e·MMC Memory

MTFC4GLMDQ-AIT Z, MTFC4GLMDQ-AIT A

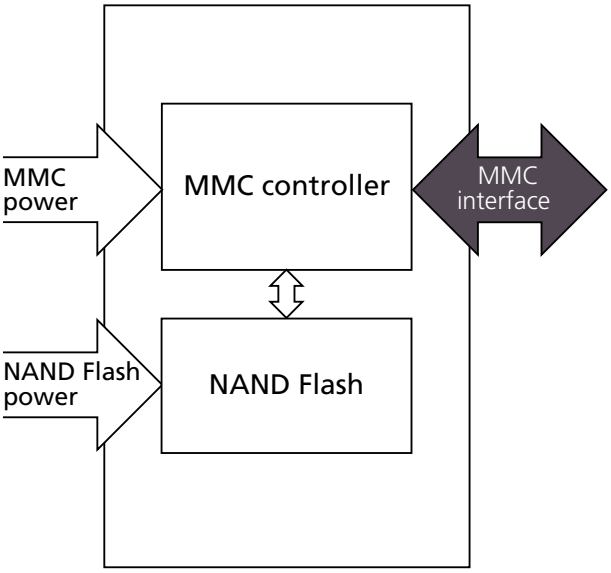
Features

- MultiMediaCard (MMC) controller and NAND Flash
- 100-ball LBGA (RoHS 6/6-compliant)
- V_{CC}: 2.7–3.6V
- V_{CCQ} (dual voltage): 1.65–1.95V; 2.7–3.6V
- Temperature ranges
  - Industrial temperature: –40˚C to +85˚C
  - Storage temperature: –40˚C to +85˚C
- Typical current consumption
  - Standby current: 130µA
  - Active current (RMS): 75mA

MMC-Specific Features

- JEDEC/MMC standard version 4.41-compliant (JEDEC Standard No. 84-A441) – SPI mode not supported (see www.jedec.org/sites/default/files/docs/JESD84-A441.pdf)
  - Advanced 11-signal interface
  - x1, x4, and x8 I/Os, selectable by host
  - MMC mode operation
  - Command classes: class 0 (basic); class 2 (block read); class 4 (block write); class 5 (erase); class 6 (write protection); class 7 (lock card)
  - MMC*plus*™ and MMC*mobile*™ protocols
  - Temporary write protection
  - 52 MHz clock speed (MAX)
  - Boot operation (high-speed boot)
  - Sleep mode
  - Replay-protected memory block (RPMB)
  - Secure erase and trim
  - Hardware reset signal
  - Multiple partitions with enhanced attribute
  - Permanent and power-on write protection
  - Double data rate (DDR) function
  - High-priority interrupt (HPI)

Figure 1: Micron e·MMC Device



MMC-Specific Features (Continued)

- Background operation
- Enhanced reliable write
- Fully enhanced configurable
- Backward-compatible with previous MMC modes

- ECC and block management implemented

e·MMC Performance

Table 1: MLC Partition Performance

Condition	Typical Values MTFC4GLMDQ-AIT Z MTFC4GLMDQ-AIT A	Units
Sequential write	6.6	MB/s
Sequential read	27	MB/s
Random write	90	IOPS
Random read	1080	IOPS

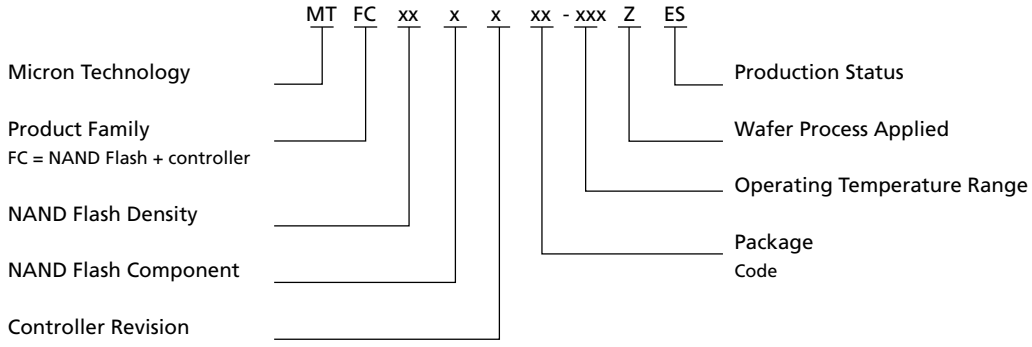
Note: 1. Bus in x8 I/O mode. Sequential access of 1MB chunk; random access of 4KB chunk. Additional performance data, such as power consumption or timing for different device modes, will be provided in a separate document upon customer request.

