	Description
TX_HSMODE_Capability	0x01	0x01	Specifies support for HS-MODE.
TX_HSGEAR_Capability	0x02	0x04	Specifies supported HS-GEARs.
TX_PWMGO_Capability	0x03	0x00	Specifies support for PWM-G0.
TX_PWMGEAR_Capability	0x04	0x04	Specifies support for PWM-GEARs other than PWM-G0.
TX_Amplitude_Capability	0x05	0x03	Specified supported signal amplitude levels LARGE_AND_SMALL_AMPLITUDE = 3.
TX_ExternalSYNC_Capability	0x06	0x01	Specifies support for external SYNC pattern.
TX_HS_Unterminated_LINE_Drive_Capability	0x07	0x00	Specifies whether or not M-TX supports driving an unterminated LINE in HS-MODE.
TX_LS_Terminated_LINE_Drive_Capability	0x08	0x01	Specifies whether or not M-TX supports driving a terminated line in LS-MODE.
TX_Min_SLEEP_NoConfig_Time_Capability	0x09	0x08	Specifies minimum time (in SI) in SLEEP state needed when inline configuration was not performed.
TX_Min_STALL_NoConfig_Time_Capability	0x0A	0x80	Specifies minimum time (in SI) in STALL state needed when inline configuration was not performed.
TX_Min_SAVE_Config_Time_Capability	0x0B	0x7F	Specifies minimum reconfiguration time (in 40ns steps) plus an additional 20 SI in the GEAR from which the configuration change was initiated. This applies only to SLEEP and STALL states.
TX_REF_CLOCK_SHARED_Capability	0x0C	0x01	Specifies support for a shared reference clock.
TX_PHY_MajorMinor_Release_Capability	0x0D	0x41	Specifies the major and minor numbers of the M- PHY version supported by the M-TX Version 3.0 = 0x30.
TX_PHY_Editorial_Release_Capability	0x0E	0x01	Specifies the sequence number of the M-PHY version supported by the M-TX.
TX_Hibern8Time_Capability	0x0F	0x01	Specifies minimum time (in 100μs steps) in HIBERN8 state.
TX_Advanced_Granularity_Capability	0x10	0x05	Support and degree of fine granularity steps for a reduced time in HIBERN8 state. If a finer granularity is specified, all coarser granularities shall be supported.
TX_Advanced_Hibern8Time_Capability	0x11	0x07	Specifies minimum time in HIBERN8 state when advanced granularity is supported in steps defined by TX_Advanced_Granularity_Capability.
TX_HS_Equalizer_Setting_Capability	0x12	0x03	Support for transmit path de-emphasis for HS- MODE.

Table 4-16 M-RX Capability Attribute Values

Attribute Name	Attribute ID	Value	Description
RX_HSMODE_Capability	0x81	0x01	Specifies support for HS-MODE.
RX_HSGEAR_Capability	0x82	0x04	Specifies supported HS-GEARS.
RX_PWMG0_Capability	0x83	0x00	Specifies support for PWM-G0.
RX_PWMGEAR_Capability	0x84	0x04	Specifies support for PWM-GEARS other than PWM-G0.
RX_HS_Unterminated_Capability	0x85	0x00	Specifies support for disconnection of resistive termination in HS-MODE.
RX_LS_Terminated_Capability	0x86	0x01	Specifies support for enabling resistive termination in LS-MODE.
RX_Min_SLEEP_NoConfig_Time_Capability	0x87	0x0F	Specifies minimum time (in SI) in SLEEP state needed when inline configuration was not performed.
RX_Min_STALL_NoConfig_Time_Capability	0x88	0xFA	Specifies minimum time (in SI) in STALL state needed when inline configuration was not performed.
RX_Min_SAVE_Config_Time_Capability	0x89	0xFA	Specifies minimum reconfiguration time (in 40ns steps). This applies only to SLEEP and STALL states.
RX_REF_CLOCK_SHARED_Capability	0x8A	0x01	Specifies support for a shared reference clock
RX_HS_G1_SYNC_LENGTH_Capability	0x8B	0x48	High Speed GEAR 1 Synchronization pattern length in SI.
RX_HS_G1_PREPARE_LENGTH_Capability	0x8C	0x0F	HS-G1 PREPARE length multiplier for M-RX.
RX_LS_PREPARE_LENGTH_Capability	0x8D	0x06	PWM-BURST or SYS-BURST PREPARE length multiplier for M-RX.
RX_PWM_Burst_Closure_Length_Capability	0x8E	0x1F	Specifies minimum burst closure time (in SI) necessary to guarantee complete data processing inside M-RX.
RX_Min_ActivateTime_Capability	0x8F	0x04	Specifies minimum activate time needed in 100μs steps.
RX_PHY_MajorMinor_Release_Capability	0x90	0x41	Specifies the major and minor numbers of the M-PHY version supported by the M-RX.
RX_PHY_Editorial_Release_Capability	0x91	0x01	Specifies the sequence number of the M-PHY version supported by the M-RX.
RX_Hibern8Time_Capability	0x92	0x01	Specifies minimum time (in 100μs steps) in HIBERN8 state.
RX_PWM_G6_G7_SYNC_LENGTH_Capability	0x93	0x0F	Synchronization pattern length, in SI, for PWM- G6 and PWM- G7 in LS-MODE.
RX_HS_G2_SYNC_LENGTH_Capability	0x94	0x48	High Speed GEAR 2 Synchronization pattern length in SI.
RX_HS_G3_SYNC_LENGTH_Capability	0x95	0x49	High Speed GEAR 3 Synchronization pattern length in SI.