Part Numbering Information

Table 2: Ordering Information

Manufacturing Part Number	Density	Package	NAND Flash Type	Shipping Media
MTFC4GLMDQ-AIT Z MTFC4GLMDQ-AIT A	4GB	100-ball LBGA 14.0mm x 18.0mm x 1.4mm	1 x 32Gb, 25nm, MLC	Tray/tape and reel

Figure 2: e·MMC Part Numbering



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General Description

Micron e.MMC is a communication and mass data storage device that includes a MultiMediaCard (MMC) interface, a NAND Flash component, and a controller on an advanced 11-signal bus, which is compliant with the MMC system specification. Its cost per bit, small package sizes, and high reliability make it an ideal choice for automotive applications, including information and entertainment, navigation tools, advanced driving assistance systems, and a variety of other industrial and portable products.

The nonvolatile e.MMC draws no power to maintain stored data, delivers high performance across a wide range of operating temperatures, and resists shock and vibration disruption.

Signal Descriptions

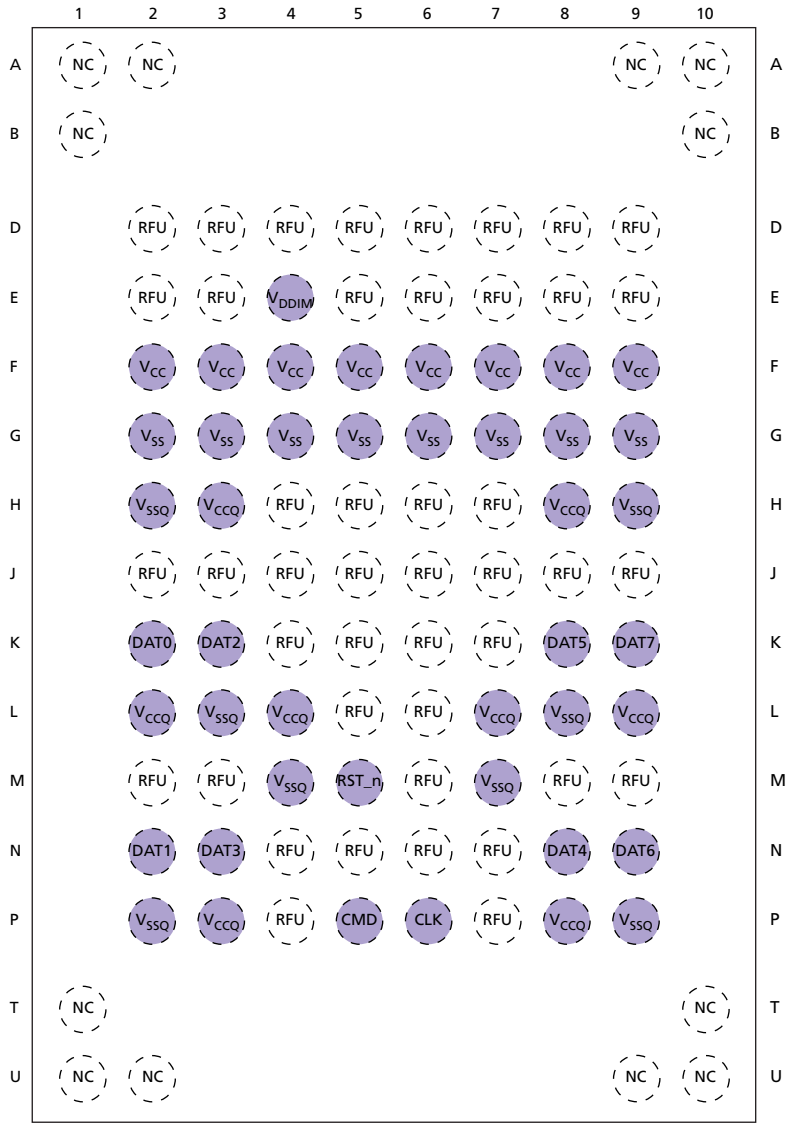
Table 3: Signal Descriptions

Symbol	Type	Description
CLK	Input	Clock: Each cycle of the clock directs a transfer on the command line and on the data line(s). The frequency can vary between the minimum and the maximum clock frequency.
RST_n	Input	Reset: The RST_n signal is used by the host for resetting the device, moving the device to the pre-idle state. By default, the RST_n signal is temporarily disabled in the device. The host must set ECSD register byte 162, bits[1:0] to 0x1 to enable this functionality before the host can use it.
CMD	I/O	Command: This signal is a bidirectional command channel used for command and response transfers. The CMD signal has two bus modes: open-drain mode and push-pull mode (see Operating Modes). Commands are sent from the MMC host to the device, and responses are sent from the device to the host.
DAT[7:0]	I/O	Data I/O: These are bidirectional data signals. The DAT signals operate in push-pull mode. By default, after power-on or assertion of the RST_n signal, only DAT0 is used for data transfer. The MMC controller can configure a wider data bus for data transfer either using DAT[3:0] (4-bit mode) or DAT[7:0] (8-bit mode). e.MMC includes internal pull-up resistors for data lines DAT[7:1]. Immediately after entering the 4-bit mode, the device disconnects the internal pull-up resistors on the DAT[3:1] lines. Upon entering the 8-bit mode, the device disconnects the internal pull-ups on the DAT[7:1] lines.
V_{CC}	Supply	V_{CC}: NAND interface (I/F) I/O and NAND Flash power supply.
V_{CCQ}	Supply	V_{CCQ}: e.MMC controller core and e.MMC I/F I/O power supply.
V_{SS}[1]	Supply	V_{SS}: NAND I/F I/O and NAND Flash ground connection.
V_{SSQ}[1]	Supply	V_{SSQ}: e.MMC controller core and e.MMC I/F ground connection.
V_{DDIM}		Internal voltage node: At least a 0.1µF capacitor is required to connect V_{DDIM} to ground. A 1µF capacitor is recommended. Do not tie to supply voltage or ground.
NC	–	No connect: No internal connection is present.
RFU	–	Reserved for future use: No internal connection is present. Leave it floating externally.

Note: 1. V_{SS} and V_{SSQ} are connected internally.

100-Ball Signal Assignments

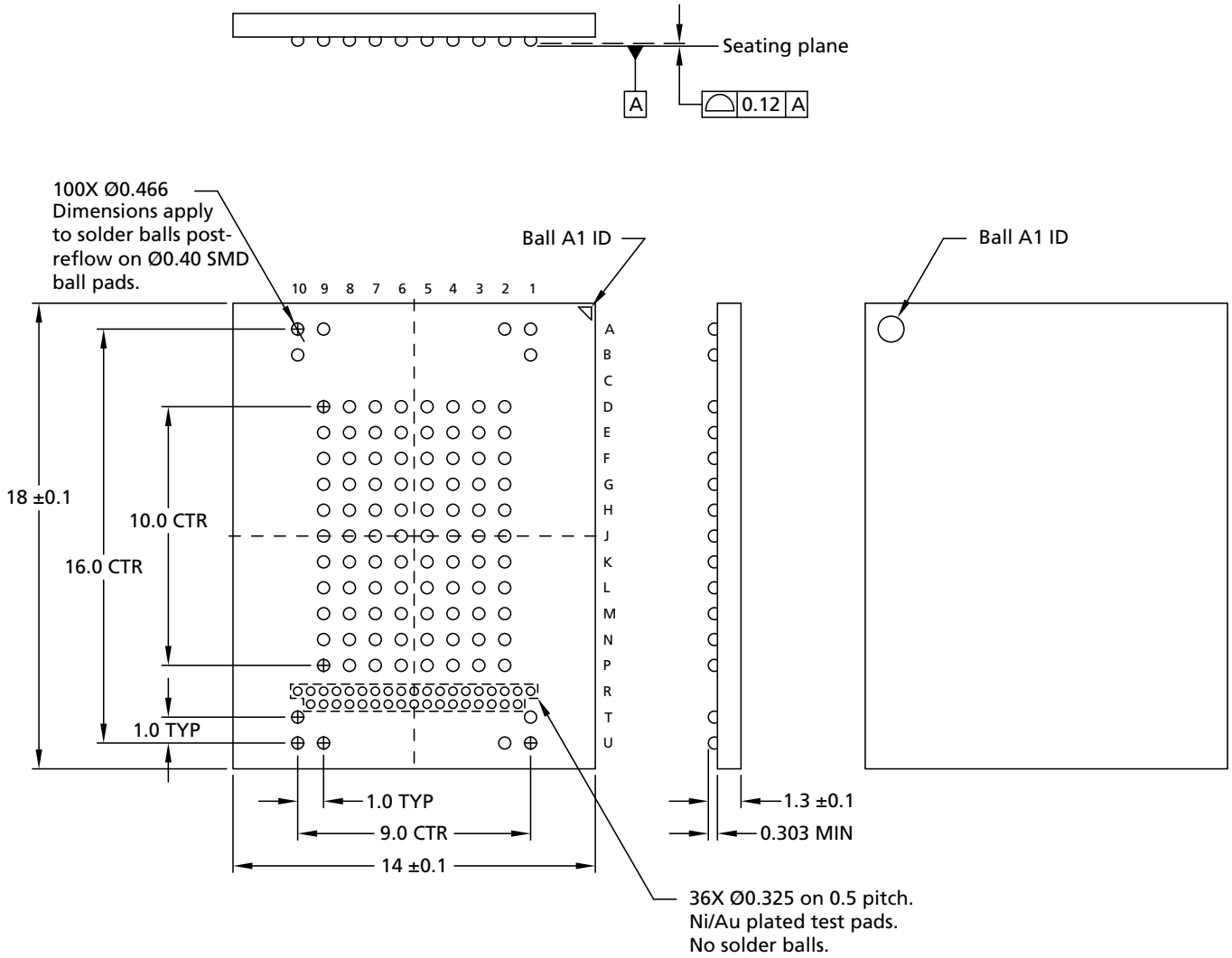
Figure 3: 100 Ball (Top View, Ball Down)