Attribute Name	Attribute ID	Value	Description
RX_HS_G2_PREPARE_LENGTH_Capability	0x96	0x0F	HS-G2 PREPARE length multiplier for M-RX.
RX_HS_G3_PREPARE_LENGTH_Capability	0x97	0x0F	HS-G3 PREPARE length multiplier for M-RX.
RX_Advanced_Granularity_Capability	0x98	0x07	Support and degree of fine granularity steps for THIBERN8 and TACTIVATE.
RX_Advanced_Hibern8Time_Capability	0x99	0x4	Specifies minimum time in HIBERN8 state when advanced granularity is supported in steps defined by RX_Advanced_Granularity_Capability.
RX_Advanced_Min_ActivateTime_Capability	0x9A	0x0B	Specifies minimum activate time when advanced granularity is supported in steps defined by RX_Advanced_Granularity_Capability.
RX_HS_G4_SYNC_LENGTH_Capability	0x9B	0x4B	High Speed GEAR 4 Synchronization pattern length in SI.
RX_HS_G4_PREPARE_LENGTH_Capability	0x9C	0xF	HS-G4 PREPARE length multiplier for M-RX.
RX_HS_Equalizer_Setting_Capability	0x9D	0x01	Support for receiver path channel equalization for HS-MODE.
RX_HS_ADAPT_REFRESH_Capability	0x9E	0x7F	REFRESH is used for RX adaptation refresh. High Speed adaptation pattern length of M-RX.
RX_HS_ADAPT_INITIAL_Capability	0x9F	0x8E	INITIAL is used for initial RX adaptation. High Speed adaptation pattern length of M-RX.

5. DC Electrical Characteristics

5.1 DC Characteristics

Table 5-1 Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Supply Voltage (I/O)	VCCQ	1.14	1.2	1.26	V
Supply Voltage (NAND)	VCC	2.4	2.5	2.7	V
		2.7	3.3	3.6	V
Supply Power-up for 3.3V	tPRUH	-	-	35	ms
Supply Power-up for 1.2V	tPRUL	-	-	25	ms
Operating Temperature	T _{OPR}	-40	-	+105	°C

Note: Operating Temperature is the case surface temperature of the UFS device.

5.2 Absolute Maximum Ratings

Permanent damage of devices may occur if the absolute maximum ratings are exceeded. These are only stress ratings, and the functional operations should be restricted with the conditions detailed in Table 5-2. Exposure to the absolute maximum rating conditions may also affect the reliability of the devices.