Notes:
1. Connect a 1µF decoupling capacitor from V_{DDIM} to ground.
2. Some previous versions of the JEDEC product or mechanical specification had defined reserved for future use (RFU) balls as no connect (NC) balls. NC balls assigned in the previous specifications could have been connected to ground on the system board. To enable new feature introduction, some of these balls are assigned as RFU in the v4.4 mechanical specification. Any new PCB footprint implementations should use the new ball assignments and leave the RFU balls floating on the system board.
3. V_{CC}, V_{CCQ}, V_{SS}, and V_{SSQ} balls must all be connected on the system board.

Package Dimensions

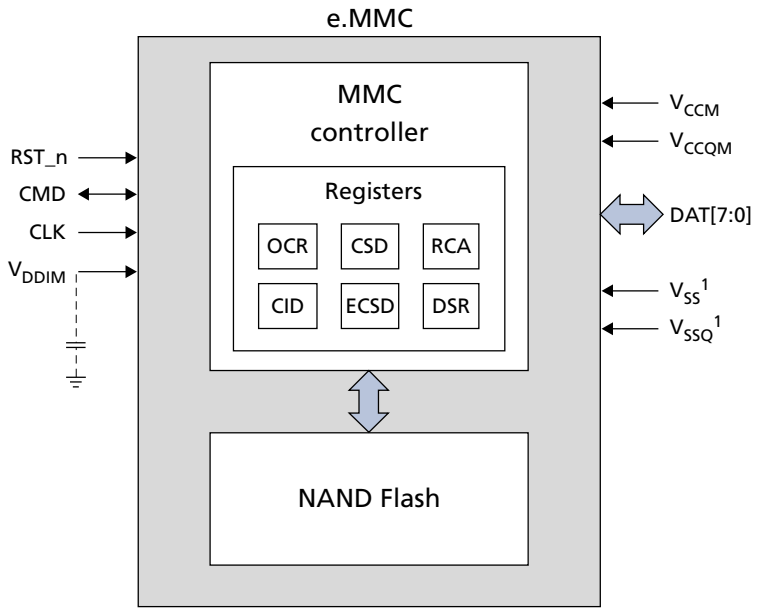
Figure 4: 100-Ball LBGA – 14.0mm x 18.00mm x 1.4mm (Package Code: DQ)



Notes:
1. Dimensions are in millimeters.
2. Solder ball material: SnAgCu (96.5% Sn, 3% Ag, 0.5% Cu).
3. Test pads are not solder balls and are for Micron internal use only.

Architecture

Figure 5: e.MMC Functional Block Diagram



Note: 1. V_{SS} and V_{SSQ} are internally connected.

MMC Protocol Independent of NAND Flash Technology

The MMC specification defines the communication protocol between a host and a device. The protocol is independent of the NAND Flash features included in the device. The device has an intelligent on-board controller that manages the MMC communication protocol.

The controller also handles block management functions such as logical block allocation and wear leveling. These management functions require complex algorithms and depend entirely on NAND Flash technology (generation or memory cell type).

The device handles these management functions internally, making them invisible to the host processor.

Defect and Error Management

Micron e.MMC incorporates advanced technology for defect and error management. If a defective block is identified, the device completely replaces the defective block with one of the spare blocks. This process is invisible to the host and does not affect data space allocated for the user.

The device also includes a built-in error correction code (ECC) algorithm to ensure that data integrity is maintained.

To make the best use of these advanced technologies and ensure proper data loading and storage over the life of the device, the host must exercise the following precautions:

- Check the status after WRITE, READ, and ERASE operations.
- Avoid power-down during WRITE and ERASE operations.

OCR Register

The 32-bit operation conditions register (OCR) stores the voltage profile of the card and the access mode indication. In addition, this register includes a status information bit.

Table 4: OCR Parameters

OCR Bits	OCR Value	Description
[31]	1b (ready)/0b (busy)[1]	Device power-on status bit
[30:29]	10b	Sector mode
[28:24]	0 0000b	Reserved
[23:15]	1 1111 1111b	2.7–3.6V voltage range
[14:8]	000 0000b	2.0–2.7V voltage range
[7]	1b	1.70–1.95V voltage range
[6:0]	000 0000b	Reserved

Note: 1. OCR = C0FF8080h after the device has completed power-up.

CID Register

The card identification (CID) register is 128 bits wide. It contains the device identification information used during the card identification phase as required by e.MMC protocol. Each device is created with a unique identification number.