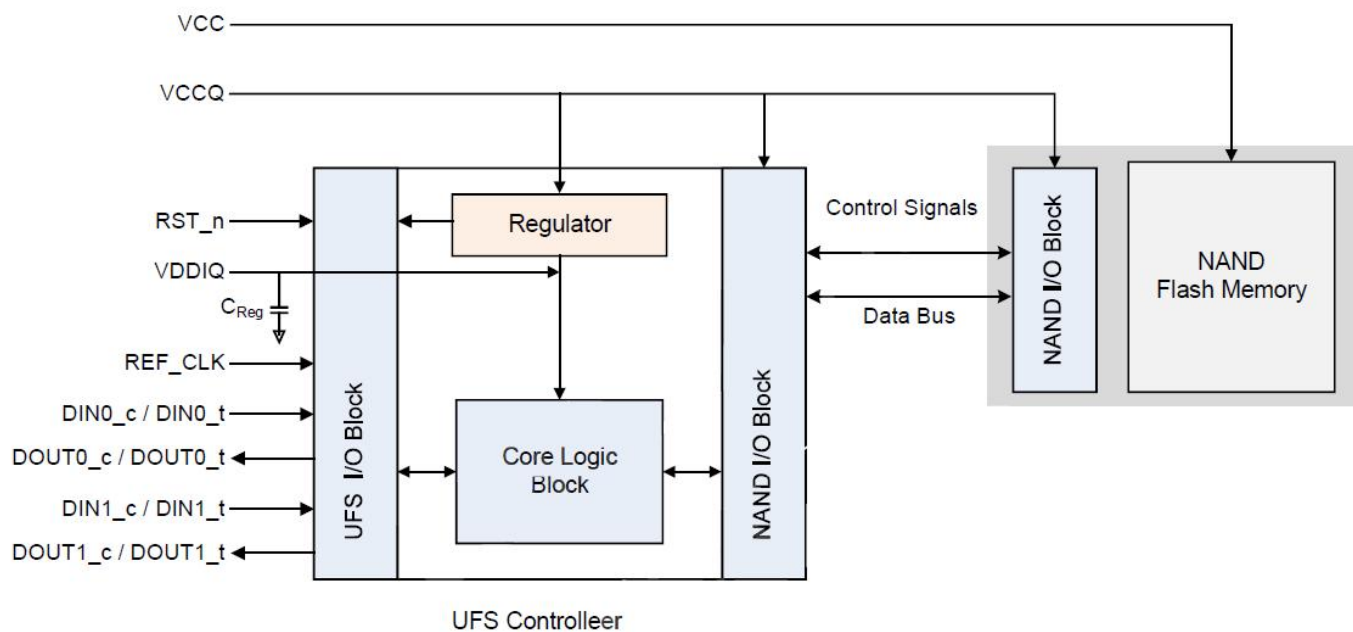
Table 5-2 Absolute Maximum Ratings

Parameter	Symbol	Min	Max	Unit
Voltage on REF_CLK and RST_n Signals	-	-0.2	1.6	V
VCCQ Supply	VCCQ	-0.2	1.6	V
VCC Supply	VCC	-0.6	4.6	V
Storage Temperature	T _{STG}	-40	+105	°C

Note: Storage Temperature is the case surface temperature of the UFS device.

In the Metorage UFS, VCC is used for the NAND flash device; and VCCQ is for the controller and the UFS interface voltage. A CReg capacitor must be connected to the VDDIQ terminal to stabilize regulator output on the system.