Table 5: CID Register Field Parameters

Name	Field	Width	CID Bits	CID Value
Manufacturer ID	MID	8	[127:120]	FEh
Reserved	–	6	[119:114]	–
Card/BGA	CBX	2	[113:112]	01h
OEM/application ID	OID	8	[111:104]	–
Product name	PNM	48	[103:56]	–
Product revision	PRV	8	[55:48]	–
Product serial number	PSN	32	[47:16]	–
Manufacturing date	MDT	8	[15:8]	–
CRC7 checksum	CRC	7	[7:1]	–
Not used; always 1	–	1	[0]	–

CSD Register

The card-specific data (CSD) register provides information about accessing the device contents. The CSD register defines the data format, error correction type, maximum data access time, and data transfer speed, as well as whether the DS register can be used. The programmable part of the register (entries marked with W or E in the following table) can be changed by the PROGRAM_CSD (CMD27) command.

Table 6: CSD Register Field Parameters

Name	Field	Width	Cell Type[1]	CSD Bits	CSD Value
CSD structure	CSD_STRUCTURE	2	R	[127:126]	3h
System specification version	SPEC_VERS	4	R	[125:122]	4h
Reserved[2]	–	2	TBD	[121:120]	–
Data read access time 1	TAAC	8	R	[119:112]	4Fh
Data read access time 2 in CLK cycles (NSAC × 100)	NSAC	8	R	[111:104]	01h
Maximum bus clock frequency	TRAN_SPEED	8	R	[103:96]	32h
Card command classes	CCC	12	R	[95:84]	0F5h
Maximum read data block length	READ_BL_LEN	4	R	[83:80]	09h
Partial blocks for reads supported	READ_BL_PARTIAL	1	R	[79]	0h
Write block misalignment	WRITE_BLK_MISALIGN	1	R	[78]	0h
Read block misalignment	READ_BLK_MISALIGN	1	R	[77]	0h
DS register implemented[3]	DSR_IMP	1	R	[76]	1h
Reserved	–	2	R	[75:74]	–
Device size	C_SIZE	12	R	[73:62]	FFFh
Maximum read current at $V_{DD,min}$	VDD_R_CURR_MIN	3	R	[61:59]	7h
Maximum read current at $V_{DD,max}$	VDD_R_CURR_MAX	3	R	[58:56]	7h
Maximum write current at $V_{DD,min}$	VDD_W_CURR_MIN	3	R	[55:53]	7h
Maximum write current at $V_{DD,max}$	VDD_W_CURR_MAX	3	R	[52:50]	7h
Device size multiplier	C_SIZE_MULT	3	R	[49:47]	7h
Erase group size	ERASE_GRP_SIZE	5	R	[46:42]	1Fh
Erase group size multiplier	ERASE_GRP_MULT	5	R	[41:37]	1Fh
Write protect group size	WP_GRP_SIZE	5	R	[36:32]	07h
Write protect group enable	WP_GRP_ENABLE	1	R	[31]	1h
Manufacturer default ECC	DEFAULT_ECC	2	R	[30:29]	0h
Write-speed factor	R2W_FACTOR	3	R	[28:26]	2h

Table 6: CSD Register Field Parameters (Continued)

Name	Field	Width	Cell Type[1]	CSD Bits	CSD Value
Maximum write data block length	WRITE_BL_LEN	4	R	[25:22]	9h
Partial blocks for writes supported	WRITE_BL_PARTIAL	1	R	[21]	0h
Reserved	–	4	R	[20:17]	–
Content protection application	CONTENT_PROT_APP	1	R	[16]	0h
File-format group	FILE_FORMAT_GRP	1	R/W	[15]	0h
Copy flag (OTP)	COPY	1	R/W	[14]	0h
Permanent write protection	PERM_WRITE_PROTECT	1	R/W	[13]	0h
Temporary write protection	TMP_WRITE_PROTECT	1	R/W/E	[12]	0h
File format	FILE_FORMAT	2	R/W	[11:10]	0h
ECC	ECC	2	R/W/E	[9:8]	0h
CRC	CRC	7	R/W/E	[7:1]	–
Not used; always 1	–	1	–	[0]	1h

Notes:
1. R = Read-only

   R/W = One-time programmable and readable

   R/W/E = Multiple writable with value kept after a power cycle, assertion of the RST_n signal, and any CMD0 reset, and readable

   TBD = To be determined
2. Reserved bits should be read as 0.
3. If (2.7V ≤ V_{CCQ} ≤ 3.6V), Micron recommends evaluating a reduction of the $I_{PEAK, max}$ driving capability to 8mA or 4mA using the SET_DSR command (CMD4). The optimal setting must be selected according to the actual capacitive load on the *e*·MMC interface signals in the user application board.

CMD4 Argument	Driving Capability (mA)
0x01000000	4
0x02000000	8
0x04000000	12 (default)
0x08000000	16
0x10000000	20
0x20000000	24
0x40000000	28
0x80000000	32

ECSD Register

The 512-byte extended card-specific data (ECSD) register defines device properties and selected modes. The most significant 320 bytes are the properties segment. This segment defines device capabilities and cannot be modified by the host. The lower 192 bytes are the modes segment. The modes segment defines the configuration in which the device is working. The host can change the properties of the modes segments using the SWITCH command.

Table 7: ECSD Register Field Parameters

Name	Field	Size (Bytes)	Cell Type[1]	ECSD Bytes	ECSD Value
Properties Segment					
Reserved[2]	–	7	–	[511:505]	–
Supported command sets	S_CMD_SET	1	R	[504]	1h
HPI features	HPI_FEATURES	1	R	[503]	3h
Background operations support	BKOPS_SUPPORT	1	R	[502]	1h
Reserved	–	255	–	[501:247]	–
Background operations status	BKOPS_STATUS	1	R	[246]	0h
Number of correctly programmed sectors	CORRECTLY_PRG_ SECTORS_NUM	4	R	[245:242]	–
First initialization time after partitioning (first CMD1 to device ready)	INI_TIMEOUT_PA	1	R	[241]	F6h
Reserved	–	1	–	[240]	–
Power class for 52 MHz, DDR at 3.6V[3]	PWR_CL_DDR_52_360	1	R	[239]	0h
Power class for 52 MHz, DDR at 1.95V[3]	PWR_CL_DDR_52_195	1	R	[238]	0h
Reserved	–	2	–	[237:236]	–
Minimum write performance for 8-bit at 52 MHz in DDR mode	MIN_PERF_DDR_W_8_52	1	R	[235]	0h
Minimum read performance for 8-bit at 52 MHz in DDR mode	MIN_PERF_DDR_R_8_52	1	R	[234]	0h
Reserved	–	1	–	[233]	–
TRIM multiplier	TRIM_MULT	1	R	[232]	06h
Secure feature support	SEC_FEATURE_SUPPORT	1	R	[231]	15h
SECURE ERASE multiplier	SEC_ERASE_MULT	1	R	[230]	02h
SECURE TRIM multiplier	SEC_TRIM_MULT	1	R	[229]	03h
Boot information	BOOT_INFO	1	R	[228]	7h
Reserved	–	1	–	[227]	–
Boot partition size	BOOT_SIZE_MULT	1	R	[226]	08h

Table 7: ECSD Register Field Parameters (Continued)

Name	Field	Size (Bytes)	Cell Type[1]	ECSD Bytes	ECSD Value
Access size	ACC_SIZE	1	R	[225]	05h
High-capacity erase unit size	HC_ERASE_GRP_SIZE	1	R	[224]	04h
High-capacity erase timeout	ERASE_TIMEOUT_MULT	1	R	[223]	01h
Reliable write-sector count	REL_WR_SEC_C	1	R	[222]	01h
High-capacity write protect group size	HC_WP_GRP_SIZE	1	R	[221]	02h
Sleep current (V_{CC})	S_C_VCC	1	R	[220]	08h
Sleep current (V_{CCQ})	S_C_VCCQ	1	R	[219]	08h
Reserved	–	1	–	[218]	–
Sleep/awake timeout	S_A_TIMEOUT	1	R	[217]	10h
Reserved	–	1	–	[216]	–
Sector count	SEC_COUNT	4	R	[215:212]	00754000h
Reserved	–	1	–	[211]	–
Minimum write performance for 8-bit at 52 MHz	MIN_PERF_W_8_52	1	R	[210]	08h
Minimum read performance for 8-bit at 52 MHz	MIN_PERF_R_8_52	1	R	[209]	08h
Minimum write performance for 8-bit at 26 MHz and 4-bit at 52 MHz	MIN_PERF_W_8_26_4_52	1	R	[208]	08h
Minimum read performance for 8-bit at 26 MHz and 4-bit at 52 MHz	MIN_PERF_R_8_26_4_52	1	R	[207]	08h
Minimum write performance for 4-bit at 26 MHz	MIN_PERF_W_4_26	1	R	[206]	08h
Minimum read performance for 4-bit at 26 MHz	MIN_PERF_R_4_26	1	R	[205]	08h
Reserved	–	1	–	[204]	–
Power class for 26 MHz at 3.6V[3]	PWR_CL_26_360	1	R	[203]	00h
Power class for 52 MHz at 3.6V[3]	PWR_CL_52_360	1	R	[202]	00h
Power class for 26 MHz at 1.95V[3]	PWR_CL_26_195	1	R	[201]	00h
Power class for 52 MHz at 1.95V[3]	PWR_CL_52_195	1	R	[200]	00h
Partition switching timing	PARTITION_SWITCH_TIME	1	R	[199]	1h
Out-of-interrupt busy timing	OUT_OF_INTERRUPT_TIME	1	R	[198]	02h
Reserved	–	1	–	[197]	–
Card type	CARD_TYPE	1	R	[196]	07h
Reserved	–	1	–	[195]	–
CSD structure version	CSD_STRUCTURE	1	R	[194]	2h