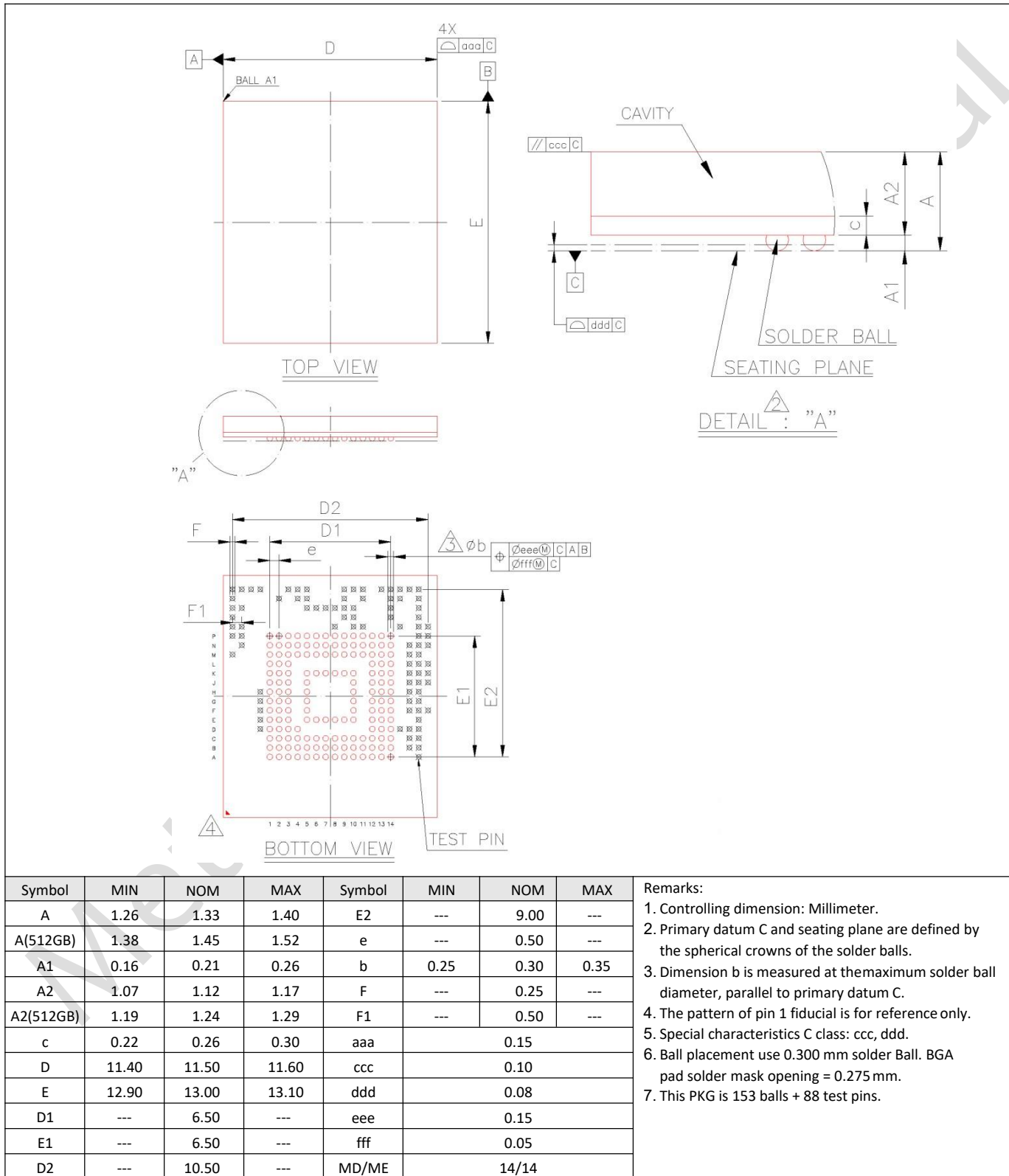
Figure 5-3 Internal Power Diagram (Example)



6. Mechanical Dimensions

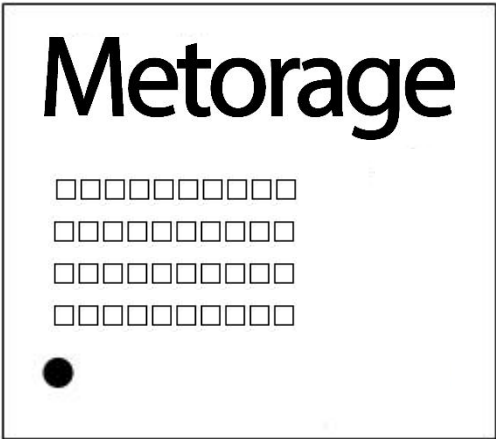
Figure6-1 153-Ball BGA Package Outline

(64GB/128GB/256GB: 11.5mmx13mmx1.4mm) (512GB: 11.5mmx13mmx1.52mm)



Note: The following package outline applies to the Metorage UFS with 64GB/128GB/256GB/512GB capacity.

7. Marking



UFS logo

□□□□□□□□□□ : Part Number

□□□□□□□□□□ : Control Code1

□□□□□□□□□□ : Control Code2

□□□□□□□□□□ : Control Code3

8. Appendix

8.1 Endurance characteristic

3,000 cycles/block