Table 7: ECSD Register Field Parameters (Continued)

Name	Field	Size (Bytes)	Cell Type[1]	ECSD Bytes	ECSD Value
Reserved	–	1	–	[193]	–
Extended CSD revision	EXT_CSD_REV	1	R	[192]	5h
Modes Segment					
Command set	CMD_SET	1	R/W/E_P	[191]	0h
Reserved	–	1	–	[190]	–
Command set revision	CMD_SET_REV	1	R	[189]	0h
Reserved	–	1	–	[188]	–
Power class	POWER_CLASS	1	R/W/E_P	[187]	0h
Reserved	–	1	–	[186]	–
High-speed interface timing	HS_TIMING	1	R/W/E_P	[185]	0h
Reserved	–	1	–	[184]	–
Bus width mode	BUS_WIDTH	1	W/E_P	[183]	0h
Reserved	–	1	–	[182]	–
Erased memory content	ERASED_MEM_CONT	1	R	[181]	0h
Reserved	–	1	–	[180]	–
Partition configuration[4]	PARTITION_CONFIG	1	R/W/E, R/W/E_P	[179]	0h
Boot configuration protection	BOOT_CONFIG_PROT	1	R/W, R/W/C_P	[178]	0h
Boot bus width	BOOT_BUS_WIDTH	1	R/W/E	[177]	0h
Reserved	–	1	–	[176]	–
High-density erase group definition[5]	ERASE_GROUP_DEF	1	R/W/E_P	[175]	00h
Reserved	–	1	–	[174]	–
Boot area write protection register	BOOT_WP	1	R/W, R/W/C_P	[173]	0h
Reserved	–	1	–	[172]	–
User write protection register	USER_WP	1	R/W, R/W/C_P, R/W/E_P	[171]	0h
Reserved	–	1	–	[170]	–
Firmware configuration	FW_CONFIG	1	R/W	[169]	0h
RPMB size	RPMB_SIZE_MULT	1	R	[168]	1h
Write reliability setting register[3]	WR_REL_SET	1	R/W	[167]	0h
Write reliability parameter register	WR_REL_PARAM	1	R	[166]	05h
Reserved	–	1	–	[165]	–

Table 7: ECSD Register Field Parameters (Continued)

Name	Field	Size (Bytes)	Cell Type[1]	ECSD Bytes	ECSD Value
Manually start background operations	BKOPS_START	1	W/E_P	[164]	–
Enable background operations handshake	BKOPS_EN	1	R/W	[163]	0h
Hardware reset function	RST_n_FUNCTION	1	R/W	[162]	0h
HPI management	HPI_MGMT	1	R/W/E_P	[161]	0h
Partitioning support	PARTITIONING_SUPPORT	1	R	[160]	3h
Maximum enhanced area size	MAX_ENH_SIZE_MULT	3	R	[159:157]	0001D5h
Partitions attribute	PARTITIONS_ATTRIBUTE	1	R/W	[156]	0h
Partitioning setting	PARTITION_SETTING_COMPLETED	1	R/W	[155]	0h
General-purpose partition size	GP_SIZE_MULT	12	R/W	[154:143]	0h
Enhanced user data area size	ENH_SIZE_MULT	3	R/W	[142:140]	0h
Enhanced user data start address	ENH_START_ADDR	4	R/W	[139:136]	0h
Reserved	–	1	–	[135]	–
Bad block management mode	SEC_BAD_BLK_MGMNT	1	R/W	[134]	0h
Reserved	–	134	–	[133:0]	–

Notes:
1. R = Read-only

   R/W = One-time programmable and readable

   R/W/E = Multiple writable with the value kept after a power cycle, assertion of the RST_n signal, and any CMD0 reset, and readable

   R/W/C_P = Writable after the value is cleared by a power cycle and assertion of the RST_n signal (the value not cleared by CMD0 reset) and readable

   R/W/E_P = Multiple writable with the value reset after a power cycle, assertion of the RST_n signal, and any CMD0 reset, and readable

   W/E_P = Multiple writable with the value reset after power cycle, assertion of the RST_n signal, and any CMD0 reset, and not readable

   TBD = To be determined
2. Reserved bits should be read as 0.
3. Micron has tested power failure under best application knowledge conditions with positive results. Customers may request a dedicated test for their specific application condition.
4. Once WRITE operations have been made on the boot partitions (1 or 2), the PARTITION_ACCESS bits[2:0] must be reset to correctly validate the modifications.
5. The SECURE ERASE commands are not supported if ERASE_GROUP_DEF = 0.

DC Electrical Specifications – Device Power

The device current consumption for various device configurations is defined in the power class fields of the ECSD register.

V_{CC} is used for the NAND Flash device and its interface voltage; V_{CCQ} is used for the controller and the e.MMC interface voltage.

Figure 6: Device Power Diagram

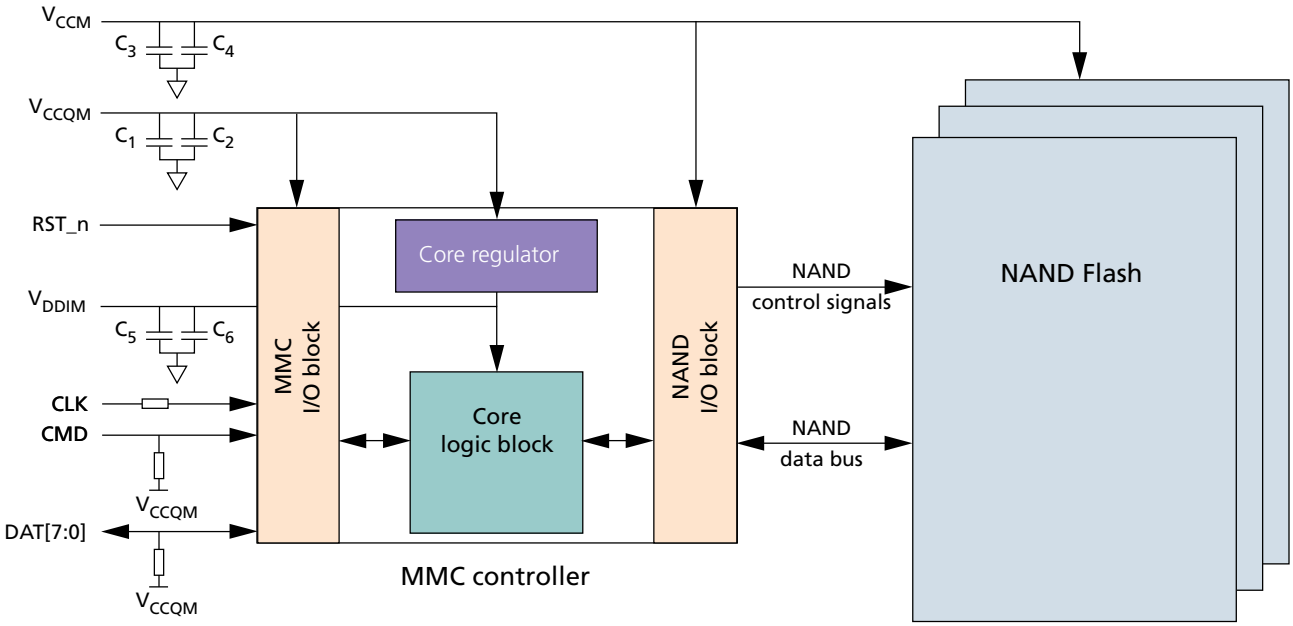


Table 8: Absolute Maximum Ratings

Parameters	Symbol	Min	Max	Unit
Voltage input	V_{IN}	–0.6	4.6	V
V_{CC} supply	V_{CC}	–0.6	4.6	V
V_{CCQ} supply	V_{CCQ}	–0.6	4.6	V
Storage temperature	T_{STG}	–40	85	°C

Note: 1. Voltage on any pin relative to V_{SS}.

Table 9: Capacitor and Resistance Specifications

Parameter	Symbol	Typ	Units	Notes
Pull-up resistance: CMD	R_CMD	10	kΩ	1
Pull-up resistance: DAT[7:0]	R_DAT	50	kΩ	1
Pull-up resistance: RST_n	R_RST_n	50	kΩ	2
CLK/CMD/DAT[7:0] impedance		50	Ω	3
Serial resistance on CLK	SR_CLK	22	Ω	
V_{CCQ} capacitor	C1	2.2	µF	4
	C2	0.1		
V_{CC} capacitor (≤8GB)	C3	2.2	µF	5
	C4	0.1		
V_{CC} capacitor (>8GB)	C3	4.7	µF	5
	C4	0.22		
V_{DDIM} capacitor (C_{reg})	C5	1	µF	6
	C6	0.1		

Notes:
1. Used to prevent bus floating.
2. If host does not use H/W RESET (RST_n), pull-up resistance is not needed on RST_n line (Extended_CSD[162] = 00h).
3. Impedance match.
4. The coupling capacitor should be connected with V_{CCQ} and V_{SSQ} as closely as possible.
5. The coupling capacitor should be connected with V_{CC} and V_{SS} as closely as possible.
6. The coupling capacitor should be connected with V_{DDIM} and V_{SS} as closely as possible.

Revision History

Rev. D – 01/19

- Added MPN

Rev. C – 08/18

- Added Important Notes and Warnings section for further clarification aligning to industry standards

Rev. B – 01/15

- Package code fixed

Rev. A – 10/14

- Initial release